Environmental Impact Study at Mount Pleasant

Final Report

Housing & Development Board (HDB)

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Client: Housing & Development Board (HDB)

Prepared by

AECOM
300 Beach Road, #23-00 The Concourse, Singapore 199555
T +65 6299 2466 F +65 6299 0297 www.aecom.com

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Prepared by Dan Lim, Dr Liang Liang, Hanzel Lalitan, Jacquelynn Chia, Jafon Ng, Mandy Yeo, Mark Shi, Mavis Lee, Phyo Zay and Camphora Pte Ltd

Reviewed by Albert Payapaya, Dr David Gallacher, Dr Thanh Nguyen and Jagriti Dawra

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Table of Contents

1.0 Executive Summary 1
2.0 Introduction 7
2.1 Purpose and Objectives of the EIS 7
2.2 Scope of Work 8
2.3 Environmental Parameters Assessed 8
2.4 Report Structure 10
2.5 Study Limitations, Assumptions and Constraints 10
3.0 Project Overview 12
3.1 Project Description 12
3.2 Location of Study Area 16
3.3 Proposed Construction Activities 18
3.3.1 Phase 1 – Demolition Works (Pre-construction Stage) 18
3.3.2 Phase 2 – Road Works for Traffic and Utility Diversion (Pre-construction Stage) 18
3.3.3 Phase 3 – Construction of Proposed Development 18
3.4 Proposed Operational Activities 22
4.0 Environmental Legislation, Policies, Plans, Standards and Criteria 23
5.0 Description of the Environment 29
5.1 Historical Land Use 29
5.2 Existing Land Use and Environment 30
5.3 Topography of the Study Area 31
5.4 Geology and Soil 31
6.0 EIS Approach and Methodology 35
6.1 Approach 35
6.2 Scoping of the Project 35
6.2.1 Study Area and Assessment Area 35
6.2.2 Identification and Classification of Sensitivity Receptors 35
6.3 Data Collection and Analysis 40
6.3.1 Sample Collection and Survey Locations 40
6.3.2 Secondary Data Collection 41
6.4 Assessment Criteria 42
6.4.1 Prediction of Impacts 42
6.4.2 Impact Evaluation 44
6.5 Mitigation, Monitoring and Management 48
7.0 Air Quality 51
7.1 Air Quality Baseline Monitoring 51
7.1.1 Baseline Monitoring Personnel 51
7.1.2 Baseline Environment 51
7.1.3 Baseline Monitoring Methodology 52
7.1.4 Baseline Monitoring Results 57
7.2 Air Quality Impact Assessment 62
7.2.1 Assessment Approach and Assumption 63
7.2.2 Identification and Classification of Sensitive Receptors 66
7.2.3 Potential Source of Impacts 67
7.2.4 Minimum Control for Potential Impacts 69
7.2.5 Prediction and Evaluation of Potential Impacts 69
7.3 Recommended Mitigation Measures 72
7.3.1 Construction Phase 72
7.3.2 Operational Phase 76
7.4 Residual Impacts 76
7.4.1 Construction Phase 76
7.4.2 Operational Phase 78
7.5 Summary of Key Findings 78
8.0 Airborne Noise 79
8.1 Baseline Noise Monitoring 79
8.1.1 Personnel 79
8.1.2 Field Assessment 79
8.1.3 Baseline Noise Results 82
8.2 Airborne Noise Impact Assessment 84

8.2.1 Assessment Approach and Assumptions 84
8.2.2 Construction Phases 84
8.2.3 Potential Sources of Impacts 85
8.2.4 Classification of Sensitive Receptors 86
8.2.5 Legislative Criteria 90
8.2.6 Prediction Methodology 101
8.2.7 Minimum Control for Impacts 102
8.2.8 Impact Prediction and Evaluation during Construction Phase 103
8.2.9 Impact Prediction and Evaluation during Operational Phase 114
8.3 Recommended Mitigation Measures 116
8.3.1 Construction Noise 116
8.3.2 Operation Noise 120
8.4 Residual Impacts 121
8.4.1 Construction Phase 121
8.4.2 Operational Phase 129
8.5 Summary of Key Findings 130
9.0 Groundborne Vibration 132
9.1 Introduction 132
9.2 Ground-borne Vibration Baseline Monitoring 132
9.2.1 Baseline Monitoring Personnel 132
9.2.2 Field Assessment 132
9.2.3 Baseline Vibration Results 133
9.3 Groundborne Noise Impact Assessment 133
9.3.1 Assessment Area 133
9.3.2 Potential Sources of Impacts 133
9.3.3 Classification of Sensitive Receptors 134
9.3.4 Assessment Criteria 138
9.3.5 Prediction Methodology 138
9.3.6 Minimum Control for Potential Impacts 139
9.3.7 Dilapidation Surveys 139
9.3.8 Equipment Selection and Maintenance 139
9.3.9 Works Scheduling 139
9.3.10 Authority Consultation 139
9.3.11 Impact Prediction and Evaluation during Construction Phase 139
9.3.12 Impact Prediction and Evaluation during the Operational Phase 150
9.4 Recommended Mitigation Measures 150
9.4.1 Construction Phase 150
9.4.2 Operational Phase 163
9.5 Residual Impacts 163
9.5.1 Construction Phase 163
9.5.2 Operational Phase 163
9.6 Summary of Key Findings 163
10.0 Hydrology and Water Quality 165
10.1 Introduction 165
10.2 Hydrology and Water Quality Baseline Assessment 167
10.2.1 Baseline Monitoring Personnel 167
10.2.2 Baseline Monitoring Methodology 167
10.2.3 Baseline Monitoring Results 170
10.3 Hydrology and Water Quality Impact Assessment 190
10.3.1 Assessment Approach and Assumption 190
10.3.2 Assessment Criteria 190
10.3.3 Identification and Classification of Sensitive Receptors 191
10.3.4 Potential Sources of Impacts 191
10.3.5 Minimum Control for Potential Impacts 193
10.3.6 Prediction and Evaluation of Potential Impacts 197
10.4 Recommended Mitigation Measures 200
10.5 Residual Impacts 203
10.6 Summary of Key Findings 208
11.0 Soil and Groundwater 219
11.1 Introduction 219
11.2 Soil and Groundwater Baseline Assessment 219

11.2.1 Baseline Assessment Personnel 219
11.2.2 Soil and Groundwater Sampling Points 219
11.2.3 Baseline Assessment Methodology 219
11.3 Baseline Soil and Groundwater Environment 223
11.3.1 Soil Profile 223
11.3.2 Soil Baseline Results 223
11.3.3 Groundwater Elevation 230
11.3.4 Groundwater Flow Direction and Velocity 230
11.3.5 Groundwater Quality 238
11.3.6 Groundwater Baseline Results 239
11.3.7 Groundwater Relationship to Surface Water 243
11.4 Soil and Groundwater Impact Assessment 245
11.4.1 Identification and Classification of Sensitive Receptors 245
11.4.2 Potential Source of Impacts 246
11.4.3 Minimum Control for Potential Impacts 247
11.4.4 Prediction and Evaluation of Potential Impacts 250
11.5 Recommended Mitigation Measures and Residual Impacts 252
11.6 Summary of Key Findings 252
12.0 Biodiversity 254
12.1 Introduction 254
12.2 Baseline Assessment Methodology 254
12.2.1 Personnel 254
12.2.2 Desktop Assessment 255
12.2.3 Native Status 256
12.2.4 Nomenclature and Taxonomy 256
12.2.5 Species of Conservation Significance 257
12.2.6 Flora Field Assessment 258
12.2.7 Flora Data Analysis 262
12.2.8 Fauna Field Assessment 262
12.2.9 Fauna Data Analysis 269
12.3 Baseline Ecological Environment 272
12.3.1 Habitat and Vegetation Types 272
12.3.2 Flora Field Assessment Results 277
12.3.3 Fauna Field Assessment Results 290
12.4 Summary of Baseline Findings and Assessment of Ecological Value 332
12.4.1 Summary of Biodiversity Baseline Findings 332
12.4.2 Ecological Value of Study Area 333
12.5 Ecological Impact Assessment 342
12.5.1 Key Ecological Receptors 342
12.5.2 Approach 344
12.5.3 Classification of Receptors 344
12.5.4 Ecological Impact Prediction and Evaluation 345
12.6 Recommended Mitigation Measures 355
12.6.1 Avoidance 355
12.6.2 Minimisation 356
12.6.3 Enhancement 360
12.6.4 Compensation 362
12.6.5 Mitigation Measures for the Protection of Threatened Fauna Species 362
12.6.6 Residual Impacts 363
12.7 Summary of Key Findings 369
13.0 Landscape and Visual Amenity 370
13.1 Introduction 370
13.2 Baseline Assessment Methodology 370
13.3 Baseline Landscape and Visual Amenity 370
13.4 Landscape and Visual Amenity Impact Assessment 370
13.4.1 Approach 371
13.4.2 Classification of Sensitive Receptors 371
13.4.3 Potential Sources of Impacts 376
13.4.4 Minimum Control for Impacts 377
13.4.5 Impact Prediction and Evaluation 377

13.5 Recommended Mitigation Measures 382
13.6 Residual Impacts 383
13.7 Summary of Key Findings 385
14.0 Proposed Environmental Monitoring and Management Plan 386
14.1 EMMP Objectives 386
14.2 Project Organisation during the Construction Phase 386
14.3 Project Organisation during the Operational Phase 387
14.4 Roles and Responsibilities of the EMMP for the Construction Phase 388
14.4.1 Technical Agencies 388
14.4.2 Project Owner (HDB) and Resident Technical Officer 388
14.4.3 The Contractor 388
14.4.4 The Superintending Officer (SO) 389
14.4.5 The Environmental Control Officer (ECO) 389
14.4.6 The Environmental, Health and Safety Officer (EHS Officer) 389
14.4.7 Arborist and Fauna Specialists 390
14.5 Roles and Responsibilities of the EMMP for the Operational Phase 390
14.5.1 Technical Agencies 390
14.5.2 Housing & Development Board 390
14.5.3 Project Owner (HDB) 390
14.5.4 EHS Officer (or Equivalent) 390
14.6 Construction Site Audit 390
14.7 Operational Phase Audit 391
14.8 Complaint Handling 391
14.9 Air Quality Monitoring Program Requirements 392
14.10 Airborne Noise Monitoring Program Requirements 392
14.11 Ground-borne Vibration Monitoring Program Requirements 393
14.12 Hydrology and Water Quality Monitoring Program Requirements 393
14.13 Soil and Groundwater Monitoring Program Requirements 394
14.14 Biodiversity Monitoring Program Requirements 395
14.14.1 Flora Monitoring Programme 395
14.14.2 Flora Management Programme 395
14.14.3 Fauna Monitoring Programme 399
14.14.4 Fauna Management Programme 401
14.15 Landscape and Visual Amenity Monitoring Program Requirements 403
14.16 Proposed EMMP 403
15.0 Conclusions 422
16.0 References 424
16.1 Maps 424
16.2 Publications and Other 424

List of Figures

Figure 1-1: Gazetted Land Use of the Study Area as per URA Master Plan 2019 1
Figure 1-2: Existing Waterbodies in the Study Area 2
Figure 1-3: Distribution of Flora Species of Conservation Significance and Vegetation Types 2
Figure 1-4: Key Ecological Receptors in Study Area 2
Figure 1-5: Overall Number of Fauna Species Recorded at Each Sampling Point along Transects 2
Figure 3-1: Land Use of Mount Pleasant and its Surrounding (URA, 2019) 13
Figure 3-2: Conceptual Development Plan 14
Figure 3-3: Building Demolition Plan 15
Figure 3-4: Location of the Study Area 17
Figure 5-1: Mount Pleasant Circa 1924, Showing Three Hills and a Valley with Ponds between Two of the High Grounds (National Archives of Singapore, 2019) 29
Figure 5-2: After Construction of the Colonial Houses and Road, Circa 1938 (National Archives of Singapore, 2019) 30
Figure 5-3: Mount Pleasant Study Area in 1945 (A), in 1950 (B), in 1966 (C) and in 2018 (D) (National Archive of Singapore (2019) and NUS Libraries (2019)). 30
Figure 5-4: Elevation Map of the Study Area (Generated Based on Topographic Data) 32
Figure 5-5: Geological Map of the Study Area 33
Figure 5-6: Soil Map of the Study Area 34
Figure 6-1: Mitigation Hierarchy 50
Figure 7-1: Air Quality Baseline Monitoring Location 54
Figure 7-2: Air Quality Monitoring Setup 55
Figure 7-3: NEA Ambient Air Quality Monitoring Stations in Singapore 56
Figure 7-4: NEA Weather Monitoring Stations in Singapore 57
Figure 7-5: Air Quality Baseline Monitoring Results 58
Figure 7-6: Hourly PSI Reading of Central Singapore 60
Figure 7-7: 24-hr PM10 Concentrations Reading of Central Singapore 60
Figure 7-8: 24-hr PM2.5 Concentrations Reading of Central Singapore 61
Figure 7-9: Daily Rainfall Monitored at MacRitchie Reservoir Monitoring Station 62
Figure 7-10: Daily Mean Temperature Monitored at Newton Monitoring Station 62
Figure 7-11: Daily Wind Speed Monitored at Newton Monitoring Station 62
Figure 8-1: Noise and Vibration Baseline Monitoring Location 81
Figure 8-2: Noise Sensitive Receptors 87
Figure 8-3: Operational Noise – Boundaries of Proposed Development Plan 89
Figure 8-4: Pre-mitigated $L_{eq(12\ hours)}$ 7am-7pm Noise Contours - Phase 1 108
Figure 8-5: Pre-mitigated $L_{eq(5mins)}$ 7am-7pm Noise Contours - Phase 1 109
Figure 8-6: Pre-mitigated $L_{eq(12\ hours)}$ 7am-7pm Noise Contours - Phase 2 110
Figure 8-7: Pre-mitigated $L_{eq(5mins)}$ 7am-7pm Noise Contours - Phase 2 111
Figure 8-8: Pre-mitigated $L_{eq(12\ hours)}$ 7am-7pm Noise Contours - Phase 3 112
Figure 8-9: Pre-mitigated $L_{eq(5mins)}$ 7am-7pm Noise Contours - Phase 3 113
Figure 8-10: Proposed Noise Barriers Location for Phase 1 119
Figure 8-11: Post-mitigated $L_{eq(12\ hours)}$ 7am-7pm Noise Contours - Phase 1 123
Figure 8-12: Post-mitigated $L_{eq(5mins)}$ 7am-7pm Noise Contours - Phase 1 124
Figure 8-13: Post-mitigated $L_{eq(12\ hours)}$ 7am-7pm Noise Contours - Phase 2 125
Figure 8-14: Post-mitigated $L_{eq(5mins)}$ 7am-7pm Noise Contours - Phase 2 126
Figure 8-15: Post-mitigated $L_{eq(12\ hours)}$ 7am-7pm Noise Contours - Phase 3 127
Figure 8-16: Post-mitigated $L_{Aeq(5mins)}$ 7am-7pm Noise Contours - Phase 3 128
Figure 9-1: Ground-borne Vibration Sensitive Receptors 137
Figure 10-1: Study Area for the Hydrology and Surface Water Quality Impact Assessment and Proposed Future Development 166
Figure 10-2: Water Quality Sampling Locations within the Study Area 169
Figure 10-3: Elevation Map with Waterbodies of the Study Area (generated based on topographic data) 172
Figure 10-4: Slope Map with Waterbodies of the Study Area (generated based on topographic data) 173
Figure 10-5: Water Catchment Map of the Study Area (generated based on topographic data) 174
Figure 10-6: Singapore Water Catchment (PUB, n.d.) 181

Figure 10-7: Average Monitoring Results of Temperature, pH, Salinity, DO and Conductivity for Wet and Dry Weather Conditions 187
Figure 10-8: Average Monitoring Results of Turbidity, TSS, TDS, TN, Nitrate, Ammonia, TP, Phosphate, BOD5, TOC, Enterococcus and Lead for Wet and Dry Weather Conditions (BDL – Below Detection Limit) 189
Figure 10-9: Indicative Alternative Service Road Plan along PIE as Mitigation Measures 202
Figure 11-1: Borehole/Groundwater Monitoring Well Locations within the Study Area 220
Figure 11-2: Photos taken during the Soil and Groundwater Investigation Works 222
Figure 11-3: Lithology Cross-Section (A-A') 227
Figure 11-4: Lithology Cross-Section (B-B') 228
Figure 11-5: Soil Analytical Results 229
Figure 11-6: Groundwater Elevation Data (MW-01 through MW-05) 230
Figure 11-7: Groundwater Elevation Contour Map (May 2019) (MW-01 through MW-05) 232
Figure 11-8: Groundwater Elevation Contour Map (June 2019) (MW-01 through MW-05) 233
Figure 11-9: Groundwater Elevation Contour Map (July 2019) (MW-01 through MW-05) 234
Figure 11-10: Groundwater Elevation Contour Map (August 2019) (MW-01 through MW-05) 235
Figure 11-11: Groundwater Flow Direction (VMW-01 and VMW-02) 237
Figure 11-12: Piper Plot of Major Ions Analysed in Groundwater 239
Figure 11-13: Groundwater Analytical Results 242
Figure 11-14: Piper Plot of Major Ions Analysed in Surface Water 243
Figure 11-15: Piper Plot of Major Ions Analysed in Surface Water and Groundwater 244
Figure 11-16: A Typical Conceptual Hydrogeological Condition 247
Figure 12-1: Locations of Flora Sampling Plots and Vegetation Types 261
Figure 12-2: Terrestrial and Stream Transects and Corresponding Sampling Points for Fauna Surveys in the Study Area 264
Figure 12-3: Location of Fish Traps Set in Stream 1 (15 Nos.), Stream 2 (8nos.) and Stream 3 (4 Nos.) 267
Figure 12-4: Examples of A) Mist Net and (B) Ground Harp Trap Deployed during Bat Trapping 268
Figure 12-5: Deployment Locations of Bat Traps and Bamboo Clusters 270
Figure 12-6: Locations of Terrestrial Camera Traps 271
Figure 12-7: Photographs Showing Canopy Dominated by Ficus variegata (Left) and Understorey of Campnosperma auriculatum Saplings (Right) 273
Figure 12-8: Site Photos Representative of Abandoned-land Forest 273
Figure 12-9: Photographs Showing the Albizia Trees (Falcataria moluccana) Forming a Continuous Canopy Layer (Left) and a Generic Shot of The Smaller Patch of Waste Woodlands (Right) 274
Figure 12-10: Site Photographs of Scrubland and Herbaceous Vegetation Dominated by the Giant Taro (Alocasia macrorrhizos), which Forms a Uniform Stratum with Open Canopy 274
Figure 12-11: Photographs of Vegetation within the Cemetery Compound Where Vegetation Has Been Cleared and the Area Occasionally Maintained (Left) as Well as Areas Where Spontaneous Vegetation Has Taken Over (Right) 275
Figure 12-12: Photographs of Managed Vegetation Showing Managed Lawn and Roadside Trees 276
Figure 12-13: Examples of Stream 1 — Open Country Habitat with Edges Overgrown with Grasses and Semi-aquatic Plants 276
Figure 12-14: Examples of Stream 2 (Left: Near S2_01, Right: Near S2_02) — Remnants of Concretised Canals are Still Noticeable at Certain Parts of the Stream. 277
Figure 12-15: Examples of Stream 3 – Most of Stream 3 has a Forest Canopy Cover, Up to Approximately 380 m in Length, Until it Opens up to Scrubland 277
Figure 12-16: Locations of Flora Individuals of Conservation Significance, excluding Those Persistent from Cultivation 280
Figure 12-17: Distribution of Large Flora Specimens and Other Specimens of Significance 283
Figure 12-18: Map of Trees of Girth ⩾1.0 m as well as Species of Conservation Significance of Girth ⩾0.3 m 284
Figure 12-19: Map of Healthy Trees of Girth ⩾1.0 m as well as Species of Conservation Significance of Girth ⩾0.3 m 285
Figure 12-20: Number of Stems of ⩾ 0.5 m Girth Recorded for Each Species in All Six Vegetation Plots Ranked In Descending Order. Bars in Light Blue Belong to the Ten Most Abundant Species. 287
Figure 12-21: Girth-Size Class Distribution of the Ten Most Abundant Tree Species of ⩾ 0.5 m Girth 288
Figure 12-22: Number of Stems of < 0.5 m Girth Recorded for Each Species in All Six Vegetation Plots Ranked in Descending Order. Bars in Light Blue Belong to the Ten Most Abundant Species. 288

Figure 12-23: Girth-Size Class Distribution of the Ten Most Abundant Tree Species of < 0.5 m Girth 289
Figure 12-24: Overall Number of Fauna Species Recorded at Each Sampling Point along the Targeted Transects 292
Figure 12-25: Coverage-based Rarefaction and Extrapolation Curve for All Species Recorded During Terrestrial and Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 294
Figure 12-26: Number of Odonate Species Recorded at Each Sampling Point along the Targeted Transects and Location of Conservation Significant Odonate Species 296
Figure 12-27: Collared Threadtail (Prodasineura collaris) Observed at Stream 1 (Source: from NParks) 297
Figure 12-28: Violet Sprite (Archibasis viola) Observed at Stream 2 297
Figure 12-29: Coverage-based Rarefaction and Extrapolation Curve for Odonate Species Recorded during Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 297
Figure 12-30: Number of Butterfly Species Recorded at Each Sampling Point along the Targeted Transects and Location of Conservation Significant Butterfly Species 299
Figure 12-31: Small Branded Swift (Pelopidas mathias mathias) Observed in the Study Area 300
Figure 12-32: Chocolate Grass Yellow (Eurema sari sodalis) Feeding on Asystasia Gangetica 300
Figure 12-33: Coverage-based Rarefaction and Extrapolation Curve for Butterfly Species Recorded during Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 300
Figure 12-34: Number of Hymenoptera Species Recorded at Each Sampling Point along the Targeted Transects 302
Figure 12-35: Coverage-based Rarefaction and Extrapolation Curve for Hymenoptera Species Recorded During Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 303
Figure 12-36: Number of Fish Species Recorded at Each Sampling Point along the Targeted Transects 305
Figure 12-37: Upper Left Corner is a Specimen of Pearl Danio (Brachydanio albolineata); Right and Bottom Corners are Two Specimens of Indo Chinese Barb (Barbodes rhombeus). 306
Figure 12-38: (Left) Paddyfield Snakehead (Channa striata) and (Right) Common Walking Catfish (Clarias Batrachus). 307
Figure 12-39: Relative Location of Tan et al's (2013) Study of Streams in Bukit Brown Cemetery to Study Area. 307
Figure 12-40: Coverage-based Rarefaction and Extrapolation Curve for Fish Species Recorded During Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 308
Figure 12-41: Number of Amphibian Species Recorded at Each Sampling Point along the Terrestrial and Aquatic Transects 311
Figure 12-42: Number of Reptile Species Recorded at Each Sampling Point along the Terrestrial And Aquatic Transects and Location of Conservation Significant Reptile Species 312
Figure 12-43: Oriental Whip Snake (Ahaetulla prasina) 313
Figure 12-44: Malesian Frog (Limnonnectes malesianus) 313
Figure 12-45: Coverage-based Rarefaction and Extrapolation Curve for Amphibian Species Recorded During Terrestrial and Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 314
Figure 12-46: Coverage-based Rarefaction and Extrapolation Curve for Reptile Species Recorded During Terrestrial and Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 314
Figure 12-47: Number of Bird Species Recorded at Each Sampling Point along the Terrestrial Transects 317
Figure 12-48: Locations of Conservation Significant Bird Species 318
Figure 12-49: Changeable Hawk Eagle (Nisaetus cirrhatus) Nest Recorded 319
Figure 12-50: Red Junglefowl (Gallus gallus) 319
Figure 12-51: Blue-Crowned Hanging Parrot (Loriculus galgulus) 319
Figure 12-52: Coverage-based Rarefaction and Extrapolation Curve for Bird Species Recorded During Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 320
Figure 12-53: Number of Non-Volant Mammal Species Recorded at Each Sampling Point along the Terrestrial Transects 322

Figure 12-54: Coverage-based Rarefaction and Extrapolation Curve for Non-volant Species Recorded During Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 323
Figure 12-55: Presence and Absence of Bats Trapped within Harp Traps and Mist Nets during Bat Trapping 325
Figure 12-56: Number of Bats Species Recorded at Each Sampling Point along the Terrestrial Transects and Locations of Conservation Significant Bat Species 326
Figure 12-57: Bamboo Bat (Tylonycteris Spp.) Caught in Harp Trap 327
Figure 12-58: Spectrogram of the Asiatic Lesser Yellow House Bat (Scotophilus kuhlii) 327
Figure 12-59: Coverage-based Rarefaction and Extrapolation Curve for Bat Species Recorded during Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications 327
Figure 12-60: Number of Mammal Species Observed at Each Camera Trap 330
Figure 12-61: Screen Capture of the Malayan Night Heron (Gorsachius melanolophus) Captured at MP02 331
Figure 12-62: Screen Capture of Common Palm Civet (Paradoxurus musangus) Captured at MP06 331
Figure 12-63: Screen Capture of the Unidentified Mammal; Possibly Malayan Porcupine (Hystrix brachyura) at MP07 331
Figure 12-64: Burrow About 15cm Wide, within 10m of the Camera Trap MP07 331
Figure 12-65: Coverage-Based Rarefaction and Extrapolation Curve for Mammals Recorded via Camera Trapping at the Study Area 332
Figure 12-66: Key Ecological Receptors Present 343
Figure 12-67: Key Ecological Receptors with Proposed Development Plans Overlaid 347
Figure 12-68: Key Ecological Receptors Overlaid with Indicative Alternative Road Plans as Mitigation Measures 358
Figure 12-69: Map Showing Proposed Development and Direction of Vegetation Clearance 359
Figure 13-1: Landscape Resources within Study Area 375
Figure 14-1: Project Organization and Lines of Communication during the Construction Phase 387
Figure 14-2: Project Organization and Lines of Communication during the Operational Phase 387
Figure 14-3: Photographs of Sampling Harvesting and Transport 399
Figure 14-4: A) Example of Harvested Saplings Not Covered during Transport and Exposed to Sun which Increase Mortality Rates & B) Example of an Inventory List Generated during Harvesting Event 399
Figure 14-5: Tree-felling Protocol 402

List of Tables

Table 1-1 Recommended Key Mitigation Measures and Best Management Practices 4
Table 1-2 Summary of Impact Significance for Construction and Operational Phases (Range if applicable) 5
Table 2-1: Environmental parameters assessed in this EIS 8
Table 4-1: Applicable Legislation 23
Table 6-1: Receptor Sensitivity Classification 36
Table 6-2: Factors Influencing the Ecological Value of an Ecological Feature and Classification Levels 39
Table 6-3: Site Visits for Data Collection 40
Table 6-4: Methodology for Prediction of Construction and Operational Impacts 42
Table 6-5: Criteria Categorising the Impact Intensity for each Environmental Parameter 45
Table 6-6: Impact Consequence Matrix 47
Table 6-7: Likelihood Criteria 48
Table 6-8: Risk-based Matrix Determining Impact Significance 48
Table 7-1: General Air Quality Descriptor Based on PSI value 56
Table 7-2: Summary of Baseline Monitoring 57
Table 7-3: Summary of NEA Air Monitoring Results Compared with Singapore Air Quality Targets 59
*Table 7-4: Overall Consequence of the Air Impact Analysis (Earthworks)** 64
*Table 7-5: Overall Consequence of the Air Impact Analysis (Construction)** 65
*Table 7-6: Overall Consequence of the Air Impact Analysis (Trackout)** 65
*Table 7-7: Overall Consequence of the Air Impact Analysis (Demolition)** 65
Table 7-8: Air Quality Impact Significance Matrix 66
Table 7-9: Receptor Sensitivity for Construction Footprint (Air Quality Impact Assessment – Construction Phase) 66
Table 7-10: Identified Air Quality Sensitive Receptors - Operational Phase 67
Table 7-11: Potential environmental impacts during the construction stage 67
Table 7-12: Potential environmental impacts during the operational stage 68
Table 7-13: Emission standard of various vehicle classes 69
Table 7-14: Impacts of Dust Risk Assessment – Demolition 71
Table 7-15: Impacts of Dust Risk Assessment – Earthworks 71
Table 7-16: Impacts of Dust Risk Assessment – Construction 71
Table 7-17: Impacts of Dust Risk Assessment – Trackout 71
Table 7-18: Proposed Air Quality Mitigation Measures based on the Outcome of the Air Quality Impact Assessment 72
Table 7-19: Impacts of Dust Risk Assessment – Demolition 77
Table 7-20: Impacts of Dust Risk Assessment – Earthworks 77
Table 7-21: Impacts of Dust Risk Assessment – Construction 77
Table 7-22: Impacts of Dust Risk Assessment – Trackout 77
Table 8-1: Baseline Noise Monitoring Methodology 80
Table 8-2: Summary of Baseline Noise Monitoring Results – for construction noise impact assessment 83
Table 8-3: Summary of Baseline Noise Monitoring Results – operational noise impact assessment 83
Table 8-4: Potential Noise Sources during Construction Stage 85
Table 8-5: Summary of Human Noise Receptor Classification (Operational) 88
Table 8-6: Maximum Permissible Noise Levels for Construction Works over a Period of 12 hours 91
Table 8-7: Maximum Permissible Noise Levels for Construction Works over a Period of 1 hour 91
Table 8-8: Maximum Permissible Noise Levels for Construction Works over a Period of 5 minutes 91
Table 8-9: Correction Factor to Account for Background Noise 91
Table 8-10: Background Noise Correction Calculations for $L_{Aeq(12\ hour)}$, dB 92
Table 8-11: Background Noise Correction Calculations for $L_{Aeq(1hr)}$, dB 94
Table 8-12: Background Noise Correction Calculations for $L_{Aeq(5mins)}$, dB 95
Table 8-13: Project Criteria for Construction Noise Impact Assessment 96
Table 8-14: Boundary Noise Limits by NEA 97
Table 8-15: Correction Factor 97
Table 8-16: Background Noise Correction Calculations for $L_{Aeq(1hr)}$, dB (Operational Noise) 99
Table 8-17: Project Criteria for Operation Noise Impact Assessment 100
Table 8-18: Hours of Operation for Construction Activities for the development in the Study Area 104
Table 8-19: Effective L_{wA} from all Construction Phases 105

Table 8-20: Summary of Prediction and Evaluation of Noise Impacts for Construction Works – Monday to Saturday 7:00am -7:00pm, $L_{Aeq(12\ hour)}$, ... 107
Table 8-21: Summary of Prediction and Evaluation of Noise Impacts for Construction Works – Monday to Saturday 7:00am -7:00pm, $L_{Aeq(5\ min)}$, ... 107
Table 8-22: Summary of Prediction and Evaluation of Noise Impacts for Construction Phases – Biodiversity Impacts 114
Table 8-23: Summary of Prediction and Evaluation of Noise Impacts for Operational Phase – Biodiversity Impacts 115
Table 8-24: Control of Noise Source from Construction Site 116
Table 8-25: Recommended Monitoring Program (Airborne Noise) 120
Table 8-26: Proposed Mitigation Measures during Operational Stage (Human Impact) 120
Table 8-27: Residual Impacts - Summary of Prediction and Evaluation of Noise Impacts for Construction Works – Monday to Saturday 7:00am -7:00pm, $L_{Aeq(12\ hour)}$ 121
Table 8-28: Residual Impacts - Summary of Prediction and Evaluation of Noise Impacts for Construction Works – Monday to Saturday 7:00am -7:00pm, $L_{Aeq(5\ minsr)}$ 121
Table 8-29: Residual Impacts - Summary of Prediction and Evaluation of Noise Impacts for Construction Phases – Biodiversity Impacts 129
Table 9-1: Summary of Baseline Ground-borne Vibration Monitoring Results 133
Table 9-2: Potential Sources of Environmental Impacts during Construction Phase 133
Table 9-3: Potential Sources of Environmental Impacts during Operational Phase 134
Table 9-4: Ground-borne Vibration Sensitive Receptor Classification for Human Impacts – Construction Phase 135
Table 9-5: Ground-borne Vibration Sensitive Receptor Classification for Human Impacts – Operational Phase 135
Table 9-6: Ground-borne Vibration Ecological Receptor Identified within the Study Area 136
Table 9-7: Vibration guidelines from BS 5228-2:2009+A1:2014 (Table B.2) 138
Table 9-8: Human Response Guidance from BS5228-2:2009+A1:2014 138
Table 9-9: Minimum Controls (Ground-borne Vibration) 139
Table 9-10: BS 5228-2:2009+A1:2014 Historical Data for Impact Bore Pile PPV Measurement Levels 140
Table 9-11: Prediction and Evaluation of Environmental Impacts – Impact Bore Piling (Human Impacts) 140
Table 9-12: Prediction and Evaluation of Environmental Impacts – Impact Bore Piling (Ecological Impacts) 145
Table 9-13: Prediction and Evaluation of Environmental Impacts – Impact Bore Piling (Human Impacts) 145
Table 9-14: Summary of the Impact Prediction and Evaluation during Operational Phase 150
Table 9-15: BS 5228-2:2009+A1:2014 Historical Data for Rotary (Auger) Bore Pile PPV Measurement Levels 151
Table 9-16: Prediction and Evaluation of Environmental Impacts – Rotary Bore Piling 151
Table 9-17: Prediction and Evaluation of Environmental Impacts –Rotary Bore Piling (Ecological Impacts) 158
Table 9-18: Prediction and Evaluation of Environmental Impacts – Rotary Bore Piling 159
Table 9-19: Recommended Monitoring Program (Ground-borne Vibration) 163
Table 10-1: Rationale for the Selection of Water Quality Sampling Locations 170
Table 10-2: Description of Existing Streams and Drains within the Study Area 176
Table 10-3: Referenced Water Quality Guidelines and Criteria 182
Table 10-4: Water Quality Monitoring Schedule 183
Table 10-5: Surface Water Quality Results 184
Table 10-6: Classification of Hydrology and Water Quality Sensitive Receptors Identified within the Study Area 191
Table 10-7: Potential Hydrology and Water Quality Impacts during the Construction Phase 191
Table 10-8: Potential Hydrology and Water Quality Impacts during Operational Phase 192
Table 10-9: Minimum Controls during the Construction Phase applicable to Hydrology and Water Quality Impact Assessments 193
Table 10-10: Minimum Controls during the Operational Phase applicable for Hydrology and Water Quality Impact Assessments 196
Table 10-11: Summary of Impact Evaluation during Construction Phase 198
Table 10-12: Summary of Impact Evaluation during Operational Phase 200
Table 10-13: Summary of Residual Impacts and its Mitigation Measures during Construction Phase 204
Table 10-14: Summary of Residual Impacts and its Mitigation Measures during Operational Phase. 206

Table 10-15: Summary of the Hydrology and Surface Water Quality Impact Assessment..... 210
Table 11-1: Groundwater Monitoring Well Completion Details 221
Table 11-2: Soil and Groundwater Parameters Analysed and the Corresponding Test Methods 222
Table 11-3: Summary of Soil Analytical Results..... 224
Table 11-4: Groundwater Elevation Data (MW-01 through MW-05)..... 230
Table 11-5: Groundwater Elevation Data (VMW-01 and VMW-02)..... 236
Table 11-6: Summary of In-Situ Groundwater Physicochemical Parameters..... 238
Table 11-7: Summary of Groundwater Analytical Results 239
Table 11-8: Comparison of Stream Invert Level to Groundwater Level..... 245
Table 11-9: Classification of Receptor Sensitivity..... 245
Table 11-10: Potential Sources of Soil and Groundwater Impacts (Construction Phase) 246
Table 11-11: Minimum Controls During Construction Phase (Soil and Groundwater) 247
Table 11-12: Minimum Controls During Operational Phase (Soil and Groundwater)..... 249
Table 11-13: Evaluation of Environmental Impacts (Soil and Groundwater) 252
Table 12-1: List and Definitions of Native Status Terms for Flora and Fauna Used in this Report..... 256
Table 12-2: List of Local and Global Conservation Statuses Used to Regard a Species as Conservation Significance. Additional Adapted Statuses for Hymenoptera are in Parentheses 257
Table 12-3: Classification of Vegetation Types Encountered in Singapore (adapted from Yee et al, 2016, Yee et al, 2019)..... 259
Table 12-4: Description and Length of Terrestrial and Aquatic Transects for Conducting Fauna Surveys..... 265
Table 12-5: Summary of the Survey Method, Timing and Frequency for Each Targeted Fauna Group 265
Table 12-6: Absolute (ha) and Relative (%) Areas Occupied by Each Vegetation Type..... 272
Table 12-7: Summary of Plant Habits in the Study Area..... 277
Table 12-8: Total Plant Species Recorded in the Study Area by their Origin and National Status..... 278
Table 12-9: List of Specimens of Significance in the Study Area by their Conservation Status and the Counts of Individuals for each Species. (Species with asterisk indicate species is likely to be cultivated, also refer to Appendix B1.)..... 281
Table 12-10: The Top Ten Most Abundant Species Ranked in Descending Order for Trees of Girth $\geqslant$ 0.5 m and < 0.5 m, Respectively 287
Table 12-11: Summary of Total Diversity of Extant, Probable and Recorded Fauna Species at Mount Pleasant..... 291
Table 12-12: The Total Number of Species Recorded, Sample Coverage and the Estimated True Fauna Species Richness for the Study Area. The Number of Sampling Units Refer to the Number of Terrestrial and Aquatic Sampling Points with Species Records. Values for Estimated True Species Richness Represent ± Standard Error. Incidental Records are Excluded. 293
Table 12-13: Table of species recorded and Native status at each Freshwater Transect..... 306
Table 12-14: List of the Bird Species of Conservation Significance Recorded within the Study Area 316
Table 12-15: Species Richness and Detection Rates of Fauna and Mammals for each Camera Trap 328
Table 12-16: Number of Independent Detections of each Species Recorded by Camera Traps in the Study Area..... 329
Table 12-17: The Number of Mammal Species Recorded via Camera Trapping, Sample Coverage and the Estimated True Mammal Species Richness. The Number of Sampling Units Refer to the Number of Trap-Nights with Mammal Species Records. Values for Estimated True Species Richness Represent ± Standard Error. 331
Table 12-18: Summary of the Assessment of Ecological Value for the Study Area and Each Habitat Type within the Study Area..... 334
Table 12-19: Summary of Fauna Species of High Ecological Value. 336
Table 12-20: Comparison of pH, DO and TSS from the Study Area against 14 Streams in the CCNR (Blakely et al, 2014). 340
Table 12-21: Classification of Receptors Identified within the Study Area..... 344
Table 12-22: Summary of Project Stages and Associated Ecological Impacts..... 346
Table 12-23: Minimum Control Measures during the Pre-Construction and Construction Phase..... 348
Table 12-24: Summary of Ecological Impact Evaluation during the Pre-Construction and Construction Phase 350
Table 12-25: Summary of Ecological Impact Evaluation during the Operational Phase 353
Table 12-26: Major Impacts, Receptors and Mitigation Measures 355
Table 12-27: List of ABC Waters Stormwater Features and Recommendations 361

Table 12-28: Recommended Mitigation Measures during the Pre-construction, Construction and Operational Phase of the development of the Study Area 364
Table 13-1: Landscape Resources within the Study Area and their Sensitivity 372
Table 13-2: Summary of the Potential Sources and Associated Impacts to Landscape and Visual Amenity during the Construction Stage 376
Table 13-3: Summary of the Potential Sources and Associated Impacts to Landscape and Visual Amenity during the Operational Stage 376
Table 13-4: Impact Significance Evaluation for Potential Construction and Operational Impacts on LR1 - Unmanaged Vegetation (Prior to Mitigation) 378
Table 13-5: Impact Significance Evaluation for Potential Construction and Operational Impacts on LR2 - Managed Vegetation (Prior to Mitigation) 379
Table 13-6: Impact Significance Evaluation for Potential Construction and Operational Impacts on LR3 – Residential Areas with Heritage Features (Prior to Mitigation) 380
Table 13-7: Recommended Mitigation Measures 382
Table 13-8: Residual Impact Significance Evaluation on Potential Construction and Operational Impacts (With Indicative Alternative Road Plan 2) 384
Table 14-1: Recommended Monitoring Program (Air Quality) 392
Table 14-2: Recommended Monitoring Program (Airborne Noise) 393
Table 14-3: Recommended Monitoring Program (Ground-borne Vibration) 393
Table 14-4: Recommended EMMP for Water Quality 393
Table 14-5: Recommended Monitoring Program (Soil and Groundwater) 394
Table 14-6: Recommended Tree Protection Zone Distances Based on Tree Girth 396
Table 14-7: Recommended Root-ball Size to be Extracted with Tree during Transplanting 397
Table 14-8: Extraction Methods to be Employed during Tree Transplanting based on Tree Girth 398
Table 14-9: Timing and Frequency for Transect Surveys for each Targeted Fauna Group 400
Table 14-10: Proposed Environmental Monitoring and Management Plan for the Construction Phase 404
Table 14-11: Proposed Environmental Monitoring and Management Plan for the Operational Phase 418
Table 15-1: Summary of Potential Residual Impact Significance (Range if applicable) 422

List of Appendices

Appendix A – Baseline Air Quality Monitoring Report
Appendix B – Air Quality Identified Sensitive Receptors
Appendix C – Baseline Noise Monitoring Report
Appendix D – Noise and Vibration Logger Calibration Certificates
Appendix E – Noise Sensitive Receptors List
Appendix F – Construction Timeline from Client
Appendix G – Noise Pre-Mitigation Results
Appendix H – Baseline Vibration Monitoring Report
Appendix I – Baseline Water Quality Laboratory Results
Appendix J – Soil Boring and Well Construction Details
Appendix K – Slug Test Data
Appendix L – Soil Laboratory Report
Appendix M – Groundwater Laboratory Report

List of Acronyms

Acronym	Definition
ABC Waters	PUB's Active, Beautiful and Clean Waters Programme
ACMV	Air Conditioning, Mechanical and Ventilation
AECOM	AECOM Singapore Pte Ltd
AGB	Aboveground Biomass
ALARP	As low as reasonably practicable
APHA	American Public Health Association
AVA	Agri-Food and Veterinary Authority of Singapore (Which was replaced by SFA since 1st April 2019)
bgs	Below ground surface
BAT	Best Available Technology
BEP	Best Environmental Practice
BMPs	Best Management Practices
BOD_5	Biological Oxygen Demand
BT	Bukit Timah Granite
BTNR	Bukit Timah Nature Reserve
CCNR	Central Catchment Nature Reserve
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COD	Chemical Oxygen Demand
COPPC	SS 593: Code of Practice for Pollution Control, 2013
CT	Contractor
CUGE	Centre for Urban Greenery and Ecology
DBH	Diameter at Breast Height
DIVs	Dutch Intervention Values
DO	Dissolved Oxygen
EC	Electrical Conductivity
ECM	Earth Control Measures
ECO	Environmental Control Officer
EHS	Environmental, Health and Safety
EIS	Environmental Impact Study
EMMP	Environmental Monitoring and Management Plan
ERP	Emergency Response Plan
ERT	Emergency Response Team
ERSS	Earth Retaining Stabilisation Structures
ESS	Ecologically Sensitive Site
ha	Hectares
HDB	Housing & Development Board of Singapore
IUCN	International Union for Conservation of Nature
LNAPL	Light Non-Aqueous Phase Liquid
LR	Landscape Resource
LTA	Land Transport Authority of Singapore
LVIA	Landscape and Visual Amenity Impact Assessment
MLS	Marchwood Laboratory Services Pte Ltd
MPA	Maritime Port Authority of Singapore
MSL	Mean Sea Level
NAS	National Archives of Singapore
NEA	National Environment Agency of Singapore
NMDS	Nonmetric Dimensional Scaling Ordination
NParks	National Parks Board of Singapore
NSR	Noise Sensitive Receptor
OPA	Old Police Academy
PIE	Pan Island Expressway
PM	Particulate Matter
PPV	Peak Particle Velocity
PRO	Public Relation Officer
PSI	Pollutant Standards Index
PUB	Public Utilities Board of Singapore
QECP	Qualified Erosion Control Professional
redox	reduction-oxidation potential
RTO	Resident Technical Officer
SFA	Singapore Food Agency

Acronym	Definition
SHESO	Superintending Officer
SIDS	Silty Imagery Detection System
SOP	Standard Operating Procedure
SPOM	Senior Police Officer's Mess
SRDB	Singapore Red Data Book
SULE	Safe Useful Life Expectancy
SWL	Stabilized Groundwater Level
TEL	Thomson-East Coast Line
TCA	Tree Conservation Area
TDS	Total Dissolved Solids
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorous
TPZ	Tree Protection Zone
TSS	Total Suspended Solids
URA	Urban Redevelopment Authority of Singapore
USEPA	United States Environmental Protection Agency
VES	Visual Encounter Surveys

Glossary of Terms

Term	Explanation
Access Roads	Access roads are considered up to 500 m from the access point of the construction area
Assessment Area	This area is used to determine any potential environmental impacts to the nearby sensitive receptors due to construction and operational activities as provided by HDB, which will vary depending on the technical discipline and will be described for each impact in the respective chapters.
Air Pollution Control Plan	Plan implemented to ensure implementation of air mitigation measures
dB(A)	A-weighted sound pressure levels (dB) – weighted to human hearing frequencies
Construction (Air Section)	Any type of construction activity involving new structures on construction area involving powered mechanical machinery
Construction Area	This area is where construction works being conducted by phases within the developmental plan.
Construction Footprint	This is an overall footprint of the construction sites as planned within the development master plan by HDB.
Coverage-based rarefaction and extrapolation sampling curves	Computes diversity estimates for rarefied and extrapolated samples with sample completeness (as measured by sample coverage) up to an appropriate coverage. This type of sampling curve plots the diversity estimates with respect to sample coverage. (Hsieh et al, 2019)
Dilapidation Studies	Studies to analyse impacts when a building/infrastructure/geological area is being demolished
Earthworks	This involves excavating material, haulage, tipping and stockpiling. This may also involve site levelling and landscaping
Earthworks Footprint	This are is where excavation works are expected to be conducted, i.e. whole area planned for development, excluding roads and parks.
Emission Sources	Sources of air emissions for different activities such as earthworks, construction, trackout and demolition
Exotic Species	Plant or animal species introduced into an area where they do not occur naturally, non-native species.
Ground Absorption Factor *Ref: SoundPLAN v7.3*	This factor is given to describe the noise propagation with respect to ground effect. For example, G = 0 describes a 100% hard ground such as asphalt, water or industrial sites G=1 describes 100% soft ground such as fields, forests or grass
Airborne Noise	Sound that is transmitted by the air e.g. speech. The term airborne noise and noise are used interchangeably in this report and mean the same
Heavy Duty Vehicle	Heavy duty vehicles defined as vehicles with a gross weight greater than 3.5 tonnes
ISO 9613-2:1996	Is the standard describing “Acoustics – Attenuation of sound during propagation outdoors – Part 2 : General method of calculation”
LAeq (1 hour)	Equivalent noise levels, averaged over a 1 - hour time period
LAeq (12 hours)	Equivalent noise levels, averaged over a 12 - hour time period
LAeq (5 mins)	Equivalent noise levels, averaged over a 5 - mins time period
$L_{pA,S,max}$	Maximum A-weighted sound pressure level evaluated with a ‘Slow’ (1.0 second) time constant
Non-volant Mammals	Non-flying mammals, i.e. all mammals in Singapore, excluding bats

Term	Explanation
Proposed Slip Road Area	The 3.4-ha land out of the 71.6-ha total Study Area which covers a portion of Jalan Mendaki entering from Mount Pleasant Road near PIE, as well as a portion of the un-developed land to the west of Jalan Mendaki.
Reactive Management Plan	Plan based on the real time situation of air impacts in an area.
Root Mean Square (RMS)	The square root of the mean of the of a certain set of values squared
Sound Power Level, Lw	Sound power is the total sound energy radiated by the source in a specified frequency band over a certain time interval, divided by the interval. In simple terms, a sound source produces sound power and this generates a sound pressure fluctuation in the air.
Sound Pressure Level, Lp	Sound pressure is the difference between the pressure produced by a sound wave and the ambient pressure at the same point in space.
Species Abundance	The number of individuals per species in an area. Relative abundance refers to the evenness of distribution of individuals amongst species in the area.
Species Distribution	Refers to how a species is distributed throughout the area.
Species Richness	Number of distinct species recorded, per sampling point or area
Study Area	This is an overall area of total 71.6 ha (including the Proposed Slip Road Area) defined via Contract as the scope of work of this project.
Trackout	The transport of dust and dirt from the construction/demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network. This arises when heavy duty vehicles (HDVs) leave the construction/demolition site with dusty materials, which may then spill onto the road, and/or when HDVs transfer dust and dirt onto the road having travelled over muddy ground on site; and
Trigger Value	The threshold value of a pollutant for which reactive management plan needs to be applied

1.0 Executive Summary

Objectives of Study

AECOM Singapore Pte Ltd was appointed by the Housing & Development Board ("HDB") to carry out an Environmental Impact Study (EIS) for the construction and operational phases of proposed housing with supporting amenities and infrastructure in Mount Pleasant area (hereinafter referred to as the "Study Area"). This EIS Report was formed: (1) to inform HDB of major issues according to HDB's conceptual plan at an early master planning stage; (2) to provide a high-level identification, prediction and evaluation of potential environmental impacts and their acceptability that are likely to arise as a result of the Study Area ; (3) to propose mitigation measures; and (4) to evaluate the acceptability of residual impacts after implementation of these recommended measures.

Project Description

The Study Area is bounded by Mount Pleasant Road to the north, Bukit Brown Woods to the west, Thomson Road to the east, and the Pan Island Expressway (PIE) to the south, which is larger than the proposed development area. It covers a total area of approximately 71.6 hectares (ha) (see Figure 1-1). It is currently a mix of cemetery park land, forested area, institutional recreational spaces and facilities, and the Mount Pleasant MRT and North-South Corridor (NSC) construction areas. The Study Area is predominantly zoned "Residential (Subject to Detailed Planning)" in URA's gazetted Master Plan 2019, while the Kopi Sua Cemetery is zoned "Cemetery". The Study Area also covers a portion of Mount Pleasant Road, which is a gazetted heritage road with the Black & White bungalows situated alongside. More details about the project background and surrounding environment are provided in Sections 3.0 and 5.0 of the EIS report.

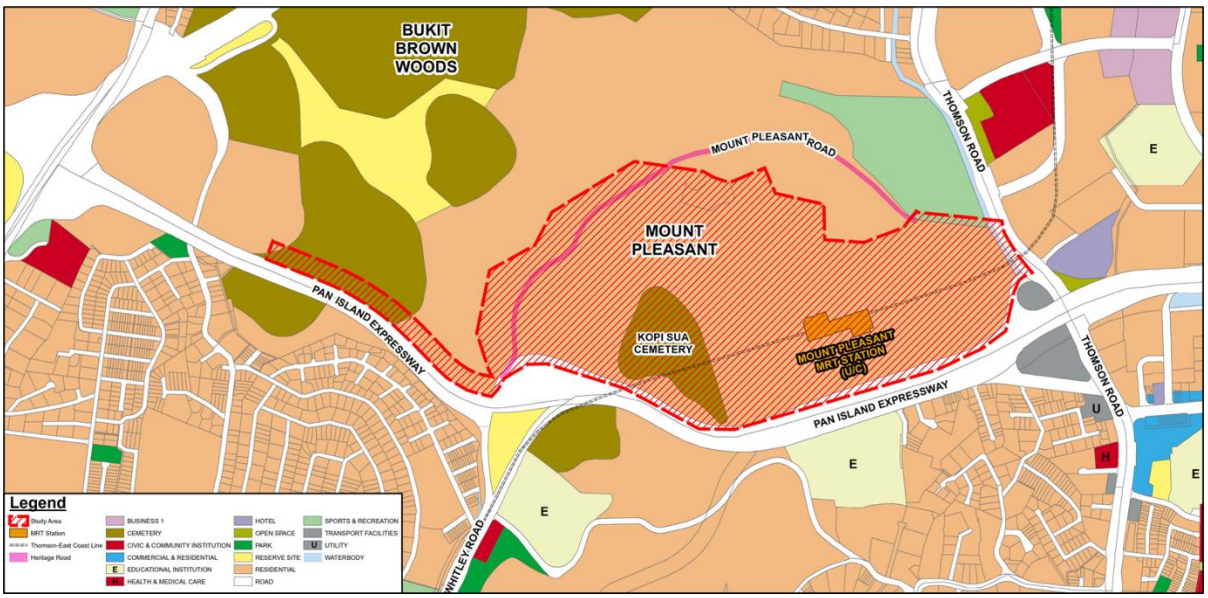

Figure 1-1: Gazetted Land Use of the Study Area as per URA Master Plan 2019

The construction (e.g. site clearance, building construction) and operational activities (e.g. roads and buildings operation) within the Study Area are expected to potentially affect the nearby human and ecologically sensitive receptors from the aspects of air quality, airborne noise, ground-borne vibration, hydrology and surface water quality, soil and groundwater quality, biodiversity, landscape and visual amenity. These identified potential impacts were then assessed in the EIS.

Environmental Baseline Findings

Baseline studies for the identified potential impacts were carried out between Jan 2019 to September 2020 around the Study Area. The summary of the baseline findings is provided below. More details can be found in Sections 7.0, 8.0, 9.0, 10.0, 11.0, 12.0 and 13.0 of the EIS report.

- **Air Quality** – Baseline air monitoring was conducted at one (1) location near Mount Pleasant Road. All pollutant (i.e. dust/ particulate matters, PM_{10} and $PM_{2.5}$) concentrations were found to be within the Singapore Ambient Air Quality Long Term Targets.
- **Airborne Noise** – Baseline noise monitoring was carried out at four (4) locations along roadsides within the Study Area to obtain baseline noise levels ($L_{Aeq(12\ hour)}$, $L_{Aeq(1\ hour)}$, $L_{Aeq(15\ min)}$, $L_{Aeq(5\ min)}$), which showed slightly elevated noise levels either for residential area or noise sensitive premises (i.e. hospitals, library, etc) mainly due to the Pan Island Expressway (PIE) nearby.
- **Ground-borne Vibration** – Baseline vibration monitoring was conducted at three (3) locations along roadsides within the Study Area. The average peak particle velocity ranged from 0.32 to 0.92 PPV, mainly due to the intermittent traffic pass-by on main road as observed during the vibration monitoring.

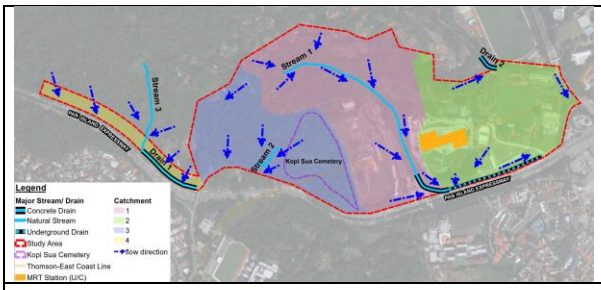

Figure 1-2: Existing Waterbodies in the Study Area

Figure 1-3: Distribution of Flora Species of Conservation Significance and Vegetation Types

Figure 1-4: Key Ecological Receptors in Study Area

Figure 1-5: Overall Number of Fauna Species Recorded at Each Sampling Point along Transects

- **Hydrology and Surface Water Quality** (see Figure 1-2) – Two (2) naturalised streams (i.e. Streams 2 and 3) and one (1) partially naturalised stream (i.e. Stream 1), as well as two (2) stormwater drains (i.e. Drains 1 and 2) were identified as watercourses within the four (4) catchment areas. Baseline water quality sampling was conducted at a total of seven (7) sampling locations across the five watercourses. The water quality in all the natural streams were found to be suitable for aquatic life.
- **Soil Quality** – A total of seven (7) boreholes was established to understand the baseline soil and groundwater conditions within the Study Area. Soil samples were mainly clayey silt with heavy metals and selected PAHs[1], but all were below the DIVs[2].
- **Groundwater Quality** – The groundwater was found to be slightly acidic to neutral and dominated by freshwater characteristics. Groundwater near Stream 3 generally flows towards the south-southwest direction, while that near Stream 1 and 2 generally flows towards the southeast direction. Groundwater samples reported detections of heavy metals, but mostly below the DIVs and the ANZGFMWQ[3], except for copper and zinc that exceeded ANZGFMWQ.
- **Vegetation Distribution** (see Figure 1-3) – The Study Area is composed of managed vegetation (46.23%), followed by the abandoned-land forest (25.94%), managed vegetation

[1] Polycyclic Aromatic Hydrocarbons (PAHs)

[2] Dutch Intervention Values (DIV)

[3] Australian and New Zealand Guidelines for Fresh and Marine Water Quality for Freshwater (ANZGFMWQ)

(cemetery) [4] (5.27%), native-dominated low secondary forest (4.27%), scrubland and herbaceous vegetation (4.12%) and waste woodlands (3.54%). The remaining 10.62% of the Study Area was covered by an existing construction area.

- **Biodiversity, Flora** (see Figure 1-3) – A total of 378 species of vascular plants (e.g. ferns and flowering plants) was recorded, in which about 23.54% were of true conservation significance[5,6], located mostly within the native-dominated secondary forest and abandoned-land forest in the Study Area. A total of 225 large trees, palms and bamboos (≥ 3m in girth/spread) were documented within the Study Area with a mix of common and exotic species.
- **Biodiversity, Fauna** (see Figure 1-5) – About 35.25% of the 468 species of probable occurrence[7] identified from desktop study were confirmed during the fauna field assessment. The highest species richness was recorded in the cemetery area with managed vegetation. Overall, a total of 14 species of conservation significance[5] were recorded, including one damselfly (i.e. Collared Threadtail[8]), one butterfly (i.e. Common Rose), one reptile (i.e. Asian Softshell Turtle[8]), ten bird (e.g. Crested Goshawk, White-rumped Shama) and one bat species (i.e. bamboo bats[9]).
- **Ecological Value** (see Figure 1-4) – The Study Area has a mix of features with low to high ecological values, with medium to high ecological value due to its proximity to the Central Catchment Nature Reserve, as well as the presence of: (1) Native-dominated secondary forest of medium-high ecological value; (2) Abandoned-land forest of medium ecological value; (3) A heritage tree (*Ficus kurzii*) along Mount Pleasant Road; (4) 225 large specimens of trees, palms or bamboos across the site; (5) Bamboo clusters and the critically endangered Lesser Bamboo Bat (*Tylonycteris* sp.); (6) Fauna of conservation significance[5,7] at all three streams.
- **Landscape and Visual Amenity** – The Study Area consist of a mix of disturbed natural habitat, managed land, construction, and residential development. The landscape and visual amenity values within the Study Area are mainly contributed by the managed vegetation with a mix of exotic and commercially available native species, as well as the colonial character of the Black and White Bungalows with heritage features along Mount Pleasant Road.

Impact Assessment Approach and Methodology

Section 6.0 describes the overall approach of an EIS. Sections 7.0, 8.0, 9.0, 10.0, 11.0, 12.0 and 13.0 of the EIS report discuss the assessment methodologies and findings in specific to the potential impacts assessed for the construction and operational phases of the Study Area.

Key Mitigation Measures

Table 1-1 summarizes the key mitigation measures and best management practices that have been recommended for adoption during the construction and operational phases of the Study Area. More details can be found in Sections 7.0, 8.0, 9.0, 10.0, 11.0, 12.0 and 13.0 of the EIS report.

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[4] The vegetation in the Kopi Sua Cemetery is defined separately as Managed Vegetation (Cemetery) as it was found to be maintained by a group of caretakers, where its floristic composition is observed to be largely different from other managed vegetation in the private compound areas (e.g. roadside trees and shrubs, managed lawns, landscape plantings).

[5] The global conservation status for fauna follow the International Union for Conservation of Nature (IUCN) Red List, while the local conservation status for both flora and fauna follow the Singapore Red Data Book (SRDB) and other updated local checklists if available. Threatened species listed as nationally and/or globally Vulnerable, Endangered, Critically Endangered, or Presumed Extinct (see Table 12-2 in EIS report for definitions) were considered species of conservation significance in this study.

[6] See Appendix B2 in the EIS Final Addendum Report for the list of locally conservation significant plants.

[7] See Appendix D in the EIS Final Addendum Report for the list of fauna species of probable occurrence.

[8] The Asian Softshell Turtle (*Amyda cartilaginea*) and Collared Threadtail (*Prodasineura collaris*) are stream dependent fauna species which are "locally threatened" (see Footnote 5).

[9] Bamboo bats (*Tylonycteris sp.*), also known as flat-headed bats, are insectivorous bats that roost in the internodes of bamboo. In Singapore, there are two species of bamboo bats—the Lesser Bamboo Bat (*Tylonycteris fulvida*) and the Greater Bamboo Bat (*Tylonycteris malayana*), where the former is listed as "Critically Endangered" (see Footnote 5). Since there was difficulty in differentiating the bamboo bats caught from their physical attributes and calls, without identifying to species level, it was assumed with possibility to be the critically endangered Lesser Bamboo Bat.

Table 1-1 Recommended Key Mitigation Measures and Best Management Practices

Environ-mental Parameter	Key Mitigation Measures and Best Management Practices	
	For Construction Phase	**For Operational Phase**
Air Quality	• Develop and implement an Air Pollution Control Plan (APCP); • Implement best management practices on site (e.g. erect hoarding around dusty activities, water suppression, perform wheel-washing, use water-assisted dust sweepers, transport/ store fine materials with enclosure, re-vegetate earthworks/exposed areas); • Impose a maximum-speed-limit of 25 km/hr on paved or surfaced haul roads and 15 km/hr on unpaved haul roads and work areas.	No suggestion of mitigation measures would be required, as the air quality impact significance is expected to be Negligible to Minor.
Airborne Noise	• Prioritize the use of construction equipment with lower noise levels; • Acoustic shed / enclosure for construction equipment where viable to implement.	• Road traffic control with low-speed postings, humps and signage; • Apply noise attenuators and other best available technologies/practices for noise control on ACMV system.
Ground-borne Vibration	• Use low vibration piling techniques during construction phase; • Use rotary bore piling/micro piling techniques for the foundations of the building.	• Road traffic control on speed limits and heavy vehicles; • Maintenance of road surfaces to be levelled.
Hydrology and Water Quality	• Ensure strict compliance with PUB Code of Practice on Surface Water Drainage, e.g. – Implement earth control measures – Implement CCTV and Silt Imagery Detection System (SIDS) to monitor surface runoff discharges from sites • Provide enclosed bins and designated waste disposal facilities, with frequent housekeeping checks and waste collections by licensed waste operator/collector.	• Ensure strict compliance with PUB Code of Practice on Surface Water Drainage with considerations during design stage to reduce operational peak flow and flood risk, e.g. provide storage system, provide more softscape/ pervious areas, etc.; • Provide sufficient disposal bins surrounding the Project to avoid improper waste disposal.
	Project-specific recommendations to mitigate major impact at Stream 1, Stream 3 and Drain 1 in both phases *(subject to detailed engineering studies and Authorities' approval – see Table 10-13 in EIS Report)* Stream 1 (mainly to preserve[10] upstream of Stream 1): • Option A: Realign proposed road at upstream of Stream 1 with 35 m buffer on both sides, convert downstream into drains, provide drain diversion during construction • Option B: Replace proposed slip road with a service road along PIE that links to the existing Onraet Road, provide drain diversion for downstream section during construction with the retention of approximately 30% of proposed roads at upstream of Stream 1 with 35 m buffer on both sides Stream 3 (aim to preserve the entire Stream 3): • Option A: Convert downstream of Stream 3 into culvert structure under the proposed slip road, provide temporary drain diversion during construction • Option B: Construct proposed slip road as a cross-over to avoid the stream • Option C: Replace proposed slip road with a service road along PIE that links to the existing Onraet Road, so that Stream 3 will remain intact Drain 1: Divert or realign the concrete drain during the construction to minimize flooding risk	
Soil and Ground-water	• Install piezometers to monitor groundwater level changes in compliance with Building Control Regulations 2003; • Conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan (e.g. wear PPE on site, provide emergency spill kits on site); • Ensure proper storage of generated toxic chemical waste and chemicals used on-site under shelter within concrete bund walls or in storage containers with good ventilation; • Provide spill trays for all waste/chemical containers and perform regular maintenance.	• Ensure proper storage of toxic chemical waste and hazardous substances/chemicals at designated sheltered area (with access-controlled entrance and concrete bund walls) or in storage containers with good ventilation; • Provide spill trays for all chemical drums, plants and machinery and potential pollutive substances used on site, and ensure regular maintenance.

[10] "Preserve" indicates that there should be no construction/operational activities disturbing the existing conditions of the stream.

Environ-mental Parameter	Key Mitigation Measures and Best Management Practices	
	For Construction Phase	For Operational Phase
Biodiversity	• Review conceptual development plan in the Study Area to avoid area of high concentration of flora species and Stream 1 which is a habitat for an odonate of conservation significance. If retained, the adjacent existing vegetation of 35m of both sides of the stream should also be maintained; • Review orientation of proposed commercial and social node to retain the cluster of 11 nos. of Tembusu (*Cyrtophyllum fragrans*); • Review work areas and access to avoid allocating excessive working spaces, this could prevent works from affecting Stream 2; • Review start location of proposed slip road from PIE to avoid Stream 3 or review construction methods that would minimise impact to the stream and the surrounding vegetation. The most biodiversity sensitive approach would be to avoid Stream 3 completely (refer to Option C in water quality); • The erection of the construction hoarding/ noise barrier (where applicable) shall be directional, starting from the area closest to the busiest road, Thomson Road, then towards Bukit Brown Woods. This is to reduce potential roadkills. The hoarding shall be continuous and complete before work commences; • Once the site hoarding is completed, determine if there are wild pigs within the hoarding; • Prior to works, if wild pigs are present within the hoarding, the contractor shall engage an approved wildlife management specialist to prepare and execute a plan for their removal; and • For all fauna that may be encountered on site, prepare a wildlife response and rescue plan in consultation with an Ecologist and have an NParks approved wildlife management specialist ready to execute if needed.	• Plant more trees along the edge of the retained vegetation and adjacent forest (Bukit Brown Woods), it can serve as a natural barrier to light, noise and filter vehicular emissions that may be harmful to animals; • Incorporate bird-friendly features for building design, e.g. presence of overhangs, replace continuous glass facades with decorative facades and grilles, UV patterned glass.
Landscape and Visual Amenity	• Tree preservation and avoidance of unintended vegetation removal; • Appropriate design of building facades; • Visual design on noise barriers; • Set up buffer zones from colonial houses; • Implementation of noise and air quality mitigation measures.	• Landscaping to mimic and merge into the surrounding nature character; • Replanting of trees within Study Area as compensation of tree felling, or along the circumference to soften the hard edge of buildings/ structures as a form of visual relief.

Summary of Environmental Impact Assessment

With the implementation of mitigation measures, the overview of impact evaluation for both construction and operational phases are summarised in Table 1-2.

Table 1-2 Summary of Impact Significance for Construction and Operational Phases (Range if applicable)

Environmental Parameter	Impact Significance (with minimum controls/best practices)	Residual Impact Significance (with mitigation measures)
Air Quality	Negligible to Major	Negligible to Minor
Airborne Noise	Negligible to Moderate (human receptors) Minor to Moderate (ecological receptors)	Negligible to Minor (human receptors) Minor to Moderate[11] (ecological receptors)

[11] While residual noise impact significance remains Moderate for ecological receptors during demolition phase, the impact intensity after applying mitigation measures was expected to be reduced from 17 db(A) to 8 dB (A). To reduce noise further, it is suggested to replace hand held pneumatic breakers with less noisy options, e.g. hand held breaker used for road.

Environmental Parameter	Impact Significance (with minimum controls/best practices)	Residual Impact Significance (with mitigation measures)
Ground-borne Vibration	Minor to Moderate (human receptors) Minor (ecological receptors)	Negligible to Minor (human receptors) Minor (ecological receptors)
Hydrological and Water Quality	Negligible to Major	Negligible to Moderate[12]
Soil and Groundwater	Negligible to Minor	Negligible to Minor
Biodiversity	Negligible to Major	Negligible to Major[13]
Landscape and Visual Amenity	Negligible to Major	Negligible to Minor

A set of Environmental Monitoring and Management Plan (EMMP) has also been developed for each environmental parameter, which will be updated and implemented during construction and operational phases, to ensure the effectiveness of the proposed mitigation measures. The EMMP is described in Section 14.0 of the EIS report.

[12] While residual water impact significance has been reduced from Major to Moderate. The impact cannot be reduced further mainly due to the immediate presence of Stream 1 segment adjacent to the construction site, as well as if the Option A of Stream 3 is being selected.

[13] Major residual biodiversity impact significance is still expected due to the irreversible loss of vegetation and habitats during site clearance in construction phase.

2.0 Introduction

AECOM Singapore Pte Ltd (AECOM) has been appointed by the Housing & Development Board ("HDB" or the "Client") to carry out an Environmental Impact Study (EIS) for the construction and operational phases of proposed housing estate with supporting amenities and infrastructure in Mount Pleasant (hereafter referred to as the "Study Area").

The Study Area with a total area of 71.6 ha is located approximately 1.5-km away from the edge of the Central Catchment Nature Reserve boundary. It is currently a mix of cemetery park land, forested area, institutional recreational space and facilities, and the LTA Mount Pleasant MRT construction area. Within the 71.6-ha Study Area, there is a 3.4-ha land which covers a portion of Jalan Mendaki entering from Mount Pleasant Road near PIE, as well as a portion of the un-developed land to the west of Jalan Mendaki, which hereinafter referred to as the "Proposed Slip Road Area". It should be noted that the EIS Study Area is larger than the proposed development area.

Overall, the Study Area has a low degree of fragmentation (urban infrastructures such as managed vegetation, roads, and houses are few). There is an adjoining forested area of Bukit Brown Woods located at the north-west of the Study Area and this forested area is within NParks' Tree Conservation Area (TCA). The Study Area, together with the Bukit Brown Woods, act as a buffer for the Central Catchment Nature Reserve (CCNR). The ecological value of the Study Area was discussed and assessed in this report.

Findings of the environmental baseline monitoring and predicted environmental impacts from the development of the Study Area and the proposed slip road have been included in this Final EIS Report. The extent and location of the Study Area is as shown in **Figure 3-4.**

This section will serve as a brief introduction of this EIS Report in terms of the purpose and objectives of EIS, scope of works of EIS, environmental parameters assessed in this report, report structure, as well as study limitations and constraints.

2.1 Purpose and Objectives of the EIS

The purpose of this EIS is to assess the nature and extent of environmental impacts arising from the construction and operation of the development of the Study Area and related activities that take place concurrently. The EIS outcomes and recommended mitigation measures will contribute to the decision making on:

- The overall acceptability of any adverse environmental consequences that are likely to arise as a result of the development of the Study Area;
- The conditions and requirements for the construction and operational phases of the Project to mitigate adverse environmental consequences whenever practicable; and
- The acceptability of residual impacts after the implementation of the proposed mitigation measures.

The objectives of the EIS are as follows:

- To identify and describe the elements of the community and environment that are likely to be affected by the Project, including both the natural and man-made environment and the associated environmental constraints to and by the development of the Study Area
- To identify and determine the baseline conditions of biodiversity and to formulate a biodiversity inventory and distribution map to identify the core biodiversity areas;
- To determine the baseline surface and groundwater hydrological conditions, and based on testing results to project the potential hydrological impact caused by the development of the Study Area;
- To identify all potential sensitive receptors within the Study Area as well as those in the vicinity of the Study Area, the ecosystem of the nearby pond, and other waterbodies in the vicinity;

- To assess the potential impacts caused by both construction, and operational periods of the proposed housing development based on the conceptual development plan, propose proper mitigation measures and recommend an Environmental Monitoring and Management Plan;
- To propose effective mitigation measures to minimise adverse impacts (e.g. pollution, environmental disturbance and nuisance) during the construction and operational phases of the development of the Study Area; and
- To propose an Environmental Monitoring and Management Plan to guide the proposed development of the Study Area including to identify, predict and evaluate the residual impacts (i.e. after practicable mitigation) and the cumulative effects expected to arise during construction and operation of the Project in relation to the sensitive receivers and potential affected uses; to identify, assess and specify methods, measures and standards, to be included during construction of the project which are necessary to mitigate the residual impacts and cumulative effects and reduce them to minimal levels.

2.2 Scope of Work

This EIS of this Study Area (titled "Proposed Housing Developments in Mount Pleasant bounded by PIE, Thomson Road and Other Future Roads") was conducted according to agreed study scope with the Client through a series of environmental consultation process including scoping meeting with various agencies/ authorities (i.e. NEA, AVA, MPA, NParks, MND/ URA), as well as discussion with Client via email correspondences. The scope of EIS was then documented in the form of Inception Report (AECOM, 2019) submitted to HDB and key technical agencies (NParks, NEA) on 6th May 2019. This EIS progressed only after acceptance of the Inception Report by HDB.

The services under this EIS shall include, but are not limited to the following:

a) Field survey, data collection and baseline study including topography survey, soil investigation, floral survey, faunal survey, hydrological and water quality survey, landscape and visual, noise, dust, and vibration;

b) Formulation of biodiversity inventory and distribution maps;

c) Environmental Impact Study;

d) Mitigation measures and EMMP; and

e) Preparation of the EIS Report.

The Study Area is currently at the master planning stage; thus, limited information regarding development plan, design elements, construction methodology, and project components were available at the time of writing. Therefore, assumptions, if any, are described in each individual assessment in their respective Sections. Should the construction and operational activities differ from our assumptions or should the build contractor make alterations to these assumptions/approaches, the contractor shall undertake a revised impact assessment addressing these changes.

2.3 Environmental Parameters Assessed

The environmental parameters that were covered as part of this EIS are detailed in **Table 2-1** below.

Table 2-1: Environmental parameters assessed in this EIS

Environmental Parameter	Description
Air Quality	This study analysed the impacts from air pollutants, including dust. An air quality baseline survey has been conducted to evaluate ambient dust (PM10 and PM2.5). Modelling and quantitative assessment has been used to analyse the construction phase air quality impacts.
Airborne Noise	This study analysed the impacts from airborne noise. A baseline measurement has been conducted to evaluate the potential airborne noise impacts. Modelling and quantitative assessment has been used to analyse the construction phase airborne noise impacts.
Ground-borne Vibration	This study analysed the impacts of construction and operational phase inducted vibration levels on human impacts and ecological impacts. A quantitative method was used to assess the construction phase and a qualitative method was used to assess the operational phase.

Environmental Parameter	Description
Hydrology	This study mapped out the permanent streams and/or waterbodies in the Study Area and investigate the flow conditions of those waterbodies. Impacts related to the stream alignment, potential runoff and water pollution were identified.
Water Quality	This study established the baseline water quality conditions through water quality sampling activity in the identified waterbodies in the Study Area. Baseline water quality data were compared to national and international water quality standards, especially water quality criteria relevant to ecological uses. Impacts related to possible construction and operational discharges in the freshwater environment were identified.
Soil and Groundwater Investigation	This study determined the soil depth, soil type, and groundwater chemistry of the Study Area. These characteristics helped to understand the development's impacts on the local vegetation and downstream waterbodies. Groundwater levels in the Study Area were measured.
Biodiversity	This study included ecological impact studies which comprised of fauna and flora impacts. The forested area within Study Area which lies north-west of Mount Pleasant Road is within NParks' Tree Conservation Area (TCA) and is acting as a buffer towards CCNR due to its close proximity to the Study Area. Species of conservation significance were identified. Appropriate mitigation measures (if warranted) were proposed for the construction phase of the development
Landscape and Visual Amenity	Areas considered to have scenic or aesthetic value in the Study Area were identified and assessed in terms of the visual impact of the proposed development.

2.4 Report Structure

In meeting the objectives of the EIS, the structure of the report is as follows:

- **Section 3.0** – Description of the development of the Study Area which includes the location of the Study Area, a general overview of the study, and proposed construction and operational activities.
- **Section 4.0** – Environmental Legislation, Policies, Plans, Standards and Criteria provides the legislative requirements relevant to the study.
- **Section 5.0** – Description of the Environment provides a general description of the historical and current land use, topography and geology of the Study Area.
- **Section 6.0** – EIS Approach and Methodology provides the overview of the methodology used for the assessment.
- **Section 7.0** – Air Quality Impact Assessment presents the methodology, baseline environment, identification of sensitive receptors, potential impacts, minimum controls and evaluation of impacts to the air quality within the Study Area, along with recommendations for mitigation measures and monitoring and management program.
- **Section 8.0** – Airborne Noise Impact Assessment presents the methodology, baseline environment, identification of sensitive receptors, potential impacts, minimum controls and evaluation of impacts resulting from Airborne Noise within the Study Area, along with recommendations for mitigation measures and monitoring and management program.
- **Section 9.0** – Ground-borne Vibration Impact Assessment presents the methodology, baseline environment, identification of sensitive receptors, potential impacts, minimum controls and evaluation of impacts resulting from Ground-borne Vibration within the Study Area, along with recommendations for mitigation measures and monitoring and management program
- **Section 10.0** – Hydrology and Water Quality Impact Assessment presents the methodology, baseline environment, identification of sensitive receptors, potential impacts, minimum controls and evaluation of impacts to the Hydrology and Water Quality within the Study Area, along with recommendations for mitigation measures and monitoring and management program.
- **Section 11.0** – Soil and Groundwater Impact Assessment presents the methodology of assessment and study of baseline environment to determine the soil profile and hydrogeological conditions of the Study Area, and also to ascertain the presence of possible pollutants in the underlying soil and groundwater that may impact the local vegetation and downstream waterbodies, along with recommendations for mitigation measures and monitoring and management program.
- **Section 12.0** – Biodiversity Impact Assessment presents the methodology, baseline environment, design recommendations and evaluation of impacts to habitat, flora and fauna within the Study Area, along with recommendations for mitigation measures and environmental monitoring and management program.
- **Section 13.0** – Landscape and Visual Amenity Impact Assessment presents the methodology of assessment and study of baseline environment to identify and evaluate areas in the vicinity of the proposed development that may be deemed to be of scenic or aesthetic appeal, along with recommendations for mitigation measures and monitoring and management program.
- **Section 14.0** – Environmental Monitoring and Management Program (EMMP) details the organisational framework, stakeholder roles and responsibilities, monitoring program requirements and detailed EMMP.
- **Section 15.0** – Conclusions and Recommendations provides a conclusive summary of the EIS's outcomes.

2.5 Study Limitations, Assumptions and Constraints

During this study, access to certain locations within Study Area are restricted, including the WRC and some demarcated areas for LTA's Mount Pleasant MRT construction, as well as the black-and-white bungalows along the Mount Pleasant's heritage road.

Besides, there were inherent limitations associated with data acquisition in flora surveys due to the variability of vegetation communities across a site and changes to the detectability and presence of species with time. Therefore, it may be possible that some flora species occurring within the Study Area, or perhaps not visibly present during the survey period, were not recorded. However, the surveys were considered to be comprehensive as survey routes were strategically planned to cover ecologically and geographically representative samples of the Study Area, and all plant species sighted were identified and recorded to the best of the team members' abilities. The team members of this study who carried out the survey and identified the species post-survey have prior experience in conducting such flora assessments in Singapore.

Regarding fauna surveys, they consisted of targeted surveys of odonates (dragonflies and damselflies), butterflies, herpetofauna (amphibians and reptiles), birds, mammals, fishes, decapod crustaceans and molluscs, as thorough and consistent as possible. However, surveys did not detect all species for which the site may be important as fauna are highly mobile, frequently cryptic and vary in presence and abundance within and between seasons. Species returned by the literature review were therefore considered to be potentially present in the site and were considered in the impact assessment. Professionals who carried out the fauna surveys are experienced field biologists and familiar with the local fauna.

Due to the above, the statements, conclusions and opinions contained in this report are approximations of the existing environmental conditions within the Study Area, based on available literature, expert observations and opinion at the time of reporting. Reliance on the report after the date of issuance as an accurate representation of current site conditions shall be at the user's sole risk.

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3.0 Project Overview

This section will provide a background overview of the development of the Study Area in terms of its location, current land uses, conceptual development plan, proposed construction activities and operational activities.

3.1 Project Description

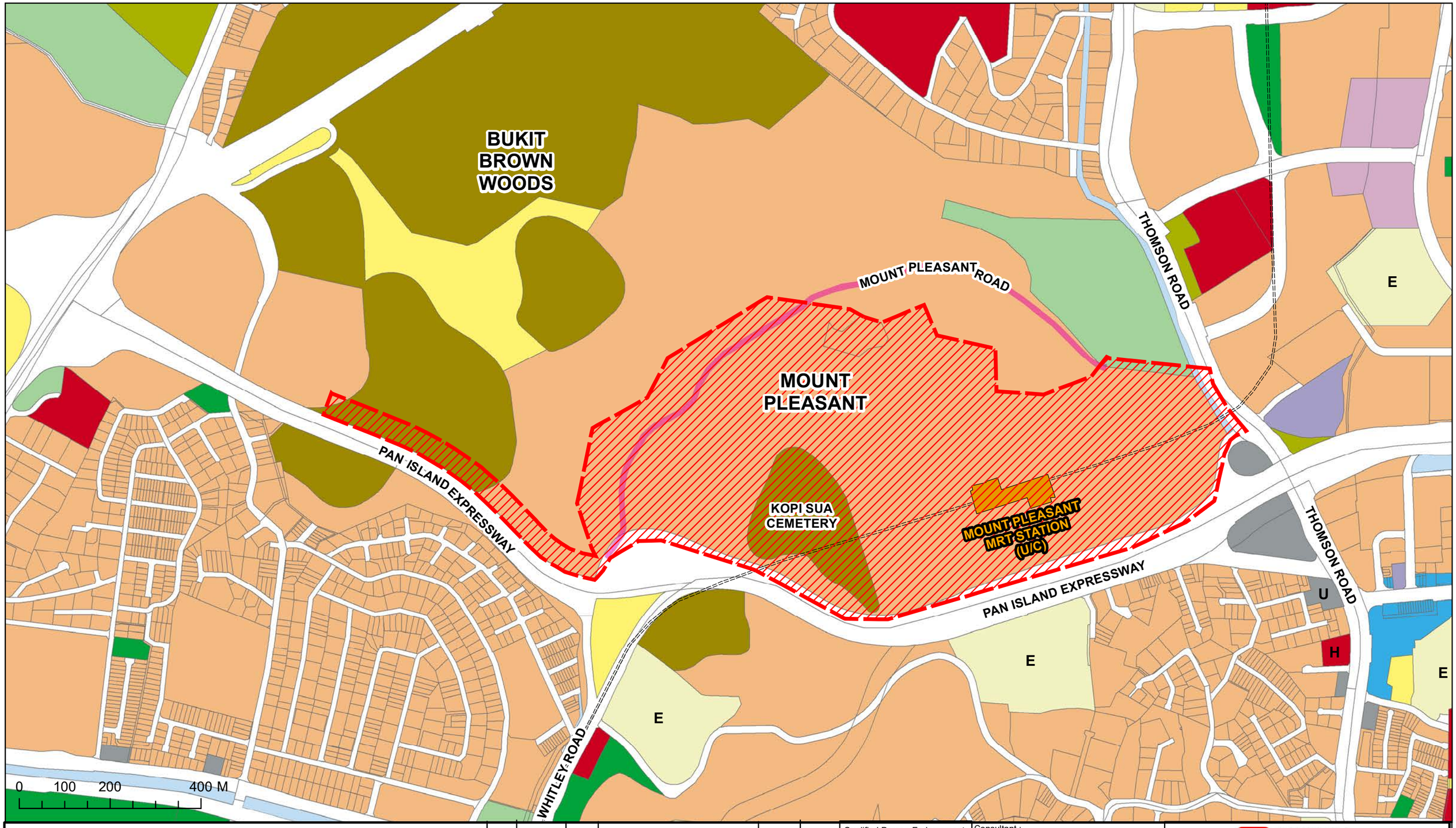
In the Urban Redevelopment Authority's (URA) gazetted Master Plan 2019, the Study Area is zoned "Residential (Subject to Detailed Planning)" and the existing Kopi Sua cemetery is zoned as "Cemetery" (refer to **Figure 3-1**). In addition, the new Thomson-East Coast MRT Line (TEL) will run through the Study Area with a station at Mount Pleasant which is currently under construction by LTA. The Mount Pleasant TEL station is located in the southern section of the Study Area near to the PIE within the site of the OPA.

As shown in the conceptual development plan (refer to **Figure 3-2**), the Study Area has been proposed to be redeveloped into a residential area, supported by commercial and social node integrated with the Mount Pleasant TEL station as part of the supporting infrastructure and amenities for the housing development. Proposed preliminary zones for future roads have also been identified which include an indicative original road plan and two (2) indicative alternative road plans, pending development in the detailed design phase at a later stage.

For comprehensiveness of the study, the indicative original road plan (linking to PIE via Mount Pleasant Road and the Proposed Slip Road Area) was assessed for each environmental parameter in this report as part of the base scenario/case. During this EIS process, the indicative alternative road plan 1 (linking to PIE via forested area near Kopi Sua Cemetery and the Proposed Slip Road Area) was first discussed with HDB to mitigate the potential environmental impacts (especially biodiversity and hydrology and water quality) from the original road plan. After the preliminary biodiversity and hydrology and water quality impact assessment, another indicative alternative road plan 2 (linking to PIE via Onraet Road) was recommended as able to better minimize the potential environmental impacts from the original road plan, if compared to the indicative alternative road plan 1. Both alternatives were discussed in **Section 10.4** (Hydrology and Water Quality) and **Section 12.6** (Biodiversity) respectively. Therefore, the indicative road plan 2, as the preferred mitigation measure, was also assessed qualitatively in the respective sections of the remaining environmental parameters in this report.

To facilitate the proposed development plans, demolition of relevant structures or buildings may be required within Study Area such as that demonstrated in **Figure 3-3**, where the WRC and some buildings under OPA were assumed to be demolished as well for the purpose of the following environmental impact assessment in this Report.

The structures and areas that remain within the Study Area comprises of the Kopi Sua cemetery, as well as the Black & White bungalows located along Mount Pleasant Road in the north west and the west of the Study Area. The Study Area is currently at master-planning stage by HDB and detailed plans are not available at the time of the EIS.



Legend

- Study Area
- MRT Station
- Thomson-East Coast Line
- Heritage Road
- BUSINESS 1
- CEMETERY
- CIVIC & COMMUNITY INSTITUTION
- COMMERCIAL & RESIDENTIAL
- E EDUCATIONAL INSTITUTION
- H HEALTH & MEDICAL CARE
- HOTEL
- OPEN SPACE
- PARK
- RESERVE SITE
- RESIDENTIAL
- ROAD
- SPORTS & RECREATION
- TRANSPORT FACILITIES
- U UTILITY
- WATERBODY

N

Rev.	Date	By	Description	Chk'd	App'd
03	NOV 2021	CQA	Final Report	NHT	JAG
-	JAN 2021	LYE	Final Report	NHT	JAG

Qualified Person Endorsement :
NA

HDB Endorsement :
NA

Consultant : AECOM

Project Title :
**CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT**

Designed	Checked	Approved
LYE	NHT	JAG
	Drawn: LYE	Date: JAN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title :
**LAND USE OF MOUNT PLEASANT
AND THE SURROUNDING**

Figure No. :	Rev.	Sheet
3 - 1	-	1 of 1

CAD File Name : NA — A3

Note: Source of basemap - URA Master Plan 2019

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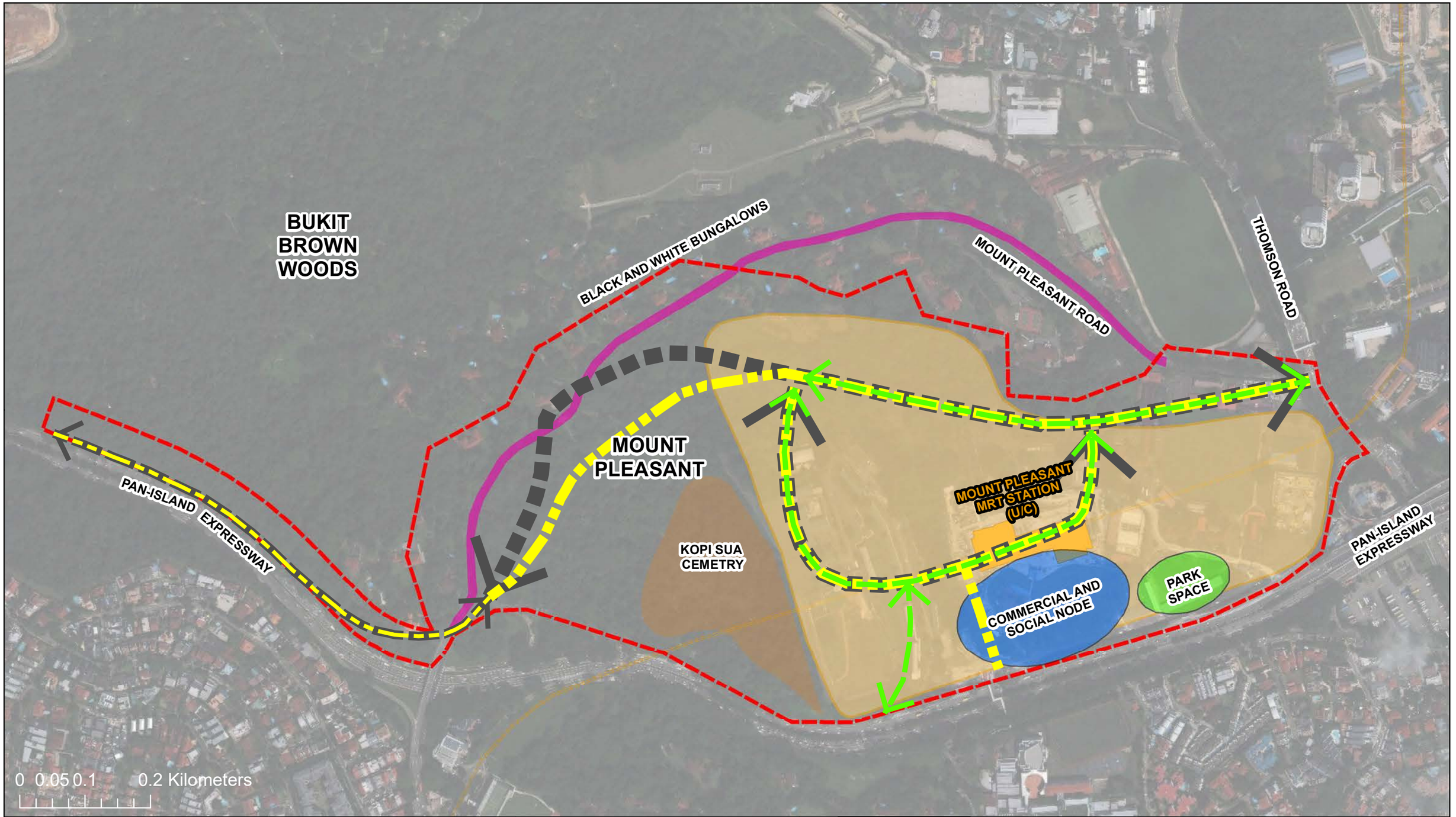

Legend

- MRT Station (U/C)
- Thomson-East Coast Line
- Heritage Road
- Kopi Sua Cemetery
- Indicative Alternative Road Plan 1 (for biodiversity, hydrology and water quality)
- Indicative Alternative Road Plan 2 (for all environmental parameters in this report)
- Indicative Original Road Plan

Proposed Layout Plan

- Commercial and Social node
- Housing with supporting amenities
- Park space
- Study Area

N

Rev.	Date	By	Description	Chk'd	App'd
02	JUN 2021	ML	Final Report	NHT	JAG
-	JAN 2021	ML	Final Report	NHT	JAG

Qualified Person Endorsement :
NA

HDB Endorsement :
NA

Consultant : AECOM

Project Title :
**CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT**

Designed	Checked	Approved
ML	NHT	JAG
	Drawn	Date
	ML	JUN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title :
CONCEPTUAL DEVELOPMENT PLAN

Figure No. :	Rev.	Sheet
3 - 2	02	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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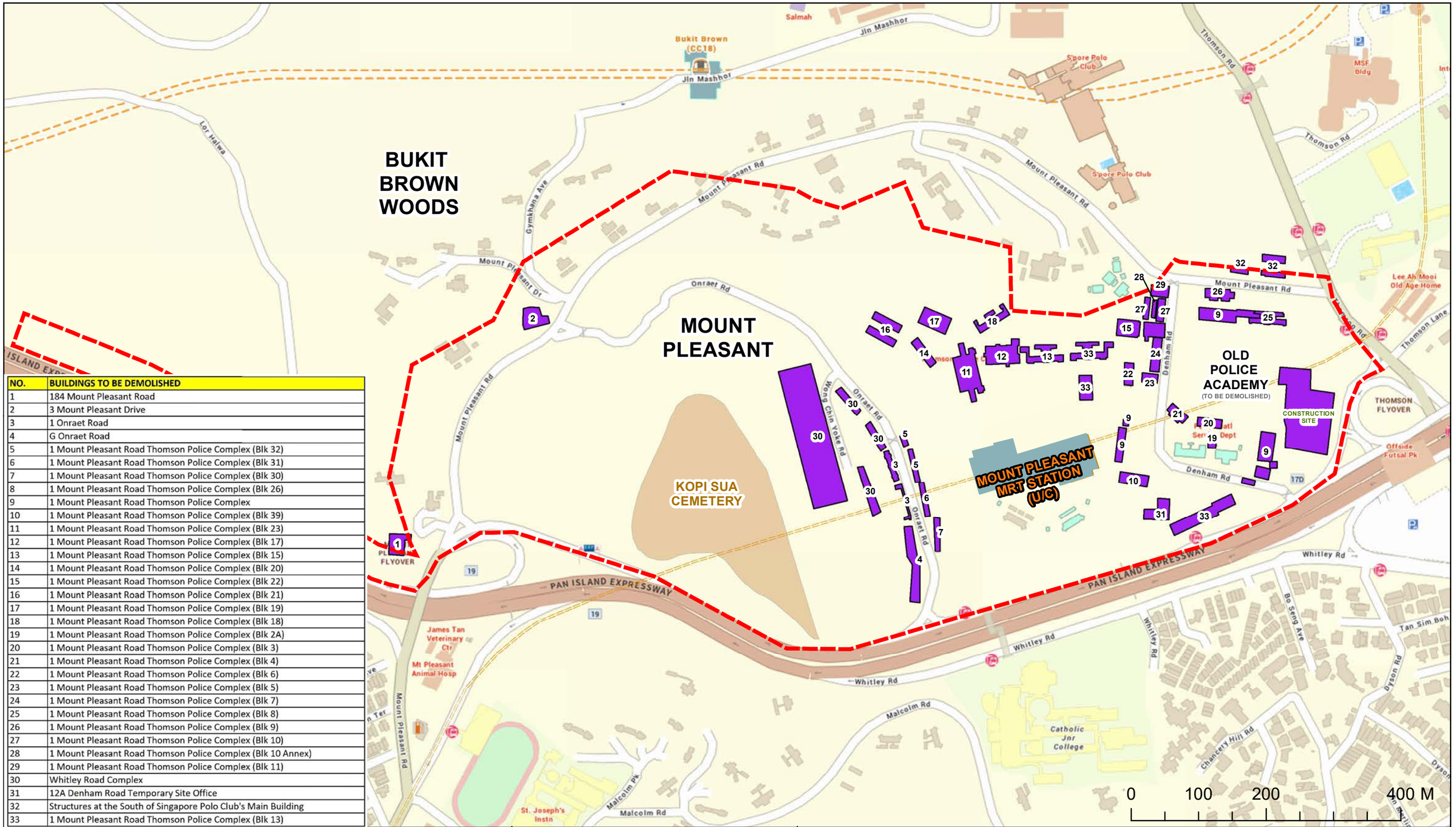

NO.	BUILDINGS TO BE DEMOLISHED
1	184 Mount Pleasant Road
2	3 Mount Pleasant Drive
3	1 Onraet Road
4	G Onraet Road
5	1 Mount Pleasant Road Thomson Police Complex (Blk 32)
6	1 Mount Pleasant Road Thomson Police Complex (Blk 31)
7	1 Mount Pleasant Road Thomson Police Complex (Blk 30)
8	1 Mount Pleasant Road Thomson Police Complex (Blk 26)
9	1 Mount Pleasant Road Thomson Police Complex
10	1 Mount Pleasant Road Thomson Police Complex (Blk 39)
11	1 Mount Pleasant Road Thomson Police Complex (Blk 23)
12	1 Mount Pleasant Road Thomson Police Complex (Blk 17)
13	1 Mount Pleasant Road Thomson Police Complex (Blk 15)
14	1 Mount Pleasant Road Thomson Police Complex (Blk 20)
15	1 Mount Pleasant Road Thomson Police Complex (Blk 22)
16	1 Mount Pleasant Road Thomson Police Complex (Blk 21)
17	1 Mount Pleasant Road Thomson Police Complex (Blk 19)
18	1 Mount Pleasant Road Thomson Police Complex (Blk 18)
19	1 Mount Pleasant Road Thomson Police Complex (Blk 2A)
20	1 Mount Pleasant Road Thomson Police Complex (Blk 3)
21	1 Mount Pleasant Road Thomson Police Complex (Blk 4)
22	1 Mount Pleasant Road Thomson Police Complex (Blk 6)
23	1 Mount Pleasant Road Thomson Police Complex (Blk 5)
24	1 Mount Pleasant Road Thomson Police Complex (Blk 7)
25	1 Mount Pleasant Road Thomson Police Complex (Blk 8)
26	1 Mount Pleasant Road Thomson Police Complex (Blk 9)
27	1 Mount Pleasant Road Thomson Police Complex (Blk 10)
28	1 Mount Pleasant Road Thomson Police Complex (Blk 10 Annex)
29	1 Mount Pleasant Road Thomson Police Complex (Blk 11)
30	Whitley Road Complex
31	12A Denham Road Temporary Site Office
32	Structures at the South of Singapore Polo Club's Main Building
33	1 Mount Pleasant Road Thomson Police Complex (Blk 13)

Legend

- Study Area
- Kopi Sua Cemetery
- Buildings Planned to be Demolished
- Thomson-East Coast Line
- Mt Pleasant MRT Station

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	LYE	Final Report	NHT	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

Project Title : **CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT**

HOUSING & DEVELOPMENT BOARD

Figure Title : **BUILDING DEMOLITION PLAN**

Designed	Checked	Approved
LYE	NHT	JAG
	Drawn	Date
	LYE	JAN 2021

Figure No. : 3 - 3 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - OneMap

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3.2 Location of Study Area

The Study Area for this EIS is estimated to be approximately 71.6 ha. It is bounded by Mount Pleasant Road to the north, Bukit Brown Woods to the west, Thomson Road to the east, and the PIE to the south.

The Study Area is currently located on undulating terrain. The Old Police Academy (OPA) and MHA's WRC are both located within the Study Area, but with restricted access as described in **Section 2.5**. At the time of the study, a large portion of the OPA is used as LTA's construction site for the ongoing construction of the Mount Pleasant TEL MRT station. A portion of the Study Area along the PIE is also used by LTA for the construction of the North-South Corridor (NSC). North-west of the Study Area, the Bukit Brown Cemetery area has been left largely unmanaged, thus secondary forest vegetation (also known as Bukit Brown Woods) has emerged.

A portion of Mount Pleasant Road within the Study Area, from the PIE slip road to Denham Road, is regarded as a heritage road due to the numerous mature trees lining the road. As such, any damage or removal of vegetation within the heritage road green buffer of up to 10m and either side of the road is strictly prohibited, except with approval of the Commissioner of Parks and Recreation (NParks, 2015). There is a cluster of Black & White bungalows along Mount Pleasant Road which is currently leased out largely for residential uses.

Besides, the Study Area includes a portion of Jalan Mendaki entering from Mount Pleasant Road near the PIE, as well as a portion of the un-developed land towards the west of Jalan Mendaki that is largely covered with vegetation within the area of Bukit Brown Woods.

Figure 3-4 shows the extent of the Study Area and its location in Singapore.

BUKIT BROWN WOODS

BLACK AND WHITE BUNGALOWS

SENIOR POLICE OFFICERS' MESS

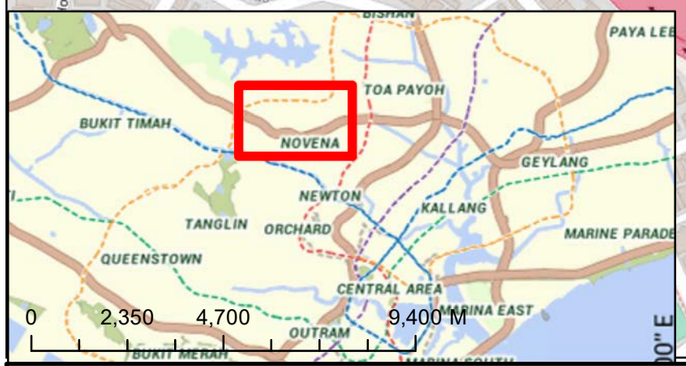
MOUNT PLEASANT

PROPOSED SLIP ROAD AREA

KOPI SUA CEMETERY

WHITLEY ROAD COMPLEX

MOUNT PLEASANT MRT STATION (U/C)



Legend

- Study Area
- Thomson-East Coast Line
- Heritage Road
- MRT Station
- Kopi Sua Cemetery

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	LYE	Final Report	NHT	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

Project Title : CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Designed	Checked	Approved
LYE	NHT	JAG
	Drawn	Date
	LYE	JAN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title : LOCATION OF THE PROJECT

Figure No. :	Rev.	Sheet
3 - 4	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Open Street Map and OneMap

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3.3 Proposed Construction Activities

In general, each above-ground project construction worksite area will require a construction worksite area for site offices, equipment and material storage, worker's canteens and worksite. The areas designated for the above ground components will also support the construction of the underground components of the development of the Study Area. These construction works may potentially impact the air quality, noise quality, biodiversity, surface water and groundwater ecosystems.

Since the project still at early master planning stage, construction phases will be discussed in general in the following sub-sections. Further discussion can be provided if more details are provided by the Client in future.

3.3.1 Phase 1 – Demolition Works (Pre-construction Stage)

This development of the Study Area may require demolition works for relevant areas, which involve the hacking of minor structure by handheld breaker and hacking of major structural on buildings by excavated mounter with breaker. During and after the hacking activities, removal of abandoned steel elements, foundation and spoils, debris (e.g. damaged window frames, doors, internal & external building furniture etc.) will be carried out using lorry cranes, excavator or dump trucks where practical.

To support the demolition works, delivery of steel plates, scaffoldings and hoarding boards for Safety Nets may be required. These demolition activities may cause potential noise impact due to operation of machineries, as well as potential air quality impact due to dust emissions from hacking activities. Other than implementing standard minimum control measures to control noise impact on site, dust control curtains may be necessary to control dust emissions. As part of the air quality control measures, dust suppression techniques such as water sprays or local extraction (e.g. local exhaust ventilation) can be implemented on site.

3.3.2 Phase 2 – Road Works for Traffic and Utility Diversion (Pre-construction Stage)

One of the pre-construction activities will be traffic and utility diversion. Sections of existing roads, which will be affected by the construction especially for the new road construction, will be either temporarily diverted or its access restricted to certain parts of the road. Works will include land clearing and tree felling, road widening activities, construction of temporary roads to divert traffic and setting up of barriers around impending cut-and-cover works or around laydown areas.

Drainage associated with temporary and permanent access roads will be constructed. Utilities which are shallow and likely to cause impedance to cut and cover works will be diverted first, so that there is no disruption in usage of utilities to nearby receptors. If required, some of the utilities will be reinstated after underground station or tunnelling is completed and the utilities need to be restored at the same place. Depending on the utility to be diverted, it may involve tree felling, excavation, access road construction and concrete resurfacing works.

Similarly to Phase 1, this Phase 2 which requires land clearance and tree felling for road works may cause potential noise nuisance and dust emission to nearby human and ecologically sensitive receptors, as well as potential water quality impact to existing streams or drains. These potential impacts were assessed in the relevant sections in this report.

3.3.3 Phase 3 – Construction of Proposed Development

The Construction Phase 3 includes pre-construction activities such as site clearance and earthworks to establish temporary worksites for the foundation works and the main construction of superstructures. After completing the construction of building structures, it will be followed by the finishing works for the buildings and structures. Thereafter, general landscaping works will be carried out to reinstate the worksite to its original condition.

3.3.3.1 Site Clearance and Earthworks (Pre-construction Stage)

To prepare the site for actual construction works, it will first require clearance of trees/ vegetation, earthworks, site levelling at the construction worksite areas and access roads. This activity would involve large machineries such as excavator, grader, concrete truck, roller, concrete vibrator, etc. For this, the construction contractor's certified Environmental Control Officer (ECO) shall prepare an Erosion Control Plan (ECP) and obtain approval from the Public Utilities Board (PUB). The contractor shall also map the

trees on site and the trees planned to be felled and obtain National Parks Board (NParks) approval. Regarding fauna, the Contractor shall also engage NParks (Wildlife Management Division) for the Wildlife Act S10 direction letter to seek site specific directions with regards to managing wildlife on site.

At this time, EIS report must be consulted by the Contractor for following requirements and therefore, plan of action:

- Have full and continuous hoarding/ noise barrier (where applicable) erected before starting any works;
- An area rich in trees of conservation interest, the contractor should employ a certified arborist to map the trees carefully while applying for tree felling approval. This is to gauge the health, species, size and conservation significance of the tree;
- If there are trees that must be transplanted, this should be done prior to commencing site clearance;
- Prior to works, if wild pigs are present within the hoarding, the contractor shall engage an approved wildlife management specialist to prepare and execute a plan for their removal;
- For all fauna that may be encountered on site, prepare a wildlife response and rescue plan in consultation with an Ecologist and have an NParks approved wildlife management specialist ready to execute if needed.

Site hoarding process and extent should also be governed by the above factors and the approved plans by NParks, PUB and/ or any other relevant agency.

In this process, the site is eventually levelled for construction to begin. This may involve cutting and stabilising of slopes in areas. In this case geotechnical engineers will develop Earth Retaining Stabilisation Structures (ERSS) schemes to stabilise the exposed slopes in their engineering design. ECO considers measures to prevent erosion of soil into the nearest drainage network. This may or may not accompany ground improvement works depending on the nature of the soil in the area.

The construction site debris, felled trees and spoil will be temporarily stored on site and then collected by licenced third parties for offsite disposal.

3.3.3.2 Establishment of Temporary Worksites (Pre-construction Stage)

Following the site clearance, the temporary worksite structures worksite structures are set up at each worksite. Generally, the site features will include areas for site offices, toilets, raw material storage area, equipment storage and workshop area, waste management facilities and storage, hazardous materials storage, internal temporary roads for movement of vehicles and vehicle parking lot. For the development of the Study Area construction worksite areas, it is not yet determined if the worksites will have/ not have concrete batching plants. As studied in this report in later sections, it has been recommended not to have onsite concrete batching plants owing to its vicinity to the Bukit Brown Woods and CCNR.

The construction works required, operation of machineries and increase in site vehicular traffic for the establishment of temporary worksites may cause potential noise nuisance and dust emission to nearby human and ecologically sensitive receptors, as well as potential water quality impact to existing streams or drains. Standard waste management practices shall be implemented on site to handle hazardous (e.g. toxic chemical wastes, oil) and non-hazardous wastes (e.g. general waste, stormwater runoff). These potential impacts were assessed in the relevant sections in this report.

3.3.3.3 Foundation Works

Once demolition and site clearance are completed and temporary worksites are established, foundation work for substructures including piles and pile caps will be constructed.

To begin the foundation piling process, erection of crawler crane and boring rig will be required, in which mobile crane might be used for lifting and transporting actions. After setting up the pile position, a temporary guide casing with an internal diameter same as pile diameter can be installed using crawler crane to the pile centre of the marked position to prevent collapse of the surrounding soil. The temporary casing will also serve as a guide in forming a uniform basis for the following boring works until the

designed depth using a bored piling machine, which can be very intensive and generates noise and vibration. Thereafter, the reinforced bars (rebar) will be installed using a crawler crane to enhance the strength of concrete pile, followed by the tremie pipe installation to better support the concreting works. The ready-mix concrete will be transported by a concrete truck and will be poured into the borehole using crawler crane. During circumstances when there is extra pile head after the completion of bored piling, pile head hacking will be conducted using breaker and excavator.

To seal the pile foundation, a pile cap will be necessary. For that, steel waler and struts are required to hold the temporary formworks to proceed with pile cap concreting. The steel will be delivered with a 40-feet trailer where hot works (e.g. welding of steel beams, brackets, etc.) may be required with the usage of welding equipment. Hoisting of waler and struts will be carried out using an excavator with lifting appliance. Upon completion of foundation works, excavator or mini excavator would be necessary for site excavation, at which dump trucks will be commissioned for spoil and slurry removal.

At this stage, the developer or contractor shall ensure proper handling and disposal of construction waste on site to avoid any potential contamination to nearby water resources, soil and groundwater. Besides, foundation works which involve piling would cause potential ground-borne vibration impact to nearby human and ecologically sensitive receptors, therefore was assessed this report as well.

3.3.3.4 Construction of Superstructure and Finishing Works

Following by the completion of foundation works, superstructures will be constructed for this development. Firstly, generators will provide the power supply on site for lighting, pumps and temporary ventilation fans operations. Before the installation of superstructures, temporary water pumps might be required to pump water from ground and rain to not affect the quality of concrete. To form the working platform, excavation below surface will be conducted using an excavator, which then following by the formation of lean concrete as the first ground layer for waterproofing purpose. Crane will be used for the spoil removal as well. To construct building until the designed height, temporary formwork is necessary at each level before casting, where air compressor will be used for cleaning. During this process, mobile crane will be used to transport rebar and for the hoisting of false work, scaffolding and the construction of temporary working platforms. A concrete truck will be used to transport ready mix concrete to the site and concrete pump will be used for the superstructure's concreting works.

After the completion of superstructures, it is generally followed by finishing works, such as interior plastering, exterior plastering, waterproofing and tiling, mechanical/ electrical/ plumbing (MEP) rough-in and ceiling installation, painting, lift installation, exterior glass walls, windows and doors installation, as well as setting up building systems (i.e. electrical, plumbing, air-conditioning, etc.). The potential environmental impacts associated with the construction of superstructures and finishing works were assessed and incorporated as a whole in the relevant sections of this report. The list of project-specific construction equipment involved in Phase 3 was provided in Section 8.2.3.1.

3.3.3.5 General Landscaping Works

For most of the projects, landscaping works will be conducted to maintain or present the landscape and visual amenity values to users or general public. In this case, green parks are planned in the prospective development plan of this Study Area as demonstrated in **Figure 3-2**, surrounded by the proposed public housing and Mount Pleasant MRT station. *Kopi Sua* Cemetery which will be remained is serving as part of the greenery for this development.

Similarly, generators will be used to provide power supply for lighting and running machineries during landscaping works. Excavator and mobile crane might be necessary for excavation and transport of construction materials as well as spoil removal. Welding or cutting equipment are commonly used to form landscape structures. The potential environmental impacts associated with the general landscaping works were assessed and incorporated as a whole in the relevant sections of this report. The list of project-specific construction equipment involved in Phase 3 was provided in Section 8.2.3.1.

3.3.3.6 Reinstatement and Stabilisation of the Study Area

As the final step towards the completion of construction activities, the developer and/or contractor shall remove all temporary works and ERSS for the reinstatement of working area to its original condition and/or required conditions. A well-reinstated and stabilised land will also enhance the landscape and

visual amenity values to create a better living environment for the public and residents of this development.

The equipment used at this stage is similar to that of the general landscaping works mentioned. Therefore, the potential environmental impacts associated with the reinstatement and stabilisation works under Phase 3 were incorporated as a whole where relevant in this report.

3.4 Proposed Operational Activities

Following this reinstatement period, human activity will increase as the development area becomes operational. The Study Area will see an associated increase in human activities such as traffic movement, lighting, and general activities.

According to current planning, the future roads constructed under the development of this Study Area will most likely be dual 2 lanes, with possibility of dual 3 lanes at the west of the Kopi Sua Cemetery, hence it was expected to observe increase in vehicular traffic volume from the operation of proposed development and its associated road network. This may result in potential traffic noise impact and potential air quality impact due to fugitive emissions from vehicle exhaust towards the nearby human and ecologically sensitive receptors within the Study Area. Besides, to support the proposed development such as housing and commercial buildings, it is common to find the installation of air-conditioning and mechanical ventilation (ACMV) (e.g. air-conditioning units, exhaust air fans, intake air fans and cooling towers) at the rooftops to provide electrical and mechanical services to the buildings. The operational noise from the ACMV may cause noise nuisance to sensitive receptors (e.g. residents, staffs, etc.) as well. Therefore, these potential air quality and airborne noise impacts were assessed in Section 7.0 and Section 8.0 of this report respectively.

Besides, given in this case that road networks with dual 2 or dual 3 lanes will be constructed, there is potential for the existing drainage network to be redesigned, where drainage works might be expected. As the natural landscape will be replaced by impervious surfaces, it will reduce infiltration of water into the ground and increase water runoff. Therefore, the potential impacts to hydrology, water quality, soil and groundwater during operational phase were also discussed in general in this report.

In addition, it was noted that the Mount Pleasant's heritage road will be retained due to the numerous mature trees lining the road and its heritage value. As advised by NParks, any damage or removal of vegetation within the heritage road green buffer of up to 10m on either side of the road is strictly prohibited, except with approval of the Commissioner of Parks and Recreation. It shall be maintained despite of the proposed construction works (e.g. construction of road networks, re-design drainage network, etc.) in the vicinity to provide landscape and amenity value to the development of the Study Area in parallel.

Since the Study Area is still at early master planning stage, potential environmental impacts from operational phase will be discussed in general in each respective chapter. Further discussion can be provided if more details are provided by the Client in future.

4.0 Environmental Legislation, Policies, Plans, Standards and Criteria

A review of applicable environmental legislation, plans, standards and criteria to the construction and operational phases of the project was carried out and listed in the following sections. Where local Singapore legislation was not located, reference has been made to international guidelines and best practices as appropriate. All the following sections analysing the environmental impacts aim to achieve compliance with the legislative references.

Table 4-1: Applicable Legislation

Environmental Parameter	Applicable Legislation	Key Points
Air Quality	Environmental Protection and Management Act, 2018	Provides standards and regulations on air impurities
	Environmental Protection and Management (Air Impurities) Regulations 2015	Regulates air emissions and impurities in Singapore.
	Singapore Ambient Air Quality Targets (Long Term Targets)	Stipulates the recommended limit values for ambient concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and O_3 to be applied from the year 2020. Target values are based on World Health Organisation (WHO) Limit Values (mixture of Interim and Final values).
	Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012	Stipulates that all off-road diesel engines (including construction equipment with diesel engines) imported for use in Singapore from July 2012 must comply with the EU Stage II, US Tier II or Japan Tier I off-road diesel engine emission standards.
	Environmental Protection and Management (Vehicular Emissions) Regulations 2008	The document provides guidance for enforcement against smoky vehicles and idling engines while the vehicle is stationary.
	UK Institute of Air Quality Management (IAQM) Guidance on the Assessment of Dust from Demolition and Construction	The document provides guidance for developers, their consultants and environmental health practitioners on how to undertake a construction impact assessment (including demolition and earthworks).
Air-borne Noise	SS593:2013 Code of Practice for Pollution Control (COPPC), 2013	Specifies recommended pollution control requirements and good practices for prevention of impacts to noise.
	SS602:2014 Code of Practice for Noise Control on Construction and Demolition Sites, 2014	Specifies recommendations and good practices for prevention of noise impacts from construction and demolition activities.
	Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008	• Stipulates a set of maximum allowable noise limits for construction sites for different time periods of the day and for different types of premises affected by construction noise. • Stipulates the correction factor that needs to be applied to the applicable noise criteria based on background noise levels.
	Technical Guideline for Land Transport Noise Impact Assessment from National Environment Agency (NEA)	Airborne noise: • Operation: Airborne noise limit (from MRT trains) of LpAeq1hr of 67 dB when measured at 1m from the façade of existing residential buildings/noise sensitive premises are set by the National Environment Agency (NEA).

Environmental Parameter	Applicable Legislation	Key Points
	Guideline on Boundary Noise Limit for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings by National Environmental Agency (NEA); Code of Practice on Pollution Control by National Environment Agency	Airborne Noise: Legislative requirements for boundary noise due to noise emissions from mechanical ventilation systems for non-industrial buildings.
Ground-borne Vibration	BS 7385-2:1993 Evaluation and measurement for vibration in buildings. Guide to damage levels from ground-borne vibration	This standard establishes the basic principles for evaluating vibration effects on buildings. It presents guide values for transient and continuous vibration, above which there is a likelihood of cosmetic damage.
	BS 5228-2 2009+A1:2014: Code of practice for noise and vibration control on construction and open sites – vibration	BS 5228-2 provides a 'best practice' guide for control of construction vibration and guidance on the human response to vibration in terms of peak particle velocity (PPV). It also provides case history vibration data and calculation methods for vibration from construction activities, including piling and tunnel boring.
	BS 6472-2:2008 Guide to Evaluation of Human Exposure to Vibration in Buildings Part 2: Blast Induced Vibration	This part of BS 6472 gives guidance on human exposure to blast induced vibration in buildings. It is used for assessing other forms of vibration that are caused by blasting, including when explosives are utilized in civil engineering works and in demolition activity.
	ISO14837:2005 Mechanical vibration - Ground-borne noise and vibration arising from rail systems. International Organization for Standardization	Advice on the prediction of ground-borne noise and vibration from rail systems.
	ASHRAE curves for sensitive equipment	In the absence of specific vibration criteria supplied by Priority 1 Receptors, generic criteria for the types of equipment will be used.
	Based on AECOM's review of both local and international standards/regulations, there are ground-borne vibration impact assessment criteria on human only. There are no relevant national or international standards setting criteria for ground-borne vibration impacts on biodiversity. In undertaking EIS, AECOM generally rely on a qualitative assessment of the various qualitative assessment of the various disturbance sources that particular receptors are likely to encounter and focus on the factors that are likely to cause the most disturbance. Based on the faunal surveys by biodiversity team at later stages, this shall be researched further and relevant references, guidelines will be included in the EIS report.	
Hydrology and Water Quality	Environmental Protection and Management Act, 2018	Regulates the discharge of trade effluent, oil chemical, sewage or other pollution matters into drains.
	SS 593: 2013 – Code of Practice for Pollution Control (COPPC)	• Provides guidelines for the appropriate discharge of any effluent into public sewer or watercourse. • Provides guidelines for the appropriate storage and accidental release of oils & chemicals.
	Environmental Protection and Management (Trade Effluent) Regulations, 2008	• Regulates the discharge of trade effluent. • Any discharge into a watercourse has to comply with the regulatory standards established in these regulations.

Environmental Parameter	Applicable Legislation	Key Points
	Sewerage and Drainage Act, 2001	• An Act to provide for and regulate the construction, maintenance, improvement, operation and use of sewerage and land drainage systems, and to regulate the discharge of sewage and trade effluent. • Regulates the protection, maintenance and provision of stormwater drainage system.
	Sewerage and Drainage (Trade Effluent) Regulations, 2007	Regulates trade effluent discharge into public sewerage system.
	Sewerage and Drainage (Surface Water Drainage) Regulations, 2007	Regulates measures to be implemented to protect the stormwater drainage system.
	PUB Code of Practice on Surface Water Drainage, 2013	Provides guidelines for measures to be implemented to protect the stormwater drainage system and manage surface water drainage (e.g. development and implementation of an Earth Control Measures (ECM) plan).
	PUB Circular on Preventing Muddy Water from the Construction Site, October 2015	All new construction sites with site area of 0.2ha and above, sites with problematic ECM, and sites within sensitive areas are required to implement CCTV including a Silty Imagery Detection System (SIDS) at the public drain to monitor the surface run-off discharges from the sites.
	Standard Statistical Classification of Surface Freshwater Quality for the Maintenance of Aquatic Life, New York and Geneva UNECE (1994)	Provides standards for water quality assessment relating to aquatic life for surface waterbodies.
	Water Quality Requirements WHO (n.d.)	Provides standards for water quality assessment relating to aquatic life for surface waterbodies.
	Water Quality Standards Handbook USEPA (2017)	Provides standards for water quality assessment relating to aquatic life for surface waterbodies.
	Australian & New Zealand Guidelines for Freshwater and Marine Water Quality (2000)	Provides standards for water quality assessment relating to aquatic life for surface waterbodies.
	Canadian Water Quality Guidelines for the Protection of Aquatic Life (2007)	Provides standards for water quality assessment relating to aquatic life for surface waterbodies.
	Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ, n.d.)	Provides standards for water quality assessment relating to aquatic life for surface waterbodies.
	National Water Quality Standards for Malaysia (DOE, n.d.)	Provides standards for water quality assessment relating to aquatic life for surface waterbodies.
	Environmental Public Health (Toxic Industrial Waste) Regulation (2000) Provide standards for toxic industrial waste water generation and disposal.	Provide standards for toxic industrial waste water generation and disposal.
Chemical Substances (Surface water and soil and groundwater sections)	The Environmental Protection and Management (Hazardous Substances) Regulations, 2008	Regulates the transport, use and storage of hazardous substances.

Environmental Parameter	Applicable Legislation	Key Points
Fire Safety (Surface water and soil and groundwater sections)	Fire Safety Act, 2013	Makes provisions for fire safety and for matters connected therewith.
	Fire Safety (Petroleum and Flammable Materials) Regulations, 2008	Regulates the transport, use and storage of flammable material to prevent occurrence of accidents.
	Code of Practice for the Storage of Flammable Liquids (SS 532:2007)	Provides guidelines for the transport, use and storage of flammable material to prevent occurrence of accidents.
Waste (Surface water and soil and groundwater sections)	Environmental Public Health Act, 2002	Regulates the storage, handling and disposal of wastes.
	Environmental Public Health (Toxic Industrial Waste) Regulations, 2000	Regulates the storage, collection and disposal of toxic industrial waste.
	Environmental Public Health (General Waste Collection) Regulations, 2000	Regulates general waste (incinerable and non-incinerable waste) disposal.
	Hazardous Waste (Control of Export, Import & Transit) Regulations 1998	Provides the application and granting of import, export, transit, Basel or special permits for hazardous wastes.
	Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal	Singapore signed the Basel Convention in 1995. Its requirements were transposed into Singaporean law through the Hazardous Waste Act. The Convention obligates parties to provide for the environmentally sound management of hazardous and other wastes, e.g. restrictions on the import, export and trans-boundary movement of hazardous wastes. Appropriate measures must be taken to ensure that the generation of such wastes, as well as the consequences of waste pollution on human health and the environmental is minimal. Adequate disposal facilities must be available.
	SS603: 2014 Code of Practice for hazardous waste management	This code provides guidance on best practice measures for managing hazardous waste on site
	Code of Practice for Licenced Waste Collector	This code provides list of wastes allowed to be collected by various licenced collector types.
	NEA circulars on import and export of waste	• Several circulars have been rolled out prohibiting certain import / export of waste • One of the circulars prohibits import/ export of metal/plastic scrap containing toxic or heavy metals (PCD/BASEL/05-0021)
Soil and Groundwater	Environmental Protection and Management Act, 2018	Regulates the discharge of trade effluent, oil chemical, sewage or other pollution onto land.
	SS 593:2013 Code of Practice for Pollution Control (COPPC)	• Provides guidelines for the control of land pollution and remediation of contaminated sites. • Provides guidelines for the appropriate storage and accidental release of oils & chemicals.
	Environmental Protection and Management (Trade Effluent) Regulations, 2008	Regulates the discharge of trade effluent into any watercourse or onto land.
	Sewerage and Drainage Act, 2001	Regulates the construction, maintenance, improvement, operation and use of sewerage and land drainage systems.

Environmental Parameter	Applicable Legislation	Key Points
	Sewerage and Drainage (Surface Water Drainage) Regulations, 2007	• Regulates measures to be implemented to protect the storm water drainage system and avoid flooding. • Regulates the provision and maintenance of ECM in accordance with the Code of Practice on Surface Water Drainage.
	JTC Guideline on Environmental Baseline Study, 2015	Provide the responsible parties necessary guidance for conducting EBS for assessing contamination of a site
	Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Target Values, Soil Remediation Intervention Values and Indicative Levels for Serious Contamination, 2020	The soil remediation intervention values indicate when the functional properties of the soil for humans, plant and animal life, is seriously impaired or threatened. They are representative of the level of contamination above which there is a serious case of soil contamination.
	Section 7 of SS 593:2013 Code of Practice for Pollution Control (COPPC)	Provides the necessary guidance for conducting Environmental Baseline Study (EBS) for assessing contamination of a site and the respective standards to be followed.
Biodiversity	National Biodiversity Strategy and Action Plan (NBSAP), 2009	This document provides a framework to guide biodiversity conservation efforts in Singapore. It intends to establish both policy frameworks and specific measures to ensure better planning and co-ordination in the sustainable use, management and conservation of biodiversity. A holistic approach has been adopted where the input of various public sector agencies and nature groups have been taken into consideration in the preparation of the document.
	Wildlife Act, Chapter 351, 2000	An Act for the protection, preservation and management of wildlife for the purposes of maintaining a healthy ecosystem and safeguarding public safety and health, and for related matters. As part of development works, the Developer shall be required to carry out any wildlife-related measure that the Director-General considers necessary to safeguard the health, welfare, safety of any wildlife or class of wildlife; public health or safety in relation to wildlife or; health of ecosystem.
	Parks and Trees Act, 2006	• An Act to provide for the planting, maintenance and conservation of trees and plants within national parks, nature reserves, tree conservation areas, heritage road green buffers and other specified areas, and for matters connected therewith. • No tree with a girth exceeding one meter (when measured 1-m from the ground) should be cut or damaged without the prior approval of the relevant authorities; and • No tree or plant will be cut or damaged if located within the heritage road green buffer.

Environmental Parameter	Applicable Legislation	Key Points
	Parks and Trees Act (Parks and Trees Regulations), 2006	Prohibitions and regulations on trees and animals within national park, nature reserve or public park.
	Parks and Trees (Heritage Road Green Buffers) Order, 2006	Lists the areas designated as heritage road green buffers.
	Parks and Trees (Preservation of Trees) Order, 1998	Lists the designated tree conservation areas No cutting or damaging of tree having girth of more than one metre.
	The Singapore Red Data Book (SRDB)	• Lists the endangered plants and animals in Singapore • Published by Singapore's Nature Society • Provides the scientific name, common name, status, description, habitat, distribution, threats, scientific interest and potential value, as well as conservation measures for each plant and animal listed.
	The International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threated Species	Provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated.
	The Hong Kong Environmental Impact Assessment Ordinance - Technical Memorandum (HK EIAO TM)*	Sets out the principles, procedures, guidelines, requirements and criteria for deciding whether the development of the Study Area is environmentally acceptable.
	National Parks Board (NParks) Biodiversity Impact Assessment (BIA) Guidelines, 2020**	This document provides a guideline on how to conduct biodiversity impact assessment as an individual study or as the biodiversity component of an EIA.
Landscape and Visual Amenity	Technical Memorandum on EIA Process (EIAO-TM): Annex 10 (Criteria for Evaluating Visual and Landscape Impact, and Impact on Sites of Cultural Heritage) and Annex 18 (Guidelines for Landscape and Visual Impact Assessment)	• Annex 10: Provides criteria for how to evaluate and assess the level of significance of impacts on landscape and visual amenity values as well as Sites of Cultural Heritage • Annex 18: Describes the general approach and methodology for assessment of landscape and visual impacts. This is not prescriptive and is subject to subjective judgement and preference.
	Environmental Impact Assessment Ordinance Guidance Note 8/2010 (Preparation of Landscape and Visual Impact Assessment under the Environmental Impact Assessment Ordinance)	A more detailed Guidance Note that serves to provide a general reference for good practices on EIA
* The HK EIAO TM and NParks' BIA will be the applied referenced guidelines for the biodiversity impact assessment of the development of the Study Area. ** Only the impact assessment considered the NParks' BIA Guidelines as baseline surveys were concluded prior to the publication of the guidelines.		

5.0 Description of the Environment

This section will describe the historical land use, existing land use and environment, topographical condition, as well as geological and soil characteristics of the Study Area.

5.1 Historical Land Use

The Study Area was named after a hill within the vicinity (National Library Board, 2019). Preceding British colonization in 1819, the interior of Singapore was covered by primary lowland dipterocarp rainforest (Corlett, 1991). Situated less than 2-km south of MacRitchie Reservoir, Mount Pleasant was likely identical to the Central Catchment Nature Reserve. The earliest interpretable topographic map of Mount Pleasant dated 1924 shows that the site was characterised by hilly terrain composed of at least three hills, with the highest elevation being 125-m a.s.l. (refer to **Figure 5-1**) within the Study Area. These hills were separated by a stream that ran through the middle of the site. By this time, the area was already inhabited by the Police Depot and the "Black and White" colonial houses that are still found there today (National Library Board, 2019). Bukit Brown Cemetery was also already established at this time being officially opened on 1st Jan 1922 (Wikipedia, 2019). The PIE was not established until the late 1970s. As much of the land stretching from the British settlements along the mouth of the Singapore River to Bukit Timah was deforested and transformed into gambier and pepper plantations by this time (Corlett, 1988), it is likely that Mount Pleasant was also occupied by plantations.

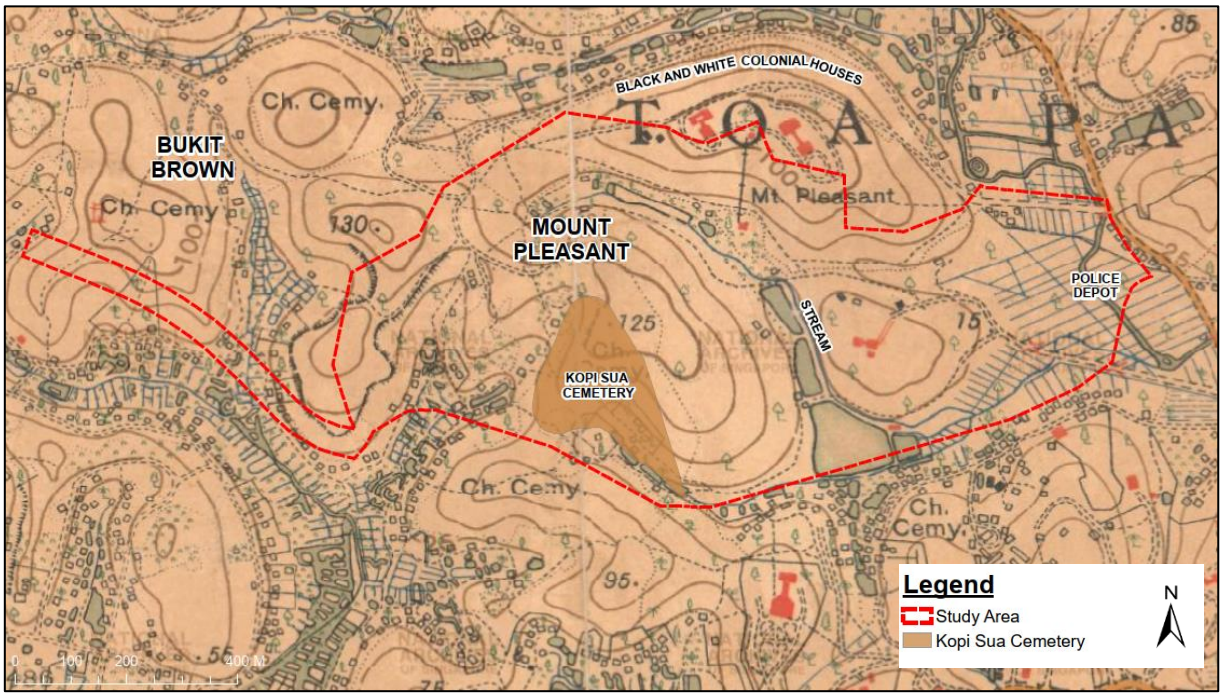


Figure 5-1: Mount Pleasant Circa 1924, Showing Three Hills and a Valley with Ponds between Two of the High Grounds (National Archives of Singapore, 2019)

The next interpretable map dated 1938 shows that Mount Pleasant Road was already established, along with the Police Depot (refer to **Figure 5-2**). The map also shows more clearly the number of residences and the extent of the cemetery. Since this map is not a topographic map, the vegetation type at this time was unknown. However, a topographic map from 1945 shows that the land occupied by the cemetery was covered by secondary forest and plantation and the land between the stream and Police Depot was plantation (refer to **Figure 5-3A**). By this time, the Singapore Polo Club was already established (National Library Board, 2019). An aerial photograph from 1950 shows a lot of open land suggesting that the area was likely dominated by scrubland and herbaceous vegetation (refer to **Figure 5-3B**), as also shown in a 1966 topographic map (refer to **Figure 5-3C**). In addition, the secondary forest occupying the cemetery was quite sparse and not covered by many trees (refer to **Figure 5-3B**). The cemetery was then closed around the 1970s and the area was left unmanaged and the vegetation succeeded into its present state (refer to **Figure 5-3D**). A plant study conducted at Bukit Brown Cemetery, particularly near to Lornie Road, revealed a diversity of mature secondary and primary forest saplings indicating dispersal from MacRitchie and successful recruitment (Lim, 2014). However,

regeneration there has been slow. Nonetheless, this has led to the area becoming suitable habitat for several threatened birds and mammals (Lee, 2015). It was unknown whether similar processes are occurring at Mount Pleasant.

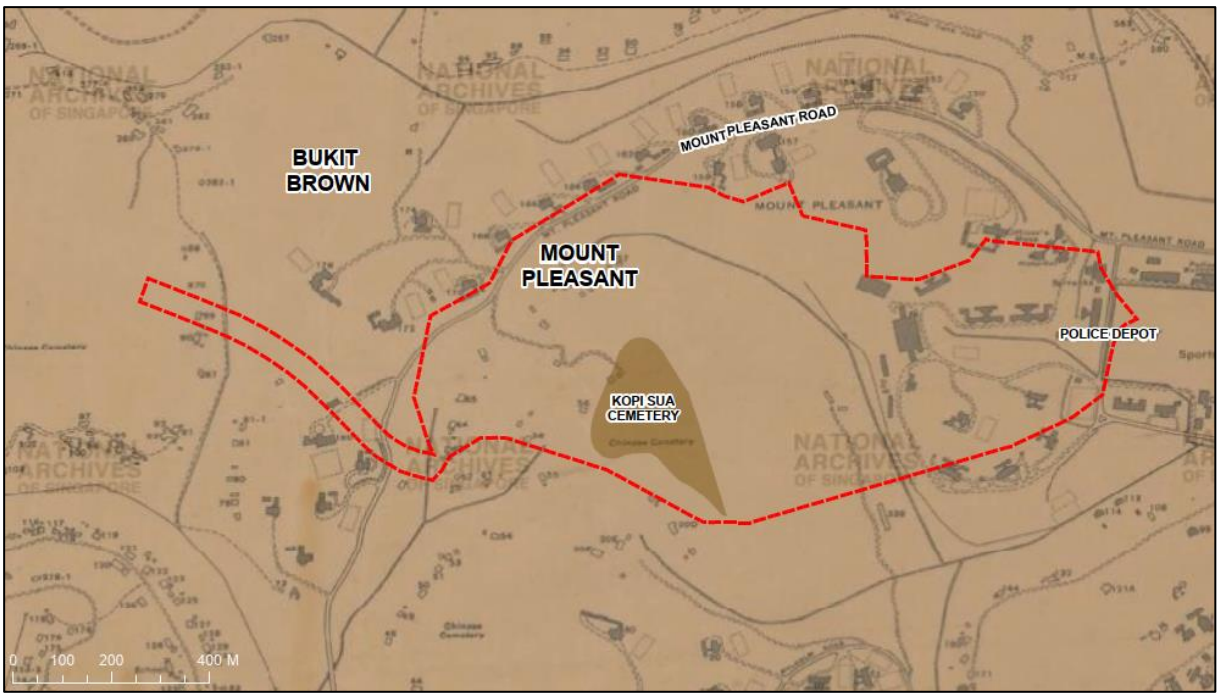


Figure 5-2: After Construction of the Colonial Houses and Road, Circa 1938 (National Archives of Singapore, 2019)

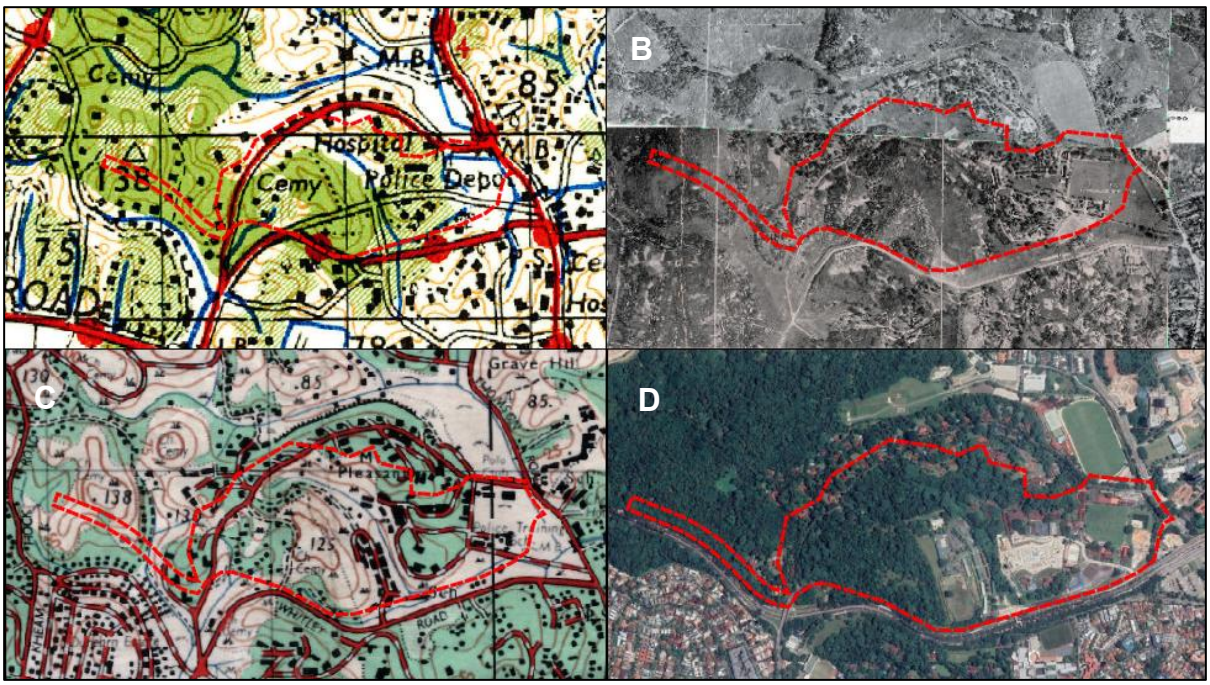


Figure 5-3: Mount Pleasant Study Area in 1945 (A), in 1950 (B), in 1966 (C) and in 2018 (D) (National Archive of Singapore (2019) and NUS Libraries (2019)).

5.2 Existing Land Use and Environment

The Study Area, located approximately 1.5-km away from the edge of the Central Catchment Nature Reserve boundary, is currently a mix of cemetery park land, forest, institutional recreational space and facilities, and the LTA's Mount Pleasant TEL station. Of these, the latter three are closed to the public, which make up about half of the site and the majority of the managed vegetation in the Study Area. The

Kopi Sua Cemetery is operated and maintained by a group of caretakers. On occasions such as *Qing Ming* Festival, higher human activities were observed. Regular visitors to the cemetery are far fewer, although it is also visited by bird-watchers and nature-lovers due to its proximity to the Central Catchment Nature Reserve and Bukit Brown. Human tracks were observed in the forested areas, which could have been made by the caretakers or other visitors foraging for food from the old fruit trees.

There are six broad vegetation types in the Study Area (refer to **Section 12.0**), with the predominant vegetation type being managed vegetation at 46.23% of the whole Study Area. This type of vegetation is not characterised by any specific plant species but by the presence of human maintenance. Abandoned-land forest made up the next most expansive vegetation type at 25.94%, within the area of the cemetery, parts of the WRC and parallel to the PIE. Here, fruit trees such as Rambutan, Durian, Mata Kuching, and Mango were observed. The remaining delineated vegetation types comprised of managed vegetation mostly within *Kopi Sua* Cemetery (5.27%), native-dominated low secondary forest (4.27%) herbaceous and scrubland vegetation (4.12%) and waste woodlands (3.54%). The remaining 10.62% of the site was covered by construction works.

Due to the presence of old settlements, three concrete drains now in various states of naturalisation were observed in the Study Area. These were found to support aquatic life made up of both exotic and native species during the assessment.

As a consequence of deforestation for development, the Study Area, together with Bukit Brown, is a forested fragment separated from the Central Catchment Nature Reserve in the north by the major roads of Lornie Road and the Lornie Highway. It is also separated from the Singapore Botanic Gardens in the south by the Pan Island Expressway, Bukit Timah Road and residential areas. While the forested areas in Singapore remain small and largely fragmented, they are critical for the long-term persistence of native biodiversity by serving as important corridors for ecological and biological exchanges between natural areas (Turner & Corlett, 1996; Pardini et al., 2005; McShea et al., 2009; Edwards et al., 2011). Mount Pleasant, together with Bukit Brown, is still regarded as an important stepping stone and refuge for biodiversity.

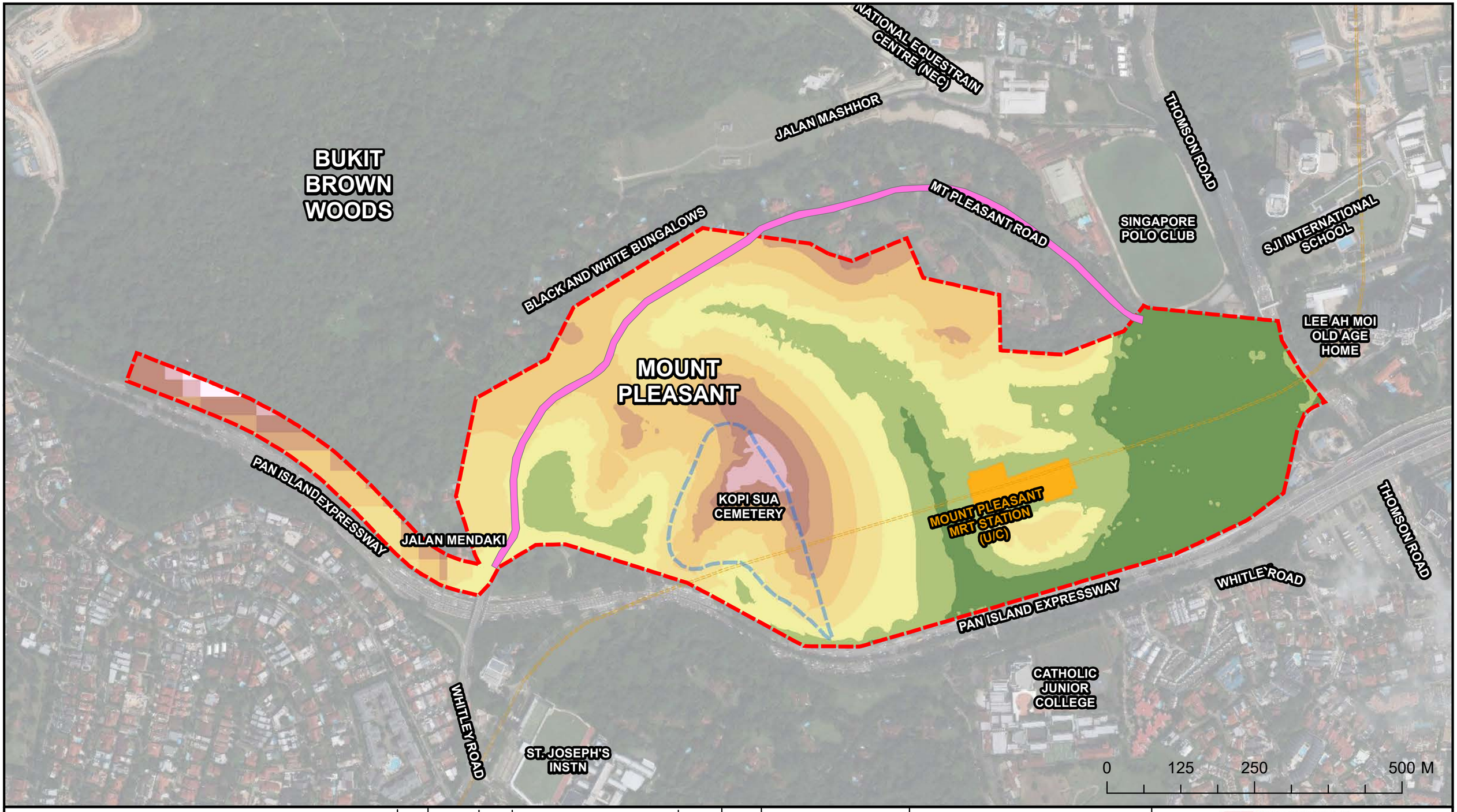
5.3 Topography of the Study Area

AECOM engaged a topography surveyor to determine the different elevations within the Study Area. Based on the review of the topography survey data, secondary data sources and observations from the site visit, it was noted that the general topography of the Study Area is generally hilly and undulating with moderate rising slopes towards the west to northwest (Refer **Figure 5-4**). The low-lying areas are located towards the southeast portion of the Study Area which include the under-construction Mount Pleasant MRT Station. The terrain of the Proposed Slip Road Area is generally undulating with moderate slopes observed towards the far east portion of the plot.

5.4 Geology and Soil

Based on the Geological Map of Singapore (2008) (refer **Figure 5-5**), the Study Area is primarily underlain by the Bukit Timah Granite (BT) of the Jurong Formation. The granite varies from granite through adamellite to granodiorite with several hybrid rocks included within the formation. Both hornblende-rich granite (BTh) and biotite-rich granite (BTb) occur within this formation. Zones of norite-granite mixed rocks are also (BThy) observed within this formation. Additionally, the presence of the Alluvium Member (Ka) of the Kallang Formation, which comprises a variable terrestrial sediment ranging from pebble beds through sand, muddy sand, and clay to peat, was also noted towards the eastern portion of the Study Area and towards the near east portion of the Proposed Slip Road Area. The member is usually unconsolidated but lightly consolidated beds may be found.

Based on the Soil Map of Republic of Singapore (1977), the general soil type underlying the Study Area is deposits of the Rengam series (Rm) granites. Eastern portion of the Study Area is also underlain by the deposits of the Tengah series (Tg) of recent alluvium. **Figure 5-6** illustrates the soil type found in the vicinity of the Study Area.



Legend

- Heritage Road
- Study Area
- Kopi Sua Cemetery
- Thomson-East Coast Line
- MRT Station (U/C)

Elevation (mRL)

- <5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- >40

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	LAL	Final Report	NHT	JAG

Qualified Person Endorsement :
NA

HDB Endorsement :
NA

Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

ELEVATION MAP OF THE STUDY AREA (GENERATED BASED ON TOPOGRAPHIC DATA)

Designed	Checked	Approved
LAL	NHT	JAG
	Drawn: LAL	Date: JAN 2021

Figure No. : 5 - 4 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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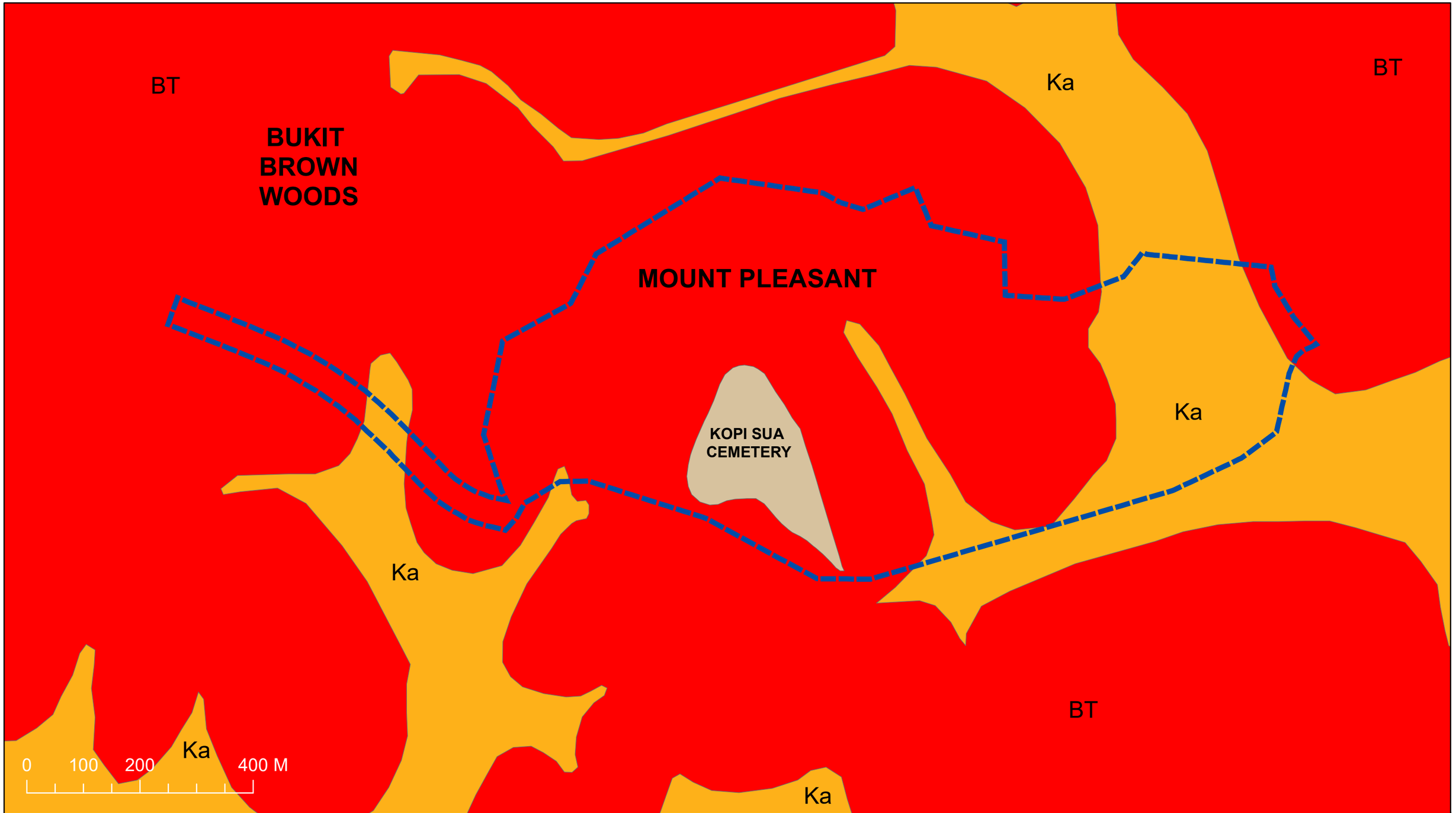

Legend

Study Area

Kopi Sua Cemetery

Kallang Formation:

Ka — Alluvial Member (Ka): A variable terrestrial sediment ranging from pebble beds through sand, muddy sand, and clay to peat. The member is usually unconsolidated but lightly consolidated beds may be found.

Jurong Formation:

BT — Bukit Timah Granite (BT): The granite varies from granite through adamellite to granodiorite, and several hybrid rocks are included within the formation. Both hornblende-rich granite (BTh) and biotite-rich granite (BTb) occur. Zones of norite-granite mixed rocks are also seen (BThy).

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	JAN	Final Report	APD	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

Project Title : CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Designed	Checked	Approved
JAN	APD	JAG
	Drawn	Date
	JAN	JAN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title : GEOLOGICAL MAP OF THE STUDY AREA

Figure No. :	Rev.	Sheet
5 - 5	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - National Archives of Singapore

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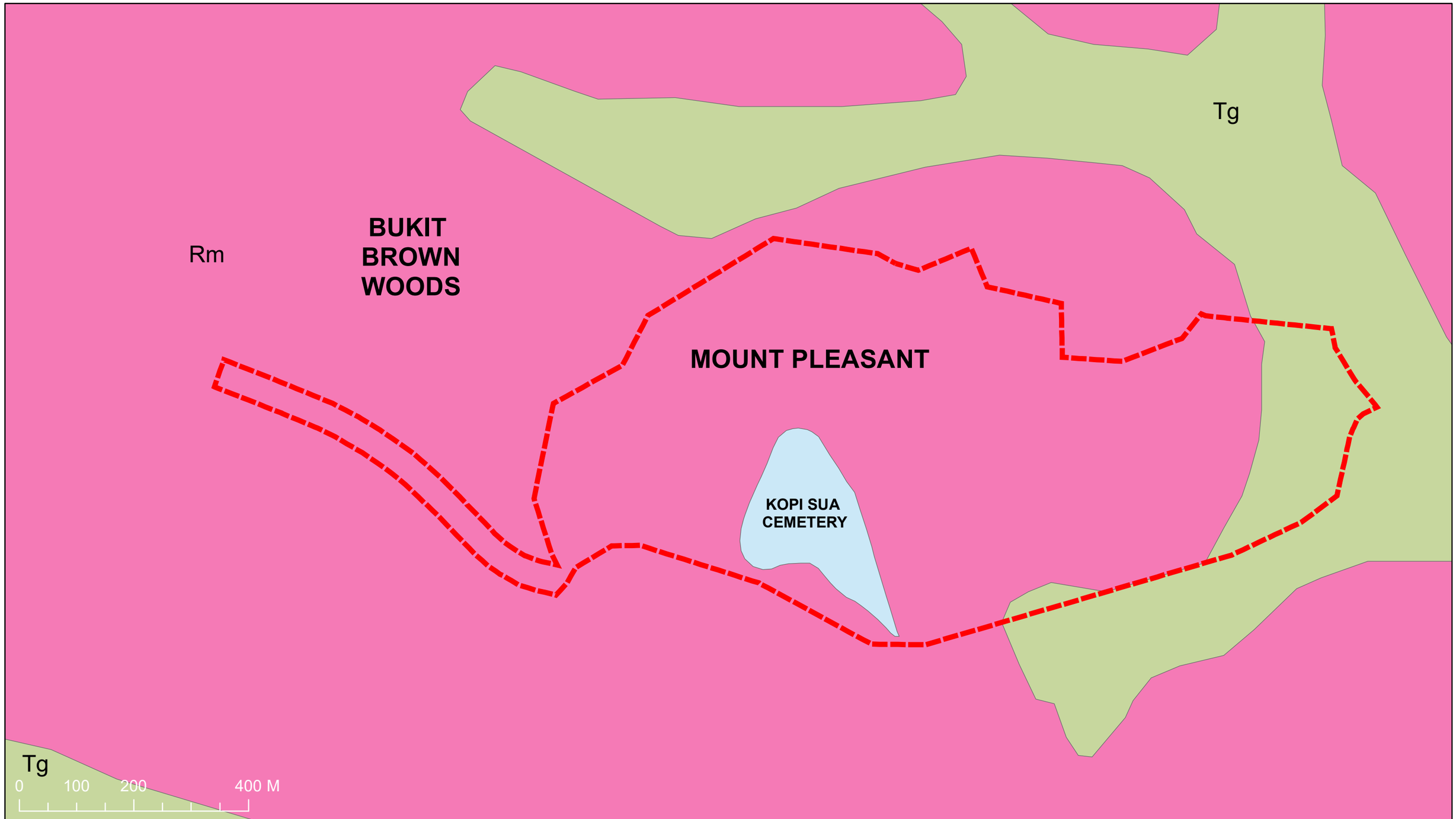

Legend

- Study Area
- Kopi Sua Cemetery
- SOILS ON IGNEOUS ROCKS - Rengam series (Rm)
- SOILS ON ALLUVIUM - Tengah series (Tg)

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	JAN	Final Report	APD	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

Project Title : CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Designed	Checked	Approved
JAN	APD	JAG
	Drawn	Date
	JAN	JAN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title : SOIL MAP OF THE STUDY AREA

Figure No. :	Rev.	Sheet
5 - 6	-	1 of 1

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Note: Source of basemap - Google Earth Map

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6.0 EIS Approach and Methodology

This section outlines the approach and methodology followed for this EIS.

6.1 Approach

The general approach to the EIS is as follows:

- Scoping of EIA (**Section 6.2**);
- Data collection and analysis (**Section 6.3**);
- Prediction of impacts (**Section 6.4.1**);
- Impact evaluation (**Section 6.4.2**);
- Recommendations of Mitigation Measures (**Section 6.5**); and
- Environmental Monitoring and Management Plan (**Section 6.5**).

6.2 Scoping of the Project

Referring to the Inception Report (AECOM, 2019) submitted to HDB and technical agencies (NPArks, NEA) on 6th May 2019, the environmental impacts resulting from the construction and operational activities of the development of the Study Area were assessed as follows:

- Air Quality
- Airborne Noise
- Groundborne Vibration
- Hydrology and Water Quality
- Soil and Groundwater
- Biodiversity
- Landscape and Visual Amenity

6.2.1 Study Area and Assessment Area

The Study Area for this EIS is presented in **Section 3.2** and **Figure 3-4** which is an area of total 71.6 ha within the study boundary delineated via legal agreement with the Client that defines the scope of works of this report. The Assessment Area was used to determine any potential environmental impacts to the nearby sensitive receptors due to construction and operational activities from the Study Area. Assessment Area varied depending on the technical discipline and will be described respectively for each impact in the following chapters.

6.2.2 Identification and Classification of Sensitivity Receptors

Sensitive receptors are those receptors within or in the vicinity of the Study Area which may potentially be impacted by the project's construction and operational activities. Environmentally sensitive receptors were sub-categorised into three categories: Priority 1, Priority 2 and Priority 3 (from the most sensitive to the least) as shown in the following table. The identification of sensitive receptors for each environmental parameter were developed based on the findings of the environmental reconnaissance surveys, baseline surveys and review of the proposed project footprint.

Table 6-1: Receptor Sensitivity Classification

Environmental Parameter	Receptor Sensitivity		
	Priority 1 (Most sensitive)	Priority 2 (Sensitive)	Priority 3 (Least sensitive)
Air Quality (Construction)[1]	Human Health Impact: • Sensitive receptors[2] (more than 100 receptors) within 50 m of the construction footprint/ proposed access roads • Sensitive receptors[2] (1-100 receptors) within 20 m of the construction footprint/ proposed access roads • Office, industrial facilities, or shops (more than 10 receptors) within 20 m of the construction footprint/ proposed access roads	Human Health Impact: • Sensitive receptors[2] (more than 100 receptors) between 50 m to 100 m of the construction footprint/ proposed access roads • Sensitive receptors[2] (1-100 receptors) between 20 m to 50 m of the construction footprint/ proposed access roads • Office, industrial facilities, or shops (more than 10 receptors) within 20 m to 50 m of the construction footprint/ proposed access roads • Office, industrial facilities, or shops (1-10 receptors) within 20 m of the construction footprint/ proposed access roads	Human Health Impact: • Public footpath, playing fields and parks within 20 m of the construction footprint/ proposed access roads • All other buildings within the assessment area of 350 m
	Ecological Impact • Flora, Fauna Species and Habitats of High Ecological Value within 20m of the construction footprint/ proposed access roads.	Ecological Impact • Flora, Fauna Species and Habitats of High Ecological Value within 20m to 50m of the construction footprint/ proposed access roads. • Ecological sites having known sensitive communities within 20m of the construction footprint/ proposed access roads.	Ecological Impact • Ecological sites having known sensitive communities within 20m to 50m of the construction footprint/ proposed access roads • Any other ecological sites within the assessment area of 50m.
Air Quality (Operational)	Schools and education buildings, hospitals and medical centres, nursing homes	Residential buildings, sport and recreation areas (outdoor)	Commercial, religious, infrastructure, industrial, others
Airborne Noise	Human Health Impact: • Schools & Education Buildings, Hospitals and Medical Centres, Nursing Homes.	Human Health Impact: • Residential buildings	Human Health Impact: • Other Buildings (Industrial, Commercial, Infrastructure, Sport & Recreation Areas, Religious Buildings, etc.).
	Ecological Impact • Fauna species and habitats of high auditory sensitivity to airborne noise.	Ecological Impact • Fauna species and habitats of moderate auditory sensitivity to airborne noise.	Ecological Impact • Fauna species and habitats of low auditory sensitivity to airborne noise.

Environmental Parameter	Receptor Sensitivity		
	Priority 1 (Most sensitive)	Priority 2 (Sensitive)	Priority 3 (Least sensitive)
Ground -borne Vibration	• Hospitals using sensitive equipment, industries/laboratories using sensitive equipment.	• Residential buildings, community centres, religious buildings, schools and education buildings, hospitals or medical centres, nursing homes, heritage buildings and national monuments.	• Commercial buildings, industrial buildings, infrastructure, industrial food centres, sports and recreation centres (e.g. golf courses, stadiums, clubhouses).
	• Fauna species and habitats of high sensitivity to ground-borne vibration.	• Fauna species and habitats of moderate auditory sensitivity to ground-borne vibration.	• Fauna species and habitats of low auditory sensitivity to ground-borne vibration.
Hydrology and Water Quality	• Surface waterbodies protected and used for drinking supply, or supporting ecosystems of biodiversity conservation significance	• Surface waterbodies used for industrial water supply or for recreational purposes, but not used for drinking water purposes, and which do not support ecosystems of biodiversity conservation significance	• Surface waterbodies not used for any purposes and not protected
Soil and Groundwater	• Sensitive groundwater (i.e. used for irrigation or drinking water, or supports ecosystems of biodiversity conservation significance)	• Groundwater which may be extracted for industrial purposes but not used for irrigation or drinking water • Groundwater partially supporting ecosystems of biodiversity conservation significance	• Not sensitive groundwater (i.e. not extracted for any purposes or does not support any ecosystems of biodiversity conservation significance
Biodiversity	Flora, fauna species and habitats of high ecological value [3] • Conservation significant flora, fauna and habitats. • Trees of conservation significance. • Heritage trees.	Flora, fauna species and habitats of moderate ecological value [3] • Native flora and fauna species and habitats. • Woodlands of abandoned kampong and plantation with good forest structure. • Species which would be involved in human-wildlife conflicts such as the Long-tailed Macaque or Wild Pig	Flora, fauna species and habitats of low ecological value [3] • Exotic or cryptogenic flora, fauna and habitats. • Managed vegetation. • Woodlands of abandoned kampong and plantation with poor forest structure.
Landscape and Visual Amenity [4]	• Landscape of particularly highly valued character and scenic quality, considered very susceptible to relatively small changes (e.g. within a designated nature reserve, designed buffer zones, wetlands, historic landscapes, scenic spots, sites or buildings of culture	• Landscape of local value, quality or rarity, exhibiting some distinct features, considered tolerant of some degree of change (e.g. within a locally designated landscape or with landscape elements of local importance).	• Landscape of lower scenic quality, with few distinctive elements or valued characteristics and considered tolerant of a large degree of change (e.g. outside any designated areas or within a degraded landscape).

Environmental Parameter	Receptor Sensitivity		
	Priority 1 (Most sensitive)	Priority 2 (Sensitive)	Priority 3 (Least sensitive)
	heritage or recognised as an iconic or important feature of the local landscape).		

Notes:

[1] Method to determine sensitivity of the Study Area was based on Institute of Air Quality Management UK (IAQM) guidance to determine sensitivity of the area to Human Health and Ecological Impacts.

[2] Sensitive receptors for air impact assessment included residential blocks, hospitals, medical centre, schools and education and residential care home. This was according to classification made in the IAQM's guidance.

[3] Refer to **Table 6-2** for the characteristics that influence the ecological value of an ecological feature. The characteristics were categorised based on the receiver of an impact (i.e., habitat or species).

[4] The landscape and visual amenity parameter followed the guidance from Hong Kong Environmental Protection Department's Environmental Impact Assessment Ordinance Technical Memorandum Annex 18, wherein the landscape and visual impact assessment is directed towards the predicting and judging the significance of the effects that new development may have on landscape character and visual amenity. The perception and aspiration of the community on landscape features must be taken into account. The assessment may vary from case to case, depending on the nature of the issues and will be subject to judgement and preference

Table 6-2: Factors Influencing the Ecological Value of an Ecological Feature and Classification Levels

Criteria	Characteristic	Definition
Habitats		
Quality	Naturalness	The degree of a habitat that is free from modification or disturbances from man (i.e. man-made, naturalised and natural). A man-made habitat is artificially made; a naturalised habitat is a man-made environment which has been recolonised by spontaneous vegetation growth; and a natural habitat is largely pristine and not affected by human actions. • In a terrestrial habitat, it is indicated by the dominant species composition type and whether it is managed or spontaneous. • In an aquatic habitat, it is indicated by the extent of human modification of disturbances.
	Size	The physical extent occupied by a habitat within the site. If all else were equal, larger areas tend to have higher carrying capacity and can support more resources, species and populations.
	Species richness	Number of floral and faunal species, and number of individuals of these species in a habitat. A habitat with higher number of native species and/or more individuals of these species, is more biodiverse, thus has higher ecological value.
	Species assemblage	Number of species of conservation significance, or species that are rare or have restricted distribution (collectively termed as "species of interest"), and number of individuals of these species in a habitat. A habitat with higher number of species of interest and/or more individuals of these species, is more biodiverse, thus have higher ecological value.
	Large specimens	The number of large specimens in a habitat. Large specimens aid connectivity and provide food and refuge for fauna. The higher the number of large specimens, the higher the ecological value.
	Rarity	The degree of how frequently observed a certain habitat type locally or globally. The less common the habitat, the higher its conservation value.
Resilience	Sensitivity	The ability for the habitat to withstand disturbances or change and/or ease of recreating the habitat type naturally or with human intervention. High sensitivity habitats have a low ability to withstand disturbances and are difficulty to recreate.
Use	Ecological linkage	The degree of importance of a site in terms of connectivity through being in close proximity with other nearby green spaces, especially with high quality habitats.
Species/population		
Conservation Significance	Conservation status	The global and local conservation status of a species. Species that are threatened or rare have higher conservation significance, thus higher ecological value
	Rarity	The degree of how frequently a certain species is found. The greater the number of rare species, the higher the ecological value. Rarity of species for each fauna group refers to the following sources: • Baker N & Lim KKP (2012) Wild Animals of Singapore: A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes. Draco Pub and Distribution, Singapore. • Khew SK (2015) A Field Guide to the Butterflies of Singapore (2nd edition). Ink Communications Pte Ltd, Singapore. • Soh M, Ngiam R, Dow R (2019) New Singapore record of a dragonfly, Indothemis carnatica, with an updated Singapore Odonata checklist. Singapore Biodiversity Records 2019: 10-17. National University of Singapore, Singapore. • Yong DL, Lim KC & Lee TK (2016) A Naturalist's Guide to the Birds of Singapore (2nd edition). John Beaufoy Publishing, United States. Fauna rarity is considered as the local guidebooks and papers for each of the above fauna groups have a more updated status of the species,

Criteria	Characteristic	Definition
		compared to the Singapore Red Data Book. There is no definition of rarity for plants in Singapore and therefore, only fauna rarity is considered.
Resilience	Distribution	The measure of extent of distribution of the species, nationally or globally. If species has either restricted global distribution or local distribution, it would still be considered restricted. Species with restricted distribution would be more susceptible to impacts.
	Sensitivity	The ability of species to withstand anthropogenic disturbances or change in environment.
Note: This parameter follows the guidance from Hong Kong Environmental Protection Department's Environmental Impact Assessment Ordinance Technical Memorandum Annex 8, wherein the ecological impact assessment is directed towards the predicting and judging the significance of the effects that new development may have on the existing habitats and species in the Study Area. The assessment may vary from case to case, depending on the nature of the issues and will be subject to judgement and preference.		

6.3 Data Collection and Analysis

Collection of pre-construction environmental baseline data within the Study Area was conducted both from primary sources and secondary sources.

6.3.1 Sample Collection and Survey Locations

The sample collection and survey locations were selected for baseline data collection based on their proximity to the Study Area and receptor priority. These locations were confirmed during a site reconnaissance survey. Site visits were undertaken as tabulated in the following **Table 6-3**.

Further information on sample collection and survey locations and parameters is provided in **Section 7.0** (Air Quality), **Section 8.0** (Airborne Noise), **Section 9.0** (Groundborne Vibration), **Section 10.0** (Hydrology and Water Quality), **Section 11.0** (Soil and Groundwater) and **Section 12.0** (Biodiversity).

Table 6-3: Site Visits for Data Collection

Environmental Parameter	Site Visits
Air Quality	Site reconnaissance survey: 30th January 2019 Sampling dates: 22nd April to 30th April 2019
Airborne Noise	Site reconnaissance survey: 30th January 2019 Sampling dates: 7th May to 14th May 2019 7th to 14th January 2020
Ground-borne Vibration	Site reconnaissance survey: 30th January 2019 Sampling dates: 7th May to 16th May 2019
Hydrology and Water Quality	Site reconnaissance survey: 30th January 2019 Sampling dates: 24th May 2019 (dry weather sampling) 31st May 2019 (dry weather sampling) 30th August 2019 (wet weather sampling) 7th January 2020 (dry weather sampling) 14th January 2020 (dry weather sampling) 21st January 2020 (wet weather sampling) 13th August 2020 (wet weather sampling)

Environmental Parameter	Site Visits
Soil and Groundwater	Site reconnaissance survey: 30th January 2019 Sampling dates: 25th April to 27th April 2019 and 20th January 2020 (soil and groundwater investigation works) 13th June 2019 and 21st January 2020 (rising head slug test) 6th May 2019 and 22nd January 2020 (groundwater sampling)
Biodiversity	Site reconnaissance survey: 18th, 29th January 2019 22nd March 2019 Flora and arboriculture baseline surveys: 12th, 14th, 15th, 21st, 22nd, 26th February 2019 1st, 6th, 7th, 8th, 12th, 13th, 14th, 18th, 19th, 20th, 25th, 26th, 27th March 2019 4th, 8th, 9th, 11th, 15th, 23rd, 25th, 29th April 2019 3rd, 4th, 7th, 10th, 11th, 12th June 2019 3rd, 5th, 8th July 2019 7th August 2019 6th, 7th, 8th, 9th, 13th, 14th January 2020 4th, 7th, 17th, 21st, 25th August 2020 1st September 2020 Fauna baseline surveys: 12th, 25th February 2019 5th, 6th, 17, 19th, 25th, 26th, 28th, 29th March 2019 16th, 17th, 18th, 22nd, 23rd, 24th, 26th, 27th, 28th April 2019 23rd, 28th May 2019 14th, 15th, 25th July 2019 31st August 2019 1st September 2019 19th, 20th, 27th, 28th December 2019 3rd, 11th January 2020 1st September 2020
Landscape and Visual Amenity	Site reconnaissance survey: 1st October 2019

6.3.2 Secondary Data Collection

Additional secondary data was collected from sources including, but not limited to, the following:

- Review of available environmental surveys previously carried out within or in the vicinity of the Study Area (e.g. tree surveys, ecological surveys, etc);
- Publicly available data, existing literature, books (e.g. Singapore Red Data Book (SRDB) and online sources);
- Historical, current and planned land uses;
- Online databases;
- Aerial photographs;
- Drainage maps of the catchment area;
- Weather Data (Rainfall, Wind, Evaporation);
- Landscape maps; and
- Commercial and recreational activities.

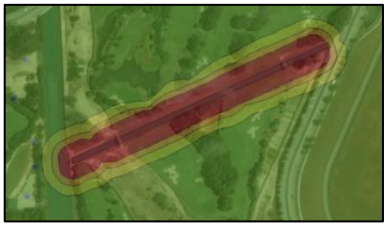
Further information on sample collection and survey locations and parameters is provided in **Section 7.0** (Air Quality), **Section 8.0** (Airborne Noise), **Section 9.0** (Groundborne Vibration), **Section 10.0** (Hydrology and Water Quality), **Section 11.0** (Soil and Groundwater) and **Section 12.0** (Biodiversity).

6.4 Assessment Criteria

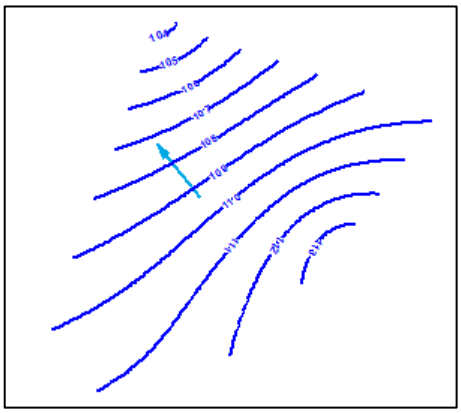
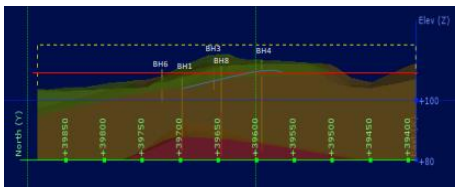
6.4.1 Prediction of Impacts

Key potential environmental impacts arising from the project's construction and operational activities were assessed within the study scope. The methodology for the prediction of impacts is as given in **Table 6-4**.

Table 6-4: Methodology for Prediction of Construction and Operational Impacts

Environmental Parameter	Proposed Methodology for Impact Prediction	Output Type
Air Quality	**Construction phase:** The methodology employed broadly followed the document titled "Guidance on the Assessment of Dust from Demolition and Construction" which was published by the UK IAQM in 2014. For the qualitative impact assessment during construction phase, this methodology provides recommendation measures based on the sensitivity of the neighbouring sites in order to reduce the impact to insignificant levels. The air quality impact assessment utilized the following information: 1. The extent of the construction area; 2. Amount of spoil generated due to excavation works; 3. Volume of building or any structure to be constructed/demolished; 4. Disposal of spoil and transport from site; and 5. All equipment / diesel engines to be operated on site. **Operational Phase:** Qualitative air quality impact assessment was also conducted to assess the potential impact due to fugitive emission from vehicle exhaust because of increase traffic to the proposed development during operational phase.	Qualitative assessment for both construction and operational phases.
Airborne Noise	**Construction Phase:** Based on the Singapore standard SS 602:2014 "Code of Practice (old CP49) for Noise Control on Construction and Demolition Sites"; and BSI British Standards BS5228-1:2009 Code of practice for noise and vibration control on construction and open sites (for sound power levels of construction equipment). Based on the information received on the different construction phases, a quantitative noise modelling using Sound PLAN was conducted, followed by recommendation of mitigation measures (if necessary). Noise levels from all the phases of construction were studied and one representative worst-case scenario was modelled to obtain impacts at the	Quantitative Assessment - Noise levels will be reported in decibels (dB), at the nearest sensitive receptors. The results will be presented graphically – example as shown below. 

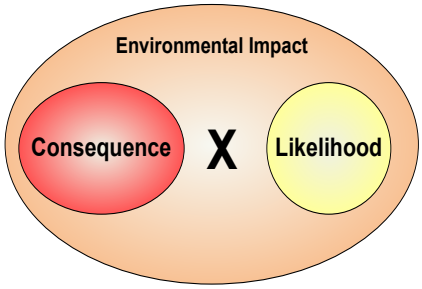
Environmental Parameter	Proposed Methodology for Impact Prediction	Output Type
	sensitive receptors. It is understood that the mitigation proposed for this worst phase encompassed impacts from all construction activities of the development of the Study Area. Unmitigated and Residual noise impacts at the nearest sensitive receptors were given both numerically and graphically, to represent the propagation of noise from project construction site. The noise requires the following input information for modelling (to be detailed and complete): 1. Noise Sensitive (Affected) Receptors surrounding the Study Area (existing and future receptors); 2. Construction activities at the Study Area, along with their equipment information and activity schedule; 3. Topographical contours of study area; 4. Specifications of noise generating equipment and operating hours for each noisy equipment (for all phases of construction); and 5. Ground absorption data. **Operational phase:** Qualitative methods were applied to assess airborne noise impacts of the project operational phase.	 Qualitative assessment of operational phase impacts
Ground-borne Vibration	**Construction Phase:** The construction schedule was reviewed to identify the construction activity that will cause the highest ground-borne vibration level – piling. Ground-borne vibration predictions were carried out using the empirical relationships defined in British Standard BS 5228-2:2009+A1:2014. If required, these relationships were supplemented by case history data in BS 5228-2:2009+A1:2014 plus AECOM database of source and propagation data. **Operational Phase:** Qualitative methods were applied to assess ground-borne vibration impacts of the project operational phase.	**Construction Phase:** Empirical relationships provided for piling activities (construction works that will produce the highest vibration levels throughout the construction period), together with a range of probabilities of exceedance for categorised ground types. If construction activities are not included in the BS 5228-2:2009+A1:2014 empirical relationships, then alternative data will be used. This will comprise either case history data from BS 5228-2:2009+A1:2014 or from AECOM's database. **Operational Phase:** During operational phase, the increase in traffic flow from land use transportation will likely be the main source of ground-borne vibration. A qualitative assessment of operational phase impacts were conducted.
Hydrology	Qualitative and analytical methods were applied to assess hydrological impacts of the development construction phase.	Hydrological impact assessment helped to understand the impact of construction activities as well as potential land use changes to hydrological conditions of the site, such as the increase in peak flow

Environmental Parameter	Proposed Methodology for Impact Prediction	Output Type
		discharge or changes in stream alignment of the site.
Water Quality	Qualitative assessment of impacts on the water quality of impacted waterbodies. Water quality parameters of the collected samples were compared with relevant water screening criteria.	Water quality impact assessment helped to qualitatively identify and evaluate potential impact of construction activities to the existing waterbodies within the site or surrounding the site. Mitigation measures will be proposed to mitigate negative the identified impact.
Soil and Groundwater	Groundwater levels were interpreted using software (e.g., Surfer) to model the groundwater flow direction. Soil lithology (using data from the 3 m boreholes) was interpreted by developing cross sections. Laboratory analytical results from the soil and groundwater samples were compared to international standards such as the Soil Remediation Circular (Dutch Standards) and Australian and New Zealand Guidelines for Fresh and Marine Water to determine potential impacts to downstream waterbodies (if any).	Groundwater flow direction was determined through groundwater contours generated by Surfer using the Kriging. method. An example of an output is shown below:  Cross-sections of lithology were obtained from soil encountered through boreholes. An example of the output is shown below: 
Biodiversity	Qualitative assessment to evaluate the impacts of construction activities on flora and fauna within the Study Area, including floral communities, fauna species and habitats. Identification of key ecological features or high conservation areas in the Study Area based on both flora and fauna survey results.	Key sensitive receptors in terms of ecology and biodiversity aspects of the Study Area was established from the pertinent characteristics identified from the environmental baseline. Mitigation measures were recommended to minimise direct and indirect impacts on flora and fauna (in the local and national context) during construction stage. Alternative options to protect conservation value of the Study Area was provided where relevant. This may require discussion with construction engineers and planners.

6.4.2 Impact Evaluation

Impacts were evaluated based on their significance, which is a measure of the weight that should be given to each impact in decision making and if it warrants impact management. It was assessed using

the following two factors in the Impact Significance Assessment Matrix (refer to **Table 6-6**) as detailed below and in the following sections:



- **Impact Consequence**: The consequence of an impact is a function of a range of considerations including impact spread, impact duration, impact intensity and nature, legal and guideline compliance (**Section 6.4.2.1**);
- **Likelihood of Occurrence:** The likelihood of the impact occurring during the project construction and operational periods, which takes into account the probability of the event happening as well as duration of the event (**Section 6.4.2.2**).

6.4.2.1 Impact Consequence

In evaluating the consequence of environmental impacts, the following aspects were taken into consideration:

- **Receptor Sensitivity:** Categorises receptors according to their susceptibility to adverse impacts from the construction and operational phases of the development of the Study Area (refer to **Table 6-1** and **Table 6-2** for the 13 characteristics that influence the ecological value of an ecological feature).
- **Impact Intensity:** defines the magnitude of the impact and the status of the impact in relation to regulations (e.g. discharge limits), standards (e.g. environmental quality criteria) and guidelines. The criteria presented in Table 6-5 will be used to categorise the impact intensity.

Table 6-5: Criteria Categorising the Impact Intensity for each Environmental Parameter

Environmental Parameters	Impact Intensity			
	Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
Air Quality (Construction)[1]	-	For Earthworks: • Total site area <2,500 m^2 • Soil type with large grain size (e.g. sand) • <5 heavy earth moving vehicles active at any one time • Formation of bunds <4 m in height • Total material moved <20,000t or • Earthworks during wetter months.	For Earthworks: • Total site area 2,500 m^3 – 10,000 m^3 • Moderately dusty soil type (e.g. silt) • 5-10 heavy earth moving vehicles active at any one time • Formation of bunds 4 m - 8 m in height or • Total material moved 20,000-100,000t.	For Earthworks: • Total site area >10,000 m^2 • potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size) • >10 heavy earth moving vehicles active at any one time • Formation of bunds >8 m in height or • Total material moved >100,000t.
		For Construction: • Total building volume <25,000 m^3 or • Construction material with low potential for dust release (e.g. metal cladding or timber).	For Construction: • Total building volume 25,000 – 100,000 m^3 • Potentially dusty construction material (e.g. concrete) or • On-site concrete batching.	For Construction: • Total building volume >100,000 m^3 • On-site concrete batching or • Sandblasting.

Environmental Parameters	Impact Intensity			
	Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
		For Demolition: • Total building volume <20,000 m^3 or • Construction material with low potential for dust release (e.g. metal cladding or timber), or • Demolition activities <10 m above ground, or • Demolition during wetter months.	For Demolition: • Total building volume 20,000 m^3 – 50,000 m^3 or • Potentially dusty construction material or • Demolition activities 10-20 m above ground level.	For Demolition: • Total building volume >50,000 m^3, or • Potentially dusty construction material (e.g. concrete) or • On-site crushing and screening or • Demolition activities >20 m above ground level
		For Trackout: • <10 HDV[2] outward movements in any one day • Surface material with low potential for dust release or • Unpaved road length <50 m.	For Trackout: • 10-50 HDV[2] outward movements in any one day • Moderately dusty surface material (e.g. high clay content) or • Unpaved road length 50-100 m.	For Trackout: • >50 HDV[2] outward movements in any one day • Potentially dusty surface material (e.g. high clay content) or • Unpaved road length >100 m.
Air Quality (Operational)	No increase in air quality levels in the vicinity of proposed development	Small scale increase in air quality levels in the vicinity of proposed development	Medium scale increase in air quality levels in the vicinity of proposed development	Large scale increase in air quality levels in the vicinity of proposed development
Airborne Noise (Construction and Operation)	The predicted noise levels are within the regulatory noise limits. No detectable change to flora, fauna and habitats.	The exceedance of values compared to regulatory noise limits is within 0-3 dB (A). Potential impacts last a short duration, are reversible and/or of a small magnitude for species with low auditory sensitivity level.	The exceedance of values compared to regulatory noise limits is 3-6 dB (A). Potential impacts last for a moderate duration, are reversible with significant input and compensatory measures, and/or of a moderate magnitude for species with auditory sensitivity level.	The exceedance of values compared to regulatory noise limits is greater than 6 dB (A). Potential impacts last for a long time, are are non-reversible, and/or of a significant magnitude for species with high auditory sensitivity level.
Ground-borne Vibration[3] (Construction and Operation)	Human & Ecological Effects: vibration levels that cannot be perceived (<0.3mm/s PPV).	Human & Ecological Effects: vibration levels that are considered perceptible (0.3-1mm/s PPV).	Human & Ecological Effects: vibration levels that are considered acceptable if people have appropriate notice and warning (1-10mm/s PPV).	Human & Ecological Effects: vibration levels that are unacceptable for any more than a very brief exposure (>10mm/s PPV).
Hydrology	Very minor change to existing hydrology and flow.	Small scale localised changes to existing hydrology or flow.	Medium scale changes to existing hydrology or peak flow.	Major changes to existing hydrology or peak flow.
Water Quality	No contamination; or	Small scale localised contamination likely to be within regulatory limits.	Medium scale contamination likely to just exceed regulatory limits.	Large scale contamination highly likely to exceed regulatory limits.

Environmental Parameters	Impact Intensity			
	Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
	Likely to be well within regulatory limits.			
Soil and Groundwater	Sensitive groundwater (i.e. used for irrigation or drinking water, or supports ecosystems of biodiversity conservation significance).	Groundwater which may be extracted for industrial purposes but not used for irrigation or drinking water Groundwater partially supporting ecosystems of biodiversity conservation significance.	Not sensitive groundwater (i.e. not extracted for any purposes or does not support any ecosystems of biodiversity conservation significance.	Sensitive groundwater (i.e. used for irrigation or drinking water, or supports ecosystems of biodiversity conservation significance).
Biodiversity	No detectable change to flora, fauna and habitats.	Small temporal and spatial (localised) scale changes to flora, fauna and habitats, with no impact to species of conservation significance	Medium scale and reversible changes to flora, fauna and habitats, and limited impact to species of conservation significance.	Large scale changes which are irreversible to flora, fauna and habitats, and/or broad impact to species of conservation significance.
Landscape and visual amenity	No discernible change in any component	Virtually imperceptible change in landscape receptors or visual amenity	Moderate change in localised areas	Notable change in landscape or visual characteristics over an extensive area ranging to a very intensive change over a more limited area
Notes: [1] This impact intensity criterion is equivalent to the Emission Magnitude as defined in IAQM's Guidance. [2] Heavy duty vehicles (HDV) defined as vehicles with a gross weight greater than 3.5 tonnes. [3] During the time that this EIS is being conducted, there are no international guidelines nor substantial literature research on vibration criteria on ecological effects, hence for the is study it is assumed that the impact intensity for human impacts will be applicable on fauna.				

For various sensitivity of the receptors, the impact intensity shall be integrated, as per the matrix presented in Table 6-6, to define the impact consequence.

Table 6-6: Impact Consequence Matrix

Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	Imperceptible	Very Low	Very Low
Low	Very Low	Low	Low
Medium	Very Low	Medium	Medium
High	Low	High	High

6.4.2.2 Likelihood of Occurrence

Likelihood was estimated on the basis of experience and/or evidence that such an outcome has previously occurred. Impacts resulting from routine/planned events (normal operations) are classified under Continuous Likelihood.

Table 6-7: Likelihood Criteria

Likelihood Criteria	Definition
Unlikely/ Remote	Would be unlikely or not expected to occur during construction and operational activities.
Less Likely/ Rare	Would less likely/ rarely occur during construction and operational activities.
Possible/ Occasional	Would possibly/ occasionally occur during construction and operational activities.
Likely/ Regular	Would likely to occur or would occur on a regular basis during construction and operational activities.
Certain/ Continuous	Would be certain to occur or would occur continuously during construction and operational activities.

6.4.2.3 Significance of Impact

The significance of each impact was determined by assessing the impact consequence against the likelihood of the impact occurring using the Impact Significance Assessment Matrix. A simple risk based matrix was used for summation of consequence and likelihood, a sample of which is shown in Table 6-8.

Table 6-8: Risk-based Matrix Determining Impact Significance

Consequence / Likelihood	Imperceptible	Very Low	Low	Medium	High
Unlikely/ Remote	Negligible	Negligible	Negligible	Negligible	Negligible
Less Likely/ Rare	Negligible	Negligible	Minor	Minor	Minor
Possible/ Occasional	Negligible	Minor	Minor	Moderate	Moderate
Likely/ Regular	Negligible	Minor	Moderate	Moderate	Major
Certain/ Continuous	Negligible	Minor	Moderate	Major	Major

Positive impacts are classified under a single category.

Impacts assessed as negligible or minor will require no additional management or mitigation measures (on the basis that the magnitude of the impact is sufficiently small, or that the receptor was of low sensitivity and/or that adequate controls were already included in the project design). Negligible and minor impacts are therefore deemed to be “Insignificant”.

Impacts evaluated as moderate or major require the adoption of management or mitigation measures. Major impacts are therefore deemed to be “Significant” and moderate impact as “Relatively Significant”. Major impacts always require further management or mitigation measures to minimize or reduce the impact to an acceptable level. An “acceptable level” is the reduction of a major impact to a moderate one after mitigation. In seeking to mitigate moderate impacts, the emphasis is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). It will not always be practical to reduce moderate impacts to minor ones in consideration of the cost-ineffectiveness of such an approach (due to the diminishing return of a reduction of impact versus cost).

6.5 Mitigation, Monitoring and Management

Where the implementation of minimum controls was insufficient to alleviate any significant environmental construction impacts (moderate to major impacts), project-specific final mitigation measures, in consultation with SDC, were proposed.

Where applicable and practical, engineering control measures were accompanied by specifications (product brochures), estimated cost and source of supply. In addition, mitigation measures at receptors' end were also recommended on a case by case basis.

For example, if the unmitigated construction noise levels are found exceeding the relevant criteria, practical direct mitigation measures such as the use of noise barriers, enclosures, quieter powered mechanical equipment (PME) and construction methods, etc. will be recommended. Effective dust control measures will be recommended to minimize dust emission from the site, where necessary.

Mitigation measures were proposed in accordance with the following principles with their hierarchies reflected in Figure 6-1:

- **Elimination/ Avoidance** - Where changes to the project design and construction methodology can be made to eliminate or avoid an identified impact (e.g. optimisation or reduction of construction footprint, shift or elimination of construction site in critical areas, exclusion of noisy construction phases to be conducted at evening/night period, etc.). If a full elimination is not possible, the next level of mitigation is to minimize the identified impact;
- **Minimisation (Substitution)** - Where changes to the project design and construction methodology cannot affect impact elimination or avoidance, use of alternative construction methodology or any enhancement measures can be adopted to minimize for identified impacts. For example, tunnel boring instead of open cut and cover, substitution of the noisier hammer piler with alternative silent piler to reduce impacts to residents, etc.;
- **Minimisation (Engineering controls)** - Where changes to the project design and construction cannot affect impact avoidance and impact minimization via substitution, engineering controls can be adopted to further reduce for identified impacts (and possibly an enhancement measure). For example, use of noise barriers to reduce noise, use of equipment enclosures wherever necessary, application of silt curtains to curb silt flow into drains, etc.;
- **Minimisation (Administrative controls)** - Where applicable, enhanced mitigation can be achieved by applying administrative controls on top of engineering controls. These controls do not remove environmental hazards, but limit or prevent receptor's exposure to hazards, such as repeated wetting of unpaved roads for dust suppression, proper scheduling of noisier construction activities, reducing work on weekends, etc.;
- **Remedy/ Repair/ Restore/ Enhance** – Where residual impacts need to be further reduced, measures should be taken to remedy/ restore/ repair/ enhance the situation after the impact, e.g. replanting of trees and shrubs in appropriate locations on the impacted site to restore part of the habitat after construction; and
- **Compensation/ Offset** - Where possible, measures should be taken to compensate/ offset the impacts in a different part of the development, wherever technically and financially feasible, e.g. rare shrubs or trees that are important to birds and mammals to be planted elsewhere in consultation with NParks, etc.

The above mitigation approach is in line with the NParks Biodiversity Impact Assessment (BIA) 2020 Guidelines and the Hong Kong EIA Ordinance Annex 16 (2019) to be adopted for the Biodiversity Impact Assessment of the EIA.

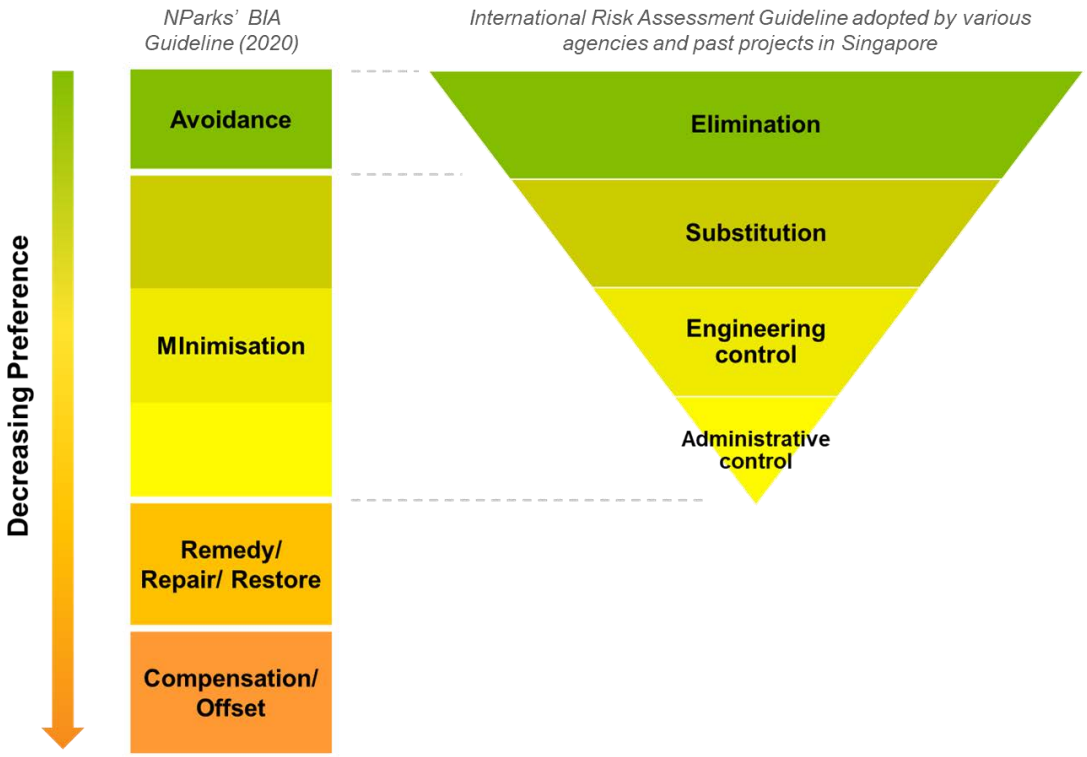


Figure 6-1: Mitigation Hierarchy

Construction Stage EMMP were formulated specifying mitigation measures, monitoring scope, methodology and location, and triggers to report and escalate the irregularities in the baseline conditions at construction stage. An EMMP was prepared for to minimise environmental impacts of the construction phase associated with the project that were assessed in the EIA report, namely biodiversity, air quality, airborne noise, and surface water quality. The EMMP details the recommended mitigation measures and assess their effectiveness.

The proposed mitigation measures and EMMP in the EIA shall be applicable and implemented where appropriate with due diligence during the construction phase inclusive of worksites outside the defined study areas, to reduce any work-related impacts to the environment.

7.0 Air Quality

This section presents the air quality impact assessment for the construction and operational phases of the development of this Study Area. The key steps for conducting the air quality impact assessment are as follows:

- Review baseline monitoring data to evaluate the existing air quality in the Study Area;
- Identify and classify sensitivity of the area around the construction footprint;
- Conduct a dust impact assessment to qualitatively assess air quality impacts during construction and operation of the development of this Study Area;
- Evaluate qualitative air quality impacts against nominated assessment criteria;
- Specify mitigation measures to be implemented; and
- Determine the overall significance of the residual air quality impacts after implementation of mitigation measures.

7.1 Air Quality Baseline Monitoring

Typically, baseline monitoring includes site reconnaissance survey, proposal and mutual agreement of baseline monitoring scope and locations in scoping and inception stage. Site reconnaissance was conducted to understand the project environment, nearest air sensitive receptors, and to determine the most representative baseline monitoring location.

Secondary data, such as NEA's long-term air quality data, hourly Pollution Standard Index (PSI), and meteorological data observed in the vicinity of the Study Area were collected from publicly available sources. Primary data collection in the form of air quality baseline monitoring was then conducted within the assessment area in order to establish the baseline air quality levels.

Primary monitoring data included monitoring equipment to be setup at the site for at least a week; while simultaneous data recorded was from nearest NEA's monitoring station from web resources. The observed site data and NEA's monitored data were compared to provide confidence in the collected data.

7.1.1 Baseline Monitoring Personnel

The assessment and site surveys were conducted by the following personnel:

- Ms. Jagriti Dawra, AECOM (EIA Specialist)
- Mr. Magaesh Naidu, AECOM (Air Quality Specialist)
- Mr. Hanzel Lalitan, AECOM (Air Quality Consultant)
- Mr. Kyaw Min Thu, ALS Technichem (S) Pte Ltd
- Mr. Tang Tiang Gan, ALS Technichem (S) Pte Ltd
- Mr. Yong Jia Wen, ALS Technichem (S) Pte Ltd
- Mr. Pang Wei Zheng, ALS Technichem (S) Pte Ltd

Site reconnaissance was conducted in 30th January 2019. Subsequently, the primary baseline air quality data collection was conducted from 22nd to 30th April 2019.

7.1.2 Baseline Environment

The Study Area is currently a mix of cemetery, park land, vegetated areas, institutional recreational space and facilities, and the ongoing Mount Pleasant MRT construction area. The Study Area is sparsely inhabited, with little human activity and mainly vegetation. Intermittent vehicular traffic was observed along Mount Pleasant Road, from the PIE slip road to Denham Road.

7.1.3 Baseline Monitoring Methodology

Baseline air quality monitoring includes monitoring of the baseline ambient air quality in the Study Area. The project design phase was still in the early master planning stage. Hence, extremely limited information was available regarding the land parcels, usage, footprints, equipment on site during construction, etc. Therefore, the impacts were only qualitatively assessed at this stage, and no quantification conducted as part of the air quality impact assessment.

During construction stage, criteria pollutants generally measured as part of ambient air monitoring, such as CO, NO_2, SO_2, PM_{10} and $PM_{2.5}$ are expected to be generated from the vehicular exhausts, generators and non-road vehicles exhausts, etc. However, particulate matter (PM_{10} and $PM_{2.5}$) or dust is expected to be dominant during the Project's construction stage given that there is substantial slope cutting and elevation balance required in this hilly terrain. Since these are the major pollutants that are likely to have more significant impact on the ambient air quality as a result of the development of the infrastructure in this area, PM_{10} and $PM_{2.5}$ were proposed to be monitored during baseline as well as once again by contractor to establish a pre-construction baseline as mentioned in Section 14.9. These pollutants (i.e. PM_{10} and $PM_{2.5}$) have been proposed and accepted by agencies in inception report before proceeding to the actual baseline and assessment.

The purpose of the baseline monitoring is to understand what the natural conditions of these air quality parameters are, so that in the event that a repeat monitoring event is to be conducted during the construction and/or operational phases of the development in this Study Area, this monitoring data can be used as a reference of the existing baseline prior to any disturbance in the Study Area.

Air quality has both short-term and long-term targets which vary from a 1 hr target to an annual target. Owing to the timeframe of the project, annual monitoring cannot be accommodated in this study; however, a short-term monitoring baseline was established. With varying seasonal fluctuations, it is understandable that wind flow and direction will vary throughout the year, and hence short-term baselines shall also fluctuate. However, a correlation, be it direct or indicative between the site baseline and NEA's central area monitoring data, will be useful for future monitoring as it provides a reliable context for any future comparisons based on the relation between the two datasets. In addition, this baseline will also help in comparing the predicted impacts from the construction and operational phases and then using this baseline as a reference, to help recommend appropriate mitigation measures such that the impacts from these two phases are as low as reasonably practicable (ALARP).

7.1.3.1 Primary Data Collection (Survey & Sampling)

Air quality monitoring services were provided by ALS Technichem (S) Pte. (ALS). Air quality monitoring was conducted for one week (22nd to 30th April 2019) to collect air quality samples for the following air quality parameters:

- Particulate matter smaller than 2.5µm, $PM_{2.5}$; and
- Particulate matter smaller than 10 µm, PM_{10}.

Monitoring was conducted within the potential future construction footprint in order to establish a baseline for existing air quality levels. The Study Area is quite uniform in its use currently, consisting largely of forested land. The disturbed area is the OPA where construction is ongoing. Temporary work activities such as construction are not a true representative of a stable baseline environment; hence it has been excluded from the area of assessment for the baseline environment. The forested, undulating land was therefore considered to be the natural baseline environment and is contained within one large airshed owing to its uniform land use; as such, one monitoring location was identified to represent the site. The monitoring location was chosen so that the equipment was more than 1 metre from any buildings or structures, and not shaded by structures or trees. This was necessary to ensure adequate airflow. The location was near 163 Mount Pleasant Road, adjacent to the main road, as indicated in **Figure 7-1**. The equipment used for ambient air monitoring is presented below:

- Particulate matter, PM_{10} – TSI Environmental DustTrak Monitoring System; and
- Particulate matter, $PM_{2.5}$ – TSI Environmental DustTrak Monitoring System.

Concentrations of PM_{10} and $PM_{2.5}$ were measured by the light scattering laser photometer principle using an Environmental DustTrak Monitoring System coupled with a heated inlet for 5-minute interval data

logging over an 8-day continuous sampling period. The photometer uses an ellipsoidal reflector and simple optical components to collect the laser-scattered light and to focus it onto a photodiode array. The mass and particle size were determined by detecting how the particles scatter light. Usually this monitoring is carried out for 7-day period; however, the equipment faltered for one day, hence its monitoring day was extended by a day.

Equipment setup is presented in **Figure 7-2**. The indicative air quality monitor was installed at 1.8m from ground level in the breathing zone. For further details of the Air Quality Monitoring, please refer to **Appendix A**.

Legend

- Study Area
- Air Quality Baseline Monitoring Location
- Mt Pleasant MRT Station (U/C)
- Thomson-East Coast Line
- Kopi Sua Cemetery
- Buildings Planned to be Demolished

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	HHL	Final Report	NHT	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title : CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title : AIR QUALITY BASELINE MONITORING LOCATION

Designed	Checked	Approved
LIA	NHT	JAG
	Drawn: HHL	Date: JAN 2021

Figure No. : 7 - 1 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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Figure 7-2: Air Quality Monitoring Setup

7.1.3.2 Secondary Data Collection (Review of Background Data)

Secondary sources of data were collected from NEA's long-term air quality data, hourly Pollution Standard Index and meteorological data of the Study Area**.**

7.1.3.2.1 NEA Long Term Ambient Air Quality

NEA carries out routine monitoring of ambient air quality through the Telemetric Air Quality Monitoring and Management System (TAQMMS). This system comprises 22 monitoring stations (refer to **Figure 7-3**) which are located around Singapore and linked into a Central Control System (CCS). The air quality monitoring stations are distributed amongst urban, industrial, suburban, coastal, and roadside locations. General NEA ambient air monitoring results for Singapore over the period 2015 – 2019 have been presented and compared with Singapore Long Term Ambient Air Quality Targets in **Section 7.1.4.2.1**. Air pollution control in Singapore is governed by legislation listed in **Section 4.0**.

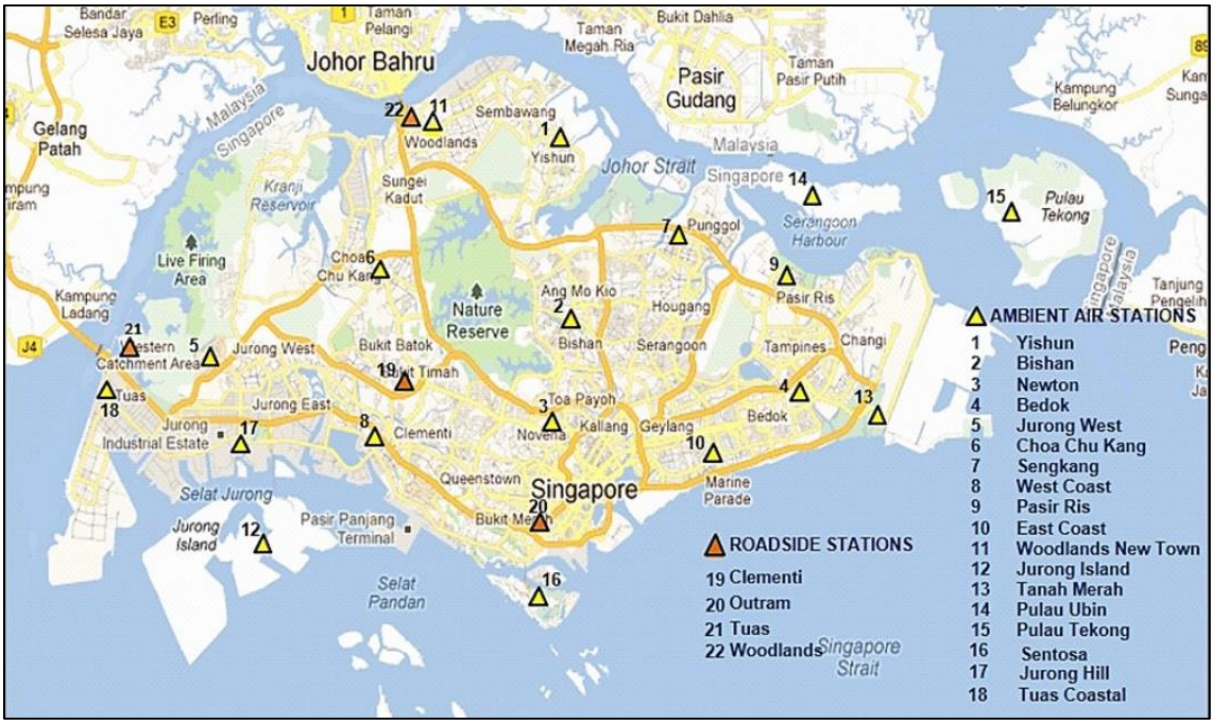

Figure 7-3: NEA Ambient Air Quality Monitoring Stations in Singapore[14]

7.1.3.2.2 Hourly Pollution Standards Index (PSI)

PSI (Pollutant Standards Index) is an index to provide accurate and easily understandable information about daily levels of air quality. The concentration levels of particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and carbon monoxide (CO) monitored by air monitoring locations located in different parts of Singapore are used to determine the PSI. The PSI value gives an indication of the air quality as shown in Table 7-1. 24-hr PM2.5 and PM10 PSI readings were available on data.gov.sg for the Central Region of Singapore during the primary data collection period, which was on 22nd April 2019 to 30th April 2019, and these are presented and discussed in **Section 7.1.4.2.2**.

Table 7-1: General Air Quality Descriptor Based on PSI value

PSI Value	Air Quality Descriptor
0 – 50	Good
51 – 100	Moderate
101 – 200	Unhealthy
201 – 300	Very unhealthy
Above 300	Hazardous

Source: https://www.nea.gov.sg/our-services/pollution-control/air-pollution/faqs

7.1.3.2.3 Other Parameters (Rainfall, Temperature, Wind Speed)

Rainfall, temperature, and wind speed can significantly affect the distribution of pollutants. MacRitchie Reservoir is the nearest monitoring station to the Study Area, located approximately 1km south of the Study Area. However, MacRitchie Reservoir station does not monitor mean temperature and mean wind speed. Hence, temperature and wind speed data were extracted from the nearest monitoring station Newton.

[14] Extracted from NEA Environmental Protection Division Annual Report (2018)

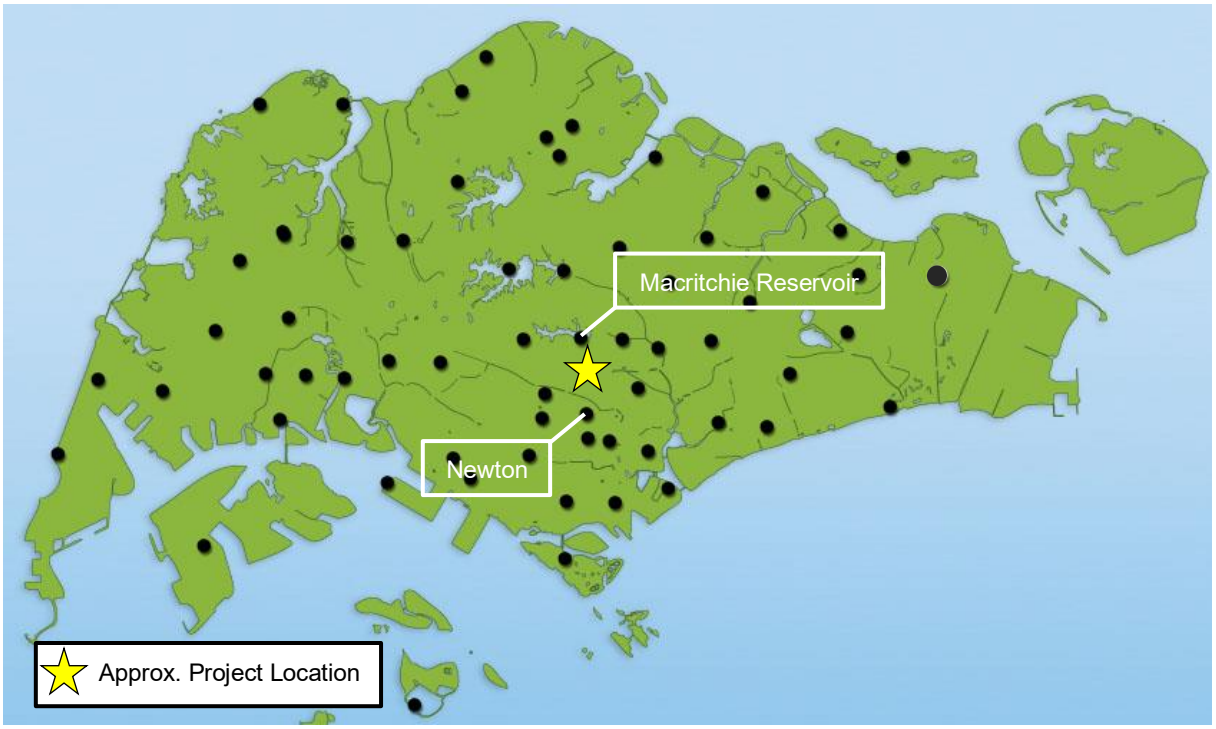

Figure 7-4: NEA Weather Monitoring Stations in Singapore

7.1.4 Baseline Monitoring Results

7.1.4.1 Primary Data Collection (Survey & Sampling)

Eight (8) days of continuous ambient air quality monitoring was conducted at the location mentioned above to determine the pollutant concentrations from existing background pollutant sources. The monitoring results for each pollutant at all monitoring locations were summarized in Table 7-2 and Figure 7-5 below, and compared with the Singapore Ambient Air Quality Long Term Targets. It can be observed from Table 7-2 and Figure 7-5 that all pollutant concentrations were within the Singapore Ambient Air Quality Long Term Targets.

Table 7-2: Summary of Baseline Monitoring

Day	PM_{10} Concentration, $\mu g/m^3$	$PM_{2.5}$ Concentration, $\mu g/m^3$
22nd to 23rd April 2019	23.8	17.6
23rd to 24th April 2019	19.5[1]	12.5[1]
24th to 25th April 2019	26.2	18.0
25th to 26th April 2019	28.9	19.7
26th to 27th April 2019	15.5	9.40
27th to 28th April 2019	13.6	7.71
28th to 29th April 2019	11.4[2]	9.65[2]
29th to 30th April 2019	15.3	12.6
Singapore Ambient Air Quality Long Term Targets	**50**	**25**

Notes:

[1] Denotes equipment stopped from 3am to 11am, presented average is for 16 hours only.

[2] Denotes equipment stopped from 2am to 8am, presented average is for 17 hours only.

Based on the USEPA Guidance, for 24-hour sampling, at least 18 hours of data is required to be representative. In case the data collected is less than 18 hours, the guidance has provided ways on interpreting the collected data.

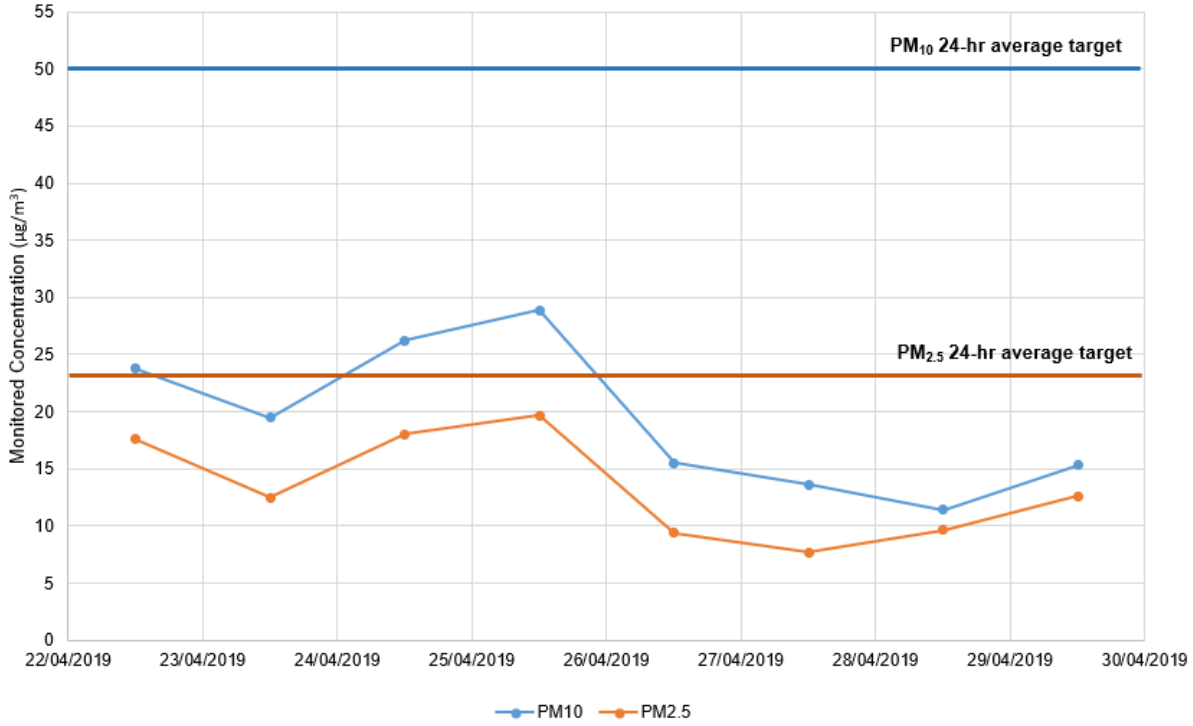

Figure 7-5: Air Quality Baseline Monitoring Results

As presented in Table 7-2 and Figure 7-5, all pollutant concentrations are within the Singapore Ambient Air Quality Long Term Targets. The results were in line with the fact that the Study Area is sparsely inhabited, with little human activity and mainly vegetation. Small concentrations of PM_{10} and $PM_{2.5}$ monitored might be attributed to intermittent vehicular emission as the air quality monitor was located at the roadside.

The results were consistent with 24-hr PM_{10} and $PM_{2.5}$ readings obtained from NEA monitored concentrations during the monitoring period for Central Singapore, which suggested that the Singapore Ambient Air Quality Long Term Target was met in Central Singapore during the primary data baseline collection period. However, as default we would recommend the construction contractor to conduct one of the monsoon periods monitoring as well for comprehensiveness of the establishment of baseline, should NEA so require as transition month has already been monitored.

7.1.4.2 Secondary Data Collection (Review of Background Data)

7.1.4.2.1 NEA Long Term Ambient Air Quality

Table 7-3 provides the general NEA ambient air monitoring results for Singapore over the period 2015 – 2019 and compares them with the Singapore Long Term Ambient Air Quality Targets. The Singapore Long Term Air Quality Targets have been adopted in this report and are generally more stringent than the USEPA National Ambient Air Quality Standards (NAAQS).

It can be observed from Table 7-3 that the NEA monitoring results for background particulate matter less than 10 µm (PM_{10}), particulate matter less than 2.5 µm ($PM_{2.5}$), and ozone (O_3) consistently exceeded the Singapore Long Term Air Quality Targets over the period 2015 - 2019. Carbon monoxide (CO) and nitrogen dioxide (NO_2) were below the Singapore Ambient Air Quality Long Term Targets between 2015 and 2019. The elevated PM_{10} and $PM_{2.5}$ concentrations in Singapore were partly attributable to the intermittent haze periods resulting from forest fires in neighbouring countries, although other significant contributors to the background levels may also be domestic emissions from industries, shipping and motor vehicles.

Table 7-3: Summary of NEA Air Monitoring Results Compared with Singapore Air Quality Targets

Pollutants	Averaging Period	2015 results ($\mu g/m^3$)	2016 results ($\mu g/m^3$)	2017 results ($\mu g/m^3$)	2018 results ($\mu g/m^3$)	2019 results ($\mu g/m^3$)	Average results 2015 – 2019 ($\mu g/m^3$)	Singapore Ambient Air Quality Long Term Targets ($\mu g/m^3$)
PM_{10}	99th %ile of 24-Hour Averages	**186**	**61**	**57**	**59**	**90**	**90.6**	50
	Annual Mean	**37**	**26**	**25**	**29**	**30**	**29.4**	20
$PM_{2.5}$	99th %ile of 24-Hour Averages	**145**	**40**	**34**	**32**	**62**	**62.6**	25
	Annual Mean	**24**	**15**	**14**	**15**	**16**	**16.8**	10
CO	Maximum 1-Hour Average	3,500	2,700	2,300	2,500	2,300	2,700	30,000
	Maximum 8-Hour Average	3,300	2,200	1,700	2,000	1,700	2,200	10,000
NO_2	Maximum 1-Hour Average	99	123	158	147	156	136.6	200
	Annual Mean	22	26	25	26	23	24.4	40
SO_2	24-Hour Average	**75**	**61**	**59**	**65**	**57**	**63.4**	50
	Annual Mean	12	13	12	9	8	10.8	15
O_3	8-Hour Average	**152**	**115**	**191**	**150**	**125**	**146.6**	100

Note: Values in **Bold** exceed the Singapore Ambient Air Quality Long Term Targets

Source: https://www.singstat.gov.sg/-/media/files/publications/reference/yearbook_2019/yos2019.pdf

7.1.4.2.2 Hourly Pollution Standard Index (PSI) Readings

According to NEA's website[15], PM_{10} and $PM_{2.5}$ data are subsumed into PSI. **Figure 7-6** below shows the variation of hourly historical PSI readings in the Central Region of Singapore during the primary data collection period, which was on 22nd April 2019 to 30th April 2019. The hourly PSI readings recorded over these days ranged from 36 to 62. The PSI readings during this period were considered Good to Moderate.

[15] http://www.haze.gov.sg/haze-updates/historical-psi-readings

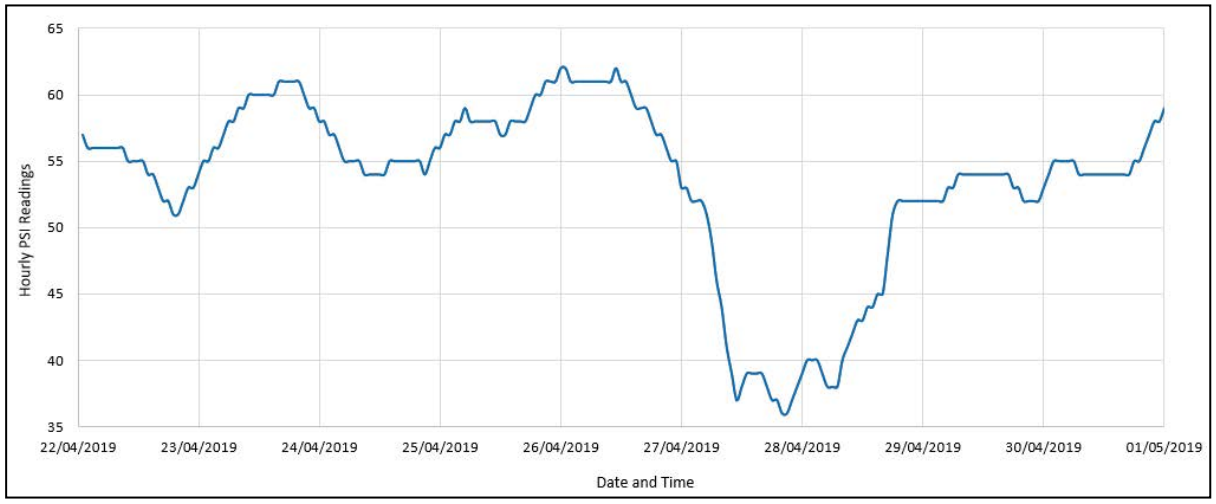

Figure 7-6: Hourly PSI Reading of Central Singapore

A review was also conducted for 24-hr $PM_{2.5}$ and PM_{10} readings available on data.gov.sg[16] for Central Singapore during the monitoring period (22nd – 30th April 2019). It should be noted that there is no data available on monitored concentration by NEA from 9 am on 23rd April 2019 – 8 am on 24th April 2019. **Figure 7-7** and **Figure 7-8** show the variation of PM_{10} and $PM_{2.5}$ concentrations recorded by the NEA during the primary baseline data collection period. As observed from the figures, both 24-hr PM_{10} and $PM_{2.5}$ concentrations were below the target throughout the monitoring period.

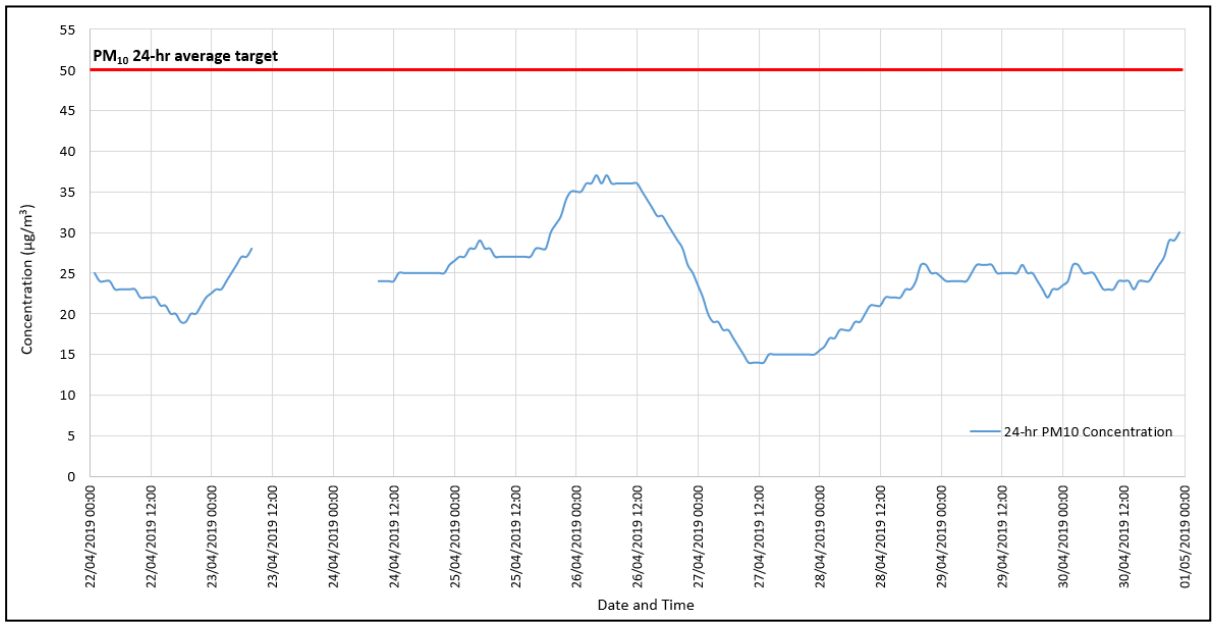

Figure 7-7: 24-hr PM10 Concentrations Reading of Central Singapore

[16] https://data.gov.sg/dataset/psi?view_id=496c77eb-6add-4e9b-9883-17864cedfe9f&resource_id=82776919-0de1-4faf-bd9e-9c997f9a729d

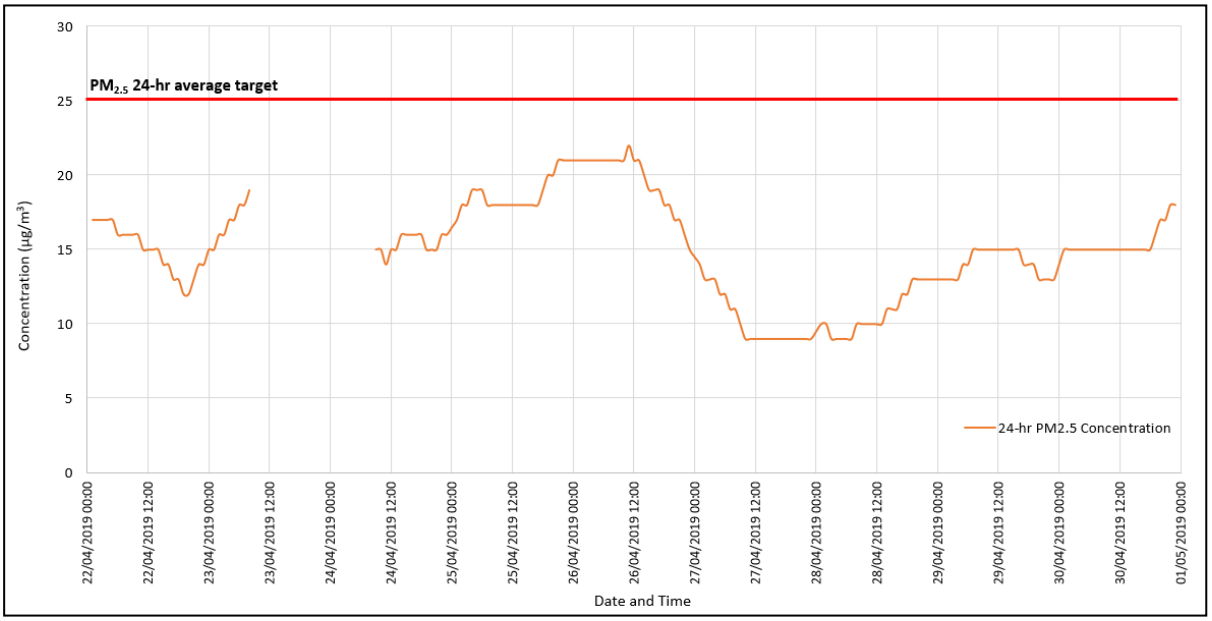

Figure 7-8: 24-hr PM2.5 Concentrations Reading of Central Singapore

7.1.4.2.3 Other Parameters (Rainfall, Temperature, Wind Speed)

Figure 7-9, **Figure 7-10,** and **Figure 7-11** below present the trend of daily total rainfall observed at MacRitchie Reservoir, and mean temperature, and mean wind speed observed at Newton monitoring station from June 2014 to May 2019[17].

[17] http://www.weather.gov.sg/climate-historical-daily

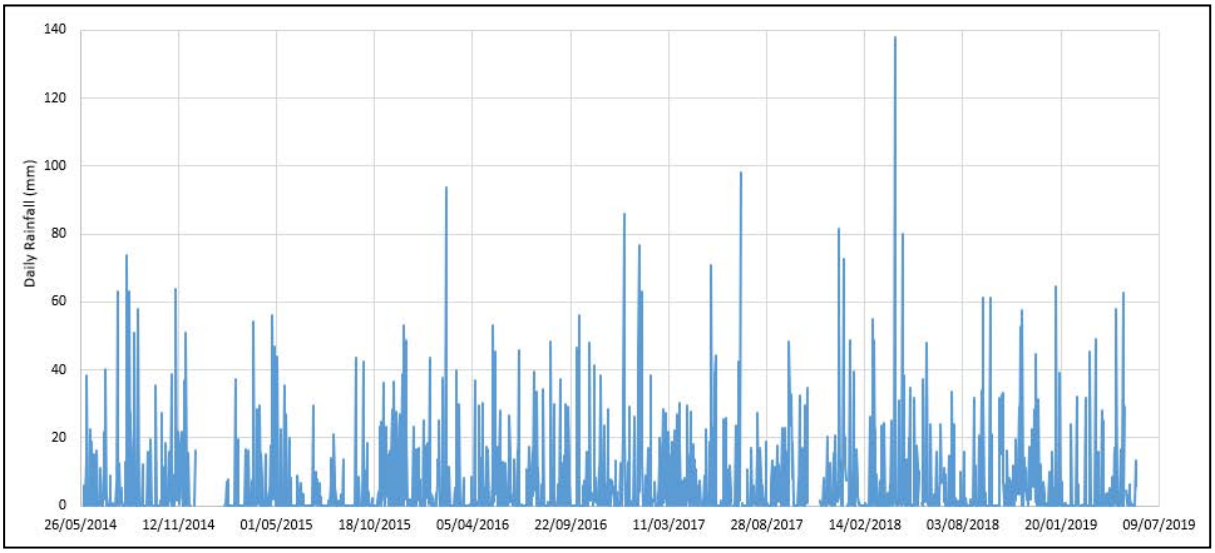

Figure 7-9: Daily Rainfall Monitored at MacRitchie Reservoir Monitoring Station

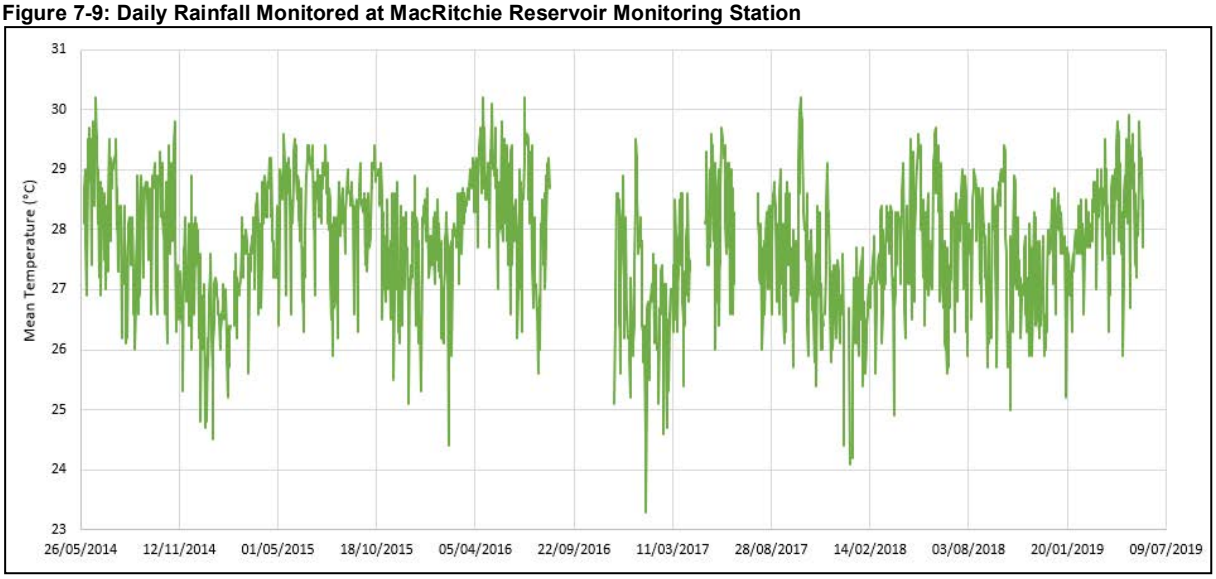

Figure 7-10: Daily Mean Temperature Monitored at Newton Monitoring Station

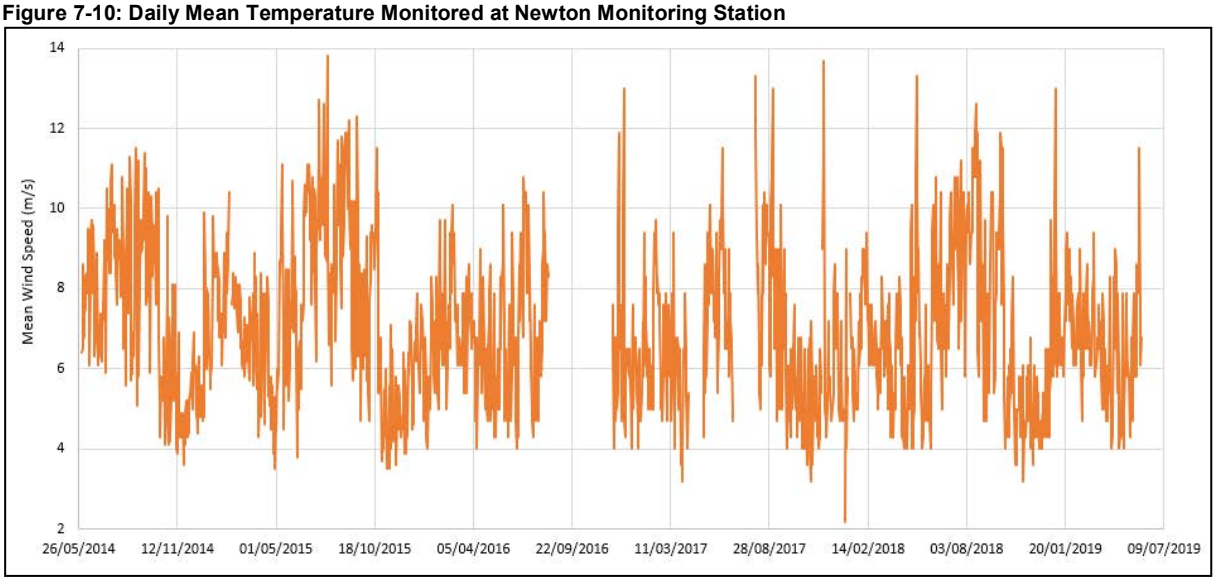

Figure 7-11: Daily Wind Speed Monitored at Newton Monitoring Station

7.2 Air Quality Impact Assessment

The purpose of the air quality impact assessment for construction and operational phases was to identify the area impacted by the construction and operation, assess and evaluate the significance of unmitigated impacts, and thereby prescribe adequate mitigation measures to reduce the potential for adverse environmental impacts. The specific activities assessed in the air quality impact assessment for construction phase are as follows:

- Earthworks (including loading and unloading of spoil): This involves excavating material, haulage, tipping and stockpiling. This may also involve soil-stripping, ground levelling, and landscaping using excavators, cranes, cherry pickers etc.;
- Construction: Any type of construction activity involving new structures on construction footprint involving PME;
- Trackout: The transport of dust and dirt from/to the construction/demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network. This arises when HDVs leave the construction site with dusty materials, which may then spill onto the road, and/or when HDVs transfer dust and dirt onto the road having travelled over muddy ground on site; and
- Demolition: Demolition of any building due to construction of the project, if any.

The assessment area used for the air impact assessment was different for the various activities listed above as the locations and activities affecting potential receptors varied. The assessment area is recommended as 350 m and 50 m from the construction footprint for human health impact and ecological impact respectively in accordance with IAQM guidance. Access roads are the roads until 500 m from the access point of construction footprint. During the scoping phase for this EIS, an initial screening of receptors in the assessment area was conducted in order to determine the areas which are sensitive to potential construction impacts.

For operational phase, assessment area of 250m around the proposed roads was used. This was because potential air quality impact during operational phase of the development would be vehicular emissions due to increased traffic to the proposed development.

7.2.1 Assessment Approach and Assumption

The air quality impact assessment includes evaluation of dust impacts from construction and operational activities.

7.2.1.1 Construction Phase

Dust impacts are assessed using the methodology outlined in the document entitled “Guidance on the Assessment of Dust from Demolition and Construction” which was published by the UK IAQM in 2014[18]. This methodology has been adapted to the general methodology outlined in this EIS. The following presented in this section was only used in assessing the air quality impact during construction phase.

7.2.1.1.1 Identification of Potential Sources of Air Quality Impacts

It is important to identify potential sources of air quality impact in the vicinity of the Study Area. While conducting the assessment, a typical construction machinery was assumed to be used during the construction equipment and activities, and only vehicular operation was assumed to be associated with the project. Typically, for air quality impacts, only above-ground areas are assessed. These have been detailed in **Section 7.2.2**.

7.2.1.1.2 Identification of Sensitive Receptors

Identification of Air Sensitive Receptors (ASRs) in the assessment area in the vicinity of above-ground construction footprint was subsequently undertaken. IAQM identifies an entire area around one continuous stretch of construction footprint as a category or sensitive receptor. It does not distinguish between each unit, household or block present in the area as a separate ASR but designates the whole area as same category of sensitivity based on an overall location, number, proximity and scale to the

[18] http://www.iaqm.co.uk/text/guidance/construction-dust-2014.pdf

construction activity. This approach thereby adopted a conservative principle to air quality. A further discussion on Receptor Sensitivity is presented in **Section 6.2.2**.

Sensitive areas identified as Priority 1, Priority 2, and Priority 3 for air quality during the screening process have been examined in the Impact Assessment in this EIS in order to provide a more refined classification for Receptor Sensitivity. Sensitivity of the area has been determined based on the usage, number of receptors, distance from the construction footprint, and the current context of sensitive buildings in Singapore.

7.2.1.1.3 Understanding of Baseline Air Quality

Primary and secondary data were collected to understand the baseline air quality of the Study Area. NEA's PSI data available from the nearest monitoring station was also reviewed for the Study Area. In addition, baseline air quality data was collected for representative location near the construction footprint. The baseline air quality review and data measured is discussed in **Section 7.1**.

7.2.1.1.4 Impact Intensity Definition

The impact intensity was determined by reviewing the scale of construction activities and classifying them as Low, Medium or High. The IAQM Guidance document provides example definitions for determining impact intensity for earthworks (based on construction footprint, heavy duty vehicles movement, formation of bunds, and material moved), for construction (based on total building volume, on-site concrete batching), for trackout (based on heavy duty vehicle outward movement, surface material, and unpaved road lengths), and for demolition (based on total demolition volume, construction material, on-site crushing of material, and height of demolition activity). The definition of parameters is defined in Table 6-5 in **Section 6.4.2.1**. It should be noted that in each case, not all criteria need to be met and that determination of magnitude is also based on the professional judgment of the air quality consultant. If the areas around the construction footprint are rated as High for one activity and Medium or Low for the other activities, the overall impact intensity result is classified as High for that site as those multiple activities may be occurring concurrently.

7.2.1.1.5 Classification of Overall Consequence

The dust impact assessment therefore evaluates the overall consequence prior to the implementation of mitigation. The work site has been assessed by considering both the impact intensity and the Receptor Sensitivity to obtain an overall consequence rating. Since the definition of impact intensity is different for each activity, the overall consequence for each activity is explained in matrices shown in Table 7-4 to Table 7-7. Each activity for the work site has been rated as being High, Medium, Low, or Imperceptible in terms of overall consequence based upon pre-mitigation measures.

Table 7-4: Overall Consequence of the Air Impact Analysis (Earthworks)*

Receptor Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Low	Low
Medium	Low	Medium	Medium
High	Low	Medium	High

*This is in accordance with IAQM Guidance on the assessment of dust from demolition and construction version 1.1

Table 7-5: Overall Consequence of the Air Impact Analysis (Construction)*

Receptor Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Low	Low
Medium	Low	Medium	Medium
High	Low	Medium	High

*This is in accordance with IAQM Guidance on the assessment of dust from demolition and construction version 1.1

Table 7-6: Overall Consequence of the Air Impact Analysis (Trackout)*

Receptor Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Imperceptible	Low
Medium	Low	Low	Medium
High	Low	Medium	High

*This is in accordance with IAQM Guidance on the assessment of dust from demolition and construction version 1.1

Table 7-7: Overall Consequence of the Air Impact Analysis (Demolition)*

Receptor Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Small	Imperceptible	Low	Medium
Medium	Low	Medium	Medium
High	Medium	High	High

*This is in accordance with IAQM Guidance on the assessment of dust from demolition and construction version 1.1

7.2.1.1.6 Establishing Impact Significance

Impact Significance was evaluated by considering both the overall Consequence and the Likelihood of occurrence of significant adverse impacts. The Likelihood of occurrence may be defined as unlikely, rare, occasional, regular, and continuous as per criteria listed in **Table 6-7**. Impact Significance has been evaluated in accordance with the matrix presented below in **Table 7-8**. The IAQM methodology does not differentiate between imperceptible and very low, due to the nature of air impacts as perceived by humans. In order to align the IAQM methodology with the methodology of this report, imperceptible and very low Consequences were consolidated.

Table 7-8: Air Quality Impact Significance Matrix

Consequence / Likelihood	Imperceptible / Very Low	Low	Medium	High
Unlikely / Remote	Negligible	Negligible	Negligible	Negligible
Less Likely / Rare	Negligible	Minor	Minor	Minor
Possible / Occasional	Minor	Minor	Moderate	Moderate
Likely / Regular	Minor	Moderate	Moderate	Major
Certain / Continuous	Minor	Moderate	Major	Major

7.2.1.1.7 Mitigation Measures Recommendations

Mitigation measures were proposed for implementation when the Impact Significance is predicted to be Moderate or Major. Where mitigation measures are required, specific mitigation measures have been proposed based on the level of overall Consequence (High, Medium, and Low) as per the IAQM guidance. This is the most efficient way of prescribing dust mitigation measures so that high Consequence areas have the most comprehensive mitigation measures implemented whilst avoiding unnecessary implementation of complex mitigation measures in low Consequence areas.

7.2.1.1.8 Establishing Residual Impact Significance

Following implementation of mitigation measures prescribed in the EIS at the proposed construction footprint, the residual Impact Significance was evaluated using the matrix outlined in Table 7-8. Ideally, the mitigation measures required should be specified within the conditions given for planning permission and should be stipulated in construction contracts.

7.2.1.2 Operational Phase

During operational phase, the air quality impact assessment followed the general EIS methodology presented in **Section 6.0**.

7.2.2 Identification and Classification of Sensitive Receptors

7.2.2.1 Construction Phase

Assessment areas of 350 m and 50 m were considered for the human health and ecological impacts respectively. This is consistent with the IAQM guidance. Table 7-9 below summarizes the sensitivity of each construction phase for earthworks, construction, demolition, and trackout, as per **Section 6.2.2**. Based on Table 7-9, the Sensitivity of the Area for both human health and ecological impact were determined to range from Priority 1 to Priority 2. Full list of identified sensitive receptors is presented in **Appendix B**.

Table 7-9: Receptor Sensitivity for Construction Footprint (Air Quality Impact Assessment – Construction Phase)

Activities	Sensitivity of the Area	
	Human Health Impact	Ecological Impact
Earthworks	Priority 1	Priority 1
Construction	Priority 1	Priority 1
Demolition	Priority 2	Priority 1
Trackout	Priority 1	Priority 1

7.2.2.2 Operational Phase

Potential air quality impact during operational phase of the development of in this Study Area would be vehicular emissions due to increased traffic to the proposed development. Potential human and ecological sensitive receptors which might be impacted by the increased traffic (within 250m assessment area) are presented in Table 7-10 below.

Table 7-10: Identified Air Quality Sensitive Receptors - Operational Phase

No	Receptor Name	Receptor Type	Sensitivity Classification
1	Bukit Brown Woods	Ecological Sensitive Receptor	Priority 1
2	Existing residential properties along Mount Pleasant Road	Residential	Priority 2
3	Existing residential properties along Jalan Mendaki	Residential	Priority 2
4	Existing residential properties along Gymkhana Avenue	Residential	Priority 2
5	Existing residential properties along Mount Pleasant Drive	Residential	Priority 2
6	Existing residential properties along Jalan Mashor	Residential	Priority 2
7	Existing residential properties along Merryn Road	Residential	Priority 2
8	Existing residential properties along Malcolm Road	Residential	Priority 2
9	Existing residential properties along Whitley Road	Residential	Priority 2
10	Singapore Polo Club	Commercial	Priority 3
11	Kopi Sua Cemetery	Others	Priority 3
12	Catholic Junior College	Educational	Priority 1
13	EtonHouse Pre-School (Thomson)	Educational	Priority 1
14	James Tan Veterinary Centre	Commercial	Priority 3
15	Mount Pleasant Animal Hospital	Commercial	Priority 3
16	Lee Ah Mooi Old Age Home	Nursing Home	Priority 1
17	Sky@Eleven Condominium	Residential	Priority 2
18	Saint Joseph International	Educational	Priority 1
19	MSF Building	Commercial	Priority 3
20	Future Public Housing	Residential	Priority 2
21	Future Park	Recreational	Priority 3

7.2.3 Potential Source of Impacts

Fugitive particulate emissions from construction and operational activities have the potential to result in adverse impacts on air quality and therefore, public and ecosystem health. Particulate emissions may also generate significant nuisance to receptors near the heavy use construction footprint.

7.2.3.1 Construction Phase

Table 7-11 listed potential sources of air quality impact during construction phase of the project.

Table 7-11: Potential environmental impacts during the construction stage

Potential Source of Impacts	Potential Associated Impacts
Dust generated from the construction of new structures, their modification or refurbishment.	Dust emissions could potentially result in adverse impacts on air quality, and public and ecosystem health, and may also generate significant nuisance at receptors in the vicinity of the construction footprint/ proposed access roads.
Dust generated from the demolition or removal of existing structures.	
Dust generated from earthworks processes, including soil-stripping, ground levelling, excavation and landscaping.	
Dust generated from transport of dust and dirt from the site onto public road network, where it may be deposited and resuspended by vehicles using the network.	

Demolition activity includes the demolition of a few buildings within the Study Area. Due to the unavailability of detailed information at this early stage, a worst-case assessment has been conducted by assuming that all buildings located within the Study Area to be demolished. It was also assumed that there would be no on-site crushing or screening of demolished construction material.

At this early stage, no detailed plan regarding the footprint and exact location of the proposed buildings was available, however land use plan was available. Therefore, the worst-case emission source for earthworks comprises the whole area planned for development, excluding roads and parks. This area has been referred as earthworks footprint. The earthworks activity includes some extent of soil-cutting, excavation, piling and excavation works, while the construction activity includes the construction of the proposed buildings. Given the area of the earthworks' footprint, it was assumed that the spoil amount would be greater than 100,000 tonnes based on at least 0.3m depth excavation works across the earthworks' footprint.

The worst-case emission source for construction has been assumed to comprise the whole area planned for development, including roads and park construction. This area has been referred as construction footprint. It was also assumed that no concrete batching plant to be located within the construction footprint.

The trucks carrying spoil to and from the construction footprint on access roads were also considered as a potential source of emission (referred to as trackout activity). Access roads were considered up to 500 m from the access point of the construction footprint. The number of outward trucks movement has been conservatively assumed to be >50 HDVs per day. The road construction works may not be completed and paved before the construction of other development commences. Hence, length of unpaved roads has been assumed to be >100m in the assessment. Impact prediction and evaluation were detailed in **Section 7.2.5.1**.

7.2.3.2 Operational Phase

As presented in Table 7-12, potential air quality impact during operational phase of the development in this Study Area would be vehicular emissions due to increased traffic to the proposed development. As per the NEA website, since 1st September 2017, all new petrol vehicles have had to meet the Euro VI emission standard, and since 1st January 2018, all new diesel vehicles have had to meet the Euro VI emission standard. The new standards will tighten fine particulate emissions from direct-injection petrol engines in addition to the other pollutants. Since 1st January 2018, the emission standard for all three-wheeled (Cat L5e) and large motorcycles with an engine capacity more than 200cc have been tightened to Euro IV standard, while smaller motorcycles with an engine capacity of 200cc and below will see the Euro IV emission standard implemented from 1st January 2020. Compared to the Euro III emission standard, the tighter Euro IV emission standard will help reduce emissions of hydrocarbons and nitrogen oxides (NOx), which are precursors to ozone. The emission standards for various vehicle classes have been summarized in Table 7-13.

The proposed project has also planned the construction of future roads. The future roads will be mostly dual 2 lanes with possibility of dual 3 lanes at the west of the Kopi Sua Cemetery. The length of the proposed roads within the Study Area is approximately 2.65km. The traffic volume of the future roads is not available at the time of writing.

It should also be noted that currently there is a large volume of traffic along the Pan Island Expressway. There might be an increase in local traffic at to and within the proposed development. Exact numbers in terms of increase in volume of traffic was not available at the time of writing of this report.

Table 7-12: Potential environmental impacts during the operational stage

Potential Source of Impacts	Potential Associated Impacts
Air emissions from vehicle exhaust due to increased traffic to and within the proposed development during project operation.	Exhaust emissions could potentially impact the air quality in the vicinity of the Study Area.

Table 7-13: Emission standard of various vehicle classes

No	Implementation Date	Vehicle Classes	Emission standard
1	1st September 2017	New petrol vehicles	Euro VI
2	1st January 2018	New diesel vehicles	Euro VI
3	1st January 2018	Three-wheeled (Cat L5e) and large motorcycles with engine capacity more than 200cc	Euro IV
4	1st January 2020	Smaller motorcycles with engine capacity of 200cc and below	Euro IV

7.2.4 Minimum Control for Potential Impacts

This section proposes minimum controls or standard practices commonly implemented that have been assumed to be implemented for the purposes of impact assessment. The following control measures should be observed during the construction stage to reduce the noise levels:

- The construction footprint shall be hoarded on all sides;
- No crushing or screening of demolished construction material shall be performed on-site;
- No concrete batching plant to be located on-site; and
- Road construction is recommended to be completed first and paved before the construction of other development commences.

7.2.5 Prediction and Evaluation of Potential Impacts

7.2.5.1 Construction Phase

Throughout the study a conservative but credible approach was adopted to assess potential dust impacts. This might lead to an over-estimation of the levels of pollutants that would arise in practice, but this was considered to be appropriate for planning purposes at this stage of the project and was consistent with precautionary principles.

NO_2 increases the risk of respiratory infection and impairs lung functions in asthmatics. CO deprives body tissues of oxygen and causes nausea and impairs vigilance. SO_2 irritates the respiratory tract and increases the risk of tract infections. PM can affect the heart and lungs, especially in people who already have chronic heart or lung disease (e.g. asthma). $PM_{2.5}$ can cause decreased lung function, increased respiratory symptoms and heart attacks. PM_{10} can cause respiratory impairment and aggravate existing respiratory and cardiovascular disease. Short term exposure to PM may also cause irritation of the eyes, nose and throat in healthy individuals [R-17]. Impact from SO_2 is not expected due low sulphur diesel fuel used in generators.

In this assessment, particulate matter (PM_{10} and $PM_{2.5}$) or dust is expected to be dominant during the Project's construction stage given that there is substantial slope cutting and elevation balance required in this hilly terrain. Since these are the major pollutants that are likely to have more significant impact on the ambient air quality as a result of the development of the infrastructure in this area, only dust emission is assessed in this study.

The assessment was conducted using the site area, hours of operation, timescale of construction, construction material, excavation quantities, surface material and number of vehicles on site as discussed in **Section 7.2.3.1**.

The Impact Intensity was determined by reviewing the scale of construction activities and classifying them as low, medium or high for each activity type (earthworks, construction, and trackout). The overall Consequence for each activity was classified by considering Impact Intensity with the Receptor Sensitivity.

Without any mitigation measures in place, the Likelihood of occurrence of impacts from construction of the project was classified as Certain / Continuous. The Impact Intensity, overall Consequence and Impact Significance was outlined in Table 7-14 to Table 7-17.

Based on the assessment, the Impact Significance was predicted to be Major for both human health and ecological impact. Hence, based on the assessment methodology in **Section 6.4.2.3**, Impact Significance evaluated as Major require the adoption of management or mitigation measures.

Table 7-14: Impacts of Dust Risk Assessment – Demolition

Demolition – before mitigation													
Key Parameters				Human Health Impact					Ecological Impact				
Total Building Volume (m^3)	Construction Material	On-site crushing or screening	Height of demolition activities (m)	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
> 50,000	Potentially dusty (e.g. concrete)	No	10-20	High	Priority 2	High	Certain / Continuous	**Major**	High	Priority 1	High	Certain / Continuous	**Major**

Table 7-15: Impacts of Dust Risk Assessment – Earthworks

Earthworks – before mitigation												
Key Parameters			Human Health Impact					Ecological Impact				
Total Site Area (m^2)	No. of Vehicles moving within the site	Total Material Moved (tonnes)	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
> 10,000	> 10	> 100,000	High	Priority 1	High	Certain / Continuous	**Major**	High	Priority 1	High	Certain / Continuous	**Major**

Table 7-16: Impacts of Dust Risk Assessment – Construction

Construction – before mitigation												
Key Parameters		Human Health Impact					Ecological Impact				
Total Building Volume (m^3)	No. of concrete batching plant	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
> 100,000	0	High	Priority 1	High	Certain / Continuous	**Major**	High	Priority 1	High	Certain / Continuous	**Major**

Table 7-17: Impacts of Dust Risk Assessment – Trackout

Trackout – before mitigation												
Key Parameters			Human Health Impact					Ecological Impact				
No. of outward trucks movement per day	Road surface material	Unpaved Road Length (m)	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
> 50	Potentially Dusty	> 100	High	Priority 1	High	Certain / Continuous	**Major**	High	Priority 1	High	Certain / Continuous	**Major**

7.2.5.2 Operational Phase

As discussed in **Section 7.2.3.2**, emissions from vehicle exhaust due to increased traffic to the project development was expected. Other sources of emissions such as road dust and resuspension due to the traffic volume were also expected. It was assumed that all new petrol and diesel vehicles would meet Euro VI emission standard, while all motorcycles would meet Euro IV standard going forward and slowly completely convert to these or better standards as they get phased out in 10 years from their onset. It should also be noted that currently there is a large traffic volume along the PIE. The proposed project has also planned the construction of future roads. The future roads will be mostly dual 2 lanes with possibility of dual 3 lanes at the west of the Kopi Sua Cemetery. The exact numbers in terms of increase in volume of traffic was not available at the time of writing of this report. Without any mitigation measures in place, the Likelihood of occurrence of impacts during the operational phase was classified as Continuous.

Overall it seems that given the two factors above (i.e. the implementation of Euro emission standard on new vehicles and current large traffic volume along PIE), no increase in air quality pollutant levels in the vicinity of proposed development was expected during the operational phase. The buffer from Kopi Sua Cemetery and Bukit Brown will also help in terms of providing cleaner air from the impact from the vehicles. Some green areas will also not be disturbed as part of the project. Hence, the Impact Intensity was considered to be Negligible.

As discussed in **Section 7.2.2**, the Sensitivity of the receptors ranges from Priority 1 to Priority 3. Thus, as per **Table 6-6**, the Impact Consequence was calculated to be Imperceptible to Very Low. Based on the assessment, the Impact Significance was predicted to be **Negligible** to **Minor**. No mitigation measures would be required during operational phase.

It is to be noted that as the increase in traffic volume along PIE and the traffic volume of the future roads was not available at the time of writing of this report. Hence, to understand the impact from roads, an air quality impact study was recommended to be conducted in the detailed design stage using the detailed traffic data.

7.3 Recommended Mitigation Measures

7.3.1 Construction Phase

Based on the assessment in **Section 7.2.5.1**, the Impact Significance was determined to be **Major** for both human health and ecological impact. In line with the general mitigation measures, the road alignment plan has also been adjusted to reduce encroachment or road works in the vicinity of sensitive receptors as much as possible. On top of this, the range of dust mitigation measures to be implemented at the construction sites are outlined in Table 7-18. Upon the implementation of mitigation measures, the Impact Significance was determined to be **Minor** as per **Section 7.4.1**.

Table 7-18: Proposed Air Quality Mitigation Measures based on the Outcome of the Air Quality Impact Assessment

Mitigation Measures	Application
GENERAL MITIGATION MEASURES TO BE IMPLEMENTED THROUGH OUT CONSTRUCTION PERIOD	
Communications	
Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.	**Mandatory**
Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager.	**Mandatory**
Develop and implement an Air Pollution Control Plan (APCP) (see paragraph below for APCP details).	**Mandatory**
Site Management	
Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.	**Mandatory**

Mitigation Measures	Application
Make the complaints log available to the local authority when asked.	**Mandatory**
Record any exceptional incidents that cause dust and/or air emissions, either on-site or off-site, and the action taken to resolve the situation in the logbook.	**Mandatory**
Hold liaison meetings with other high-risk construction sites within 500 m of the site boundary, if any, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised.	**Mandatory**
Monitoring	
Undertake regular (daily frequency recommended) on-site and off-site inspections and record results. The log should be made available to the NEA or other Government Agencies if required. Inspections should include regular dust soiling checks of surfaces such as street furniture, cars, and windowsills within 100 m of site boundary. Cleaning should be provided if necessary.	**Mandatory**
Carry out regular site inspections to monitor and record compliance with the Air Pollution Control Plan.	**Mandatory**
Increase the frequency of site inspections during prolonged dry or windy conditions.	**Mandatory**
Conduct monitoring for PM_{10} and $PM_{2.5}$ at suitable locations (refer to **Section 14.9)**	**Mandatory**
Preparing and maintaining the site	
Plan site layout so that machinery and dust causing activities are located away from receptors, where possible.	**Mandatory**
Erect hoarding around dusty activities and at the site boundary wherever possible. Boundary screens should be at least as high as any stockpiles or dust emission sources on site.	**Mandatory**
Fully enclose specific activities where there is a known high potential for dust production and the site will be active for an extensive period of time.	**Mandatory**
Keep site fencing, barriers, and scaffolding clean by cleaning regularly using wet methods (dry methods may give rise to fugitive dust).	**Mandatory**
Remove materials that have the potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site, stockpiled material should be covered, seeded, fenced or enclosed to prevent fugitive dust formation.	**Mandatory**
Operating vehicle/machinery and sustainable travel	
Ensure all vehicles and engine powered equipment comply with the legislative requirements of Singapore.	**Mandatory**
Ensure all vehicles and equipment switch off their engines when stationary – i.e. no idling vehicles or engines. Clear signs shall be erected at site entrance to inform all visitors.	**Mandatory**
Where practicable, avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment. If diesel needs to be used, low sulphur diesel fuel is to be used in generators.	**Mandatory**
Impose and signpost a maximum-speed-limit of 25 km/hr on paved or surfaced haul roads and 15 km/hr on unpaved haul roads and work areas.	**Mandatory**
Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials.	**Mandatory**
Construction Operations	

Mitigation Measures	Application
Only use cutting, grinding or sawing equipment fitted with, or in conjunction with, suitable dust suppression techniques such as water sprays or local extraction e.g. local exhaust ventilation system.	**Mandatory**
Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	**Mandatory**
Use enclosed chutes and conveyors and covered skips wherever possible.	**Mandatory**
Minimise drop heights from conveyors, loading shovels, hoppers, and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	**Mandatory**
A stringent "Clean as you go" Policy should be implemented on site to ensure no loose dry material is left exposed when not in use. Equipment should be readily available on site to clean any dry spillages, and cleaning should be conducted as soon as reasonably practicable after the event using wet cleaning methods.	**Mandatory**
Waste Management	
Avoid burning of waste or other materials.	**Mandatory**
MITIGATION MEASURES FOR DEMOLITION	
Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust).	**Mandatory**
Ensure effective water suppression is used during demolition operations. Hand held sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground.	**Mandatory**
Avoid explosive blasting, using appropriate manual or mechanical alternatives	**Mandatory**
Bag and remove any biological debris or damp down such material before demolition	**Mandatory**
MITIGATION MEASURES FOR EARTHWORKS	
Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.	**Mandatory**
Use Hessian, mulches or soil tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.	**Mandatory**
Only remove the cover in small areas during work and not all at once.	**Mandatory**
MITIGATION MEASURES FOR CONSTRUCTION	
Avoid scabbling (roughening of concrete surfaces) if possible.	**Recommended**
Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.	**Mandatory**
Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery.	**Recommended**

Mitigation Measures	Application
For smaller supplies of fine power materials ensure bags are sealed after use and stored appropriately to prevent dust.	**Recommended**
MITIGATION MEASURES FOR TRACKOUT	
Use water-assisted dust sweeper(s) on the access and affected local roads, to remove, as necessary, any material tracked out of the site. This may require the sweeper being continuously in use.	**Mandatory**
Avoid dry sweeping of large areas.	**Mandatory**
Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	**Mandatory**
Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.	**Mandatory**
Record all inspections of haul routes and any subsequent action in a site log book.	**Mandatory**
Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned.	**Mandatory**
Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable).	**Mandatory**
Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.	**Mandatory**
Site access gates to be located at least 10 m from receptors where possible.	**Mandatory**

The APCP shall include the following information as a minimum:

- Summary of all work to be carried out including breakdown of phases and individual activities that may give rise to fugitive dust formation, including heavy vehicular emissions and construction equipment (e.g. genset) emissions during the construction phase;
- Project title, Study Area location and area size, description of the site layout and locations of areas where dust is most likely to be generated such as haulage routes, excavation areas, etc. This description shall also include the location of the water supply or chemical suppressants for applying to the dust generating areas on site;
- List of each dust generating activity, the likely schedule for each activity and the dust control measures to be implemented and frequency for their implementation. The level of detail will depend on the overall Consequence classification identified in this report and should include as a minimum the mitigation measures listed as mandatory in this document;
- Summary of the air monitoring to be undertaken including monitoring location and schedule. The air monitoring results shall be recorded, and trends observed to determine the efficacy of dust control measures over the different construction phases;
- Details and procedures on using the site logbook which is used to record information on incidents such as dust episodes, the sources identified, and the action taken and its efficacy. Any complaints shall also be recorded within the logbook along with the subsequent mitigation implemented and time to close out the complaint. The logbook should also be used to keep track of the daily dust control measures implemented such as wheel washing, site watering, site inspections etc.;
- Details of the Superintending Officer (SO) should be included in this plan for managing dust management at the site. The responsibilities of the SO are listed in **Section 14.4.4**; and

- The air pollution control plan shall be reviewed at regular intervals during the construction phase to ensure the effectiveness of the procedures in place and to maintain the goal of minimisation of dust and emissions through the use of best practice and procedures.

Detailed air emissions and its relevance need to be considered in the Contractor's Air Pollution Control Plan as more details on project schedule, parcel split will be made available then. At the concept stage these details are not yet clearly defined.

7.3.2 Operational Phase

No mitigation measures would be required during operational phase as only Negligible to Minor air quality impact significance was expected during operational phase of the development in the Study Area.

7.4 Residual Impacts

7.4.1 Construction Phase

Residual Impact Assessment assumed that the mitigation measures within **Section 7.3.1** are implemented in the construction footprint. In assessing the residual impact, the indicative alternative road plan 2 (see Figure 3-2) has also been considered. The indicative alternative road plan 2 has allowed for reduction of road works in the vicinity of sensitive receptors as much as possible. Based on the assessment, the indicative alternative road plan 2 is preferred compared to indicative original road plan.

The Likelihood of occurrence of a significant adverse impact would be classified as Less Likely/ Rare, subject to relevant mitigation measures identified being implemented. This Likelihood is combined with Impact Consequence to provide the residual Impact Significance results for the construction footprint. The residual Impact Significance is listed in Table 7-19 to Table 7-22 below.

Based on the assessment, by implementing the proposed mitigation measures, the Likelihood of the impact was expected to reduce from Certain/ Continuous to Less Likely/ Rare, resulting in 'Minor' Impact Significance for both human health and ecological impact.

Table 7-19: Impacts of Dust Risk Assessment – Demolition

Demolition – after mitigation													
Key Parameters				Human Health Impact					Ecological Impact				
Total Building Volume (m^3)	Construction Material	On-site crushing or screening	Height of demolition activities (m)	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
> 50,000	Potentially dusty (e.g. concrete)	No	10-20	High	Priority 2	High	Less Likely / Rare	**Minor**	High	Priority 1	High	Less Likely / Rare	**Minor**

Table 7-20: Impacts of Dust Risk Assessment – Earthworks

Earthworks – after mitigation												
Key Parameters			Human Health Impact					Ecological Impact				
Total Site Area (m^2)	No. of Vehicles moving within the site	Total Material Moved (tonnes)	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
> 10,000	> 10	> 100,000	High	Priority 1	High	Less Likely / Rare	**Minor**	High	Priority 1	High	Less Likely / Rare	**Minor**

Table 7-21: Impacts of Dust Risk Assessment – Construction

Construction – after mitigation											
Key Parameters		Human Health Impact					Ecological Impact				
Total Building Volume (m^3)	No. of concrete batching plant	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
> 100,000	0	High	Priority 1	High	Less Likely / Rare	**Minor**	High	Priority 1	High	Less Likely / Rare	**Minor**

Table 7-22: Impacts of Dust Risk Assessment – Trackout

Trackout – after mitigation											
Key Parameters			Human Health Impact					Ecological Impact				
No. of outward trucks movement per day	Road surface material	Unpaved Road Length (m)	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
> 50	Potentially Dusty	> 100	High	Priority 1	High	Less Likely / Rare	**Minor**	High	Priority 1	High	Less Likely / Rare	**Minor**

7.4.2 Operational Phase

As discussed in **Section 7.2.5.2**, the potential impact significance due to increased traffic was considered Negligible to Minor. No mitigation measures would be required during operational phase.

7.5 Summary of Key Findings

Air quality impacts from the construction and operation of the proposed development were assessed on air sensitive receptors (ASRs) in the vicinity of the Study Area. Potential impacts to the neighbouring sensitive receptors during construction phase mainly include emissions from the heavy vehicular exhaust and dust emitted from the demolition, earthworks, construction and trackout activities. During the operational phase, emissions from vehicle exhaust due to increased traffic to the proposed development was identified as the predominant air emission source whose impacts have been assessed in this report. A baseline air quality was measured for this study from 22nd to 30th April 2019. All measured pollutant concentrations were within the Singapore Ambient Air Quality Long Term Targets.

Air quality impact assessment for construction phase was undertaken in accordance with the UK IAQM Guidance on the Assessment of Dust from Demolition and Construction. The results of the assessment show that unmitigated impact significance (i.e. with minimum controls) is classified as “Major” and have the potential to affect the receptors near the construction footprint unless mitigation measures are put in place (see **Section 7.2.5.1** for assessment details). This was largely because of extent of footprint of the project amidst a natural predominant setting with small intermittent areas of human developments besides the flora, fauna and habitat with high ecological value. This report pulls together mitigation measures that can be implemented by the contractor as administrative or management measures, sourcing from best practice measures internationally, which are detailed **Section 7.3.1**, which when applied successfully, the impact significance was anticipated to be reduced to “Minor” (see **Section 7.4.1** for details). The key control and mitigation measures include but not limited to avoidance of on-site concrete batching plant, onsite crushing and screening of demolished construction materials, development of air pollution control plan, dust control measures on site, site hoarding, planning of dust causing activities-location and timing, reinstating land upon completion of works amongst several others. In assessing the residual impact, the indicative alternative road plan 2 (see Figure 3-2) has also been considered. The indicative alternative road plan 2 has allowed for reduction of road works in the vicinity of sensitive receptors as much as possible. Based on the assessment, the indicative alternative road 2 plan is preferred compared to indicative original road plan.

Air quality impacts were also qualitatively weighed during operational phase. Fugitive emission from vehicle exhaust due to increased traffic to the project development was expected. It was assumed that all new vehicles to meet their Euro emission standard. Furthermore, there is currently a large traffic volume along the PIE. The exact numbers in terms of increase in volume of traffic was not available at the time of writing. The buffer from Kopi Sua Cemetery and Bukit Brown Woods will also help in terms of providing cleaner air from the impact from the vehicles. Some green areas will also not be disturbed as part of the project. Overall, the air quality impact significance contributed from the proposed development was anticipated to be Negligible to Minor during the operational phase.

Based on the assessment, by implementing the proposed mitigation measures, the impact significance would reduce to Minor for both human health and ecological impact during construction phase. No mitigation measures would be required during operational phase as no significant air quality impact was expected from project operation.

8.0 Airborne Noise

Noise from construction and operational activities may be perceivable, especially to receptors in proximity and those having a direct line-of-sight to the noise sources from the Study Area. This section presents the assessment of noise impacts arising from the construction and operational phases of the project.

The construction noise impacts assessment has been conducted quantitatively. The operation noise impact assessment has been conducted qualitatively. The key steps for conducting the noise impact assessment are as follows:

- Review baseline noise monitoring data to assess current baseline noise level in the Study Area;
- Identify and classify sensitivity of the receptors surrounding the Study Area;
- Conduct a noise impact assessment to quantitatively assess noise impacts during the construction phase;
- Conduct a noise impact assessment to qualitatively assess noise impacts during the operational phase;
- Recommend minimum control and mitigation measures to be implemented; and
- Determine the overall significance of the residual noise impacts after the implementation of mitigation measures.

8.1 Baseline Noise Monitoring

Baseline airborne noise monitoring includes monitoring of the baseline airborne noise quality in the Study Area. As part of airborne noise monitoring, sound level meters were setup at selected baseline monitoring locations to record the noise levels over a week to generate overall $L_{Aeq(12\ hour)}$, average $L_{Aeq(1\ hour)}$, average $L_{Aeq(15\ min)}$ and $L_{Aeq(5\ min)}$ noise levels at each monitoring location for the construction noise impact assessment. The purpose of the baseline noise monitoring was to understand the existing noise levels so that a background noise correction factor can be determined to develop a construction noise criterion for the project in accordance with the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008* and the boundary noise criterion for the developments post-construction in accordance with the *Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building*.

8.1.1 Personnel

The assessment and site surveys were conducted by the following personnel:

- Ms. Jagriti Dawra, AECOM Singapore Pte Ltd (EIA specialist)
- Mr. Magaesh Naidu, AECOM Singapore Pte Ltd (EIA specialist)
- Mr. Mark Shi, AECOM Singapore Pte Ltd (Noise and Vibration Consultant)
- Ms. Mandy Yeo, AECOM Singapore Pte Ltd (Noise and Vibration Consultant)

Site reconnaissance was conducted in 30th January 2019. Subsequently, the primary baseline noise was conducted from 7th to 14th May 2019 and 7th to 14th January 2020 and vibration data collections from 7th to 16th May 2019.

8.1.2 Field Assessment

Four locations have been proposed for baseline noise and vibration monitoring (refer to **Figure 8-1**), which were approved as part of the Scoping stage. These are based on the identification of Noise Sensitive Receptors (NSRs) nearest to the Study Area. Selected locations are:

- Along Mount Pleasant Road (opposite OPA Field) – NM01);
- 3 Mount Pleasant Road – NM02;

- 182 Mount Pleasant Road - NM03; and
- Along PIE – NM04.

Details for the baseline airborne noise monitoring are shown in **Table 8-1**.

Table 8-1: Baseline Noise Monitoring Methodology

Parameter	Monitoring/ Assessment Methodology	Justification
Airborne Noise		
Project Phase	Construction Phase	In accordance with *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008.*
	Operational Phase	In accordance with T*echnical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building* and *Technical Guideline.*
		In accordance with T*echnical Guideline for Land Traffic Noise Impact Assessment.*
Duration	One week (7 days)	Based on prior experience of EIA projects approved by Government agencies including National Environment Agency (NEA).
Parameters	$L_{Aeq(12\ hour)}$, $L_{Aeq(1\ hour)}$, $L_{Aeq(5\ min)}$	In accordance with *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008.*
	$L_{Aeq(15\ min)}$	In accordance with T*echnical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building.*

Legend

- Study Area
- Baseline Monitoring Locations
  - Noise
  - Vibration

N

Rev.	Date	By	Description	Chk'd	App'd
02	JUN 2021	PZ	Final Report	JAG	JAG
-	JAN 2021	PZ	Final Report	JAG	JAG

Qualified Person Endorsement :
NA

HDB Endorsement :
NA

Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title :
CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :
NOISE AND VIBRATION BASELINE MONITORING LOCATION

Designed	Checked	Approved
PZ	JAG	JAG
	Drawn	Date
	PZ	JUN 2021

Figure No. : 8 - 1 | Rev. 02 | Sheet 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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8.1.3 Baseline Noise Results

Baseline monitoring to establish the existing noise levels near the worksite in the Study Area was conducted from 7th May 2019 to 14th May 2019 and from 7th January 2020 to 14th January 2020. Baseline monitoring was conducted to understand the ambient noise level in the proximity of the Study Area at monitoring locations and to obtain correction factors to be used for the adjustment of NEA Maximum Permissible Noise levels. The baseline noise monitoring results from NM01, NM02, NM03 and NM04 are summarised in accordance to local noise guidelines.

Table 8-2 presents the summary of the baseline noise monitoring results in $L_{Aeq(12hrs)}$, $L_{Aeq(1hr)}$ and $L_{Aeq(5mins)}$, dB for construction noise impact assessment and **Table 8-3** presents the summary of the baseline noise monitoring results in $L_{Aeq(15\ min)}$, dB for operational noise impact assessment.

It can be observed from **Table 8-2** that the baseline noise monitoring results for L_{Aeq} averaging period of 12 hours lie between 53 dB and 73 dB which was typical for noise from traffic along small and major highways respectively. The monitoring results were below NEA's construction noise limits for residential area (i.e. 75 dB), but exceeded NEA's construction noise limits for noise sensitive premise (i.e. 60 dB). The criteria was appropriately corrected as per *EPM (Control of Noise at Construction Sites) Regulations* in **Table 8-13**.

L_{Aeq} averaging period of 1 hour which is normally a noise descriptor for residential area during evening and night-time, was found to range between 44 dB and 64 dB, which was typical for traffic noise along small and quiet roads. The monitoring results were below NEA's limits for evening time (i.e. 65 dB), but exceeded NEA's limits for night-time (i.e. 55 dB). The criteria was appropriately corrected as per *EPM (Control of Noise at Construction Sites) Regulations* in **Table 8-13**.

The baseline noise monitoring results for L_{Aeq} averaging period of 5 mins lay between 52 dB and 75 dB, which was typical for traffic noise along small and major highways respectively. The monitoring results were below NEA's construction noise limits for residential area (i.e. 75 dB), but exceeded NEA's construction noise limits for noise sensitive premises (i.e. 60 dB). The criteria was appropriately corrected as per *EPM (Control of Noise at Construction Sites) Regulations* in **Table 8-13**.

For further details of the baseline noise monitoring, refer to **Appendix C** and calibration certificates in **Appendix D**.

Table 8-2: Summary of Baseline Noise Monitoring Results – for construction noise impact assessment

Monitoring Period		NM01							NM02							NM03							NM04						
		$L_{Aeq(12\ hour)}$, dB		$L_{Aeq(1\ hour)}$, dB		$L_{Aeq(5\ min)}$, dB			$L_{Aeq(12\ hour)}$, dB		$L_{Aeq(1\ hour)}$, dB		$L_{Aeq(5\ min)}$, dB			$L_{Aeq(12\ hour)}$, dB		$L_{Aeq(1\ hour)}$, dB		$L_{Aeq(5\ min)}$, dB			$L_{Aeq(12\ hour)}$, dB		$L_{Aeq(1\ hour)}$, dB		$L_{Aeq(5\ min)}$, dB		
		7am – 7pm	7pm – 10pm	7pm – 10pm	10pm - 7am	7am - 7pm	7pm – 10pm	10pm – 7am	7am – 7pm	7pm – 10pm	7pm – 10pm	10pm - 7am	7am – 7pm	7pm – 10pm	10pm – 7am	7am – 7pm	7pm – 10pm	7pm – 10pm	10pm - 7am	7am – 7pm	7pm – 10pm	10pm – 7am	7am – 7pm	7pm – 10pm	7pm – 10pm	10pm - 7am	7am – 7pm	7pm – 10pm	10pm – 7am
Monday to Saturday																													
7th – 11th May 2019 & 13th May 2019 for NM01, NM02, NM03 7th – 11th Jan 2020 & 13th Jan 2020 for NM04	**Max**	69	66	61	63	82	72	80	70	69	58	63	80	72	80	65	66	55	58	81	71	84	74	72	71	71	79	74	74
	Min	68	61	52	36	43	55	41	68	62	54	43	56	59	43	60	55	44	33	53	52	43	73	70	61	56	69	69	65
	Overall for $L_{Aeq(12hrs)}$ / Average for $L_{Aeq(1hr)}$ and $L_{Aeq(5mins)}$	68	62	55	46	66	64	54	69	64	56	52	68	66	52	63	58	48	44	61	58	53	73	71	63	61	73	72	71
Sunday																													
12th May 2019 for NM01, NM02, NM03 12th Jan 2020 for NM04	**Max**	NA	NA	52	52	69	66	66	NA	NA	52	52	68	68	68	NA	NA	47	47	62	66	66	NA	NA	64	64	74	75	75
	Min	NA	NA	51	51	43	56	56	NA	NA	51	51	55	61	61	NA	NA	43	43	51	53	53	NA	NA	64	64	68	73	73
	Overall for $L_{Aeq(12hrs)}$ / Average for $L_{Aeq(1hr)}$ and $L_{Aeq(5mins)}$	64	59	52	52	63	63	63	60	69	52	52	64	64	64	58	53	45	45	57	56	56	72	72	64	64	72	75	75

Table 8-3: Summary of Baseline Noise Monitoring Results – operational noise impact assessment

Monitoring Period		NM01			NM02			NM03			NM04		
		$L_{Aeq(15\ min)}$, dB			$L_{Aeq(15\ min)}$, dB			$L_{Aeq(15\ min)}$, dB			$L_{Aeq(15\ min)}$, dB		
		Day 7am to 7pm	Evening 7pm to 11pm	Night 11pm to 7 am	Day 7am to 7pm	Evening 7pm to 11pm	Night 11pm to 7 am	Day 7am to 7pm	Evening 7pm to 11pm	Night 11pm to 7 am	Day 7am to 7pm	Evening 7pm to 11pm	Night 11pm to 7 am
7th – 13th May 2019 for NM01, NM02, NM03 7th – 13th Jan 2020 for NM04	**Max**	79	71	76	79	72	78	77	67	82	78	74	73
	Min	49	61	42	58	63	50	55	50	43	70	70	66
	Average for $L_{Aeq(15mins)}$, dB	67	66	57	68	67	59	62	58	53	73	72	70

8.2 Airborne Noise Impact Assessment

This section presents the assessment of airborne noise impacts arising from the demolition of existing buildings, the construction of the Project and also operation activities of the Project within the Study Area.

8.2.1 Assessment Approach and Assumptions

The noise impact assessment evaluated the noise impacts from construction and operational activities to human receptors and ecological receptors.

For construction noise impact assessment, four phases of construction were assumed in **Section 8.2.2**. It is to be noted that the four phases of construction were assumed to be constructed in sequence and would not overlap (phase 1 precedes phase 2 and so forth). The identification and classification of noise sensitive receptors (human and ecological) are presented in **Section 8.2.4.1**. The noise sensitive receptors to be identified are to be within 150m of the Study Area for the four construction phases. Quantitative methods were applied to assess construction noise impacts to the human receptors. However, due to the lack of literature on noise impacts to the ecological receptors identified in **Section 8.2.4**, ecological impacts from construction noise was assessed qualitatively. Additional assumptions were made for the activities involved in the construction areas as detailed in **Section 8.2.8.1.1**.

For operational noise impact assessment on human receptors, both the ACMV boundary noise study and traffic noise impact assessment is mandatory to be conducted at the prelim design stage by an appointment Noise Consultant and is hence, omitted from this study. AECOM instead recommended both assessments on human receptors to be conducted as further studies during the preliminary design stage. Notwithstanding the above, AECOM has provided an indicative criterion as an example detailed in **Section 8.2.5.2.1** for the ACMV boundary noise study. For operational noise impact assessment on ecological receptors, qualitative assessment was applied to assess the noise impacts due to the lack of literature on operational noise impact to the identified ecological receptors.

8.2.2 Construction Phases

Based on the conceptual development plan with limited information and assumption provided by the Client, the construction noise impact was assessed based on the following phases:

1) Demolition – Demolition of existing buildings;
2) Roadworks – Laying of roads for the ingress and egress of construction vehicles;
3) Construction of Proposed Development – Construction of HDB residential developments.

8.2.3 Potential Sources of Impacts

8.2.3.1 Potential Impacts during Construction Phase

As stated in **Section 8.2.2**, assessment for construction phase consists of demolition of existing buildings and the construction of the development in the Study Area which encompasses road networks and building structures. Potential major noise sources for the project during construction phases are listed in **Table 8-4**.

Table 8-4: Potential Noise Sources during Construction Stage

Construction Phases	Potential Noise Sources Powered Mechanical Equipment	Sound Pressure Level at 10 m, dB(A) [1]
Phase 1 (Demolition)	Lorry Cranes	70
	Handheld Breaker	93
	Excavator mounted with Breaker	72
	Excavator	78
	Dump Trucks	79
Phase 2 (Roadworks)	Excavator	78
	Grader	86
	Concrete Truck	80
	Roller	73
Phase 3 (HDB Construction)	40 ft Trailer	79
	Excavator	78
	Grader	86
	Concrete Truck	80
	Roller	73
	Air Compressor	75
	Bored Piling Machine	89
	Compressor	75
	Concrete pump	78
	Concrete Vibrator	89
	Crane	67
	Crawler Crane	86
	Dump Trucks	79
	Excavator mounted sheet pile vibrator	72
	Excavator mounted sheet pile vibrator	72
	Excavator mounted with Breaker	72
	Excavator via breaker and 40 pounds breaker	78
	Excavator with lifting appliance	78
	Generator	65
	Handheld Breaker	93
	Lorry	70
	Lorry Cranes	70
	Mini Excavator	68
	Mobile Crane	67
	Mobile Crane, 50T	67
	Ready Mix Concrete Truck	80
	Ready Mix Concrete Truck & crawler crane	80
	Temporary Water Pump	68

Construction Phases	Potential Noise Sources Powered Mechanical Equipment	Sound Pressure Level at 10 m, dB(A) [1]
	Welding Equipment	73
	welding/cutting equipment	73
Note: [1] SPL of the equipment are made reference to "BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise		

The construction noise impacts generated from various construction activities will depend on the inventory adopted during each activity of the construction programme. Based on the type of potential construction activities at the Study Area, the noisiest scenario will potentially be the piling phase. Individual noise sources that have the highest noise levels should be limited to day time operations and were not expected to create an impact beyond 50m.

The associated noise impacts from the identified works as shown in **Table 8-4** is Human Annoyance and Sleep Disturbance to the nearest receptors to the construction area. In addition, disturbance to Fauna was also identified. Potential impacts to Fauna include affecting ecological foraging behaviour, Intra-species and inter-species communication.

Section 8.2.8 discusses the Impact Prediction and Evaluation during the Construction Phase.

8.2.3.2 Potential Impacts during Operational Phase

The typical noise sources during operational phase includes the follow:

- Traffic noise due to increase in vehicular volume
- Air-conditioning and mechanical ventilation noise from services at the developments due to mechanical and electrical services.

Potential impacts due to the increase in noise level from the above-mentioned sources includes noise disturbance to humans. In addition, disturbance to Fauna was also identified. Potential impacts to Fauna include affecting ecological foraging behaviour, Intra-species and inter-species communication. **Section 8.2.9** discusses the Impact Prediction and Evaluation during the Operational Phase.

8.2.4 Classification of Sensitive Receptors

8.2.4.1 Construction Noise

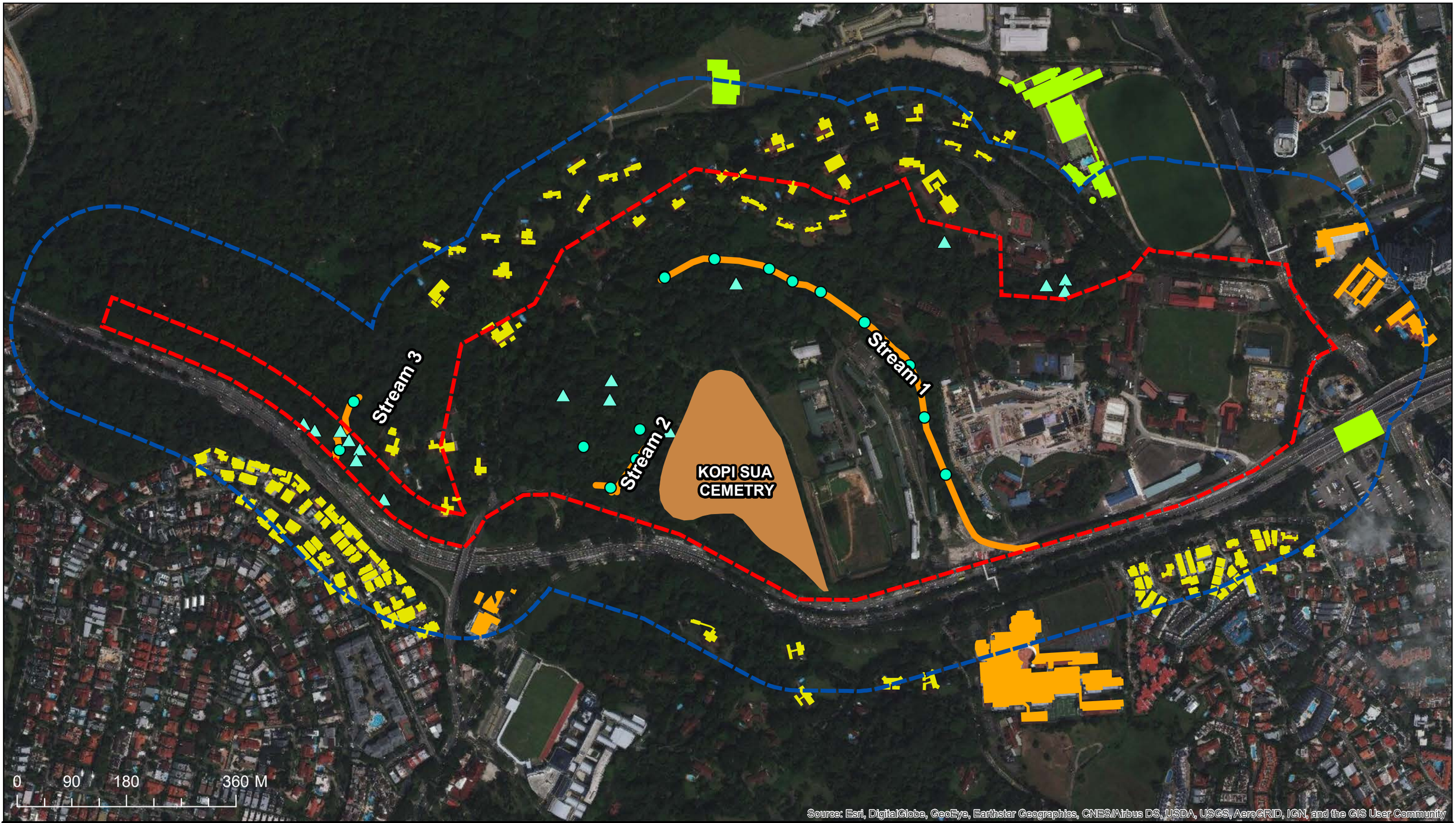
Human Impacts

As the initial step of the construction noise impact assessment, the buildings in the Study Area that may be potentially sensitive to the construction noise from the project were analysed. According to the Environmental Protection and Management Regulation, the sensitive receptors are buildings within 150 m from the Study Area. As a result, the noise sensitive receptors for the construction phase are presented in **Figure 8-2** where the respective receptor sensitivity classifications were based on **Table 6-1**.

The list of noise sensitive receptors is presented in **Appendix E**. It is to be noted that the list of receptors for human impacts do not include the proposed residentials in construction Phase 3. It was assumed that these buildings would only be occupied upon competition of all developments. It is to be noted that the existing residential buildings within 150m of the project Study Area has been assessed at this master planning stage as a worst-case scenario.

Ecological Impacts

As Priority 1 fauna has been identified throughout the forested area near Kopi Sua Cemetery (refer to **Section 12.0**), AECOM has conservatively assessed to have a Priority 1 receptor sensitivity towards construction noise. The identified receptors which falls under Priority 1 includes Bamboo Clusters which serves as habitats for Bamboo Bats and Streams 1 and 2 which are habitat to the Collared Threadtail. In addition, birds and a butterfly of conservation significance were identified within the Study Area. The ecological noise sensitive receptors are presented in **Figure 8-2** (refer to stream 1 and stream 2 for Collared Threadtail habitat and Bamboo Clusters for Bamboo Bats habitat).



Legend

- Study Area
- Kopi Sua Cemetery
- Bamboo Clusters
- Ecological Receptors
- Noise Assessment Area (150m)

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

N

Rev.	Date	By	Description	Chk'd	App'd
02	JUN 2021	PZ	Final Report	JAG	JAG
-	JUNE 2021	PZ	Final Report	JAG	JAG

Qualified Person Endorsement :
NA

HDB Endorsement :
NA

Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title :
CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :
NOISE SENSITIVE RECEPTORS

Designed	Checked	Approved
PZ	JAG	JAG
	Drawn	Date
	PZ	JUN 2021

Figure No. : 8 - 2 | Rev. 02 | Sheet 1 of 1

CAD File Name : NA | A3

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8.2.4.2 Operational Noise

Human Impacts

The boundaries of the proposed public housing in the Study Area were analysed. According to NEA's boundary noise criteria for non-industrial buildings, the classification of the building boundaries was dependent on the adjacent affected premises. The classification of the boundaries was marked in **Figure 8-3** for residential buildings to be assessed.

The residential developments are fronting parks, other residential developments and existing residential, The boundary operational noise impact assessment with the most stringent criteria for the residential developments would be 'Noise Sensitive Premises' – the proposed parks

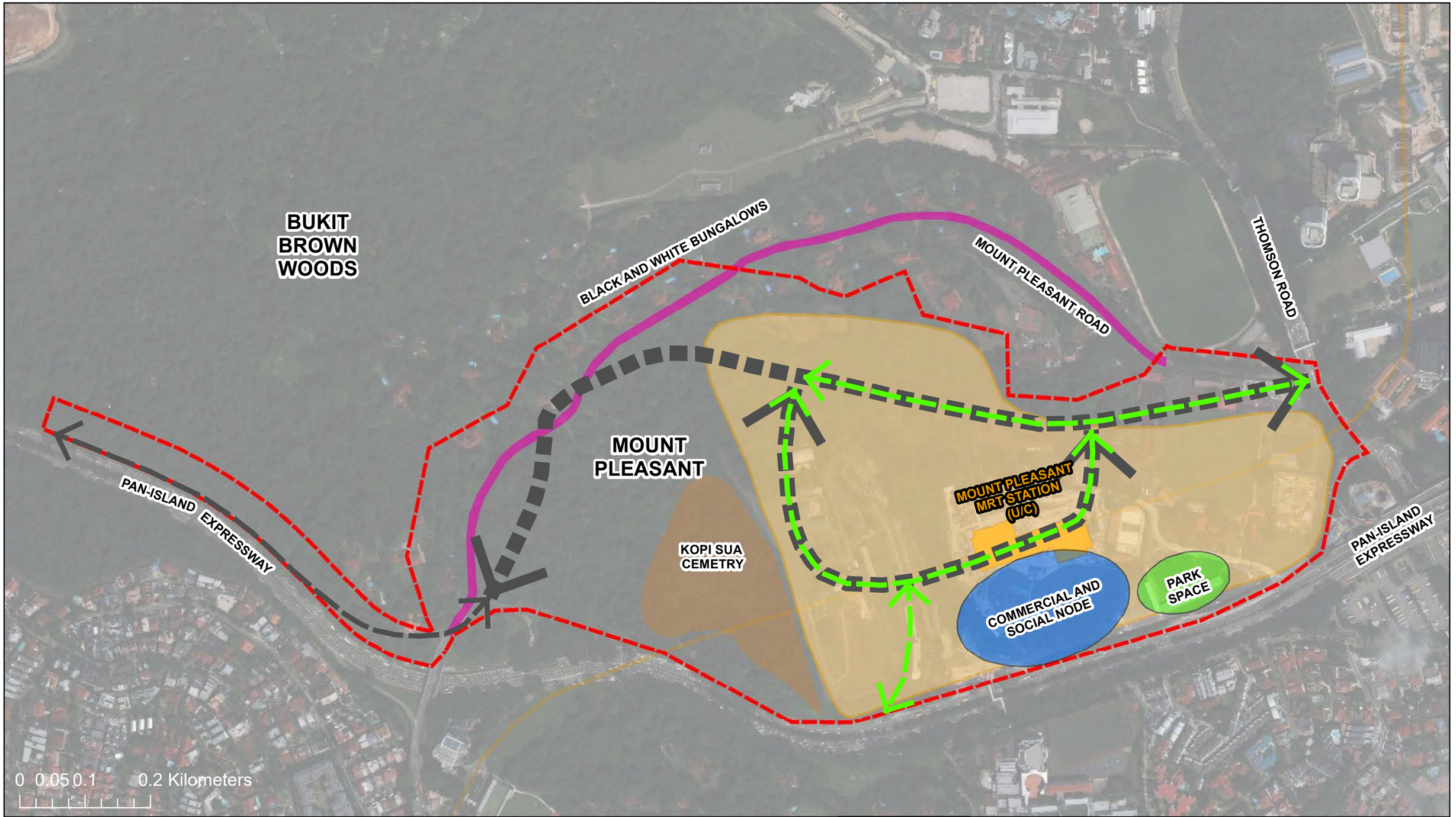
A summary of the type of buildings and classifications of sensitive receptors at any development's boundary is shown in **Table 8-5**.

Table 8-5: Summary of Human Noise Receptor Classification (Operational)

Type of Affected Premises	Receptor Sensitivity
Noise Sensitive Premises such as hospital, home for the aged sick, library, etc.	Priority 1
Residential Premises	Priority 2
Others	Priority 3

Ecological Impacts

As Priority 1 fauna has been identified throughout the forested area near Kopi Sua Cemetery (refer to **Section 12.0**), AECOM has conservatively assessed to have a Priority 1 receptor sensitivity towards construction noise. The identified receptors which falls under Priority 1 are Bamboo Clusters serving as habitats for Bamboo Bats. It is to be noted that Streams 1 and 2, which are habitat to the Collared Threadtail, are under Priority 1 receptors sensitivity. Birds and a butterfly within the Study Area were not considered as identified receptors since their habitats will be change and disappear after construction phase. The larger impact than noise in this area was due to redevelopment of the streams and habitat itself. Whether the biodiversity species will eventually take shelter or develop new habitat is uncertain at this stage, hence it is difficult to analyse the impact of noise on these species related to the streams. The ecological noise sensitive receptors are presented in **Figure 8-2** (refer to streams 1 and stream 2 for Collared Threadtail habitat and Bamboo Clusters for Bamboo Bats habitat).



Legend

- MRT Station (U/C)
- Thomson-East Coast Line
- Heritage Road
- Indicative Alternative Road Plan 2
- Indicative Original Road Plan
- Kopi Sua Cemetery

Proposed Layout Plan

- Commercial and Social node
- Housing with supporting amenities
- Park space
- Study Area

N

Rev.	Date	By	Description	Chk'd	App'd
02	JUN 2021	ML	Final Report	NHT	JAG
-	JAN 2021	ML	Final Report	NHT	JAG

Qualified Person Endorsement :
NA

HDB Endorsement :
NA

Consultant : AECOM

Project Title :
**CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT**

Designed	Checked	Approved
ML	NHT	JAG
	Drawn	Date
	ML	JUN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title :
OPERATION NOISE-BOUNDARIES OF PROPOSED DEVELOPMENT PLAN

Figure No. :	Rev.	Sheet
8 - 3	02	1 of 1

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8.2.5 Legislative Criteria

Applicable noise legislations for construction and operational phases for the development in the Study Area have been reviewed in this section to develop specific project criteria for the impact assessment study. It is to be noted that the ACMV boundary noise study criterion provided only serves as an indicative criterion and is to be re-established during the prelim design stage by an appointed Noise Consultant.

8.2.5.1 Construction Noise

In order to identify the noise criteria to be met during construction and operational phases at the development in the Study Area, the baseline noise levels were identified and analysed with respect to the affected premises identified and the appropriate background noise correction factor was applied to the Maximum Permissible Levels as per the regulations detailed below.

Potential construction noise impacts were assessed in accordance with the criteria stipulated in the *Second Schedule of the Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 revised edition*. These regulations prescribe maximum allowable noise limits for construction sites for different time periods of the day and for different types of premises that may be affected by construction noise.

Based on the regulations, noise levels have to be assessed at the following locations:

- One metre away from the outside of any affected building regardless of the distance between the affected building and the boundary of the construction site; or
- Other locations which the NEA may specify, if suitable locations cannot be found at one metre away from the outside of any affected buildings.

Regulated prohibited work periods for construction sites located within 150 m from residential premises and noise sensitive premises as follows:

- From 10:00 pm every Saturday to 7:00 am on the following Monday; and
- From 10:00 pm on the eve of a public holiday (PH) to 7:00 am on the day following the public holiday.

These regulated work periods can be amended subject to waiver sought from NEA on a case by case basis.

Construction Works for this project include the following:

- Site clearance, demolition and site preparatory works;
- The Civil works consisting of piling, excavation and reinforced concrete works for construction of the different project components; and
- Installation of underground services and M&E equipment.

The corresponding maximum permissible noise criteria are provided in Table 8-7, Table 8-8 and Table 8-9 for different periods. The legislation directs the project proponent to record three units of noise levels in order to ensure compliance; these are:

- $L_{Aeq(12hrs)}$, dB which refers to equivalent continuous noise level over a period of 12 hours; $L_{Aeq(1hr)}$, dB which refers to equivalent continuous noise level over a period of 1 hour within a 24-hr period; and
- $L_{Aeq(5mins)}$, dB which refers to equivalent continuous noise level over a period of 5 minutes within a 24 hours period.

Table 8-6: Maximum Permissible Noise Levels for Construction Works over a Period of 12 hours

Types of Affected Buildings	Days of the Week	Maximum Permissible $L_{Aeq(12\ hour)}$, dB	
		7am – 7pm	7pm – 7 am
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	All days	60	50
(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	All days	75	-
(c) Buildings (other than those in paragraphs (a) and (b))	All days	75	65
Notes: Regulated prohibited work periods for construction sites located within 150m from residential premises and noise sensitive premises as follows: • From 10:00 pm every Saturday to 7:00 am on the following Monday; and • From 10:00 pm on the eve of a public holiday (PH) to 7:00 am on the day following the public holiday.			

Table 8-7: Maximum Permissible Noise Levels for Construction Works over a Period of 1 hour

Types of Affected Buildings	Days of the Week	Maximum Permissible $L_{Aeq(1\ hour)}$, dB		
		7am – 7pm	7pm – 10pm	10pm – 7am
Residential buildings located less than 150 m from the construction site where the noise is being emitted	Monday to Saturday	-	65	55

Table 8-8: Maximum Permissible Noise Levels for Construction Works over a Period of 5 minutes

Types of Affected Buildings	Days of the Week	Maximum Permissible $L_{Aeq(5\ min)}$, dB		
		7am – 7pm	7pm – 10pm	10pm – 7am
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	All days	75	55	55
(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	Monday to Saturday	90	70	55
	Sundays & PHs	75	55	55
(c) Buildings (other than those in paragraphs (a) and (b))	All days	90	70	70
Notes: Regulated prohibited work periods for construction sites located within 150 m from residential premises and noise sensitive premises as follows: • From 10:00 pm every Saturday to 7am on the following Monday; and • From 10:00 pm on the eve of a public holiday (PH) to 7:00 am on the day following the public holiday.				

Based on the level of exceedances, noise barriers and other mitigation measures were proposed in the later sections of the report accordingly.

As per the legislation, if there are other sources of noise affecting the measurement of noise emitted from the construction site, the maximum permissible noise levels for construction sites are supposed to be adjusted by the addition of a correction factor to account for the existing background noise levels in the area. The correction factor corresponding to the difference between the relevant permissible level, and the background noise level is presented in **Table 8-9**. The difference in the noise levels was then added to the higher of the two noise levels (background noise/ criteria as appropriate) to give the applicable noise criteria for the specified construction area.

Table 8-9: Correction Factor to Account for Background Noise

Difference between Permissible & Background Noise Levels, db(A)	Correction Factor to be Added to the Higher of the Two Noise Levels, db(A)
Below 2	3

Difference between Permissible & Background Noise Levels, db(A)	Correction Factor to be Added to the Higher of the Two Noise Levels, db(A)
2 to 4	2
4 to 10	1
10 and above	Nil
Reference: Third Schedule of Environmental Protection and Management (Control of Noise at Construction Sites),2008	

Based on the baseline noise monitoring results above, the overall noise levels for $L_{Aeq(12\ hour)}$ / Average for $L_{Aeq(1\ hour)}$ and $L_{Aeq(5\ min)}$ dB at NM01, NM02, NM03 and NM04 were used to calculate the "adjusted maximum permissible noise level" in line with the directions given in **Table 8-9** to determine the construction noise criteria for this project.

Table 8-10 demonstrates application of the background noise correction factor to derive a construction noise criterion for $L_{Aeq(12\ hour)}$, dB for this project.

Table 8-10: Background Noise Correction Calculations for $L_{Aeq(12\ hour)}$, dB

Types of Affected Buildings	Noise Criteria for $L_{Aeq(12\ hour)}$, dB (Monday to Saturday)								Noise Criteria for $L_{Aeq(12\ hour)}$, dB (Sunday & Public Holiday)							
	NM01		NM02		NM03		NM04		NM01		NM02		NM03		NM04	
	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.																
Construction noise criteria as per **Table 8-6**	60	50	60	50	60	50	60	50	60	50	60	50	60	50	60	50
Overall baseline noise level as per **Table 8-2**	68	62	69	64	63	58	73	71	64	59	60	69	58	53	72	72
Difference between maximum permissible construction noise level and overall baseline noise level	8	12	9	14	3	8	13	21	4	9	0	19	2	3	12	22
Background noise correction factor based on **Table 8-9**	1	0	1	0	2	1	0	0	1	1	3	0	2	2	0	0
Corrected noise sensitive receptor criteria	69	62	70	64	65	59	73	71	65	60	63	69	62	55	72	72
(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted																
Construction noise criteria as per **Table 8-6**	75	NA	75	NA	75	NA	75	NA	75	NA	75	NA	75	NA	75	NA
Overall baseline noise level as per **Table 8-2**	68	62	69	64	63	58	73	71	64	59	60	69	58	53	72	72
Difference between maximum permissible construction noise level and overall baseline noise level	7	NA	6	NA	12	NA	2	NA	11	NA	15	NA	17	NA	3	NA

Types of Affected Buildings	Noise Criteria for $L_{Aeq(12\ hour)}$, dB (Monday to Saturday)								Noise Criteria for $L_{Aeq(12\ hour)}$, dB (Sunday & Public Holiday)							
	NM01		NM02		NM03		NM04		NM01		NM02		NM03		NM04	
	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am	7am – 7pm	7pm – 7am
Background noise correction factor based on **Table 8-9**	1	0	1	0	0	0	2	0	0	0	0	0	0	0	2	0
Corrected noise sensitive receptor criteria	76	NA	76	NA	75	NA	77	NA	75	NA	75	NA	75	NA	77	NA
(c) Buildings (other than those in paragraphs (a) and (b))																
Construction noise criteria as per **Table 8-6**	75	65	75	65	75	65	75	65	75	65	75	65	75	65	75	65
Overall baseline noise level as per **Table 8-2**	68	62	69	64	63	58	73	71	64	59	60	69	58	53	72	72
Difference between maximum permissible construction noise level and overall baseline noise level	7	3	6	1	12	7	2	6	11	6	15	4	17	12	3	7
Background noise correction factor	1	2	1	3	0	1	2	1	0	1	0	1	0	0	2	1
Corrected noise sensitive receptor criteria	76	67	76	68	75	66	77	72	75	66	75	70	75	65	77	73

Table 8-11 demonstrates application of the background noise correction factor to derive a construction noise criterion for $L_{Aeq(1\ hour)}$, dB - Monday to Saturday for this project.

Table 8-11: Background Noise Correction Calculations for $L_{Aeq(1hr)}$, dB

Types of Affected Buildings	Noise Criteria for $L_{Aeq(1\ hour)}$, dB (Monday to Saturday)							
	NM01		NM02		NM03		NM04	
	7pm – 10pm	10pm – 7am	7pm – 10pm	10pm – 7am	7pm – 10pm	10pm – 7am	7pm – 10pm	10pm – 7am
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.								
Construction noise criteria as per **Table 8-7**	65	55	65	55	65	55	65	55
Average baseline noise level as per **Table 8-2**	64	57	67	61	58	54	72	70
Difference between maximum permissible construction noise level and average baseline noise level	10	9	9	3	17	11	7	15
Background noise correction factor based on **Table 8-9**	0	1	0	2	0	0	1	0
Corrected noise sensitive receptor criteria	65	56	65	57	65	55	73	70

Table 8-12 demonstrates application of the background noise correction factor to derive a construction noise criterion for $L_{Aeq(5\ min)}$, dB for this project.

Table 8-12: Background Noise Correction Calculations for $L_{Aeq(5mins)}$, dB

Types of Affected Buildings	Noise Criteria for $L_{Aeq(5\ min)}$, dB (Monday to Saturday)												Noise Criteria $L_{Aeq(5\ min)}$, dB (Sunday & Public Holiday)											
	NM01			NM02			NM03			NM04			NM01			NM02			NM03			NM04		
	7am – 7pm	7pm – 10pm	10pm – 7am	7am – 7pm	7pm – 10pm	10pm – 7am	7am – 7pm	7pm – 7am	10pm – 7am	7am – 7pm	7pm – 7am	10pm – 7am	7am – 7pm	7pm – 10pm	10pm – 7am	7am – 7pm	7pm – 10pm	10pm – 7am	7am – 7pm	7pm – 7am	10pm – 7am	7am – 7pm	7pm – 7am	10pm – 7am
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.																								
Construction noise criteria as per **Table 8-8**	75	55	55	75	55	55	75	55	55	75	55	55	75	55	55	75	55	55	75	55	55	75	55	55
Average baseline noise level as per **Table 8-2**	66	64	54	68	66	61	61	58	53	73	72	71	63	63	63	64	64	64	57	56	56	72	75	75
Difference between maximum permissible construction noise level and average baseline noise level	9	9	1	7	11	6	14	3	2	2	17	16	12	8	8	11	9	9	18	1	1	3	20	20
Background noise correction factor based on **Table 8-9**	1	1	3	1	0	1	0	2	2	2	0	0	0	1	1	0	1	1	0	3	3	2	0	0
Corrected noise sensitive receptor criteria	76	65	58	76	66	62	75	60	57	77	72	71	75	64	64	75	65	65	75	59	59	77	75	75
(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted																								
Construction noise criteria as per **Table 8-8**	90	70	55	90	70	55	90	70	55	90	70	55	75	55	55	75	55	55	75	55	55	90	70	55
Average baseline noise level as per **Table 8-2**	66	64	54	68	66	61	61	58	53	73	72	71	63	63	63	64	64	64	57	56	56	72	75	75
Difference between maximum permissible construction noise level and average baseline noise level	24	6	1	22	4	6	29	12	2	17	2	16	12	8	8	11	9	9	18	1	1	18	5	20
Background noise correction factor based on **Table 8-9**	0	1	3	0	1	1	0	0	2	0	2	0	0	1	1	0	1	1	0	3	3	0	1	0
Corrected noise sensitive receptor criteria	90	71	58	90	71	62	90	70	57	90	74	71	75	64	64	75	65	65	75	59	59	90	76	75
(c) Buildings (other than those in paragraphs (a) and (b))																								
Construction noise criteria as per **Table 8-8**	90	70	70	90	70	70	90	70	70	90	70	70	90	70	70	90	70	70	90	70	70	90	70	70
Average baseline noise level as per **Table 8-2**	66	64	54	68	66	61	61	58	53	73	72	71	63	63	63	64	64	64	57	56	56	72	75	75
Difference between maximum permissible construction noise level and average baseline noise level	24	6	16	22	4	9	29	12	17	17	2	1	27	7	7	26	6	6	33	14	14	18	5	5
Background noise correction factor based on **Table 8-9**	0	1	0	0	1	1	0	0	0	0	2	3	0	1	1	0	1	1	0	0	0	0	1	1
Corrected noise sensitive receptor criteria	90	71	70	90	71	71	90	70	70	90	74	74	90	71	71	90	71	71	90	70	70	90	76	76

Following the background noise correction calculations above, the project criteria for construction noise impact assessment have been summarized in **Table 8-13.**

Table 8-13: Project Criteria for Construction Noise Impact Assessment

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq(12\ hour)}$, dB		Noise Criteria for $L_{Aeq(1\ hour)}$, dB		Noise Criteria for $L_{Aeq(5\ min)}$, dB		
		7am - 7pm	7pm - 7am	7pm -10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
Monday to Saturday								
NM01	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	69	62	NA	NA	76	65	58
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	76	NA	65	56	90	71	58
	(c) Buildings (other than those in paragraphs (a) and (b))	76	67	NA	NA	90	71	70
NM02	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	70	64	NA	NA	76	66	62
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	76	NA	65	57	90	71	62
	(c) Buildings (other than those in paragraphs (a) and (b))	76	68	NA	NA	90	71	71
NMO3	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	65	59	NA	NA	75	60	57
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	65	55	90	70	57
	(c) Buildings (other than those in paragraphs (a) and (b))	75	66	NA	NA	90	70	70
NMO4	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	73	71	NA	NA	77	72	71
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	77	NA	73	70	90	74	71
	(c) Buildings (other than those in paragraphs (a) and (b))	77	72	NA	NA	90	74	74
Sunday & Public Holiday								
NM01	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	65	60	NA	NA	75	64	64
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	NA	NA	75	64	64
	(c) Buildings (other than those in paragraphs (a) and (b))	75	66	NA	NA	90	71	71
NM02	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	63	69	NA	NA	75	65	65
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	NA	NA	75	65	65
	(c) Buildings (other than those in paragraphs (a) and (b))	75	70	NA	NA	90	71	71
NM03	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	55	NA	NA	75	59	59
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	NA	NA	75	59	59
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	NA	NA	90	70	70
NMO4	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	72	72	NA	NA	77	75	75
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	77	NA	NA	NA	90	76	75
	(c) Buildings (other than those in paragraphs (a) and (b))	77	73	NA	NA	90	76	76

8.2.5.2 Operation Noise

For operational noise, there are two aspects of impact: 1) operation of the air-conditioning and mechanical ventilation systems at the developments in the Study Area and 2) vehicular noise from road traffic at the developments in the Study Area.

8.2.5.2.1 Air-Conditioning and Mechanical Ventilation Systems Noise

The NEA Noise Guideline describes a non-industrial building as:

"Any permanent or temporary building or structure used for the purposes of trade, business or commerce and includes any shopping complex, financial institution, office tower, hotel, educational institution, hospital, transport infrastructures, community infrastructure, sport and recreational infrastructure but does not include any factory and residential premises."

The noise limits outlined in the NEA Noise Guideline shall, therefore, be used. These noise limits are outlined in **Table 8-14**.

Table 8-14: Boundary Noise Limits by NEA

Type of Affected Premises	Boundary Noise Limits (reckoned as the equivalent continuous noise level over 15 minutes), dB(A)		
	Day 7am to 7pm	Evening 7pm to 11pm	Night 11pm to 7 am
Noise Sensitive Premises such as hospital, home for the aged sick, library, etc.	60	55	50
Residential Premises	65	60	55
Others	70	65	60

In accordance with the guideline, noise from the sources under consideration was measured so as to determine the impact over a continuous 15-minute period. Adjustments to the measured noise level were applied to account for the effects of duration, tonality, intermittency and impulsiveness of the noise. The measured, adjusted 15-minute noise level was then assessed in relation to the noise limits.

Based on NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building **Section 4**, measurements were conducted as follows:

"For equipment installed at ground level, the noise measurements should be made at the site boundary. For equipment that is installed above ground level e.g. at roof-top, the noise measurements should be taken at least 1m from the noise source and at the same height as the equipment. The noise level shall be computed for a point that is at the site boundary and at the same height as the equipment."

It shall be noted that as per the Guideline, Correction Factors shall be applied to the values in **Table 8-15** to determine the final project-specific criteria. These Correction Factors shall be determined using the background noise level measured when each equipment item is switched OFF and incorporating the values into the proposed measurement methodology detailed in the following paragraph, which is based on **Section 5** of the NEA Guideline.

The maximum permissible noise levels for the project shall be selected on the basis of the above assumption and adjusted by the addition of a Correction Factor, to account for the existing background noise levels in the area. The Correction Factor corresponds to the difference between the applicable permissible level, and the background noise level (as stated in the Third Schedule of the legislation) and is presented in **Table 8-15.**

Table 8-15: Correction Factor

Difference between Permissible and Background Noise Levels dB(A)	Correction Factor dB(A)
Below 2	3
2 to less than 4	2

Difference between Permissible and Background Noise Levels dB(A)	Correction Factor dB(A)
4 to less than 10	1
10 and above	0

Based on the baseline noise monitoring results above, the overall noise levels for $L_{Aeq(15\ min)}$ dB at NM01, NM02, NM03 and NM04 were used to calculate the "adjusted maximum permissible noise level" in line with the directions given in **Table 8-15** to determine the operational boundary noise criteria for this project.

Table 8-16 demonstrates application of the background noise correction factor to derive an operation noise criterion for $L_{Aeq(15\ min)}$, dB – all days for this project.

Table 8-16: Background Noise Correction Calculations for $L_{Aeq(1hr)}$, dB (Operational Noise)

Type of Affected Premises	Noise Criteria for $L_{Aeq(15\ min)}$, dB											
	NM01			NM02			NM03			NM03		
	7am - 7pm	7pm - 11pm	11pm - 7am	7am - 7pm	7pm - 11pm	11pm - 7am	7am - 7pm	7pm - 11pm	11pm - 7am	7am - 7pm	7pm - 11pm	11pm - 7am
Noise Sensitive Premises such as hospital, home for the aged sick, library, etc.												
Boundary noise criteria as per **Table 8-14**	60	55	50	60	55	50	60	55	50	60	55	50
Average baseline noise level as per **Table 8-3**	67	66	57	68	67	59	62	58	53	73	72	70
Difference between maximum permissible construction noise level and average baseline noise level	7	11	7	8	12	9	2	3	3	13	17	20
Background noise correction factor based on Table **8-15**	1	0	1	1	0	1	3	2	2	0	0	0
Corrected noise boundary noise criteria	68	66	58	69	67	60	65	60	55	73	72	70
Residential Premises												
Boundary noise criteria as per **Table 8-14**	65	60	55	65	60	55	65	60	55	65	60	55
Average baseline noise level as per **Table 8-3**	67	66	57	68	67	59	62	58	53	73	72	70
Difference between maximum permissible construction noise level and average baseline noise level	2	6	2	3	7	4	3	2	2	8	12	15
Background noise correction factor based on Table **8-15**	3	1	3	2	1	1	2	2	3	1	0	0
Corrected noise boundary noise criteria	70	67	60	70	68	60	67	62	58	74	72	70
***Others**												
Boundary noise criteria as per **Table 8-14**	70	65	60	70	65	60	70	65	60	70	65	60
Average baseline noise level as per **Table 8-3**	67	66	57	68	67	59	62	58	53	73	72	70
Difference between maximum permissible construction noise level and average baseline noise level	3	1	3	2	2	1	8	7	7	3	7	10
Background noise correction factor based on Table **8-15**	2	3	2	2	3	3	1	1	1	2	1	0
Corrected noise boundary noise criteria	72	69	62	72	70	63	71	66	61	75	73	70

*Note that during the development of this report, there is no regulating noise criteria when the boundary of a Study Area is adjacent to a commercial premises. Based on past project experiences, a 5 dB(A) is added to the boundary noise criteria for “Residential Premises” to develop a noise criterion for this scenario.

Based on the baseline noise monitoring results, project-specific criteria have been developed in **Table 8-17**.

Table 8-17: Project Criteria for Operation Noise Impact Assessment

No	Type of Affected Premises	Noise Criteria for $L_{Aeq(15mins)}$, dB		
		7am - 7pm	7pm - 11pm	11pm - 7am
NM01	Noise Sensitive Premises such as hospital, home for the aged sick, library, etc.	68	66	58
	Residential Premises	70	67	60
	Others	72	69	62
NM02	Noise Sensitive Premises such as hospital, home for the aged sick, library, etc.	69	67	60
	Residential Premises	70	68	60
	Others	72	70	63
NMO3	Noise Sensitive Premises such as hospital, home for the aged sick, library, etc.	65	60	55
	Residential Premises	67	62	58
	Others	71	66	61
NMO4	Noise Sensitive Premises such as hospital, home for the aged sick, library, etc.	73	72	70
	Residential Premises	74	72	70
	Others	75	73	70

The boundary noise emissions due to the operation of the air-conditioning and mechanical ventilation systems at the proposed development is usually assessed against this NEA boundary noise guideline for non-industrial buildings. During the development of this EIS study, there were no building services design details available from the proposed developments in the Study Area. Hence, a quantitative impact assessment has been omitted in this report. Typically, a Noise Consultant is appointed by the design team for the individual HDB proposed development to carry out during the detailed design stage. Hence, the project-specific criteria developed above in **Table 8-17** only serves a guidance for the appointed Noise Consultants of the respective developments at a later stage.

8.2.5.2.2 Land Traffic Noise

Technical Guideline for Land Traffic Noise Impact Assessment provides guidance to conduct for the following:

Part 1 – Land traffic Noise Impact Assessment on new residential and noise sensitive developments located in close proximity to existing land traffic noise sources/hotspots (e.g. expressways/major arterial roads/MRT tracks); and

Part 2 – Land traffic Noise Impact Assessment on existing residential and noise sensitive developments located in close proximity to new transport-related developments (e.g. expressway/major arterial roads/MRT track/bus interchanges/bus depots), inclusive of the expansion of existing transport-related infrastructures.

The noise emissions due to movement of traffic shall be assessed against NEA's guidelines for the proposed development for operation of transportation network in the development within the Study Area. The noise levels of the new residential and noise sensitive development shall comply with the following NEA's noise requirement:

NEA's noise requirements are as follows:

(i) The noise levels at 1 m from the façade of the new residential/noise sensitive building shall not exceed $L_{Aeq(1hr)}$ 67 dB; and

(ii) The indoor noise level of the new residential/noise sensitive building under natural ventilation shall not exceed $L_{Aeq(1hr)}$ 57 dB.

This traffic noise assessment is typically conducted by a Noise Consultant appointed for the proposed developments for the residential and noise sensitive buildings for the project hence have been omitted in this report.

8.2.6 Prediction Methodology

8.2.6.1 Construction Noise

A quantitative assessment was conducted in accordance with the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008* which defines the noise criteria for buildings within 150 m from the boundary of the different construction areas. In order to assess the noise impact in line with the legislation, a 150 m assessment area was considered in this assessment from the Study Area. It is understood that if the noise impacts are reduced to non-significant levels within this Study Area, the impacts on receptors beyond the Study Area will be further reduced owing to both the distance and/or shielding from the front-line receptors. The noise impact assessment was conducted based on the master planning conducted by HDB for the development in the Study Area, hence conservative yet practical assumptions and necessary updates have been taken throughout the prediction modelling and assessment (wherever needed).

Based on the information received on the different construction phases, a quantitative noise modelling using Sound PLAN was conducted, followed by recommendation of mitigation measures (if necessary). Noise levels from all the phases of construction was studied and one representative worst-case scenario was modelled to obtain impacts at the sensitive receptors. It is understood that the mitigation proposed for this worst phase encompassed impacts from all construction activities of the project.

Unmitigated and Residual noise impacts at the nearest sensitive receptors were given both numerically and graphically, to represent the propagation of noise from project construction site.

The noise requires the following input information for modelling (to be detailed and complete):

1. Noise Sensitive (Affected) Receptors surrounding the study area (existing and future receptors);
2. Construction activities at the Study Area, along with their equipment information and activity schedule;
3. Topographical contours of Study Area;
4. Specifications of noise generating equipment and operating hours for each noisy equipment (for all phases of construction); and
5. Ground absorption data.

For item 4, AECOM assumed equipment information based on *BSI British Standards BS5228-1:2009 Code of practice for noise and vibration control on construction and open sites (Part 1: Noise)*. For item 5, ground absorption was assumed to be typical soil for non-paved areas and asphalt for roads.

8.2.6.2 Operational Noise

Referring to **Section 8.2.5.2**, it is mandatory for the proposed developments to comply against NEA's guidelines for traffic noise impact assessment and boundary noise impact assessment for non-industrial buildings. Usually conducted by an appointed Noise Consultant during the development stage, AECOM recommends the works for traffic noise impact assessment and ACMV boundary noise impact assessment be conducted in the later stages of the development in accordance with NEA's *Technical Guideline for Land Traffic Noise Impact Assessment* and *Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building* respectively.

8.2.7 Minimum Control for Impacts

This section proposes minimum controls or standard practices commonly implemented that have been assumed to be implemented for the purposes of impact assessment.

8.2.7.1 Construction Noise

Mitigation measures with the following principles were developed to control construction noise levels that are predicted to exceed the project criteria at the nearest noise sensitive receivers:

- **Elimination** - Where changes to the project design and construction methodology can be made to eliminate an identified impact, e.g., Exclusion of noisy construction phases to be conducted at evening/night period.
- **Substitution** - Where changes to the project design and construction methodology cannot affect impact elimination, compensatory measures can be adopted to mitigate for identified impacts. For e.g., substitution of the noisier Hammer Piler with alternative Silent Piler to reduce impacts to residents. As much as possible, alternative quieter equipment shall be used for the construction of the development in the Study Area.
- **Engineering controls** - Where changes to the project design and construction cannot affect impact avoidance or minimization, engineering controls can be adopted to mitigate for identified impacts (e.g. use of equipment enclosures wherever necessary).
- **Administrative controls** - Where applicable, enhanced mitigation can be achieved by applying administrative controls on top of engineering controls. Examples include proper scheduling of noisier construction activities, reducing work on weekends, etc.

The following control measures should be observed during the construction stage to reduce the noise levels:

- Construction prohibition period should be followed, as per fourth schedule of Environment Protection and Management regulation;
- Prepare a Construction Noise Management Plan, to establish pre-construction baseline monitoring, plan for monitoring during the construction phase, and procedure for complaint handling;
- The contractor shall review the equipment to be used on site and erect localised noise barriers prior to undertaking high noise generating work;

- Machines (such as trucks) that may be in intermittent use shall be shut down between work periods or shall be throttled down to a minimum;
- Only well-maintained plants shall be utilized on-site and plants shall be serviced regularly during the entire construction period;
- The number of PMEs shall be reduced as far as practicable when construction works are carried out at areas close to the noise sensitive receivers:
- Consider use of silencers or mufflers on construction equipment which are properly maintained during the construction programme while facing sensitive receptors;
- Behavioral practices including no shouting, no loud stereos/ radios on site, no dropping of materials from height, no throwing of metal items shall be ensured;
- Construction respite: Restrict high noise generating drilling activities only in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block, if possible;
- Periodic noise monitoring by an independent third party, to establish compliance with requirements and to advise on equipment causing concern, and additional potential mitigation measures;
- Plan the layout of the site by considering using materials and other large structural equipment as noise barriers;
- Plant known to emit noise strongly in one direction shall, wherever possible, be orientated so that the noise is directed away from the nearby NSRs; and
- Material stockpiles and other structures shall be effectively utilized, wherever practicable, in screening noise from on-site construction activities.
- Acoustic sheds should be provided at the locations of the noise generating activity such as operation of hand-held breaker.
- All construction works should be conducted within 8am to 6pm.

8.2.7.2 Operation Noise

The mechanical ventilation equipment would be designed and sited appropriately during detailed design phases to ensure boundary noise levels are in compliance with the adjusted boundary noise limits derived in **Table 8-17**. Some noise sources might be located close to the boundary and might need special attention for boundary noise limits compliance, and if necessary, would be equipped with additional mitigation measures, and are detailed in **Section 8.3**.

Minimum controls for the noise emission from the operation of the air-conditioning and mechanical ventilation systems are listed below:

- Use low air-conditioning and mechanical ventilation system equipment;
- Ensure that any exhaust outlet or intake from the mechanical ventilation system is designed to be adequately set back as far as possible from the boundary line of the development;
- Acoustic treatment if any to be designed and implemented;
- AC system to be designed with the AHU units placed at appropriate locations as set back from the boundary line of the development as possible; and
- Acoustic enclosures for outdoor equipment.

8.2.8 Impact Prediction and Evaluation during Construction Phase

Several assumptions had to be made for noise impact prediction and evaluation. These includes phasing of the construction, activities involved in construction, and construction areas. The construction areas are detailed in **Section 8.2.2**.

8.2.8.1.1 Construction Activities

While the project is in a preliminary design stage, the full scale, techniques, and schedule for construction and operational activities is not currently determined. For this EIS study, it has been assumed that the construction sequence for the proposed development will following the following order:

1. Demolition
2. Road Works
3. Clearance for Construction Area
4. Foundation Work (Substructures including piles and pile caps)
5. Superstructure (Pre-fab installation)
6. Landscape Works
7. Remove all temporary works and re-instatement

AECOM has conservatively assumed the timeline of road works based on the typical sequence of construction for roads. Refer to **Appendix F** for the typical construction timeline provided by HDB.

8.2.8.1.2 Construction Areas

It is understood that prior to commencing construction for the proposed development, preparatory works will be required to prepare road users, park users, surrounding buildings, and the site for the impending works. Typical preparatory work activities are discussed further in this section. A key initial preparation activity will be demolition of existing buildings and construction of road excess to the Study Area.

For the construction noise impact assessment, the construction areas have been modelled according to the construction phases detailed in **Section 8.2.2**.

AECOM also understands that the project will be constructed during normal hours of operation, and construction activities at night have not been considered. **Table 8-18** summarises typical working days and hours for construction.

Table 8-18: Hours of Operation for Construction Activities for the development in the Study Area

Construction Activities	Key Points
General Construction (Excavation, Truck Movements, Equipment Operating, etc.)	8am to 6pm, 6 days per week (site will be closed on Sundays)

8.2.8.1.3 Construction Schedule and Calculation of Source Sound Power Levels

The timeline and duration of all construction activities and the equipment inventory list provided by HDB were reviewed to provide a basis for determining noise levels. For the construction noise impact assessment, the following noise sources have been input into the noise model. The four phases detailed below are explained in **Section 8.2.2**.

Phase 1 Demolition - The cumulative noise emissions from the construction activities during demolition have been modelled to assess the construction noise impacts for this phase assuming that these works will have to be completed before access is available into the Study Area for further construction works in the Study Area.

Phase 2 Roadworks - The cumulative noise emissions from the construction activities during the road works have been modelled to assess the construction noise impacts for this phase assuming that these works will have to be completed before access is available into the Study Area for further construction works in the Study Area.

Phase 3 Construction of Proposed Development - Based on the high-level project timeline provided, construction activities at all construction areas for the public housing construction footprints will happen simultaneously. Within the proposed timeline, the phase of construction with highest cumulative noise emissions from the different construction phases was then modelled to predict the noise levels at the nearby sensitive receptors.

8.2.8.2 Prediction of Noise Impacts

The cumulative noise generated by PMEs was predicted. For the prediction calculations, the effective sound power level (L_w, dB) from all equipment was considered as a noise emission area source for all equipment operating concurrently.

The purpose of the calculation was to estimate an expected noise level for assessing the potential noise impacts to the NSRs, and subsequently providing appropriate mitigation measures wherever perceived necessary.

To provide a conservative and practical noise level assessment, the PME for the proposed project was assessed for the different construction areas and the specific construction phase with the highest cumulative Sound Power Level (L_w, dB) generated of all the components was considered for the quantitative assessment. The assumption is conservative yet practical and is consistent with the precautionary principle for environmental impacts. Details on sound power levels from individual PMEs for every construction phase is provided in **Appendix F.**

Table 8-19: Effective L_{wA} from all Construction Phases

Construction phase	Effective sound power level, L_{wA}, dB from overall construction activities	
	$L_{Aeq(12\ hour)}$, dB	$L_{Aeq(5\ min)}$, dB
Demolition – Phase 1	124	127
Roadworks – Phase 2	113	116
Foundation Work	119	122
Superstructure (Prefab Installation) – Phase 3	124	127
Landscape Works	106	109
Removal of all Temporary Works and Re-instatement	107	110

Based on the analysis of the results in **Table** 8-19, the highest effective L_{wA} was predicted during 'Demolition' and 'Superstructure'. Hence, the assessment was carried out for the predicted level of $L_{Aeq(12hours)}$ - 124Db and $L_{Aeq(5mins)}$ - 127dB for Phase 1and 3. For Phase 2, the assessment was carried out with the predicted level of $L_{Aeq(12hours)}$ – 113dB and $L_{Aeq(5mins)}$ – 116dB.

8.2.8.3 "Pre" Mitigation Noise Impact Assessment Results

The predicted noise levels from SoundPLAN for the worst-case scenario for $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ were assessed against the applicable noise criteria for each receptor. The summary of results for $L_{Aeq(12\ hour)}$ are provided in **Table 8-20,** while the summary of results for $L_{Aeq(5\ min)}$ are provided in **Table 8-21**. **Appendix G** shows the detailed tabulated results for the "pre" mitigation noise impact assessment.

Human Impacts

For Phase 1 (Demolition), the predicted unmitigated noise level shows exceedances of the project criteria at up to 27 noise sensitive receptors with the maximum exceedances of 3dB(A) at , NSR Priority 1, 5 db(A) at NSR Priority 2 and 2 dB(A) at NSR Priority 3. Based on the impact evaluation methodology stated in **Section 6.4**, the highest exceedance 3 dB(A) at NSR Priority 1 resulted in Low impact intensity, resulting in Low impact consequence. The likelihood of the noise level exceeding during the duration of construction is Occasional. Hence, the worst-case impact significance level is **Minor** for NSR Priority 1. For the NSR Priority 2, the highest exceedance 5 dB(A) resulted in Medium impact intensity, resulting Medium impact consequence and the impact significance level became **Moderate**. For the NSR Priority 3, the highest exceedance 2 dB(A) resulted in Low impact intensity, resulting Low impact consequence and the impact significance level became **Minor**. Mitigation measures are required for impact significance of Moderate (refer to **Section 8.3.1** for proposed mitigation measures).

The predicted construction noise level for Phase 2 (Roadworks) and Phase 3 (Construction of proposed development) show no exceedances and were predicted to meet the project criteria for both $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ mins)}$. Hence, the overall impact significance is **Minor** for NSR Priority 1 and NSR Priority 2 and **Negligible** for NSR Priority 3 .

It is to be noted that exceedances were also expected at Eton House Pre-School (Thomson), Saint Joseph Institute and Lee Ah Mooi Old Age Home. These receptors are located beyond the busy highway of PIE and Thomson Road. However, the adjusted criteria for these receptors were derived based on

monitoring results from NM01 noise logger, which was located along Mount Pleasant Road, away from Thomson Road (refer to **Figure 8-1** for baseline monitoring location). Hence, the baseline noise levels at these receptors may have been much higher compared to what were assumed based on NM01. Therefore, even though there were some exceedances predicted at these receptors, further mitigation specific for these 3 receptors was not considered or assessed at this stage. AECOM recommends the contractor to conduct baseline monitoring for future mitigation and assessment. **Figure 8-4** to **Figure 8-9** shows the noise contours for $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ for Phase 1, Phase 2 and Phase 3 of the construction sequence respectively.

Table 8-20: Summary of Prediction and Evaluation of Noise Impacts for Construction Works – Monday to Saturday 7:00am -7:00pm, $L_{Aeq(12\ hour)}$,

Phase	Receptor Sensitivity	Worst-case Exceedance L_{Aeq}, dB	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
1 - Demolition	1	3	Low	Low	Occasional	Minor
	2	5	Medium	Medium	Occasional	Moderate
	3	2	Low	Very Low	Occasional	Minor
2 - Roadworks	1	-	Negligible	Very Low	Occasional	Minor
	2	-	Negligible	Very Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible
3 – Construction of Proposed Development	1	-	Negligible	Very Low	Occasional	Minor
	2	-	Negligible	Very Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible

Table 8-21: Summary of Prediction and Evaluation of Noise Impacts for Construction Works – Monday to Saturday 7:00am -7:00pm, $L_{Aeq(5\ min)}$,

Phase	Receptor Sensitivity	Worst-case Exceedance L_{Aeq}, dB	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
1 - Demolition	1	2	Low	Low	Occasional	Minor
	2	-	Negligible	Very Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible
2 - Roadworks	1	-	Negligible	Very Low	Occasional	Minor
	2	-	Negligible	Very Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible
3 – Construction of Proposed Development	1	-	Negligible	Very Low	Occasional	Minor
	2	-	Negligible	Very Low	Occasional	Minor

KOPI SUA
CEMETRY

0 105 210 420 M

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptors
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity
- 1
- 2
- 3

Criterion:
Priority 1: 69 to 73 dB(A)
Priority 2: 75 to 77 dB(A)
Priority 3: 76 dB(A)

Noise level
Leq (12 Hours)
in dB(A)

	<= 66
66 <	<= 69
69 <	<= 72
72 <	<= 75
75 <	<= 78
78 <	<= 81
81 <	<= 84
84 <	

N

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**CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT**

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Figure Title :
**PRE-MITIGATED (LEQ12 HOURS) 7am-7pm
NOISE CONTOURS-PHASE 1**

Figure No. :	Rev.	Sheet
8 - 4	02	1 of 1

CAD File Name : NA A3

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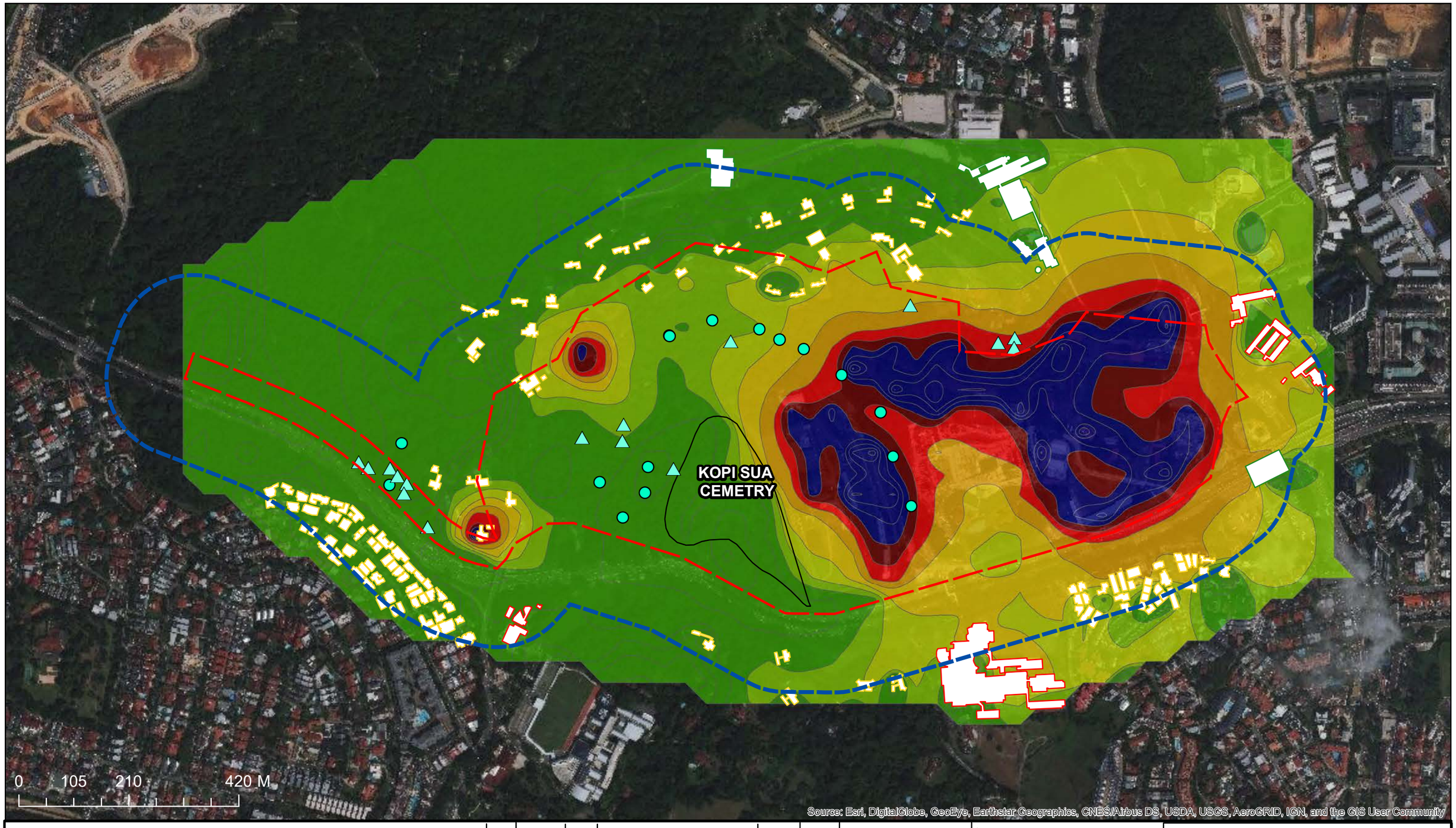

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptors
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

Criterion:
Priority 1: 75 to 77 dB(A)
Priority 2: 90 dB(A)
Priority 3: 90 dB(A)

Noise level
Leq (5 Mins)
in dB(A)

72 <	<= 72
75 <	<= 75
78 <	<= 78
81 <	<= 81
84 <	<= 84
87 <	<= 87
90 <	<= 90

N

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Figure Title :
**PRE-MITIGATED (LEQ5 MINS) 7am-7pm
NOISE CONTOURS-PHASE 1**

Figure No. :	Rev.	Sheet
8 - 5	02	1 of 1

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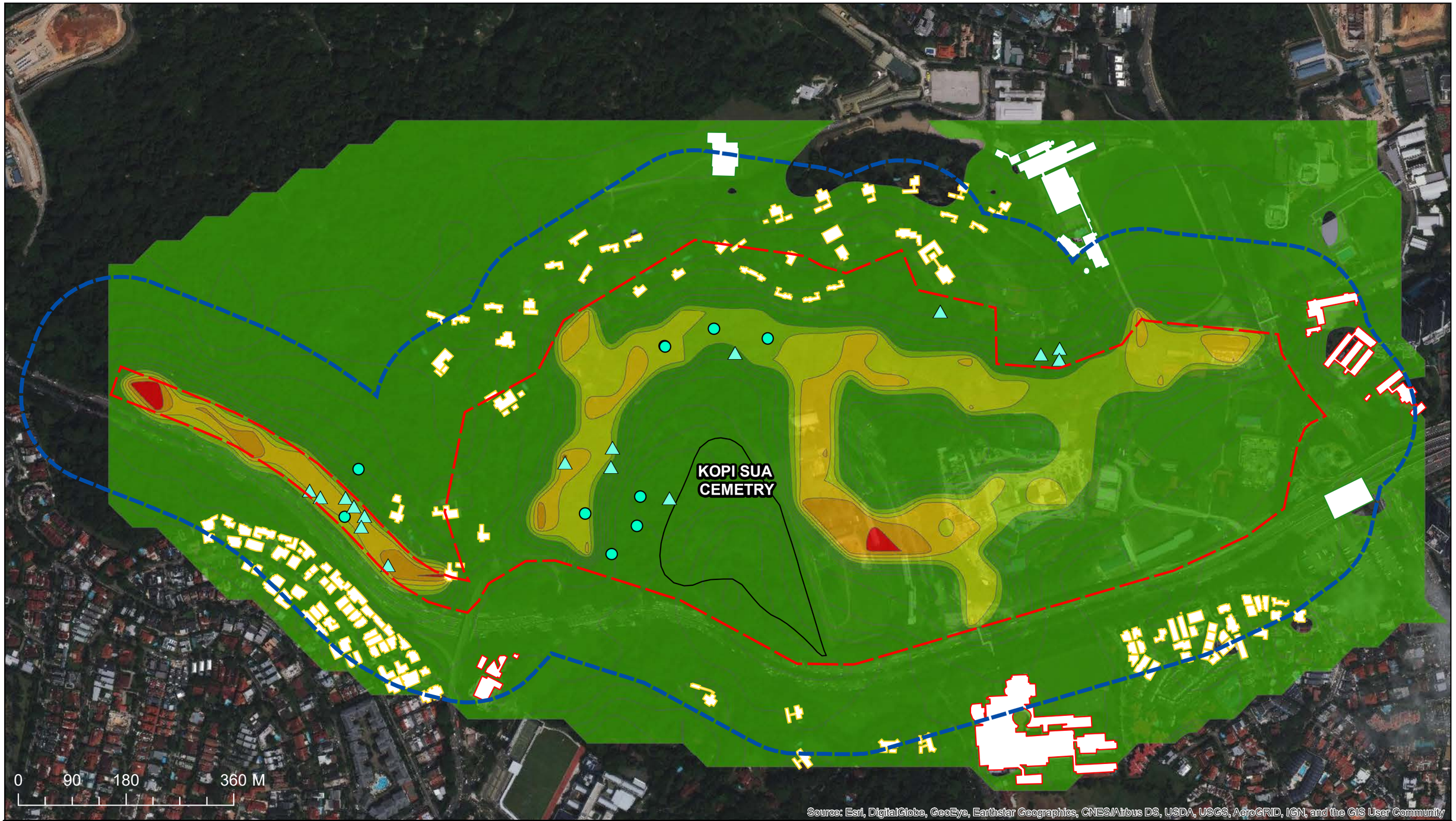

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

Criterion:
Priority 1: 69 to 73 dB(A)
Priority 2: 75 to 77 dB(A)
Priority 3: 76 dB(A)

Noise level
Leq (12 Hours)
in dB(A)

66 <	<= 66
69 <	<= 72
72 <	<= 75
75 <	<= 78
78 <	<= 81
81 <	<= 84
84 <	

N

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Figure Title :
**PRE-MITIGATED (LEQ12 HOURS) 7am-7pm
NOISE CONTOURS-PHASE 2**

Figure No. :	Rev.	Sheet
8 - 6	02	1 of 1

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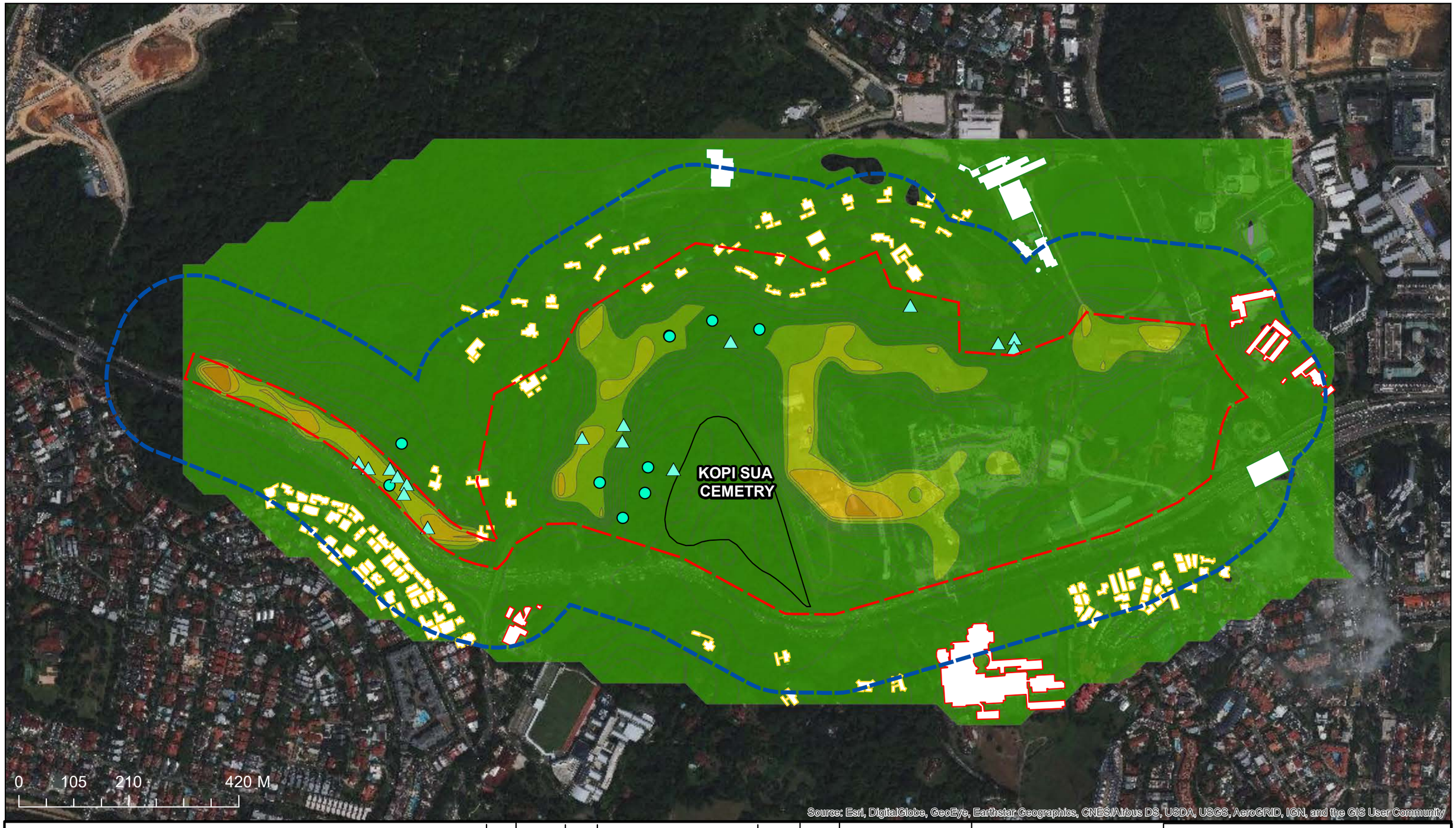

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

Criterion:
Priority 1: 75 to 77 dB(A)
Priority 2: 90 dB(A)
Priority 3: 90 dB(A)

Noise level
Leq (5 Mins)
in dB(A)

72 <	<= 72
75 <	<= 75
78 <	<= 78
81 <	<= 81
84 <	<= 84
87 <	<= 87
90 <	<= 90

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Figure Title :
**PRE-MITIGATED (LEQ5 MINS) 7am-7pm
NOISE CONTOURS-PHASE 2**

Figure No. :	Rev.	Sheet
8 - 7	02	1 of 1

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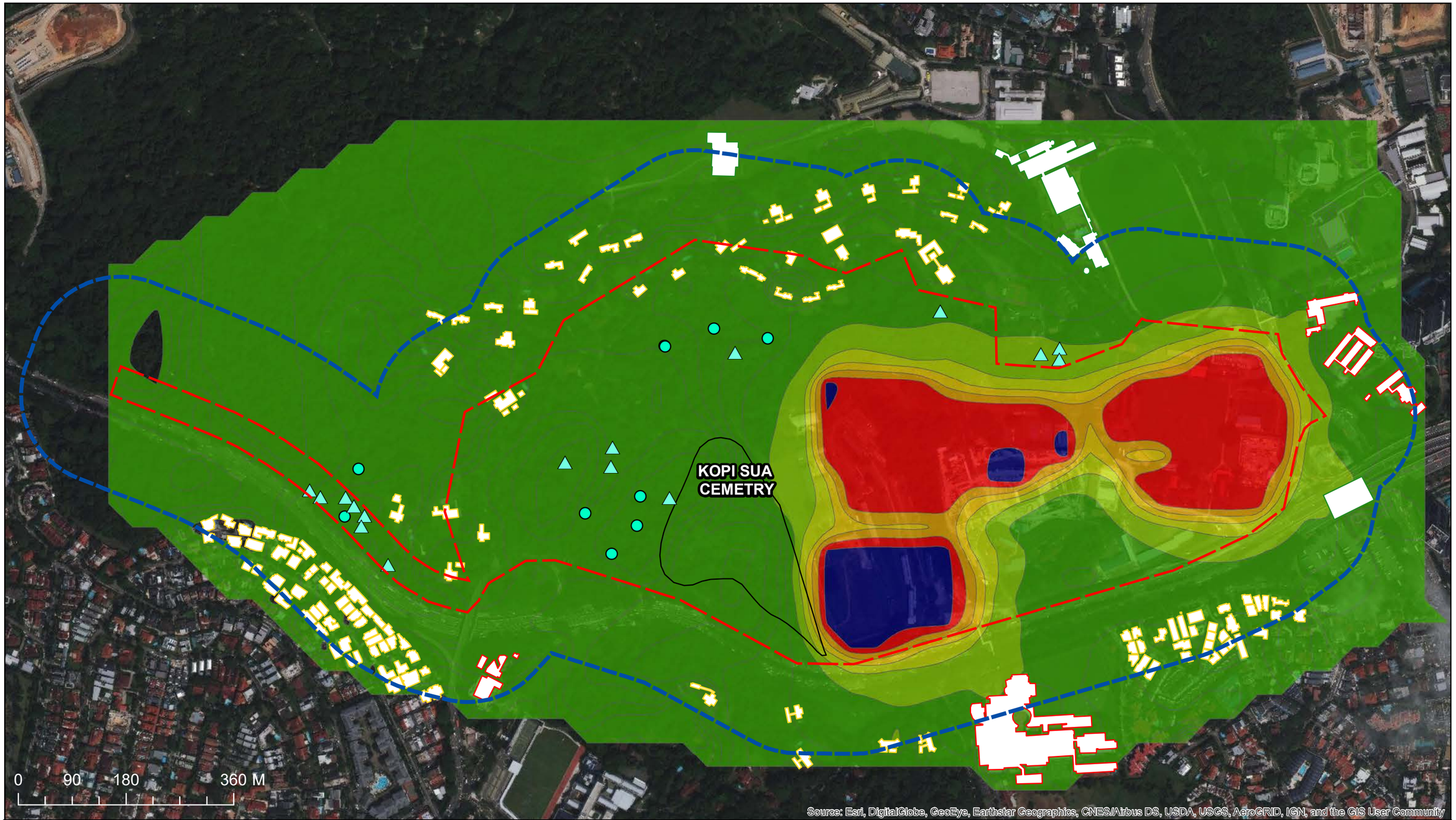

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

Criterion:
Priority 1: 69 to 73 dB(A)
Priority 2: 75 to 77 dB(A)
Priority 3: 76 dB(A)

Noise level
Leq (12 Hours)
in dB(A)

	<= 66
66 <	<= 69
69 <	<= 72
72 <	<= 75
75 <	<= 78
78 <	<= 81
81 <	<= 84
84 <	

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Figure Title :
**PRE-MITIGATED (LEQ12 HOURS) 7am-7pm
NOISE CONTOURS-PHASE 3**

Figure No. :	Rev.	Sheet
8 - 8	02	1 of 1

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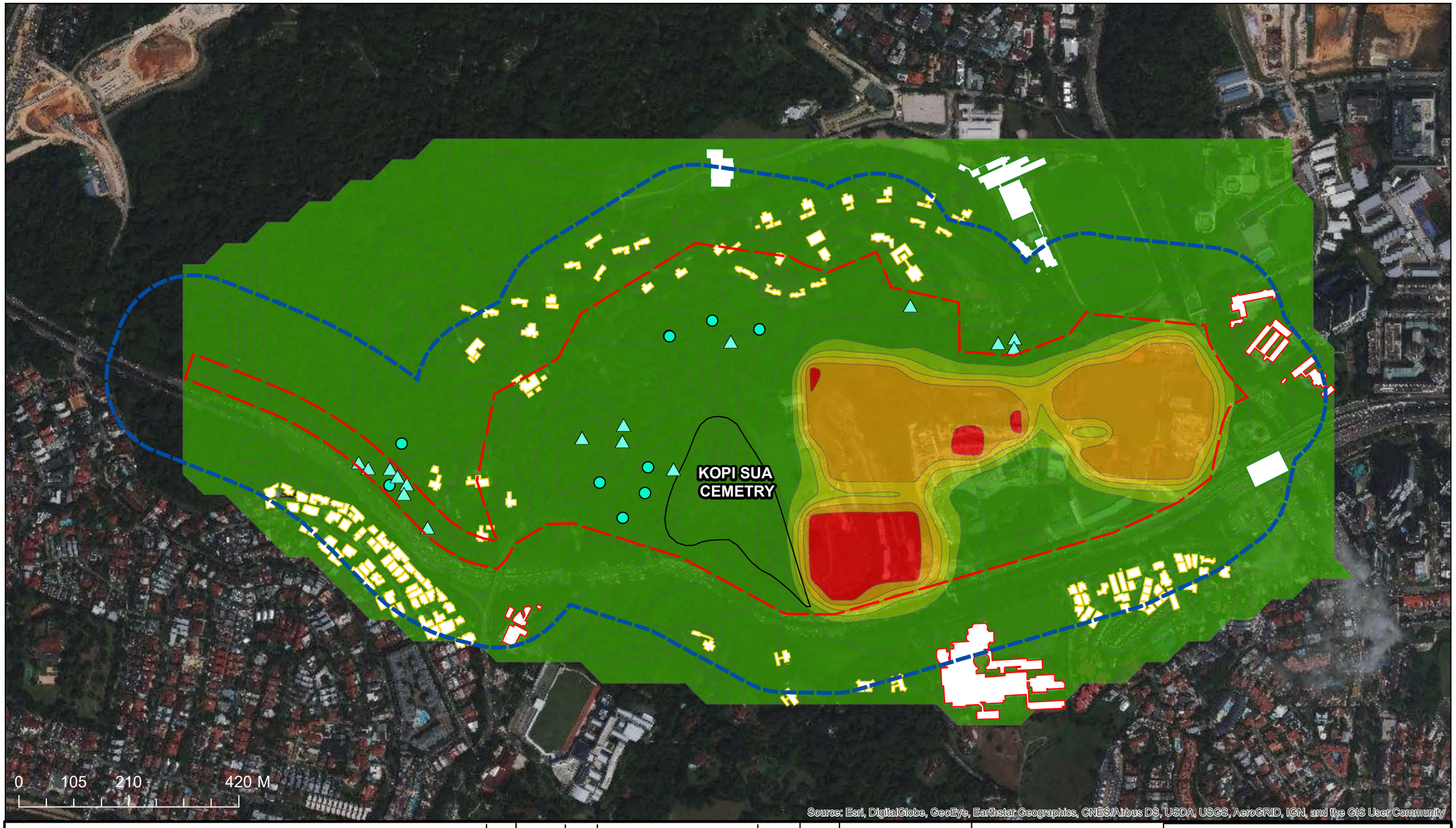

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

Noise level
Leq (5 Mins)
in dB(A)

72 <	<= 72
75 <	<= 75
78 <	<= 78
81 <	<= 81
84 <	<= 84
87 <	<= 87
90 <	<= 90

Criterion:
Priority 1: 75 to 77 dB(A)
Priority 2: 90 dB(A)
Priority 3: 90 dB(A)

N

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Figure Title :
**PRE-MITIGATED (LEQ5 MINS) 7am-7pm
NOISE CONTOURS-PHASE 3**

Figure No. :	Rev.	Sheet
8 - 9	02	1 of 1

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Ecological Impacts

Referring to **Section 8.2.1,** it is understood that during the construction phase, the nearby forested area which includes Kopi Sua Cemetery houses several habitats for the ecological receptors (fauna). For this EIS study, construction noise impacts on fauna was evaluated based on the noise sensitivity of the species. For this project, Priority 1 fauna has been identified within the Study Area based on the outcomes of the biodiversity surveys. Known Priority 1 receptors include Bamboo Clusters which serve as habitats for Bamboo Bats. Stream 1 and 2, which are habitats to the Collared Threadtail damselfly, as well as other birds, odonates and butterflies within the Study Area were not identified as receptors since their habitats will be removed due to road construction. For the rest of the construction period, these receptors will no longer exist once they are cleared. The larger impact of noise in this area is due to redevelopment of the streams and habitat itself. Whether these species will eventually take shelter or develop new habitat during the construction phase is uncertain, hence it was difficult to analyse the impact of noise on these species related to the streams. However, the construction noise impact to birds and butterflies which are mobile are deemed unlikely to be affected due to their ability to migrate to the nearby Kopi Sua Cemetery or Bukit Brown Woods.

For Phase 1 (Demolition), the predicted $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ mins)}$ noise levels at ecological receptors exceeded the project criteria at up to 15 noise sensitive receptors with maximum exceedances of 17 dB(A) for Monday to Saturday 7am – 7pm. Based on the impact evaluation methodology stated in **Section 6.4**, the exceedance resulted in a High impact intensity and High impact consequence. The likelihood of the noise level exceeding during the duration of construction is Occasional. Hence, the impact significance level is **Moderate**.

For Phase 2 (Roadworks), the predicted $L_{Aeq(12\ hour)}$ noise levels at ecological receptors exceeded the project criteria at up to 6 noise sensitive receptors with maximum exceedances of 7 dB(A) for Monday to Saturday 7am – 7pm. the exceedance resulted in a High impact intensity and High impact consequence. The likelihood of the noise level exceeding the $L_{Aeq(12\ hour)}$ criteria during the duration of construction is Occasional. Hence, the impact significance level is **Moderate**. Mitigation measures are required for impact significance of Moderate (refer to **Section 8.3.1** for proposed mitigation measures).

The predicted construction noise level for Phase 3 (Construction of Proposed Development) showed no exceedances and met the project criteria for both $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ mins)}$ especially because the receptors were no longer considered existent at and around the stream habitat. Hence, the overall impact significance is **Minor**.

In accordance with the impact with the impact evaluation in **Section 6.4.2**, the impact prediction and evaluation during construction phase is presented in **Table 8-22**.

Table 8-22: Summary of Prediction and Evaluation of Noise Impacts for Construction Phases – Biodiversity Impacts

Phase	Biodiversity Sensitive Receptor	Worst-case Exceedance L_{Aeq}, dB	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
Demolition	Priority 1	17	High	High	Occasional	Moderate
Roadworks	Priority 1	7	High	High	Occasional	Moderate
Construction of Proposed Development	Priority 1	-	Negligible	Very Low	Occasional	Minor

Mitigation measures were recommended to reduce the Impact Significance as presented in **Section 8.3.**

8.2.9 Impact Prediction and Evaluation during Operational Phase

Human Impacts

Referring to **Section 8.2.5.2.1**, it is mandatory for the proposed developments to comply against NEA's guidelines for traffic noise impact assessment and boundary noise impact assessment for non-industrial buildings. Usually conducted by an appointed Noise Consultant during the development stage, AECOM recommends the works for traffic noise impact assessment and ACMV boundary noise impact assessment be conducted in the prelim design stage of the development in accordance with NEA's *Technical Guideline for Land Traffic Noise Impact Assessment* and *Technical Guideline on Boundary*

Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building respectively.

For the ACMV boundary noise impact assessment, immediate boundary of the developments should be assessed against the corrected criteria, especially for boundaries fronting noise sensitive receptors. For traffic noise impact assessment, the developers of the residential developments should assess the noise impact from the proposed roads and the PIE (if within audible range).

Ecological Impacts

Referring to **Section 8.2.1**, it is understood that during the operational phase, the nearby forested area which includes Kopi Sua Cemetery houses several habitats for the ecological receptors (fauna). For this EIS study, operational noise impacts on fauna were evaluated based on the noise sensitivity of the species. For this project, Priority 1 receptors include bamboo clusters which serve as habitats for Bamboo Bats and the streams. If the streams are impacted due to do the road construction, then the bamboos directly surrounding the streams would be impacted by the clearance of the streams, rather than by the noise impacts. Therefore, the more severe impact considered is the redevelopment of the stream, compared to the airborne noise in this area. Whether these species will eventually shift roosting locations or new suitable bamboo clusters will grow is uncertain at this stage, hence it was difficult to analyse the impact of noise and a more conservative approach is taken.

For species with habitats in the Kopi Sua such as bamboo bats, the distance of the nearest new road development from the identified habitat is 210m. It is known that the noise propagation reduces with distance. It is also possible that with time in operational stage, the faunal species may adapt itself to a continuous noise level. However, at this stage data was neither available as to the traffic predicted on the road, or the ACMV details, for the report to predict the increase in baseline noise levels.

NM02 is the nearest noise monitoring location to the ecological receptor. The average baseline at NM02 $L_{Aeq(15min)}$ is 59-68 dB(A). Compared with the NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building for the most stringent, noise sensitive criteria, the baseline at NM02 is higher than the regulation. Assuming that this regulation will be met, there will be minimal to no detectable change in noise level in the area. The impact intensity will be negligible and Very Low impact consequence. The likelihood of the noise level exceeding the criteria during the operation is Occasional. Hence, the impact significance level is Minor.

In accordance with the impact with the impact evaluation in **Section 6.4.2**, the impact prediction and evaluation during operational phase is presented in **Table 8-22**.

Table 8-23: Summary of Prediction and Evaluation of Noise Impacts for Operational Phase – Biodiversity Impacts

Biodiversity Sensitive Receptor	Receptor Sensitivity	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
Priority 1	1	Negligible	Very Low	Occasional	Minor

8.3 Recommended Mitigation Measures

8.3.1 Construction Noise

Due to the proximity of sensitive receptors to the construction boundary, mitigation measures for control of noise at the source were recommended. Special attention was called for in assessing and mitigating impacts from construction in the vicinity of the Bukit Brown Woods which has features and habitats of high ecological value.

Based on the *Singapore Standards Code of Practice for Noise Control at Construction Sites, 2014 (SS602:2014)*, the typical materials used for noise barriers are given below:

Noise Barriers

The barrier height and placement position of a noise barrier are the prime factors determining its efficiency. Acoustic specification of the noise barrier shall be determined based on the quantitative noise impact assessment to be conducted at later stage. The following factors are to be accounted for, while erecting a barrier:

- The barrier shall be placed as close as possible to either the source or the receiver position, for maximum effectiveness;
- Materials having noise absorptive properties shall be used for the inner side of the noise barrier (facing the site); and
- It is necessary to bend the barriers around the noise source, so as to avoid passage of sound around the ends. Typically, the length of the barrier shall be at least ten times the height of the barrier.
- AECOM proposes noise barrier based on the predicted noise impact assessment 5m and 12m high noise barrier to be erected during Phase 1-Demolition at the location near the demolition building which is facing the noise sensitive receptors in order to mitigate the construction noise. Location of noise barrier are presented in Figure 8-10 .

For the birds and butterflies of high conservation significance, it is possible that due to the mobility of these species, migration to either Kopi Sua Cemetery or Bukit Brown Woods could occur.

Source Control Measures

Table 8-24 provides information on methods of quietening PME to be adopted as further mitigation. The maximum reduction level in **Table 8-24** is achievable when all source control measures stated in this table are adopted. Noise enclosures should be used at the locations of the noise generating equipment at the construction site. Acoustic sheds should be provided at the locations of the noise generating activity such as operation of hand-held breaker.

Table 8-24: Control of Noise Source from Construction Site

Type of Equipment	Equipment	Reduction Level, dB(A) [1]	Description of Source Control
Compressors & Generators	Generators	-20	Acoustic dampening of metal casing of body shell; acoustic enclosure or screen between the generator and receptor. The acoustic casing for the generator shall be proprietary product supplied by the generator manufacturer. The screen, if used, shall be as close as possible to the generator and it shall be of a solid construction (minimum STC 20 or surface density > 20kg/m^2) with no gaps at the bottom or in-between panels.
Hacking major structures	Excavator with Rock Breaker	-15	Use of an acoustic shed with adequate ventilation for the machine and bit.
Earth-moving Plant	Crane	-10	Manufacturers' enclosure panels to be kept

Type of Equipment	Equipment	Reduction Level, dB(A) [1]	Description of Source Control
	Roller	-10	closed. The engines of these vehicles shall not be exposed and clad with the manufacturers' enclosure to reduce noise break-out. Manufacturer-supplied silencers for the engine exhausts shall be installed and maintained.
	Gantry Crane	-10	
	Dump Truck	-10	
	Excavator with Rock Breaker	-10	
	Excavator	-10	
	Concrete Mix Truck	-10	
	Lorry	-10	
	Paver	-10	
Pumps	All Pumps	-10 to -20	Use of acoustic enclosure
Piling Rig	Bore Piling Machine	-10	Acoustic dampening of panels and covers; careful alignment of pile and rig; regular cleaning, oiling and greasing of the rig. The screening shall be as close as possible to the pile-driving and extracting activities and shall be of a solid construction (minimum STC 20 or surface density > 20kg/m^2) with no gaps at the bottom or in-between panels (in the direction of the receiver cutting line-of-sight between the noise source and the receiver, on three sides as a minimum). A micropile (small diameter pile) may be used for smaller construction footprint for impact on biodiversity, however, this aspect does not impact noise assessment significantly.
Note: [1] The noise reduction level makes reference to BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise			

Based on the *Singapore Standards Code of Practice for Noise Control at Construction Sites, 2014 (SS602:2014)*, the typical materials used for acoustic shed/ enclosure are given below:

Acoustic Shed / Enclosure:

A typical machine acoustic enclosure covers the machine as fully as possible (with/without ventilation), providing adequate sound insulation that noise energy does not readily pass through it. In addition, it could also have a sound absorbing material lining, to avoid the build-up of sound energy inside. In general, an acoustic enclosure could include:

- Outer cover material made up of brickwork, fibreboard or plasterboard. Thickness of the insulating cover depends on the material used;
- Inner lining of sound absorbing material such as glass fibre, mineral wool, straw slabs, wood wool slabs can be used. A thickness of at least 25mm is to be provided in case of high frequency sound, whereas a 12mm thick lining would suffice for low frequency sound; and
- Perforated sheet coverings can be used to protect the inner lining material, especially if it is glass wool or mineral wool-based lining.

In the case of a more permanent or substantial machine enclosure or acoustic shed, concrete breezeblock and open textured blockwork can be more effective alternatives as these are known to be durable, inexpensive and quick to assemble, and provide a useful degree of sound absorption.

In addition to the above measures, an EMMP for noise has been prepared, for management of potential impacts from noise during construction phase. Details of the same are provided in **Section 14.16.**

KOPI SUA CEMETRY

0 100 200 400 M

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Proposed Noise Barrier (12m)
- Proposed Noise Barrier (5m)
- Ecological Receptor
- Study Area
- Kopi Sua Cemetery
- Bamboo Clusters
- Noise Assessment Area (150m)

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

N

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Figure Title : **Proposed Noise Barrier Loacations For Phase 1**

Figure No. : 8 - 10 | Rev. 02 | Sheet 1 of 1

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8.3.1.1 Recommended Monitoring Program

An airborne noise monitoring program can be implemented if required by the Client, see AECOM's proposed program in **Table 8-25**. Catholic Junior School, 23 Mount Pleasant Drive, 151 Mount Pleasant Road, Singapore Polo Club and 115 Whiley Road were recommended as those are the nearest sensitive airborne noise receptor to the construction area which are representative of human impacts.

Table 8-25: Recommended Monitoring Program (Airborne Noise)

No.	Location	Parameter/s	Frequency and duration
1	Catholic Junior School	$L_{Aeq(12\ hour)}$, $L_{Aeq(1\ hour)}$, and $L_{Aeq(5\ min)}$	For construction phase: pre-construction baseline and continuous monitoring for the entire duration of the construction phase of the fore mentioned parameters at these locations or at boundary of each construction boundary
2	23 Mount Pleasant Drive		
3	115 Whiley Road		
4	151 Mount Pleasant Road		
5	Singapore Polo Club		

8.3.2 Operation Noise

At this stage, we have provided preliminary mitigation measures for consideration in **Table 8-26**.

Table 8-26: Proposed Mitigation Measures during Operational Stage (Human Impact)

Potential Noise Sources		Proposed Mitigation Measures
Public Residential development,	ACMV System, e.g. Intake/Exhaust Fans and Outdoor Compressors, etc.	Noise attenuators and other Best Available Technology (BAT) and Best Environmental Practice (BEP) noise control measures shall be utilised
	Increased road traffic at the developments	Traffic noise at the drop-off points and parking areas shall be mitigated with low speed postings, humps and signage. The addition of these speed will likely lower noise levels from the traffic as the vehicles will be cruising at lower speeds.

Due to lack of literature available regarding possible impacts of operational noise (ACMV and traffic) to the ecological receptors, the approach to mitigate noise proposed above for human impact was employed. It was assumed that due to operation of the buildings specified above, ecology receptors with high mobility (Bamboo bats, birds and butterflies of conservation significance) will migrate to either Kopi Sua Cemetery or Bukit Brown Woods to distant from these operational noises. The approach to mitigate noise due to ACMV systems and road traffic as per **Table 8-26** is recommended to be employed to reduce operational noise as far as possible.

A noise monitoring programme for the operational phase is not required at this stage due to lack of information regarding the traffic volume and ACMV design. Hence, AECOM recommends the works for traffic noise impact assessment and ACMV boundary noise impact assessment be conducted in the prelim design stage of the development in accordance with NEA's *Technical Guideline for Land Traffic Noise Impact Assessment* and *Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building* respectively.

8.4 Residual Impacts

8.4.1 Construction Phase

Human Impacts

Residual construction impact assessment assumes that the mitigation measures within Section 8.3 are implemented in the construction areas. The impact intensity at the receptors were expected to be reduced from Moderate to Minor in Phase 1.

For Phase 1 (Demolition), the predicted residual noise level shows exceedances of the project criteria at up to 6 noise sensitive receptors with the maximum exceedances of 2 dB(A) at NSR Priority 1, 2 db(A) at NSR Priority 2. Based on the impact evaluation methodology stated in **Section 6.4**, the highest exceedance 2 dB(A) at NSR Priority 1 resulted in Low impact intensity, resulting in Low impact consequence. The likelihood of the noise level exceeding during the duration of construction is Occasional. Hence, the worst-case impact significance level is **Minor** for NSR Priority 1.

For the NSR Priority 2, the highest $L_{Aeq(12\ hours)}$ exceedance 2 dB(A) resulted in Low impact intensity, resulting Low impact consequence and the impact significance level became **Minor**. No exceedance were predicted for $L_{Aeq(5\ mins)}$ at NSR Priority 2 and impact significance level became **Negligible**. No exceedances were predicted at NSR Priority 3 and impact significance level became **Negligible**.

The predicted residual construction noise level for Phase 2 (Alternative Roadworks) and Phase 3 (Construction of Proposed Development) show no exceedances and were predicted to meet the project criteria for both $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ mins)}$. Hence, the overall impact significance is **Minor** for NSR Priority 1 and NSR Priority 2 and **Negligible** for NSR Priority 3. The residual Impact Significance is shown in Table 8-27 to Table 8-28 and Figure 8-11 to Figure 8-16 shows the noise contours for $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ for Phase 1, Phase 2 and Phase 3 of the construction sequence respectively.

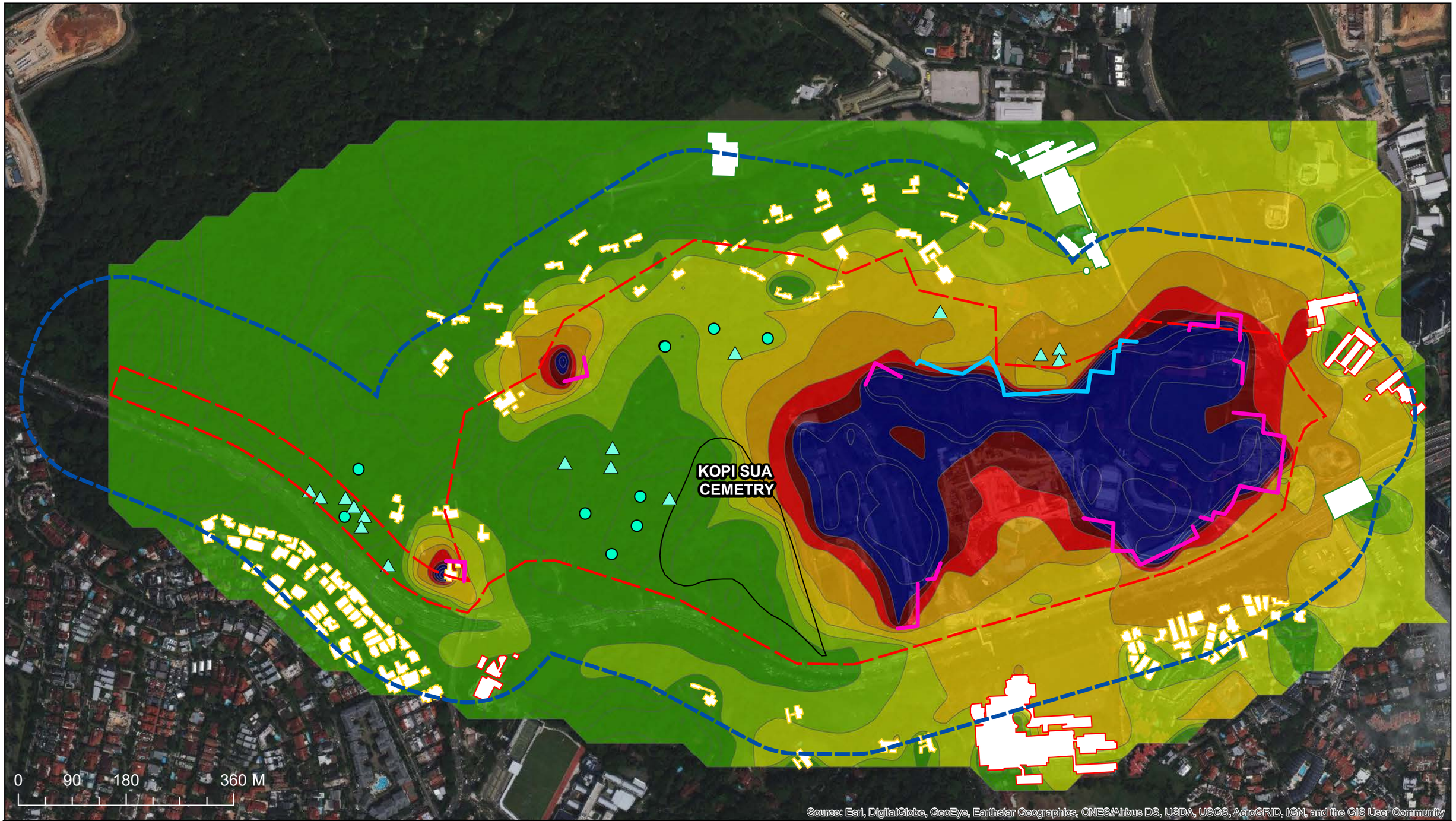
Table 8-27: Residual Impacts - Summary of Prediction and Evaluation of Noise Impacts for Construction Works – Monday to Saturday 7:00am -7:00pm, $L_{Aeq(12\ hour)}$

Phase	Receptor Sensitivity	Worst-case Exceedance L_{Aeq}, dB	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
1 - Demolition	1	2	Low	Low	Occasional	Minor
	2	2	Low	Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible
2 – Alternative Roadworks	1	-	Negligible	Very Low	Occasional	Minor
	2	-	Negligible	Very Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible
3 – Construction of Residential	1	-	Negligible	Very Low	Occasional	Minor
	2	-	Negligible	Very Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible

Table 8-28: Residual Impacts - Summary of Prediction and Evaluation of Noise Impacts for Construction Works – Monday to Saturday 7:00am -7:00pm, $L_{Aeq(5\ minsr)}$

Phase	Receptor Sensitivity	Worst-case Exceedance L_{Aeq}, dB	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
1 - Demolition	1	1	Low	Low	Occasional	Minor
	2		Negligible	Very Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible
2 – Alternative Roadworks	1	-	Negligible	Very Low	Occasional	Minor
	2	-	Negligible	Very Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible
	1	-	Negligible	Very Low	Occasional	Minor

Phase	Receptor Sensitivity	Worst-case Exceedance L_{Aeq}, dB	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
3 – Construction of Residential	2	-	Negligible	Very Low	Occasional	Minor
	3	-	Negligible	Imperceptible	Occasional	Negligible



Legend

- Proposed Noise Barrier (12m)
- Proposed Noise Barrier (5m)
- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

Criterion:
Priority 1: 69 to 73 dB(A)
Priority 2: 75 to 77 dB(A)
Priority 3: 76 dB(A)

Noise level
Leq (12 Hours)
in dB(A)

66 <	<= 66
69 <	<= 72
72 <	<= 75
75 <	<= 78
78 <	<= 81
81 <	<= 84
84 <	

N

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Qualified Person Endorsement :
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HDB Endorsement :
NA

Consultant : AECOM

Project Title :
**CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT**

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Figure Title :
**POST-MITIGATED (LEQ12 HOURS) 7am-7pm
NOISE CONTOURS-PHASE 1**

Figure No. :	Rev.	Sheet
8 - 11	02	1 of 1

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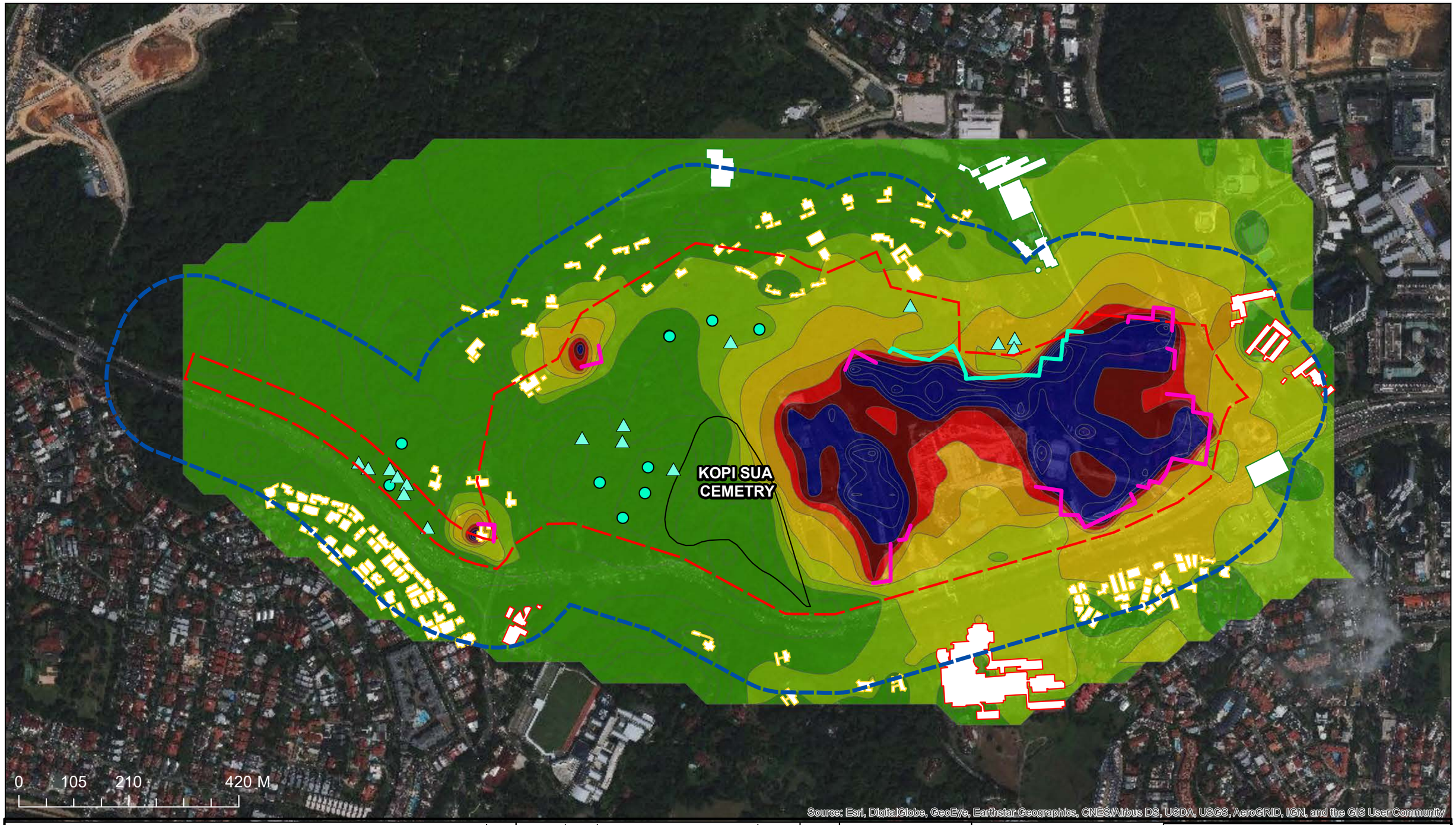

Legend

- Proposed Noise Barrier (12m)
- Proposed Noise Barrier (5m)
- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity
- 1
- 2
- 3

Criterion:
Priority 1: 75 to 77 dB(A)
Priority 2: 90 dB(A)
Priority 3: 90 dB(A)

Noise level
Leq (5 Mins)
in dB(A)

72 <	<= 72
75 <	<= 75
78 <	<= 78
81 <	<= 81
84 <	<= 84
87 <	<= 87
90 <	<= 90

N

Rev.	Date	By	Description	Chk'd	App'd
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Project Title :
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	Drawn	Date
	PZ	JUN 2021

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Figure Title :
POST-MITIGATED (LEQ5 MINS) 7am-7pm NOISE CONTOURS-PHASE 1

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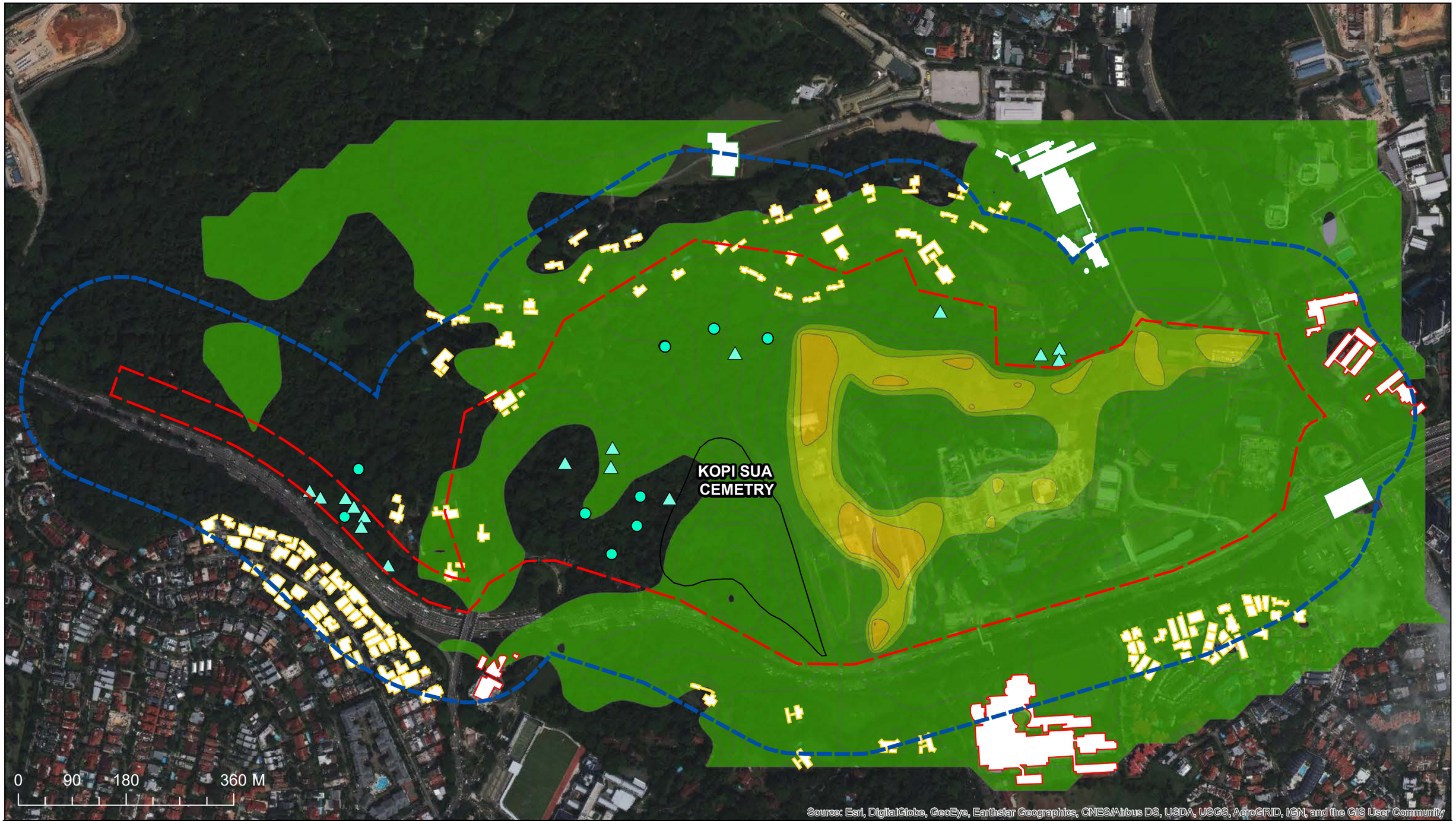

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

Criterion:
Priority 1: 69 to 73 dB(A)
Priority 2: 75 to 77 dB(A)
Priority 3: 76 dB(A)

Noise level
Leq (12 Hours)
in dB(A)

66 <	<= 66
69 <	<= 72
72 <	<= 75
75 <	<= 78
78 <	<= 81
81 <	<= 84
84 <	

N

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AT MOUNT PLEASANT**

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Figure Title :
**POST-MITIGATED (LEQ12 HOURS) 7am-7pm
NOISE CONTOURS-PHASE 2**

Figure No. :	Rev.	Sheet
8 - 13	02	1 of 1

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KOPI SUA
CEMETRY

0 105 210 420 M

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity
- 1
- 2
- 3

Criterion:
Priority 1: 75 to 77 dB(A)
Priority 2: 90 dB(A)
Priority 3: 90 dB(A)

Noise level
Leq (5 Mins)
in dB(A)

72 <	<= 72
75 <	<= 75
78 <	<= 78
81 <	<= 81
84 <	<= 84
87 <	<= 87
90 <	<= 90

N

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Qualified Person Endorsement :
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	PZ	JUN 2021

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Figure Title :
POST-MITIGATED (LEQ5 MINS) 7am-7pm NOISE CONTOURS-PHASE 2

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8 - 14	02	1 of 1

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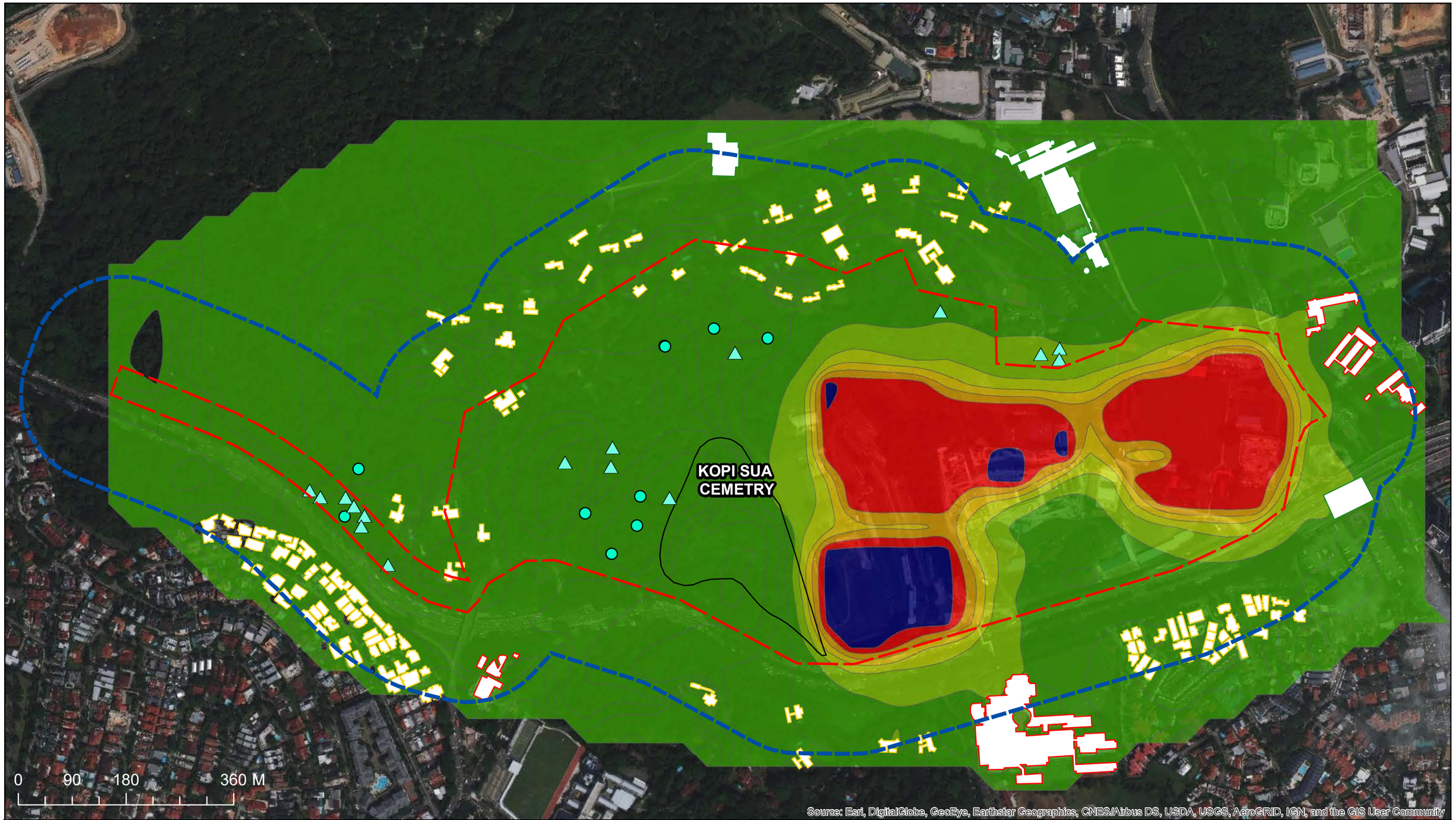

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

Criterion:
Priority 1: 69 to 73 dB(A)
Priority 2: 75 to 77 dB(A)
Priority 3: 76 dB(A)

Noise level Leq (12 Hours) in dB(A)

	<= 66
66 <	<= 69
69 <	<= 72
72 <	<= 75
75 <	<= 78
78 <	<= 81
81 <	<= 84
84 <	

N

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Figure Title :
**POST-MITIGATED (LEQ12 HOURS) 7am-7pm
NOISE CONTOURS-PHASE 3**

Figure No. :	Rev.	Sheet
8 - 15	02	1 of 1

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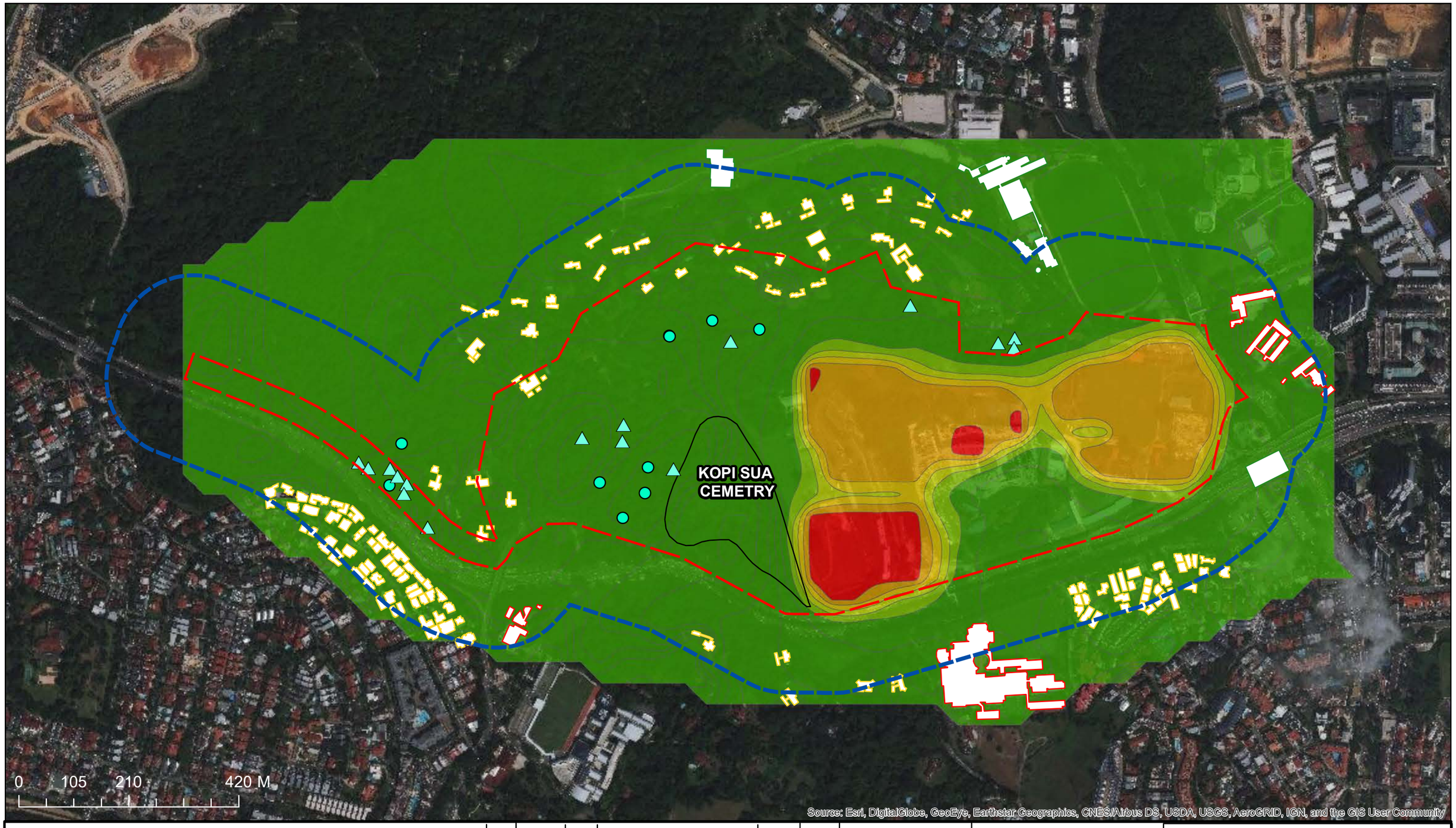

Legend

- Study Area
- Noise Assessment Area
- Bamboo Clusters
- Ecological Receptor
- Kopi Sua Cemetery

Noise Sensitive Receptors (Human Impact)

Receptor Sensitivity

- 1
- 2
- 3

Criterion:
Priority 1: 75 to 77 dB(A)
Priority 2: 90 dB(A)
Priority 3: 90 dB(A)

Noise level
Leq (5 Mins)
in dB(A)

72 <	<= 72
75 <	<= 75
78 <	<= 78
81 <	<= 81
84 <	<= 84
87 <	<= 87
90 <	<= 90

N

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Qualified Person Endorsement :
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**CONTRACT L/003/19
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AT MOUNT PLEASANT**

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Figure Title :
**POST-MITIGATED (LEQ5 MINS) 7am-7pm
NOISE CONTOURS-PHASE 3**

Figure No. :	Rev.	Sheet
8 - 16	02	1 of 1

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Ecological Impacts

Residual construction impact assessment assumes that the mitigation measures within **Section 8.3** are implemented in the construction areas. The impact intensity at the receptors was expected to be reduced from 17 db(A) to 8 dB (A). It was also assumed that the fauna residing near the PIE are accustomed to the elevated ambient noise levels and may not be severely impacted by construction noise following migration. And also the ecological receptors with high mobility will be deemed capable of migrating to either Kopi Sua Cemetery or Bukit Brown Woods.

Based on the assessment, by implementing the proposed mitigation measures, the impact significance on ecological receptors for Phase 1 is Moderate. In order to mitigate noise further, an opinion would be replacing hand held pneumatic breakers with less noisy options such as hand held breaker used for road, etc. The predicted construction noise level for Phase 2 and Phase 3 showed no exceedance. Hence, the overall impact significances are Minor. The residual impact significance is shown in **Table 8-29**.

Table 8-29: Residual Impacts - Summary of Prediction and Evaluation of Noise Impacts for Construction Phases – Biodiversity Impacts

Phase	Biodiversity Sensitive Receptor	Worst-case Exceedance L_{Aeq}, dB	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
Demolition	Priority 1	8	High	High	Occasional	Moderate
Alternative Roadworks	Priority 1	-	Negligible	Very Low	Occasional	Minor
Construction of Proposed Development	Priority 1	-	Negligible	Very Low	Occasional	Minor

8.4.2 Operational Phase

Human Impacts

Referring to **Section 8.2.9**, it is mandatory for the proposed developments to comply against NEA's guidelines for traffic noise impact assessment and boundary noise impact assessment for non-industrial buildings. Usually conducted by an appointed Noise Consultant during the development stage, AECOM recommends the works for traffic noise impact assessment and ACMV boundary noise impact assessment be conducted in the later stages of the development in accordance with NEA's *Technical Guideline for Land Traffic Noise Impact Assessment* and *Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building* respectively.

Ecological Impacts

Residual operational Impact Assessment assumes that the mitigation measures within **Section 8.3** are implemented for the development/operation areas. The impact intensity at the receptors was expected to be reduced due to employing BAT and BEP for ACMV systems and reducing road traffic noise by slowing down traffic with speed postings, humps and signage. It was also assumed that ecology receptors with high mobility would migrate to either Kopi Sua Cemetery or Bukit Brown Woods to distant from the operational noise impacts.

8.5 Summary of Key Findings

Noise impact assessment was carried for both the construction and the operational phase of the proposed construction works and post-construction development at Mount Pleasant. The assessment has been further divided to assess human impacts and ecological impacts. The construction noise Study Area was defined as 150m from the project's Study Area. A noise baseline monitoring was carried out at four locations within the Study Area. The baseline study recorded average $L_{Aeq(12\ hour)}$, $L_{Aeq(1\ hour)}$, $L_{Aeq(15\ min)}$ and $L_{Aeq(5\ min)}$ baseline noise levels and compared against the construction and operational criteria provided by NEA guidelines. The baseline noise levels were used to develop project-specific criteria for the construction phase and for the operational phase for the developments.

The construction noise impact assessment was conducted in accordance with the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008.* The construction noise impact assessment was assessed on the following phases of construction: 1) Demolition 2) Road Works; and 3) Construction of Proposed Development;. Using the construction programme from the client, the construction sound power level was calculated for each phase of the construction works based on typical Powered Mechanical equipment (PME) used. Based on the analysis of each phase of construction, the highest effective LwA is predicted during 'Demolition' and 'Superstructure' for phase 1 and 3. The effective LwA predicted for Road Works was used for the phase 2 assessment. Based on logical deduction of the noise levels with respect to the distance of receptors, the construction activities are likely to cause annoyance and sleep disturbance to residential receptors and disturbance to fauna. Ecological receptors identified includes the priority 1 fauna (Bamboo Clusters, Birds, Butterflies and Odonates of conservation significance) within Bukit Brown Woods.

The construction noise pre-mitigated impact significance for human impact was predicted to range from 'Negligible' to 'Moderate' due to predicted exceedances of up to 5 dB(A) in Phase 1. For ecological receptors, the predicted $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ noise levels exceeded the project criteria with maximum exceedances of 17 dB(A), the exceedance resulted in a High impact intensity and hence, the impact significance level is Moderate in Phase 1. There was no exceedance for $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ in Phase 2 for human, but for ecological receptors, the predicted $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ noise levels exceeded the project criteria at up to 6 noise sensitive receptors with maximum exceedances of 7 dB(A), the exceedance resulted in a High impact intensity and hence, the impact significance level is Moderate in Phase 2. There was no exceedance for $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ in Phase 3 for both human and ecological receptors.

Residual construction impact assessment assumes that the mitigation measures within Section 8.3 are implemented in the construction areas. The residual impact significance for human impact was reduced and predicted to range from 'Negligible' to 'Minor' due to predicted exceedances of up to 2 dB(A) in Phase 1. For ecological receptors, the impact intensity at the receptors was expected to be reduced from 17 db(A) to 8 dB (A). The residual exceedance eventually for such case is then predicted to be in a High impact intensity and hence, the impact significance level is Moderate in Phase 1. In order to mitigate noise further, an opinion would be replacing hand held pneumatic breakers with less noisy options such as hand held breaker used for road, etc. There was no exceedance for $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ in Phase 2 – Alternative Roadworks and Phase 3 for both human and ecological receptors. Hence the residual impact significance for Priority 1 and 2 receptors are Minor, and Priority 3 receptors is Negligible.

Operational noise impact assessment focuses on the ACMV systems (residential development)) and traffic noise due to increase in vehicular volume from the additional roads. For human impacts, it is mandatory for the proposed developments to comply against NEA's guidelines for traffic noise impact assessment and boundary noise impact assessment for non-industrial buildings. Usually conducted by an appointed Noise Consultant during the development stage, AECOM recommends the work for traffic noise impact assessment and ACMV boundary noise impact assessment be conducted in the later stages of the development as a requirement in accordance with NEA's *Technical Guideline for Land Traffic Noise Impact Assessment* and *Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building* respectively. Hence, the quantitative impact assessment (human impacts) has been omitted in this report.

For ecological receptors, priority 1 fauna has been identified within the Study Area. Known receptors includes Bamboo Clusters which serves as habitats for Bamboo Bats. However, the impacts which are larger than noise impact in this area is due to redevelopment of the streams and habitat itself. Where

these species will eventually take shelter or develop new habitat is uncertain at this stage, hence it is difficult to analyse the impact of noise on these species related to the streams.

For species with habitats in the Kopi Sua such as bamboo bats, the distance of the nearest new road development from the identified habitat is 210m. The noise propagation reduces with distance. It is also possible that with time in operational stage, the faunal species may adapt itself to a continuous noise level. However, at this stage data was neither available as to the traffic predicted on the road, or the ACMV details, for the report to predict the increase in baseline noise levels.

NM02 is the nearest noise monitoring location to the ecological receptor. The average baseline at NM02 $L_{Aeq(15min)}$ is 59-68 dB(A). Compared with the NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building for the most stringent, noise sensitive criteria, the baseline at NM02 is higher than the regulation. Assuming that this regulation will be met, there will be minimal to no detectable change in noise level in the area. The impact intensity will be negligible and Very Low impact consequence. The likelihood of the noise level exceeding the criteria during the operation is Occasional. Hence, the impact significance level is Minor.

9.0 Groundborne Vibration

9.1 Introduction

Ground-borne vibration from construction and operational activities may be felt, especially by receptors in proximity to the vibration sources from the Study Area. This section presents the assessment of ground-borne vibration impacts arising from the construction and operational phases of the development in the Study Area.

The construction ground-borne vibration impacts assessment has been conducted quantitatively, while the operation ground-borne vibration impact assessment has been conducted qualitatively. The key steps for conducting the noise impact assessment are as follows:

- Review baseline vibration monitoring data to assess current baseline noise level in the Study Area;
- Identify and classify sensitivity of the receptors surrounding the Study Area;
- Conduct a noise impact assessment to quantitatively assess noise impacts during the construction phase and qualitatively for the operational phase of the development in the Study Area;
- Recommend minimum control and mitigation measures to be implemented; and
- Determine the overall significance of the residual noise impacts after the implementation of mitigation measures

9.2 Ground-borne Vibration Baseline Monitoring

Baseline ground-borne vibration monitoring includes monitoring of the baseline ground-borne vibration levels in the Study Area.

For baseline ground-borne vibration measurements, the monitoring equipment was setup to measure at each baseline monitoring location for at least 24 hours. The baseline ground-borne vibration data were analysed and evaluated in accordance to guidance for “structural damage”, “human annoyance” and “magnitude of impact” from *BSI British Standards BS 5228-2 2009+A1:2014: Code of Practice for Noise and Vibration Control on Construction and Open Sites*. The average and maximum vibration levels measured can be used as a reference of existing baseline prior to the construction in the Study Area. In addition, this baseline also assisted to compare the predicted impacts from construction phase and then with this baseline as a reference, to recommend appropriate mitigation measures such that the magnitude of impacts on human annoyance from the construction phase is not worse off compared to the baseline.

9.2.1 Baseline Monitoring Personnel

The assessment and site surveys were conducted by the following personnel:

- Ms. Jagriti Dawra, AECOM Singapore Pte Ltd (EIA specialist)
- Mr. Mark Shi, AECOM Singapore Pte Ltd (Noise and Vibration Consultant)
- Ms. Mandy Yeo, AECOM Singapore Pte Ltd (Noise and Vibration Consultant)

Site reconnaissance was conducted in 30th January 2019. Subsequently, the primary baseline noise and vibration data collections were conducted from 7th to 14th May 2019 and 7th to 16th May 2019, respectively.

9.2.2 Field Assessment

Three locations have been proposed for baseline ground-borne vibration monitoring (refer to **Figure 8-1**) which were approved as per the Inception Report. These are based on the identification of Vibration Sensitive Receptors (VSRs) nearest to the construction boundary of the Study Area. Selected locations are:

- Along Mount Pleasant Road (opposite OPA Field) – VM01);

- 3 Mount Pleasant Road – VM02; and
- 182 Mount Pleasant Road VM03.

Details for the baseline ground-borne vibration monitoring are shown in **Section 9.2.3.**

9.2.3 Baseline Vibration Results

For the purpose of the study, unattended vibration monitoring was conducted from 7th to 16th May 2019 to determine the typical vibration levels at the proposed site. The main source of vibration was observed to be the intermittent traffic pass-by on the main road.

The summary of the baseline ground-borne vibration monitoring at VM01, VM02, and VM03 is provided in **Table 9-1**. Further details of the vibration monitoring report are provided in **Appendix H** and calibration certificates in **Appendix D**. Based on the analysis of the monitored results, there are anomalous peaks in the vibration levels measured during the monitoring period, which are not representative of the baseline environment of the Study Area. Based on the site visit, vibration was not perceptible. As such, based on BS5228-2, PPV vibration velocities above 1 mm/s are likely to have been caused by anomalous events such as pedestrian traffic and fauna. For the purpose of this study, peaks were removed in the calculation for average PPV. It should be noted that the vibration measurements have been influenced by traffic pass-by on Mount Pleasant Road. The nearest sensitive receptors surrounding and within the Study Area are set back from the road and were expected to have lower baseline vibration levels.

Table 9-1: Summary of Baseline Ground-borne Vibration Monitoring Results

Location	Date and Time of Measurement	Average Peak Particle Velocity, PPV (mm/s) *
VM01	2:01 PM 7th May 2019 – 7:46 AM 10th May 2019	0.92
VM02	10:47 AM 10th May 2019 – 9:57 AM 14th May 2019	0.32
VM03	10:37 AM 14th May 2019 – 10:02 AM 16th May 2019	0.91
Notes: * Anomalous peak PPV vibration measurements have been removed in calculating the average PPV vibration levels.		

9.3 Groundborne Noise Impact Assessment

9.3.1 Assessment Area

Construction Phase and Operational Phase

The construction and operation ground-borne vibration impacts were assessed within the Study Area as shown in **Figure 9-1**. It should be noted that ecological sites are not in a building environment, hence, ground-borne noise impact assessment does not apply and have been scoped out of the report.

9.3.2 Potential Sources of Impacts

9.3.2.1 Potential Impacts during Construction Phase

The sources of vibration during construction are presented in **Table 9-7** together with the associated potential impacts.

Table 9-2: Potential Sources of Environmental Impacts during Construction Phase

Construction Activity	Potential Source of Impacts	Potential Associated Impacts
Construction of proposed development (e.g. housing with supporting amenities, commercial facilities). • Compacting of concrete using the vibrator equipment; and	Ground-borne Vibration	Structural Damage Interference with Vibration Sensitive Equipment

Construction Activity	Potential Source of Impacts	Potential Associated Impacts
• Impact/rotary piling works for the foundations of the building.		Ecological Foraging Behavior

Potential major vibration source for the project during the construction phase are the piling works. Piling activity typically causes the highest vibration levels compared to other construction activities. The construction ground-borne vibration impacts generated from piling works will depend on the piling method and geological conditions of the Study Area. During the preparation of this report, the Study Area was still in a high-level design and planning stage, thus for this study, the construction ground-borne vibration impact assessment has assumed "impact bore pilling" method as this is the pilling method that generates the highest vibration levels and will be representative for the worst case scenario for the Study Area. The associated ground-borne vibration impacts from the piling works are Human Annoyance and Sleep Disturbance to the nearest receptors from the construction area.

9.3.2.2 Potential Impacts during Operational Phase

During the operational phase, the vibration sources will potentially be the increased road traffic inside the Study Area. Traffic vibration is mainly due to heavy vehicles passing at relatively high speed on a road with an uneven surface profile. Interaction between wheels and road surface causes a dynamic excitation which generates waves propagating in the soil and to the foundations of nearby sensitive building receptor structures. During the operational phase, the sources of vibration are presented in **Table 9-8**.

Table 9-3: Potential Sources of Environmental Impacts during Operational Phase

Operation Activity	Potential Source of Impacts	Potential Associated Impacts
Road traffic	Ground-borne vibration Structure-borne vibration	Human Annoyance Ecological Foraging Behavior

Based on the land use of the Study Area, the presence of heavy vehicles at relatively high speed will be rare. Given that the construction of roads in Singapore will relatively have an even surface profile, it is unlikely that the road traffic will cause high ground-borne vibration levels in the Study Area and will not have a significant impact on nearby sensitive receptor buildings or ecological receptors. **Section 9.3.12** discusses the impact prediction and evaluation during the operational phase qualitatively.

9.3.3 Classification of Sensitive Receptors

9.3.3.1 Construction Phase and Operational Phase

Sensitive receptors are those buildings, activities, forested areas or other land uses within the Study Area which may potentially be impacted by the construction and operation activities of the development in the Study Area. Sensitive receptors are identified with respect to the location of the project within the Study Area (i.e. 100 m around the Study Area). It was anticipated that effects from vibration generated by construction and operational activities would not occur at distances greater than 100 m from the Study Area. This was based on the experience of similar projects. In an event that an impact is found to be significant within the whole Study Area, this area is typically increased to assess and envelop a wider area. Vibration sensitive receptors are sub-categorised into three categories: Priority 1, Priority 2 and Priority 3 (from the most sensitive to the least).

Human Impacts

Based on the study results, Priority 1 vibration sensitive building receptors have not been identified in the Study Area during Construction Phase. A total of 76 vibration sensitive building receptors have been identified for Priority 2 and 3 collectively and this is summarised in **Table 9-4.** The locations of these vibration sensitive receptors have been identified in **Figure 9-1.**

A summary of the receptor classification for human impacts assessment during Construction Phase is presented in **Table 9-4**.

Table 9-4: Ground-borne Vibration Sensitive Receptor Classification for Human Impacts – Construction Phase

Sensitivity Classification	Number of Receptor Buildings
Priority 1	0
Priority 2	73
Priority 3	3
Total	76

Based on the understanding of the conceptual development plan (see Figure 3-2), there will be additional sensitive building receptors during the Operational Phase such as housing with supporting amenities and other commercial facilities. As mentioned in **Section 6.2.2**, these will be classified as Priority 2 sensitive building receptors. The total number of sensitive building receptors during the operational phase will consist of at least 80 sensitive building receptors.

A summary of the receptor classification for human impacts assessment during Construction Phase is presented in **Table 9-6**.

Table 9-5: Ground-borne Vibration Sensitive Receptor Classification for Human Impacts – Operational Phase

Sensitivity Classification	Number of Receptor Buildings
Priority 1	0
Priority 2	77
Priority 3	3
Total	80

Ecological Impacts

The ecological sensitive receptors, identified for ground-borne vibration impact assessment, were based on the results of the biodiversity survey conducted in the Study Area. In accordance to **Section 12.0**, Priority 1 fauna identified throughout the forested area near Kopi Sua Cemetery include the Bamboo Clusters which serve as habitats for Bamboo Bats (classified as Priority 1 biodiversity receptors), as well as Stream 1 and Stream 2 which are habitats for the Collared Threadtail (classified as Priority 1 biodiversity receptors). Besides, birds and butterfly are of conservation significance within the Study Area (refer to **Section 12.0**).

The sensitivity classification for the ecological sensitive receptors for ground-borne vibration impact assessment is dependent on the fauna's sensitivity to ground-borne vibration levels.

Bamboo Clusters – During Construction Phase, ground-borne vibration is caused by piling works and during piling works, the vibration source will generate waves propagating in the soil and to the nearby bamboo clusters. There is very scarce literature on the propagation of vibration from the ground to bamboo clusters and Bamboo Bats. Bamboo Bats can be found roosting in them during the day, however, it is reasonable to assume that the vibration impacts will barely be perceptible by the Bamboo Bats as the piling activities are at least 10 m away from the bamboo clusters on site. Thus, it is also reasonable to assume that, the propagation of the vibration is potentially insignificant and unlikely to cause disturbances to the Bamboo Bats during the day. During the Operational Phase, ground-borne vibration is caused by road traffic. Similarly, in consideration of the vibration transmission path from source to a receptor and the structure of the Bamboo plant, the Bamboo Bats are unlikely to experience impacts during the Operational Phase. Thus, Bamboo Clusters are classified as Priority 3 ecological receptors for the ground-borne vibration impact assessment.

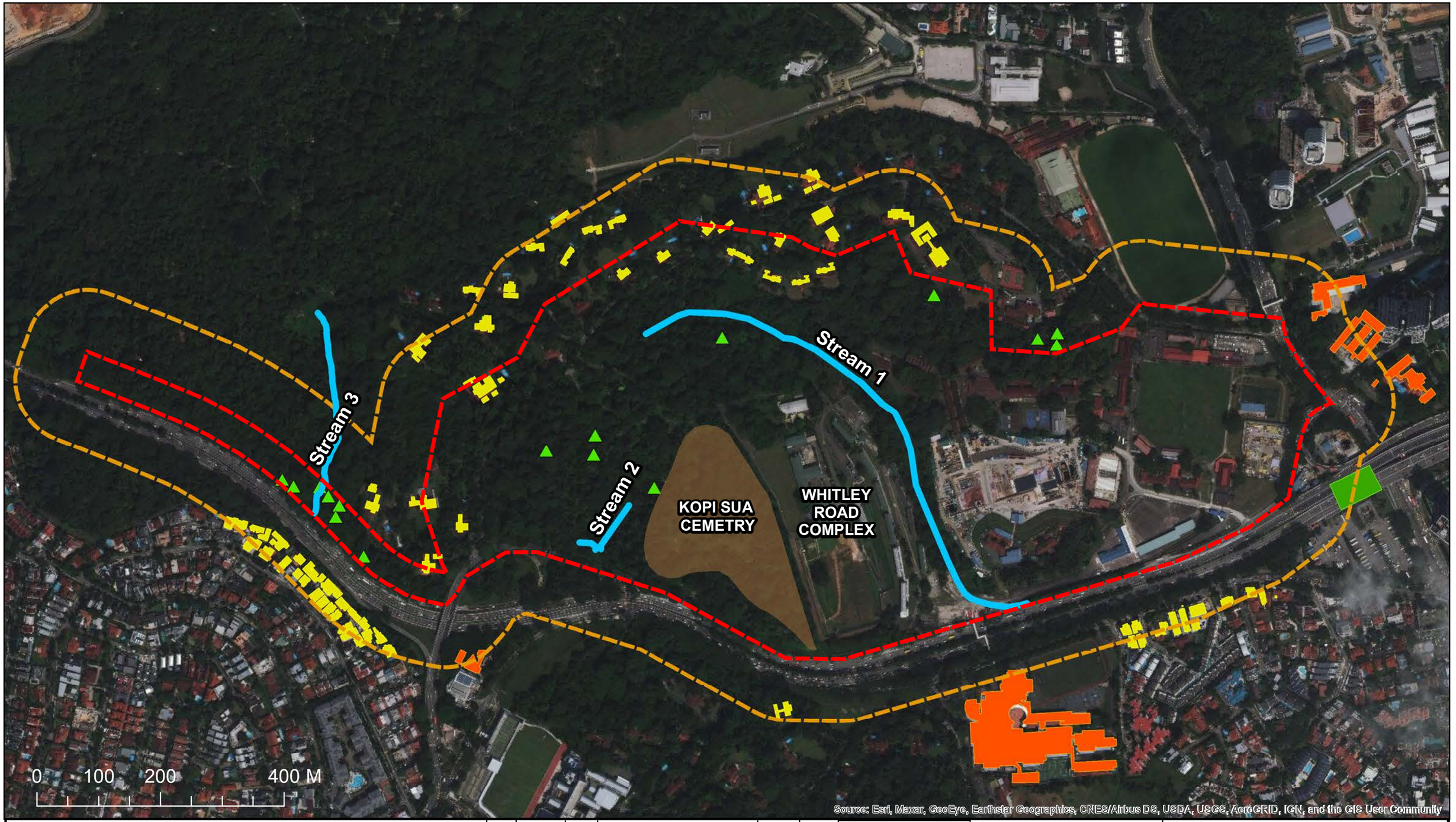
Streams 1 and 2 – During Construction Phase, ground-borne vibration is caused by piling works; during the Operational Phase, road traffic causes ground-borne vibration. Vibration sources will generate waves propagating in the soil and to the nearby water bodies and the flora in the water bodies. Although Streams 1 and 2 are habitats for Collared Threadtail, it should be noted that these species are not fossorial or terrestrial, this will potentially have low sensitivity towards ground-borne vibration levels. Hence, Streams 1 and 2 were classified as Priority 3 ecological receptors for the ground-borne vibration impact

Other areas in Study Area – Similarly, the birds and butterflies have high mobility and unlikely to forage at ground level, thus other areas in Study Area have been classified as Priority 3 receptors.

A summary of the receptor classification for ecological impacts is presented in **Table 9-6**.

Table 9-6: Ground-borne Vibration Ecological Receptor Identified within the Study Area

Ecological Receptor	Sensitivity Classification
Bamboo Clusters (habitat for Bamboo Bats)	Priority 3
Stream 1 (habitat for Collared Threadtail)	Priority 3
Stream 2 (habitat for Collared Threadtail)	Priority 3
Other areas in Study Area (habitat for birds and butterflies)	Priority 3



Legend

- Study Area
- Kopi Sua Cemetery
- Streams
- Bamboo Clusters
- Vibration Assessment Area (100m)

Vibration Sensitive Receptors

Receptor Sensitivity

- 1
- 2
- 3

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	HHL	Final Report	JAG	JAG

Qualified Person Endorsement :
NA

HDB Endorsement :
NA

Consultant : AECOM

Project Title :
CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Designed	Checked	Approved
LIA	JAG	JAG
	Drawn: HHL	Date: JAN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title :
GROUND-BORNE VIBRATION SENSITIVE RECEPTORS

Figure No. :	Rev.	Sheet
9 - 1	-	1 of 1

CAD File Name : NA — A3

Note: Source of basemap - Google Earth Map

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9.3.4 Assessment Criteria

The assessment criteria reviewed in this section has been used for the construction vibration impact assessment. No known facilities with sensitive vibration equipment were found in the Study Area. Hence vibration impacts on sensitive equipment have not been assessed in this report.

9.3.4.1 Cosmetic Damage

The vibration threshold for cosmetic damage from BS 5228-2:2009+A1:2014 are presented in terms of peak particle velocities (PPV). The guideline vibration levels based on transient vibration guide values for building cosmetic damage is presented in **Table 9-7.** For a conservative assessment at the time of the development of this report, the predicted results were assessed against the most stringent threshold value of 15 mm/s PPV for Priority 2 and 3 building receptors.

Table 9-7: Vibration guidelines from BS 5228-2:2009+A1:2014 (Table B.2)

Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4 Hz to 15 Hz	15 Hz and above
Industrial and Heavy Commercial Buildings	50 mm/s at 4 Hz and above	50 mm/s at 4 Hz and above
Residential or Light Commercial Buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz

9.3.4.2 Human Response

Construction induced ground-borne vibration is known to cause disturbance and annoyance to human beings. BS5228-2:2009+A1:2014 provides guidance on the effects of vibration levels for human response to vibration. The guidance is replicated in **Table 9-8**.

Table 9-8: Human Response Guidance from BS5228-2:2009+A1:2014

Vibration Level	Effect
0.14 mm/s	Vibration might be perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residual environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complain but can be tolerated if prior warning and explanation have been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than very brief exposure to this level in most building environments.

9.3.5 Prediction Methodology

9.3.5.1 Prediction Method

Empirical relationships have been developed for vibration impact and rotary piling activities using historical data from BS 5228-2:2009+A1:2014. The Peak Particle Velocity (PPV) levels presented in the assessment are conservative predictions at the receptors, based on the most similar ground conditions and piling activities recorded as historical data. The prediction methodology is explained in **Section 9.6**

The following general assumptions were used in the prediction and evaluation of noise impacts:

Soil Conditions

Based on **Section 5.4**, the general soil profile underneath the site is primarily composed of granites and alluvium. The most similar soil conditions recorded in historical data from BS 5228-2:2009+A1:2014 is chosen to match the site in question as a basis of analysis.

Vibration Sources

The predictions presented were based on conservative assumptions and the maximum vibration levels from the piling phases (installation of the casing, boring of the pile and extraction of the casing).

9.3.6 Minimum Control for Potential Impacts

9.3.6.1 Construction Phase

This section proposes minimum controls, or standard practices commonly implemented in Singapore for similar construction activities, that were assumed to be implemented for impact assessment. Where the equipment was not yet available for study, both worst case vibration impact and best case were studied, such as piling methods.

Table 9-9: Minimum Controls (Ground-borne Vibration)

Potential Source of Impacts	Minimum Controls
• Compacting of concrete using the vibrator equipment; and • Impact Bore piling works for the foundations of the building.	• Use low vibration equipment and construction techniques; and • Use rotary bore piling/micro piling techniques for the foundations of the building

9.3.7 Dilapidation Surveys

Dilapidation surveys would normally be recommended when the predicted vibration levels approach or exceed a level of 80 % of the lowest damage criteria (typically 7.5 mm/s PPV for continuous vibration at 4 Hz). As the vibration at any receptor was not likely to exceed this threshold, no surveys were considered warranted.

9.3.8 Equipment Selection and Maintenance

As the piling technique for the construction of the site foundations has not been selected at the time of writing this report, both impact bore piling and rotary piling methods has been assessed. Therefore, the vibration impact assessment evaluated the potential impacts from a high-vibration piling technique (i.e., impact bore piling) and compared with a low-vibration piling technique (i.e., rotary piling).

9.3.9 Works Scheduling

For the impact bore piling activities, it was expected that these works would not occur during evening and night time.

9.3.10 Authority Consultation

It is recommended that the authority maintaining the adjacent park area (i.e. NParks) will be notified before the commencing of any piling related works.

9.3.10.1 Operational Phase

This section proposes minimum controls, or standard practices commonly implemented in Singapore for road networks in Singapore that were assumed to be implemented for impact assessment. The vehicle speed of road traffic is regulated by the Land Transport Authority in Singapore and all vehicles travelling within the Study Area will be within the speed limits; the construction of roads will follow the guidelines regulated by the local authority.

9.3.11 Impact Prediction and Evaluation during Construction Phase

9.3.11.1 Impact Bore Piling

Historical data was replicated from BS 5228-2:2009+A1:2014 in **Table 9-10.** For the analysis of historical data, only PPV measurements recorded in soil conditions of “loose rock fill over weathered rock over rock” have been used in this assessment.

Table 9-10: BS 5228-2:2009+A1:2014 Historical Data for Impact Bore Pile PPV Measurement Levels

BS5228-2 (Table No.)	Distance (m)	PPV (mm/s)	Soil conditions	Pile dimensions	Mode
D11	10	0.8	Loose rock fill over weathered rock over rock	500mm diameter 15m to 17m depth	Boring
D11	10	1.5	Loose rock fill over weathered rock over rock	500mm diameter 15m to 17m depth	Base ramming
D11	15	1.3	Loose rock fill over weathered rock over rock	500mm diameter 15m to 17m depth	Base ramming
D11	25	0.65	Loose rock fill over weathered rock over rock	500mm diameter 15m to 17m depth	Boring
D11	30	1.2	Loose rock fill over weathered rock over rock	500mm diameter 15m to 17m depth	Base ramming
D11	48	0.45	Loose rock fill over weathered rock over rock	500mm diameter 15m to 17m depth	Boring

To show the mathematical relationship between PPV and distance, a best-fit non-linear regression "power curve" was drawn for the historical data set. For a conservative assessment, AECOM considered the 95th percentile in the historical data pool to form a best fit "power curve" to predict the PPV levels at the distance of the ground-borne vibration sensitive receptors from this Study Area.

Cosmetic Damage Impacts

Predicted vibration levels from impact bore piling is presented in Table 9-13. These predicted PPV levels were assessed against a most stringent threshold value of 20 mm/s PPV for Priority 3 building receptors and of 5 mm/s PPV for Priority 2 building receptors (refer to **Section 9.4**). All sensitive building receptors comply with the assessment for Cosmetic Damage Impacts.

Table 9-11: Prediction and Evaluation of Environmental Impacts – Impact Bore Piling (Human Impacts)

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No
1	80 Mount Pleasant Road	3	3	5	4.4	15	Yes
2	27 Jalan Mendaki	2	3	17	1.8	15	Yes
3	157 Mount Pleasant Road	2	3	25	1.3	15	Yes
4	4 Gymkhana Avenue	2	3	35	1.0	15	Yes
5	155 Mount Pleasant Road	2	3	40	0.9	15	Yes
6	160 Mount Pleasant Road	2	3	43	1.3	15	Yes
7	18 Mount Pleasant Drive	2	3	43	1.3	15	Yes
8	500 Thomson Road	2	4	46	1.3	15	Yes

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No
9	8 Gymkhana Avenue	2	3	47	0.8	15	Yes
10	6 Gymkhana Avenue	2	3	50	0.8	15	Yes
11	1 Thomson Lane	2	1	51	0.8	15	Yes
12	23 Mount Pleasant Drive	2	3	54	0.7	15	Yes
13	45 Merryn Road	2	2	55	0.7	15	Yes
14	150 Mount Pleasant Road	2	2	57	0.7	15	Yes
15	149 Mount Pleasant Road	2	3	59	0.7	15	Yes
16	39 Merryn Road	2	3	59	0.7	15	Yes
17	2 Whitley Road	2	2	60	0.7	15	Yes
18	2 Whitley Road	2	3	60	0.7	15	Yes
19	53 Merryn Road	2	3	61	0.7	15	Yes
20	37 Merryn Road	2	2	61	0.7	15	Yes
21	53A Merryn Road	2	3	63	0.7	15	Yes
22	153 Mount Pleasant Road	2	3	64	0.7	15	Yes
23	31A Merryn Road	2	3	64	0.7	15	Yes
24	55 Merryn Road	2	3	65	0.6	15	Yes
25	20 Malcolm Road	3	1	69	0.6	15	Yes
26	20 Malcolm Road	3	1	69	0.6	15	Yes
27	115 Whitley Road	2	3	70	0.6	15	Yes
28	8 Thomson Lane	2	3	70	0.6	15	Yes
29	31 Merryn Road	2	3	70	0.6	15	Yes

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No
30	27 Mount Pleasant Drive	2	3	72	0.6	15	Yes
31	121G Whitley Road	2	3	72	0.6	15	Yes
32	61A Merryn Road	2	3	72	0.6	15	Yes
33	3 Gymkhana Avenue	2	3	73	0.6	15	Yes
34	121F Whitley Road	2	3	73	0.6	15	Yes
35	121D Whitley Road	2	3	73	0.6	15	Yes
36	121E Whitley Road	2	3	74	0.6	15	Yes
37	158 Mount Pleasant Road	2	3	75	0.6	15	Yes
38	115A Whitley Road	2	3	75	0.6	15	Yes
39	49 Merryn Road	2	3	75	0.6	15	Yes
40	115K Whitley Road	2	3	76	0.6	15	Yes
41	113B Whitley Road	2	3	76	0.6	15	Yes
42	43A Merryn Road	2	3	76	0.6	15	Yes
43	41 Merryn Road	2	2	76	0.6	15	Yes
44	113A Whitley Road	2	3	77	0.6	15	Yes
45	113 Whitley Road	2	3	77	0.6	15	Yes
46	61 Merryn Road	2	3	77	0.6	15	Yes
47	51 Merryn Road	2	2	77	0.6	15	Yes
48	49A Merryn Road	2	3	77	0.6	15	Yes
49	43 Merryn Road	2	2	77	0.6	15	Yes

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No
50	111B Whitley Road	2	3	78	0.6	15	Yes
51	51A Merryn Road	2	2	79	0.6	15	Yes
52	29 Merryn Road	2	2	80	0.6	15	Yes
53	57 Merryn Road	2	3	82	0.5	15	Yes
54	115J Whitley Road	2	3	84	0.5	15	Yes
55	115B Whitley Road	2	3	85	0.5	15	Yes
56	117 Whitley Road	2	3	86	0.5	15	Yes
57	103 Whitley Road	2	3	86	0.5	15	Yes
58	1 Bo Seng Avenue	2	3	86	0.5	15	Yes
59	57A Merryn Road	2	2	86	0.5	15	Yes
60	35 Merryn Road	2	3	86	0.5	15	Yes
61	101 Whitley Road	2	3	87	0.5	15	Yes
62	33 Merryn Road	2	2	89	0.5	15	Yes
63	129 Whitley Road	2	4	91	0.5	15	Yes
64	230 Whitley Road	2	2	92	0.5	15	Yes
65	115H Whitley Road	2	3	92	0.5	15	Yes
66	115C Whitley Road	2	3	92	0.5	15	Yes
67	63 Merryn Road	2	3	92	0.5	15	Yes
68	59A Merryn Road	2	2	92	0.5	15	Yes
69	121H Whitley Road	2	3	94	0.5	15	Yes
70	121C Whitley Road	2	3	95	0.5	15	Yes

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No
71	151 Mount Pleasant Road	2	3	96	0.5	15	Yes
72	7 Gymkhana Avenue	2	3	96	0.5	15	Yes
73	111A Whitley Road	2	3	97	0.5	15	Yes
74	97 Whitley Road	2	3	98	0.5	15	Yes
75	115G Whitley Road	2	3	99	0.5	15	Yes
76	115D Whitley Road	2	3	99	0.5	15	Yes

Human Impacts

Predicted vibration levels from impact bore piling is presented in **Table 9-13.** From the analysis, impact bore piling was predicted to cause a vibration level of 0.5 mm/s (at 99 m from the construction area) and up to 4.4 mm/s (at 5 m from the construction area). Out of the 76 sensitive building receptors assessed, 69 sensitive building receptors will potentially experience a Low impact intensity, and seven (7) will potentially experience a Medium impact intensity.

With regards to impact evaluation matrix defined in **Section 6.4.2**, receptors 1 (Singapore Polo Club at 80 Mount Pleasant Road), 25 (China Collection) and 26 (Benchmark Wines), which were classified as Priority 3, would have a Very Low Consequence impact. As the likelihood of the impact bore piling activity is Occasional, the resulting impact significance is Minor.

Out of the 73 vibration sensitivity receptors which were classified as Priority 2, 67 receptors would have Low impact intensity, Low sensitivity consequence. As the likelihood of the impact bore piling activity is Occasional, the resulting impact significance is Minor. Based on the assessment criteria, vibration mitigation measures will not be required to lower the impact significance level.

The remaining six (6) Priority 2 receptors were predicted to experience construction induced vibration levels from 1.0 mm/s to 1.8 mm/s thus would have a Medium impact intensity and Medium sensitivity consequence. As the likelihood of the impact bore piling activity is Occasional, the resulting impact significance is Moderate. Based on the assessment criteria, vibration mitigation measures will be required to lower the impact significance level from Moderate to Minor. One of the mitigation measures recommended will be the use of a piling method that produces lower vibration levels and impacts on the sensitive building receptors.

Ecological Impacts

For a conservative assessment, the PPV levels at 10 m from an assumed bore piling rig within the Study Area has been predicted to assess the impacts on any Bamboo Clusters, Stream 1, Stream 2 and other areas found to be within a 10 m radius of a piling rig. The summary of the impact assessment and evaluation is stated in **Table 9-12**.

At 10 m the PPV level is predicted to be 2.6 mm/s at ground level. With the impact evaluation matrix explained in **Section 6.4.2**, the predicted impact intensity is Medium, impact consequence is Very Low. Given that impact bore piling activity will only occur occasionally, the resulting impact significance is Minor. Since the impact was predicted to be insignificant, no further mitigation measures were envisaged at this stage of the study to reduce the impact significance any more.

Table 9-12: Prediction and Evaluation of Environmental Impacts – Impact Bore Piling (Ecological Impacts)

S/N	Ecological Receptor	Sensitivity Classification	Distance to Piling Rig, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
1	Bamboo Clusters (habitat for Bamboo Bats)	3	10	2.6	Medium	Very Low	Occasional	Minor
2	Stream 1 (habitat for Collared Threadtail)							
3	Stream 2 (habitat for Collared Threadtail)							
4	Other areas in Study Area (habitat for birds and butterflies)							

Table 9-13: Prediction and Evaluation of Environmental Impacts – Impact Bore Piling (Human Impacts)

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
1	80 Mount Pleasant Road	3	3	5	4.4	Medium	Very Low	Occasional	Minor
2	27 Jalan Mendaki	2	3	17	1.8	Medium	Medium	Occasional	Moderate
3	157 Mount Pleasant Road	2	3	25	1.3	Medium	Medium	Occasional	Moderate
4	4 Gymkhana Avenue	2	3	35	1.0	Medium	Medium	Occasional	Moderate
5	155 Mount Pleasant Road	2	3	40	0.9	Low	Low	Occasional	Minor
6	160 Mount Pleasant Road	2	3	43	1.3	Medium	Medium	Occasional	Moderate
7	18 Mount Pleasant Drive	2	3	43	1.3	Medium	Medium	Occasional	Moderate
8	500 Thomson Road	2	4	46	1.3	Medium	Medium	Occasional	Moderate
9	8 Gymkhana Avenue	2	3	47	0.8	Low	Low	Occasional	Minor

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
10	6 Gymkhana Avenue	2	3	50	0.8	Low	Low	Occasional	Minor
11	1 Thomson Lane	2	1	51	0.8	Low	Low	Occasional	Minor
12	23 Mount Pleasant Drive	2	3	54	0.7	Low	Low	Occasional	Minor
13	45 Merryn Road	2	2	55	0.7	Low	Low	Occasional	Minor
14	150 Mount Pleasant Road	2	2	57	0.7	Low	Low	Occasional	Minor
15	149 Mount Pleasant Road	2	3	59	0.7	Low	Low	Occasional	Minor
16	39 Merryn Road	2	3	59	0.7	Low	Low	Occasional	Minor
17	2 Whitley Road	2	2	60	0.7	Low	Low	Occasional	Minor
18	2 Whitley Road	2	3	60	0.7	Low	Low	Occasional	Minor
19	53 Merryn Road	2	3	61	0.7	Low	Low	Occasional	Minor
20	37 Merryn Road	2	2	61	0.7	Low	Low	Occasional	Minor
21	53A Merryn Road	2	3	63	0.7	Low	Low	Occasional	Minor
22	153 Mount Pleasant Road	2	3	64	0.7	Low	Low	Occasional	Minor
23	31A Merryn Road	2	3	64	0.7	Low	Low	Occasional	Minor
24	55 Merryn Road	2	3	65	0.6	Low	Low	Occasional	Minor
25	20 Malcolm Road	3	1	69	0.6	Low	Very Low	Occasional	Minor
26	20 Malcolm Road	3	1	69	0.6	Low	Very Low	Occasional	Minor
27	115 Whitley Road	2	3	70	0.6	Low	Low	Occasional	Minor
28	8 Thomson Lane	2	3	70	0.6	Low	Low	Occasional	Minor
29	31 Merryn Road	2	3	70	0.6	Low	Low	Occasional	Minor
30	27 Mount Pleasant Drive	2	3	72	0.6	Low	Low	Occasional	Minor

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
31	121G Whitley Road	2	3	72	0.6	Low	Low	Occasional	Minor
32	61A Merryn Road	2	3	72	0.6	Low	Low	Occasional	Minor
33	3 Gymkhana Avenue	2	3	73	0.6	Low	Low	Occasional	Minor
34	121F Whitley Road	2	3	73	0.6	Low	Low	Occasional	Minor
35	121D Whitley Road	2	3	73	0.6	Low	Low	Occasional	Minor
36	121E Whitley Road	2	3	74	0.6	Low	Low	Occasional	Minor
37	158 Mount Pleasant Road	2	3	75	0.6	Low	Low	Occasional	Minor
38	115A Whitley Road	2	3	75	0.6	Low	Low	Occasional	Minor
39	49 Merryn Road	2	3	75	0.6	Low	Low	Occasional	Minor
40	115K Whitley Road	2	3	76	0.6	Low	Low	Occasional	Minor
41	113B Whitley Road	2	3	76	0.6	Low	Low	Occasional	Minor
42	43A Merryn Road	2	3	76	0.6	Low	Low	Occasional	Minor
43	41 Merryn Road	2	2	76	0.6	Low	Low	Occasional	Minor
44	113A Whitley Road	2	3	77	0.6	Low	Low	Occasional	Minor
45	113 Whitley Road	2	3	77	0.6	Low	Low	Occasional	Minor
46	61 Merryn Road	2	3	77	0.6	Low	Low	Occasional	Minor
47	51 Merryn Road	2	2	77	0.6	Low	Low	Occasional	Minor
48	49A Merryn Road	2	3	77	0.6	Low	Low	Occasional	Minor
49	43 Merryn Road	2	2	77	0.6	Low	Low	Occasional	Minor

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
50	111B Whitley Road	2	3	78	0.6	Low	Low	Occasional	Minor
51	51A Merryn Road	2	2	79	0.6	Low	Low	Occasional	Minor
52	29 Merryn Road	2	2	80	0.6	Low	Low	Occasional	Minor
53	57 Merryn Road	2	3	82	0.5	Low	Low	Occasional	Minor
54	115J Whitley Road	2	3	84	0.5	Low	Low	Occasional	Minor
55	115B Whitley Road	2	3	85	0.5	Low	Low	Occasional	Minor
56	117 Whitley Road	2	3	86	0.5	Low	Low	Occasional	Minor
57	103 Whitley Road	2	3	86	0.5	Low	Low	Occasional	Minor
58	1 Bo Seng Avenue	2	3	86	0.5	Low	Low	Occasional	Minor
59	57A Merryn Road	2	2	86	0.5	Low	Low	Occasional	Minor
60	35 Merryn Road	2	3	86	0.5	Low	Low	Occasional	Minor
61	101 Whitley Road	2	3	87	0.5	Low	Low	Occasional	Minor
62	33 Merryn Road	2	2	89	0.5	Low	Low	Occasional	Minor
63	129 Whitley Road	2	4	91	0.5	Low	Low	Occasional	Minor
64	230 Whitley Road	2	2	92	0.5	Low	Low	Occasional	Minor
65	115H Whitley Road	2	3	92	0.5	Low	Low	Occasional	Minor
66	115C Whitley Road	2	3	92	0.5	Low	Low	Occasional	Minor
67	63 Merryn Road	2	3	92	0.5	Low	Low	Occasional	Minor
68	59A Merryn Road	2	2	92	0.5	Low	Low	Occasional	Minor
69	121H Whitley Road	2	3	94	0.5	Low	Low	Occasional	Minor

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
70	121C Whitley Road	2	3	95	0.5	Low	Low	Occasional	Minor
71	151 Mount Pleasant Road	2	3	96	0.5	Low	Low	Occasional	Minor
72	7 Gymkhana Avenue	2	3	96	0.5	Low	Low	Occasional	Minor
73	111A Whitley Road	2	3	97	0.5	Low	Low	Occasional	Minor
74	97 Whitley Road	2	3	98	0.5	Low	Low	Occasional	Minor
75	115G Whitley Road	2	3	99	0.5	Low	Low	Occasional	Minor
76	115D Whitley Road	2	3	99	0.5	Low	Low	Occasional	Minor

Notes:

1. Based on the study of the sensitive building receptor locations and buildings information, the buildings listed do not have basement levels and are assumed to have reinforced concrete (RC) piles as building foundations.
2. There are no Priority 1 sensitive building receptors within the Study Area.

9.3.12 Impact Prediction and Evaluation during the Operational Phase

Human and Ecological Impacts

Concerning **Section 9.3.2.2**, it is stated that the potential major source of vibration is road traffic. As also explained in **Section 9.3.2.2**, the presence of heavy vehicles at relatively high speed travelling on uneven road profile will be extremely rare. For the assessment of human impacts and ecological impacts during the operational phase, PPV levels of road traffic were not predicted. The baseline vibration monitoring results in **Section 9.2.3** serve as useful information to understand typical road traffic-induced vibration levels near the Study Area, which is unlikely to differ greatly in the future (road construction is fairly similar around Singapore and there is a speed limit for the roads, thus heavy vehicles, if any, are unlikely to travel fast). With these assumptions made, the impact assessment was qualitatively conducted for operational phase for human and ecological impacts.

With a PPV level of 0.32 mm/s to 0.92 mm/s, the impact intensity for Priority 2 and 3 receptors is Low. For Priority 2 receptors, Low consequence; for Priority 3 receptors – Very Low consequence. As the likelihood is Regular (representative of daily traffic conditions), the resulting impact significance is Minor to Moderate.

To reduce the impact significance from Moderate to Minor, mitigation measures will be required.

Table 9-14: Summary of the Impact Prediction and Evaluation during Operational Phase

S/N	Receptors	Sensitivity Classification	Baseline PPV levels, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
1	All Building Sensitive Receptors	2	0.32 – 0.92	Low	Low	Regular	Moderate
2	All Building Sensitive Receptors	3		Low	Very Low		Minor
3	Bamboo Clusters, Stream 1 and Steam 2	3		Low	Very Low		Minor

9.4 Recommended Mitigation Measures

9.4.1 Construction Phase

Given that the implementation of minimum controls will not be sufficient to alleviate any significant environmental construction impacts, project-specific final mitigation measures are proposed in this section for consideration.

The piling method was typically determined based on the requirements for the foundations' construction. The rotary method is a relatively low-vibration piling method compared to the impact piling method. The impact prediction and evaluation for rotary piling method are detailed in **Section 9.4.1.1**.

If rotary piling is not suitable due to technical reasons, and a high vibration piling method is preferred, it is recommended that the main civil works construction contractor provides prior warning and details on the likely duration of the temporary vibration impacts to the Client and develop a detailed monitoring and stakeholder management plan for responding to community complaints and concerns.

9.4.1.1 Rotary Bore Piling

For the analysis of historical data, only PPV measurements recorded in soil conditions of "and "fill/sand/clay" have been used in this assessment as per **Table 9-15.**

Table 9-15: BS 5228-2:2009+A1:2014 Historical Data for Rotary (Auger) Bore Pile PPV Measurement Levels

BS5228-2 (Table No.)	Distance (m)	PPV (mm/s)	Soil conditions	Pile dimensions	Mode
D6 104	10	1	Fill/sand/clay	500mm diameter	Dollying casing
D6 104	10	0.4	Fill/sand/clay	500mm diameter	Augering
D6 104	10	0.3	Fill/sand/clay	500mm diameter	Mudding in
D6 104	14	0.8	Fill/sand/clay	500mm diameter	Dollying casing
D6 104	14	0.3	Fill/sand/clay	500mm diameter	Auger hitting base of hole
D6 104	14	0.2	Fill/sand/clay	500mm diameter	Mudding in
D6 104	15	0.1	Fill/sand/clay	500mm diameter	Augering
D6 104	26	0.1	Fill/sand/clay	500mm diameter	Auger hitting base of hole
D6 104	26	0.02	Fill/sand/clay	500mm diameter	Augering

As per the previous section, a best-fit non-linear regression “power curve” was drawn for the historical data set. For a conservative assessment, AECOM considered the 95th percentile in the historical data pool to form a best fit “power curve” to predict the PPV levels at the distance of the ground-borne vibration sensitive receptors of this project.

Cosmetic Damage Impacts

Predicted vibration levels from impact bore piling is presented in Table 9-16**.** These predicted PPV levels were assessed against most stringent PPV threshold value in Section. All ground-borne vibration sensitive building receptors comply with the assessment for Cosmetic Damage Impacts.

Table 9-16: Prediction and Evaluation of Environmental Impacts – Rotary Bore Piling

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No	Criteria PPV, mm/s	Compliance Yes/ No
1	80 Mount Pleasant Road	3	3	5	1.4	20	Yes	15	Yes
2	27 Jalan Mendaki	2	3	17	0.6	5	Yes	15	Yes
3	157 Mount Pleasant Road	2	3	25	0.4	5	Yes	15	Yes
4	4 Gymkhana Avenue	2	3	35	0.3	5	Yes	15	Yes
5	155 Mount Pleasant Road	2	3	40	0.3	5	Yes	15	Yes

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No	Criteria PPV, mm/s	Compliance Yes/ No
6	160 Mount Pleasant Road	2	3	43	0.3	5	Yes	15	Yes
7	18 Mount Pleasant Drive	2	3	43	0.3	5	Yes	15	Yes
8	500 Thomson Road	2	4	46	0.3	5	Yes	15	Yes
9	8 Gymkhana Avenue	2	3	47	0.3	5	Yes	15	Yes
10	6 Gymkhana Avenue	2	3	50	0.3	5	Yes	15	Yes
11	1 Thomson Lane	2	1	51	0.2	5	Yes	15	Yes
12	23 Mount Pleasant Drive	2	3	54	0.2	5	Yes	15	Yes
13	45 Merryn Road	2	2	55	0.2	5	Yes	15	Yes
14	150 Mount Pleasant Road	2	2	57	0.2	5	Yes	15	Yes
15	149 Mount Pleasant Road	2	3	59	0.2	5	Yes	15	Yes
16	39 Merryn Road	2	3	59	0.2	5	Yes	15	Yes
17	2 Whitley Road	2	2	60	0.2	5	Yes	15	Yes
18	2 Whitley Road	2	3	60	0.2	5	Yes	15	Yes
19	53 Merryn Road	2	3	61	0.2	5	Yes	15	Yes
20	37 Merryn Road	2	2	61	0.2	5	Yes	15	Yes
21	53A Merryn Road	2	3	63	0.2	5	Yes	15	Yes
22	153 Mount	2	3	64	0.2	5	Yes	15	Yes

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No	Criteria PPV, mm/s	Compliance Yes/ No
	Pleasant Road								
23	31A Merryn Road	2	3	64	0.2	5	Yes	15	Yes
24	55 Merryn Road	2	3	65	0.2	5	Yes	15	Yes
25	20 Malcolm Road	3	1	69	0.2	20	Yes	15	Yes
26	20 Malcolm Road	3	1	69	0.2	20	Yes	15	Yes
27	115 Whitley Road	2	3	70	0.2	5	Yes	15	Yes
28	8 Thomson Lane	2	3	70	0.2	5	Yes	15	Yes
29	31 Merryn Road	2	3	70	0.2	5	Yes	15	Yes
30	27 Mount Pleasant Drive	2	3	72	0.2	5	Yes	15	Yes
31	121G Whitley Road	2	3	72	0.2	5	Yes	15	Yes
32	61A Merryn Road	2	3	72	0.2	5	Yes	15	Yes
33	3 Gymkhana Avenue	2	3	73	0.2	5	Yes	15	Yes
34	121F Whitley Road	2	3	73	0.2	5	Yes	15	Yes
35	121D Whitley Road	2	3	73	0.2	5	Yes	15	Yes
36	121E Whitley Road	2	3	74	0.2	5	Yes	15	Yes
37	158 Mount Pleasant Road	2	3	75	0.2	5	Yes	15	Yes

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No	Criteria PPV, mm/s	Compliance Yes/ No
38	115A Whitley Road	2	3	75	0.2	5	Yes	15	Yes
39	49 Merryn Road	2	3	75	0.2	5	Yes	15	Yes
40	115K Whitley Road	2	3	76	0.2	5	Yes	15	Yes
41	113B Whitley Road	2	3	76	0.2	5	Yes	15	Yes
42	43A Merryn Road	2	3	76	0.2	5	Yes	15	Yes
43	41 Merryn Road	2	2	76	0.2	5	Yes	15	Yes
44	113A Whitley Road	2	3	77	0.2	5	Yes	15	Yes
45	113 Whitley Road	2	3	77	0.2	5	Yes	15	Yes
46	61 Merryn Road	2	3	77	0.2	5	Yes	15	Yes
47	51 Merryn Road	2	2	77	0.2	5	Yes	15	Yes
48	49A Merryn Road	2	3	77	0.2	5	Yes	15	Yes
49	43 Merryn Road	2	2	77	0.2	5	Yes	15	Yes
50	111B Whitley Road	2	3	78	0.2	5	Yes	15	Yes
51	51A Merryn Road	2	2	79	0.2	5	Yes	15	Yes
52	29 Merryn Road	2	2	80	0.2	5	Yes	15	Yes
53	57 Merryn Road	2	3	82	0.2	5	Yes	15	Yes

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No	Criteria PPV, mm/s	Compliance Yes/ No
54	115J Whitley Road	2	3	84	0.2	5	Yes	15	Yes
55	115B Whitley Road	2	3	85	0.2	5	Yes	15	Yes
56	117 Whitley Road	2	3	86	0.2	5	Yes	15	Yes
57	103 Whitley Road	2	3	86	0.2	5	Yes	15	Yes
58	1 Bo Seng Avenue	2	3	86	0.2	5	Yes	15	Yes
59	57A Merryn Road	2	2	86	0.2	5	Yes	15	Yes
60	35 Merryn Road	2	3	86	0.2	5	Yes	15	Yes
61	101 Whitley Road	2	3	87	0.2	5	Yes	15	Yes
62	33 Merryn Road	2	2	89	0.2	5	Yes	15	Yes
63	129 Whitley Road	2	4	91	0.2	5	Yes	15	Yes
64	230 Whitley Road	2	2	92	0.2	5	Yes	15	Yes
65	115H Whitley Road	2	3	92	0.2	5	Yes	15	Yes
66	115C Whitley Road	2	3	92	0.2	5	Yes	15	Yes
67	63 Merryn Road	2	3	92	0.2	5	Yes	15	Yes
68	59A Merryn Road	2	2	92	0.2	5	Yes	15	Yes

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Criteria PPV, mm/s	Compliance Yes/No	Criteria PPV, mm/s	Compliance Yes/ No
69	121H Whitley Road	2	3	94	0.2	5	Yes	15	Yes
70	121C Whitley Road	2	3	95	0.2	5	Yes	15	Yes
71	151 Mount Pleasant Road	2	3	96	0.2	5	Yes	15	Yes
72	7 Gymkhana Avenue	2	3	96	0.2	5	Yes	15	Yes
73	111A Whitley Road	2	3	97	0.2	5	Yes	15	Yes
74	97 Whitley Road	2	3	98	0.2	5	Yes	15	Yes
75	115G Whitley Road	2	3	99	0.2	5	Yes	15	Yes
76	115D Whitley Road	2	3	99	0.2	5	Yes	15	Yes

Notes:

1. Based on the study of the sensitive building receptor locations and buildings information, the buildings listed do not have basement levels and are assumed to have reinforced concrete (RC) piles as building foundations.
2. There are no Priority 1 sensitive building receptors within the Study Area.

Human Impacts

Predicted vibration levels from rotary bore piling are presented in **Table 9-18**. From the analysis, impact bore piling was predicted to cause a vibration level of 0.2 mm/s (at 99 m from the construction area) and up to 1.4 mm/s (at 5 m from the construction area). Out of the 76 sensitive building receptors assessed, 72 sensitive building receptors will potentially experience Negligible impact intensity, three (3) sensitive building receptors will potentially experience a Low impact intensity, and one (1) will potentially experience a Medium impact intensity.

Concerning the impact assessment evaluation matrix defined in **Section 6.4.2**, receptors 25 (China Collection) and 26 (Benchmark Wines), which were classified as Priority 3, would have an Imperceptible sensitivity consequence. As the likelihood of the rotary impact bore piling activity is Occasional, the resulting impact significance is Negligible.

There are 70 Priority 2 and one (1) Priority 3 sensitive building receptors will have a Very Low sensitivity consequence. As the likelihood of the rotary bore piling activity is Occasional, the resulting impact significance is Minor.

Out of the 73 vibration sensitivity receptors which were classified as Priority 2, three (3) receptors would have Low impact intensity, Low sensitivity consequence. As the likelihood of the rotary bore piling activity is Occasional, the resulting impact significance is Minor.

Based on the assessment criteria, vibration mitigation measures will not be required to lower the impact significance level if the rotary bore piling method is used.

Ecological Impacts

For a conservative assessment, the PPV levels at 10 m from an assumed rotary bore piling rig within the Study Area has been predicted to assess the impacts if any Bamboo Clusters, Stream 1, Stream 2 and other areas of the Study Area found to be within a 10 m radius of a piling rig. The summary of the impact assessment and evaluation is stated in **Table 9-18**.

At 10 m the PPV level was predicted to be 0.8 mm/s at ground level. In accordance to the impact evaluation matrix explained in **Section 6.4.2**, the predicted impact intensity is Low, impact consequence is Very Low. Given that impact bore piling activity will only occur occasionally, the resulting impact significance is Minor. No further mitigation measures will be required to reduce the impact of significance any more.

Table 9-17: Prediction and Evaluation of Environmental Impacts –Rotary Bore Piling (Ecological Impacts)

S/N	Ecological Receptor	Sensitivity Classification	Distance to Piling Rig, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
1	Bamboo Clusters (habitat for Bamboo Bats)	3	10	0.8	Low	Very Low	Occasional	Minor
2	Stream 1 (habitat for Collared Threadtail)							
3	Stream 2 (habitat for Collared Threadtail)							
4	Other areas in Study Area (habitat for birds and butterflies)							

Table 9-18: Prediction and Evaluation of Environmental Impacts – Rotary Bore Piling

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
1	80 Mount Pleasant Road	3	3	5	1.4	Medium	Very Low	Occasional	Minor
2	27 Jalan Mendaki	2	3	17	0.6	Low	Low	Occasional	Minor
3	157 Mount Pleasant Road	2	3	25	0.4	Low	Low	Occasional	Minor
4	4 Gymkhana Avenue	2	3	35	0.3	Low	Low	Occasional	Minor
5	155 Mount Pleasant Road	2	3	40	0.3	Negligible	Very Low	Occasional	Minor
6	160 Mount Pleasant Road	2	3	43	0.3	Negligible	Very Low	Occasional	Minor
7	18 Mount Pleasant Drive	2	3	43	0.3	Negligible	Very Low	Occasional	Minor
8	500 Thomson Road	2	4	46	0.3	Negligible	Very Low	Occasional	Minor
9	8 Gymkhana Avenue	2	3	47	0.3	Negligible	Very Low	Occasional	Minor
10	6 Gymkhana Avenue	2	3	50	0.3	Negligible	Very Low	Occasional	Minor
11	1 Thomson Lane	2	1	51	0.2	Negligible	Very Low	Occasional	Minor
12	23 Mount Pleasant Drive	2	3	54	0.2	Negligible	Very Low	Occasional	Minor
13	45 Merryn Road	2	2	55	0.2	Negligible	Very Low	Occasional	Minor
14	150 Mount Pleasant Road	2	2	57	0.2	Negligible	Very Low	Occasional	Minor
15	149 Mount Pleasant Road	2	3	59	0.2	Negligible	Very Low	Occasional	Minor
16	39 Merryn Road	2	3	59	0.2	Negligible	Very Low	Occasional	Minor
17	2 Whitley Road	2	2	60	0.2	Negligible	Very Low	Occasional	Minor

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
18	2 Whitley Road	2	3	60	0.2	Negligible	Very Low	Occasional	Minor
19	53 Merryn Road	2	3	61	0.2	Negligible	Very Low	Occasional	Minor
20	37 Merryn Road	2	2	61	0.2	Negligible	Very Low	Occasional	Minor
21	53A Merryn Road	2	3	63	0.2	Negligible	Very Low	Occasional	Minor
22	153 Mount Pleasant Road	2	3	64	0.2	Negligible	Very Low	Occasional	Minor
23	31A Merryn Road	2	3	64	0.2	Negligible	Very Low	Occasional	Minor
24	55 Merryn Road	2	3	65	0.2	Negligible	Very Low	Occasional	Minor
25	20 Malcolm Road	3	1	69	0.2	Negligible	Imperceptible	Occasional	Negligible
26	20 Malcolm Road	3	1	69	0.2	Negligible	Imperceptible	Occasional	Negligible
27	115 Whitley Road	2	3	70	0.2	Negligible	Very Low	Occasional	Minor
28	8 Thomson Lane	2	3	70	0.2	Negligible	Very Low	Occasional	Minor
29	31 Merryn Road	2	3	70	0.2	Negligible	Very Low	Occasional	Minor
30	27 Mount Pleasant Drive	2	3	72	0.2	Negligible	Very Low	Occasional	Minor
31	121G Whitley Road	2	3	72	0.2	Negligible	Very Low	Occasional	Minor
32	61A Merryn Road	2	3	72	0.2	Negligible	Very Low	Occasional	Minor
33	3 Gymkhana Avenue	2	3	73	0.2	Negligible	Very Low	Occasional	Minor
34	121F Whitley Road	2	3	73	0.2	Negligible	Very Low	Occasional	Minor
35	121D Whitley Road	2	3	73	0.2	Negligible	Very Low	Occasional	Minor
36	121E Whitley Road	2	3	74	0.2	Negligible	Very Low	Occasional	Minor
37	158 Mount Pleasant Road	2	3	75	0.2	Negligible	Very Low	Occasional	Minor
38	115A Whitley Road	2	3	75	0.2	Negligible	Very Low	Occasional	Minor

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
39	49 Merryn Road	2	3	75	0.2	Negligible	Very Low	Occasional	Minor
40	115K Whitley Road	2	3	76	0.2	Negligible	Very Low	Occasional	Minor
41	113B Whitley Road	2	3	76	0.2	Negligible	Very Low	Occasional	Minor
42	43A Merryn Road	2	3	76	0.2	Negligible	Very Low	Occasional	Minor
43	41 Merryn Road	2	2	76	0.2	Negligible	Very Low	Occasional	Minor
44	113A Whitley Road	2	3	77	0.2	Negligible	Very Low	Occasional	Minor
45	113 Whitley Road	2	3	77	0.2	Negligible	Very Low	Occasional	Minor
46	61 Merryn Road	2	3	77	0.2	Negligible	Very Low	Occasional	Minor
47	51 Merryn Road	2	2	77	0.2	Negligible	Very Low	Occasional	Minor
48	49A Merryn Road	2	3	77	0.2	Negligible	Very Low	Occasional	Minor
49	43 Merryn Road	2	2	77	0.2	Negligible	Very Low	Occasional	Minor
50	111B Whitley Road	2	3	78	0.2	Negligible	Very Low	Occasional	Minor
51	51A Merryn Road	2	2	79	0.2	Negligible	Very Low	Occasional	Minor
52	29 Merryn Road	2	2	80	0.2	Negligible	Very Low	Occasional	Minor
53	57 Merryn Road	2	3	82	0.2	Negligible	Very Low	Occasional	Minor
54	115J Whitley Road	2	3	84	0.2	Negligible	Very Low	Occasional	Minor
55	115B Whitley Road	2	3	85	0.2	Negligible	Very Low	Occasional	Minor
56	117 Whitley Road	2	3	86	0.2	Negligible	Very Low	Occasional	Minor
57	103 Whitley Road	2	3	86	0.2	Negligible	Very Low	Occasional	Minor
58	1 Bo Seng Avenue	2	3	86	0.2	Negligible	Very Low	Occasional	Minor
59	57A Merryn Road	2	2	86	0.2	Negligible	Very Low	Occasional	Minor
60	35 Merryn Road	2	3	86	0.2	Negligible	Very Low	Occasional	Minor

S/N	Sensitive Building Receptor	Sensitivity Classification	Number of Floors above Ground	Distance to Construction Area, m	Predicted PPV, mm/s	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
61	101 Whitley Road	2	3	87	0.2	Negligible	Very Low	Occasional	Minor
62	33 Merryn Road	2	2	89	0.2	Negligible	Very Low	Occasional	Minor
63	129 Whitley Road	2	4	91	0.2	Negligible	Very Low	Occasional	Minor
64	230 Whitley Road	2	2	92	0.2	Negligible	Very Low	Occasional	Minor
65	115H Whitley Road	2	3	92	0.2	Negligible	Very Low	Occasional	Minor
66	115C Whitley Road	2	3	92	0.2	Negligible	Very Low	Occasional	Minor
67	63 Merryn Road	2	3	92	0.2	Negligible	Very Low	Occasional	Minor
68	59A Merryn Road	2	2	92	0.2	Negligible	Very Low	Occasional	Minor
69	121H Whitley Road	2	3	94	0.2	Negligible	Very Low	Occasional	Minor
70	121C Whitley Road	2	3	95	0.2	Negligible	Very Low	Occasional	Minor
71	151 Mount Pleasant Road	2	3	96	0.2	Negligible	Very Low	Occasional	Minor
72	7 Gymkhana Avenue	2	3	96	0.2	Negligible	Very Low	Occasional	Minor
73	111A Whitley Road	2	3	97	0.2	Negligible	Very Low	Occasional	Minor
74	97 Whitley Road	2	3	98	0.2	Negligible	Very Low	Occasional	Minor
75	115G Whitley Road	2	3	99	0.2	Negligible	Very Low	Occasional	Minor
76	115D Whitley Road	2	3	99	0.2	Negligible	Very Low	Occasional	Minor

Notes:

3. Based on the study of the sensitive building receptor locations and buildings information, the buildings listed do not have basement levels and are assumed to have reinforced concrete (RC) piles as building foundations.
4. There are no Priority 1 sensitive building receptors within the Study Area.

9.4.1.2 Recommended Monitoring Program

From the analysis presented in **Section 9.3.11,** additional mitigation measures are not required for the works. A ground-borne vibration monitoring program can be implemented if required by the Client, see AECOM's proposed program in **Table 9-19**. The vibration monitoring program is typically measuring the vibration levels caused by construction works throughout the construction phase in real-time. AECOM recommends installing a monitoring program that is capable to transmit 'trigger level alert' and 'stop work alert' messages to the Client to manage the ground-borne vibration levels emitted to the nearby sensitive receptors.

80 Mount Pleasant Road was recommended as this is the nearest sensitive ground-borne vibration building receptor to the Study Area that is representative of human impacts.

Table 9-19: Recommended Monitoring Program (Ground-borne Vibration)

No.	Location	Parameter/s	Frequency and duration
1	80 Mount Pleasant Road	Vibration Velocity PPV	Construction Phase

9.4.2 Operational Phase

The implementation of minimum controls will be sufficient to mitigate the ground-borne vibration impacts on the ground-borne vibration sensitive receptors.

9.5 Residual Impacts

9.5.1 Construction Phase

From the analysis presented in **Section 9.3.11**, by using the rotary piling method, the overall impact significance level is Minor. However, with the controls in place, these impacts will last for a few days only within the entire duration of the construction period.

The typical construction equipment for the road construction of the indicative alternative road plan 2 along PIE that produce vibration impacts are bulldozer, loaded trucks and vibratory roller. These impacts will last for a few days only among the entire duration of the construction period. Occupants of nearby sensitive buildings could be notified of potential works so that they are informed of the potential disturbances. Therefore, the overall impact significance is Minor.

9.5.2 Operational Phase

From the analysis presented in **Section 9.3.12**, the overall impact significance level is Moderate for Priority 2 building receptors. However, with further controls of the traffic and proper maintenance of the surface of the roads, these impacts can be reduced to Minor during the operation period. Heavy traffic flow for the indicative alternative road plan 2 along PIE is unlikely, therefore the overall impact significance is potentially Negligible.

9.6 Summary of Key Findings

Ground-borne noise and vibration impact assessment was conducted within the Study Area. It should be noted that forested area are not in a building environment hence ground-borne noise impact assessment does not apply and have been scoped out of the report. Baseline vibration levels were monitored at three locations to understand the baseline ground-borne vibration levels within the Study Area (See **Figure 9-1**).

The impacts of vibration (from impact and rotary piling) on the sensitive receptors were analysed, regarding the available information at the time of assessment. Several conservative yet practical assumptions were made throughout this assessment. For ground-borne vibration impact assessment during construction phase, 76 (Priority 2 – 73; Priority 3 – 3) sensitive building receptors have been identified within a potential impact zone of 100 m around the Study Area. Building receptors such as housing and school were classified as Priority 2 sensitive receptors.

Priority 2 and 3 ground-borne vibration sensitive building receptors were assessed for cosmetic damage impacts and human impacts. The analysis indicates that the ground-borne vibration levels caused by impact and rotary piling methods are unlikely to cause any building cosmetic damage as the predicted PPV levels comply to the most stringent PPV threshold criteria. It was recognised that a low vibration piling method (rotary) may reduce the predicted vibration levels and human impacts.

For the assessment on ecological impacts, Bamboo Clusters, Stream 1 and Stream 2 were assessed as ecological receptors for construction and operational phases. Bamboo Bats are likely going to roost in the bamboo clusters during the day, thus they are classified as Priority 3 sensitive ecological receptors. As their foraging behaviour is not on ground level for the Collared Threadtail (from Stream 1 and 2), and birds and butterflies are highly mobile, they have been classified as Priority 3 sensitive ecological receptors. Based on the quantitative analysis for the construction phase and qualitative analysis for the operational phase, the overall impact significance level was assessed to be Minor.

The impact assessment for the indicative alternative road plan 2 along PIE is qualitative. During construction phase of the road, the overall impact significance is Minor since potential disturbances are temporary and will only last for a few days within the entire duration of the construction period. During operational phase, heavy traffic flow on the indicative alternative road plan 2 along PIE is unlikely, therefore the overall impact significance is potentially Negligible.

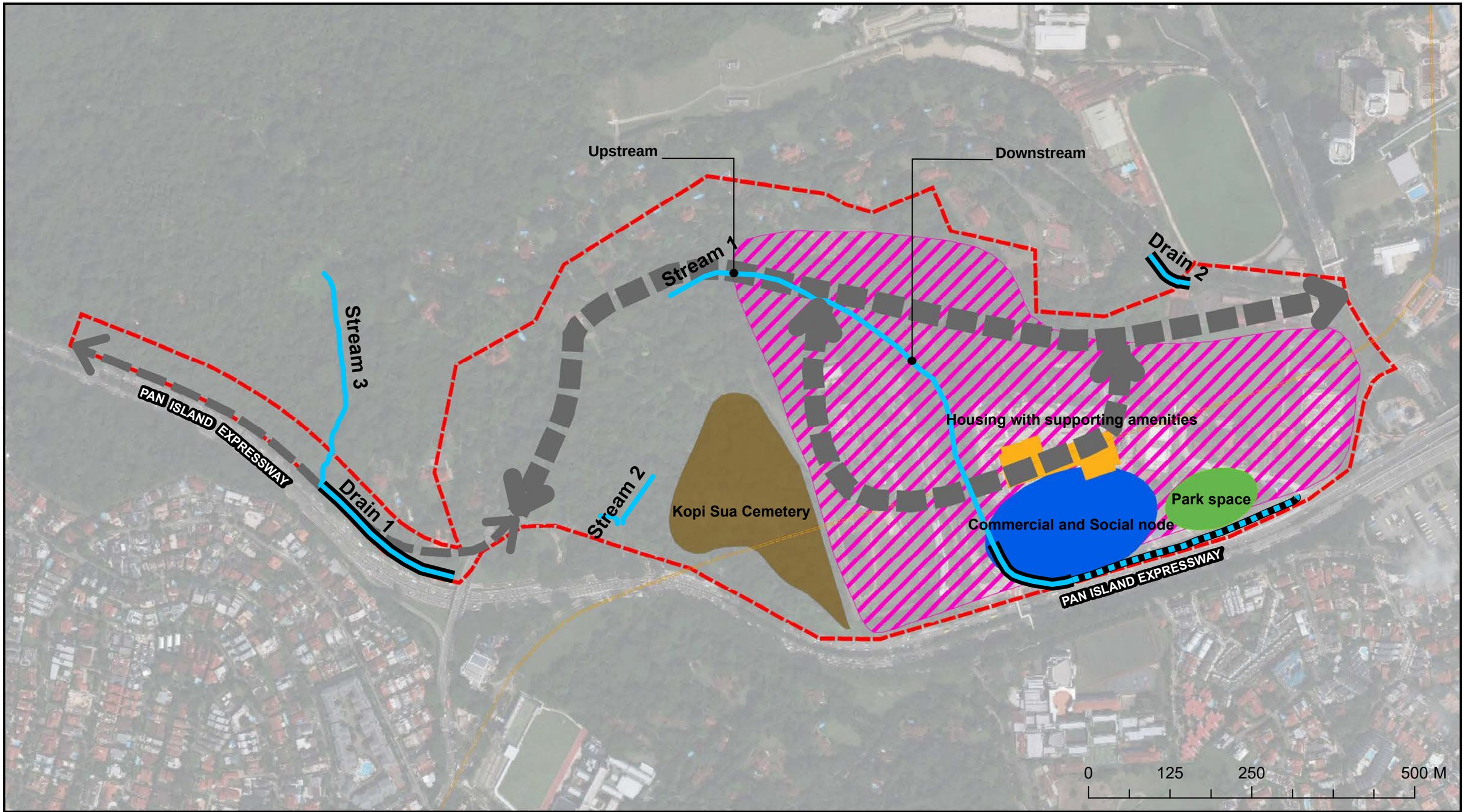
10.0 Hydrology and Water Quality

10.1 Introduction

This section includes the assessment of surface water quality and stream characteristics within the Study Area, as well as the evaluation of the impacts from the construction and operational phases of the development on the waterbodies and hydrology of the Study Area (refer to **Figure 10-1**). Results from the site surveys were presented to establish the baseline conditions which were used to analyze the subsequent changes due to construction and operational activities associated with the project. Sensitive receptors were identified and classified according to the sensitivity categorization defined in **Section 6.2.2**. Potential sources of impact from the project that could affect the identified sensitive receptors and the minimum controls put in place to reduce them were also described to allow for impact prediction. Thereafter, an impact evaluation was carried out to assign significance to predicted impacts and where necessary, mitigation measures were proposed. An EMMP was also developed to specify methods and measures to be included during construction and operation of the project which are necessary to reduce the environmental impacts to minimal levels (see **Section 14.0**).

The scope of work of the hydrological and surface water quality impact assessment consisted of:

- Reviewing data provided by the Client and topographic surveyor to understand the topographic and hydrographic characteristics of the Study Area;
- Site reconnaissance survey for a better understanding of the Study Area's topography, hydrology, land cover and existing waterbodies with their properties (i.e. locations, water flow conditions and bank characteristics);
- Identification of sampling locations for in-situ and ex-situ water quality analysis of existing waterbodies located within the Study Area; and
- Hydrological and surface water quality impact analysis to assess the potential impacts of the project during construction and operational phases.



Legend

Major Stream/ Drain
- Concrete Drain
- Natural Stream
- Underground Drain
- Indicative Original Road Plan
- Thomson-East Coast Line
- MRT Station (U/C)

Proposed Layout Plan
- Commercial and Social node
- Housing with supporting amenities
- Park space
- Kopi Sua Cemetery
- Study Area

N

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-	JAN 2021	LAL	Final Report	NHT	JAG

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HOUSING & DEVELOPMENT BOARD

Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT

Figure Title :

STUDY AREA FOR THE HYDROLOGY AND SURFACE WATER QUALITY IMPACT ASSESSMENT AND PROPOSED FUTURE DEVELOPMENT

Designed	Checked	Approved
LAL	NHT	JAG
	Drawn: LAL	Date: JUN 2021

Figure No. :	Rev.	Sheet
10 - 1	02	1 of 1

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10.2 Hydrology and Water Quality Baseline Assessment

The activities performed as part of the baseline assessment included the following:

- To assess the accessibility of the waterbodies within the Study Area;
- To verify the information collected from the available topographic survey and satellite images;
- To identify and map out the location of existing waterbodies within the Study Area;
- To determine the drain and stream flow conditions and bank characteristics; and
- To assess current surface water quality conditions in existing waterbodies within the Study Area.

10.2.1 Baseline Monitoring Personnel

The assessment and site surveys were conducted by the following AECOM personnel:

- Dr. Thanh Nguyen (Technical Lead and Reviewer of Water Resources);
- Dr. Liang Liang (Hydrology and Water Quality Specialist);
- Ms. Jacquelynn Chia (Hydrology and Water Quality Specialist); and
- Mr. Grujica Sarenac (Hydrology and Water Quality Specialist).

10.2.2 Baseline Monitoring Methodology

10.2.2.1 Desktop Assessment

Desktop research aided in determining the location of existing waterbodies within the Study Area. Using the topographic survey data, ArcGIS was applied to develop an elevation map for the Study Area to support the findings of the hydrological survey. With the aid of these maps, the catchment area (i.e. the source of water flow to existing streams or drains) was identified and analysed to further support the environmental impact study. The information, retrieved during the desktop assessment, comprised of publicly available data from government and technical agencies, existing publicly-available data (e.g. rainfall data, online satellite images), as well as published books, relevant articles, and other online sources.

10.2.2.2 Hydrology Baseline Assessment

Hydrology baseline assessment was first carried out through the review of topographic survey data to development an elevation and drainage map. Satellite images from online sources were also used.

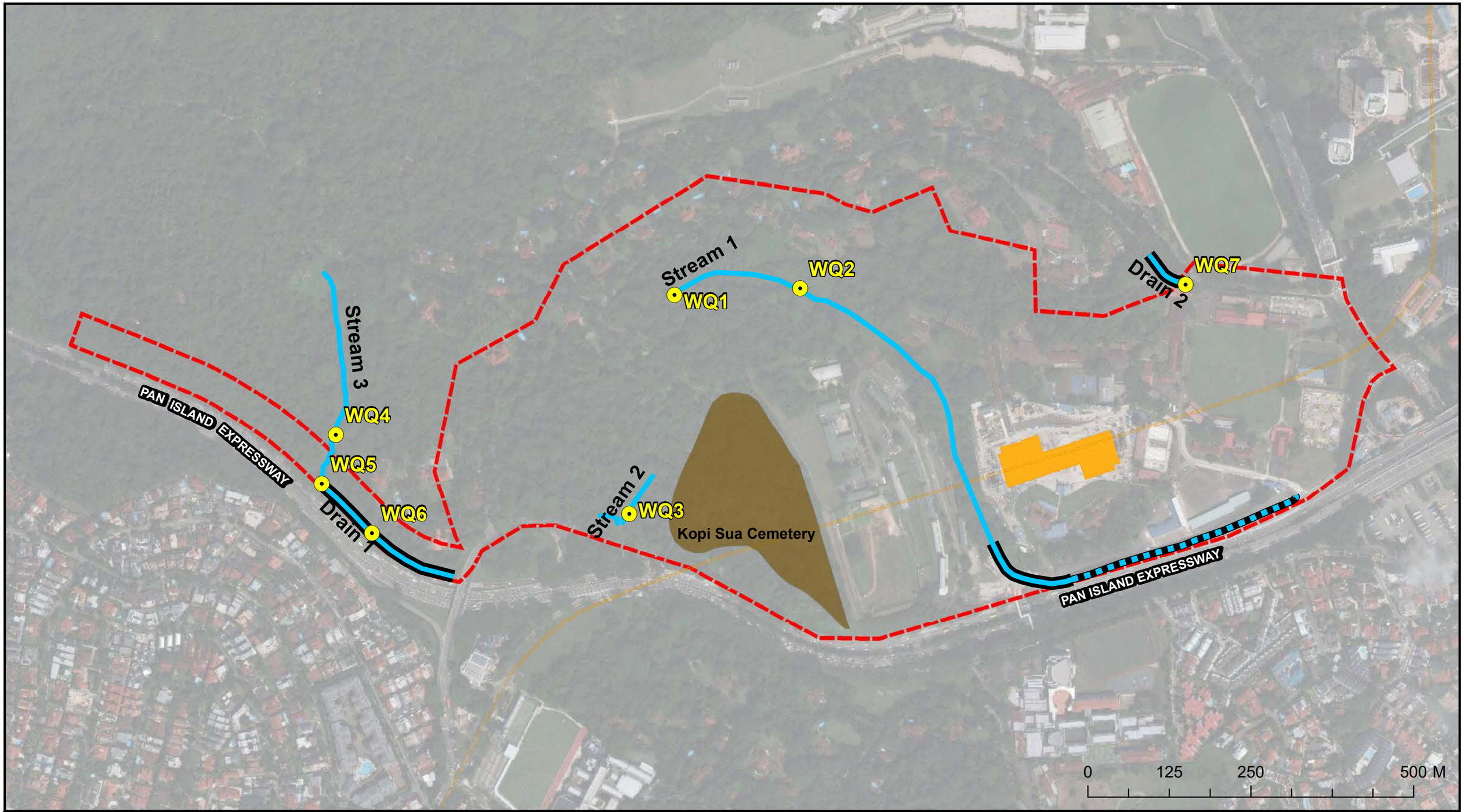
The hydrological survey was conducted by casual exploration methods to identify and outline existing major streams and waterbodies within the Study Area. The surface waterbody conditions, such as stream bank characteristics (e.g. natural bank or artificial bank), were estimated based on visual observations and the water specialist's technical experience. A GPS device was used to track the hydrology survey route. The GPS data was then synchronised with the photos taken on-site to identify the exact location of identified waterbodies.

10.2.2.3 Water Quality Baseline Assessment

As mentioned in the section above, waterbodies present in the Study Area were identified during site surveys. Suitable locations were selected within the identified waterbodies for collection of water samples in order to assess the baseline in-situ and ex-situ water quality of existing waterbodies within the Study Area. The baseline conditions of the surface water quality at the Study Area were then established.

Water samples were collected at seven (7) water quality stations along the streams as detailed in **Figure 10-2** and **Table 10-1**. Stations WQ1 and WQ2 were selected to capture the upstream and downstream water quality within Stream 1. Only one station, WQ3, was selected to capture the downstream water quality within Stream 2, due to its short overall length. Similarly, Stations WQ4 and WQ5 were selected to determine the upstream and downstream water quality of Stream 3. Stations WQ6 and WQ7 were selected to study the runoff quality in the stormwater drains.

Apart from WQ6 and WQ7, two dry weather (normal conditions) and one wet weather (after a storm event) samples were collected from each water quality station. Only wet weather samples were collected at WQ6 and WQ7, as dry weather sampling was not viable due to low flow. Dry-weather conditions are defined as after a continuous 48-hour period of no-rain, and wet-weather conditions are defined as a rainfall event having more than 10mm of rainfall, with samples to be collected within 3 hours after the rain stops. A total of seventeen (17) samples were collected for this study.



Legend

- Water Quality Sampling Locations
- Thomson-East Coast Line
- MRT Station (U/C)
- Study Area

Major Stream/ Drain

- Concrete Drain
- Natural Stream
- Underground Drain
- Kopi Sua Cemetery

N

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ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

WATER QUALITY SAMPLING LOCATIONS WITHIN THE STUDY AREA

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LAL	NHT	JAG	10 - 2	-	1 of 1
	Drawn LAL	Date JAN 2021	CAD File Name : NA		A3

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Table 10-1: Rationale for the Selection of Water Quality Sampling Locations

Survey Locations	Rationale
WQ1	To capture water quality at an upstream location of Stream 1
WQ2	To capture water quality at a downstream location of Stream 1 before the water quality in the stream to be disturbed by on-going construction activities and urbanized area
WQ3	To capture water quality at a downstream location of Stream 2. Only one sample was taken due to the short length of Stream 2
WQ4	To capture water quality at an upstream location of Stream 3 before entering the Study Area
WQ5	To capture water quality at a downstream location of Stream 3
WQ6	To capture water quality at the storm water drain (Drain) next to the Pan Island Expressway
WQ7	To capture water quality at the stormwater drain (Drain 2) running along Mount Pleasant Road before reaching Denham Road.

In-situ water quality parameters assessed in this study were all measured using a calibrated multi-parameter digital sensor (YSI ProDSS) with USEPA approved testing methods for water quality parameters and included:

- Temperature;
- pH;
- Salinity;
- Conductivity; and
- Dissolved oxygen (DO).

The ex-situ parameters analysed by Marchwood Laboratory Services Pte Ltd (MLS) are listed below:

- Turbidity;
- Total Suspended Solids (TSS);
- Total Dissolved Solids (TDS);
- Biochemical Oxygen Demand (BOD5);
- Total Organic Carbon (TOC);
- Total Nitrogen (TN);
- Nitrate (NO3-N);
- Ammonia (NH4-N);
- Total Phosphorus (TP);
- Orthophosphate (PO4-P);
- Enterococcus; and
- Lead (Pb).

10.2.3 Baseline Monitoring Results

This report presents the hydrology and water quality findings of the field assessments carried out on the following dates:

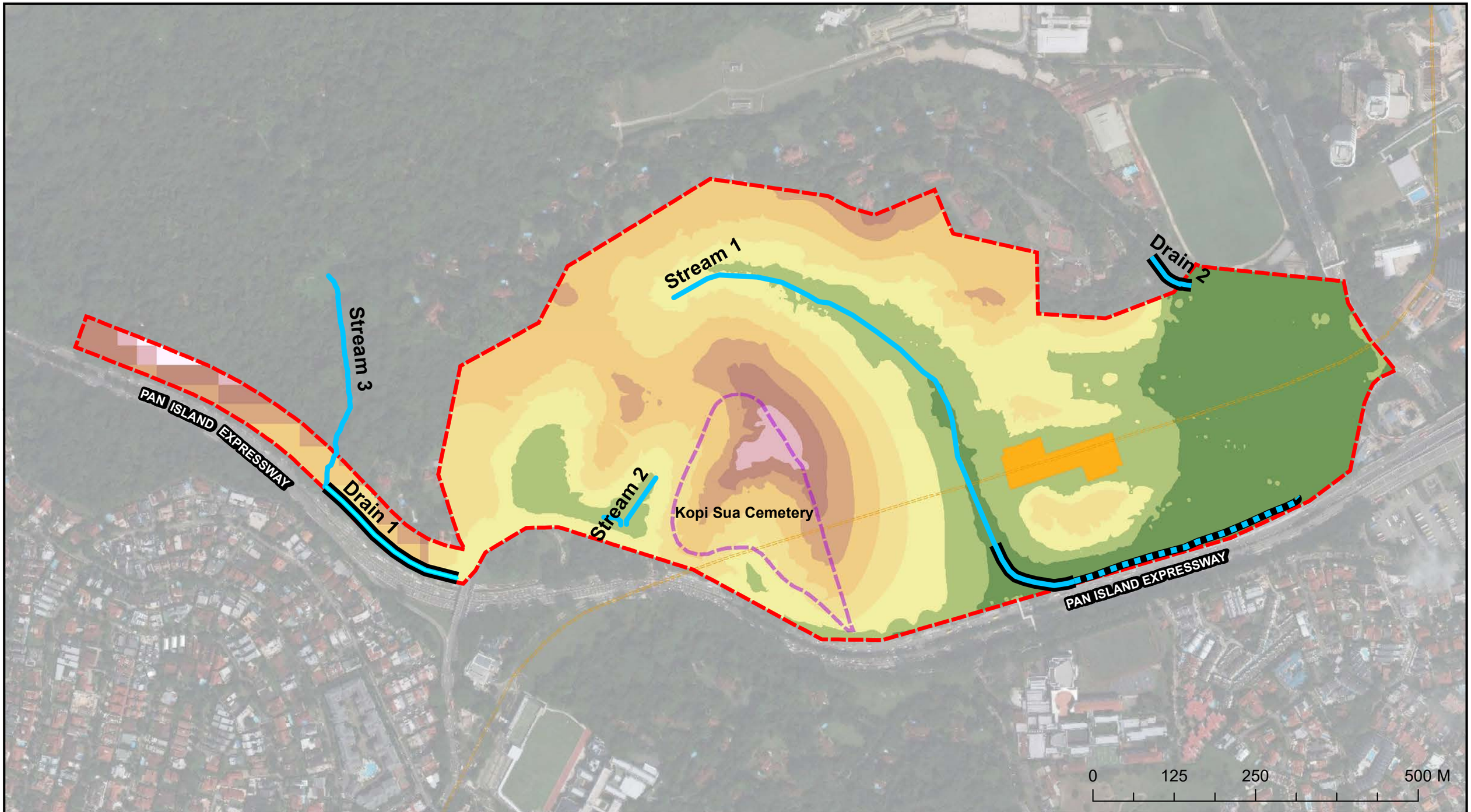
- 30th January 2019 (site reconnaissance);
- 24th May 2019 (dry weather sampling);
- 31st May 2019 (dry weather sampling);
- 30th August 2019 (wet weather sampling);

- 7th January 2020 (dry weather sampling);
- 14th January 2020 (dry weather sampling);
- 21st January 2020 (wet weather sampling); and
- 13th August 2020 (wet weather sampling)

10.2.3.1 Hydrological Conditions in the Study Area

During site reconnaissance, three main natural streams were observed, with Stream 1 flowing alongside Onraet Road, Stream 2 flowing close to the Pan Island Expressway and Stream 3 running across the new Proposed Slip Road Area from north to south towards the PIE (**Figure 10-2**). A stormwater drain (Drain 1) adjacent to Pan Island Expressway (PIE) has been selected for this study as it runs along the proposed road, while another stormwater drain (Drain 2) running along Mount Pleasant Road was selected as it receiving storm runoff from the northeast part of the Study Area.

One (1) set of site contour data in CAD files was received from the Client on 15th February 2019 while the other set of topographic survey was received from topographic surveyor on 4th September 2020. Elevation map overlaid with surface waterbodies (**Figure 10-3**) was generated with the topographic survey data using ArcGIS. As shown in **Figure 10-3** and **Figure 10-4**, Study Area can be described as a hilly and undulating, with moderate rising slopes towards the northwest in the Study Area and decreasing slopes towards the south. The low-lying areas within the Study Area include the OPA and the under-construction Mount Pleasant MRT Station, located towards the southeast portion of the Study Area. Hence, water generally flows from northwest to southeast of the Study Area. In the Proposed Slip Road Area, the low-lying area is along the PIE and thus water generally flows from northeast to southwest. Based on the elevation map, catchment delineation has been generated for the study area as shown in **Figure 10-5**. Generally, the water catchment of the Study Area has been delineated into four (4) sub-catchment areas. As shown in **Figure 10-5**, Stream 1 mainly collects water from north and centre sub-catchment of the Study Area, while Stream 2 collects water from south and west sub-catchment of the Study Area. Drain 2 collects water from northeast of the Study Area. Stream 3 and Drain 1 collect water from the Proposed Slip Road Area. However, it should be noted that both Streams 1 and 3 also receive water from further upstream which is outside the Study Area. This again demonstrates the strategic locations of all the surface water sampling stations.



Legend

Major Stream/ Drain
- Concrete Drain
- Natural Stream
- Underground Drain
- Study Area
- Kopi Sua Cemetery
- Thomson-East Coast Line
- MRT Station (U/C)

Elevation (mRL)
- <5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- >40

N

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ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT

Figure Title :

ELEVATION MAP WITH WATERBODIES OF THE STUDY AREA (GENERATED BASED ON TOPOGRAPHIC DATA)

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LAL	NHT	JAG	10 - 3	-	1 of 1
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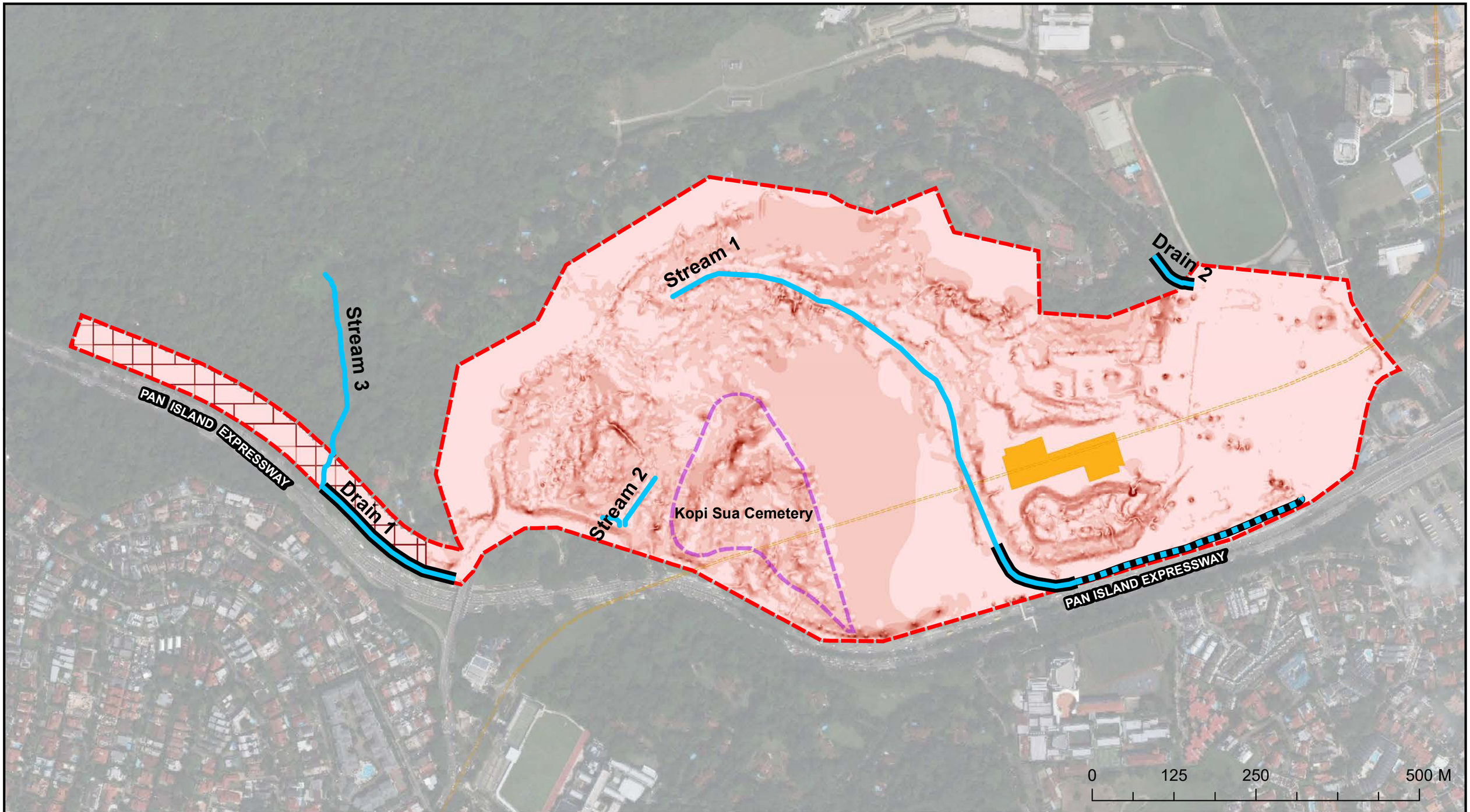

Legend

Major Stream/ Drain
- Concrete Drain
- Natural Stream
- Underground Drain
- Study Area
- Kopi Sua Cemetery
- Thomson-East Coast Line
- MRT Station (U/C)

Slope (%)
- <10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- >100

N

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CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

SLOPE MAP WITH WATERBODIES OF THE STUDY AREA (GENERATED BASED ON TOPOGRAPHIC DATA)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
LAL	NHT	JAG	10 - 4	-	1 of 1
	Drawn LAL	Date JAN 2021	CAD File Name : NA		A3

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Stream 1
Stream 2
Stream 3
Drain 1
Drain 2
Kopi Sua Cemetery
PAN ISLAND EXPRESSWAY
PAN ISLAND EXPRESSWAY
0 125 250 500 M

Legend

Major Stream/ Drain
- Concrete Drain
- Natural Stream
- Underground Drain
- Study Area
- Kopi Sua Cemetery
- Thomson-East Coast Line
- MRT Station (U/C)

Catchment
- 1
- 2
- 3
- 4
- flow direction

N

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ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

WATER CATCHMENT MAP OF THE STUDY AREA (GENERATED BASED ON TOPOGRAPHIC DATA)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
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Table 10-2 below provides details regarding the observed bank features and water flow conditions of the three streams during dry and wet weather. Field observations suggest that the natural waterbodies are surrounded by dense vegetation. The three (3) identified streams and two (2) drains carry the runoff in the Study Area. Stagnant/very low flowing water was observed during both dry and wet weather at the upstream point of Stream 1, while increased dry weather flow was observed at its downstream point. In Stream 2, Drain 1 and Drain 2, low dry weather flow was observed, with increased flow rate during wet weather. Moderate flow rate was observed for Stream 3 during dry weather and an increase of flow during wet weather.

Table 10-2: Description of Existing Streams and Drains within the Study Area

Waterbodies	Bank Characteristics	Water Flow Conditions	Photos
Stream 1	Upstream of the stream is a closed culvert which is partially collapsed. After the culvert, the bank of the stream is natural bank. The stream ran underground partly in the middle. Concrete banks are located downstream. Both upstream and downstream are covered by dense vegetation. This stream is likely to be old drains during kampong life getting naturalised as some level of concreting and partial cover was observed. Estimated stream length was 730m.	• Originates from the Study Area and upstream residential area • Perennial shallow flow During Dry weather condition: • Upstream: stagnant or very slow water flow observed (flow rate estimated at 0.16 m^3/s) • Approximately 15 - 20 cm depth and an approximate width of 80 -100 cm, at time of survey • Downstream: slow dry weather flow • Approximately 30 - 50 cm depth and an approximate width of 80 -100 cm, at time of survey • Water is clear and no smell During wet weather condition: • Upstream: stagnant or very slow water flow • Approximately 20 - 30 cm depth and an approximate 80 – 100 cm width for upstream water • Downstream: increased flow rate found after a storm event • Approximately 50 - 60 cm depth and an approximate 80 – 100	During Dry Weather Upstream (WQ1) Downstream (WQ2) During Wet Weather Upstream (WQ1) Downstream (WQ2)

Waterbodies	Bank Characteristics	Water Flow Conditions	Photos
		cm width for downstream water • Water is clear and no smell	
Stream 2	Natural earth bank covered by dense vegetation. Stream ran continuously above ground. Estimated stream length was 100 m.	• Originates from the forest within the Study Area During Dry weather condition: • Perennial shallow flow (flow rate estimated at 0.16 m^3/s) • Approximately 5 – 10 cm water depth and approximately 30 – 60 cm water width at time of survey • Water is clear and no smell During Wet weather condition: • Increased flow rate found after a storm event • Approximately 5 - 10 cm water depth and approximately 50 – 100 cm water width, at time of survey • Water is clear and no smell	During Dry Weather During Wet Weather
Stream 3			During Dry Weather

<table>
<tr><th>Waterbodies</th><th>Bank Characteristics</th><th>Water Flow Conditions</th><th colspan="2">Photos</th></tr>
<tr><td rowspan="4"></td><td rowspan="4">Natural earth bank covered by dense vegetation. Estimated stream length was 125 m.</td><td rowspan="4">• Originates from forest area to the north of study boundary

During Dry weather condition:
• <u>Upstream</u>: Moderate perennial flow (flow rate estimated at 0.2 m^3/s)
• Approximately 6 – 8 cm water depth, and a channel width of approximately 40 – 90 cm at time of survey
• Water is clear and no smell
• <u>Downstream</u>: Moderate perennial flow, smaller channel width thus higher flow velocity than upstream
• Approximately 6 – 8 cm water depth
• Water is clear and no smell

During Wet weather condition:
• Increased flow rate and channel width after a storm event
• Approximately 6 – 8 cm water depth
• Water is clear and no smell</td><td>Upstream (WQ4)
 </td><td>Downstream (WQ5)
 </td></tr>
<tr><td colspan="2">During Wet Weather</td></tr>
<tr><td>Upstream (WQ4)
 </td><td>Downstream (WQ5)
 </td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Drain 1</td><td></td><td></td><td colspan="2">During Dry Weather</td></tr>
</table>

Waterbodies	Bank Characteristics	Water Flow Conditions	Photos
	Concrete banks without drain covers Stream channel width is approximately 1m wide.	• Originates from Study Area During Dry weather: • Almost no water flowing During Wet weather: • Increased flow rate was observed. However, when compared to other waterbodies, flow rate is considered relatively low. • Approximately 2 – 3 cm water depth • Water is clear and no smell	 During Wet Weather
Drain 2			During Wet Weather

Waterbodies	Bank Characteristics	Water Flow Conditions	Photos
	Concrete banks without drain covers Stream channel width is approximately 0.8m wide.	• Originates from Study Area During Dry weather: • Almost no water flowing During Wet weather: • Increased flow rate was observed. However, when compared to other waterbodies, flow rate is considered relatively low. • Approximately 8-9 cm water depth • Water is clear and no smell	

As Singapore does not have extensive natural aquifers or lakes and has limited land to collected stormwater, it needs to maximize stormwater harvesting. Stormwater is collected through a network of rivers, canals and drains and channelled to 17 reservoirs, after which it is treated, filtered and disinfected at the water treatment plants. Stormwater is one of Singapore's main sources of drinking water and industrial water. As shown in **Figure 10-6**, this Study Area is located within the water catchment area of Marina Reservoir, indicating that the stormwater within the Study Area is collected for drinking water purposes.

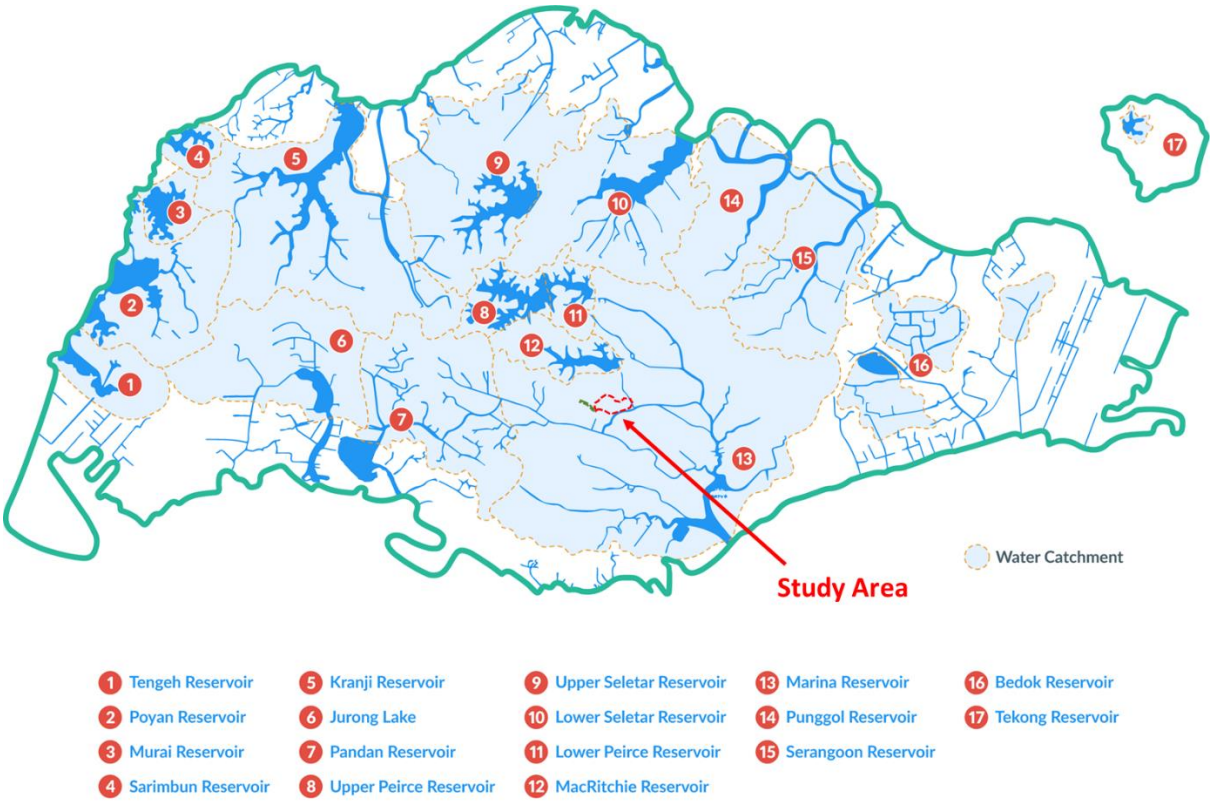


Figure 10-6: Singapore Water Catchment (PUB, n.d.)

10.2.3.2 Water Quality Conditions in the Study Area

The water quality data were assessed based on relevant guideline and criteria as described in the section below.

Relevant Guidelines and Criteria for Water Quality

The baseline water quality of the waterbodies located within the Study Area was analysed against the NEA Trade Effluent Discharge limits for uncontrolled watercourses. This comparison supports the impact assessment as it can be used to determine whether the baseline water quality of the waterbodies within the Study Area complies with NEA limits or already exceeds these limits. It should also be noted that water quality of the wastewater discharged from project should comply with these limits. Therefore, the stormwater and wastewater generated from the future development should comply with NEA Trade Effluent Discharge limits.

However, the NEA Trade Effluent Discharge limits do not provide criteria for the preservation and growth of aquatic life. To assess whether the water quality along the identified streams is suitable for aquatic life, certain parameters were compared to the water quality criteria for aquatic life from other countries (refer to **Table 10-3**), which provides guidelines for the protection of aquatic life.

The relevant limits and guidelines for water quality parameters are summarised in **Table 10-3**; however, where no guidelines exist, the monitored results were considered to be the baseline.

Table 10-3: Referenced Water Quality Guidelines and Criteria

Parameter	NEA Trade Effluent Discharge Limits[1]	Water Quality Criteria for Aquatic Life from other countries
pH	6 -9	6.5 - 9
Temperature (°C)	45	-
Salinity (ppt)	-	-
Conductivity (µS/cm)	-	-
Total Dissolved Solids, TDS (mg/L)	1000	1000
Dissolved Oxygen, DO (mg/L)	-	> 4.0
Turbidity (NTU)	-	50
Total Suspended Solids, TSS (mg/L)	30	50
Biological Oxygen Demand, BOD_5 (mg/L)[3]	20	< 3
Total Organic Carbon, TOC (mg/L)	-	-
Total Phosphorous, TP (mg/L)	-	Eutrophic limit: 0.075 mg/L
Orthophosphate, PO_4-P (mg/L)	0.65 (equivalent to 2 as PO_4)	<0.033 (equivalent to <0.1 as PO_4)
Total Nitrogen, TN (mg/L)	-	Eutrophic limit: 1.5mg/L
Nitrate, NO_3-N (mg/L)	4.52 (equivalent to 20 as NO_3)	10 (equivalent to 44 as NO_3)
Ammonia, NH_4-N (mg/L)	-	1
Enterococcus (cfu/100mL)[4]	-	-
Lead, Pb (µg/L)	100	Acute LOEL[5]: 82 Chronic LOEL[5]: 3.2

Notes:

1. *NEA Trade Effluent Discharge Limits for discharge into a controlled watercourse.*
2. *The sources incudes United Nations Economic Commission for Europe (UNECE, 1994), World Health Organization (WHO, n.d.), Water Quality Standards Handbook (USEPA, 2017), Australian & New Zealand Guidelines for Freshwater and Marine Water Quality (2000), Canadian Water Quality Guidelines for the Protection of Aquatic Life (2007), Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ, n.d.), and National Water Quality Standards for Malaysia (DOE, n.d.).*
3. *BOD_5 is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material per litre of sample during 5 days of incubation at 20 °C.*
4. *Singapore's Water Quality Guidelines for Recreational Beaches and Fresh Water Bodies requires that the Enterococcus count should be less than or equal to 200 counts per 100 millilitres of water at 95% of the time*
5. *LOEL – Lowest Observed Effect Level*

Surface Water Quality Results

From May 2019 to August 2020, the water quality sampling was conducted in the Study Area as shown in Table 10-4. For WQ1 to WQ5, sampling was conducted for two (2) dry weather events and one (1) wet weather event. However, due to the ephemeral flow conditions in the concrete drains, it was considered unlikely that any aquatic life exists there. Hence, samples were only taken from WQ6 and WQ7 during wet days and its water quality was not compared with criteria for aquatic life.

The water quality results are presented in **Table 10-5**, and were assessed against guidelines listed in **Table 10-3**. The laboratory results for surface water quality parameters are also presented in **Appendix I**. If there are no guidelines available for any parameters, the monitored results were considered to be the baseline. This comparison supports the impact assessment as the streams/drains within the Study

Area were found to flow into public watercourses, and it allows for an assessment of whether the existing water quality is in compliance with the identified limits.

It should be noted that the water quality of any water generated from the project's activities during both construction and operational phases should comply with the NEA allowable limits for discharge into an uncontrolled watercourse.

Table 10-4: Water Quality Monitoring Schedule

Sampling Event / Water Quality Sampling Location		Dry Weather				Wet Weather		
		24th MAY 2019	31st MAY 2019	7th JAN 2020	14th JAN 2020	30th AUG 2019	21st JAN 2020	13th AUG 2020
Stream 1	WQ1	√	√	-	-	√	-	-
	WQ2	√	√	-	-	√	-	-
Stream 2	WQ3	√	√	-	-	√	-	-
Stream 3	WQ4	-	-	√	√	-	√	-
	WQ5	-	-	√	√	-	√	-
Drain 1	WQ6	-	-	-	-	-	√	-
Drain 2	WQ7	-	-	-	-	-	-	√

Table 10-5: Surface Water Quality Results

Parameter	Dry					Wet							Average	Detection Limit	NEA Allowable Limits [1]	Water Quality Criteria for Aquatic Life from other countries [2]
	WQ1	WQ2	WQ3	WQ4	WQ5	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6	WQ7				
Temperature (˚C)	27.3	26.6	26.5	25.6	25.6	25.6	26.2	26.1	26.0	26.0	27.2	26.6	26.3	-	45	-
pH	5.56	5.90	6.03	5.49	5.85	*[3]	*[3]	*[3]	5.87	6.08	7.72	7.35	6.31	-	6 – 9	6.5 – 9
Salinity (PSU)	0.07	0.03	0.04	0.03	0.04	0.05	0.08	0.04	0.04	0.04	0.06	0.02	0.04	-	-	-
Conductivity (µS/cm)	148	73	85	74	82	108	168	92	95	96	163	49	102	-	-	-
DO (mg/L)	1.09	2.22	1.48	3.81	5.14	4.56	1.99	1.99	3.56	4.89	7.58	8.00	4.37	-	-	>4
Turbidity (NTU)	2.1	4.4	2.8	6.4	7.9	11.0	13.0	5.2	30.0	25.0	9.8	13.0	9.5	-	-	50
Total Suspended Solids, TSS (mg/L)	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	19.3	26.7	BDL[4]	20.7	BDL[4]	BDL[4]	BDL[4]	11.7	10	30	50
Total Dissolved Solids, TDS (mg/L)	83	46	50	48	52	72	114	60	69	66	106	36	64.9	10	1000	1000
Total Nitrogen, TN (mg/L)	1.21	0.41	0.21	0.20	0.32	1.52	1.52	0.53	0.48	0.69	2.00	0.89	0.86	0.01	-	Eutrophic Limit: 1.5
Nitrate as NO_3-N (mg/L)	1.02	0.18	0.12	0.076	0.079	0.58	0.49	0.24	0.19	0.24	1.38	0.79	0.53	0.015	4.52	10
Ammonia as NH_4-N (mg/L)	0.025	0.043	0.028	0.037	0.150	0.200	0.360	0.056	0.064	0.120	0.010	0.011	0.068	0.01	-	1
Total Phosphorous, TP (mg/L)	0.025	0.041	0.043	0.046	0.052	0.230	0.056	0.044	0.063	0.072	0.047	0.043	0.055	0.01	-	Eutrophic Limit: 0.075
Orthophosphate as PO_4-P (mg/L)	BDL[4]	BDL[4]	0.029	0.041	0.042	0.180	0.025	0.035	0.046	0.046	0.035	BDL[4]	0.040	0.025	0.65	0.033

Parameter	Dry					Wet							Average	Detection Limit	NEA Allowable Limits [1]	Water Quality Criteria for Aquatic Life from other countries [2]
	WQ1	WQ2	WQ3	WQ4	WQ5	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6	WQ7				
Biochemical Oxygen Demand, BOD_5 (mg/L)	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	2	20	<3
Total Organic Carbon, TOC (mg/L)	BDL[4]	1.21	BDL[4]	1.25	1.14	7.09	2.50	1.93	2.32	2.28	12.9	2.33	3.48	1	-	-
Enterococcus[5] (cfu/100ml)	1,700	480	241	7	51	25,000	6,000	1,300	140	160	700	1,400	2,095	1	-	-
Lead, Pb (µg/L)	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	BDL[4]	5	100	Acute LOEL: 82 Chronic LOEL: 3.2

Notes:

1. *Limits for discharge into a watercourse other than an uncontrolled watercourse.*
2. *The sources incudes United Nations Economic Commission for Europe (UNECE, 1994), World Health Organization (WHO, n.d.), Water Quality Standards Handbook (USEPA, 2017), Australian & New Zealand Guidelines for Freshwater and Marine Water Quality (2000), Canadian Water Quality Guidelines for the Protection of Aquatic Life (2007), Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ, n.d.), and National Water Quality Standards for Malaysia (DOE, n.d.).*
3. ** Missing value due to malfunction of multi-parameter sensor. But based on AECOM's previous experience, the variation in pH is minimal between dry and wet days.*
4. *BDL – Below Detection Limit*
5. *Singapore's Water Quality Guidelines for Recreational Beaches and Fresh Water Bodies requires that the Enterococcus count should be less than or equal to 200 counts per 100 millilitres of water at 95% of the time*
6. *Red values mean data exceeding the NEA limits or aquatic life criteria.*

Generally, the existing baseline surface water quality (i.e. Temperature, TSS, BOD_5, PO_4-P and Pb) met the NEA guidelines as shown in **Table 10-3**. The detailed explanation on each water quality parameter is provided as below. As all the natural streams had perennial shallow flow and the concrete drains had ephemeral flow, it is unlikely the drains would have any aquatic life. Hence, water quality of all stations was compared with NEA guidelines, while that of Stations WQ1 to WQ5 was compared against criteria for aquatic life.

As shown in **Figure 10-7**, water temperature across all water quality stations during both dry and wet conditions ranged from 25.6 ˚C – 27.3 ˚C, which is below the NEA limit of 45˚C.

The pH of the streams within the Study Area did not vary significantly, ranging from 5.49 to 7.72, with an average of 6.31. Although pH range of NEA guideline is 6 to 9, our baseline pH data were consistent with a previous study, which showed pH generally ranged from 4 to 9 in Singapore drain/streams (Blakely, 2014). Generally, pH did not vary a lot during dry and wet weather days. The pH values of samples from Streams 1 and 2 during wet conditions were not determined due to the malfunction of the multi-parameter sensor on site. However, the variation in pH should be minimal between dry and wet samples based on AECOM's previous experience.

The conductivity of water is strongly dependent on the number of ions available to participate in the conduction process. This parameter positively correlated to salinity which measures the amount of salts dissolved in water. The salinity and conductivity of the waterbodies found within the study were low (i.e. less than 0.08 PSU and 168 µS/cm, respectively), which confirmed prevalence of freshwater in the Study Area, given that the seawater generally has conductivity of around 3.31×10^6 µS/m (Tyler et al, 2017) and salinity of around 35 PSU (NOAA, n.d.).

Decomposition of organic matter from forest vegetation may have also resulted in the depletion of DO in the water, which was indicated by the relatively low DO measurements found at all five natural water sampling points, ranging from 1.09 to 5.14 mg/L. Compared with Stream 3 (i.e. WQ4 and WQ5), Streams 1 and 2 (i.e. WQ1 to 3) had slightly lower DO due to lower flow velocity or even stagnant conditions. According to water quality criteria for aquatic life, DO below 4 mg/L may lead to stressful conditions for aquatic life. However, previous study (Blakely, 2014) has shown that DO lower than 4 mg/L was normal in natural streams of Singapore, which is consistent with our study. This may indicate that freshwater aquatic life may have adapted to low DO below 4 mg/L.

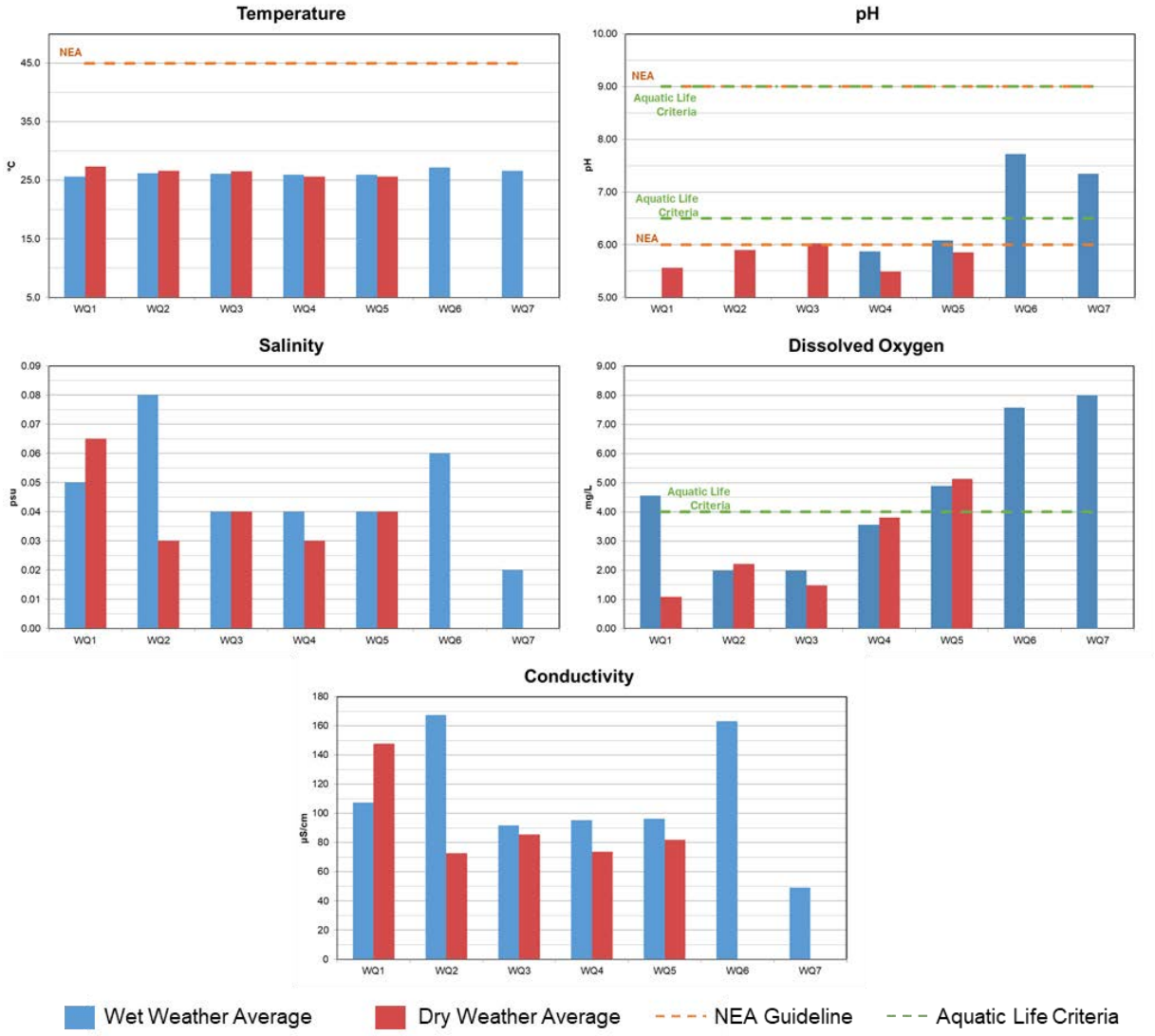


Figure 10-7: Average Monitoring Results of Temperature, pH, Salinity, DO and Conductivity for Wet and Dry Weather Conditions
Note: only available guidelines of parameters are shown in the figures.

As shown in **Figure 10-8**, the turbidity of dry day samples at all the natural streams (i.e. WQ1 to WQ5) was below 10 Nephelometric Turbidity Units (NTU), which indicates that the waterbodies may be clear enough to support aquatic life. The turbidity of all wet weather samples was slightly higher than their dry weather counterparts, which could be due to resuspended sediment from the stream bed when the water is disturbed, or soil is flushed from the surrounding forest during a storm event. Similarly, Total Suspended Solids (TSS) also showed the same trends with a slightly higher concentration during wet days (Below detection limit [BDL] to 26.7 mg/L) than dry days (all BDL) but is still within the NEA limits (i.e. 50 mg/L).

Total Dissolved Solids (TDS) concentrations at Stations WQ1 to WQ7 ranged from 46 to 114 mg/L, with an average value of 64.9 mg/L during dry and wet weather. Generally, water with a TDS concentration at around 35,000 mg/L were considered as seawater (USEPA, n.d.). This again confirmed the freshwater condition of the waterbodies within the Study Area.

Total Nitrogen (TN) had an average concentration of 0.86 mg/L, ranging from 0.20 mg/L to 2.00 mg/L. Comparing with the water quality criteria for aquatic life, the detected TN exceeded the eutrophic limit of TN in rivers or streams (i.e. 1.5 mg/L) at WQ1, WQ2 and WQ6 only during wet days, while all stations had TN below the eutrophic limit of TN during dry days. This suggested only temporary slightly higher TN loads happened after storm events, when runoff flushed nutrients from the surrounding forest soil, which may not be able to cause of eutrophication in the waterbodies.

NO_3-N (Nitrate) had an average concentration of 0.53 mg/L, ranging from 0.076 mg/L to 1.38 mg/L. NH_4-N (Ammonia) had an average concentration of 0.068 mg/L, ranging from 0.01 mg/L to 0.36 mg/L. Compared with water quality criteria for aquatic life, the nitrogen levels in all streams were generally low and again might not result in eutrophication, which is consistent with TN results.

Total Phosphorus (TP) had an average concentration of 0.055 mg/L, ranging from 0.025 mg/L to 0.23 mg/L, without significant variation within the Study Area. Compared with water quality criteria for aquatic life, only TP of WQ1 at Stream 1 exceeded the eutrophication limit (i.e. 0.075 mg/L) temporarily during wet day, while all stations had lower TP and below the eutrophication limit during dry days, suggesting all the natural waterbodies within the Study Area had low eutrophication potential. The concentration of PO_4-P (Orthophosphate) ranged from below detection limit (i.e. 0.025 mg/L) to 0.18 mg/L. Although PO_4-P exceeded the aquatic life criteria (i.e. 0.033 mg/L) slightly at WQ4 and WQ5 during both dry and wet days, both haven't reached the eutrophication limit.

Biochemical Oxygen Demand (BOD_5) at all water quality stations was below detection limit (i.e. 2 mg/L) and met the NEA guidelines, implying a low concentration of organics within the streams and good quality of water. This can also be deduced from the low Total Organic Carbon (TOC) concentration, which was lower than 8 mg/L at all natural streams. Although TOC slightly increased during the storm event, BOD_5 was still below the detection limit. This suggested that TOC flushed from the surrounding environment mainly consists of stable soil organic compounds that do not decay readily.

Enterococcus counts ranged from 7 to 25,000 cfu/100ml with an average value of 2,095 cfu/100ml in the natural streams. The NEA Recreational Water Quality Guidelines requires enterococcus to be below 200 cfu/100ml, indicating possible human or animal faecal pollution in the streams. However, it should be noted that all waterbodies are not expected to hold any recreational activities that involve direct human contact. Among the streams, Stream 1 (i.e. WQ1 and WQ2) had relatively higher concentration (i.e. 480 to 25,000 cfu/100ml), due to its stagnant conditions and its source coming from upstream residential area as described in Table 10-2. The enterococcus counts at Streams 2 and 3 (below 1,300 cfu/100ml) were much lower than Stream 1 as water in both streams mainly comes from the forest area, which was aligned with the counts of 20 to 1200 cfu/100ml in previous study (Blakely, 2014). Compared with dry days, enterococcus generally increased at all locations due to the flushing effect of storm water run-off. During the site survey, culvert structures connecting to roadside drains along the residential area were observed at upstream of WQ1 (Stream 1). Hence, it is likely the high enterococcus counts after a storm event may be from the upstream forest area or the surrounding residential area.

Lead (Pb) was always below detection limit (i.e. 5 µg/L), indicating low Pb pollution within this Study Area, which corroborates with the soil and groundwater results in **Section 11.0**. Due to the proximity of the streams to the cemetery area, higher heavy metal concentrations than a normal forest area were expected. However, due to the age of the existing cemetery area, the quantity present is at very small quantities.

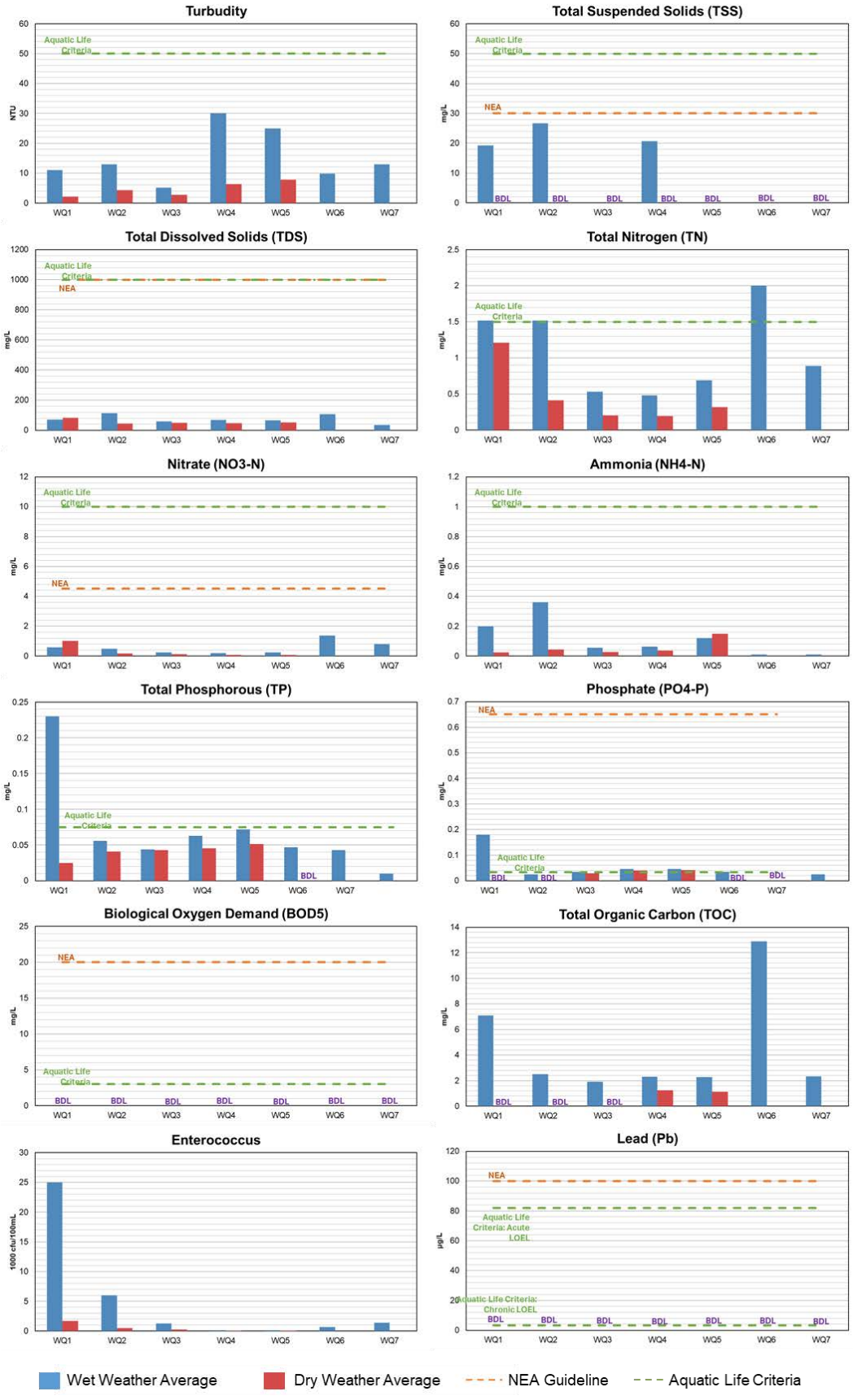


Figure 10-8: Average Monitoring Results of Turbidity, TSS, TDS, TN, Nitrate, Ammonia, TP, Phosphate, BOD5, TOC, Enterococcus and Lead for Wet and Dry Weather Conditions (BDL – Below Detection Limit)
Note: only available guidelines of parameters are shown in the figures.

10.2.3.3 Summary of Key Findings

The hydrological baseline study aimed to identify waterbodies present in the Study Area including their location, water flow conditions and bank characteristics. Based on topographic survey data and site survey, water catchment areas within the vicinity of the Study Area mainly contribute to the identified three main natural streams, which are covered by dense vegetation. Within the Study Area, one large natural stream (Stream 1) uphill which was partially covered and ran underground partially in the middle, and another smaller but continuously aboveground stream (Stream 2) at lower regions of the hilly area. A third perennial stream (Stream 3) was identified in the new Proposed Slip Road Area, running across the Proposed Slip Road Area from north to south. Two (2) stormwater drains (i.e. Drain 1 and Drain 2) running along the proposed road expansion and northeast of Mount Pleasant Road with ephemeral flow were also identified in the Study Area. Flow in Streams 1 and 2 is slower than that in Stream 3 and the upstream of Stream 1 has stagnant water. Therefore, Streams 1 and 3 were sampled both upstream and downstream, while the smaller stream and drains were only sampled downstream, making a total of seven (7) sampling locations in the Study Area. Water quality parameters were analysed during two (2) dry weather events and one (1) wet weather event at each location.

Water samples were tested for parameters including temperature, pH, salinity, conductivity, DO, turbidity, TSS, TDS, BOD_5, TOC, TN, NO_3-N, NH_4-N, TP, PO_4-P, enterococcus and lead. Between dry and wet conditions, there were fluctuations, as sudden storm events potentially affected these parameters due to flushing, dilution, and/or aeration effects that these storms bring.

Results were compared with both NEA discharge guidelines in Singapore and criteria for aquatic life from other countries. According to NEA discharge guidelines, temperature, TSS, BOD_5, PO_4-P and Pb could met the discharge limits at all sampling locations. Temperature did not vary much across all the sampling stations or between dry and wet days. Although pH in the natural streams was slightly lower than the NEA guidelines, it was consistent with a previous study which showed pH generally ranged from 4 to 9 in Singapore drain/streams. Given that the area is far from the influence of the sea, the salinity, conductivity and TDS of the water confirmed the prevalence of freshwater. DO was lower than 4 mg/L (i.e. water quality criteria for aquatic life) at most of natural waterbodies due to the decomposition of organic matter from forest vegetation. However, previous study also showed DO below 4 mg/L among Singapore nature streams, indicating that freshwater aquatic life may have adapted to such low DO environment in Singapore. Low turbidity, TSS, nutrients (i.e. TN, NO_3-N, NH_4-N, TP and PO_4-P) and Pb indicated clear water and low possibility of eutrophication. Elevated enterococcus counts were observed at Stream 1 due to its stagnant conditions and faecal sources from upstream residential area, while Streams 2 and 3 had lower counts and consistent with previous study on natural streams in Singapore.

In summary, all the natural streams were generally perennial fed from rainwater. The water quality inside all the natural streams was good enough for aquatic life.

10.3 Hydrology and Water Quality Impact Assessment

During construction phase, construction footprint has potential to impact hydrology and water quality. During operational phase, increased urbanized area and human activities may lead to increased surface runoff and improper littering. Hence, any waterbodies with direct impact from the proposed development were included in the impact assessment.

10.3.1 Assessment Approach and Assumption

Qualitative and analytical methods were applied to assess hydrological and water quality impacts of the development construction phases.

Hydrological impact study helped to understand the impact of construction/operational activities as well as potential land use changes to hydrological conditions of the site, such as the increase in peak flow discharge or changes in stream alignment of the site.

Water Quality impact study helped to evaluate potential impact of construction/operational activities on the existing waterbodies within/surrounding the site using analytical methods.

10.3.2 Assessment Criteria

The assessment criteria is mainly based on the Singapore Environmental Protection and Management (Trade Effluent) Regulations as well as water quality criteria for aquatic life from other countries including United Nations Economic Commission for Europe (UNECE, 1994), World Health Organization (WHO, n.d.), United States Environmental Protection Agency (USEPA, 2017), Mitigating Impact from

Aquaculture in the Philippines (PHILMINAQ, n.d.), Australian & New Zealand (2000), Canada (2007) and Malaysia (n.d.).

10.3.3 Identification and Classification of Sensitive Receptors

Receptor screening for surface water was conducted within Study Area (**Figure 10-1**). The criteria detailed in **Table 6-1** were used to determine the sensitivity of the surface water receptors presented in **Table 10-6**.

Table 10-6: Classification of Hydrology and Water Quality Sensitive Receptors Identified within the Study Area

Sensitive Receptor	Description	Water Use	Sensitivity Classification
Stream 1 **(Figure 10-2)**	The natural stream is a freshwater stream that discharges into public drains. Observations from the site walkover included presence of aquatic life.	The surface waterbodies is supporting ecosystems of biodiversity conservation significance.	Priority 1
Stream 2 **(Figure 10-2)**	The natural stream is a freshwater stream that discharges into public drains. Observations from the site walkover included presence of aquatic life.	The surface waterbodies is supporting ecosystems of biodiversity conservation significance.	Priority 1
Stream 3 **(Figure 10-2)**	The natural stream is a freshwater stream that discharges into public drains. Observations from the site walkover included presence of aquatic life.	The surface waterbodies is supporting ecosystems of biodiversity conservation significance.	Priority 1
Drain 1 **(Figure 10-2)**	The concrete Drain is a freshwater public drain. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	The surface waterbodies will be used for drinking supply.	Priority 1
Drain 2 **(Figure 10-2)**	The concrete Drain is a stormwater public drain. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	The surface waterbodies eventually drain to catchment reservoirs which are used for drinking supply.	Priority 1

10.3.4 Potential Sources of Impacts

This section discusses the potential environmental impacts arising from the construction and operational phases of the project.

10.3.4.1 Construction Phase

Nearby waterbodies can be potentially exposed to contamination due to the activities taking place during the project's construction phase. The sources that could potentially impact on the nearby freshwater quality and quantity include, but are not limited to, those listed in **Table 10-7**.

Table 10-7: Potential Hydrology and Water Quality Impacts during the Construction Phase

Activity	Potential Source of Impacts	Potential Associated Impacts
Land clearing, earthworks and excavation activities	• Run-off from exposed soil surfaces, earth work areas, soil stockpiles; • Stormwater/groundwater pumped out from excavated areas; • Release of grouting and cement materials; • Run-off from dust suppression sprays; • Elevated suspended solids (e.g. silt and sediment) in site run-off due to heavy rain;	Hydrology: • Increased stormwater peak flow contributions to the channel can lead to increased water level and subsequent flooding of surrounding areas adjacent to the stream/drain due to the land use change from land clearing; and • Stormwater run-off from exposed and unstable slopes may cause soil erosion. Water contamination:

Activity	Potential Source of Impacts	Potential Associated Impacts
	• Spoil generation, handling and transport; and • Heavy rain during construction.	• Elevated levels of suspended solids leading to increased turbidity and sedimentation rates, solid waste, toxic material, etc; and • Increase in the levels of oil, grease, and other chemical substances. Liquid effluent generation: • Inappropriate discharge of wastewater to the watercourse will result in contamination in nearby water sources; and • Inappropriate discharge of domestic sewage and poor maintenance of the portable toilet (e.g. overflow or overload) can result in run-off to nearby water sources and potentially contaminate the waterbodies located adjacent to the construction sites. Solid wastes: • Solid waste generated can lead to elevated levels of suspended solids entering water-bodies via run-off or improper handling/disposal. This waste can also block the temporary drains leading to contamination of receiving waterbodies; and • Improper storage, handling, disposal or leakage of toxic waste generated at temporary work areas can lead to water contamination. Improper management of chemical substances: • Contaminated stormwater due to improper storage/disposal/transport of chemical materials handled and stored on site leading to an increase in the levels of oil, grease and other chemical substances in the nearby waterbodies; and • Fuel and lubricants spillage from maintenance of construction vehicles and mechanical equipment can also lead to elevation in levels of oil in the nearby waterbodies.
Storage and disposal of solid wastes	• Improper handling, transfer, storage, and disposal of spoil and solid waste (e.g. excavated earth, construction debris).	
Storage and disposal of liquid wastes	• Improper management of sewage effluents from on-site; and • Inappropriate discharge of domestic sewage and poor maintenance of the portable chemical toilet, storage tanks and septic tanks (e.g. overflow or overload).	
Storage and disposal of toxic wastes	• Improper handling, transfer, and storage of toxic waste (e.g. contaminated excavated earth).	
Use and storage of chemical substances, and refuelling activities	• Improper handling, transfer, and storage of chemical substances; • Accidental spill and leaks; and • Fuel and lubricants spillage from maintenance of construction vehicles and mechanical equipment.	

10.3.4.2 Operational Phase

Waterbodies can potentially be exposed to contamination due to the activities taking place during the project's operational phase. The sources that could potentially impact on nearby surface water quality and quantity include but are not limited to the ones listed in Table 10-8.

Table 10-8: Potential Hydrology and Water Quality Impacts during Operational Phase

Activity	Potential Source of Impacts	Potential Associated Impacts
Stormwater Run-off Generation	• Heavy rain and stormwater wash-off pollutants built-up in the new development area and discharge to the streams; • Increase of runoff peak flow draining to the stream or drain during storm events due to the increase in urbanized area; and • Reduce the baseflow (sub-surface water discharge) due to the change in land use of the new development	Hydrology: • Increased stormwater peak flow contributions to the channel can lead to increased water level and subsequent flooding of surrounding areas adjacent to the stream/drain; • Reduced the baseflow contributing to natural stream; and • Stormwater run-off from exposed and unstable slopes may cause soil erosion Stormwater Quality: • Elevated suspended solids (e.g. silt and sediment) and pollutants (e.g. heavy metals and nutrients from human activities) in site run-off

10.3.5 Minimum Control for Potential Impacts

This section proposes minimum controls, or standard practices, commonly implemented in Singapore for similar construction and operational activities, that have been assumed to be implemented for the purposes of impact assessment.

10.3.5.1 Construction Phase

Table 10-9 has a non-exhaustive list of minimum controls for each potential impact identified in **Section 10.3.4.1** for construction phase.

Table 10-9: Minimum Controls during the Construction Phase applicable to Hydrology and Water Quality Impact Assessments

Environmental Parameter	Activity	Minimum Control
Solid & Toxic Waste Generation	Site clearing, earthworks and general construction activities	• Development of a Standard Operation Procedure (SOP) for safe handling, transfer, storage and disposal of solid waste; • Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into the stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations; • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, slope stability, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to waterbodies, etc.; • Implementation of CCTV including SIDS at the public drain to monitor the surface run-off discharges from the sites as per the Public Utilities Board of Singapore's (PUB) circular on Preventing Muddy Waters from the Construction Sites (October 2015); • Provision of enclosed bins and waste disposal facilities cleared up as often as necessary to prevent build-up. Housekeeping checks will be carried out once a day to ensure all litter is cleared from site; • All wastes will be disposed only in the designated waste disposal facilities and appropriately separated, i.e. by trained workers to properly sort and label the different types of waste (reusable and recyclable waste, toxic and non-toxic waste, etc.); and • Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector.
Liquid Effluent Generation and Stormwater Run-Off	Construction wastewater resulting from site clearance, excavation etc.	• A full inventory of all anticipated wastewater streams and volumes should be finalised before the onset of the construction works; • No unmanaged discharge of wastewater stream permitted; • Reduce, reuse, and recycle hierarchy principle to be applied to wastewater on-site; • Regular audits on environmental management procedures shall be carried out on site; • No hazardous liquids to be sent to the settling pond; • Hazardous wastewater, such as oily water, thinners, solvents, or paints, are to be stored and removed for treatment and disposal off-site by an approved Waste Management Contractor. Hazardous liquids to be handled as Hazardous Waste; • Settling ponds will be of impervious material and be designed with sufficient capacity to hold volumes of wastewater produced on-site, as well as allowance for stormwater run-off and potential fire-fighting wastewater; • Temporary storage volumes should be provided for overflow situations. Temporary storage to be of sufficient capacity to capture any additional volumes that may be expected to ensure untreated wastewater is not released to waterbodies unless it complies with Singapore NEA Guidelines on trade effluent discharge concentrations; • A responsible person (e.g. ECO) to be assigned to oversee the efficient operation of the settling ponds where 'Good

Environmental Parameter	Activity	Minimum Control
		Housekeeping' practices would be adhered to. Also, the area would be carefully managed to avoid spills, leaks, and odour issues, with the settling ponds checked at least daily to ensure proper functionality; • Daily record volume of wastewater, as well as volumes of sludge and other produced wastes; • The settling ponds, as well as wastewater generating areas on-site, to be equipped with spill clean-up kits; • Adequate drainage, cut-off drains sump pit, road kerb, piping, toe wall and/or channelling of construction process wastewater streams (e.g. concrete batching, wash water, etc.) to be assured through detailed design for capture and treatment in the settling ponds. Where applicable (e.g. in the vicinity of liquid storage or refuelling areas), this infrastructure shall include oil-water separators to capture inadvertent spills or leaked oils or greases; • Implement a construction EMMP and ensure full preparation of associated plans and procedures including the following: ➢ EMMP to include SOPs, an Emergency Response Plan (ERP), an inventory of wastewater streams, training of staff as well as an inspection, maintenance and audit schedule; and ➢ Full development of EMMP Wastewater Management Procedures to include dedicated management and monitoring procedures that covers all eventualities related to the proper operation of the settling ponds, or any other wastewater discharge location/equipment. • Regular and dedicated procedures for the inspection and maintenance of wastewater collection, storage, and treatment infrastructure, such as pipes, oil water separators, silt screens, etc.; ➢ Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to waterbodies. This should also include associated measures required (e.g. silt curtains) to prevent high sediment concentration stormwater drainage to waterbodies; and ➢ A training programme for all on-site workers, including sub-contractors, in relation to their obligations for ensuring proper water quality management.
	Storage and disposal of domestic liquid wastes	• Provision of portable toilets and on-site septic tank; • Regular cleaning of the portable toilets and clearing of sewage waste; • Appropriate location of toilet facilities away from any nearby waterbodies; • Inspections and audits to ascertain the hygienic conditions onsite; • The toilet facilities will be placed at least 30 m away from any nearby watercourse; • Training of workers on the best practices to contribute in environmental protection; and • Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector.

Environmental Parameter	Activity	Minimum Control
	Storage and disposal of construction solid wastes	• Surface Water Drainage, to be endorsed by a Qualified Erosion Control Professional (QECP) and submitted to PUB; • Implementation of the ECM plan before the start of any construction work; • Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations; • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to water bodies (canals, drains, streams), etc. • Implementation of CCTV including a SIDS at the public drain to monitor the surface run-off discharges from the sites as per the PUB circular on Preventing Muddy Waters from the Construction Sites (October 2015); • Runoff within, upstream of, and adjacent to the work site shall be effectively drained away without causing flooding in the vicinity; • Manholes should always be adequately covered and temporarily sealed; • Protection of stockpiles with erosion blanket coverage and proper scheduling of the demolition and earthworks to reduce the quantity of stockpiles to be stored onsite; • Coverage of temporary/open storage of excavated materials; • All vehicles and plant should be cleaned before leaving the site to ensure no earth, mud, debris, etc., is deposited on roads; and the wastewater hence generated shall be treated prior to discharge to the public sewers; and • Appropriate permits for discharge to be obtained from relevant authority prior to discharge. No trade effluent other than that of a nature or type approved by NEA Director-General shall be discharged into any watercourse or land.
	Stormwater Run-off Generation	Stormwater Quality: • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to waterbodies (canals, drains, streams), etc. • Adequate drainage, piping and/or channelling of stormwater run-off to be assured through detailed design for capture and treatment before discharge into surface waterbodies • Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment infrastructure, such as pipes, oil water separation, silt screens, etc.; and • Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to surface waters. This should also include associated measures required to prevent high sediment concentration stormwater drainage to surface waters; Hydrology: • Runoff within, upstream of, and adjacent to the work site shall be effectively drained away without causing flooding in the vicinity; • Potential increase of peak-flow due to the change in the land use at the worksite can be mitigated by providing detention tanks or ponds within the Study Area. Detention tanks or ponds can

Environmental Parameter	Activity	Minimum Control
		capture stormwater during heavy storm events to reduce the peak runoff; • Geotechnical aspect of site's slope stability (such as Earth Retaining and Stabilising structures (ERSS) to be included in detailed design engineering for the construction stage; and • The design engineers for detailed design may need to ensure that Earth Retaining Stabilisation structures (ERSS) are proposed when the site is cleared and excavated. Concurrently the Environmental Control Officer (ECO) must ensure that these measures are implemented in the construction phase, as cutting of slopes may result in slope instability.
Improper Management of Chemical Substances	Use, storage and disposal of chemical substances Refuelling activities	• Development of SOP for safe handling, transfer and storage of toxic waste; housekeeping checks once a day to ensure all toxic waste is cleared from site; • Appropriate tests to ascertain the presence/absence of contamination of the excavated earth and sand; • Appropriate storage area (enclosed on at least 3 sides, covered and with adequate ventilation); • Appropriate construction material for toxic waste storage containers with leak detection tests conducted periodically; • Provision of secondary containment for all toxic waste stored in bulk as per the requirements in the COPPC/SS593; • Preparation of an emergency response plan, training of the emergency response team (ERT) to be competent in the response mechanism and provision of response kits for any spillages; • Consignment notification/tracking system and transport emergency response plan for transport of toxic waste; and • Appropriate disposal of toxic waste as per required in the Environmental Public Health (Toxic Industrial Waste) Regulations by licensed waste operator/collector.

10.3.5.2 Operational Phase

Table 10-10 has a non-exhaustive list of minimum controls for each potential impact identified in **Section 10.3.4.2** for operational phase.

Table 10-10: Minimum Controls during the Operational Phase applicable for Hydrology and Water Quality Impact Assessments

Environmental Parameter	Activity	Minimum Control
Stormwater Run-off	Stormwater Run-off Generation	Stormwater Quality: • Adequate drainage, piping and/or channelling of stormwater run-off to be assured through detailed design [such as Active, Beautiful, Clean Water (ABC) Water Design approach] for capture and treatment before discharge into surface water; and • Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment infrastructure, such as pipes, oil water separation, silt screens, etc.; ➢ Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to surface waters. This should also include associated measures required to prevent high sediment concentration stormwater drainage to surface waters; Hydrology: • Potential increase of peak-flow due to the change in the land use at the new developments can be mitigated by providing detention tanks within the Study Area. Detention tanks can capture stormwater during heavy storm events to reduce the peak runoff. Stored water can then be discharged back to the system after the storm event. As required by PUB, the storage system needs to

Environmental Parameter	Activity	Minimum Control
		be in place to reduce the peak flow at the operational phase to be the same or less than that of the existing condition; • Active, Beautiful, Clean Water (ABC) Water Design approach can be considered to reduce the peak-flow as well; • Geotechnical aspect of site's slope stability (such as ERSS) to be included in detailed design engineering for the operational stage; and • Providing more softscape area should be considered in the design of the development to reduce the runoff coefficient which will help to reduce the peak-flow and reduce flood risk at downstream area.

10.3.6 Prediction and Evaluation of Potential Impacts

10.3.6.1 Construction Phase

10.3.6.1.1 Solid & Toxic Waste Generation (Water Quality)

The quantity of solid and toxic waste stored on site (e.g. chemical waste, construction debris, etc.) was expected to be limited and will be periodically disposed of by licensed waste management contractors as provided for in the minimum controls. The discharge of suspended solids into the waterbodies is also limited with the implementation of a settling pond to allow for sedimentation. Water soluble parameters such as TDS, nutrients, heavy metals, etc. will be monitored and treatment for these parameters will be put in place before the effluent is released into the waterbodies.

Given the limited amount of solid and toxic waste stored, the regular disposal of spoil and use of settling treatment to minimise solids discharge, the intensity of contamination was assessed to be **Medium** for the all the streams/drain except for Stream 2. As the Stream 2 is relatively remote from all the proposed construction sites, its intensity of contamination would be **Low**. The consequence to waterbodies due to spillage or run-off of solid and toxic waste was classified as being **Medium** for all Priority 1 freshwater receptors except for Stream 2 based on Impact Consequence Matrix in Table 6-6. Stream 2 would have impact consequence as **Low**.

Provided that all control measures detailed in **Table 10-9** are in place and precautionary management controls are implemented on-site (such as regular inspection, housekeeping and training of workers), it is unlikely that spills or run-off from waste stored on-site will regularly or occasionally occur in Stream 2 and Drain 2. In addition, the suspended solids discharge is kept to a minimum with the settling pond. However, as part Stream 1, Stream 3 and Drain 1 will be occupied by the construction activities, it is unavoidable to have spills of solid & toxic waste regular. Therefore, the likelihood of occurrence was expected to be **Rare** for Stream 2 and Drain 2, while **Regular** for Stream 1, Stream 3 and Drain 1.

Thus, the overall significance of solid and toxic waste spillage or run-off impact was assessed to be of **Minor** Impact on Stream 2 and Drain 2, while **Moderate** Impact on Stream 1, Stream 3 and Drain 1 based on **Table 6-8.**

10.3.6.1.2 Liquid Effluent and Stormwater Run-off Generation (Hydrology and Water Quality)

Hydrology

Land use modification due to site clearance during construction phase may affect existing hydrology condition of Study Area. Due to the land use changes with less vegetation and exposed earth, it may lead to increased surface run-off volume and water level in existing channel, and subsequent flooding of surrounding areas adjacent to the streams and drains. As shown in **Figure 10-1**, proposed future building blocks will occupy mainly the existing urbanized land and the most of the western forested area will remain the same in the Study Area, while the expanded road will occupy up to 10-20 m along the existing PIE in the Proposed Slip Road Area. This indicates that Stream 1, Stream 3 and the Drain 1 could be directly impacted by the construction footprint, while Stream 2 and Drain 2 might not be directly affected. Hence, the impact intensity on waterbodies Stream 1, Stream 3 and the Drain 1 due to hydrological change was assessed to be **High**, while on Stream 2 and Drain 2 was **Negligible**. All the streams and drain are part of Singapore water catchment in this area hence are **Priority 1** sensitive receptors, thus the impact consequence would be **High** on Stream 1, Stream 3 and the Drain 1, while **Very Low** on Stream 2 and Drain 2 based on Impact Consequence Matrix in **Table 6-6**.

With minimum controls in place as mentioned in **Table 10-9**, especially the installation of temporary storage volumes can prevent overflow situations at site. Temporary storage with sufficient capacity will capture any additional volumes that may be expected due to proposed construction site. Flooding can be minimized at nearby stream and drains as CCTV will be implemented at existing drain to monitor the surface run-off discharges from the sites. The likelihood of flooding in Stream 2 and Drain 2 would be **Unlikely** due to hydrological changes. However, as the future urban development will directly cover the Stream 1, Stream 3 and the Drain 1, the likelihood of flooding is **Regular**.

Overall impact significance of stormwater run-off on Stream 1, Stream 3 and the Drain 1 was assessed to be **Major**, while on Stream 2 and Drain 2 would be **Negligible** based on **Table 6-8**.

Water Quality

Liquid effluents generated from the construction activities commonly include extracted groundwater, sanitary discharges, and stormwater run-off from exposed and unstable slopes. For sanitary discharges, portable toilets will be installed as part of the minimum control provided by the project and sanitary effluents from portable toilets will be collected every week by the appointed contractor for disposal. Management controls are also expected to be implemented, such as regular inspection and housekeeping. To avoid additional stormwater run-off flowing from site's unstable slope to adjacent forested slopes during construction phase, it was also recommended that geotechnical aspect of slope stability should be planned well before construction.

With proper application of the minimum controls described in **Table 10-9**, such as the implementation of settling ponds to hold wastewater produced during construction, impacts to the surface water quality from the construction site surface run-off can be reduced. Extracted groundwater, stormwater run-off and construction wastewater generated from construction activities will be channelled to a settling pond and treated before the effluent is released to the waterbodies. Thus, the intensity of potential contamination from liquid effluent and stormwater run-off would be **Low** for concrete drains, but still be **High** for natural streams due to their highly ecological sensitivity to even minor pollutions. The impact consequence of the waterbodies due to the potential contamination was classified as **Low** for concrete drains, but still be **High** for natural stream receptors based on Impact Consequence Matrix in **Table 6-6**.

Other controls, such as putting in place regular and dedicated procedures for inspection and the maintenance of wastewater collection and storage will reduce the likelihood to **Rare** for Stream 2 and Drain 2. However, as Stream 1, Stream 3 and Drain 1 will be occupied by proposed construction site, all of them were expected to have **Regular** impact from the construction site.

Hence, the overall significance of liquid effluent and stormwater run-off impact to water was assessed to be **Minor** impact on Stream 2 and Drain 2, While **Major** impact on Stream 1 and Stream 3, and **Moderate** on Drain 1 based on **Table 6-8**.

10.3.6.1.3 Improper Management of Chemical Substances (Water Quality)

Chemical substances will be stored on concrete surfaces with containment bunds or on spill control palettes. Moreover, SOP was expected to be developed to ensure the proper handling, transfer and storage of these substances, which will also contribute to reduce the frequency and impact of chemical spillage.

Thus, the intensity of potential contamination from chemical substances is **Medium** for all freshwater receptors except for Stream 2. The impact consequence to waterbody receptors was classified as **Medium**. As the Stream 2 is relatively remote from all the proposed construction sites, its intensity of contamination would be **Low**. The consequence to waterbodies due to spillage or run-off of chemical substances was classified as being **Medium** for all Priority 1 freshwater receptors except for Stream 2 based on Impact Consequence Matrix in **Table 6-6**. Stream 2 would have impact consequence as **Low**.

Other minimum control measures described in **Table 10-9** will be implemented, such as periodically conducting leak detection tests. Therefore, the likelihood of occurrence of a spill leading to run-off into Stream 2 and Drain 2 was assessed to be **Rare**. However, as part Stream 1, Stream 3 and Drain 1 will be occupied by the construction activities, it is unavoidable to have spills of solid & toxic waste regular. Therefore, the likelihood of occurrence was expected to be **Regular** for Stream 1, Stream 3 and Drain 1.

Table 10-11: Summary of Impact Evaluation during Construction Phase

Potential Source of Impacts	Receptor Sensitivity	Impact Intensity	Consequence	Likelihood	Significance
	Priority 1 (Stream 1)	Medium	Medium	Regular	Moderate

Potential Source of Impacts	Receptor Sensitivity	Impact Intensity	Consequence	Likelihood	Significance
Solid & Toxic Waste Generation (Water Quality)	Priority 1 (Stream 2)	Low	Low	Rare	Minor
	Priority 1 (Stream 3)	Medium	Medium	Regular	Moderate
	Priority 1 (Drain 1)	Medium	Medium	Regular	Moderate
	Priority 1 (Drain 2)	Medium	Medium	Rare	Minor
Liquid Effluent Generation and Stormwater Run-off (Hydrology)	Priority 1 (Stream 1)	High	High	Regular	Major
	Priority 1 (Stream 2)	Negligible	Very Low	Unlikely	Negligible
	Priority 1 (Stream 3)	High	High	Regular	Major
	Priority 1 (Drain 1)	High	High	Regular	Major
	Priority 1 (Drain 2)	Negligible	Very Low	Unlikely	Negligible
Liquid Effluent Generation and Stormwater Run-off (Water Quality)	Priority 1 (Stream 1)	High	High	Regular	Major
	Priority 1 (Stream 2)	High	High	Rare	Minor
	Priority 1 (Stream 3)	High	High	Regular	Major
	Priority 1 (Drain 1)	Low	Low	Regular	Moderate
	Priority 1 (Drain 2)	Low	Low	Rare	Minor
Improper Management of Chemical Substances (Water Quality)	Priority 1 (Stream 1)	Medium	Medium	Regular	Moderate
	Priority 1 (Stream 2)	Low	Low	Rare	Minor
	Priority 1 (Stream 3)	Medium	Medium	Regular	Moderate
	Priority 1 (Drain 1)	Medium	Medium	Regular	Moderate
	Priority 1 (Drain 2)	Medium	Medium	Rare	Minor

10.3.6.2 Operational Phase

10.3.6.2.1 Stormwater Run-off Generation (Hydrology and Water Quality)

Hydrology

The stormwater run-off peak flow will increase and soil erosion may occur due to land use change of Study Area during operational stage. Due to the land use changes with less vegetation and low pervious area, it may lead to increased surface run-off volume and water level in existing channel, and subsequent flooding of surrounding areas adjacent to the streams and drains. As shown in **Figure 10-1**, proposed future building blocks will occupy mainly the existing urbanized land and the most of the forest area will remain the same in the Study Area, while the expanded road will occupy up to 10-20 m along the existing PIE in the Proposed Slip Road Area. This indicates that Stream 1, Stream 3 and the Drain will be heavily disturbed by the proposed development, while Stream 2 and Drain 2 will not. Hence, the impact intensity on waterbodies Stream 1, Stream 3 and the Drain 1 due to hydrological change would be **High,** while on Stream 2 and Drain 2 would be **Negligible**. As all the receptors are Priority 1, the impact consequence would be **High** on Stream 1, Stream 3 and the Drain 1, while Very **Low** on Stream 2 and Drain 2 based on Impact Consequence Matrix in **Table 6-6**.

All the streams and drain are **Priority 1** sensitive receptors. With proper implementation of the minimum controls as described in **Table 10-10** such as the construction of drainage to direct stormwater run-off and potential spillages, providing detention tanks, and applying ABC Water Design concept, impacts related to stormwater run-off generation from the future development to Stream 2 can be reduced. Furthermore, in order to avoid additional stormwater run-off flowing from site's unstable slope to adjacent forested slopes during operational phase, it is recommended that geotechnical team to be engaged in detailed design phase for ensuring slope stability is incorporated in all operational plans. Hence, the likelihood of flooding would be **Unlikely** in Stream 2 and Drain 2. However, as the future urban development will block the Stream 1, Stream 3 and the Drain 1, their likelihood of flooding would be **Regular**.

Overall impact significance of stormwater run-off on Stream 1, Stream 3 and the Drain 1 is assessed to be **Major**, while on Stream 2 and Drain 2 is **Negligible** based on **Table 6-8**.

Water Quality

Stormwater run-off generated from the development site commonly has good water quality with negligible contaminants. With proper application of the minimum controls described in **Table 10-10**, such as the ABC water design approach for capture and treatment before discharge into surface water and regular dedicated procedures for the inspection and maintenance of stormwater systems, the intensity of potential contamination from stormwater run-off would be **Low** for freshwater receptors. The impact consequence of the waterbodies due to the potential contamination was classified as **Low** for all freshwater receptors (Priority 1) based on Impact Consequence Matrix in **Table 6-6.** The likelihood would be **Rare** for Stream 2 and Drain 2. However, as Stream 1, Stream 3 and Drain 1 will be occupied by proposed construction site, all of them were expected to have **Regular** impact from the construction site.

Hence, the overall significance of liquid effluent and stormwater run-off impact to water was assessed to be **Minor** impact on Stream 2 and Drain 2, While **Moderate** impact on Stream 1, Stream 3, and Drain 1 based on **Table 6-8**.

Table 10-12: Summary of Impact Evaluation during Operational Phase

Potential Source of Impacts	Receptor Sensitivity	Impact Intensity	Consequence	Likelihood	Significance
Stormwater Run-off Generation (Hydrology)	Priority 1 (Stream 1)	High	High	Regular	Major
	Priority 1 (Stream 2)	Negligible	Very Low	Unlikely	Negligible
	Priority 1 (Stream 3)	High	High	Regular	Major
	Priority 1 (Drain 1)	High	High	Regular	Major
	Priority 1 (Drain 2)	Negligible	Very Low	Unlikely	Negligible
Stormwater Run-off Generation (Water Quality)	Priority 1 (Stream 1)	Low	Low	Regular	Moderate
	Priority 1 (Stream 2)	Low	Low	Rare	Minor
	Priority 1 (Stream 3)	Low	Low	Regular	Moderate
	Priority 1 (Drain 1)	Low	Low	Regular	Moderate
	Priority 1 (Drain 2)	Low	Low	Rare	Minor

10.4 Recommended Mitigation Measures

In this section, mitigation measures are proposed to further minimise the adverse impacts on the environment where impact significance were assessed to be moderate or major.

The impact on water quality was Minor in Stream 2 and Drain 2 during both construction and operational phases. The hydrological impact was assessed to be Negligible on Stream 2 and Drain 2 during both construction and operational phases. Thus, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the construction and operational plans are required for Stream 2 and Drain 2.

The impact on hydrology during both construction and operational phases was assessed to cause significant Major impact on Stream 1, Stream 3 and the Drain 1, while the impact on water quality would be Moderate to Major in Stream 1, Stream 3 and Drain 1 during construction phase and Moderate during operational phase, even with implemented minimum controls. In addition, the ecological findings from **Section 12.0** shows that all the natural streams in the Study Area have high ecological values. Based on the future development plan (**Figure 10-9**), the proposed new road in the Study Area will be on top of Stream 1 and the proposed slip road along PIE will cross the downstream of Stream 3. Hence, following mitigation measures were recommended.

- **Stream 1:** two (2) options were proposed as below and both options will be subject to detailed engineering studies and Authorities' approval at later stage.

  Option A:

  - To realign the proposed road at upstream of Stream 1 (refer to alternative road plan 1 in **Figure 10-9**) with 35m buffer on both sides of the stream to preserve its upstream;

- To convert the downstream of Stream 1 (refer to downstream portion in **Figure 10-9**) into drains; and
- To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.

Option B:

- To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved;
- To convert the downstream of Stream 1 (refer to downstream portion in **Figure 10-9**) into drains; and
- To provide drain diversion for downstream section during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.

- **Stream 3:** three (3) options were proposed as below, however, all the options will be subject to detailed engineering studies and Authorities' approval at later stage.

  Option A:

  - To convert downstream of Stream 3 into culvert structure under the proposed slip road; and
  - To provide temporary drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed slip road.

  Option B:

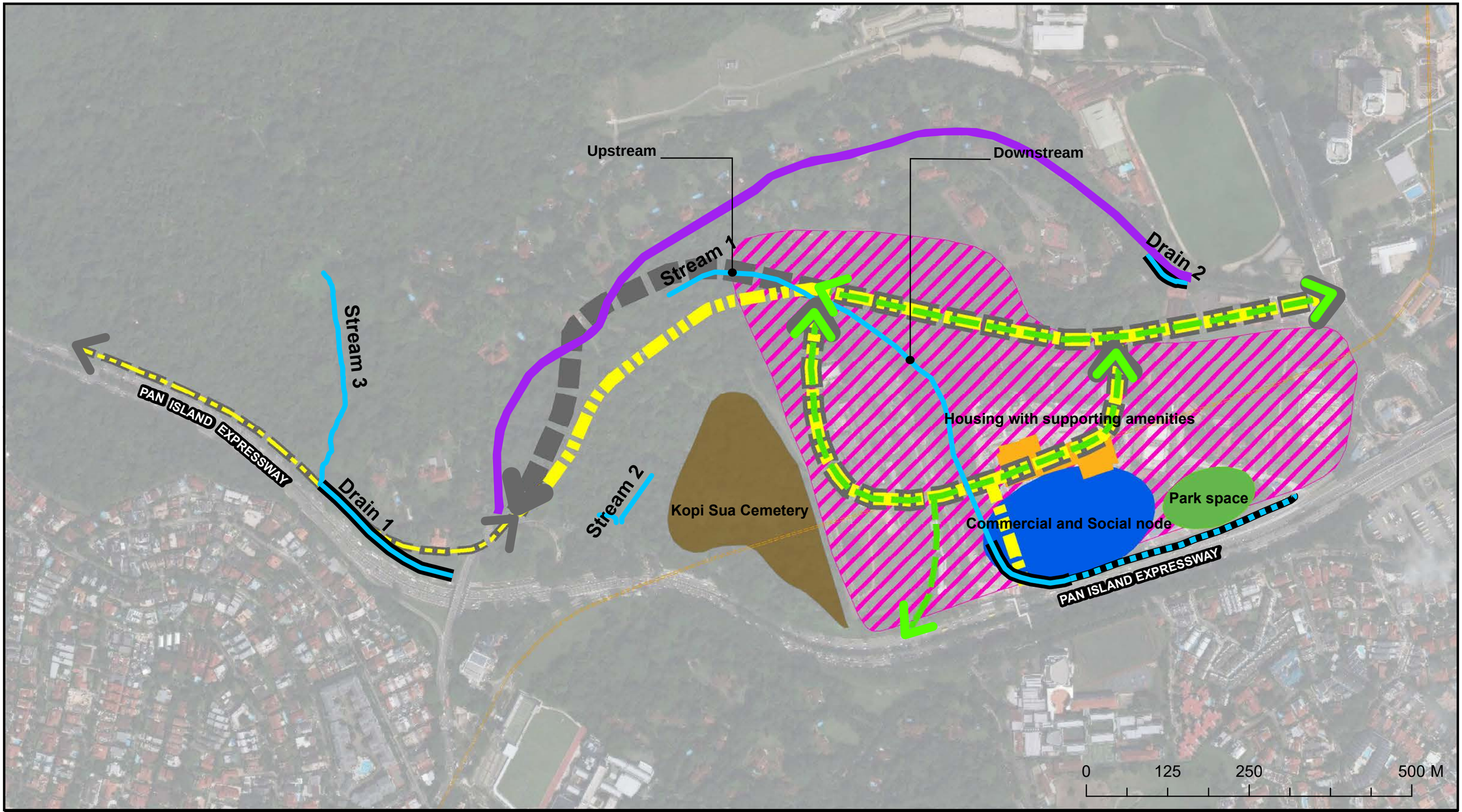
  - To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.

  Option C:

  - To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that Stream 3 will remain intact.

- **Drain 1:** Divert or realign the concrete drain.

It should be noted that "preserve" means that there should be no construction/operational activities disturbing the existing conditions of the stream.



Legend

- Heritage Road
- **Major Stream/ Drain**
  - Concrete Drain
  - Natural Stream
  - Underground Drain
- Indicative Alternative Road Plan 1
- Indicative Alternative Road Plan 2
- Indicative Original Road Plan
- Thomson-East Coast Line
- MRT Station (U/C)
- **Proposed Layout Plan**
  - Commercial and Social node
  - Housing with supporting amenities
  - Park space
  - Kopi Sua Cemetery

N

Rev.	Date	By	Description	Chk'd	App'd
02	JUN 2021	LAL	Final Report	NHT	JAG

Qualified Person Endorsement : NA

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Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT

Figure Title :

INDICATIVE ALTERNATIVE SERVICE ROAD PLAN ALONG PIE AS MITIGATION MEASURES

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
LAL	NHT	JAG	10 - 9	02	1 of 1
	Drawn LAL	Date JUN 2021	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

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10.5 Residual Impacts

A residual impact assessment has been undertaken assuming the mitigation measures recommended in the previous section are implemented.

The preserved upstream of Stream 1 and whole Stream 3 could continue provide freshwater supply to the aquatic life and forest. With the implementation of the recommended mitigation measures in conjunction with the identified minimum controls, the intensity of the hydrological residual impact on the Stream 1, Stream 3 and Drain can be reduced to Negligible – Low for both construction and operational phases. Thereafter, the impact significance on hydrology of Stream 1, Stream 3 and Drain was reduced to Negligible – Minor. In terms of impact on water quality, Drain will have Minor Impact with mitigation measures implemented for both construction and operational phases. However, during construction phase, the impact on water quality of Stream 1 can only reach Minor to Moderate for both mitigation **Option A** (i.e. realign road at upstream of Stream 1 and convert downstream of Stream 1 to drains) and **Option B** (i.e. construct a service road along PIE to link existing Onraet Road to avoid upstream of Stream 1 and convert downstream of Stream 1 to drains), because the impact on immediate stream segment adjacent to construction site cannot be further reduced.

For Stream 3, if **Option A** (i.e. convert downstream of Stream 3 into culvert) is selected, it will still have Minor to Moderate Impact on the water quality of Stream 3 during construction phase, because the impact on immediate stream segment adjacent to construction site could not be further reduced. If **Option B** (i.e. construct the proposed slip road as a cross-over) or **Option C** (i.e. construct a service road along PIE to link existing Onraet Road to avoid Stream 3) is selected for Stream 3, the residual impact on water quality of Stream 3 during construction phase could be reduced to Minor and Negligible, respectively. During operational phase, with the proposed mitigation measures, the impact on water quality of Streams 1 and 3 could be reduced to Minor. The construction and operational residual impacts have been summarized in **Table 10-13** and **Table 10-14**, respectively.

Table 10-13: Summary of Residual Impacts and its Mitigation Measures during Construction Phase

Activity	Receptor Sensitivity	Impacts	Impact Significance (with minimum controls)	Mitigation Measures	Significance of Residual Impact (with mitigation measures)
• Land clearing, earthworks and excavation activities; • Storage and disposal of solid, liquid and toxic wastes; and • Use and storage of chemical substances, and refuelling activities.	Stream 1 (Priority 1)	• Increased stormwater peak flow, increased water level and subsequent flooding of surrounding; • Elevated levels of contaminants (i.e. solid, liquid and toxic wastes, and chemical substances) leading to worse water quality; • Reduction of baseflow due to land use change; and • Habitat disruption of flora and fauna along the streams.	• Hydrology: Major • Water Quality: Moderate to Major	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To realign the proposed road at upstream of Stream 1 (Refer to alternative road plan 1 in **Figure 10-9**) with 35m buffers from both sides of the stream to preserve its upstream; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.	• Hydrology: Minor • Water Quality: Minor to Moderate
				Option B: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion for downstream section during construction to make sure no flooding will occur during the construction of the proposed road and building development.	• Hydrology: Minor • Water Quality: Minor to Moderate

Activity	Receptor Sensitivity	Impacts	Impact Significance (with minimum controls)	Mitigation Measures	Significance of Residual Impact (with mitigation measures)
	Stream 3 (Priority 1)	• Increased stormwater peak flow, increased water level and subsequent flooding of surrounding; • Elevated levels of contaminants (i.e. solid, liquid and toxic wastes, and chemical substances) leading to worse water quality; • Reduction of baseflow due to land use change; and • Habitat disruption of flora and fauna along the streams.	• Hydrology: Major • Water Quality: Moderate to Major	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To convert downstream of Stream 3 into culvert structure under the proposed slip road; and • To provide temporary drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed slip road.	• Hydrology: Minor • Water Quality: Minor to Moderate
				Option B: (subject to detailed engineering studies and Authorities' approval) • To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.	• Hydrology: Minor • Water Quality: Minor
				Option C: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that Stream 3 will remain intact.	• Hydrology: Negligible • Water Quality: Negligible
	Drain (Priority 1)	• Increased stormwater peak flow, increased water level and subsequent flooding of surrounding; and • Elevated levels of contaminants (i.e. solid, liquid and toxic wastes, and chemical substances) leading to worse water quality.	• Hydrology: Major • Water Quality: Moderate	• Divert or realign of the Drain	• Hydrology: Minor • Water Quality: Minor

Table 10-14: Summary of Residual Impacts and its Mitigation Measures during Operational Phase

Activity	Receptor Sensitivity	Impacts	Impact Significance (with minimum controls)	Mitigation Measures	Significance of Residual Impact (with mitigation measures)
• Land use changes due to future development	Stream 1 (Priority 1)	• Increased stormwater peak flow, increased water level and subsequent flooding of surrounding; • Elevated levels of contaminants (i.e. solid, liquid and toxic wastes, and chemical substances) leading to worse water quality; • Reduction of baseflow due to land use change; and • Habitat disruption of flora and fauna along the streams	• Hydrology: Major • Water Quality: Moderate	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To realign the proposed road at upstream of Stream 1 (Refer to alternative road plan 1 in **Figure 10-9**) with 35m buffers from both sides of the stream to preserve its upstream; and • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains.	• Hydrology: Minor • Water Quality: Minor
				Option B: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; and • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains.	• Hydrology: Minor • Water Quality: Minor
	Stream 3 (Priority 1)	• Increased stormwater peak flow, increased water level and subsequent flooding of surrounding; • Elevated levels of contaminants (i.e. solid, liquid and toxic wastes, and chemical substances) leading to worse water quality;	• Hydrology: Major • Water Quality: Moderate	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To convert downstream of Stream 3 into culvert structure under the proposed slip road.	• Hydrology: Minor • Water Quality: Minor
				Option B: (subject to detailed engineering studies and Authorities' approval) • To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.	• Hydrology: Minor • Water Quality: Minor

Activity	Receptor Sensitivity	Impacts	Impact Significance (with minimum controls)	Mitigation Measures	Significance of Residual Impact (with mitigation measures)
		• Reduction of baseflow due to land use change; and • Habitat disruption of flora and fauna along the streams		**Option C:** (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that Stream 3 will remain intact.	• Hydrology: Minor • Water Quality: Minor
	Drain (Priority 1)	• Increased stormwater peak flow, increased water level and subsequent flooding of surrounding; and • Elevated levels of contaminants (i.e. solid, liquid and toxic wastes, and chemical substances) leading to worse water quality.	• Hydrology: Major • Water Quality: Moderate	• Divert or realign of the Drain	• Hydrology: Minor • Water Quality: Minor

10.6 Summary of Key Findings

The hydrological baseline study aimed to identify waterbodies present in the Study Area including their location, water flow conditions and bank characteristics. Based on topographic survey data and site survey, water catchment areas within the vicinity of the Study Area mainly contribute to the identified three perennial streams, which are covered by dense vegetation. Within the Study Area, one large main stream (Stream 1) uphill which was partially covered and ran underground partially in the middle, and another smaller but continuously aboveground stream (Stream 2) at lower regions of the hilly area. A third perennial stream (Stream 3) was identified in the new Proposed Slip Road Area, running across the Proposed Slip Road Area from north to south. Two (2) stormwater drains (i.e. Drain 1 and Drain 2) running along the proposed road expansion and northeast of Mount Pleasant Road with ephemeral flow were also identified in the Study Area. Flow in Streams 1 and 2 is slower than that in Stream 3 and the upstream of Stream 1 has stagnant water. Therefore, Streams 1 and 3 were sampled both upstream and downstream, while the smaller stream and drains were only sampled downstream, making a total of seven (7) sampling locations in the Study Area. Water quality parameters were analysed during two (2) dry weather events and one (1) wet weather event at each location.

Water samples were tested for parameters including temperature, pH, salinity, conductivity, DO, turbidity, TSS, TDS, BOD_5, TOC, TN, NO_3-N, NH_4-N, TP, PO_4-P, enterococcus and lead. Between dry and wet conditions, there were fluctuations, as sudden storm events potentially affected these parameters due to flushing, dilution, and/or aeration effects that these storms bring.

Results were compared with both NEA discharge guidelines in Singapore and criteria for aquatic life from other countries. Generally, all the natural streams were generally perennial fed from rainwater, but with low flow. The water quality inside all the natural streams was good enough for aquatic life according to the baseline survey data.

Based on the assessment of the hydrology and surface water quality related impacts on the various sensitive receptors, the assessment findings have been summarised in **Table 10-15**. The impact on water quality was Minor in Stream 2 and Drain 2 during both construction and operational phases. The hydrological impact was assessed to be Negligible on Stream 2 and Drain 2 during both construction and operational phases. Thus, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the construction and operational plans are required for Stream 2 and Drain 2.

However, the impact on hydrology during both construction and operational phases was assessed to cause significant Major impact on Stream 1, Stream 3 and the Drain 1, while the impact on water quality would be Moderate to Major in Stream 1, Stream 3 and Drain 1 during construction phase and Moderate during operational phase, even with implemented minimum controls. Hence, following mitigation measures were recommended:

- **Stream 1:** two (2) options were proposed as below and both options will be subject to detailed engineering studies and Authorities' approval at later stage.

  Option A:

  - To realign the proposed road at upstream of Stream 1 (refer to alternative road plan 1 in **Figure 10-9**) with 35m buffer on both sides of the stream to preserve its upstream;
  - To convert the downstream of Stream 1 (refer to downstream portion in **Figure 10-9**) into drains; and
  - To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.

  Option B:

  - To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved;
  - To convert the downstream of Stream 1 (refer to downstream portion in **Figure 10-9**) into drains; and
  - To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.

- **Stream 3:** three (3) options were proposed as below, however, all the options will be subject to detailed engineering studies and Authorities' approval at later stage.

  Option A:

  - To convert downstream of Stream 3 into culvert structure under the proposed slip road; and
  - To provide temporary drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed slip road.

  Option B:

  - To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.

  Option C:

  - To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that Stream 3 will remain intact.

- **Drain 1:** Divert or realign the concrete drain.

It should be noted that "preserve" means that there should be no construction/operational activities disturbing the existing conditions of the stream.

With the implementation of the recommended mitigation measures in conjunction with the identified minimum controls, the intensity of the hydrological residual impact on the Stream 1, Stream 3 and Drain can be reduced to Negligible – Low for both construction and operational phases. Thereafter, the impact significance on hydrology of Stream 1, Stream 3 and Drain was reduced to Negligible – Minor. In terms of impact on water quality, Drain will have Minor Impact with mitigation measures implemented for both construction and operational phases. However, during construction phase, the impact on water quality of Stream 1 could only reach Minor to Moderate for both mitigation measure **Option A** (i.e. realign road at upstream of Stream 1 and convert downstream of Stream 1 to drains) and **Option B** (i.e. construct a service road along PIE to link existing Onraet Road to avoid upstream of Stream 1 and convert downstream of Stream 1 to drains), because the impact on immediate stream segment adjacent to construction site could not be further reduced.

For Stream 3, if **Option A** (i.e. convert downstream of Stream 3 into culvert) is selected, it will still have Minor to Moderate Impact on the water quality of Stream 3 during construction phase, because the impact on immediate stream segment adjacent to construction site could not be further reduced. If **Option B** (i.e. construct the proposed slip road as a cross-over) or **Option C** (i.e. construct a service road along PIE to link existing Onraet Road to avoid Stream 3) is selected for Stream 3, the residual impact on water quality of Stream 3 during construction phase could be reduced to Minor and Negligible, respectively. During operational phase, with the proposed mitigation measures, the impact on water quality of Streams 1 and 3 could be reduced to Minor.

Table 10-15: Summary of the Hydrology and Surface Water Quality Impact Assessment

Environmental Parameters	Sensitive Receptor	Potential Environmental Impacts	Significance of Potential Impact (with minimum control)	Mitigation Measures	Significance of Residual Impact
During Construction Phase					
Solid & Toxic Waste Generation	Stream 1 (Priority 1)	Water contamination: • Elevated levels of suspended solids leading to increased turbidity and sedimentation rates, solid waste, toxic material, etc; and • Increase in the levels of oil, grease, and other chemical substances. Solid wastes: • Solid waste generated can lead to elevated levels of suspended solids entering water-bodies via run-off or improper handling/disposal. This waste can also block the temporary drains leading to contamination of receiving waterbodies; and • Improper storage, handling, disposal or leakage of toxic waste generated at temporary work areas can lead to water contamination.	Moderate	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To realign the proposed road at upstream of Stream 1 (Refer to alternative road plan 1 in **Figure 10-9**) with 35m buffers from both sides of the stream to preserve its upstream; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.	Minor
				Option B: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.	Minor
	Stream 2 (Priority 1)		Minor	N.A.	Minor
	Stream 3 (Priority 1)		Moderate	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To convert downstream of Stream 3 into culvert structure under the proposed slip road; and	Minor

Environmental Parameters	Sensitive Receptor	Potential Environmental Impacts	Significance of Potential Impact (with minimum control)	Mitigation Measures	Significance of Residual Impact
				• To provide temporary drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed slip road.	
				Option B: (subject to detailed engineering studies and Authorities' approval) • To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.	Minor
				Option C: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that Stream 3 will remain intact.	Minor
	Drain 1 (Priority 1)		Moderate	Divert or realign the Drain 1	Minor
	Drain 2 (Priority 1)		Minor	N.A.	Minor
Liquid Effluent Generation and Stormwater Run-off (Hydrology)	Stream 1 (Priority 1)	• Increased stormwater peak flow contributions to the channel can lead to increased water level and subsequent flooding of surrounding areas adjacent to the stream/drain due to the land use change from land clearing; and • Stormwater run-off from exposed and unstable slopes may cause soil erosion	Major	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To realign the proposed road at upstream of Stream 1 (Refer to alternative road plan 1 in **Figure 10-9**) with 35m buffers from both sides of the stream to preserve its upstream; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.	Minor
				Option B: (subject to detailed engineering studies and Authorities' approval)	Minor

Environmental Parameters	Sensitive Receptor	Potential Environmental Impacts	Significance of Potential Impact (with minimum control)	Mitigation Measures	Significance of Residual Impact
				• To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.	
	Stream 2 (Priority 1)		Negligible	N.A.	Negligible
	Stream 3 (Priority 1)		Major	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To convert downstream of Stream 3 into culvert structure under the proposed slip road; and • To provide temporary drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed slip road.	Minor
				Option B: (subject to detailed engineering studies and Authorities' approval) • To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.	Minor
				Option C: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that Stream 3 will remain intact.	Negligible
	Drain 1 (Priority 1)		Major	Divert or realign the Drain 1	Minor

Environmental Parameters	Sensitive Receptor	Potential Environmental Impacts	Significance of Potential Impact (with minimum control)	Mitigation Measures	Significance of Residual Impact
	Drain 2 (Priority 1)		Negligible	N.A.	Negligible
Liquid Effluent Generation and Stormwater Run-off (Water Quality)	Stream 1 (Priority 1)	Liquid effluent generation: • Inappropriate discharge of wastewater to the watercourse will result in contamination in nearby water sources; and • Inappropriate discharge of domestic sewage and poor maintenance of the portable toilet (e.g. overflow or overload) can result in run-off to nearby water sources and potentially contaminate the waterbodies located adjacent to the construction sites. Water contamination: • Elevated levels of suspended solids leading to increased turbidity and sedimentation rates, solid waste, toxic material, etc; and • Increase in the levels of oil, grease, and other chemical substances.	Major	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To realign the proposed road at upstream of Stream 1 (Refer to alternative road plan 1 in **Figure 10-9**) with 35m buffers from both sides of the stream to preserve its upstream; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.	Moderate
				Option B: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.	Moderate
	Stream 2 (Priority 1)		Minor	N.A.	Minor
	Stream 3 (Priority 1)		Major	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To convert downstream of Stream 3 into culvert structure under the proposed slip road; and	Moderate

Environmental Parameters	Sensitive Receptor	Potential Environmental Impacts	Significance of Potential Impact (with minimum control)	Mitigation Measures	Significance of Residual Impact
				• To provide temporary drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed slip road.	
				Option B: (subject to detailed engineering studies and Authorities' approval) • To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.	Minor
				Option C: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that Stream 3 will remain intact.	Negligible
	Drain 1 (Priority 1)		Moderate	Divert or realign the Drain 1	Minor
	Drain 2 (Priority 1)		Minor	N.A.	Minor
Improper Management of Chemical Substances (Water Quality)	Stream 1 (Priority 1)	Improper management of chemical substances: • Contaminated stormwater due to improper storage/disposal/transport of chemical materials handled and stored on site leading to an increase in the levels of oil, grease and other chemical substances in the nearby waterbodies; and	Moderate	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To realign the proposed road at upstream of Stream 1 (Refer to alternative road plan 1 in **Figure 10-9**) with 35m buffers from both sides of the stream to preserve its upstream; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.	Minor
				Option B: (subject to detailed engineering studies and Authorities' approval)	Minor

Environmental Parameters	Sensitive Receptor	Potential Environmental Impacts	Significance of Potential Impact (with minimum control)	Mitigation Measures	Significance of Residual Impact
		• Fuel and lubricants spillage from maintenance of construction vehicles and mechanical equipment can also lead to elevation in levels of oil in the nearby waterbodies.		• To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains; and • To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development.	
	Stream 2 (Priority 1)		Minor	N.A.	Minor
	Stream 3 (Priority 1)		Moderate	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To convert downstream of Stream 3 into culvert structure under the proposed slip road; and • To provide temporary drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed slip road.	Minor
				Option B: (subject to detailed engineering studies and Authorities' approval) • To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.	Minor
				Option C: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that Stream 3 will remain intact.	Minor
	Drain 1 (Priority 1)		Moderate	Divert or realign the Drain 1	Minor

Environmental Parameters	Sensitive Receptor	Potential Environmental Impacts	Significance of Potential Impact (with minimum control)	Mitigation Measures	Significance of Residual Impact
	Drain 2 (Priority 1)		Minor	N.A.	Minor
During Operational Phase					
Stormwater Run-off Generation (Hydrology)	Stream 1 (Priority 1)	• Increased stormwater peak flow contributions to the channel can lead to increased water level and subsequent flooding of surrounding areas adjacent to the stream/drain; • Reduced the baseflow contributing to natural stream; and • Stormwater run-off from exposed and unstable slopes may cause soil erosion.	Major	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To realign the proposed road at upstream of Stream 1 (Refer to alternative road plan 1 in **Figure 10-9**) with 35m buffers from both sides of the stream to preserve its upstream; and • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains.	Minor
				Option B: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; and • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains.	Minor
	Stream 2 (Priority 1)		Negligible	N.A.	Negligible
	Stream 3 (Priority 1)		Major	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To convert downstream of Stream 3 into culvert structure under the proposed slip road.	Minor
				Option B: (subject to detailed engineering studies and Authorities' approval) • To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.	Minor
				Option C: (subject to detailed engineering studies and Authorities' approval)	Minor

Environmental Parameters	Sensitive Receptor	Potential Environmental Impacts	Significance of Potential Impact (with minimum control)	Mitigation Measures	Significance of Residual Impact
				• To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that Stream 3 will remain intact.	
	Drain 1 (Priority 1)		Major	Divert or realign the Drain 1	Minor
	Drain 2 (Priority 1)		Negligible	N.A.	Negligible
Stormwater Run-off Generation (Water Quality)	Stream 1 (Priority 1)	Elevated suspended solids (e.g. silt and sediment) and pollutants (e.g. heavy metals and nutrients from human activities) in site run-off	Moderate	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To realign the proposed road at upstream of Stream 1 (Refer to alternative road plan 1 in **Figure 10-9**) with 35m buffers from both sides of the stream to preserve its upstream; and • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains.	Minor
				Option B: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; and • To convert the downstream of Stream 1 (Refer to downstream portion in **Figure 10-9**) into drains.	Minor
	Stream 2 (Priority 1)		Minor	N.A.	Minor
	Stream 3 (Priority 1)		Moderate	**Option A:** (subject to detailed engineering studies and Authorities' approval) • To convert downstream of Stream 3 into culvert structure under the proposed slip road.	Minor
				Option B: (subject to detailed engineering studies and Authorities' approval)	Minor

Environmental Parameters	Sensitive Receptor	Potential Environmental Impacts	Significance of Potential Impact (with minimum control)	Mitigation Measures	Significance of Residual Impact
				• To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat.	
				Option C: (subject to detailed engineering studies and Authorities' approval) • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 **Figure 10-9**), so that Stream 3 will remain intact.	Minor
	Drain 1 (Priority 1)		Moderate	Divert or realign the Drain 1	Minor
	Drain 2 (Priority 1)		Minor	N.A.	Minor
Note: 1. N.A. – as the impact with minimum control is Negligible to Minor, no mitigation measures were proposed.					

11.0 Soil and Groundwater

11.1 Introduction

A soil and groundwater baseline study was carried out as part of the EIS to determine the soil profile and hydrogeological conditions of the Study Area, and also to ascertain the presence of possible pollutants in the underlying soil and groundwater that may impact the local vegetation and downstream waterbodies.

The following sub-sections describe the field activities and investigation methodology, and results of the impact assessment.

11.2 Soil and Groundwater Baseline Assessment

11.2.1 Baseline Assessment Personnel

The assessment and site surveys were conducted by the following personnel:

Mr. Albert Payapaya, AECOM Singapore Pte Ltd (Soil and Groundwater Specialist);
Mr. Jaypee Bautista, AECOM Singapore Pte Ltd (Soil and Groundwater Consultant);
Mr. Jafon Ng, AECOM Singapore Pte Ltd (Soil and Groundwater Consultant);
Mr. Oh Guo Liang, AECOM Singapore Pte Ltd (Soil and Groundwater Consultant); and
Ground Instrumentation and Engineering Pte Ltd (Drilling Specialist).

11.2.2 Soil and Groundwater Sampling Points

A total of seven (7) boreholes, designated as BH-01 through BH-05, VBH-01 and VBH-02 were established within the Study Area.

The borehole/groundwater monitoring well location map is presented in **Figure 11-1**.

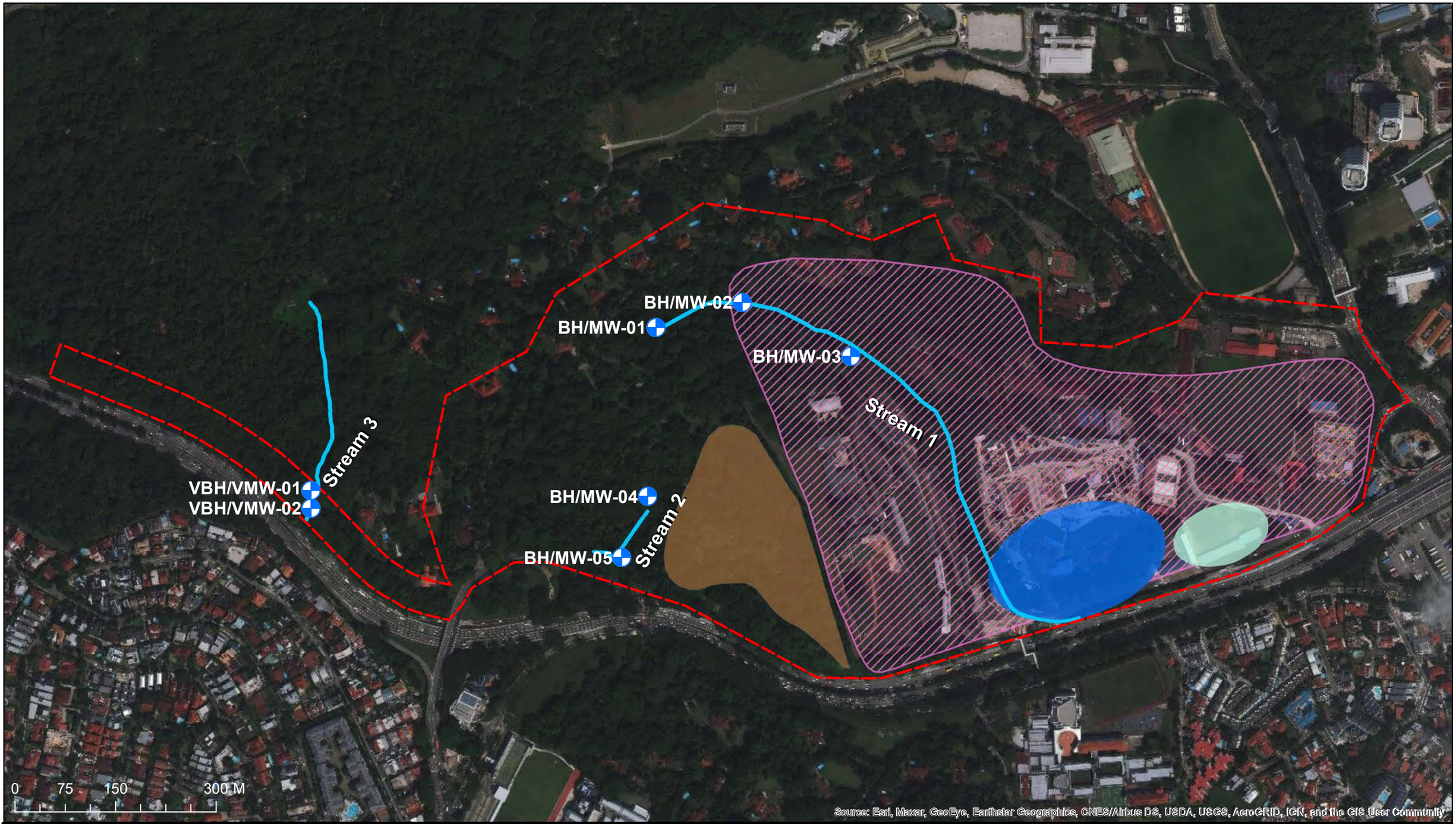
11.2.3 Baseline Assessment Methodology

11.2.3.1 Soil Boring and Soil Sampling

The boreholes within the Study Area were installed between April 25th, 2019 and April 27th, 2019 and on January 20th, 2020. As agreed with the Board and NParks during the scoping meeting, the boreholes were established at locations along the banks of the naturalised section of the stream within the Study Area. All boreholes were advanced up to approximately 3.0 m below ground surface (bgs) using a hand auger to assess the potential impact(s) to the top soil layers which may potentially relate to hydrology and soil erosion. A total of two (2) soil samples; one (1) at 0.5 m bgs and one (1) at 3.0 m bgs was selected at each borehole for laboratory analysis. The soil boring details are provided in **Appendix J**.

11.2.3.2 Monitoring Well Installation and Elevation Survey

Upon collection of the soil samples, all boreholes were converted into temporary groundwater monitoring wells to enable groundwater sampling (MW-01 through MW-05 and VMW-01 through VMW-02). Well casings consisted of 50-millimetre (mm) internal diameter unplasticized polyvinyl chloride (uPVC) pipes. Well screens consisted of machine-slotted (with nominal slot aperture of 0.5 mm) 50-mm internal diameter uPVC pipes which were installed such that the screens intersect the water table to the base of the borehole/monitoring well. The well screens were fixed across the anticipated water table fluctuation range to enable detection of light non-aqueous phase liquid (LNAPL), if any, on the surface of the groundwater table. A filter pack comprising uniformly graded fine gravel was placed in the annular space between the uPVC screen/casing and borehole wall up to ground level.



Legend

- Borehole/Monitoring Well Locations
- Study Area
- Kopi Sua Cemetery
- Major Stream/Drain

LandUse

- Commercial and Social node
- Housing with supporting amenities
- Park space

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	JAN	Final Report	APD	JAG

Qualified Person Endorsement :
NA

HDB Endorsement :
NA

Consultant : AECOM

Project Title :
**CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT**

Designed	Checked	Approved
JAN	APD	JAG
	Drawn	Date
	JAN	JAN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title :
BOREHOLE/GROUNDWATER MONITORING WELL LOCATIONS WITHIN THE STUDY AREA

Figure No. :	Rev.	Sheet
11 - 1	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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Following the installation of the groundwater monitoring wells, elevation surveys were performed to obtain the relative elevation of the monitoring wells. The northing and easting coordinates of the groundwater monitoring wells were also collected using the SVY21 system. The groundwater monitoring well completion details are summarized in Table 11-1. The well construction details are provided in **Appendix J**.

Table 11-1: Groundwater Monitoring Well Completion Details

Monitoring Well ID	Coordinates SVY21 (m)		Top of Casing Elevation (m MSL)	Screen Interval (m bgs)	Screened Lithology
	Northing	Easting			
MW-01	34775.26	27589.06	112.660	0.5 – 3.0	Silty SAND, clayey SILT and peaty SILT
MW-02	34812.76	27717.67	111.0904	0.5 – 3.0	Silty CLAY and clayey SILT
MW-03	34731.86	27880.00	108.836	0.5 – 3.0	Silty CLAY
MW-04	34522.88	27570.88	112.252	0.5 – 3.0	Silty CLAY
MW-05	34431.74	27538.46	107.546	0.5 – 3.0	Clayey SILT and peaty SILT
VMW-01	34531.5060	27074.3243	105.1145	0.5 – 3.0	Sandy SILT, clayey SILT and SILT
VMW-02	34505.2249	27074.2657	105.3151	0.5 – 3.0	Silty SAND, sandy CLAY, clayey SILT and SILT

11.2.3.3 Groundwater Gauging, Sampling and Slug Test

All groundwater monitoring wells were developed at least 24 hours after installation to remove fine particles that may have accumulated in the well during well installation activities and enhance the hydraulic connection between the well screen and target water-bearing zone. Development of each monitoring well included purging a minimum of five (5) well volumes of groundwater or until dry, whichever was achieved first, and this was conducted using dedicated disposable 1-L polyvinyl chloride (PVC) bailers.

The monitoring wells were then gauged for groundwater levels and presence of LNAPL using an intrinsically safe oil-water interface meter prior to well purging and sample collection. Following the stabilization of the in-situ physicochemical parameters (pH, electrical conductivity [EC], oxidation and redox potential [ORP], dissolved oxygen [DO], total dissolved solids [TDS] and temperature), one (1) groundwater sample was collected from each groundwater monitoring well for laboratory analysis. Groundwater samples from MW-01 through MW-05 was collected on May 6th, 2019 while groundwater samples from VMW-01 and VMW-02 was collected on January 22nd, 2020.

Following the groundwater monitoring event, another three (3) rounds of groundwater gauging were carried out monthly between June 2019 and August 2019 at MW-01 through MW-05 to monitor the groundwater levels.

A rising head slug test was also conducted on MW-01 through MW-5 on June 13th, 2019 and on VMW-01 and VMW-02 on January 21st, 2020. During the slug test, groundwater was purged from the monitoring wells, and the change in hydraulic head was monitored through time via a water level data logger or oil-water interface meter to determine the hydraulic conductivity of the Study Area.

Figure 11-2: Photos taken during the Soil and Groundwater Investigation Works

11.2.3.4 Soil and Groundwater Laboratory Analysis Program

The collected soil and groundwater samples, i.e. 14 soil samples and seven (7) groundwater samples, were sent for laboratory analyses at Marchwood Laboratory Services Pte. Ltd. (MLS), a Singapore Accreditation Council (SAC) certified laboratory under the Singapore Laboratory Accreditation Scheme (SINGLAS). The following parameters, as listed in in the Dutch Remediation Circular 2013 were analysed (Table 11-2). Major anions and cations were also analysed to determine the geochemical characteristics of the groundwater.

Table 11-2: Soil and Groundwater Parameters Analysed and the Corresponding Test Methods

Test Parameter	Test Method	
	Soil (mg/kg)	Groundwater (mg/L)
Heavy metals[19]	USEPA 3051A / APHA 3120B / 3125B / USEPA 245.1	APHA 3125B
Total Cyanide	APHA 4500-CN	APHA 4500-CN
Volatile Organic Compounds (VOCs)	USEPA 5021A / 8260C	USEPA 5021A / 8260C
Semi-Volatile Organic Compounds (SVOCs)	USEPA 3545A / 8270D	USEPA 3510C / 8270D
Total Petroleum Hydrocarbon (TPH)	USEPA 8015C	USEPA 8015C
Miscellaneous Parameters[20]	-	APHA 22nd Edition 2012
Major Anions and Cations[21]	-	APHA 4500-CO_2 (D) / 3120B
Moisture (% w/w) and organic matter (%)	BS1377: Pt 2&3: 1990	-

[19] The analysed heavy metals include arsenic, antimony, barium, cadmium, chromium, cobalt, copper, mercury, lead, molybdenum, nickel and zinc
[20] The miscellaneous parameters include Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), total organic compound (TOC), fluoride, chloride, bromide, phosphate, sulphate and total ammonical nitrogen
[21] The major anions and cations include bicarbonate, carbonate, calcium, potassium, magnesium and sodium.

11.2.3.5 Soil and Groundwater Assessment Criteria

The Dutch Intervention Values (DIV) in the Dutch Environmental Guidelines Soil Remediation Circular (DEQ, 2013) were adopted in this study for screening of the 12 priority pollutant metals, inorganic compounds, aromatic compounds, polycyclic aromatic hydrocarbons (PAHs), chlorinated hydrocarbons, pesticides and other pollutants in soil and groundwater. The DIV was referenced in the latest Code of Practice for Pollution Control, 2013 (COPPC) by the National Environmental Agency (NEA).

The DIVs are related to spatial parameters and define soil as being seriously contaminated if the mean soil/sediment concentration of at least one substance in at least 25 cubic metres (m3) of soil-volume, or groundwater concentration in at least 100 m^3 of pore-saturated soil-volume, exceeds the DIV. It is noted that the intervention values for groundwater are not based on a separate risk assessment with regards to the contaminants present in the groundwater but are calculated based on partitioning of chemicals at concentrations equivalent to the intervention values in soil/sediment.

It is recognized that the Dutch Guidelines were developed to assess the acceptability of impacted soil and groundwater at housing estates in the Netherlands and is based on local Dutch ecotoxicology and soil condition (that is, soil made of 10% organic clay or 25% clay), without reference to commercial or industrial general, or similar land uses in Singapore. On that basis, exceedances of the DIVs should not necessarily be interpreted as conclusive regarding the need for remediation. Conversely, if the concentrations of COPCs were below these criteria, it would be reasonable to conclude that the concentrations are not of concern.

The groundwater results were also compared against the Australian and New Zealand Guidelines for Fresh and Marine Water (ANZGFMW)'s fresh water trigger values to provide an indication of potential impacts to downstream waterbodies (if any). The guideline provides authoritative guidance on the management of water quality for natural and semi-natural water resources in Australia and New Zealand. This guideline applies to the quality of both surface water and groundwater since the environmental values which they protect relate to above-ground uses (e.g. maintenance of aquatic ecosystems). As the streams are receiving surface runoff from the upstream areas which can be considered to be a slightly to moderately disturbed ecosystems, a 95% protection level is applied for the purpose of this study.

11.3 Baseline Soil and Groundwater Environment

11.3.1 Soil Profile

Based on the information obtained during the soil and groundwater investigation study, the soil profile encountered at BH-01 through BH-05 generally consisted of clayey SILT and silty CLAY, with peaty SILT observed at BH01 and BH05 at their termination depths of 3.0 meter (m) below ground surface (bgs). Soil profile encountered at VBH-01 and VBH-02 generally consisted of clayey SILT and SILT with evidence of decomposed organic materials observed at depths between 1.5 m bgs and termination depth of 3.0 m bgs. The cross-sections of the lithology for the Study Area is presented in **Figure 11-3** and **Figure 11-4**.

11.3.2 Soil Baseline Results

Soil samples collected from the subsurface (from 0.5 m bgs up to the termination depth of all boreholes) during field activities did not exhibit signs of visual or olfactory contamination. Photoionization detector (PID) readings recorded were generally between 0 and 0.3 parts per million (ppm), indicating negligible concentration of VOCs. A summary of the detected constituents in soil and a comparison of the soil analytical results with the DIVs are summarized in **Table 11-3** and **Figure 11-5**. A copy of the full laboratory report for the soil samples is included in **Appendix L**.

Table 11-3: Summary of Soil Analytical Results

Test Parameters	Unit	DIV (2013)	BH-01		BH-02		BH-03		BH-04		BH-05		VBH-01		VBH-02	
			0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m
Heavy Metals																
Arsenic	mg/kg	76	3.12	1.91	2.70	1.03	1.02	1.56	1.41	6.79	1.26	N.D.	6.39	9.59	17.94	9.27
Antimony	mg/kg	22	18.26	1.59	1.30	N.D.	0.37	N.D.	N.D.	0.88	N.D.	N.D.	0.66	N.D.	N.D.	N.D.
Barium	mg/kg	- [a]	9.48	6.02	4.63	6.11	2.06	2.01	4.41	5.63	9.96	35.90	52.67	21.68	31.82	24.74
Cadmium	mg/kg	13	0.21	0.10	0.32	0.15	0.55	0.46	0.47	0.79	0.31	0.08	2.41	0.53	0.85	0.50
Chromium	mg/kg	180 / 78[b]	15.06	31.20	18.02	14.95	46.42	40.15	29.75	34.11	38.13	65.06	42.79	N.D.	19.77	17.69
Cobalt	mg/kg	190	N.D.	0.25	N.D.	N.D.	N.D.	N.D.	N.D.	0.44	0.20	0.54	1.15	3.21	2.30	1.18
Copper	mg/kg	190	8.78	8.75	3.02	4.05	0.97	0.36	6.84	2.26	2.65	5.17	34.23	9.78	142.13	58.17
Mercury	mg/kg	36 / 4[c]	0.239	0.100	0.099	0.090	0.110	N.D.	0.085	0.097	N.D.	0.105	0.74	N.D.	0.40	0.23
Lead	mg/kg	530	31.76	15.54	5.19	8.44	3.94	2.57	6.59	10.79	4.53	30.76	55.66	23.71	115.90	23.76
Molybdenum	mg/kg	190	1.88	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	4.86	0.22	0.19
Nickel	mg/kg	100	N.D.	1.59	1.53	N.D.	2.41	1.87	2.51	3.36	1.55	1.53	8.58	5.79	11.01	3.69
Zinc	mg/kg	720	52.13	11.21	22.42	5.16	7.82	5.59	21.46	14.96	18.65	12.98	245.13	28.23	185.40	75.27
Cyanide																
Cyanide (Total)	mg/kg	20 / 50[d]	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
TPH																
C6-C9	mg/kg	NA	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
C10-C14	mg/kg	NA	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	32.87	N.D.	29.46
C15-C28	mg/kg	NA	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	65.81	251.88	44.32	343.10
C29-C36	mg/kg	NA	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	11.30	113.78	945.69	25.38	1,577.14
C6-C36 (Sum) / Mineral Oils	mg/kg	5,000[e]	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	11.30	179.59	1,230.44	69.70	1,949.70
VOCs																

Test Parameters	Unit	DIV (2013)	BH-01		BH-02		BH-03		BH-04		BH-05		VBH-01		VBH-02	
			0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m	0.5 m	3.0 m
25 compounds	mg/kg	Various	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
SVOCs																
Benzo(a)anthracene	mg/kg	NA	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1.20	N.D.	5.10
PAHs (sum)	mg/kg	40	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N,D.	1.20	N.D.	5.10
49 other compounds	mg/kg	Various	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Other Pollutants																
Phthalates (total)	mg/kg	NA	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.5	0.4	2.1	0.9
5 other compounds	mg/kg	Various	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Miscellaneous Parameters																
pH	-	NA	6.1	4.5	4.3	4.3	4.4	4.2	5.0	4.6	6.4	5.2	5.6	4.0	4.1	4.4
Moisture Content	%	NA	16.80	66.12	31.54	30.52	47.45	56.6	2.85	53.73	30.64	61.52	25.73	81.85	8.16	81.27
Organic Matter	%	NA	4.61	14.59	8.87	8.18	11.28	8.97	11.06	12.22	7.55	14.49	5.20	46.68	4.87	56.94

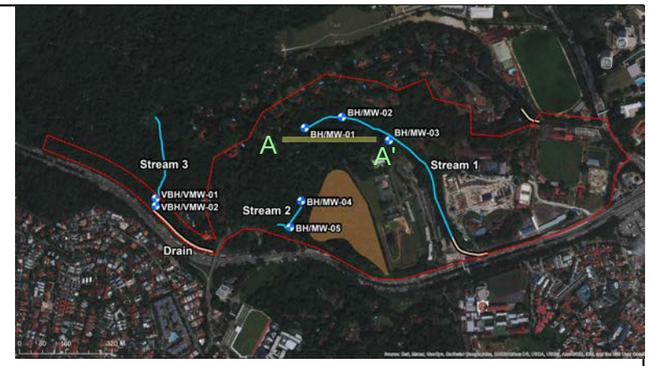
Notes:
NA – Not Available (value not specified in standard)
N.D. – Not Detected above the limit of reporting (LOR)
a - The barium standard has been repealed because the intervention value for barium proved to be lower than the concentration naturally occurring in the soil.
b - Intervention value for Chromium (III) = 180 mg/kg; Chromium (IV) = 78 mg/kg
c - Intervention value for Inorganic Mercury = 36 mg/kg; Organic Mercury = 4 mg/kg
d - Intervention value for free cyanide = 20 mg/kg; complex cyanide = 50 mg/kg
e - Intervention value for mineral oil; This applies to contamination due to mixtures (e.g. gasoline or domestic heating oil), then not only the alkane content but also the content of aromatic and/or polycyclic aromatic hydrocarbons must be determined. This aggregate parameter has been adopted for practical reasons. Further toxicological and chemical disaggregation is under study.

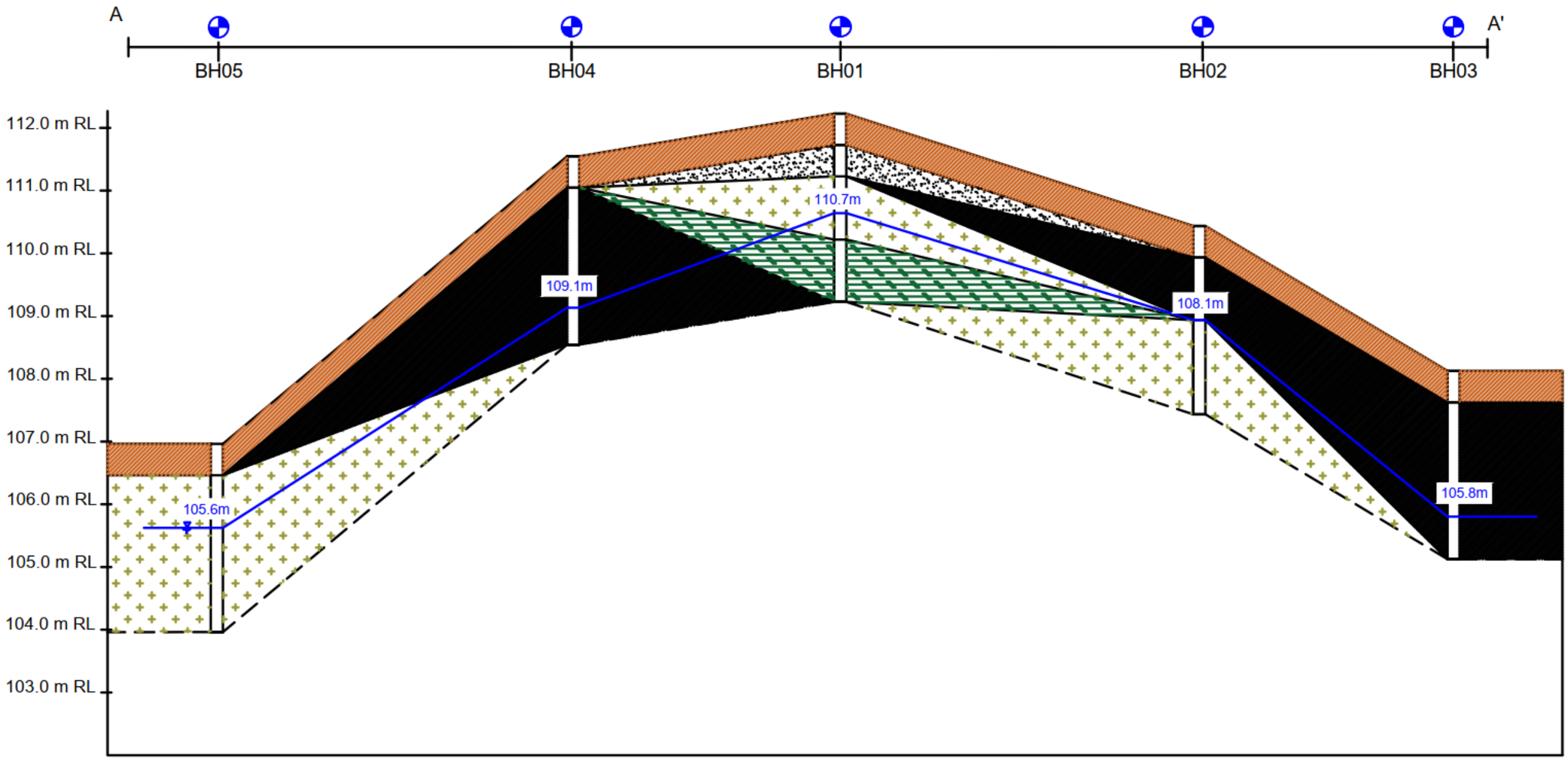
Heavy metals including arsenic, antimony, barium, cadmium, chromium, cobalt, copper, mercury, lead, molybdenum, nickel and zinc were detected in most soil samples at concentrations above their respective level of reporting (LOR).

TPH was also detected in soil samples collected from BH-05 (at 3.0 m bgs), VBH-01 (0.5 m), VBH-01 (3.0 m), VBH-02 (0.5 m) and VBH-02 (3.0 m). The detected concentrations were; however, all below the DIV.

Other than that, benzo(a)anthracene was detected in soil samples collected at 3.0 m depth at both VBH-01 and VBH-02, These detections were below the DIVs of PAHs (total). Phthalates was also detected in soil samples collected from VBH-01 (0.5 m), VBH-01 (3.0 m), VBH-02 (0.5 m) and VBH-02 (3.0 m).

These detections were all below the DIVs. The remaining parameters analyzed for the soil samples were below their respective LORs.





Legend

- Topsoil
- Silty SAND
- Peaty SILT
- Clayey SILT
- Silty CLAY

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-	JAN 2021	JAN	Final Report	APD	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

Project Title : **CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT**

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	JAN	JAN 2021

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Figure Title : **LITHOLOGY CROSS-SECTION (A - A')**

Figure No. :	Rev.	Sheet
11 - 3	-	1 of 1

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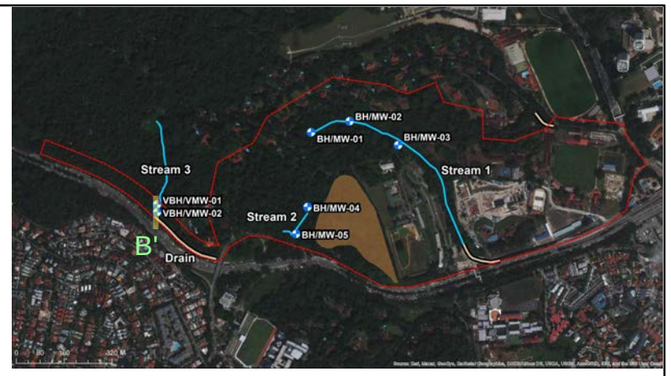

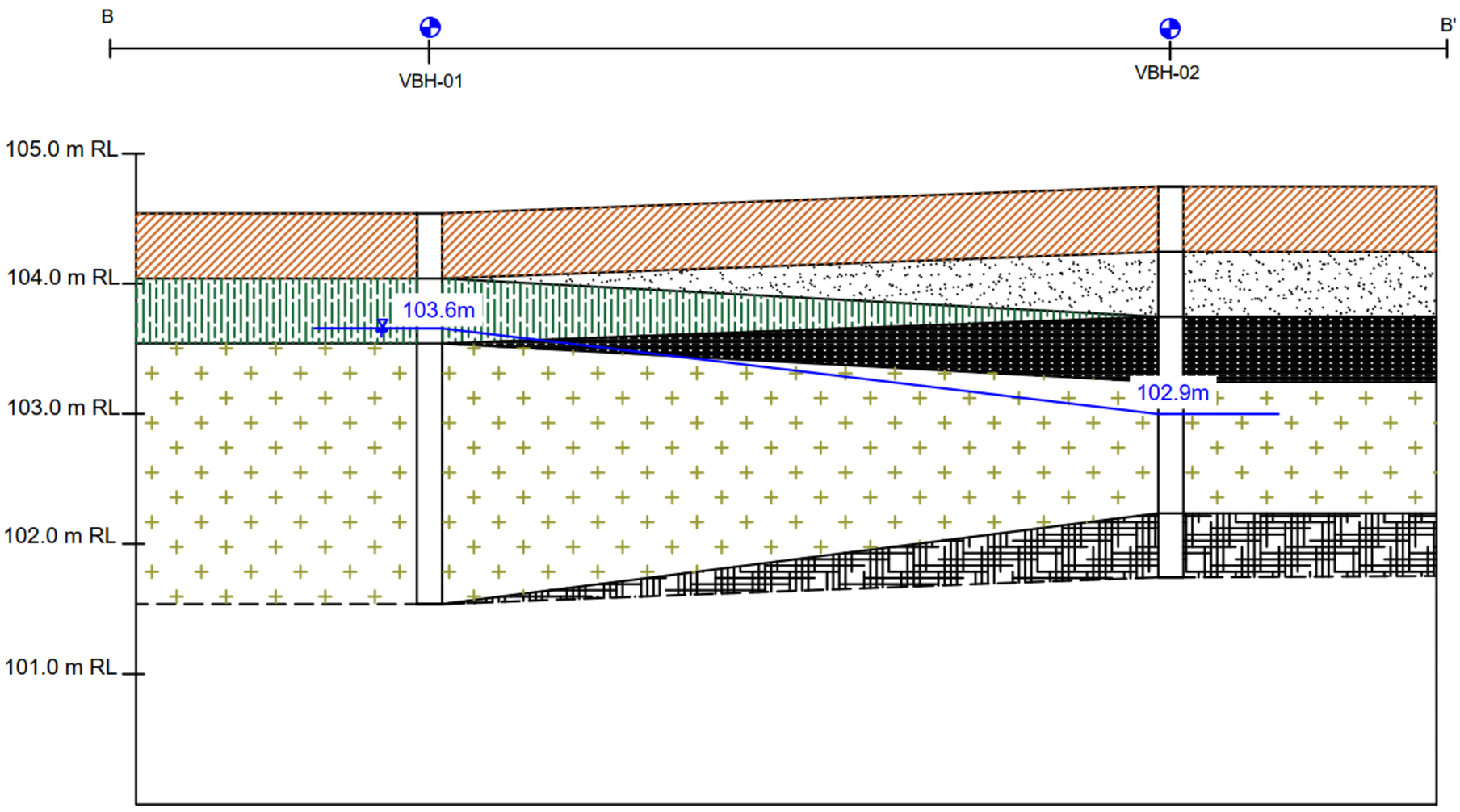

Legend

Topsoil
Silty SAND
Sandy SILT
Sandy CLAY
Clayey SILT
SILT

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Consultant : AECOM

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	JAN	JAN 2021

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Figure Title :
LITHOLOGY CROSS-SECTION (B - B')

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11 - 4	-	1 of 1

CAD File Name : NA — A3

Note: Cross-section drawn with AutoCAD

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Borehole I. D.	VBH-01	
Sample Depth	0.5	3.0
Metals (mg/kg)		
Arsenic	6.39	9.59
Antimony	0.66	N.D.
Barium	52.67	21.68
Cadmium	2.41	0.53
Chromium	42.79	N.D.
Cobalt	1.15	3.21
Copper	34.23	9.78
Mercury	0.74	N.D.
Lead	55.66	23.71
Molybdenum	N.D.	4.86
Nickel	8.58	5.79
Zinc	245.13	28.23

Borehole I. D.	BH-01	
Sample Depth	0.5	3.0
Metals (mg/kg)		
Arsenic	3.12	1.91
Antimony	18.26	1.59
Barium	9.48	6.02
Cadmium	0.21	0.10
Chromium	15.06	31.20
Cobalt	N.D.	0.25
Copper	8.78	8.75
Mercury	0.239	0.100
Lead	31.76	15.54
Molybdenum	1.88	N.D.
Nickel	N.D.	1.59
Zinc	52.13	11.21

Borehole I. D.	BH-02	
Sample Depth	0.5	3.0
Metals (mg/kg)		
Arsenic	2.70	1.03
Antimony	1.30	N.D.
Barium	4.63	6.11
Cadmium	0.32	0.15
Chromium	18.02	14.95
Copper	3.02	4.05
Mercury	0.10	0.09
Lead	5.191	8.442
Nickel	1.53	N.D.
Zinc	22.42	5.16

Borehole I. D.	VBH-02	
Sample Depth	0.5	3.0
Metals (mg/kg)		
Arsenic	17.94	9.27
Barium	31.82	24.74
Cadmium	0.85	0.50
Chromium	19.77	17.69
Cobalt	2.30	1.18
Copper	142.13	58.17
Mercury	0.40	0.23
Lead	115.90	23.76
Molybdenum	0.22	0.19
Nickel	11.01	3.69
Zinc	185.40	75.27

Borehole I. D.	BH-05	
Sample Depth	0.5	3.0
Metals (mg/kg)		
Arsenic	1.26	N.D.
Barium	9.96	35.90
Cadmium	0.31	0.08
Chromium	38.13	65.06
Cobalt	0.20	0.54
Copper	2.65	5.17
Mercury	N.D.	0.10
Lead	4.528	30.757
Nickel	1.55	1.53
Zinc	18.65	12.98
Total Petroleum Hydrocarbons (TPH)		
C_{29}-C_{36}	N.D.	11.30
C_6-C_{36} (Sum)/ Mineral	N.D.	11.30

Borehole I. D.	BH-04	
Sample Depth	0.5	3.0
Metals (mg/kg)		
Arsenic	1.41	6.79
Antimony	N.D.	0.88
Barium	4.41	5.63
Cadmium	0.47	0.79
Chromium	29.75	34.11
Cobalt	N.D.	0.44
Copper	6.84	2.26
Mercury	0.085	0.097
Lead	6.59	10.79
Nickel	2.51	3.36
Zinc	21.46	14.96

Borehole I. D.	BH-03	
Sample Depth	0.5	3.0
Metals (mg/kg)		
Arsenic	1.02	1.56
Antimony	0.37	N.D.
Barium	2.06	2.01
Cadmium	0.55	0.46
Chromium	46.42	40.15
Copper	0.97	0.36
Mercury	0.11	N.D.
Lead	3.944	2.566
Nickel	2.41	1.87
Zinc	7.82	5.59

BH/MW-01
BH/MW-02
BH/MW-03
BH/MW-04
BH/MW-05
VBH/VMW-01
VBH/VMW-02
Stream 1
Stream 2
Stream 3
Drain

0 80 160 320 M

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Study Area
- Borehole/ Monitoring Well Location
- Kopi Sua Cemetery

Major Stream/Drain

- Concrete
- Naturalised

Notes

1. BH-01 through BH-05 were advanced from 25 April 2019 to 27 April 2019, while VBH-01 and VBH-02 were advanced on 20 January 2020.
2. Samples were sent to MLS for analysis on 7 May 2019 and 22 January 2020.

N

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Figure Title :
SOIL ANALYTICAL RESULTS

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11 - 5	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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11.3.3 Groundwater Elevation

Based on the gauging records of MW-01 through MW-05 measured monthly between May 2019 and August 2019, the average stabilized groundwater level (SWL) in areas near the water bodies ranged from 105.603 m mean sea level (MSL) (0.725 m bgs) in MW-05 to 110.650 m MSL (1.166 m bgs) in MW-01. The SWL from the four (4) gauging sessions are presented in Table 11-4.

Table 11-4: Groundwater Elevation Data (MW-01 through MW-05)

Monitoring Well ID	Groundwater Elevation (m MSL)				
	May 2019	June 2019	July 2019	August 2019	Average
MW-01	110.774	110.628	110.686	110.511	110.650
MW-02	108.072	108.487	108.038	107.780	108.094
MW-03	105.757	106.202	105.741	105.509	105.802
MW-04	108.923	109.915	108.999	108.751	109.147
MW-05	105.512	105.741	105.642	105.516	105.603

The stabilized groundwater level trend is also graphically presented in **Figure 11-6**.

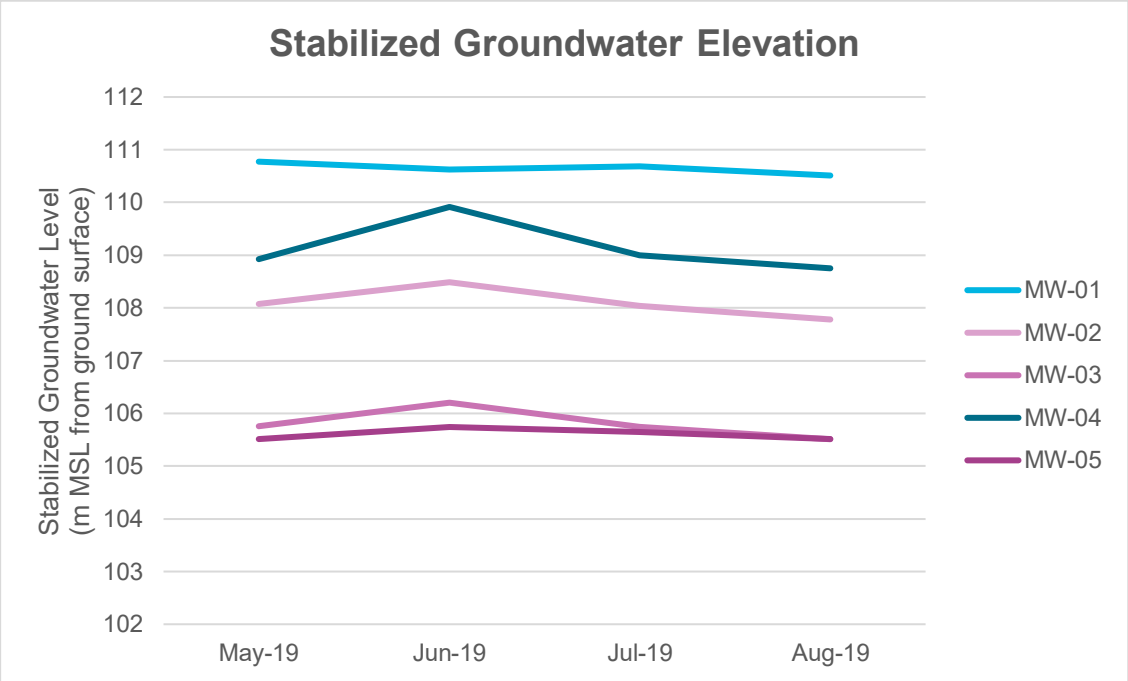


Figure 11-6: Groundwater Elevation Data (MW-01 through MW-05)

A rise in groundwater levels was observed at MW-01 through MW-05 in June 2019, compared to the levels measured in May 2019. The stabilized groundwater level in all of these wells in the subsequent months was observed to be trending downwards from June to August 2019.

11.3.4 Groundwater Flow Direction and Velocity

The hydraulic gradient, calculated using the EPA On-Line Tools for Site Assessment is 0.01683 meter/meter (m/m) to 0.01883 m/m. The linear velocity of the groundwater flow was calculated based on the Darcy's Equation as follows:

$$V = \frac{(Ki)}{n}$$

Where V = Groundwater flow velocity;

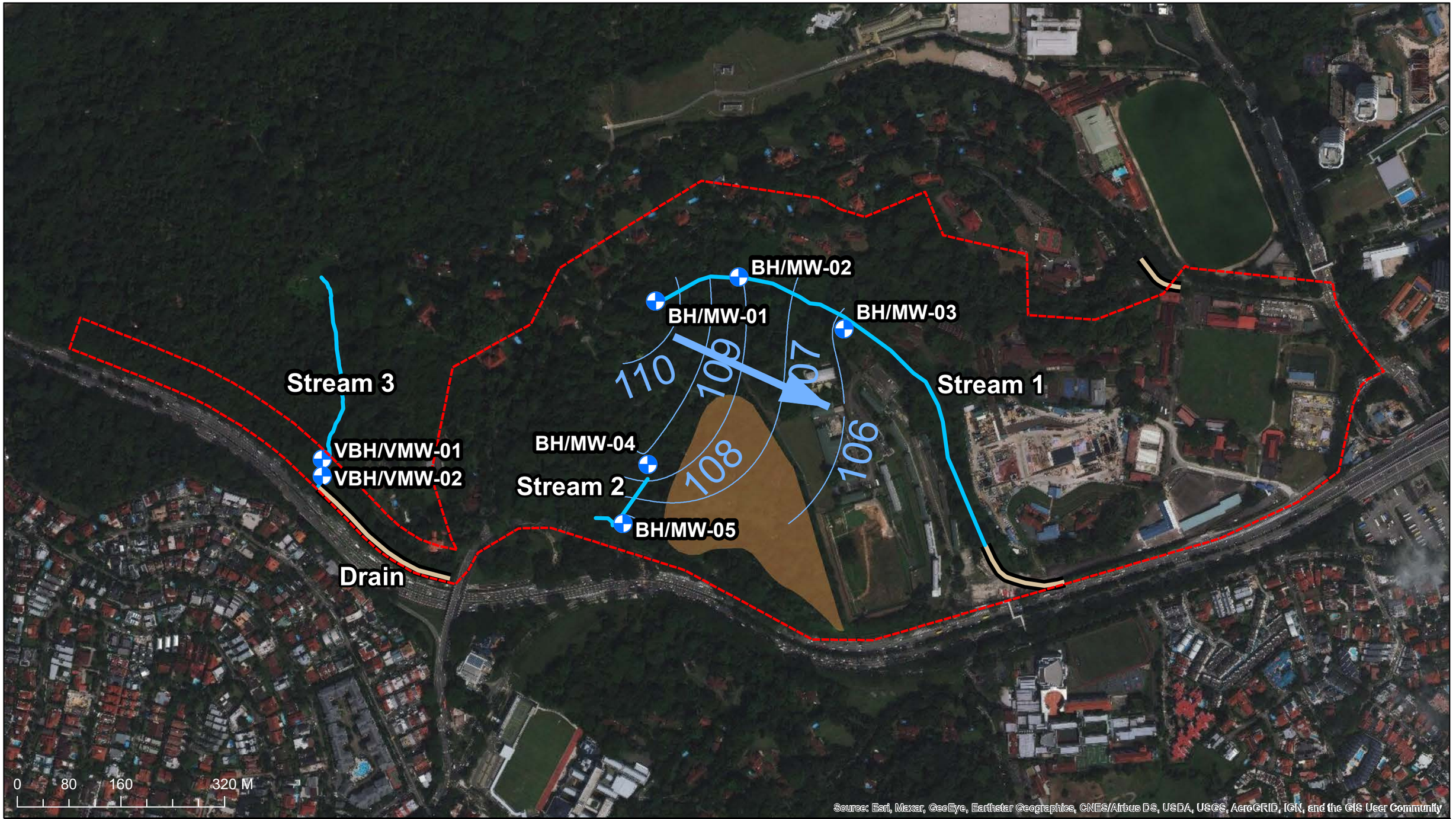
K = Hydraulic conductivity obtained from slug test: 2.2 x 10-5 to 8.7 x 10^{-4} centimetre per second (cm/s) (see attached **Appendix K**);

n = Effective porosity: 0.36 for both clayey SILT and silty CLAY; and

i = Hydraulic gradient: 0.01683 mm/m to 0.01883 m/m.

Based on the groundwater elevation contour maps (**Figure 11-7** to **Figure 11-10**), groundwater within MW-01 through MW-05 was inferred to be flowing towards the southeast with a calculated flow velocity between 0.32 m per year (silty CLAY) and 14 m per year (clayey SILT). The groundwater seepage velocity varies depending on the varying clay, silt and sand contents at a specific location and should be used as a general guide only.

Based on the inferred groundwater flows, there is no significant changes on how groundwater moves in the area. The inferred groundwater direction follows the direction of the flow of the streams observed within the site. The groundwater isocontours and the inferred groundwater flow are presented in **Figure 11-7** to **Figure 11-10**.



Legend

- Inferred groundwater flow direction
- Groundwater Isocontour
- Study Area
- Borehole/ Monitoring Well Location
- Kopi Sua Cemetery

Major Stream/Drain

- Concrete
- Naturalised

110.5 **RL Stabilized Water Level (SWL)**

Notes

1. MW-01 through MW-05 were gauged on 6 May 2019.
2. Groundwater isocontours were generated using the Surfer software (Kriging gridding method).
3. Groundwater near MW-01 through MW-05 has an inferred flow towards the south-east direction.

N

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Figure Title :
GROUNDWATER ELEVATION CONTOUR MAP (MAY 2019) (MW-01 through MW-05)

Figure No. :	Rev.	Sheet
11 - 7	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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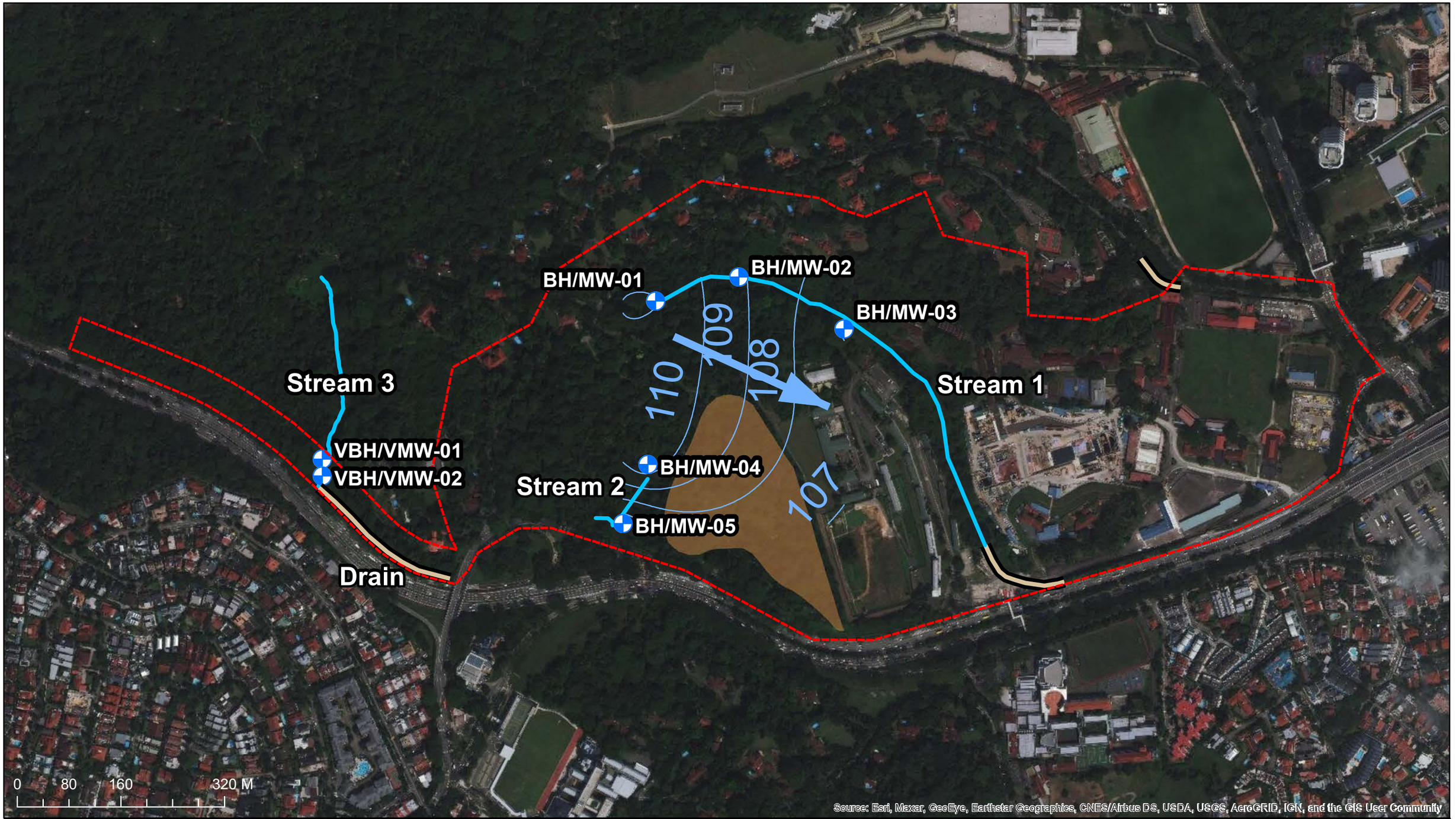

Legend

- Inferred groundwater flow direction
- Groundwater Isocontour
- Study Area
- Borehole/ Monitoring Well Location
- Kopi Sua Cemetery

Major Stream/Drain

- Concrete
- Naturalised

110.5 **RL Stabilized Water Level (SWL)**

Notes

1. MW-01 through MW-05 were gauged on 13 June 2019.
2. Groundwater isocontours were generated using the Surfer software (Kriging gridding method).
3. Groundwater near MW-01 through MW-05 has an inferred flow towards the south-east direction.

N

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Figure Title :
GROUNDWATER ELEVATION CONTOUR MAP (JUNE 2019) (MW-01 through MW-05)

Figure No. :	Rev.	Sheet
11 - 8	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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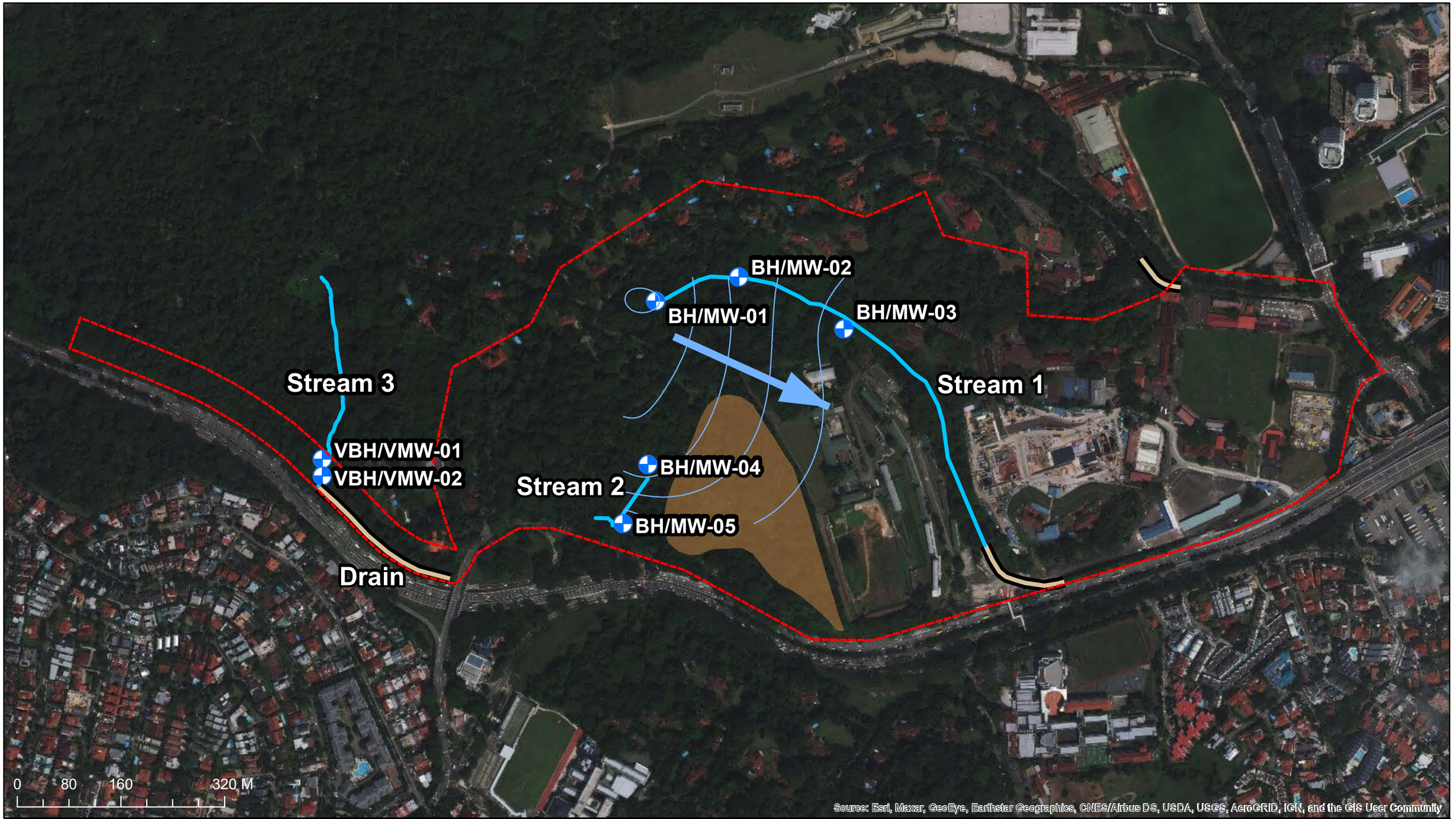

Legend

- Inferred groundwater flow direction
- Groundwater Isocontour
- Study Area
- Borehole/ Monitoring Well Location
- Kopi Sua Cemetery

Major Stream/Drain

- Concrete
- Naturalised

110.5 **RL Stabilized Water Level (SWL)**

Notes

1. MW-01 through MW-05 were gauged on 17 July 2019.
2. Groundwater isocontours were generated using the Surfer software (Kriging gridding method).
3. Groundwater near MW-01 through MW-05 has an inferred flow towards the south-east direction.

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Figure Title :
GROUNDWATER ELEVATION CONTOUR MAP (JULY 2019) (MW-01 through MW-05)

Figure No. :	Rev.	Sheet
11 - 9	-	1 of 1

CAD File Name : NA | A3

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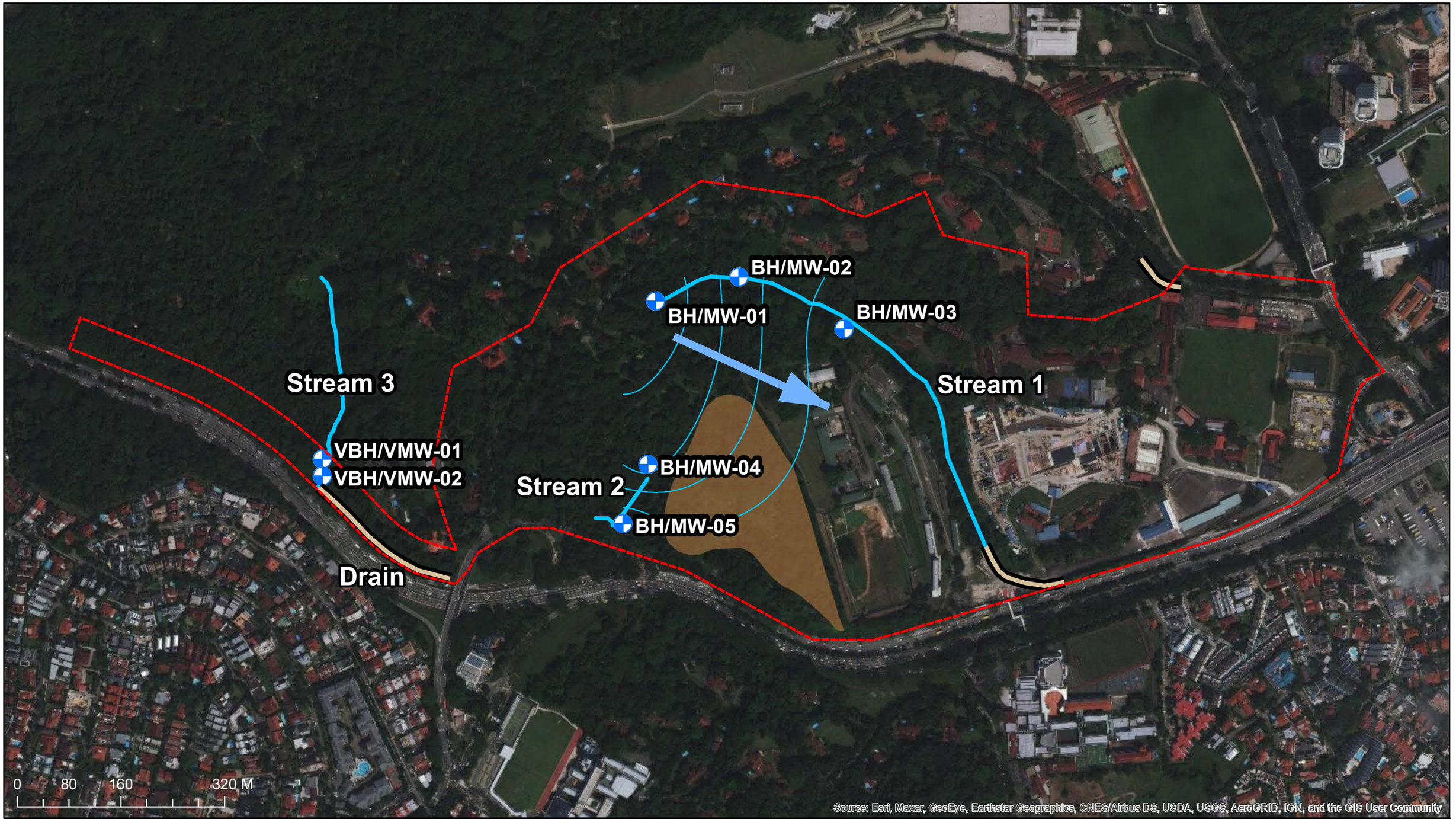

Legend

- Inferred groundwater flow direction
- Groundwater Isocontour
- Study Area
- Borehole/ Monitoring Well Location
- Kopi Sua Cemetery

Major Stream/Drain

- Concrete
- Naturalised

110.5 **RL Stabilized Water Level (SWL)**

Notes

1. MW-01 through MW-05 were gauged on 15 August 2019.
2. Groundwater isocontours were generated using the Surfer software (Kriging gridding method).
3. Groundwater near MW-01 through MW-05 has an inferred flow towards the south-east direction.

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Figure Title : **GROUNDWATER ELEVATION CONTOUR MAP (AUGUST 2019) (MW-01 through MW-05)**

Figure No. :	Rev.	Sheet
11 - 10	-	1 of 1

CAD File Name : NA | A3

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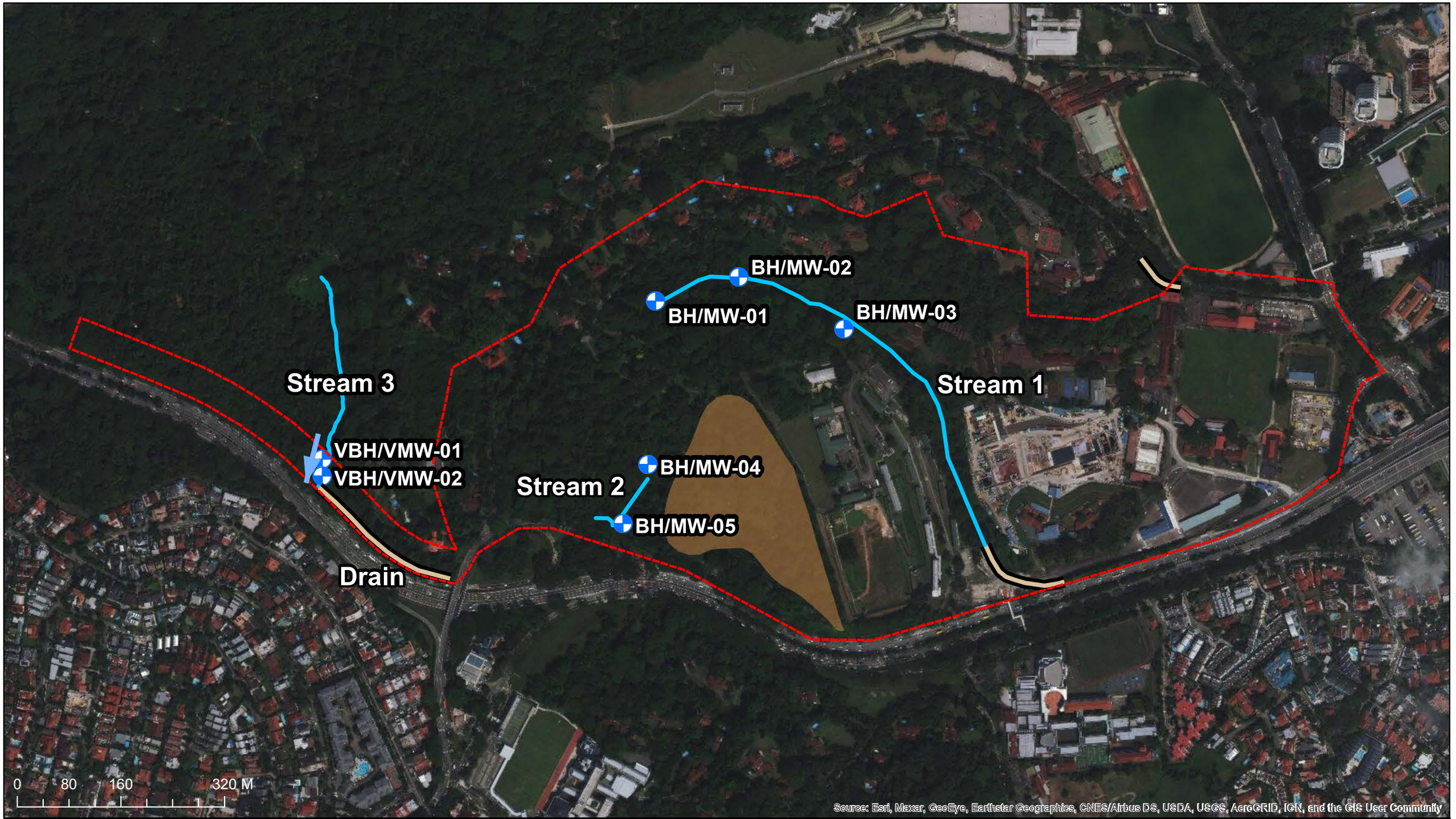
The SWL for the VMW-01 and VMW-02 is presented in **Table 11-5**.

Table 11-5: Groundwater Elevation Data (VMW-01 and VMW-02)

Monitoring Well ID	Groundwater Elevation (m)
VMW-01	103.582
VMW-02	102.910

Based on the groundwater elevation data for VMW-01 and VMW-02, the inferred groundwater flow direction at this area is to the south-southwest (see **Figure 11-11**). The inferred groundwater direction follows the direction of the flow of the Stream 3.

Most groundwater monitoring wells exhibited poor recovery during well purging activity, except for MW-01 which exhibited moderate recovery, and VMW-01 and VMW-02 which exhibited good recovery. LNAPL, hydrocarbon/chemical odour and oil sheen were not observed in any of the groundwater monitoring wells during well purging and sampling activity.



Legend

- Inferred groundwater flow direction
- Study Area
- Borehole/ Monitoring Well Location
- Kopi Sua Cemetery

Major Stream/Drain

- Concrete
- Naturalised

Notes

1. VMW-01 and VMW-02 were gauged on 21 January 2020.
2. Groundwater near to VMW-01 and VMW-02 has an inferred flow towards the south-southwest direction.

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Figure Title : **GROUNDWATER FLOW DIRECTION (VMW-01 and VMW-02)**

Figure No. :	Rev.	Sheet
11 - 11	-	1 of 1

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11.3.5 Groundwater Quality

The assessed groundwater physicochemical parameters are presented in **Table 11-6**.

Table 11-6: Summary of In-Situ Groundwater Physicochemical Parameters

Well ID	In-Situ Physiochemical Parameters					
	pH	EC (µS/cm)	ORP (mV)	DO (mg/L)	TDS (mg/L)	Temperature (°C)
MW-01	6.15	267	-4.0	1.93	166	27.3
MW-02	6.98	630	41.8	4.53	395	27.1
MW-03	6.82	855	81.1	3.45	533	27.4
MW-04	7.03	701	76.5	4.20	438	27.0
MW-05	7.04	442	-75.1	3.20	278	27.3
VMW-01	6.97	521	-5.0	2.40	332	36.5
	6.96	533	-8.7	2.78	337	26.5
	6.98	493	-14.2	2.72	308	26.5
VMW-02	6.87	573	-23.7	2.78	357	27.0
	6.84	531	-22.7	2.98	332	27.1

Based on the physico-chemical parameters assessed, the following can be observed:

- The groundwater beneath the Study Area can be described as slightly acidic to neutral, with conductivity and total dissolved solids (TDS) indicative of freshwater; and
- Measured redox potential shows that groundwater underlying MW-01, MW-05, VMW-01 and VMW-02 have reducing condition while groundwater underlying MW-02, MW-03 and MW-04 have oxidizing condition.

The major ions analysed in the groundwater from MW-01 to MW-05 and VMW-01 to VMW-02 were plotted on a Piper plot as shown in the following figure.

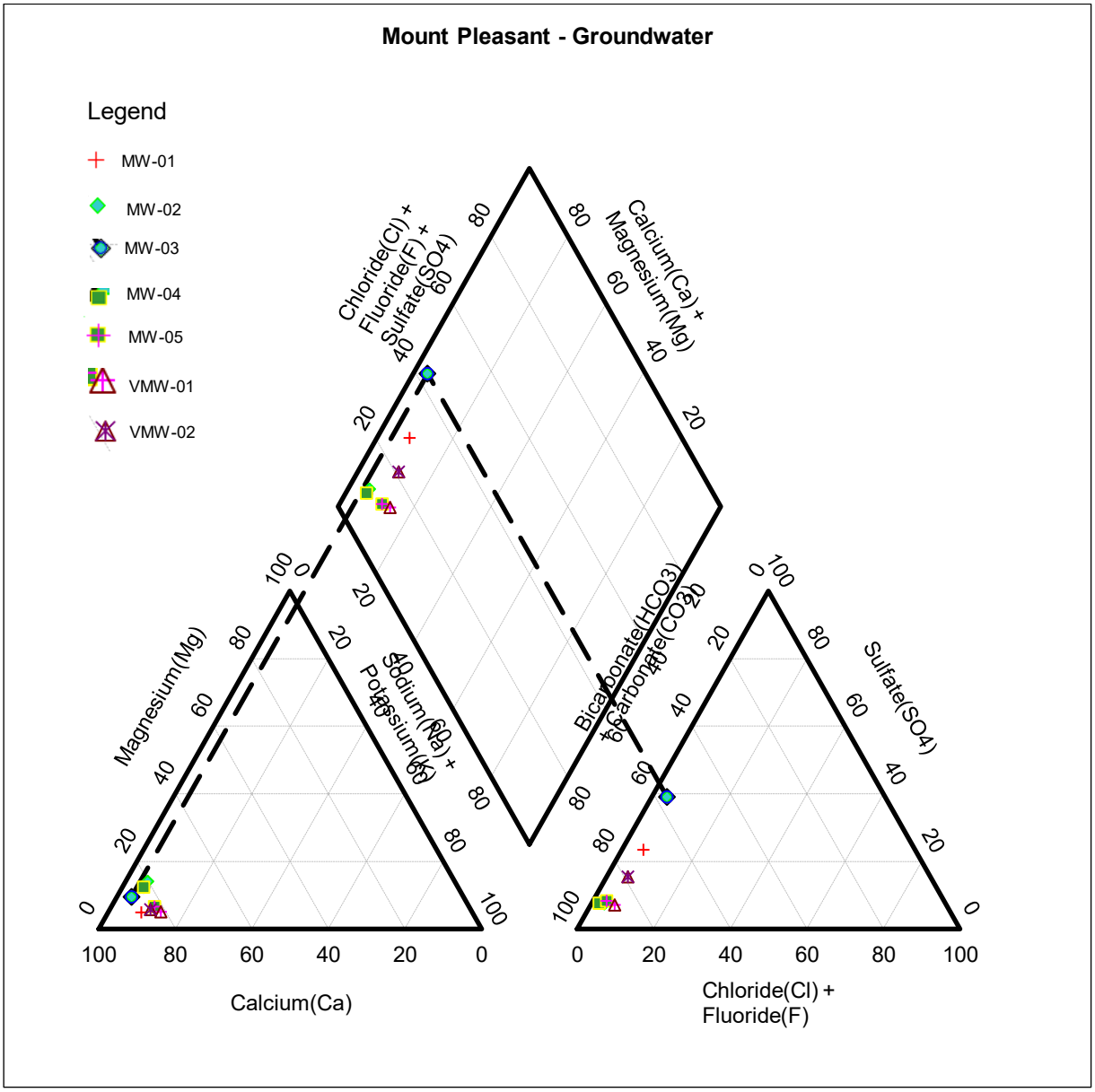


Figure 11-12: Piper Plot of Major Ions Analysed in Groundwater

Based on the Piper Plot of the groundwater samples collected from the monitoring wells, the hydrochemical facies of all the groundwater samples fall within the calcium-carbonate type. The groundwater in the Study Area is dominated mainly by calcium cations and bicarbonate anions which are characteristics of shallow freshwater.

11.3.6 Groundwater Baseline Results

A summary of the detected constituents in groundwater and a comparison of the groundwater analytical results with the ANZGFMWQ and DIVs for groundwater are summarized in **Table 11-7** and **Figure 11-13**. A copy of the full laboratory report for the groundwater samples is included in **Appendix M.**

Table 11-7: Summary of Groundwater Analytical Results

Test Parameters	Unit	ANZGFMWQ (2000)	DIV (2013)	MW-01	MW-02	MW-03	MW-04	MW-05	VMW-01	VMW-02
Heavy Metals										
Arsenic	µg/L	13/24[a]	60	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1.8
Antimony	µg/L	ID	20	2.3	1.8	1.2	1.3	N.D.	N.D.	N.D.

Test Parameters	Unit	ANZGFMWQ (2000)	DIV (2013)	MW-01	MW-02	MW-03	MW-04	MW-05	VMW-01	VMW-02
Barium	µg/L	NA	625	5.4	21.9	19.4	14.9	23.6	28.3	53
Chromium	µg/L	1[b]	30	0.1	2.1	0.3	2.7	0.7	0.1	0.1
Copper	µg/L	1.4	75	N.D.	N.D.	N.D.	15.3	2.6	N.D.	N.D.
Mercury	µg/L	0.6[c]	0.3	N.D.	0.04	0.03	0.02	N.D.	N.D.	N.D.
Molybdenum	µg/L	ID	300	1.2	2.0	N.D.	1.7	1.9	5.0	4.2
Zinc	µg/L	8.0[d]	800	2.6	4.0	1.5	10.7	9.5	1.7	8.6
Four (4) other metals	µg/L	Various	Various	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cyanide										
Cyanide (Total)	µg/L	NA	1,500	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
TPH										
C6-C36 (Sum) / Mineral Oils	µg/L	NA	600[e]	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
VOCs										
25 compounds	µg/L	NA	Various	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
SVOCs										
50 compounds	µg/L	NA	Various	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Major Anions and Cations										
Bicarbonate	mg/L	NA	NA	90.98	339.44	261.78	301.53	135.91	245	278
Carbonate	mg/L	NA	NA	0.019	0.554	0.219	0.46	0.084	0.12	0.2
Calcium	mg/L	NA	NA	46.09	120.50	158.09	116.43	52.24	84.5	99.9
Potassium	mg/L	NA	NA	1.575	6.81	4.55	4.694	7.28	5.5	4.92
Magnesium	mg/L	NA	NA	1.594	12.77	10.49	10.69	2.579	3.2	4.14
Sodium	mg/L	NA	NA	4.34	5.86	5.22	6.26	3.87	13.2	11.8
Miscellaneous Parameters										
BOD	mg/L	NA	NA	N.D.	N.D.	N.D.	N.D.	N.D.	12.3	5.0
COD	mg/L	NA	NA	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
TOC	mg/L	NA	NA	1.5	3.2	2.7	2.0	2.5	5.0	4.3
Fluoride	mg/L	NA	NA	N.D.	0.8	N.D.	N.D.	N.D.	N.D.	N.D.
Chloride	mg/L	NA	NA	4.1	6.1	10.7	3.7	3.3	10.4	11.3
Bromide	mg/L	NA	NA	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Phosphate	mg/L	NA	NA	N.D.	0.1	N.D.	0.1	N.D.	0.2	0.3
Sulphate	mg/L	NA	NA	23.6	22.3	141.4	20.0	10.0	15.8	42.8

Test Parameters	Unit	ANZGFMWQ (2000)	DIV (2013)	MW-01	MW-02	MW-03	MW-04	MW-05	VMW-01	VMW-02
Total Ammoniacal Nitrogen	mg/L	NA	NA	0.1	0.0	0.1	0.1	0.2	2.9	2.0

Notes:
123 - Exceedance of the ANZGFMWQ (2000)

NA – Not Available (value not specified in standard)
N.D. – Not Detected above the LOR
ID - Insufficient data to derive a reliable trigger value
ANZGFMWQ – Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Trigger Value for Fresh Water, Level of Protection 95%
DIV – Dutch Intervention Value

a – Trigger value for Arsenic (as III) = 24 µg/L; trigger value for Arsenic (as V) = 13 µg/L
b – Trigger value for Chromium (VI)
c – Trigger value for mercury (organic)
d - Figure may not protect key test species from chronic toxicity
e - Intervention value for mineral oil; This applies to contamination due to mixtures (e.g. gasoline or domestic heating oil), then not only the alkane content but also the content of aromatic and/or polycyclic aromatic hydrocarbons must be determined. This aggregate parameter has been adopted for practical reasons. Further toxicological and chemical disaggregation is under study.

Heavy metals including antimony, barium, chromium, mercury, molybdenum and zinc were detected in most groundwater samples at concentrations above their respective LORs. Arsenic was detected only in groundwater sample VMW-02 while copper was detected in groundwater samples MW-04 and MW-05. The concentrations of these metals were all below the DIVs and ANZGFMWQ for Freshwater (95% level of protection), except for copper and zinc, where exceedances of the ANZGFMWQ was detected in groundwater samples MW-04 and MW-05.

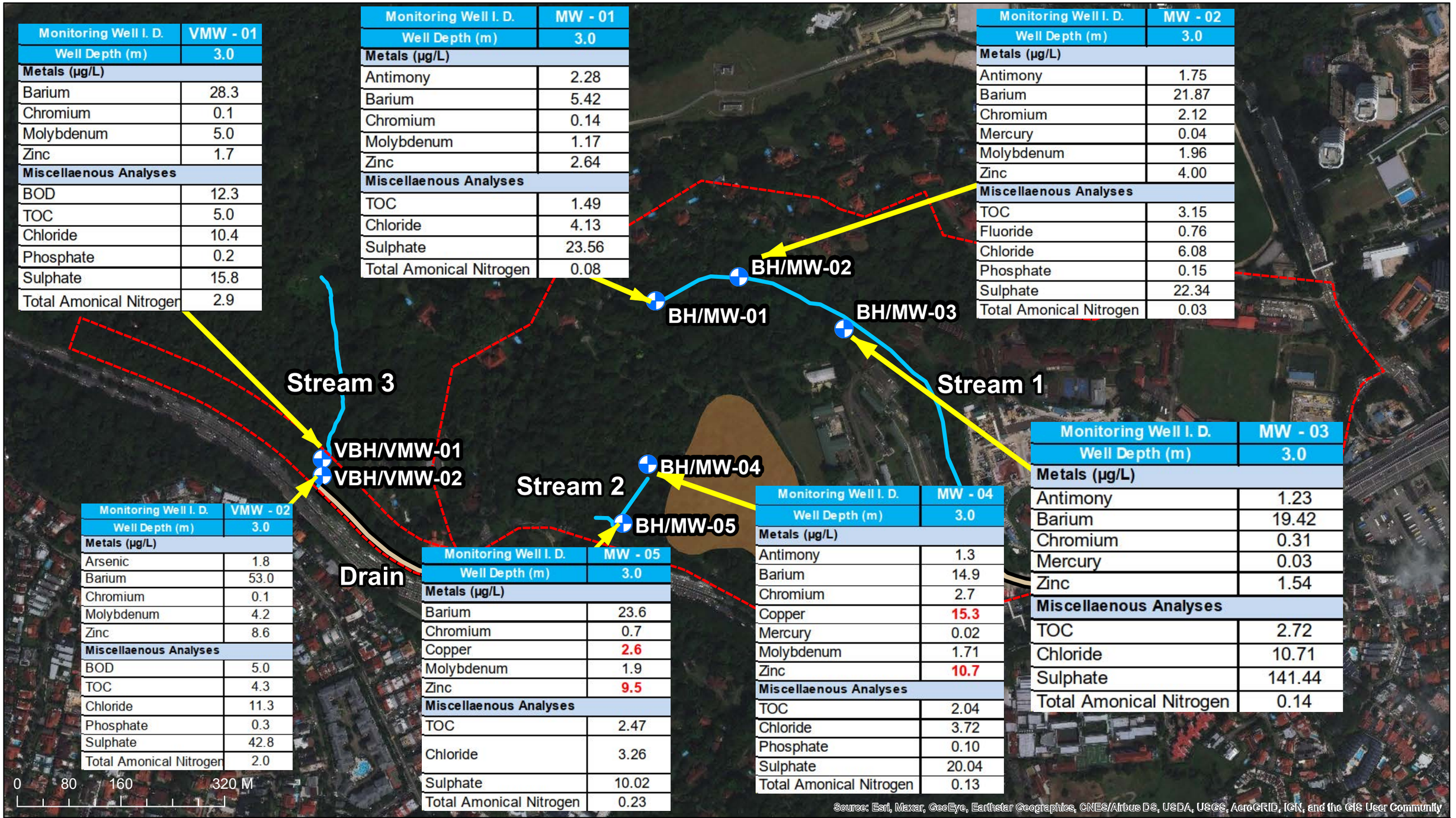
Major anions and cations were detected in all groundwater samples. Bicarbonate was detected at concentrations between 91 mg/L and 339 mg/L, while carbonate was detected at concentrations between 0.019 mg/L and 0.55 mg/L. Calcium was detected at concentrations from 46.1 mg/L till 158 mg/L while potassium was detected at concentrations between 1.57 mg/L and 7.28 mg/L. Magnesium reported concentrations between 1.59 mg/L and 12.8 mg/L while sodium reported concentrations ranging from 3.87 mg/L to 13.2 mg/L.

BOD was only detected in groundwater samples VMW-01 and VMW-02 at concentrations of 12.3 mg/L and 5.0 mg/L, respectively. TOC was detected in all groundwater samples, registering concentrations between 1.5 mg/L and 5 mg/L. Fluoride was only detected in groundwater sample MW-02 at a concentration of 0.8 mg/L. Chloride was detected in all groundwater samples, ranging from 3.3 mg/L to 11.3 mg/L. Phosphate was detected in MW-02, MW-04, VMW-01 and VMW-02 at concentrations between 0.1 mg/L and 0.3 mg/L. Sulphate and total ammoniacal nitrogen were detected in all groundwater samples, ranging between 10 mg/L and 141.4 mg/L, and between 0.03 mg/L and 2.9 mg/L respectively.

The remaining parameters analyzed for the groundwater samples were below their respective LORs.

MW-04 reported detections of copper at 15.3 µg/L and zinc at 10.7 µg/L while MW-05 reported detections of copper at 2.6 µg/L and zinc at 9.5 µg/L. MW-04 and MW-05 are located along and near to Stream 2. Surface water samples collected from WQ3 (Stream 2; dry season sampling; May 31st, 2019) reported detections of copper at 18 µg/L and zinc at 73 µg/L. Given the distance from the groundwater monitoring wells to the stream (less than 50 m away), the likelihood of the detected contaminants i.e. copper and zinc from MW-04 and MW-05 to migrate towards the stream could not be discounted. However, as there is no species identified in Stream 2 that is of high ecological value except for the Collared Threadtail, which is non-aquatic, exposure (i.e., via ingestion) to the elevated heavy metals in groundwater (through the surface water) is considered limited.

None of the receptors are currently known or reported to be affected by the concentrations detected in soil and groundwater. Available data does not allow for estimation of timing of any affects.



Monitoring Well I. D.	VMW - 01
Well Depth (m)	3.0
Metals (µg/L)	
Barium	28.3
Chromium	0.1
Molybdenum	5.0
Zinc	1.7
Miscellaenous Analyses	
BOD	12.3
TOC	5.0
Chloride	10.4
Phosphate	0.2
Sulphate	15.8
Total Amonical Nitroger	2.9

Monitoring Well I. D.	VMW - 02
Well Depth (m)	3.0
Metals (µg/L)	
Arsenic	1.8
Barium	53.0
Chromium	0.1
Molybdenum	4.2
Zinc	8.6
Miscellaenous Analyses	
BOD	5.0
TOC	4.3
Chloride	11.3
Phosphate	0.3
Sulphate	42.8
Total Amonical Nitrogen	2.0

Monitoring Well I. D.	MW - 01
Well Depth (m)	3.0
Metals (µg/L)	
Antimony	2.28
Barium	5.42
Chromium	0.14
Molybdenum	1.17
Zinc	2.64
Miscellaenous Analyses	
TOC	1.49
Chloride	4.13
Sulphate	23.56
Total Amonical Nitrogen	0.08

Monitoring Well I. D.	MW - 02
Well Depth (m)	3.0
Metals (µg/L)	
Antimony	1.75
Barium	21.87
Chromium	2.12
Mercury	0.04
Molybdenum	1.96
Zinc	4.00
Miscellaenous Analyses	
TOC	3.15
Fluoride	0.76
Chloride	6.08
Phosphate	0.15
Sulphate	22.34
Total Amonical Nitrogen	0.03

Monitoring Well I. D.	MW - 03
Well Depth (m)	3.0
Metals (µg/L)	
Antimony	1.23
Barium	19.42
Chromium	0.31
Mercury	0.03
Zinc	1.54
Miscellaenous Analyses	
TOC	2.72
Chloride	10.71
Sulphate	141.44
Total Amonical Nitrogen	0.14

Monitoring Well I. D.	MW - 04
Well Depth (m)	3.0
Metals (µg/L)	
Antimony	1.3
Barium	14.9
Chromium	2.7
Copper	15.3
Mercury	0.02
Molybdenum	1.71
Zinc	10.7
Miscellaenous Analyses	
TOC	2.04
Chloride	3.72
Phosphate	0.10
Sulphate	20.04
Total Amonical Nitrogen	0.13

Monitoring Well I. D.	MW - 05
Well Depth (m)	3.0
Metals (µg/L)	
Barium	23.6
Chromium	0.7
Copper	2.6
Molybdenum	1.9
Zinc	9.5
Miscellaenous Analyses	
TOC	2.47
Chloride	3.26
Sulphate	10.02
Total Amonical Nitrogen	0.23

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Inferred groundwater flow direction
- Study Area
- Borehole/ Monitoring Well Location
- Kopi Sua Cemetery

Major Stream/Drain

- Concrete
- Naturalised

Notes

1. Groundwater Sampling of MW-01 through MW-05 was performed on 6 May 2019, while groundwater sampling of VMW-01 and VMW-02 was performed on 22 January 2020.
2. Samples were sent to MLS for analysis on 7 May 2019 and 22 January 2020.

N

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Figure Title : GROUNDWATER ANALYTICAL RESULTS

Figure No. :	Rev.	Sheet
11 - 13	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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11.3.7 Groundwater Relationship to Surface Water

The in-situ surface water quality parameters are presented in Table 10-5 and the surface water sampling locations are presented in **Figure 10-2**.

The surface water from the streams was found to be slightly acidic, with pH ranging from 5.56 to 7.72. According to the analysis results, the pH of the surface water within the Study Area did not change significantly either spatially or temporally.

The electrical conductivity of surface water ranged from 72.84 µS/cm to 1,167.56 µS/cm with an average of 112.15 µS/cm; while the salinity ranged from 0.03 ppt to 0.08 ppt with an average of 0.05 ppt. These qualities denote the freshwater characteristics of the surface water.

The pH range of the groundwater is from 6.15 to 7.04 which denotes slight acidic to neutral characteristics. The conductivity range measured was from 267 µS/cm to 855 µS/cm, which also denotes freshwater characteristics similar with the surface water. However, the groundwater has relatively higher conductivity measured.

The major ions analysed in the surface water collected from Stream 1, Stream 2 and Stream 3 were plotted on a Piper plot as shown in **Figure 11-14**.

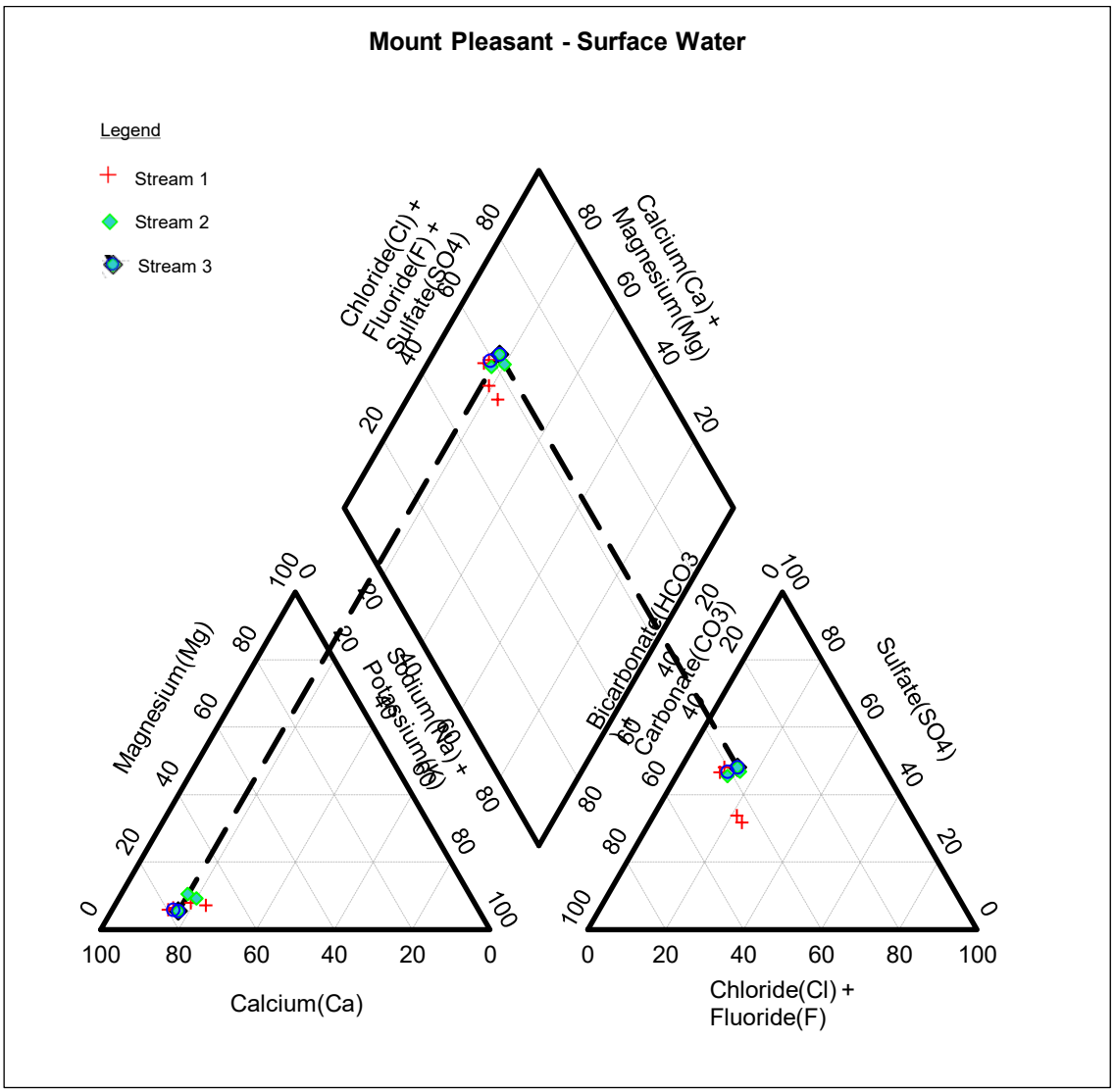

Figure 11-14: Piper Plot of Major Ions Analysed in Surface Water

The Piper Plot indicates that the three (3) streams located within the Study Area have mixed water type, with dominant calcium ions and no dominant anions. There is no significant change in the hydrochemical facies between the two (2) sampling events at Stream 1 and Stream 2 for surface water.

To determine the potential relationship between groundwater and surface water, a Piper Plot of the major ions of the groundwater and surface water were plotted, as shown in **Figure 11-15**.

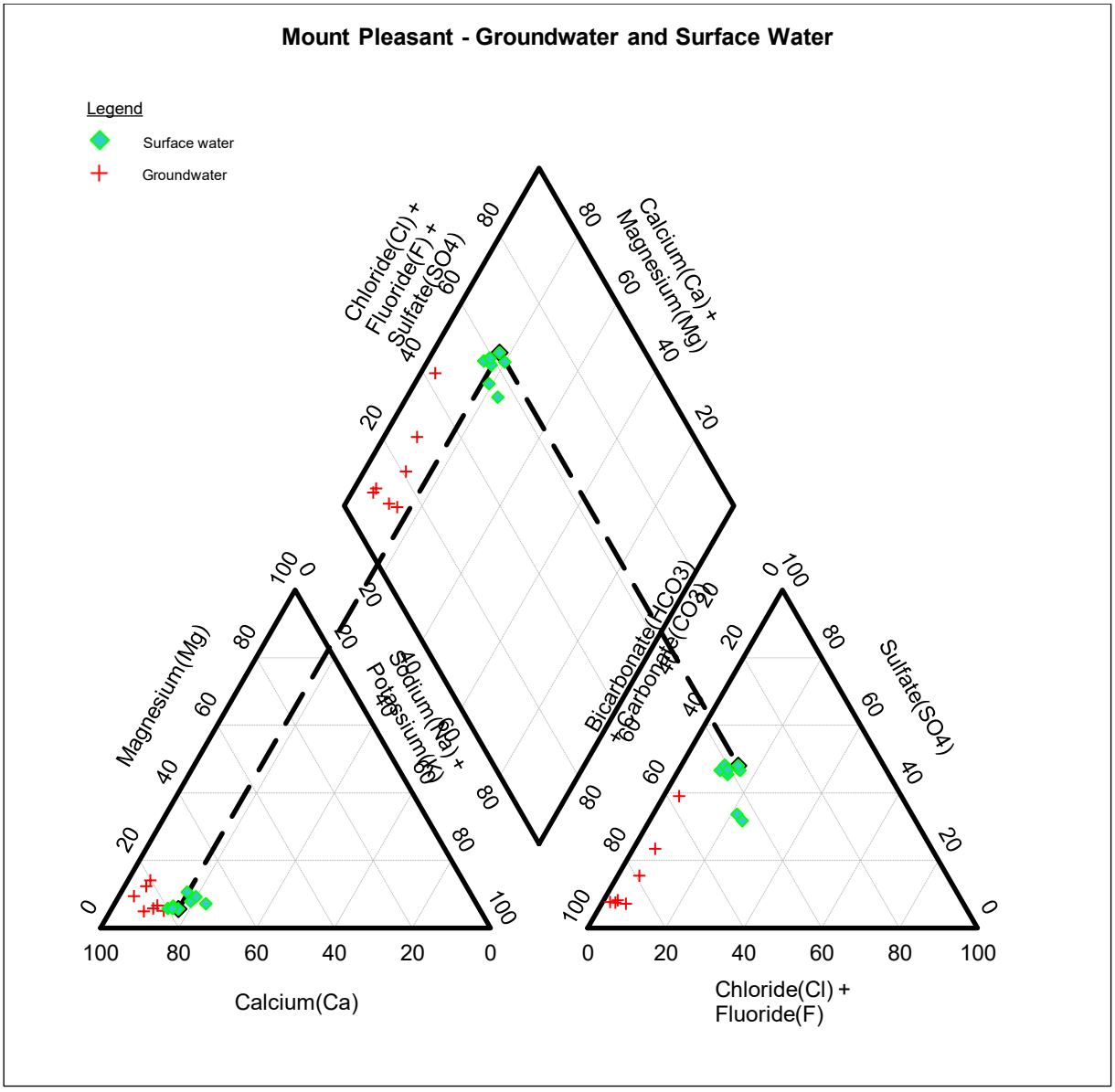

Figure 11-15: Piper Plot of Major Ions Analysed in Surface Water and Groundwater

The trilinear diagram above shows that the groundwater has a distinct calcium-carbonate type while the surface water has a mixed type hydrochemical facies, suggesting various water sources feeding to the streams. The potential sources of water for the streams include rainwater, surface runoff and potentially groundwater due to similar hydrochemical facies (especially the cations).

A review of the elevation data obtained from the topography survey and soil and groundwater investigation showed that the groundwater elevation is higher than the stream's invert level which suggests that groundwater potentially may be feeding into the streams. A snapshot of the stream invert levels and groundwater level (in m MSL) is presented in **Table 11-8** below.

Table 11-8: Comparison of Stream Invert Level to Groundwater Level

Groundwater Well ID	Groundwater Level (m MSL)	Stream Invert Level (m MSL)	Stream No.
MW-01	110.500 – 110.700	110.000	Stream 1
MW-02	107.780 – 108.480	108.510 – 108.660	
MW-03	105.500 – 106.200	106.460 – 106.860	
MW-04	108.700 - 109.000	108.550 – 109.390	Stream 2
MW-05	105.500 – 105.700	105.340 – 105.480	
VMW-01	103.582	Invert levels not available for Proposed Slip Road Area	Stream 3
VMW-02	102.910		

11.4 Soil and Groundwater Impact Assessment

11.4.1 Identification and Classification of Sensitive Receptors

The soil and groundwater analytical results showed that the concentrations, which are below the DIVs does not pose potentially unacceptable risks to future construction workers and residents in the HDB housing. It is understood that presently groundwater in Singapore is not extracted for beneficial use i.e. as a source for potable water, industrial water or irrigation purposes, and hence was considered as Priority 3.

Based on the assessment on the ecological value of the streams, the streams are highly sensitive and supports a strong and established population of restricted and endangered species (i.e. Collared Threadtail at Streams 1, 2 and 3, and softshell turtles at Stream 3). The baseline assessment above showed that the groundwater may be potentially feeding into the streams based on the hydrochemical facies and elevations. As the groundwater, especially in proximity of the streams may be partially supporting the ecosystems of biodiversity of significance, the streams, which are potentially receiving groundwater as a source are classified as Priority 2 receptors (refer to Table 6-1 for sensitive receptor classification).

Receptor screening for groundwater was conducted within the boundary of the Study Area. This section introduces a comprehensive list of groundwater receptors that is considered for the present impact assessment. The classification of the groundwater sensitive receptors within the Study Area is tabulated in **Table 11-9**.

Table 11-9: Classification of Receptor Sensitivity

Sensitive Receptor	Description	Receptor Sensitivity	Sensitivity Classification
Stream 1	• A strong and established population of damselflies (i.e., Collared Threadtail) identified on this area.	Groundwater partially supporting the stream with biodiversity conservation significance.	Priority 2
Stream 2	• A strong and established population of damselflies (i.e., Collared Threadtail) identified on this area.	Groundwater partially supporting the stream with biodiversity conservation significance.	Priority 2
Stream 3	• A strong and established population of damselflies (i.e., Collared Threadtail) identified on this area. Also, Softshell Turtles were observed in this area.	Groundwater partially supporting the stream with biodiversity conservation significance.	Priority 2
Soil and Groundwater within the Study Area	• The soil and groundwater within the Study Area does not pose unacceptable risks to future workers and HDB residents based on comparison with screening criteria (i.e., DIV)	Not sensitive groundwater (i.e. not extracted for any purposes such as drinking or commercial/industrial use)	Priority 3

11.4.2 Potential Source of Impacts

11.4.2.1 Construction Phase

A conceptual hydrogeological condition is represented in Figure 11-16. The potential impacts on soil and groundwater resources during the construction phase are likely to be attributed to site clearance and reshaping of the topography, construction of the residential building and associated roads and infrastructure, improper handling, transfer, storage and/or refiling of hazardous materials i.e. toxic chemical waste and hazardous substances/chemicals used at the site. The potential sources of soil and groundwater impacts anticipated during the construction phase are summarized in **Table 11-10**.

Table 11-10: Potential Sources of Soil and Groundwater Impacts (Construction Phase)

Activity	Potential Source(s) of Impact(s)	Potential Associated Impacts
Site clearance and re-shaping of topography Construction of the residential buildings and associated roads and infrastructures	Increased runoff from hard standing and decreased infiltration into the ground.	• Decreased groundwater baseflow feeding into the streams.
Improper management and disposal of excavated soils and/or groundwater during excavations activities.	Contaminated excavated soils (if encountered), if not stored, handled, transported and disposed properly, can lead to direct or indirect contamination.	• Potential for direct soil and/or groundwater contamination within the Study Area. • Potential pollution to the adjacent areas within the immediate vicinity of the project due to migration of soil and groundwater contamination, off-site.
Improper handling, transfer and storage of toxic chemical waste	Discharge of toxic chemical waste due to spillage or leakage during storage, handling and transfer	
Improper handling, transfer, refuelling and storage of chemicals (e.g. diesel, bentonite, lubricants, oils, grease, paints, solvents, waste treatment chemicals, etc.) generated during construction activities.	Discharge of chemical due to spillage or leakage during storage, handling, transfer and refuelling (oil, grease or other chemical substance release).	

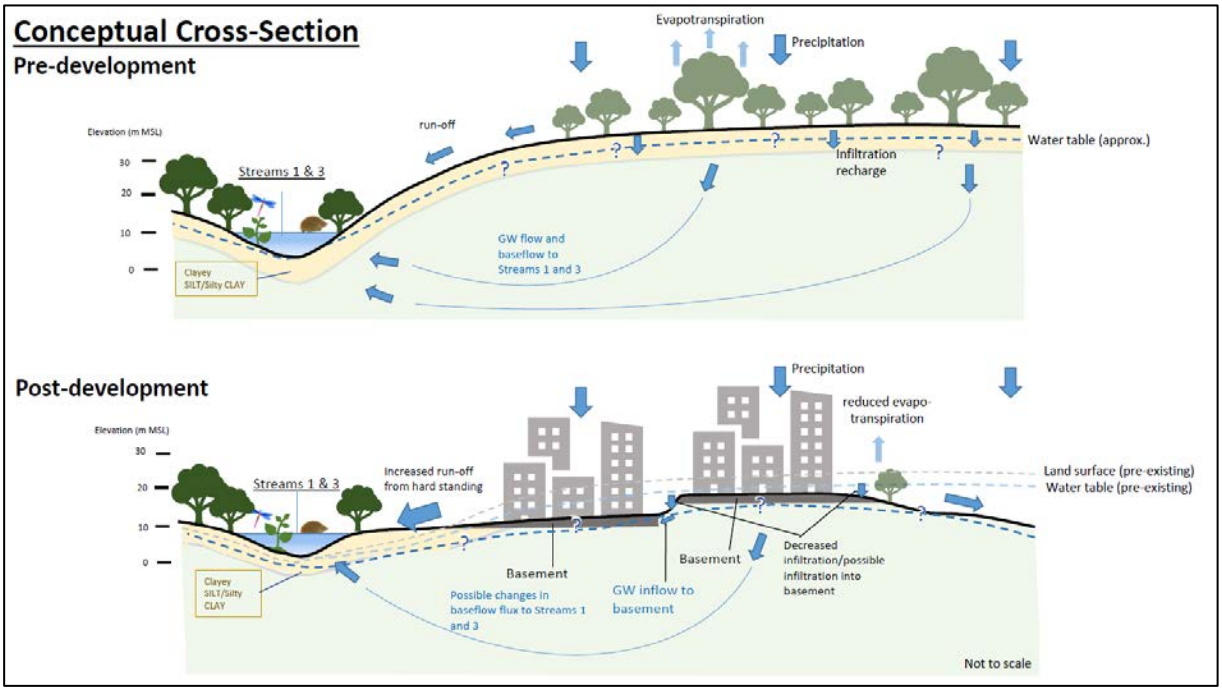

Figure 11-16: A Typical Conceptual Hydrogeological Condition

11.4.2.2 Operational Phase

It was anticipated that there would be limited sources of impacts to soil and groundwater during the operational phase as use of chemicals and generation of toxic chemical waste were expected to be of limited quantities.

Once the future developments are fully constructed and in operations, the water table in the long-term will equilibrate to its new groundwater level. The potential impact on groundwater during the operational stage is the reduced groundwater infiltration due to natural landscape replacement by impervious surfaces such as the proposed road networks on Stream 1 and 3. Although the water from these streams originates from different sources (such as surface runoff and rainwater), a decrease in the groundwater baseflow (if any) discharging into these streams should be noted.

11.4.3 Minimum Control for Potential Impacts

This section proposes minimum controls or standard practices commonly implemented in Singapore for similar developments that have been assumed to be implemented for the purposes of impact assessment during both construction and operational phases.

11.4.3.1 Construction Phase

Table 11-11 sets out the minimum controls that have been identified for the project during construction phase. Regular inspection and workers training must be conducted to ensure these measures are inculcated in the behaviour and practice of all the staff at the site.

Table 11-11: Minimum Controls During Construction Phase (Soil and Groundwater)

Potential Sources of Impacts	Minimum Controls	Further Assessment
Decreased groundwater baseflow feeding into the streams	Install piezometers to monitor the changes in groundwater level in compliance with Building Control Regulations 2003 as part of its instrumentation and monitoring plan to be endorsed by the Qualified Professional (QP).	Impacts assessed in **Section 11.4.4.1**.
Toxic Chemical Waste Generation during Construction Phase	Identify all types of toxic chemical waste and implement comprehensive waste	Impacts assessed in **Section 11.4.4.1**

Potential Sources of Impacts	Minimum Controls	Further Assessment
	management system at the site in order to ensure proper disposal and prevent pollution to the environment. This contractor should conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan. If health impacts to workers are foreseen due to the handling of such waste, necessary precautionary measures as per the safety data sheets (SDS) including personal protective equipment should be implemented on site.	
	Inspect all equipment prior to entering the site for fuel/hydraulic lines, leaking tanks, and other potential faulty parts that could potentially cause contamination to soil or groundwater.	
	Dispose all construction debris (under category C&D) at the gazetted Government dumping grounds or at such other sites or locations as directed by NEA.	
	Store generated toxic chemical waste under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all waste containers Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances.	
	Note that the Earth Control Measures (ECM) is for the containment and treatment of silty discharge due to the impact of rainwater. ECM is not meant for the treatment of wastewater due to construction activities (such as pipe-jacking and bore-piling works) which shall be treated to comply with the requirements under prevailing legislation.	
Improper Handling of Hazardous Chemicals/Substances during Construction Phase	Remove any hazardous substance or chemical if there are safer alternatives.	Impacts assessed in **Section 11.4.4.2**
	Ensure all hazardous substance and chemical containers are labelled its movement is recorded and returned to the designated storage areas when not in use.	
	Assess the SDS of all the hazardous substances and chemicals prior to its entry to site for its suitability in terms of SHE hazards and consider safer alternatives.	

Potential Sources of Impacts	Minimum Controls	Further Assessment
	Ensure no trade effluent other than that of a nature or type approved by NEA Director-General shall be discharged into any watercourse or land.	
	Ensure all activities involving repair, servicing, engine overhaul works, etc. shall be carried out on an area which is appropriately contained (e.g. concreted area and with proper containment/sumps) and all wastes are channelled for appropriate treatment or disposal to meet the regulations.	
	Store chemicals stored under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances.	
	Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team shall also be competent in the use of these spill kits.	

11.4.3.2 Operational Phase

Table 11-12 sets out the minimum controls that have been identified for the project during operational phase.

Table 11-12: Minimum Controls During Operational Phase (Soil and Groundwater)

Potential Sources of Impacts	Minimum Controls	Further Assessment
Small Quantities of Toxic Chemical Waste Generated during Operational Phase (used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.)	Store all toxic chemical waste at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all chemical drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances.	Impacts assessed in **Section 11.4.4.1**
	Dispose all toxic waste chemicals to licensed TIW collectors for treatment.	
Improper Handling of Hazardous Chemical/Substances during Operational Phase	Store all hazardous substances/chemicals at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation. Spill trays shall be	Impacts assessed in **Section 11.4.4.2**

Potential Sources of Impacts	Minimum Controls	Further Assessment
	provided for all chemical drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances.	
	Ensure all hazardous chemicals/substances are labelled its movement is recorded and returned to the designated storage areas when not in use.	
	Ensure all activities including repair, servicing, engine overhaul works, etc. involving the use of hazardous chemicals/substances are carried out on an area which is appropriately contained (e.g. concreted area and with proper containment/sumps).	
	Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team shall also be competent in the use of these spill kits.	
	Ensure no trade effluent other than that of a nature or type approved by NEA Director-General shall be discharged into any watercourse or land.	

11.4.4 Prediction and Evaluation of Potential Impacts

11.4.4.1 Decreased groundwater baseflow feeding into the streams

The streams identified within the Study Area receives water from the upstream surface runoff and rainfall, and potentially baseflow contribution from groundwater. Based on the footprint of the future HDB development, a portion of Stream 1's catchment will be converted into roads and HDB high-rise development which may experience deep excavations for the foundation and dewatering process during construction phase, leading to potential groundwater drawdown and decreased baseflow. However, based on the catchment analysis for Stream 1 carried out in **Section 10.2.3.1**, Stream 1 receives water from the catchment outside of the Study Area in the north in addition to the sub-catchment area within the Study Area. The total catchment area of Stream 1 is much larger than the area of potential construction footprint, indicating the impact on groundwater baseflow is low. In addition, generally the HDB high-rise development will be constructed phase by phase instead of the whole area together, which further reduces its construction footprint by phases and reduce the potential impact on groundwater baseflow due to dewatering process. Hence, this might have **Low** impact intensity on the groundwater baseflow. Impact consequence was assessed to be **Low** as Stream 1 had Priority 2 sensitivity. Given that the occurrence of the expected decreased baseflow is only during the initial stage of the construction and or during the dry seasons (i.e., **Occasional**), therefore, impact significance of the decreased groundwater baseflow to Stream 1 is **Minor**.

Based on the footprint of the future HDB development, none of the sections of Stream 2 will be affected with the proposed development. As this stream will continue to receive surface runoff and groundwater baseflow, the intensity of the decrease in baseflow impact was considered to be **Negligible**. Impact consequence was assessed to be **Very Low**. Given that the occurrence of the expected decreased baseflow is **Unlikely** as this area will not be affected by the future construction works, impact significance to Stream 2 is **Negligible**.

A section of Stream 3 is planned for future road works which is expected to be less than 0.5 m. As this is a small-scale localised groundwater baseflow impacts to the southern section of Stream 3, the intensity of this impact was considered **Low**. Impact consequence was assessed to be **Low**. Given that the occurrence of the expected decreased baseflow is limited due to the shallow excavations with the road construction, likelihood of the impact is **Rare**. Impact significance of the decreased groundwater baseflow to Stream 1 is **Minor**.

As mentioned in **Section 11.4.2.2**, the operational stage of the project will mainly consist of human activities related to their occupancy of the future HDB development. As the future HDB development area will be replaced with impervious surfaces especially for majority of the sections in Stream 1 and some portions of Stream 3, reduced infiltration is expected. With this, impact consequence is similar with the construction phase (**very low to low**). However, after the construction phase, the groundwater level is expected to achieve a steady state and will equilibrate with the surrounding groundwater level. Hence, the operational phase (i.e., human occupancy) of the project will not have impact on the groundwater drawdown and baseflow to the streams. Hence, the likelihood of the groundwater baseflow during the operational phase is **Unlikely**. Based on this, the impact significance of the decrease groundwater baseflow to the freshwater streams identified is **Negligible** in the operational phase.

11.4.4.2 Toxic Chemical Waste Generation

The quantity of toxic chemical waste stored on site is expected to be limited with the assumption that waste generated on-site will be periodically removed and disposed off-site by licensed TIW contractors during the construction phase. During the operational phase, toxic chemical waste generation will be limited; the chemical wastes are often generated from the building maintenance works and operations of ancillary structures.

The impact intensity was considered **Low** (small scale localised soil and groundwater impacts which is not likely to extend beyond the Study Area and possible to remediate), with the consequence of soil and/or groundwater contamination was assessed to be **Very Low**. During operational phase, the Study Area will have very limited toxic chemical waste generation hence it was considered that only small localised contamination may exist in certain areas. Hence during operational phase, the impact intensity was considered as **Low** with overall consequence of **Very Low**.

Based upon implementation of the minimum controls and that the controls are approved by the relevant agency, where applicable, it is unlikely that discharge, spillage or leakage from toxic waste in a quantity that may adversely impact the environment will regularly occur during the construction phase. Mandatory worker training regarding environmental management and spill management and regular site inspections serve as preventative measure for such occurrences. On this basis, the likelihood of occurrence during construction phase was expected to be **Occasional**.

For operational phase, as the site will have limited activities which can generate toxic chemical waste, the likelihood of occurrence was expected to be Rare.

Overall, based upon an assessment of the likelihood and consequences, and considering the routine, standard industry practices implemented during the construction phase, the potential impact of toxic chemical waste spillage or leakage to soil and/or groundwater was assessed to be **Minor**. As the generation of chemical waste during the operational phase is limited, the potential impact during this period was assessed to be **Negligible**.

11.4.4.3 Improper Handling of Hazardous Chemicals/Substances

Chemicals used during the construction phase will be stored at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation or on spill pallets. In the event of chemical spillage, spill kits will be available on site to be operated by an emergency response team competent in their use. Hence, the consequence of potential contamination (**Low** impact intensity) from chemical spillage was considered to be **Very Low** during the construction phase.

During the operational phase, the Study Area will have little use of hazardous chemicals/substances. Small scale localized contamination may happen in certain areas in an accidental spillage due to improper handling of chemicals. As such, the intensity was considered **Low** with overall consequence of **Very Low**.

With the minimum controls implemented and listed in **Table 11-11** and **Table 11-12**, the likelihood of occurrence of a chemical spill leading to soil and/or groundwater contamination was assessed to be Occasional during construction phase while the likelihood of occurrence was expected to be **Rare** during operational phase.

Therefore, the overall environmental impact of chemical spillage to soil and/or groundwater likely to occur during the construction phase was assessed to be **Minor** while the overall impact for the operational phase was assessed to be **Negligible**.

11.5 Recommended Mitigation Measures and Residual Impacts

In this section, mitigation measures are proposed to further minimise the adverse impacts on the environment where impact significance were assessed to be moderate.

The significance of the identified impacts on the sensitive receptors to soil and groundwater range from **minor to negligible** during both construction and operational phases. Thus, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the construction and operational plans are required.

However, to minimize the significant adverse impact on water in Streams 1 and 3, as well as biodiversity in the vicinity of Streams 1 and 3, the indicative alternative road plan 2 (i.e. to replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road [refer to **Figure 10-9**]) has been proposed. It should be noted that such indicative alternative road plan 2 will not further reduce the **negligible to minor** impacts on soil and groundwater during both construction and operational phases.

11.6 Summary of Key Findings

Assuming implementation of the minimum controls listed in **Table 11-11** and **Table 11-12**, the evaluation of environmental impacts on soil and groundwater is presented in **Table 11-13** below. The indicative alternative road plan 2 (i.e. to replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road [refer to **Figure 10-9**]) will not reduce the **negligible to minor** impacts on soil and groundwater any further.

Table 11-13: Evaluation of Environmental Impacts (Soil and Groundwater)

Potential Source of Impacts	Receptor	Sensitivity	Consequences	Likelihood	Significance
Construction Phase					
Decreased groundwater baseflow feeding into the streams	Stream 1	Priority 2	Low	Occasional	Minor
	Stream 2	Priority 2	Very Low	Unlikely	Negligible
	Stream 3	Priority 2	Low	Rare	Minor
Toxic Chemical Waste Generation	Soil and groundwater within the Study Area	Priority 3	Very Low	Occasional	Minor
Improper Handling of Hazardous Chemicals/Substances	Soil and groundwater within the Study Area	Priority 3	Very Low	Occasional	Minor
Operational Phase					
Decreased groundwater baseflow feeding into the streams	Stream 1	Priority 2	Low	Unlikely	Negligible
	Stream 2	Priority 2	Very Low	Unlikely	Negligible
	Stream 3	Priority 2	Low	Unlikely	Negligible
Toxic Chemical Waste Generation	Soil and groundwater within the Study Area	Priority 3	Very Low	Rare	Negligible

Potential Source of Impacts	Receptor	Sensitivity	Consequences	Likelihood	Significance
Improper Handling of Hazardous Chemicals/Substances	Soil and groundwater within the Study Area	Priority 3	Very Low	Rare	Negligible

12.0 Biodiversity

12.1 Introduction

The aims of the biodiversity study were to:

- Conduct a desktop assessment to obtain publicly available historical references and biodiversity records from the Study Area and surrounding areas;
- Identify, describe and map vegetation types present within the Study Area, particularly those that are of conservation significance;
- Compile a biodiversity inventory and generate spatial distribution maps on vegetation, habitats and species of conservation significance for the Study Area;
- Survey and document targeted terrestrial and aquatic flora and fauna, including vascular plants (ferns to flowering plants), hymenoptera, odonates (dragonflies and damselflies), butterflies, herpetofauna (amphibians and reptiles), birds, mammals, fishes and decapod crustaceans, Locations and distribution of these flora and fauna species across the Study Area were mapped.
- Indicate species of conservation significance based on the relevant authorities such as the International Union for Conservation of Nature (IUCN) Red List, Singapore Red Data Book (SRDB) (2008) and published literature;
- Verify tree species and the locations of large trees, bamboos and palms of high retention value.
- Based on the field and desktop data collected, generate an understanding of the ecological value of the Study Area;
- Predict and assess the impacts of the development works to the Study Area; and
- Propose mitigation measures to reduce the impact of the development works and the subsequent operation of the site.

All raw data collected as part of this baseline study has been included in the Addendum to this report (Addendum).

12.2 Baseline Assessment Methodology

12.2.1 Personnel

The assessment, field work and report preparation were conducted by the following personnel:

- Ms. Boo Chih Min (B.Sc. Hons.), Uvaria Tide
- Mr. Derek Yap (B.Sc. Hons.), Camphora Pte Ltd
- Mr. Sim Eng Koon (B.Sc.), Camphora Pte Ltd
- Mr. Jeb Yeo (B.Sc.), Camphora Pte Ltd
- Dr. Alex Figueroa (Ph.D.), Camphora Pte Ltd
- Ms. Joys Tan (B.Sc. Hons.), Camphora Pte Ltd
- Ms. Bronwyn Tan (MLA), Camphora Pte Ltd
- Ms. Chloe Tan (B.Sc. Hons.), Camphora Pte Ltd
- Ms. Joan Lee (B.Sc. Hons.), Camphora Pte Ltd
- Ms. Sheryl Seet (B.Sc. Hons.), Camphora Pte Ltd
- Mr. Dennis Tan (intern), Camphora Pte Ltd
- Ms. Twang Fangqi (B.Sc. Hons.), Camphora Pte Ltd
- Ms. Thio Hui Bing (B. Eng. (Civil) Hons), Camphora Pte Ltd
- Ms. Sherry Hung Ming Xuan (B.Sc. Hons.), Camphora Pte Ltd

- Mr. Gan Cheong-Weei (Butterfly Specialist)
- Mr. John Lee (Hymenoptera Specialist)
- Mr. Movin Nyanasengeran (Freshwater Invertebrate Specialist)
- Mr. Lim Kim Seng (Bird Specialist)

12.2.2 Desktop Assessment

The fauna desktop assessment involved a literature review to gather historical information on the Study Area and generate a list of fauna species that may potentially exist in the Study Area. The project location and historical land use information are discussed in **Sections 3.2** and **Section 5.1**. The list of species of probable occurrence takes into account species previously documented at the Study Area, and in areas within a 2-km radius; which include the CCNR and Bukit Brown Woods. The species list also considers species suspected to occur at the Study Area based on available habitats. The species list was generated using a fauna database (odonates, butterflies, decapod crustaceans, fish, herpetofauna, birds, and mammals) created by Camphora Pte Ltd that includes all extant species from the respective fauna groups in Singapore, their local and global conservation statuses, population status, origin, habitat preferences, and local distribution. The fauna database was constructed through a series of reviews of scientific publications, technical reports, online databases, as well as consultations with taxonomic specialists. No species list was generated for hymenopterans as the information on the faunal group is limited.

The flora desktop assessment involved conducting a literature review to gather historical land use in the Study Area, which correlates to the past and present vegetation types. Its connectivity to the CCNR and Bukit Brown Woods was considered as these act as a seed source for some of the plant species that are found on site. After the field work was completed, the native status of plant species recorded was referenced to complete the flora inventory of the Study Area.

The key references of information are:

A. Published Literature:

- Ascher JS, Soh ZWW, Ho BM, Lee RYY, Leong AQEL, Chui SX, Lai JJL, Lee JXQ, Foo MS & Soh EJY (2019) Bees of the Bukit Timah Nature Reserve and vicinity. Gardens' Bulletin Singapore, 71(Supplement 1): 245–271.
- Ascher JS, Risch S, Soh ZWW, Lee JXQ & Soh EJY (2016) Megachile leaf-cutter and resin bees of Singapore (Hymenoptera: Apoidea: Megachilidae). Raffles Bulletin of Zoology, 32: 33–55.
- Baker N & Lim KKP (2012) Wild Animals of Singapore: A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes. Draco Pub and Distribution, Singapore, 180 pp.
- Chong KY, Tan HTW & Corlett RT (2009) A Checklist of the Total Vascular Plant Flora of Singapore: Native, Naturalised and Cultivated Species. Raffles Museum of Biodiversity Research, National University of Singapore, 273 pp.
- Davison GWH, Ng PKL & Ho HC (eds.) (2008) The Singapore Red Data Book: Threatened Plants and Animals of Singapore. Second Edition. Nature Society (Singapore), Singapore, 285 pp.
- Ho JK, Ramchunder SJ, Memory A, Theng M, Li T, Clews E, Cai Y, Tan HH, & Yeo DC (2016) A Guide to the Freshwater Fauna of Nee Soon Swamp Forest. Lee Kong Chian Natural History Museum & Tropical Marine Science Institute, National University of Singapore, 147 pp.
- Keng H (2003) Orders and Families of Malayan Seed Plants. Singapore University Press, National University of Singapore, 442 pp.
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- Kottelat, M (2013) The fishes of the inland waters of Southeast Asia: a catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. Raffles Bulletin of Zoology, Supplement 27: 1–663.

- Liow LH, Sodhi NS & Elmqvist T (2001) Bee diversity along a disturbance gradient in tropical lowland forests of south-east Asia. Journal of Applied Ecology, 38(1): 180–192.Ng PK, Corlett RT & Tan HT (eds.) (2011) Singapore Biodiversity: An Encyclopedia of the Natural Environment and Sustainable Development. Editions Didier Millet Pte Ltd, Singapore, 552 pp.
- Soh M, M Ng & Ngiam RWJ (2019) New Singapore record of a dragonfly, *Indothemis carnatica*, with an updated Singapore Odonata checklist. Singapore Biodiversity Records, 2019: 10-17.
- Soh ZWW & Ngiam RWJ (2013) Flower-visiting bees and wasps in Singapore parks (Insecta: Hymenoptera). Nature in Singapore, 6: 153–172.Yong DL, Lim KC & Lee TK (2017) A Naturalist's Guide to the Birds of Singapore. Third Edition. John Beaufoy Publishing, Oxford, 176 pp.

B. Unpublished Literature:
- Boo CM (1996) A Study of Secondary Forest in Singapore. Unpublished Honours Thesis. National University of Singapore, 97 pp.

C. Online databases:
- Digital Nature Archive of Singapore (Lee Kong Chian Natural History Museum) http://lkcnhm.nus.edu.sg/dna/)Digital Nature Archive of Singapore (Lee Kong Chian Natural History Museum) http://lkcnhm.nus.edu.sg/dna/)
- Information on land use history is primarily retrieved from old maps archived in The National Archives of Singapore (NAS) online collection (http://www.nas.gov.sg/archivesonline/) and the Historical Map portals in OneMap (http://hm.onemap.sg/ and https://ohm.onemap.sg/#/index/main).
- National Parks Board's Flora and Fauna Web (https://florafaunaweb.nparks.gov.sg)
- The Biodiversity of Singapore (Hosted by the Lee Kong Chian Natural History Museum; http://singapore.biodiversity.online/)

12.2.3 Native Status

The native status for flora and fauna were categorised as native, non-native or cryptogenic. In addition, non-native flora species were further classified into casual, naturalised, and cultivated species as shown in table below.

Table 12-1: List and Definitions of Native Status Terms for Flora and Fauna Used in this Report

Status	Definition
Native	Naturally occurring species maintaining self-sustaining populations
Non-native	Species existing outside of its natural range
Invasive	Non-native species that bears negative impacts in new environment
Cryptogenic	Species with unknown origin
Non-native Species Categories for flora (adapted from Chong et al., 2009)	
Casual	Non-native species that do not maintain self-sustaining populations
Naturalised	Non-native species that maintain self-sustaining populations
Cultivated	Species not naturally found in the wild that is produced and maintained by horticultural techniques

12.2.4 Nomenclature and Taxonomy

Nomenclature and taxonomy in this report reflect the following databases:

- Flora – http://florafaunaweb.nparks.gov.sg; http://singapore.biodiversity.online/
- Hymenopterans - http://catalogueoflife.org/col/details/database/id/118; http://www.discoverlife.org/
- Odonates – https://www.pugetsound.edu/academics/academic-resources/slater-museum/biodiversity-resources/dragonflies/world-odonata-list2/
- Lepidopterans – http://www.nhm.ac.uk/our-science/data/butmoth/search/

- Prawns – http://www.marinespecies.org/index.php
- Crabs – https://www.crabdatabase.info/en
- Fishes – http://www.fishbase.org/search.php
- Amphibians – http://research.amnh.org/vz/herpetology/amphibia/Amphibia
- Reptiles – http://reptile-database.reptarium.cz/advanced_search
- Birds – https://avibase.bsc-eoc.org/avibase.jsp?lang=EN
- Mammals – https://www.departments.bucknell.edu/biology/resources/msw3/

12.2.5 Species of Conservation Significance

The local conservation status for both flora and fauna follow the Singapore Red Data Book (SRDB) (Davison et al., 2008) or other published papers with information on the updated assessment of the species nomenclature and/or conservation status. The global conservation status for fauna follow the International Union for Conservation of Nature (ICUN) and Natural Resources Red List (IUCN, 2012) (refer to Table 12-2). Threatened species listed as nationally and/or globally Vulnerable, Endangered, Critically Endangered, or Presumed Extinct were considered species of conservation significance in this study (i.e., species listed as Near Threatened are excluded). Fauna species of conservation significance are often rare, elusive, and/or display seasonality in activity trends, thus making it challenging to detect. Therefore, it is important to account for species of conservation significance occurring at the Study Area in the Impact Assessment.

Few resources with the local conservation status of species from the order Hymenoptera are available presently. A comprehensive paper on the conservation status of bees found in Singapore by Ascher et al. is in the works. Apart from this, only a few bee species are listed in the Singapore Red Data Book (Davison et al., 2008). Here, this study references Ascher et al. (in preparation) in defining the conservation status categories for bees and wasps found in Singapore.

Table 12-2: List of Local and Global Conservation Statuses Used to Regard a Species as Conservation Significance. Additional Adapted Statuses for Hymenoptera are in Parentheses

Conservation Status	Definition
Local – Singapore Red Data Book	
Vulnerable (VU)	Species with <1,000 mature individuals and >250 total individuals. (Species recently encountered from two to five sites, largely comprising of natural, declining habitats.)
Endangered (EN)	Species with <250 mature individuals. (Species encountered since 2014 from a single site.)
Critically Endangered (CR)	Species with <50 mature individuals or <250 total individuals. (Recorded from 1969 to 1979, none thereafter)
Presumed Nationally Extinct (NE)	Flora and fauna not recorded within the last 30 and 50 years, respectively. (Unrecorded since 1970.)
Globally Extinct (EX)	Globally extinct, including in captivity or through cultivation.
Global – ICUN Red List	
Vulnerable (VU)	Species facing a high risk of extinction in the wild.
Endangered (EN)	Species facing a very high risk of extinction in the wild.
Critically Endangered (CR)	Species facing an extremely high risk of extinction in the wild.
Extinct in the Wild (NW)	Species that only survives through cultivation, captivity or as a naturalized population(s) outside its natural range.
Extinct (EX)	Globally extinct, including in captivity or through cultivation.

12.2.6 Flora Field Assessment

The flora field assessment comprised of (1) floristic surveys, (2) arboricultural assessment and mapping, (3) vegetation mapping, and (4) vegetation plots.

12.2.6.1 Floristic Surveys

All plants observed in the Study Area, wherever accessible, during floristic surveys were identified to species whenever possible. A checklist of all the plant species recorded from the present floristic surveys was compiled. The nomenclature and national conservation status follow that of Chong et al (2009), or other published papers with information on the updated assessment of the species nomenclature and/or conservation status. The latter is usually for one or a few individual species. Other information on the plant species was also crosschecked with online databases, namely, the National Parks Board Flora and Fauna Web and The Biodiversity of Singapore (refer to **sub-sections 12.2.2** and **12.2.4**).The inaccessible areas included the WRC, part of LTA's construction work site and Black and White bungalows along Mount Pleasant Road.

For plants that could not be immediately identified with certainty in the field, photographs using a camera with 30× optical zoom and/or voucher specimens were taken. They were then identified using identification keys, taxonomic descriptions, online plant photo databases, with the help of taxonomic experts, and/or by matching the pressed and dried collected specimens with existing specimens in the Singapore Botanic Gardens' Herbarium (SING).

For very tall unidentifiable trees with leaves that were too high in the canopy to photograph, dried leaves matching the live ones were collected from the forest floor and used to aid in species identification.

12.2.6.1.1 Species of Conservation Significance

The geographic coordinates of plants of conservation significance—i.e., listed in Chong et al. (2009) as nationally Vulnerable, Endangered, Critically Endangered or Presumed Extinct (which indicates a rediscovery)—were marked using a Global Positioning System (GPS) handheld receiver (Garmin GPSMap® 64s), which recorded locations with accuracy of ± 4 m. Where there were clusters of plants of conservation significance—i.e., more than one individual occurring within 5 m or less of another individual—the geographic coordinates of the approximated centre of the area were marked using the GPS handheld receiver.

12.2.6.1.2 Large Specimens

The GPS handheld receiver (Garmin GPSMap® 64s) was used to record locations of all trees of ≥ 3 m girth and are not storm-vulnerable species, as well as palm clusters, bamboo clusters, and strangling *Ficus* species of ≥ 3 m spread. Storm-vulnerable tree species whose individual large tree locations were not recorded is *Falataria moluccana*. Girth (for trees) and spread (for palm clusters, bamboo clusters, and strangling *Ficus* species) were measured and estimated, respectively. The height of the specimens was also estimated and recorded. Specifically, for tembusu (*Cyrtophyllum fragrans*), which is a native, slow-growing species, healthy trees of ⩾ 2.5 m girth were also noted as large

Vegetation Types in Singapore

A map of the Study Area's vegetation types was created by mapping the vegetation type boundaries collected with the handheld GPS onto satellite images from Google Maps v.9.61.1 (Google Inc., 2019). Terrestrial vegetation types in Singapore are divided into the following categories (refer to Table 12-3):

1) Primary vegetation: vegetation that has never been cleared or removed and has occupied the site continuously for thousands of years;
2) Secondary vegetation: vegetation that succeeds on a site where clearance or removal has been made by nature or mankind (Corlett, 1995). Based on the classification of Yee et al (2016), secondary vegetation in Singapore is split into the following three categories: 1) native-dominated forests; 2) abandoned-land forests, and; 3) waste-woodlands;
3) Coastal vegetation: vegetation found growing at the edge of the sea, and;
4) Managed vegetation: comprises roadside plantings, public parks, gardens, golf courses and farms.

Table 12-3: Classification of Vegetation Types Encountered in Singapore (adapted from Yee et al, 2016, Yee et al, 2019)

	Major Vegetation Types	Description	Dominant Species
Primary Forest	Primary lowland dipterocarp forest	Lowland forest dominated by dipterocarp trees that has never been cleared.	*Dipterocarpus grandifolius, Shorea leprosula, Shorea macroptera, Shorea ovalis, Shorea parvifolia*
	Primary hill dipterocarp forest	Hill forest dominated by dipterocarp trees that has never been cleared.	*Dipterocarpus caudatus* ssp. *penangianus, Shorea curtisii*
	Primary freshwater swamp forest	Forest semi-permanently inundated by freshwater that has never been cleared.	*Palaquium xanthochymum, Salacca conferta, Xylopia fusca*
Secondary Forest (Native-Dominated)	Native-dominated tall secondary forest	Developed on land cleared before the 1950s. Developed from early successional forest and contains higher species richness.	*Adinandra dumosa, Archidendron clypearia, Calophyllum* spp., *Cyathocalyx* spp., *Elaeocarpus* spp., *Garcinia parvifolia, Lindera lucida, Litsea* spp., *Macaranga* spp., *Porterandia anisophylla, Rhodamnia cinerea, Timonius wallichianus, Xylopia* spp.
	Native-dominated low secondary forest	Developed on land cleared before the 1950s. Dominated by native pioneer trees.	*Adinandra dumosa, Arthrophyllum diversifolium, Cyrtophyllum fragrans, Dicranopteris linearis, Dillenia suffruticosa, Eriachne pallescens, Ficus grossularioides Gahnia tristis, Lycopodiella cernua, Macaranga heynei, Melastoma malabathricum, Morella esculenta, Nepenthes* spp., *Ploiarium alternifolium, Rhodamnia cinerea, Rhodomyrtus tomentosa, Syzygium lineatum, Syzygium zeylanicum, Vitex pinnata*
Secondary Forest (Exotic-Dominated)	Abandoned-land forests	Developed from abandoned plantations or kampong with mature trees largely left intact. Dominated by exotic plant species.	<u>Abandoned plantation</u> Dominated by rubber (*Hevea brasiliensis*). <u>Abandoned kampong or orchard</u> Dominated by fruit trees (*Artocarpus* spp., *Durio zibethinus, Lansium domesticum, Musa* spp., *Nephelium lappaceum)* or ornamentals and crops (*Aglaonema commutatum*, *Dieffenbachia seguine*, *Elaeis guineensis, Heliconia* spp., *Hevea brasiliensis, Spathodea campanulata,* and *Theobroma cocao*.
	Waste-woodlands	Developed on land cleared after the 1960s. Dominated by exotic plant species with high propagule pressure in surrounding landscape.	*Acacia auriculiformis, Falcataria moluccana, Leucaena leucocephala, Spathodea campanulata*
Shrubland	Scrubland vegetation	Land dominated by shrubs and short trees.	*Dillenia suffruticosa, Lantana camara, Melastoma malabathricum, Trema* spp., sometimes with scattered trees of *Acacia auriculiformis, Falcataria moluccana, Leucaena leucocephala*

	Major Vegetation Types	Description	Dominant Species
	Herbaceous vegetation	Land covered by non-woody vegetation.	*Imperata cylindrica, Panicum maximum, Urochloa mutica,* sometimes with scattered trees of *Acacia auriculiformis, Falcataria moluccana, Leucaena leucocephala, Mimosa pigra*
Coastal vegetation	Mangrove forest	Forest growing on anaerobic soils along coastal intertidal zones.	*Avicennia* spp., *Bruguiera* spp., *Rhizophora* spp., *Sonneratia* spp., *Xylocarpus* spp.
	Back mangrove forest	Mangrove forest situated far from the coast.	*Bruguiera* spp., *Ceriops* spp., *Heritiera littorale, Xylocarpus* spp.
	Sandy beach vegetation	Vegetation growing along sandy coastlines.	*Barringtonia asiatica, Casuarina equisetifolia, Cerbera odollam, Ipomoea pes-caprae, Peltophorum pterocarpum, Scaevola taccada, Terminalia catappa, Taliparitiliaceum*
Managed Vegetation	Managed vegetation	Vegetation that is maintained by humans such as parks, gardens, and roadsides.	Exotic and commercially available native species.

12.2.6.2 Plot Sampling

Six 20 × 20 m vegetation plots were set up and surveyed in the Study Area (refer to **Figure 12-1**). Plots were set up within each identified vegetation type, excluding herbaceous vegetation and scrublands, and distributed evenly across the forested areas as much as possible. The actual plot locations were adjusted on-site based on an estimated minimum stem count of 100. A minimum distance of 30 m from the forest edge was kept to avoid edge effect. Surveyors identified to species and measured the stem diameter at breast height (DBH) of all individuals of ≥ 0.05 m girth and/or ≥-1 m height. All other plant species observed in the plots were also recorded.

Legend

- Study Area
- Construction, no vegetation
- Flora Sampling Plot Location
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

N

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Figure Title :

LOCATIONS OF FLORA SAMPLING PLOTS AND VEGETATION TYPES

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12.2.6.3 Tree Mapping and Arboriculture Assessment

Large trees and palms serve as the cornerstone of forest ecosystems. Large, old trees are indicative of late successional forest and achieve a number of ecological functions, such as influencing microclimatic and hydrological regimes, storing large volumes of carbon, as well as, creating numerous environmental niches for a large suite of flora and fauna (Willson, 1974; Parker, 1995; Laurance & Bierregaard, 1997). In addition, native tree species have the potential to accelerate biodiversity recovery and enhance natural regeneration, creating a self-sustaining forest ecosystem (Tucker & Murphy, 1997).

Within the Study Area, all trees and palms with girth ≥ 1.0 m and all trees of conservation significance, from Vulnerable status and above, with girth ≥ 0.3 m were tagged using laminated cards and nails or laminated cards tied with raffia string, with the exception of trees along Mount Pleasant Road.

All trees were assessed using the Safe Useful Life Expectancy (SULE) method. The SULE method measures the tree's health and structure by determining the tree's age and observing for signs of damage, decay and asymmetry in canopy structure that may compromise longevity and stability (Barrell, 1993). In addition, the following parameters were recorded for each tree – species, biodata (girth and height), location, photos, and significant ecological function (if any). From the data, specimens of significance were extracted and their distribution presented in a map. The arboriculture assessment is submitted with the EIS Report.

12.2.7 Flora Data Analysis

12.2.7.1 Flora Species List and Vegetation Mapping

Analysis of vegetation types was carried out by verifying the vegetation types identified in the desktop vegetation assessment during site reconnaissance and ground-truthing. The vegetation classification was based on the inland vegetation listed in Table 12-3. A checklist of all recorded plant species was compiled along with the location coordinates of flora species and large trees of conservation significance. The data was used to produce spatial distribution maps of vegetation, habitat and rare species for the Study Area.

12.2.7.2 Forest Regeneration Analysis

The trees were broadly categorised into two main girth-size classes: ≥ 0.5 m and < 0.5 m. They were first ranked by abundance and examined to see which species made up the larger and smaller trees, respectively. The ten most abundant species present in the vegetation plots were then ranked according to their size-class distribution and examined.

12.2.8 Fauna Field Assessment

Field surveys consisted of visual encounter surveys (VES) along terrestrial and aquatic line transects, trapping and netting for selected fauna groups, and terrestrial camera trapping. This is an advantageous survey method because it provides data on presence, abundance, and distribution. VES were performed for three terrestrial and three aquatic transects. For species that are difficult to be observed visually, particularly bats and the aquatic fauna, sampling via trapping and netting were used. This is also more effective for surveying uncommon and/or cryptic species. All incidental observations were documented.

The terrestrial transects amounted to about 3.72-km and traversed all major habitat types within the area to capture variation in habitats and habitat use by animals, and to allow for detecting a greater diversity of species. The transects are described in Table 12-4. Similarly, the aquatic transects amounted to about 0.97-km of both streams in the Study Area. Along each transect, sampling points were placed at intervals of 100 m. Fauna encountered during the surveys were recorded to the nearest sampling point. In total, there were 33 terrestrial sampling points and 12 freshwater sampling points. Alignment of the aquatic transects and sampling locations are shown in **Figure 12-2**. The eastern side of the Study Area which included LTA's Mount Pleasant MRT Station construction area and WRC were deemed highly disturbed and unsuitable for fauna surveys.

Within the Study Area near the proposed road, part of the terrestrial transect (T3) was completed outside of the given Study Area boundary as the habitat faced high light and noise disturbances from the vehicles on the PIE and it was more conducive to conduct the survey further away. It was assessed that the vegetation type was similar to that of the Study Area. The aquatic transect (S3) near the proposed slip road, extends about 50 m beyond the given Study Area or approximately 100 m beyond the PIE edge;

upstream. This was because the stream flows perpendicular to the majority of the survey area and is a sensitive habitat. Therefore, the survey transect was extended. This allowed for two sampling points along the freshwater transect, which were 100 m apart, following the standardised method for the rest of the site. The surveyed stream immediately transitions to a concrete culvert that flows underneath the PIE and was therefore not a natural waterway and not surveyed.

Legend

- Study Area
- Construction, no vegetation

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Terrestrial Transect 1 (1.62km)
- Terrestrial Transect 2 (1.13km)
- Terrestrial Transect 3 (0.97km)
- Stream Transect 1 (0.74km)
- Stream Transect 2, concrete (0.03km)
- Stream Transect 2, naturalised (0.08km)
- Freshwater Transect 3 (0.12km)
- Stream 3 (unsurveyed)

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ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

TERRESTRIAL AND STREAM TRANSECTS AND CORRESPONDING SAMPLING POINTS FOR FAUNA SURVEYS IN THE STUDY AREA

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BT	DY	JAG	12-2	-	1 of 1
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Table 12-4: Description and Length of Terrestrial and Aquatic Transects for Conducting Fauna Surveys

Transect Type	Transect Reference (Sampling Points)	Length of Transect (km)	Description
Terrestrial	T1 (T1_01 – T1_15)	1.62	North-central section of site covering Mount Pleasant Road, waste woodlands, abandoned-land forest and herbaceous and scrubland vegetation
Terrestrial	T2 (T2_01 – T2_10)	1.13	Western section of site covering Mount Pleasant Road, managed vegetation including that of the cemetery, abandoned-land forest and waste woodlands
Terrestrial	T3 (T3_01 – T3_08)	0.97	Across entire Proposed Slip Road Area, covering waste woodlands, native-dominated low secondary forest, abandoned-land forest and herbaceous and scrubland vegetation
Aquatic	S1 (S1_01 – S1_08)	0.74	Northcentral section of site running through scrubland
Aquatic	S2 (S2_01)	0.08	Naturalised drain in southwestern section of site
Aquatic	S2 (S2_02)	0.03	Concrete drain in southwestern section of site, approximately 1.5m deep
Aquatic	S3 (S3_01 – S3_02)	0.12	Naturalised drain perpendicular to PIE, ending in a culvert under PIE

The following targeted fauna groups were assessed from February 2019 to January 2020 (Refer to **Table 6-3**) hymenopterans, odonates (dragonflies and damselflies), butterflies, freshwater decapod crustaceans and fish, herpetofauna (amphibians and reptiles), birds, and mammals. The surveying methods for each targeted fauna group is discussed below with a summary provided in Table 12-5.

Table 12-5: Summary of the Survey Method, Timing and Frequency for Each Targeted Fauna Group

Fauna group	Survey timing (h)	Description
Hymenoptera	0900 – 1600	VES along terrestrial transects with hand-netting. Two surveys per transect.
Odonates	0900 – 1600	VES along aquatic transects. Two surveys per transect.
Butterflies	0900 – 1600	VES along terrestrial transects with hand-netting. Two surveys per transect.
Freshwater decapod crustaceans and fish	0900 – 1600, 2000 – 0000	VES + tray-netting and baited minnow traps along stream transects. Two diurnal and two nocturnal surveys per transect.
Herpetofauna	0700 – 1600, 2000 – 0000	VES + amphibian call recognition along terrestrial and aquatic transects. Two diurnal and two nocturnal surveys per transect.
Birds	0700 – 1000, 2000 – 0000	VES + call recognition along terrestrial transects. Two diurnal and two nocturnal surveys per transect.
Non-volant Mammals	0700 – 1000, 2000 – 0000	VES + call recognition along terrestrial transects. Two diurnal and two nocturnal surveys per transect.
Bats	2000 – 0000, 2000 – 0900 (overnight for harp traps only)	Live-trapping using three ground mist nests and three ground harp traps + acoustic recording. Two sessions of live trapping. Visual roost emergence was conducted for identified bamboo clusters within the survey areas covered in September 2020.

12.2.8.1 Hymenopterans (Bees and Wasps)

Hymenopteran surveys consisted of searching for adult bees and wasps, nests and host plants along the terrestrial survey route. Bees and wasps were identified by way of sight or photography whenever possible. When not so, bees and wasps were collected using handheld insect nets. Individuals that could

be identified in the field were released immediately after identification, and when identification in the field was not possible, specimens were taken and later examined under a microscope. Attempts to identify them to species level or the lowest taxonomic level possible were made using relevant references or keys if available, or through consultation with experts in the relevant groups.

12.2.8.2 Odonates (Dragonflies and Damselflies)

Odonates have a bipartite life cycle consisting of an aquatic larval stage and a terrestrial adult stage associated with freshwater ecosystems. Therefore, odonate surveys concentrated on searching for adults along aquatic transect (freshwater streams) between 0900-h and 1600-h, on days with fair weather when odonates are most active. Due to the difficulties in sampling and identification, aquatic larvae and exuviae were not surveyed. Binoculars and photography were used to assist in identifying species.

12.2.8.3 Butterflies

Butterfly surveys consisted of searching for adult butterflies, caterpillars, pupae, eggs, and host plants along the terrestrial transects between 0900-h and 1600-h, on days with fair weather when butterflies are most active. Binoculars and photography were used to assist in the identification of species. Butterflies were identified by way of sight, binoculars, photography, or by collecting them with insect nets. Individuals that are collected were released immediately after identification.

12.2.8.4 Freshwater Decapod Crustaceans and Fish

Surveys for freshwater decapod crustaceans and fishes included both diurnal (0900 – 1600-h) and nocturnal (2000 – 0000-h) visual surveys along aquatic transects, tray netting, and minnow trapping. Tray netting was performed by using a rigid-frame push net (61- x 49 cm; 5 mm mesh) to capture any species within the water column or along the stream's bottom. Minnow traps were baited with halal meat (e.g., sausage) and deployed at systematic locations with deeper water (refer to **Figure 12-3**). The traps were left overnight and then checked and removed the following morning. Nocturnal transects consisted of using torches to spot-light for nocturnal species, especially Walking Catfishes (*Clarias* spp.).

12.2.8.5 Herpetofauna (Reptiles and Amphibians)

Herpetofauna surveys consisted of diurnal surveys (0700–1600-h) and nocturnal surveys (2000–0000-h) along the terrestrial and aquatic transects (freshwater streams). The search for amphibians concentrated on aquatic habitats. Surveys involved searching for individuals on the ground, under rocks, logs, leaf litter and debris, in the water, and on vegetation. For nocturnal surveys, flashlights were used for spot-lighting individuals and for revealing eyeshine. Some species are capable of quick retreats and escapes; thus, some individuals required capture by way of hand, hooks, tongs, or dip nets for identification, and binoculars were used to identify individuals perched high on vegetation. Sound-producing geckos and frogs were located or identified by call recognition.

12.2.8.6 Birds

Bird surveys consisted of diurnal surveys (0700–1000-h), as well as nocturnal surveys (2000–0000-h) along terrestrial transects. All birds were identified by way of sight, binoculars, photography, and call recognition. Nocturnal birds (i.e., owls and nightjars) were detected by illumination with flashlight, eyeshine and call recognition.

12.2.8.7 Non-volant Mammals

Mammal surveys consisted of diurnal surveys (0700–1000-h), as well as nocturnal surveys (2000–0000-h) along terrestrial transects. Since the majority of mammalian species in Singapore are nocturnal, efforts concentrated on nocturnal surveys. Mammals were searched for on the ground and on vegetation, and in burrows and tree holes. In addition, tracks and scats were scanned for, which can be used to identify some species or genera. All mammals were identified by way of sight, binoculars, photography and call recognition. Nocturnal mammals were detected by illumination with flashlight and eyeshine, and afterwards, were observed and identified with flashlights fitted with red filters to reduce disturbance to their behaviour. In addition to visual surveys, camera trapping was conducted to complement the documentation of mammal composition with the site.

Legend

- Study Area
- Construction, no vegetation
- Stream 3 (unsurveyed)
- Fish Trap Locations

Fauna Transects

- Stream Transect 1 (0.74km)
- Stream Transect 2, concrete (0.03km)
- Stream Transect 2, naturalised (0.08km)
- Freshwater Transect 3 (0.12km)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

N

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Figure Title :

LOCATION OF FISH TRAPS SET IN STREAM 1 (15 NOS.), STREAM 2 (8NOS.) AND STREAM 3 (4 NOS.)

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12.2.8.8 Volant Mammals: Bats

Due to the difficulty in finding roost sites and the inability to visually identify bats to the species-level when they are flying at night, bats are sampled and discussed separately from all other mammals. Besides nocturnal surveys (2000-0000-h) along terrestrial transects, additional sampling involved performing live-trapping and acoustic sampling. Live-trapping consisted of mist netting and harp trapping in the Study Area, a mist net was also set up in the tree canopy to capture bats which fly higher; at height 3 to 5 m. Mist netting targeted the larger-sized fruit/nectar bats, while harp trapping targeted the smaller insectivorous bats (refer to **Figure 12-4**). Each trapping session consisted of three mist nets and three harp traps set in different locations (refer to **Figure 12-5**). Typically, each ground mist net and harp trap were placed near to one another. Trap set up was between 1730-h and 1930-h and trapping commenced from 2000-h – 0000-h, with traps being checked repeatedly throughout the night. The mist nets were disassembled by 0000-h and removed, while the harp traps were left overnight and checked the following morning between 0800- and 0900-hrs, then removed. Bats collected in the traps were identified and released immediately.

In light of the COVID-19 outbreak, bat trapping was not conducted in the August 2020 survey. Instead, a visual roost emergence survey was conducted at the bamboo cluster identified to assess the residency of bamboo bats. During the survey, three personnel were stationed around the bamboo cluster to observe for bats flying out from or towards the bamboo and identify slits that are at least 0.5-cm side and 2-cm long. Active slits and the number of individuals residing within each slit were documented where possible. The acoustic detector was also used.

The echolocation calls of bats are unique to each species and can be used to identify bats to species level (Fenton & Bell, 1981). Echolocation is only used by microchiropteran bats, and for the purposes of navigating through their environment and locating food (Schnitzler et al., 2003). Call structure varies depending on habitat type (cluttered vs. uncluttered) and foraging mode (gleaning, trawling, aerial) (Schnitzler et al., 2003). Acoustic sampling was executed by using the default settings on an Echo Meter Touch 2 Pro (Wildlife Acoustics, Inc.) attached to an iPad (Apple, Inc.) during nocturnal transects. The Echo Meter is a handheld bat detector that detects ultrasonic sounds in real-time and converts them into digital signals, using the Echo Meter Touch App on the iPad, that are audible to the human ear. The Echo Meter Touch App also displays a spectrogram of the ultrasonic sounds. When a bat call was detected, it was automatically recorded and saved as 16-bit WAV files on the iPad.

Figure 12-4: Examples of A) Mist Net and (B) Ground Harp Trap Deployed during Bat Trapping

12.2.8.9 Camera Trapping

Camera trapping is a beneficial approach for surveying wildlife because it is non-invasive (i.e., does not require capture and handling of animals), non-labour intensive (after deployment), can be used to record species richness, abundance, distribution, and provides a 24-h sampling regime, allowing for the detection of uncommon species. In addition, it documents natural history information (Rovero et al., 2010). Although appropriate for surveying a variety of taxa, camera traps are mainly used to survey mammals, particularly large mammals, given the ease of identifying them readily through or videos.

In the Study Area, a total of eight camera traps (Model: Browning Strike Force Pro, BTC-5HDP) were deployed for 30 nights (refer to **Figure 12-6**). Each camera trap was placed at a height of 20- to 80-cm from the ground and secured to a tree with a Python Master lock. The cameras were programmed to be active 24-h a day at high sensitivity, recording 10-s of video footage when triggered by movement or changes in temperature, with a 10-sec quiet period after each trigger. Camera traps were checked at the first week after deployment to ensure that they were properly functioning, and then collected at the end of the survey period. In the Study Area, one camera trap was placed per 200 m by 200 m grid whereas in the Study Area near the proposed road, the site was linear and the two cameras were placed to be spaced apart across the site. Potential animal movement corridors and presence of fruiting trees were considered in the placement of all camera traps in forested areas.

12.2.9 Fauna Data Analysis

12.2.9.1 Species Richness and Distribution

To determine species richness at each sampling point, every sighting of a targeted fauna species recorded during the surveys was tied to a sampling point. The sightings were consolidated, and the number of unique species was counted to determine species richness. In addition, distribution maps were created for using QGIS v.2.18.14 (Quantum GIS Development Team, 2017).

To determine the adequacy of sampling effort, coverage-based rarefaction and extrapolation sampling curves were generated for all taxa in RStudio Version 1.1.447 (RStudio, Inc.) using the iNEXT function available in the package “iNEXT” (Chao et al., 2016). For this analysis, sampling-units-based incidence data was used with 50 bootstrap replications, 0.95 confidence interval, endpoint of double the minimum reference sample size and 40 knots. The total number of species will be approximated using the Chao estimator in “iNEXT” package 2.0.19 (Heish et al., 2019) —by estimating the number of undetected species and adding them to the observed species richness (Palmer 1990; Colwell & Coddington, 1994).

12.2.9.2 Camera Trapping

For camera trapping, camera trap location, species identity, and abundance were recorded for each video with a positive capture (i.e., with a fauna species recorded on the video). Independent detections of individuals of the same species captured at the same camera trap was standardised to 60 min intervals. The number of independent detections were used for calculation of detection history for each species as well as modelling sampling effort and estimating species richness.

To determine the adequacy of sampling effort, coverage-based rarefaction and extrapolation sampling curves were generated for non-volant mammals using the iNEXT Online software (Chao et al., 2016). For this analysis, sampling-units-based incidence data was used with 50 bootstrap replications, 0.95 confidence interval, endpoint of double the minimum reference sample size and 40 knots. The total number of species will be approximated using the chao estimator in “iNEXT” package 2.0.19 (Heish et al., 2019) —by estimating the number of undetected species and adding them to the observed species richness (Palmer 1990; Colwell & Coddington, 1994).

12.2.9.3 Acoustic Bat Sampling

All recorded bat calls were analysed using Kaleidoscope v.4.5.4 (Wildlife Acoustics, Inc.). Only bat calls with ≥ 5 pulses were analysed. Identification of calls to species level was based on the call shape, maximum frequency, minimum peak, call duration and pulse repetition rate (Pottie et al., 2005). Once these parameters were analysed, the results were compared to Pottie et al. (2005), who provides bat echolocation signatures for Singapore.

Legend

- Study Area
- Construction, no vegetation
- Bamboo
- Stream
- Stream 3 (unsurveyed)
- Visual Roost Emergence Survey

Bat Trap Type and Location
- Canopy Mist Net
- Harp Trap
- Mist Net

Vegetation Map
- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

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Figure Title :

DEPLOYMENT LOCATIONS OF BAT TRAPS AND BAMBOO CLUSTERS

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BT	DY	JAG	12-5	-	1 of 1
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Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)
- Camera Trap Location

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	BT	Final Report	DY	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title :

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ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

LOCATIONS OF TERRESTRIAL CAMERA TRAPS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
BT	DY	JAG	12-6	-	1 of 1
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12.3 Baseline Ecological Environment

Baseline results from the field are complemented by desktop studies as described in **Section 12.2.2**. The desktop studies consider that the site, together with the Bukit Brown Woods, is in close proximity to Central Catchment Nature Reserve. The Central Catchment Nature Reserve is a core habitat of conservation significance in Singapore for both flora and fauna. The forested areas of Mount Pleasant and Bukit Brown Woods potentially provide valuable green buffers and corridors to the Central Catchment Nature Reserve. The flora and fauna recorded within the Study Area highlight the importance of Mount Pleasant as an extended habitat where plants and animals disperse and forage respectively.

12.3.1 Habitat and Vegetation Types

The overall flora field assessment revealed the presence of six major vegetation types and areas, excluding the area affected by construction of the Mount Pleasant MRT Station that is not vegetated. The Study Area was composed largely of managed vegetation (46.23%) that is found within the private compound areas of the OPA, WRC and Black and White bungalows along Mount Pleasant Road. Abandoned-land forest takes up the largest area (25.94%), mostly found within the *Kopi Sua* Cemetery and WRC. The remaining delineated vegetation types comprised managed vegetation mostly within *Kopi Sua* Cemetery (5.27%), native-dominated secondary forest (4.27%), scrubland and herbaceous vegetation (4.12%) and waste woodlands (3.54%) (**Figure 12-1**). No stream-associated vegetation was observed at streams found on site but the stream habitats are described in this section.

The vegetation in the *Kopi Sua* Cemetery is classified as managed vegetation as it was found to be maintained by a group of caretakers. As the floristic composition of the managed vegetation within the cemetery is observed to be largely different from that within the private compound areas, the two vegetation types will be defined and described separately. Namely, “managed vegetation (cemetery)” and “managed vegetation (others)” for the areas of *Kopi Sua* Cemetery and private compound areas, respectively. Scrubland and herbaceous vegetation patches are interspersed among the other vegetation types, particularly along the forest edges of Mount Pleasant Road, along the PIE and between the private compound areas.

Table 12-6: Absolute (ha) and Relative (%) Areas Occupied by Each Vegetation Type

Vegetation type	Area (ha)	Percentage (%)
Native-dominated secondary forest	3.1	4.27
Abandoned-land forest	18.6	25.94
Waste woodlands	2.5	3.54
Scrubland and herbaceous vegetation	3.0	4.12
Managed vegetation (cemetery)	3.8	5.27
Managed vegetation (others)	33.1	46.23
Construction	7.6	10.62
Total	**71.6**	**100.00**

Native-dominated Secondary Forest

A thin strip of early-successional native-dominated secondary forest is located in the area around the proposed slip road, including the forest fringe adjacent to the PIE. This forested area is the smallest compared to all other vegetation types (refer to **Table 12-6**, **Figure 12-7**).

Floristic composition of early-successional native-dominated secondary forest is usually characterised by the presence of light-demanding species, such as *Macaranga heynei* and *Macaranga gigantea* (Yee et al., 2016).

Other native tree species that form the canopy layer associated to this vegetation type includes terentang (*Campnosperma auriculata*), *Litsea elliptica*, sea apple (*Syzygium grande*) and common kelat (*Syzygium lineatum*).

Elements of waste-woodland were observed to be scattered within the native-dominated forest with some exotic trees such as earleaf acacia (*Acacia auriculiformis*), African tulip (*Spathodea campanulata*) and albizia (*Falcataria moluccana*) due to past land-use as a cemetery and disturbances to the surrounding.

Figure 12-7: Photographs Showing Canopy Dominated by *Ficus variegata* (Left) and Understorey of *Campnosperma auriculatum* Saplings (Right)

Abandoned-land Forest

Species found in such forest types are mainly fruit trees or crop plants cultivated in the past. Some of these plants may persist through time and grow into large woody trees after the plantation area is abandoned and the forest regenerates as spontaneous vegetation takes over.

The dominant edible fruit tree species dominant include rambutan (*Nephelium lappaceum*), durian (*Durio zibethinus*), mata kuching (*Dimocarpus longan* ssp. *malesianus*), and mango (*Mangifera indica*). Other crop plants are rubber (*Hevea brasiliensis*) and oil palm (*Elaeis guineensis*). Shrub species observed are teh kampong (*Acalypha siamensis*) and variegated croton (*Codiaeum variegatum*).

The native species found here include the common red-stem fig (*Ficus variegata*), tembusu (*Cyrtophyllum fragrans*), wild cinnamon (*Cinnamomum iners*), and elephant ear tree (*Macaranga gigantea*).

Figure 12-8: Site Photos Representative of Abandoned-land Forest

Waste Woodlands

Owing to the nature of the site being highly disturbed with vegetation being cleared and construction works taking place within close proximity, a large number of exotic tree species was observed to be widespread across the site. These trees are largely interspersed among all vegetation types, making it

challenging to delineate the boundaries for waste woodlands. However, in particular, there is one patch west of the Study Area that is dominated by large woody trees of exotic origin.

The dominant exotic tree species are the albizia (*Falcataria moluccana*) and African tulip (*Spathodea campanulata*). These two exotic species are fast-growing and known to be able to quickly establish themselves in disturbed vegetation. The species with a few large native trees recorded in the small patch of waste woodlands include *Litsea elliptica* and *Vitex pinnata*.

Figure 12-9: Photographs Showing the Albizia Trees (*Falcataria moluccana*) Forming a Continuous Canopy Layer (Left) and a Generic Shot of The Smaller Patch of Waste Woodlands (Right)

Scrubland and Herbaceous Vegetation

Several scrubland and herbaceous vegetation patches are interspersed among the other vegetation types, particularly along Mount Pleasant Road, the PIE, and within the private compounds.

This vegetation type is characterised by short vegetation with uniform stratum and/or open canopy. In the Study Area, scrubland and herbaceous vegetation are dominated by short shrubs and grasses such as the giant taro (*Alocasia macrorrhizos*), arrowleaf elephant ear (*Xanthosoma sagittifolium*), and tapioca (*Manihot esculenta*).

Climbing and/or creeping plants such as the lesser Malayan stinkwort (*Paederia foetida*) and arrowhead vine (*Syngonium podophyllum*) were also found to be widespread across this vegetation landscape. This vegetation type is largely distributed along Freshwater Transect 1 (refer to **Figure 12-10**) where it likely colonised an old road that ran parallel to the stream.

Figure 12-10: Site Photographs of Scrubland and Herbaceous Vegetation Dominated by the Giant Taro (*Alocasia macrorrhizos*), which Forms a Uniform Stratum with Open Canopy

Managed Vegetation (Cemetery)

The vegetation in the *Kopi Sua* Cemetery was classified as a vegetation type distinct from the one described in “managed vegetation (others)” because the area is still presently maintained and managed by a group of caretakers. Fundamentally, the floristic composition of both types of managed vegetation are largely different. Hence, they are presented in separate sub-sections in this report.

While many of the graves have been cleared of vegetation and are being maintained occasionally, some are clearly abandoned, evidenced by spontaneous vegetation growing over them. Some of the native species growing among/over these plots are kenidai (*Bridelia tomentosa*), Malayan banyan (*Ficus microcarpa*), Malayan teak (*Vitex pinnata*), and salam (*Syzygium polyanthum*).

Figure 12-11: Photographs of Vegetation within the Cemetery Compound Where Vegetation Has Been Cleared and the Area Occasionally Maintained (Right) as Well as Areas Where Spontaneous Vegetation Has Taken Over (Left)

Managed Vegetation (Others)

Managed vegetation takes up the largest area compared to other vegetation types (refer to **Table 12-6**, **Figure 12-1**). It is made up of landscape and streetscape plantings, green verges, and managed lawns. These are largely within the private compounds of the OPA, WRC, and Black and White bungalows along Mount Pleasant Road. Roadside trees and shrubs were mainly planted along Mount Pleasant Road, Onraet Road, and the PIE.

Species recorded were a mix of native and exotic ones. Native species include the yellow flame (*Peltophorum pterocarpum*), jetutong (*Dyera costulata*), tembusu *(Cyrtophyllum fragrans*), and the sealing wax palm (*Cyrtostachys renda*). These species were either cultivated in the past or are still being cultivated at present.

Figure 12-12: Photographs of Managed Vegetation Showing Managed Lawn and Roadside Trees

Streams

Three streams were found in the Study Area: Stream 1, Stream 2 and Stream 3.

Stream 1 and 2 are found on the east of Mount Pleasant Road. Stream 1 was characterised by more open scrubland vegetation; the stream itself can be considered an open country aquatic habitat according to Johnson (1973). The bed is covered with sediment and dead leaves, and the edges are overgrown with grasses and semi-aquatic plants such as *Alocasia macrorrhizos* (refer to **Figure 12-13**). On the contrary, Stream 2 was characterised by forest habitat with a closed canopy. The stream is partially naturalised at S2_01 with sediments and dead leaves in the stream bed. Both streams had been canalised previously and are at various stages of naturalisation (refer to **Figure 12-14**) with the exception of the area around S2_02, which remains a concrete canal approximately 1.5m deep.

Around the proposed slip road, Stream 3 was also previously a drain which has since naturalised (refer to **Figure 12-15**). It has a closed forest canopy and the bed is covered with sediments and dead leaves, with abandoned-land forest and waste woodlands on each side, making it conducive for fauna which are more forest dependent.

Figure 12-13: Examples of Stream 1 — Open Country Habitat with Edges Overgrown with Grasses and Semi-aquatic Plants

Figure 12-14: Examples of Stream 2 (Left: Near S2_01, Right: Near S2_02) — Remnants of Concretised Canals are Still Noticeable at Certain Parts of the Stream.

Figure 12-15: Examples of Stream 3 – Most of Stream 3 has a Forest Canopy Cover, Up to Approximately 380 m in Length, Until it Opens up to Scrubland

12.3.2 Flora Field Assessment Results

12.3.2.1 Floristic Surveys

A total of 378 species of vascular plants from 107 families were catalogued in a flora inventory provided in **Appendix A of the Addendum**.

Of these, 181 species are exotic (47.89%), 175 species are native (46.29%), 22 species are cryptogenic, i.e., of unknown origin (5.03%) and three species whose origins are indeterminate (0.79%). There are 173 species of trees, 72 species of herbs, 65 species of climbers, 52 species of shrubs, 10 species of epiphytes, and 6 species of stranglers (refer to **Table 12-7**, **Table 12-8**).

Table 12-7: Summary of Plant Habits in the Study Area

Habit	No. of Species in Study Area	Percentage of all Species (%)
Climber	65	17.19
Epiphyte	10	2.64
Herb	72	19.05
Shrub	52	13.76
Strangler	6	1.59
Tree	173	45.77
Total	378	100.00

Table 12-8: Total Plant Species Recorded in the Study Area by their Origin and National Status

Origin	National Status	No. of Species	Percentage of all Species (%)
Native Note: Bracketed numbers indicate the number of species that have a conservation status but are persistent through cultivation	Common	86	22.75
	Vulnerable	42 (7)	11.11
	Endangered	17 (3)	4.50
	Critically endangered	25 (7)	6.61
	Extinct	5 (5)	1.32
	Sub-Total	**175**	**46.29**
Exotic	Cultivated	76	20.11
	Casual	46	12.17
	Naturalised	54	14.29
	Not assessed	5	1.32
	Sub-Total	**181**	**47.89**
Cryptogenic	**Sub-Total**	**19**	**5.03**
Indeterminate	**Sub-Total**	**3**	**0.79**
Total		**378**	**100.00**

12.3.2.2 Plants of Conservation Significance

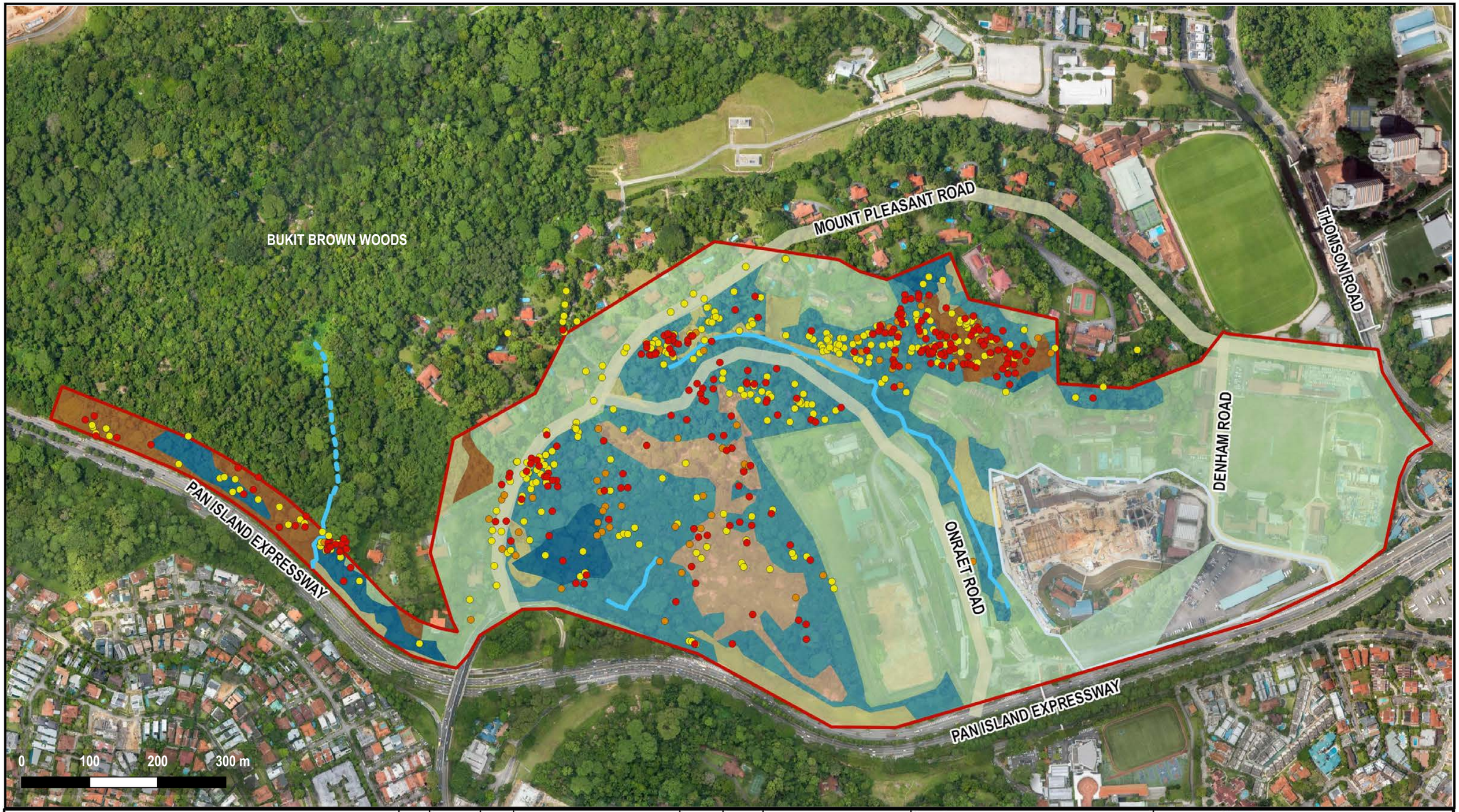
Out of all the native species recorded, 89 (50.86%) are species of conservation significance, i.e., listed in Chong et al. (2009) as nationally Vulnerable, Endangered, Critically Endangered or Extinct (which indicates a rediscovery or a plant that was likely cultivated) (refer to **Table 12-8**). The list of locally conservation significant plants are found in **Appendix B1 of the Addendum**.

The five species listed as Extinct are namely, *Cyrtostachys renda*, *Elatostema repens* var. *pulchrum*, *Salacca affinis*, *Syzygium myrtifolium*, and *Thunbergia laurifolia*.

Crytostachys renda and *Salacca affinis* were thought to be extinct in Singapore until their rediscovery in the Western Catchment by NParks, and the Nee Soon Swamp Forest (NSSF), respectively (Loo, 2011; Loo et al., 2015). Even though these species have been rediscovered, their conservation status will be revised only when an assessment has been conducted and the information officially published. Since their rediscovery, there has not been any update published with regard to their new conservation status. As the only known locality of *Cyrtostachys renda* with naturally-occurring individuals is in the Western Catchment, those present in the forest could be escapees from local cultivated stocks given that it is a commonly planted wayside plant. Similarly, in view that *Salacca affinis* occurs naturally in swamp forest but that the NSSF is a considerable distance away from the Study Area, it is likely that the presence of this species came from cultivated stocks, grown for its edible fruit. In addition, *Elatostema repens* var. *pulchrum*, *Syzygium myrtifolium*, and *Thunbergia laurifolia* are also commonly planted in Singapore, along streetscapes, and building facades, respectively, amongst others. Hence, all five species are not considered of conservation significance.

Out of the 25 species that are nationally Critically Endangered, seven are cultivated in Singapore. The remaining 18 species are those of conservation significance (**Table 12-8**). Fourteen of the 17 nationally Endangered species are of conservation significance. Of the 14, the identity of one species is unconfirmed (*Triomma* cf. *malaccensis*). Thirty-five of the 42 nationally Vulnerable species are of

conservation significance. Locations of individual specimens of these taxa are shown in **Figure 12-16** and a list of their locations is provided in **Appendix B2 of the Addendum**.



Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Location of Conservation Significant Flora Specimens

- Critically endangered
- Endangered
- Vulnerable

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

N

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-	JAN 2021	BT	Final Report	DY	JAG

Qualified Person Endorsement : NA

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Consultant : AECOM

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Project Title :

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ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

LOCATIONS OF FLORA INDIVIDUALS OF CONSERVATION SIGNIFICANCE, EXCLUDING THOSE PERSISTENT FROM CULTIVATION

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BT	DY	JAG	12-16	-	1 of 1
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12.3.2.3 Distribution of Large Specimens

A total of 225 specimens are identified as large specimens, comprising 31 species (refer to **Table 12-9**). The most common large tree was the tembusu (*Cyrtophyllum fragrans*), a native slow-growing species, with 75 large specimens. These constituted trees of girth size ⩾2.5 m.

In the Study Area, large specimens were observed to be distributed evenly across the abandoned-land forest and managed vegetation – cemetery areas. In particular, a cluster of 11 large-sized tembusu (*Cyrtophyllum fragrans*), that are good specimens for retention, was identified within the Mount Pleasant MRT Station construction area compound. Other large specimens include trees of the *Ficus* genus, which fruit all year round and provide a food source of fauna. A distribution map illustrating large specimens of significance in the Study Area is presented in **Figure 12-17**, healthy specimens were also highlighted in the same figure. The list of locations of the large specimens is provided in Appendix C in the Addendum.

Table 12-9: List of Specimens of Significance in the Study Area by their Conservation Status and the Counts of Individuals for each Species. (Species with asterisk indicate species is likely to be cultivated, also refer to Appendix B1.)

Species	Status	No. of Specimens
Gnetum gnemon var. *gnemon*	Critically endangered*	2
Nephelium lappaceum	Critically endangered*	3
Peltophorum pterocarpum	Critically endangered*	8
Sterculia cordata	Critically endangered	1
Sandoricum koetjape	Endangered*	1
Archidendron jiringa	Vulnerable*	3
Oncosperma horridum	Vulnerable	5
Oncosperma tigillaria	Vulnerable	1
Pouteria obovata	Vulnerable	4
Syzygium polyanthum	Vulnerable	1
Alstonia angustiloba	Common	1
Cyrtophyllum fragrans	Common	75
Ficus caulocarpa	Common	2
Ficus microcarpa	Common	38
Ficus variegata	Common	7
Macaranga gigantea	Common	1
Syzygium grande	Common	2
Terminalia catappa	Common	1
Vitex pinnata	Common	1
Ficus benjamina	Cryptogenic	20
Adenanthera pavonina	Exotic	1
Bambusa vulgaris	Exotic	11
Bambusa cf. *vulgaris*	Exotic	4
Callerya atropurpurea	Exotic	1
Durio zibethinus	Exotic	7
Elaeis guineensis	Exotic	1
Ficus elastica	Exotic	1
Ficus kurzii	Exotic	1
Mangifera indica	Exotic	2

Species	Status	No. of Specimens
Pterocarpus indicus	Exotic	6
Samanea saman	Exotic	8
Swietenia macrophylla	Exotic	5
Total		**225**

12.3.2.4 Arboriculture Assessment and Mapping

A total of 2,574 specimens were tagged and assessed during arboricultural surveys (refer to **Figure 12-18**). Of these, the common red-stem fig (*Ficus variegata*; *n*=308), African tulip (*Spathodea campanulata*; *n*=251), rambutan (*Nephelium lappaceum*; *n*=211), albizia (*Falcataria moluccana,* n=205) and oil palm (*Elaeis guineensis*; *n=1*88) are the five most abundant species, making up more than 45% of total specimen count. **Figure 12-19** shows specimens in good health (n=1903) and storm vulnerable species (n=467),which should be removed if the individual specimens are within or close to development areas. From the mapping, no distinct patterns could be identified. The list of locations of all surveyed trees is provided in **Appendix C of the Addendum**.

Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Large Specimens

- Critically endangered
- Endangered
- Vulnerable
- Common
- Exotic
- Cryptogenic
- Healthy Specimen

N

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Qualified Person Endorsement : NA

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Project Title :

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ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

DISTRIBUTION OF LARGE FLORA SPECIMENS AND OTHER SPECIMENS OF SIGNIFICANCE

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Figure No. :	Rev.	Sheet
12-17	-	1 of 1

CAD File Name : NA — A3

Note: Source of basemap - Google Earth Map

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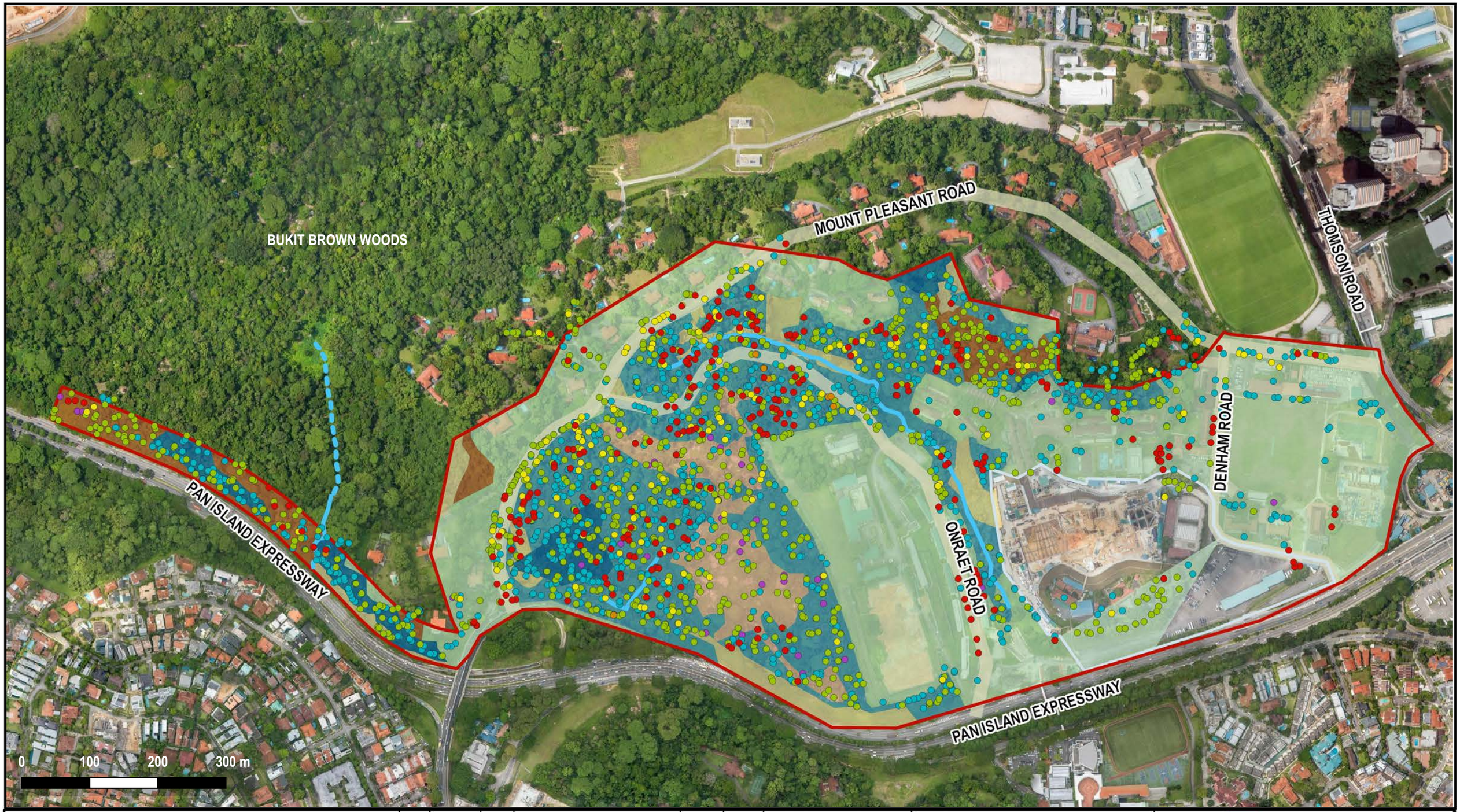

Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Location of Flora Specimen Assessed

- Critically endangered
- Endangered
- Vulnerable
- Common
- Exotic
- Cryptogenic

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	BT	Final Report	DY	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title :

CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

MAP OF TREES OF GIRTH ≥1.0 M AS WELL AS SPECIES OF CONSERVATION SIGNIFICANCE OF GIRTH ≥0.3 M

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BT	DY	JAG	12-18	-	1 of 1
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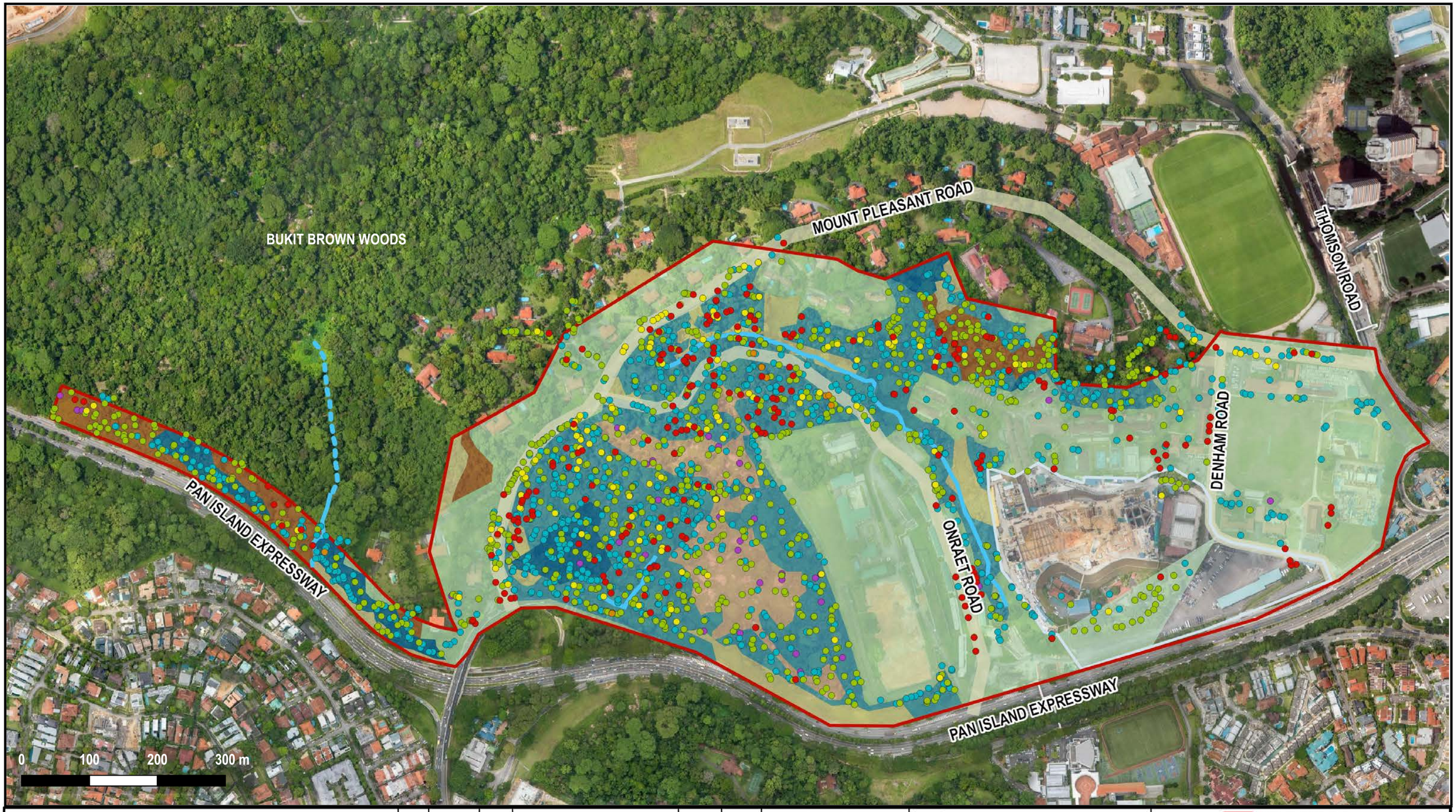

Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Location of Healthy Flora Specimen Assessed

- Critically endangered
- Endangered
- Vulnerable
- Common
- Exotic
- Cryptogenic

N

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-	JAN 2021	BT	Final Report	DY	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title :

CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

MAP OF HEALTHY TREES OF GIRTH ≥1.0 M AS WELL AS SPECIES OF CONSERVATION SIGNIFICANCE OF GIRTH ≥0.3 M

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12.3.2.5 Forest Regeneration

The ten most abundant tree and palm species found in the six vegetation plots in two broad girth-size classes—≥ 0.5 m girth and < 0.5 m girth—are listed in descending order in **Table 12-10**. The girth-size classes were further divided and the trends in girth frequency distribution are shown in **Figure 12-21** and **Figure 12-23**.

There are very few trees in the larger size class (≥ 0.5 m girth), where the maximum stem count for each species is fewer than ten. There is also a mix of native species (including light-demanding ones), fruit tree species, as well as fast-growing exotic tree species (**Table 12-10**). As such, no distinct trends can be observed nor conclusive inferences can be drawn from data gathered on the larger trees.

On the contrary, there are numerous seedings and saplings found in the lower forest strata. All ten most abundant species of < 0.5 m girth generally exhibit a typical reverse-J distribution pattern (**Figure 12-23**), indicating high recruitment of seedlings for these species. Up to 90.3% of the total stems encountered measure ≤ 0.2 m in girth. In addition, three out of the top five most abundant seedling and sapling species belong to edible fruit tree species, i.e., rambutan (*Nephelium lappaceum*), durian (*Durio zibethinus*), mata kuching (*Dimocarpus longan* ssp. *malesianus*) (**Figure 12-23**). This trend corroborates with the finding that abandoned-land forest constitutes the majority of the spontaneous vegetation/forested area (**Section 12.3.1**).

It is likely that large fruit trees are still persistent, and hence act as seed sources in the forest. Although these trees were not encountered in the vegetation plots, they were encountered in the other parts of the forest during arboricultural surveys (**Appendix C of the Addendum**).

Apart from these fruit tree species, there are also several native non-fruit tree species that make up the top ten most abundant seedlings and saplings. They are the wild cinnamon (*Cinnamomum iners*), ivy palm (*Arthrophyllum diversifolium*), rambai (*Baccaurea motleyana*), sea apple (*Syzygium grande*), common yellow-stem fig (*Ficus fistulosa*), and belinjau (*Gnetum gnenom* var. *gnemon*). (**Table 12-10**, **Figure 12-22**). Although there is a likelihood that most of these seedlings are escapees from local cultivated stocks and therefore may not be from native stock propagules, the presence of native species in the forests is still preferred to their exotic counterparts. Considering that most areas in Singapore have been developed and the remaining areas covered with spontaneous vegetation are secondary forests, forested patches in the Study Area are valuable and should be considered in conservation efforts (Yee et al., 2016).

Dysoxylum cauliflorum also constitutes one of the top ten most abundant seedlings and saplings (**Table 12-10**). This is a nationally Vulnerable tree species not known to be cultivated presently nor in the past (Chong et al., 2009). Thus, young specimens of this species present in the Study Area in relatively high concentration likely belong to the native stock. Mature trees of this species are able to attain heights of up to 30 m (National Parks Board, 2020).There is, however, only one record of a larger specimen of 0.4 m girth and 10 m height encountered at the forest edge along Mount Pleasant Road. This is tree number “TR0075” and may be found **Appendix C of the Addendum**. Large parent trees that act as seed sources not encountered in this study could be present in adjacent forest patches. For example, the proximity of the Study Area to MacRitchie Reservoir and the rest of the Central Catchment Nature Reserve provides nearby sources for the arrival of propagules. This could explain the high recruitment of seedlings in the Study Area. However, we also note that out of the six vegetation plots sampled in this study, 6 plots (33.33%) were located within the native-dominated secondary forest even though it only takes up 4.3% of the total area. As such, the total count of native stems is likely to be inflated.

The high saturation of seedlings belonging to both native and fruit tree species occupying the same forest strata indicates that there could be inter- and intra-specific competition for space, nutrients, light, and other resources. Should the native seedling species successfully outcompete the exotic seedling species when there are forest canopy openings, e.g., from natural treefall events, the forest may gradually revert to a native secondary forest over a long period of time if left undisturbed. However, if the exotic seedlings persist, seedling competition between the exotic and native species is likely to continue. Native species that are unable to outcompete their exotic counterparts would eventually be shaded out. In such scenarios, the forest would continue to be dominated by exotic species. It should be noted that these conclusions are drawn based on the assumption that the data gathered from the vegetation plots is representative of the entire site.

Table 12-10: The Top Ten Most Abundant Species Ranked in Descending Order for Trees of Girth ⩾ 0.5 m and < 0.5 m, Respectively

Trees of girth ⩾ 0.5 m (Figure 12-21)	Trees of girth < 0.5 m (Figure 12-23)
Cinnamomum iners	*Cinnamomum iners*
Macaranga gigantea	*Arthrophyllum diversifolium*
Nephelium lappaceum	*Nephelium lappaceum*
Ficus variegata	*Dimocarpus longan* ssp. *malesianus*
Arthrophyllum diversifolium	*Durio zibethinus*
Elaeis guineensis	*Baccaurea motleyana*
Spathodea campanulata	*Syzygium grande*
Durio zibethinus	*Dysoxylum cauliflorum*
Livistona rotundifolia	*Ficus fistulosa*
Vitex pinnata	*Gnetum gnemon* var. *gnemon*

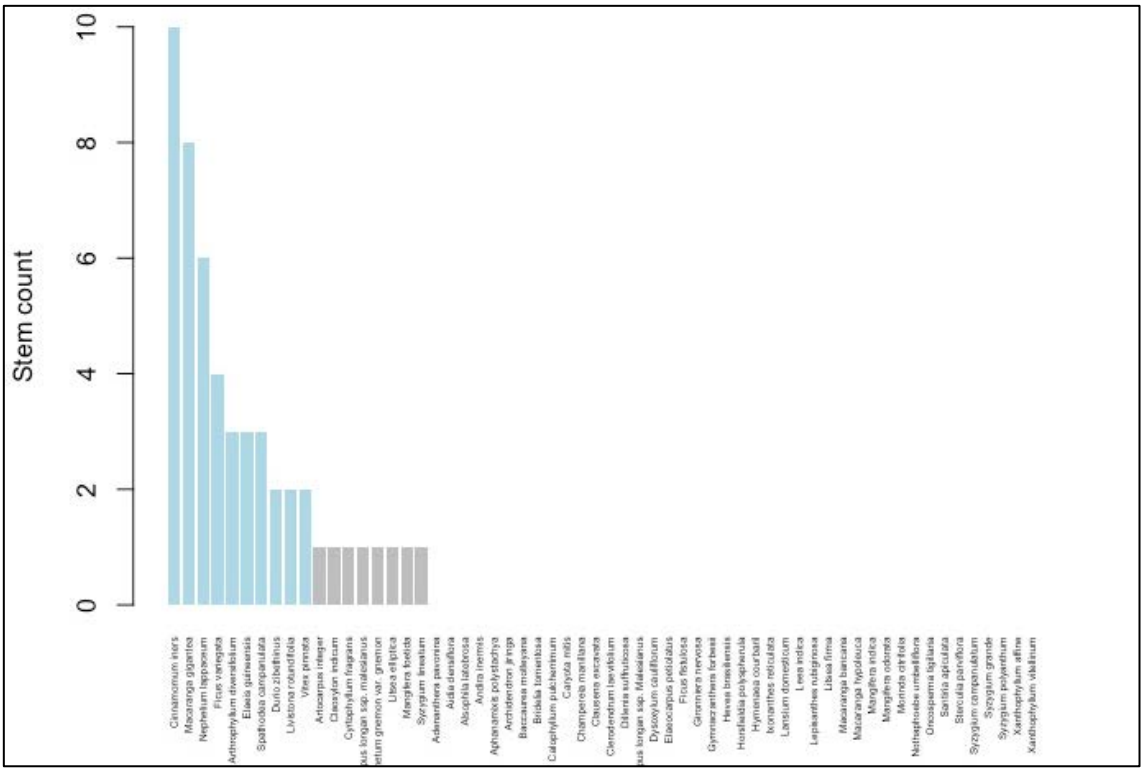

Figure 12-20: Number of Stems of ⩾ 0.5 m Girth Recorded for Each Species in All Six Vegetation Plots Ranked In Descending Order. Bars in Light Blue Belong to the Ten Most Abundant Species.

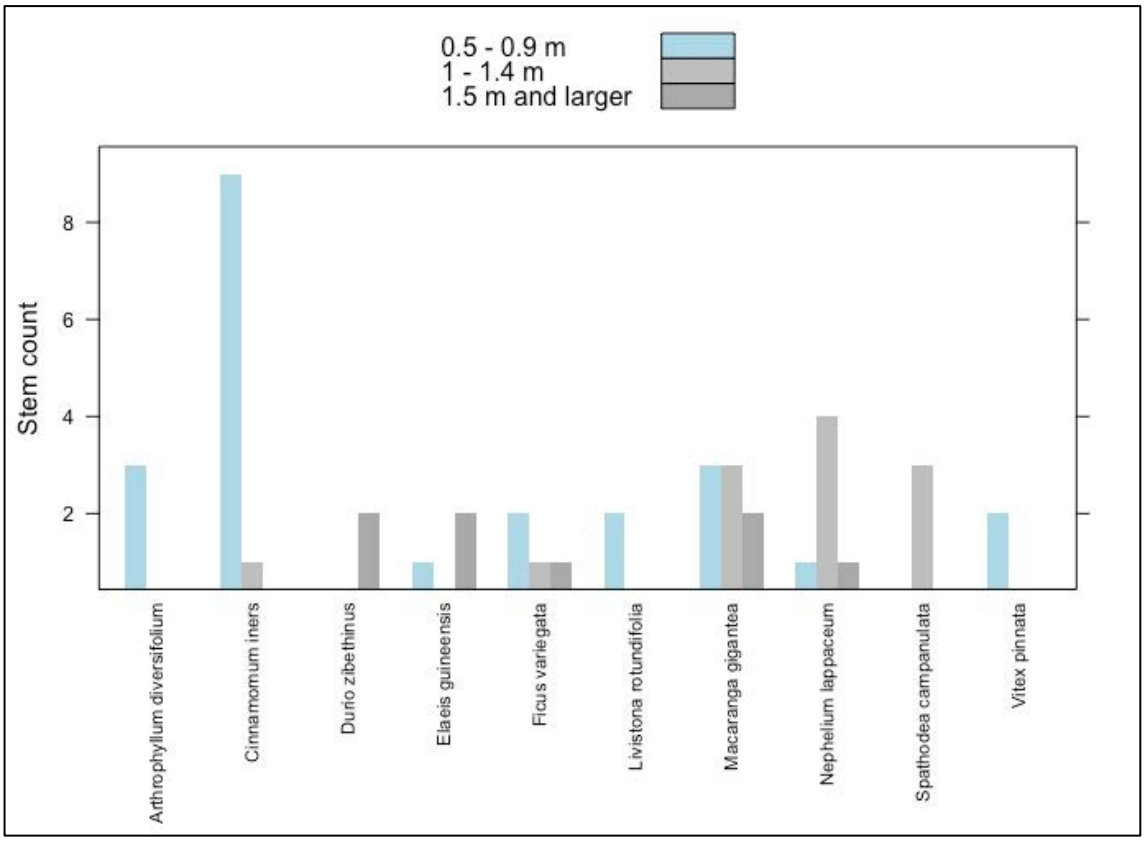

Figure 12-21: Girth-Size Class Distribution of the Ten Most Abundant Tree Species of ⩾ 0.5 m Girth

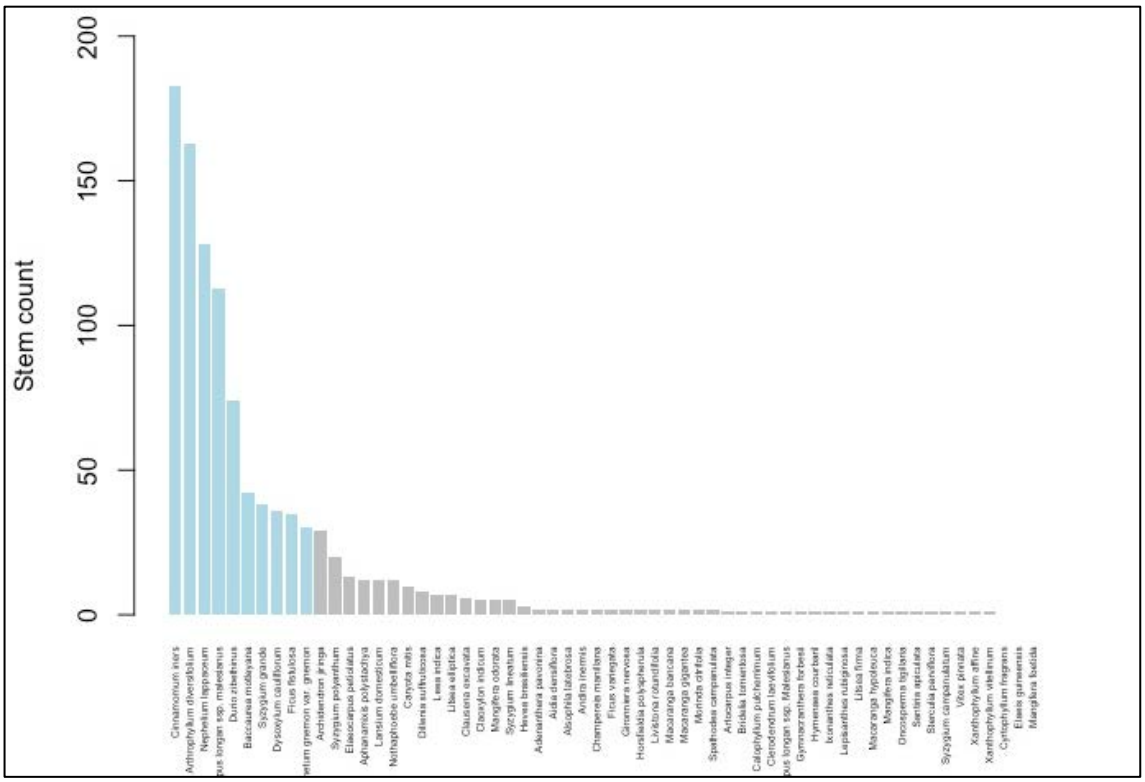

Figure 12-22: Number of Stems of < 0.5 m Girth Recorded for Each Species in All Six Vegetation Plots Ranked in Descending Order. Bars in Light Blue Belong to the Ten Most Abundant Species.

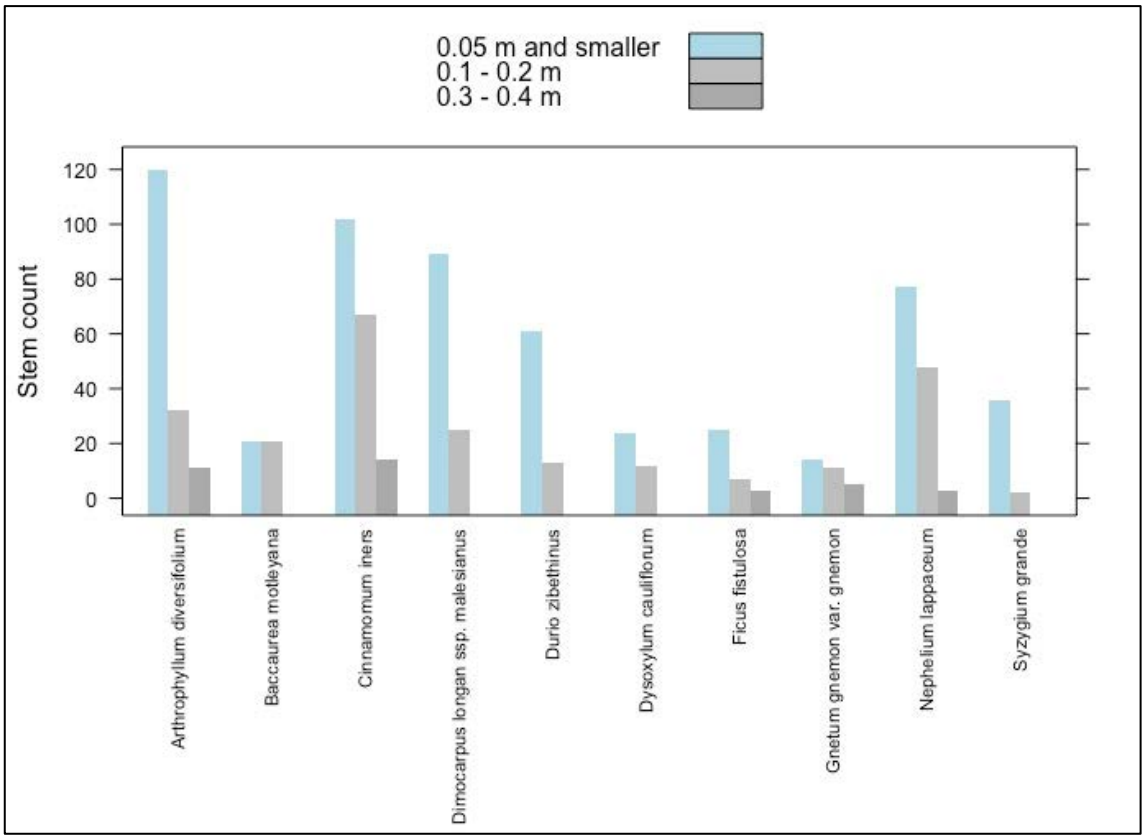

Figure 12-23: Girth-Size Class Distribution of the Ten Most Abundant Tree Species of < 0.5 m Girth

12.3.3 Fauna Field Assessment Results

12.3.3.1 Fauna Surveys

The desktop assessment identified 468 species of probable occurrence (refer to **Table 12-11** and **Appendix D of the Addendum**). The majority of species of probable occurrence were made up of birds (156 species; 33.4%) and butterflies (182 species; 39.97%). Overall, a total of 197 unique species and six unique genera not identified to species level were recorded, the six unique genera are observations of morphospecies that could be distinguished as distinct species. 14 species of conservation significance were present (one damselfly, one butterfly, one reptile, 10 birds and one bat). While not identified to species level, the bamboo bat (*Tylonycteris sp.*) recorded may be of conservation significance (refer to sub-section on Bats below).

In the targeted transect surveys, the field assessment recorded a total of 184 unique species and six unique genera not identified to species level, confirming the presence of 32.69% of the species of probable occurrence. This figure excludes the hymenopterans as there was no expected species list generated for the group, an additional 31 unique species of hymenopterans were recorded.

Based on the field assessment at the Study Area, the highest faunal species richness was recorded at point T2_04 (*n*=50), at the edge of the cemetery (managed vegetation) and forested areas (refer to **Figure 12-24**). Species recorded were dominated by birds and butterflies. However, there was no clear hotspot for conservation significant species, as they were distributed across the site and in various vegetation types. As the vegetation at T2_04 was relatively open, it was also relatively easy to detect fauna such as the sun-loving butterflies, which may have contributed to the high species richness at that point. However, species that use the open areas are also likely to use the forest interior for resting, breeding and shelter. Thus, this coincides with the generally higher species richness in the forested areas (T2_02 to T2_07).

Based on the field assessment at the around the proposed slip road, the highest faunal species richness was recorded at point T3_02 (*n*=31), in front of the temple which has some graves in front of it. It has managed vegetation to its west and forested areas to its east (refer to **Figure 12-24**). Species recorded were dominated by birds and butterflies which may be moving between the open and closed canopies. General species richness was lower at T3_06 to T3_08, where there was high disturbance from vehicular traffic from the PIE. It is possible that there were less fauna in the disturbed edge and that the disturbance hindered the surveyors from observing species by calls. There was no clear hotspot for conservation significant species, as they were distributed across the site and in various vegetation types including the stream habitat.

The estimated true species richness for all the taxa was lower than the number of species recorded although the sampling effort achieved 92.02% of the sample coverage for both the terrestrial and aquatic sampling points (refer to **Table 12-12**, **Figure 12-25**). These analyses are based only on the transect and point count surveys for targeted taxa, and excludes the data obtained from incidental records, fish, bat and camera trapping. The estimated true species richness and sampling coverage for camera trapping is described in **Section 12.3.3.2**. It is important to note that it is unlikely for any ecological survey to capture the full species diversity, emphasizing the importance of considering the species of probable occurrence that were not recorded, during the impact assessment.

The full set of data from the fauna field assessments is available in **Appendix E of the Addendum**.

Table 12-11: Summary of Total Diversity of Extant, Probable and Recorded Fauna Species at Mount Pleasant

Fauna Group	Total # of Extant Species	Total # of Probable Species	Total # of Probable Conservation Significant Species	Study Area (T1, T2, S1, S2)		Area around Slip Road (T3, S3)		Total	
				Total # of Recorded Species	Total # of Recorded Conservation Significant Species	Total # of Recorded Species	Total # of Recorded Conservation Significant Species	Total # of Recorded Species	Total # of Recorded Conservation Significant Species
Odonates	**133**	**49**	**3**	**13**	**1**	**6**	**0**	**15**	**1**
Dragonflies	83	37	0	7	0	5	0	9	0
Damselflies	50	12	3	6	1	1	0	6	1
Butterflies [a]	**334**	**182**	**12**	**44 + 2***	**1**	**17 + 1***	**0**	**49 + 2***	**1**
Hymenoptera	**82**	**NA**	**NA**	**29**	**NA**	**8**	**NA**	**31**	**NA**
Fishes	**85**	**17**	**0**	**7**	**0**	**4**	**0**	**7**	**0**
Decapod crustaceans	**24**	**4**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Herpetofauna [a]	**132**	**38**	**3**	**16**	**0**	**8**	**1**	**18**	**1**
Amphibians [a]	29	11	0	6	0	4	0	6	0
Reptiles [a]	103	27	3	10	0	4	1	12	1
Birds [a]	**397**	**156**	**24**	**60 + 2***	**9 + 1***	**42 + 1***	**5**	**66 + 2***	**10**
Mammals [a]	**54**	**22**	**1**	**11 + 2***	**1***	**8 + 2***	**1***	**11 + 2***	**1***
Non-volant Mammals	29	13	0	5	0	4	0	5	0
Bats	25	9	1	6 + 2*	1*	4 + 2*	1*	6 + 2*	1*
Total	**>1,241**	**468**	**44**	**180 + 6***	**12 + 2***	**93 + 5***	**6 + 1***	**197 + 6***	**13 + 1***

Note: Observations include those from transect surveys, camera trapping, live trapping and incidental records

* *unique genera not identified to species level*

[a] *Fauna group recorded species not of probably occurrence*

Legend

- Study Area
- Construction, no vegetation
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Terrestrial Transect 1 (1.62km)
- Terrestrial Transect 2 (1.13km)
- Terrestrial Transect 3 (0.97km)
- Stream Transect 1 (0.74km)
- Stream Transect 2, concrete (0.03km)
- Stream Transect 2, naturalised (0.08km)
- Stream Transect 3 (0.12km)

Overall Species Richness

- 1 - 10
- 11 - 18
- 19 - 27
- 28 - 38
- 39 - 50

N

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Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

OVERALL NUMBER OF FAUNA SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TARGETED TRANSECTS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
BT	DY	JAG	12-24	-	1 of 1
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Table 12-12: The Total Number of Species Recorded, Sample Coverage and the Estimated True Fauna Species Richness for the Study Area. The Number of Sampling Units Refer to the Number of Terrestrial and Aquatic Sampling Points with Species Records. Values for Estimated True Species Richness Represent ± Standard Error. Incidental Records are Excluded.

Terrestrial Fauna Group	Recorded	n	Estimated True Species Richness (Chao)	Sampling Coverage (%)
All (terrestrial + aquatic)	190	45	278.76.10 ± 29.26	92.02
All (terrestrial)	169	33	252.75 ± 28.21	91.10
All (aquatic)	26	12	27.03 ± 1.65	98.04
Odonates	13	11	13.61 ± 1.2	97.10
Butterflies	50	30	100.35 ± 29.64	85.70
Hymenoptera	31	24	50.78 ± 12.95	74.75
Fish	7	12	7 ± 0.22	100
Decapod Crustaceans	0	-	-	-
Amphibians	6	26	6 ± 0.20	100
Reptiles	12	19	20.53 ± 9.66	75.89
Birds	63	31	74.68 ± 8.55	96.37
Non-volant Mammals	3	13	3.92 ± 1.97	87.76
Bats	6	29	6.97 ± 2.15	96.61

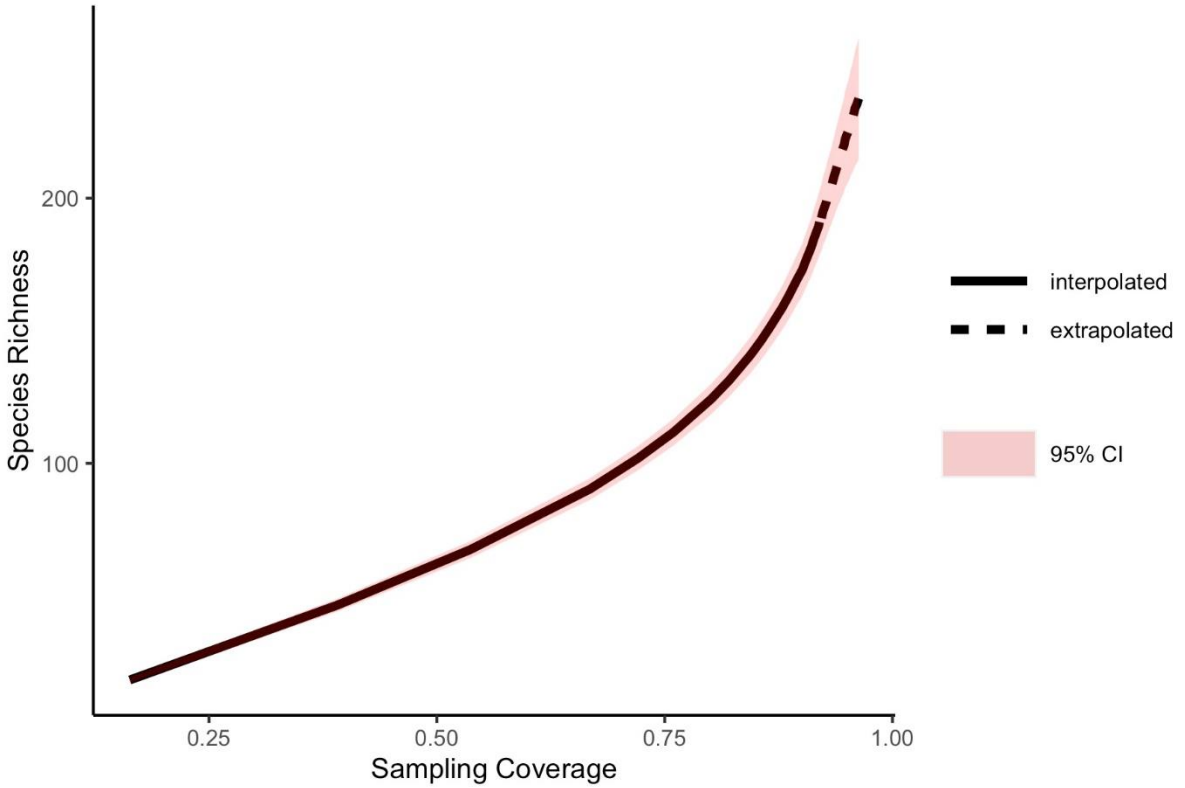

Figure 12-25: Coverage-based Rarefaction and Extrapolation Curve for All Species Recorded During Terrestrial and Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

Odonates

The Malay Peninsula lies near the epicentre of odonate diversity and is exemplified by high endemicity (Kalkman et al., 2008). Singapore contains a total of 133 extant species, constituting 83 dragonflies and 50 damselflies. Of these, 49 species (37.4%) were determined to be of probable occurrence in the Study Area and 13 species were recorded (refer to **Table 12-11** and **Appendix D of the Addendum**). The recorded species were made up of seven dragonflies and six damselflies.

From the list of odonates of probable occurrence, most odonates expected to be found within the Study Area were widespread and common throughout Singapore. However, the Singapore Shadowdamsel (*Drepanosticta quadrata*) and Common Flashwing (*Vestalis amethystina*) are restricted and common, and the Collared Threadtail (*Prodasineura collaris*) is restricted and uncommon. All three are of national conservation significance (**Appendix D of the Addendum**) and found in uncommon habitats of forest streams and restricted to the Central Catchment Nature Reserve.

Only the Collared Threadtail (*Prodasineura collaris*) (refer to **Figure 12-26**, **Figure 12-27**) was recorded at Stream 1 and 2. Specifically, at S1_05, three individual females were observed together; the females are rarely observed and in such high numbers, therefore, both streams can be considered a stronghold of the damselfly's population (Tang *pers. comm.*). Unlike the known forested stream habitat of the Collared Threadtail, Stream 1 was characterised by open scrubland vegetation but species could be moving in and out of the forested areas adjacent to Stream 1.

The highest richness of odonates was recorded at S1_06 (n=9; refer to **Figure 12-26**) but since the habitats of Stream 1 and 2 are different, this cannot be used as the sole comparison of stream quality.

11 species were observed at Stream 1, including the Slender Blue Skimmer (*Orthetrum luzonicum*), Variable Wisp (*Agriocnemis femina*), Blue Sprite (*Pseudagrion microcephalum*) and Indigo Dropwing (*Trithemis festiva*), all of which are known to prefer open or urban streams and drains. Notably, the Orange-striped Threadtail (*Prodasineura humeralis*), which is known to prefer forest streams, was observed at Stream 1 only, at S1_06 and S1_08, both of which are connected to a thin strip of forested area. The species observed at Stream 2 included the Grenadier (*Agrionoptera insignis*), Violet Sprite

(*Archibasis viola*) (refer to **Figure 12-28**), Spine-tufted Skimmer (*Orchithemis pulcherrima*), Collared Threadtail (*Prodasineura collaris*) and Treehugger (*Tyriobapta torrida*), all of which prefer darker forest streams.

Around the proposed slip road, only three species of odonates were observed at Stream 3 during the surveys, all of which were common and observed in Stream 1 and 2. The species three were the Violet Sprite (*Archibasis viola*), Treehugger (*Tyriobapta torrida*) and Spine-tufted Skimmer (*Orchithemis pulcherrima*). All three species were observed at S3_01, where n=3, no observations were made at S3_02. However, the habitat of the stream at both sampling points were similar.

Two additional species, the Dark-tipped Forest Skimmer (*Cratilla metallica*) and Blue Skimmer (*Orthetrum glaucum*) were observed incidentally during the surveys and were not observed in Stream 1 and 2. Both species are common and widespread.

The sampling effort achieved 97.10% of the sample coverage (refer to **Table 12-12**, **Figure 12-29**), indicating that the faunal survey effort was sufficient to capture most of the odonate species within the site. The true species richness based on the estimators for the Study Area is between 12 and 15 species, which is close to the observed odonate species number of 13 during transect surveys, suggesting high sampling completeness.

Legend

- Study Area
- Construction, no vegetation
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Stream Transect 1 (0.74km)
- Stream Transect 2, concrete (0.03km)
- Stream Transect 2, naturalised (0.08km)
- Stream Transect 3 (0.12km)
- Prodasineura collaris

Odonates Species Richness

- 0
- 1
- 3 - 4
- 5 - 6
- 9

N

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Figure Title :

NUMBER OF ODONATE SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TARGETED TRANSECTS AND LOCATION OF CONSERVATION SIGNIFICANT ODONATE SPECIES

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BT	DY	JAG	12-26	-	1 of 1
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Figure 12-27: Collared Threadtail (*Prodasineura collaris*) Observed at Stream 1 (Source: from NParks)

Figure 12-28: Violet Sprite (*Archibasis viola*) Observed at Stream 2

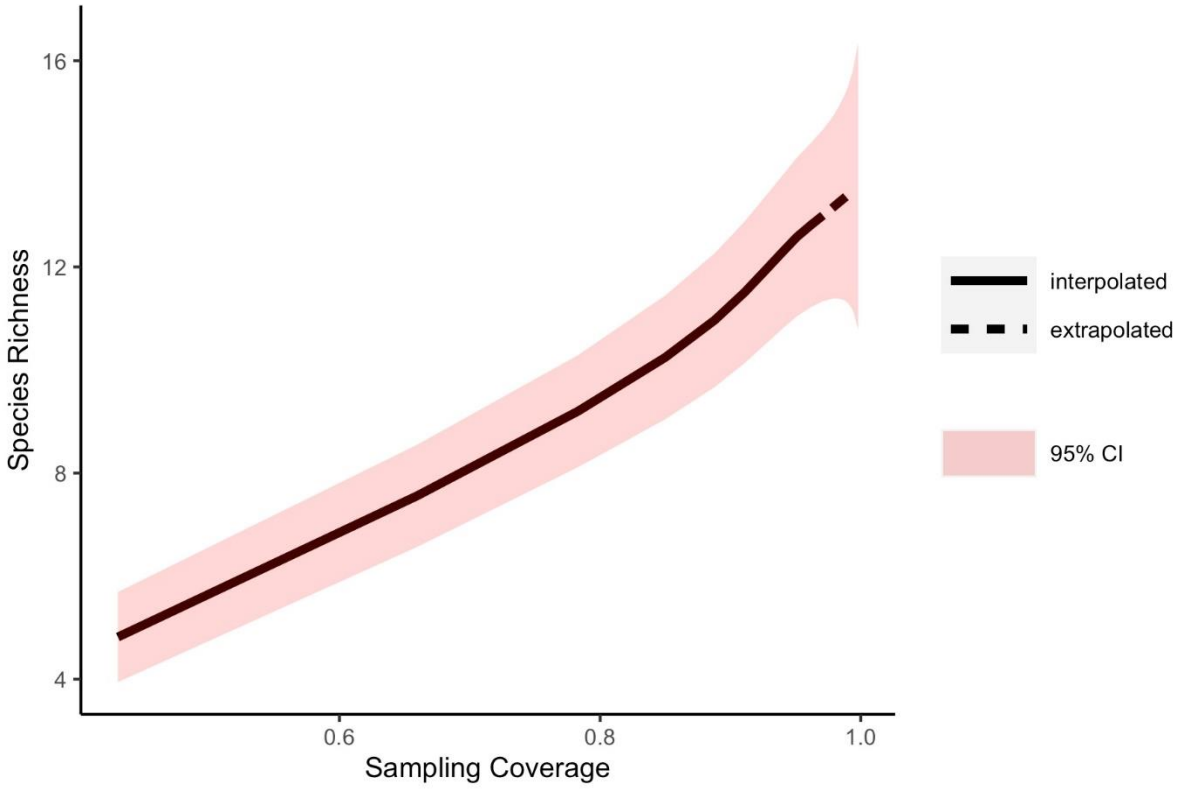

Figure 12-29: Coverage-based Rarefaction and Extrapolation Curve for Odonate Species Recorded during Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

Butterflies

The latest assessment placed the number of butterfly species recorded in Singapore between 1990 to December 2017 as 478 (Jain et al., 2018). Based on this assessment, a total of 334 butterfly species are recognised as extant, including nine species that are considered to be potentially extirpated due to lack of sightings in the last 10 years. Of the 301 species recognised as residents, five species were migrants and 19 were vagrants; these non-residents either never recorded before or have been declared extirpated for more than 50 years (Jain et al., 2018).

Since butterflies are host-specific, the high extinction of plant species from rapid, widespread deforestation resulted in the successive extinction of many butterfly species (Khew, 2015). Accordingly,

the diversity of butterflies at a particular site is largely dependent on the presence of specific larval host plants. In addition, the presence of native plant species is important for the survival of forest-dependent butterflies as many of these species are flower-specialists that only feed on native plant species (Jain et al., 2016). Thus, habitats with a greater diversity of native plants are of higher quality for butterflies. Based on the presence of host plants or suitable habitat conditions, 182 butterfly species were deemed of probable occurrence within the Study Area, accounting for 54.2% of Singapore's 334 species (refer to **Table 12-11** and **Appendix D of the Addendum**). The list of probable species predominantly consists of butterflies which are adapted to disturbed habitats.

116 out of 182 species of probable occurrence are common or moderately common and 68 species are considered moderately rare to very rare. A total of 11 species of conservation significance were expected, and one was recorded. The nationally vulnerable Common Rose (*Pachliopta aristolochiae asteris*) was recorded once in the forested area at T2_06, although its host plant, *Aristolochia acuminata*, was not recorded in the flora surveys. It is a strong flyer with a flying radius estimated to be 2 – 2.5km (Jain pers. comms.) and its host plant may have been planted in the residential areas along Mount Pleasant Road.

At T1 and T2, 44 species were recorded (refer to **Table 12-11** and **Appendix D of the Addendum**), with an additional unique two genera recorded not identifiable to species level – Burara sp. and Miletus sp. The highest diversity of butterflies was recorded at T2_04 (n=16), followed by T2_03 and (n=14), in the open managed vegetation of the cemetery. In general, the forested area from T2_02 to T2_06 had the highest number of butterfly species recorded per sampling point in the Study Area (refer to **Figure 12-30**). The lowest number species of butterflies was recorded at T1_12 and T1_02 (n=0); in general, Mount Pleasant Road had a lowest number of butterfly species recorded per sampling point.

Around the slip road, 16 species were recorded (refer to **Table 12-11** and **Appendix D of the Addendum**), most of which are common except for the Orange Awlet (*Burara harisa consobrina*) and Full Stop Swift (*Caltoris cormasa*), which are moderately rare. No species of local conservation significance were observed. The highest species richness of butterflies observed were in the open area with managed vegetation in front of the temple at T3_02 (refer to **Figure 12-30**), and in the herbaceous and scrubland vegetation at T3_06 and T3_07, where n=8. The observation at T3_02 is similar to that for the hymenopterans, where there was more sun and flowering shrubs for the pollinator species.

The sampling effort achieved 85.70% of the sample coverage (refer to **Table 12-12**, **Figure 12-33**) indicating that more surveys may be needed to achieve a complete coverage of the species richness. The true species richness based on the estimators for the Study Area is between 70 and 130 species, whereas the species recorded during transect surveys was 50.

Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Terrestrial Transect 1
- Terrestrial Transect 2
- Terrestrial Transect 3
- Pachliopta aristolochiae asteris

Butterflies Species Richness

- 0
- 1 - 4
- 5 - 8
- 9 - 12
- 13 - 16

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Figure Title :

NUMBER OF BUTTERFLY SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TARGETED TRANSECTS AND LOCATION OF CONSERVATION SIGNIFICANT BUTTERFLY SPECIES

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BT	DY	JAG	12-30	-	1 of 1
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Note: Source of basemap - Google Earth Map

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Figure 12-31: Small Branded Swift (*Pelopidas mathias mathias*) Observed in the Study Area

Figure 12-32: Chocolate Grass Yellow (*Eurema sari sodalis*) Feeding on *Asystasia Gangetica*

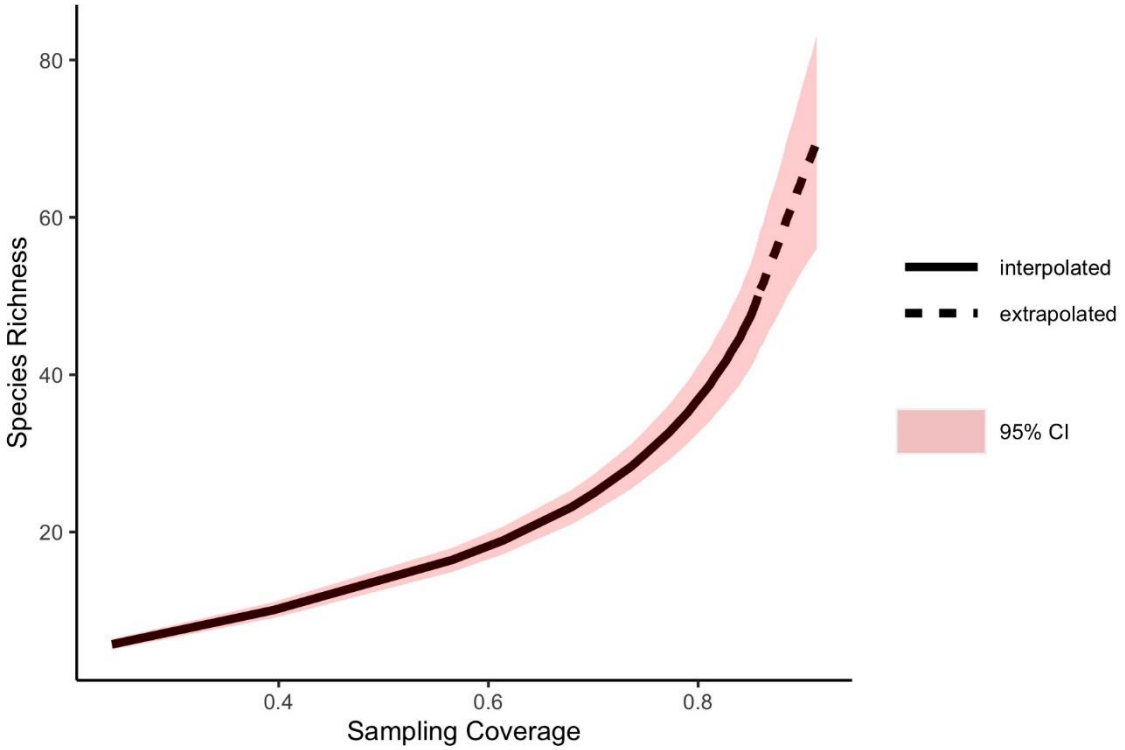

Figure 12-33: Coverage-based Rarefaction and Extrapolation Curve for Butterfly Species Recorded during Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

Hymenoptera

At least 82 species of hymenoptera are present in Singapore (Wen et al, 2013). However, the group is not well-studied and few resources on the habitat preference of bees and wasps in Singapore are available. Hence, it was not possible to generate a list of probable species. However, Hymenoptera were included in the surveys as they are pollinators and play a key roles in the ecosystem, ensuring reproductive fitness and conservation of plant populations and playing an important part in food webs as they pollinate flowers which produce fruit for frugivores such as bats, birds and mammals (Wen et al, 2013). At Mount Pleasant, a total of 31 species were recorded, all of which were native and not of conservation significance.

At T1 and T2, 29 species or morphospecies were recorded during the targeted surveys. While this number is relatively low, it is reasonable considering the short survey period over a particular season. Also, by personal observation, the abundance of bees and wasps in general has been lower than normal

in many parts of Singapore throughout 2017 and 2018, and this trend continued into 2019, although no studies have been done to verify this (Lee J, *pers. comm.*). It is possible to survey a certain area for a full year and not record a given species there, only to find it there at another future time.

More observations of bees and wasps were made in semi-open areas of the Study Area, as compared to the forested areas. This is consistent with observations in other similar areas, and does not mean that they are not present within the forest; rather, they are not easily observed in dense vegetation and are usually seen just flying through. In the more open areas, plants such as *Leea indica*, *Melastoma malabathricum* and *Asystasia gangetica* attracted bees and wasps, making it easier to spot, photograph and collect specimens. However, the rate of flowering was not very high overall; both the number of species recorded and overall abundance could be much higher with a higher rate of flowering.

The highest diversity of hymenoptera was recorded at two points (T2_03, T2_04, n=6; refer to **Figure 12-34**, in the area of the managed vegetation – cemetery, followed by T1_01 and T1_04 (n=5), along Onraet Road, which also had open canopy.

Around the proposed slip road, seven species of hymenoptera were recorded during the targeted surveys. The highest diversity of hymenoptera was T3_02 (n=6; refer to **Figure 12-34**), in the open area in front of the temple which had managed vegetation which was flowering.

Throughout the Study Area, there is secondary forest which has emerged from unmanaged land, it highly promising as an environment for bees and wasps, and this often indicates that the habitat is similarly good for other insect fauna and thus other types of wildlife.

The sampling effort achieved 74.75% of the sample coverage (refer to **Table 12-12**, **Figure 12-35**), indicating that more surveys may be needed to achieve a complete coverage of the species richness. The true species richness based on the estimators for the Study Area is between 37 and 64 species, whereas the species recorded during transect surveys was 31.

Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Terrestrial Transect 1
- Terrestrial Transect 2
- Terrestrial Transect 3

Hymenoptera Species Richness

- 0
- 1 - 2
- 3 - 4
- 5 - 6

N

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Figure Title :

NUMBER OF HYMENOPTERA SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TARGETED TRANSECTS

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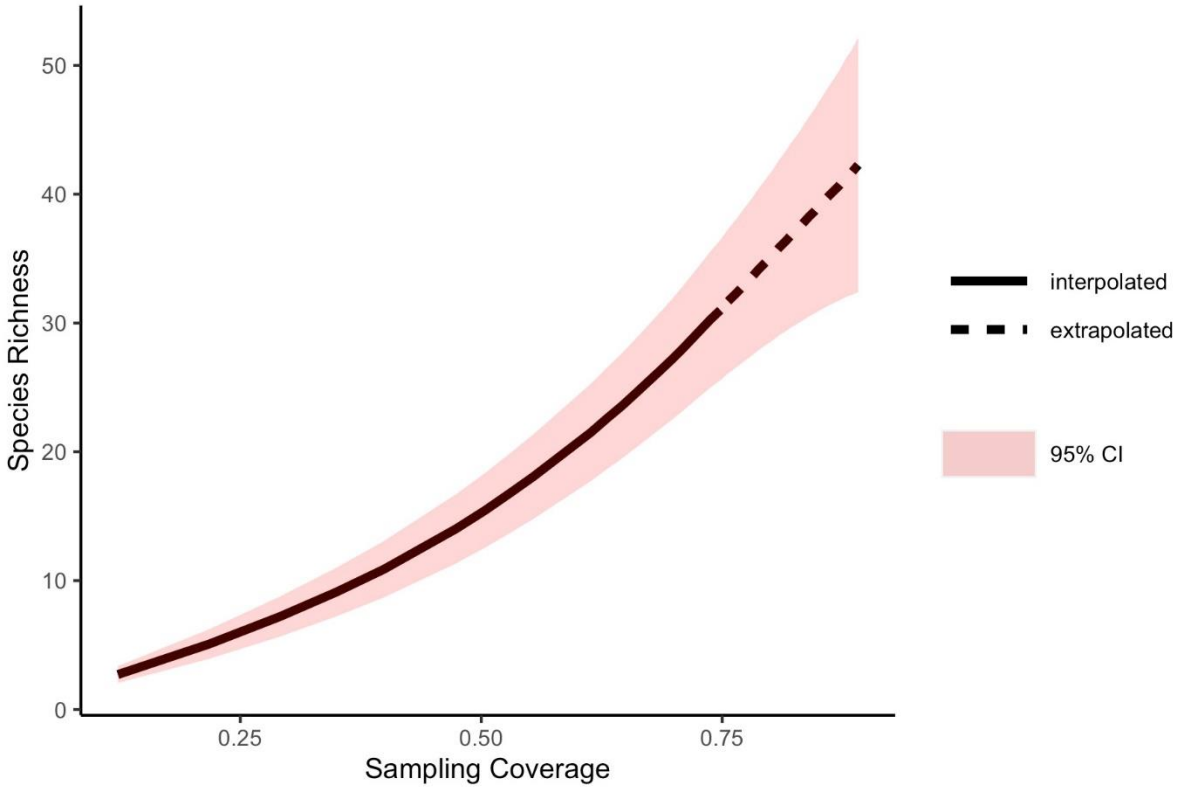

Figure 12-35: Coverage-based Rarefaction and Extrapolation Curve for Hymenoptera Species Recorded During Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

Freshwater Fishes

Singapore's freshwater fish populations have been dwindling since the 1850s as a result of deforestation, reservoir impoundment, and channel concretization, which changed the biophysical environment of stream habitats, especially of forest streams (Ng and Lim, 1990). To make matters worse, the release of aquarium species that compete with native species pose an ever-intensifying threat. A total of 85 species of freshwater fish are known to occur in Singapore, of which a large proportion (52 species; Ng and Lim, 1997) are non-native. Estimates vary on the number of species that have become locally extinct, ranging from 11 (Giam et al., 2011) to 26 species (Ng and Lim, 1997). Regarding the remaining native species, most are restricted to forested streams within BTNR and CCNR, and eight are only known from Nee Soon Swamp Forest (Ng and Lim, 1997).

The desktop assessment identified 16 species of probable occurrence at Study Area (refer to **Table 12-11** and **Appendix D of the Addendum**), which makes up 18.8% of extant species in Singapore. Species of probable occurrence consist mainly of common species that are relatively tolerant to disturbances such as Whitespot (*Aplocheilus armatus*) and species from the Poeciliidae Family – Guppies, Mollies and Mosquitofish. These species can reside in a range of environment from low oxygenated freshwaters to hypersaline waters of meagre pockets of water and ditches to vegetated canals (Ng et al., 2018). Overall, seven species of fish from five families were encountered during the surveys. Comparing against the probable species list from the desktop review, all seven species recorded were expected to occur. No species of conservation significance were considered to be probable or were recorded.

Most points along Stream 1 recorded four to five species, with the highest species count at S1_08 (*n*=6) (refer to **Figure 12-36**); while S1_05 had the lowest species count (*n*=1), Paddyfield Snakehead (*Channa striata*). However, this should not be misinterpreted as S1_05 is located between sampling points with relatively high species counts. Instead, results should be analysed collectively to draw applicable conclusions as the stream is too short to have discernible environmental differences between points. Therefore, the consistency of four to five species being recorded at all other sampling points along Stream 1 illustrates that there is connectivity between the sampling points and that species utilise the entire stream. Stream 2 is much shorter than Stream 1, allowing for only two sampling points. Both

points captured the same number of species (*n*=5). Species composition was similar in both streams although the native Paddyfield Snakehead (*Channa striata*) was only recorded in Freshwater Transect 1.

A total of four introduced species and three native species were recorded. Both Streams 1 and 2 recorded the same number of introduced species (refer to **Table 12-13**). The high number of introduced species is expected from environmental conditions on site and indicative of the presence of high human impact on the habitat. One such activity that would have contributed to the presence of introduced species such as the Guppy (*Poecilia reticulata*) and Pearl Danio (*Brachydanio albolineata*) could possibly be the deliberate release of an animal in captivity for the purpose of '*fang sheng*' (see Ng & Tan, 2010). Both species are popular in fish farms and aquariums because of their bright and varied ornamental colouration (Baker and Lim, 2012). The Guppy (*Poecilia reticulata*) was first introduced into Singapore in the early 1900s for mosquito control (Lim, 1995). However, like most invasive species, it is very tolerant of polluted and disturbed waters and breeds prolifically (Lim, 1995).

Fish trap survey data in Streams 1 and 2 captured three species — Pearl Danio (*Brachydanio albolineata*), Guppy (*Poecilia reticulata*) and Indo Chinese Barb (*Barbodes rhombeus*). Results obtained from fish trapping were not particularly useful to add any insights to discussion as species obtained from trapping were also recorded along the aquatic visual transect.

In the Study Area, four species of fish from four families were encountered at Stream 3. These were the Guppy (*Poecilia reticulata*), Pearl Danio (*Brachydanio albolineata*), Indochinese Spotted Barb (*Barbodes rhombeus*) and Asian Swamp-eel (*Monopterus javanensis*), all of which were also observed in the S1 and S2. While the species richness at S3_01 was n=4 and S3_02 was n=3 (refer to **Figure 12-36**), there is no meaningful comparison between the two points as the distance between the sampling points is short, the habitats are similar and the fish species are common. No fish were trapped in the fish traps in Stream 3.

Overall, it is of interest to note the absence of a number of locally common native fish species that are frequently found in open-country habitats alike to environmental conditions of Stream 1. These include Sunda Pygmy Halfbeak (*Dermogenys collettei*), Whitespot (*Aplocheilus panchax*), Climbing Perch (*Anabas testudineus*), Three-spot Gourami (*Trichopodus trichopterus*), and Croaking Gourami (*Trichopsis vittata*), as well as the introduced Mozambique tilapia (*Oreochromis mossambicus*; see Johnson, 1973; Baker & Lim, 2012). It is highly probable that these species may have occurred in the past waterways of Mount Pleasant (both Stream 1 and 2) prior to their concretisation. However, presently, Common Walking Catfish (*Clarias batrachus*), Asian Swamp-eel (*Monopterus albus*) and *Channa striata* are dominantly found, which would suggest that they are the main piscine predators in the streams. These species may have re-colonised these water bodies by their ability to survive out of water for a limited time and travel over land in search of new habitats.

Whilst this study concluded with seven species from five families, adjacent baseline studies at Bukit Brown reveals 11 species from six families (Tan et al., 2013). In Tan et al. (2013), the two streams surveyed, Bukit Brown and Mount Pleasant are relatively near the Study Area (refer to **Figure 12-39**). However, the streams are not connected. Of the 11 species Tan et al. (2013) recorded, five of them were recorded from our baseline surveys. As mentioned above, the few certain species are able to travel over land in search of better/new habitats have all been found in the surveys as well.

The sampling effort achieved 100% of the sample coverage (refer to **Table 12-12**, **Figure 12-40**), indicating that the faunal survey effort was sufficient to capture most of the fish species within the site. The true species richness based on the estimators for the Study Area is between six to eight species, whereas seven species were observed, suggesting sampling completeness.

Legend

- Study Area
- Construction, no vegetation
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Stream Transect 1 (0.74km)
- Stream Transect 2, concrete (0.03km)
- Stream Transect 2, naturalised (0.08km)
- Stream Transect 3 (0.12km)

Fish Species Richness

- 1
- 3 - 4
- 5 - 6

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	BT	Final Report	DY	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

NUMBER OF FISH SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TARGETED TRANSECTS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
BT	DY	JAG	12-36	-	1 of 1
	Drawn BT	Date JAN 2021	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

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Table 12-13: Table of species recorded and Native status at each Freshwater Transect

Species Recorded	Native Status	Freshwater Transect 1	Freshwater Transect 2	Freshwater Transect 3
Barbodes rhombeus	Introduced	Yes	Yes	Yes
Brachydanio albolineata	Introduced	Yes	Yes	Yes
Channa striata	Native	Yes	No	No
Clarias cf. batrachus	Native	Yes	Yes	No
Gambusia affinis	Introduced	Yes	Yes	No
Poecilia reticulata	Introduced	Yes	Yes	Yes
Monopterus javanensis	Native	Yes	Yes	Yes

Figure 12-37: Upper Left Corner is a Specimen of Pearl Danio (*Brachydanio albolineata*); Right and Bottom Corners are Two Specimens of Indo Chinese Barb (*Barbodes rhombeus*).

Figure 12-38: (Left) Paddyfield Snakehead (*Channa striata*) and (Right) Common Walking Catfish (*Clarias Batrachus*).

Figure 12-39: Relative Location of Tan et al's (2013) Study of Streams in Bukit Brown Cemetery to Study Area.

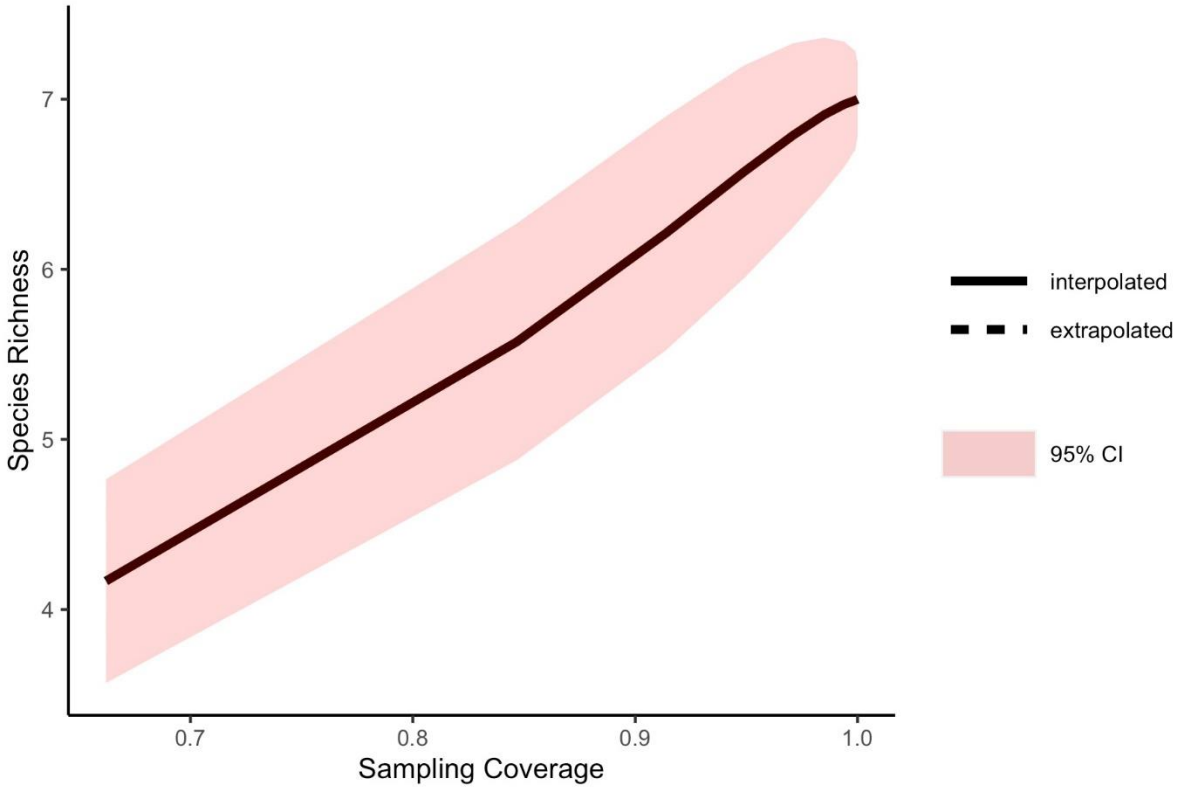

Figure 12-40: Coverage-based Rarefaction and Extrapolation Curve for Fish Species Recorded During Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

Freshwater Decapod Crustaceans

Freshwater decapod crustaceans in Singapore are exceptionally well-studied, with 24 species having been recorded (Ng, 1997). Three species are endemic, Johnson's Freshwater Crab (*Irmengardia johnsoni*), Swamp Forest Crab (*Parathelphusa reticulata*) and Singapore Freshwater Crab (*Johora singaporensis*) and two are locally extinct (Giant Freshwater Prawn [*Macrobrachium rosenbergii*] and Goda River Prawn [*Macrobrachium scabriculum*]).

A total of four species (16.17% of extant species in Singapore) were of probable occurrence base on the aquatic habitats present in Study Area refer to **Table 12-11** and **Appendix D of the Addendum**). Only one of these species is of conservation significance – the locally vulnerable, Peracca's Land Crab (*Geosesarma peraccae*). The majority of the species found in Singapore are either interior forest specialists or require a marine/estuarine phase for their larval stage, and the lack of connectivity of the Mount Pleasant streams to marine habitats would preclude their presence here.

Stream 2 in the Stream 3 both have suitable habitats made up of shallow, slow-flowing water with adequate leaf litter for species such as Freshwater Prawn (*Macrobrachium malayanum*) and the Maculate Freshwater Crab (*Parathelphusa maculata*). However, aquatic surveys detected no decapod crustaceans despite deploying live traps. The lack of connectivity and length of stream could have been the limiting factor in this situation.

Herpetofauna

Singapore supports a species-rich extant herpetofauna assemblage consisting of 29 amphibians and 103 reptiles comprising nine non-marine turtles, one crocodile, 32 lizards, and 61 non-marine snakes (Baker and Lim, 2012). Water bodies are important habitats for amphibians, as they must remain reasonably moist to prevent dehydration. Like odonates, amphibians are also characterized by a bipartite lifestyle and their diversity is also pre-determined by site-variability in breeding and larval habitats (Berry, 1975). In Singapore where humidity is high, some species may remain away from water, instead inhabiting moist leaf litter and vegetation as adults, and returning to water only to breed. After

heavy downpours, depressions and pits on the forest floor as well as phytotelmata get filled up with water, serving as ephemeral breeding grounds, especially for species with a short tadpole phase. In Singapore, all the non-marine turtles require freshwater habitats (Baker and Lim, 2012). Lizards and snakes are extremely variable in their habits, with habitat use ranging from subterranean to arboreal environments (Tweedie, 1983; Grismer, 2011).

Herpetofauna site-diversity is largely based on habitat quality and many species are restricted to mature forests. Due to historical site disturbance and lack of connectivity to mature forests, species likely to occur within the forested area of the Study Area are those that are widespread and common.

The probable species list amounted to 37 species comprising 11 amphibians (all frogs) and 26 reptiles (three turtles, 11 lizards and 12 snakes) (refer to **Table 12-11** and **Appendix D of the Addendum**) (Berry, 1975; Tweedie, 1983; Grismer, 2011). The amphibians expected at the site are mainly species that are able to thrive and breed in disturbed habitats with temporary pools of poor water quality (Bickford et al., 2010; Baker and Lim, 2012). Similarly, the reptile list included mostly common and widespread species.

At T1 and T2, the herpetofauna field assessment recorded 16 species comprising 6 amphibians (all frogs) and 10 reptiles (seven lizards and three snakes; refer to **Table 12-11** and **Appendix D of the Addendum**). Of the two conservation significant species of probable occurrence, none were recorded.

Amphibians were recorded throughout Transects 1 and 2, with no clear areas of higher richness (refer to **Figure 12-41**). T1_05, T1_09, T1_15, T2_06, T2_07 and S1_07 all recorded equally high species richness (*n*=3) and all species recorded were widespread and common, except for the Malesian Frog (*Limnonnectes malesianus*) (Near Threatened). The Greenhouse Frog (*Eleutherodactylus planirostris*) was observed at several sampling points along Terrestrial Transect 1. It was first reported in Singapore in 2016 at Sembawang (Groenewoud and Law, 2016), and has since been reported from Clementi Woods (Tay et al., 2017) and Dairy Farm Nature Park (Yeo et al., 2018). These records, along with recent studies by Camphora Pte Ltd show that this frog has quickly invaded disturbed sites throughout Singapore.

Unlike amphibians, reptiles were not as equally distributed throughout T1 and T2 and were recorded at 16 out of 35 sampling points (vs 24 out of 35 sampling points) (refer to **Figure 12-41**). The highest species richness of reptiles was recorded at T1_05 (*n*=3), which was in herbaceous and scrubland vegetation parallel to the stream. In the forested area around T2_06 and T2_07, there was also a slightly higher concentration of species observed (*n*=2). The most commonly observed reptiles on the transect surveys were the Oriental Whip Snake (*Ahaetulla prasina*) (refer to **Figure 12-43**) and Many-lined Sun Skink (*Eutropis mutlifasciata*), both seen five times.

Around the proposed slip road, the herpetofauna field assessment recorded right species comprising four amphibians (all frogs) and four reptiles (seven lizards and three snakes; refer to **Table 12-11** and **Appendix D of the Addendum**). No conservation significant species were recorded.

Amphibians were only recorded at areas with water: T3_02 (n=2) where there is a small artificial water body maintained by people at the temple and S3_01 and S3_02 (n=1). All species were frogs which were also observed in T1 and T2, including the restricted but common Malesian Frog (*Limnonnectes malesianus*).

Reptiles were a bit more widespread around the proposed slip road compared to amphibians but generally were also observed to be in low abundance. Sampling points T3_03, T3_05, T3_07, S3_01 and S3_02 all had one record of species each while the rest of the sampling points had none. Two species not observed at T1 and T2 were observed: the Garden Supple Skink (*Lygosoma bowringii*) and the Asian Softshell Turtle (*Amyda cartilaginea*). The Garden Supple Skink (*Lygosoma bowringii*) is cryptic and usually hides within the leaf litter and therefore while common, is not so commonly observed. The Asian Softshell Turtle (*Amyda cartilaginea*) was a notable observation as it is locally endangered and is restricted to forest streams, therefore, it was also not expected to be present at all. There was another larger individual of Softshell Turtle (*Amyda* sp.*)* observed but it was only identified to the genus level, this could have been the Asian Softshell Turtle (*Amyda cartilaginea*) or the introduced Chinese Softshell Turtle (*Amyda ornata*).

Generally, the Malesian Frog (*Limnonnectes malesianus*) (refer to **Figure 12-44** the Clouded Monitor (*Varanus nebulosus*) and the Green Crested Lizard (*Bronchocela cristatella*) were recorded but not

expected. The Malesian Frog (*Limnonnectes malesianus*) prefers mature swampy forests (Berry, 1975) which was not recorded at the site. The Clouded Monitor (*Varanus nebulosus)* is common but also known to prefer more mature forest habitats, with a restricted range in the Central Catchment Nature Reserves, Bukit Batok Nature Park, Pulau Ubin, and Pulau Tekong (Baker and Lim, 2012), although it has been recorded at other locations such as the Singapore Botanic Gardens. The Study Area is near to the Central Catchment Nature Reserves so it is not unusual that the monitor is found here as well. The Green Crested Lizard (*Bronchocela cristatella*) used to be common in urban areas but has since been outcompeted by the more aggressive non-native Changeable Lizard (*Calotes versicolor*) (Baker and Lim, 2012), which was also recorded.

The sampling effort for amphibians achieved 100% of the sample coverage (refer to **Table 12-12**, **Figure 12-45**), indicating that the faunal survey effort was sufficient to capture most of the amphibian species within the site. The true species richness based on the estimators for the Study Area is between five and seven species, whereas six species were observed during the targeted surveys, suggesting sampling completeness.

The sampling effort for reptiles achieved 75.89% of the sample coverage (refer to **Table 12-12**, **Figure 12-46**), indicating that the faunal survey effort may be insufficient to capture most of the reptile species within the site. The true species richness based on the estimators for the Study Area is between 10 and 31 species and the number of observed species of 12 falls within the projected range. However, as noted above, only 26 species of reptiles were expected within the Study Area.

Legend

- Study Area
- Construction, no vegetation
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Terrestrial Transect 1 (1.62km)
- Terrestrial Transect 2 (1.13km)
- Terrestrial Transect 3 (0.97km)
- Stream Transect 1 (0.74km)
- Stream Transect 2, concrete (0.03km)
- Stream Transect 2, naturalised (0.08km)
- Stream Transect 3 (0.12km)

Amphibians Species Richness

- 0
- 1
- 2
- 3

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-	JAN 2021	BT	Final Report	DY	JAG

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Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

NUMBER OF AMPHIBIAN SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TERRESTRIAL AND AQUATIC TRANSECTS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
BT	DY	JAG	12-41	-	1 of 1
	Drawn BT	Date JAN 2021	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

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Legend

- Study Area
- Construction, no vegetation
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Stream Transect 1 (0.74km)
- Stream Transect 2, concrete (0.03km)
- Stream Transect 2, naturalised (0.08km)
- Stream Transect 3 (0.12km)

CS Species Distribution

- Amyda cartilaginea
- Amyda sp.

Reptile Species Richness

- 0
- 1
- 2
- 3

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	BT	Final Report	DY	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

NUMBER OF REPTILE SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TERRESTRIAL AND AQUATIC TRANSECTS AND LOCATION OF CONSERVATION SIGNIFICANT REPTILE SPECIES

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
BT	DY	JAG	12-42	-	1 of 1
	Drawn BT	Date JAN 2021	CAD File Name : NA		A3

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Figure 12-43: Oriental Whip Snake (*Ahaetulla prasina*)

Figure 12-44: Malesian Frog (*Limnonnectes malesianus*)

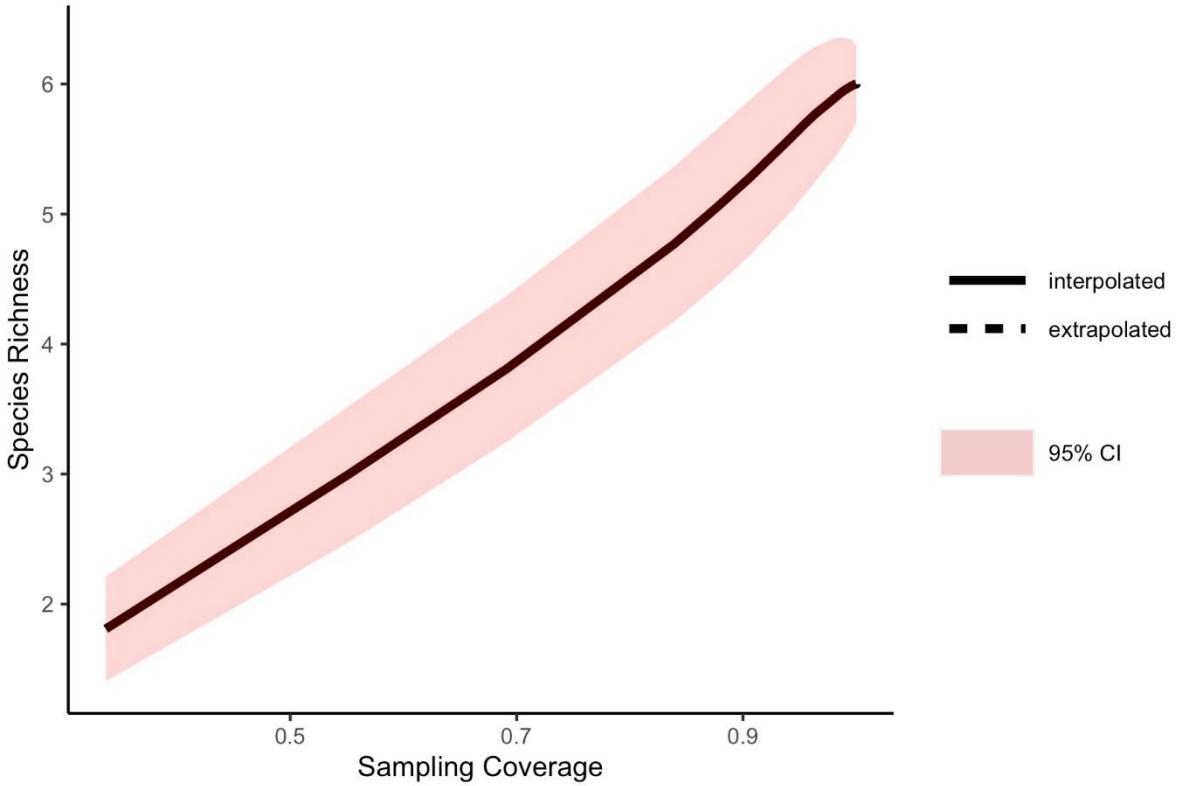

Figure 12-45: Coverage-based Rarefaction and Extrapolation Curve for Amphibian Species Recorded During Terrestrial and Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

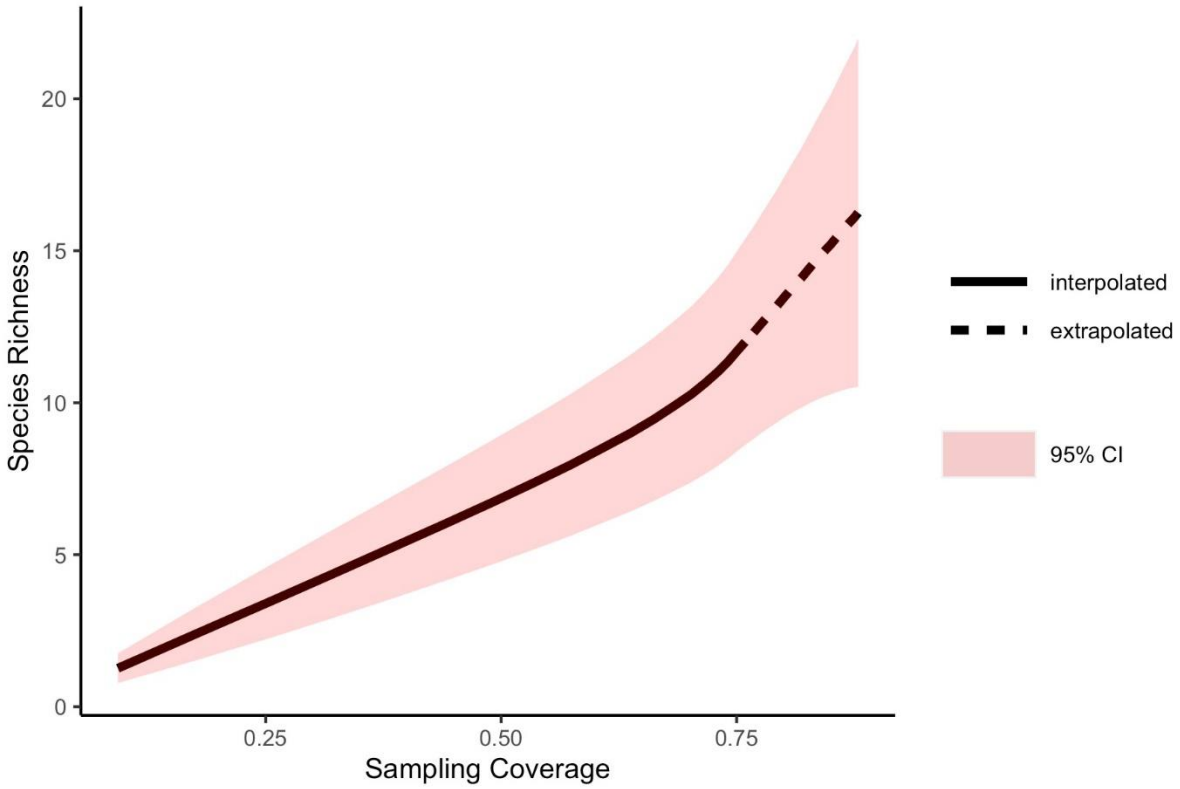

Figure 12-46: Coverage-based Rarefaction and Extrapolation Curve for Reptile Species Recorded During Terrestrial and Freshwater Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

Birds

Situated along the East Asian-Australasian Flyway, Singapore receives a high number of migratory bird species (219 species) moving between northern breeding grounds and southern overwintering haunts from September and March (Yong et al., 2016). Many of these winter visitors overwinter in Singapore, whereas others (i.e., passage migrants) stopover before continuing their journey. Therefore, birds are classified into several categories based on resident, migratory, and vagrant statuses. Currently, Singapore has 397 species, of which only 168 are resident species (*ibid*). The remaining 229 species is made up of 93 winter visitors, 29 passage migrants, 97 visitors, and 10 introduced species. An additional 70, mainly forest-dependent, are recognized as extinct (Lim, 1997), with many more continually disappearing (Castelletta et al., 2005).

A total of 156 species of birds were deemed of probable occurrence, of which 54 are migratory species, 88 are residents, and 14 are introduced (refer to **Table 12-11** and **Appendix D of the Addendum**). This accounts for 39.29% of the 397 species that have been recorded in Singapore. These species of probable occurrence are known to occur in secondary forests and forest edges. The proximity to the Central Catchment Nature Reserve also means that species restricted to mature forests may be able to utilise the Study Area.

At T1 and T2, the field assessment recorded 50 residents, four migratory species and nine introduced species of birds (refer to **Table 12-11** and **Appendix D of the Addendum**). As the surveys were conducted towards the tail end of the migratory season, many migratory species that may occur at the Study Area were not recorded in this study. The migratory species recorded include the Japanese Sparrowhawk (*Accipiter gularis*), Asian Brown Flycatcher (*Muscicapa dauurica*), which are common migrants. Uncommon migrants recorded include the Tiger Shrike (*Lanius tigrinus*) and the Malayan Night Heron (*Gorsachius melanolophus*). The Malayan Night Heron was only recorded via camera trapping and not in the transects.

Areas of higher richness of birds were recorded within the waste woodlands area along Transect 1 (T1_01 to T1_06), and the managed vegetation area along Transect 2 (T2_01 to T2_04) with the highest richness (*n*=27) recorded at T1_05 (refer to **Figure 12-47**). Species recorded were typical of urban areas, parks and gardens, and forest habitats. Of the 21 probable conservation significant species, seven were recorded (refer to **Figure 12-48**, **Table 12-11** and **Appendix D of the Addendum**). Records of conservation significant species were distributed across the Study Area with no distinct hotspot.

Amongst the findings, the significant observations would include the nationally critically endangered White-rumped Shama (*Copsychus malabaricus*) that was recorded once just outside of the Study Area (T1_09) and the endangered Asian Red-eyed Bulbul (*Pycnonotus brunneus*) which was recorded incidentally near T1_06. Both are uncommon residents usually confined to the Central Catchment Nature Reserve on the main island on Singapore, although the shama is common on Pulau Ubin (Yong et al., 2016). The proximity of the Study Area to the Central Catchment Nature Reserve likely facilitated the presence of these forest-dependent species in the Study Area. The nationally endangered Straw-headed Bulbul (*Pycnonotus zeylanicus*) was regularly recorded across the Study Area during the study. This species is also critically endangered as a result of the rampant songbird trade. Singapore is considered as a global stronghold for this species, where it can be found in forested areas in the Central Catchment and the Western Catchment, as well as on Pulau Ubin. The locally endangered Changeable Hawk-Eagle (*Nisaetus cirrhatus*) was recorded on five occasions in the northern part of the Study Area. Notably, a Changeable Hawk-Eagle nest was found in the forested area near T1_05 (identification of the nest is based on height, size and structure; refer to **Figure 12-49**), indicating that the Study Area is a breeding ground for this species. Other species of conservation significance include the Oriental Magpie-Robin (*Copsychus saularis*), Red Junglefowl (*Gallus gallus*) (refer to **Figure 12-50**), Blue-crowned Hanging Parrot (*Loriculus galgulus*) (refer to **Figure 12-51**), and Red-legged Crake (*Rallina fasciata*). Populations of most of these species have been showing improving trends except for the Red-legged Crake, which have been showing a decreasing trend (Lim & Yong, 2011). These birds were formerly rare but are now more widespread in mainland Singapore and appear to tolerate degraded forests and edge habitats such as that in Mount Pleasant.

Around the proposed slip road, the field assessment recorded 32 residents, four migratory species and seven introduced species of birds (refer to **Table 12-11** and **Appendix D of the Addendum**). For the migratory birds, the Eyebrowed Thrush (*Turdus obscurus*) and Indian Cuckoo (*Cuculus micropterus*) were only recorded in this area and not in T1 and T2. The Eyebrowed Thrush (*Turdus obscurus*) is a

notable record as it is a forest dependent species; it was recorded only in the camera trap (MP07, refer to **Figure 12-60** for location).

Along T3, the highest species richness of birds recorded was within the forest at T3_04 (n=21), whereas the edges of the forest along the PIE generally recorded less species. This is likely due to the disturbance from vehicular traffic which may cause the birds which are less tolerant of such disturbance to inhabit the interior environment. Surveyors were also less likely to observe birds by their calls due to the noise. Species recorded were typical of urban areas, parks and gardens, and forest habitats.

Five species of conservation significance were observed around the proposed slip road (refer to **Figure 12-48**), with the most significant observation being three locally endangered Changeable Hawk-Eagle (*Nisaetus cirrhatus*) perched together on the tall Albizias (*Falcataria moluccana*) on the edge of the waste woodlands. The locally critically endangered Crested Goshawk (*Accipiter trivirgatus*) was seen flying from the Bukit Brown Woods across the slip road to the PIE, before resting in the traffic island whereas the Purple Heron (*Ardea purpurea*) was observed flying overhead only.

The sampling effort achieved 96.37% of the sample coverage (refer to **Table 12-12**, **Figure 12-52**), indicating that the faunal survey effort was sufficient to capture most of the species within the site. The true species richness based on the estimators for the Study Area is between 66 and 84 species, which is close to the observed bird species number of 63.

Table 12-14: List of the Bird Species of Conservation Significance Recorded within the Study Area

Scientific name	Common name	Local status	Global status	Location of records
Accipiter trivirgatus	Crested Goshawk	CR	LC	1.327091977, 103.82688 (incidental)
Ardea purpurea	Purple Heron	EN	LC	T3_05
Copsychus malabaricus	White-rumped Shama	CR	LC	T1_09
Copsychus saularis	Oriental Magpie-Robin	EN	LC	T1_11
Gallus gallus	Red Junglefowl	EN	LC	T1_10/15, T2_03/04/08, T3_06
Loriculus galgulus	Blue-crowned Hanging-parrot	EN	LC	T1_03/04/-05/10/13, T2_02/04/05/08, T3_02/03/05/07/08
Nisaetus cirrhatus	Changeable Hawk-Eagle	EN	LC	T1_05/10, T3_04/07, 1.33101, 103.81994 (incidental)
Pycnonotus brunneus	Asian Red-eyed Bulbul	EN	LC	1.33108, 103.83381
Pycnonotus zeylanicus	Straw-headed Bulbul	EN	CR	T1_04/06/12, T2_01/04/10

NOTE: (LC = Least Concern, NT = Near-threatened; VUL = Vulnerable, EN = Endangered, CR = Critically Endangered). The local status follows the Singapore Red Data Book and the global status follows the IUCN Red List.

Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Terrestrial Transect 1
- Terrestrial Transect 2
- Terrestrial Transect 3

Bird Species Richness

- 0
- 2 - 8
- 9 - 13
- 14 - 21
- 22 - 27

N

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HOUSING & DEVELOPMENT BOARD

Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

NUMBER OF BIRD SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TERRESTRIAL TRANSECTS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
BT	DY	JAG	12-47	-	1 of 1
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Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Accipiter trivirgatus
- Ardea purpurea
- Copsychus saularis
- Copsychus malabaricus
- Gallus gallus
- Loriculus galgulus
- Nisaetus cirrhatus
- Pycnonotus brunneus
- Pycnonotus zeylanicus
- Rallina fasciata
- Nisaetus cirrhatus nest

N

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Project Title :

CONTRACT L/003/19 ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

LOCATIONS OF CONSERVATION SIGNIFICANT BIRD SPECIES

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
BT	DY	JAG	12-48	-	1 of 1
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Figure 12-49: Changeable Hawk Eagle (*Nisaetus cirrhatus*) Nest Recorded

Figure 12-50: Red Junglefowl (*Gallus gallus*)

Figure 12-51: Blue-Crowned Hanging Parrot (*Loriculus galgulus*)

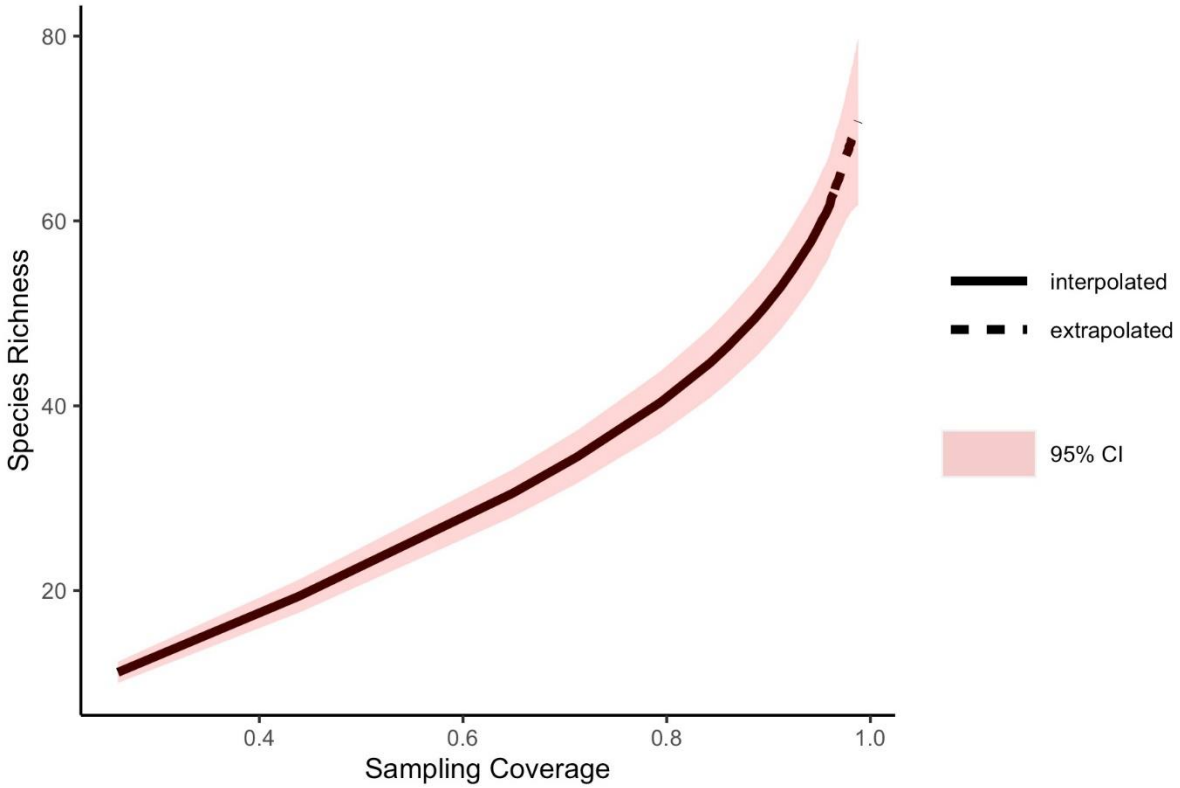

Figure 12-52: Coverage-based Rarefaction and Extrapolation Curve for Bird Species Recorded During Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

Non-volant Mammals

Historically, Singapore's mammalian fauna numbered upwards of 86 indigenous terrestrial species (Baker and Lim, 2012). Following deforestation and urbanisation, Singapore's mammal assemblage has strongly decreased to 54 species (*ibid*). Particularly susceptible to extinction were the bats, which constitute the bulk of Singapore's mammalian fauna, and large mammals (Corlett, 1992; Teo and Rajathurai, 1997; Lane et al., 2006). As a result, Singapore's mammal assemblage today is comprised largely of small mammals (15 species) and bats (25 species).

Excluding bats, 13 of the 30 species of non-volant mammals were deemed of probable occurrence refer to **Table 12-11** and **Appendix D of the Addendum**).

At T1 and T2, terrestrial transects and camera trapping documented the presence of five species of non-volant mammals (refer to **Appendices D and F of the Addendum**) that are the common inhabitants of such forests. This includes Annandale's Rat (*Rattus annandalei*), Plantain Squirrel (*Callosciurus notatus*) Common Treeshrew (*Tupaia glis*), and Common Palm Civet (*Paradoxurus musangus*). The species are recorded along both transects with the exception of along Mount Pleasant Road (T1_08 to T1_15) and are expected to be using the entire Study Area (refer to **Figure 12-53**). The Long-tailed Macaque (*Macaca fascicularis*) was recorded several times incidentally along T1, T2, Mount Pleasant Road, and in camera traps as well. The results from camera trapping will be discussed in detail in the **Section 12.3.3.2**.

Around the proposed slip road, terrestrial transects and camera trapping documented the presence of four species of non-volant mammals (**Appendices D and F of the Addendum**) that are the common inhabitants of such forests. This includes Annandale's Rat (*Rattus annandalei*), Plantain Squirrel (*Callosciurus notatus*) Common Treeshrew (*Tupaia glis*), and Common Palm Civet (*Paradoxurus musangus*). The Long-tailed Macaque (*Macaca fascicularis*) was not recorded in the targeted surveys or incidentally but are likely to use the Study Area on both sides of Mount Pleasant Road as they have been observed along the road. There were no patterns or hotspots observed for mammal usage in this area.

The camera trapping had an unconfirmed recording of the critically endangered Malayan Porcupine (*Hystrix brachyura*). The detailed discussion is in the camera trapping section, **Section 12.3.3.2**.

The sampling effort achieved 87.76% of the sample coverage (refer to **Table 12-12**, **Figure 12-54**), indicating that more surveys may be needed to achieve a complete coverage of the species richness. The true species richness based on the estimators for the Study Area is between one and six species, which is close to the observed species number of three.

Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Terrestrial Transect 1
- Terrestrial Transect 2
- Terrestrial Transect 3

Non-volant Mammal Species Richness

- 0
- 1
- 2

N

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ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

NUMBER OF NON-VOLANT MAMMAL SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TERRESTRIAL TRANSECTS

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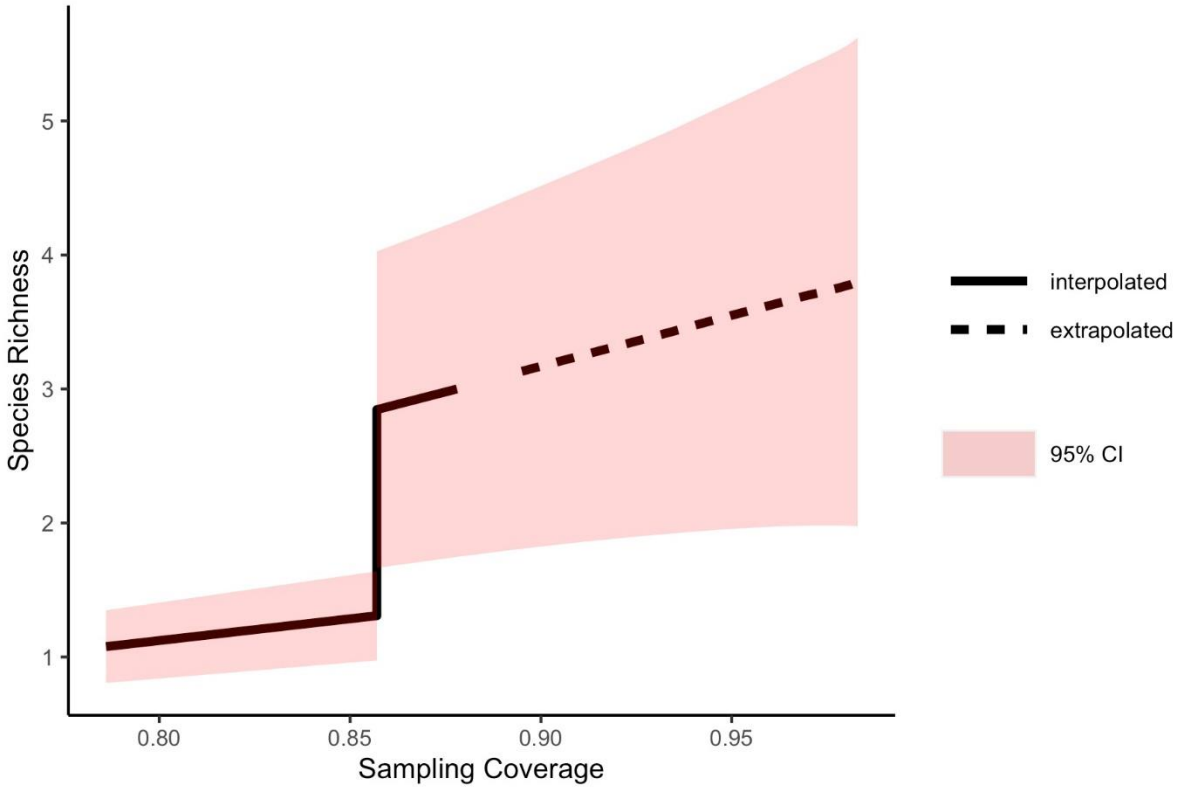

Figure 12-54: Coverage-based Rarefaction and Extrapolation Curve for Non-volant Species Recorded During Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

Volant Mammals: Bats

As mentioned above, bats constitute the bulk of Singapore's mammal assemblage, with 25 extant species. The bat assemblage is split between six Megachiroptera (fruit bats) and 19 Microchiroptera (insectivorous bats). Singapore is situated along the centre of bat diversity for the Old World (Lane et al., 2006), and it is estimated that Singapore's bat diversity once numbered between 60 and 72 species, prior to British settlement in 1819 (*ibid*). However, only ten species are known to have gone extinct in Singapore (Lane et al., 2006; Leong and Chan, 2011). The Large Flying Fox (*Pteropus vampyrus*) used to exist in large numbers, but presently, only appears occasionally in Singapore as a visitor (Lane et al., 2006). Many of the extant bats are rare or occur outside of the CCNR (Pottie et al., 2005; Baker and Lim, 2012).

Only nine bats (two fruit bats and seven insectivorous bats) were deemed of probable occurrence within the Study Area (refer to **Table 12-11** and **Appendix D of the Addendum**). Of these, eight species and one unique genus of bats were recorded, comprising of two fruit bats and one genus of insectivorous bats detected via trapping, and five insect bats detected via acoustic sampling during the transect surveys. Six species are common and widespread in urban Singapore.

Bamboo bats (*Tylonycteris* spp.), also known as flat-headed bats, are insectivorous bats that roost in the internodes of bamboo. The bats enter and exit the internodes via slits on the bamboo stem made by beetles (Medway and Marshall, 1970). In Singapore, there are two species of bamboo bats—the Lesser Bamboo Bat (*Tylonycteris fulvida*) and the Greater Bamboo Bat (*Tylonycteris malayana*). The Lesser Bamboo Bat is listed as Critically Endangered in the Singapore Red Data Book (Davison et al., 2008) whereas the Greater Bamboo Bat is not assessed in the Singapore Red Data Book (Davison et al., 2008). Due to the difficulty in differentiating the two bat species from their physical attributes and calls, the bamboo bats caught are not identified to the species level and it is assumed that there is a possibility that the bats caught are the critically endangered Lesser Bamboo Bat.

Bamboo bats were caught in three harp traps and one mist net across the site (HT03, HT04, HT05; refer to **Figure 12-55**, **Figure 12-57**), where the bamboo species at HT03 and HT05 was identified as *Bambusa vulgaris*. HT04 was not placed at a bamboo cluster. One individual of the widespread but

uncommon Cave Nectar Bat (*Eonycteris spelaea*) and five individuals of the widespread and common Lesser Dog-faced Fruit Bat (*Cynopterus brachyotis*) were caught in the canopy mist net, while no bats were caught in the mist nets at ground level.

Along Transects 1 and 2, the Glossy Horseshoe Bat (*Rhinolophus lepidus*), which is common but restricted, was recorded once at T2_06 via acoustic sampling. Insectivorous bats were observed to be feeding on flying insects attracted to the light around the street lamps at T1_01 and T2_01. Acoustic sampling recorded these to be predominantly the Asiatic Lesser Yellow House Bat (*Scotophilus kuhlii*) (refer to **Figure 12-58**), although the Whiskered Myotis (*Myotis muricola*) and a species of bat from the Emballonuridae family were also recorded. The Pouch-bearing Bat (*Saccolaimus saccolaimus*) and the Black-bearded Tomb Bat (*Taphozous melanopogon*) are from the Emballonuridae family but have acoustic calls which are difficult to differentiate (Hughes et al., 2011). The Pouch-bearing Bat (*Saccolaimus saccolaimus*) was an expected species while the Black-bearded Tomb Bat (*Taphozous melanopogon*) was not expected but is locally endangered. Whiskered Myotis are known to roost inside banana plants which are commonly seen in parks and gardens. The Asiatic Lesser Yellow House Bat is known to roost in large colonies in spaces of buildings and are commensal with humans. Most of the bat observations were made along the roads and open paths, not within the forest interior.

Around the proposed slip road, at least two individuals of bamboo bats were caught in mist net (MN09) targeted at a cluster of *Bambusa vulgaris* close to the PIE (refer to **Figure 12-55**). The first bat that was trapped escaped and no measurements were taken, therefore, it could not be concluded if the same bat was trapped again subsequently. One individual of the Glossy Horseshoe Bat (*Rhinolophus Lepidus*) was caught in HT09. The observation is notable as this species is more forest dependent, indicating a good forest habitat in the hinterland of the Bukit Brown Woods.

Along Transect 3, acoustic and visual surveys observed four common and widespread species of bats, all of which were also observed in Transects 1 and 2 . This included the common Lesser Dog-faced Fruit Bat (*Cynopterus brachyotis*), Asiatic Lesser Yellow House Bat (*Scotophilus kuhlii*), Whiskered Myotis (*Myotis muricola*) and a species of bat from the Emballonuridae family. There were no patterns or distinct hotspots for the observation of bats.

The sampling effort achieved 96.61% of the sample coverage (refer to **Table 12-12**, **Figure 12-59**), indicating that the faunal survey effort was sufficient to capture most of the species within the site. The true species richness based on the estimators for the Study Area is between four and ten species, which is close to the observed species number of six, suggesting sampling completeness.

Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Bat Trap Results

- Canopy Mist Net, Present
- Harp Trap, Absent
- Harp Trap, Present
- Mist Net, Absent
- Mist Net, Present

VO Bat Trap Results

- Visual Roost Emergence, Present

N

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Project Title :

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Figure Title :

PRESENCE AND ABSENCE OF BATS TRAPPED WITHIN HARP TRAPS AND MIST NETS DURING BAT TRAPPING

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Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Terrestrial Transect 1
- Terrestrial Transect 2
- Terrestrial Transect 3

Bat Species Richness

- 0
- 1 - 2
- 3 - 4
- 5
- Tylonycteris sp.

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ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

NUMBER OF BATS SPECIES RECORDED AT EACH SAMPLING POINT ALONG THE TERRESTRIAL TRANSECTS AND LOCATIONS OF CONSERVATION SIGNIFICANT BAT SPECIES

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Figure No. : 12-56 | Rev. : - | Sheet : 1 of 1

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Figure 12-57: Bamboo Bat (*Tylonycteris* Spp.) Caught in Harp Trap

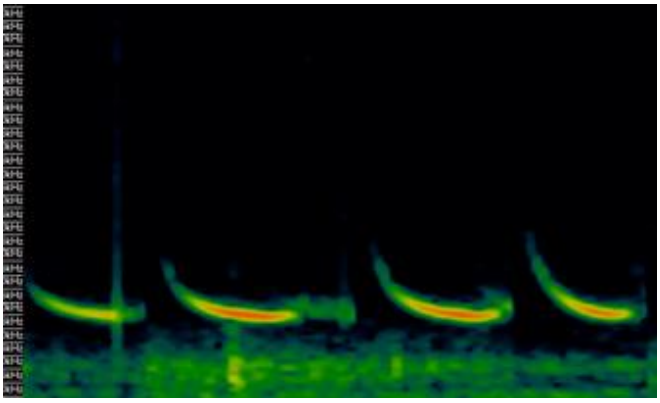

Figure 12-58: Spectrogram of the Asiatic Lesser Yellow House Bat (*Scotophilus kuhlii*)

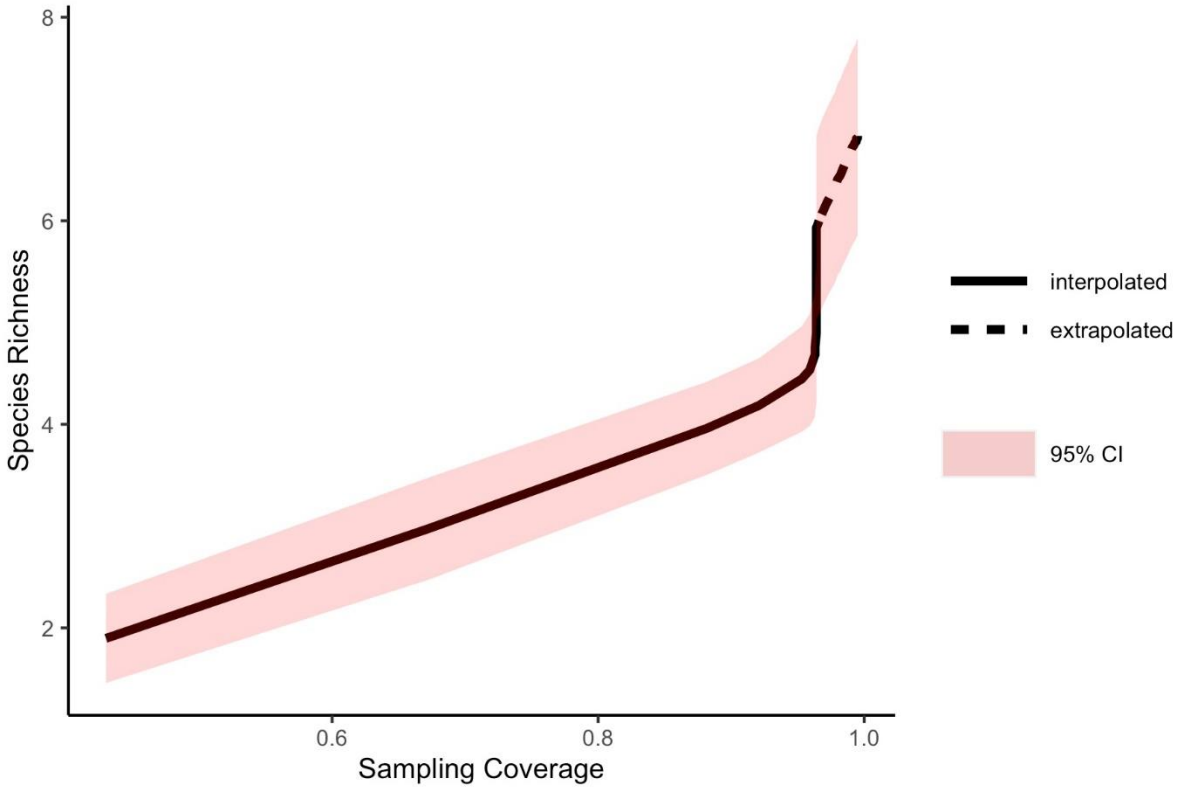

Figure 12-59: Coverage-based Rarefaction and Extrapolation Curve for Bat Species Recorded during Terrestrial Transect Surveys in the Study Area, with 95% Confidence Interval (CI) (Shaded Areas), Based on a Bootstrap Method with 50 Replications

12.3.3.2 Camera Trapping

Eight camera traps yielded 131 independent detections of fauna species over 224 trap-nights (mean night per camera trap = 28; refer Table 12-15). MP08 was faulty and only active for only 11 nights despite a regular maintenance check during the survey period, resulting in less data. The full set of camera trap data is available in **Appendix F of the Addendum**.

A total of 16 species was recorded, comprising eight birds, six mammals, two reptiles, and some unidentifiable fauna species (refer to **Table 12-15**). Out of the six mammal species observed, one mammal species observed could have been a Malayan Porcupine (*Hystrix brachyura*; refer to below). The Common Treeshrew (*Tupaia glis*), Annandale's Rat (*Rattus annandalei*) and Malayan Night Heron (*Gorsachius melanolophus*) (refer to **Figure 12-61**) were observed only in the camera traps and not in the other surveys.

The most commonly recorded mammal species was the Plantain Squirrel (*Callosciurus notatus*; *n*=33), followed by Annandale's Rat (*Rattus annandalei*; *n*=18) (refer to **Table 12-17**), both of which are highly adaptable species which use both the forest floor and canopy. The Common Palm Civet (*Paradoxurus musangus*) was only observed twice (refer to **Table 12-17**; **Figure 12-62**) which is likely due to its arboreal habits (Baker and Lim, 2012).

The highest mammal richness (*n*=5) was recorded on both sides of Onraet Road at MP_02 and MP_05 whereas the highest fauna richness (*n*=8) was recorded at MP02 (refer to **Table 12-17**, **Figure 12-60**). Correspondingly, the detection rate of all fauna and only mammals were also the highest at MP_02 (refer to **Table 12-15**). The detection rate is the number of independent detections captured at the same camera trap, over the number of independent nights; the detections were standardised to 60 mins (Chua, 2016).

Interestingly, in MP07, the unidentifiable mammal which was unlikely to be a rat, shrew or squirrel species due to its height and possible quills could have been a Malayan Porcupine (*Hystrix brachyura*) (refer to **Figure 12-63**), which is locally critically endangered and a significant observation. While Malayan Porcupines (*Hystrix brachyura*) are known to take regular routes based on previous studies undertaken by Camphora Pte Ltd, no other videos of the mammal were recorded. However, a burrow was observed within 10m of the camera trap (refer to **Figure 12-64**). To take a conservative approach, Camphora Pte Ltd does not rule out the presence of the species as it is of conservation significance. Another notable observation, seen only on the camera trap MP07, is the Eyebrowed Thrush (*Turdus obscurus*), an uncommon migrant. This observation, along with the other transect observations, indicates that the Study Area is a stop-over ground for migratory birds.

The sample coverage for the Study Area was 100% (refer to **Table 12-12**, **Figure 12-65**), indicating that the camera trapping effort was adequate to capture most of the mammal species potentially detectable by camera trapping. The true mammal species richness based on the estimators for the area is between four and six species (refer to **Figure 12-65**), which is close to the mammals species detected of five, suggesting sampling completeness.

Table 12-15: Species Richness and Detection Rates of Fauna and Mammals for each Camera Trap

Camera trap no.	No. of trap-nights	Detection rate of fauna	Detection rate of mammals	No. of fauna species recorded	No. of mammal species recorded
MP01	30	0.30	0.23	3	2
MP02	30	1.03	0.70	8	4
MP03	30	1.17	0.33	6	3
MP04	30	0.63	0.57	4	3
MP05	30	0.63	0.63	3	4
MP06	30	0.23	0.20	4	3
MP07	33	0.3	0.15	7	4
MP08	11	0.01	0	2	0

Table 12-16: Number of Independent Detections of each Species Recorded by Camera Traps in the Study Area

Taxon	Scientific Name	Common Name	No. of independent detections in the Study Area (n)
Bird	*Acridotheres javanicus*	Javan Mynah	4
Bird	*Amauronis phoenicurus*	White-breasted Waterhen	14
Mammal	*Callosciurus notatus*	Plantain Squirrel	33
Reptile	*Eutropis multifasciata*	Many-lined Sun Skink	1
Bird	*Garrulax leucolophus*	White-crested Laughingthrush	7
Bird	*Gorsachius melanolophus*	Malayan Night Heron	2
Mammal	*Macaca fascicularis*	Long-tailed Macaque	4
Bird	*Oriolus chinensis*	Black-naped Oriole	2
Mammal	*Paradoxurus musangus*	Common Palm Civet	2
Bird	*Picus vittatus*	Laced Woodpecker	1
Mammal	*Rattus annandalei*	Annandale's Rat	18
Bird	*Spilopelia chinensis*	Spotted Dove	7
Mammal	*Tupaia glis*	Common Treeshrew	17
Bird	*Turdus obscurus*	Eyebrowed Thrush	1
Reptile	*Varanus nebulosus*	Clouded Monitor	3
Reptile	*Varanus* sp.	Monitor Lizard sp	2
Mammal	unidentified squirrel/shrew	N/A	5
Bird	unidentified bird	N/A	1
Mammal	unidentified mammal	N/A	6 (including unconfirmed *H. brachyura)*
-	unidentified species	N/A	1
Total			**132**

Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)

Vegetation Map

- Scrubland and Herbaceous Vegetation
- Managed Vegetation (cemetery)
- Managed Vegetation (others)
- Abandoned-land Forest
- Waste Woodlands
- Native-dominated Secondary Forest

Fauna Transects

- Terrestrial Transect 1
- Terrestrial Transect 2
- Terrestrial Transect 3

Species Richness per Camera Trap

- 0
- 2
- 3
- 4

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Figure Title :

NUMBER OF MAMMAL SPECIES OBSERVED AT EACH CAMERA TRAP

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Figure 12-61: Screen Capture of the Malayan Night Heron (*Gorsachius melanolophus*) Captured at MP02

Figure 12-62: Screen Capture of Common Palm Civet (*Paradoxurus musangus*) Captured at MP06

Figure 12-63: Screen Capture of the Unidentified Mammal; Possibly Malayan Porcupine (*Hystrix brachyura*) at MP07

Figure 12-64: Burrow About 15cm Wide, within 10m of the Camera Trap MP07

Table 12-17: The Number of Mammal Species Recorded via Camera Trapping, Sample Coverage and the Estimated True Mammal Species Richness. The Number of Sampling Units Refer to the Number of Trap-Nights with Mammal Species Records. Values for Estimated True Species Richness Represent ± Standard Error.

Terrestrial Fauna Group	Recorded	n	Estimated True Species Richness (Chao)	Sampling Coverage (%)
Non-volant mammals	5	67	5 ± 0.50	100

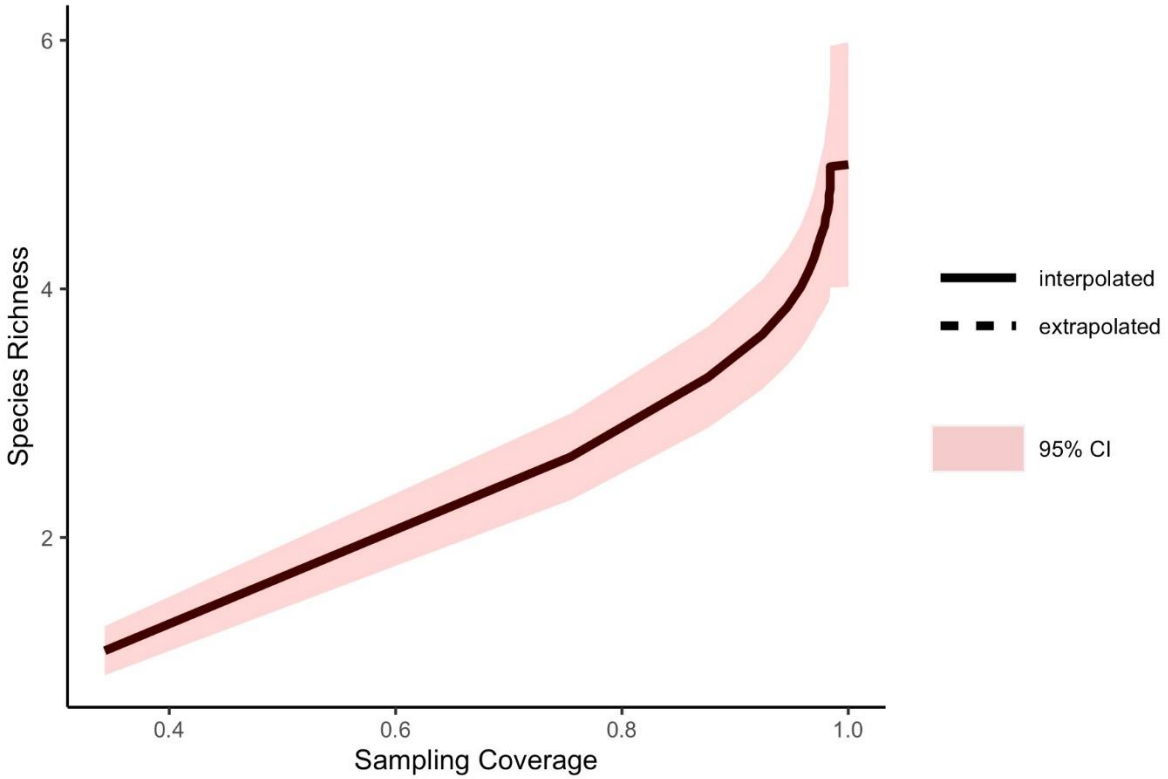

Figure 12-65: Coverage-Based Rarefaction and Extrapolation Curve for Mammals Recorded via Camera Trapping at the Study Area

12.4 Summary of Baseline Findings and Assessment of Ecological Value

12.4.1 Summary of Biodiversity Baseline Findings

The Study Area is composed of six vegetation types, excluding the area affected by the construction of Mount Pleasant MRT Station that is not vegetated. The area is composed largely of managed vegetation (46.23%) that is found within the private compound areas of the WRC, and Black and White bungalows along Mount Pleasant Road. Abandoned-land forest made up the next most expansive vegetation type (25.94%). The remaining delineated vegetation types comprised of managed vegetation (cemetery) (5.27%), native-dominated low secondary forest (4.27%), scrubland and herbaceous vegetation (4.12%) and waste woodlands (3.54%) and There was no distinct species composition around the three streams.

The flora inventory revealed a total of 378 species of vascular plants from 107 families. 23.54% (n=89) of the recorded plant species were of true conservation significance. The plant species of conservation significance were concentrated mostly within the native-dominated secondary forest and abandoned-land forest in the west of SPOM (refer to **Figure 12-66**). A total of 225 large trees, palms and bamboos (≥ 3 m in girth or spread), were documented within the Study Area (refer to **Figure 12-66**) and was a mix of both common and exotic species. The native tembusu (*Cyrtophyllum fragrans,* n=75) was the most commonly recorded large tree specimen, followed by the native Malayan Banyan (*Ficus microcarpa*, n=38).

The fauna desktop assessment identified 468 species of probable occurrence with the field assessment confirming the presence of 35.25% (n=165) of the species of probable occurrence (refer to **Table 12-11**). The list of probable species of hymenoptera is not available and thus not considered in this figure; a total of 31 species of hymenoptera were recorded. A total of 14 species of conservation significance were recorded, including one dragonfly, one butterfly, one reptile, 10 bird and one bat species. These include the Collared Threadtail (*Prodasineura collaris*), the Common Rose (*Pachliopta aristolochiae asteris*), the Asian Softshell Turtle (*Amyda cartilaginea*), the Crested Goshawk (*Accipiter trivirgatus*), the White-rumped Shama (*Copsychus malabaricus*), the Asian Red-eyed Bulbul (*Pycnonotus brunneus*) and Blue-crowned Hanging Parrot (*Loriculus galgulus*). While not identified to species level, the bamboo bat (*Tylonycteris sp.*) recorded may be of conservation significance.

Around T1 and T2, species richness recorded along Mount Pleasant Road appeared low than that of the interior areas of the site, with the highest species richness recorded in the cemetery area with managed vegetation (refer to **Figure 12-24**). Around the proposed slip road, species richness recorded along the PIE appeared lower than that of the areas further away from the PIE (refer to **Figure 12-24**), which is expected due to the level of disturbance from the PIE. However, the size of both Study Areas is small and most species recorded were expected to be capable of using the entire area.

At least 15 clusters of bamboo assessed to be suitable for bamboo bats to roost in were also observed across the Study Area. The presence of bamboo bats was documented at four bamboo clusters in the Study Area. As the morphometric measurements of the Lesser Bamboo Bat (*Tylonycteris fulvida*) and the Greater Bamboo Bat (*Tylonycteris malayana*) overlap and it is difficult to differentiate the acoustic calls, Camphora Pte Ltd was unable to distinguish the identity of the records. Nevertheless, both species reside in bamboo internodes and are especially susceptible to injury and mortality if the roost bamboo clusters are affected by construction works and are thus highlighted.

Key ecological features present in the Study Area are discussed as receptors in **Section 12.5.1**.

12.4.2 Ecological Value of Study Area

The ecological value of the Study Area was evaluated based on eight characteristics for habitats and three characteristics for species listed in **Table 6-2** (adapted from Hong Kong EIA Ordinance, 2019). The characteristics are classified based on the receptor of an impact, where ecological features are defined as receptors (i.e., habitat or species). For example, vegetation loss is a habitat-related impact whereas roadkill is a species-related impact.

Overall, the Study Area was assessed to have a mix of features of low, medium and high ecological values (refer to **Table 12-18**).

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Table 12-18: Summary of the Assessment of Ecological Value for the Study Area and Each Habitat Type within the Study Area.

Overall Evaluation of Ecological Value of Study Area
[Levels of assessment: Low, Medium and High]

The ecological value of the Study Area was assessed based on the habitat types present, as well as:

(i) The low degree of fragmentation (urban infrastructures such as managed vegetation, roads, and houses are) within the Study Area;
(ii) Its proximity to CCNR (1.5km away) with high ecological linkage and
(iii) The Study Area being within Tree Conservation Area.

The area of LTA's construction site was 10.62% of the Study Area and was not assessed as a habitat type.

Evaluation for each Habitat Type		Native-dominated Secondary Forest	Abandoned-land Forest	Waste Woodlands	Managed Vegetation (cemetery)	Scrubland and Herbaceous Vegetation	Managed Vegetation (others)	Waterbody (Streams 1 and 2)	Waterbody (Stream 3)
Ecological Value of each Habitat Type		Low	Medium	Medium-low	Low	Medium-low	Medium-high	High	High
Habitat									
Quality	**Naturalness**	Managed, mix of exotic and native species	Spontaneous, mostly of exotic species	Managed and spontaneous, mostly of exotic species	Spontaneous, mostly of exotic species	Spontaneous, mostly of exotic species	Spontaneous, mix of exotic and native species	Naturalised	Naturalised
	Size (ha) (% of total Study Area)	3.06-ha (4.27%)	18.56-ha (25.94%)	2.53-ha (3.54%)	3.77-ha (5.27%)	2.95-ha (4.12%)	33.09-ha (46.23%)	740 m and 110 m	Surveyed length: 100 m, based on satellite imagery, at least 380 m
	Species richness	Medium flora and fauna diversity.	Medium flora diversity, high fauna diversity.	Low flora and fauna diversity.	Low to medium flora diversity, high fauna diversity.	Low flora and fauna diversity.	Medium flora diversity and low fauna diversity.	Low flora and fauna diversity.	Low flora and fauna diversity.
	Species assemblage	23 individuals of eight species of conservation significant flora observed Four species of conservation significant fauna observed	357 individuals of 45 species of conservation significant flora observed Six species of conservation significant fauna observed	33 individuals of 16 species of conservation significant flora observed Two species of conservation significant fauna observed	36 individuals of 10 species of conservation significant flora observed Three species of conservation significant fauna observed	10 individuals of eight species of conservation significant flora observed Three species of conservation significant fauna observed	44 individuals of 19 species of conservation significant flora observed Five species of conservation significant fauna observed	NA (flora) One species of conservation significant fauna observed Presence of fauna species with restricted distribution	NA (flora) One species of conservation significant fauna observed Presence of fauna species with restricted distribution

Overall Evaluation of Ecological Value of Study Area
[Levels of assessment: Low, Medium and High]

The ecological value of the Study Area was assessed based on the habitat types present, as well as:

(i) The low degree of fragmentation (urban infrastructures such as managed vegetation, roads, and houses are) within the Study Area;
(ii) Its proximity to CCNR (1.5km away) with high ecological linkage and
(iii) The Study Area being within Tree Conservation Area.

The area of LTA's construction site was 10.62% of the Study Area and was not assessed as a habitat type.

Evaluation for each Habitat Type		Native-dominated Secondary Forest	Abandoned-land Forest	Waste Woodlands	Managed Vegetation (cemetery)	Scrubland and Herbaceous Vegetation	Managed Vegetation (others)	Waterbody (Streams 1 and 2)	Waterbody (Stream 3)
Ecological Value of each Habitat Type		Low	Medium	Medium-low	Low	Medium-low	Medium-high	High	High
Habitat									
			Presence of fauna species with restricted roosting site (*Tylonycteris* sp.).	Presence of fauna species with restricted roosting site (*Tylonycteris* sp.). Note: The bamboo bats were trapped at the edge of the habitat type, adjacent to the native-dominated secondary forest.				(*Prodasineura collaris*)	(*Amyda cartilaginea)*.
	Large specimens	18 large specimens	92 large specimens	Seven large specimens	13 large specimens	One large specimen	70 large specimens	NA	NA
	Rarity	Common	Common	Common	Common	Common	Uncommon	Rare	Rare
Resilience	**Sensitivity**	Low	Medium	Medium	Low	Low	High	High	High

Table 12-19: Summary of Fauna Species of High Ecological Value.

Faunal Group	Scientific name	Common name	Local status	Global status	Distribution/ Rarity	Recorded Species	Location of records
Odonate	*Drepanosticta quadrata*	Singapore Shadowdamsel	Vulnerable	Not assessed	Restricted but Common	No	NA
Odonate	*Vestalis amethystina*	Common Flashwing	Vulnerable	Not assessed	Restricted but Common	No	NA
Odonate	*Prodasineura collaris*	Collared Threadtail	Endangered	Least Concern	Restricted & Uncommon	Yes	S1_01 - 06, S2_02
Butterfly	*Astictopterus jama*	Forest Hopper	Nationally Extinct (Rediscovered)	Not assessed	Moderately rare	No	NA
Butterfly	*Catopyrops ancyra*	Ancyra Blue	Vulnerable	Not assessed	Moderately rare	No	NA
Butterfly	*Cephrenes acalle niasicus*	Plain Palm Dart	Nationally Extinct (Rediscovered)	Not assessed	Moderately rare	No	NA
Butterfly	*Discophora sondaica despoliata*	Common Duffer	Critically Endangered	Not assessed	Rare	No	NA
Butterfly	*Jamides alecto ageladas*	Metallic Caerulean	Nationally Extinct (Rediscovered)	Not assessed	Moderately rare	No	NA
Butterfly	*Liphyra brassolis abbreviata*	Moth Butterfly	Nationally Extinct (Rediscovered)	Not assessed	Very rare	No	NA
Butterfly	*Papilio prexaspes*	Blue Helen	Vulnerable	Not assessed	Rare	No	NA
Butterfly	*Pelopidas agna*	Bengal Swift	Endangered	Not assessed	Moderately common	No	NA
Butterfly	*Pseudotajuria donatana*	Golden Royal	Critically Endangered	Not assessed	Very rare	No	NA
Butterfly	*Rachana jalindra burbona*	Banded Royal	Critically Endangered	Not assessed	Very rare	No	NA
Butterfly	*Troides helena cerberus*	Common Birdwing	Vulnerable	Not assessed; CITES protected (Appendix II)	Moderately common	No	NA
Butterfly	*Pachliopta aristolochiae asteris*	Common Rose	Vulnerable	Not assessed	Moderately common	Yes	T2_06
Reptile	*Amyda cartilaginea*	Asian softshell turtle	Endangered	Vulnerable	Restricted and Uncommon	Yes	S3_01
Reptile	*Cuora amboinensis*	Malayan Box Terrapin	Endangered	Vulnerable	Restricted but Common	No	NA
Bird	*Alcedo meninting*	Blue-eared Kingfisher	Critically Endangered	Least Concern	Rare	No	NA
Bird	*Anthracoceros albirostris*	Oriental Pied Hornbill	Critically Endangered	Critically Endangered	Common	No	NA
Bird	*Cacomantis sepulcralis*	Rusty-breasted Cuckoo	Vulnerable	Least Concern	Uncommon	No	NA
Bird	*Chrysococcyx xanthorhynchus*	Violet Cuckoo	Endangered	Least Concern	Rare	No	NA
Bird	*Dryocopus javensis*	White-bellied Woodpecker	Critically Endangered	Least Concern	Very rare	No	NA

Faunal Group	Scientific name	Common name	Local status	Global status	Distribution/ Rarity	Recorded Species	Location of records
Bird	*Halcyon coromanda*	Ruddy Kingfisher	Critically Endangered	Least Concern	Rare	No	NA
Bird	*Haliaeetus ichthyaetus*	Grey-headed Fish Eagle	Critically Endangered	Near Threatened	Uncommon	No	NA
Bird	*Psittinus cyanurus*	Blue-rumped Parrot	Critically Endangered	Near Threatened	Uncommon	No	NA
Bird	*Pycnonotus atriceps*	Black-headed Bulbul	Critically Endangered	Least Concern	Rare	No	NA
Bird	*Pycnonotus zeylanicus*	Straw-headed Bulbul	Endangered	Critically Endangered	Uncommon	No	NA
Bird	*Spilornis cheela*	Crested Serpent Eagle	Critically Endangered	Least Concern	Rare	No	NA
Bird	*Strix seloputo*	Spotted Wood Owl	Critically Endangered	Least Concern	Uncommon	No	NA
Bird	*Surniculus lugubris*	Square-tailed Drongo-Cuckoo	Critically Endangered	Least Concern	Uncommon	No	NA
Bird	*Treron curvirostra*	Thick-billed Green Pigeon	Endangered	Least Concern	Uncommon	No	NA
Bird	*Accipiter trivirgatus*	Crested Goshawk	Critically Endangered	Least Concern	Uncommon	Yes	1.327091977, 103.82688 (incidental)
Bird	*Ardea purpurea*	Purple Heron	Endangered	Least Concern	Uncommon	Yes	T3_05
Bird	*Copsychus malabaricus*	White-rumped Shama	Critically Endangered	Least Concern	Uncommon	Yes	T1_09
Bird	*Copsychus saularis*	Oriental Magpie-Robin	Endangered	Least Concern	Uncommon	Yes	T1_11
Bird	*Gallus gallus*	Red Junglefowl	Endangered	Least Concern	Common	Yes	T1_10/15, T2_03/04/08, T3_06
Bird	*Loriculus galgulus*	Blue-crowned Hanging-parrot	Endangered	Least Concern	Common	Yes	T1_03/04/-05/10/13, T2_02/04/05/08, T3_02/03/05/07/08
Bird	*Nisaetus cirrhatus*	Changeable Hawk-Eagle	Endangered	Least Concern	Uncommon	Yes	T1_05/10, T3_04/07, 1.33101, 103.81994 (incidental)
Bird	*Pycnonotus brunneus*	Asian Red-eyed Bulbul	Endangered	Least Concern	Uncommon	Yes	1.33108, 103.83381
Bird	*Pycnonotus zeylanicus*	Straw-headed Bulbul	Endangered	Critically Endangered	Uncommon	Yes	T1_04/06/12, T2_01/04/10
Bird	*Rallina fasciata*	Red-legged Crake	Vulnerable	Least Concern	Uncommon	Yes	T1_04/05

Faunal Group	Scientific name	Common name	Local status	Global status	Distribution/ Rarity	Recorded Species	Location of records
Bat	*Eonycteris spelaea*	Cave Nectar Bat	Not Listed	Least Concern	Widespread but Uncommon	Yes	CMN01
Bat	*Rhinolophus lepidus*	Glossy Horseshoe Bat	Not Listed	Least Concern	Restricted but Common	Yes	HT09
Bat	*Tylonycteris pachypus**	Lesser Bamboo Bat	Critically Endangered	Least Concern	Rare & Restricted	Yes	HT03/04/05, MN09
Bat	*Tylonycteris robustula**	Greater Bamboo Bat	Not Listed	Least Concern	Widespread but Uncommon	Yes	HT03/04/05, MN09

* The bamboo bats cannot be differentiated.

12.4.2.1 Habitat Descriptions

The managed vegetation and scrubland and herbaceous vegetation covered more than half the Study Area (55.62%) and have a low ecological value. Native-dominated secondary forest is a rare habitat type but covers only a small portion of the Study Area (4.27%). It is therefore deemed to have a medium to high ecological value. The three streams, which have a total length of 970-m within the Study Area is a rare habitat type with fauna dependent on it, it is therefore given a high ecological value.

Migratory birds were observed over two migratory seasons during the surveys at the beginning and end of 2019. Winter visitors such as the Japanese Sparrowhawk (*Accipiter gularis*) and Asian Brown Flycatcher (*Muscicapa dauurica*) were observed during the night surveys, indicating that the site is a resting ground for migratory birds.

The Study Area also has a low degree of fragmentation from urban infrastructures, has the presence of the heritage road and tree, has ecological connectivity to the Central Catchment Nature Reserve and Bukit Brown Woods and is part of the Tree Conservation Area, all of which add to its value.

Large trees were evenly distributed throughout the site and provided an almost continuous forest cover on the western half of the Study Area. Additionally, the Study Area experiences a low degree of fragmentation with the exception of Mount Pleasant Road and low-rise buildings in some parts of the site. While the road may pose a barrier to some species, most species present at the Study Area are adaptable and likely able to move across the roads. The Study Area on the west of Mount Pleasant Road is part of the larger forest at Bukit Brown and is also thus deemed to be important for ecological connectivity, however, it is a thin upward sloping strip parallel to the PIE and faces higher light and noise disturbance from vehicular traffic compared to the forest interior. Consequently, about 400m of the fauna transect was conducted away from the study boundary as the disturbance from the PIE was deemed to be too disruptive for observation of fauna and while the flora surveys did not cover the fauna transect, it was observed that the forest type was similar and could therefore also have the native-dominated secondary forest type which has high ecological value.

Managed Vegetation (others)

The managed vegetated is rated with low ecological value. It is a man-made habitat created from planting of exotic and rare (cultivated) flora species, which is common in private compounds and along streetscapes. The habitat occupies the majority of the Study Area (46.23% in total), comprising of a moderate diversity of cultivated native flora species that is highly re-creatable. Due to planting, flora species of conservation significance with restricted distribution were recorded. No particular fauna species was associated with the managed vegetation and species observed were common and of widespread distribution.

Abandoned-land Forest

The abandoned-land forest is rated with a medium ecological value. It is a human-modified habitat comprising of forest regrown from land that was previously used for plantations or kampungs. It is common in Singapore and forms 25.94% of Study Area. However, such habitat is also increasingly uncommon with greater deforestation. It harbours a medium diversity of flora species and a high diversity fauna species within the site. Species of restricted distribution such as the Bamboo Bats (*Tylonycteris* sp.) were observed roosting in bamboo clusters here.

Managed Vegetation (cemetery)

The managed vegetated within the area of the cemetery grounds is rated with medium-low ecological value. Various area of the vegetation is maintained and cleared of vegetation, at least on a yearly basis due to the existing graves. The flora comprised of a mosaic of cultivated species and self-sown common native species. Less than ten flora species of conservation significance were scattered throughout the vegetation type. The habitat occupies 5.27% of the Study Area, comprising of a low to medium diversity of cultivated and self-sown native flora species that is re-creatable. In addition, some specimens of significance are present. No particular fauna species was associated with the managed vegetation although fauna species diversity was high.

Scrubland and Herbaceous Vegetation

The scrubland and herbaceous vegetation is rated with a low ecological value. It is characterised by spontaneous low vegetation dominated by exotic flora species, which is common and highly re-creatable. This vegetation type exists mostly along forest edge at the PIE and what may be an old road along the Freshwater Transect 1. It comprises of a small proportion of the Study Area (4.12%). No particular fauna species was associated with the managed vegetation.

Waste Woodlands

The waste woodlands is rated with a medium-low ecological value. It is an area that is highly disturbed and populated with a large number of exotic tree species that establish spontaneously and quickly in areas that have been cleared. It has a low diversity of self-sown native flora species and is easily re-creatable. It is a common in Singapore but forms only 3.54% of the Study Area. However, it forms a continuous forest habitat with the abandoned-land forest and native-dominated low secondary forest and its ecological value should be considered in this larger context. 35 nos. of flora specimens of conservation significance were scattered throughout the vegetation type. The habitat harbours a medium diversity of fauna species. Bamboo Bats (*Tylonycteris* sp.) were observed roosting in bamboo clusters here.

Native-dominated Secondary Forest

The native-dominated secondary forest is found on both sides of Mount Pleasant Road and forms 4.27% of the site. It is rated with a medium-high ecological value as it is uncommon and not easily re-creatable. In the Study Area, it is a small patch of about 1-ha surrounded by other types of vegetation and between to the edge of the forest and Mount Pleasant Road. Around the proposed slip road, the vegetation type exists as a forest edge on the edge of the PIE and receives disturbance from the expressway, it is observed that it could extend much further away from the PIE and beyond the Study Area. Thus, it is also an important buffer for the forest interior. It harbours a low diversity of self-sown native flora species and has a medium diversity of fauna species although this has to be taken in consideration with the size of the vegetation which was small. Large bamboo clusters were present, which could be potential roosts for the bamboo bat (*Tylonycteris* sp.).

Streams

There are three streams in the Study Area – Stream 1, Stream 2 and Stream 3, all of which are naturalised concrete canals but rated with a high ecological value. Forest streams are uncommon across Singapore; they host communities that are highly dependent on the unique and highly-specific environmental parameters that are maintained (Kwik & Yeo, 2015). While the vegetation structure and composition surrounding Streams 1 and 2 are not close to that a natural forest stream, it was noted to have a strong and established population of the restricted and endangered Collared Threadtail (*Prodasineura collaris*). Two individuals of Softshell Turtles, including one restricted and endangered Asian Softshell Turtle (*Amyda cartilaginea*) were observed in Stream 3.

pH, DO, TSS, water flow rate, canopy cover and leaf litter cover in the stream bed are important environmental conditions for biodiversity in freshwater streams. pH, DO and TSS were measured as part of the baseline studies and the data is compared to a comprehensive study that sampled 14 forest streams within the Central Catchment Nature Reserve (Blakely et al, 2014). The parameters in the surveyed streams are comparable to those of the Central Catchment Nature Reserve study.

Table 12-20: Comparison of pH, DO and TSS from the Study Area against 14 Streams in the CCNR (Blakely et al, 2014).

Parameter	Average from site readings at WQ1 to WQ6	Average value, Blakely et al (2014)	Range value, Blakely et al (2014)
pH	5.83	5.1	4 - 7
DO	2.22	5.6mg/l	3.3. - 7.0 mg/l
TSS	12.045 mg/l	100 mg/l	10 - 810 mg/l

Tropical forests streams naturally tend to be acidic due to the decomposing organic matter in the streams. This is correlated to the leaf litter and other organic matter that lie in the stream bed that form a suitable habitat for aquatic fauna. The pH of the streams are comparable to that of the 14 streams sampled in the Central Catchment Nature Reserve.

TSS affects the clarity of the stream which may in turn reduce the amount of sunlight reaching submerged aquatic plants if the streams are deep. However, the streams in Mount Pleasant are not

deep (observed to be less than 60-cm; refer to **Table 10-2**) and there were few submerged plants observed in the stream. A high TSS also negatively affects the respiratory system of aquatic fauna if the fauna are not surface breathers as solid particles may enter the respiratory systems of the fauna. The TSS of the surveyed streams are much lower than the range of the 14 streams sampled in the Central Catchment Nature Reserve and much lower than the average recorded.

DO is crucial for aquatic fauna which are not surface breathers and stay in the water for oxygen. DO concentrations below 5 mg/l may adversely affect function and survival of biological communities and concentrations below 2 mg/l can lead to death of fish that are not adapted to such conditions (Nguyen & Cai, 2019). The average DO at Mount Pleasant is low at 2.22mg/l compared to the average of 5.6mg/l in (Blakely et al, 2019), Notably, the low DO readings came mainly from Stream 1, where about 50% of the stream surface was covered with vegetation, which may have blocked the oxygen exchange on the water surface. It was noted to have a very slow to stagnant dry weather flow rate upstream and a low dry weather flow rate downstream (refer to **Table 10-2**), which could have also contributed to the low DO. The population of the endangered Collared Threadtail (*Prodasineura collaris*) does not seem to be negatively impacted by the low DO and this could be due to the existing bio load (number of individuals) in the stream being low.

12.4.2.2 Species Descriptions

A total of 89 plants of true conservation significance were recorded on site and a high concentration of saplings of certain species were observed although no mature trees were found in the vicinity. Given the Study Area's proximity to the Central Catchment Nature Reserve, it could be a receptor site for the arrival of seed propagules, adding to the ecological value of the Study Area. The list of conservation significant flora species is found in **Appendix B1 of the Addendum**.

14 species of locally conservation significant fauna and 3 species of fauna of interest were observed. This is expected since the site is in close proximity of the Central Catchment Nature Reserve and connected to Bukit Brown Woods.

An additional 28 species of high ecological value were identified to be likely found in the Study Area based on their conservation status, rarity and distribution (refer to **Table 6-2**). This includes two odonate species, 11 butterfly species, one reptile species and 14 bird species not observed during the surveys but considered to be of probably occurrence and included in the evaluation. A list of the fauna species is found in **Table 12-19**.

12.5 Ecological Impact Assessment

12.5.1 Key Ecological Receptors

Key ecological receptors present within and around the Study Area include (refer to **Figure 12-66**):

(i) Habitat type of medium-high ecological value (Native-dominated secondary forest) which covers 4.27% of the Study Area;

(ii) Habitat type of medium ecological value covering approximately a fourth of the Study Area (i.e. abandoned-land forest) which is approximately 25.94% of the Study Area;

(iii) Mount Pleasant Road as a Heritage Road which includes a heritage tree, *Ficus kurzii;*

(iv) 225 nos. of large specimens of trees, palms or bamboos across the site. The large specimens are made up of common, exotic, or critically endangered statuses. This includes a cluster 11 large Tembusu (*Cyrtophyllum fragrans*) in LTA's construction area and 69 nos. of *Ficus* spp. scattered across the site, which provide a food source for fauna all year round;

(v) Bamboo clusters which are potential habitats for bamboo bats, including the critically endangered Lesser Bamboo Bat (*Tylonycteris* sp.);

(vi) Stream 1 and 2 with sizeable populations of the endangered and restricted Collared Threadtail (*Prodasineura collaris*);

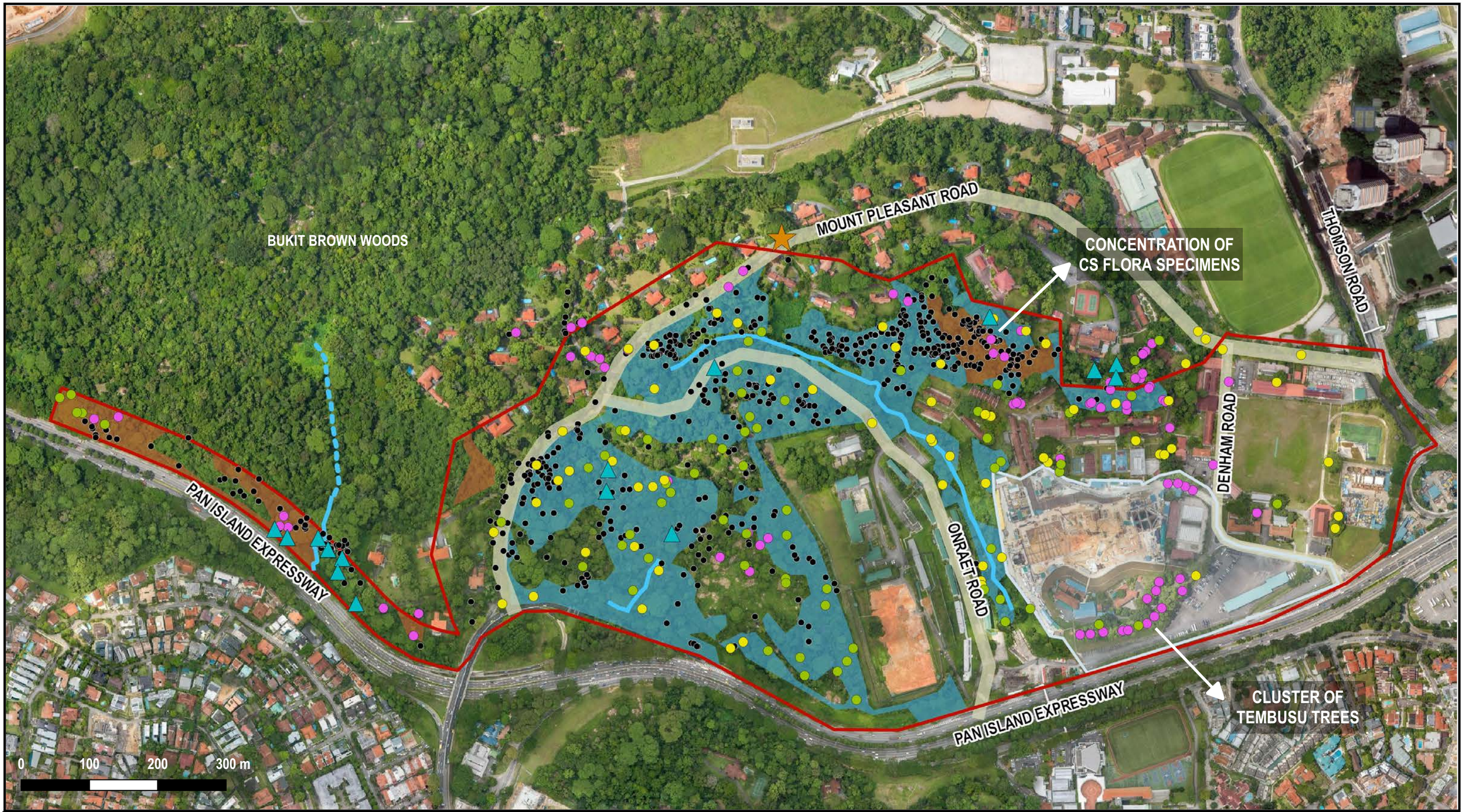
(vii) Stream 3 with one confirmed record of the endangered Asian Softshell Turtle (*Amyda cartilaginea*) and a separate record of an individual of *Amyda* species;

(viii) 17 faunal species and 89 floral species of high ecological value. In addition, 28 other faunal species of high ecological value were probable on site. For floral species, there was a concentration of specimens found in the west of SPOM;

(ix) Long-tailed Macaques. While the species are not of local conservation significance, macaques were observed on site and will be a likely source of human-wildlife conflict and fauna injury;

(x) Wild pigs. The species were not observed during the biodiversity surveys but it is a highly mobile mammal and could colonise the Study Area (not reflected in **Figure 12-66**). It is often involved in human-wildlife conflicts; and

(xi) Adjacent Bukit Brown Woods.



Legend

- Study Area
- Construction, no vegetation
- Stream
- Stream 3 (unsurveyed)
- Abandoned-land Forest
- Native-dominated Secondary Forest
- Location of Flora of Conservation Significance

Large Flora Specimens

- Ficus kurzii
- Bamboo species
- Tembusu
- Ficus species
- Other large tree

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	BT	Final Report	DY	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

KEY ECOLOGICAL RECEPTORS PRESENT

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
BT	DY	JAG	12-66	-	1 of 1
	Drawn BT	Date JAN 2021	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

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12.5.2 Approach

The ecological impact assessment evaluates the significance of impacts on various ecological components (i.e. flora, fauna and habitat) identified as the sensitive receptors within the Study Area.

An ecological impact is defined as an entity that alters the integrity and quality of the ecological components. Integrity refers to the "the ability of an ecological system to support and maintain a community of organisms that has a species composition, diversity, and functional organization comparable to those of natural habitats within a region" et al., 2008). The assessment was based on a precautionary principle. While it was based on the best available scientific evidence, in cases of reasonable doubt, where it is not possible to robustly justify a conclusion of no significant effect, a significant effect was assumed.

The sensitivity of the receptors is defined in **Table 6-1** and the impacts to respective receptors were evaluated based on the potential construction and operational activities described in **Section 3.2** and **3.4**. An assessment is provided for the overall development of the Study Area and for each development phase.

12.5.3 Classification of Receptors

Table 12-21: Classification of Receptors Identified within the Study Area

Receptor	Description of Ecological Value	Sensitivity Classification
Heritage road and tree	Heritage roads are scenic and significant tree-lined roads identified under the Heritage Road Scheme whereas heritage trees are mature trees identified under the Heritage Tree Scheme to conserve natural heritage of Singapore and serve as important green landmarks of Singapore. Mount Pleasant Road is one of the five heritage roads in Singapore. The large trees provide ecological connectivity and habitats for fauna within Bukit Brown Woods.	Priority 1
Bamboo clusters	Bamboo clusters serve as habitats for the Bamboo Bat (*Tylonycteris* sp.). The Lesser Bamboo Bat (*Tylonycteris fulvida*) is locally critically endangered.	Priority 1
Large Flora Specimens	Trees, palms and bamboos which are large provide a certain biomass and serve as habitats for a variety of fauna and other flora such as creepers and epiphytes. A total of 225 specimens were identified across the Study Area.	Priority 1
Streams 1 and 2	The streams are concrete drains which have been abandoned and subsequently naturalised. Stream 1 is more grassy and open whereas 2 is in a forested area and shady with part of the waterway still a large concrete drain taking water from the PIE. It is habitat to the locally endangered Collared Threadtail (*Prodasineura collaris*).	Priority 1
Stream 3	The stream is a concrete drain which has been abandoned and subsequently naturalised. It is at least 380m long based on satellite imagery and connected to and forested and scrubland habitat types. It is habitat to the locally endangered Asian Softshell Turtle (*Amyda cartilaginea)*.	Priority 1
Native-dominated Low Secondary Forest	The native-dominated low secondary forest is a vegetation type that is developed on land cleared before the 1950s. It is naturally developed from early successional forest and contains higher flora species richness. It occupies 4.27% of the site. It is the result of spontaneous growth of dominantly light-demanding native common species and is uncommon in Singapore.	Priority 1
Fauna and flora of high ecological value	The loss of individuals of species of high ecological value due to conservation status, rarity or distribution are given the highest priority as any loss would be detrimental to the local population.	Priority 1
Adjacent forest outside of Site (i.e. Bukit Brown Woods)	The adjacent forest at Bukit Brown is expected to be a mix of habitats, similar to that of Mount Pleasant. While the vegetation will not be cleared due to the development works, it is expected that wildlife in the	Priority 1

Receptor	Description of Ecological Value	Sensitivity Classification
	adjacent forest may still be impacted as they may be using both the Study Area and the Bukit Brown Woods.	
Managed Vegetation (cemetery)	The vegetation is a man-made habitat that is created by planting exotic and native flora species. However, maintenance of the vegetation type is low and native flora species have been observed to be sown naturally, suggesting some natural recruitment. It occupies 5.27% of the site.	Priority 2
Abandoned-land Forest	Abandoned-land forest is secondary forest regenerated from abandoned kampongs and/or plantations. It occupies 25.94% of the site and is considered of moderate ecological value.	Priority 2
Conservation significant floral specimens	A total of 653 specimens were recorded across the site and towards the west of the SPOM, there was a higher concentration of conservation significant flora specimens. These individuals could be present as native plants are dispersed from the CCNR and there is some natural recruitment.	Priority 2
Species of concern: Long-tail Macaque	Macaques are highly adept to urban settings and may persist throughout the construction stage into the operational stage. Increased interactions between humans and macaques may be detrimental for macaques or cause conflict between the two.	Priority 2
Species of concern: Wild Pig*	Wild pigs would be the largest mammal in the Study Area. They are highly mobile and adept to urbanised conditions. Pigs have been involved in human-wildlife conflicts where either pigs or humans are seriously injured. This is contributed by the increasing interaction between humans and pigs due to urbanisation and loss of their natural habitat.	Priority 2
Waste Woodlands	The waste woodlands is a human-modified habitat with forest that has regrown after the land has been cleared before the 1950s and is dominated by common native species. It is moderately rare in Singapore. It occupies 3.54% of the site and is considered of moderate ecological value.	Priority 3
Managed Vegetation (others)	The managed vegetation is a man-made habitat created from planting exotic and rare (cultivated) flora species, which is common in parks and along streetscapes. The species planted within the managed vegetation of the Study Area is a mix of both exotic and native species. It occupies 46.23% of the site and is considered of low ecological value.	Priority 3
Scrubland and Herbaceous Vegetation	Scrubland and herbaceous vegetation is characterized by low vegetation, dominated by short shrubs and grasses. It occupies 4.12% of the site and is considered of low ecological value.	Priority 3
Adjacent managed vegetation outside of Site	The adjacent managed vegetation is the vegetation that is around or within the Black and White bungalows along Mount Pleasant Road. While the vegetation is not expected to be cleared for the development works, it is expected that wildlife that are tolerant to urban conditions and environments may still be impacted. The managed vegetation between Mount Pleasant Road and the Bukit Brown Woods is approximately 100m wide.	Priority 3

* Wild pigs were not observed during the biodiversity baseline survey period from January 2019 to September 2020. However, incidental observations of pig signs were recorded by NParks staff on a site visit on 18th January 2021. The signs include hoof marks and disturbed soil in proximity to sampling point S1_02.

12.5.4 Ecological Impact Prediction and Evaluation

12.5.4.1 Potential Sources of Impact

The overall ecological impact from the development was expected to be major based on the ecological value of and impacts to sensitive receptors potentially affected by the development works (refer to **Figure 12-67**). The Study Area comprises of habitat types of low to high ecological value and other ecological features with high ecological value. Since most of the impacts expected were considered

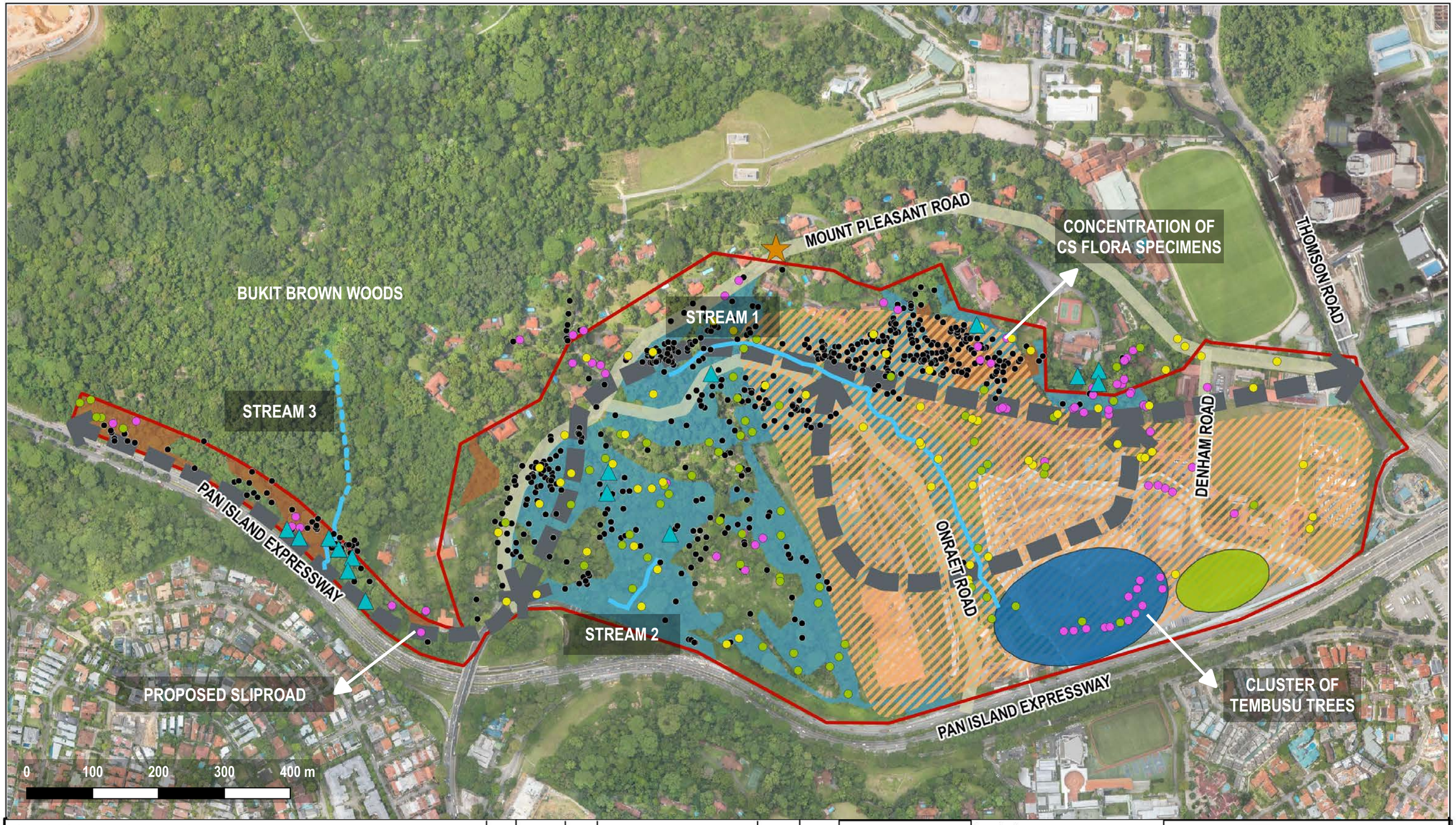
permanent and irreversible, and that major impacts expected from habitat loss, disturbance to soil and disturbance to wildlife occur over about half the site, the impact was expected to be major. While there were no immediate plans indicated for the area of the *Kopi Sua* Cemetery, it was assumed that it would face a large amount of disturbance from surrounding construction activities and some parts of the cemetery and its vegetation would be affected by topographical changes from new road works, where construction access was expected to be at least 5 to 10m on both sides of the new road. With the creation of the new road, the cemetery will be fragmented internally and the gap in ecological connectivity between the Bukit Brown Woods and Mount Pleasant will be further amplified.

A summary of the associated impacts during each development stage is provided in **Table 12-22**. The assumed minimum control for the mitigation of biodiversity impacts are provided in **Table 12-23** and only for the construction phase as controls would have been assumed to be integrated into the design and master planning stage. Nevertheless, sensible housekeeping and maintenance of the estate's environment during the operational stage will help to maintain a minimal impact to the adjacent forests and fauna species that remain. The impact on the receptors is evaluated in the construction and operational phases in **Table 12-24** and **Table 12-25** respectively.

12.5.4.2 Description of Ecological Impacts

Table 12-22: Summary of Project Stages and Associated Ecological Impacts

Project Stage	Associated impacts on environment
Pre-construction and Construction	
Preparatory Works - Site Investigation	- Localised loss/change of habitat and vegetation along machinery access routes - Disturbance of soil (soil compaction, soil erosion, soil removal) - Potential fauna mortality or injury - Disturbances to wildlife due to noise, vibration, dust, light and human presence - Habitat degradation due to improper waste disposal, pollution from soil erosion or release of hazardous substances - Drop in surface water quality or contamination of surface water - Human-wildlife conflict
Preparatory Works - Clearing of vegetation and excavation	- Habitat loss and loss of connectivity - Disruption of ecological processes - Disturbance of soil (soil compaction and soil removal) - Fauna mortality or injury - Disturbances to wildlife due to noise, vibration, dust, light and human presence - Habitat degradation due to improper waste disposal, pollution from soil erosion or release of hazardous substances - Drop in surface water quality or contamination of surface water - Human-wildlife conflict
Construction of piling, footing, and retaining wall; Construction of buildings and facilities	- Disturbance of soil (soil compaction and soil removal) - Potential fauna mortality or injury - Disturbances to wildlife due to noise, vibration, dust, light and human presence - Habitat degradation due to improper waste disposal, pollution from soil erosion or release of hazardous substances - Drop in surface water quality or contamination of surface water - Human-wildlife conflict
Operational	
Operational	- Disturbances to wildlife and habitat due to noise, dust, light and human presence - Habitat degradation due to edge effects, improper waste disposal (littering from public) or release of toxic substances (insecticides) - Forest edge effects - Drop in surface water quality or contamination of surface water - Introduction of non-native species - Fauna mortality or injury - Bird collision with buildings - Human-wildlife conflict



Legend

- Study Area
- Proposed Land Use
  - Stream
  - Abandoned-land Forest
  - Native-dominated Secondary Forest
  - Commercial and Social node
  - Park space
  - Housing with supporting amenities
  - Indicative Original Road Plan
- Flora CS Species
- Large Flora Specimens
  - Tembusu
  - Ficus species
  - Other Large Tree
- Ficus kurzii (heritage tree)
- Bamboo

N

Rev.	Date	By	Description	Chk'd	App'd
02	JUN 2021	BT	Final Report Rev. 02	DY	JAG
01	SEP 2020	BT	Draft Final Report Rev. 01	DY	JAG
-	FEB 2020	BT	Draft Final Report	DY	JAG

Qualified Person Endorsement :

HDB Endorsement :

Consultant : AECOM

Project Title :
CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Designed	Checked	Approved
BT	DY	JAG
	Drawn: BT	Date: JUN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title :
KEY ECOLOGICAL RECEPTORS WITH PROPOSED DEVELOPMENT PLANS OVERLAID

Figure No. :	Rev.	Sheet
12-67	02	1 of 1

CAD File Name : NA — A3

Note: Source of basemap - Google Earth Map

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12.5.4.3 Minimum Control for Potential Biodiversity Impacts

Biodiversity-specific minimum controls commonly implemented in Singapore for similar construction activities are described below. These were assumed to be implemented for the purpose of the impact mitigation. These measures should be proposed in tandem with that proposed for other environmental receptors (i.e. hydrology, noise, etc).

Main construction activities that would likely occur at all work sites include vegetation clearance for site investigations, work access, excavation for levelling ground (especially along the PIE), followed by above and below ground construction. With these work activities anticipated, the related minimum control measures are listed down in **Table 12-23**.

Table 12-23: Minimum Control Measures during the Pre-Construction and Construction Phase

Work activities	Minimum controls
Site Investigation, clearing of vegetation	• Trees that are to be retained within work site would require an arborist to clearly mark out Tree Protection Zones where no works are allowed. The Tree Protection Zones should be set up in accordance with NParks guidelines. • Before vegetation removal, pre-felling fauna inspection should be conducted by an Ecologist to identify wildlife or nesting structures that are being actively used such as bird nests, tree hollows and burrows. A biodiversity awareness training should also be conducted for all personnel on site to ensure that they are aware of fauna response and rescue protocol. • Soil erosion control measures are to be executed once vegetation has been removed and soil is exposed.
Excavation	• Implement soil erosion control measures (see **Table 14-10**) • Implement dust control measures (see **Table 14-10**)
Construction of piling, footing, and retaining wall; construction of buildings and facilities, inclusive of piling works.	• Proper storage of materials that are likely to leech harmful chemicals and fuel-powered equipment away from waterbodies (Streams) forested areas meant to be retained (see **Table 14-10**) • Ensure noise levels are within approved limits (see **Table 14-10**) • Ensure vibration levels are within approved limits (see **Table 14-10**)

12.5.4.4 Ecological Impact Prediction and Evaluation during Pre-construction and Construction Phase

The ecological impacts expected during construction phase are summarised in **Table 12-24**, these assume that the minimum controls have been taken.

<u>Preparatory Works</u>

The most significant impacts were expected from vegetation clearance and soil excavation works at the start of the construction phase. This involves permanent, loss of all forest habitats that are already dwindling in Singapore (Brook et al., 2003). Furthermore, soil excavation or land levelling will remove and/or alter the soil structure and communities, which in turn will affect the larger food webs and ecosystem. Forested areas play an important role in regulating rainwater run-off and local climate. Dead plant materials decompose quickly and the nutrients are absorbed by the plants and cycled back into the ecosystem, keeping the soil enriched. With site clearance, rainwater will quickly discharge as run-off and nutrients will be washed away. Natural regeneration of the forest could be impacted as the populations of pollinators and seed dispersers such as bats, birds, butterflies and civets are reduced with habitat loss. Accordingly, habitat fragmentation, disruption to ecological processes, and fauna mortality and injury are expected.

Based on incidental observations of their hoof marks and diggings from a site visit by NParks on 18th January 2021, it was suspected that Wild Pigs have also found their way to the Study Area, likely coming from the Bukit Brown Woods. Wild Pigs may also be a source of human-wildlife conflict: pigs may be injured by heavy machinery that is in operation or humans may be injured if the pigs run into workers on site if provoked or scared. The human-wildlife conflict may be exacerbated with the clearance of vegetation during the preparatory stages.

At this stage, hoarding around the planned works and soil investigation works will be erected before the clearance of vegetation. The vegetation clearance process involves the use of heavy machinery for the removal of above-ground vegetation (several weeks) and placement of erosion control measures. This is followed by earthworks involving an excavation and regrading of soil (over a few months). As the terrain is sloping down towards the PIE around the proposed slip road, it is expected that additional localised soil grading will occur to allow for the mobilisation of vehicles and machinery on flat ground. Examples of the machinery used include excavators, vibro hammers, and piling rakes which can weigh up to a few hundred tonnes. This stage also involves the mobilisation of construction equipment and resources, and erection of workers' camps.

Construction of hard structures

After vegetation clearance, construction of infrastructure begins. This will include bringing in of heavy machinery for large scale levelling/piling works and excavation for laying of drains, pipes and lines, completely changing the topography and thus hydrology of the site. In the development of the residential area, approximately 6.5-ha of the unmanaged forest vegetation (abandoned-land forest, native-dominated secondary forest, waste woodlands) and all of Stream 1 were expected to be completely decimated. Stream 2 is retained but in close proximity to the construction works for the new slip road from the PIE. Subsequently, excavation for basements, foundation works and piling works are expected. This process will involve the use of heavy machineries, such as vibro hammer, fork lift, piling rigs, tower and mobile cranes. Around the proposed slip road, the downstream portion of Stream 3 was expected to be canalised, and this may degrade the quality of the upstream habitat. With vegetation clearance, the forest edge along the PIE was expected to shift inwards; edge effects were expected to arise along the new edge and the forest interior is expected to shrink.

Major impacts were expected from vegetation clearance and soil excavation, from species to the ecosystem level. Habitats will be lost as all above, and some under-ground features, would be removed completely. Often during these activities, fauna communities get displaced and may get killed if they are unable to escape quickly or become roadkills. Fauna injury may also occur due to human-wildlife conflicts as there are Long-tailed Macaques (*Macaca fascicularis*) in the Study Area. The construction for the proposed development is likely to result in increased anthropogenic food availability and shared spaces, creating more 'zones of interaction' and greater opportunities for human-macaque interactions (Lim & Sivasothi, 2017). Therefore, human-macaque conflicts could potentially be a problem.

During installation of hard structures, disturbances to wildlife are expected from noise (refer to Section 8.0), vibration (refer to Section 9.0), dust (refer to Section 7.0), light and human presence. Due to the scale of construction and size of equipment involved, these activities are likely to result in elevated dust, noise and brightness levels, which can affect behavioural patterns and biological rhythms of fauna and habitats at adjacent vegetation. These disturbances are wide-ranging, influencing the behaviours and long-term survival of wildlife in adjacent sites. Animals "rely on meaningful sounds for communication, navigation, avoiding danger and finding food against a background of noise" (Bowles, 1995). Elevated noise levels can cause disturbances to wildlife and lead to long-term effects on physiology, morphology and behaviours that in turn affect the reproductive success and survival of a species (Dutta & Dutta, 2016). For example, some birds and amphibians have been observed to adjust their vocal behaviours in response to noisy environments, incurring greater energetic costs (Dutta & Dutta, 2016). Other birds such as house sparrows feed young less, perhaps due to the additional noise masking the call of the begging young (Schroeder et al, 2012). Similarly, changes to ground-borne vibration have impacts on how tetrapods (amphibians, reptiles, birds, mammals) and arthropods (insects and arachnids) interact with one another and their environment (Hill, 2001). This is affected either through the creation of new noise sources which overlap with the low frequencies that animals use or through the introduction of artificial ground substrates, which propagate animal vibrations with moderate only attenuation (Wu & Elias, 2014). These impacts are similar to those of air-borne noise and may influence vocalisation, anti-predator, foraging and reproductive behaviours (Wu & Elias, 2014). For nocturnal fauna such as bats, the presence of lighting is known to delay bat emergence from the roost, as observed in some *Myotis*, *Rhinolopus* and *Pipistrellus* species (Stone et al., 2015).

Harmful substances may come from the overflow of bentonite slurry from boring works or diesel from generators, paint and solvents. This is a source of concern especially when a rain event washes the uncontained substances onto the rest of the site, affecting the surface water quality.

NEA requires insecticide/anti-mosquito oil to be applied to all stagnant water and water-bearing receptacles at ground level and in upper floors weekly and after rain. If a mosquito breeding ground is

found, fogging will also be required. This could impact other insects and animals that rely on insects as their food source.

Negative impacts were expected for all terrestrial fauna groups over both the short and long term. Non-flying fauna (i.e., herpetofauna and ground mammals) are likely to be the most affected as they would have the most difficulty in escaping. Fauna that live in burrows or are nocturnal may be more susceptible as they may not active when the clearance activities occur, this could be true for the unconfirmed observation of the Malayan Porcupine (*Hystrix brachyura*). While the animals are able to move to adjacent habitats that are not affected, fauna mortality or injuries may occur from construction activities. Flying fauna (e.g., birds, bats, butterflies and other insects) appear to be less vulnerable, many species are at risk if they are unable to find an alternative, suitable habitat. This is particularly true for butterflies, which have short lifespans. Disturbances from construction works may displace fauna residing in proximity, such as the bamboo bats. The most affected species; however, are conservation significant species because habitat loss will result in them becoming rarer and more endangered.

Table 12-24: Summary of Ecological Impact Evaluation during the Pre-Construction and Construction Phase

Potential Source of Impacts	Receptor and approximate impacted quantity (Sensitivity)	Impact Intensity (I)	Consequence (S x I = C)	Likelihood (L)	Significance (C x L)
Habitat/ vegetation loss, loss of connectivity and disruption of ecological processes; Disturbance of soil (soil compaction and soil removal)	Heritage road and tree (Priority 1)	High	High	Unlikely	Negligible
	Bamboo clusters, 7 nos. (Priority 1)	High	High	Certain	**Major**
	Large flora specimens, 113 nos. (Priority 1)	High	High	Certain	**Major**
	Stream 1, all 740m (Priority 1)	High	High	Certain	**Major**
	Stream 2 (Priority 1)	High	High	Unlikely	Negligible
	Stream 3, 25m (Priority 1)	High	High	Certain	Moderate
	Native-dominated Secondary Forest, 1.8ha (Priority 1)	High	High	Certain	**Major**
	Adjacent forest outside of Study Area (i.e. Bukit Brown Woods) (Priority 1)	Low	Low	Unlikely	Negligible
	Managed Vegetation (cemetery), 0.2ha (Priority 2)	Medium	Medium	Likely	Moderate
	Abandoned-land Forest, 6.0ha (Priority 2)	High	High	Certain	**Major**
	Conservation significant flora specimens, approximately 285 nos. (Priority 2)	High	High	Certain	**Major**
	Waste Woodlands, 0.7ha (Priority 3)	High	Low	Certain	Moderate
	Managed Vegetation (others), 19.4ha (Priority 3)	Medium	Low	Certain	Minor
	Scrubland and Herbaceous Vegetation, 0.2ha (Priority 3)	Medium	Low	Certain	Minor
	Adjacent managed vegetation outside of Study Area (Priority 3)	Low	Very Low	Unlikely	Negligible
Fauna mortality or injury and roadkills	All fauna of high ecological value, 45 faunal species (Priority 1)	High	High	Likely	**Major**
Disturbances to wildlife due to noise (refer to Section 8.0),	Bamboo clusters, 8 nos. remaining (Priority 1)	Medium	Medium	Regular	Moderate
	Stream 1 (Priority 1)	Medium	Medium	Regular	Moderate

Potential Source of Impacts	Receptor and approximate impacted quantity (Sensitivity)	Impact Intensity (I)	Consequence (S x I = C)	Likelihood (L)	Significance (C x L)
vibration (refer to Section 9.0), dust (refer to Section 7.0), light and human presence, all wildlife in each habitat type is assessed This assumes some vegetation remains or is cleared in phases.	Stream 2 (Priority 1)	Low	Low	Unlikely	Negligible
	Stream 3 (Priority 1)	Low	Low	Possible	Minor
	Native-dominated Secondary Forest (Priority 1)* *This considers that the area is already heavily disturbed	Medium	Medium	Unlikely	Negligible
	Adjacent forest outside of Study Area, (i.e. Bukit Brown Woods) (Priority 1)	Low	Low	Unlikely	Negligible
	Managed Vegetation, (cemetery) (Priority 2)	Medium	Medium	Regular	Moderate
	Abandoned-land Forest, (Priority 2)	High	High	Occasional	Moderate
	Waste Woodlands (Priority 3)	Medium	Very Low	Continuous	Minor
	Managed Vegetation (others), (Priority 3)	Low	Very Low	Continuous	Minor
	Scrubland and Herbaceous Vegetation (Priority 3)	Low	Very Low	Continuous	Minor
	Adjacent managed vegetation outside of Study Area (Priority 3)	Low	Very Low	Continuous	Minor
Habitat degradation due to improper waste disposal, pollution from soil erosion and release of hazardous substances This assumes some vegetation remains or is cleared in phases.	Bamboo clusters, 8 nos. remaining (Priority 1)	Medium	Medium	Likely	Moderate
	Stream 1 (Priority 1)	High	High	Likely	**Major**
	Stream 2 (Priority 1)	High	High	Unlikely	Negligible
	Stream 3, 25m upstream from affected area (Priority 1)	High	High	Possible	Moderate
	Native-dominated Secondary Forest (Priority 1)	Medium	Medium	Possible	Moderate
	Adjacent forest outside of Study Area (i.e. Bukit Brown Woods) (Priority 1)	Low	Low	Unlikely	Negligible
	Managed Vegetation (cemetery) (Priority 2)	Medium	Medium	Possible	Moderate
	Abandoned-land Forest (Priority 2)	High	High	Possible	Moderate
	Waste Woodlands (Priority 3)	Medium	Very Low	Certain	Minor
	Managed Vegetation (others) (Priority 3)	Low	Very Low	Certain	Minor
	Scrubland and Herbaceous Vegetation (Priority 3)	Low	Very Low	Certain	Minor
	Adjacent managed vegetation outside of Study Area (Priority 3)	Low	Very Low	Certain	Minor
Drop in surface water quality or contamination	Stream 1 (Priority 1)	High	High	Certain	**Major**
	Stream 2 (Priority 1)	High	High	Unlikely	Negligible

Potential Source of Impacts	Receptor and approximate impacted quantity (Sensitivity)	Impact Intensity (I)	Consequence (S x I = C)	Likelihood (L)	Significance (C x L)
of surface water (refer to Section 10.0) This assumes some vegetation remains or is cleared in phases.	Stream 3, 25m upstream from affected area (Priority 1)	High	High	Possible	Moderate
	Native-dominated Secondary Forest (Priority 1)	Medium	Medium	Less likely	Minor
	Adjacent forest outside of Study Area (i.e. Bukit Brown Woods) (Priority 1)	Medium	Medium	Unlikely	Negligible
	Managed Vegetation (cemetery) (Priority 2)	Medium	Medium	Possible	Moderate
	Abandoned-land Forest (Priority 2)	Medium	Medium	Possible	Moderate
	Waste Woodlands (Priority 3)	Low	Low	Possible	Minor
	Managed Vegetation (Priority 3)	Low	Low	Possible	Minor
	Scrubland and Herbaceous Vegetation (Priority 3)	Low	Low	Possible	Minor
	Adjacent managed vegetation outside of Study Area (Priority 3)	Medium	Very Low	Unlikely	Negligible
Human-wildlife conflict	Long-tailed Macaques, Wild Pigs (Priority 2)	Medium	Medium	Occasional	Moderate

12.5.4.5 Ecological Impact Prediction and Evaluation during Operational Phase

At this stage, all building works would have been completed. Around the development area, it is assumed that the Stream 1 and parts of the existing vegetation would have already been removed but the area around the cemetery remains mostly intact. Around the proposed slip road, it is assumed that the Scrubland and Herbaceous Vegetation, parts of the Native-dominated Secondary Forest and Waste Woodlands would have been completely removed.

The only major impact expected is the forest edge effect to the adjacent Bukit Brown Woods, where the newly created forest edge may see a change in flora and fauna species composition and the structure of the once interior forest vegetation may also change due to exposure to the exterior. Moderate impacts are expected from sustained disturbances to wildlife in the adjacent forested areas (from noise, vibration, dust, light and human presence) over a long-term.

Macaques and signs of wild pigs were sighted in the Study Area and human-wildlife conflict is expected to be a moderate concern as these species are highly mobile and adaptable to urban environments. Furthermore, the Bukit Brown Woods will remain as a hinterland and fauna may move in and out of the forested areas into the Mount Pleasant development. During the operational stage, as people move into the development, there is a higher chance of these fauna species interacting with humans. For macaques, there are two concerns: collision with vehicles and macaque feeding, which could lead to aggression towards humans or unnatural behaviours. For wild pigs, collision with vehicles or injury to pedestrians are both issues of concern.

With the additional built up areas, birds may collide into buildings if the surfaces are reflective and mirrors that of an open sky, it is expected that is a minor impact.

Mid- to long-term positive impacts are expected from landscaping (re-planting) around the development but are not evaluated in this Impact Assessment.

The ecological impacts expected during operational phase are summarised in **Table 12-25**.

Table 12-25: Summary of Ecological Impact Evaluation during the Operational Phase

Potential Source of Impacts	Receptor (Sensitivity)	Impact Intensity (I)	Consequence (S x I = C)	Likelihood (L)	Significance (C x L)
Disturbances to wildlife due to noise (refer to Section 8.0), vibration (refer to Section 9.0), dust (refer to Section 7.0), light and human presence. Wildlife in each habitat type is assessed.	Bamboo cluster, 8 no. (Priority 1)	Low	Low	Regular	Moderate
	Stream 2, all (Priority 1)	Low	Low	Unlikely	Negligible
	Stream 3, upstream remaining portion (Priority 1)	Low	Low	Unlikely	Negligible
	Native-dominated Low Secondary Forest, 1.3ha (Priority 1)	Low	Low	Regular	Moderate
	Adjacent forest outside of Study Area (i.e. Bukit Brown Woods) (Priority 1)	Low	Low	Regular	Moderate
	Managed Vegetation (cemetery), 3.6ha (Priority 2)	Low	Low	Regular	Moderate
	Abandoned-land Forest, 12.6ha (Priority 2)	Low	Low	Regular	Moderate
	Waste Woodlands, 1.8ha (Priority 3)	Low	Very Low	Regular	Minor
	Managed Vegetation (others), 13.7ha (Priority 3)	Low	Very Low	Regular	Minor
	Adjacent managed vegetation outside of Study Area (Priority 3)	Low	Very Low	Regular	Minor
Habitat degradation due to edge effects, improper waste disposal (littering from public) or release of toxic substances (insecticides)	Bamboo cluster, 8 no. (Priority 1)	Low	Low	Unlikely	Negligible
	Stream 2, all (Priority 1)	Medium	Medium	Unlikely	Negligible
	Stream 3, upstream remaining portion (Priority 1)	Medium	Medium	Unlikely	Negligible
	Native-dominated Low Secondary Forest, 1.3ha (Priority 1)	Low	Low	Unlikely	Negligible
	Adjacent forest outside of Study Area (i.e. Bukit Brown Woods) (Priority 1)	Low	Low	Unlikely	Negligible
	Managed Vegetation (cemetery), 3.6ha (Priority 2)	Low	Low	Occasional	Minor
	Abandoned-land Forest, 12.6ha (Priority 2)	Low	Low	Occasional	Minor
	Waste Woodlands, 1.8ha (Priority 3)	Low	Low	Occasional	Minor
	Managed Vegetation (others), 13.7ha (Priority 3)	Low	Low	Occasional	Minor
	Adjacent managed vegetation outside of Study Area (Priority 3)	Low	Low	Occasional	Minor
Forest edge effects	Adjacent forest outside of Study Area (i.e. Bukit Brown Woods) (Priority 1)	High	High	Continuous	**Major**
	Stream 2, all (Priority 1)	High	High	Less likely	Minor

Potential Source of Impacts	Receptor (Sensitivity)	Impact Intensity (I)	Consequence (S x I = C)	Likelihood (L)	Significance (C x L)
Drop in surface water quality or contamination of surface water (refer to Section 10.0)	Stream 3 (Priority 1)* *The likelihood of drop in surface water quality is low as the remaining stream is upstream.	High	High	Less likely	Minor
	Native-dominated Low Secondary Forest, 1.3ha (Priority 1)	High	High	Unlikely	Negligible
	Adjacent forest outside of Site (i.e. Bukit Brown Woods) (Priority 1)	Medium	Medium	Unlikely	Negligible
	Managed Vegetation (cemetery), 3.6ha (Priority 2)	Medium	Medium	Unlikely	Negligible
	Abandoned-land Forest, 12.6ha (Priority 2)	Low	Low	Unlikely	Negligible
	Waste Woodlands, 1.8ha (Priority 3)	Low	Very Low	Unlikely	Negligible
	Managed Vegetation (others) 13.7ha (Priority 3)	Low	Very Low	Unlikely	Negligible
	Adjacent managed vegetation outside of Study Area (Priority 3)	Medium	Very Low	Unlikely	Negligible
Introduction of non-native species	Stream 2 (Priority 1)	Medium	Medium	Less likely	Minor
	Stream 3 (Priority 1)	Medium	Medium	Unlikely	Negligible
	Native-dominated Low Secondary Forest (Priority 1)	High	High	Less likely	Minor
	Adjacent forest outside of Study Area (i.e. Bukit Brown Woods) (Priority 1)	Medium	Medium	Less likely	Minor
	Managed Vegetation (cemetery) (Priority 2)	Negligible	Very Low	Less likely	Negligible
	Abandoned-land Forest (Priority 2)	Negligible	Very Low	Less likely	Negligible
	Waste Woodlands (Priority 3)	Negligible	Imperceptible	Less likely	Negligible
	Managed Vegetation (others) (Priority 3)	Negligible	Imperceptible	Less likely	Negligible
	Adjacent managed vegetation outside of Study Area (Priority 3)	Negligible	Imperceptible	Less likely	Negligible
Fauna mortality or injury and roadkills	All fauna (Priority 1)	Medium	Medium	Less likely	Minor
Bird collisions with buildings	All birds (Priority 1)	Medium	Medium	Less likely	Minor
Human-wildlife conflict	Long-tailed Macaques, Wild Pigs (Priority 2)	Medium	Medium	Occasional	Moderate

12.6 Recommended Mitigation Measures

In this section, mitigation measures for the future HDB development are discussed in order of priority: avoidance, minimisation, enhancement and compensation. The successful implementation of mitigation measures requires the commitment of contractors, arborists and biodiversity specialists. A summary of major impacts, receptors and mitigation measures are listed in the table below.

Table 12-26: Major Impacts, Receptors and Mitigation Measures

Impact	Receptor	Mitigation Measure
Pre-construction and Construction Phase		
Habitat/ vegetation loss, loss of connectivity and disruption of ecological processes; Disturbance of soil (soil compaction and soil removal)	• Bamboo clusters • Large flora specimens • Stream 1 • Native-dominated Secondary Forest • Abandoned-land Forest • Conservation significant flora specimens	• Avoidance via review of land use allocation • Avoid or minimisation via review of work areas and access to avoid allocating excessive working spaces • For Stream 1 and bamboo bats in bamboo clusters, a review of whether translocation of affected species of conservation significance is feasible prior to works
Fauna mortality or injury and roadkills	• All fauna	EMMP measures during construction stage to raise awareness on site
Disturbances to wildlife due to noise (refer to Section 8.0), vibration (refer to Section 9.0), dust (refer to Section 7.0), light and human presence, wildlife in each habitat type is assessed	• Bamboo clusters • Stream 1	• For Stream 1 and bamboo bats in bamboo clusters, a review of whether translocation of affected species of conservation significance is feasible prior to works • EMMP measures during construction stage to raise awareness on site
Habitat degradation due to improper waste disposal, pollution from soil erosion and release of hazardous substances	• Bamboo clusters • Stream 1	
Drop in surface water quality or contamination of surface water (refer to Section 10.0)	• Stream 1	
Operational Phase		
Forest edge effects	• Adjacent forest outside of Site (i.e. Bukit Brown Woods)	Compensation via landscaping of new development

Although impacts only occur during the downstream stages (i.e. pre-construction stage onwards), the design is stage of paramount importance. The design can significantly influence the extent of impacts, as the structural design will dictate the location of structures, construction methods and the amount of impacts caused during pre-construction, construction and operation stage. The design recommendations are integrated into the mitigation measures proposed in this section, with options for Stream 1 and 3 studied in more detail with HDB.

12.6.1 Avoidance

12.6.1.1 Design Stage

Based on the future HDB development plan provided by HDB and the construction of a slip road from the PIE, most of the key ecological receptors will be impacted by means of site preparation works and vegetation clearance. A review of the development plans may avoid impacting some of these key features:

- Review the building footprint within the proposed commercial and social node to avoid the entire cluster of 11 nos. of tembusu (*Cyrtophyllum fragrans,* refer to **Figure 12-67***).*
    - Re-align the proposed road to completely avoid Stream 1. Where it is possible, a 35m buffer on both sides should also be retained to maintain some forest habitat and the

microclimate around the stream. Avoiding the upstream portion of the stream would have a greater mitigation effect than avoiding the downstream portion of the stream as impacts such as drop in water quality and habitat degradation upstream may also be felt downstream.

- Avoid Stream 2 when designing the new road from PIE. Based on the current layout, the working space for the proposed road should avoid the stream completely (refer to **Figure 12-67**).
- Re-configured the proposed slip road from PIE to link up to the existing Onraet Road, thus avoiding the sensitive habitat of Stream 3 (refer to **Figure 12-67**). This is described as Option C in **Section 10.4**. However, if this is not feasible, refer to enhancement measures in **Section 12.6.2.3.**
- Establish Tree Protection Zones (TPZs) or areas where large trees are to be conserved. For example, the trees along the Heritage Road which give it its character should be preserved as an entity.

12.6.2 Minimisation

12.6.2.1 Design Stage

In recent years, there have been calls for a more ecologically sensitive urban planning and design in the face of rapid urbanisation. This helps to reduce the overall adverse impact of the development and reduces urban-related problems to wildlife. Below are some recommendations for bird collisions related issue.

Bird-friendly building design can help significantly reduce the incidences of bird collisions, especially for higher storeys that are above tree canopy height. Some examples are stated here (Sheppard & Phillips, 2015):

- Minimise the quantity or surface area of glass. This could be achieved by reducing the amount of glass façade or installing a decorative cladding over the glass façade so that the reflections on the glass facades would be broken up.
- Incorporate features that increase the visibility of glass (including mirrored and non-mirrored reflective glass, and transparent glass) or dampen reflections to reduce the appearance of clear passage to sky or vegetation. Possible strategies include film coating (E.g. CollidEscape; http://www.collidescape.org), angled glass, interior or exterior shades, decals, fenestration patterns, grilles, sunshades, screens, blinds and netting. Exterior shades confer the freedom of choosing to only use it during periods where bird collisions are expected to be most frequent, e.g. migration seasons.
- When decals or patterns are added to increase the visibility of the glass, it is advised that the pattern should be as dense as possible as it will appear more clearly as a solid object to birds thus more effective (GDS, 2007). For example, for WindowAlert decals, it is recommended for decals to be 5cm apart horizontally and 10 cm apart vertically (FLAP, n.d.).
- Avoid interior vegetation near windows as birds may confuse this with exterior vegetation and fly towards them.
- Avoid planting vegetation close to glass so that reflection of vegetation does not confuse birds, which may fly into the building. If there are sides which are close to the natural vegetation, the façade should have shades installed or netting that are a short distance away from the glass to prevent birds from crashing into it.
- Buildings should not have courtyards or corridors that are enclosed by glass as these may confuse birds to fly through.

Bird-friendly designs do not necessarily add restrictions or cost to the project. References that can be used for designing a bird-friendly building are:

- Sheppard C & Phillips G (2015) Bird-friendly building design (2nd edition). American Bird Conservancy, 1–58. [Retrieved from https://abcbirds.org/wp-content/uploads/2015/05/Bird-friendly-Building-Guide_2015.pdf].

- Green Development Standard (GDS) (2007) Bird-friendly development guidelines. City of Toronto, 1–42. [Retrieved from https://www1.toronto.ca/city_of_toronto/city_planning/zoning__environment/files/pdf/development_guidelines.pdf].

For Stream 1, two options (Option A and Option B) were proposed by HDB to reduce hydrological impacts of the development by re-aligning part of the new road (refer to **Section 10.4**, **Figure 12-68**). However, it is estimated that 75% of the length of Stream 1 habitat may still be impacted and therefore, would not be considered a mitigation measure for biodiversity.

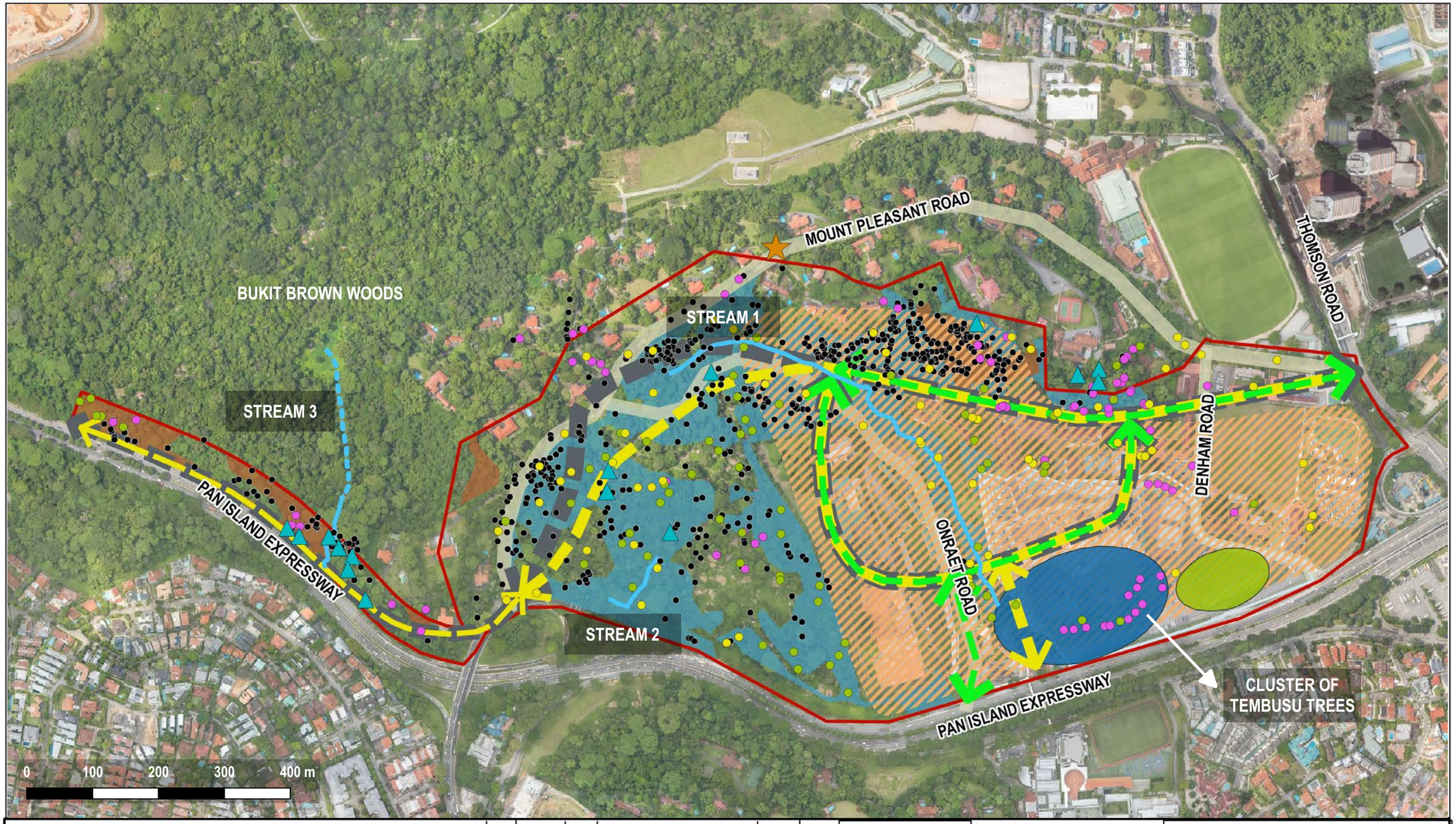
For Stream 3, three options (Option A, Option B and Option C) were proposed by HDB to reduce the overall impacts of the development of the new PIE slip road (refer to **Section 10.4**, **Figure 12-69**). In Option A and B, different road structures were proposed, with Option A being an on-grade road and Option B being a viaduct, bridging over the existing stream. Since both options would still impact the surrounding vegetation, these were not considered as a mitigation measure for biodiversity. However, in Option C, the slip road at Stream 3 is not built at all and instead, vehicular entrance to Mount Pleasant is through the existing service road at Onraet Road. This would reduce the mitigation impact from "moderate" to "negligible" at Stream 3 and leave the forest edge intact.

Stream 1 Option B together with Stream 3 Option C is also known as the alternative road plan 2.

12.6.2.2 Pre-construction Stage

It is recommended:

- To review method statements by the Contractor to minimise unnecessary clearance works and reduce fauna impacts;
- That the erection of the hoarding shall be directional, starting from the area closest to the busiest road, Thomson Road, then towards Bukit Brown Woods. The hoarding shall be continuous and complete before work commences. This is to avoid potential roadkills;
- To transplant or harvest trees or saplings of conservation significance unavoidably affected by the works. This should be coordinated with NParks and led by a Flora Specialist;
- That the Contractor shall determine if there are wild pigs present within the hoarding as part of the pre-construction baseline survey. This is done after the hoarding has been completed, to ensure no movement of wild pigs in and out of the hoarded area. If wild pigs are present, the Contractor shall engage an approved wildlife management specialist to trap and remove wild pigs in view of workers' safety concerns. A registry of approved contractors can be found at: www.nparks.gov.sg/avs/animals/animal-related-businesses/animal-management-companies/public-registry-of-certified-animal-management-specialists
- That prior to the clearance trees and vegetation, have an Ecologist to inspect the vegetation so as to ensure it is free of nests, burrows or signs of animal dwelling. This includes inspecting affected bamboo clusters for bamboo bats;
- Have tree felling and vegetation clearance activities phased, in the direction of the Bukit Brown Woods and the remaining Kopi Sua Cemetery, so that arboreal fauna can move towards the area of refuge, rather than towards Thomson Road or the PIE (refer to **Figure 12-69**).



Legend

- Study Area
- Stream
- Abandoned-land Forest
- Native-dominated Secondary Forest

Proposed Works

- Housing with supporting amenities
- Commercial and Social node
- Park space
- Indicative Original Road Plan
- Indicative Alternative Road Plan 1
- Indicative Alternative Road Plan 2

- Flora CS Species

Large Flora Specimens

- Tembusu
- Ficus species
- Other Large Tree
- Ficus kurzii (heritage tree)
- Bamboo

N

Rev.	Date	By	Description	Chk'd	App'd
02	JUN 2021	BT	Final Report Rev. 02	DY	JAG
01	SEP 2020	BT	Draft Final Report Rev. 01	DY	JAG
-	FEB 2020	BT	Draft Final Report	DY	JAG

Qualified Person Endorsement :

HDB Endorsement :

Consultant : AECOM

Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Designed	Checked	Approved
BT	DY	JAG
	Drawn: BT	Date: JUN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title :

KEY ECOLOGICAL RECEPTORS OVERLAID WITH INDICATIVE ALTERNATIVE ROAD PLANS AS MITIGATION MEASURES

Figure No. :	Rev.	Sheet
12-68	02	1 of 1

CAD File Name :NA — A3

Note: Source of basemap - Google Earth Map

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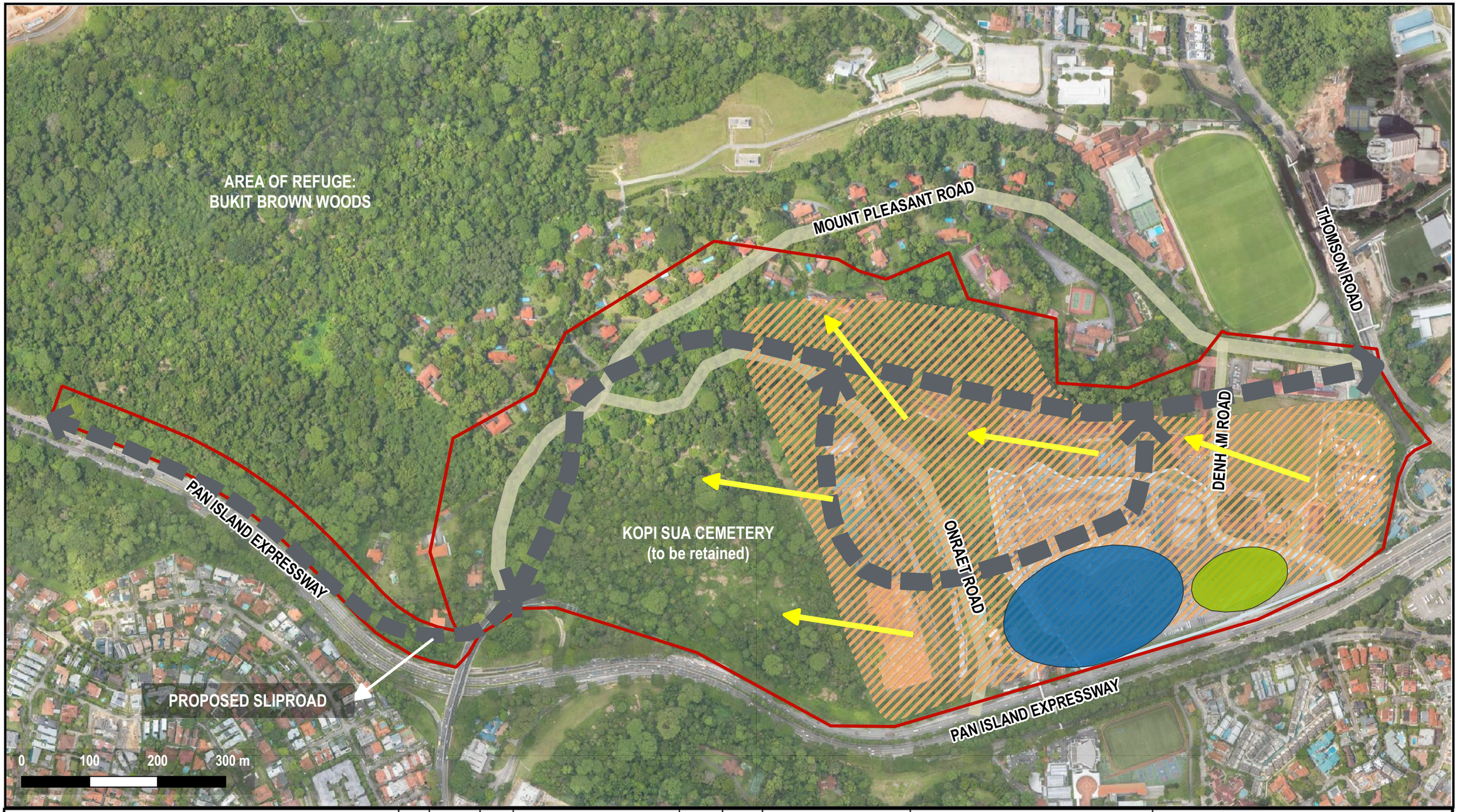

Legend

- Study Area
- Existing Roads
- Construction, no vegetation
- Direction of vegetation clearance

Proposed Development

- Housing with supporting amenities
- Commercial and Social node
- Park space
- Indicative Original Road Plan

N

Rev.	Date	By	Description	Chk'd	App'd
01	JUN 2021	BT	Final Report Rev. 02	DY	JAG
-	JAN 2021	BT	Final Report	DY	JAG

Qualified Person Endorsement : NA

HDB Endorsement : NA

Consultant : AECOM

HOUSING & DEVELOPMENT BOARD

Project Title :

CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY AT MOUNT PLEASANT

Figure Title :

MAP SHOWING PROPSOED DEVELOPMENT AND DIRECTION OF VEGETATION CLEARANCE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
BT	DY	JAG	12-69	01	1 of 1
	Drawn BT	Date JUNE 2021	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

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12.6.2.3 Construction Stage

Mitigation measures should focus on careful execution of construction activities to minimise working space, putting control measures in place to prevent fauna from accessing or being trapped within the construction zone, prevention of soil erosion particularly into the streams and reducing disturbances to the adjacent forested areas. The details of these mitigation measures are listed in **Section 12.6**. The key measures are also provided below:

- At Stream 2, ensure that the working space needed for the construction of the new road does not encroach into the stream; reduce the working space in the localised area near the stream.
- At Stream 3, if complete avoidance of the stream is not possible and Option A or Option B is the final proposal, the Contractor would have to ensure that water in Stream 3 is still able to flow continuously and not become stagnant. This ensures the upstream portion of Stream 3 is not impacted by any stagnant or pooling water.
- Monitoring of the water quality of the remaining stream is recommended to ensure the health of the core conservation area.
- Tree-felling works should be executed outside of peak bird breeding and nesting season where possible.
- Regular site inspections for contractor compliance and identify features that may result in fauna mortality and monitor for possible negative impacts to surrounding habitats.
- Toolbox briefing for workers to raise awareness on biodiversity to minimise human-wildlife conflict and ecological impacts.
- Execute fauna response and rescue protocol when fauna is found on site.

12.6.2.4 Operational Stage

A resident macaque troop is known to be present within the Study Area. If the macaques remain in the area when human traffic increases, there may be a higher chance of interaction between humans and macaques, and this may lead to conflict when food is involved. In managing human-macaque conflict, management of food availability and enforcement of no feeding by humans are crucial:

- Use macaque-proof bins in public area;
- Erecting educational signs about the possible interactions with macaques;
- Ensure proper and efficient food waste/rubbish disposal system.

12.6.3 Enhancement

12.6.3.1 Enhance Landscape Connectivity

HDB's Biophilic Town Framework outlines the strategies needed to plan and design urban landscapes, to achieve the larger urban development goals of sustainability, liveability and resilience (HDB, 2018). Of the 17 ecosystem services listed, eight apply:

1. Nutrient recycling (Soil)
2. Provision of Wildlife Habitat (Flora and Fauna)
3. Heat Mitigation (Outdoor Comfort)
4. Sense of Place (People)
5. Aesthetic Values (People)
6. Social Relations (People)
7. Education Values (People)
8. Recreation (People)

Based on the development plans, most of the green spaces around the Study Area will be cleared, transforming the relatively quiet Study Area into a hub of human activity. The development will still be adjacent to the Bukit Brown Woods and in close proximity to the Central Catchment Nature Reserve, therefore, it is important to have as much urban greenery as possible. This can be done via landscaping and planting. Native plant species are highly recommended because being genetically representative of the region's biodiversity; these plants themselves have higher conservation value.

Landscaping through ground and skyrise greenery (e.g. rooftop gardens and green walls) are beneficial to both biodiversity and humans. Adapted from CUGE's Design Guidelines to Promote Biodiversity on Roof Gardens (2017), considerations for roof gardens include:

- The overall height of the building with a rooftop garden should be no more than 50 m tall. Comparatively, roof gardens at a lower height attract a wide variety of birds and butterflies;
- Rooftop gardens exposed to the sky are better for attracting biodiversity as compared to mid-storey gardens which may be more enclosed, therefore, intensive gardens may be planned on the rooftop and extensive gardens may be planned for mid-storey gardens;
- Select a diversity of nectaring, flowering and fruiting plant species. The planting palette should be planned for continuous flowering and fruiting throughout the year in order to provide food and improve ecological processes.
- Consider a naturalistic "protected zone" on the rooftop garden where human access is limited and maintenance of plants can be less intensive.
- The presence of water on rooftops helps attract biodiversity, they can be designed as biotic water bodies such as landscaped, non-chlorinated ponds.

Additionally, on the ground, considerations for increasing connectivity include:

- Plant keystone flora species such as fig trees. These trees have uncoordinated fruiting periods but fruit abundantly when in season. Fig trees are important food source for avian fauna and small mammals.
- Increase vertical vegetation structures (i.e., ground cover, shrub, understory and canopy layers) and forms (e.g., epiphytes, shrubs, ferns, trees).
- Native plant species are highly recommended because they are genetically representative of the region's biodiversity and higher conservation value.
- Prioritise intensive greening along streets or in areas with low disturbances (e.g., low traffic volumes and speeds, low human activities).

12.6.3.2 ABC Waters Features

ABC Waters Features are stormwater management system features built to mimic natural systems and can be integrated into the landscape. These features include vegetated swales, bio-retention basins (also known as rain gardens), detention ponds and wetlands and they replace the traditional stormwater management features such as concrete drains, canals, culverts and underground detention tanks. Studies have shown that fauna species richness and composition in these type of stormwater features is higher than that of lawn-type or garden-bed type of greenspaces (Kazemi et al., 2009) and therefore, by inference, concrete-based infrastructure. The presence of plants, leaf litter, soil, gravel and rocks create habitats that provide both food and refuge (Kazemi et al., 2009) for animals such as invertebrates, amphibians and reptiles. On the larger precinct scale, the presence of these aquatic and semi-aquatic features in the landscape increase habitat heterogeneity (Kazemi et al., 2009, Zhang et al., 2018). **Table 12-27** describes the specific recommendations for each feature.

Table 12-27: List of ABC Waters Stormwater Features and Recommendations

Stormwater Feature	Water	Habitat Created	Specific Recommendations
Swale	Temporary water	Ephemeral freshwater stream after a rain event	• Swale should be vegetated on the side slopes and base • For fauna to move in and out of the swale, the slope should be at a gradient of at least 1:4
Rain garden	Temporary water	Ephemeral freshwater body after a rain event	• Rain garden should be vegetated on the sides and base • For fauna to move in and out of the rain garden, the slope should be at a gradient of at least 1:4

Stormwater Feature	Water	Habitat Created	Specific Recommendations
			• Flowering and fruiting plants should be used to attract wildlife such as butterflies and birds
Detention or retention pond or wetland	Permanent water	Pond with plants on water edge	• Detention ponds normally serve as temporary water bodies and drain out shortly after a rain event to meet PUB's Code of Practice on Surface Water Drainage, whereas retention ponds are permanent water bodies. The designed pond may have both detention and retention functions, therefore having a permanent water level with an additional fluctuating water depth. Designing smaller and shallower pockets of water at the edges will be beneficial to fauna which are dependent on semi-aquatic habitats. Water depth of these pockets may vary from 30–100-mm • Keep the edges and base of the pond as natural as possible – some organic matter such as fallen leaves should be kept at the base on the pond as this acts as a base food source for detritivores, which in turn are a food source for other fauna • For fauna to move in and out of the pond, the gradient of portions of the slope should be at least 1:4 • Have a mix of ground cover, water tolerant, floating and emergent plants, which will provide different perching and refuge structures for fauna around the edges of the pond • Consider a maintenance strategy for the clearing of the plants that is naturalistic and removes plants in an alternating fashion. This will ensure that there will always be mature plants in the pond or wetland

The Bamboo Bats may be a suitable species for translocation from affected bamboo clusters to retained bamboo clusters: The *Kopi Sua* Cemetery and Bukit Brown Woods will be retained with unaffected bamboo clusters, habitats and environmental conditions are likely to be the same.

12.6.4 Compensation

For Stream 1, where it is not possible to avoid the stream and the stream and associated vegetation has to be removed, compensatory measures of replacing the stream with a natural habitat such as ABC Waters features (refer to **Section 12.6.3.2**) are recommended.

Due to the lack of space, the replanting of trees to the numerical replacement ratio of 1:1 to compensate for unavoidable tree felling may not be feasible within the Study Area when development occurs. However, recreating planting structures which are more complex, introducing native flora species and keystone species such as *Ficus* species which fruit all year round, thus providing a food source to support urban wildlife could add value to the compensatory planting. In doing so, compensatory planting would be closer to enhancement planting and is detailed further below.

12.6.5 Mitigation Measures for the Protection of Threatened Fauna Species

Another proactive mitigation measure on site to protect threatened fauna species would include the translocation of specific species.

Translocation of specific species may be considered as a last measure if the original habitats may not be retained. However, these measures are not considered to lower the impact significance of the works

as the success rate of the translocation exercise cannot be secured as many environmental factors have to be considered and cannot be pre-determined. For example, the sex and number of individuals captured for the translocation exercise, finding similar habitat conditions which provide food and refuge for the species translocated and existing populations in the receptor sites, the stress that translocated individuals face and whether the individuals translocated return to the original habitats which are meant to be cleared.

The Bamboo Bats may be a suitable species for translocation from affected bamboo clusters to retained bamboo clusters: The *Kopi Sua* Cemetery and Bukit Brown Woods will be retained with unaffected bamboo clusters, habitats and environmental conditions are likely to be the same.

Further studies have to be made to investigate the feasibility of translocation and if it is carried out, studies should also be planned for the monitoring of the translocated species to determine the success of the exercise. Furthermore, if the baseline surveys would have been completed more than two years from the time of site vegetation clearance, new studies will need to be done with ascertain if the target species is still on site.

12.6.6 Residual Impacts

With the implementation of mitigation measures, the impact significance for most of the construction activities are reduced to minor. However, the residual impact for site clearance remains as major as it is a permanent and irreversible impact that cannot be mitigated to a moderate level. Hence, the overall impact significance of the proposed development on the Study Area is still expected to be **major**. The significance of residual impact for each construction activity is listed in **Table 12-28**.

Table 12-28: Recommended Mitigation Measures during the Pre-construction, Construction and Operational Phase of the development of the Study Area

Construction Activity	Ecological Impact	Impact Significance	Description of the Recommended Mitigation Measures	Significance of Residual Impact
1. PRE-CONSTRUCTION				
Site clearance and excavation involving: • Use of heavy machineries to remove all above-ground vegetation; • Placement of soil control measure; • Soil excavation; and • Mobilisation of construction equipment, resources and erection of workers' camps.	• Habitat loss & loss of connectivity • Disturbance to soil • Disruption of ecological processes • Drop in surface water quality or contamination of surface water • Fauna mortality or injury (direct or indirect); including those arising from human-wildlife conflicts • Road kills	**Moderate to Major** (Irreversible permanent site clearance for overall site. The original impact to Stream 3 was considered moderate and three specific mitigation options were studied further)	1) In Stream 1, as it is not possible to avoid clearance works and preserve the stream, consider compensatory measures such as replacing the natural stream with ABC Waters Features. While compensatory planting and habitat replacement will provide new habitats, during construction, the existing natural habitat will be lost and fauna mortality is still likely to occur.	**Major**
			1) Consider translocation of Bamboo Bats from affected bamboo clusters to retained bamboo clusters on site or in the adjacent Bukit Brown Woods. While this exercise would mitigate the risk of certain mortality of the bats, the translocation has certain drawbacks: bats may be stressed from the handling and bats may not stay in the final receptor bamboo cluster. Therefore, the impact remains as major.	**Major**
			2) In Stream 3, three mitigation options to reduce impact are proposed but only Option C is considered to reduce impact for biodiversity: <u>Option C</u>: The slip road avoids the stream completely and only begins past Mount Pleasant Road, connecting to the existing Onraet Road. - All options would require further engineering studies.	Negligible

Construction Activity	Ecological Impact	Impact Significance	Description of the Recommended Mitigation Measures	Significance of Residual Impact
			1) Review parcellation around the cluster of 11 tembusus to avoid removing the trees and preserving them with minimal changes to the existing grade. 2) Engage arborist, flora and fauna specialists to clearly mark out areas and plants with conservation value clearly before construction works. Plants may also be harvested and transplanted in partnership with NParks.	Negligible Minor
			3) The erection of the hoarding shall be directional, starting from the area closest to the busiest road, Thomson Road, then towards Bukit Brown Woods. The hoarding shall be continuous and complete before work commences. This is to reduce potential roadkills. 4) Once the site hoarding is completed, determine if there are wild pigs within the hoarding. If wild pigs are present, the Contractor shall engage an approved wildlife management specialist to trap and remove wild pigs in view of workers' safety concerns. 5) Avoid site clearance during peak bird breeding season (March to July). 6) Engage arborist and ecologist to monitor site clearance to inspect and ensure preserved areas and vegetation are not affected by the activity. 7) Careful planning to reduce working space of machinery, access roads and avoid unnecessary and excessive vegetation clearance. E.g. To allow access of machinery from areas that are already disturbed and to be cleared. No storage or access should be made within the areas of the *Kopi Sua* Cemetery to be retained. 8) Have tree felling and vegetation clearance activities phased, in the direction of the Bukit Brown Woods and the remaining *Kopi Sua* Cemetery, so that arboreal fauna may have an opportunity to move towards the area of refuge, rather than towards Thomson Road or the PIE. 9) During site clearance, contractors are to ensure that equipment stays within development site and not exceed the boundary limits 10) Implement soil erosion control measures. Retain ground cover as long as possible before removal. When ground cover is removed, Earth Control Measures (ECM) is to be installed. Use only fully biodegradable ECM mats to reduce the likelihood of trapping small animals such as snakes. 11) Personnel on site to practise good house-keeping with daily clearance of food waste and other rubbish. All meals should be taken in allocated	**Major** (items 3 – 5, 7 – 10) (permanent irreversible clearance of habitat) The specific risk of human-wildlife conflict is lowered to minor.

Construction Activity	Ecological Impact	Impact Significance	Description of the Recommended Mitigation Measures	Significance of Residual Impact
			shelters and not in areas where fauna such as macaques can access easily. 12) Daily toolbox for briefing construction personnel and sub-contractors to remind them to practise caution during work. If any animal is encountered, especially those of conservation status, they must stop work and inform HDB or the attending ecologist-in-charge.	
	• Disturbances to wildlife due to noise (refer to Section 8.0), vibration (refer to Section 9.0), dust (refer to Section 7.0), light and human presence	**Moderate to Major**	1) Implement dust control measures to suppress dust to reduce its impact. This includes using dust screens and water suppression systems to control the amount of dust. 2) Avoid carrying out any work at night and minimise noise even in daytime. Adhere to NEA's noise control guidelines. 3) To source for quieter construction equipment as far as possible. E.g. through use of silent piler. 4) Daily toolbox for briefing construction personnel and sub-contractors to brief them on procedure. E.g. informing ecologist if they encounter any fauna.	Moderate
	• Habitat degradation due to improper waste disposal and release of harmful substances	**Major**	1) Establish and maintain proper construction waste and debris disposal system. This involves establishing clearly the standard operating procedure of waste management and training the personnel so that they are familiar with the procedure. 2) Daily toolbox for construction personnel and sub-contractors on mitigating actions, proper waste disposal and equipment storage. 3) Practise due diligence in proper storage and handling of machineries to prevent leaching of oil or harmful materials such as bentonite slurry. 4) Reduce the use of insecticide so that insects in forest would not be affected by it, which in turn harms insectivorous birds. Current MQ requires inspection for mosquito larvae and not regular preventive application of BTI. BTI is a non-specific larvicide and its constant use will result in loss of butterflies and odonates larvae. BTI should only be applied in areas where its inaccessible and typical solutions have not been able to resolve stagnant water. 5) Practise due diligence in proper storage and handling of machineries to prevent leaching of oil or harmful materials such as bentonite slurry. Store and handle harmful materials well away from water bodies. 6) Engage a Qualified Erosion Control Professional to formulate and implement an Earth Control Measures Plan in accordance with PUB requirements.	Minor

Construction Activity	Ecological Impact	Impact Significance	Description of the Recommended Mitigation Measures	Significance of Residual Impact
			7) Ensure silt fence at hoarding are installed and maintained properly.	
2. CONSTRUCTION				
Piling and installation of super structures involving: • Use of heavy machineries; • Piling for the construction of basement and foundation systems; and • Installation of buildings and super structures.	• Disturbances to wildlife due to noise, light and human presence • Habitat degradation due to improper waste disposal and release of harmful substances including insecticide • Drop in surface water quality or contamination of surface water (refer to Section 10.0) • Fauna mortality or injury (direct or indirect)	**Major**	1) Implement dust control measure to suppress dust to reduce its impact. 2) Reduce the use of insecticides during the construction as it may spread to nearby areas and kill insects which are food for insectivorous birds. 3) Avoid carrying out any work at night and minimise noise even in daytime. 4) To source for quieter construction equipment as far as possible. 5) Plant more trees along the edge of the forest can serve as a natural barrier to light, noise and filter dust that comes from the construction site. 6) Daily toolbox for construction personnel and sub-contractors on mitigating actions, proper waste disposal and equipment storage. 7) Practise due diligence in proper storage and handling of machineries to prevent leaching of oil or harmful materials such as bentonite slurry. Store and handle harmful materials well away from water bodies. 8) Engage a Qualified Erosion Control Professional to formulate and implement an Earth Control Measures Plan in accordance with PUB requirements. 9) Ensure silt fence at hoarding are installed and maintained properly to reduce animals moving into the work areas.	Moderate
3. POST-CONSTRUCTION/OPERATION				
Construction of the development completed and involving: • Demolition, removal of construction materials and vehicles, and withdrawal of personnel; • Human presence; and • New buildings.	• Habitat degradation due to improper waste disposal and release of harmful substances including insecticide • Disturbances to wildlife due to noise, light and human presence • Forest edge effects	Minor to Negligible **Major**	1) Ensure all construction waste has been disposed of properly. 2) Reduce the use of insecticide so that insects in forest would not be affected by it, which in turn harms insectivorous birds. Current MQ requires inspection for mosquito larvae and not regular preventive application of BTI. BTI is a non-specific larvicide and its constant use will result in loss of butterflies and odonates larvae. BTI should only be applied in areas where its inaccessible and typical solutions have not been able to resolve stagnant water. 3) Plant more trees along the edge of the retained vegetation and adjacent forest (Bukit Brown Woods), it can serve as a natural barrier to light, noise and filter vehicular emissions that may be harmful to animals.	Negligible Minor Moderate

Construction Activity	Ecological Impact	Impact Significance	Description of the Recommended Mitigation Measures	Significance of Residual Impact
	• Bird collisions	Minor	1) Incorporate bird-friendly features for building design. E.g. Presence of overhangs, replace continuous glass facades with decorative facades and grilles, UV patterned glass.	Negligible
	• Human-wildlife conflict	Moderate	1) Ensure proper food disposal and enforcement of no feeding of wildlife to avoid human-wildlife conflicts, particularly with macaques and pigs.	Minor

12.7 Summary of Key Findings

1) The ecological value of the Study Area is medium to high.

2) The overall ecological impact significance of the development to the Study Area is expected to be **major**.

   The Study Area acts as a buffer to the Central Catchment Nature Reserve and biodiversity that may be restricted to the Central Catchment Nature Reserve are found to be present in the Study Area as well – this includes both flora and fauna of conservation status. The residual impact for the construction stage remains as **major** as impacts such as vegetation clearance, disruption to ecological processes, habitat loss, disturbance to soil are permanent and irreversible and cannot be mitigated to a lower level.

3) The residual impact for the operation stage is considered **moderate to negligible** as most of the vegetation and habitats would have been cleared. Remaining wildlife in the Study Area or in the surrounding forest are likely to be more resilient and tolerant to urban conditions. The impact significance can be further reduced with some design and educational measures to raise awareness.

13.0 Landscape and Visual Amenity

13.1 Introduction

A qualitative Landscape and Visual Amenity Impact Assessment (LVIA) was conducted as part of the EIS to indicate areas in the vicinity of the proposed development that may be deemed to be of scenic or aesthetic appeal. These values are referred to when determining impacts as a result of the construction and operational phases of the development in the Study Area.

This section follows the guidance from Hong Kong Environmental Protection Department's Environmental Impact Assessment Ordinance Technical Memorandum Annex 18, wherein the landscape and visual impact assessment is directed towards the predicting and judging the significance of the effects that new development may have on landscape character and visual amenity. The perception and aspiration of the community on landscape features must be taken into account. The assessment may vary from case to case, depending on the nature of the issues and will be subject to judgement and preference.

The following sub-sections describe the field activity and investigation methodology, and results of the assessment.

13.2 Baseline Assessment Methodology

The baseline assessment consisted of desktop study, observation surveys, and photography, during biodiversity monitoring and a separate field assessment, to identify existing landscape features and visual amenities (henceforth referred to as 'Landscape Resources') with scenic or aesthetic value in the Study Area. Existing Landscape Resources (LRs) were identified, described, and evaluated using a method adapted from Hong Kong's Technical Memorandum on the EIA Process (Annex 10 and 18) and Environmental Impact Assessment Ordinance Guidance Note 8/2010, and the process for impact assessment used by the other technical disciplines and described in **Section 6.0**.

When determining Receptor Sensitivity, the sensitivity categories in **Table 6-1** were primarily used to determine the Priority of each LR. To assist in determining the Priority of each LR, the following factors from Hong Kong's EIA guidance documents (discussed above) were also considered:

- Quality and Maturity: The condition and value of LRs, taking into account general quality, maturity and condition of the vegetation;
- Rarity: The importance and/or rarity of LRs in the context of the surrounding landscape, including whether the LR is of local, regional, national or global importance; and
- Ability to Accommodate Change: The ability of LRs to accommodate change without compromising their essential nature.

Each LR and its final Priority determination are assessed in **Section 13.3**.

13.3 Baseline Landscape and Visual Amenity

The Study Area is a mix of disturbed natural habitat, managed land, construction, and residential development. While some vegetation recovery has occurred, the Study Area is heavily disturbed by human activity, impacting its baseline Landscape and Visual amenity. This is evident in the managed vegetation of the WRC and OPA, the concretised channels within the abandoned land forest, and little to no vegetation in the MRT construction site. Around the cemetery and residential area with heritage features (i.e. Black and White Bungalows along Mount Pleasant Road), managed vegetation is a mix of exotic and native species, which appear to provide the best landscape and visual amenity values within the Study Area.

13.4 Landscape and Visual Amenity Impact Assessment

The Landscape and Visual Amenity assessment was conducted within the Study Area and did not require any buffers.

13.4.1 Approach

Understanding the potential for and significance of impacts to landscape and visual amenity within the Study Area by the proposed development is a central objective of the EIS. This section therefore aims to evaluate the significance of these impacts on landscape and visual amenity values.

As discussed in **Section 4.0**, there is no consistent guidance on the conductance of Landscape and Visual Amenity Impact Assessment (LVIA) for Singapore. Therefore, this study has referenced the guidelines and provisions outlined in Hong Kong's Technical Memorandum on the EIA Process (Annex 10 and 18), the Environmental Impact Assessment Ordinance Guidance Note 8/2010, and structured the impact assessment as per the process used by the other technical disciplines and described in **Section 6**.

The impact assessment for the construction and operational phases of the development on Landscape and Visual Amenity of the Study Area was conducted using a qualitative process. In order to understand the potential impacts of construction and operational activities, the sources and associated impacts need to first be identified. As the Study Area are currently in a preliminary master-planning stage, details of the actual works are not available, therefore a high-level assessment of activities has been conducted in **Sections 3.2** and **Section 3.4**. This information is referred to during the process for impact evaluation, described in **Section 6.4.2**, which is a function of determining the impact consequence and comparing against the significance of the impact for each LR. Where impacts were considered to be significant (moderate to major), mitigation measures have been recommended to reduce the landscape impacts potentially resulting from the design, construction, and operation of the development.

13.4.2 Classification of Sensitive Receptors

Following the Biodiversity and field assessments, the landscape features and visual amenities present within the Study Area were split into LR categories based largely on the Biodiversity assessment and the identified man-made features. There were 3 types of LRs identified in this study as listed below:

- LR1 – Unmanaged Vegetation;
- LR2 – Managed Vegetation; and
- LR3 – Residential Area with Heritage Features.

Vegetation-related LRs were split into Unmanaged and Managed Vegetation categories based on the amount of human-influence on the Vegetation Types described in **Section 12.0**. Managed Vegetation is defined as vegetation to be maintained by humans such as parks, gardens and roadsides, which is a mix of exotic and commercially available native species, whereas Unmanaged Vegetation would be vice versa.

Note that as mentioned in **Section 12.3.1**, Kopi Sua Cemetery has a mix of planted vegetation maintained by a group of caretakers and native plants which are clearly abandoned and largely naturalised due to the nature of this property with low level of human disturbance. Therefore, the managed vegetation near the grave area will be categorised under LR1, while the native plants within and surrounding the Kopi Sua Cemetery will be categorised under LR2.

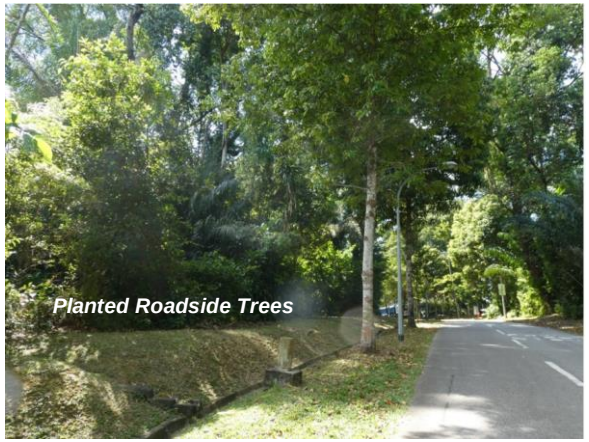
The man-made LR is represented by the Residential Area with Heritage Features, which is represented by the colonial houses, or namely Black and White bungalows along Mount Pleasant Road, that have been present since the early 1900s and provide historical amenity to the Study Area. Mount Pleasant Road is also listed as a 'Heritage Road' by NParks[22].

The following table summarises each the classification of LRs within the Study Area and determines their respective sensitivity/ priority as per **Section 6.4.2.** The overview of landscape resources within Study Area is demonstrated in **Figure 13-1.**

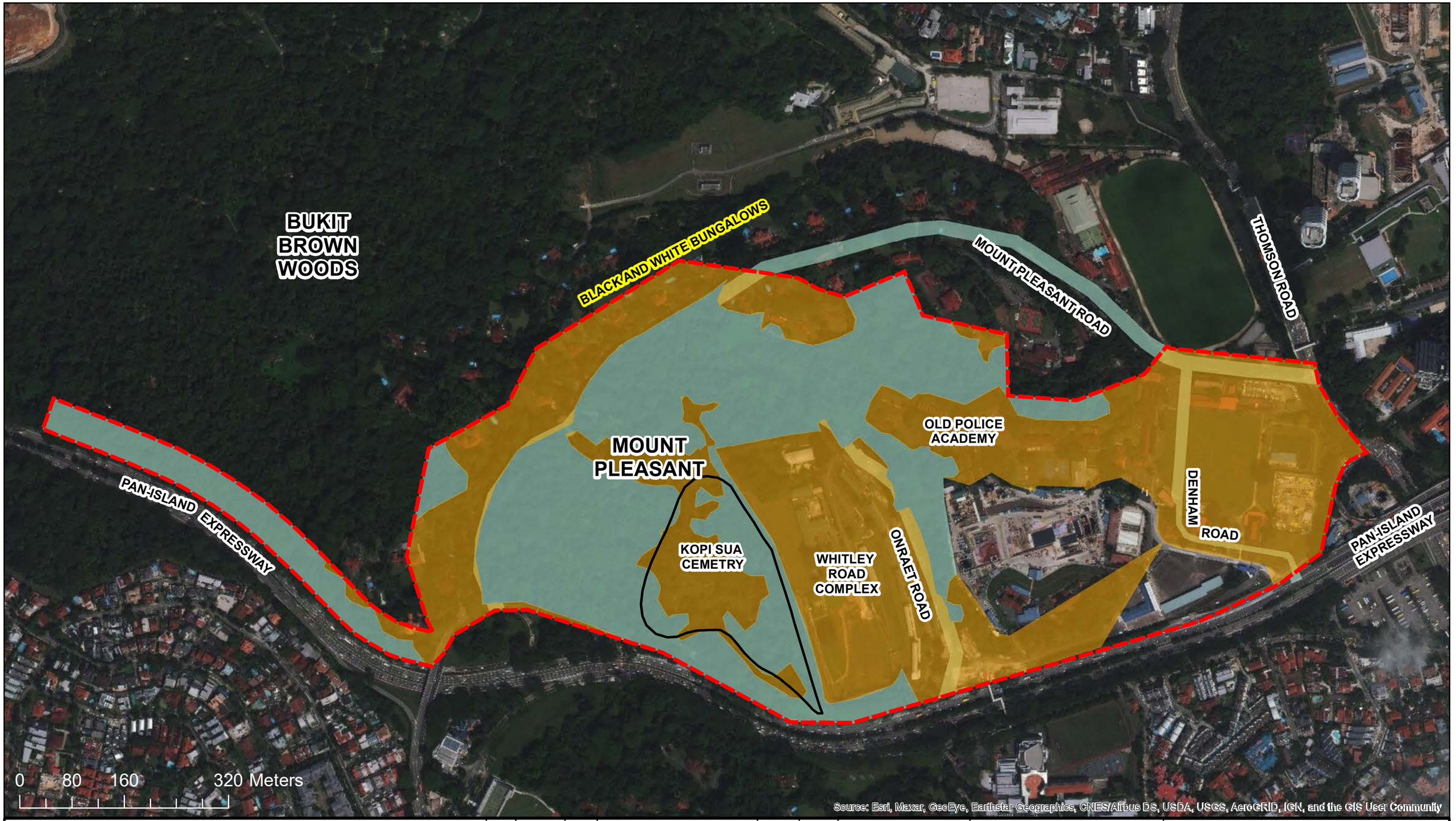
[22] https://www.nparks.gov.sg/gardens-parks-and-nature/heritage-roads/mount-pleasant-road

Table 13-1: Landscape Resources within the Study Area and their Sensitivity

LR No.	LR Name	List of LR (See Figure 13-1)	Quality & Maturity (High/ Medium/ Low)	Rarity (High/ Medium/ Low)	Ability to Accommodate Change (High/Medium/Low)	Sensitivity (Priority 1/2/3)	Photos
LR1	Unmanaged Vegetation	• Abandoned-land forest • Waste woodlands • Herbaceous and scrubland vegetation • Native-dominated low secondary forest • Native plants within and surrounding Kopi Sua Cemetery.	Medium	Low	Low	Priority 3	 *Native plants in/ around Kopi Sua Cemetery*

LR No.	LR Name	List of LR (See Figure 13-1)	Quality & Maturity (High/ Medium/ Low)	Rarity (High/ Medium/ Low)	Ability to Accommodate Change (High/Medium/Low)	Sensitivity (Priority 1/2/3)	Photos
LR2	Managed Vegetation	• Managed vegetation (e.g. landscape planting, streetscape, green verges, managed lawns) within the private compound areas of the OPA, WRC, surrounding the Black and White Bungalows along Mount Pleasant Road, as well as managed vegetation near the grave area within Kopi Sua Cemetery. • Planted roadside trees and shrubs along Mount Pleasant Road, Onraet Road and the Pan Island Expressway.	Low	Low	Medium	Priority 3	 

LR No.	LR Name	List of LR (See Figure 13-1)	Quality & Maturity (High/ Medium/ Low)	Rarity (High/ Medium/ Low)	Ability to Accommodate Change (High/Medium/Low)	Sensitivity (Priority 1/2/3)	Photos
LR3	Residential Areas with Heritage Features	Colonial houses (alternatively known as Black and White bungalows) along Mount Pleasant Road	High	High	Low	Priority 2	



Legend

- Study Area
- Kopi Sua Cemetery

Landscape Resources (LRs)

- LR1 - Unmanaged Vegetation
- LR2 - Managed Vegetation
- TEXT LR3 - Residential Area with Heritage Features

N

Rev.	Date	By	Description	Chk'd	App'd
-	JAN 2021	LYE	Final Report	NHT	JAG

Qualified Person Endorsement :
NA

HDB Endorsement :
NA

Consultant : AECOM

Project Title :
**CONTRACT L/003/19
ENVIRONMENTAL IMPACT STUDY
AT MOUNT PLEASANT**

Designed	Checked	Approved
LYE	NHT	JAG
	Drawn	Date
	LYE	JAN 2021

HOUSING & DEVELOPMENT BOARD

Figure Title :
**LANDSCAPE RESOURCES
WITHIN STUDY AREA**

Figure No. :	Rev.	Sheet
13 - 1	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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13.4.3 Potential Sources of Impacts

Impacts to the landscape and visual amenity values within the Study Area may occur in either the construction or operational phases of the project. These impacts are generally closely tied to impacts to the flora within the study; however, consideration is also given to the heritage value of Mount Pleasant Road and the colonial houses, as identified by NParks. The potential sources and associated impacts for the construction and operational phases of the project are summarised, but not limited, to those listed in **Table 13-2** and **Table 13-3** respectively.

Table 13-2: Summary of the Potential Sources and Associated Impacts to Landscape and Visual Amenity during the Construction Stage

Activity	Potential Source of Impacts	Potential Associated Impacts
Road works	• Re-alignment of roads and construction of access roads	• Change to the character of Mount Pleasant Road.
Site investigation	• Clearing of vegetation for access tracks; • Use of drilling rigs	• Loss of vegetation within the LR1 and LR2 will impact their ecological function and baseline character.
Land clearing, earthworks and excavation activities	• Vegetation clearance in preparation for construction works	
Construction works	• Creation of laydown areas and other temporary facilities such as site offices and parking areas; • Stockpiling of construction and demolition materials, including topsoil; • Construction of building basements, foundations and superstructures; • Installation of utilities and services; • Re-alignment of streams and watercourses; • Vehicle movement and machinery operation.	• Increase in heavy vehicle and site vehicle traffic; • Potential dust and noise impacts from construction works and materials stockpiling; • Loss of greater areas of vegetation than will be required once construction completed.

Table 13-3: Summary of the Potential Sources and Associated Impacts to Landscape and Visual Amenity during the Operational Stage

Activity	Potential Source of Impacts	Potential Associated Impacts
Operation of buildings and new roads	• Increase in traffic movements by residents and visitors; • Permanent lighting sources in the evening; • Increased in general activities; • Visual impact from tall buildings.	• Increase in the number of residents and visitors driving in the area above baseline conditions; • Increase in permanent evening lighting; • HDB tower blocks visible in an area previously occupied by low-rise housing and vegetation, potentially of different architectural style to colonial houses; • Loss of quiet suburban character at Mount Pleasant Road.
Provision of open spaces	• Replacement of forest vegetation with landscaping.	• Change in visual amenity; • Loss of ecological function; • Change from low-density residential to high-density residential.
Residual impacts from loss of trees and vegetation	• Reduction in volume and cover of vegetation.	
Change in Land use	• Removal of vegetation and increase in impervious services.	

13.4.4 Minimum Control for Impacts

Given the early stage of the current project, specific control measures are difficult to recommend; however, at the very minimum, the overall landscape and visual amenity of the Study Area should be considered when designing the HDB residential blocks and associated facilities. This includes, but is not limited to, consideration of the ecological function of the LRs, the heritage value of Mount Pleasant Road and the colonial houses, and the overall character of the Study Area.

In addition, it is noted that any damage or removal of vegetation within the heritage road green buffer of up to 10m and either side of the road is strictly prohibited, except with approval of the Commissioner of Parks and Recreation (NParks, 2015). Therefore, this development of the Study Area is unlikely to cause significant landscape and visual amenity impact on the road character and heritage value of Mount Pleasant Road where the colonial houses are situated.

13.4.5 Impact Prediction and Evaluation

The assessment of Impact Intensity, Consequence, Likelihood and Significance is in accordance with the methodology detailed in **Section 6.0**. To evaluate potential impacts on landscape and visual amenity values within the Study Area prior to application of mitigation measures, an understanding of the Impact Consequence against the Likelihood of Occurrence must be developed. As per **Section 6.4.2.1**, Impact Consequence is a combination of Impact Consequence and Receptor Sensitivity. Criteria for determining the Impact Intensity are contained in **Table 6-5**, and Receptor Sensitivity is established in **Table 6-1**.

Once Impact Consequence has been established, the Likelihood of Occurrence of an impact must be understood. The criteria used to determine Likelihood of Occurrence are included in **Table 6-7**. These factors are considered together for each LR in **Table 13-4** to **Table 13-6** below to first determine the Impact Significance of each potential impact identified for both the construction and operational phases prior to mitigation.

The results of the impact evaluation suggest that for LR1, site investigation work is likely to have a **moderate** impact during the construction phase, while the operation of the project is also likely to result in a **moderate** impact. During the construction phase, LR2 is likely to have a **minor** impact, and, similar to LR1, operation of the project is likely to result in a **moderate** impact. For LR3, as it is a residential area with heritage features and human inhabitants, the site investigation work, earthwork and other construction works are likely to cause **moderate** impact during construction phase. Similarly, during the operational phase, all identified impacts are considered to have a **moderate** or **major** impact on LR3 given its unique heritage value and the potential for significant change to the overall character of the Study Area following completion of the project.

To reduce the **moderate** and **major** landscape and visual amenity impacts, potential mitigation measures were recommended as listed in **Section 13.5**.

Table 13-4: Impact Significance Evaluation for Potential Construction and Operational Impacts on LR1 - Unmanaged Vegetation (Prior to Mitigation)

Activities	Potential Associated Impacts	Receptor Sensitivity	Impact Intensity	Impact Consequence	Likelihood of Occurrence	Impact Significance
Construction Impacts						
Site investigation Land clearing, earthworks and excavation activities	Loss of vegetation within the LRs impacting their ecological function and baseline character	Priority 3	High	Low	Continuous	**Moderate**
Construction works	Increase in heavy vehicle and site vehicle traffic		Medium	Very Low	Regular	Minor
	Potential dust and noise impacts from construction works and materials stockpiling		Low	Very Low	Regular	Minor
	Loss of greater areas of vegetation than will be required once construction completed		Medium	Very Low	Rare	Negligible
Road works	Change to the character of Mount Pleasant Road with heritage road green buffer of 10m from either side of the road		Medium	Very Low	Continuous	Minor
Operational Impacts						
Operation of buildings and new roads	Increase in the number of residents and visitors driving in the area above baseline conditions	Priority 3	High	Low	Continuous	**Moderate**
	Increase in permanent evening lighting		Medium	Very Low	Regular	Minor
	HDB tower blocks visible in an area previously occupied by low-rise housing and vegetation, potentially of different architectural style to colonial houses		High	Low	Continuous	**Moderate**
	Loss of quiet suburban character at Mount Pleasant Road.		High	Low	Continuous	**Moderate**
Provision of open spaces	Change in visual amenity		High	Low	Continuous	**Moderate**
	Loss of ecological function		High	Low	Continuous	**Moderate**

Activities	Potential Associated Impacts	Receptor Sensitivity	Impact Intensity	Impact Consequence	Likelihood of Occurrence	Impact Significance
Residual impacts from loss of trees and vegetation Change in Land use	Change from low-density residential to high-density residential		High	Low	Continuous	**Moderate**

Table 13-5: Impact Significance Evaluation for Potential Construction and Operational Impacts on LR2 - Managed Vegetation (Prior to Mitigation)

Activities	Potential Associated Impacts	Receptor Sensitivity	Impact Intensity	Impact Consequence	Likelihood of Occurrence	Impact Significance
Construction Impacts						
Site investigation Land clearing, earthworks and excavation activities	Loss of vegetation within the LRs impacting their ecological function and baseline character	Priority 3	Medium	Very Low	Continuous	Minor
Construction works	Increase in heavy vehicle and site vehicle traffic		Medium	Very Low	Regular	Minor
	Potential dust and noise impacts from construction works and materials stockpiling		Low	Very Low	Regular	Minor
	Loss of greater areas of vegetation than will be required once construction completed		Medium	Very Low	Rare	Negligible
Road works	Change to the character of Mount Pleasant Road with heritage road green buffer of 10m from either side of the road		Medium	Very Low	Continuous	Minor
Operational Impacts						
Operation of buildings and new roads	Increase in the number of residents and visitors driving in the area above baseline conditions	Priority 3	High	Low	Continuous	**Moderate**
	Increase in permanent evening lighting		Medium	Very Low	Regular	Minor
	HDB tower blocks visible in an area previously occupied by low-rise housing and vegetation, potentially of different		High	Low	Continuous	**Moderate**

Activities	Potential Associated Impacts	Receptor Sensitivity	Impact Intensity	Impact Consequence	Likelihood of Occurrence	Impact Significance
	architectural style to colonial houses					
	Loss of quiet suburban character at Mount Pleasant Road.		High	Low	Continuous	**Moderate**
Provision of open spaces	Change in visual amenity		High	Low	Continuous	**Moderate**
	Loss of ecological function		Medium	Very Low	Continuous	Minor
Residual impacts from loss of trees and vegetation Change in Land use	Change from low-density residential to high-density residential		High	Low	Continuous	**Moderate**

Table 13-6: Impact Significance Evaluation for Potential Construction and Operational Impacts on LR3 – Residential Areas with Heritage Features (Prior to Mitigation)

Activities	Potential Associated Impacts	Receptor Sensitivity	Impact Intensity	Impact Consequence	Likelihood of Occurrence	Impact Significance
Construction Impacts						
Site investigation Land clearing, earthworks and excavation activities	Loss of vegetation within the LRs impacting their ecological function and baseline character	Priority 2	Medium	Medium	Occasional	**Moderate**
Construction works	Increase in heavy vehicle and site vehicle traffic		Medium	Medium	Regular	**Moderate**
	Potential dust and noise impacts from construction works and materials stockpiling		Low	Low	Regular	**Moderate**
	Loss of greater areas of vegetation than will be required once construction completed		Low	Low	Unlikely	Negligible
Road works	Change to the character of Mount Pleasant Road with heritage road green buffer of 10m from either side of the road		Medium	Very Low	Continuous	Minor
Operational Impacts						
Operation of buildings and new roads	Increase in the number of residents and visitors driving in	Priority 2	High	High	Continuous	**Major**

Activities	Potential Associated Impacts	Receptor Sensitivity	Impact Intensity	Impact Consequence	Likelihood of Occurrence	Impact Significance
	the area above baseline conditions					
	Increase in permanent evening lighting		Medium	Medium	Regular	**Moderate**
	HDB tower blocks visible in an area previously occupied by low-rise housing and vegetation, potentially of different architectural style to colonial houses		High	High	Continuous	**Major**
	Loss of quiet suburban character at Mount Pleasant Road.		High	High	Continuous	**Major**
Provision of open spaces Residual impacts from loss of trees and vegetation Change in Land use	Change in visual amenity		High	High	Continuous	**Major**
	Loss of ecological function		Low	Low	Continuous	**Moderate**
	Change from low-density residential to high-density residential		High	High	Continuous	**Major**

13.5 Recommended Mitigation Measures

Given the intangible nature of the Landscape and Visual Amenity values within the Study Area, represented by their heritage value, overall character and vegetation, changes brought about by construction of the project are likely to have a significant impact. This is highlighted in the impact assessment conducted in, where the Impact Significance were determined to have **Moderate** and **Major** impacts on the landscape and visual amenity resources within the Study Area. As the project is still in the early master planning stage, there is the possibility to reduce the **Moderate and Major** Impact Significance to **Minor and/or to acceptable levels**; however, this largely dependent on the final design and construction work plan, which was not available at the time of the current impact assessment.

Mitigation measures recommended in this section therefore are general in nature and are intended to be considered during the design phase to mitigate some of the impacts to the LRs. These mitigation measures may include, but are not limited, to those listed in **Table 13-7**. In addition, relevant mitigation measures from other technical disciplines (e.g. setting up noise barriers, etc.) could be taken into consideration into reducing landscape and visual impacts.

Table 13-7: Recommended Mitigation Measures

Mitigation Measure	Description
Design Phase	
Avoid and/or reduce vegetation loss as much as possible	The Study Area has large patches of vegetation which provide much of the character of the landscape and visual amenity values. Preserving this vegetation as much as possible as-is is likely to have a reduced impact on these values.
Retain large, old, mature trees where possible	The ecological character of the LRs is also likely to be impacted by the project; however, preservation of those ecological components which provide the greatest habitat value, may reduce the impact from the project.
Appropriate design of building facades	The colonial character of the residential buildings in the Study Area are a key feature of their heritage value and character and is largely behind its sensitivity rating. Design of the HDB tower blocks and associated facilities should consider these values when developing facades and layout of the new buildings and landscaping.
Visual design on noise mitigation measures	The visual impact of noise mitigation structures could be mitigated by appropriate detailed design in accordance with *Guidelines on Design of Noise Barriers by HyD and EPD in 2003*, such as suitable combination of transparent and sound absorbent materials, appropriate colour selection of panels and supporting structures to incorporate a high level of quality and aesthetics.
Buffer zones from colonial houses	A buffer zone may be designed into the project to screen the colonial houses from much of the on-ground construction impacts of the project.
Landscaping	Consideration of the size and species composition of landscaping in the context of the current baseline conditions should also be taken into account during design to reduce the impact on the landscape and visual amenity values within the Study Area. Options may include, but is not limited to, slope landscaping, green roofs, road greening, screen planting, vertical greening, and planting of native species (with consideration given to keystone species, and vertical vegetation structure).
Construction Phase	

Mitigation Measure	Description
Implement noise and dust mitigation measures	These measures are described in detail in **Section 7.0** and **Section 8.0** respectively and should be implemented to reduce their impacts on the existing landscape and visual amenity values.
Avoid unintended vegetation removal	Vegetation not earmarked to be removed should be protected from clearance during the construction phase to reduce any inadvertent additional impacts to the values of the LRs.
Minimize visual disturbance from work sites	Screen hoarding could be implemented to mitigate the visual impacts during construction phase, especially towards the human inhabitants near LR3. Besides, construction lighting should be controlled to a suitable level of brightness, especially during evening time to minimize visual disturbance from construction sites.
Operational Phase	
Reinstate construction area	The developer or appointed contractor should conduct reinstatement of working area to original condition and/or required conditions to mitigate the landscape and visual impacts of the development in the Study Area.
Compensatory tree planting	This may be done through replanting of trees to compensate for unavoidable tree felling.
Buffer tree planting	Trees and shrubs could be planted along the circumference of the finished buildings, associated facilities and road networks to soften the hard edge of the structure and improve compatibility with the surrounding environment, as well as providing a form of visual relief.

13.6 Residual Impacts

During construction phase, with the mitigation measures proposed in **Table 13-7**, as well as relevant mitigation measures from other technical disciplines, it was anticipated that the **Moderate and/or Major** landscape and visual impacts significance in overall could be reduced to **Minor and/or to acceptable levels**, however this would be subject to incorporation of the proposed mitigation measures into the actual detailed design and construction work plan, which was not available at the time of the current impact assessment.

Besides, as mentioned in **Section 3.1**, an indicative alternative road plan 2 (see **Figure 3-2**) was proposed as the preferred mitigation measure in this report, where it uses the existing Onraet Road to connect the development to PIE, which differs from the indicative original road plan which uses the existing Mount Pleasant Road instead. The residual impact significance for the landscape and visual amenity impact with the indicative alternative road plan 2 was assessed and the comparison was made as shown in **Table 13-8** below. With the implementation of indicative alternative road plan 2, the impact intensity of landscape and visual amenity for LR1 (Unmanaged Vegetation) and LR2 (Managed Vegetation) is able to reduce from Medium to Low, therefore giving a Very Low impact consequence. Given consideration of that this event is still Certain/ Continuous to occur during construction phase, the impact significance of LR1 and LR2 are remained **Minor**. During operational phase, since there will be no discernible change to the landscape and visual amenity characters of the existing Onraet Road which is already disturbed with development around, therefore the overall impact significance can be reduced to **Negligible**.

As for LR3, since the indicative alternative road plan 2 does not pass through or nearby the residual area with heritage features along Mt Pleasant Road, thus there will be no residual impact for both construction and operational phase. This will indirectly able to mitigate the Major impact significance of

LR3 in terms of landscape and visual amenity impact without causing loss of road character of the heritage road if compared to the indicative original road plan.

Table 13-8: Residual Impact Significance Evaluation on Potential Construction and Operational Impacts (With Indicative Alternative Road Plan 2)

LR	Potential Impacts and Evaluation	Receptor Sensitivity	Impact Intensity	Impact Consequence	Likelihood of Occurrence	Impact Significance
Construction Impacts (Before Mitigation using Indicative Original Road Plan) *– Extracted from Table 13-4 to Table 13-6*						
LR1	Road Works causing change to the character of Mount Pleasant Road (heritage road)	Priority 3	Medium	Very Low	Continuous	Minor
LR2		Priority 3	Medium	Very Low	Continuous	Minor
LR3		Priority 2	Medium	Very Low	Continuous	Minor
Construction Impacts (After Mitigation using Indicative Alternative Road Plan 2)						
LR1	No discernible change to landscape characters on an existing Onraet Road which is not a heritage road. Only potential visual amenity impact to the surrounding neighbourhood during construction phase where the general mitigation measures in Section 13.5 are applicable.	Priority 3	Low	Very Low	Continuous	Minor
LR2		Priority 3	Low	Very Low	Continuous	Minor
LR3	Not Applicable, as there will be no road plans near LR3 (representing Black and White Bungalows along Mount Pleasant Road)	Priority 2	N/A	N/A	N/A	N/A
Operational Impacts (Before Mitigation using Indicative Original Road Plan) *– Extracted from Table 13-4 to Table 13-6*						
LR1	Loss of quiet suburban character at Mount Pleasant Road	Priority 3	High	Low	Continuous	**Moderate**
LR2		Priority 3	High	Low	Continuous	**Moderate**
LR3		Priority 2	High	High	Continuous	**Major**
Operational Impacts (After Mitigation using Indicative Alternative Road Plan 2)						
LR1	No discernible change as the existing Onraet Road is a highly disturbed road with building operations and construction site at its surrounding	Priority 3	Negligible	Imperceptible	Continuous	Negligible
LR2		Priority 3	Negligible	Imperceptible	Continuous	Negligible
LR3	Not Applicable, as there will be no road plans near LR3 (representing Black and White Bungalows along Mount Pleasant Road)	Priority 2	N/A	N/A	N/A	N/A

To further reduce residual impacts during construction phase, the proposed environmental monitoring and management plan from other technical disciplines (See **Table 14-10** and **Table 14-11**) shall be incorporated for the development in the Study Area. Further assessment of the landscape and visual impacts of the Project was recommended to be conducted upon finalization of the detailed design and implementation plan of the development in the Study Area with the consideration of proposed mitigation measures. For operational phase, given the potential for significant change of landscape and visual characters of the Study Area with the proposed land uses being developed, it is anticipated that there will be no adverse residual impacts after incorporating the proposed mitigation measures, hence EMMP measure for operational phase is not required in this case.

13.7 Summary of Key Findings

Three (3) landscape and visual sensitive receptors (LRs) were identified in this study, where LR1 represents unmanaged vegetation; LR2 represents managed vegetation at both public and/or private compound areas; LR3 represents residential area with heritage features which is represented by colonial houses along Mount Pleasant Road.

The results of landscape and visual impact evaluation has suggested that the impact significance of the project on LR1 and LR2 within the Study Area to be varying from **Negligible** to **Moderate** for construction and operational phases; and LR3 to be varying from **Negligible** to **Major** given its unique heritage value and the potential for significant change to the overall character of the Study Area following completion of the project.

Mitigation measures have been proposed for works during design, construction and operational phases, such as trees planting, visual design, etc. With the mitigation measures proposed in **Table 13-7**, as well as mitigation measures and EMMP from other technical disciplines (See **Table 14-10** and **Table 14-11**), it was anticipated that the **Moderate and/or Major** landscape and visual impacts significance could be reduced to **Minor and or Acceptable Levels**. However, this would be subject to incorporation of the proposed mitigation measures into the actual detailed design and construction work plan, which was not available at the time of the current impact assessment.

In particular about the indicative alternative road plan 2 as described in **Section 3.1** or shown in **Figure 3-2**, which was assessed as the preferred mitigation measure in this report, was evaluated to be remain as **Minor** impact significance for LR1 and LR2 during construction phase, while reduced from **Moderate** to **Negligible** for both during operational phase. Since there will be no road works near the Black and White bungalows along Mount Pleasant Road in the indicative alternative road plan 2, thus LR3 will no longer be affected, therefore eliminating direct landscape and visual amenity impact on LR3.

Since the development in the Study Area is currently at early master planning stage, further assessment of the landscape and visual impacts of the development in the Study Area was recommended to be conducted upon finalization of the Project's detailed design and implementation plan with the consideration of proposed mitigation measures.

As part of the environmental monitoring and management measures, site audits or inspections should be undertaken at least once every two weeks during the construction phase of the development in the Study Area to check that the proposed landscape and visual mitigation measures are properly implemented and maintained as per their intended objectives during construction phase.

14.0 Proposed Environmental Monitoring and Management Plan

The proposed Environmental Monitoring and Management Plan (EMMP) is prepared for environmental impacts of the construction and operational phases associated with the project, and that were assessed in this EIS study, namely air quality, airborne noise, ground borne vibration, hydrology and water quality, biodiversity, landscape and visual amenity. The EMMP details how the recommended mitigation measures prepared for the impact assessment are to be implemented and specifies recommended monitoring measures to assess the effectiveness of the mitigation measures. This document is also intended to provide a broad framework for the ECO to develop a more contract-specific EMMP, as per their responsibilities in **Section 14.4.5**. Since the project will evolve over time, the EMMP is an adaptive document meant to be amended where necessary. Copies of the EMMP must be kept on-site for reference at all times.

This section outlines the objectives of the EMMP, the project organisation, describes the roles and responsibilities relevant to implementation of the EMMP, and summarises the EMMP requirements for each discipline.

14.1 EMMP Objectives

The Environmental Monitoring and Management Programme (EMMP) details the implementation and deliverables of the recommended mitigation measures identified from the impact assessment for each technical discipline. The EMMP progressively scrutinizes construction and operational activities as they ensue and applies flexible monitoring and management procedures to protect the project's environmental values throughout the construction and operational phases. The objective of the EMMP is twofold:

a) Environmental monitoring focuses on overseeing that impacts to the project's environmental values from construction and operations are within the anticipated level and tackle unforeseen impacts that may arise; and
b) It also tracks the effectiveness of the recommended mitigation measures to allow amendment or review of the mitigation measures to better address any issues faced during construction and operation of the project.

Environmental management employs a more active approach to ensure that impacts to flora and fauna are directly avoided through documentation, auditing and enforcement.

14.2 Project Organisation during the Construction Phase

The roles and responsibilities of the various parties responsible for implementing the EMMP during the construction phase are outlined below. The proposed project organization and lines of communication with respect to environmental protection works are presented in **Figure 14-1**.

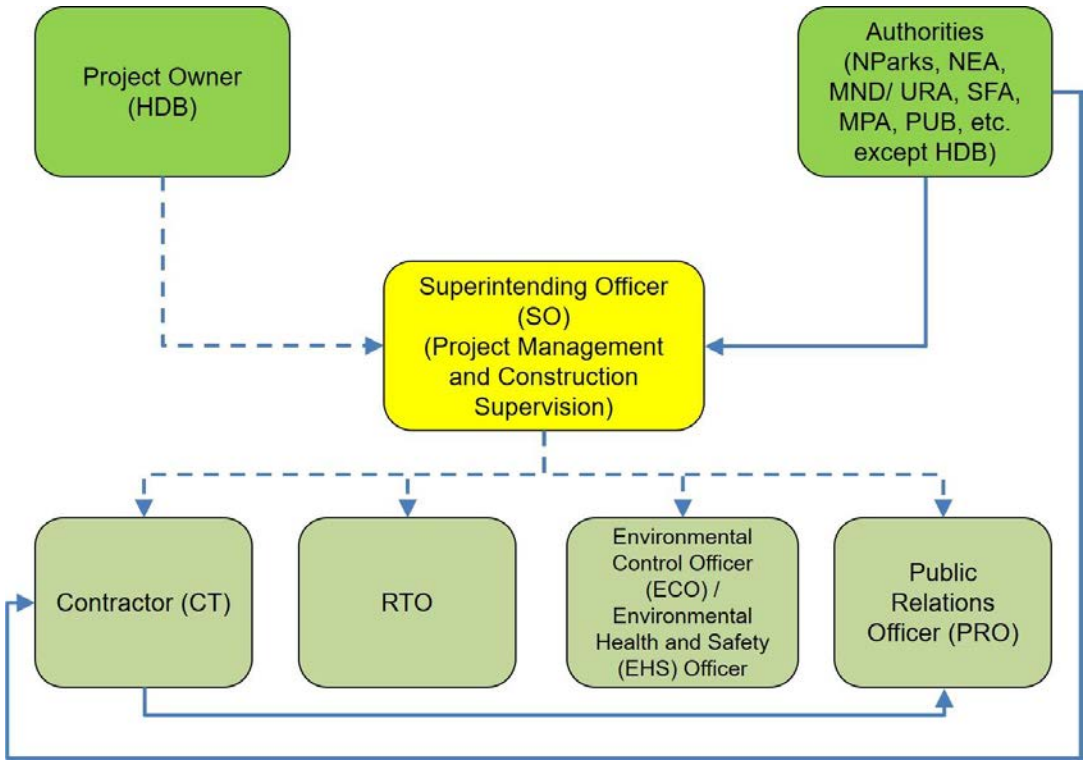

Figure 14-1: Project Organization and Lines of Communication during the Construction Phase

14.3 Project Organisation during the Operational Phase

The roles and responsibilities of the various parties responsible for implementing the EMMP during the operational phase are outlined below. The proposed project organization and lines of communication with respect to environmental protection works are presented in **Figure 14-2**.

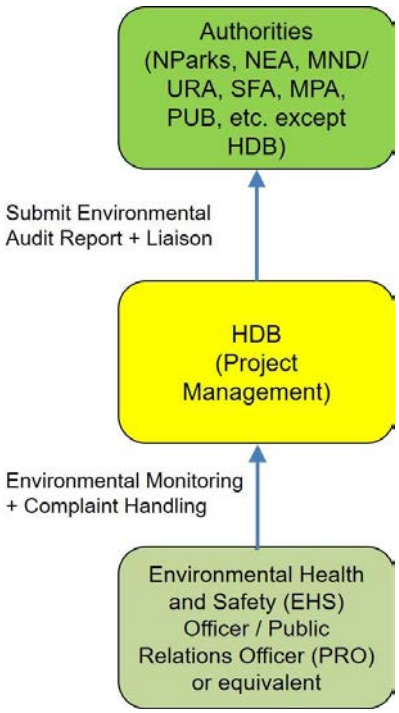

Figure 14-2: Project Organization and Lines of Communication during the Operational Phase

14.4 Roles and Responsibilities of the EMMP for the Construction Phase

14.4.1 Technical Agencies

Technical agencies constitute but are not limited to NParks, PUB, NEA, and URA. These agencies shall assess and approve the detailed EMMP for the construction and operational phases prior to commencement of works and where required during the course of the project.

14.4.2 Project Owner (HDB) and Resident Technical Officer

HDB, being the project owner oversees the construction phase of the project in accordance with the design. HDB, in conjunction with the Resident Technical Officer (RTO) (Contractor), are required to:

- Ensure resources are available to achieve the requirements of the EMMP;
- Provide leadership in the development and implementation of the EMMP;
- Ensure all environmental incidents and near misses are promptly investigated and reported;
- Resolve any non-compliance issues;
- Record, respond to, and action any complaints from members of the public, if any, with inputs from the Technical agencies, if required; and
- Reporting to the Technical Agencies regarding implementation of the EMMP.

14.4.3 The Contractor

The term “Contractor” refers to all construction contractors and sub-contractors working onsite at any time. In addition to reporting to the SO, the Contractor should:

- Work under the relevant contract scope, specifications, and other tender conditions;
- Ensure that the roles of RTO, Superintending Officer (SO), Environmental, Health and Safety Officer (EHS Officer), Environmental Control Officer (ECO), Certified Arborist, and Fauna Specialist/s are adequately resourced;
- Participate in the required environmental site audits (via the SO) undertaken by the ECO and undertake any corrective actions;
- Provide up-to-date information and advice to the RTO, SO, ECO, Certified Arborist, and Fauna Specialist/s regarding any work activities which may contribute or continuously create adverse environmental conditions, or any changes to the work plan;
- Implement measures to reduce impacts where emission/discharge levels are exceeded;
- Prepare a detailed contract-specific EMMP, incorporating the relevant mitigation measures and monitoring works recommended in this EIS report and seek technical agencies’ approval prior to the commencement of any works. This detailed EMMP shall include, as a minimum, a Standard Operating Procedure (SOP) detailing:
  - Handling and storage of hazardous chemicals;
  - Wildlife response and rescue plan;
  - Individual environmental management plans as detailed in the NEA’s SHE Specifications (air, vector, waste, noise, water pollution management plans);
  - Monitoring plans (including but not limited to noise, air, waste, ecology and water pollution);
  - Environmental impact register;
  - Existing legislation and environmental best practices to be implemented; and
  - Contingency planning during emergency situations.

Besides, for site and/or vegetation clearance before the commencement of actual construction, the Contractor shall engage a certified QECP to prepare an Erosion Control Plan (ECP) and obtain approval from the Public Utilities Board (PUB). The Contractor shall also map the trees on site and the trees planned to be felled and obtain National Parks Board (NParks) approval.

For tree-felling, the Contractor shall map the trees on site and the trees planned for removal or retention and NParks approval, where the Contractor shall consider the following requirements:

- An area rich in trees of conservation interest, the contractor should employ a certified arborist to map the trees carefully while applying for tree felling approval. This is to gauge the health, species, size and conservation significance of the tree;
- If there are trees that must be transplanted, this should be done prior to commencing site clearance;

Regarding fauna, the Contractor shall also engage NParks (Wildlife Management Division) for the Wildlife Act S10 direction letter to seek site specific directions with regards to managing wildlife on site. The Contractor shall have a fauna specialist/ecologist to advise on the wildlife management plan AND a NParks approved wildlife management specialist ready to respond to any wildlife on site if needed.

14.4.4 The Superintending Officer (SO)

The Superintending Officer is responsible for overseeing the construction works undertaken by various staff, contractors and sub-contractors. The SO should ensure that the construction works are performed by the contractors and personnel in accordance with the specification, contractual requirements, and EMMP. The SO should also:

- Communicate the requirements of this plan to all staff, contractors and sub-contractors
- Monitor all staff, contractor's and sub-contractor's compliance with contract specifications and regulatory requirements, including the implementation of the environmental mitigation and monitoring measures and ensure their effectiveness, and other aspects of the environmental audit program;
- Coordinate with the project's EHS Officer to monitor and participate in the implementation of the environmental audit program, with assistance from the ECO, and ensure that the requirements in the environmental audit program are correctly followed;
- Implement measures to reduce impacts where emission/discharge levels are exceeded;
- Coordinate with the Project Owner and RTO for submission of environmental audit reports;
- Carry out any complaint investigations as per **Section 14.8**;
- Resolve any non-compliance issues; and
- Promote environmental awareness and responsibility and lead by example.

14.4.5 The Environmental Control Officer (ECO)

The ECO shall be employed by the Contractor but may not be in any way an associated body of the Contractor, the SO, or the project's SHE team. The ECO is responsible for implementing the elements of the environmental monitoring program that fall within their responsibilities as outlined in the Code of Practice for Environmental Control Officers (Environmental Health Department, 2000). He/she should be a registered Environmental Control Officer (ECO) with NEA and has at least two years' experience in environmental monitoring and auditing works. Resources to implement the environmental monitoring program should be allocated time to fulfil the environmental audit requirements during construction works as specified in the EIS Report. The ECO's duties include:

- Coordinate with the SO to monitor and participate in the implementation of the environmental audit program, with assistance from the EHS Officer;
- Assist the SO with the resolution of near misses/incidents, non-compliance issues, and complaint management; and
- Assist the EHS Officer with reporting of monitoring results to the SO.

14.4.6 The Environmental, Health and Safety Officer (EHS Officer)

The Environmental, Health and Safety Officer is responsible for the overall environmental, health and safety during the construction phase of the project. With respect to the EMMP, their duty is to:

- Carry out monitoring of environmental parameters and conduct laboratory analysis;
- Conduct regular site inspections, report monitoring results, and audit environmental performance as required in the EMMP;
- Coordinate with the SO and ECO regarding equipment, locations, and schedule of monitoring and auditing works;
- Analyse environmental monitoring data and audit findings, review the adequacy of implementation of mitigation measures, identify adverse environmental impacts, and liaise with the SO and ECO;
- Formulate and implement the environmental audit program and carry out regular site audits against the Contractor's site practices, equipment and work methodologies with respect to pollution control and environmental mitigation, and effect proactive actions to pre-empt problems in coordination with the SO and ECO;
- Monitor compliance with conditions in the EMMP, relevant environmental protection, pollution prevention and control regulations and contract specifications; and

- Report the results of the environmental monitoring program, and any required changes to meet the requirements of the EMMP and legal obligations to the SO and ECO in a timely manner.

14.4.7 Arborist and Fauna Specialists

These roles play an important part of the construction process with respect to management of flora and fauna. A Certified Arborist is required to monitor and manage all matters related to the adequate and successful conservation of trees and flora within and adjacent to the contract boundary. Fauna specialists are required for regular fauna monitoring during the construction period and to conduct tree-felling inspections and fauna salvage where required. A detailed list of the responsibilities for each role is provided in **Section 14.14**.

14.5 Roles and Responsibilities of the EMMP for the Operational Phase

14.5.1 Technical Agencies

Technical agencies constitute but are not limited to NParks, PUB, NEA, and MND/ URA. These agencies shall assess and approve the detailed EMMP for the construction and operational phases, prior to commencement of works and, where required, during the course of the project.

14.5.2 Housing & Development Board

The Housing & Development Board (HDB) is a statutory board in Singapore under the Ministry of National Development responsible for public housing in Singapore, which is also the project owner for this Project.

14.5.3 Project Owner (HDB)

HDB is responsible for overseeing and managing the environmental monitoring detailed in the EMMP for the operational phase. HDB are required to:

- Ensure resources and appropriate personnel are available to achieve the requirements of the EMMP;
- Provide leadership in the implementation of the EMMP;
- Ensure all environmental incidents and near misses are promptly investigated and reported;
- Resolve any non-compliance issues;
- Record, respond to, and action any complaints from members of the public, if any, with inputs from the Technical agencies, if required; and
- Reporting to the Technical Agencies and SDC regarding implementation of the EMMP.

14.5.4 EHS Officer (or Equivalent)

Appointed by HDB and is responsible for the overall environmental, health and safety during the operational phase of the project. With respect to the EMMP, the EHS Officer is required to:

- Carry out monitoring of environmental parameters and conduct any required laboratory analysis;
- Conduct site inspections, report monitoring results, and coordinate environmental auditing as stipulated in the EMMP;
- Coordinate with HDB regarding equipment, locations, and schedule of monitoring and auditing works;
- Analyse environmental monitoring data and audit findings, review the adequacy of implementation of mitigation measures, identify adverse environmental impacts, and liaise with the HDB;
- Monitor compliance with conditions in the EMMP, relevant environmental protection and control regulations; and
- Report the results of the environmental monitoring program, and any required changes, to meet the requirements of the EMMP to HDB in a timely manner.

14.6 Construction Site Audit

Site surveillance provides a direct means to assess and ensure the project's environmental protection and pollution control measures are in compliance with the contract specifications and the EMMP. The ECO should inspect the construction activities regularly and routinely to ensure that the appropriate environmental protection and pollution control mitigation measures are properly and timely implemented,

based on the EMMP's recommendations. With well-defined pollution control and impact mitigation measures outlined, and a well-established efficient remedial action reporting system, the site inspection is an effective "tool" to ensure acceptable environmental performance at the construction site.

The ECO is responsible to formulate environmental site inspections, deficiencies and the remedial action reporting system, and to carry out the site inspections. After consultation with project's EHS Officer and SO, the ECO should prepare a procedure for the site inspections, deficiencies, remedial action, and reporting requirements. This documentation shall be agreed to by the RTO and Contractor representative, and approved by the Project Owner within 21 days of the commencement of the construction contract.

Regular site inspections should be carried out at least once weekly for all the work areas during the construction phase. The inspections should cover the onsite environmental situation, pollution control and mitigation measures. Offsite environmental situations, which may be affected by onsite activities, (directly or indirectly) should also be reviewed.

14.7 Operational Phase Audit

During the operation of the project, annual monitoring (minimum frequency) for all environmental parameters should be conducted to ensure that all implemented measures are meeting their intended purpose, and that any potential changes in project conditions such as increased traffic, track lighting, etc are not having an adverse impact over and above the impacts identified in this assessment. A log tracking all maintenance procedures of equipment and carrying out of audits should be maintained by the Project Owner and the EHS Officer.

A minimum of annual monitoring periods also enables the Project Owner and EHS Officer to address any potential issues, not originally identified during the current impact assessment, that may arise during the course of the project. In this instance, the Project Owner should consider the impacts and, in consultation with the Technical Agencies and qualified professionals, develop measures to mitigate any identified impacts.

Details of monitoring requirements are provided in **Table 14-11**.

14.8 Complaint Handling

The Public Relation Officer (PRO) is responsible for handling complaints and managing feedback and investigative work. The PRO shall be supported by the Project Owner, ECO, Contractor representatives, and any other relevant party.

During the construction phase, upon receipt of complaints, the PRO should undertake the following procedures:

- Log the complaint and record the date when the complaint is received onto the complaint database and inform the Project Owner, SO, and EHS Officer immediately;
- Investigate the complaint with the ECO to determine its validity and assess whether the source of the problem is due to construction works (the target time for response to the complainant is proposed to be 48 hours);
- If a complaint is valid and due to construction works, liaise with the ECO and EHS Officer on the mitigation measures and seek agreement from SO;
- Review the current situation and the ECO's and SO's implementation of the mitigation measures;
- Engage the ECO to undertake additional monitoring and auditing to verify the complaint if necessary. Ensure that any valid reasons for complaints do not re-occur by revising the work methods, procedures, machines and/or equipment, etc.;
- Submit complaint report (as well as the implementation of mitigation measures and the effectiveness of the mitigation measures as advised by the ECO) to the Project Owner, RTO and the SO; and
- Log a record of the complaint, investigation, follow-up actions and the results in the environmental audit reports.

The ECO, EHS Officer, and SO should provide all the necessary information and assistance to the PRO in order to complete the complaint investigation. Following the investigation, the Contractor should

promptly undertake the mitigation measures. The PRO and SO should ensure that the measures have been appropriately implemented. The Contractor, RTO, and SO should also be responsible for the reporting of complaint investigation results and followed up actions to the Project Owner.

During the operational phase, upon receipt of complaints, the PRO should undertake the following procedures:

- Log the complaint and record the date when the complaint is received onto the complaint database and inform the Project Owner and EHS Officer immediately;
- Investigate the complaint with the ECO to determine its validity and assess whether the source of the problem is due to construction works (the target time for response to the complainant is proposed to be 48 hours);
- If a complaint is valid and due to construction works, liaise with the ECO and EHS Officer on the mitigation measures and seek agreement from SO;
- Review the current situation and the ECO's and SO's implementation of the mitigation measures;
- Engage the ECO to undertake additional monitoring and auditing to verify the complaint if necessary. Ensure that any valid reasons for complaints do not re-occur by revising the work methods, procedures, machines and/or equipment, etc.;
- Submit complaint report (as well as the implementation of mitigation measures and the effectiveness of the mitigation measures as advised by the ECO) to the Project Owner, RTO and the SO; and
- Log a record of the complaint, investigation, follow-up actions and the results in the environmental audit reports.

The PRO should work with the Project Owner and EHS Officer to gather all the necessary information and resources necessary to complete a complaint investigation. Following the investigation, the Project Manager and EHS Officer to undertake appropriate mitigation measures. Follow is required by the PRO to ensure that the mitigation measures have been appropriately implemented. Reporting of the complaint investigation results and followed up actions should be provided to SDC and the Authorities.

14.9 Air Quality Monitoring Program Requirements

As noted in the mitigation measures (**Section 7.3.1**), routine dust monitoring shall be undertaken during the construction phase. Based on a review of sensitive receptors as listed in **Section 7.2.2.1** around the construction footprint, a continuous monitoring program as per Table 14-1 is proposed to be conducted during project construction. During operational phase, ambient air quality monitoring may not be required.

Before the start of the construction, AECOM recommends the construction contractor to conduct another round of monitoring in one of the monsoon periods for comprehensiveness of the establishment of baseline.

Table 14-1: Recommended Monitoring Program (Air Quality)

Location	Parameters	Frequency and Duration
Monitoring at the following locations: • 27 Jalan Mendaki • 157C Mount Pleasant Road • Singapore Polo Club	PM_{10} and $PM_{2.5}$	• Particulate monitoring at least once, one month before the construction works, to establish the pre-construction levels. • In the event of a valid complaint, once a month for as long as the particular complaint related construction activity continues.

14.10 Airborne Noise Monitoring Program Requirements

Airborne noise monitoring program can be implemented if required by the Client, see AECOM's proposed program in **Table 14-2**. Catholic Junior School, 23 Mount Pleasant Drive, 151 Mount Pleasant Road, Singapore Polo Club and 115 Whiley Road are recommended as this is the nearest sensitive airborne noise receptor to the construction area that is representative of human impacts.

Table 14-2: Recommended Monitoring Program (Airborne Noise)

No.	Location	Parameter/s	Frequency and duration
1	Catholic Junior School	$L_{Aeq(12\ hour)}$, $L_{Aeq(1\ hour)}$, and $L_{Aeq(5\ min)}$	For construction phase: pre-construction baseline and continuous monitoring for the entire duration of the construction phase of the fore mentioned parameters at these locations
2	23 Mount Pleasant Drive		
3	115 Whiley Road		
4	151 Mount Pleasant Road		
5	Singapore Polo Club		

14.11 Ground-borne Vibration Monitoring Program Requirements

As mentioned in **Section 9.4.1.2**, a ground-borne vibration monitoring program can be implemented if required by the Client, see AECOM's proposed program in **Table 9-19**. The vibration monitoring program is typically measuring the vibration levels caused by construction works throughout the construction phase in real time. AECOM recommends installing a monitoring program that is capable to transmit 'trigger level alert' and 'stop work alert' messages to the Client to manage the ground-borne vibration levels emitted to the nearby sensitive receptors.

80 Mount Pleasant Road is recommended as this is the nearest sensitive ground-borne vibration building receptor to the Study Area that is representative of human impacts.

Table 14-3: Recommended Monitoring Program (Ground-borne Vibration)

No.	Location	Parameter/s	Frequency and duration
1	80 Mount Pleasant Road	Vibration Velocity PPV	Construction Phase

14.12 Hydrology and Water Quality Monitoring Program Requirements

In order to ensure that procedures are followed appropriately, the construction phase of the project should be accompanied by an EMMP. Water quality monitoring is essential as discharge of excess contaminants, especially pH, nutrients and heavy metals, may lead to severe consequences (e.g. algae blooms).

Discharges via settling ponds will take place during the construction phase, therefore monitoring of settling pond discharge waters is recommended to be undertaken to complement surface water quality to assure compliance with the relevant standards. Recommended standards/guidelines and parameters for water quality monitoring are Singapore NEA's Allowable Limits for Trade Effluent Discharge to Sewer/Watercourse/Controlled Watercourse as well as water quality criteria for aquatic life as listed in **Table 10-3**.

Table 14-4: Recommended EMMP for Water Quality

Test	Parameter	Monitoring Recommendation and Frequency
In-situ	Temperature	Construction phase: • Online real time monitoring for TSS at the discharge point location at all the construction site throughout the construction period;
	pH	
	Turbidity and Total Suspended Solids (TSS)	
	Salinity/Conductivity	
	Dissolved Oxygen (DO)	

Test	Parameter	Monitoring Recommendation and Frequency
		• Monthly monitoring for temperature, pH, turbidity, salinity/conductivity, DO at all the discharge locations at the construction site throughout the construction period; and • Monthly monitoring for all the in-situ parameters at the identified sensitive receptors with high ecological importance including Streams 1 and 3 throughout the construction period. Operational phase: • Monthly monitoring for all the in-situ parameters at the identified sensitive receptors with high ecological importance including Streams 1 and 3 during the 1st three (3) months of operation period.
Ex-situ	Biochemical Oxygen Demand (BOD_5) Total Organic Carbon (TOC) Total Dissolved Solids (TDS) Phosphate (as PO_4) Total Phosphorous (TN) Total Nitrogen (TP) Nitrate (as NO_3-N) Ammonia (as NH_4-N) *Enterococcus* Lead (Pb)	Construction phase: • Monthly monitoring for the construction period at the discharge point if discharging into public drains. Operational phase: • Only carry out monthly monitoring for the identified sensitive receptors with high ecological importance including Streams 1 and 3 if the in-situ parameters exceed the criteria for aquatic life (refer to **Table 10-3**).

14.13 Soil and Groundwater Monitoring Program Requirements

A summary of the recommended monitoring for soil and groundwater is provided below in Table 14-5.

Table 14-5: Recommended Monitoring Program (Soil and Groundwater)

Location	Parameters	Frequency and Duration
Within the development boundary	Groundwater level	• Continuous monitoring of groundwater level throughout the lifetime of the construction phase as per the instrumentation and monitoring plan developed by the QP; • Monitor and record amount and type of toxic chemical waste generated, weekly during construction phase, and monthly during operational phase. Records on chemical waste from the waste generator should be properly kept and records produced when requested; • Inspection of hazardous chemical/substances storage condition weekly during construction phase, and
At locations within the Study Area where toxic chemical waste is generated/stored	Toxic Chemical Waste Generation	
At locations within the Study Area where hazardous	Improper Handling of Hazardous Chemical/Substances	

Location	Parameters	Frequency and Duration
chemicals/substances are used/stored		monthly during operational phase; and • Environmental audits, quarterly during construction phase.

14.14 Biodiversity Monitoring Program Requirements

Flora, arboriculture and fauna monitoring take place within and on the edge of the future HDB development boundary. This includes the proposed areas of conservation (Stream 1, Stream 3 and vegetation to be retained) (refer to Section 12.5). A breakdown of the biodiversity EMMP to be implemented is provided in Section 14.16.

14.14.1 Flora Monitoring Programme

The flora monitoring aims to assess the impacts of construction to vegetation and habitats, such as tree health, unauthorised and/or excessive vegetation removal, edge effects, habitat degradation from soil erosion and rubbish dumping. The main objectives are as follow:

a) Monitor health of the adjacent Bukit Brown Woods, heritage road and vegetation in Study Area to be retained.
b) Assess impact of construction on the physiological health and structural stability of vegetation and trees at proximity to the development.
c) Determine whether there has been excessive and unauthorized removal of vegetation and trees beyond the development boundary.
d) Monitor and assess potential edge effects (e.g. predictable failures, accelerated growth of climbers on canopy, change in species composition at the edge) within vegetation adjacent to the development. Make recommendations on mitigating measures where necessary.
e) Determine occurrence of mechanical damage to the trees beyond the development boundary from nearby construction. These would include damage to the canopy, trunk or roots that may impair the structural stability of the trees.
f) Visual inspection for soil erosion locations that resulted from construction activities.
g) Determine if there was unauthorized dumping of rubbish (e.g. food materials), construction debris and materials, oil/chemical leakage that may contaminate soil and water bodies.

14.14.2 Flora Management Programme

The responsibilities of the contractor's flora and arborist team are to monitor and manage all matters related to the adequate and successful conservation of trees and flora vegetation within and adjacent to the contract boundary (into flora vegetation and trees up to 10-m from the contract boundary). These responsibilities include:

1) Conduct fortnightly inspections at the beginning of vegetation clearance and subsequently monthly inspections once vegetation has been cleared to: ensure tree conditions have not deteriorated; check that integrity of the Tree Protection Zone (TPZ) has not been compromised; verify no mechanical damage to trees has occurred, and; monitor for edge effects at new forest edge.
2) Conduct monthly inspections at sensitive aquatic areas to ensure that the state of environment have not deteriorated.
3) Provide brief monthly report with recommendations of mitigating measure(s) if any. Reports should include photos of tree and TPZs conditions.
4) Assessment to determine need for additional tree removal due to construction constraints and liaise with NParks for permission to remove roots where necessary.
5) Review method statements from builders for construction at proximity to trees.

6) Liaise and coordinate with selected tree works contractor to carry out tree pruning works and carry out inspection to ensure that works is carried out to NParks standards.
7) Work with architects and structural engineer on design changes and structural solutions at proximity to the trees that will meet NParks guidelines and help justify the works within the tree protection zone if necessary.
8) Flora specialist and arborist team should have at least 10 years' relevant experience and demonstrate experience in developments of similar forested context, size, and construction complexity.
9) The Arboriculture Contractor should meet NParks' safety requirements for work at height and LTA's requirements for temporary works along roadsides. All arboriculture workers engaged by the Arboriculture Contractor to perform tree climbing and chainsaw work shall possess a valid basic tree climbing certification based upon demonstrated competence in the Workforce Skills Qualifications (WSQ) module conducted by CUGE or an equivalent WSQ-approved training organisation.
10) The arboriculture crew deployed by the Arboriculture Contractor for the Contract shall possess the following valid competences:
    - Operation of chainsaw for ground work (LS-MT-103E-1)
    - Chainsaw safety and maintenance (LS-MT-102E-1)
    - Perform formative pruning of young trees (LS-MT-114E-1)
    - Provide Arboriculture support on site (LS-MT-116E-1)
    - Workplace safety and health – operators (ES-WSH-101G-1)
    - Respond to Emergency (LS-HM-208E-1)
    - Perform advance rigging and climbing techniques (LS-HM-308S-1)
    - Perform aerial tree access and aerial rescue skills (LS-HM-204S-1)
    - Implement and apply appropriate risk and safety management to sector practices (LS- BP-301S-1)
    - Prepare risk assessment report (LS-HM-406S-1)
    - Operate and work from an elevated work platform (CUGE-ARB-3501)
11) The Contractor and the attending arborist shall complete the 'Verification of Tree Protection Checklist' prior to the start of site clearance (refer to Appendix G of the Addendum: Annex A).
12) The Contractor shall instil discipline and raise awareness amongst all personnel on measures and mitigations to prevent damage to retained and protected trees throughout construction by including reminders on tree conservation guidelines within their daily toolbox briefings to workers and crane/excavator operators.

14.14.2.1 Tree Protection Zones

1) The Contractor shall identify and mark out plants for retention on site based on approved plans and set up TPZs individually or in clusters according to the Tree Protection and Conservation Guidelines (refer to **Appendix G of the Addendum**).
2) In addition, as this is a forested site, attention is also given to trees less than 1-m girth and not highlighted within plans. Of particular importance are small plants with conservation status (e.g., Critically Endangered [CR], Endangered [EN], and Vulnerable [VU]). Where identified, these trees should be assessed for transplanting (trees > 0.2-m girth) or harvesting (saplings < 0.2-m girth) potential (refer to Sapling Harvesting sub-section below)
3) Any proposal to remove any trees > 1-m girth (regardless of native or SRDB status), or flora which are listed as EN, CR, or VU in SRDB will need approval from NParks.
4) The TPZ, developed in accordance with NParks TPZ guidelines, shall be installed around each tree identified for retention, prior to any site clearance works and/or works involving soil disturbance according to the distances in **Table 14-6**.
5) No removal of the TPZ shall be permitted under any circumstances during the duration of the project.
6) All other necessary tree protection measures and work requirements at proximity to trees shall be referenced from the Tree Protection and Conservation Guidelines (refer to **Appendix G of the Addendum**).

Table 14-6: Recommended Tree Protection Zone Distances Based on Tree Girth

Tree Girth (m)	Recommended Tree Protection Zones
< 0.5-m	1-m radius

Tree Girth (m)	Recommended Tree Protection Zones
> 0.5-m but less than 1-m	2-m radius
> 1-m but less than 1.5-m	3-m radius
> 1.5-m but less than 2-m	4-m radius
> 2-m	5-m radius
Fig trees and trees with critically endangered status	Prescribed individually on a case by case basis

14.14.2.2 Site Clearance and Tree Felling

1) Flora specialist and Arborist to review tree felling method statement and proposed schedule of works.
2) Only directional felling methods with a hinge and back cut shall be deployed. Trees SHALL NOT be felled by pushing over with heavy machinery.
3) Tree removal is to be carried out according to the method statement to be submitted and approved by the Superintendent Officer (SO).
4) The Contractor shall ensure that TPZs are set up for trees designated to be conserved prior to any site clearance work.
5) Tree removal must be carried out in a manner that will not affect conserved trees at proximity. On occasions where adjacent TPZ and/or root-balls of retained trees would be affected, the attending Arborist will make an assessment and furnish the necessary recommendation to the SO and receive approval prior to proceeding.
6) Where a tree to be felled is found to have an animal nest, hollow, or burrow within, the ecologist and NParks are to be notified immediately and the tree shall be tagged accordingly. Thereafter, ecologist may carry out fauna rescue or recommend other measures before removal can restart.

14.14.2.3 Tree Transplanting

1) Arborist to verify suitability of transplant candidate proposed by Contractor's Arborist. Transplant candidates need to exhibit good physiological health and vigour and be free from structural defects that would reduce their transplant value. They will also be free from disease infestation.
2) Method statement and transplanting schedule to be submitted at least two (2) weeks prior to commencement of any transplanting work. Transplanting to proceed only upon approval of method statement by the SO.
3) Pruning for candidates to be transplanted is to be prescribed by Contractor's Arborist so as to reduce undue stress to the tree and prevent asymmetric trunk formation.
4) Prepare ball of soil at roots to be removed with each tree based on the recommended sizes (refer to Table 14-7). Actual size of root-balls is to be proposed by attending Arborist and approved by SO prior to works.
5) Contractor shall furnish method statement to show how weight of transplant is calculated and therefore deploy adequate machinery to carry out the lift for the transplant. Extraction methods vary according to tree girth (refer to Table 14-8). The Contractor shall consider this AND his calculated weight of transplant in his proposal.
6) The Contractor shall provide documentation of trees, including photographs, before and after transplanting. Photographs should show intact root balls at the different stages (i.e., during generation of root ball; when tree is lifted, and; when tree is installed into the receiving site).

Table 14-7: Recommended Root-ball Size to be Extracted with Tree during Transplanting

Girth	Root Ball diameter to extract
< 0.1-m	Minimum 0.4-m diameter
0.1- – 0.2-m	Minimum 0.6-m diameter
0.2- – 0.3-m	Minimum 0.8-m diameter
0.3- – 0.4-m	Minimum 1.2-m diameter
0.4- – 0.5-m	Minimum 1.5-m diameter

Girth	Root Ball diameter to extract
> 0.5-m	Size determined in consultation with attending arborist

Table 14-8: Extraction Methods to be Employed during Tree Transplanting based on Tree Girth

Girth Size	Extraction
< 0.3-m	Manual labour
0.3- – 1.5-m	Heavy machinery or mobile crane up to 200 tonnes
> 1.5-m	Large/Mobile crane (up to 500 tonnes)

14.14.2.4 Sapling Harvesting

The Contractor shall observe the following guidelines during the planning and execution of works and reflect these considerations in his submissions:

1) Engage flora specialist/arborist to identify and locate species of conservation significance to be harvested.
2) Method statement and harvesting schedule to be submitted at least two (2) weeks prior to commencement of any transplanting work. Harvesting to proceed only upon approval of method statement by the SO.
3) Document (with photographs) condition of saplings before and after harvesting. Photographs of a sample of saplings shall clearly show intact root balls at the different stages, during generation of root ball, and when sapling is installed into the receiving site.
4) Operations shall be planned and coordinated so that the amount of time that the sapling spends in any position other than standing upright with its roots in the ground is kept to a minimum.

Contractor shall ensure that appropriate equipment, machinery, and manpower resources are deployed for the adequate execution of the harvesting works.

14.14.2.5 Transport of Saplings

1) All saplings shall be manually extracted unless directed otherwise by the Employer and Flora specialist/attending Arborist.
2) Plants to be transported or moved are to be thoroughly wrapped and tied with polythene bags and protected prior to transporting. Exposed trunks are to be wrapped including the lower parts of the branch system and the upper branch system, especially if well-furnished with leaves and twigs during transport (refer to **Figure 14-3**).
3) Saplings shall be covered and not left exposed under the sun during the transportation process (refer to **Figure 14-4-A**). Otherwise, damaged plant material will automatically be rejected on arrival at site.
4) An inventory list should be kept during the harvesting event (refer to **Figure 14-4-B**).

14.14.2.6 Planting of Saplings

Prior to planting saplings, the Contractor shall consult the Employer and the Flora specialist/attending Arborist for identified locations to plant the samplings, and conduct combined site walks to assess the following:

- Structure of existing vegetation cover to determine the ideal planting locations. Planting should be carried out to species suitability (e.g., shade-tolerant species will be planted in shaded areas and vice versa).
- Areas utilised by existing wildlife to avoid unnecessary impact.
- If necessary for waterlogging conditions, methods for subsoil drainage should be formulated in consultation with the attending Arborist and Landscape Architect and approved by the SO prior to execution.

Contractor shall propose a maintenance regime to include application of bio-stimulants (humic acid, high EC molasses, fish kelp, mycorrhizae or equivalent) application and watering frequencies and upon approval, carry out the maintenance as agreed.

Figure 14-3: Photographs of Sampling Harvesting and Transport
NOTE: A) Small saplings being extracted manually; and B) saplings being wrapped completely to reduce desiccation loss and transplant shock.

Figure 14-4: A) Example of Harvested Saplings Not Covered during Transport and Exposed to Sun which Increase Mortality Rates & B) Example of an Inventory List Generated during Harvesting Event

14.14.3 Fauna Monitoring Programme

The objectives of fauna monitoring are as follow:

a) Minimize negative impacts to terrestrial and aquatic fauna, particularly to species of conservation significance.
b) Prevent human-wildlife conflicts.
c) Monitor presence of targeted fauna groups within and outside of work areas

Fauna monitoring surveys will comprise of transect surveys and site inspection surveys conducted together, at within and outside of hoarded areas. Below is a workflow for performing the fauna monitoring surveys:

1) Perform reconnaissance surveys to become familiarised with the Study Area and to identify sensitive habitats and habitat features in relation to the proposed construction.
2) Conduct monthly diurnal and nocturnal fauna and site inspection surveys beginning one month prior to construction (pre-felling surveys) and ending two months after reinstatement. This includes both fauna surveys and site inspections.
3) Refer to Fauna Response and Rescue Plan for how to deal with significant wildlife detections (**Appendix H of the Addendum**).
4) Fill out Wildlife Incident Form (**Appendix I of the Addendum**)

14.14.3.1 Fauna surveys

With his Ecologist, the Contractor shall engage NParks (Wildlife Management Division) for the Wildlife Act S10 direction letter to seek site specific directions with regards to managing wildlife on site. The division is contactable at nparks_wildlife_management@nparks.gov.sg.

Prior to any vegetation clearance and construction, an Ecologist should be engaged to conduct the pre-felling surveys to ascertain the faunal species on site. The surveys would be especially useful in detecting wild pigs and macaques, thus reducing the risk of human-wildlife conflicts. To detect fauna which are highly mobile or elusive, transect surveys as well as camera trapping are recommended. Once the pre-construction surveys are completed, a further consultation with NParks should be made if needed (e.g. when new species of interest not detected in the baseline surveys are detected in the pre-construction surveys). If wild pigs are located within the site hoarding, the Contractor shall be required to trap and remove them with the engagement of a NParks approved wildlife management specialist (See **Section 12.6.2.2**). The trapping and removal process may take about 4-8 weeks.

Over the course of the construction period, the regular monthly fauna surveys will be conducted along terrestrial and aquatic transects and will target the following fauna groups: odonates (dragonflies and damselflies); butterflies; decapod crustaceans (shrimps and crabs); fishes; herpetofauna (amphibians and reptiles); birds; and non-volant mammals and bats. Comparison of species presence can be made with the baseline studies, where appropriate, to provide an indication of the changes in fauna diversity.

Timing and frequency for transect surveys for each targeted fauna group is provided in Table 14-9: Timing and Frequency for Transect Surveys for each Targeted Fauna Group. Diurnal and nocturnal surveys are to be performed by a minimum of two surveyors. All fauna encountered are to be identified to species-level, or to the lowest taxonomic level possible. In addition, the location of each individual is to be recorded using a handheld GPS. Where a species was recorded, the number of individuals observed is to be documented. Lastly, significant incidental observations are to be documented.

Further details of the surveys (type, numbers, length and location) should be determined in consultation with NParks and should take into account construction phases, final construction footprint, final development hoarding plan and baseline studies. Camera trapping could be considered near Freshwater Stream 3 (MP07) to verify the presence of the Malayan Porcupine (*Hystrix brachyura*).

Table 14-9: Timing and Frequency for Transect Surveys for each Targeted Fauna Group

Fauna group	Survey timing (h)	Survey method
Odonates (dragonflies and damselflies)	09.00–16.00	Diurnal visual surveys along aquatic transect (freshwater streams; mangrove and mudflat).
Butterflies and Hymenoptera	09.00–16.00	Diurnal visual surveys along the terrestrial transect.
Fishes	Low tide between 0.8m to 1.5m	Visual surveys and fish trapping (including tray netting and cast netting) along aquatic transects.
Decapod crustaceans	Tide level of 0.0m to 0.1m	Diurnal and nocturnal visual surveys along aquatic transects.

Fauna group	Survey timing (h)	Survey method
Herpetofauna (reptiles and amphibians)	07.00–16.00, 20.00–00.00	Diurnal and nocturnal visual and auditory surveys, along both terrestrial and aquatic transects.
Birds	07.00–10.00, 20.00–00.00	Diurnal and nocturnal visual and auditory surveys along the terrestrial transect.
Non-volant Mammals	07.00–10.00, 20.00–00.00	Diurnal and nocturnal visual and auditory surveys along the terrestrial transect.
Bats	20.00–00.00	Nocturnal visual and acoustic surveys along the terrestrial transect

14.14.3.1.1 Site inspections

Site inspections involve visual inspection of areas within and outside of the hoarding areas for contractor compliance, fauna mortality and habitat degradation resulting from the construction activities. In particular, site inspection shall include written and photo documentation of the following parameters:

a) Presence of rubbish and chemical pollution resulting from the construction;
b) Presence of nutrient enrichment or algae blooms;
c) Presence of fauna mortality, particularly mass die-off of aquatic fauna (fish and frogs);
d) Appearance of water;
e) Odour of water, if any; and
f) Velocity of water (slow or fast).

14.14.4 Fauna Management Programme

Fauna management will consist of managing fauna within and around all designated work areas. It consists of site orientation and continued biodiversity awareness training for the site team, tree felling inspections, and fauna response plan in event of animal encounters. The objectives of fauna management are as follow:

a) Minimize negative impacts to fauna, particularly to species of conservation interest.
b) Inspect hoarded areas for any compromises that may allow smaller-sized animals to enter.
c) Prevent human-wildlife conflicts.
d) Monitor presence of trapped/injured/dead fauna inside hoarded areas.
e) Monitor and compare presence of targeted fauna groups within and outside of hoarded areas. During each survey, fill out Pre-felling Inspection Form (**Appendix J of the Addendum**).

14.14.4.1 Tree-Felling Inspections

The aim of tree-felling inspections is to ensure that trees slated to be felled, transplanted or harvested are free of wildlife that are unable to escape, specifically fledgling birds and bird eggs. Accordingly, tree-felling should be executed outside of peak bird breeding and nesting season where possible.

Tree-felling inspections includes scanning all parts of trees for fauna, active nests, epiphytic ferns, and tree cavities. In addition, surrounding vegetation and burrows are also inspected. In the event that animals are found, the tree is not to be felled. Instead, the animal is to be given 48 hours to leave the tree on its own and the tree is to be reinspected. For active nests, the nests are to be removed prior to felling and the eggs given to the Jurong Bird Park for care. If epiphytic ferns, tree cavities, and fresh burrows are found, then the tree is to be felled under supervision. If no significant findings are made, then the tree can be felled. Tree-felling inspection are to be completed within seven days prior to felling. If trees are not felled within the seven-day period, then the tree is to be reinspected.

Below is a workflow for performing tree felling inspections; (refer to **Figure 14-5**):

1) Prior to tree-felling, transplanting, harvesting, and site-clearance, survey designated work site.

2) Obtain tree-felling, transplanting, and harvesting schedule from contractor for when these activities will take place.
3) Inspect trees within seven days prior to removal to ensure absence of wildlife and active bird nests.
4) During each survey, fill out Pre-felling Tree Inspection From (**Appendix J of the Addendum**).
5) Refer to Fauna Response and Rescue Plan for how to deal with significant wildlife detections (**Appendix H of the Addendum**).
6) Fill out Wildlife Incident Form (**Appendix I of the Addendum**).

14.14.4.2 Fauna Response and Rescue Plan

Whenever fauna is encountered in or around work areas by construction personnel, all work activity in the immediate areas is to be suspended and the Fauna Response and Rescue Plan is to be followed (**Appendix H of the Addendum**). The workers are to contact their immediate supervisor who will notify the Ecologist. The Ecologist is to decide whether the encountered fauna is to be given time to leave the site on their own accord or whether it must be captured or rescued and removed from site by the approved wildlife management specialist. Specifically for wild pigs, NParks must be informed and the Contractor shall be prepared to for trapping and removal. All wildlife encounters are to be documented within 24 hours using the Wildlife Incident Form (**Appendix I of the Addendum**).

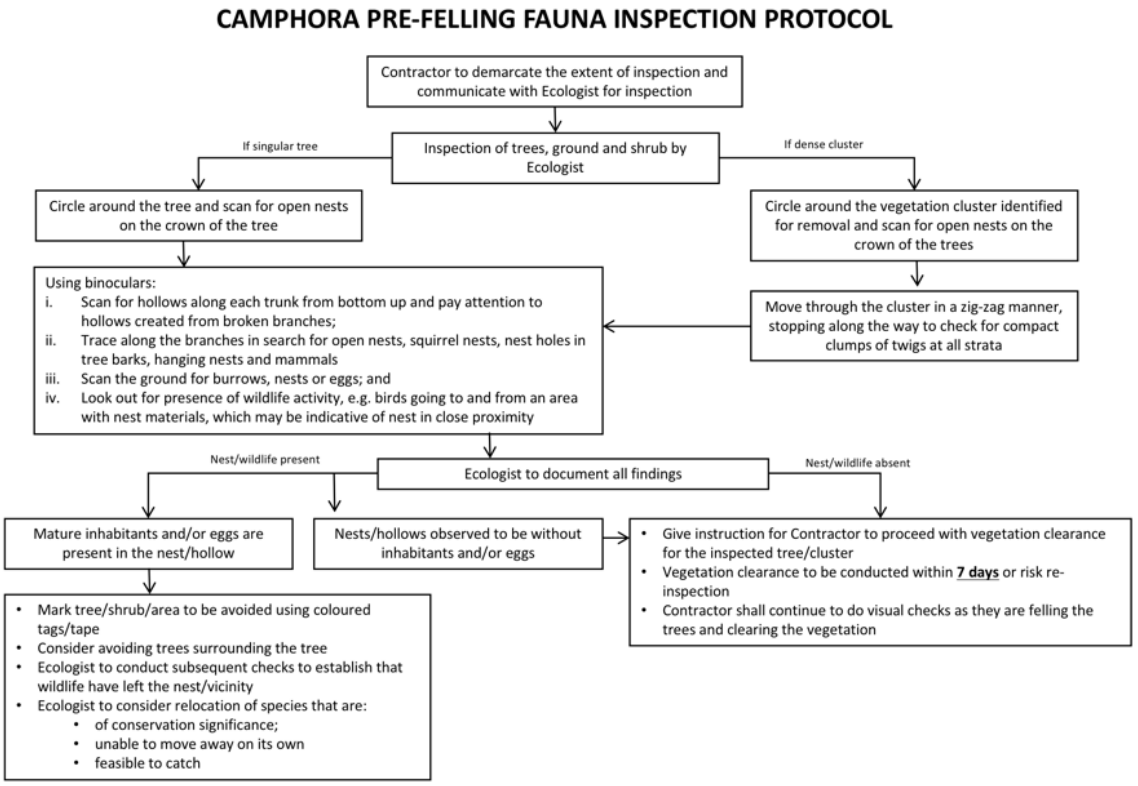

Figure 14-5: Tree-felling Protocol

14.15 Landscape and Visual Amenity Monitoring Program Requirements

A monitoring program for landscape and visual amenity is only required for the construction phase as the impact significance during operational phase is possible to be reduced to minor and/or acceptable levels with the proposed mitigation measures being implemented as discussed in **Section 13.5**.

As part of the environmental monitoring and management measures, it is recommended to undertake site audits or inspections for at least once every two weeks during the construction phase of the development of the Study Area to check that the proposed landscape and visual mitigation measures are properly implemented and maintained as per their intended objectives during construction phase.

The EMMP for concerns related to landscape and visual amenity, which include noise and air quality, as well as unintended vegetation removal from biodiversity sections are summarised in **Table 14-10** and **Table 14-11** as they are already incorporated by other programs.

14.16 Proposed EMMP

The framework for the proposed EMMP is detailed below; however, it is important to note that this is not an exhaustive list of potential impacts, monitoring requirements, and triggers. This EMMP is intended to be a living document and should be reviewed thoroughly by the client and Contractor (CT) prior to implementation. Development of the following inputs, that have not been addressed in this report, by the CT are also required including, but not limited to:

- Stakeholder Communications Plan;
- Air Pollution Control Plan;
- Site log for all monitoring activities and complaints;
- Construction Logistics Plan;
- Standard Operating Procedures for processes identified in **Table 14-10** and **Table 14-11** below;
- Emergency Response Plan;
- Inventory of wastewater streams;
- Training protocols for staff, where appropriate; and
- Maintenance and Audit Schedules.

Table 14-10: Proposed Environmental Monitoring and Management Plan for the Construction Phase

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
Air Quality						
Air quality impact from dust nuisance from the construction activities and gaseous emissions from the construction equipment and vehicles	Before the start of the construction, AECOM recommends the construction contractor to conduct another round of monitoring in one of the monsoon periods for comprehensiveness of the establishment of baseline. Mitigation Measures: General mitigation measures to be implemented throughout construction period. Communications: • Develop and implement a stakeholder communications plan that includes community engagement before work commences on site. • Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager. • Develop and implement an Air Pollution Control Plan (APCP) Site Management: • Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken. • Make the complaints log available to the local authority when asked. • Record any exceptional incidents# that cause dust and/or air emissions, either on-site or off- site, and the action taken to resolve the situation in the log book. • Hold liaison meetings with other high risk construction sites within 500m of the site boundary, if any, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. Monitoring: • Undertake regular (daily frequency recommended) on-site and off-site inspections and record results. The log should be made available to the NEA or other Government Agencies if required. Inspections should include regular dust soiling checks of surfaces such as street furniture, cars and window sills within 100m of site boundary. Cleaning should be provided if necessary. • Carry out regular site inspections to monitor and record compliance with the Air Pollution Control Plan. • Increase the frequency of site inspections during prolonged dry or windy conditions. • Conduct monitoring for PM_{10} and $PM_{2.5}$ at suitable locations (refer to **Section 14.9**) Preparing and maintaining the site: • Plan site layout so that machinery and dust causing activities are located away from receptors, where possible. • Erect hoarding around dusty activities and at the site boundary wherever possible. Boundary screens should be at least as high as any stockpiles or dust emission sources on site. • Fully enclose specific activities where there is a known high potential for dust production and the site will be active for an extensive period of time.	PM_{10}, $PM_{2.5}$	• 27 Jalan Mendaki • 157C Mount Pleasant Road • Singapore Polo Club	• In the event of a valid complaint, once a month for as long as the particular complaint related construction activity continues. • Particulate monitoring at least once, one month before the construction works, to establish the pre-construction levels.	CT, ECO	Investigation and corrective actions to be taken, when 1. Any of the following documentation are found inadequate / missing: • Air Pollution Control Plan; • Compliance certificate of an Off-Road Diesel engine; • Monitoring Log. 2. If the monitored parameters exceed Singapore long term air quality targets. 3. If complaints are received due to project activities. 4. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	• Keep site fencing, barriers, and scaffolding clean by cleaning regularly using wet methods (dry methods may give rise to fugitive dust). • Remove materials that have the potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site, stockpiled material should be covered, seeded, fenced or enclosed to prevent fugitive dust formation. Operating vehicle/machinery and sustainable travel: • Impose and signpost a maximum-speed-limit of 25 km/hr on paved or surfaced haul roads and 15 km/hr on unpaved haul roads and work areas. • Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials. • Ensure all vehicles and engine powered equipment comply with the legislative requirements of Singapore • Ensure all vehicles and equipment switch off their engines when stationary – i.e. no idling vehicles or engines. Clear signs shall be erected at site entrance to inform all visitors. • Where practicable, avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment. If diesel needs to be used, low sulphur diesel fuel is to be used in generators. Construction: • Only use cutting, grinding or sawing equipment fitted with, or in conjunction with, suitable dust suppression techniques such as water sprays or local extraction e.g. local exhaust ventilation system. • Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate. • Use enclosed chutes and conveyors and covered skips wherever possible. • Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate. • A stringent “Clean as you go” Policy should be implemented on site to ensure no loose dry material is left exposed when not in use. Equipment should be readily available on site to clean and dry spillages, and cleaning should be conducted as soon as reasonably practicable after the event using wet cleaning methods. Waste Management: • Avoid burning of waste or other materials					
	MITIGATION MEASURES FOR EARTHWORKS • Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable. • Use Hessian, mulches or soil tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable. • Only remove the cover in small areas during work and not all at once.					
	MITIGATION MEASURES FOR CONSTRUCTION • Avoid scabbling (roughening of concrete surfaces) if possible. • Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a					

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	particular process, in which case ensure that appropriate additional control measures are in place. • Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery. • For smaller supplies of fine power materials ensure bags are sealed after use and stored appropriately to prevent dust.					
	MITIGATION MEASURES FOR TRACKOUT • Use water-assisted dust sweeper(s) on the access and affected local roads, to remove, as necessary, any material tracked out of the site. This may require the sweeper being continuously in use. • Avoid dry sweeping of large areas. • Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport. • Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable. • Record all inspections of haul routes and any subsequent action in a site log book. • Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned. • Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable). • Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits. • Site access gates to be located at least 10m from receptors where possible					
	MITIGATION MEASURES FOR DEMOLITION • Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust). • Ensure effective water suppression is used during demolition operations. Handheld sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground. • Avoid explosive blasting, using appropriate manual or mechanical alternatives. • Bag and remove any biological debris or damp down such material before demolition.					
Airborne Noise						
Noise from construction machines and equipment, especially rotational and vibratory equipment (e.g. dozers, cranes, excavators, trailers, generators, etc.))	Minimum Controls: • Construction prohibition period should be followed, as per fourth schedule of Environment Protection and Management regulation; • Prepare a Construction Noise Management Plan, to establish pre-construction baseline monitoring, plan for monitoring during the construction phase, and procedure for complaint handling;	Leq 12hours, Leq1hour and Leq 5mins	• Catholic Junior School • 23 Mount Pleasant Drive • 115 Whiley Road • 151 Mount Pleasant Road	• In the event of a valid complaint, Leq 12 hrs, Leq 1hr & Leq 5 mins to be monitored for the period of one week, or until the complaint has been resolved.	CT, ECO	Investigation and corrective actions to be taken, when 1. Any of the following documentation are found inadequate / missing: • Construction Noise Management Plan; • Monitoring Log.

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	• The contractor shall review the equipment to be used on site and erect localised noise barriers prior to undertaking high noise generating work; • Machines (such as trucks) that may be in intermittent use shall be shut down between work periods or shall be throttled down to a minimum; • Only well-maintained plants shall be utilized on-site and plants shall be serviced regularly during the entire construction period; • The number of PMEs shall be reduced as far as practicable when construction works are carried out at areas close to the noise sensitive receivers: • Consider use of silencers or mufflers on construction equipment which are properly maintained during the construction programme while facing sensitive receptors; • Behavioural practices including no shouting, no loud stereos/ radios on site, no dropping of materials from height, no throwing of metal items shall be ensured; • Construction respite: Restrict high noise generating drilling activities only in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block, if possible; • Periodic noise monitoring by an independent third party, to establish compliance with requirements and to advise on equipment causing concern, and additional potential mitigation measures; • Plan the layout of the site by considering using materials and other large structural equipment as noise barriers; • Plant known to emit noise strongly in one direction shall, wherever possible, be orientated so that the noise is directed away from the nearby NSRs; and • Material stockpiles and other structures shall be effectively utilized, wherever practicable, in screening noise from on-site construction activities. • Acoustic sheds should be provided at the locations of the noise generating activity such as operation of hand-held breaker. • All construction works should be conducted within 8am to 6pm.		• Singapore Polo Club	• Records on noise levels from construction sites should be properly kept and produced when requested.		2. If the monitored parameters exceed applicable values of EPM regulations. 3. If complaints are received due to project activities. 4. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site. 5. If there are any cracks / leaks present on the noise barrier erected.
	MITIGATION MEASURES FOR GENERAL CONSTRUCTION NOISE CONTROL: • Control of noise sources at the source from construction site – Analyse construction inventory list and check equipment causing high noise levels. The equipment with lower noise level hall be prioritized. • Where controlling noise sources at the source is not feasible, acoustic enclosures or sheds are to be introduced to mitigate noise at the source. Typical acoustic enclosure covers the machine as fully as possible (with or without ventilation where applicable) to provide sound insulation. MITIGATION MEASURES FOR CONSTRUCTION NOISE: • Noise barriers (5m and 12m high) are proposed during Phase 1 at the location near the demolition building which is facing the noise sensitive receptors.					
Groundborne Vibration						

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
Ground-borne vibration from construction machines and equipment (e.g. vibratory roller, hydraulic hammer / rock breaker, jackhammer)	• Vibration generating activities shall be conducted in the Day. Real time continuous vibration monitoring program can be conducting during the construction phase at the nearest sensitive building receptor to the construction area. The monitoring program should be capable to transmit 'trigger level alert' and 'stop work alert' messages to the Client to manage the ground-borne vibration levels emitted to the nearby sensitive receptors. • If there are justified complaints from the operations, particularly from the piling works, then the operation may need to consider the use of reduced energy to the driving of the pile, i.e. reduced drop height of the driving weight, or smaller weight.	Vibration Levels, PPV (mm/s)	Mid-span in the affected room(s) of the complainant's building	In the event of a valid complaint, until the complaint has been resolved.	CT, ECO	Investigation and corrective actions to be taken, when 1. The monitoring program log documentation is found inadequate / missing. 2. If the monitored parameters exceed applicable limits. 3. If complaints are received due to project activities. 4. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.
Hydrology and Water Quality						
Hydrology and Surface Water Quality impacts due to Solid & Toxic Waste Generation, Liquid Effluent Generation, Stormwater Run-off, and Improper Management of Chemical Substances	*Minimal Control:* • Development of a Standard Operation Procedure (SOP) for safe handling, transfer, storage and disposal of solid waste; • Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into the stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations; • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, slope stability, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to waterbodies, etc.; • Implementation of CCTV including SIDS at the public drain to monitor the surface run-off discharges from the sites as per the Public Utilities Board of Singapore's (PUB) circular on Preventing Muddy Waters from the Construction Sites (October 2015); • Provision of enclosed bins and waste disposal facilities cleared up as often as necessary to prevent build-up. Housekeeping checks will be carried out once a day to ensure all litter is cleared from site; • All wastes will be disposed only in the designated waste disposal facilities and appropriately separated, i.e. by trained workers to properly sort and label the different types of waste (reusable and recyclable waste, toxic and non-toxic waste, etc.); and • Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector. • A full inventory of all anticipated wastewater streams and volumes should be finalised before the onset of the construction works; • No unmanaged discharge of wastewater stream permitted; • Reduce, reuse, and recycle hierarchy principle to be applied to wastewater on-site; • Regular audits on environmental management procedures shall be carried out on site; • No hazardous liquids to be sent to the settling pond; • Hazardous wastewater, such as oily water, thinners, solvents, or paints, are to be stored and removed for treatment and disposal off-site by an approved Waste Management	Parameters identified in **Table 14-4**	Before discharge outlet and near identified sensitive receptors	Permanent TSS monitor installed at every discharge outlet Implementation of CCTV including a SIDS at every discharge outlet to monitor the surface run-off discharges from the sites; and Monthly freshwater quality monitoring for the duration of the construction phase. Intensity of the laboratory analysis will be increased (e.g. fortnightly, weekly) if in-situ measurements and/or monthly laboratory results indicate deterioration in the water quality. Intensified monitoring will be carried out until in-situ measurements and/or laboratory results indicate 'normality'/consistency with earlier monitored conditions.	CT, ECO	Investigation and corrective actions to be taken, when: 1. The following documentation are found inadequate/missing: ECM Plan; - Monitoring Log; - Training Log; - Audit Reports; 2. If the monitored parameters exceed applicable values of Sewerage and Drainage (Surface Water Drainage) Regulations as listed in **Table 10-3** or existing baseline conditions in **Table 10-5** (whichever is higher) at any discharge outlet; 3. If the monitored parameters exceed applicable values of criteria for aquatic life as listed in **Table 10-3** or existing baseline conditions in **Table 10-5** (whichever is higher) at identified sensitive receptors; 4. If complaints are received due to project activities; and 5. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	Contractor. Hazardous liquids to be handled as Hazardous Waste; • Settling ponds will be of impervious material and be designed with sufficient capacity to hold volumes of wastewater produced on-site, as well as allowance for stormwater run-off and potential fire-fighting wastewater; • Temporary storage volumes should be provided for overflow situations. Temporary storage to be of sufficient capacity to capture any additional volumes that may be expected to ensure untreated wastewater is not released to waterbodies unless it complies with Singapore NEA Guidelines on trade effluent discharge concentrations; • A responsible person (e.g. ECO) to be assigned to oversee the efficient operation of the settling ponds where 'Good Housekeeping' practices would be adhered to. Also, the area would be carefully managed to avoid spills, leaks, and odour issues, with the settling ponds checked at least daily to ensure proper functionality; • Daily record volume of wastewater, as well as volumes of sludge and other produced wastes; • The settling ponds, as well as wastewater generating areas on-site, to be equipped with spill clean-up kits; • Adequate drainage, cut-off drains sump pit, road kerb, piping, toe wall and/or channelling of construction process wastewater streams (e.g. concrete batching, wash water, etc.) to be assured through detailed design for capture and treatment in the settling ponds. Where applicable (e.g. in the vicinity of liquid storage or refuelling areas), this infrastructure shall include oil-water separators to capture inadvertent spills or leaked oils or greases; • Implement a construction EMMP and ensure full preparation of associated plans and procedures including the following: • EMMP to include SOPs, an Emergency Response Plan (ERP), an inventory of wastewater streams, training of staff as well as an inspection, maintenance and audit schedule; and • Full development of EMMP Wastewater Management Procedures to include dedicated management and monitoring procedures that covers all eventualities related to the proper operation of the settling ponds, or any other wastewater discharge location/equipment. • Regular and dedicated procedures for the inspection and maintenance of wastewater collection, storage, and treatment infrastructure, such as pipes, oil water separators, silt screens, etc.; • Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to waterbodies. This should also include associated measures required (e.g. silt curtains) to prevent high sediment concentration stormwater drainage to waterbodies; and • A training programme for all on-site workers, including sub-contractors, in relation to their obligations for ensuring proper water quality management. • Provision of portable toilets and on-site septic tank; • Regular cleaning of the portable toilets and clearing of sewage waste; • Appropriate location of toilet facilities away from any nearby waterbodies;					

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	• Inspections and audits to ascertain the hygienic conditions onsite; • The toilet facilities will be placed at least 30 m away from any nearby watercourse; • Training of workers on the best practices to contribute in environmental protection; and • Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector. • Surface Water Drainage, to be endorsed by a Qualified Erosion Control Professional (QECP) and submitted to PUB; • Implementation of the ECM plan before the start of any construction work; • Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations; • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to water bodies (canals, drains, streams), etc. • Implementation of CCTV including a SIDS at the public drain to monitor the surface run-off discharges from the sites as per the PUB circular on Preventing Muddy Waters from the Construction Sites (October 2015); • Runoff within, upstream of, and adjacent to the work site shall be effectively drained away without causing flooding in the vicinity; • Manholes should always be adequately covered and temporarily sealed; • Protection of stockpiles with erosion blanket coverage and proper scheduling of the demolition and earthworks to reduce the quantity of stockpiles to be stored onsite; • Coverage of temporary/open storage of excavated materials; • All vehicles and plant should be cleaned before leaving the site to ensure no earth, mud, debris, etc., is deposited on roads; and the wastewater hence generated shall be treated prior to discharge to the public sewers; and • Appropriate permits for discharge to be obtained from relevant authority prior to discharge. No trade effluent other than that of a nature or type approved by NEA Director-General shall be discharged into any watercourse or land. Stormwater Quality: • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to waterbodies (canals, drains, streams), etc. • Adequate drainage, piping and/or channelling of stormwater run-off to be assured through detailed design for capture and treatment before discharge into surface waterbodies • Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment					

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	infrastructure, such as pipes, oil water separation, silt screens, etc.; and • Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to surface waters. This should also include associated measures required to prevent high sediment concentration stormwater drainage to surface waters; Hydrology: • Runoff within, upstream of, and adjacent to the work site shall be effectively drained away without causing flooding in the vicinity; • Potential increase of peak-flow due to the change in the land use at the worksite can be mitigated by providing detention tanks or ponds within the Study Area. Detention tanks or ponds can capture stormwater during heavy storm events to reduce the peak runoff. • Geotechnical aspect of site's slope stability (such as Earth Retaining and Stabilising structures (ERSS) to be included in detailed design engineering for the construction stage. • The design engineers for detailed design may need to ensure that Earth Retaining Stabilisation structures (ERSS) are proposed when the site is cleared and excavated. Concurrently the ECO must ensure that these measures are implemented in the construction phase, as cutting of slopes may result in slope instability. • Development of SOP for safe handling, transfer and storage of toxic waste; housekeeping checks once a day to ensure all toxic waste is cleared from site; • Appropriate tests to ascertain the presence/absence of contamination of the excavated earth and sand; • Appropriate storage area (enclosed on at least 3 sides, covered and with adequate ventilation); • Appropriate construction material for toxic waste storage containers with leak detection tests conducted periodically; • Provision of secondary containment for all toxic waste stored in bulk as per the requirements in the COPPC/SS593; • Preparation of an emergency response plan, training of the emergency response team (ERT) to be competent in the response mechanism and provision of response kits for any spillages; • Consignment notification/tracking system and transport emergency response plan for transport of toxic waste; and • Appropriate disposal of toxic waste as per required in the Environmental Public Health (Toxic Industrial Waste) Regulations by licensed waste operator/collector. *Mitigation Measures:* • **Stream 1:** two (2) options were proposed as below and both options will be subject to detailed engineering studies and Authorities' approval at later stage. *<u>Option A:</u>* – To realign the proposed road at upstream of Stream 1 (refer to alternative road plan 1 in **Figure 10-9**) with 35m buffer on both sides of the stream to preserve its upstream;					

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	– To convert the downstream of Stream 1 (refer to downstream portion in **Figure 10-9**) into drains; and – To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development. *Option B:* – To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; – To convert the downstream of Stream 1 (refer to downstream portion in **Figure 10-9**) into drains; and – To provide drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed road and building development. • **Stream 3:** three (3) options were proposed as below, however, all the options will be subject to detailed engineering studies and Authorities' approval at later stage. *Option A:* – To convert downstream of Stream 3 into culvert structure under the proposed slip road; and – To provide temporary drain diversion during construction phase to make sure no flooding will occur during the construction of the proposed slip road. *Option B:* – To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat. *Option C:* • To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that Stream 3 will remain intact. • **Drain 1:** Divert or realign the concrete drain.					
Soil and Groundwater						
Decreased groundwater baseflow feeding into the streams	*Minimum Controls* • The Contractor is required to install piezometers to monitor the changes in groundwater level in compliance with Building Control Regulations 2003 as part of its instrumentation and monitoring plan to be endorsed by the QP.	Groundwater level	Actual monitoring location to be decided by QP	To continuously monitor the groundwater level throughout the lifetime of the construction phase	CT, ECO	Investigation and corrective actions to be taken there is a significant drawdown of groundwater level.
Toxic chemical waste generation	*Minimum Controls* • Identify all types of toxic chemical waste and implement comprehensive waste management system at the site in order to ensure proper disposal and prevent pollution to the environment. This contractor should conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan. If health impacts to workers are foreseen due to the handling of such waste, necessary precautionary measures as per the safety data sheets (SDS)	• Records on waste generated and hazardous chemicals used at the construction site should be properly kept and records produced when requested.	• At locations where toxic chemical wastes are generated and store. • At locations where hazardous chemicals/substances are used and stored	• Monitoring records of the amount and type of toxic chemical waste generated, once a week. • Inspection of hazardous chemical/substances	CT, ECO	Investigation and corrective actions to be taken, when: • There are no/poor records of toxic chemical waste amount and type; and • There is evidence of poor handling/storage of toxic chemical waste and hazardous chemical.

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	including personal protective equipment should be implemented on site. • Inspect all equipment prior to entering the site for fuel/hydraulic lines, leaking tanks, and other potential faulty parts that could potentially cause contamination to soil or groundwater. • Dispose all construction debris (under category C&D) at the gazetted Government dumping grounds or at such other sites or locations as directed by NEA. • Store generated toxic chemical waste within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all waste containers Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. • Note that the ECM is for the containment and treatment of silty discharge due to the impact of rainwater. ECM is not meant for the treatment of wastewater due to construction activities (such as pipe-jacking and bore-piling works) which shall be treated to comply with the requirements under prevailing legislation.			storage conditions, once a week. • Environmental audits, quarterly.		
Improper handling of hazardous chemicals/substances	*Minimum Controls* • Remove any hazardous substance or chemical, if possible if there are safer alternatives. • Ensure that all hazardous substance and chemical containers are labelled its movement is recorded and returned to the designated storage areas when not in use. • Assess the SDS of all the hazardous substances and chemicals prior to its entry to site for its suitability in terms of SHE hazards and consider safer alternatives. • Ensure no trade effluent other than that of a nature or type approved by NEA Director-General are discharged into any watercourse or land. • Ensure all activities involving repair, servicing, engine overhaul works, etc. are carried out on an area which is appropriately contained (e.g. concreted area and with proper containment/sumps) and all wastes shall be channelled for appropriate treatment or disposal to meet the regulations. • Store chemicals under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. • Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team shall also be competent in the use of these spill kits.					
Biodiversity						
Release of hazardous substances/waste in the vicinity of construction sites, habitat degradation	Implement soil erosion control measures.	Visual inspection for erosion / scouring	Whole Study Area	Daily inspection	CT, ECO, QECP	Investigation and corrective actions to be taken, when 1. The following documentation are found inadequate / missing in the detailed EMMP: • Relevant SOPs; • Toolbox Meeting Log; • Site Inspection Log; • Wastewater discharge monitoring log;
		See surface water quality monitoring requirements				
	Implement dust control measure to suppress dust to reduce its impact.	See air quality monitoring requirements				
Drop in surface water quality or contamination of surface water (refer to Section 10.0)	Store chemicals, fuels and oils in designated site.	Inspection of hazardous chemical and oil storage conditions, inspection of sensitive habitats in proximity	All storage locations	Daily inspection	CT, ECO	

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	During site clearance, contractors are to ensure that equipment stay within working space. Set up hard hoarding to demarcate development site	Visual inspection for site encroachment	Whole Study Area	Weekly inspection during site clearance		• House-keeping Log. 2. If complaints are received due to project activities. 3. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site in particular for the following: • Any leaks or openings in the site hard hoardings; • Any leakage of wastewater/ effluent/ chemical outside of the hoarding; • Any disturbance in vegetation outside the hoarding; • Absence of secondary containment for chemicals; • Any leaks in the recycling or treatment of bentonite. • Clearance of vegetation in an opposite direction to the specified one in the EIA; • Encroachment of TPZ, decline in condition of tree, mechanical damage to tree to be retained Fauna mortality or injury due to works
	Establish and maintain proper construction waste and debris disposal system. This involves establishing clearly the standard operating procedure of waste management and training the personnel so that they are familiar with the procedure.	Amount and type of waste generated	Whole Study Area	Continuous. Records on waste from construction sites should be properly kept and produced when requested		
	Practise due diligence in proper storage and handling of machineries to prevent leaching of oil or harmful materials such as bentonite slurry.	Inspection of machineries and storage locations	Whole Study Area, special attention given to areas that are identified sensitive receptors such as Freshwater Stream 3	Once a month, for the duration of construction activities		
	Ensure that all construction debris are removed from site and not buried under the ground.	Amount and type of waste generated	Whole Study Area	Continuous. Records on waste from construction sites should be properly kept and produced when requested		
	Running generators should have secondary containment trays to prevent leaks from seeping into the ground.	Inspection of machineries and storage locations	Whole Study Area, special attention given to areas that are identified sensitive receptors such as Freshwater Stream 3	Daily, for the duration of construction activities		
	Where bentonite is used, the contractor will select the appropriate equipment to ensure that they are adequately recycled and transferred to containers without any leaks.	Visual inspection	Whole Study Area, special attention given to areas that are identified sensitive receptors such as Freshwater Stream 3	Once a month, for the duration of construction activities		
	Contractor to work within approved worksite boundary, in accordance with the site plan and tree felling plan. Any changes to hoarding line, including for temporary works, must be approved by the Client.	Visual inspection for site encroachment	Site boundaries	Monthly inspection		
Encroachment into Tree Protection Zones	While setting up the hoarding, Contractor's Arborist to walk the site with the Client's Arborist to ensure the tree roots outside the contract boundary will not be affected, i.e. to make necessary adjustments, or seek Contractor's Arborist's report and NParks' approval to trim tree roots or prune trees. Identify individual trees within the site boundary to transplant, with consideration of tree size, health and transplant logistics. The Contractor's Arborist should verify all trees tagged on site.	Inspection of trees that will be affected by the construction works	Whole Study Area	Prior to the vegetation clearance	CT, ECO, Contractor's Arborist	
Vegetation and habitat clearance of sensitive stream habitats	At Stream 1, one mitigation option relevant to biodiversity is proposed to reduce the impact: – To realign the proposed road at upstream of Stream 1 (Refer to **Figure 10-1**) with 35m buffers from both sides of the stream to preserve the upstream portion of Stream 1; In Stream 3, three mitigation options with varying degrees of reduced impact are proposed: Option A: An on-grade slip road from the PIE is built and the stream is converted into a culvert. As the PIE is on higher ground than the stream, backfilling works are expected. Option B: The slip road is constructed as a raised viaduct and the span between the columns would be sufficiently wide to avoid the stream completely. As the PIE is on higher ground	N/A	N/A	N/A	CT, Client	

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	than the stream, backfilling works are expected but to an even greater area than Option A, to allow for the construction of the footings of the columns. Option C: The slip road avoids the stream completely and only begins past Mount Pleasant Road, connecting to the existing Onraet Road. - It was considered that only the downstream portion of the stream would be affected in Options A and B. - All options would require further engineering studies.					
Clearing of Conservation Significant Flora Specimens	Flora Specialist to identify locations of saplings with conservation significance that are affected by construction, work with NParks where applicable to harvest saplings.		Area of site to be cleared	Prior to the vegetation clearance	CT, ECO, Flora Specialist	
Fauna mortality or injury	Where possible, the clearance of the forest vegetation shall avoid peak bird breeding/nesting season (March to July).	N/A			CT/ECO, Ecologist	
	Prior to any clearing, conduct a walkover of the area by a suitably qualified person to identify any nests or tree hollows that may provide habitat. If fauna is sighted, mark the tree with tape, and check back daily until fauna has left the tree before felling. This should be conducted in the presence of someone familiar with birds and tree nesting animals. The Contractor shall prepare a wildlife response and rescue plan including SOP for clearance of trees, setting up and managing hoarding, site access control (e.g. around wildlife corridor), SOP when encountering nests or hollows and will be included as a minimum. The Contractor shall engage and have ready an NParks approved wildlife management specialist to execute wildlife response and rescue when necessary.	• Identify features that may result in fauna mortality. • Document trapped/injured/dead fauna within work areas. • Identify types and locations of animals around construction site. • Record activities if possible.	Area of site to be cleared	Prior to the vegetation clearance	CT, Ecologist, Wildlife Management Specialist	
	Have hoarding set up from along the busiest road of Thomson Road first, towards Bukit Brown Woods, to avoid and reduce roadkills. Maintain a closed and continuous hoarding/ noise barrer (where applicable) throughout the construction period. Clear vegetation progressively in one direction to encourage arboreal wildlife into neighbouring forested areas. In the Study Area, vegetation should be cleared in a northwest direction towards Bukit Brown Woods, with considerations to Mount Pleasant Road and the existing houses. Around the proposed slip road, vegetation should be cleared in a northward's direction away from PIE.	N/A			CT, Ecologist	
General	Daily toolbox for construction personnel and sub-contractors to: • Remind to practise caution during work. • Create conservation awareness, brief on mitigating actions, proper waste disposal and equipment storage. • Remind mitigating actions, proper waste disposal and equipment storage. • Practise due diligence in proper storage and handling of machineries, materials to prevent leaching of oil or harmful materials. Monthly biodiversity toolbox briefing may be conducted to highlight to workers: • Of their responsibilities on-site towards biodiversity; • On how to minimize ecological impacts; and	N/A			CT,ECO, Ecologist	NA

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	• On how to identify key fauna.					
	Conduct site inspection surveys to monitor for fauna presence in and around work areas for site awareness.	Document condition of terrestrial and freshwater environment in relation to degradation of fauna habitats.	Whole Study Area	Once every month with monthly reporting	CT, Ecologist	NA
	Conduct diurnal and nocturnal transect surveys to monitor for fauna presence in and around work areas for site awareness.	• Monitor for fauna presence around site as construction is on-going. • Identify features that may result in fauna mortality. • Document trapped/injured/dead fauna within work areas. • Identify types and locations of animals around construction site. Record activities if possible.	Whole Study Area, transect to be confirmed	Once every month with monthly reporting	CT, Ecologist	NA
Landscape and Visual Amenity						
Functionality and Efficiency of the Proposed Landscape and Visual Mitigation Measures	• To conduct site audits or inspections at least once every two weeks to check that the proposed landscape and visual mitigation measures are properly implemented and maintained as per their intended objectives during construction phase; • Ensure that mitigation measures from noise, air quality and biodiversity are well-incorporated.	N/A	Whole Study Area	Once every two weeks	CT, ECO	Refer to other technical aspects, such as noise, air quality, water quality and biodiversity.
General						
Waste generated from the construction activities, - General non-hazardous waste such as waste paper, refuse from the kitchen facilities, empty bags, litter, filters etc. - Hazardous wastes such as scrap metals, contaminated debris - Chemical wastes (such as scrap batteries and used solvents, paint and cleaners) - Sewage effluents from onsite human activities)	• All wastes will be disposed only in the designated waste disposal facilities and appropriately separated, i.e. by training workers to properly sort and label the different types of waste (reusable and recyclable waste, toxic and non-toxic waste, etc.); • Development of procedures in the Waste Management Plan for safe handling, transfer and storage of toxic waste which includes sorting of toxic and non-toxic waste, training of workers, etc.; • Appropriate storage area (enclosed on at least 3 sides, covered and with adequate ventilation); • Appropriate construction material for toxic waste storage containers, and occasional leak tests conducted on these containers to notify for accidental spills; • Provision of secondary containment for all toxic waste stored in bulk as per the requirements in the COPPC; • Preparing Emergency response plan, training the ERT to be competent in the response mechanism and ensuring availability of response kits for any spillages; • Consignment notification / tracking system and transport emergency response plan for transport of toxic waste; and • Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector.	Amount and type of waste generated	Whole Study Area	Continuous. Records on waste from construction sites should be properly kept and produced when requested	CT, ECO	Investigation and corrective actions to be taken, when 1. The following documentation are found inadequate / missing : • Site specific EMMP including a Waste management plan and a monitoring plan ; • Emergency Response Plan (Spillages on-site and transport of toxic waste); • Consignment Notification System; • Monitoring Log; • House-keeping Log. 2. If non-compliance noted to Environmental Public Health (General Waste Collection) Regulations and Environmental Public Health (Toxic Industrial Waste) Regulations. 3. If complaints are received due to project activities. 4. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	• Appropriate disposal of any toxic waste by licensed toxic waste collectors as per required in the Environmental Public Health (Toxic Industrial Waste) Regulations. • Provision of enclosed bins and waste disposal facilities cleared up as often as necessary to prevent build-up. Housekeeping checks will be carried out once a day to ensure all litter is cleared from site;					
Vectors due to accumulation of solid waste (especially food waste) and stagnant water	• Prepare a Vector management plan detailing procedures to control vector at the site; • Regular monitoring of the adult mosquito population using well-maintained gravitraps or other appropriate devices; • Prompt and effective drainage of stagnating water: • Applying appropriate covers such as concrete paving, milled asphalt waste or steel plates to prevent puddles from forming; • Sloping/pitched roof for all site offices, where possible; • Preparation and implementation of an effective vector control plan and measures as provided in Code of Practice for Environmental Control Officers; • Conduct in-house vector surveillance and eradication operations especially after rainfall; • Eliminate all stagnant water sources. • Use environmentally-friendly methods for vector control and search & destroy operation etc. instead of anti-malaria oil, or chemical larvicides. • Bacillus Thuringiensis Israelensis (Bti) is a non-specific larvicide and its constant use will result in loss of butterflies and odonates larvae. BTI should only be applied in areas where its inaccessible and typical solutions have not been able to resolve stagnant water. • Thermal fogging shall only be carried out when there is high population of adult mosquitoes and/or when there are dengue/zika outbreaks near the construction site in accordance to the CP on ECO. The Contractor shall ensure that approval is obtained from NEA before fogging is carried out on site. • Sloping/pitched roof for all site containers; • Store food in rodent proof storage containers/cabinets with at least 60 cm clearance above ground level. • Monitor any form of water receptacle and clear water daily to prevent mosquitos from breeding; • Effective housekeeping; • Treat active burrows with rodenticides until all rats are eradicated and subsequently seal burrows with compacted earth; and • Enclose food waste in plastic bags before disposal into waste bins. Food waste to be removed daily and bins to be cleared regularly to prevent fly and rodent infestation.	Inspection of potential mosquito breeding grounds (stagnant water) and rodent burrows	Near identified sensitive receptors	Once a week	CT,ECO	Investigation and corrective actions to be taken, when 1. The following documentation are found inadequate / missing : • Vector Control Plan; • Monitoring Log; • Site Inspection Log; • House-keeping Log. 2. If complaints are received due to project activities. 3. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site. 4. Non-compliance to Control of Vectors and Pesticides Act, 2002.

Note:

1. Resident Technical Officer (RTO) and Site Officers (SO, EHS Officer, and ECO) check the study area for construction progress and implementation of environmental mitigation measures.
2. If there is trigger then all the mitigation and management measures should be audited in detail for compliance and corrective action must be taken in liaison with the Project Owner.

Table 14-11: Proposed Environmental Monitoring and Management Plan for the Operational Phase

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
Airborne Noise						
Noise from Air-conditioning and Mechanical Ventilation, Traffic Noise.	MINIMUM CONTROLS FOR ACMV NOISE: Minimum Controls below should be applied at the prelim design stage of the development by the appointed M&E consultants. An appointed Noise consultant should validate the noise in accordance with *NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building.* In addition, mitigation measures will be provided by the appointed Noise Consultants during the prelim design stage. • Use low air-conditioning and mechanical ventilation system equipment; • Ensure that any exhaust outlet or intake from the mechanical ventilation system is designed to be adequately set back as far as possible from the boundary line of the development; • Acoustic treatment if any to be designed and implemented; • AC system to be designed with the AHU units placed at appropriate locations as set back from the boundary line of the development as possible; and • Acoustic enclosures for outdoor equipment. MINIMUM CONTROLS FOR TRAFFIC NOISE: Due to the lack of information at this juncture of reporting, assessment, minimum controls and mitigation will be provided by the appointed Noise Consultant during the prelim design stage and in accordance with *Technical Guideline for Land Traffic Noise Impact Assessment*	N/A	N/A	N/A	N/A	N/A
Groundborne Vibration						
Ground-borne Vibration from Road Traffic	• Road traffic control on speed limits and heavy vehicles. • Maintenance of road surfaces to be levelled.	Vibration, PPV levels (mm/s)	• Vibration monitoring not required	• Vibration monitoring not required	Local Authorities	1. Ground-borne Vibration from Road Traffic Road traffic control on speed limits and heavy vehicles. 2. Maintenance of road surfaces to be levelled. Vibration, PPV levels (mm/s) Vibration monitoring not required Vibration monitoring not required Local Authorities Investigation and corrective actions to be taken, when 3. Heavy vehicles have frequent access to the Study Area; and 4. The roads have worn out and become uneven.
Hydrology and Water Quality						
Surface Water Quality impact due to stormwater runoff	Minimum Control: *Stormwater Quality:* • Adequate drainage, piping and/or channelling of stormwater run-off to be assured through detailed design [such as Active, Beautiful, Clean Water (ABC) Water Design approach] for capture and treatment before discharge into surface water; and	In-situ parameters identified in Table 14-4	Near identified sensitive receptors	Monthly monitoring at the sensitive receptors (i.e. main natural streams) during the 1st three (3) months of operation period.	CT, ECO	Investigation and corrective actions to be taken, when 1. The following documentation are found inadequate / missing ; • ECM Plan; • Monitoring Log;

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	• Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment infrastructure, such as pipes, oil water separation, silt screens, etc.; o Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to surface waters. This should also include associated measures required to prevent high sediment concentration stormwater drainage to surface waters; *Hydrology:* • Potential increase of peak-flow due to the change in the land use at the new developments can be mitigated by providing detention tanks within the Study Area. Detention tanks can capture stormwater during heavy storm events to reduce the peak runoff. Stored water can then be discharged back to the system after the storm event. As required by PUB, the storage system needs to be in place to reduce the peak flow at the operational phase to be the same or less than that of the existing condition; • Active, Beautiful, Clean Water (ABC) Water Design approach can be considered to reduce the peak-flow as well; • Geotechnical aspect of site's slope stability (such as ERSS) to be included in detailed design engineering for the operational stage; and • Providing more softscape area should be considered in the design of the development to reduce the runoff coefficient which will help to reduce the peak-flow and reduce flood risk at downstream area. *Mitigation Measures:* • **Stream 1:** two (2) options were proposed as below and both options will be subject to detailed engineering studies and Authorities' approval at later stage. <u>*Option A:*</u> − To realign the proposed road at upstream of Stream 1 (refer to alternative road plan 1 in **Figure 10-9**) with 35m buffer on both sides of the stream to preserve its upstream; and − To convert the downstream of Stream 1 (refer to downstream portion in **Figure 10-9**) into drains. <u>*Option B:*</u> − To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that the upstream of Stream 1 with 35m buffer on both sides (refer to upstream portion in **Figure 10-9**) can be preserved; and − To convert the downstream of Stream 1 (refer to downstream portion in **Figure 10-9**) into drains.					• Training Log; • Audit Reports. 2. If the monitored parameters exceed applicable values of criteria for aquatic life as listed in **Table 10-3** or existing baseline conditions in **Table 10-5** (whichever is higher) for natural streams. 3. If complaints are received due to project activities. 4. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
	• **Stream 3:** three (3) options were proposed as below, however, all the options will be subject to detailed engineering studies and Authorities' approval at later stage. <u>*Option A:*</u> − To convert downstream of Stream 3 into culvert structure under the proposed slip road. <u>*Option B:*</u> − To construct the proposed slip road as a cross-over to avoid the stream as well as its ecological habitat. <u>*Option C:*</u> − To replace the proposed slip road by constructing a service road along PIE which will link up to existing Onraet Road (refer to alternative road plan 2 in **Figure 10-9**), so that Stream 3 will remain intact. • **Drain 1:** Divert or realign the concrete drain.					
Soil and Groundwater						
Generation of small quantities of toxic chemical waste (used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.)	*Minimum Controls* • Store all toxic chemical waste at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all chemical drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances; and • Dispose all toxic waste chemicals off-site to licensed TIW collectors for treatment.	• Records on waste generated and hazardous chemicals used at the study area should be properly kept and records produced when requested.	• At locations where toxic chemical waste are generated and store. • At locations where hazardous chemicals/substances are used and stored.	• Monitoring records of the amount and type of toxic chemical waste generated, monthly. • Inspection of hazardous chemical/substances storage conditions, monthly.	CT, ECO	Investigation and corrective actions to be taken, when: • There are no/poor records of toxic chemical waste amount and type; and • There is evidence of poor handling/storage of toxic chemical waste and hazardous chemical.
Improper handling of hazardous chemical/substances	*Minimum Controls* • Store all hazardous substances/chemicals at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all chemical drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances; • Ensure that all hazardous chemicals/substances are labelled its movement is recorded and returned to the designated storage areas when not in use; • Ensure all activities including repair, servicing, engine overhaul works, etc. involving the use of hazardous chemicals/substances are carried out on an area which is appropriately contained (e.g. concreted area and with proper containment/sumps); • Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team shall also be competent in the use of these spill kits; and • Ensure no trade effluent other than that of a nature or type approved by NEA Director-General are discharged into any watercourse or land.					
Biodiversity						

Environmental Issue	Mitigation / Management Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers[1,2]
Habitat degradation due to improper waste disposal and release of harmful substances including insecticide	Use environmentally-friendly methods for vector control and search & destroy operation etc. instead of anti-malaria oil, or chemical larvicides. Bacillus Thuringiensis Israelensis (Bti) is a non-specific larvicide and its constant use will result in loss of butterflies and odonates larvae. BTI should only be applied in areas where its inaccessible and typical solutions have not been able to resolve stagnant water.	Various stakeholders to monitor and manage				On-going monitoring and management.
Human-wildlife conflict	Ensure proper food disposal and enforcement of no feeding of wildlife to avoid human-wildlife conflict, particularly macaques.					

Note:

1. Resident Technical Officer (RTO) and Site Officers (SO, EHS Officer, and ECO) check the study area for construction progress and implementation of environmental mitigation measures.
2. If there is trigger then all the mitigation and management measures should be audited in detail for compliance and corrective action must be taken in liaison with the Project Owner.

15.0 Conclusions

This section will present the summary of conclusions and recommendations from the assessed potential environmental impacts. The impact significance (with minimum controls before mitigation) and potential residual impact significance (with mitigation measures) of the assessed environmental aspects are summarised in table below.

Table 15-1: Summary of Potential Residual Impact Significance (Range if applicable)

Environmental Parameter	EIA Section	Impact Significance (with minimum controls)	Residual Impact Significance (with mitigation measures)
Construction Phase			
Air Quality	**Section 7.0**	Major	Minor
Airborne Noise	**Section 8.0**	Negligible to Moderate (Human Receptors) Moderate (Ecological Receptors)	Negligible to Minor (Human Receptors) Moderate (Ecological Receptors)
Ground-borne Vibration	**Section 9.0**	Minor to Moderate (Human Receptors) Minor (Ecological Receptors)	Negligible to Minor (Human Receptors) Minor (Ecological Receptors)
Hydrological and Water Quality	**Section 10.0**	Negligible to Major	Negligible to Moderate
Soil and Groundwater	**Section 11.0**	Negligible to Minor	Negligible to Minor
Biodiversity	**Section 12.0**	Negligible to Major	Negligible to Major
Landscape and Visual Amenity	**Section 13.0**	Negligible to Moderate	Negligible to Minor
Operational Phase			
Air Quality	**Section 7.0**	Negligible to Minor	Negligible to Minor
Airborne Noise	**Section 8.0**	N/A (Human Receptors) Minor (Ecological Receptors)	N/A (Human Receptors) Minor (Ecological Receptors)
Ground-borne Vibration	**Section 9.0**	Minor to Moderate (Human Receptors) Minor (Ecological Receptors)	Minor (Human Receptors) Minor (Ecological Receptors)
Hydrological and Water Quality	**Section 10.0**	Negligible to Major	Negligible to Minor
Soil and Groundwater	**Section 11.0**	Negligible	Negligible
Biodiversity	**Section 12.0**	Negligible to Major	Negligible to Moderate
Landscape and Visual Amenity	**Section 13.0**	Minor to Major	Negligible and/or Acceptable Levels to Minor

Note:

1) N/A – Not Assessed as no information available at current early design stage. AECOM recommends that the operational noise impact assessment which focuses on ACMV and vehicular traffic noise to be conducted by the appointed Noise Consultant at later stages of the development, which is a mandatory requirement under NEA's *Technical Guideline for Land Traffic Noise Impact Assessment* and *Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building*.

Further Studies

AECOM understands that the project is at the early master-planning stage by HDB (the Client) and does not currently have a detailed design or construction footprint, where the data provided is preliminary in nature for the study area. Therefore, this EIS Report is formed to inform the Client of major issues according to the planning at this early stage, as well as to provide a high-level identification, prediction and evaluation of potential environmental impacts from the study area.

Shall any project-specific detailed implementation plans be finalized in future, it may require revision or a separate study based on the level of details provided, which also subject to any major changes compared to the current study. With sufficient details provided by the Client, cumulative impacts of different construction and/or operational phases of the project along with any surrounding potential sensitive uses or other concurrent projects could be considered.

For biodiversity, this includes:

1. A detailed arboriculture assessment to be made for trees to be retained, this should include the details of construction works nearby which may affect the tree or its TPZ and the method of protection.
2. A pre-construction biodiversity baseline survey may be conducted if more than two years has passed since the time of the majority of the field work (last fauna survey was completed in September 2020 with the majority of the surveys completed in 2019) to confirm the presence of conservation significant fauna on site.
3. If translocation of a conservation significant fauna species is proposed, a species and population specific feasibility study should be made.

For Airborne Noise, this includes:

1. ACMV Boundary Noise Assessment for proposed development. To be conducted by an appointed Noise Consultant during development phase in accordance with *Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building and Technical Guideline.*
2. Traffic Noise Impact Assessment for impacts to proposed development. To be conducted by an appointed Noise Consultant during development phase in accordance with Technical Guideline for *Land Traffic Noise Impact Assessment.*
3. Recommend the contractor to measure baseline monitoring for future mitigation and to estimate the existing noise levels and to calculate the “adjusted maximum permissible noise level” to determine the construction noise criteria for this project at Eton House Pre-School (Thomson), Saint Joseph Institute and Lee Ah Mooi Old Age Home.

For ground-borne vibration impacts during, construction phase, dilapidation surveys would normally be recommended when the predicted vibration levels approach or exceed a level of 80 % of the lowest damage criteria (typically 7.5 mm/s PPV for continuous vibration at 4 Hz). As the vibration at any receptor is not likely to exceed this threshold, no surveys are considered warranted.

For other environmental impacts such as air quality, water quality, soil and groundwater, landscape and visual amenity, it will most likely involve a re-assessment using the current assessment approach but with higher level of details and/or larger scope of work (if applicable in future). With sufficient details provided by the Client, cumulative impacts of different construction and/or operational phases of the project along with any surrounding potential sensitive uses or other concurrent projects could be considered.

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Appendix A

Baseline Air Quality Monitoring Report

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

ALS Technichem (S) Pte Ltd
121 Genting Lane #04-01, Singapore 349572
Tel: (65) 6589 0118 Fax : (65) 6283 9689 E-mail: alssg@alsglobal.com
Co. Reg No. 198403076R

Our Ref: SG1905638 Date: 09 May 2019

MT PLEASANT EIS (DUST MONITORING)

FOR

AECOM SINGAPORE PTE LTD

300 BEACH ROAD #23-00 THE CONCOURSE

SINGAPORE 199555

Edmundo II Dio Casapao
Environmental Engineer

Tan Teong Huat
Assistant General Manager
BSc, MSc (SHE Tech.), MSNIC

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Executive Summary

ALS Technichem (S) Pte Ltd is appointed by AECOM Singapore Pte Ltd to carry out Ambient Air Monitoring for the Mt Pleasant EIS (Dust Monitoring – PM_{10} and $PM_{2.5}$). The monitoring was undertaken to determine the ambient air quality of Particulate Matter as 2.5um and 10um ($PM_{2.5}$ and PM_{10}), for 8 days continuously from 22nd to 30th April 2019. The objective of this monitoring is to establish a baseline ambient air quality at the selected point and compare whether it is in compliance with the limits stipulated by Singapore Ambient Air Quality Targets by 2020 and the Long Term Targets.

In general, the monitoring results for PM10 was found to be satisfactory and is in compliance to Singapore Ambient Air Quality Targets by 2020.

For $PM_{2.5}$, the monitoring results were found to be satisfactory and is in compliance to Singapore Ambient Air Quality Long Term Targets.

It should be noted that the Ambient Air Monitoring project was carried out to the best of our knowledge and ability as well as responsibility towards the code of practice in the performance and reliability of our business to be accurate, precise and representative at the date/time and locations sampled so as to achieve a satisfactory baseline study.

List of Content

Executive Summary i
List of Content ii
List of Tables iii
List of Figures iii
List of Abbreviations iii
1.0 Monitoring Requirement 1
1.1 Introduction 1
1.2 Scope of Work 1
1.3 Monitoring Requirement 1
2.0 Sampling and Field Monitoring 2
2.1 Sampling Equipment 2
2.2 Monitoring Location 3
2.3 Detail Ambient Air Monitoring Point 4
3.0 Sampling and Analysis Methodology 5
3.1 Quality Assurance / Quality Control 6
4.0 Results of Monitoring at AQ01 7
7.0 Conclusion 10

List of Tables

Table 1.1: Summary of test parameters and limits for ambient air monitoring..... 2
Table 2.1: Details of monitoring points..... 4
Table 3.1: Summary of methodologies and limit of reporting (LOR)…….. 5
Table 4.1: Summary of results for Particulate Matter as $PM_{2.5}$ & PM_{10} based on 24-hour average at AQ01..... 7

List of Figures

Figure 2.1: AQ01, No. 163 Mount Pleasant Road (Along Mount Pleasant Road) ……..... 4
Figure 4.1: 24-Hour Average for $PM_{2.5}$ at AQ01 from 22 to 30 April 2019 ……..... 8
Figure 4.2: 24-Hour Average for PM10 at AQ01 from 22 to 30 April 2019 ……..... 9

List of Abbreviations

PM_{10}	Particulate matter with aerodynamic diameter less than 10µm
$PM_{2.5}$	Particulate matter with aerodynamic diameter less than 2.5µm
μgm^{-3}	Microgram per cubic metre
mgm^{-3}	Milgram per cubic metre
LOR	Limit of Reporting

1.0 Monitoring Requirement

1.1 Introduction

ALS Technichem (S) Pte Ltd (hereafter as "ALS") has been appointed as the contractor to perform Ambient Air Monitoring at the selected location for the Mt Pleasant EIS (Dust Monitoring – PM_{10} and $PM_{2.5}$) at the request of AECOM Singapore Pte Ltd (hereafter as "AECOM").

The ambient air monitoring is aimed to provide an air quality baseline information on the targeted area which was pre-determined by AECOM and to evaluate the results whether it is in compliance against National Environmental Agency- Singapore Ambient Air Quality Targets by 2020 and the Long Term Targets.

1.2 Scope of Work

The scope of works for the ambient air quality monitoring includes:

1. Preparation of an Ambient Air Monitoring Plan;

2. Ambient air monitoring station setup and sampling at selected sampling point, identified as AQ01 (sampling point was dictated by AECOM);

3. Collected air samples were analysed for:
   - Particulate Matter as 10um and 2.5um (PM_{10} & $PM_{2.5}$);

4. Assessing the analytical results against Singapore Ambient Air Quality Targets by 2020 and the Long Term Targets

5. Providing a report outlining the findings and results of the study.

1.3 Monitoring Requirement

Ambient air monitoring was conducted at No. 163 Mount Pleasant Road. Particulate Matter as 10um and 2.5um (PM_{10} & $PM_{2.5}$), were monitored as required. Monitored parameters were dictated by AECOM and compared with the Singapore Ambient Air Quality Targets by 2020 and the Long Term Targets. Table 1.1 lists the details of the limits of each parameter in this study.

Table 1.1: Summary of test parameters and limits for ambient air monitoring

Parameters	**Limits** (mgm^{-3} or μgm^{-3})	**Guidelines**
$PM_{2.5}$	25 μgm^{-3} (24-hour averaging period)	Singapore Ambient Air Quality Long Term Targets
PM_{10}	50 μgm^{-3} (24-hour averaging period)	Singapore Ambient Air Quality Targets by 2020

2.0 Sampling and Field Monitoring

2.1 Sampling Equipment

The following equipment was mobilized and used during the environmental monitoring activities.

Parameter	**Instrument Type**
Particulate matter (PM_{10} & $PM_{2.5}$)	TSI Environmental DustTrak Monitoring System

2.2 Monitoring Location (★ indicates air monitoring location)

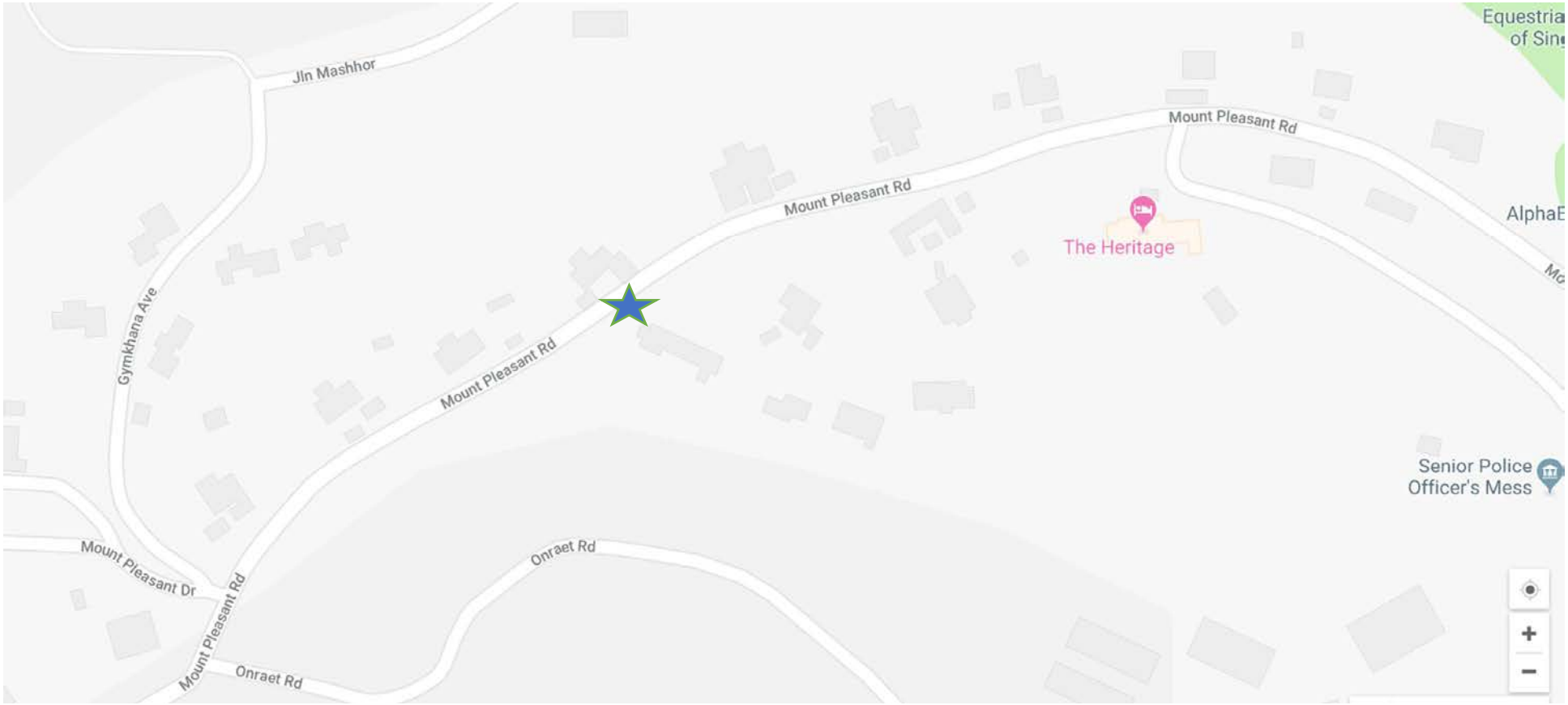


Figure 2.1: AQ01, No. 163 Mount Pleasant Road (Along Mount Pleasant Road)

2.3 Detail Ambient Air Monitoring Point

The air monitoring point, identified as AQ01 was dictated by AECOM. The details of the monitoring point is listed in Table 2.1 below.

Table 2.1: Details of monitoring points

Sampling ID	Monitoring Point	Parameter	Sampling Start		Sampling Stop	
			Date	Time (hr)	Date	Time (hr)
AQ01	163 Mount Pleasant Road (Along Mount Pleasant Road)	PM_{10} & $PM_{2.5}$ (24 hours)	22 April 2019	1400	30 April 2019	1300

3.0 Sampling and Analysis Methodology

Brief method description, method reference and reporting limit of the analytical methods are provided in Table 3.1.

Table 3.1: Summary of methodologies and limit of reporting (LOR)

No.	Parameter	Referenced Analytical Method	Description of Method	LOR
1.	Particulate matter (PM_{10} & $PM_{2.5}$)	TSI Environmental DustTrak Monitoring System Operation Manual	Concentrations of PM_{10} & $PM_{2.5}$ were measured by Light scattering laser photometer principle using an Environmental DustTrak Monitoring Equipment coupled with heated inlet for 5 minutes interval data log over 8 days continuous sampling period	1.0 μgm^{-3}

3.1 Quality Assurance / Quality Control

The certificate of field equipment calibration is attached below.

CERTIFICATE OF CALIBRATION AND TESTING

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 http://www.tsi.com

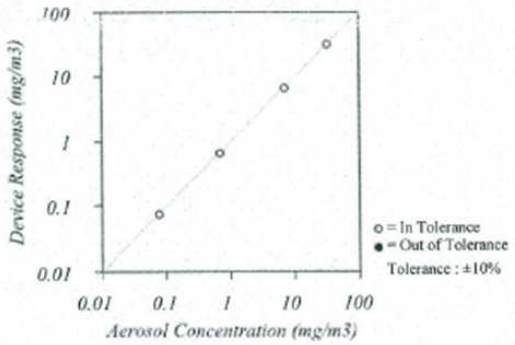
Environment Conditions		
Temperature	76.56 (24.8)	°F (°C)
Relative Humidity	24.0	%RH
Barometric Pressure	29.13 (986.5)	inHg (hPa)

Model	**8543**
Serial Number	**8543191207**

☒ As Left ☐ As Found

☒ In Tolerance ☐ Out of Tolerance

Concentration Linearity Plot



System ID: DTII01-01

FLOW AND PRESSURE VERIFICATION — **SYSTEM DTII01-01**

Parameter	Standard	Measured	Allowable Range	Parameter	Standard	Measured	Allowable Range
Flow lpm	3.00	3.07	2.91 ~ 3.09	Pressure kPa	98.8	98.8	93.86 ~ 103.74

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. There is no NIST standard for optical mass measurements. Calibration of this instrument performed by TSI has been done using emery oil and has been nominally adjusted to respirable mass per standard ISO 12103-1, A1 test dust (Arizona dust). Our calibration ratio is greater than 1.2:1

Measurement Variable	System ID	Last Cal.	Cal. Due	Measurement Variable	System ID	Last Cal.	Cal. Due
Photometer	E003433	03-19-19	09-30-19	Flowmeter	E002475	09-12-18	09-30-19
DC Voltage(Keithley)	E002859	08-22-18	08-31-19	Microbalance	M001324	10-03-18	10-31-20
Temp/Humidity	E005410	10-15-18	10-31-19	Pressure	E003440	07-24-18	07-31-19
1 um PSL	698880	n/a	n/a	3 um PSL	180387	n/a	n/a
10 um PSL	198441	n/a	n/a	Temp/Humidity	E005409	10-12-18	10-31-19

Juan Cornejo
Calibrated

March 21, 2019
Date

TSI P/N 2300157

4.0 Results of Monitoring at AQ01

Table 4.1: Summary of results for Particulate Matter as $PM_{2.5}$, and PM_{10} based on 24-hour average at AQ01

Sampling Point	Day	Particulate Matter ($PM_{2.5}$), μgm^{-3}	Particulate Matter (PM_{10}), μgm^{-3}
Mount Pleasant Road	22 to 23 April 2019	17.6	23.8
	23 to 24 April 2019	12.5*	19.5*
	24 to 25 April 2019	18.0	26.2
	25 to 26 April 2019	19.7	28.9
	26 to 27 April 2019	9.40	15.5
	27 to 28 April 2019	7.71	13.6
	28 to 29 April 2019	9.65**	11.4**
	29 to 30 April 2019	12.6	15.3
Limits (μgm^{-3})		**25**[a]	**50**[b]

Notes:

* Denotes equipment stopped from 3AM to 11AM, presented average is for 16 hours only.

** Denotes equipment stopped from 2AM to 8AM, presented average is for 17 hours only.

[a] Denotes as per client request, the results are compared to the limits stipulated by Singapore Ambient Air Quality Long Term Targets

[b] Denotes results are compared to the limits stipulated by Singapore Ambient Air Quality Targets by 2020.

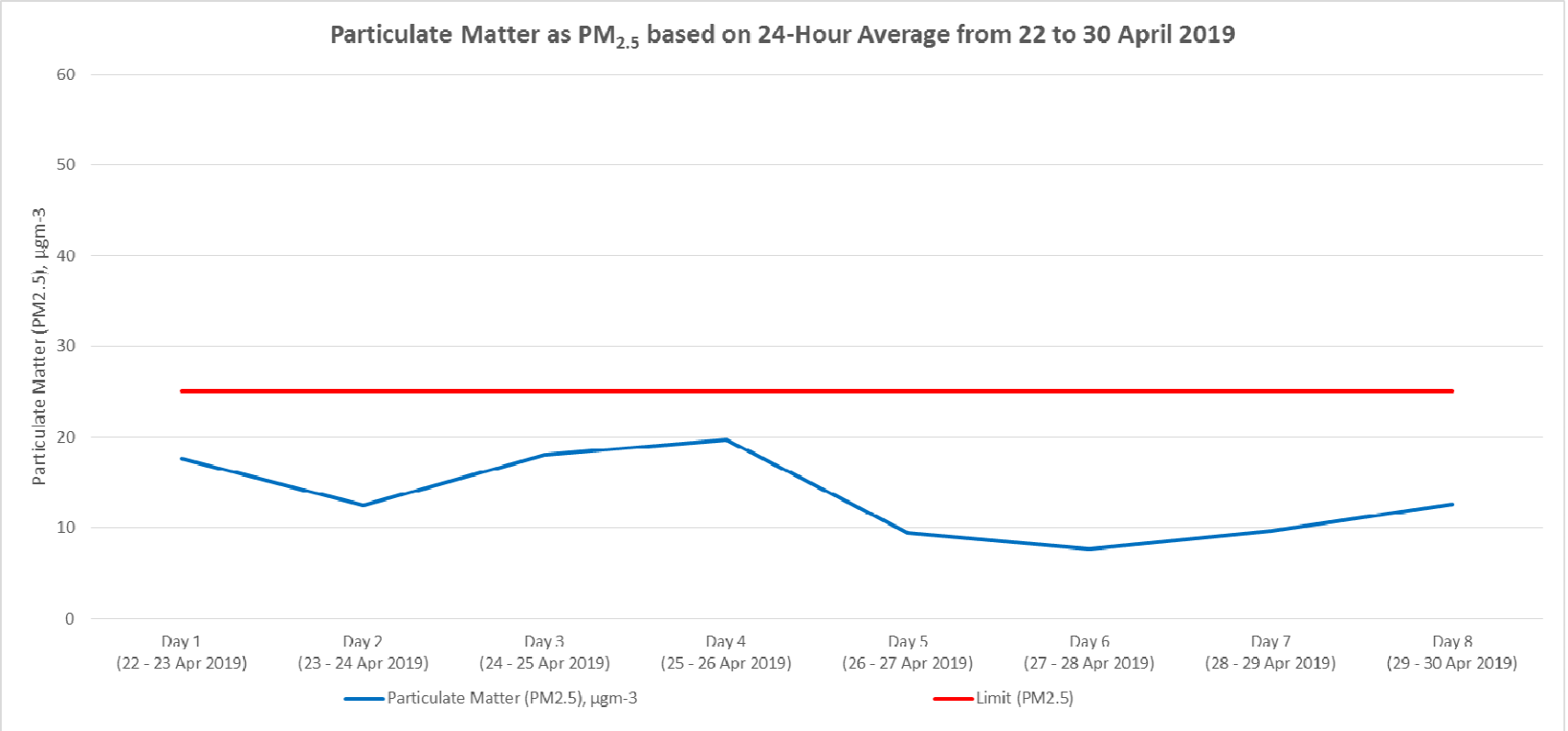


Figure 4.1: 24-Hour Average for $PM_{2.5}$ at AQ01 from 22 to 30 April 2019

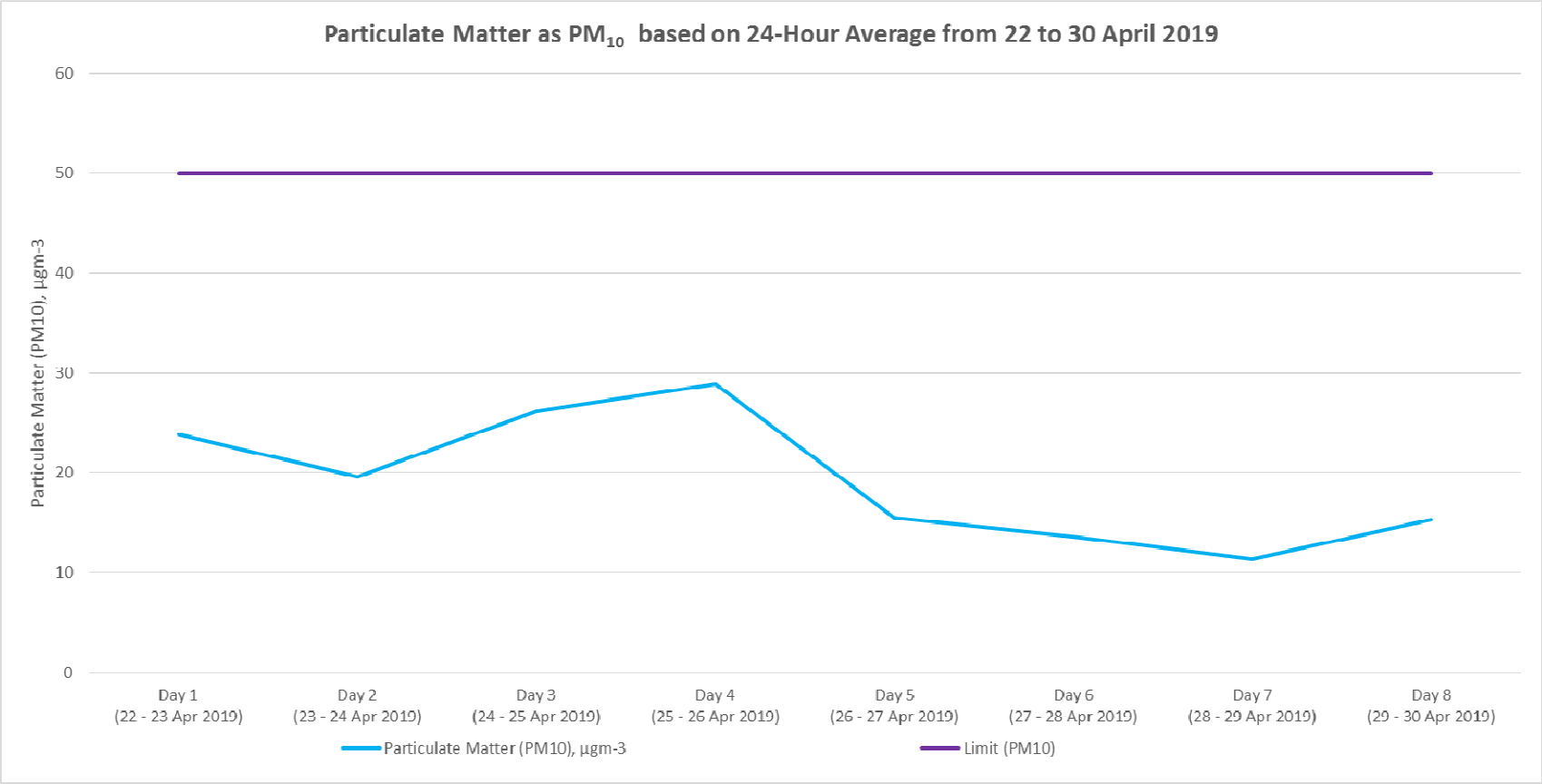


Figure 4.2: 24-Hour Average for PM_{10} at AQ01 from 22 to 30 April 2019

7.0 Conclusion

The monitoring results are summarized in Table 4.1. The monitoring results for PM10 were found to be satisfactory and is in compliance to Singapore Ambient Air Quality Targets by 2020. For PM2.5, the monitoring results were found to be satisfactory and is in compliance to Singapore Ambient Air Quality Long Term Targets.

It should be noted that the Ambient Air Monitoring project was carried out to the best of our knowledge and ability as well as responsibility towards the code of practice in the performance and reliability of our business to be accurate, precise and representative at the date/time and locations sampled so as to achieve a satisfactory baseline study.

APPENDIX 1: Site Photos

Appendix B

Air Quality Identified Sensitive Receptors

Table B-1: List of sensitive receptors for each activity and its sensitivity

Distance[1]	Land Use	Number of R [2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
For Earthworks				
Within 20m	Residential: 27 Jalan Mendaki Ecological Sensitive Receptor: Bukit Brown Woods[3]	<10	Priority 1	Priority 1
Between 20m to 50m	Educational Institution: Saint Joseph Institute International Residential: 1. 157 Mount Pleasant Road 2. 4 Gymkhana Avenue 3. 18 Mount Pleasant Drive 4. 160 Mount Pleasant Road 5. 8 Gymkhana Avenue 6. 6 Gymkhana Avenue Ecological Sensitive Receptor: Bukit Brown Woods[3]	>100 <10		
Between 50m to 100m	Educational Institution: 1. EtonHouse Pre-School (Thomson) 2. Catholic Junior College Nursing Home: Lee Ah Mooi Old Age Home Residential: 1. 23 Mount Pleasant Drive 2. 153 Mount Pleasant Road 3. 47 Merryn Road 4. 45 Merryn Road 5. 39 Merryn Road 6. 53,53A Merryn Road 7. 37 Merryn Road 8. 55 Merryn Road 9. 31,31A Merry Road 10. 115 Whitley Road 11. 20 Malcolm Road 12. 27 Mount Pleasant Drive 13. 61,61A Merryn Road 14. 121D,121E Whitley Road 15. 121F,121G Whitey Road 16. 158 Mount Pleasant Road 17. 3 Gymkhana Avenue 18. 115A,B,C,D,E Whitley Road 19. 115K,J,H,G,F Whitley Road 20. 49,49A Merryn Road 21. 111B,113,113A,B Whitley Road 22. 41 Merryn Road 23. 43A Merryn Road 24. 51,51A Merryn Road 25. 29 Merryn Road 26. 57 Merryn Road 27. 101,103 Whitley Road 28. 35 Merryn Road	>100 10-100 10-100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	29. 57A Merryn Road 30. 1 Bo Seng Avenue 31. 117 Whitley Road 32. 33 Merryn Road 33. 59,59A Merryn Road 34. 121H,121J Whitley Road 35. 151 Mount Pleasant Road 36. 7 Gymkhana Avenue 37. 111A Whitley Road 38. 22 Mount Pleasant Drive 39. 97 Whitley Road 40. 95 Whitley Road Commercial: 1. Senior Police Officer's Mess 2. Offside Futsal Park 3. Singapore Polo Club 4. James Tan Veterinary Centre Ecological Sensitive Receptor: Bukit Brown Woods[3]			
Between 100m to 200m	Educational Institution: 60 Kheam Hock Road Residential: 1. 155 Mount Pleasant Road 2. 131H,J Whitley Road 3. 23 Merryn Road 4. 3,5 Bo Seng Avenue 5. 10,12 Bo Seng Avenue 6. 121C,121A Whitley Road 7. 21 Merryn Road 8. 30 Malcolm Road 9. 27, 27A Merryn Road 10. 2 Dyson Road 11. 42A Merryn Road 12. 19 Merryn Road 13. 121 Whitley Road 14. 131F,G Whitley Road 15. 133F,G Whitley Road 16. 44 Merryn Road 17. 32 Merryn Road 18. 119 Whitley Road 19. 156 Mount Pleasant Road 20. Montclair@Whitley 21. 54 Merryn Road 22. 133,133A Whitley Road 23. 25 Merryn Road 24. 151C Mount Pleasant Road 25. 42 Merryn Road 26. 131D,E Whitley Road 27. 26 Mount Pleasant Drive 28. 4D Dyson Road 29. 30 Merryn Road 30. 56 Merryn Road 31. 15 Malcolm Road 32. 119A Whitley Road	10-100 >100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	33. 63 Merryn Road 34. 61A Merryn Road 35. 40A Merryn Road 36. 46 Merryn Road 37. 56, 58 Kheam Hock Road 38. 34 Merryn Road 39. 131C,B Whitley Road 40. 39 Merryn Avenue 41. 133B,C Whitley Road 42. 14,16,16A,16B Bo Seng Avenue 43. 22 Malcolm Road 44. 20A merryn Road 45. 56A Merryn Road 46. 9 Bo Seng Avenue 47. 11 Malcolm Road 48. 17A Merryn Road 49. 133D,E Whitley Road 50. 28 Mount Pleasant Drive 51. 4,4A Dyson Road 52. 52A Merryn Road 53. 137K,L Whitley Road 54. 54 Kheam Hock Road 55. 20 Merryn Road 56. 52 Kheam Hock Road 57. 55 Merryn Road 58. 18A Merryn Road 59. 123,123A Whitley Road 60. 4E Dyson Road 61. 61 Merryn Road 62. 62 Kheam Hock Road 63. 40 Merryn Road 64. 11 Merryn Road 65. 48 Merryn Road 66. 28A Merryn Road 67. 53A Merryn Road 68. 35,37 Merryn Avenue 69. 36,38,40,42,44,46 Merryn Avenue 70. 42 Kheam Hock Road 71. 131,131A Whitley Road 72. 1,1A Dyson Road 73. 137J,H Whitley Road 74. 139,139A Whitley Road 75. 17 Merryn Road 76. 52 Merryn Road 77. 5 Sky@Eleven 78. 15 Merryn Road 79. 58 Merryn Road 80. 65 Merryn Road 81. 123B,123C Whitley Road 82. 139B,C Whitley Road 83. 135,135A Whitley Road 84. 22 Merryn Road 85. 38 Merryn Road 86. 53 Merryn Road 87. 82 Trevose Cresent 88. 18 Merryn Road 89. 28 Merryn Road 90. 76 Trevose Cresent			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	91. 11 Bo Seng Avenue 92. 47 Merryn Road 93. 137F,G Whitley Road 94. 4B,C Dyson Road 95. 135B,C Whitley Road 96. 141 Whitley Road 97. 84 Trevose Cresent 98. 74 Trevose Cresent 99. 10 Malcolm Park 100. 147 Mount Pleasant Road 101. 154 Mount Pleasant Road 102. 59A Merryn Road 103. 19 Malcolm Road 104. 57A Merryn Road 105. 135D,E Whitley Road 106. 139K,L Whitley Road 107. 1B,C Dyson Road 108. 9A Merryn Road 109. 139D,E Whitley Road 110. 57 Merryn Road 111. 50 Merryn Road 112. 135F,G Whitley Road 113. 139H,J Whitley Road 114. 86 Trevose Cresent 115. 1,3,5,7,9,11,15,17,19,21,23, 24 Merryn Terrace 116. 137D,E Whitley Road 117. 88 Trevose Cresent 118. 72C Trevose Cresent 119. 68 Trevose Crescent Trevose Park 120. 51A Merryn Road 121. 7 Merryn Road 122. 7, 7A Merryn Road 123. 18 Bo Seng Avenue 124. 31,33 Merryn Avenue 125. 12 Merryn Road 126. 45 Merryn Road 127. 12 Merryn Road 128. 135H,J Whitley Road 129. 139F,G Whitley Road 130. 28 Malcolm Road 131. 51 Merryn Road 132. 67 Merryn Road 133. 3,3A Dyson Road 134. 38 Kheam Hock Gardens 135. 38 Kheam Hock Road 136. 72B Trevose Cresent 137. 59 Merryn Road 138. 9 Merryn Road 139. 90 Trevose Cresent 140. 149 Mount Pleasant Road 141. 137B,C Whitley Road 142. 24,26,28,30,32,34 Merryn Avenue 143. 49A Merryn Road 144. 16 Merryn Road 145. 125 Whitley Road Villa Des Flores 146. 135K,L Whitley Road 147. 16 Merryn Road 148. 17 Bo Seng Avenue			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	149. 17,19 Whitley Road 150. 10, 10A, 10B Merryn Road 151. 10B Merryn Road 152. 16 Chancery Hill Road Villa Chancerita 153. 87 Kheam Hock Road 154. 21 Malcolm Road 155. 6D Dyson Road 156. 8 Malcolm Park 157. 85 Kheam Hock Road 158. 92 Trevose Cresent 159. 7A Merryn Road 160. 49 Merryn Road 161. 91 Kheam Hock Road 162. 135M, 135N Whitley Road 163. 135M,N Whitley Road 164. 137,137A Whitley Road 165. 173 Lorong 1 Toa Payoh 166. 7 Sky@Eleven Commercial: 1. Bukit Brown MRT Station 2. Mount Pleasant Animal Hospital Ecological Sensitive Receptor: Bukit Brown Woods[3]			
Between 200m to 350m	Educational Institution: 1. Saint Joseph Institution 2. CHIJ Primary School 3. CHIJ Secondary School Place of Worship: Masjid Omar Salmah Residential: 1. 83, 83A Kheam Hock Road 2. 79 Kheam Hock Road 3. 24 Malcolm Road 4. 20, 20A Bo Seng Avenue 5. 5 Merryn Road 6. 152 Mount Pleasant Road 7. 15 Whitley Road 8. 135P, 135Q Whitley Road 9. 39 Merryn Road 10. 6B,C Dyson Road 11. 12 Malcolm Park 12. 43A Merryn Road 13. 19,19A Bo Seng Avenue 14. 18 Chancery Hill Road 15. 96 Trevose Crescent 16. 128 University Road 17. 94 Trevose Crescent 18. 34,34A,34B,34C,34D,34E, 36,36A,36B,36C,36D Kew Lodge 19. 8, 8A Merryn Road 20. 43 Merryn Road 21. 2,6, 7, 8,10,12,16,18 Merryn Terrace 22. 56 Merryn Road	>100 10-100 >100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	23. 70 Trevose Crescent Trevose Park 24. 61 Trevose Crescent 25. 22 Bo Seng Avenue 26. 3 Tan Sim Boh Road 27. 135T, 135S, 135R Whitley Road 28. 54 Merryn Road 29. 98 Trevose Crescent 30. 5 Tan Sim Boh Road 31. 37 Merryn Road 32. 6 Dyson Road 33. 81 Kheam Hock Road 34. 120,122 University Road Capitol Park 35. 376 Thomson Road Cube 8 36. 6A Dyson Road 37. 1,3, 4, 7 Trevose Place 38. 118 University Road Capitol Park 39. 116 University Road Capitol Park 40. 20 Chancery Hill Road Chancery Lodge 41. 21 Bo Seng Avenue 42. 9 Chancery Hill Road 43. 12 Dyson Road Espana 44. 376 Thomson Road Cube 8 45. 44 Merryn Road 46. 41 Merryn Road 47. 7,9 Tan Sim Boh Road 48. 11 Whitley Road 49. 150 Mount Pleasant Road 50. 56A Merryn Road 51. 100 Trevose Crescent 52. 63 Trevose Crescent 53. 2,5,6,8,9,10,11,12 Trevose Place 54. 42A Merryn Road 55. 68 Trevose Cresent 56. 3 Merryn Road 57. 26, 26A, 26B Berrima Road 58. 150 Mount Pleasant Road 59. 28 Berrima Road 60. 174 Lorong 1 Toa Payoh 61. 8 Dyson Road 62. 28A Berrima Road 63. 124 University Road Capitol Park 64. 65 Trevose Crescent 65. 77 Kheam Hock Road 66. 102 Trevose Crescent 67. 1,3,5,7,9,11,15 Merryn Close 68. 18 Malcolm Park 69. 29 Malcolm Road 70. 52A Merryn Road 71. 9 Sky@Eleven 72. 31A Merryn Road 73. 64A Merryn Road 74. 30 Berrima Road 75. 42 Merryn Road 76. 8A Dyson Road 77. 5, 7, 9 Whitley Road 78. 46 Merryn Road 79. 35 Merryn Road 80. 58 Merryn Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	81. 66 Trevose Crescent Trevose Park 82. 68 Jalan Bahasa 83. 2 Tan Sim Boh Road 84. 26B Malcolm Road 85. 31 Merryn Road 86. 70 Trevose Cresent 87. 8B Dyson Road 88. 67 Trevose Crescent 89. 1 Merryn Road 90. 12H, 12J Chancery Hill Road 91. 12D, 12E Chancery Hill Road 92. 12F, 12G Chancery Hill Road 93. 4A, 4B Merryn Road 94. 32 Merryn Road 95. 40A Merryn Road 96. 52 Merryn Road 97. 24, 24A Berrima Road 98. 26A Malcolm Road 99. 64 Trevose Cresent 100. 112A,112 University Road Capitol Park 101. 4A Malcolm Road 102. 73 Kheam Hock Road 103. 15 Chancery Hill Road 104. 6 Tan Sim Boh Road 105. 2A Merryn Road 106. 114 University Road Capitol Park 107. 172A Lorong 1 Toa Payoh 108. 33 Merryn Road 109. 32 Berrima Road 110. 22A Berrima Road 111. 10 Dyson Road 112. 12K, 12L Chancery Hill Road 113. 48 Merryn Road 114. 5B, 5C Chancery Hill Road 115. 22 Berrima Road 116. 40 Merryn Road 117. 69, 71 Trevose Crescent 118. 1 Padang Chancery 119. 8, 8A Tan Sim Boh Road 120. 72B Trevose Crescent 121. 72C Trevose Crescent 122. 25 Malcolm Road 123. 115 University Road Capitol Park 124. 12S,R,Q,P Chancery Hill Road 125. 370 Thomson Road Tan Tong Meng Tower 126. 9,9A Dyson Road 127. 70 Jalan Bahasa 128. 71 Kheam Hock Road 129. 110 University Road Capitol Park 130. 74 Trevose Crescent 131. 62 Merryn Road 132. 20A Berrima Road 133. 11 Chancery Hill Road 134. 29 Merryn Road 135. 76 Trevose Crescent 136. 108,108A University Road Capitol Park 137. 73A Kheam Hock Road 138. 12M, 12N Chancery Hill Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	139. 18 Tan Sim Boh Road 140. 50 Merryn Road 141. 11 Sky@Eleven 142. 34 Merryn Road 143. 69, 71, 73, 75 Merryn Road 144. 25, 23A Berrima Road 145. 38 Merryn Road 146. 10 Tan Sim Boh Road 147. 63 Kheam Hock Road 148. 74 Andrew Road 149. 17 Harlyn Riad 150. 16 Tan Sim Boh Road 151. 30 Merryn Road 152. 66 Andrew Road 153. 9B,C Dyson Road 154. 64A Andrew Road 155. 60,66 Jalan Bahasa 156. 56, 58 Jalan Sejarah Capitol Park 157. 85, 83 Trevose Cresent 158. 76,78 Jalan Bahasa 159. 113 University Road 160. 72 Andrew Road 161. 14 Tan Sim Boh Road 162. 27 Malcolm Road 163. 10 Jalan Bahasa Capitol Park 164. 89, 87 Trevose Cresent 165. 10A Jalan Bahasa Capitol Park 166. 56 Jalan Bahasa 167. 19 Camborne Road 168. 25A Berrima Road 169. 9D Dyson Road 170. 64 Andrew Road 171. 14 Mount Rosie Road 172. 2 Padang Chancery 173. 66 Trevose Cresent 174. 7 Chancery Hill Road 175. 82 Trevose Crescent 176. 73 Trevose Crescent 177. 12 Chancery Hill Road 178. 5, 5A Chancery Hill Road 179. 25B Berrima Road 180. 3 Padang Chancery 181. 7B Chancery Hill Road 182. 69 Kheam Hock Road 183. 76 Andrew Road 184. 23 Jalan Raja Udang The Arte 185. 1, 1A Tan Sim Boh Road 186. 12 Tan Sim Boh Road 187. 27, 27A Merryn Road 188. 28A Merryn Road 189. 62 Andrew Road 190. 27, 27A, 27B Berrima Road 191. 31, 31A, 31B Trevose Crescent 192. 96 Jalan Bahasa Capitol Park 193. 77,79, 81 Trevose Crescent 194. 20 Tan Sim Boh Road 195. 34 Berrima Road 196. 531 Andrew Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	197. 15, 17 Tan Sim Boh Road 198. 52 Jalan Sejarah Capitol Park 199. 54 Jalan Sejarah Capitol Park 200. 19 Berrima Road 201. 98 Jalan Bahasa Capitol Park 202. 15 Harlyn Road 203. 75 Trevose Crescent 204. 20 Berrima Road 205. 25 Dalkeith Road 206. 77 Merryn Road 207. 84 Trevose Crescent 208. 59A,59 Kheam Hock Road 209. 14 Chancery Hill Road 210. 15, 15A Dyson Road 211. 14 Dyson Road 212. 368 Thomson Road 368 Thomson 213. 54 Jalan Bahasa 214. 28 Merryn Road 215. 61,61A Kheam Hock Road 216. 5 Malcolm Road 217. 533 Andrew Road 218. 24, 26, 28,30 Kheam Hock Road 219. 11 Dyson Road 220. 62 Trevose Crescent Trevose Park 221. 20A Merryn Road 222. 171 Lorong 1 Toa Payoh 223. 21 Berrima Road 224. 23 Merryn Road 225. 43 Trevose Cresent 226. 45,47 Trevose Cresent 227. 5 Padang Chancery 228. 51 Trevose Cresent 229. 111 University Road Capitol Park 230. 17, 19, 21 Dyson Road 231. 170 Lorong 1 Toa Payoh 232. 41 Trevose Cresent 233. 8,10 Padang Chancery 234. 23 Berrima Road 235. 86 Trevose Crescent 236. 23 Dalkeith Road 237. 53 Trevose Cresent 238. 65 Kheam Hock Road 239. 34A Berrima Road 240. 39 Trevose Cresent 241. 18A Berrima Road 242. 535 Andrew Road 243. 17A, 17B Camborne Road 244. 35 Tan Sim Boh Road 245. 55 Trevose Cresent 246. 48, 50 Jalan Sejarah Capitol Park 247. 21 Jalan Raja Udang The Arte 248. 37 Trevose Cresent 249. 17, 17A, 17B Berrima Road 250. 20 Merryn Road 251. 3D Chancery Hill Road 252. 10 Chancery Hill Road 253. 19 Tan Sim Boh Road 254. 40 Berrima Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	255. 65,67,69 Dyson Road 256. 36 Berrima Road 257. 38 Berrima Road 258. 57,59 Trevose Cresent 259. 35 Trevose Cresent 260. 35,33 Jalan Adat Capitol Park 261. 62 Trevose Cresent 262. 88 Trevose Crescent 263. 32,30,28 Jalan Ilmu Capitol Park 264. 33 Tan Sim Boh Road 265. 20 Harlyn Road 266. 67 Kheam Hock Road 267. 57,55 Kheam Hock Road 268. 11A Jalan Ilmu Capitol Park 269. 15 Jalan Ilmu Capitol Park 270. 21,21A Tan Sim Boh Road 271. 22 Merryn Road 272. 80 Andrew Road 273. 28 Jalan Bahasa 274. 25 Merryn Road 275. 18 Berrima Road 276. 18 Harlyn Road 277. 29 Tan Sim Boh Road 278. 51 Jalan Bahasa 279. 18A Merryn Road 280. 3C Chancery Hill Road 281. 33 Trevose Cresent 282. 7,9 Padang Chancery 283. 68 Andrew Road Commercial: 1. The National Equestrian Park 2. 373 Thomson Road Thomson Exchange 3. RDA Centre 4. 236 Whitley Road Caltex Whitley 5. 171A Lorong 1 Toa Payoh Government: Ministry of Social and Family Development Building Recreation: Kheam Hock Park Ecological Sensitive Receptor: Bukit Brown Woods[3]			
For Construction				
Within 20m	Residential: 27 Jalan Mendaki Ecological Sensitive Receptor: Bukit Brown Woods[3]	<10	Priority 1	Priority 1
Between 20m to 50m	Educational Institution: Saint Joseph Institute International Residential: 1. 157 Mount Pleasant Road	>100 <10		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	2. 4 Gymkhana Avenue 3. 18 Mount Pleasant Drive 4. 160 Mount Pleasant Road 5. 8 Gymkhana Avenue 6. 6 Gymkhana Avenue Ecological Sensitive Receptor: Bukit Brown Woods[3]			
Between 50m to 100m	Educational Institution: 1. EtonHouse Pre-School (Thomson) 2. Catholic Junior College Nursing Home: Lee Ah Mooi Old Age Home Residential: 1. 23 Mount Pleasant Drive 2. 153 Mount Pleasant Road 3. 47 Merryn Road 4. 45 Merryn Road 5. 39 Merryn Road 6. 53,53A Merryn Road 7. 37 Merryn Road 8. 55 Merryn Road 9. 31,31A Merry Road 10. 115 Whitley Road 11. 20 Malcolm Road 12. 27 Mount Pleasant Drive 13. 61,61A Merryn Road 14. 121D,121E Whitley Road 15. 121F,121G Whitey Road 16. 158 Mount Pleasant Road 17. 3 Gymkhana Avenue 18. 115A,B,C,D,E Whitley Road 19. 115K,J,H,G,F Whitley Road 20. 49,49A Merryn Road 21. 111B,113,113A,B Whitley Road 22. 41 Merryn Road 23. 43A Merryn Road 24. 51,51A Merryn Road 25. 29 Merryn Road 26. 57 Merryn Road 27. 101,103 Whitley Road 28. 35 Merryn Road 29. 57A Merryn Road 30. 1 Bo Seng Avenue 31. 117 Whitley Road 32. 33 Merryn Road 33. 59,59A Merryn Road 34. 121H,121J Whitley Road 35. 151 Mount Pleasant Road 36. 7 Gymkhana Avenue 37. 111A Whitley Road 38. 22 Mount Pleasant Drive 39. 97 Whitley Road 40. 95 Whitley Road	>100 10-100 10-100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	Commercial: 1. Senior Police Officer's Mess 2. Offside Futsal Park 3. Singapore Polo Club 4. James Tan Veterinary Centre Ecological Sensitive Receptor: Bukit Brown Woods[3]			
Between 100m to 200m	Educational Institution: 60 Kheam Hock Road Residential: 1. 155 Mount Pleasant Road 2. 131H,J Whitley Road 3. 23 Merryn Road 4. 3,5 Bo Seng Avenue 5. 10,12 Bo Seng Avenue 6. 121C,121A Whitley Road 7. 21 Merryn Road 8. 30 Malcolm Road 9. 27, 27A Merryn Road 10. 2 Dyson Road 11. 42A Merryn Road 12. 19 Merryn Road 13. 121 Whitley Road 14. 131F,G Whitley Road 15. 133F,G Whitley Road 16. 44 Merryn Road 17. 32 Merryn Road 18. 119 Whitley Road 19. 156 Mount Pleasant Road 20. Montclair@Whitley 21. 54 Merryn Road 22. 133,133A Whitley Road 23. 25 Merryn Road 24. 151C Mount Pleasant Road 25. 42 Merryn Road 26. 131D,E Whitley Road 27. 26 Mount Pleasant Drive 28. 4D Dyson Road 29. 30 Merryn Road 30. 56 Merryn Road 31. 15 Malcolm Road 32. 119A Whitley Road 33. 63 Merryn Road 34. 61A Merryn Road 35. 40A Merryn Road 36. 46 Merryn Road 37. 56, 58 Kheam Hock Road 38. 34 Merryn Road 39. 131C,B Whitley Road 40. 39 Merryn Avenue 41. 133B,C Whitley Road 42. 14,16,16A,16B Bo Seng Avenue 43. 22 Malcolm Road 44. 20A merryn Road 45. 56A Merryn Road	10-100 >100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	46. 9 Bo Seng Avenue 47. 11 Malcolm Road 48. 17A Merryn Road 49. 133D,E Whitley Road 50. 28 Mount Pleasant Drive 51. 4,4A Dyson Road 52. 52A Merryn Road 53. 137K,L Whitley Road 54. 54 Kheam Hock Road 55. 20 Merryn Road 56. 52 Kheam Hock Road 57. 55 Merryn Road 58. 18A Merryn Road 59. 123,123A Whitley Road 60. 4E Dyson Road 61. 61 Merryn Road 62. 62 Kheam Hock Road 63. 40 Merryn Road 64. 11 Merryn Road 65. 48 Merryn Road 66. 28A Merryn Road 67. 53A Merryn Road 68. 35,37 Merryn Avenue 69. 36,38,40,42,44,46 Merryn Avenue 70. 42 Kheam Hock Road 71. 131,131A Whitley Road 72. 1,1A Dyson Road 73. 137J,H Whitley Road 74. 139,139A Whitley Road 75. 17 Merryn Road 76. 52 Merryn Road 77. 5 Sky@Eleven 78. 15 Merryn Road 79. 58 Merryn Road 80. 65 Merryn Road 81. 123B,123C Whitley Road 82. 139B,C Whitley Road 83. 135,135A Whitley Road 84. 22 Merryn Road 85. 38 Merryn Road 86. 53 Merryn Road 87. 82 Trevose Cresent 88. 18 Merryn Road 89. 28 Merryn Road 90. 76 Trevose Cresent 91. 11 Bo Seng Avenue 92. 47 Merryn Road 93. 137F,G Whitley Road 94. 4B,C Dyson Road 95. 135B,C Whitley Road 96. 141 Whitley Road 97. 84 Trevose Cresent 98. 74 Trevose Cresent 99. 10 Malcolm Park 100. 147 Mount Pleasant Road 101. 154 Mount Pleasant Road 102. 59A Merryn Road 103. 19 Malcolm Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	104. 57A Merryn Road 105. 135D,E Whitley Road 106. 139K,L Whitley Road 107. 1B,C Dyson Road 108. 9A Merryn Road 109. 139D,E Whitley Road 110. 57 Merryn Road 111. 50 Merryn Road 112. 135F,G Whitley Road 113. 139H,J Whitley Road 114. 86 Trevose Cresent 115. 1,3,5,7,9,11,15,17,19,21,23, 24 Merryn Terrace 116. 137D,E Whitley Road 117. 88 Trevose Cresent 118. 72C Trevose Cresent 119. 68 Trevose Crescent Trevose Park 120. 51A Merryn Road 121. 7 Merryn Road 122. 7, 7A Merryn Road 123. 18 Bo Seng Avenue 124. 31,33 Merryn Avenue 125. 12 Merryn Road 126. 45 Merryn Road 127. 12 Merryn Road 128. 135H,J Whitley Road 129. 139F,G Whitley Road 130. 28 Malcolm Road 131. 51 Merryn Road 132. 67 Merryn Road 133. 3,3A Dyson Road 134. 38 Kheam Hock Gardens 135. 38 Kheam Hock Road 136. 72B Trevose Cresent 137. 59 Merryn Road 138. 9 Merryn Road 139. 90 Trevose Cresent 140. 149 Mount Pleasant Road 141. 137B,C Whitley Road 142. 24,26,28,30,32,34 Merryn Avenue 143. 49A Merryn Road 144. 16 Merryn Road 145. 125 Whitley Road Villa Des Flores 146. 135K,L Whitley Road 147. 16 Merryn Road 148. 17 Bo Seng Avenue 149. 17,19 Whitley Road 150. 10, 10A, 10B Merryn Road 151. 10B Merryn Road 152. 16 Chancery Hill Road Villa Chancerita 153. 87 Kheam Hock Road 154. 21 Malcolm Road 155. 6D Dyson Road 156. 8 Malcolm Park 157. 85 Kheam Hock Road 158. 92 Trevose Cresent 159. 7A Merryn Road 160. 49 Merryn Road 161. 91 Kheam Hock Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	162. 135M, 135N Whitley Road 163. 135M,N Whitley Road 164. 137,137A Whitley Road 165. 173 Lorong 1 Toa Payoh 166. 7 Sky@Eleven Commercial: 1. Bukit Brown MRT Station 2. Mount Pleasant Animal Hospital Ecological Sensitive Receptor: Bukit Brown Woods[3]			
Between 200m to 350m	Educational Institution: 1. Saint Joseph Institution 2. CHIJ Primary School 3. CHIJ Secondary School Place of Worship: Masjid Omar Salmah Residential: 1. 83, 83A Kheam Hock Road 2. 79 Kheam Hock Road 3. 24 Malcolm Road 4. 20, 20A Bo Seng Avenue 5. 5 Merryn Road 6. 152 Mount Pleasant Road 7. 15 Whitley Road 8. 135P, 135Q Whitley Road 9. 39 Merryn Road 10. 6B,C Dyson Road 11. 12 Malcolm Park 12. 43A Merryn Road 13. 19,19A Bo Seng Avenue 14. 18 Chancery Hill Road 15. 96 Trevose Crescent 16. 128 University Road 17. 94 Trevose Crescent 18. 34,34A,34B,34C,34D,34E, 36,36A,36B,36C,36D Kew Lodge 19. 8, 8A Merryn Road 20. 43 Merryn Road 21. 2,6, 7, 8,10,12,16,18 Merryn Terrace 22. 56 Merryn Road 23. 70 Trevose Crescent Trevose Park 24. 61 Trevose Crescent 25. 22 Bo Seng Avenue 26. 3 Tan Sim Boh Road 27. 135T, 135S, 135R Whitley Road 28. 54 Merryn Road 29. 98 Trevose Crescent 30. 5 Tan Sim Boh Road 31. 37 Merryn Road 32. 6 Dyson Road 33. 81 Kheam Hock Road 34. 120,122 University Road Capitol Park 35. 376 Thomson Road Cube 8	>100 10-100 >100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	36. 6A Dyson Road 37. 1,3, 4, 7 Trevose Place 38. 118 University Road Capitol Park 39. 116 University Road Capitol Park 40. 20 Chancery Hill Road Chancery Lodge 41. 21 Bo Seng Avenue 42. 9 Chancery Hill Road 43. 12 Dyson Road Espana 44. 376 Thomson Road Cube 8 45. 44 Merryn Road 46. 41 Merryn Road 47. 7,9 Tan Sim Boh Road 48. 11 Whitley Road 49. 150 Mount Pleasant Road 50. 56A Merryn Road 51. 100 Trevose Crescent 52. 63 Trevose Crescent 53. 2,5,6,8,9,10,11,12 Trevose Place 54. 42A Merryn Road 55. 68 Trevose Cresent 56. 3 Merryn Road 57. 26, 26A, 26B Berrima Road 58. 150 Mount Pleasant Road 59. 28 Berrima Road 60. 174 Lorong 1 Toa Payoh 61. 8 Dyson Road 62. 28A Berrima Road 63. 124 University Road Capitol Park 64. 65 Trevose Crescent 65. 77 Kheam Hock Road 66. 102 Trevose Crescent 67. 1,3,5,7,9,11,15 Merryn Close 68. 18 Malcolm Park 69. 29 Malcolm Road 70. 52A Merryn Road 71. 9 Sky@Eleven 72. 31A Merryn Road 73. 64A Merryn Road 74. 30 Berrima Road 75. 42 Merryn Road 76. 8A Dyson Road 77. 5, 7, 9 Whitley Road 78. 46 Merryn Road 79. 35 Merryn Road 80. 58 Merryn Road 81. 66 Trevose Crescent Trevose Park 82. 68 Jalan Bahasa 83. 2 Tan Sim Boh Road 84. 26B Malcolm Road 85. 31 Merryn Road 86. 70 Trevose Cresent 87. 8B Dyson Road 88. 67 Trevose Crescent 89. 1 Merryn Road 90. 12H, 12J Chancery Hill Road 91. 12D, 12E Chancery Hill Road 92. 12F, 12G Chancery Hill Road 93. 4A, 4B Merryn Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	94. 32 Merryn Road 95. 40A Merryn Road 96. 52 Merryn Road 97. 24, 24A Berrima Road 98. 26A Malcolm Road 99. 64 Trevose Cresent 100. 112A,112 University Road Capitol Park 101. 4A Malcolm Road 102. 73 Kheam Hock Road 103. 15 Chancery Hill Road 104. 6 Tan Sim Boh Road 105. 2A Merryn Road 106. 114 University Road Capitol Park 107. 172A Lorong 1 Toa Payoh 108. 33 Merryn Road 109. 32 Berrima Road 110. 22A Berrima Road 111. 10 Dyson Road 112. 12K, 12L Chancery Hill Road 113. 48 Merryn Road 114. 5B, 5C Chancery Hill Road 115. 22 Berrima Road 116. 40 Merryn Road 117. 69, 71 Trevose Crescent 118. 1 Padang Chancery 119. 8, 8A Tan Sim Boh Road 120. 72B Trevose Crescent 121. 72C Trevose Crescent 122. 25 Malcolm Road 123. 115 University Road Capitol Park 124. 12S,R,Q,P Chancery Hill Road 125. 370 Thomson Road Tan Tong Meng Tower 126. 9,9A Dyson Road 127. 70 Jalan Bahasa 128. 71 Kheam Hock Road 129. 110 University Road Capitol Park 130. 74 Trevose Crescent 131. 62 Merryn Road 132. 20A Berrima Road 133. 11 Chancery Hill Road 134. 29 Merryn Road 135. 76 Trevose Crescent 136. 108,108A University Road Capitol Park 137. 73A Kheam Hock Road 138. 12M, 12N Chancery Hill Road 139. 18 Tan Sim Boh Road 140. 50 Merryn Road 141. 11 Sky@Eleven 142. 34 Merryn Road 143. 69, 71, 73, 75 Merryn Road 144. 25, 23A Berrima Road 145. 38 Merryn Road 146. 10 Tan Sim Boh Road 147. 63 Kheam Hock Road 148. 74 Andrew Road 149. 17 Harlyn Riad 150. 16 Tan Sim Boh Road 151. 30 Merryn Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	152. 66 Andrew Road 153. 9B,C Dyson Road 154. 64A Andrew Road 155. 60,66 Jalan Bahasa 156. 56, 58 Jalan Sejarah Capitol Park 157. 85, 83 Trevose Cresent 158. 76,78 Jalan Bahasa 159. 113 University Road 160. 72 Andrew Road 161. 14 Tan Sim Boh Road 162. 27 Malcolm Road 163. 10 Jalan Bahasa Capitol Park 164. 89, 87 Trevose Cresent 165. 10A Jalan Bahasa Capitol Park 166. 56 Jalan Bahasa 167. 19 Camborne Road 168. 25A Berrima Road 169. 9D Dyson Road 170. 64 Andrew Road 171. 14 Mount Rosie Road 172. 2 Padang Chancery 173. 66 Trevose Cresent 174. 7 Chancery Hill Road 175. 82 Trevose Crescent 176. 73 Trevose Crescent 177. 12 Chancery Hill Road 178. 5, 5A Chancery Hill Road 179. 25B Berrima Road 180. 3 Padang Chancery 181. 7B Chancery Hill Road 182. 69 Kheam Hock Road 183. 76 Andrew Road 184. 23 Jalan Raja Udang The Arte 185. 1, 1A Tan Sim Boh Road 186. 12 Tan Sim Boh Road 187. 27, 27A Merryn Road 188. 28A Merryn Road 189. 62 Andrew Road 190. 27, 27A, 27B Berrima Road 191. 31, 31A, 31B Trevose Crescent 192. 96 Jalan Bahasa Capitol Park 193. 77,79, 81 Trevose Crescent 194. 20 Tan Sim Boh Road 195. 34 Berrima Road 196. 531 Andrew Road 197. 15, 17 Tan Sim Boh Road 198. 52 Jalan Sejarah Capitol Park 199. 54 Jalan Sejarah Capitol Park 200. 19 Berrima Road 201. 98 Jalan Bahasa Capitol Park 202. 15 Harlyn Road 203. 75 Trevose Crescent 204. 20 Berrima Road 205. 25 Dalkeith Road 206. 77 Merryn Road 207. 84 Trevose Crescent 208. 59A,59 Kheam Hock Road 209. 14 Chancery Hill Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	210. 15, 15A Dyson Road 211. 14 Dyson Road 212. 368 Thomson Road 368 Thomson 213. 54 Jalan Bahasa 214. 28 Merryn Road 215. 61,61A Kheam Hock Road 216. 5 Malcolm Road 217. 533 Andrew Road 218. 24, 26, 28,30 Kheam Hock Road 219. 11 Dyson Road 220. 62 Trevose Crescent Trevose Park 221. 20A Merryn Road 222. 171 Lorong 1 Toa Payoh 223. 21 Berrima Road 224. 23 Merryn Road 225. 43 Trevose Cresent 226. 45,47 Trevose Cresent 227. 5 Padang Chancery 228. 51 Trevose Cresent 229. 111 University Road Capitol Park 230. 17, 19, 21 Dyson Road 231. 170 Lorong 1 Toa Payoh 232. 41 Trevose Cresent 233. 8,10 Padang Chancery 234. 23 Berrima Road 235. 86 Trevose Crescent 236. 23 Dalkeith Road 237. 53 Trevose Cresent 238. 65 Kheam Hock Road 239. 34A Berrima Road 240. 39 Trevose Cresent 241. 18A Berrima Road 242. 535 Andrew Road 243. 17A, 17B Camborne Road 244. 35 Tan Sim Boh Road 245. 55 Trevose Cresent 246. 48, 50 Jalan Sejarah Capitol Park 247. 21 Jalan Raja Udang The Arte 248. 37 Trevose Cresent 249. 17, 17A, 17B Berrima Road 250. 20 Merryn Road 251. 3D Chancery Hill Road 252. 10 Chancery Hill Road 253. 19 Tan Sim Boh Road 254. 40 Berrima Road 255. 65,67,69 Dyson Road 256. 36 Berrima Road 257. 38 Berrima Road 258. 57,59 Trevose Cresent 259. 35 Trevose Cresent 260. 35,33 Jalan Adat Capitol Park 261. 62 Trevose Cresent 262. 88 Trevose Crescent 263. 32,30,28 Jalan Ilmu Capitol Park 264. 33 Tan Sim Boh Road 265. 20 Harlyn Road 266. 67 Kheam Hock Road 267. 57,55 Kheam Hock Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	268. 11A Jalan Ilmu Capitol Park 269. 15 Jalan Ilmu Capitol Park 270. 21,21A Tan Sim Boh Road 271. 22 Merryn Road 272. 80 Andrew Road 273. 28 Jalan Bahasa 274. 25 Merryn Road 275. 18 Berrima Road 276. 18 Harlyn Road 277. 29 Tan Sim Boh Road 278. 51 Jalan Bahasa 279. 18A Merryn Road 280. 3C Chancery Hill Road 281. 33 Trevose Cresent 282. 7,9 Padang Chancery 283. 68 Andrew Road Commercial: 1. The National Equestrian Park 2. 373 Thomson Road Thomson Exchange 3. RDA Centre 4. 236 Whitley Road Caltex Whitley 5. 171A Lorong 1 Toa Payoh Government: Ministry of Social and Family Development Building Recreation: Kheam Hock Park Ecological Sensitive Receptor: Bukit Brown Woods[3]			
<u>For Demolition</u>				
Within 20m	Ecological Sensitive Receptor: Bukit Brown Woods[3]		Priority 2	Priority 1
Between 20m to 50m	Residential: 1. 182 Mount Pleasant Road Commercial: Singapore Polo Club Ecological Sensitive Receptor: Bukit Brown Woods[3]	<10		
Between 50m to 100m	Residential: 1. 182 Mount Pleasant Road 2. 180 Mount Pleasant Road 3. 11 Mount Pleasant Drive 4. 23 Mount Pleasant Drive 5. 18 Mount Pleasant Drive 6. 168 Mount Pleasant Road 7. 151 Mount Pleasant Road 8. 2 Whitley Road Offside Futsal Park 1. Commercial: Singapore Polo Club	10-100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	Ecological Sensitive Receptor: Bukit Brown Woods[3]			
Between 100m to 200m	Nursing Home: Lee Ah Mooi Old Age Home	10-100		
	Educational Institution: 1. EtonHouse Pre-School (Thomson) 2. Catholic Junior College 3. Saint Joseph Institute International	>100		
	Residential: 1. 27 Mount Pleasant Drive 2. 11 Mount Pleasant Drive 3. 23 Mount Pleasant Drive 4. 18 Mount Pleasant Drive 5. 22 Mount Pleasant Drive 6. 26 Mount Pleasant Drive 7. 3 Gymkhana Avenue 8. 4 Gymkhana Avenue 9. 6 Gymkhana Avenue 10. 7 Gymkhana Avenue 11. 168 Mount Pleasant Road 12. 166 Mount Pleasant Road 13. 157 Mount Pleasant Road 14. 157A,B,C Mount Pleasant Road 15. 159 Mount Pleasant Road 16. 155 Mount Pleasant Road 17. 151 Mount Pleasant Road 18. 147 Mount Pleasant Road 19. 149 Mount Pleasant Road 20. 150 Mount Pleasant Road 21. 152 Mount Pleasant Road 22. 2 Whitley Road Offside Futsal Park 23. 2 Dyson Road 24. 4D,E Dyson Road 25. 95, 97 Whitley Road Whitleyville 26. 1,3,5 Bo Seng Avenue Whitleyville 27. 9 Bo Seng Avenue 28. 101, 103 Whitley Road 29. 10,12 Whitley Road 30. 14,16 Bo Seng Avenue 31. 133, 133A Whitley Road 32. 133B,C,D,E Whitley Road 33. 133F,G Whitley Road 34. 131A,B,C,D,E,F,G,H,J Whitley Road The Whitley Residences 35. 111, 111A,B Whitley Road 36. 113, 113A,B Whitley Road 37. 115, 115A,B,C,D,E,F,G,J,K Whitley Road Whitley Villas 38. 119, 199A Whitley Road 39. 139, 139A,,C Whitley Road The Whitley Residences 40. 117 Whitley Road 41. 121,121A,C,D,E,F,G,H,J Whitley Road	10-100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	42. 121B Whitley Road Montclair @Whitley 43. 141 Whitley Road The Whitley Residences 44. 139, 139A,B Whitley Road The Whitley Residences 45. 137H,J,K,L Whitley Road The Whitley Residences 46. 123, 123A,B,C Whitley Road 47. 11, 15 Malcolm Road 48. 36,38,40,42,44 Merryn Avenue Sanny Park 49. 31, 33 Merryn Avenue 50. 35,37 Merryn Avenue 51. 39 Merryn Avenue 52. 67 Merryn Road 53. 65 Merryn Road 54. 63 Merryn Road 55. 61, 61A Merryn Road 56. 59, 59A Merryn Road 57. 57, 57A Merryn Road 58. 55 Merryn Road 59. 53, 53A Merryn Road 60. 51, 51A Merryn Road 61. 49, 49A Merryn Road 62. 47 Merryn Road 63. 45 Merryn Road 64. 39 Merryn Road 65. 43, 43A Merryn Road 66. 39 Merryn Road 67. 56 Merryn Road 68. 54 Merryn Road 69. 44 Merryn Road 70. 27 Jalan Mendaki Commercial: 1. Singapore Polo Club 2. James Tan Veterinary Centre 3. Mount Pleasant Animal Hospital Government: Ministry of Social and Family Development Building Ecological Sensitive Receptor: Bukit Brown Woods[3]			
Between 200m to 350m	Nursing Home: Lee Ah Mooi Old Age Home Educational Institution: 1. Saint Joseph Institute International 2. EtonHouse Pre-School (Thomson) 3. Catholic Junior College 4. Saint Joseph's Institution Residential: 1. 27 Mount Pleasant Drive 2. 28 Mount Pleasant Drive 3. 7 Gymkhana Avenue 4. 6 Gymkhana Avenue 5. 8 Gymkhana Avenue	10-100 >100 10-100 >100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	6. 164 Mount Pleasant Road 7. 162 Mount Pleasant Road 8. 160 Mount Pleasant Road 9. 158 Mount Pleasant Road 10. 156 Mount Pleasant Road 11. 154 Mount Pleasant Road 12. 161 Mount Pleasant Road 13. 159 Mount Pleasant Road 14. 157, 157C Mount Pleasant Road 15. 5 Thomson Lane Sky@Eleven 16. 7 Thomson Lane Sky@Eleven 17. 9 Thomson Lane Sky@Eleven 18. 11 Thomson Lane Sky@Eleven 19. 376 Thomson Road Cube 8 20. 370 Thomson Road Tan Tong Meng Tower 21. 368 Thomson Road 22. 373 Thomson Road 23. 15,17 Tan Sim Boh Road 24. 5,7,9 Whitley Road 25. 11 Whitley Road 26. 7,9 Tan Sim Boh Road 27. 5 Tan Sim Boh Road 28. 3 Tan Sim Boh Road 29. 1, 1A Tan Sim Boh Road 30. 15 Whitley Road 31. 17, 19 Whitley Road 32. 1, 1A,B,C Dyson Road 33. 12 Tan Sim Boh Road 34. 14 Tan Sim Boh Road 35. 16 Tan Sim Boh Road 36. 18 Tan Sim Boh Road 37. 10 Tan Sim Boh Road 38. 8, 8A Tan Sim Boh Road 39. 6 Tan Sim Boh Road 40. 2 Tan Sim Boh Road 41. 20 Tan Sim Boh Road 42. 9, 9A,B,C,D Dyson Road 43. 4, 4A,B,C Dyson Road 44. 4E Dyson Road 45. 9 Bo Seng Avenue 46. 11 Bo Seng Avenue 47. 17 Bo Seng Avenue 48. 19, 19A Bo Seng Avenue 49. 21 Bo Seng Avenue 50. 6,6A Dyson Road 51. 6B,C Dyson Road 52. 6D Dyson Road 53. 8, 8A,B Dyson Road 54. 10 Dyson Road 55. 12 Dyson Road Espana 56. 21 Bo Seng Avenue 57. 12 Chancery Hill Road 58. 14 Dyson Road 59. 14 Chancery Hill Road Chancery Hill Villas 60. 12H,J Chancery Hill Road Chancery Hill Villas 61. 12K,L Chancery Hill Road Chancery Hill Villas 62. 12 M,N Chancery Hill Road Chancery Hill Villas 63. 12F,G Chancery Hill Road Chancery Hill Villas			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	64. 12E,D Chancery Hill Road Chancery Hill Villas 65. 12R,S Chancery Hill Road Chancery Hill Villas 66. 12Q,P Chancery Hill Road Chancery Hill Villas 67. 12E,D Chancery Hill Road Chancery Hill Villas 68. 16A,B Bo Seng Avenue 69. 18 Bo Seng Avenue 70. 20,20A Bo Seng Avenue 71. 22 Bo Seng Avenue 72. 16 Chancery Hill Road Villa Chancerita 73. 135, 135A,B,C,D,E,F,G,H,J,K,L,M,N,P,Q,R,S,T Whitley Road The Whitley Residences 74. 133F,G Whitley Road The Whitley Residences 75. 131, 141 Whitley Road The Whitley Residences 76. 139A,B,C,D,E,F,G,H,J,K,L Whitley Road The Whitley Residences 77. 123, 123A,B,C Whitley Road 78. 137, 137A,B,C,D,E,F,G,H,J 79. 125 Whitley Road Villa Des Flores 80. 18 Chancery Hill Road 81. 20 Chancery Hill Road Chancery Lodge 82. 11,15 Chancery Hill Road 83. 7, 7B Chancery Hill Road 84. 2 Padang Chancery 85. 1,3 Padang Chancery 86. 5A,B,C Chncery Hill Road 87. 4A Malcolm Road 88. 11,15 Malcolm Road 89. 19, 21 Malcolm Road 90. 22 Malcolm Road 91. 20 Malcolm Road 92. 30 Malcolm Road 93. 75,77 Merryn Road 94. 69,71 Merryn Road 95. 1,3,5,7,9,11,15 Merryn Close 96. 2,4,6,8,10,12,14,16,18 Merryn Terrace 97. 1,3,5,7,9,11,15,17,19,21,23 Merryn Terrace 98. 24,26,28,30,32,34,36 Merryn Avenue 99. 31 Merryn Avenue 100. 66,68,70 Trevose Cresent Trevose Park 101. 62 Merryn Road 102. 64, 64A Merryn Road 103. 66 Merryn Road 104. 56, 56A Merryn Road 105. 58 Merryn Road 106. 50 Merryn Road 107. 52, 52A Merryn Road 108. 54 Merryn Road 109. 72B,C Trevose Crescent 110. 74, 76 Trevose Crescent 111. 44,46,48 Merryn Road 112. 38,40,40A, 42,42A Merryn Road 113. 32, 34 Merryn Road 114. 82, 84 Trevose Crescent 115. 34,32 Merryn Road 116. 86, 88 Trevose Crescent 117. 28, 28A Merryn Road 118. 30 Merryn Road 119. 20, 20A Merryn Road			

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	120. 22 Merryn Road 121. 18, 18A Merryn Road 122. 90, 92 Trevose Crescent 123. 33,35,37,39 Trevose Crescent 124. 20A Berrima Road 125. 22, 22A Berrima Road 126. 41, 43 Trevose Crescent 127. 24, 24A Berrima Road 128. 45, 47 Trevose Crescent 129. 26, 26A,B Berrima Road 130. 49,51 Trevose Crescent 131. 53, 55 Trevose Crescent 132. 28, 28A Berrima Road 133. 57,59 Trevose Crescent 134. 61 Trevose Crescent 135. 43 Merryn Road 136. 39 Merryn Road 137. 41 Merryn Road 138. 37 Merryn Road 139. 31, 31A Merryn Road 140. 33, 33A Merryn Road 141. 27, 27A Merryn Road 142. 25 Merryn Road 143. 29 Merryn Road 144. 23 Merryn Road z Commercial: 1. Singapore Polo Club 2. 5 RDA Centre 3. 236 Whitley Road Caltex Whitley 4. Mount Pleasant Animal Hospital Government: Ministry of Social and Family Development Building Ecological Sensitive Receptor: Bukit Brown Woods[3]			
<u>For Trackout</u>				
Within 20m	Residential: 1. 184 Mount Pleasant Road 2. 7 Gymkhana Avenue 3. 4 Gymkhana Avenue 4. 166 Mount Pleasant Road 5. 164 Mount Pleasant Road 6. 162 Mount Pleasant Road 7. 160 Mount Pleasant Road 8. 158 Mount Pleasant Road 9. 156 Mount Pleasant Road 10. 154 Mount Pleasant Road 11. 152 Mount Pleasant Road 12. 150 Mount Pleasant Road 13. 149 Mount Pleasant Road 14. 147 Mount Pleasant Road 15. 157 Mount Pleasant Road 16. 161 Mount Pleasant Road	10-100	Priority 1	Priority 1

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	Commercial: 1. Bukit Brown MRT Station 2. 236 Whitely Road Caltex Whitley Ecological Sensitive Receptor: Bukit Brown Woods[3]			
Between 20m to 50m	Educational Institution: EtonHouse Pre-School (Thomson) Nursing Home: Lee Ah Mooi Old Age Home Residential: 1. 27 Jalan Mendaki 2. 6 Gymkhana Avenue 3. 4 Gymkhana Avenue 4. 7 Gymkhana Avenue 5. 3 Gymkhana Avenue 6. 8 Gymkhana Avenue 7. 168 Mount Pleasant Road 8. 155 Mount Pleasant Road 9. 147 Mount Pleasant Road 10. 149 Mount Pleasant Road 11. 157 Mount Pleasant Road 12. 160 Mount Pleasant Road 13. 158 Mount Pleasant Road 14. 156 Mount Pleasant Road 15. 154 Mount Pleasant Road 16. 152 Mount Pleasant Road 17. 150 Mount Pleasant Road 18. 80 Andrew Road 19. 535 Andrew Road 20. 533 Andrew Road 21. 531 Andrew Road 22. 21,21A Tan Sim Boh Road 23. 368 Thomson Road 368 Thomson 24. 370 Thomson Road Tan Tong Meng Tower 25. 376 Thomson Road Cube 8 26. 173 Lorong 1 Toa Payoh 27. 37 Merryn Road 28. 39 Merryn Road 29. 45 Merryn Road 30. 47 Merryn Road 31. 53 Merryn Road 32. 39 Merryn Avenue 33. 38,40,42,44,46 Merryn Avenue 34. 15,17,21,23 Merryn Terrace 35. 8,10,12,16,18 Merryn Terrace 36. 5,7,9,11,15 Merryn Close 37. 69,71,73,75,77 Merryn Road 38. 1,3,5,7,9,11,15,17 Merryn Drive 39. The Trevose Commercial: 1. Bukit Brown Mrt Station 2. Singapore Polo Club 3. 236 Whitley Road Caltex	10-100 10-100 >100		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	4. Tanglin Community Club 5. James Tan Veterinary Centre 6. 373 Thomson Road Thomson Exchange Ecological Sensitive Receptor: Bukit Brown Woods[3]			
Between 50m to 100m	Medical Institution: 339 Thomson Road Thomson Medical Centre Educational Institution: 1. Catholic Junior College 2. Saint Joseph's Institution 3. EtonHouse Pre-School (Thomson) 4. Saint Joseph's Institution International Nursing Home: Lee Ah Mooi Old Age Home Residential: 1. 27 Jalan Mendaki 2. 180 Mount Pleasant Road 3. 61A Merryn Road 4. 55 Merryn Road 5. 53, 53A Merryn Road 6. 47 Merryn Road 7. 45 Merryn Road 8. 39 Merryn Road 9. 37 Merryn Road 10. 31, 31A Merryn Road 11. 56,58 Merryn Road 12. 128 University Road 13. 56,58 Jalan Sejarah 14. 18 Mount Pleasant Drive 15. 3 Gymkhana Avenue 16. 8 Gymkhana Avenue 17. 161 Mount Pleasant Road 18. 159 Mount Pleasant Road 19. 157B,C Mount Pleasant Road 20. 157 Mount Pleasant Road 21. 155 Mount Pleasant Road 22. 151 Mount Pleasant Road 23. 76 Andrew Road 24. 17 Joan Road 25. 551 Thomson Road 26. 553 Thomson Road 27. 174 Lorong 1 Toa Payoh 28. 172, 172A Lorong 1 Toa Payoh 29. 700 Lorong 1 Toa Payoh 30. 376 Thomson Road Cube 8 31. 370 Thomson Road 32. 368 Thomson Road 33. 2,4 Jalan Raja Udang 34. 592 Balestier Road Value Hotel 35. 633,635,637,639 Balestier Road 36. 23, 23A Tan Sim Boh Road 37. 21, 21A Tan Sim Boh Road 38. 19 Tan Sim Boh Road	>100 >100 10-100 >10 0		

Distance[1]	Land Use	Number of Receivers[2]	Sensitivity of the Area	
			Human Health Impact	Ecological Impact
	39. 16,17 Tan Sim Boh Road 40. 373 Thomson Road 41. 5 Whitley Road 42. 7,9 Whitley Road 43. 11 Whitley Road 44. 184 Mount Pleasant Road 45. 2 Dyson Road 46. 95, 97 Whitley Road 47. 1,3,5 Bo Seng Avenue 48. 101,103 Whitley Road 49. 111, 111A,B Whitley Road 50. 113, 113A,B Whitley Road 51. 115, 115A,B,C,D,E,F,G,H,J,K Whitley Road 52. 117 Whitley Road 53. 121D,E Whitley Road 54. 121F,G Whitley Road 55. 121A,C Whitley Road 56. 121H,J Whitley Road 57. 20 Malcolm Road 58. 1,3,5,7,9,11,15,17,19,21,23 Merryn Drive 59. 62 Trevose Crescent 60. 70 Trevose Crescent 61. 1,3 Merryn Close 62. 2,4,6 Merryn Terrace 63. 1,3,5,7,9 Merryn Terrace 64. 24,26,28,30,32,34 Merryn Avenue 65. 33 Merryn Avenue 66. 35,37 Merryn Avenue 67. 39 Merryn Avenue 68. 65 Merryn Road 69. 63 Merryn Road 70. 61A Merryn Road Commercial: 1. Singapore Polo Club 2. Balestier Hill Shopping Centre 3. James Tan Veterinary Centre 4. Tanglin Community Centre 5. Mt Pleasant Animal Hospital Government: Ministry of Social and Family Development Building Ecological Sensitive Receptor: 1. Bukit Brown Woods[3] 2. Malcolm Park			

Notes:
[1] The distances tabulated in this table were calculated based on detailed confidential land use plan design which was not presented in this report.
[2] The sensitivity of the area was determined based on the cumulative number of receivers within each distance band. The sensitivity was determined as 'Priority 1' after counting the number of receivers for sensitive receptors (e.g. place of worship, residential, and educational institution). Hence, counting of number of receivers for other type of receivers was not conducted.
[3] Bukit Brown Woods is deemed to have Flora, Fauna Species and Habitat with High Ecological Value.

Appendix C

Baseline Noise Monitoring Report

Baseline Noise Monitoring Report

Table of Contents

1.0 INTRODUCTION 3

1.1 Airborne Noise Monitoring Schedule 3
1.2 Airborne Noise Monitoring Equipment 3
1.3 Baseline Airborne Noise Monitoring Data 5
1.3.1 SUMMARY OF BASELINE NOISE MONITORING RESULTS FOR CONSTRUCTION NOISE IMPACT ASSESSMENT 9

List of Figures

Figure 1 Airborne Noise Monitoring Locations 3
Figure 2 Airborne Noise Monitoring Setup 4

List of Tables

Table 1 Airborne Noise Monitoring Equipment 3
Table 2 Noise Monitoring Location NM01 5
Table 3 Noise Monitoring Location NM02 6
Table 4 Noise Monitoring Location NM03 7
Table 5 Noise Monitoring Location NM04 8
Table 6: Summary of Baseline Noise Monitoring Results for Monday to Saturday at NM01 9
Table 7: Summary of Baseline Noise Monitoring Results for Sunday and Public Holiday at NM01 9
Table 8: Summary of Baseline Noise Monitoring Results for Monday to Saturday at NM02 9
Table 9: Summary of Baseline Noise Monitoring Results for Sunday and Public Holiday at NM02 9
Table 10: Summary of Baseline Noise Monitoring Results for Monday to Saturday at NM03 10
Table 11: Summary of Baseline Noise Monitoring Results for Sunday and Public Holiday at NM03 10
Table 12: Summary of Baseline Noise Monitoring Results for Monday to Saturday at NM04 10
Table 13: Summary of Baseline Noise Monitoring Results for Sunday and Public Holiday at NM04 10

1.0 Introduction

Under the contract "Environmental Impact Study (EIS) for future residential development located at Mount Pleasant area", the Housing Development Board (HDB) appointed AECOM Singapore Pte Ltd (AECOM) to undertake an Environmental Impact Study (EIS) of the future residential development (hereafter referred to as the "Project") located at Mount Pleasant area.

Part of the study will involve assessment of the noise impacts arising from the construction activities of the project. This report details the noise monitoring plan to carry out the baseline noise monitoring at the project site due to proposed construction activities. The purpose of conducting a baseline noise monitoring is to determine the existing noise levels from these areas for further assessments and validation of noise level predictions.

1.1 Airborne Noise Monitoring Schedule

The airborne noise monitoring (unattended) was conducted between 7th and 14th May 2019 at the monitoring locations NM01, NM02, NM03 and between 7th and 14th Jan 2020 at NM04 shown on Figure 1.

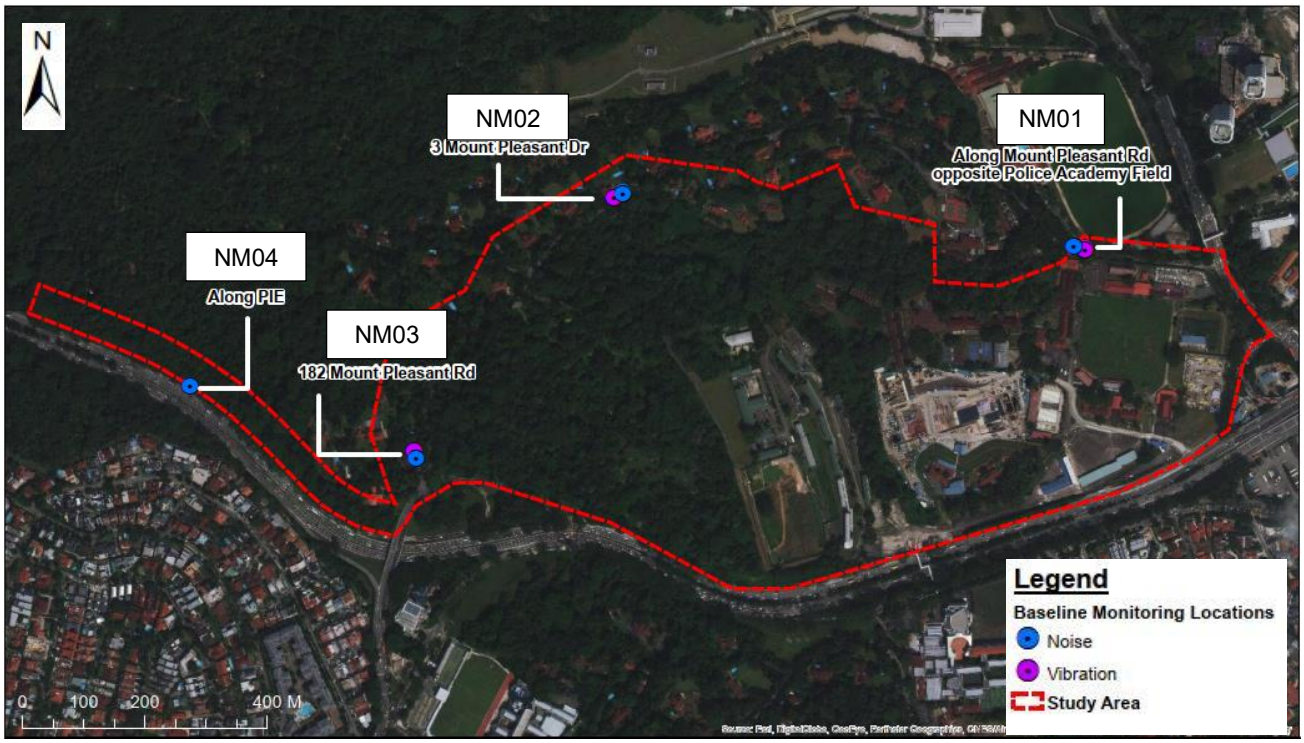


Figure 1 Airborne Noise Monitoring Locations

1.2 Airborne Noise Monitoring Equipment

Three (3) Svantek SVAN 971 Type 1 Sound Level Meter (SLM) and one (1) Norsonic 131 Type 1 SLM with microphones was utilized to collect data for the Project. For the purpose of QA/QC, SLM was calibrated before each monitoring session without any drift in calibration before and after monitoring to ensure that equipment readings remain within acceptable margins of error. In order to reduce the chances of recording unwanted noise caused by wind, a windshield was attached onto the microphone. Noise levels were recorded in 1-minute intervals using the L_{Aeq} descriptor, under 'fast' time-weighting. Calibration certificates of the noise monitoring equipment, as per Table 1 are presented in **Appendix E**. L_{eq} noise levels have been assessed as the representative baseline noise level for the site (see Section 0).

Table 1 Airborne Noise Monitoring Equipment

Instrument	Brand	Model	Serial Numbers	Type
Sound Level Meter	Svantek	SVAN 971	80326	1
Sound Level Meter	Svantek	SVAN 971	80329	1

Sound Level Meter	Svantek	SVAN 971	80331	1
Norsonic 131	Norsonic	Norsonic 131	1313989	1

Figure 2 Airborne Noise Monitoring Setup

1.3 Baseline Airborne Noise Monitoring Data

The daily baseline airborne noise monitoring results for from NM01, NM02, NM03 and NM04 for 7:00 am – 7:00 pm, 7:00 pm – 10:00 pm and 10:00 pm – 7:00 am are listed in this section. The time period that will be used for the airborne noise impact assessments for Construction Phases is 7:00 am – 7:00 pm Monday to Saturday. The corresponding graphs for the daily monitoring data are displayed in **Annex A**.

The recorded background levels in Table 2, Table 3, Table 4 and Table 5 are used to calculate the "adjusted maximum permissible noise level" in line with the directions given in the applicable legislation for the construction airborne noise impact assessment.

Table 2 Noise Monitoring Location NM01

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
7 May 2019	Max	NA	NA	NA	68	73	NA	71	80
	Min	NA	NA	NA	63	54	NA	57	43
	Average / Overall	NA	66	NA	66	62	NA	65	57
8 May 2019	Max	NA	NA	73	68	63	77	72	68
	Min	NA	NA	67	63	47	46	55	43
	Average / Overall	69	61	69	66	55	67	65	51
9 May 2019	Max	NA	NA	71	66	67	77	70	71
	Min	NA	NA	66	63	51	45	58	42
	Average / Overall	68	62	67	64	58	66	64	55
10 May 2019	Max	NA	NA	69	66	63	74	68	66
	Min	NA	NA	66	64	51	52	60	41
	Average / Overall	68	61	68	65	56	67	65	53
11 May 2019	Max	NA	NA	72	64	64	80	67	71
	Min	NA	NA	63	63	48	43	59	42
	Average / Overall	68	61	67	64	56	65	63	54
12 May 2019	Max	NA	NA	66	63	63	69	66	66
	Min	NA	NA	62	62	62	43	56	56
	Average / Overall	64	59	64	62	62	63	62	62
13 May 2019	Max	NA	NA	75	61	65	82	69	72
	Min	NA	NA	65	61	51	44	59	42
	Average / Overall	69	61	68	61	55	66	64	51

Table 3 Noise Monitoring Location NM02

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
7 May 2019	Max	NA	NA	NA	69	73	NA	72	80
	Min	NA	NA	NA	68	58	NA	64	58
	Average / Overall	NA	67	NA	68	64	NA	68	64
8 May 2019	Max	NA	NA	76	69	63	80	71	63
	Min	NA	NA	68	65	54	65	59	51
	Average / Overall	70	63	70	67	57	69	66	57
9 May 2019	Max	NA	NA	70	68	72	71	69	72
	Min	NA	NA	67	65	55	67	63	55
	Average / Overall	68	69	68	67	62	67	67	62
10 May 2019	Max	NA	NA	70	68	64	73	69	64
	Min	NA	NA	67	65	54	64	63	54
	Average / Overall	69	62	68	66	58	68	66	58
11 May 2019	Max	NA	NA	72	65	64	79	68	64
	Min	NA	NA	63	65	53	57	59	53
	Average / Overall	68	62	68	65	58	67	65	58
12 May 2019	Max	NA	NA	67	65	62	68	68	62
	Min	NA	NA	62	63	55	58	60	55
	Average / Overall	65	69	65	64	58	65	63	58
13 May 2019	Max	NA	NA	74	69	64	80	71	64
	Min	NA	NA	66	64	66	62	60	66
	Average / Overall	69	63	69	66	66	68	66	66

Table 4 Noise Monitoring Location NM03

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
7 May 2019	Max	NA	NA	NA	63	76	NA	71	84
	Min	NA	NA	NA	57	50	NA	54	44
	Average / Overall	NA	66	NA	61	58	NA	59	55
8 May 2019	Max	NA	NA	73	63	55	76	68	60
	Min	NA	NA	61	57	45	57	52	43
	Average / Overall	65	56	64	60	50	63	59	60
9 May 2019	Max	NA	NA	61	60	69	65	62	72
	Min	NA	NA	59	57	48	56	53	43
	Average / Overall	60	61	60	58	57	60	58	54
10 May 2019	Max	NA	NA	65	60	57	71	61	62
	Min	NA	NA	60	59	47	57	53	43
	Average / Overall	62	55	62	59	52	61	59	51
11 May 2019	Max	NA	NA	71	59	57	81	61	60
	Min	NA	NA	56	57	46	53	54	43
	Average / Overall	64	55	62	58	52	60	58	50
12 May 2019	Max	NA	NA	59	58	58	62	66	66
	Min	NA	NA	56	56	56	51	53	53
	Average / Overall	58	53	58	57	57	57	56	56
13 May 2019	Max	NA	NA	71	55	57	76	63	63
	Min	NA	NA	59	55	57	56	52	43
	Average / Overall	64	56	63	55	57	61	58	50

Table 5 Noise Monitoring Location NM04

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
7 Jan 2020	Max	NA	NA	NA	73	73	NA	74	74
	Min	NA	NA	NA	73	68	NA	72	66
	Average / Overall	NA	71	NA	73	70	NA	73	70
8 Jan 2020	Max	NA	NA	74	72	72	76	73	74
	Min	NA	NA	72	72	67	70	71	65
	Average / Overall	73	70	73	72	69	73	72	74
9 Jan 2020	Max	NA	NA	74	72	72	75	73	74
	Min	NA	NA	72	72	67	70	71	66
	Average / Overall	73	70	73	72	69	72	72	69
10 Jan 2020	Max	NA	NA	76	74	73	79	74	74
	Min	NA	NA	71	72	69	69	69	67
	Average / Overall	74	72	73	73	71	73	73	71
11 Jan 2020	Max	NA	NA	74	72	72	75	74	74
	Min	NA	NA	72	72	68	71	71	67
	Average / Overall	73	71	73	72	70	73	72	70
12 Jan 2020	Max	NA	NA	73	75	75	74	75	75
	Min	NA	NA	72	74	74	68	73	73
	Average / Overall	72	72	72	75	75	72	75	75
13 Jan 2020	Max	NA	NA	74	71	71	75	74	74
	Min	NA	NA	72	71	71	71	70	65
	Average / Overall	73	71	73	71	71	73	72	69

1.3.1 Summary of Baseline Noise Monitoring Results for Construction Noise Impact Assessment

The baseline noise monitoring results from NM01, NM02, NM03 and NM04 are summarised in this section. These data with background noise correction factor applied will be used to develop the noise criteria for this project.

Table 6: Summary of Baseline Noise Monitoring Results for Monday to Saturday at NM01

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
7 May 2019 to 11 May 2019 & 13 May 2019	Max	69	66	75	68	73	82	72	80
	Min	68	61	63	61	47	43	55	41
	Average / Overall	68	62	68	64	57	66	64	54

Table 7: Summary of Baseline Noise Monitoring Results for Sunday and Public Holiday at NM01

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
12-May-19	Max	NA	NA	66	63	63	69	66	66
	Min	NA	NA	62	62	62	43	56	56
	Average / Overall	64	59	64	62	62	63	63	63

Table 8: Summary of Baseline Noise Monitoring Results for Monday to Saturday at NM02

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
7 May 2019 to 11 May 2019 & 13 May 2019	Max	70	69	76	69	73	80	72	80
	Min	68	62	63	64	53	57	59	51
	Average / Overall	69	64	68	67	61	68	66	61

Table 9: Summary of Baseline Noise Monitoring Results for Sunday and Public Holiday at NM02

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
12-May-19	Max	NA	NA	67	63	63	68	68	68
	Min	NA	NA	64	62	62	55	61	61
	Average / Overall	60	69	65	63	63	64	64	64

Table 10: Summary of Baseline Noise Monitoring Results for Monday to Saturday at NM03

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
7 May 2019 to 11 May 2019 & 13 May 2019	Max	65	66	73	63	76	81	71	84
	Min	60	55	56	55	45	53	52	43
	Average / Overall	63	58	62	58	54	61	58	53

Table 11: Summary of Baseline Noise Monitoring Results for Sunday and Public Holiday at NM03

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
12-May-19	Max	NA	NA	59	58	58	62	66	66
	Min	NA	NA	56	56	56	51	53	53
	Average / Overall	58	53	58	57	57	57	56	56

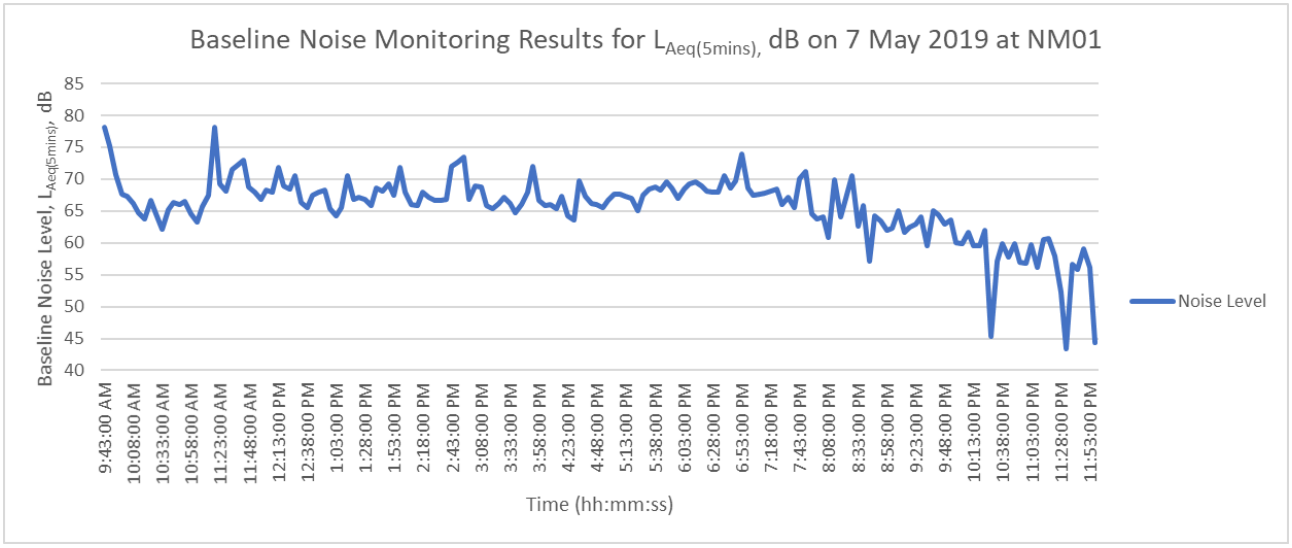
Table 12: Summary of Baseline Noise Monitoring Results for Monday to Saturday at NM04

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
7 Jan 2020 to 11 Jan 2020 & 13 Jan 2020	Max	74	72	76	74	74	79	74	74
	Min	73	70	71	71	67	69	69	65
	Average / Overall	73	71	73	72	70	73	72	71

Table 13: Summary of Baseline Noise Monitoring Results for Sunday and Public Holiday at NM04

Monitoring period		$L_{Aeq(12hours)}$, dB		$L_{Aeq(1hour)}$, dB			$L_{Aeq(5mins)}$, dB		
		7:00 am – 7:00 pm	7:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am	7:00 am – 7:00 pm	7:00 pm – 10:00 pm	10:00 pm – 7:00 am
12-Jan-20	Max	NA	NA	73	75	75	74	75	75
	Min	NA	NA	72	74	74	68	73	73
	Average / Overall	72	72	72	75	75	72	75	75

Annex A


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 7 May 2019 at NM01
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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80
75
70
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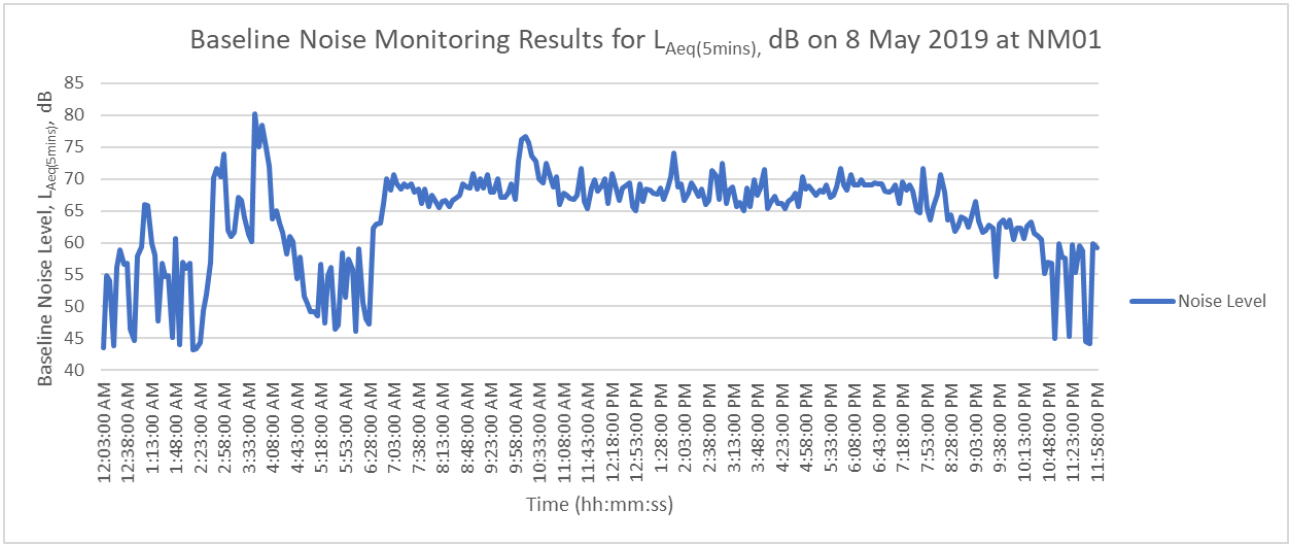
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 8 May 2019 at NM01
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
75
70
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60
55
50
45
40
12:03:00 AM
12:38:00 AM
1:13:00 AM
1:48:00 AM
2:23:00 AM
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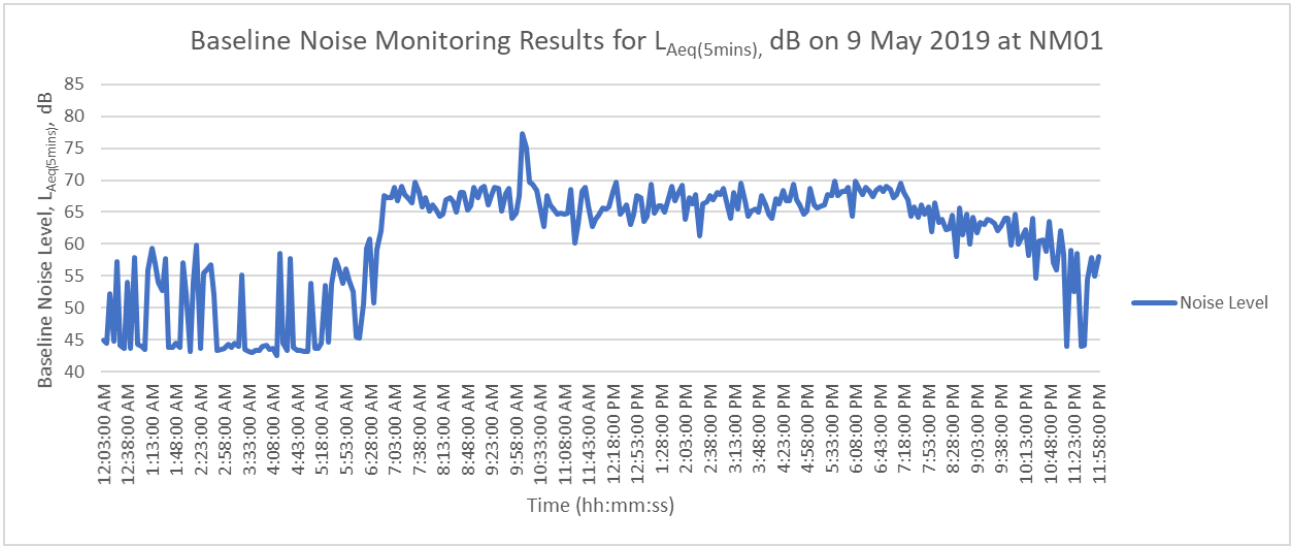
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 9 May 2019 at NM01
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
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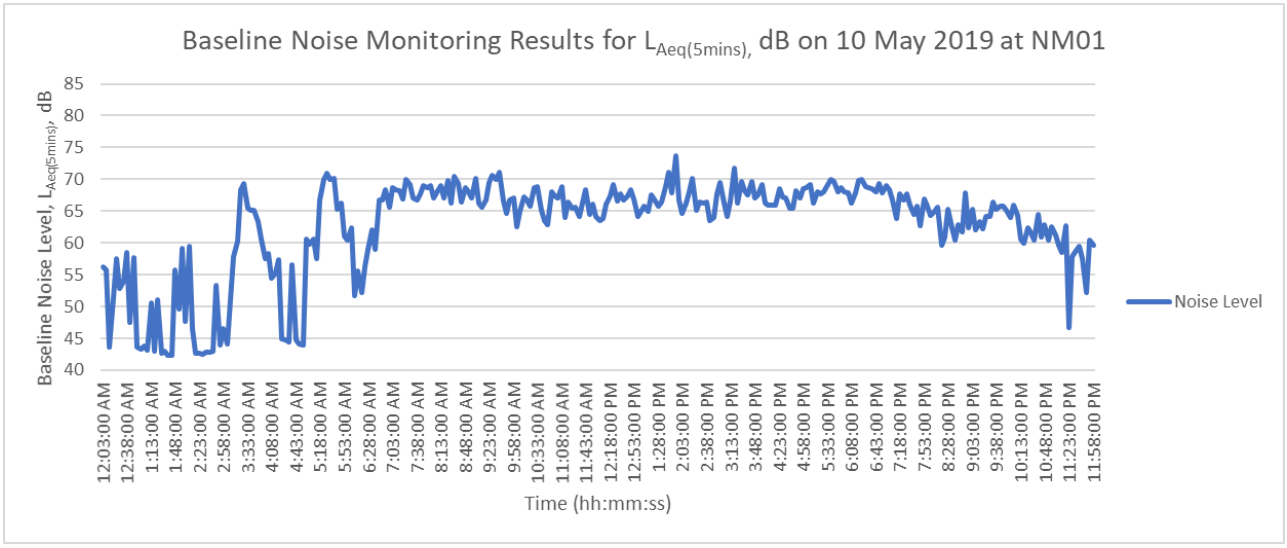
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 10 May 2019 at NM01
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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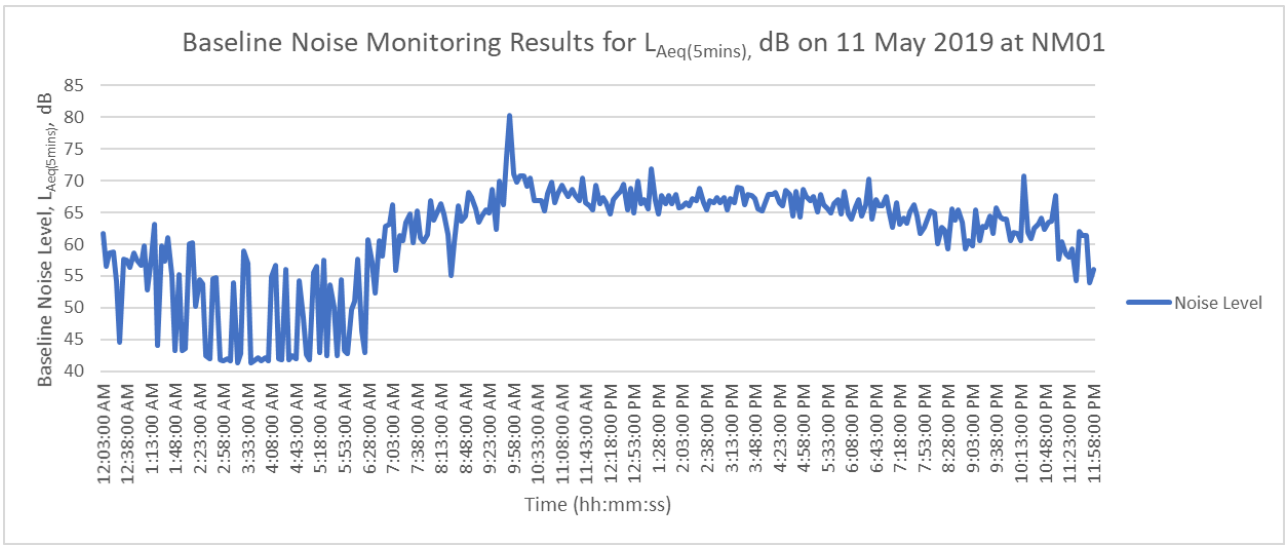
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 11 May 2019 at NM01
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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80
75
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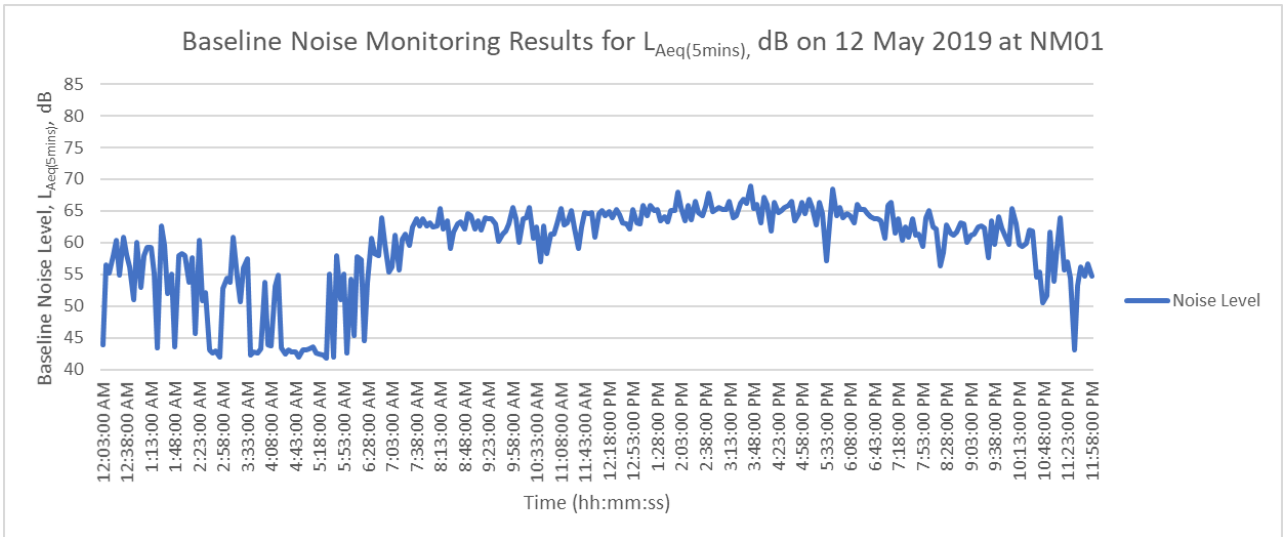
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 12 May 2019 at NM01
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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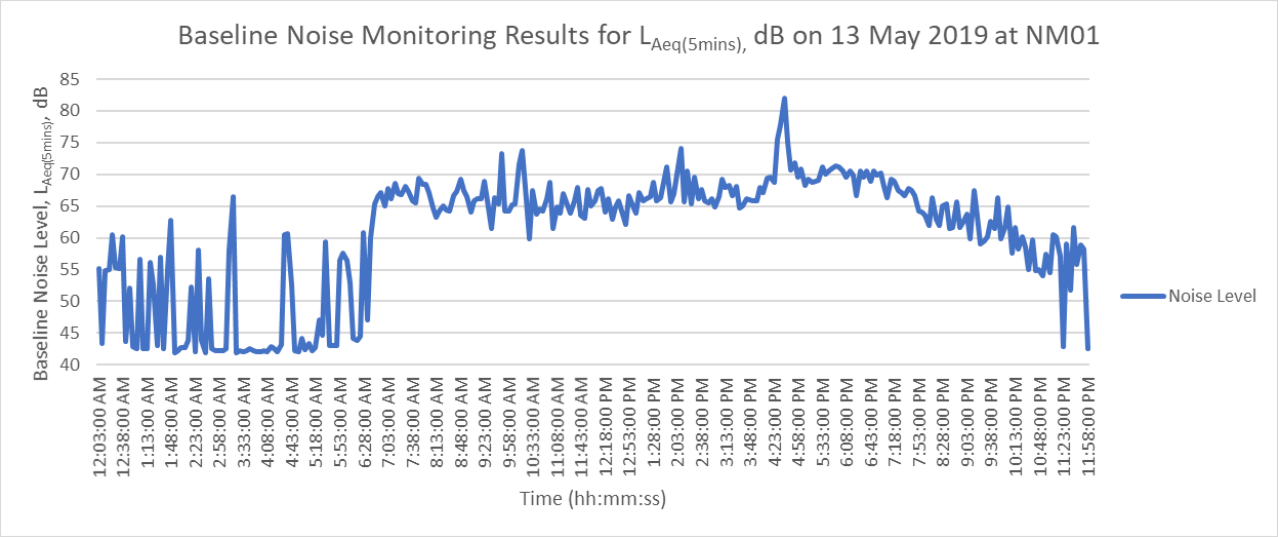
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 13 May 2019 at NM01
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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70
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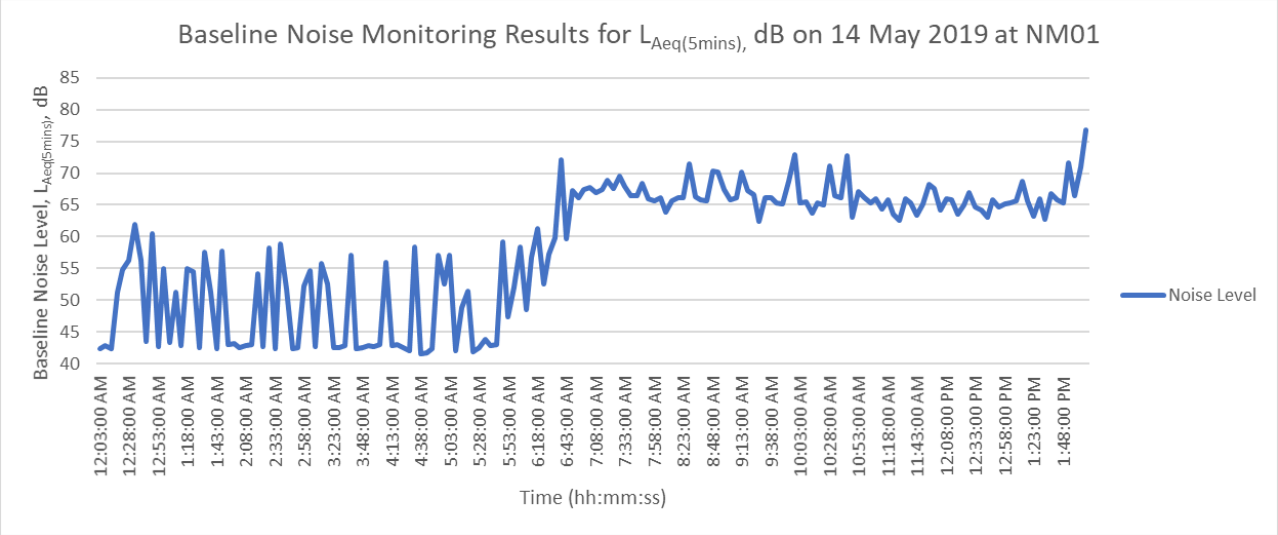
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 14 May 2019 at NM01
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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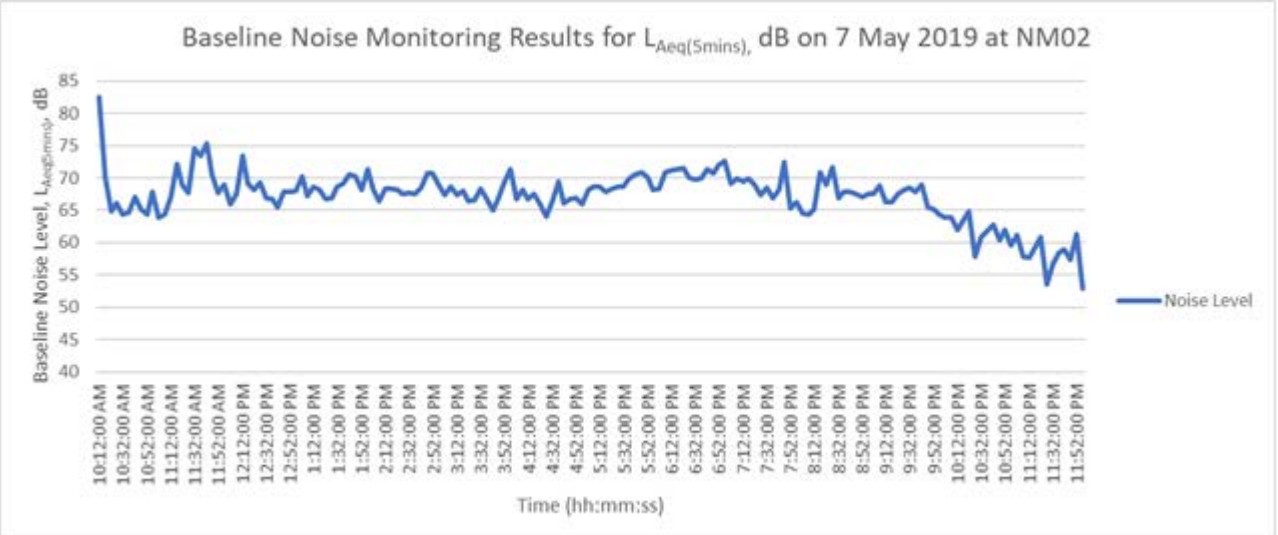
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 7 May 2019 at NM02
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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75
70
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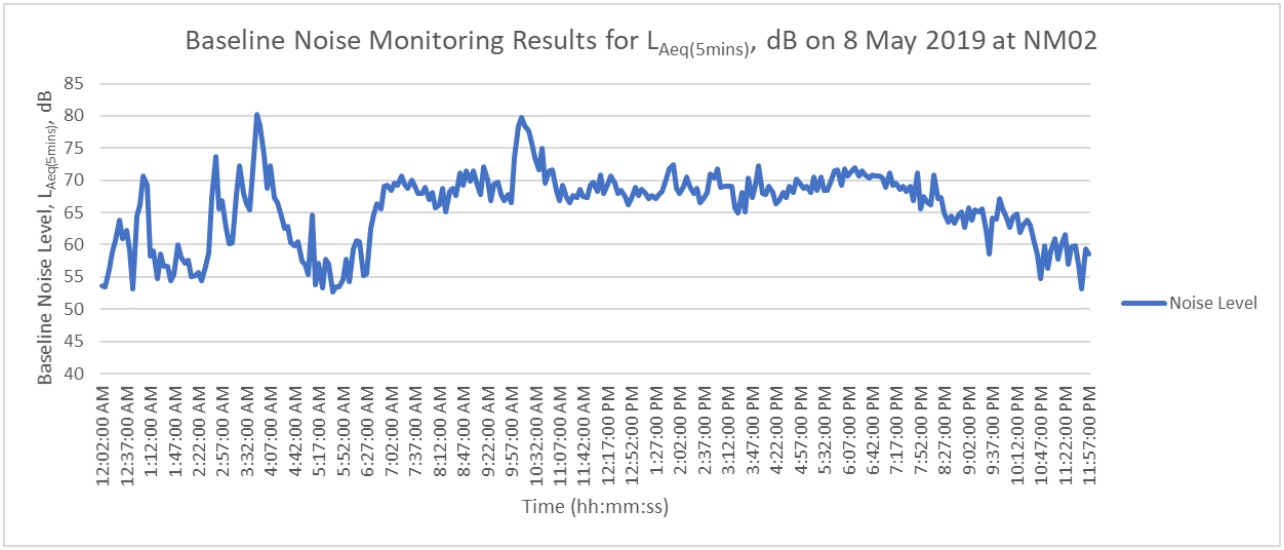
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 8 May 2019 at NM02
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
75
70
65
60
55
50
45
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8:27:00 PM
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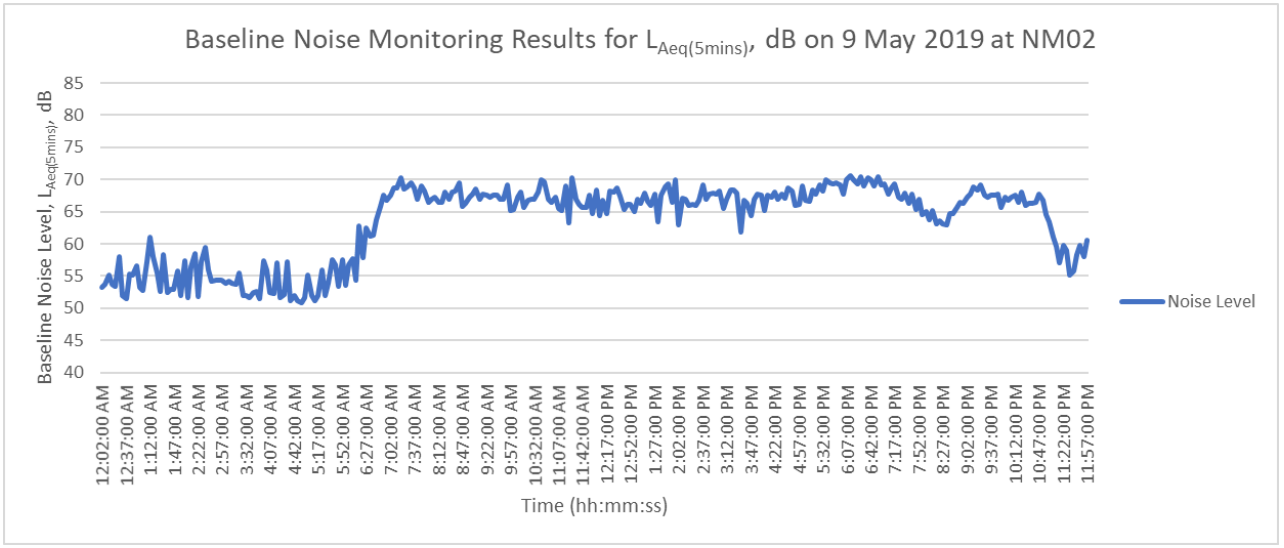
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 9 May 2019 at NM02
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
75
70
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50
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1:12:00 AM
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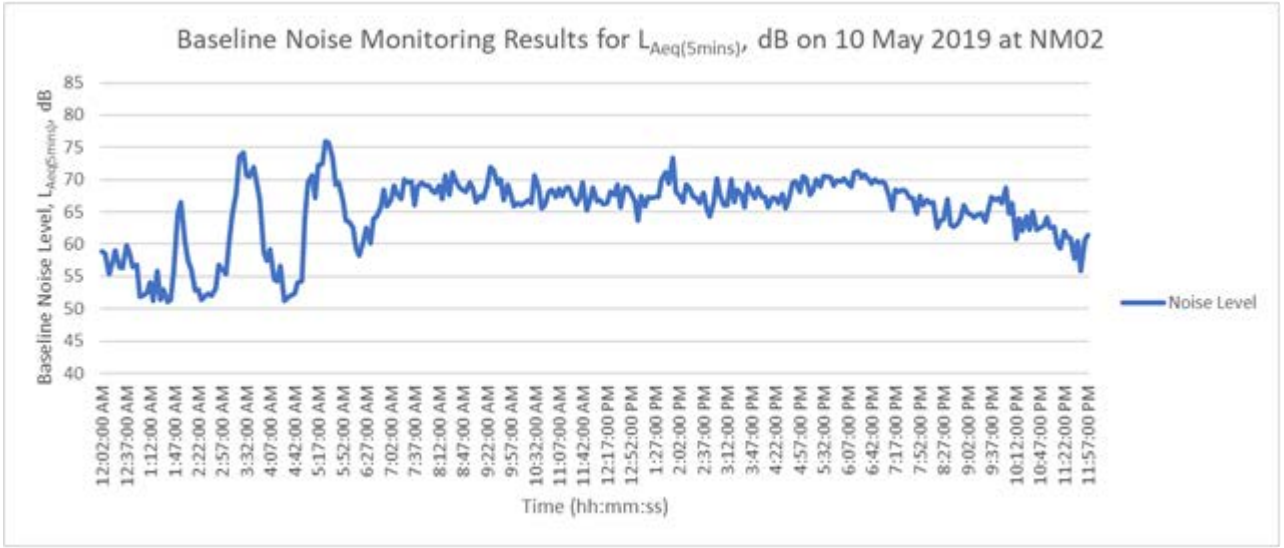
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 10 May 2019 at NM02
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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80
75
70
65
60
55
50
45
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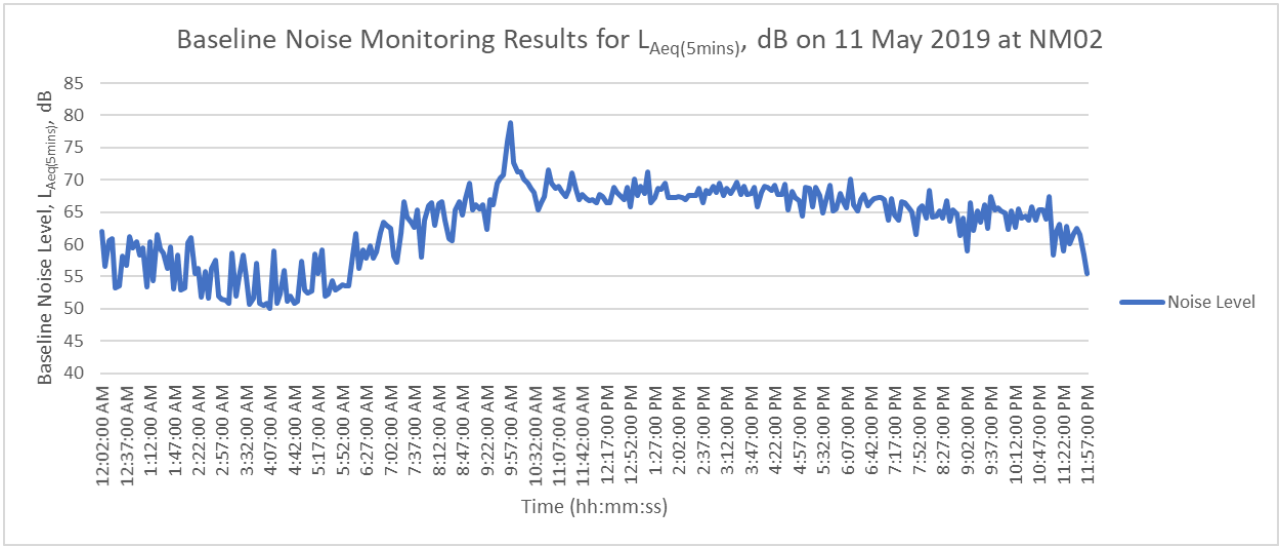
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 11 May 2019 at NM02
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
75
70
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60
55
50
45
40
12:02:00 AM
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1:12:00 AM
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2:22:00 AM
2:57:00 AM
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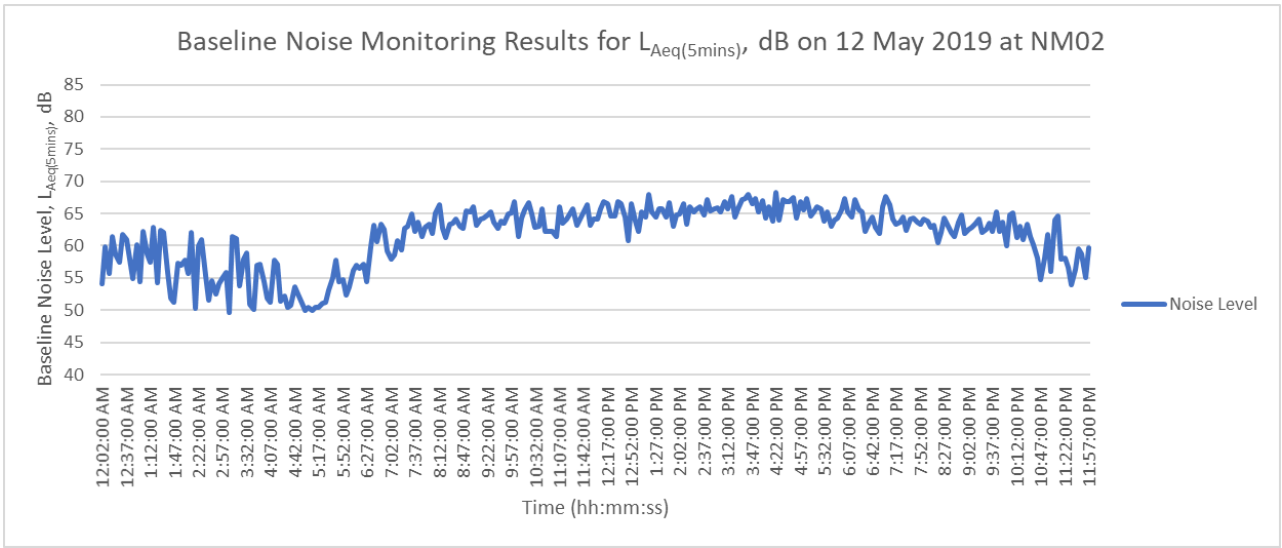
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 12 May 2019 at NM02
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
75
70
65
60
55
50
45
40
12:02:00 AM
12:37:00 AM
1:12:00 AM
1:47:00 AM
2:22:00 AM
2:57:00 AM
3:32:00 AM
4:07:00 AM
4:42:00 AM
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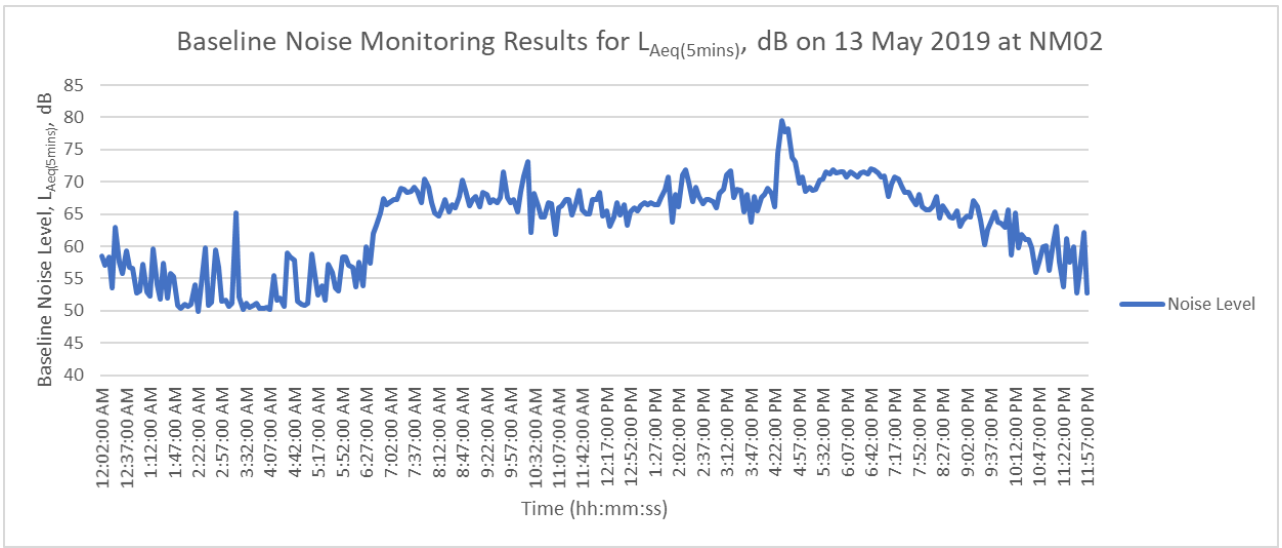
11:57:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 13 May 2019 at NM02
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
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65
60
55
50
45
40
12:02:00 AM
12:37:00 AM
1:12:00 AM
1:47:00 AM
2:22:00 AM
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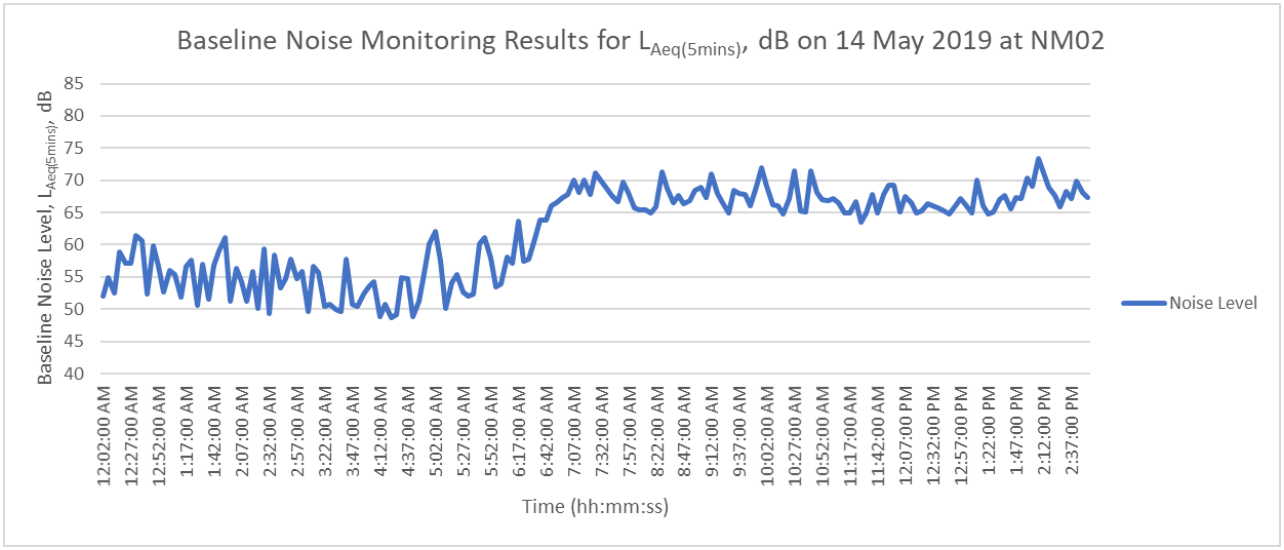
11:57:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 14 May 2019 at NM02
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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60
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12:02:00 AM
12:27:00 AM
12:52:00 AM
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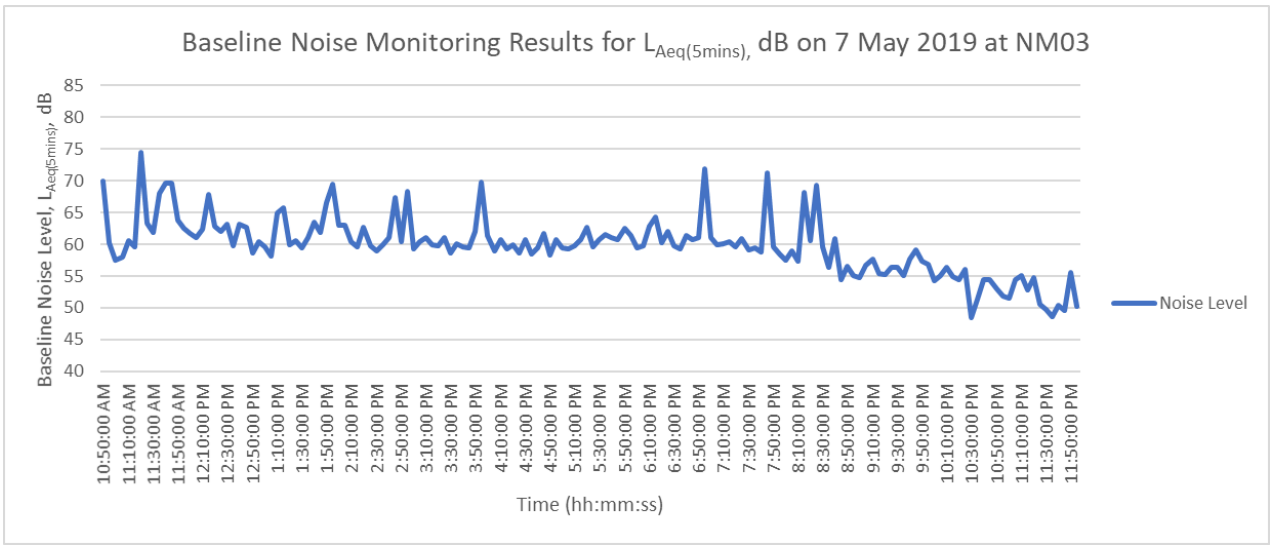
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 7 May 2019 at NM03
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
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60
55
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45
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10:50:00 AM
11:10:00 AM
11:30:00 AM
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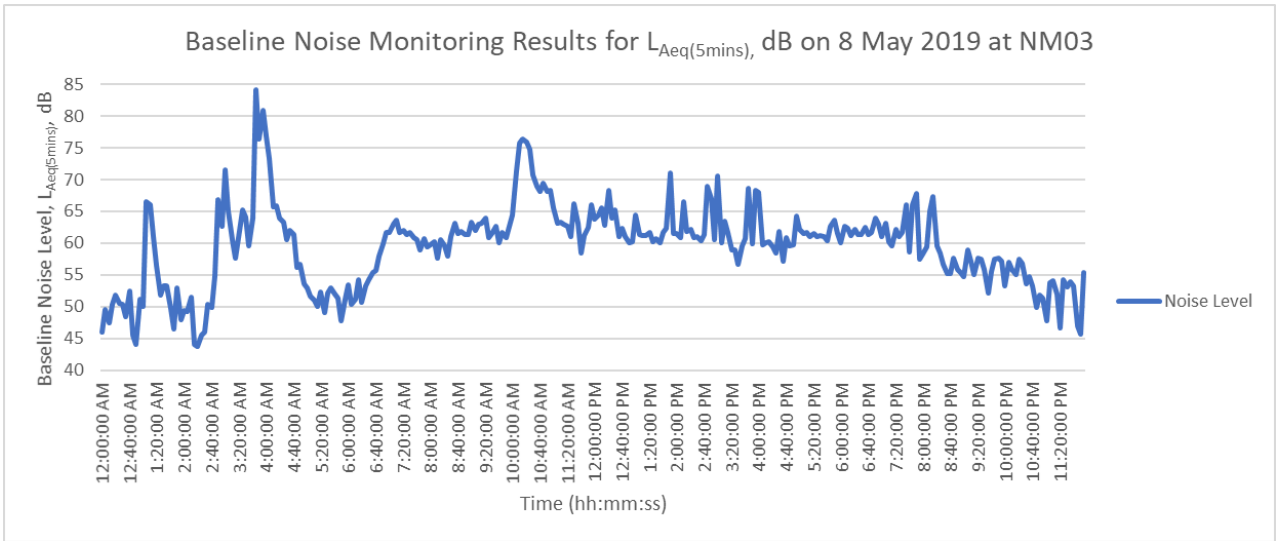
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 8 May 2019 at NM03
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
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60
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12:00:00 AM
12:40:00 AM
1:20:00 AM
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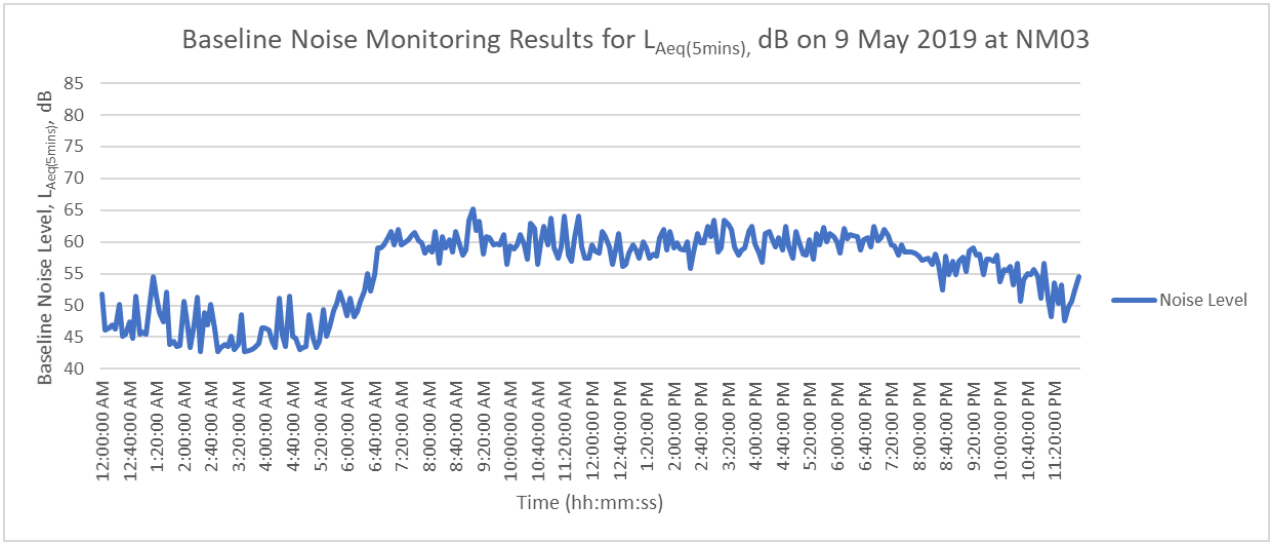
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 9 May 2019 at NM03
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
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60
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12:00:00 AM
12:40:00 AM
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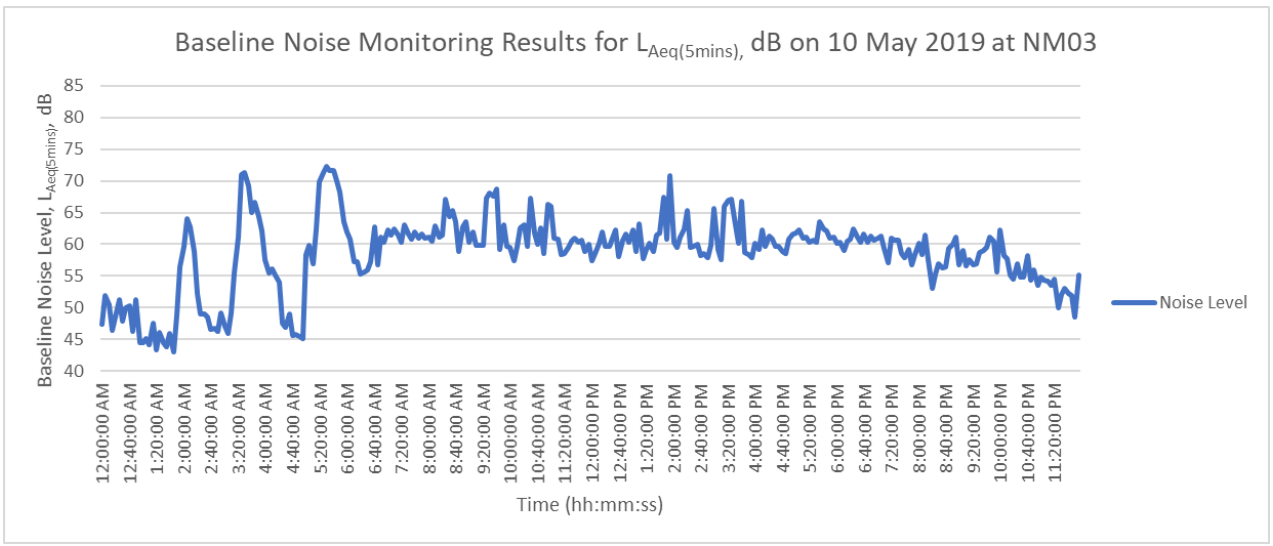
11:20:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 10 May 2019 at NM03
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
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60
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12:00:00 AM
12:40:00 AM
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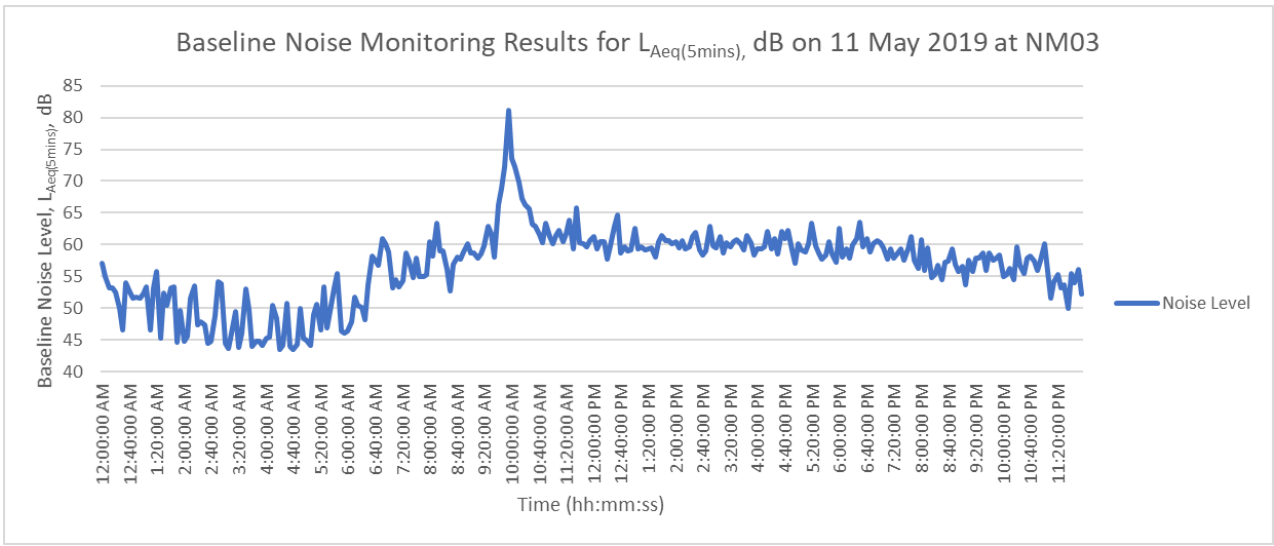
10:40:00 PM
11:20:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 11 May 2019 at NM03
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
75
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65
60
55
50
45
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12:00:00 AM
12:40:00 AM
1:20:00 AM
2:00:00 AM
2:40:00 AM
3:20:00 AM
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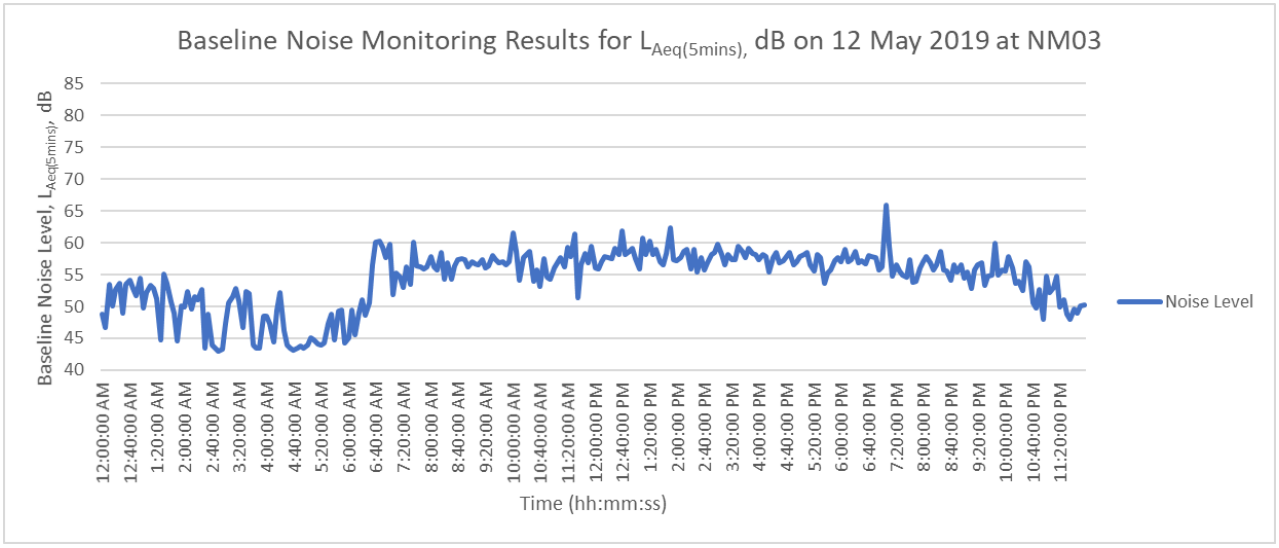
11:20:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 12 May 2019 at NM03
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
75
70
65
60
55
50
45
40
12:00:00 AM
12:40:00 AM
1:20:00 AM
2:00:00 AM
2:40:00 AM
3:20:00 AM
4:00:00 AM
4:40:00 AM
5:20:00 AM
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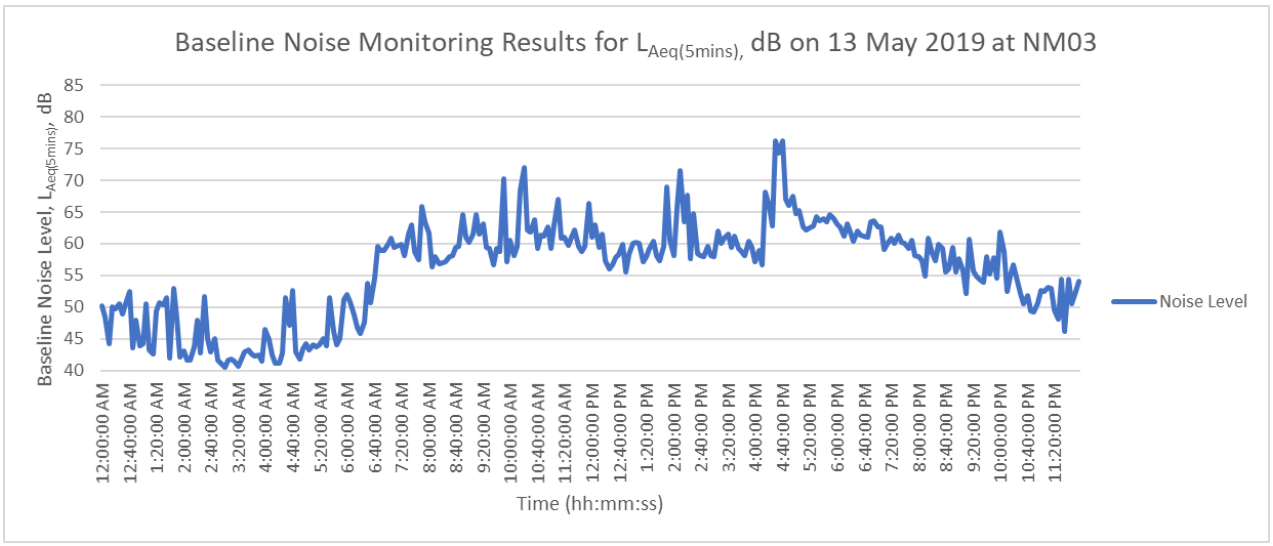
8:40:00 PM
9:20:00 PM
10:00:00 PM
10:40:00 PM
11:20:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 13 May 2019 at NM03
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
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65
60
55
50
45
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12:00:00 AM
12:40:00 AM
1:20:00 AM
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2:40:00 AM
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4:00:00 AM
4:40:00 AM
5:20:00 AM
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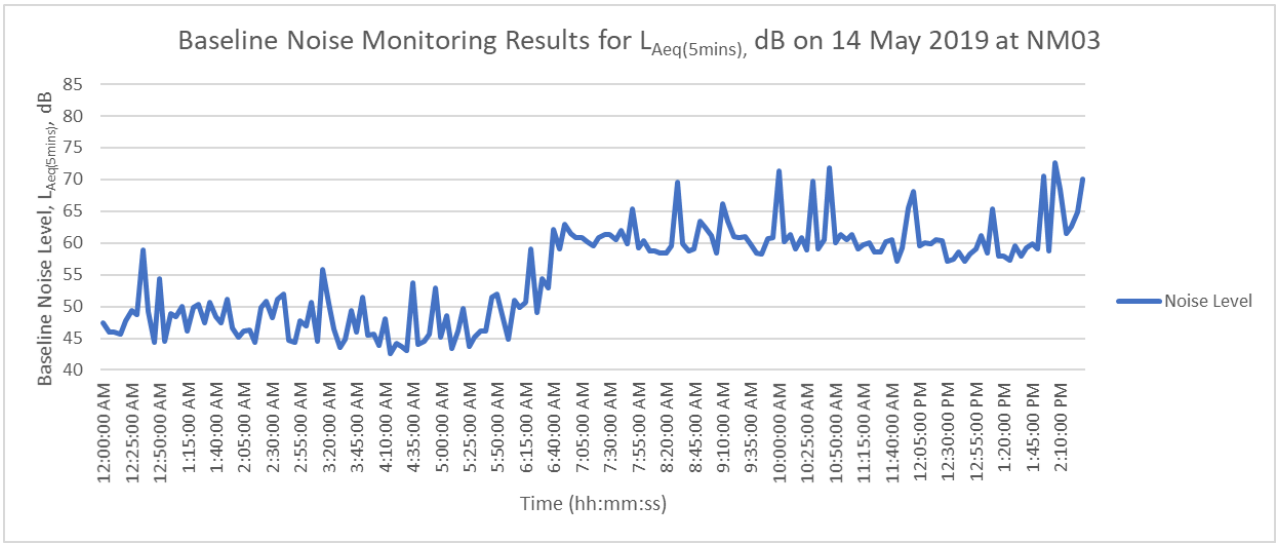
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 14 May 2019 at NM03
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
75
70
65
60
55
50
45
40
12:00:00 AM
12:25:00 AM
12:50:00 AM
1:15:00 AM
1:40:00 AM
2:05:00 AM
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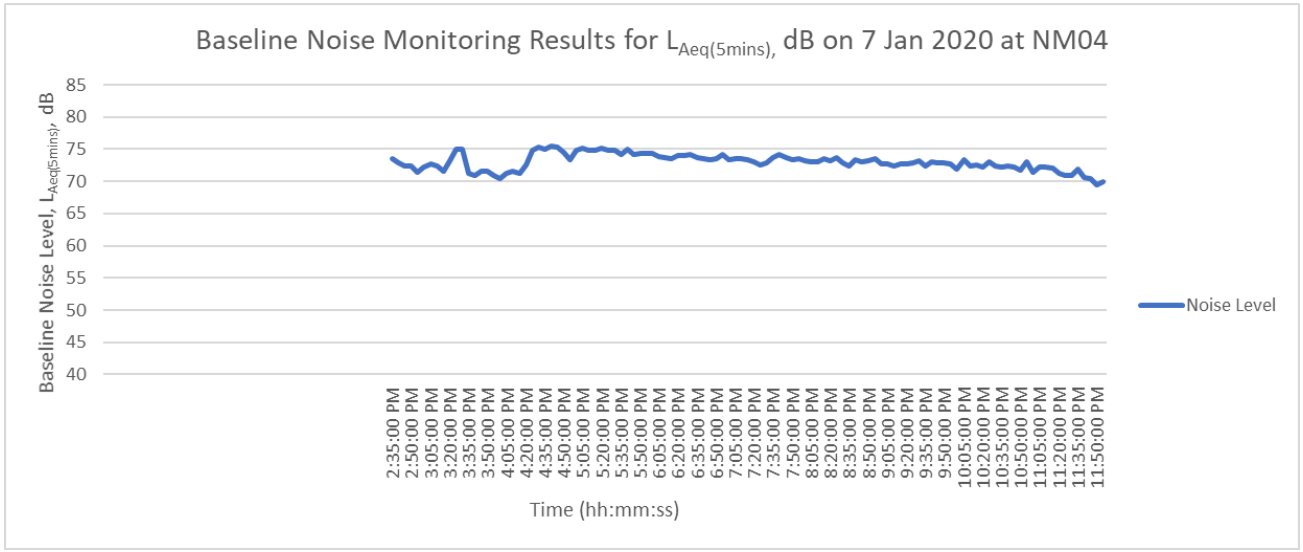
2:10:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 7 Jan 2020 at NM04
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85
80
75
70
65
60
55
50
45
40
2:35:00 PM
2:50:00 PM
3:05:00 PM
3:20:00 PM
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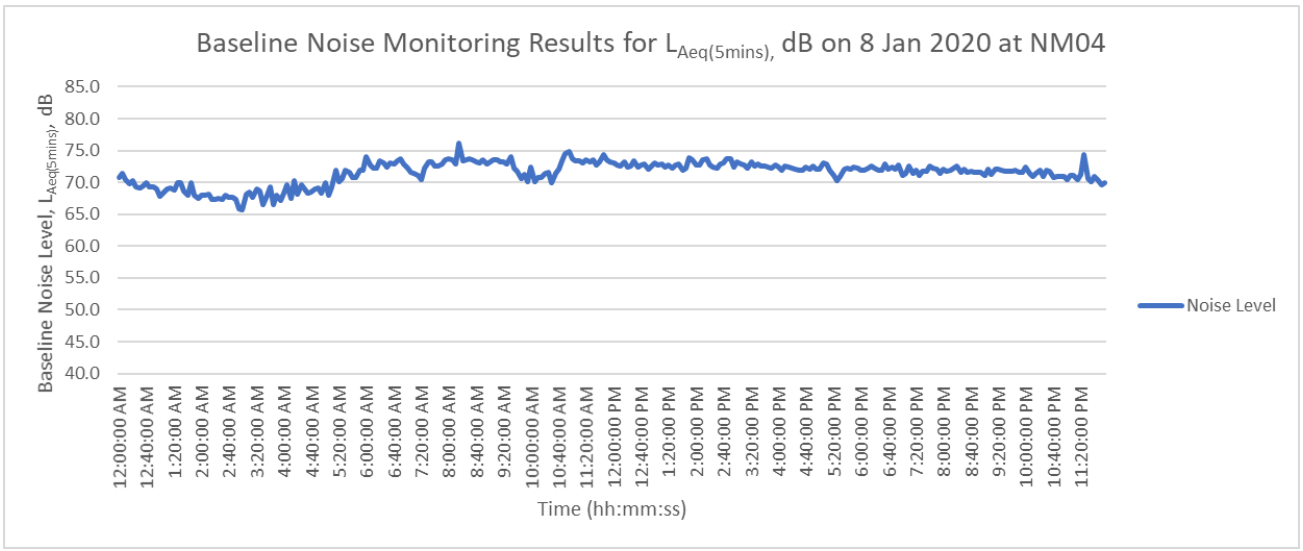
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 8 Jan 2020 at NM04
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
12:00:00 AM
12:40:00 AM
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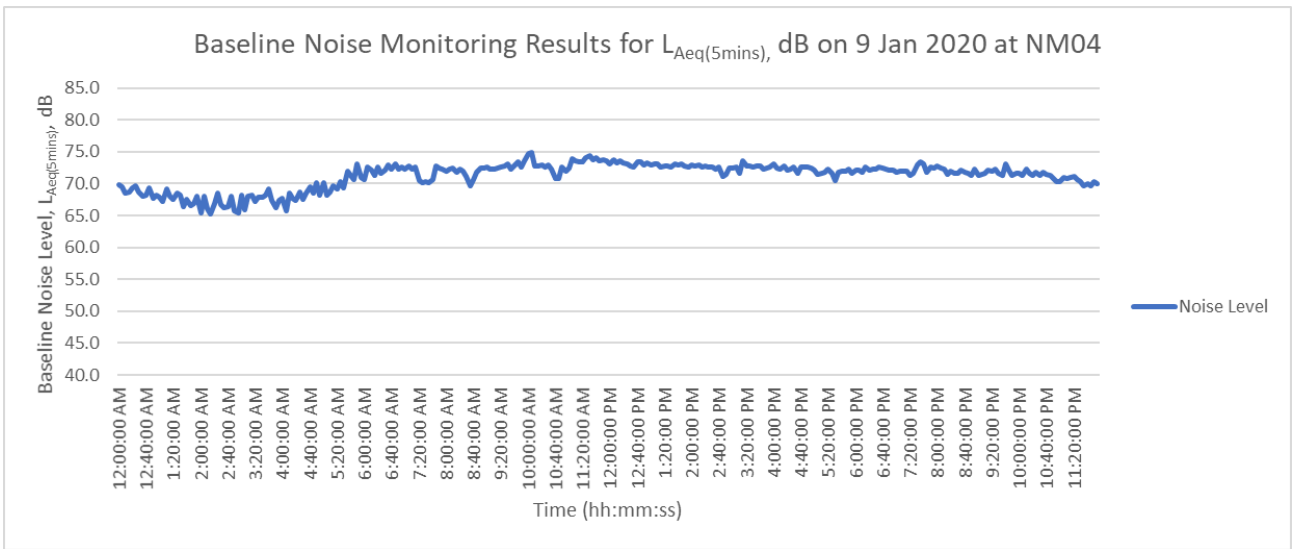
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 9 Jan 2020 at NM04
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
12:00:00 AM
12:40:00 AM
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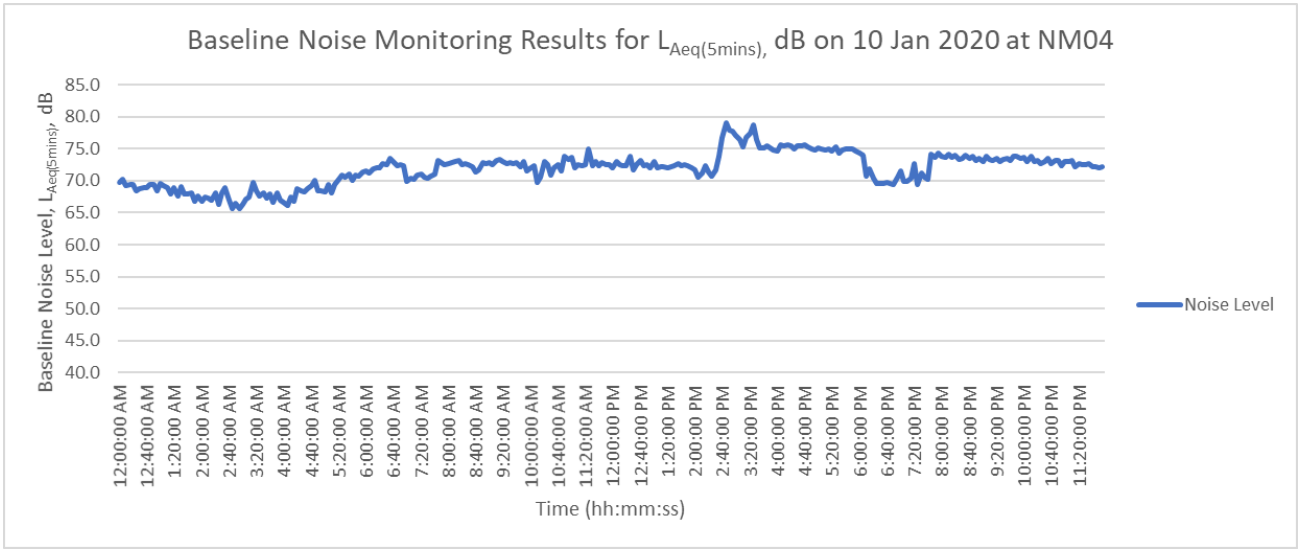
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 10 Jan 2020 at NM04
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
12:00:00 AM
12:40:00 AM
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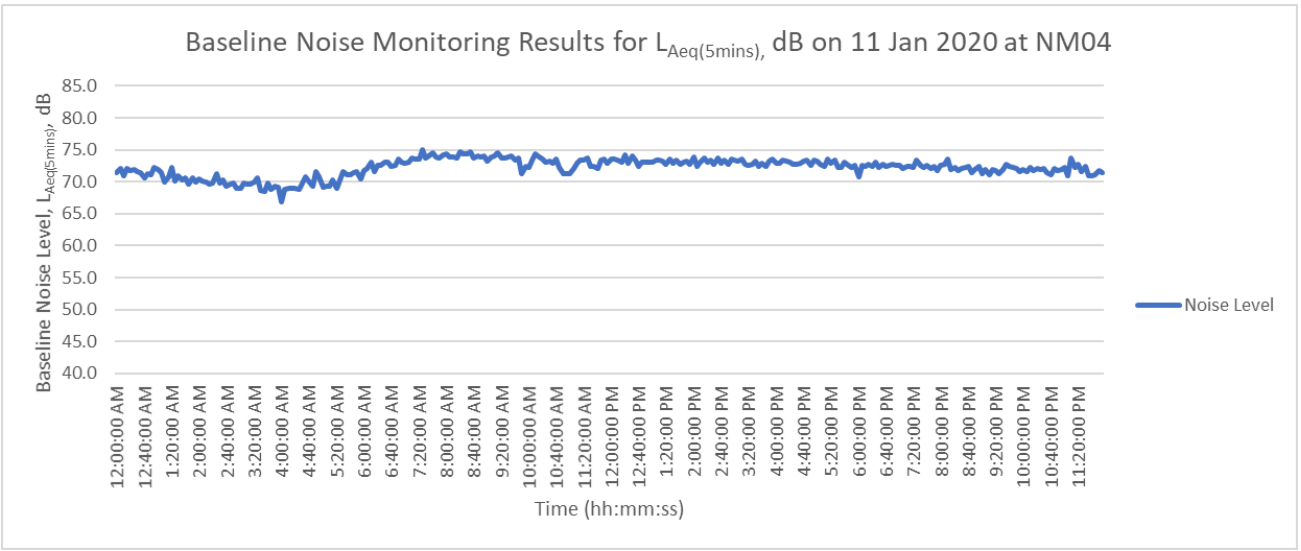
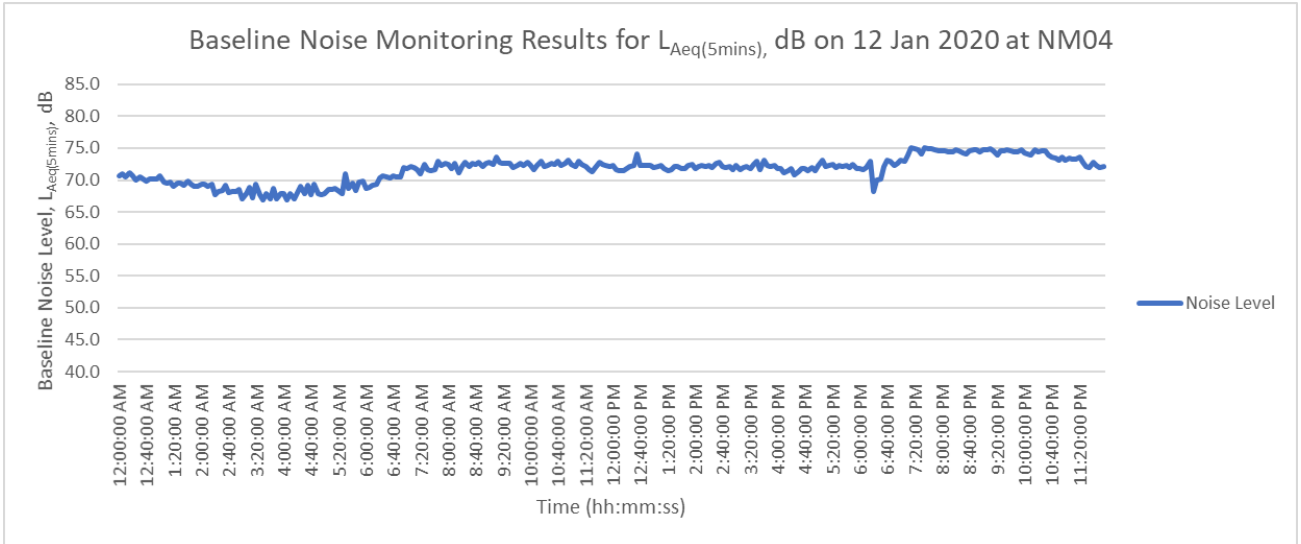
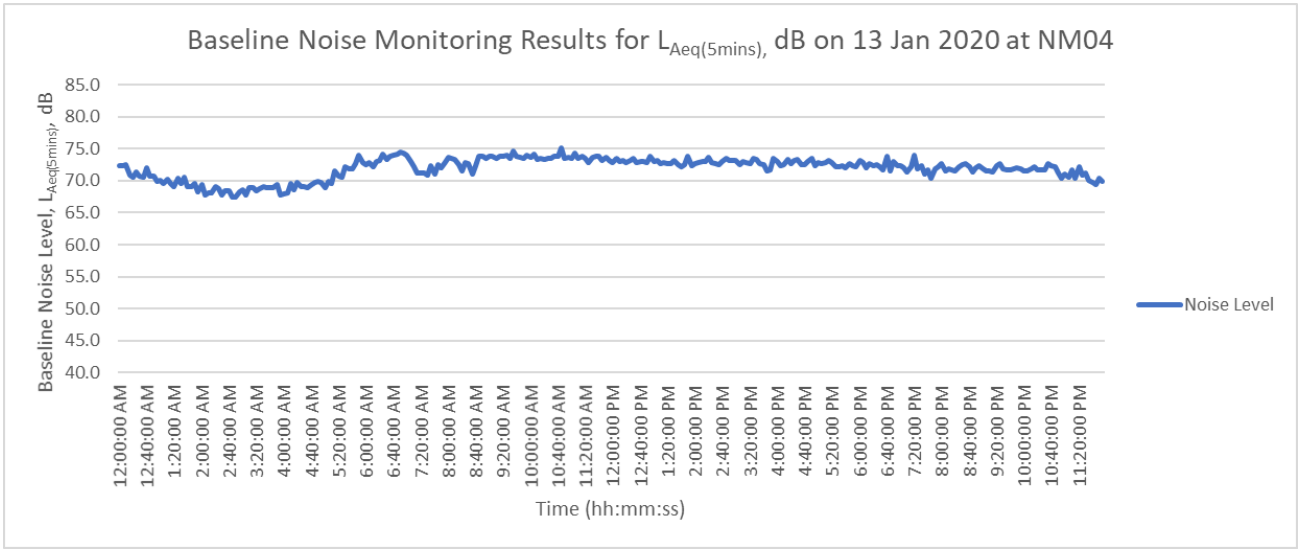
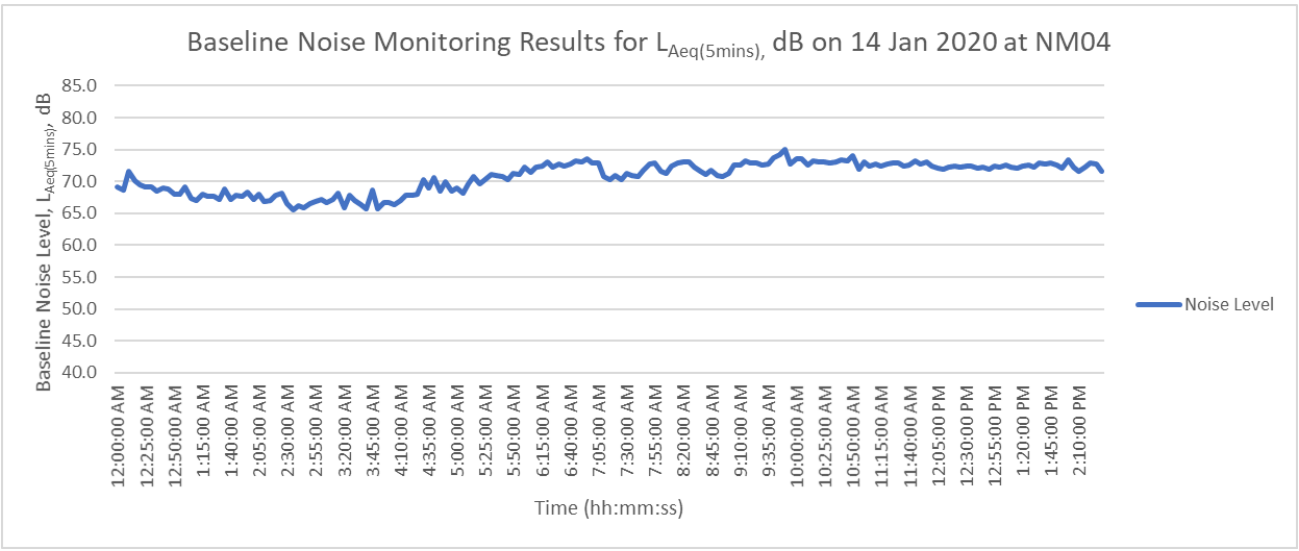
7:20:00 PM
8:00:00 PM
8:40:00 PM
9:20:00 PM
10:00:00 PM
10:40:00 PM
11:20:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 11 Jan 2020 at NM04
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
12:00:00 AM
12:40:00 AM
1:20:00 AM
2:00:00 AM
2:40:00 AM
3:20:00 AM
4:00:00 AM
4:40:00 AM
5:20:00 AM
6:00:00 AM
6:40:00 AM
7:20:00 AM
8:00:00 AM
8:40:00 AM
9:20:00 AM
10:00:00 AM
10:40:00 AM
11:20:00 AM
12:00:00 PM
12:40:00 PM
1:20:00 PM
2:00:00 PM
2:40:00 PM
3:20:00 PM
4:00:00 PM
4:40:00 PM
5:20:00 PM
6:00:00 PM
6:40:00 PM
7:20:00 PM
8:00:00 PM
8:40:00 PM
9:20:00 PM
10:00:00 PM
10:40:00 PM
11:20:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 12 Jan 2020 at NM04
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
12:00:00 AM
12:40:00 AM
1:20:00 AM
2:00:00 AM
2:40:00 AM
3:20:00 AM
4:00:00 AM
4:40:00 AM
5:20:00 AM
6:00:00 AM
6:40:00 AM
7:20:00 AM
8:00:00 AM
8:40:00 AM
9:20:00 AM
10:00:00 AM
10:40:00 AM
11:20:00 AM
12:00:00 PM
12:40:00 PM
1:20:00 PM
2:00:00 PM
2:40:00 PM
3:20:00 PM
4:00:00 PM
4:40:00 PM
5:20:00 PM
6:00:00 PM
6:40:00 PM
7:20:00 PM
8:00:00 PM
8:40:00 PM
9:20:00 PM
10:00:00 PM
10:40:00 PM
11:20:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 13 Jan 2020 at NM04
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
12:00:00 AM
12:40:00 AM
1:20:00 AM
2:00:00 AM
2:40:00 AM
3:20:00 AM
4:00:00 AM
4:40:00 AM
5:20:00 AM
6:00:00 AM
6:40:00 AM
7:20:00 AM
8:00:00 AM
8:40:00 AM
9:20:00 AM
10:00:00 AM
10:40:00 AM
11:20:00 AM
12:00:00 PM
12:40:00 PM
1:20:00 PM
2:00:00 PM
2:40:00 PM
3:20:00 PM
4:00:00 PM
4:40:00 PM
5:20:00 PM
6:00:00 PM
6:40:00 PM
7:20:00 PM
8:00:00 PM
8:40:00 PM
9:20:00 PM
10:00:00 PM
10:40:00 PM
11:20:00 PM
Time (hh:mm:ss)
Noise Level


Baseline Noise Monitoring Results for $L_{Aeq(5mins)}$, dB on 14 Jan 2020 at NM04
Baseline Noise Level, $L_{Aeq(5mins)}$, dB
85.0
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
12:00:00 AM
12:25:00 AM
12:50:00 AM
1:15:00 AM
1:40:00 AM
2:05:00 AM
2:30:00 AM
2:55:00 AM
3:20:00 AM
3:45:00 AM
4:10:00 AM
4:35:00 AM
5:00:00 AM
5:25:00 AM
5:50:00 AM
6:15:00 AM
6:40:00 AM
7:05:00 AM
7:30:00 AM
7:55:00 AM
8:20:00 AM
8:45:00 AM
9:10:00 AM
9:35:00 AM
10:00:00 AM
10:25:00 AM
10:50:00 AM
11:15:00 AM
11:40:00 AM
12:05:00 PM
12:30:00 PM
12:55:00 PM
1:20:00 PM
1:45:00 PM
2:10:00 PM
Time (hh:mm:ss)
Noise Level

Appendix D

Noise and Vibration Logger Calibration Certificates

Calibration Certificate

Calibration Number: 190301000591

Customer Name	:	Absolute Instrument Systems (Pte.) Ltd.	**Job Reference No**:	19030100
Customer Address	:	11 Kallang Place, #06-03 Singapore 339155	**Certificate Issue Date**:	14/03/2019
Manufacturer	:	Svantek	**Calibration Date**:	14/03/2019
Item Description	:	Sound Level Meter Class I	**Test Conditions**:	
Model Number	:	SVAN 971	Ambient Temperature:	23 °C
Serial Number	:	80332	Relative Humidity:	53 %R.H.
Sub-Assemblies S/N	:	SV18 71580/ 7052E 66604	Pressure:	101.3 kPa

Absolute Laboratories Pte. Ltd. certifies that the above product listed was calibrated in compliance with a quality management system using the applicable and approved Absolute Laboratories Pte. Ltd. calibration procedures as specified.

The equipments used in the test and calibration of this instrument are traceable to the National Metrology Centre (NMC) Singapore and National Institute of Standards and Technology (NIST) U.S.

Calibration Method:

The instrument was calibrated following AL calibration procedure WI- 22-Rev-3

Calibration Equipment(s) Used			
Apparatus	**Serial Number**	**Cal Due Date**	**Certificate Number**
Arbitrary Function Generator	C012134	23/04/2019	RL001816
Actuator Supply	181056	18/12/2019	181201362801
Calibrator	QOG060008	26/10/2019	754438 QOG060008
Digital Multimeter	MY45034436	02/10/2019	1-10458563436-1

Ambient Condition Range:
Temperature: (20-26)°C , Humidity: (25-70)%RH, Pressure: (80-105)kPa

Calibration By : Julius W. Inumpa
Calibration Officer

Reviewed/Approved By : Rodrigo Manansala
Approving Officer

This calibration document shall not be reproduced except in full, without written approval of Absolute Laboratories Pte. Ltd.

Absolute Laboratories Pte. Ltd. is an affiliated company of Absolute Instrument Systems (Pte.) Ltd.

Absolute Laboratories Pte. Ltd.
11 Kallang Place #06-02 Singapore 339155
Tel: 65 6296 8012 Fax: 65 6296 3242

Calibration Certificate

Calibration Number: 190302030666

Customer Name	:	Absolute Instrument Systems (Pte.) Ltd.	**Job Reference No**:	19030203
Customer Address	:	11 Kallang Place, #06-03 Singapore 339155	**Certificate Issue Date**:	27/03/2019
Manufacturer	:	Svantek	**Calibration Date**:	27/03/2019
Item Description	:	Sound Level Meter Class I	**Test Conditions**:	
Model Number	:	SVAN 971	Ambient Temperature:	24 °C
Serial Number	:	60666	Relative Humidity:	55 %R.H.
Sub-Assemblies S/N	:	SV18 58934/ 7052E 65586	Pressure:	101.4 kPa

Absolute Laboratories Pte. Ltd. certifies that the above product listed was calibrated in compliance with a quality management system using the applicable and approved Absolute Laboratories Pte. Ltd. calibration procedures as specified.

The equipments used in the test and calibration of this instrument are traceable to the National Metrology Centre (NMC) Singapore and National Institute of Standards and Technology (NIST) U.S.

Calibration Method:

The instrument was calibrated following AL calibration procedure WI- 22-Rev-3

Calibration Equipment(s) Used			
Apparatus	**Serial Number**	**Cal Due Date**	**Certificate Number**
Arbitrary Function Generator	C012134	23/04/2019	RL001816
Actuator Supply	181056	18/12/2019	181201362801
Calibrator	QOG060008	26/10/2019	754438 QOG060008
Digital Multimeter	MY45034436	02/10/2019	1-10458563436-1

Ambient Condition Range:
Temperature: (20-26)°C , Humidity: (25-70)%RH, Pressure: (80-105)kPa

Calibration By : Julius W. Inumpa
Calibration Officer

Reviewed/Approved By : Rodrigo Manansala
Approving Officer

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Absolute Laboratories Pte. Ltd.
11 Kallang Place #06-02 Singapore 339155
Tel: 65 6296 8012 Fax: 65 6296 3242

Calibration Certificate

Calibration Number: 190500641074

Customer Name	:	Absolute Instrument Systems (Pte.) Ltd.	**Job Reference No**:	19050064
Customer Address	:	11 Kallang Place, #06-03 Singapore 339155	**Certificate Issue Date**:	09/05/2019
Manufacturer	:	Svantek	**Calibration Date**:	09/05/2019
Item Description	:	Sound Level Meter Class I	**Test Conditions**:	
Model Number	:	SVAN 971	Ambient Temperature:	23 °C
Serial Number	:	61504	Relative Humidity:	51 %R.H.
Sub-Assemblies S/N	:	7052E 67970	Pressure:	101.3 kPa

Absolute Laboratories Pte. Ltd. certifies that the above product listed was calibrated in compliance with a quality management system using the applicable and approved Absolute Laboratories Pte. Ltd. calibration procedures as specified.

The equipments used in the test and calibration of this instrument are traceable to the National Metrology Centre (NMC) Singapore and National Institute of Standards and Technology (NIST) U.S.

Calibration Method:

The instrument was calibrated following AL calibration procedure WI- 47-Rev-3

Calibration Equipment(s) Used			
Apparatus	**Serial Number**	**Cal Due Date**	**Certificate Number**
Multifunction Acoustic Calibrator	3094457	31/07/2019	CDK1806063
Digital Multimeter	MY57225429	22/01/2020	1-10829807862-1
Arbitrary Function Generator	C010657	09/07/2019	RL001845

Ambient Condition Range:
Temperature: (20-26)°C , Humidity: (25-70)%RH, Pressure: (80-105)kPa

Calibration By : Julius W. Inumpa
Calibration Officer

Reviewed/Approved By : Rodrigo Manansala
Approving Officer

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Absolute Laboratories Pte. Ltd. is an affiliated company of Absolute Instrument Systems (Pte.) Ltd.

Absolute Laboratories Pte. Ltd.
11 Kallang Place #06-02 Singapore 339155
Tel: 65 6296 8012 Fax: 65 6296 3242

Certificate of Calibration

Certificate No.: 475066194

Object:	Precision Sound Level Meter Nor131
Supplier:	Norsonic AS
Type:	Nor131
Serial number:	1313989
Client:	AECOM SINGAPORE PTE LTD

This instrument is tested and calibrated in accordance to the Norsonic production standard set for Nor131, ensuring that the instrument conforms to the following standards;

IEC 61672-1:2002 class 1
IEC 61260-1 class 1 Ed 1.0 2014-02
ANSI S1.4-1983 (R2001) with amd. S1.4A-1985 class 1
ANSI S1.43-1997 (R2002) class 1
ANSI S1.11-2004 class 1
DIN 45 657, Applicable parts
IEC 61094 part 4

Instrumentation used for calibration traceable to:

Electrical Parameters: MT, Norway
Acoustical Parameters: PTB, Germany
Environmental Parameters: Justervesenet. Norway

FW version:	4.0.1312 2019-03-20 13:16r
Id no.:	5066194
Accessories:	Preamplifier type: 1207 S.no: 21146 Microphone type: 1228 S.no: 03138
Comments:	None

Date of calibration:	**Calibration interval recommended:**
2019-08-01	2 years

The environmental parameters applicable to this calibration are kept well within limits ensuring negligible deviation on obtained measurement results.

Calibrated by:
Anders Amundsen

Sign.

Norsonic
PO.BOX 24, N 3420 LIERSKOGEN, NORWAY
TEL: +47 32 85 89 00

Norsonic AS, P.B 24, 3421 Lierskogen. Visitor address: Gunnersbråtan 2, Tranby, Norway.
Phone +47 32858900 Fax.: +47 32852208. email: info@norsonic.com

Norsonic **Calibration Chart**

Model: Nor 1228 Serial No: 03138

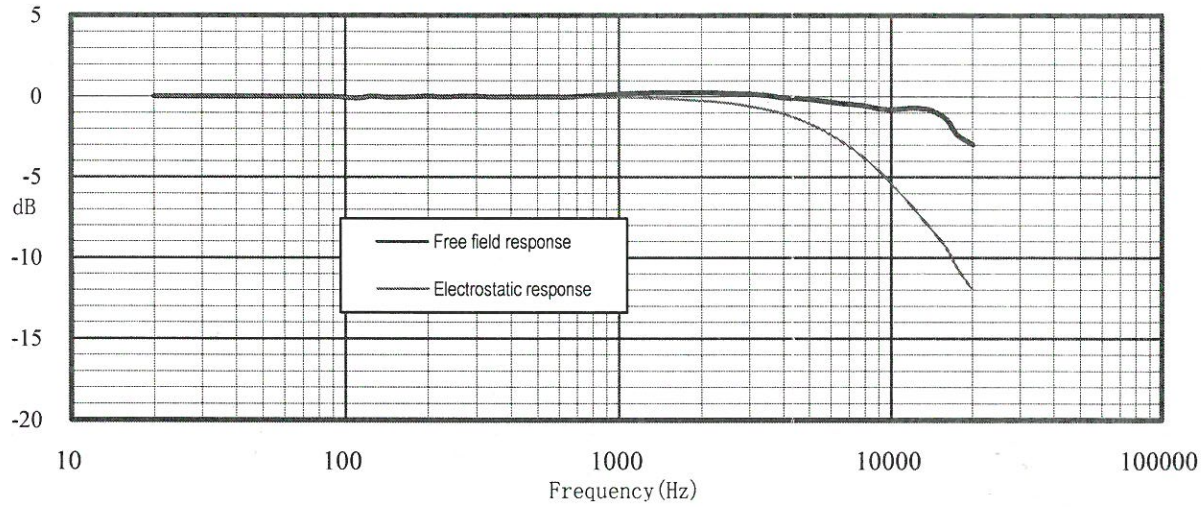
Open Circuit Sensitivity Level:

-26.0dB ref 1 V/Pa or 50.2mV/Pa @ 250Hz

Signature: _____ Date: 03/06/2019

Test Conditions:

Polarization Voltage : 0 V
Relative Humidity: 47%
Temperature: 22 ℃



CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: **SLM 22433 & FILT 4574**

Equipment Description:	Sound & Vibration Analyser		
Manufacturer:	Svantek		
Model No:	Svan-977	**Serial No:**	36828
Microphone Type:	7052E	**Serial No:**	59466
Filter Type:	1/3 Octave	**Serial No:**	36828
Comments:	All tests passed for class 1. (See over for details)		
Owner:	AECOM Singapore Pte Ltd 300 Beach Rd #03-00,The Concourse Singapore 199555		
Ambient Pressure:	1000 hPa ±1.5 hPa		
Temperature:	24 °C ±2° C	**Relative Humidity:**	51% ±5%
Date of Calibration:	29/03/2018	**Issue Date:**	03/04/2018

Acu-Vib Test Procedure: AVP10 (SLM) & AVP06 (Filters)

CHECKED BY: ..... **AUTHORISED SIGNATURE:** .....

Jack Kelt

Accredited for compliance with ISO/IEC 17025 - Calibration
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA
WORLD RECOGNISED ACCREDITATION

Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB
ELECTRONICS

HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

CERTIFICATE NO.: SLM 22433 & FILT 4574

The performance characteristics listed below were tested. The tests are based on the relevant clauses of IEC 61672-3:2013

Tests Performed:	*Clause*	*Result*
Absolute Calibration	10	Pass
Acoustical Frequency Weighting	12	Pass
Self Generated Noise	11.1	Entered
Electrical Noise	11.2	Entered
Long Term Stability	15	Pass
Electrical Frequency Weightings	13	Pass
Frequency and Time Weightings	14	Pass
Reference Level Linearity	16	Pass
Range Level Linearity	17	Pass
Toneburst	18	Pass
Peak C Sound Level	19	Pass
Overload Indicator	20	Pass
High Level Stability	21	Pass

Statement of Compliance: The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent organization responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2013, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013, the sound level meter submitted for testing conforms to the class 1 requirements of IEC61672-1:2013.
A full technical report is available if required.

This Sound Level Meter included an Octave Filter Set. Tests were based on IEC 1260: 1995 and AS/NZS 4476 - 1997 and were conducted to test the following performance characteristics:

1. Relative attenuation clause 5.3

Least uncertainty for relative attenuation (at 95% c.l.) k=2:
±0.1 dB for attenuation equal to an less than 6 dB
±0.3 dB for RA from above 6 dB to 18 dB
±0.6 dB for RA from above 18 dB to 80 dB

Date of Calibration: 29/03/2018 **Issue Date:** 03/04/2018

Checked by: ...

Accredited for compliance with ISO/IEC 17025 - Calibration
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA
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Appendix E

Noise Sensitive Receptors List

Noise Sensitive Receptors for Construction Noise

No.	Receptor	Classification of Affected Premises	Nearest Distance to the Construction Site Boundary (m)	Receptor Sensitivity	Nearest Noise Logger
1	Bukit Brown MRT Station	Commercial	120	3	NM02
2	Offisde Futsal Park	Commercial	60	3	NM01
3	Singapore Polo Club	Commercial	52	3	NM01
4	Catholic Junior College	Education	92	1	NM04
5	EtonHouse Pre-School (Thomson)	Education	111	1	NM01
6	Saint Joseph Institute	Education	55	1	NM01
7	James Tan Veterinary Centre	Medical	114	1	NM04
8	Lee Ah Mooi Old Age Home	Medical	80	1	NM01
9	131F,G Whitley Road	Residential	116	2	NM04
10	131H,J Whitley Road	Residential	115	2	NM04
11	159 Mount Pleasant Road	Residential	52	2	NM02
12	27 Mount Pleasant Drive	Residential	90	2	NM03
13	1 Bo Seng Avenue	Residential	85	2	NM04
14	10,12 Bo Seng Avenue	Residential	84	2	NM04
15	101,103 Whitley Road	Residential	89	2	NM04
16	11 Malcolm Road	Residential	140	2	NM04
17	11 Mount Pleasant Drive	Residential	136	2	NM03
18	111A Whitley Road	Residential	98	2	NM04
19	111B,113,113A,B Whitley Road	Residential	75	2	NM04
20	115 Whitley Road	Residential	72	2	NM04
21	115A,B,C,D,E Whitley Road	Residential	75	2	NM04
22	115K,J,H,G,F Whitley Road	Residential	75	2	NM04
23	117 Whitley Road	Residential	80	2	NM04
24	119 Whitley Road	Residential	113	2	NM04
25	119A Whitley Road	Residential	136	2	NM04
26	121 Whitley Road	Residential	115	2	NM04
27	121C,121A Whitley Road	Residential	92	2	NM04
28	121D,121E Whitley Road	Residential	74	2	NM04
29	121F,121G Whitey Road	Residential	74	2	NM04
30	121H,121J Whitley Road	Residential	92	2	NM04
31	131C,B Whitley Road	Residential	140	2	NM04
32	131D,E Whitley Road	Residential	127	2	NM04
33	133,133A Whitley Road	Residential	126	2	NM04
34	133B,C Whitley Road	Residential	142	2	NM04
35	133D,E Whitley Road	Residential	148	2	NM04
36	133F,G Whitley Road	Residential	149	2	NM04
37	14,16,16A,16B Bo Seng Avenue	Residential	135	2	NM04
38	147 Mount Pleasant Road	Residential	109	2	NM02
39	149 Mount pleasant Road	Residential	60	2	NM02
40	15 Malcolm Road	Residential	135	2	NM04
41	150 Mount Pleasant Road	Residential	57	2	NM02
42	151 Mount Pleasant Road	Residential	40	2	NM02
43	152 Mount Pleasant Road	Residential	122	2	NM02
44	154 Mount Pleasant Road	Residential	119	2	NM02
45	155 Mount Pleasant Road	Residential	41	2	NM02
46	156 Mount Pleasant Road	Residential	108	2	NM02
47	157 Mount Pleasant Road	Residential	73	2	NM02
48	157A Mount Pleasant Road	Residential	10	2	NM02
49	157B Mount Pleasant Road	Residential	18	2	NM02

50	157C Mount Pleasant Road	Residential	10	2	NM02
51	158 Mount Pleasant Road	Residential	126	2	NM02
52	160 Mount Pleasant Road	Residential	110	2	NM02
53	161 Mount Pleasant Road	Residential	20	2	NM02
54	162 Mount Pleasant Road	Residential	63	2	NM02
55	164 Mount Pleasant Road	Residential	40	2	NM02
56	166 Mount Pleasant Road	Residential	60	2	NM02
57	17A Merryn Road	Residential	145	2	NM04
58	18 Mount Pleasant Drive	Residential	44	2	NM03
59	180 Mount Pleasant Road	Residential	67	2	NM03
60	182 Mount Pleasant Road	Residential	25	2	NM03
61	184 Mount Pleasant Road	Residential	20	2	NM03
62	19 Merryn Road	Residential	113	2	NM04
63	2 Dyson Road	Residential	110	2	NM04
64	20 Malcolm Road	Residential	94	2	NM04
65	20 Merryn Road	Residential	149	2	NM04
66	20A Merryn Road	Residential	145	2	NM04
67	21 Merryn Road	Residential	111	2	NM04
68	22 Malcolm Road	Residential	140	2	NM04
69	22 Mount Pleasant Drive	Residential	104	2	NM03
70	23 Merryn Road	Residential	105	2	NM04
71	23 Mount Pleasant Drive	Residential	63	2	NM03
72	25 Merryn Road	Residential	124	2	NM04
73	26 Mount Pleasant Drive	Residential	143	2	NM03
74	27 Jalan Mendaki	Residential	41	2	NM03
75	27/27A Merryn Road	Residential	108	2	NM04
76	28 Mount Pleasant Drive	Residential	149	2	NM03
77	28A Merryn Road	Residential	149	2	NM04
78	29 Merryn Road	Residential	85	2	NM04
79	3 Gymkhana Avenue	Residential	75	2	NM02
80	3,5 Bo Seng Avenue	Residential	97	2	NM04
81	30 Malcolm Road	Residential	108	2	NM04
82	30 Merryn Road	Residential	138	2	NM04
83	31 Merryn Road	Residential	64	2	NM04
84	31/33 Merryn Avenue	Residential	139	2	NM04
85	31A Merryn Road	Residential	60	2	NM04
86	32 Merryn Road	Residential	124	2	NM04
87	33 Merryn Road	Residential	89	2	NM04
88	34 Merryn Road	Residential	145	2	NM04
89	35 Merryn Road	Residential	86	2	NM04
90	35/37 Merryn Avenue	Residential	123	2	NM04
91	36 -46 Merryn Avenue	Residential	149	2	NM04
92	37 Merryn Road	Residential	62	2	NM04
93	39 Merryn Avenue	Residential	119	2	NM04
94	39 Merryn Road	Residential	59	2	NM04
95	4 Gymkhana Avenue	Residential	42	2	NM02
96	4,4A Dyson Road	Residential	150	2	NM04
97	40A Merryn Road	Residential	136	2	NM04
98	41 Merryn Road	Residential	76	2	NM04
99	42 Merryn Road	Residential	125	2	NM04
100	42A Merryn Road	Residential	112	2	NM04
101	43 Merryn Road	Residential	74	2	NM04
102	43A Merryn Road	Residential	77	2	NM04
103	44 Merryn Road	Residential	118	2	NM04

104	45 Merryn Road	Residential	55	2	NM04
105	46 Merryn Road	Residential	140	2	NM04
106	47 Merryn Road	Residential	54	2	NM04
107	49 Merryn Road	Residential	76	2	NM04
108	49A Merryn Road	Residential	75	2	NM04
109	4D Dyson Road	Residential	131	2	NM04
110	51 Merryn Road	Residential	74	2	NM04
111	51A Merryn Road	Residential	78	2	NM04
112	52A Merryn Road	Residential	147	2	NM04
113	53 Merryn Road	Residential	62	2	NM04
114	53A Merryn Road	Residential	66	2	NM04
115	54 Merryn Road	Residential	121	2	NM04
116	55 Merryn Road	Residential	65	2	NM04
117	56 Merryn Road	Residential	130	2	NM04
118	56A Merryn Road	Residential	138	2	NM04
119	57 Merryn Road	Residential	82	2	NM04
120	57A Merryn Road	Residential	92	2	NM04
121	59 Merryn Road	Residential	110	2	NM04
122	59A Merryn Road	Residential	90	2	NM04
123	6 Gymkhana Avenue	Residential	100	2	NM02
124	61 Merryn Road	Residential	75	2	NM04
125	61A Merryn Road	Residential	77	2	NM04
126	63 Merryn Road	Residential	93	2	NM04
127	65 Merryn Road	Residential	122	2	NM04
128	67 Merryn Road	Residential	132	2	NM04
129	7 Gymkhana Avenue	Residential	100	2	NM02
130	8 Gymkhana Avenue	Residential	105	2	NM02
131	9 Bo Seng Avenue	Residential	150	2	NM04
132	95 Whitley Road	Residential	101	2	NM04
133	97 Whitley Road	Residential	101	2	NM04
134	Montclair@Whitley	Residential	132	2	NM04

Appendix F

Construction Timeline from Client

Proposed Residential Development at Mt Pleasant

Activity by sequence [General activity in sequence]	Typical construction activity for each general activity]	PME [Breakdown of all Construction Equipment used for that particular construction activity]	No [Quantity of that particular construction equipment used for that particular construction activity]	On-time(%) / daily working hours [how long in percentage that particular equipment will be used in a day]	Approximate no of months for this activity [in months]	Working hours per day [please indicate the working hours of every phase . Eg., 7am to 7pm, 6am to 10pm or 24 hrs]
1. Demolition - 10 months (4Q 2020)						
1	Removal of abandon steel element, debris eg damage window frames,doors, internal & external building furnitures etc and delivery steel plates, scaffoldings and hoarding boards for Safety Nets & dust control curtains	Lorry Cranes	2	50%	10	8am to 7pm
2	Hacking of minor structure	Hand held Breaker	4	50%	10	
3	Hacking of major structural on buildings	Excavator mounted with Breaker	4	50%	10	
4	Removal of foundation & spoils	Excavator	4	50%	10	
5	Removal of Debris	Dump Trucks	4	50%	10	
1a. Road Works - AECOM assumption based on typical road work construction sequence						
1	Clearing and Excavation	Excavator	1	50%	10	8am to 7pm
2	Mounting	Excavator	1	50%	10	
3	Fine Grading/Surface Levelling	Grader	1	50%	10	
4	Aggregate Base (Aggregate Laying Truck)	Concrete Truck	1	50%	10	
5	Asphalt Paving	Roller	1	50%	10	
2. Clearance for Construction Area -20 months (from 3Q 2023)						
1	Earthworks to prepare platform	Excavator	8	50%	20	8am to 7pm
		Lorry	50	50%		
		Generator	2	50%		
		Excavator	4	50%		
		Concrete Vibrator	1	50%		
		Air Compressor	1	50%		
		Concrete truck	0	50%		
2	Construction Access	Lorry	1	50%	20	
		Excavator	1	50%		
3. Foundation Work (Substructures including piles and pile caps) -10 months (from 2Q 2025)						
1	Erection of crawler crane & boring rig	Mobile Crane	1	50%	8	8am to 7pm
2	Installation of Casing	Crawler Crane	3	50%	8	
3	Boring Work	Bored Piling Machine	6	50%	8	
4	Rebar Cage & Tremix Pipe Installation	Crawler Crane	3	50%	8	
5	Concreting works	Ready Mix Concrete Truck & crawler crane	3	50%	8	
6	Pile Head hacking	Excavator via breaker and 40 pounds breaker	3	50%	8	
7	Hot works - welding of steel beams, brackets, etc	Welding Equipment	1	50%	8	
8	Delivery of Steel sections	40 ft Trailer	2	50%	8	
9	Hoisting of Waler & Struts	Excavator with lifting appliance	1	50%	2	
10	Stage excavation for walers & struts	Excavator with lifting appliance	1	50%	2	
11	Stage Excavation	Excavator	4	50%	2	
		Mini Excavator	2	50%		
12	Spoi and slurry removal	Dump trucks	2	50%	2	
4. Superstructure (Prefab installation) -20 months (from 1Q 2026)						
1	Pumping of water from ground or rain	Temporary Water Pump	2	50%	20	8am to 7pm
2	Power supply for lighting, pumps and temporary ventilation fans	Generator	2	50%	20	
3	Excavation below surface for working platform	Excavator	4	50%	20	
4	Stage Excavation to prepare Lean concrete	Mini Excavator	2	50%	20	
5	Excavation below surface - removal of spoil	Crane	2	50%	20	
6	Spoil removal	Dump Trucks	2	50%	20	
7	Air compressor for cleaning formwork before casting	Compressor	1	50%	20	
8	Handle re-bar & hoisting of false work, scaffolding, temporary working platforms	Mobile Crane	1	50%	20	
9	For Casting	Ready Mix Concrete Truck	2	50%	20	
		Concrete pump	1	50%		
5. Landscape Works - from 1Q 2028						
1	Landscape works	Generator	2	50%	XX	8am to 7pm
		Excavator mounted sheet pile vibrator	2	50%	XX	
		Mobile Crane, 50T	2	50%	XX	
		welding/cutting equipment	4	50%	XX	
6. Remove all temporary works and re-instatement - from 4Q 2028						
1	Removal of ERSS	Generator	2	50%	XX	8am to 7pm
		Excavator mounted sheetpile vibrator	2	50%	XX	
		Mobile Crane, 50T	2	50%	XX	
		Welding/Cutting equipment	4	50%	XX	
2	Reininstate working area to original condition or required condition	Lorry	2	50%	XX	

Appendix G

Noise Pre and Post Mitigation Results

Phase 1 "Pre" Mitigation Results						Criteria		Results		Exceedance	
No,	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 1 Laeq(12 Hrs)	Phase 1 Laeq(5 Mins)	Phase 1 Laeq(12 Hrs)	Phase 1 Laeq(5 Mins)
1	Bukit Brown MRT Station	Commercial	120	3	NM02	76	90	62	65	-	-
2	Offiside Futsal Park	Commercial	60	3	NM01	76	90	77	80	1	-
3	Singapore Polo Club	Commercial	52	3	NM01	76	90	78	81	2	-
4	Catholic Junior College	Education	92	1	NM04	73	77	76	79	3	2
5	EtonHouse Pre-School (Thomson)	Education	111	1	NM01	69	76	77	80	8	4
6	Saint Joseph Institute	Education	55	1	NM01	69	76	81	84	12	8
7	James Tan Veterinary Centre	Medical	114	1	NM04	73	77	70	73	-	-
8	Lee Ah Mooi Old Age Home	Medical	80	1	NM01	69	76	78	81	9	5
9	131F,G Whitley Road	Residential	116	2	NM04	77	90	77	80	-	-
10	131H,J Whitley Road	Residential	115	2	NM04	77	90	79	82	2	-
11	159 Mount Pleasant Road	Residential	52	2	NM02	76	90	73	76	-	-
12	27 Mount Pleasant Drive	Residential	90	2	NM03	75	90	67	70	-	-
13	1 Bo Seng Avenue	Residential	85	2	NM04	77	90	78	81	1	-
14	10,12 Bo Seng Avenue	Residential	84	2	NM04	77	90	78	81	1	-
15	101,103 Whitley Road	Residential	89	2	NM04	77	90	79	82	2	-
16	11 Malcolm Road	Residential	140	2	NM04	77	90	75	78	-	-
17	11 Mount Pleasant Drive	Residential	136	2	NM03	75	90	75	78	-	-
18	111A Whitley Road	Residential	98	2	NM04	77	90	79	82	2	-
19	111B,113,113A,B Whitley Road	Residential	75	2	NM04	77	90	78	81	1	-
20	115 Whitley Road	Residential	72	2	NM04	77	90	81	84	4	-
21	115A,B,C,D,E Whitley Road	Residential	75	2	NM04	77	90	78	81	1	-
22	115K,J,H,G,F Whitley Road	Residential	75	2	NM04	77	90	80	83	3	-
23	117 Whitley Road	Residential	80	2	NM04	77	90	79	82	2	-
24	119 Whitley Road	Residential	113	2	NM04	77	90	78	81	1	-
25	119A Whitley Road	Residential	136	2	NM04	77	90	78	81	1	-
26	121 Whitley Road	Residential	115	2	NM04	77	90	76	79	-	-
27	121C,121A Whitley Road	Residential	92	2	NM04	77	90	78	81	1	-
28	121D,121E Whitley Road	Residential	74	2	NM04	77	90	79	82	2	-
29	121F,121G Whitey Road	Residential	74	2	NM04	77	90	78	81	1	-
30	121H,121J Whitley Road	Residential	92	2	NM04	77	90	78	81	1	-
31	131C,B Whitley Road	Residential	140	2	NM04	77	90	75	78	-	-
32	131D,E Whitley Road	Residential	127	2	NM04	77	90	77	80	-	-
33	133,133A Whitley Road	Residential	126	2	NM04	77	90	78	81	1	-
34	133B,C Whitley Road	Residential	142	2	NM04	77	90	76	79	-	-
35	133D,E Whitley Road	Residential	148	2	NM04	77	90	76	79	-	-
36	133F,G Whitley Road	Residential	149	2	NM04	77	90	74	77	-	-
37	14,16,16A,16B Bo Seng Avenue	Residential	135	2	NM04	77	90	77	80	-	-
38	147 Mount Pleasant Road	Residential	109	2	NM02	76	90	70	73	-	-
39	149 Mount pleasant Road	Residential	60	2	NM02	76	90	74	77	-	-
40	15 Malcolm Road	Residential	135	2	NM04	77	90	73	76	-	-
41	150 Mount Pleasant Road	Residential	57	2	NM02	76	90	73	76	-	-
42	151 Mount Pleasant Road	Residential	40	2	NM02	76	90	79	82	3	-
43	152 Mount Pleasant Road	Residential	122	2	NM02	76	90	70	73	-	-
44	154 Mount Pleasant Road	Residential	119	2	NM02	76	90	67	70	-	-
45	155 Mount Pleasant Road	Residential	41	2	NM02	76	90	75	78	-	-
46	156 Mount Pleasant Road	Residential	108	2	NM02	76	90	69	72	-	-
47	157 Mount Pleasant Road	Residential	73	2	NM02	76	90	76	79	-	-
48	157A Mount Pleasant Road	Residential	10	2	NM02	76	90	76	79	-	-
49	157B Mount Pleasant Road	Residential	18	2	NM02	76	90	76	79	-	-
50	157C Mount Pleasant Road	Residential	10	2	NM02	76	90	75	78	-	-
51	158 Mount Pleasant Road	Residential	126	2	NM02	76	90	66	69	-	-
52	160 Mount Pleasant Road	Residential	110	2	NM02	76	90	68	71	-	-
53	161 Mount Pleasant Road	Residential	20	2	NM02	76	90	75	78	-	-
54	162 Mount Pleasant Road	Residential	63	2	NM02	76	90	71	74	-	-
55	164 Mount Pleasant Road	Residential	40	2	NM02	76	90	71	74	-	-
56	166 Mount Pleasant Road	Residential	60	2	NM02	76	90	72	75	-	-
57	17A Merryn Road	Residential	145	2	NM04	77	90	60	63	-	-
58	18 Mount Pleasant Drive	Residential	44	2	NM03	75	90	72	75	-	-
59	180 Mount Pleasant Road	Residential	67	2	NM03	75	90	75	78	-	-
60	182 Mount Pleasant Road	Residential	25	2	NM03	75	90	80	83	5	-
61	19 Merryn Road	Residential	113	2	NM04	77	90	59	62	-	-
62	2 Dyson Road	Residential	110	2	NM04	77	90	79	82	2	-
63	20 Malcolm Road	Residential	94	2	NM04	77	90	71	74	-	-
64	20 Merryn Road	Residential	149	2	NM04	77	90	60	63	-	-
65	20A Merryn Road	Residential	145	2	NM04	77	90	62	65	-	-
66	21 Merryn Road	Residential	111	2	NM04	77	90	61	64	-	-
67	22 Malcolm Road	Residential	140	2	NM04	77	90	73	76	-	-
68	22 Mount Pleasant Drive	Residential	104	2	NM03	75	90	69	72	-	-
69	23 Merryn Road	Residential	105	2	NM04	77	90	58	61	-	-
70	23 Mount Pleasant Drive	Residential	63	2	NM03	75	90	75	78	-	-
71	25 Merryn Road	Residential	124	2	NM04	77	90	58	61	-	-
72	26 Mount Pleasant Drive	Residential	143	2	NM03	75	90	66	69	-	-
73	27 Jalan Mendaki	Residential	41	2	NM03	75	90	67	70	-	-
74	27/27A Merryn Road	Residential	108	2	NM04	77	90	59	62	-	-
75	28 Mount Pleasant Drive	Residential	149	2	NM03	75	90	64	67	-	-
76	28A Merryn Road	Residential	149	2	NM04	77	90	64	67	-	-
77	29 Merryn Road	Residential	85	2	NM04	77	90	59	62	-	-
78	3 Gymkhana Avenue	Residential	75	2	NM02	76	90	69	72	-	-
79	3,5 Bo Seng Avenue	Residential	97	2	NM04	77	90	79	82	2	-
80	30 Malcolm Road	Residential	108	2	NM04	77	90	71	74	-	-
81	30 Merryn Road	Residential	138	2	NM04	77	90	61	64	-	-
82	31 Merryn Road	Residential	64	2	NM04	77	90	60	63	-	-
83	31/33 Merryn Avenue	Residential	139	2	NM04	77	90	64	67	-	-
84	31A Merryn Road	Residential	60	2	NM04	77	90	59	62	-	-
85	32 Merryn Road	Residential	124	2	NM04	77	90	61	64	-	-
86	33 Merryn Road	Residential	89	2	NM04	77	90	60	63	-	-
87	34 Merryn Road	Residential	145	2	NM04	77	90	64	67	-	-
88	35 Merryn Road	Residential	86	2	NM04	77	90	62	65	-	-
89	35/37 Merryn Avenue	Residential	123	2	NM04	77	90	67	70	-	-
90	36 -46 Merryn Avenue	Residential	149	2	NM04	77	90	68	71	-	-
91	37 Merryn Road	Residential	62	2	NM04	77	90	59	62	-	-
92	39 Merryn Avenue	Residential	119	2	NM04	77	90	69	72	-	-
93	39 Merryn Road	Residential	59	2	NM04	77	90	59	62	-	-
94	4 Gymkhana Avenue	Residential	42	2	NM02	76	90	70	73	-	-
95	4,4A Dyson Road	Residential	150	2	NM04	77	90	75	78	-	-
96	40A Merryn Road	Residential	136	2	NM04	77	90	63	66	-	-
97	41 Merryn Road	Residential	76	2	NM04	77	90	60	63	-	-
98	42 Merryn Road	Residential	125	2	NM04	77	90	66	69	-	-
99	42A Merryn Road	Residential	112	2	NM04	77	90	64	67	-	-
100	43 Merryn Road	Residential	74	2	NM04	77	90	60	63	-	-
101	43A Merryn Road	Residential	77	2	NM04	77	90	65	68	-	-
102	44 Merryn Road	Residential	118	2	NM04	77	90	64	67	-	-
103	45 Merryn Road	Residential	55	2	NM04	77	90	62	65	-	-
104	46 Merryn Road	Residential	140	2	NM04	77	90	64	67	-	-
105	47 Merryn Road	Residential	54	2	NM04	77	90	64	67	-	-
106	49 Merryn Road	Residential	76	2	NM04	77	90	58	61	-	-
107	49A Merryn Road	Residential	75	2	NM04	77	90	62	65	-	-
108	4D Dyson Road	Residential	131	2	NM04	77	90	75	78	-	-
109	51 Merryn Road	Residential	74	2	NM04	77	90	62	65	-	-
110	51A Merryn Road	Residential	78	2	NM04	77	90	63	66	-	-
111	52A Merryn Road	Residential	147	2	NM04	77	90	67	70	-	-
112	53 Merryn Road	Residential	62	2	NM04	77	90	64	67	-	-
113	53A Merryn Road	Residential	66	2	NM04	77	90	66	69	-	-
114	54 Merryn Road	Residential	121	2	NM04	77	90	66	69	-	-
115	55 Merryn Road	Residential	65	2	NM04	77	90	69	72	-	-
116	56 Merryn Road	Residential	130	2	NM04	77	90	65	68	-	-
117	56A Merryn Road	Residential	138	2	NM04	77	90	64	67	-	-
118	57 Merryn Road	Residential	82	2	NM04	77	90	65	68	-	-

Phase 1 "Pre" Mitigation Results						Criteria		Results		Exceedance	
No,	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 1 Laeq(12 Hrs)	Phase 1 Laeq(5 Mins)	Phase 1 Laeq(12 Hrs)	Phase 1 Laeq(5 Mins)
119	57A Merryn Road	Residential	92	2	NM04	77	90	65	68	-	-
120	59 Merryn Road	Residential	110	2	NM04	77	90	65	68	-	-
121	59A Merryn Road	Residential	90	2	NM04	77	90	62	65	-	-
122	6 Gymkhana Avenue	Residential	100	2	NM02	76	90	69	72	-	-
123	61 Merryn Road	Residential	75	2	NM04	77	90	65	68	-	-
124	61A Merryn Road	Residential	77	2	NM04	77	90	70	73	-	-
125	63 Merryn Road	Residential	93	2	NM04	77	90	68	71	-	-
126	65 Merryn Road	Residential	122	2	NM04	77	90	68	71	-	-
127	67 Merryn Road	Residential	132	2	NM04	77	90	66	69	-	-
128	7 Gymkhana Avenue	Residential	100	2	NM02	76	90	68	71	-	-
129	8 Gymkhana Avenue	Residential	105	2	NM02	76	90	70	73	-	-
130	9 Bo Seng Avenue	Residential	150	2	NM04	77	90	78	81	1	-
131	95 Whitley Road	Residential	101	2	NM04	77	90	78	81	1	-
132	97 Whitley Road	Residential	101	2	NM04	77	90	78	81	1	-
133	Montclair@Whitley	Residential	132	2	NM04	77	90	76	79	-	-
E1	Bamboo Cluster 1	Ecological		1	NM04	73	77	59	62	-	-
E2	Bamboo Cluster 2	Ecological		1	NM04	73	77	58	61	-	-
E3	Bamboo Cluster 3	Ecological		1	NM03	73	77	55	58	-	-
E4	Bamboo Cluster 4	Ecological		1	NM03	73	77	54	57	-	-
E5	Bamboo Cluster 5	Ecological		1	NM03	73	77	55	58	-	-
E6	Bamboo Cluster 6	Ecological		1	NM03	73	77	55	58	-	-
E7	Bamboo Cluster 7	Ecological		1	NM03	73	77	58	61	-	-
E8	Bamboo Cluster 8	Ecological		1	NM02	65	75	69	72	4	-
E9	Bamboo Cluster 9	Ecological		1	NM02	65	75	70	73	5	-
E10	Bamboo Cluster 10	Ecological		1	NM03	65	75	63	66	-	-
E11	Bamboo Cluster 11	Ecological		1	NM02	70	76	73	76	3	-
E12	Bamboo Cluster 12	Ecological		1	NM01	69	76	82	85	13	9
E13	Bamboo Cluster 13	Ecological		1	NM01	69	76	81	84	12	8
E14	Bamboo Cluster 14	Ecological		1	NM01	69	76	83	86	14	10
E15	Bamboo Cluster 15	Ecological		1	NM01	69	76	79	82	10	6
E16	Stream 1 No.1	Ecological		1	NM02	70	76	68	71	-	-
E17	Stream 1 No.2	Ecological		1	NM02	70	76	70	73	-	-
E18	Stream 1 No.3	Ecological		1	NM02	70	76	71	74	1	-
E19	Stream 1 No.4	Ecological		1	NM02	70	76	76	79	6	3
E20	Stream 1 No.5	Ecological		1	NM02	70	76	78	81	8	5
E21	Stream 1 No.6	Ecological		1	NM02	70	76	84	87	14	11
E22	Stream 1 No.7	Ecological		1	NM02	70	76	83	86	13	10
E23	Stream 1 No.8	Ecological		1	NM01	69	76	86	89	17	13
E24	Stream 1 No.9	Ecological		1	NM01	69	76	84	87	15	11
E25	Stream 2 No.1	Ecological		1	NM03	65	75	63	66	-	-
E26	Stream 2 No.2	Ecological		1	NM03	65	75	63	66	-	-
E27	Stream 3 No.1	Ecological		1	NM04	73	77	55	58	-	-
E28	Stream 3 No.2	Ecological		1	NM04	73	77	55	58	-	-
E29	Near Stream 2 No.1	Ecological		1	NM03	65	75	68	71	3	-
E30	Near Stream 2 No.2	Ecological		1	NM03	65	75	61	64	-	-

Phase 2 "Pre" Mitigation Results						Criteria		Results		Exceedance	
No,	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 2 Laeq(12 Hrs)	Phase 2 Laeq(5 Mins)	Phase 2 Laeq(12 Hrs)	Phase 2 Laeq(5 Mins)
1	Bukit Brown MRT Station	Commercial	120	3	NM02	76	90	43	46	-	-
2	Offside Futsal Park	Commercial	60	3	NM01	76	90	46	49	-	-
3	Singapore Polo Club	Commercial	52	3	NM01	76	90	50	53	-	-
4	Catholic Junior College	Education	92	1	NM04	73	77	53	56	-	-
5	EtonHouse Pre-School (Thomson)	Education	111	1	NM01	69	76	47	50	-	-
6	Saint Joseph Institute	Education	55	1	NM01	69	76	54	57	-	-
7	James Tan Veterinary Centre	Medical	114	1	NM04	73	77	52	55	-	-
8	Lee Ah Mooi Old Age Home	Medical	80	1	NM01	69	76	49	52	-	-
9	131F,G Whitley Road	Residential	116	2	NM04	77	90	47	50	-	-
10	131H,J Whitley Road	Residential	115	2	NM04	77	90	48	51	-	-
11	159 Mount Pleasant Road	Residential	52	2	NM02	76	90	53	56	-	-
12	27 Mount Pleasant Drive	Residential	90	2	NM03	75	90	49	52	-	-
13	1 Bo Seng Avenue	Residential	85	2	NM04	77	90	47	50	-	-
14	10,12 Bo Seng Avenue	Residential	84	2	NM04	77	90	48	51	-	-
15	101,103 Whitley Road	Residential	89	2	NM04	77	90	48	51	-	-
16	11 Malcolm Road	Residential	140	2	NM04	77	90	50	53	-	-
17	11 Mount Pleasant Drive	Residential	136	2	NM03	75	90	55	58	-	-
18	111A Whitley Road	Residential	98	2	NM04	77	90	48	51	-	-
19	111B,113,113A,B Whitley Road	Residential	75	2	NM04	77	90	48	51	-	-
20	115 Whitley Road	Residential	72	2	NM04	77	90	50	53	-	-
21	115A,B,C,D,E Whitley Road	Residential	75	2	NM04	77	90	48	51	-	-
22	115K,J,H,G,F Whitley Road	Residential	75	2	NM04	77	90	49	52	-	-
23	117 Whitley Road	Residential	80	2	NM04	77	90	50	53	-	-
24	119 Whitley Road	Residential	113	2	NM04	77	90	49	52	-	-
25	119A Whitley Road	Residential	136	2	NM04	77	90	48	51	-	-
26	121 Whitley Road	Residential	115	2	NM04	77	90	48	51	-	-
27	121C,121A Whitley Road	Residential	92	2	NM04	77	90	49	52	-	-
28	121D,121E Whitley Road	Residential	74	2	NM04	77	90	49	52	-	-
29	121F,121G Whitey Road	Residential	74	2	NM04	77	90	50	53	-	-
30	121H,121J Whitley Road	Residential	92	2	NM04	77	90	50	53	-	-
31	131C,B Whitley Road	Residential	140	2	NM04	77	90	45	48	-	-
32	131D,E Whitley Road	Residential	127	2	NM04	77	90	47	50	-	-
33	133,133A Whitley Road	Residential	126	2	NM04	77	90	48	51	-	-
34	133B,C Whitley Road	Residential	142	2	NM04	77	90	47	50	-	-
35	133D,E Whitley Road	Residential	148	2	NM04	77	90	46	49	-	-
36	133F,G Whitley Road	Residential	149	2	NM04	77	90	47	50	-	-
37	14,16,16A,16B Bo Seng Avenue	Residential	135	2	NM04	77	90	47	50	-	-
38	147 Mount Pleasant Road	Residential	109	2	NM02	76	90	44	47	-	-
39	149 Mount pleasant Road	Residential	60	2	NM02	76	90	47	50	-	-
40	15 Malcolm Road	Residential	135	2	NM04	77	90	49	52	-	-
41	150 Mount Pleasant Road	Residential	57	2	NM02	76	90	46	49	-	-
42	151 Mount Pleasant Road	Residential	40	2	NM02	76	90	54	57	-	-
43	152 Mount Pleasant Road	Residential	122	2	NM02	76	90	43	46	-	-
44	154 Mount Pleasant Road	Residential	119	2	NM02	76	90	41	44	-	-
45	155 Mount Pleasant Road	Residential	41	2	NM02	76	90	52	55	-	-
46	156 Mount Pleasant Road	Residential	108	2	NM02	76	90	44	47	-	-
47	157 Mount Pleasant Road	Residential	73	2	NM02	76	90	53	56	-	-
48	157A Mount Pleasant Road	Residential	10	2	NM02	76	90	56	59	-	-
49	157B Mount Pleasant Road	Residential	18	2	NM02	76	90	59	62	-	-
50	157C Mount Pleasant Road	Residential	10	2	NM02	76	90	59	62	-	-
51	158 Mount Pleasant Road	Residential	126	2	NM02	76	90	44	47	-	-
52	160 Mount Pleasant Road	Residential	110	2	NM02	76	90	48	51	-	-
53	161 Mount Pleasant Road	Residential	20	2	NM02	76	90	57	60	-	-
54	162 Mount Pleasant Road	Residential	63	2	NM02	76	90	53	56	-	-
55	164 Mount Pleasant Road	Residential	40	2	NM02	76	90	55	58	-	-
56	166 Mount Pleasant Road	Residential	60	2	NM02	76	90	56	59	-	-
57	17A Merryn Road	Residential	145	2	NM04	77	90	52	55	-	-
58	18 Mount Pleasant Drive	Residential	44	2	NM03	75	90	53	56	-	-
59	180 Mount Pleasant Road	Residential	67	2	NM03	75	90	55	58	-	-
60	182 Mount Pleasant Road	Residential	25	2	NM03	75	90	55	58	-	-
61	19 Merryn Road	Residential	113	2	NM04	77	90	54	57	-	-
62	2 Dyson Road	Residential	110	2	NM04	77	90	47	50	-	-
63	20 Malcolm Road	Residential	94	2	NM04	77	90	47	50	-	-
64	20 Merryn Road	Residential	149	2	NM04	77	90	52	55	-	-
65	20A Merryn Road	Residential	145	2	NM04	77	90	53	56	-	-
66	21 Merryn Road	Residential	111	2	NM04	77	90	56	59	-	-
67	22 Malcolm Road	Residential	140	2	NM04	77	90	48	51	-	-
68	22 Mount Pleasant Drive	Residential	104	2	NM03	75	90	49	52	-	-
69	23 Merryn Road	Residential	105	2	NM04	77	90	56	59	-	-
70	23 Mount Pleasant Drive	Residential	63	2	NM03	75	90	55	58	-	-
71	25 Merryn Road	Residential	124	2	NM04	77	90	52	55	-	-
72	26 Mount Pleasant Drive	Residential	143	2	NM03	75	90	48	51	-	-
73	27 Jalan Mendaki	Residential	41	2	NM03	75	90	63	66	-	-
74	27/27A Merryn Road	Residential	108	2	NM04	77	90	52	55	-	-
75	28 Mount Pleasant Drive	Residential	149	2	NM03	75	90	47	50	-	-
76	28A Merryn Road	Residential	149	2	NM04	77	90	54	57	-	-
77	29 Merryn Road	Residential	85	2	NM04	77	90	57	60	-	-
78	3 Gymkhana Avenue	Residential	75	2	NM02	76	90	50	53	-	-
79	3,5 Bo Seng Avenue	Residential	97	2	NM04	77	90	48	51	-	-
80	30 Malcolm Road	Residential	108	2	NM04	77	90	48	51	-	-
81	30 Merryn Road	Residential	138	2	NM04	77	90	54	57	-	-
82	31 Merryn Road	Residential	64	2	NM04	77	90	57	60	-	-
83	31/33 Merryn Avenue	Residential	139	2	NM04	77	90	50	53	-	-
84	31A Merryn Road	Residential	60	2	NM04	77	90	57	60	-	-
85	32 Merryn Road	Residential	124	2	NM04	77	90	54	57	-	-
86	33 Merryn Road	Residential	89	2	NM04	77	90	54	57	-	-
87	34 Merryn Road	Residential	145	2	NM04	77	90	54	57	-	-
88	35 Merryn Road	Residential	86	2	NM04	77	90	55	58	-	-
89	35/37 Merryn Avenue	Residential	123	2	NM04	77	90	51	54	-	-
90	36 -46 Merryn Avenue	Residential	149	2	NM04	77	90	53	56	-	-
91	37 Merryn Road	Residential	62	2	NM04	77	90	58	61	-	-
92	39 Merryn Avenue	Residential	119	2	NM04	77	90	54	57	-	-
93	39 Merryn Road	Residential	59	2	NM04	77	90	58	61	-	-
94	4 Gymkhana Avenue	Residential	42	2	NM02	76	90	53	56	-	-
95	4,4A Dyson Road	Residential	150	2	NM04	77	90	44	47	-	-
96	40A Merryn Road	Residential	136	2	NM04	77	90	54	57	-	-
97	41 Merryn Road	Residential	76	2	NM04	77	90	57	60	-	-
98	42 Merryn Road	Residential	125	2	NM04	77	90	53	56	-	-
99	42A Merryn Road	Residential	112	2	NM04	77	90	55	58	-	-
100	43 Merryn Road	Residential	74	2	NM04	77	90	56	59	-	-
101	43A Merryn Road	Residential	77	2	NM04	77	90	56	59	-	-
102	44 Merryn Road	Residential	118	2	NM04	77	90	55	58	-	-
103	45 Merryn Road	Residential	55	2	NM04	77	90	59	62	-	-
104	46 Merryn Road	Residential	140	2	NM04	77	90	53	56	-	-
105	47 Merryn Road	Residential	54	2	NM04	77	90	58	61	-	-
106	49 Merryn Road	Residential	76	2	NM04	77	90	55	58	-	-
107	49A Merryn Road	Residential	75	2	NM04	77	90	54	57	-	-
108	4D Dyson Road	Residential	131	2	NM04	77	90	46	49	-	-
109	51 Merryn Road	Residential	74	2	NM04	77	90	56	59	-	-
110	51A Merryn Road	Residential	78	2	NM04	77	90	53	56	-	-
111	52A Merryn Road	Residential	147	2	NM04	77	90	53	56	-	-
112	53 Merryn Road	Residential	62	2	NM04	77	90	57	60	-	-
113	53A Merryn Road	Residential	66	2	NM04	77	90	57	60	-	-
114	54 Merryn Road	Residential	121	2	NM04	77	90	53	56	-	-
115	55 Merryn Road	Residential	65	2	NM04	77	90	57	60	-	-
116	56 Merryn Road	Residential	130	2	NM04	77	90	52	55	-	-
117	56A Merryn Road	Residential	138	2	NM04	77	90	52	55	-	-
118	57 Merryn Road	Residential	82	2	NM04	77	90	53	56	-	-

Phase 2 "Pre" Mitigation Results						Criteria		Results		Exceedance	
No,	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 2 Laeq(12 Hrs)	Phase 2 Laeq(5 Mins)	Phase 2 Laeq(12 Hrs)	Phase 2 Laeq(5 Mins)
119	57A Merryn Road	Residential	92	2	NM04	77	90	53	56	-	-
120	59 Merryn Road	Residential	110	2	NM04	77	90	50	53	-	-
121	59A Merryn Road	Residential	90	2	NM04	77	90	51	54	-	-
122	6 Gymkhana Avenue	Residential	100	2	NM02	76	90	51	54	-	-
123	61 Merryn Road	Residential	75	2	NM04	77	90	54	57	-	-
124	61A Merryn Road	Residential	77	2	NM04	77	90	57	60	-	-
125	63 Merryn Road	Residential	93	2	NM04	77	90	54	57	-	-
126	65 Merryn Road	Residential	122	2	NM04	77	90	53	56	-	-
127	67 Merryn Road	Residential	132	2	NM04	77	90	52	55	-	-
128	7 Gymkhana Avenue	Residential	100	2	NM02	76	90	48	51	-	-
129	8 Gymkhana Avenue	Residential	105	2	NM02	76	90	51	54	-	-
130	9 Bo Seng Avenue	Residential	150	2	NM04	77	90	48	51	-	-
131	95 Whitley Road	Residential	101	2	NM04	77	90	47	50	-	-
132	97 Whitley Road	Residential	101	2	NM04	77	90	47	50	-	-
133	Montclair@Whitley	Residential	132	2	NM04	77	90	47	50	-	-
E1	Bamboo Cluster 1	Ecological		1	NM04	73	77	73	76	-	-
E2	Bamboo Cluster 2	Ecological		1	NM04	73	77	73	76	-	-
E3	Bamboo Cluster 3	Ecological		1	NM03	73	77	74	77	1	-
E4	Bamboo Cluster 4	Ecological		1	NM03	73	77	72	75	-	-
E5	Bamboo Cluster 5	Ecological		1	NM03	73	77	71	74	-	-
E6	Bamboo Cluster 6	Ecological		1	NM03	73	77	72	75	-	-
E7	Bamboo Cluster 7	Ecological		1	NM03	73	77	74	77	1	-
E8	Bamboo Cluster 8	Ecological		1	NM02	65	75	71	74	6	-
E9	Bamboo Cluster 9	Ecological		1	NM02	65	75	69	72	4	-
E10	Bamboo Cluster 10	Ecological		1	NM03	65	75	46	49	-	-
E11	Bamboo Cluster 11	Ecological		1	NM02	70	76	67	70	-	-
E12	Bamboo Cluster 12	Ecological		1	NM01	69	76	57	60	-	-
E13	Bamboo Cluster 13	Ecological		1	NM01	69	76	55	58	-	-
E14	Bamboo Cluster 14	Ecological		1	NM01	69	76	58	61	-	-
E15	Bamboo Cluster 15	Ecological		1	NM01	69	76	54	57	-	-
E16	Stream 1 No.1	Ecological		1	NM02	70	76	72	75	2	-
E17	Stream 1 No.2	Ecological		1	NM02	70	76	69	72	-	-
E18	Stream 1 No.3	Ecological		1	NM02	70	76	70	73	-	-
E25	Stream 2 No.1	Ecological		1	NM03	65	75	54	57	-	-
E26	Stream 2 No.2	Ecological		1	NM03	65	75	47	50	-	-
E27	Stream 3 No.1	Ecological		1	NM04	73	77	72	75	-	-
E28	Stream 3 No.2	Ecological		1	NM04	73	77	58	61	-	-
E29	Near Stream 2 No.1	Ecological		1	NM03	65	75	72	75	7	-
E30	Near Stream 2 No.2	Ecological		1	NM03	65	75	46	49	-	-

Phase 3 "Pre" Mitigation Results						Criteria		Results		Exceedance	
No.	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 3 Laeq(12 Hrs)	Phase 3 Laeq(5 Mins)	Phase 3 Laeq(12 Hrs)	Phase 3 Laeq(5 Mins)
1	Bukit Brown MRT Station	Commercial	120	3	NM02	76	90	49	52	-	-
2	Offside Futsal Park	Commercial	60	3	NM01	76	90	65	68	-	-
3	Singapore Polo Club	Commercial	52	3	NM01	76	90	62	65	-	-
4	Catholic Junior College	Education	92	1	NM04	73	77	68	71	-	-
5	EtonHouse Pre-School (Thomson)	Education	111	1	NM01	69	76	65	68	-	-
6	Saint Joseph Institute	Education	55	1	NM01	69	76	69	72	-	-
7	James Tan Veterinary Centre	Medical	114	1	NM04	73	77	51	54	-	-
8	Lee Ah Mooi Old Age Home	Medical	80	1	NM01	69	76	67	70	-	-
9	131F,G Whitley Road	Residential	116	2	NM04	77	90	62	65	-	-
10	131H,J Whitley Road	Residential	115	2	NM04	77	90	64	67	-	-
11	159 Mount Pleasant Road	Residential	52	2	NM02	76	90	61	64	-	-
12	27 Mount Pleasant Drive	Residential	90	2	NM03	75	90	53	56	-	-
13	1 Bo Seng Avenue	Residential	85	2	NM04	77	90	64	67	-	-
14	10,12 Bo Seng Avenue	Residential	84	2	NM04	77	90	63	66	-	-
15	101,103 Whitley Road	Residential	89	2	NM04	77	90	65	68	-	-
16	11 Malcolm Road	Residential	140	2	NM04	77	90	67	70	-	-
17	11 Mount Pleasant Drive	Residential	136	2	NM03	75	90	57	60	-	-
18	111A Whitley Road	Residential	98	2	NM04	77	90	64	67	-	-
19	111B,113,113A,B Whitley Road	Residential	75	2	NM04	77	90	64	67	-	-
20	115 Whitley Road	Residential	72	2	NM04	77	90	65	68	-	-
21	115A,B,C,D,E Whitley Road	Residential	75	2	NM04	77	90	64	67	-	-
22	115K,J,H,G,F Whitley Road	Residential	75	2	NM04	77	90	65	68	-	-
23	117 Whitley Road	Residential	80	2	NM04	77	90	64	67	-	-
24	119 Whitley Road	Residential	113	2	NM04	77	90	64	67	-	-
25	119A Whitley Road	Residential	136	2	NM04	77	90	63	66	-	-
26	121 Whitley Road	Residential	115	2	NM04	77	90	63	66	-	-
27	121C,121A Whitley Road	Residential	92	2	NM04	77	90	64	67	-	-
28	121D,121E Whitley Road	Residential	74	2	NM04	77	90	64	67	-	-
29	121F,121G Whitey Road	Residential	74	2	NM04	77	90	64	67	-	-
30	121H,121J Whitley Road	Residential	92	2	NM04	77	90	65	68	-	-
31	131C,B Whitley Road	Residential	140	2	NM04	77	90	61	64	-	-
32	131D,E Whitley Road	Residential	127	2	NM04	77	90	63	66	-	-
33	133,133A Whitley Road	Residential	126	2	NM04	77	90	63	66	-	-
34	133B,C Whitley Road	Residential	142	2	NM04	77	90	62	65	-	-
35	133D,E Whitley Road	Residential	148	2	NM04	77	90	62	65	-	-
36	133F,G Whitley Road	Residential	149	2	NM04	77	90	61	64	-	-
37	14,16,16A,16B Bo Seng Avenue	Residential	135	2	NM04	77	90	63	66	-	-
38	147 Mount Pleasant Road	Residential	109	2	NM02	76	90	57	60	-	-
39	149 Mount pleasant Road	Residential	60	2	NM02	76	90	61	64	-	-
40	15 Malcolm Road	Residential	135	2	NM04	77	90	66	69	-	-
41	150 Mount Pleasant Road	Residential	57	2	NM02	76	90	60	63	-	-
42	151 Mount Pleasant Road	Residential	40	2	NM02	76	90	66	69	-	-
43	152 Mount Pleasant Road	Residential	122	2	NM02	76	90	57	60	-	-
44	154 Mount Pleasant Road	Residential	119	2	NM02	76	90	53	56	-	-
45	155 Mount Pleasant Road	Residential	41	2	NM02	76	90	64	67	-	-
46	156 Mount Pleasant Road	Residential	108	2	NM02	76	90	58	61	-	-
47	157 Mount Pleasant Road	Residential	73	2	NM02	76	90	64	67	-	-
48	157A Mount Pleasant Road	Residential	10	2	NM02	76	90	64	67	-	-
49	157B Mount Pleasant Road	Residential	18	2	NM02	76	90	64	67	-	-
50	157C Mount Pleasant Road	Residential	10	2	NM02	76	90	63	66	-	-
51	158 Mount Pleasant Road	Residential	126	2	NM02	76	90	54	57	-	-
52	160 Mount Pleasant Road	Residential	110	2	NM02	76	90	57	60	-	-
53	161 Mount Pleasant Road	Residential	20	2	NM02	76	90	64	67	-	-
54	162 Mount Pleasant Road	Residential	63	2	NM02	76	90	59	62	-	-
55	164 Mount Pleasant Road	Residential	40	2	NM02	76	90	59	62	-	-
56	166 Mount Pleasant Road	Residential	60	2	NM02	76	90	58	61	-	-
57	17A Merryn Road	Residential	145	2	NM04	77	90	48	51	-	-
58	18 Mount Pleasant Drive	Residential	44	2	NM03	75	90	56	59	-	-
59	180 Mount Pleasant Road	Residential	67	2	NM03	75	90	53	56	-	-
60	182 Mount Pleasant Road	Residential	25	2	NM03	75	90	54	57	-	-
61	19 Merryn Road	Residential	113	2	NM04	77	90	47	50	-	-
62	2 Dyson Road	Residential	110	2	NM04	77	90	65	68	-	-
63	20 Malcolm Road	Residential	94	2	NM04	77	90	67	70	-	-
64	20 Merryn Road	Residential	149	2	NM04	77	90	47	50	-	-
65	20A Merryn Road	Residential	145	2	NM04	77	90	49	52	-	-
66	21 Merryn Road	Residential	111	2	NM04	77	90	49	52	-	-
67	22 Malcolm Road	Residential	140	2	NM04	77	90	66	69	-	-
68	22 Mount Pleasant Drive	Residential	104	2	NM03	75	90	54	57	-	-
69	23 Merryn Road	Residential	105	2	NM04	77	90	45	48	-	-
70	23 Mount Pleasant Drive	Residential	63	2	NM03	75	90	57	60	-	-
71	25 Merryn Road	Residential	124	2	NM04	77	90	46	49	-	-
72	26 Mount Pleasant Drive	Residential	143	2	NM03	75	90	53	56	-	-
73	27 Jalan Mendaki	Residential	41	2	NM03	75	90	49	52	-	-
74	27/27A Merryn Road	Residential	108	2	NM04	77	90	46	49	-	-
75	28 Mount Pleasant Drive	Residential	149	2	NM03	75	90	52	55	-	-
76	28A Merryn Road	Residential	149	2	NM04	77	90	51	54	-	-
77	29 Merryn Road	Residential	85	2	NM04	77	90	47	50	-	-
78	3 Gymkhana Avenue	Residential	75	2	NM02	76	90	53	56	-	-
79	3,5 Bo Seng Avenue	Residential	97	2	NM04	77	90	64	67	-	-
80	30 Malcolm Road	Residential	108	2	NM04	77	90	64	67	-	-
81	30 Merryn Road	Residential	138	2	NM04	77	90	49	52	-	-
82	31 Merryn Road	Residential	64	2	NM04	77	90	46	49	-	-
83	31/33 Merryn Avenue	Residential	139	2	NM04	77	90	50	53	-	-
84	31A Merryn Road	Residential	60	2	NM04	77	90	46	49	-	-
85	32 Merryn Road	Residential	124	2	NM04	77	90	48	51	-	-
86	33 Merryn Road	Residential	89	2	NM04	77	90	48	51	-	-
87	34 Merryn Road	Residential	145	2	NM04	77	90	50	53	-	-
88	35 Merryn Road	Residential	86	2	NM04	77	90	48	51	-	-
89	35/37 Merryn Avenue	Residential	123	2	NM04	77	90	52	55	-	-
90	36 -46 Merryn Avenue	Residential	149	2	NM04	77	90	52	55	-	-
91	37 Merryn Road	Residential	62	2	NM04	77	90	46	49	-	-
92	39 Merryn Avenue	Residential	119	2	NM04	77	90	52	55	-	-
93	39 Merryn Road	Residential	59	2	NM04	77	90	46	49	-	-
94	4 Gymkhana Avenue	Residential	42	2	NM02	76	90	57	60	-	-
95	4,4A Dyson Road	Residential	150	2	NM04	77	90	62	65	-	-
96	40A Merryn Road	Residential	136	2	NM04	77	90	50	53	-	-
97	41 Merryn Road	Residential	76	2	NM04	77	90	47	50	-	-
98	42 Merryn Road	Residential	125	2	NM04	77	90	53	56	-	-
99	42A Merryn Road	Residential	112	2	NM04	77	90	48	51	-	-
100	43 Merryn Road	Residential	74	2	NM04	77	90	46	49	-	-
101	43A Merryn Road	Residential	77	2	NM04	77	90	49	52	-	-
102	44 Merryn Road	Residential	118	2	NM04	77	90	50	53	-	-
103	45 Merryn Road	Residential	55	2	NM04	77	90	49	52	-	-
104	46 Merryn Road	Residential	140	2	NM04	77	90	50	53	-	-
105	47 Merryn Road	Residential	54	2	NM04	77	90	49	52	-	-
106	49 Merryn Road	Residential	76	2	NM04	77	90	46	49	-	-
107	49A Merryn Road	Residential	75	2	NM04	77	90	45	48	-	-
108	4D Dyson Road	Residential	131	2	NM04	77	90	61	64	-	-
109	51 Merryn Road	Residential	74	2	NM04	77	90	47	50	-	-
110	51A Merryn Road	Residential	78	2	NM04	77	90	50	53	-	-
111	52A Merryn Road	Residential	147	2	NM04	77	90	51	54	-	-
112	53 Merryn Road	Residential	62	2	NM04	77	90	49	52	-	-
113	53A Merryn Road	Residential	66	2	NM04	77	90	51	54	-	-
114	54 Merryn Road	Residential	121	2	NM04	77	90	51	54	-	-
115	55 Merryn Road	Residential	65	2	NM04	77	90	53	56	-	-
116	56 Merryn Road	Residential	130	2	NM04	77	90	51	54	-	-
117	56A Merryn Road	Residential	138	2	NM04	77	90	50	53	-	-
118	57 Merryn Road	Residential	82	2	NM04	77	90	49	52	-	-
119	57A Merryn Road	Residential	92	2	NM04	77	90	49	52	-	-
120	59 Merryn Road	Residential	110	2	NM04	77	90	49	52	-	-
121	59A Merryn Road	Residential	90	2	NM04	77	90	48	51	-	-
122	6 Gymkhana Avenue	Residential	100	2	NM02	76	90	57	60	-	-
123	61 Merryn Road	Residential	75	2	NM04	77	90	46	49	-	-

Phase 3 "Pre" Mitigation Results						Criteria		Results		Exceedance	
No.	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 3 Laeq(12 Hrs)	Phase 3 Laeq(5 Mins)	Phase 3 Laeq(12 Hrs)	Phase 3 Laeq(5 Mins)
124	61A Merryn Road	Residential	77	2	NM04	77	90	52	55	-	-
125	63 Merryn Road	Residential	93	2	NM04	77	90	52	55	-	-
126	65 Merryn Road	Residential	122	2	NM04	77	90	50	53	-	-
127	67 Merryn Road	Residential	132	2	NM04	77	90	48	51	-	-
128	7 Gymkhana Avenue	Residential	100	2	NM02	76	90	55	58	-	-
129	8 Gymkhana Avenue	Residential	105	2	NM02	76	90	58	61	-	-
130	9 Bo Seng Avenue	Residential	150	2	NM04	77	90	65	68	-	-
131	95 Whitley Road	Residential	101	2	NM04	77	90	64	67	-	-
132	97 Whitley Road	Residential	101	2	NM04	77	90	64	67	-	-
133	Montclair@Whitley	Residential	132	2	NM04	77	90	62	65	-	-
E1	Bamboo Cluster 1	Ecological		1	NM04	73	77	46	49	-	-
E2	Bamboo Cluster 2	Ecological		1	NM04	73	77	44	47	-	-
E3	Bamboo Cluster 3	Ecological		1	NM03	73	77	40	43	-	-
E4	Bamboo Cluster 4	Ecological		1	NM03	73	77	38	41	-	-
E5	Bamboo Cluster 5	Ecological		1	NM03	73	77	38	41	-	-
E6	Bamboo Cluster 6	Ecological		1	NM03	73	77	39	42	-	-
E7	Bamboo Cluster 7	Ecological		1	NM03	73	77	39	42	-	-
E8	Bamboo Cluster 8	Ecological		1	NM02	65	75	52	55	-	-
E9	Bamboo Cluster 9	Ecological		1	NM02	65	75	52	55	-	-
E10	Bamboo Cluster 10	Ecological		1	NM03	65	75	52	55	-	-
E11	Bamboo Cluster 11	Ecological		1	NM02	70	76	52	55	-	-
E12	Bamboo Cluster 12	Ecological		1	NM01	69	76	52	55	-	-
E13	Bamboo Cluster 13	Ecological		1	NM01	69	76	52	55	-	-
E14	Bamboo Cluster 14	Ecological		1	NM01	69	76	52	55	-	-
E15	Bamboo Cluster 15	Ecological		1	NM01	69	76	52	55	-	-
E16	Stream 1 No.1	Ecological		1	NM02	70	76	52	55	-	-
E17	Stream 1 No.2	Ecological		1	NM02	70	76	52	55	-	-
E18	Stream 1 No.3	Ecological		1	NM02	70	76	52	55	-	-
E25	Stream 2 No.1	Ecological		1	NM03	65	75	52	55	-	-
E26	Stream 2 No.2	Ecological		1	NM03	65	75	52	55	-	-
E27	Stream 3 No.1	Ecological		1	NM04	73	77	52	55	-	-
E28	Stream 3 No.2	Ecological		1	NM04	73	77	52	55	-	-
E29	Near Stream 2 No.1	Ecological		1	NM03	65	75	52	55	-	-
E30	Near Stream 2 No.2	Ecological		1	NM03	65	75	52	55	-	-

Phase 1 "Post" Mitigation Results						Criteria		Results		Exceedance	
No,	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 1 Laeq(12 Hrs)	Phase 1 Laeq(5 Mins)	Phase 1 Laeq(12 Hrs)	Phase 1 Laeq(5 Mins)
1	Bukit Brown MRT Station	Commercial	120	3	NM02	76	90	61	64	-	-
2	Offisde Futsal Park	Commercial	60	3	NM01	76	90	75	78	-	-
3	Singapore Polo Club	Commercial	52	3	NM01	76	90	74	77	-	-
7	James Tan Veterinary Centre	Medical	114	1	NM04	73	77	70	73	-	-
9	131F,G Whitley Road	Residential	116	2	NM04	77	90	75	78	-	-
10	131H,J Whitley Road	Residential	115	2	NM04	77	90	77	80	-	-
11	159 Mount Pleasant Road	Residential	52	2	NM02	76	90	72	75	-	-
12	27 Mount Pleasant Drive	Residential	90	2	NM03	75	90	68	71	-	-
13	1 Bo Seng Avenue	Residential	85	2	NM04	77	90	76	79	-	-
14	10,12 Bo Seng Avenue	Residential	84	2	NM04	77	90	77	80	-	-
15	101,103 Whitley Road	Residential	89	2	NM04	77	90	77	80	-	-
16	11 Malcolm Road	Residential	140	2	NM04	77	90	75	78	-	-
17	11 Mount Pleasant Drive	Residential	136	2	NM03	75	90	76	79	1	-
18	111A Whitley Road	Residential	98	2	NM04	77	90	77	80	-	-
19	111B,113,113A,B Whitley Road	Residential	75	2	NM04	77	90	76	79	-	-
20	115 Whitley Road	Residential	72	2	NM04	77	90	79	82	2	-
21	115A,B,C,D,E Whitley Road	Residential	75	2	NM04	77	90	76	79	-	-
22	115K,J,H,G,F Whitley Road	Residential	75	2	NM04	77	90	78	81	1	-
23	117 Whitley Road	Residential	80	2	NM04	77	90	78	81	1	-
24	119 Whitley Road	Residential	113	2	NM04	77	90	77	80	-	-
25	119A Whitley Road	Residential	136	2	NM04	77	90	76	79	-	-
26	121 Whitley Road	Residential	115	2	NM04	77	90	73	76	-	-
27	121C,121A Whitley Road	Residential	92	2	NM04	77	90	76	79	-	-
28	121D,121E Whitley Road	Residential	74	2	NM04	77	90	77	80	-	-
29	121F,121G Whitey Road	Residential	74	2	NM04	77	90	77	80	-	-
30	121H,121J Whitley Road	Residential	92	2	NM04	77	90	74	77	-	-
31	131C,B Whitley Road	Residential	140	2	NM04	77	90	74	77	-	-
32	131D,E Whitley Road	Residential	127	2	NM04	77	90	75	78	-	-
33	133,133A Whitley Road	Residential	126	2	NM04	77	90	77	80	-	-
34	133B,C Whitley Road	Residential	142	2	NM04	77	90	75	78	-	-
35	133D,E Whitley Road	Residential	148	2	NM04	77	90	75	78	-	-
36	133F,G Whitley Road	Residential	149	2	NM04	77	90	73	76	-	-
37	14,16,16A,16B Bo Seng Avenue	Residential	135	2	NM04	77	90	75	78	-	-
38	147 Mount Pleasant Road	Residential	109	2	NM02	76	90	69	72	-	-
39	149 Mount pleasant Road	Residential	60	2	NM02	76	90	73	76	-	-
40	15 Malcolm Road	Residential	135	2	NM04	77	90	73	76	-	-
41	150 Mount Pleasant Road	Residential	57	2	NM02	76	90	71	74	-	-
42	151 Mount Pleasant Road	Residential	40	2	NM02	76	90	76	79	-	-
43	152 Mount Pleasant Road	Residential	122	2	NM02	76	90	69	72	-	-
44	154 Mount Pleasant Road	Residential	119	2	NM02	76	90	65	68	-	-
45	155 Mount Pleasant Road	Residential	41	2	NM02	76	90	74	77	-	-
46	156 Mount Pleasant Road	Residential	108	2	NM02	76	90	68	71	-	-
47	157 Mount Pleasant Road	Residential	73	2	NM02	76	90	75	78	-	-
48	157A Mount Pleasant Road	Residential	10	2	NM02	76	90	75	78	-	-
49	157B Mount Pleasant Road	Residential	18	2	NM02	76	90	75	78	-	-
50	157C Mount Pleasant Road	Residential	10	2	NM02	76	90	74	77	-	-
51	158 Mount Pleasant Road	Residential	126	2	NM02	76	90	64	67	-	-
52	160 Mount Pleasant Road	Residential	110	2	NM02	76	90	68	71	-	-
53	161 Mount Pleasant Road	Residential	20	2	NM02	76	90	74	77	-	-
54	162 Mount Pleasant Road	Residential	63	2	NM02	76	90	70	73	-	-
55	164 Mount Pleasant Road	Residential	40	2	NM02	76	90	71	74	-	-
56	166 Mount Pleasant Road	Residential	60	2	NM02	76	90	71	74	-	-
57	17A Merryn Road	Residential	145	2	NM04	77	90	60	63	-	-
58	18 Mount Pleasant Drive	Residential	44	2	NM03	75	90	73	76	-	-
59	180 Mount Pleasant Road	Residential	67	2	NM03	75	90	72	75	-	-
60	182 Mount Pleasant Road	Residential	25	2	NM03	75	90	73	76	-	-
61	19 Merryn Road	Residential	113	2	NM04	77	90	59	62	-	-
62	2 Dyson Road	Residential	110	2	NM04	77	90	77	80	-	-
63	20 Malcolm Road	Residential	94	2	NM04	77	90	72	75	-	-
64	20 Merryn Road	Residential	149	2	NM04	77	90	60	63	-	-
65	20A Merryn Road	Residential	145	2	NM04	77	90	62	65	-	-
66	21 Merryn Road	Residential	111	2	NM04	77	90	60	63	-	-
67	22 Malcolm Road	Residential	140	2	NM04	77	90	73	76	-	-
68	22 Mount Pleasant Drive	Residential	104	2	NM03	75	90	71	74	-	-
69	23 Merryn Road	Residential	105	2	NM04	77	90	57	60	-	-
70	23 Mount Pleasant Drive	Residential	63	2	NM03	75	90	77	80	2	-
71	25 Merryn Road	Residential	124	2	NM04	77	90	58	61	-	-
72	26 Mount Pleasant Drive	Residential	143	2	NM03	75	90	66	69	-	-
73	27 Jalan Mendaki	Residential	41	2	NM03	75	90	67	70	-	-
74	27/27A Merryn Road	Residential	108	2	NM04	77	90	60	63	-	-
75	28 Mount Pleasant Drive	Residential	149	2	NM03	75	90	65	68	-	-
76	28A Merryn Road	Residential	149	2	NM04	77	90	64	67	-	-
77	29 Merryn Road	Residential	85	2	NM04	77	90	59	62	-	-
78	3 Gymkhana Avenue	Residential	75	2	NM02	76	90	70	73	-	-
79	3,5 Bo Seng Avenue	Residential	97	2	NM04	77	90	76	79	-	-
80	30 Malcolm Road	Residential	108	2	NM04	77	90	72	75	-	-
81	30 Merryn Road	Residential	138	2	NM04	77	90	61	64	-	-
82	31 Merryn Road	Residential	64	2	NM04	77	90	60	63	-	-
83	31/33 Merryn Avenue	Residential	139	2	NM04	77	90	64	67	-	-
84	31A Merryn Road	Residential	60	2	NM04	77	90	59	62	-	-
85	32 Merryn Road	Residential	124	2	NM04	77	90	62	65	-	-
86	33 Merryn Road	Residential	89	2	NM04	77	90	61	64	-	-
87	34 Merryn Road	Residential	145	2	NM04	77	90	64	67	-	-
88	35 Merryn Road	Residential	86	2	NM04	77	90	63	66	-	-
89	35/37 Merryn Avenue	Residential	123	2	NM04	77	90	67	70	-	-
90	36 -46 Merryn Avenue	Residential	149	2	NM04	77	90	69	72	-	-
91	37 Merryn Road	Residential	62	2	NM04	77	90	59	62	-	-
92	39 Merryn Avenue	Residential	119	2	NM04	77	90	69	72	-	-
93	39 Merryn Road	Residential	59	2	NM04	77	90	60	63	-	-
94	4 Gymkhana Avenue	Residential	42	2	NM02	76	90	71	74	-	-
95	4,4A Dyson Road	Residential	150	2	NM04	77	90	73	76	-	-
96	40A Merryn Road	Residential	136	2	NM04	77	90	64	67	-	-
97	41 Merryn Road	Residential	76	2	NM04	77	90	60	63	-	-
98	42 Merryn Road	Residential	125	2	NM04	77	90	66	69	-	-
99	42A Merryn Road	Residential	112	2	NM04	77	90	65	68	-	-
100	43 Merryn Road	Residential	74	2	NM04	77	90	61	64	-	-
101	43A Merryn Road	Residential	77	2	NM04	77	90	65	68	-	-
102	44 Merryn Road	Residential	118	2	NM04	77	90	65	68	-	-
103	45 Merryn Road	Residential	55	2	NM04	77	90	63	66	-	-
104	46 Merryn Road	Residential	140	2	NM04	77	90	65	68	-	-
105	47 Merryn Road	Residential	54	2	NM04	77	90	66	69	-	-
106	49 Merryn Road	Residential	76	2	NM04	77	90	59	62	-	-
107	49A Merryn Road	Residential	75	2	NM04	77	90	64	67	-	-
108	4D Dyson Road	Residential	131	2	NM04	77	90	73	76	-	-
109	51 Merryn Road	Residential	74	2	NM04	77	90	63	66	-	-
110	51A Merryn Road	Residential	78	2	NM04	77	90	64	67	-	-
111	52A Merryn Road	Residential	147	2	NM04	77	90	67	70	-	-
112	53 Merryn Road	Residential	62	2	NM04	77	90	66	69	-	-
113	53A Merryn Road	Residential	66	2	NM04	77	90	67	70	-	-
114	54 Merryn Road	Residential	121	2	NM04	77	90	67	70	-	-
115	55 Merryn Road	Residential	65	2	NM04	77	90	70	73	-	-
116	56 Merryn Road	Residential	130	2	NM04	77	90	66	69	-	-
117	56A Merryn Road	Residential	138	2	NM04	77	90	65	68	-	-
118	57 Merryn Road	Residential	82	2	NM04	77	90	66	69	-	-
119	57A Merryn Road	Residential	92	2	NM04	77	90	66	69	-	-
120	59 Merryn Road	Residential	110	2	NM04	77	90	66	69	-	-
121	59A Merryn Road	Residential	90	2	NM04	77	90	63	66	-	-
122	6 Gymkhana Avenue	Residential	100	2	NM02	76	90	69	72	-	-

Phase 1 "Post" Mitigation Results						Criteria		Results		Exceedance	
No,	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 1 Laeq(12 Hrs)	Phase 1 Laeq(5 Mins)	Phase 1 Laeq(12 Hrs)	Phase 1 Laeq(5 Mins)
123	61 Merryn Road	Residential	75	2	NM04	77	90	66	69	-	-
124	61A Merryn Road	Residential	77	2	NM04	77	90	71	74	-	-
125	63 Merryn Road	Residential	93	2	NM04	77	90	68	71	-	-
126	65 Merryn Road	Residential	122	2	NM04	77	90	68	71	-	-
127	67 Merryn Road	Residential	132	2	NM04	77	90	67	70	-	-
128	7 Gymkhana Avenue	Residential	100	2	NM02	76	90	69	72	-	-
129	8 Gymkhana Avenue	Residential	105	2	NM02	76	90	70	73	-	-
130	9 Bo Seng Avenue	Residential	150	2	NM04	77	90	77	80	-	-
131	95 Whitley Road	Residential	101	2	NM04	77	90	76	79	-	-
132	97 Whitley Road	Residential	101	2	NM04	77	90	76	79	-	-
133	Montclair@Whitley	Residential	132	2	NM04	77	90	76	79	-	-
E1	Bamboo Cluster 1	Ecological		1	NM04	73	77	58	61	-	-
E2	Bamboo Cluster 2	Ecological		1	NM04	73	77	57	60	-	-
E3	Bamboo Cluster 3	Ecological		1	NM03	73	77	55	58	-	-
E4	Bamboo Cluster 4	Ecological		1	NM03	73	77	54	57	-	-
E5	Bamboo Cluster 5	Ecological		1	NM03	73	77	56	59	-	-
E6	Bamboo Cluster 6	Ecological		1	NM03	73	77	56	59	-	-
E7	Bamboo Cluster 7	Ecological		1	NM03	73	77	59	62	-	-
E8	Bamboo Cluster 8	Ecological		1	NM02	65	75	65	68	-	-
E9	Bamboo Cluster 9	Ecological		1	NM02	65	75	66	69	1	-
E10	Bamboo Cluster 10	Ecological		1	NM03	65	75	59	62	-	-
E11	Bamboo Cluster 11	Ecological		1	NM02	70	76	72	75	2	-
E16	Stream 1 No.1	Ecological		1	NM02	70	76	65	68	-	-
E17	Stream 1 No.2	Ecological		1	NM02	70	76	68	71	-	-
E18	Stream 1 No.3	Ecological		1	NM02	70	76	70	73	-	-
E25	Stream 2 No.1	Ecological		1	NM03	65	75	58	61	-	-
E26	Stream 2 No.2	Ecological		1	NM03	65	75	59	62	-	-
E27	Stream 3 No.1	Ecological		1	NM04	73	77	54	57	-	-
E28	Stream 3 No.2	Ecological		1	NM04	73	77	55	58	-	-
E29	Near Stream 2 No.1	Ecological		1	NM03	65	75	63	66	-	-
E30	Near Stream 2 No.2	Ecological		1	NM03	65	75	57	60	-	-

Phase 2 (Alternative Roadworks) "Post" Mitigation Results						Criteria		Results		Exceedance	
No,	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 2 Laeq(12 Hrs)	Phase 2 Laeq(5 Mins)	Phase 2 Laeq(12 Hrs)	Phase 2 Laeq(5 Mins)
1	Bukit Brown MRT Station	Commercial	120	3	NM02	76	90	38	41	-	-
2	Offside Futsal Park	Commercial	60	3	NM01	76	90	47	50	-	-
3	Singapore Polo Club	Commercial	52	3	NM01	76	90	51	54	-	-
4	Catholic Junior College	Education	92	1	NM04	73	77	54	57	-	-
5	EtonHouse Pre-School (Thomson)	Education	111	1	NM01	69	76	48	51	-	-
6	Saint Joseph Institute	Education	55	1	NM01	69	76	55	58	-	-
7	James Tan Veterinary Centre	Medical	114	1	NM04	73	77	38	41	-	-
8	Lee Ah Mooi Old Age Home	Medical	80	1	NM01	69	76	49	52	-	-
9	131F,G Whitley Road	Residential	116	2	NM04	77	90	48	51	-	-
10	131H,J Whitley Road	Residential	115	2	NM04	77	90	49	52	-	-
11	159 Mount Pleasant Road	Residential	52	2	NM02	76	90	52	55	-	-
12	27 Mount Pleasant Drive	Residential	90	2	NM03	75	90	42	45	-	-
13	1 Bo Seng Avenue	Residential	85	2	NM04	77	90	48	51	-	-
14	10,12 Bo Seng Avenue	Residential	84	2	NM04	77	90	49	52	-	-
15	101,103 Whitley Road	Residential	89	2	NM04	77	90	49	52	-	-
16	11 Malcolm Road	Residential	140	2	NM04	77	90	53	56	-	-
17	11 Mount Pleasant Drive	Residential	136	2	NM03	75	90	45	48	-	-
18	111A Whitley Road	Residential	98	2	NM04	77	90	49	52	-	-
19	111B,113,113A,B Whitley Road	Residential	75	2	NM04	77	90	49	52	-	-
20	115 Whitley Road	Residential	72	2	NM04	77	90	50	53	-	-
21	115A,B,C,D,E Whitley Road	Residential	75	2	NM04	77	90	49	52	-	-
22	115K,J,H,G,F Whitley Road	Residential	75	2	NM04	77	90	50	53	-	-
23	117 Whitley Road	Residential	80	2	NM04	77	90	51	54	-	-
24	119 Whitley Road	Residential	113	2	NM04	77	90	50	53	-	-
25	119A Whitley Road	Residential	136	2	NM04	77	90	48	51	-	-
26	121 Whitley Road	Residential	115	2	NM04	77	90	49	52	-	-
27	121C,121A Whitley Road	Residential	92	2	NM04	77	90	50	53	-	-
28	121D,121E Whitley Road	Residential	74	2	NM04	77	90	50	53	-	-
29	121F,121G Whitey Road	Residential	74	2	NM04	77	90	50	53	-	-
30	121H,121J Whitley Road	Residential	92	2	NM04	77	90	51	54	-	-
31	131C,B Whitley Road	Residential	140	2	NM04	77	90	46	49	-	-
32	131D,E Whitley Road	Residential	127	2	NM04	77	90	48	51	-	-
33	133,133A Whitley Road	Residential	126	2	NM04	77	90	49	52	-	-
34	133B,C Whitley Road	Residential	142	2	NM04	77	90	48	51	-	-
35	133D,E Whitley Road	Residential	148	2	NM04	77	90	47	50	-	-
36	133F,G Whitley Road	Residential	149	2	NM04	77	90	48	51	-	-
37	14,16,16A,16B Bo Seng Avenue	Residential	135	2	NM04	77	90	48	51	-	-
38	147 Mount Pleasant Road	Residential	109	2	NM02	76	90	45	48	-	-
39	149 Mount pleasant Road	Residential	60	2	NM02	76	90	48	51	-	-
40	15 Malcolm Road	Residential	135	2	NM04	77	90	51	54	-	-
41	150 Mount Pleasant Road	Residential	57	2	NM02	76	90	46	49	-	-
42	151 Mount Pleasant Road	Residential	40	2	NM02	76	90	55	58	-	-
43	152 Mount Pleasant Road	Residential	122	2	NM02	76	90	44	47	-	-
44	154 Mount Pleasant Road	Residential	119	2	NM02	76	90	42	45	-	-
45	155 Mount Pleasant Road	Residential	41	2	NM02	76	90	53	56	-	-
46	156 Mount Pleasant Road	Residential	108	2	NM02	76	90	46	49	-	-
47	157 Mount Pleasant Road	Residential	73	2	NM02	76	90	54	57	-	-
48	157A Mount Pleasant Road	Residential	10	2	NM02	76	90	57	60	-	-
49	157B Mount Pleasant Road	Residential	18	2	NM02	76	90	59	62	-	-
50	157C Mount Pleasant Road	Residential	10	2	NM02	76	90	57	60	-	-
51	158 Mount Pleasant Road	Residential	126	2	NM02	76	90	43	46	-	-
52	160 Mount Pleasant Road	Residential	110	2	NM02	76	90	47	50	-	-
53	161 Mount Pleasant Road	Residential	20	2	NM02	76	90	55	58	-	-
54	162 Mount Pleasant Road	Residential	63	2	NM02	76	90	49	52	-	-
55	164 Mount Pleasant Road	Residential	40	2	NM02	76	90	49	52	-	-
56	166 Mount Pleasant Road	Residential	60	2	NM02	76	90	48	51	-	-
57	17A Merryn Road	Residential	145	2	NM04	77	90	34	37	-	-
58	18 Mount Pleasant Drive	Residential	44	2	NM03	75	90	46	49	-	-
59	180 Mount Pleasant Road	Residential	67	2	NM03	75	90	41	44	-	-
60	182 Mount Pleasant Road	Residential	25	2	NM03	75	90	42	45	-	-
61	19 Merryn Road	Residential	113	2	NM04	77	90	34	37	-	-
62	2 Dyson Road	Residential	110	2	NM04	77	90	48	51	-	-
63	20 Malcolm Road	Residential	94	2	NM04	77	90	50	53	-	-
64	20 Merryn Road	Residential	149	2	NM04	77	90	33	36	-	-
65	20A Merryn Road	Residential	145	2	NM04	77	90	34	37	-	-
66	21 Merryn Road	Residential	111	2	NM04	77	90	36	39	-	-
67	22 Malcolm Road	Residential	140	2	NM04	77	90	50	53	-	-
68	22 Mount Pleasant Drive	Residential	104	2	NM03	75	90	43	46	-	-
69	23 Merryn Road	Residential	105	2	NM04	77	90	35	38	-	-
70	23 Mount Pleasant Drive	Residential	63	2	NM03	75	90	46	49	-	-
71	25 Merryn Road	Residential	124	2	NM04	77	90	33	36	-	-
72	26 Mount Pleasant Drive	Residential	143	2	NM03	75	90	42	45	-	-
73	27 Jalan Mendaki	Residential	41	2	NM03	75	90	36	39	-	-
74	27/27A Merryn Road	Residential	108	2	NM04	77	90	32	35	-	-
75	28 Mount Pleasant Drive	Residential	149	2	NM03	75	90	40	43	-	-
76	28A Merryn Road	Residential	149	2	NM04	77	90	36	39	-	-
77	29 Merryn Road	Residential	85	2	NM04	77	90	35	38	-	-
78	3 Gymkhana Avenue	Residential	75	2	NM02	76	90	41	44	-	-
79	3,5 Bo Seng Avenue	Residential	97	2	NM04	77	90	49	52	-	-
80	30 Malcolm Road	Residential	108	2	NM04	77	90	48	51	-	-
81	30 Merryn Road	Residential	138	2	NM04	77	90	33	36	-	-
82	31 Merryn Road	Residential	64	2	NM04	77	90	33	36	-	-
83	31/33 Merryn Avenue	Residential	139	2	NM04	77	90	35	38	-	-
84	31A Merryn Road	Residential	60	2	NM04	77	90	32	35	-	-
85	32 Merryn Road	Residential	124	2	NM04	77	90	33	36	-	-
86	33 Merryn Road	Residential	89	2	NM04	77	90	33	36	-	-
87	34 Merryn Road	Residential	145	2	NM04	77	90	36	39	-	-
88	35 Merryn Road	Residential	86	2	NM04	77	90	35	38	-	-
89	35/37 Merryn Avenue	Residential	123	2	NM04	77	90	37	40	-	-
90	36 -46 Merryn Avenue	Residential	149	2	NM04	77	90	39	42	-	-
91	37 Merryn Road	Residential	62	2	NM04	77	90	32	35	-	-
92	39 Merryn Avenue	Residential	119	2	NM04	77	90	39	42	-	-
93	39 Merryn Road	Residential	59	2	NM04	77	90	32	35	-	-
94	4 Gymkhana Avenue	Residential	42	2	NM02	76	90	46	49	-	-
95	4,4A Dyson Road	Residential	150	2	NM04	77	90	44	47	-	-
96	40A Merryn Road	Residential	136	2	NM04	77	90	35	38	-	-
97	41 Merryn Road	Residential	76	2	NM04	77	90	32	35	-	-
98	42 Merryn Road	Residential	125	2	NM04	77	90	37	40	-	-
99	42A Merryn Road	Residential	112	2	NM04	77	90	35	38	-	-
100	43 Merryn Road	Residential	74	2	NM04	77	90	32	35	-	-
101	43A Merryn Road	Residential	77	2	NM04	77	90	36	39	-	-
102	44 Merryn Road	Residential	118	2	NM04	77	90	36	39	-	-
103	45 Merryn Road	Residential	55	2	NM04	77	90	34	37	-	-
104	46 Merryn Road	Residential	140	2	NM04	77	90	36	39	-	-
105	47 Merryn Road	Residential	54	2	NM04	77	90	33	36	-	-
106	49 Merryn Road	Residential	76	2	NM04	77	90	30	33	-	-
107	49A Merryn Road	Residential	75	2	NM04	77	90	31	34	-	-
108	4D Dyson Road	Residential	131	2	NM04	77	90	47	50	-	-
109	51 Merryn Road	Residential	74	2	NM04	77	90	30	33	-	-
110	51A Merryn Road	Residential	78	2	NM04	77	90	33	36	-	-
111	52A Merryn Road	Residential	147	2	NM04	77	90	38	41	-	-
112	53 Merryn Road	Residential	62	2	NM04	77	90	34	37	-	-
113	53A Merryn Road	Residential	66	2	NM04	77	90	36	39	-	-
114	54 Merryn Road	Residential	121	2	NM04	77	90	37	40	-	-
115	55 Merryn Road	Residential	65	2	NM04	77	90	39	42	-	-
116	56 Merryn Road	Residential	130	2	NM04	77	90	36	39	-	-
117	56A Merryn Road	Residential	138	2	NM04	77	90	35	38	-	-
118	57 Merryn Road	Residential	82	2	NM04	77	90	35	38	-	-

Phase 2 (Alternative Roadworks) "Post" Mitigation Results						Criteria		Results		Exceedance	
No,	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 2 Laeq(12 Hrs)	Phase 2 Laeq(5 Mins)	Phase 2 Laeq(12 Hrs)	Phase 2 Laeq(5 Mins)
119	57A Merryn Road	Residential	92	2	NM04	77	90	34	37	-	-
120	59 Merryn Road	Residential	110	2	NM04	77	90	35	38	-	-
121	59A Merryn Road	Residential	90	2	NM04	77	90	31	34	-	-
122	6 Gymkhana Avenue	Residential	100	2	NM02	76	90	46	49	-	-
123	61 Merryn Road	Residential	75	2	NM04	77	90	32	35	-	-
124	61A Merryn Road	Residential	77	2	NM04	77	90	39	42	-	-
125	63 Merryn Road	Residential	93	2	NM04	77	90	39	42	-	-
126	65 Merryn Road	Residential	122	2	NM04	77	90	36	39	-	-
127	67 Merryn Road	Residential	132	2	NM04	77	90	35	38	-	-
128	7 Gymkhana Avenue	Residential	100	2	NM02	76	90	44	47	-	-
129	8 Gymkhana Avenue	Residential	105	2	NM02	76	90	47	50	-	-
130	9 Bo Seng Avenue	Residential	150	2	NM04	77	90	49	52	-	-
131	95 Whitley Road	Residential	101	2	NM04	77	90	48	51	-	-
132	97 Whitley Road	Residential	101	2	NM04	77	90	48	51	-	-
133	Montclair@Whitley	Residential	132	2	NM04	77	90	48	51	-	-
E1	Bamboo Cluster 1	Ecological		1	NM04	73	77	34	37	-	-
E2	Bamboo Cluster 2	Ecological		1	NM04	73	77	33	36	-	-
E3	Bamboo Cluster 3	Ecological		1	NM03	73	77	30	33	-	-
E4	Bamboo Cluster 4	Ecological		1	NM03	73	77	26	29	-	-
E5	Bamboo Cluster 5	Ecological		1	NM03	73	77	25	28	-	-
E6	Bamboo Cluster 6	Ecological		1	NM03	73	77	26	29	-	-
E7	Bamboo Cluster 7	Ecological		1	NM03	73	77	26	29	-	-
E8	Bamboo Cluster 8	Ecological		1	NM02	65	75	40	43	-	-
E9	Bamboo Cluster 9	Ecological		1	NM02	65	75	41	44	-	-
E10	Bamboo Cluster 10	Ecological		1	NM03	65	75	34	37	-	-
E11	Bamboo Cluster 11	Ecological		1	NM02	70	76	53	56	-	-
E12	Bamboo Cluster 12	Ecological		1	NM01	69	76	57	60	-	-
E13	Bamboo Cluster 13	Ecological		1	NM01	69	76	56	59	-	-
E14	Bamboo Cluster 14	Ecological		1	NM01	69	76	59	62	-	-
E15	Bamboo Cluster 15	Ecological		1	NM01	69	76	55	58	-	-
E16	Stream 1 No.1	Ecological		1	NM02	70	76	43	46	-	-
E17	Stream 1 No.2	Ecological		1	NM02	70	76	50	53	-	-
E18	Stream 1 No.3	Ecological		1	NM02	70	76	55	58	-	-
E25	Stream 2 No.1	Ecological		1	NM03	65	75	33	36	-	-
E26	Stream 2 No.2	Ecological		1	NM03	65	75	32	35	-	-
E27	Stream 3 No.1	Ecological		1	NM04	73	77	26	29	-	-
E28	Stream 3 No.2	Ecological		1	NM04	73	77	31	34	-	-
E29	Near Stream 2 No.1	Ecological		1	NM03	65	75	37	40	-	-
E30	Near Stream 2 No.2	Ecological		1	NM03	65	75	34	37	-	-

Phase 3 "Post" Mitigation Results						Criteria		Results		Exceedance	
No.	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 3 Laeq(12 Hrs)	Phase 3 Laeq(5 Mins)	Phase 3 Laeq(12 Hrs)	Phase 3 Laeq(5 Mins)
1	Bukit Brown MRT Station	Commercial	120	3	NM02	76	90	49	52	-	-
2	Offiside Futsal Park	Commercial	60	3	NM01	76	90	65	68	-	-
3	Singapore Polo Club	Commercial	52	3	NM01	76	90	62	65	-	-
4	Catholic Junior College	Education	92	1	NM04	73	77	68	71	-	-
5	EtonHouse Pre-School (Thomson)	Education	111	1	NM01	69	76	65	68	-	-
6	Saint Joseph Institute	Education	55	1	NM01	69	76	69	72	-	-
7	James Tan Veterinary Centre	Medical	114	1	NM04	73	77	51	54	-	-
8	Lee Ah Mooi Old Age Home	Medical	80	1	NM01	69	76	67	70	-	-
9	131F,G Whitley Road	Residential	116	2	NM04	77	90	62	65	-	-
10	131H,J Whitley Road	Residential	115	2	NM04	77	90	64	67	-	-
11	159 Mount Pleasant Road	Residential	52	2	NM02	76	90	61	64	-	-
12	27 Mount Pleasant Drive	Residential	90	2	NM03	75	90	53	56	-	-
13	1 Bo Seng Avenue	Residential	85	2	NM04	77	90	64	67	-	-
14	10,12 Bo Seng Avenue	Residential	84	2	NM04	77	90	63	66	-	-
15	101,103 Whitley Road	Residential	89	2	NM04	77	90	65	68	-	-
16	11 Malcolm Road	Residential	140	2	NM04	77	90	67	70	-	-
17	11 Mount Pleasant Drive	Residential	136	2	NM03	75	90	57	60	-	-
18	111A Whitley Road	Residential	98	2	NM04	77	90	64	67	-	-
19	111B,113,113A,B Whitley Road	Residential	75	2	NM04	77	90	64	67	-	-
20	115 Whitley Road	Residential	72	2	NM04	77	90	65	68	-	-
21	115A,B,C,D,E Whitley Road	Residential	75	2	NM04	77	90	64	67	-	-
22	115K,J,H,G,F Whitley Road	Residential	75	2	NM04	77	90	65	68	-	-
23	117 Whitley Road	Residential	80	2	NM04	77	90	64	67	-	-
24	119 Whitley Road	Residential	113	2	NM04	77	90	64	67	-	-
25	119A Whitley Road	Residential	136	2	NM04	77	90	63	66	-	-
26	121 Whitley Road	Residential	115	2	NM04	77	90	63	66	-	-
27	121C,121A Whitley Road	Residential	92	2	NM04	77	90	64	67	-	-
28	121D,121E Whitley Road	Residential	74	2	NM04	77	90	64	67	-	-
29	121F,121G Whitey Road	Residential	74	2	NM04	77	90	64	67	-	-
30	121H,121J Whitley Road	Residential	92	2	NM04	77	90	65	68	-	-
31	131C,B Whitley Road	Residential	140	2	NM04	77	90	61	64	-	-
32	131D,E Whitley Road	Residential	127	2	NM04	77	90	63	66	-	-
33	133,133A Whitley Road	Residential	126	2	NM04	77	90	63	66	-	-
34	133B,C Whitley Road	Residential	142	2	NM04	77	90	62	65	-	-
35	133D,E Whitley Road	Residential	148	2	NM04	77	90	62	65	-	-
36	133F,G Whitley Road	Residential	149	2	NM04	77	90	61	64	-	-
37	14,16,16A,16B Bo Seng Avenue	Residential	135	2	NM04	77	90	63	66	-	-
38	147 Mount Pleasant Road	Residential	109	2	NM02	76	90	57	60	-	-
39	149 Mount pleasant Road	Residential	60	2	NM02	76	90	61	64	-	-
40	15 Malcolm Road	Residential	135	2	NM04	77	90	66	69	-	-
41	150 Mount Pleasant Road	Residential	57	2	NM02	76	90	60	63	-	-
42	151 Mount Pleasant Road	Residential	40	2	NM02	76	90	66	69	-	-
43	152 Mount Pleasant Road	Residential	122	2	NM02	76	90	57	60	-	-
44	154 Mount Pleasant Road	Residential	119	2	NM02	76	90	53	56	-	-
45	155 Mount Pleasant Road	Residential	41	2	NM02	76	90	64	67	-	-
46	156 Mount Pleasant Road	Residential	108	2	NM02	76	90	58	61	-	-
47	157 Mount Pleasant Road	Residential	73	2	NM02	76	90	64	67	-	-
48	157A Mount Pleasant Road	Residential	10	2	NM02	76	90	64	67	-	-
49	157B Mount Pleasant Road	Residential	18	2	NM02	76	90	64	67	-	-
50	157C Mount Pleasant Road	Residential	10	2	NM02	76	90	63	66	-	-
51	158 Mount Pleasant Road	Residential	126	2	NM02	76	90	54	57	-	-
52	160 Mount Pleasant Road	Residential	110	2	NM02	76	90	57	60	-	-
53	161 Mount Pleasant Road	Residential	20	2	NM02	76	90	64	67	-	-
54	162 Mount Pleasant Road	Residential	63	2	NM02	76	90	59	62	-	-
55	164 Mount Pleasant Road	Residential	40	2	NM02	76	90	59	62	-	-
56	166 Mount Pleasant Road	Residential	60	2	NM02	76	90	58	61	-	-
57	17A Merryn Road	Residential	145	2	NM04	77	90	48	51	-	-
58	18 Mount Pleasant Drive	Residential	44	2	NM03	75	90	56	59	-	-
59	180 Mount Pleasant Road	Residential	67	2	NM03	75	90	53	56	-	-
60	182 Mount Pleasant Road	Residential	25	2	NM03	75	90	54	57	-	-
61	19 Merryn Road	Residential	113	2	NM04	77	90	47	50	-	-
62	2 Dyson Road	Residential	110	2	NM04	77	90	65	68	-	-
63	20 Malcolm Road	Residential	94	2	NM04	77	90	67	70	-	-
64	20 Merryn Road	Residential	149	2	NM04	77	90	47	50	-	-
65	20A Merryn Road	Residential	145	2	NM04	77	90	49	52	-	-
66	21 Merryn Road	Residential	111	2	NM04	77	90	49	52	-	-
67	22 Malcolm Road	Residential	140	2	NM04	77	90	66	69	-	-
68	22 Mount Pleasant Drive	Residential	104	2	NM03	75	90	54	57	-	-
69	23 Merryn Road	Residential	105	2	NM04	77	90	45	48	-	-
70	23 Mount Pleasant Drive	Residential	63	2	NM03	75	90	57	60	-	-
71	25 Merryn Road	Residential	124	2	NM04	77	90	46	49	-	-
72	26 Mount Pleasant Drive	Residential	143	2	NM03	75	90	53	56	-	-
73	27 Jalan Mendaki	Residential	41	2	NM03	75	90	49	52	-	-
74	27/27A Merryn Road	Residential	108	2	NM04	77	90	46	49	-	-
75	28 Mount Pleasant Drive	Residential	149	2	NM03	75	90	52	55	-	-
76	28A Merryn Road	Residential	149	2	NM04	77	90	51	54	-	-
77	29 Merryn Road	Residential	85	2	NM04	77	90	47	50	-	-
78	3 Gymkhana Avenue	Residential	75	2	NM02	76	90	53	56	-	-
79	3,5 Bo Seng Avenue	Residential	97	2	NM04	77	90	64	67	-	-
80	30 Malcolm Road	Residential	108	2	NM04	77	90	64	67	-	-
81	30 Merryn Road	Residential	138	2	NM04	77	90	49	52	-	-
82	31 Merryn Road	Residential	64	2	NM04	77	90	46	49	-	-
83	31/33 Merryn Avenue	Residential	139	2	NM04	77	90	50	53	-	-
84	31A Merryn Road	Residential	60	2	NM04	77	90	46	49	-	-
85	32 Merryn Road	Residential	124	2	NM04	77	90	48	51	-	-
86	33 Merryn Road	Residential	89	2	NM04	77	90	48	51	-	-
87	34 Merryn Road	Residential	145	2	NM04	77	90	50	53	-	-
88	35 Merryn Road	Residential	86	2	NM04	77	90	48	51	-	-
89	35/37 Merryn Avenue	Residential	123	2	NM04	77	90	52	55	-	-
90	36 -46 Merryn Avenue	Residential	149	2	NM04	77	90	52	55	-	-
91	37 Merryn Road	Residential	62	2	NM04	77	90	46	49	-	-
92	39 Merryn Avenue	Residential	119	2	NM04	77	90	52	55	-	-
93	39 Merryn Road	Residential	59	2	NM04	77	90	46	49	-	-
94	4 Gymkhana Avenue	Residential	42	2	NM02	76	90	57	60	-	-
95	4,4A Dyson Road	Residential	150	2	NM04	77	90	62	65	-	-
96	40A Merryn Road	Residential	136	2	NM04	77	90	50	53	-	-
97	41 Merryn Road	Residential	76	2	NM04	77	90	47	50	-	-
98	42 Merryn Road	Residential	125	2	NM04	77	90	53	56	-	-
99	42A Merryn Road	Residential	112	2	NM04	77	90	48	51	-	-
100	43 Merryn Road	Residential	74	2	NM04	77	90	46	49	-	-
101	43A Merryn Road	Residential	77	2	NM04	77	90	49	52	-	-
102	44 Merryn Road	Residential	118	2	NM04	77	90	50	53	-	-
103	45 Merryn Road	Residential	55	2	NM04	77	90	49	52	-	-
104	46 Merryn Road	Residential	140	2	NM04	77	90	50	53	-	-
105	47 Merryn Road	Residential	54	2	NM04	77	90	49	52	-	-
106	49 Merryn Road	Residential	76	2	NM04	77	90	46	49	-	-
107	49A Merryn Road	Residential	75	2	NM04	77	90	45	48	-	-
108	4D Dyson Road	Residential	131	2	NM04	77	90	61	64	-	-
109	51 Merryn Road	Residential	74	2	NM04	77	90	47	50	-	-
110	51A Merryn Road	Residential	78	2	NM04	77	90	50	53	-	-
111	52A Merryn Road	Residential	147	2	NM04	77	90	51	54	-	-
112	53 Merryn Road	Residential	62	2	NM04	77	90	49	52	-	-
113	53A Merryn Road	Residential	66	2	NM04	77	90	51	54	-	-
114	54 Merryn Road	Residential	121	2	NM04	77	90	51	54	-	-
115	55 Merryn Road	Residential	65	2	NM04	77	90	53	56	-	-
116	56 Merryn Road	Residential	130	2	NM04	77	90	51	54	-	-
117	56A Merryn Road	Residential	138	2	NM04	77	90	50	53	-	-
118	57 Merryn Road	Residential	82	2	NM04	77	90	49	52	-	-
119	57A Merryn Road	Residential	92	2	NM04	77	90	49	52	-	-
120	59 Merryn Road	Residential	110	2	NM04	77	90	49	52	-	-
121	59A Merryn Road	Residential	90	2	NM04	77	90	48	51	-	-
122	6 Gymkhana Avenue	Residential	100	2	NM02	76	90	57	60	-	-
123	61 Merryn Road	Residential	75	2	NM04	77	90	46	49	-	-

Phase 3 "Post" Mitigation Results						Criteria		Results		Exceedance	
No.	Name	Type	Nearest Distance to Construction Area Boundary (m)	Receptor Sensitivity	Nearest Noise Logger (Baseline)	Laeq(12 Hrs) Criteria 7am - 7pm	Laeq(5 Mins) Criteria 7am - 7pm	Phase 3 Laeq(12 Hrs)	Phase 3 Laeq(5 Mins)	Phase 3 Laeq(12 Hrs)	Phase 3 Laeq(5 Mins)
124	61A Merryn Road	Residential	77	2	NM04	77	90	52	55	-	-
125	63 Merryn Road	Residential	93	2	NM04	77	90	52	55	-	-
126	65 Merryn Road	Residential	122	2	NM04	77	90	50	53	-	-
127	67 Merryn Road	Residential	132	2	NM04	77	90	48	51	-	-
128	7 Gymkhana Avenue	Residential	100	2	NM02	76	90	55	58	-	-
129	8 Gymkhana Avenue	Residential	105	2	NM02	76	90	58	61	-	-
130	9 Bo Seng Avenue	Residential	150	2	NM04	77	90	65	68	-	-
131	95 Whitley Road	Residential	101	2	NM04	77	90	64	67	-	-
132	97 Whitley Road	Residential	101	2	NM04	77	90	64	67	-	-
133	Montclair@Whitley	Residential	132	2	NM04	77	90	62	65	-	-
E1	Bamboo Cluster 1	Ecological		1	NM04	73	77	46	49	-	-
E2	Bamboo Cluster 2	Ecological		1	NM04	73	77	44	47	-	-
E3	Bamboo Cluster 3	Ecological		1	NM03	73	77	40	43	-	-
E4	Bamboo Cluster 4	Ecological		1	NM03	73	77	38	41	-	-
E5	Bamboo Cluster 5	Ecological		1	NM03	73	77	38	41	-	-
E6	Bamboo Cluster 6	Ecological		1	NM03	73	77	39	42	-	-
E7	Bamboo Cluster 7	Ecological		1	NM03	73	77	39	42	-	-
E8	Bamboo Cluster 8	Ecological		1	NM02	65	75	52	55	-	-
E9	Bamboo Cluster 9	Ecological		1	NM02	65	75	52	55	-	-
E10	Bamboo Cluster 10	Ecological		1	NM03	65	75	52	55	-	-
E11	Bamboo Cluster 11	Ecological		1	NM02	70	76	52	55	-	-
E12	Bamboo Cluster 12	Ecological		1	NM01	69	76	52	55	-	-
E13	Bamboo Cluster 13	Ecological		1	NM01	69	76	52	55	-	-
E14	Bamboo Cluster 14	Ecological		1	NM01	69	76	52	55	-	-
E15	Bamboo Cluster 15	Ecological		1	NM01	69	76	52	55	-	-
E16	Stream 1 No.1	Ecological		1	NM02	70	76	52	55	-	-
E17	Stream 1 No.2	Ecological		1	NM02	70	76	52	55	-	-
E18	Stream 1 No.3	Ecological		1	NM02	70	76	52	55	-	-
E25	Stream 2 No.1	Ecological		1	NM03	65	75	52	55	-	-
E26	Stream 2 No.2	Ecological		1	NM03	65	75	52	55	-	-
E27	Stream 3 No.1	Ecological		1	NM04	73	77	52	55	-	-
E28	Stream 3 No.2	Ecological		1	NM04	73	77	52	55	-	-
E29	Near Stream 2 No.1	Ecological		1	NM03	65	75	52	55	-	-
E30	Near Stream 2 No.2	Ecological		1	NM03	65	75	52	55	-	-

Appendix H

Baseline Vibration Monitoring Report

Baseline Vibration Monitoring Report

Table of Contents

1.0 INTRODUCTION 3

1.1 Ground-borne Vibration Monitoring Schedule 3
1.2 Ground-borne Vibration Monitoring Equipment 3
1.3 Baseline Ground-borne Vibration Monitoring Data 4

List of Figures

Figure 1 Baseline Vibration Monitoring Location 3
Figure 2 Vibration Monitoring Setup 4

List of Tables

Table 1 Ground-borne Vibration Monitoring Equipment 4
Table 2 Summary of Ground-borne Vibration Baseline Levels 4
Table 3 Summary of Baseline Vibration Monitoring Results 5

1.0 Introduction

Under the contract "Environmental Impact Study (EIS) for future residential development located at Mount Pleasant area", the Housing Development Board (HDB) appointed AECOM Singapore Pte Ltd (AECOM) to undertake an Environmental Impact Study (EIS) of the a future residential development (hereafter referred to as the "Projects") located at Mount Pleasant area.

Part of the study will involve assessment of the vibration impacts arising from the construction activities of the project. This report details the vibration monitoring plan to carry out the baseline vibration monitoring at the project site due to proposed construction activities. The purpose of conducting a baseline vibration monitoring is to determine the existing vibration levels from these areas for further assessments and validation of vibration level predictions.

1.1 Ground-borne Vibration Monitoring Schedule

The ground-borne vibration monitoring (unattended) was conducted between 7th and 14th May 2019 at the monitoring locations VM01, VM02 and VM03 shown on Figure 1.

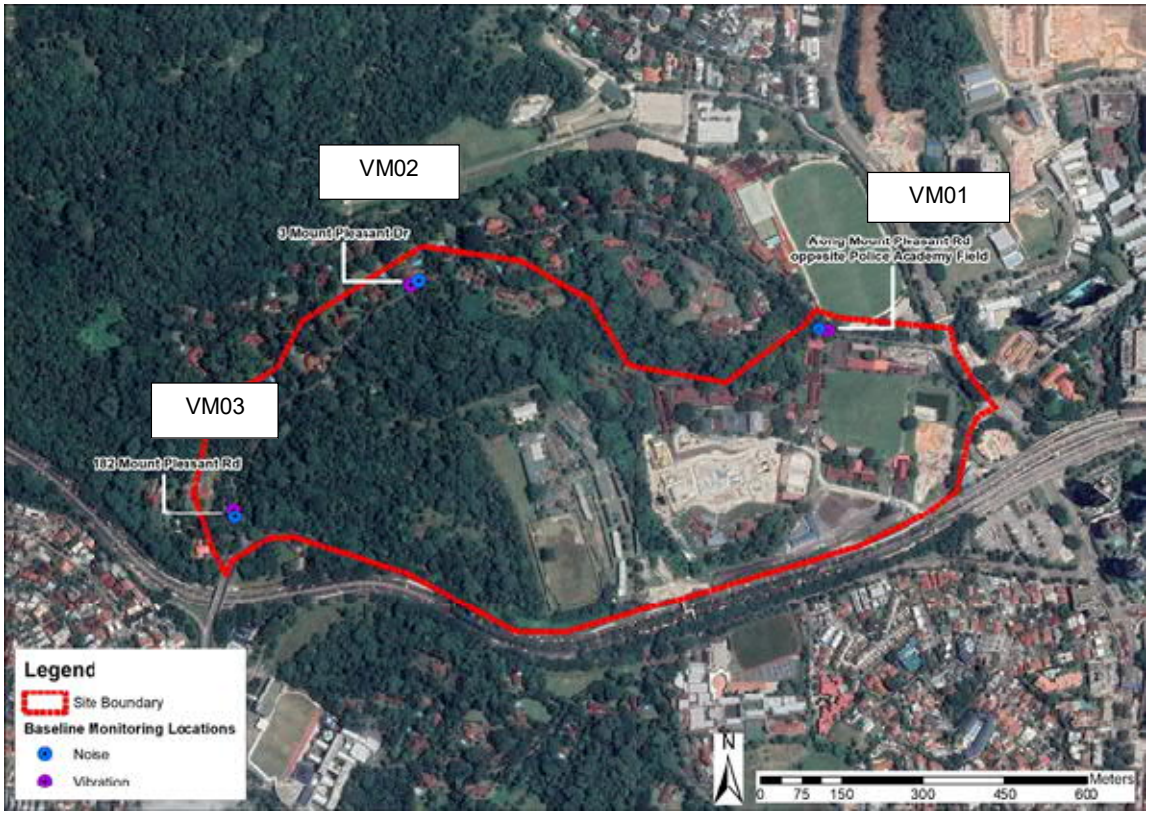


Figure 1 Baseline Vibration Monitoring Location

1.2 Ground-borne Vibration Monitoring Equipment

Three (3) Svantek SVAN 977 Type 1 Sound Level Meter (SLM) with microphone was utilized to collect data for the Project. For the purpose of QA/QC, SLM was calibrated before each monitoring session without any drift in calibration before and after monitoring to ensure that equipment readings remains within acceptable margins of error. In order to reduce the chances of recording unwanted noise caused by wind, a windshield was attached onto the microphone. Vibration levels were recorded in 5-minute intervals using the Peak Particle Velocity (PPV) descriptor. Calibration certificates of the vibration monitoring equipment, as per
Table 1 are presented in **Appendix J**. Peak Particle Velocity (PPV) vibration levels have been assessed as the representative baseline ground-borne vibration level for the site (see Section 1.3).

Table 1 Ground-borne Vibration Monitoring Equipment

Instrument	Brand	Model	Serial Numbers	Type
Sound & Vibration Analyser	Svantek	Svan-977	369828	1

Figure 2 Vibration Monitoring Setup

1.3 Baseline Ground-borne Vibration Monitoring Data

Daily baseline ground-borne vibration levels are monitored on the following dates:

- VM01 (7 May 2019 – 10 May 2019; 2:01 PM – 7:46 AM)
- VM02 (10 May 2019 – 14 May 2019; 10:47 AM – 9:57 AM)
- VM03 (14 May 2019 – 16 May 2019; 10:37 AM – 10:02 AM)

The corresponding graphs for the daily monitoring data are displayed in **Annex A**.

The recorded background levels are summarised and presented in Table 2.

Table 2 Summary of Ground-borne Vibration Baseline Levels

Monitoring period		Peak Particle Velocity (PPV), mm/s		
		VM01	VM02	VM03
7 May 2019	Max	15.42	NA	NA
	Min	0.06	NA	NA
	Average	1.04	NA	NA
8 May 2019	Max	72.03	NA	NA
	Min	0.23	NA	NA
	Average	3.38	NA	NA
9 May 2019	Max	194.54	NA	NA
	Min	0.01	NA	NA

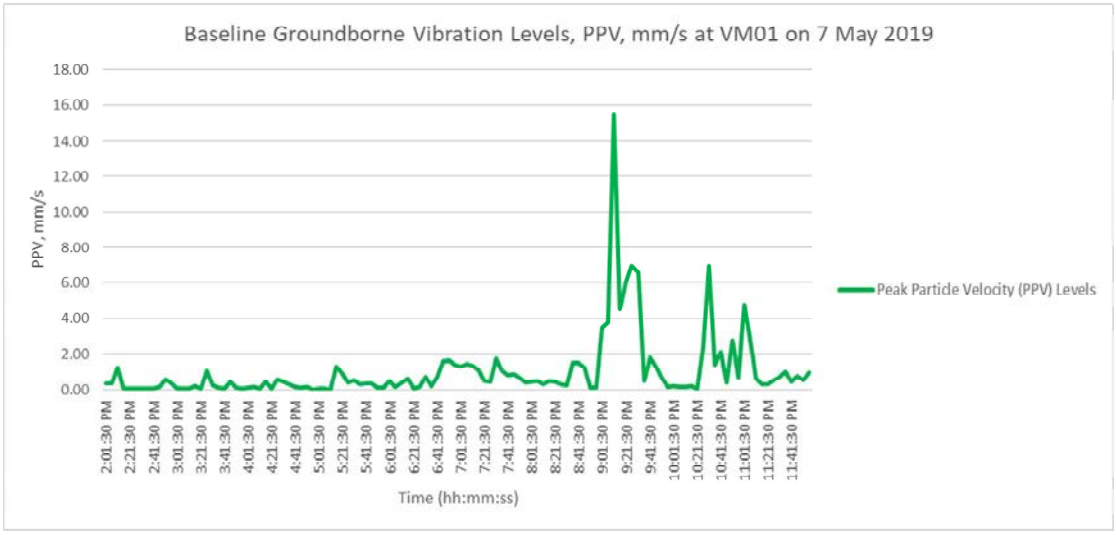
Monitoring period		Peak Particle Velocity (PPV), mm/s		
		VM01	VM02	VM03
	Average	2.54	NA	NA
10 May 2019	Max	94.51	23.12	NA
	Min	0.01	0.01	NA
	Average	1.95	0.78	NA
11 May 2019	Max	NA	467.74	NA
	Min	NA	0.02	NA
	Average	NA	4.73	NA
12 May 2019	Max	NA	474.79	NA
	Min	NA	0.01	NA
	Average	NA	3.23	NA
13 May 2019	Max	NA	154.88	NA
	Min	NA	0.01	NA
	Average	NA	1.37	NA
14 May 2019	Max	NA	8.15	647.89
	Min	NA	0.03	0.03
	Average	NA	0.30	7.97
15 May 2019	Max	NA	NA	2070.14
	Min	NA	NA	0.01
	Average	NA	NA	31.95
16 May 2019	Max	NA	NA	2.71
	Min	NA	NA	0.08
	Average	NA	NA	0.59

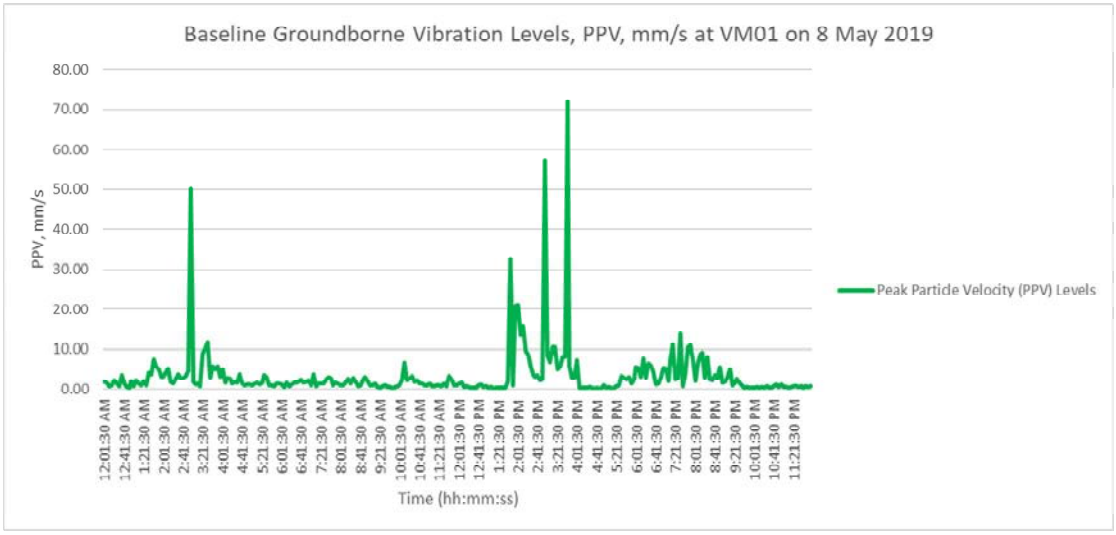
The summary of the baseline vibration monitoring at VM01, VM02 and VM03 is provided in Table 3.

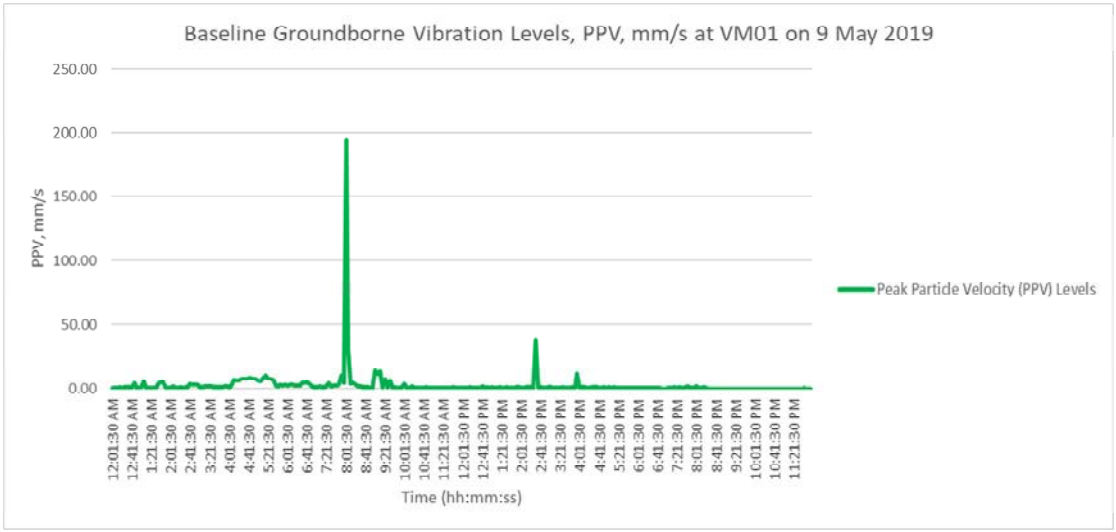
Table 3 Summary of Baseline Vibration Monitoring Results

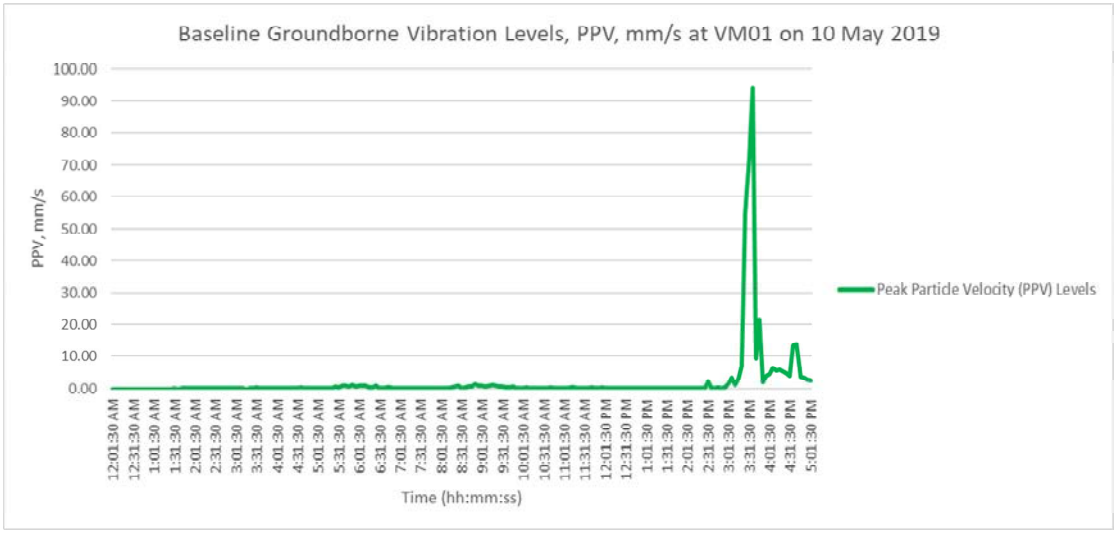
Location	Date and Time of Measurement	Peak Particle Velocity, PPV (mm/s)		
		Average	Max	Min
VM01	7 May 2019 – 10 May 2019; 2:01 PM – 7:46 AM	2.22	194.54	0.01
VM02	10 May 2019 – 14 May 2019; 10:47 AM – 9:57 AM	2.05	474.79	0.01
VM03	14 May 2019 – 16 May 2019; 10:37 AM – 10:02 AM	20.57	2070.14	0.01

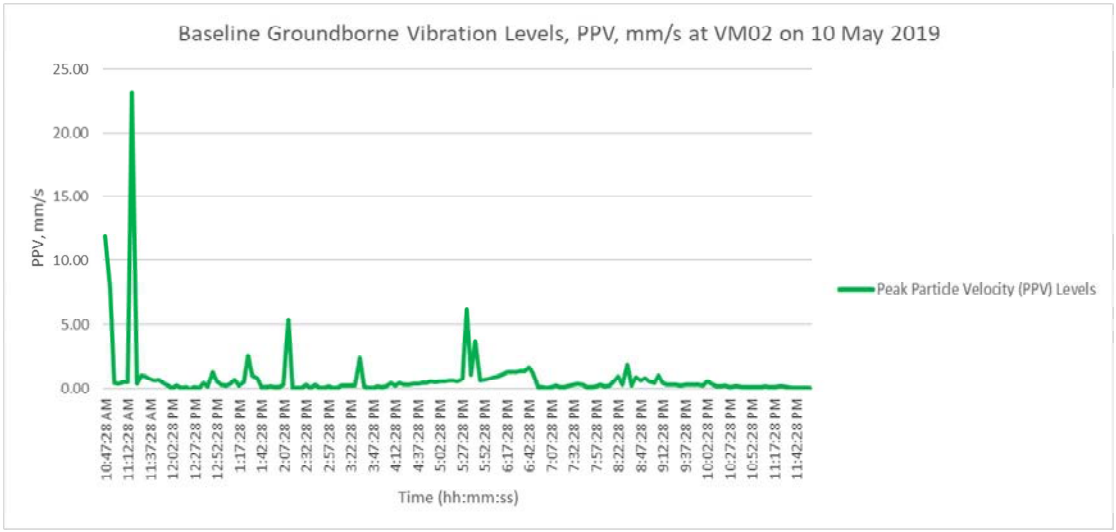
Annex A

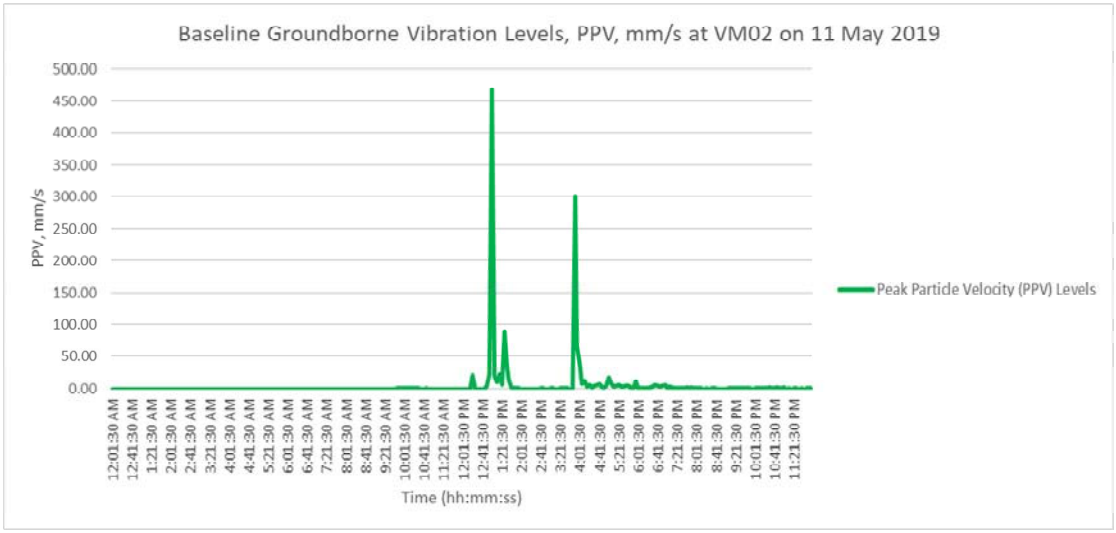

Baseline Groundborne Vibration Levels, PPV, mm/s at VM01 on 7 May 2019
PPV, mm/s
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2:01:30 PM
2:21:30 PM
2:41:30 PM
3:01:30 PM
3:21:30 PM
3:41:30 PM
4:01:30 PM
4:21:30 PM
4:41:30 PM
5:01:30 PM
5:21:30 PM
5:41:30 PM
6:01:30 PM
6:21:30 PM
6:41:30 PM
7:01:30 PM
7:21:30 PM
7:41:30 PM
8:01:30 PM
8:21:30 PM
8:41:30 PM
9:01:30 PM
9:21:30 PM
9:41:30 PM
10:01:30 PM
10:21:30 PM
10:41:30 PM
11:01:30 PM
11:21:30 PM
11:41:30 PM
Time (hh:mm:ss)
Peak Particle Velocity (PPV) Levels

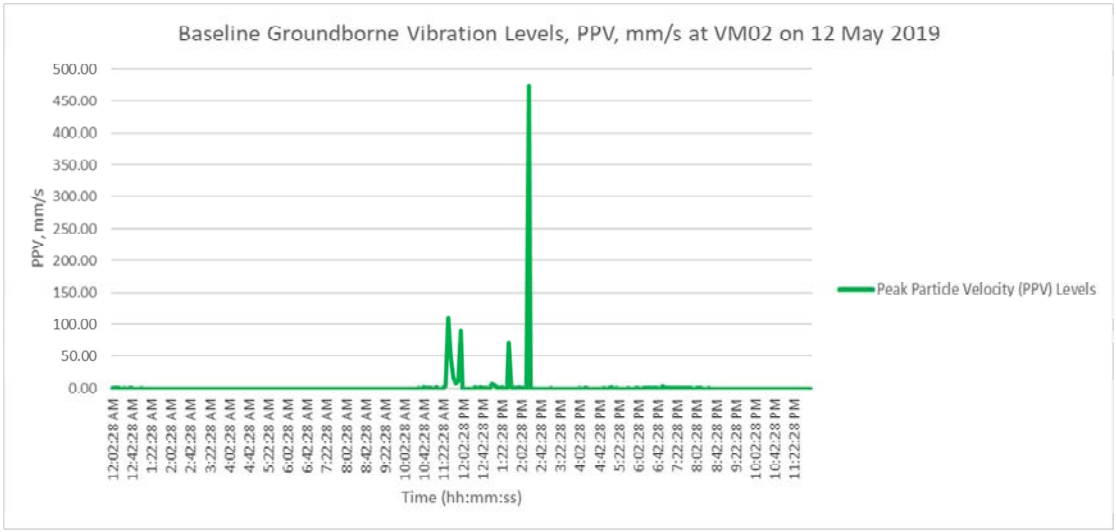

Baseline Groundborne Vibration Levels, PPV, mm/s at VM01 on 8 May 2019
PPV, mm/s
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
12:01:30 AM
12:41:30 AM
1:21:30 AM
2:01:30 AM
2:41:30 AM
3:21:30 AM
4:01:30 AM
4:41:30 AM
5:21:30 AM
6:01:30 AM
6:41:30 AM
7:21:30 AM
8:01:30 AM
8:41:30 AM
9:21:30 AM
10:01:30 AM
10:41:30 AM
11:21:30 AM
12:01:30 PM
12:41:30 PM
1:21:30 PM
2:01:30 PM
2:41:30 PM
3:21:30 PM
4:01:30 PM
4:41:30 PM
5:21:30 PM
6:01:30 PM
6:41:30 PM
7:21:30 PM
8:01:30 PM
8:41:30 PM
9:21:30 PM
10:01:30 PM
10:41:30 PM
11:21:30 PM
Time (hh:mm:ss)
Peak Particle Velocity (PPV) Levels

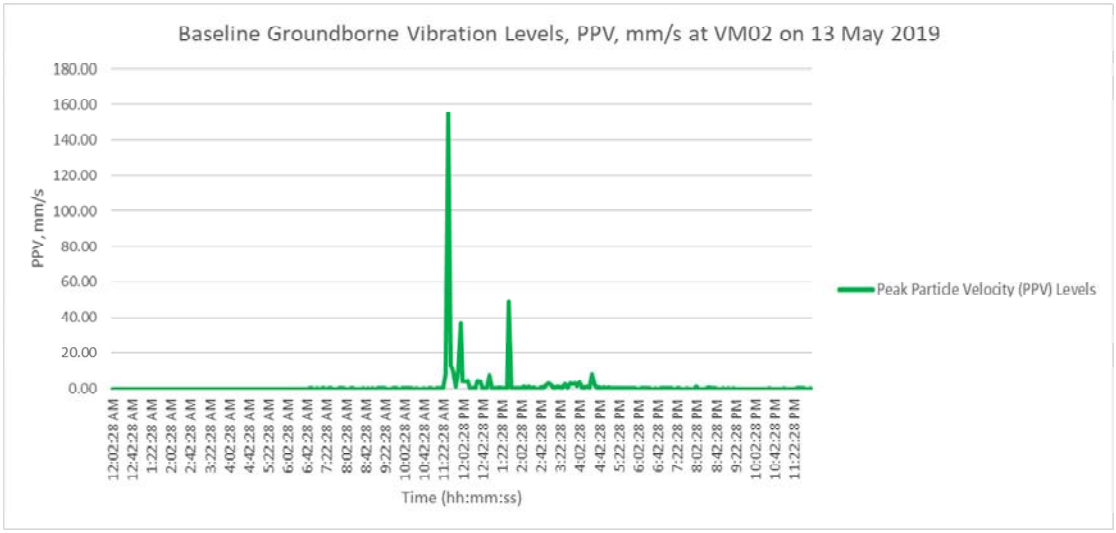

Baseline Groundborne Vibration Levels, PPV, mm/s at VM01 on 9 May 2019
PPV, mm/s
250.00
200.00
150.00
100.00
50.00
0.00
Time (hh:mm:ss)
Peak Partide Velocity (PPV) Levels

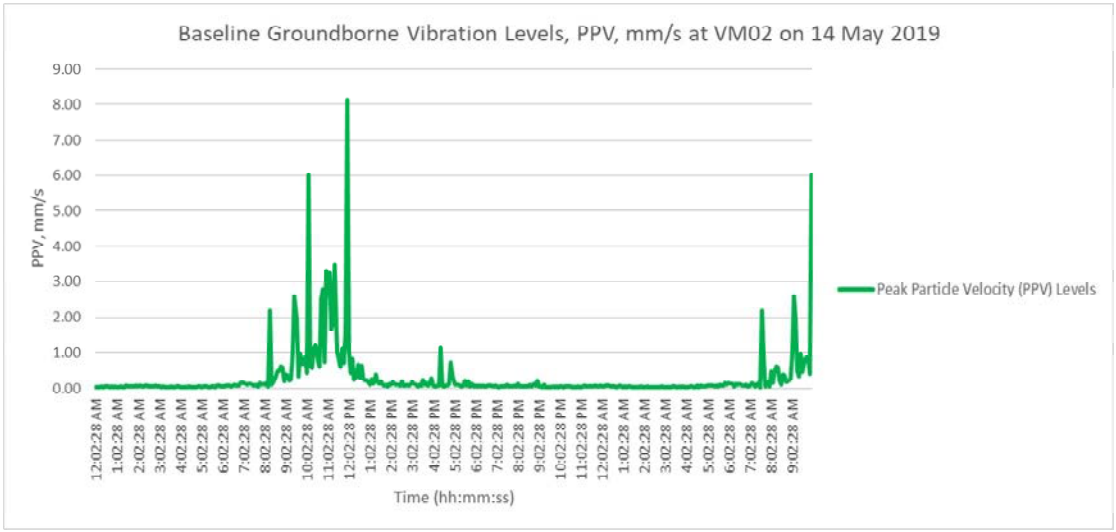

Baseline Groundborne Vibration Levels, PPV, mm/s at VM01 on 10 May 2019
PPV, mm/s
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Time (hh:mm:ss)
Peak Partide Velocity (PPV) Levels

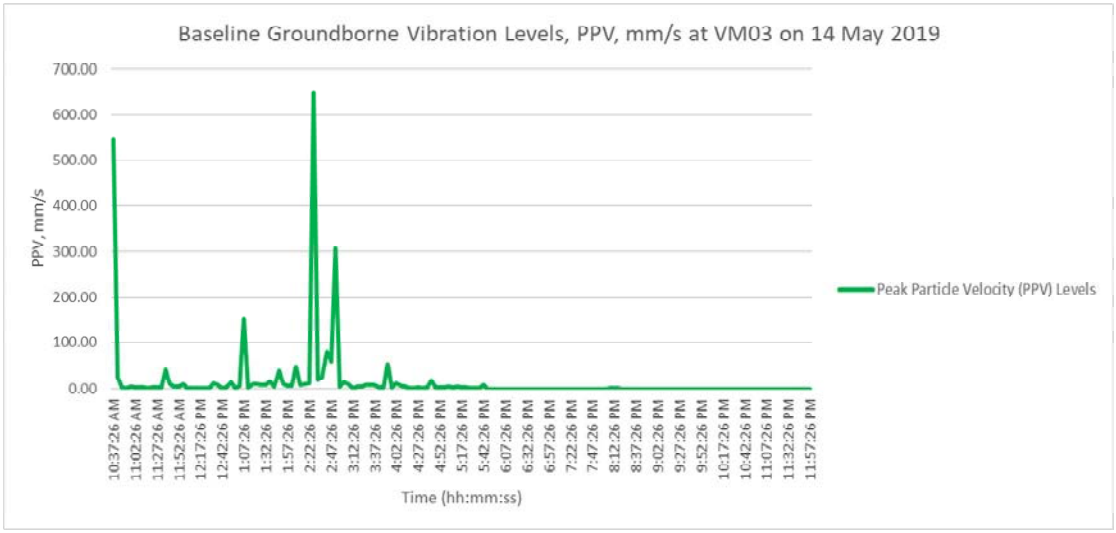

Baseline Groundborne Vibration Levels, PPV, mm/s at VM02 on 10 May 2019
PPV, mm/s
25.00
20.00
15.00
10.00
5.00
0.00
10:47:28 AM
11:12:28 AM
11:37:28 AM
12:02:28 PM
12:27:28 PM
12:52:28 PM
1:17:28 PM
1:42:28 PM
2:07:28 PM
2:32:28 PM
2:57:28 PM
3:22:28 PM
3:47:28 PM
4:12:28 PM
4:37:28 PM
5:02:28 PM
5:27:28 PM
5:52:28 PM
6:17:28 PM
6:42:28 PM
7:07:28 PM
7:32:28 PM
7:57:28 PM
8:22:28 PM
8:47:28 PM
9:12:28 PM
9:37:28 PM
10:02:28 PM
10:27:28 PM
10:52:28 PM
11:17:28 PM
11:42:28 PM
Time (hh:mm:ss)
Peak Partide Velocity (PPV) Levels

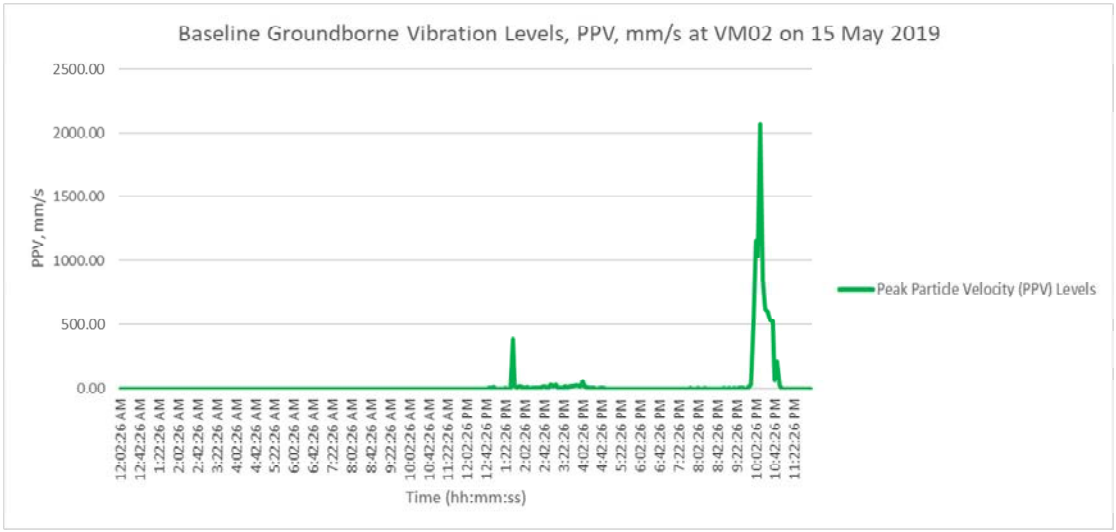

Baseline Groundborne Vibration Levels, PPV, mm/s at VM02 on 11 May 2019
PPV, mm/s
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
12:01:30 AM
12:41:30 AM
1:21:30 AM
2:01:30 AM
2:41:30 AM
3:21:30 AM
4:01:30 AM
4:41:30 AM
5:21:30 AM
6:01:30 AM
6:41:30 AM
7:21:30 AM
8:01:30 AM
8:41:30 AM
9:21:30 AM
10:01:30 AM
10:41:30 AM
11:21:30 AM
12:01:30 PM
12:41:30 PM
1:21:30 PM
2:01:30 PM
2:41:30 PM
3:21:30 PM
4:01:30 PM
4:41:30 PM
5:21:30 PM
6:01:30 PM
6:41:30 PM
7:21:30 PM
8:01:30 PM
8:41:30 PM
9:21:30 PM
10:01:30 PM
10:41:30 PM
11:21:30 PM
Time (hh:mm:ss)
Peak Partide Velocity (PPV) Levels

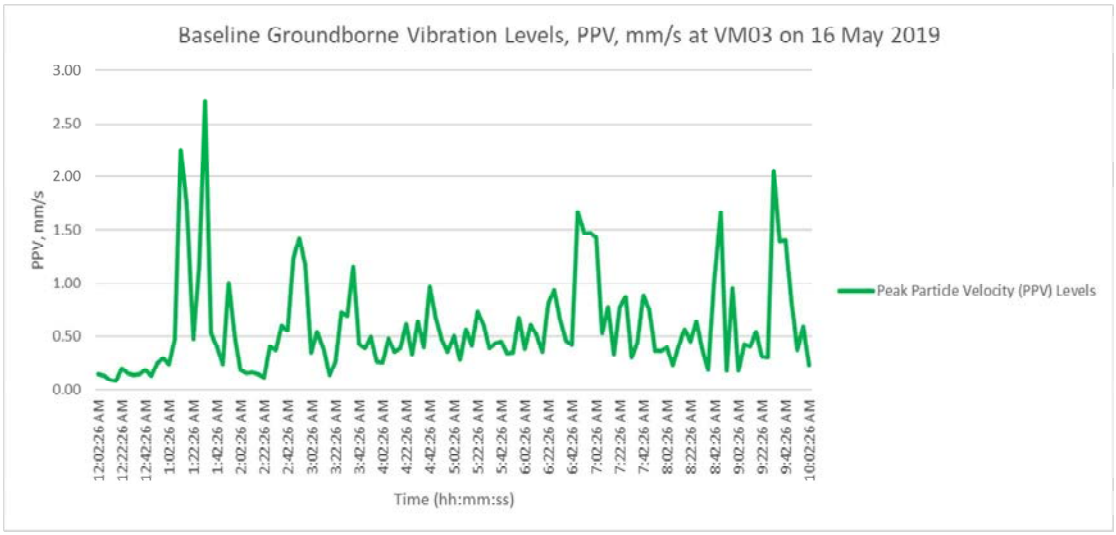

Baseline Groundborne Vibration Levels, PPV, mm/s at VM02 on 12 May 2019
PPV, mm/s
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Time (hh:mm:ss)
Peak Partide Velocity (PPV) Levels


Baseline Groundborne Vibration Levels, PPV, mm/s at VM02 on 13 May 2019
PPV, mm/s
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Time (hh:mm:ss)
Peak Partide Velocity (PPV) Levels


Baseline Groundborne Vibration Levels, PPV, mm/s at VM02 on 14 May 2019
PPV, mm/s
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
12:02:28 AM
1:02:28 AM
2:02:28 AM
3:02:28 AM
4:02:28 AM
5:02:28 AM
6:02:28 AM
7:02:28 AM
8:02:28 AM
9:02:28 AM
10:02:28 AM
11:02:28 AM
12:02:28 PM
1:02:28 PM
2:02:28 PM
3:02:28 PM
4:02:28 PM
5:02:28 PM
6:02:28 PM
7:02:28 PM
8:02:28 PM
9:02:28 PM
10:02:28 PM
11:02:28 PM
12:02:28 AM
1:02:28 AM
2:02:28 AM
3:02:28 AM
4:02:28 AM
5:02:28 AM
6:02:28 AM
7:02:28 AM
8:02:28 AM
9:02:28 AM
Time (hh:mm:ss)
Peak Partide Velocity (PPV) Levels


Baseline Groundborne Vibration Levels, PPV, mm/s at VM03 on 14 May 2019
PPV, mm/s
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
10:37:26 AM
11:02:26 AM
11:27:26 AM
11:52:26 AM
12:17:26 PM
12:42:26 PM
1:07:26 PM
1:32:26 PM
1:57:26 PM
2:22:26 PM
2:47:26 PM
3:12:26 PM
3:37:26 PM
4:02:26 PM
4:27:26 PM
4:52:26 PM
5:17:26 PM
5:42:26 PM
6:07:26 PM
6:32:26 PM
6:57:26 PM
7:22:26 PM
7:47:26 PM
8:12:26 PM
8:37:26 PM
9:02:26 PM
9:27:26 PM
9:52:26 PM
10:17:26 PM
10:42:26 PM
11:07:26 PM
11:32:26 PM
11:57:26 PM
Time (hh:mm:ss)
Peak Partide Velocity (PPV) Levels


Baseline Groundborne Vibration Levels, PPV, mm/s at VM02 on 15 May 2019
2500.00
2000.00
1500.00
1000.00
500.00
0.00
PPV, mm/s
Peak Partide Velocity (PPV) Levels
Time (hh:mm:ss)


Baseline Groundborne Vibration Levels, PPV, mm/s at VM03 on 16 May 2019
3.00
2.50
2.00
1.50
1.00
0.50
0.00
PPV, mm/s
Peak Partide Velocity (PPV) Levels
Time (hh:mm:ss)

Appendix I

Baseline Water Quality Laboratory Results

TEST REPORT

Our Reference No.	: **R193115**		Date Received	: 24/05/2019
Project Code / Ref.	: -		Date Commenced	: 24/05/2019
			Date Reported	: 04/06/2019
Customer Ref. No.	: -			
Customer Name	: AECOM Singapore Pte Ltd			
Customer Address	: 300 Beach Road #03-00 The Concourse Singapore 199555			
Attention To	: Ms Liang Liang			
Sample Description	: 3 Water Samples			
RESULTS:	Refer to Page 2			

Tan Thuan Piang
Laboratory Manager

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Main (Office and Laboratory): 116 Tuas South Ave 2, West Point Bizhub Singapore 637163 ☎ : +65 6790 0118 : +65 6790 0091
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Website: www.mls.sg

R193115

RESULTS

Test Parameter	Unit	Test Method	Sampling Date: 24/05/2019			LOR
			WQ1	WQ2	WQ3	
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	<2	<2	<2	2
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	10
Total Dissolved Solids, TDS	mg/L	APHA 2540C	83.0	49.0	49.0	10
Turbidity	NTU	APHA 2130B	1.0	2.1	2.5	-
Total Organic Carbon,TOC	mg/L	APHA 5310B	<1	<1	<1	1
Total Nitrogen as TN	mg/L	APHA 4500-N (C)	1.19	0.27	0.17	0.01
Total Phosphorus as TP	mg/L	APHA 4500-P (H)	0.025	0.031	0.034	0.01
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (I)	1.00	0.12	0.10	0.015
Ammonia as NH_4-N	mg/L	APHA 4500-NH_3 (H)	0.026	0.041	0.023	0.01
Orthophosphates as PO_4-P	mg/L	APHA 4500-P (G)	<0.025	<0.025	0.032	0.025
Enterococcus	cfu/100ml	APHA 9230C	100	260	<1	1
Sulphate as SO_4	mg/L	APHA 4110B	21.5	9.49	13.0	-
Chloride as Cl	mg/L	APHA 4110B	3.61	4.46	2.80	-
Carbonate	mg/L	APHA 4500-CO_2 (D)	<0.01	<0.01	<0.01	-
Bicarbonate as ($CaCO_3$)	mg/L	APHA 4500-CO_2 (D)	25.0	16.0	15.0	-
Calcium as Ca	mg/L	APHA 3120B	19.1	10.2	9.95	-
Potassium as K	mg/L	APHA 3120B	1.10	0.59	0.54	-
Magnesium as Mg	mg/L	APHA 3120B	0.85	0.67	0.88	-
Sodium as Na	mg/L	APHA 3120B	3.32	2.72	2.36	-
Lead as Pb	µg/L	APHA 3120B	<5	<5	<5	5

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.

TEST REPORT

Our Reference No.	:	**R193228**	Date Received	:	31/05/2019
Project Code / Ref.	:	-	Date Commenced	:	31/05/2019
			Date Reported	:	11/06/2019
Customer Ref. No.	:	-			
Customer Name	:	AECOM Singapore Pte Ltd			
Customer Address	:	300 Beach Road #03-00 The Concourse Singapore 199555			
Attention To	:	Ms Liang Liang			
Sample Description	:	3 Water Samples			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Laboratory Manager

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2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

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Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 ☎ : +65 6262 3736 (Lab) ☎ : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

R193228

RESULTS

Test Parameter	Unit	Test Method	Sampling Date: 31/05/2019			LOR
			WQ1	WQ2	WQ3	
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	<2	<2	<2	2
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	10
Total Dissolved Solids, TDS	mg/L	APHA 2540C	83.0	42.0	50.0	10
Turbidity	NTU	APHA 2130B	3.2	6.6	3.1	-
Total Organic Carbon,TOC	mg/L	APHA 5310B	<1	1.41	<1	1
Total Nitrogen as TN	mg/L	APHA 4500-N (C)	1.23	0.55	0.24	0.01
Total Phosphorus as TP	mg/L	APHA 4500-P (H)	0.025	0.051	0.052	0.01
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (I)	1.04	0.23	0.13	0.015
Ammonia as NH_4-N	mg/L	APHA 4500-NH_3 (H)	0.023	0.045	0.032	0.01
Orthophosphates as PO_4-P	mg/L	APHA 4500-P (G)	<0.025	<0.025	<0.025	0.025
Enterococcus	cfu/100ml	APHA 9230C	3,300	700	480	1
Lead as Pb	µg/L	APHA 3120B	<5	<5	<5	5
Sulphate as SO_4	mg/L	APHA 4110B	23.2	7.88	13.7	-
Chloride as Cl	mg/L	APHA 4110B	3.92	4.34	3.41	-
Carbonate as $CaCO_3$	mg/L	APHA 2320B	<2	<2	<2	-
Bicarbonate as $CaCO_3$	mg/L	APHA 4500-CO_2 (D)	25.0	14.0	14.0	-
Calcium as Ca	mg/L	APHA 3120B	18.3	7.79	9.26	-
Potassium as K	mg/L	APHA 3120B	1.17	0.94	0.91	-
Magnesium as Mg	mg/L	APHA 3120B	0.92	0.49	0.73	-
Sodium as Na	mg/L	APHA 3120B	3.44	2.47	2.45	-

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.

TEST REPORT

Our Reference No.	:	**R194454**	Date Received	:	30/08/2019
Project Code / Ref.	:	-	Date Commenced	:	30/08/2019
			Date Reported	:	09/09/2019
Customer Ref. No.	:	-			
Customer Name	:	AECOM Singapore Pte Ltd			
Customer Address	:	300 Beach Road #03-00 The Concourse Singapore 199555			
Attention To	:	Ms Liang Liang			
Sample Description	:	3 Water Samples			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Laboratory Manager

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R194454

RESULTS

Test Parameter	Unit	Test Method	Sampling Date: 30/08/2019			LOR
			WQ1	WQ2	WQ3	
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	<2	<2	<2	2
Total Suspended Solids, TSS	mg/L	APHA 2540D	19.3	26.7	<10	10
Total Dissolved Solids, TDS	mg/L	APHA 2540C	72.0	114	60.0	10
Turbidity	NTU	APHA 2130B	11	13	5.2	-
Total Organic Carbon,TOC	mg/L	APHA 5310B	7.09	2.50	1.93	1
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.52	1.52	0.53	0.01
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.23	0.056	0.044	0.01
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (I)	0.58	0.49	0.24	0.015
Ammonia as NH_4-N	mg/L	APHA 4500-NH_3 (H)	0.20	0.36	0.056	0.01
Orthophosphates as PO_4-P	mg/L	APHA 4500-P (G)	0.18	0.025	0.035	0.025
Enterococcus	cfu/100ml	APHA 9230C	25,000	6,000	1,300	1
Lead as Pb	µg/L	APHA 3125B	<5	<5	<5	5

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.

TEST REPORT

Our Reference No.	: **R200094**	Date Received	: 07/01/2020
Project Code / Ref.	: -	Date Commenced	: 07/01/2020
		Date Reported	: 15/01/2020
Customer Ref. No.	: -		
Customer Name	: AECOM Singapore Pte Ltd		
Customer Address	: 300 Beach Road #03-00 The Concourse Singapore 199555		
Attention To	: Ms Liang Liang		
Sample Description	: 2 Water Samples		
RESULTS:	Refer to Page 2		

Tan Thuan Piang
Laboratory Manager

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R200094

RESULTS

Test Parameter	Unit	Test Method	Sampling Date: 07/01/2020		LOR
			WQ4	WQ5	
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	<2	<2	2
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	10
Total Dissolved Solids, TDS	mg/L	APHA 2540C	47.0	52.0	10
Turbidity	NTU	APHA 2130B	6.3	6.7	-
Total Organic Carbon,TOC	mg/L	APHA 5310B	1.36	1.14	1
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.16	0.35	0.01
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.037	0.048	0.01
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (I)	0.090	0.092	0.015
Ammonia as NH_4-N	mg/L	APHA 4500-NH_3 (H)	0.032	0.14	0.01
Orthophosphates as PO_4-P	mg/L	APHA 4500-P (G)	0.035	0.036	0.025
Enterococcus	cfu/100ml	APHA 9230C	10	<1	1
Sulphate as SO_4	mg/L	APHA 4110B	16.2	18.1	-
Chloride as Cl	mg/L	APHA 4110B	3.61	3.57	-
Carbonate as $CaCO_3$	mg/L	APHA 4500-CO_2 (D) /2320B	<0.01	<0.01	-
Bicarbonate as $CaCO_3$	mg/L	APHA 4500-CO_2 (D) /2320B	16.0	20.0	-
Calcium as Ca	mg/L	APHA 3120B	10.8	11.1	-
Potassium as K	mg/L	APHA 3120B	0.24	0.28	-
Magnesium as Mg	mg/L	APHA 3120B	0.47	0.50	-
Sodium as Na	mg/L	APHA 3120B	2.62	2.37	-
Lead as Pb	µg/L	APHA 3125B	<5	<5	5

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.

TEST REPORT

Our Reference No.	:	**R200235**	Date Received	:	14/01/2020
Project Code / Ref.	:	60596697	Date Commenced	:	14/01/2020
			Date Reported	:	22/01/2020
Customer Ref. No.	:	-			
Customer Name	:	AECOM Singapore Pte Ltd			
Customer Address	:	300 Beach Road #03-00 The Concourse Singapore 199555			
Attention To	:	Ms Liang Liang			
Sample Description	:	2 Water Samples			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Laboratory Manager

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R200235

RESULTS

Test Parameter	Unit	Test Method	Sampling Date: 14/01/2020		Detection Limit
			WQ4	WQ5	
Turbidity	NTU	APHA 2130B	6.5	9.0	-
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	<2	<2	2
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.23	0.29	0.01
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.054	0.055	0.01
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (I)	0.061	0.065	0.015
Ammonia as NH_4-N	mg/L	APHA 4500-NH_3 (H)	0.041	0.16	0.01
Total Dissolved Solids,TDS	mg/L	APHA 2540C	48.0	52.0	10
Orthophosphates as PO_4	mg/L	APHA 4500-P (G)	0.14	0.14	0.025
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	10
Total Organic Carbon,TOC	mg/L	APHA 5310B	1.14	1.14	1
Enterococcus	cfu/100ml	APHA 9230C	4	100	1
Lead as Pb	µg/L	APHA 3120B	<5	<5	5

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.

TEST REPORT

Our Reference No.	: **R200352**	Date Received	: 21/01/2020
Project Code / Ref.	: 60596697	Date Commenced	: 21/01/2020
		Date Reported	: 03/02/2020

Customer Ref. No.	:	-
Customer Name	:	AECOM Singapore Pte Ltd
Customer Address	:	300 Beach Road #03-00 The Concourse Singapore 199555
Attention To	:	Ms Liang Liang
Sample Description	:	3 Water Samples
RESULTS:		Refer to Page 2

Tan Thuan Piang
Laboratory Manager

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R200352

RESULTS

Test Parameter	Unit	Test Method	Sampling Date: 21/01/2020			Detection Limit
			WQ4	WQ5	WQ6	
Turbidity	NTU	APHA 2130B	30	25	9.8	-
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	<2	<2	<2	2
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.48	0.69	2.00	0.01
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.063	0.072	0.047	0.01
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (I)	0.19	0.24	1.38	0.015
Ammonia as NH_4-N	mg/L	APHA 4500-NH_3 (H)	0.064	0.12	0.010	0.01
Total Dissolved Solids,TDS	mg/L	APHA 2540C	69.0	66.0	106	10
Orthophosphates as PO_4	mg/L	APHA 4500-P (G)	0.14	0.14	0.11	0.025
Total Suspended Solids, TSS	mg/L	APHA 2540D	20.7	<10	<10	10
Total Organic Carbon,TOC	mg/L	APHA 5310B	2.32	2.28	12.9	1
Enterococcus	cfu/100ml	APHA 9230C	140	160	700	1
Lead as Pb	µg/L	APHA 3120B	<5	<5	<5	5

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.

Appendix J

Soil Boring and Well Construction Details

BOREHOLE LOG BH01

PROJECT NUMBER	60596697	**DATE**	Apr 25, 19
PROJECT NAME	Mount Pleasant EIS	**NORTHING**	34775.26
LOCATION	Mount Pleasant	**EASTING**	27589.06
DRILLING METHOD	Hand Auger	**SURFACE ELEVATION**	112.238 m RL
SAMPLING METHOD	Grab	**TOP OF CASING (TOC)**	112.660 m RL
WATER FIRST NOTICED	1.5 m BGS	**BLANK**	0 - 0.5m BGS m
STABILIZED WATER LEVEL	1.464 m BGS	**SCREEN**	0.5 - 3.0 m BGS m
LOGGED BY	OGL/JPB	**GRAVEL PACK**	0 - 3.0 m BGS m
COMMENTS	Converted to MW	**SANITARY SEAL/BENTONITE**	0

RECOVERY	SAMPLE ID	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGY DESCRIPTION	CONTACT DEPTH	WELL DIAGRAM
					TOPSOIL	Topsoil		
	BH01-0.5m	✳	0.5		SP-SM	Silty sand Brown Fine grained Poorly Graded Medium dense Wet	0.50	
			1.0		MH	Clayey silt Brown Medium Plasticity Firm Wet	1.00	
			1.5		MH	Clayey silt Brown Medium plasticity Soft Wet - saturated with water	1.50	Filter Pack Screen
			2.0		OL	Wet Grey-brown	2.00	
			2.5		OL	Peaty silt Black to dark grey Very wet Low plasticity Very soft	2.50	
	BH01-3.0m	✳	3.0		OL	Total Depth: 3.00 m	3.00	Bottom Cap

MOUNT PLEASANT BORELOG.GPJ 8/30/19

BOREHOLE LOG BH02

PROJECT NUMBER	60596697	**DATE**	Apr 25, 19
PROJECT NAME	Mount Pleasant EIS	**NORTHING**	34812.76
LOCATION	Mount Pleasant	**EASTING**	27717.67
DRILLING METHOD	Hand Auger	**SURFACE ELEVATION**	110.432 m RL
SAMPLING METHOD	Grab	**TOP OF CASING (TOC)**	111.090 m RL
WATER FIRST NOTICED	3.0 m BGS	**BLANK**	0 - 0.5m BGS m
STABILIZED WATER LEVEL	2.360 m BGS	**SCREEN**	0.5 - 3.0 m BGS m
LOGGED BY	OGL/JPB	**GRAVEL PACK**	0 - 3.0 m BGS m
COMMENTS	Converted to MW	**SANITARY SEAL/BENTONITE**	0

RECOVERY	SAMPLE ID	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGY DESCRIPTION	CONTACT DEPTH
			0.0		TOPSOIL	TOPSOIL	
	BH02-0.5m	✳	0.5		CL-ML	Silty Clay with traces of coarse grained sand Yellow-brown Moist Low plasticity Stiff	0.50
			1.0		CL-ML		1.00
			1.5		MH	Clayey silt Yellow-brown Wet(likely from rain) Low plasticity Firm	1.50
			2.0		MH	Clayey silt Grey-brown Moist Medium plasticity Firm	2.00
			2.5		MH		2.50
	BH02-3.0m	✳	3.0		MH	Clayey silt with some fine grained sand Grey-brown Medium plasticity Firm Wet Total Depth: 3.00 m	3.00

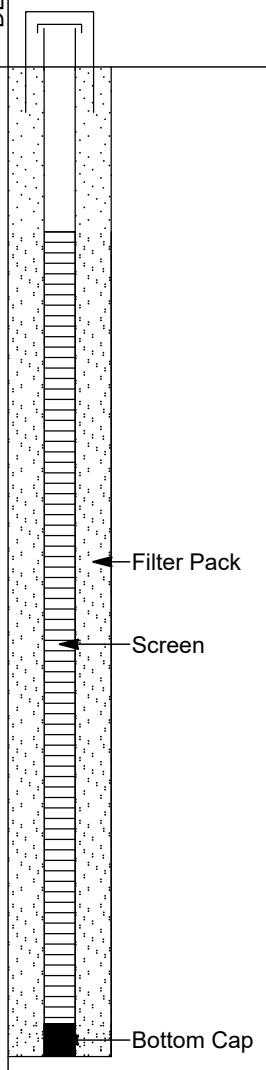
WELL DIAGRAM: Filter Pack; Screen; Bottom Cap

MOUNT PLEASANT BORELOG.GPJ 8/30/19

BOREHOLE LOG BH03

PROJECT NUMBER	60596697	**DATE**	Apr 26, 19
PROJECT NAME	Mount Pleasant EIS	**NORTHING**	34731.86
LOCATION	Mount Pleasant	**EASTING**	27880
DRILLING METHOD	Hand Auger	**SURFACE ELEVATION**	108.116 m RL
SAMPLING METHOD	Grab	**TOP OF CASING (TOC)**	108.836 m RL
WATER FIRST NOTICED	2.2 m BGS	**BLANK**	0 - 0.5m BGS m
STABILIZED WATER LEVEL	2.359 m BGS	**SCREEN**	0.5 - 3.0 m BGS m
LOGGED BY	OGL/JPB	**GRAVEL PACK**	0 - 3.0 m BGS m
COMMENTS	Converted to MW	**SANITARY SEAL/BENTONITE**	0

RECOVERY	SAMPLE ID	ANALYSED	DEPTH (m BGL)	USCS CLASS	LITHOLOGY DESCRIPTION	CONTACT DEPTH
				TOPSOIL	TOPSOIL	
	BH03-0.5m	✳	0.5	CL-ML	Silty clay Yellow - brown Medium Plasticity Moist Firm	0.50
			1.0	CL-ML		1.00
			1.5	CL-ML		1.50
			2.0	CL-ML	Wet	2.00
			2.5	CL-ML		2.50
	BH03-3.0m	✳	3.0	CL-ML	Very wet Total Depth: 3.00 m	3.00



MOUNT PLEASANT BORELOG.GPJ 8/30/19

BOREHOLE LOG BH04

PROJECT NUMBER	60596697	**DATE**	Apr 27, 19
PROJECT NAME	Mount Pleasant EIS	**NORTHING**	34522.88
LOCATION	Mount Pleasant	**EASTING**	27570.88
DRILLING METHOD	Hand Auger	**SURFACE ELEVATION**	111.538 m RL
SAMPLING METHOD	Grab	**TOP OF CASING (TOC)**	112.252 m RL
WATER FIRST NOTICED	3.0 m BGS	**BLANK**	0 - 0.5m BGS m
STABILIZED WATER LEVEL	2.615 m BGS	**SCREEN**	0.5 - 3.0 m BGS m
LOGGED BY	OGL/JPB	**GRAVEL PACK**	0 - 3.0 m BGS m
COMMENTS	Converted to MW	**SANITARY SEAL/BENTONITE**	0

RECOVERY	SAMPLE ID	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGY DESCRIPTION	CONTACT DEPTH	WELL DIAGRAM
			0		TOPSOIL	Top soil with silty sand Loose Poorly graded Fine grained Grey brown		
	BH04-0.5m	✳	0.5		CL-ML	Silty clay Orange-brown Firm Moist Low plasticity	0.50	
			1.0					
			1.5		CL-ML		1.50	Filter Pack Screen
			2.0					
			2.5					
	BH04-3.0m	✳	3.0		CL-ML	Silty clay Brown Stiff Wet Medium Plasticity Total Depth: 3.00 m	3.00	Bottom Cap

MOUNT PLEASANT BORELOG.GPJ 8/30/19

BOREHOLE LOG BH05

PROJECT NUMBER	60596697	**DATE**	Apr 27, 19
PROJECT NAME	Mount Pleasant EIS	**NORTHING**	34431.74
LOCATION	Mount Pleasant	**EASTING**	27538.46
DRILLING METHOD	Hand Auger	**SURFACE ELEVATION**	106.937 m RL
SAMPLING METHOD	Grab	**TOP OF CASING (TOC)**	107.546 m RL
WATER FIRST NOTICED	3.0 m BGS	**BLANK**	0 - 0.5m BGS m
STABILIZED WATER LEVEL	1.425 m BGS	**SCREEN**	0.5 - 3.0 m BGS m
LOGGED BY	OGL/JPB	**GRAVEL PACK**	0 - 3.0 m BGS m
COMMENTS	Converted to MW	**SANITARY SEAL/BENTONITE**	0

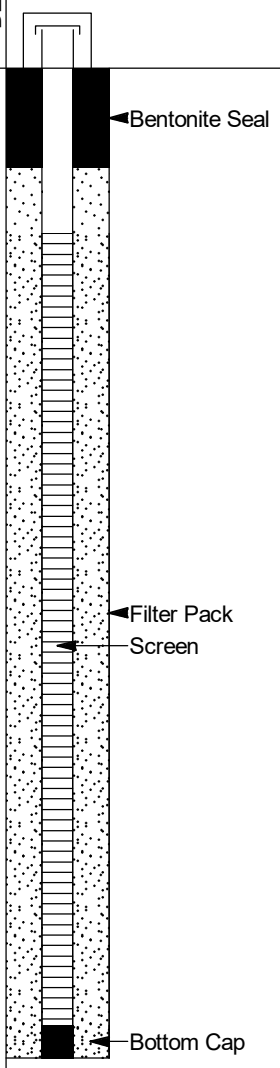
RECOVERY	SAMPLE ID	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGY DESCRIPTION	CONTACT DEPTH	WELL DIAGRAM
					TOPSOIL	TOPSOIL		
	BH05-0.5m	✳	0.5		MH	Clayey silt with trace coarse sand Light brown Soft Wet Medium plasticity	0.50	
			1.0		MH	Color changed to grey Very wet Very soft	1.00	
			1.5					Filter Pack
			2.0		MH		2.00	Screen
			2.5					
	BH05-3.0m	✳	3.0		OH	Peaty silt Dark grey Very soft Very wet High plasticity	3.00	Bottom Cap
						Total Depth: 3.00 m		

MOUNT PLEASANT BORELOG.GPJ 8/30/19

MONITORING WELL LOG VBH/VMW-01

PROJECT NUMBER	60596697	**DATE**	Jan 20, 20
PROJECT NAME	Mount Pleasant EIS	**NORTHING**	34531.506
LOCATION	Mount Pleasant, Singapore	**EASTING**	27074.3243
DRILLING METHOD	Hand Auger	**SURFACE ELEVATION**	104.525 m RL
SAMPLING METHOD	Grab	**TOP OF CASING (TOC)**	105.115 m RL
WATER FIRST NOTICED	1.0 m BGS	**BLANK**	0 - 0.5 m
STABILIZED WATER LEVEL	0.353 m BGS	**SCREEN**	0.5 - 3.0 m
LOGGED BY	OGL/SCY	**GRAVEL PACK**	0.3 - 3.0 m
COMMENTS	Borehole converted into temporary monitoring well	**SANITARY SEAL/BENTONITE**	0 - 0.3

RECOVERY	SAMPLE ID	ANALYSED	DEPTH (m BGL)	USCS CLASS	LITHOLOGY DESCRIPTION	CONTACT DEPTH
			0	TOPSOIL	Topsoil	
	VBH-01 (0.5 m)	✳	0.5	MLS	Sandy SILT; dark brown, soft, moist, no plasticity, no stain and no odour	0.50
			1.0 ▽	MH	Clayey SILT; brown, soft, wet, low plasticity, no stain and no odour	1.00
			1.5	MH	Organic material (timber) observed	1.50
			2.0	MH		2.00
			2.5	MH		2.50
	VBH-01 (3.0 m)	✳	3.0	ML	SILT; dark brown, soft, wet, low plasticity, no stain, no odour and organic matetrial (timber) observed Total Depth: 3.00 m	3.00



WELL DIAGRAM

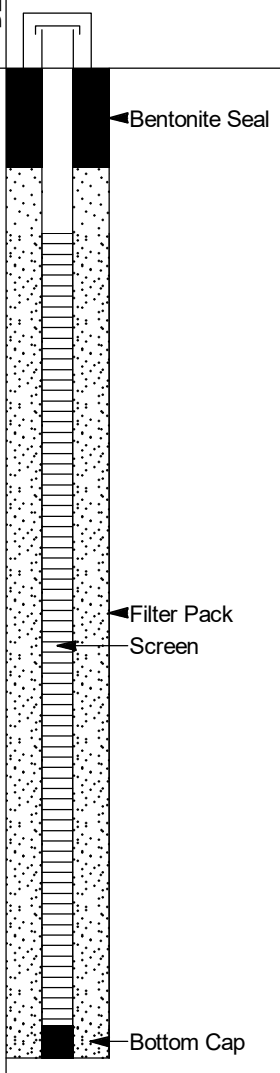
MOUNT PLEASANT BORELOG.GPJ 2/12/20

MONITORING WELL LOG VBH/VMW-02

PROJECT NUMBER	60596697	**DATE**	Jan 20, 20
PROJECT NAME	Mount Pleasant EIS	**NORTHING**	34505.2249
LOCATION	Mount Pleasant, Singapore	**EASTING**	27074.2657
DRILLING METHOD	Hand Auger	**SURFACE ELEVATION**	104.725 m RL
SAMPLING METHOD	Grab	**TOP OF CASING (TOC)**	105.315 m RL
WATER FIRST NOTICED	1.5 m BGS	**BLANK**	0 - 0.5 m
STABILIZED WATER LEVEL	1.225 m BGS	**SCREEN**	0.5 - 3.0 m
LOGGED BY	OGL/SCY	**GRAVEL PACK**	0.3 - 3.0 m
COMMENTS	Borehole converted into temporary monitoring well	**SANITARY SEAL/BENTONITE**	0 - 0.3

RECOVERY	SAMPLE ID	ANALYSED	DEPTH (m BGL)	GRAPHIC LOG	USCS CLASS	LITHOLOGY DESCRIPTION	CONTACT DEPTH
			0		TOPSOIL	Topsoil	
	VBH-02 (0.5 m)	✳	0.5		SP-SM	Silty SAND; fine grained, poorly graded, dark brown, loose, dry, no stain and no odour	0.50
			1.0		CLS	Sandy CLAY, brown, firm, moist, low plasticity, no stain, no odour, some fabric material observed	1.00
			1.5		MH	Clayey SILT, dark brown, soft, wet, low plasticity, no stain, no odour and some organic material (timber) observed	1.50
			2.0		MH		2.00
			2.5		ML	SILT, black, soft, wet, no stain, no odour and organic material observed	2.50
	VBH-02 (3.0 m)	✳	3.0		ML	Total Depth: 3.00 m	3.00

WELL DIAGRAM



MOUNT PLEASANT BORELOG.GPJ 2/12/20

Appendix K

Slug Test Data

WELL ID: MW1 - Rising Head Test

Local ID: MW1
Date: 13/6/2019
Time: 13:40

INPUT

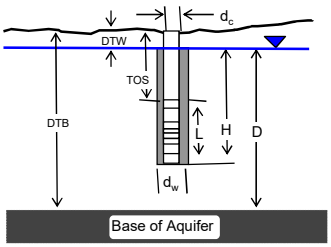
Construction:	
Casing dia. (d_c)	0.0508 Meter
Annulus dia. (d_w)	0.1016 Meter
Screen Length (L)	2.5 Meter
Depths to:	
water level (DTW)	1.078 Meter
top of screen (TOS)	0.5 Meter
Base of Aquifer (DTB)	10 Meter
Annular Fill:	
across screen --	Medium Sand
above screen --	Open Hole
Aquifer Material --	Medium Sand

COMPUTED

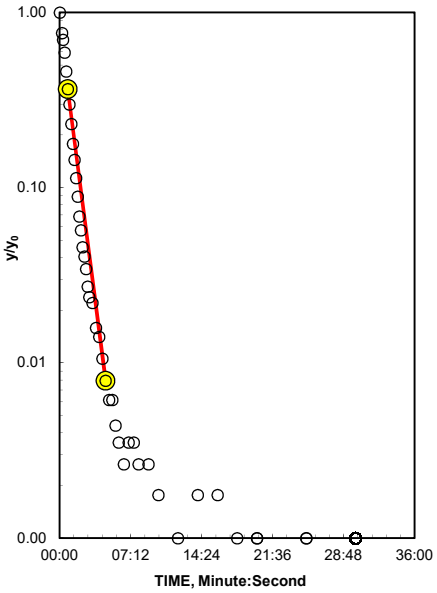
L_{wetted}	1.922 Meter
D =	8.922 Meter
H =	1.922 Meter
L/r_w =	37.83
$y_{0\text{-DISPLACEMENT}}$ =	2.23 Meter
$y_{0\text{-SLUG}}$ =	0.00 Meter
From look-up table using L/r_w	
Partial penetrate A =	2.777
B =	0.451
ln(Re/rw) =	2.300
Re =	1.66 Meter
Slope =	0.007233937 $\log_{10}$/sec
$t_{90\%}$ recovery =	138 sec

Input is consistent.

K =	0.0000064 Meter/Second
	0.00064



Adjust slope of line to estimate K



Entry	Reduced Data Time, Hr:Min:Sec	Water Level
1	0:00:00.0	2.23
2	0:00:15.0	1.96
3	0:00:20.0	1.89
4	0:00:30.0	1.77
5	0:00:40.0	1.62
6	0:00:50.0	1.51
7	0:01:00.0	1.43
8	0:01:10.0	1.36
9	0:01:20.0	1.30
10	0:01:30.0	1.26
11	0:01:40.0	1.22
12	0:01:50.0	1.19
13	0:02:00.0	1.17
14	0:02:10.0	1.16
15	0:02:20.0	1.15
16	0:02:30.0	1.14
17	0:02:40.0	1.13
18	0:02:50.0	1.12
19	0:03:00.0	1.12
20	0:03:20.0	1.12
21	0:03:40.0	1.11
22	0:04:00.0	1.11
23	0:04:20.0	1.11
24	0:04:40.0	1.10
25	0:05:00.0	1.10
26	0:05:20.0	1.10
27	0:05:40.0	1.10
28	0:06:00.0	1.10
29	0:06:30.0	1.10
30	0:07:00.0	1.10
31	0:07:30.0	1.10
32	0:08:00.0	1.10
33	0:09:00.0	1.10
34	0:10:00.0	1.10
35	0:12:00.0	1.09
36	0:14:00.0	1.10
37	0:16:00.0	1.10
38	0:18:00.0	1.09
39	0:20:00.0	1.09
40	0:25:00.0	1.09
41	0:30:00.0	1.09
42	0:20:00.0	1.09
43	0:25:00.0	1.09

K= 0.0000064 is less than likely minimum of 0.0000705 for Medium Sand

REMARKS: Bouwer and Rice analysis of slug test, WRR 1976

- Rising head test
- Groundwater was extracted via vacuum pump

WELL ID: MW2 - Rising Head Test

Local ID: MW2
Date: 13/6/2019
Time: 14:20

INPUT

Construction:	
Casing dia. (d_c)	0.0508 Meter
Annulus dia. (d_w)	0.1016 Meter
Screen Length (L)	2.5 Meter
Depths to:	
water level (DTW)	1.905 Meter
top of screen (TOS)	0.5 Meter
Base of Aquifer (DTB)	10 Meter
Annular Fill:	
across screen --	Medium Sand
above screen --	Open Hole
Aquifer Material --	Clay soils (surface)

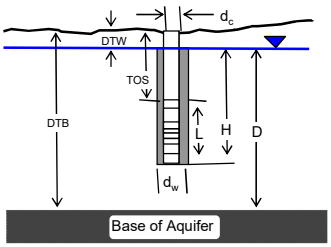
COMPUTED

L_{wetted}	1.095 Meter
D =	8.095 Meter
H =	1.095 Meter
L/r_w =	21.56
$y_{0\text{-DISPLACEMENT}}$ =	2.89 Meter
$y_{0\text{-SLUG}}$ =	0.00 Meter
From look-up table using L/r_w	
Partial penetrate A =	2.256
B =	0.358
ln(Re/rw) =	1.836
Re =	1.05 Meter
Slope =	0.000180837 $\log_{10}$/sec
$t_{90\%}$ recovery =	5530 sec

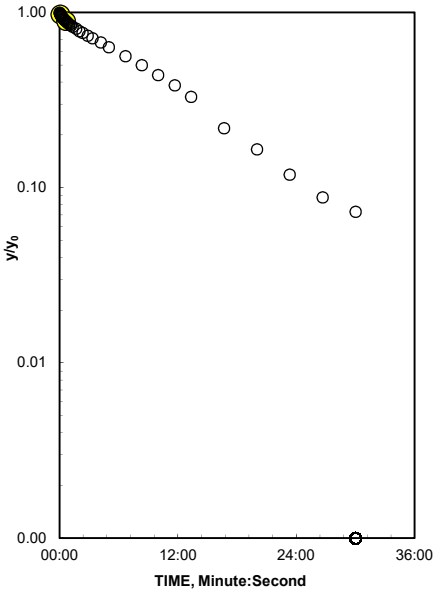
Input is consistent.

K = 0.00000022 Meter/Second

0.000022



Adjust slope of line to estimate K



Entry	Reduced Data Time, Hr:Min:Sec	Water Level
1	0:00:00.0	3.25
2	0:00:10.0	3.23
3	0:00:15.0	3.23
4	0:00:20.0	3.22
5	0:00:25.0	3.22
6	0:00:30.0	3.21
7	0:00:40.0	3.20
8	0:00:50.0	3.19
9	0:01:00.0	3.19
10	0:01:10.0	3.18
11	0:01:20.0	3.17
12	0:01:40.0	3.17
13	0:02:00.0	3.15
14	0:02:20.0	3.14
15	0:02:40.0	3.13
16	0:03:00.0	3.12
17	0:03:30.0	3.11
18	0:04:00.0	3.10
19	0:04:30.0	3.09
20	0:05:00.0	3.08
21	0:06:00.0	3.06
22	0:07:00.0	3.04
23	0:08:00.0	3.02
24	0:10:00.0	2.99
25	0:12:00.0	2.96
26	0:14:00.0	2.94
27	0:17:00.0	2.90
28	0:20:00.0	2.87
29	0:25:00.0	2.82
30	0:30:00.0	2.77
31	0:40:00.0	2.68
32	0:50:00.0	2.60
33	1:00:00.0	2.51
34	1:10:00.0	2.44
35	1:20:00.0	2.37
36	1:40:00.0	2.23
37	2:00:00.0	2.16
38	2:20:00.0	2.10
39	2:40:00.0	2.06

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

- Rising head test
- Groundwater was extracted via vacuum pump

WELL ID: MW3 - Rising Head Test

Local ID: MW3
Date: 13/6/2019
Time: 15:45

INPUT

Construction:	
Casing dia. (d_c)	0.0508 Meter
Annulus dia. (d_w)	0.1016 Meter
Screen Length (L)	2.5 Meter
Depths to:	
water level (DTW)	1.939 Meter
top of screen (TOS)	0.5 Meter
Base of Aquifer (DTB)	10 Meter
Annular Fill:	
across screen --	Coarse Sand
above screen --	Open Hole
Aquifer Material --	Medium Sand

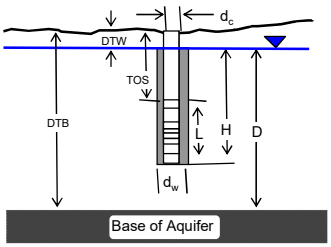
COMPUTED

L_{wetted}	1.061 Meter
D =	8.061 Meter
H =	1.061 Meter
L/r_w =	20.89
$y_{0\text{-DISPLACEMENT}}$ =	2.89 Meter
$y_{0\text{-SLUG}}$ =	0.00 Meter
From look-up table using L/r_w	
Partial penetrate A =	2.233
B =	0.353
ln(Re/rw) =	1.811
Re =	1.02 Meter
Slope =	0.006871508 $\log_{10}$/sec
$t_{90\%}$ recovery =	146 sec

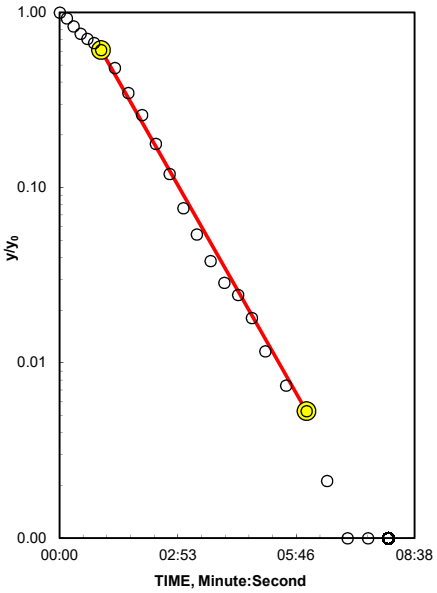
Input is consistent.

K = 0.0000087 Meter/Second

0.00087



Adjust slope of line to estimate K



Entry	Reduced Data Time, Hr:Min:Sec	Water Level
1	0:00:00.0	2.89
2	0:00:10.0	2.81
3	0:00:20.0	2.73
4	0:00:30.0	2.65
5	0:00:40.0	2.61
6	0:00:50.0	2.57
7	0:01:00.0	2.52
8	0:01:20.0	2.40
9	0:01:40.0	2.27
10	0:02:00.0	2.19
11	0:02:20.0	2.11
12	0:02:40.0	2.06
13	0:03:00.0	2.01
14	0:03:20.0	1.99
15	0:03:40.0	1.98
16	0:04:00.0	1.97
17	0:04:20.0	1.97
18	0:04:40.0	1.96
19	0:05:00.0	1.95
20	0:05:30.0	1.95
21	0:06:00.0	1.95
22	0:06:30.0	1.94
23	0:07:00.0	1.94
24	0:07:30.0	1.94

K= 0.0000087 is less than likely minimum of 0.0000705 for Medium Sand

REMARKS: Bouwer and Rice analysis of slug test, WRR 1976

- Rising head test
- Groundwater was extracted via vacuum pump

WELL ID: MW4 - Rising Head Test

Local ID: MW4
Date: 13/6/2019
Time: 9:40

INPUT

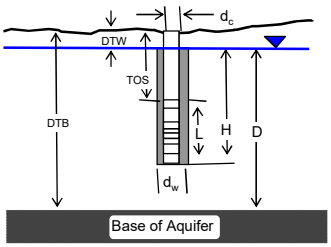
Construction:	
Casing dia. (d_c)	0.0508 Meter
Annulus dia. (d_w)	0.1016 Meter
Screen Length (L)	2.5 Meter
Depths to:	
water level (DTW)	1.623 Meter
top of screen (TOS)	0.5 Meter
Base of Aquifer (DTB)	10 Meter
Annular Fill:	
across screen --	Coarse Sand
above screen --	Open Hole
Aquifer Material --	Clay soils (surface)

COMPUTED

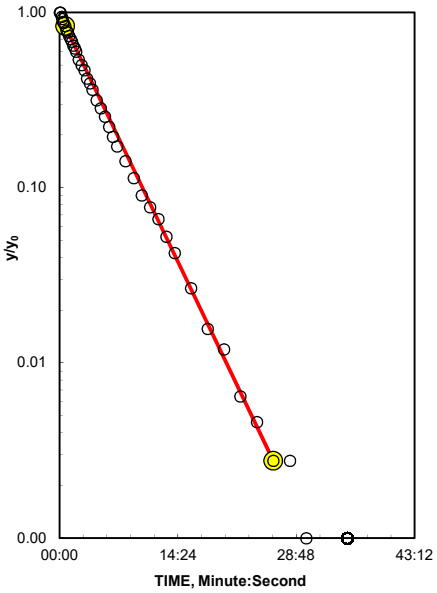
L_{wetted}	1.377 Meter
D =	8.377 Meter
H =	1.377 Meter
L/r_w =	27.11
$y_{0\text{-DISPLACEMENT}}$ =	2.72 Meter
$y_{0\text{-SLUG}}$ =	0.00 Meter
From look-up table using L/r_w	
Partial penetrate A =	2.423
B =	0.397
ln(Re/rw) =	2.021
Re =	1.26 Meter
Slope =	0.001632214 $\log_{10}$/sec
$t_{90\%}$ recovery =	613 sec

Input is consistent.

K =	0.0000018 Meter/Second
	0.00018



Adjust slope of line to estimate K



Bouwer and Rice analysis of slug test, WRR 1976

REMARKS:

- Rising head test
- Groundwater was extracted via vacuum pump

Entry	Reduced Data Time, Hr:Min:Sec	Water Level
1	0:00:00.0	2.72
2	0:00:05.0	2.72
3	0:00:15.0	2.66
4	0:00:20.0	2.63
5	0:00:25.0	2.59
6	0:00:30.0	2.58
7	0:00:40.0	2.54
8	0:00:50.0	2.49
9	0:01:00.0	2.47
10	0:01:10.0	2.43
11	0:01:20.0	2.40
12	0:01:30.0	2.37
13	0:01:40.0	2.34
14	0:01:50.0	2.31
15	0:02:00.0	2.28
16	0:02:20.0	2.22
17	0:02:40.0	2.18
18	0:03:00.0	2.14
19	0:03:20.0	2.09
20	0:03:40.0	2.06
21	0:04:00.0	2.03
22	0:04:30.0	1.98
23	0:05:00.0	1.94
24	0:05:30.0	1.91
25	0:06:00.0	1.88
26	0:06:30.0	1.85
27	0:07:00.0	1.82
28	0:08:00.0	1.79
29	0:09:00.0	1.76
30	0:10:00.0	1.73
31	0:11:00.0	1.72
32	0:12:00.0	1.71
33	0:13:00.0	1.69
34	0:14:00.0	1.68
35	0:16:00.0	1.66
36	0:18:00.0	1.65
37	0:20:00.0	1.65
38	0:22:00.0	1.64
39	0:24:00.0	1.64
40	0:26:00.0	1.64
41	0:28:00.0	1.64
42	0:30:00.0	1.64

WELL ID: MW5 - Rising Head Test

Local ID: MW5
Date: 13/6/2019
Time: 10:36

INPUT

Construction:	
Casing dia. (d_c)	0.0508 Meter
Annulus dia. (d_w)	0.1016 Meter
Screen Length (L)	2.5 Meter
Depths to:	
water level (DTW)	1.196 Meter
top of screen (TOS)	0.5 Meter
Base of Aquifer (DTB)	10 Meter
Annular Fill:	
across screen --	Coarse Sand
above screen --	Open Hole
Aquifer Material --	Clay soils (surface)

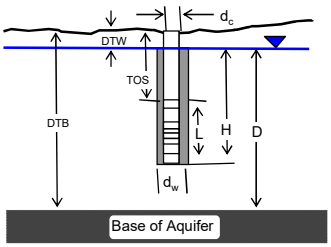
COMPUTED

L_{wetted}	1.804 Meter
D =	8.804 Meter
H =	1.804 Meter
L/r_w =	35.51
$y_{0\text{-DISPLACEMENT}}$ =	2.62 Meter
$y_{0\text{-SLUG}}$ =	0.00 Meter
From look-up table using L/r_w	
Partial penetrate A =	2.705
B =	0.441
ln(Re/rw) =	2.245
Re =	1.57 Meter
Slope =	0.000836447 $\log_{10}$/sec
$t_{90\%}$ recovery =	1196 sec

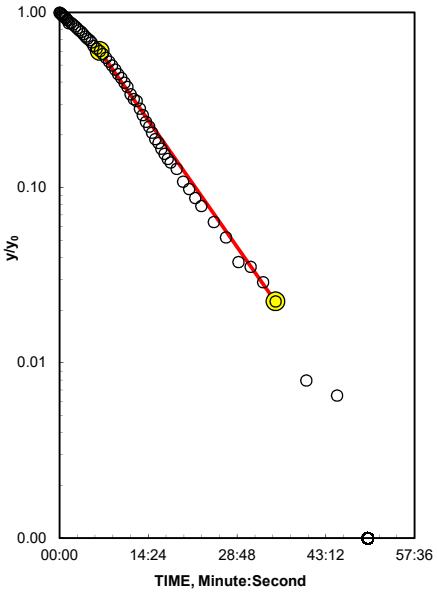
Input is consistent.

K = 0.00000077 Meter/Second

0.000077



Adjust slope of line to estimate K



REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

- Rising head test
- Groundwater was extracted via vacuum pump

Entry	Reduced Data Time, Hr:Min:Sec	Water Level
1	0:00:00.0	2.62
2	0:00:05.0	2.61
3	0:00:10.0	2.60
4	0:00:20.0	2.59
5	0:00:25.0	2.57
6	0:00:30.0	2.56
7	0:00:40.0	2.55
8	0:00:50.0	2.53
9	0:01:00.0	2.52
10	0:01:10.0	2.49
11	0:01:20.0	2.48
12	0:01:30.0	2.44
13	0:01:50.0	2.44
14	0:02:10.0	2.42
15	0:02:30.0	2.38
16	0:02:50.0	2.36
17	0:03:10.0	2.33
18	0:03:30.0	2.31
19	0:03:50.0	2.27
20	0:04:10.0	2.24
21	0:04:30.0	2.22
22	0:04:50.0	2.19
23	0:05:10.0	2.17
24	0:05:30.0	2.12
25	0:06:00.0	2.09
26	0:06:30.0	2.07
27	0:07:00.0	2.03
28	0:07:30.0	1.99
29	0:08:00.0	1.96
30	0:08:30.0	1.92
31	0:09:00.0	1.88
32	0:09:30.0	1.85
33	0:10:00.0	1.82
34	0:10:30.0	1.78
35	0:11:00.0	1.75
36	0:11:30.0	1.70
37	0:12:00.0	1.68
38	0:12:30.0	1.66
39	0:13:00.0	1.62
40	0:13:30.0	1.59
41	0:14:00.0	1.56
42	0:14:30.0	1.54
43	0:15:00.0	1.52
44	0:15:30.0	1.49
45	0:16:00.0	1.48

Appendix L

Soil Laboratory Report

TEST REPORT

Our Reference No.	: **R191834/2**	Date Received	: 07/05/2019
Project Code / Ref.	: Mount Pleasant	Date Commenced	: 07/05/2019
		Date Reported	: 22/05/2019
Customer Ref. No.	: -		
Customer Name	: AECOM Singapore Pte Ltd		
Customer Address	: 300 Beach Road #03-00 The Concourse Singapore 199555		
Attention To	: Mr Albert Payapaya		
Sample Description	: 10 Soil Samples		
RESULTS:	Refer to Page 2 to 5		

Tan Thuan Piang
Laboratory Manager

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2) The results in this report only apply to the sample received/analysed.
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Marchwood Laboratory Services Pte Ltd: Co. Reg No. : 201422686C
Main (Office and Laboratory): 116 Tuas South Ave 2, West Point Bizhub Singapore 637163 ☎ : +65 6790 0118 🖷 : +65 6790 0091
Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 ☎ : +65 6262 3736 (Lab) ☎ : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

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TEST RESULTS FOR SOIL (in mg/kg unless otherwise specified):

Sample Bore Hole	BH-01	BH-01	BH-02	BH-02	BH-03	BH-03	BH-04	BH-04	BH-05	BH-05	Method BLK	DUTCH	DUTCH	LOR
Sample Depth m bgl	0.50	3.00	0.50	3.00	0.50	3.00	0.50	3.00	0.50	3.00	-	(Target)	(Intervention)	-
pH	6.1	4.5	4.3	4.3	4.4	4.2	5.0	4.6	6.4	5.2	-	-	-	-
Metals : by USEPA 3051A / APHA 3120B / 3125B / USEPA 245.1														
Arsenic (As)	3.12	1.91	2.70	1.03	1.02	1.56	1.41	6.79	1.26	N.D.	N.D.	-	76	0.15
Antimony (Sb)	18.26	1.59	1.30	N.D.	0.37	N.D.	N.D.	0.88	N.D.	N.D.	N.D.	-	22	0.15
Barium (Ba)	9.48	6.02	4.63	6.11	2.06	2.01	4.41	5.63	9.96	35.90	N.D.	-	-	0.30
Cadmium (Cd)	0.21	0.10	0.32	0.15	0.55	0.46	0.47	0.79	0.31	0.08	N.D.	-	6	0.075
Chromium (Cr)	15.06	31.20	18.02	14.95	46.42	40.15	29.75	34.11	38.13	65.06	N.D.	-	-	0.075
Cobalt (Co)	N.D.	0.25	N.D.	N.D.	N.D.	N.D.	N.D.	0.44	0.20	0.54	N.D.	-	190	0.075
Copper (Cu)	8.78	8.75	3.02	4.05	0.97	0.36	6.84	2.26	2.65	5.17	N.D.	-	190	0.075
Mercury (Hg)	0.239	0.100	0.099	0.090	0.110	N.D.	0.085	0.097	N.D.	0.105	N.D.	-	-	0.075
Lead (Pb)	31.76	15.54	5.19	8.44	3.94	2.57	6.59	10.79	4.53	30.76	N.D.	-	530	0.10
Molybdenum (Mo)	1.88	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	190	0.15
Nickel (Ni)	N.D.	1.59	1.53	N.D.	2.41	1.87	2.51	3.36	1.55	1.53	N.D.	-	100	1.50
Zinc (Zn)	52.13	11.21	22.42	5.16	7.82	5.59	21.46	14.96	18.65	12.98	N.D.	-	720	0.75
Inorganic Compound : Cyanide (CN) by APHA 4500-CN(N) - Total Cyanide after Distillation using Micro Dist by Lachat FIA														
Cyanide (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1	20	1.0
Aromatic Compounds : BTEX - Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C														
Benzene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	1.1	0.1
Ethylbenzene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	110	0.1
Toluene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	32	0.1
Xylene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	17	0.2
Styrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	86	0.1
Aromatic Compounds : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D														
Phenol	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	14	0.1
Cresols	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	13	0.2
Catechol	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	1.0
Resorcinol	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.4
Hydrochinon	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.4

Total Cyanide consists of Free Cyanide, Complex Cyanide and Total Thiocyanates. In this study, the Target and Intervention values of Free Cyanide, which are the most stringent Target and Intervention values of all three Cyanide species, are applied to the concentration of Total Cyanide (i.e. Free Cyanide + Complex Cyanide + Total Thiocyanates).

MLS

TEST RESULTS FOR SOIL (in mg/kg unless otherwise specified):

Sample Bore Hole	BH-01	BH-01	BH-02	BH-02	BH-03	BH-03	BH-04	BH-04	BH-05	BH-05	Method BLK	DUTCH	DUTCH	LOR
Sample Depth m bgl	0.50	3.00	0.50	3.00	0.50	3.00	0.50	3.00	0.50	3.00	-	(Target)	(Intervention)	-
pH	6.1	4.5	4.3	4.3	4.4	4.2	5.0	4.6	6.4	5.2	-	-	-	-
Polynuclear Aromatic Hydrocarbon (PAH) : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D														
Naphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Phenanthrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Benzo(a)anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Chrysene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Benzo(a)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Benzo(ghi)perylene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Benzo(k)fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Indeno(1,2,3cd)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
PAH (total of 10)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	40	0.1
Chlorinated Hydrocarbons : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C														
Vinyl Chloride	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.1	0.1
Dichloromethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	3.9	0.1
1,1-Dichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	15	0.1
1,2-Dichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	6.4	0.1
1,1-Dichloroethene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.3	0.1
1,2-Dichloroethene (cis + trans)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	1	0.1
Dichloropropanes	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	2	0.1
Trichloromethane (Chloroform)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	5.6	0.1
1,1,1-Trichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	15	0.1
1,1,2-Trichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	10	0.1
Trichloroethene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	2.5	0.1
Tetrachloromethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.7	0.1
Tetrachloroethene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	8.8	0.1
Chlorobenzenes (total of 6)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.2
Monochlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	15	0.1
Dichlorobenzenes (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	19	0.1
Chlorinated Hydrocarbons : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D														
Trichlorobenzenes (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	11	0.1
Tetrachlorobenzenes (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	2.2	0.2
Pentachlorobenzenes	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	6.7	0.1
Hexachlorobenzenes	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	2	0.1
Chlorophenols (total of 5)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.3
Monochlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	5.4	0.2
Dichlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	22	0.3
Trichlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	22	0.1
Tetrachlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	21	0.3
Pentachlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	12	0.4
Chloronaphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	23	0.2
Monochloroanilines	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	50	0.2
Polychlorobiphenyls (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	1	0.1

MLS

TEST RESULTS FOR SOIL (in mg/kg unless otherwise specified):

Sample Bore Hole	BH-01	BH-01	BH-02	BH-02	BH-03	BH-03	BH-04	BH-04	BH-05	BH-05	Method BLK	DUTCH	DUTCH	LOR
Sample Depth m bgl	0.50	3.00	0.50	3.00	0.50	3.00	0.50	3.00	0.50	3.00	-	(Target)	(Intervention)	-
pH	6.1	4.5	4.3	4.3	4.4	4.2	5.0	4.6	6.4	5.2	-	-	-	-
Pesticides : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D														
sum DDT/DDD/DDE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.2
DDT	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	1.7	0.2
DDE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	2.3	0.1
DDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	34	0.1
sum aldrin, dieldrin, endrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Aldrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.32	0.1
Dieldrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Endrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
sum HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
a-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	17	0.1
b-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	1.6	0.1
g-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	1.2	0.1
d-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Atrazine	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.71	0.1
Carbaryl	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.45	0.4
Carbofuran	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.017	0.4
Chlordane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Endosulfan	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Heptachlor	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Heptachlor Epoxide	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Maneb	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	2.8
Other Pollutants : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C														
Cyclohexanone	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	150	0.6
Tetrahydrofuran	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	7	0.2
Tetrahydrothiophene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	8.8	0.2
Tribromomethane (Bromoform)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	75	0.1
Other Pollutants : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D														
Phthalates (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.2
Pyridine	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	11	0.2
Other Pollutants : Total Petroleum Hydrocarbons (TPH) by US EPA Method 8015C														
C6 - C9	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
C10 - C14	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	10.0
C15 - C28	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	10.0
C29 - C36	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	11.3	N.D.	-	-	10.0
C6 - C36 (Total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	11.3	N.D.	50*	5,000*	10.0

(*Dutch Standard for mineral oil)

Miscellaneous : Moisture Content and Organic Matter (LOI) by BS 1377 : Pt 2 & 3 : 1990														
Moisture Content, %	16.80	66.12	31.54	30.52	47.45	56.61	2.85	53.73	30.64	61.52	-	-	-	0.01
Organic Matter (LOI), %	4.61	14.59	8.87	8.18	11.28	8.97	11.06	12.22	7.55	14.49	-	-	-	0.03

MLS

TEST RESULTS FOR SOIL (in mg/kg unless otherwise specified):

Sample Bore Hole	BH-01	BH-01	BH-02	BH-02	BH-03	BH-03	BH-04	BH-04	BH-05	BH-05	Method BLK	DUTCH	DUTCH	LOR
Sample Depth m bgl	0.50	3.00	0.50	3.00	0.50	3.00	0.50	3.00	0.50	3.00	-	(Target)	(Intervention)	-
pH	6.1	4.5	4.3	4.3	4.4	4.2	5.0	4.6	6.4	5.2	-	-	-	-
Surrogate Recovery by USEPA 8260C														
1,2-Dichloroethane-d4 (%)	83.6	83.3	106	84.7	104	83.7	114	95.8	93.8	103	80.6			
Toluene-d8 (%)	117	114	103	110	107	118	108	105	110	112	105			
p-Bromofluorobenzene (%)	119	115	113	106	118	112	117	118	98.6	119	113			
Surrogate Recovery by USEPA 8270D														
Benzene-d5, nitro- (%)	77.7	63.0	63.5	69.1	72.0	63.4	67.7	69.1	75.4	61.2	79.6			
1,1'-biphenyl,2-fluoro (%)	66.2	68.0	77.5	72.0	67.3	60.8	65.4	65.1	68.8	60.1	79.3			
p-Terphenyl-d14 (%)	70.3	67.7	68.3	64.1	76.4	70.9	64.1	64.0	60.3	70.9	83.7			
Phenol, 2-fluoro (%)	63.1	64.0	60.1	65.4	84.3	70.0	68.3	71.1	65.5	74.6	103			
Phenol-d5 (%)	65.3	65.8	63.7	66.8	91.9	78.6	76.5	77.7	73.5	77.5	99.8			
Phenol, 2,4,6-Tribromo (%)	63.5	76.6	65.2	70.8	84.3	71.1	70.0	68.2	69.0	83.0	103			

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017).
2. LOR = Limit of Reporting. Detection Limit is based on the highest detection limit obtained from the individual compound.
3. "ND" = Not detected. The data reported is less than the LOR.
4. (d) = Detection Threshold.
5. C10-C14, C15-C28, C29-C36 results are derived using the area under the peak against a hydrocarbon reference standard.
6. The target and interventions values are derived from Soil Remediation Circular 2013

MARCHWOOD LABORATORY SERVICES PTE LTD

CHAIN OF CUSTODY DOCUMENT / ANALYSIS REQUEST

Priority Queue / Urgent / Report Needed by: _____

CLIENT	: AECOM Singapore Pte Ltd
CONTACT (Name / Tel / email)	: Jaypee Bautista / Oh Guo Liang
ADDRESS / COUNTRY	: 300 Beach Rd, #03-00 The Concourse
PROJECT Code / Ref.	: 60596697
SITE	: Mount Pleasant
QUOTATION / JOB REQUEST / PO No.	:
SEND REPORT TO	: Albert Payapaya / JP Bautista / Oh Guo Liang
COMMENT / SPECIAL INSTRUCTION	:
STORAGE / DISPOSAL	:

S/N	SAMPLE ID / LOCATION	SAMPLING DEPTH (m)	MATRIX* (Water/Soil/Sand/Sed/Sludge/Air)	DATE (DD/MM/YY)	TIME (HRS)	TOTAL NOs OF CONTAINERS# / SAMPLING MEDIA$	STORAGE CONDITION**	Sample Seal (Y / N) ☐ Tick if all sealed	ANALYSIS PARAMETER (Enter "x" below to indicate Request)											REMARKS / OBSERVATION / SAMPLE CONDITION
									JTC EBS Suite	VOCs	Major ions(Calcium, magnesium, sodium, potassium, bicarbonate, carbonate, chloride, sulphate, fluoride)										
1	BH01 - 0.5m	0.5	Soil	25-Apr-19	1040	1 Jar	C	N	x												
2	BH01 - 3.0m	3	Soil	25-Apr-19	1145	1 Jar	C	N	x												
3	BH02 - 0.5m	0.5	Soil	25-Apr-19	1400	1 Jar	C	N	x												
4	BH02 - 3.0m	3	Soil	25-Apr-19	1605	1 Jar	C	N	x												
5	BH03 - 0.5m	0.5	Soil	26-Apr-19	0915	1 Jar	C	N	x												
6	BH03 - 3.0m	3	Soil	26-Apr-19	1440	1 Jar	C	N	x												
7	BH04 - 0.5m	0.5	Soil	27-Apr-19	1005	1 Jar	C	N	x												
8	BH04 - 3.0m	3	Soil	27-Apr-19	1110	1 Jar	C	N	x												
9	BH05 - 0.5m	0.5	Soil	27-Apr-19	1343	1 Jar	C	N	x												
10	BH05 - 3.0m	3	Soil	27-Apr-19	1438	1 Jar	C	N	x												
11	MW01	-	Water	6-May-19	0930	1 G, 1 P, 2 V	C	N	x		x										
12	MW02	-	Water	6-May-19	1530	1 G, 1 P, 2 V	C	N	x		x										
13	MW03	-	Water	6-May-19	1545	1 G, 1 P, 2 V	C	N	x		x										
14	MW04	-	Water	6-May-19	1430	1 G, 1 P, 2 V	C	N	x		x										
15	MW05	-	Water	6-May-19	1500	1 G, 1 P, 2 V	C	N	x		x										
16	Trip Blank	-	Water	-	-	2 V	C	N		x											
17																					
18																					
19																					
20																					

MLS LAB USE ONLY

Job No.: R191834

PRESERVATION DONE:

☐ On Site

☐ By Lab

Cold Box temp. at receipt: _____°C (if applicable)

☐ Sampling done by MLS

RELINQUISHED BY:	DATE / TIME
Name: Oh Guo Liang	07/052019
Sign:	14:30 hrs
Company: AECOM	

RECEIVED BY:	DATE / TIME
Name: A. Vairavan	07-05-19
Sign: A. Vairavan	2.52pm hrs
Company: MLS	

RELINQUISHED BY:	DATE / TIME
Name: A. Vairavan	07-05-19
Sign: A. Vairavan	5.25pm hrs
Company: MLS	

RECEIVED BY:	DATE / TIME
Name:	
Sign:	hrs
Company:	

SHIPMENT BY COURIER:

Courier Co. / Carrier Name:

Consignment Note/Airway Bill:

* = **For Water sample:** Please Indicate FW (Fresh Water), SW (Seawater), BW (Ballast Water), DW (Drinking Water), GW (Ground water), WW (Wastewater), OW (Other type of water e.g. canal/storm water)

\# **Type of Sampling Containers/Bottles:** G = Glass; P = Plastic; T = Tube; V = VOC vial; S = Steriled bottle/bag; B = Bag.

** **Storage Condition:** C = Refrigerate at 4 °C; R = Room Temperature; P = Preserved as per Lab's instruction.

$ **Type of Sampling Media:** ST = Sorbent Tube; IM = Impinger solution; F = Filter; RT = Resin Trap; AP = Agar Plate; W = Wipe Sample; Others (PUF, etc. - please specify).

TEST REPORT

Our Reference No.	:	**R200376/2**	Date Received	:	22/01/2020
Project Code / Ref.	:	Mount Pleasant	Date Commenced	:	22/01/2020
			Date Reported	:	05/02/2020
Customer Ref. No.	:	-			
Customer Name	:	AECOM Singapore Pte Ltd			
Customer Address	:	300 Beach Road #03-00 The Concourse Singapore 199555			
Attention To	:	Mr Albert Payapaya			
Sample Description	:	4 Soil Samples			
RESULTS:		Refer to Page 2 to 5			

Tan Thuan Piang
Laboratory Manager

Terms & Conditions:
1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

Marchwood Laboratory Services Pte Ltd: Co. Reg No. : 201422686C
Main (Office and Laboratory): 116 Tuas South Ave 2, West Point Bizhub Singapore 637163 ☎ : +65 6790 0118 🖷 : +65 6790 0091
Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 ☎ : +65 6262 3736 (Lab) ☎ : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

MLS

TEST RESULTS FOR SOIL (in mg/kg unless otherwise specified):

Sample Bore Hole	VBH - 02	VBH - 02	VBH - 01	VBH - 01	Method BLK	DUTCH	DUTCH	LOR
Sample Depth m bgl	0.50	3.00	0.50	3.00	-	(Target)	(Intervention)	-
pH	4.1	4.4	5.6	4.0	-	-	-	-
Metals : by USEPA 3051A / APHA 3120B / USEPA 245.1								
Arsenic (As)	17.94	9.27	6.39	9.59	N.D.	-	76	0.15
Antimony (Sb)	N.D.	N.D.	0.66	N.D.	N.D.	-	22	0.15
Barium (Ba)	31.82	24.74	52.67	21.68	N.D.	-	-	0.30
Cadmium (Cd)	0.85	0.50	2.41	0.53	N.D.	-	13	0.075
Chromium (Cr)	19.77	17.69	42.79	N.D.	N.D.	-	-	0.075
Cobalt (Co)	2.30	1.18	1.15	3.21	N.D.	-	190	0.075
Copper (Cu)	142.13	58.17	34.23	9.78	N.D.	-	190	0.075
Mercury (Hg)	0.40	0.23	0.74	N.D.	N.D.	-	-	0.075
Lead (Pb)	115.90	23.76	55.66	23.71	N.D.	-	530	0.10
Molybdenum (Mo)	0.22	0.19	N.D.	4.86	N.D.	-	190	0.15
Nickel (Ni)	11.01	3.69	8.58	5.79	N.D.	-	100	1.50
Zinc (Zn)	185.40	75.27	245.13	28.23	N.D.	-	720	0.75
Inorganic Compound : Cyanide (CN) by APHA 4500-CN(N) - Total Cyanide after Distillation using Micro Dist by Lachat FIA								
Cyanide (total)	N.D.	N.D.	N.D.	N.D.	N.D.	1	20	1.0
Aromatic Compounds : BTEX - Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C								
Benzene	N.D.	N.D.	N.D.	N.D.	N.D.	-	1.1	0.1
Ethylbenzene	N.D.	N.D.	N.D.	N.D.	N.D.	-	110	0.1
Toluene	N.D.	N.D.	N.D.	N.D.	N.D.	-	32	0.1
Xylene	N.D.	N.D.	N.D.	N.D.	N.D.	-	17	0.2
Styrene	N.D.	N.D.	N.D.	N.D.	N.D.	-	86	0.1
Aromatic Compounds : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D								
Phenol	N.D.	N.D.	N.D.	N.D.	N.D.	-	14	0.1
Cresols	N.D.	N.D.	N.D.	N.D.	N.D.	-	13	0.2
Catechol	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	1.0
Resorcinol	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.4
Hydrochinon	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.4

Total Cyanide consists of Free Cyanide, Complex Cyanide and Total Thiocyanates. In this study, the Target and Intervention values of Free Cyanide, which are the most stringent Target and Intervention values of all three Cyanide species, are applied to the concentration of Total Cyanide (i.e. Free Cyanide + Complex Cyanide + Total Thiocyanates).

MLS

TEST RESULTS FOR SOIL (in mg/kg unless otherwise specified):

Sample Bore Hole	VBH - 02	VBH - 02	VBH - 01	VBH - 01	Method BLK	DUTCH	DUTCH	LOR
Sample Depth m bgl	0.50	3.00	0.50	3.00	-	(Target)	(Intervention)	-
pH	4.1	4.4	5.6	4.0	-	-	-	-
Polynuclear Aromatic Hydrocarbon (PAH) : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D								
Naphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Phenanthrene	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Benzo(a)anthracene	N.D.	5.1	N.D.	1.2	N.D.	-	-	0.1
Chrysene	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Benzo(a)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Benzo(ghi)perylene	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Benzo(k)fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Indeno(1,2,3cd)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
PAH (total of 10)	N.D.	5.1	N.D.	1.2	N.D.	-	40	0.1
Chlorinated Hydrocarbons : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C								
Vinyl Chloride	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.1	0.1
Dichloromethane	N.D.	N.D.	N.D.	N.D.	N.D.	-	3.9	0.1
1,1-Dichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	-	15	0.1
1,2-Dichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	-	6.4	0.1
1,1-Dichloroethene	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.3	0.1
1,2-Dichloroethene (cis + trans)	N.D.	N.D.	N.D.	N.D.	N.D.	-	1	0.1
Dichloropropanes	N.D.	N.D.	N.D.	N.D.	N.D.	-	2	0.1
Trichloromethane (Chloroform)	N.D.	N.D.	N.D.	N.D.	N.D.	-	5.6	0.1
1,1,1-Trichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	-	15	0.1
1,1,2-Trichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	-	10	0.1
Trichloroethene	N.D.	N.D.	N.D.	N.D.	N.D.	-	2.5	0.1
Tetrachloromethane	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.7	0.1
Tetrachloroethene	N.D.	N.D.	N.D.	N.D.	N.D.	-	8.8	0.1
Chlorobenzenes (total of 6)	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.2
Monochlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	-	15	0.1
Dichlorobenzenes (total)	N.D.	N.D.	N.D.	N.D.	N.D.	-	19	0.1
Chlorinated Hydrocarbons : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D								
Trichlorobenzenes (total)	N.D.	N.D.	N.D.	N.D.	N.D.	-	11	0.1
Tetrachlorobenzenes (total)	N.D.	N.D.	N.D.	N.D.	N.D.	-	2.2	0.2
Pentachlorobenzenes	N.D.	N.D.	N.D.	N.D.	N.D.	-	6.7	0.1
Hexachlorobenzenes	N.D.	N.D.	N.D.	N.D.	N.D.	-	2	0.1
Chlorophenols (total of 5)	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.3
Monochlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	-	5.4	0.2
Dichlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	-	22	0.3
Trichlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	-	22	0.1
Tetrachlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	-	21	0.3
Pentachlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	-	12	0.4
Chloronaphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	-	23	0.2
Monochloroanilines	N.D.	N.D.	N.D.	N.D.	N.D.	-	50	0.2
Polychlorobiphenyls (total)	N.D.	N.D.	N.D.	N.D.	N.D.	-	1	0.1

MLS

TEST RESULTS FOR SOIL (in mg/kg unless otherwise specified):

Sample Bore Hole	VBH - 02	VBH - 02	VBH - 01	VBH - 01	Method BLK	DUTCH	DUTCH	LOR
Sample Depth m bgl	0.50	3.00	0.50	3.00	-	(Target)	(Intervention)	-
pH	4.1	4.4	5.6	4.0	-	-	-	-
Pesticides : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D								
sum DDT/DDD/DDE	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.2
DDT	N.D.	N.D.	N.D.	N.D.	N.D.	-	1.7	0.2
DDE	N.D.	N.D.	N.D.	N.D.	N.D.	-	2.3	0.1
DDD	N.D.	N.D.	N.D.	N.D.	N.D.	-	34	0.1
sum aldrin, dieldrin, endrin	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Aldrin	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.32	0.1
Dieldrin	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Endrin	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
sum HCH	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
a-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	-	17	0.1
b-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	-	1.6	0.1
g-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	-	1.2	0.1
d-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
Atrazine	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.71	0.1
Carbaryl	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.45	0.4
Carbofuran	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.017	0.4
Chlordane	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Endosulfan	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Heptachlor	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Heptachlor Epoxide	N.D.	N.D.	N.D.	N.D.	N.D.	-	4	0.1
Other Pollutants : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C								
Cyclohexanone	N.D.	N.D.	N.D.	N.D.	N.D.	-	150	0.6
Tetrahydrofuran	N.D.	N.D.	N.D.	N.D.	N.D.	-	7	0.2
Tetrahydrothiophene	N.D.	N.D.	N.D.	N.D.	N.D.	-	8.8	0.2
Tribromomethane (Bromoform)	N.D.	N.D.	N.D.	N.D.	N.D.	-	75	0.1
Other Pollutants : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3545A / 8270D								
Phthalates (total)	2.1	0.9	0.5	0.4	N.D.	-	-	0.2
Pyridine	N.D.	N.D.	N.D.	N.D.	N.D.	-	11	0.2
Other Pollutants : Total Petroleum Hydrocarbons (TPH) by US EPA Method 8015C								
C6 - C9	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	0.1
C10 - C14	N.D.	29.5	N.D.	32.9	N.D.	-	-	10.0
C15 - C28	44.3	343.1	65.8	251.9	N.D.	-	-	10.0
C29 - C36	25.4	1577.1	113.8	945.7	N.D.	-	-	10.0
C6 - C36 (Total)	69.7	1949.7	179.6	1230.4	N.D.	-	5,000*	10.0

(*Dutch Standard for mineral oil)

MLS

TEST RESULTS FOR SOIL (in mg/kg unless otherwise specified):

Sample Bore Hole	VBH - 02	VBH - 02	VBH - 01	VBH - 01	Method BLK	DUTCH	DUTCH	LOR
Sample Depth m bgl	0.50	3.00	0.50	3.00	-	(Target)	(Intervention)	-
pH	4.1	4.4	5.6	4.0	-	-	-	-
Miscellaneous : Moisture Content and Organic Matter (LOI) by BS 1377 : Pt 2 & 3 : 1990								
Moisture Content, %	8.16	81.27	25.73	81.85	-	-	-	0.01
Organic Matter (LOI), %	4.87	56.94	5.20	46.68	-	-	-	0.03
Surrogate Recovery by USEPA 8260C								
1,2-Dichloroethane-d4 (%)	116	98.2	111	91.4	82.0			
Toluene-d8 (%)	117	113	105	120	105			
p-Bromofluorobenzene (%)	117	118	105	118	115			
Surrogate Recovery by USEPA 8270D								
Benzene-d5, nitro- (%)	98.5	82.8	76.4	84.2	81.2			
1,1'-biphenyl,2-fluoro (%)	70.4	88.3	93.7	83.5	74.8			
p-Terphenyl-d14 (%)	70.3	77.5	72.9	91.1	71.8			
Phenol, 2-fluoro (%)	84.2	71.8	85.8	77.7	92.0			
Phenol-d5 (%)	73.0	89.3	74.2	86.4	93.5			
Phenol, 2,4,6-Tribromo (%)	76.1	98.4	75.1	85.4	84.6			

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017).
2. LOR = Limit of Reporting. Detection Limit is based on the highest detection limit obtained from the individual compound.
3. "ND" = Not detected. The data reported is less than the LOR.
4. (d) = Detection Threshold.
5. C10-C14, C15-C28, C29-C36 results are derived using the area under the peak against a hydrocarbon reference standard.
6. The target and interventions values are derived from Soil Remediation Circular 2013

MARCHWOOD LABORATORY SERVICES PTE LTD

22 JAN 2020

MLS-QF 001 Rev (4), Mar 2017

Page 1 of 1

CHAIN OF CUSTODY DOCUMENT / ANALYSIS REQUEST

Priority Queue / Urgent / Report Needed by: 5 Feb 2020

CLIENT	: AECOM SINGAPORE PTE LTD
CONTACT (Name / Tel / email)	: JAFON NG / +65 9825 7919
ADDRESS / COUNTRY	: 300 BEACH ROAD, THE CONCOURSE, #39-00
PROJECT Code / Ref.	: 60596697. Task 1.4
SITE	: MT. PLEASANT
QUOTATION / JOB REQUEST / PO No.	: -
SEND REPORT TO	: JAFON NG, CHENG YI; [illegible]@aecom.com
COMMENT / SPECIAL INSTRUCTION	: -
STORAGE / DISPOSAL	: -

MLS LAB USE ONLY

Job No.: R00376 2

PRESERVATION DONE:

☐ On Site

☐ By Lab

Cold Box temp. at receipt: ____ °C (if applicable)

☐ Sampling done by MLS

S/N	SAMPLE ID / LOCATION	SAMPLING DEPTH (m)	MATRIX* (Water/Soil/Sand/Sed/Sludge/Air)	DATE (DD/MM/YY)	TIME (HRS)	TOTAL NOs OF CONTAINERS# / SAMPLING MEDIA$	STORAGE CONDITION**	Sample Seal (Y / N) ☐ Tick if all sealed	ANALYSIS PARAMETER: OTCERS Suite (Soil)	OTCERS Suite (GW)	Major Ions *	VOCs	REMARKS / OBSERVATION / SAMPLE CONDITION
1	VBH - 02	0.5	S	20/01/20	AM	1			✓	-	-	-	* Major Ions include: - bicarbonate; - carbonate; - calcium; - potassium; - magnesium; and - Sodium - Chloride; - sulfate; and - Fluoride.
2	VBH - 02	3.0	S	20/01/20	AM	1			✓	-	-	-	
3	VBH - 01	0.5	S	20/01/20	AM	1			✓	-	-	-	
4	VBH - 01	3.0	S	20/01/20	AM	1			✓	-	-	-	
5	TRIP BLANK	-	W	-	-	1			-	-	-	✓	
6	VMW - 01	-	W	22/01/20	AM	5			-	✓	✓	-	
7	VMW - 02	-	W	22/01/20	AM	5			-	✓	✓	-	
8													
9						15							
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													

RELINQUISHED BY:	DATE / TIME
Name: Zafon Ng	22/1/2020
Sign:	2pm hrs
Company: AECOM Singapore	AECOM

RECEIVED BY:	DATE / TIME
Name: A. Vairavan	22-01-2020
Sign: A. Vairavan	3.40pm hrs
Company: MLS	

RELINQUISHED BY:	DATE / TIME
Name: A. Vairavan	22-01-2020
Sign: A. Vairavan	4.40pm hrs
Company: MLS	

RECEIVED BY:	DATE / TIME
Name: [illegible]	22/1/2020
Sign:	1700 hrs
Company: MLS	

SHIPMENT BY COURIER:

Courier Co. / Carrier Name:

Consignment Note/Airway Bill:

* = For Water sample: Please Indicate FW (Fresh Water), SW (Seawater), BW (Ballast Water), DW (Drinking Water), GW (Ground water), WW (Wastewater), OW (Other type of water e.g. canal/storm water)

Type of Sampling Containers/Bottles: G = Glass; P = Plastic; T = Tube; V = VOC vial; S = Steriled bottle/bag; B = Bag.

** Storage Condition: C = Refrigerate at 4 °C; R = Room Temperature; P = Preserved as per Lab's instruction.

$ Type of Sampling Media: ST = Sorbent Tube; IM = Impinger solution; F = Filter; RT = Resin Trap; AP = Agar Plate; W = Wipe Sample; Others (PUF, etc. - please specify).

Appendix M

Groundwater Laboratory Report

TEST REPORT

Our Reference No.	:	**R191834/1A**	Date Received	:	07/05/2019
Project Code / Ref.	:	Mount Pleasant	Date Commenced	:	07/05/2019
			Date Reported	:	23/05/2019
Customer Ref. No.	:	-			
Customer Name	:	AECOM Singapore Pte Ltd			
Customer Address	:	300 Beach Road #03-00 The Concourse Singapore 199555			
Attention To	:	Mr Albert Payapaya			
Sample Description	:	5 Water Samples and 1 Trip Blank			
RESULTS:		Refer to Page 2 to 6			

Tan Thuan Piang
Laboratory Manager

Terms & Conditions:

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2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

Marchwood Laboratory Services Pte Ltd: Co. Reg No. : 201422686C
Main (Office and Laboratory): 116 Tuas South Ave 2, West Point Bizhub Singapore 637163 ☎ : +65 6790 0118 🖷 : +65 6790 0091
Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 ☎ : +65 6262 3736 (Lab) ☎ : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	MW01	MW02	MW03	MW04	MW05	Method BLK	DUTCH (Target)	DUTCH (Intervention)	LOR	
pH value	6.4	7.2	7.0	7.2	6.8	-	-	-	-	APHA 4500-H^+
@ Temperature (deg. C)	23.4	22.9	23.3	23.0	23.1	-				

Metals by APHA 3125B

Arsenic (As)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	10	60	1.0
Antimony (Sb)	2.3	1.8	1.2	1.3	N.D.	N.D.	-	20	1.0
Barium (Ba)	5.4	21.9	19.4	14.9	23.6	N.D.	50	625	1.0
Cadmium (Cd)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.4	6	0.25
Chromium (Cr)	0.1	2.1	0.3	2.7	0.7	N.D.	1	30	0.1
Cobalt (Co)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	20	100	1.0
Copper (Cu)	N.D.	N.D.	N.D.	15.3	2.6	N.D.	15	75	1.5
Mercury (Hg)	N.D.	0.04	0.03	0.02	N.D.	N.D.	0.05	0.3	0.02
Lead (Pb)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	15	75	1.5
Molybdenum (Mo)	1.2	2.0	N.D.	1.7	1.9	N.D.	5	300	0.5
Nickel (Ni)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	15	75	1.5
Zinc (Zn)	2.6	4.0	1.5	10.7	9.5	N.D.	65	800	1.0

Miscellaneous Analyses by APHA 22nd Edition 2012

BOD (mg/L)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	2.0	APHA 5210B
COD (mg/L)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	50	HACH 8000
TOC (mg/L)	1.5	3.2	2.7	2.0	2.5	N.D.	-	-	1.0	APHA 5310B
Fluoride (mg/L)	N.D.	0.8	N.D.	N.D.	N.D.	N.D.	-	-	0.5	APHA 4110B
Chloride (mg/L)	4.1	6.1	10.7	3.7	3.3	N.D.	-	-	1.0	APHA 4110B
Bromide (mg/L)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	1.0	APHA 4110B
Phosphate (mg/L)	N.D.	0.15	N.D.	0.10	N.D.	N.D.	-	-	0.08	APHA 4500-P
Sulphate (mg/L)	23.6	22.3	141.4	20.0	10.0	N.D.	-	-	1.0	APHA 4110B
Total Ammonical Nitrogen (mg/L)	0.08	0.03	0.14	0.13	0.23	N.D.	-	-	0.01	APHA 4500-NH_3

Inorganic Compound : Cyanide (CN) by APHA 4500-CN(N) - Total Cyanide after Distillation using Micro Dist by Lachat FIA

Cyanide (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	5	1,500	20

Total Cyanide consists of Free Cyanide, Complex Cyanide and Total Thiocyanates. In this study, the Target and Intervention values of Free Cyanide, which are the most stringent Target and Intervention values of all three Cyanide species, are applied to the concentration of Total Cyanide (i.e. Free Cyanide + Complex Cyanide + Total Thiocyanates).

Aromatic Compounds : BTEX - Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C

Benzene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.2	30	1.0
Ethylbenzene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	4	150	1.0
Toluene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	7	1,000	1.0
Xylene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.2	70	2.0
Styrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	6	300	2.0

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	MW01	MW02	MW03	MW04	MW05	Method BLK	DUTCH (Target)	DUTCH (Intervention)	LOR	
pH value	6.4	7.2	7.0	7.2	6.8	-			-	APHA 4500-H+
@ Temperature (deg. C)	23.4	22.9	23.3	23.0	23.1	-	-	-	-	

Aromatic Compounds : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D

Phenol	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.2	2,000	1.0
Cresols	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.2	200	2.0
Catechol	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	10
Resorcinol	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	4.0
Hydrochinon	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	4.0

Polynuclear Aromatic Hydrocarbon (PAH) : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D

Naphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	70	1.0
Anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0007	5	1.0
Phenanthrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.003	5	1.0
Fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.003	1	1.0
Benzo(a)anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0001	0.5	1.0
Chrysene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.003	0.2	1.0
Benzo(a)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0005	0.05	1.0
Benzo(ghi)perylene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0003	0.05	1.0
Benzo(k)fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0004	0.05	1.0
Indeno(1,2,3cd)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0004	0.05	1.0
PAH (total of 10)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	1.0

Chlorinated Hydrocarbons : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C

Vinyl Chloride	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	5	2.0
Dichloromethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	1,000	5.0
1,1-Dichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	7	900	1.0
1,2-Dichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	7	400	1.0
1,1-Dichloroethene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	10	1.0
1,2-Dichloroethene (cis + trans)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	20	1.0
Dichloropropanes	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.8	80	1.0
Trichloromethane (Chloroform)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	6	400	1.0
1,1,1-Trichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	300	1.0
1,1,2-Trichloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	130	1.0
Trichloroethene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	24	500	1.0
Tetrachloromethane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	10	1.0
Tetrachloroethene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	40	1.0
Chlorobenzenes (total of 6)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	3.0
Monochlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	7	180	1.0
Dichlorobenzenes (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	3	50	3.0

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	MW01	MW02	MW03	MW04	MW05	Method BLK	DUTCH (Target)	DUTCH (Intervention)	LOR	
pH value	6.4	7.2	7.0	7.2	6.8	-	-	-	-	APHA 4500-H^+
@ Temperature (deg. C)	23.4	22.9	23.3	23.0	23.1	-	-	-	-	

Chlorinated Hydrocarbons : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D

Trichlorobenzenes (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	10	1.0
Tetrachlorobenzenes (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	2.5	2.0
Pentachlorobenzenes	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.003	1	1.0
Hexachlorobenzenes	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.00009	0.5	1.0
Chlorophenols (total of 5)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	3.0
Monochlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.30	100	2.0
Dichlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.20	30	3.0
Trichlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.03	10	1.0
Tetrachlorophenols (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	10	3.0
Pentachlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.04	3	4.0
Chloronaphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	6	2.0
Monochloroanilines	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	30	2.0
Polychlorobiphenyls (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.01 (d)	0.01	1.0

Pesticides : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D

sum DDT/DDD/DDE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.000004	0.01	2.0
DDT	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	2.0
DDE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	1.0
DDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	1.0
sum aldrin, dieldrin, endrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	0.1	1.0
Aldrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.000009	-	1.0
Dieldrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0001	-	1.0
Endrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.00004	-	1.0
sum HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.05	1	1.0
a-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.033	-	1.0
b-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.008	-	1.0
g-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.009	-	1.0
d-HCH	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	1.0
Atrazine	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.029	150	1.0
Carbaryl	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.002	50	4.0
Carbofuran	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.009	100	4.0
Chlordane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.00002	0.2	1.0
Endosulfan	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0002	5	1.0
Heptachlor	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.000005	0.3	1.0
Heptachlor Epoxide	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.000005	3	1.0
Maneb	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.00005	0.1	560

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	MW01	MW02	MW03	MW04	MW05	Method BLK	DUTCH (Target)	DUTCH (Intervention)	LOR	
pH value	6.4	7.2	7.0	7.2	6.8	-	-	-	-	APHA 4500-H+
@ Temperature (deg. C)	23.4	22.9	23.3	23.0	23.1	-	-	-	-	

Other Pollutants : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C

Cyclohexanone	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.5	15,000	10
Tetrahydrofuran	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.5	300	2.0
Tetrahydrothiophene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.5	5,000	2.0
Tribromomethane (Bromoform)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	630	1.0

Other Pollutants : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D

Phthalates (total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.5	5	2.0
Pyridine	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.5	30	2.0

Other Pollutants : Total Petroleum Hydrocarbons (TPH) by USEPA 8015C

C6 - C9	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	20
C10 - C14	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	100
C15 - C28	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	100
C29 - C36	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	-	100
C6 - C36 (Total)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	50*	600*	100

(*Dutch Standard for mineral oil)

Surrogate Recovery by USEPA 8260C

1,2-Dichloroethane-d4 (%)	102	101	94.4	93.6	92.8	83.8
Toluene-d8 (%)	81.8	88.2	92.7	98.8	106	101
p-Bromofluorobenzene (%)	113	116	109	98.7	117	104

Surrogate Recovery by USEPA 8270D

Benzene-d5, nitro- (%)	78.9	69.2	77.8	74.0	83.6	80.4
1,1'-biphenyl,2-fluoro (%)	68.6	64.1	73.0	67.7	78.0	74.7
p-Terphenyl-d14 (%)	71.9	86.4	92.4	92.4	106	84.9
Phenol, 2-fluoro (%)	57.6	83.1	94.9	96.9	94.7	90.8
Phenol-d5 (%)	84.4	50.5	55.5	61.3	56.7	52.4
Phenol, 2,4,6-Tribromo (%)	62.6	113	120	114	119	113

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017).
2. LOR = Limit of Reporting. Detection Limit is based on the highest detection limit obtained from the individual compound.
3. "ND" = Not detected. The data reported is less than the LOR.
4. (d) = Detection Threshold.
5. C10-C14, C15-C28, C29-C36 results are derived using the area under the peak against a hydrocarbon reference standard.
6. The target and interventions values are derived from Soil Remediation Circular 2013

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	Trip Blank	Method BLK	DUTCH	DUTCH	LOR
Static Water Table Depth (m-TOC)	-	-	(Target)	(Intervention)	-
Aromatic Compounds : BTEX - Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C					
Benzene	N.D.	N.D.	0.2	30	1.0
Ethylbenzene	N.D.	N.D.	4	150	1.0
Toluene	N.D.	N.D.	7	1,000	1.0
Xylene	N.D.	N.D.	0.2	70	2.0
Styrene	N.D.	N.D.	6	300	2.0
Chlorinated Hydrocarbons : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C					
Vinyl Chloride	N.D.	N.D.	0.01	5	2.0
Dichloromethane	N.D.	N.D.	0.01	1,000	5.0
1,1-Dichloroethane	N.D.	N.D.	7	900	1.0
1,2-Dichloroethane	N.D.	N.D.	7	400	1.0
1,1-Dichloroethene	N.D.	N.D.	0.01	10	1.0
1,2-Dichloroethene (cis + trans)	N.D.	N.D.	0.01	20	1.0
Dichloropropanes	N.D.	N.D.	0.8	80	1.0
Trichloromethane (Chloroform)	N.D.	N.D.	6	400	1.0
1,1,1-Trichloroethane	N.D.	N.D.	0.01	300	1.0
1,1,2-Trichloroethane	N.D.	N.D.	0.01	130	1.0
Trichloroethene	N.D.	N.D.	24	500	1.0
Tetrachloromethane	N.D.	N.D.	0.01	10	1.0
Tetrachloroethene	N.D.	N.D.	0.01	40	1.0
Monochlorobenzene	N.D.	N.D.	7	180	1.0
Dichlorobenzenes (total)	N.D.	N.D.	3	50	3.0
Other Pollutants : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C					
Cyclohexanone	N.D.	N.D.	0.5	15,000	10
Tetrahydrofuran	N.D.	N.D.	0.5	300	2.0
Tetrahydrothiophene	N.D.	N.D.	0.5	5,000	2.0
Tribromomethane (Bromoform)	N.D.	N.D.	-	630	1.0
Surrogate Recovery by USEPA 8260C					
1,2-Dichloroethane-d4 (%)	97.0	83.8			
Toluene-d8 (%)	98.0	101			
p-Bromofluorobenzene (%)	109	104			

Note:

1. LOR = Limit of Reporting. Detection Limit is based on the highest detection limit obtained from the individual compound.
2. "ND" = Not detected. The data reported is less than the LOR.
3. The target and interventions values are derived from Soil Remediation Circular 2013

TEST REPORT

Our Reference No.	:	**R191834/1B**	Date Received	:	07/05/2019
Project Code / Ref.	:	Mount Pleasant	Date Commenced	:	07/05/2019
			Date Reported	:	23/05/2019
Customer Ref. No.	:	-			
Customer Name	:	AECOM Singapore Pte Ltd			
Customer Address	:	300 Beach Road #03-00 The Concourse Singapore 199555			
Attention To	:	Mr Albert Payapaya			
Sample Description	:	5 Water Samples			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Laboratory Manager

Terms & Conditions:

1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

Marchwood Laboratory Services Pte Ltd: Co. Reg No. : 201422686C
Main (Office and Laboratory): 116 Tuas South Ave 2, West Point Bizhub Singapore 637163 : +65 6790 0118 : +65 6790 0091
Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 : +65 6262 3736 (Lab) : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

R191834/1B

Results:

Test Parameter	Unit	Test Method	Sample Date : 06/05/2019				
			MW01	MW02	MW03	MW04	MW05
Bicarbonate as HCO^{3-}	mg/L	APHA 4500-CO_2 (D)	91.0	339	262	302	136
Carbonate as CO_3^{2-}	mg/L	APHA 4500-CO_2 (D)	0.019	0.55	0.22	0.46	0.084
Calcium as Ca^{2+}	mg/L	APHA 3120B	46.1	120	158	116	52.2
Potassium as K^+	mg/L	APHA 3120B	1.57	6.81	4.55	4.69	7.28
Magnesium as Mg^{2+}	mg/L	APHA 3120B	1.59	12.8	10.5	10.7	2.58
Sodium as Na^+	mg/L	APHA 3120B	4.34	5.86	5.22	6.26	3.87

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.

MARCHWOOD LABORATORY SERVICES PTE LTD

CHAIN OF CUSTODY DOCUMENT / ANALYSIS REQUEST

7 MAY 2019

Priority Queue / Urgent / Report Needed by: _____

CLIENT	: AECOM Singapore Pte Ltd
CONTACT (Name / Tel / email)	: Jaypee Bautista / Oh Guo Liang
ADDRESS / COUNTRY	: 300 Beach Rd, #03-00 The Concourse
PROJECT Code / Ref.	: 60596697
SITE	: Mount Pleasant
QUOTATION / JOB REQUEST / PO No.	:
SEND REPORT TO	: Albert Payapaya / JP Bautista / Oh Guo Liang
COMMENT / SPECIAL INSTRUCTION	:
STORAGE / DISPOSAL	:

MLS LAB USE ONLY

Job No.: R191834/1

PRESERVATION DONE:

☐ On Site

☐ By Lab

Cold Box temp. at receipt: ____°C (if applicable)

☐ Sampling done by MLS

S/N	SAMPLE ID / LOCATION	SAMPLING DEPTH (m)	MATRIX* (Water/Soil/Sand/Sed/Sludge/Air)	DATE (DD/MM/YY)	TIME (HRS)	TOTAL NOs OF CONTAINERS# / SAMPLING MEDIA$	STORAGE CONDITION**	Sample Seal (Y / N) ☐ Tick if all sealed	ANALYSIS PARAMETER (Enter "x" below to indicate Request)										REMARKS / OBSERVATION / SAMPLE CONDITION
									JTC EBS Suite	VOCs	Major Ions(Calcium, magnesium, sodium, potassium, bicarbonate, carbonate, chloride, sulphate, fluoride)								
~~1~~	BH01 - 0.5m	0.5	Soil	25-Apr-19	1040	1 Jar	C	N	x										
~~2~~	BH01 - 3.0m	3	Soil	25-Apr-19	1145	1 Jar	C	N	x										
~~3~~	BH02 - 0.5m	0.5	Soil	25-Apr-19	1400	1 Jar	C	N	x										
~~4~~	BH02 - 3.0m	3	Soil	25-Apr-19	1605	1 Jar	C	N	x										
~~5~~	BH03 - 0.5m	0.5	Soil	26-Apr-19	0915	1 Jar	C	N	x										
~~6~~	BH03 - 3.0m	3	Soil	26-Apr-19	1440	1 Jar	C	N	x										
~~7~~	BH04 - 0.5m	0.5	Soil	27-Apr-19	1005	1 Jar	C	N	x										
~~8~~	BH04 - 3.0m	3	Soil	27-Apr-19	1110	1 Jar	C	N	x										
~~9~~	BH05 - 0.5m	0.5	Soil	27-Apr-19	1343	1 Jar	C	N	x										
~~10~~	BH05 - 3.0m	3	Soil	27-Apr-19	1438	1 Jar	C	N	x										
~~11~~	MW01 1	-	Water	6-May-19	0930	1 G, 1 P, 2 V	C	N	x		x								
~~12~~	MW02 2	-	Water	6-May-19	1530	1 G, 1 P, 2 V	C	N	x		x								
~~13~~	MW03 3	-	Water	6-May-19	1545	1 G, 1 P, 2 V	C	N	x		x								
~~14~~	MW04 4	-	Water	6-May-19	1430	1 G, 1 P, 2 V	C	N	x		x								
~~15~~	MW05 5	-	Water	6-May-19	1500	1 G, 1 P, 2 V	C	N	x		x								
~~16~~	Trip Blank 6	-	Water	-	-	2 V	C	N		x									
17																			
18																			
19																			
20																			

RELINQUISHED BY:	DATE / TIME
Name: Oh Guo Liang	07/052019
Sign:	14:30 hrs
Company: AECOM	

RECEIVED BY:	DATE / TIME
Name: A-Vairavan	07-05-19
Sign: A-Vair	2.50pm hrs
Company: MLS	

RELINQUISHED BY:	DATE / TIME
Name: A-Vairavan	07-05-19
Sign: A-Vair	5.25pm hrs
Company: MLS	

RECEIVED BY:	DATE / TIME
Name: NSS	7/5/19
Sign:	0800 hrs
Company: MLS	

SHIPMENT BY COURIER:

Courier Co. / Carrier Name:

Consignment Note/Airway Bill:

* = **For Water sample:** Please Indicate FW (Fresh Water), SW (Seawater), BW (Ballast Water), DW (Drinking Water), GW (Ground water), WW (Wastewater), OW (Other type of water e.g. canal/storm water)

\# **Type of Sampling Containers/Bottles:** G = Glass; P = Plastic; T = Tube; V = VOC vial; S = Steriled bottle/bag; B = Bag.

$ **Type of Sampling Media:** ST = Sorbent Tube; IM = Impinger solution; F = Filter; RT = Resin Trap; AP = Agar Plate; W = Wipe Sample; Others (PUF, etc. - please specify).

** **Storage Condition:** C = Refrigerate at 4 °C; R = Room Temperature; P = Preserved as per Lab's instruction.

TEST REPORT

Our Reference No.	:	**R200376/1A**	Date Received	:	22/01/2020
Project Code / Ref.	:	Mount Pleasant	Date Commenced	:	22/01/2020
			Date Reported	:	05/02/2020
Customer Ref. No.	:	-			
Customer Name	:	AECOM Singapore Pte Ltd			
Customer Address	:	300 Beach Road #03-00 The Concourse Singapore 199555			
Attention To	:	Mr Albert Payapaya			
Sample Description	:	2 Water Samples and 1 Trip Blank			
RESULTS:		Refer to Pages 2 to 6			

Tan Thuan Piang
Laboratory Manager

Terms & Conditions:

1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

Marchwood Laboratory Services Pte Ltd: Co. Reg No. : 201422686C
Main (Office and Laboratory): 116 Tuas South Ave 2, West Point Bizhub Singapore 637163 ☎ : +65 6790 0118 🖷 : +65 6790 0091
Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 ☎ : +65 6262 3736 (Lab) ☎ : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	VMW - 01	VMW - 02	Method BLK	DUTCH (Target)	DUTCH (Intervention)	LOR	
pH value	7.0	7.2	-	-	-	-	APHA 4500-H+
@ Temperature (deg. C)	22.4	22.8	-	-	-	-	

Metals by APHA 3125B / USEPA 245.1

Arsenic (As)	N.D.	1.8	N.D.	10	60	1.0
Antimony (Sb)	N.D.	N.D.	N.D.	-	20	1.0
Barium (Ba)	28.3	53.0	N.D.	50	625	1.0
Cadmium (Cd)	N.D.	N.D.	N.D.	0.4	6	0.25
Chromium (Cr)	0.1	0.1	N.D.	1	30	0.1
Cobalt (Co)	N.D.	N.D.	N.D.	20	100	1.0
Copper (Cu)	N.D.	N.D.	N.D.	15	75	1.5
Mercury (Hg)	N.D.	N.D.	N.D.	0.05	0.3	0.02
Lead (Pb)	N.D.	N.D.	N.D.	15	75	1.5
Molybdenum (Mo)	5.0	4.2	N.D.	5	300	0.5
Nickel (Ni)	N.D.	N.D.	N.D.	15	75	1.5
Zinc (Zn)	1.7	8.6	N.D.	65	800	1.0

Miscellaneous Analyses by APHA 23rd Edition 2017

BOD (mg/L)	12.3	5.0	N.D.	-	-	2.0	APHA 5210B
COD (mg/L)	N.D.	N.D.	N.D.	-	-	50	HACH 8000
TOC (mg/L)	5.0	4.3	N.D.	-	-	1.0	APHA 5310B
Fluoride (mg/L)	N.D.	N.D.	N.D.	-	-	0.5	APHA 4110B
Chloride (mg/L)	10	11	N.D.	100	-	1.0	APHA 4110B
Bromide (mg/L)	N.D.	N.D.	N.D.	-	-	1.0	APHA 4110B
Phosphate (mg/L)	0.19	0.27	N.D.	-	-	0.08	APHA 4500-P
Sulphate (mg/L)	16	43	N.D.	-	-	1.0	APHA 4110B
Total Ammonical Nitrogen (mg/L)	2.86	1.96	N.D.	-	-	0.01	APHA 4500-NH_3

Inorganic Compound : Cyanide (CN) by APHA 4500-CN(N) - Total Cyanide after Distillation using Micro Dist by Lachat FIA

Cyanide (total)	N.D.	N.D.	N.D.	5	1,500	20

Total Cyanide consists of Free Cyanide, Complex Cyanide and Total Thiocyanates. In this study, the Target and Intervention values of Free Cyanide, which are the most stringent Target and Intervention values of all three Cyanide species, are applied to the concentration of Total Cyanide (i.e. Free Cyanide + Complex Cyanide + Total Thiocyanates).

Aromatic Compounds : BTEX - Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C

Benzene	N.D.	N.D.	N.D.	0.2	30	1.0
Ethylbenzene	N.D.	N.D.	N.D.	4	150	1.0
Toluene	N.D.	N.D.	N.D.	7	1,000	1.0
Xylene	N.D.	N.D.	N.D.	0.2	70	2.0
Styrene	N.D.	N.D.	N.D.	6	300	2.0

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	VMW - 01	VMW - 02	Method BLK	DUTCH	DUTCH	LOR	
pH value	7.0	7.2	-	(Target)	(Intervention)	-	APHA 4500-H+
@ Temperature (deg. C)	22.4	22.8	-	-	-	-	

Aromatic Compounds : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D

Phenol	N.D.	N.D.	N.D.	0.2	2,000	1.0
Cresols	N.D.	N.D.	N.D.	0.2	200	2.0
Catechol	N.D.	N.D.	N.D.	-	-	10
Resorcinol	N.D.	N.D.	N.D.	-	-	4.0
Hydrochinon	N.D.	N.D.	N.D.	-	-	4.0

Polynuclear Aromatic Hydrocarbon (PAH) : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D

Naphthalene	N.D.	N.D.	N.D.	0.01	70	1.0
Anthracene	N.D.	N.D.	N.D.	0.0007	5	1.0
Phenanthrene	N.D.	N.D.	N.D.	0.003	5	1.0
Fluoranthene	N.D.	N.D.	N.D.	0.003	1	1.0
Benzo(a)anthracene	N.D.	N.D.	N.D.	0.0001	0.5	1.0
Chrysene	N.D.	N.D.	N.D.	0.003	0.2	1.0
Benzo(a)pyrene	N.D.	N.D.	N.D.	0.0005	0.05	1.0
Benzo(ghi)perylene	N.D.	N.D.	N.D.	0.0003	0.05	1.0
Benzo(k)fluoranthene	N.D.	N.D.	N.D.	0.0004	0.05	1.0
Indeno(1,2,3cd)pyrene	N.D.	N.D.	N.D.	0.0004	0.05	1.0
PAH (total of 10)	N.D.	N.D.	N.D.	-	-	1.0

Chlorinated Hydrocarbons : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C

Vinyl Chloride	N.D.	N.D.	N.D.	0.01	5	2.0
Dichloromethane	N.D.	N.D.	N.D.	0.01	1,000	5.0
1,1-Dichloroethane	N.D.	N.D.	N.D.	7	900	1.0
1,2-Dichloroethane	N.D.	N.D.	N.D.	7	400	1.0
1,1-Dichloroethene	N.D.	N.D.	N.D.	0.01	10	1.0
1,2-Dichloroethene (cis + trans)	N.D.	N.D.	N.D.	0.01	20	1.0
Dichloropropanes	N.D.	N.D.	N.D.	0.8	80	1.0
Trichloromethane (Chloroform)	N.D.	N.D.	N.D.	6	400	1.0
1,1,1-Trichloroethane	N.D.	N.D.	N.D.	0.01	300	1.0
1,1,2-Trichloroethane	N.D.	N.D.	N.D.	0.01	130	1.0
Trichloroethene	N.D.	N.D.	N.D.	24	500	1.0
Tetrachloromethane	N.D.	N.D.	N.D.	0.01	10	1.0
Tetrachloroethene	N.D.	N.D.	N.D.	0.01	40	1.0
Chlorobenzenes (total of 6)	N.D.	N.D.	N.D.	-	-	3.0
Monochlorobenzene	N.D.	N.D.	N.D.	7	180	1.0
Dichlorobenzenes (total)	N.D.	N.D.	N.D.	3	50	3.0

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	VMW - 01	VMW - 02	Method BLK	DUTCH	DUTCH	LOR	
pH value	7.0	7.2	-	(Target)	(Intervention)	-	APHA 4500-H+
@ Temperature (deg. C)	22.4	22.8	-	-	-	-	

Chlorinated Hydrocarbons : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D

Trichlorobenzenes (total)	N.D.	N.D.	N.D.	0.01	10	1.0
Tetrachlorobenzenes (total)	N.D.	N.D.	N.D.	0.01	2.5	2.0
Pentachlorobenzenes	N.D.	N.D.	N.D.	0.003	1	1.0
Hexachlorobenzenes	N.D.	N.D.	N.D.	0.00009	0.5	1.0
Chlorophenols (total of 5)	N.D.	N.D.	N.D.	-	-	3.0
Monochlorophenols (total)	N.D.	N.D.	N.D.	0.30	100	2.0
Dichlorophenols (total)	N.D.	N.D.	N.D.	0.20	30	3.0
Trichlorophenols (total)	N.D.	N.D.	N.D.	0.03	10	1.0
Tetrachlorophenols (total)	N.D.	N.D.	N.D.	0.01	10	3.0
Pentachlorophenol	N.D.	N.D.	N.D.	0.04	3	4.0
Chloronaphthalene	N.D.	N.D.	N.D.	-	6	2.0
Monochloroanilines	N.D.	N.D.	N.D.	-	30	2.0
Polychlorobiphenyls (total)	N.D.	N.D.	N.D.	0.01 (d)	0.01	1.0

Pesticides : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D

sum DDT/DDD/DDE	N.D.	N.D.	N.D.	0.000004	0.01	2.0
DDT	N.D.	N.D.	N.D.	-	-	2.0
DDE	N.D.	N.D.	N.D.	-	-	1.0
DDD	N.D.	N.D.	N.D.	-	-	1.0
sum aldrin, dieldrin, endrin	N.D.	N.D.	N.D.	-	0.1	1.0
Aldrin	N.D.	N.D.	N.D.	0.000009	-	1.0
Dieldrin	N.D.	N.D.	N.D.	0.0001	-	1.0
Endrin	N.D.	N.D.	N.D.	0.00004	-	1.0
sum HCH	N.D.	N.D.	N.D.	0.05	1	1.0
a-HCH	N.D.	N.D.	N.D.	0.033	-	1.0
b-HCH	N.D.	N.D.	N.D.	0.008	-	1.0
g-HCH	N.D.	N.D.	N.D.	0.009	-	1.0
d-HCH	N.D.	N.D.	N.D.	-	-	1.0
Atrazine	N.D.	N.D.	N.D.	0.029	150	1.0
Carbaryl	N.D.	N.D.	N.D.	0.002	50	4.0
Carbofuran	N.D.	N.D.	N.D.	0.009	100	4.0
Chlordane	N.D.	N.D.	N.D.	0.00002	0.2	1.0
Endosulfan	N.D.	N.D.	N.D.	0.0002	5	1.0
Heptachlor	N.D.	N.D.	N.D.	0.000005	0.3	1.0
Heptachlor Epoxide	N.D.	N.D.	N.D.	0.000005	3	1.0

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	VMW - 01	VMW - 02	Method BLK	DUTCH (Target)	DUTCH (Intervention)	LOR	
pH value	7.0	7.2	-	-	-	-	APHA 4500-H+
@ Temperature (deg. C)	22.4	22.8	-				
Other Pollutants : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C							
Cyclohexanone	N.D.	N.D.	N.D.	0.5	15,000	10	
Tetrahydrofuran	N.D.	N.D.	N.D.	0.5	300	2.0	
Tetrahydrothiophene	N.D.	N.D.	N.D.	0.5	5,000	2.0	
Tribromomethane (Bromoform)	N.D.	N.D.	N.D.	-	630	1.0	
Other Pollutants : Semi-Volatile Organic Compounds (SVOC's) by USEPA 3510C / 8270D							
Phthalates (total)	N.D.	N.D.	N.D.	0.5	5	2.0	
Pyridine	N.D.	N.D.	N.D.	0.5	30	2.0	
Other Pollutants : Total Petroleum Hydrocarbons (TPH) by USEPA 8015C							
C6 - C9	N.D.	N.D.	N.D.	-	-	20	
C10 - C14	N.D.	N.D.	N.D.	-	-	100	
C15 - C28	N.D.	N.D.	N.D.	-	-	100	
C29 - C36	N.D.	N.D.	N.D.	-	-	100	
C6 - C36 (Total)	N.D.	N.D.	N.D.	50*	600*	100	

(*Dutch Standard for mineral oil)

Surrogate Recovery by USEPA 8260C			
1,2-Dichloroethane-d4 (%)	91.2	93.0	90.6
Toluene-d8 (%)	102	99.8	104
p-Bromofluorobenzene (%)	109	102	109

Surrogate Recovery by USEPA 8270D			
Benzene-d5, nitro- (%)	80.7	71.0	82.0
1,1'-biphenyl,2-fluoro (%)	92.6	105	79.7
p-Terphenyl-d14 (%)	73.0	79.7	78.4
Phenol, 2-fluoro (%)	91.6	83.6	84.4
Phenol-d5 (%)	89.0	92.5	79.9
Phenol, 2,4,6-Tribromo (%)	80.9	90.6	70.0

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017).
2. LOR = Limit of Reporting. Detection Limit is based on the highest detection limit obtained from the individual compound.
3. "ND" = Not detected. The data reported is less than the LOR.
4. (d) = Detection Threshold.
5. C10-C14, C15-C28, C29-C36 results are derived using the area under the peak against a hydrocarbon reference standard.
6. The target and interventions values are derived from Soil Remediation Circular 2013

MLS

TEST RESULTS FOR WATER (in ug/L unless otherwise specified):

Sample ID / Monitoring Well	TB	Method BLK	DUTCH	DUTCH	LOR
Static Water Table Depth (m-TOC)	-	-	(Target)	(Intervention)	-
Aromatic Compounds : BTEX - Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C					
Benzene	N.D.	N.D.	0.2	30	1.0
Ethylbenzene	N.D.	N.D.	4	150	1.0
Toluene	N.D.	N.D.	7	1,000	1.0
Xylene	N.D.	N.D.	0.2	70	2.0
Styrene	N.D.	N.D.	6	300	2.0
Chlorinated Hydrocarbons : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C					
Vinyl Chloride	N.D.	N.D.	0.01	5	2.0
Dichloromethane	N.D.	N.D.	0.01	1,000	5.0
1,1-Dichloroethane	N.D.	N.D.	7	900	1.0
1,2-Dichloroethane	N.D.	N.D.	7	400	1.0
1,1-Dichloroethene	N.D.	N.D.	0.01	10	1.0
1,2-Dichloroethene (cis + trans)	N.D.	N.D.	0.01	20	1.0
Dichloropropanes	N.D.	N.D.	0.8	80	1.0
Trichloromethane (Chloroform)	N.D.	N.D.	6	400	1.0
1,1,1-Trichloroethane	N.D.	N.D.	0.01	300	1.0
1,1,2-Trichloroethane	N.D.	N.D.	0.01	130	1.0
Trichloroethene	N.D.	N.D.	24	500	1.0
Tetrachloromethane	N.D.	N.D.	0.01	10	1.0
Tetrachloroethene	N.D.	N.D.	0.01	40	1.0
Monochlorobenzene	N.D.	N.D.	7	180	1.0
Dichlorobenzenes (total)	N.D.	N.D.	3	50	3.0
Other Pollutants : Volatile Organic Compounds (VOC's) by USEPA 5021A / 8260C					
Cyclohexanone	N.D.	N.D.	0.5	15,000	10
Tetrahydrofuran	N.D.	N.D.	0.5	300	2.0
Tetrahydrothiophene	N.D.	N.D.	0.5	5,000	2.0
Tribromomethane (Bromoform)	N.D.	N.D.	-	630	1.0

Surrogate Recovery by USEPA 8260C

1,2-Dichloroethane-d4 (%)	81.3	90.6
Toluene-d8 (%)	107	104
p-Bromofluorobenzene (%)	109	109

Note:

1. LOR = Limit of Reporting. Detection Limit is based on the highest detection limit obtained from the individual compound.
2. "ND" = Not detected. The data reported is less than the LOR.
3. The target and interventions values are derived from Soil Remediation Circular 2013

MARCHWOOD LABORATORY SERVICES PTE LTD

22 JAN 2020

MLS-QF 001 Rev (4), Mar 2017

Page 1 of 1

CHAIN OF CUSTODY DOCUMENT / ANALYSIS REQUEST

Priority Queue / Urgent / Report Needed by: 5 Feb 2020

CLIENT	: AECOM SINGAPORE PTE LTD
CONTACT (Name / Tel / email)	: JAFON NG / +65 9825 7919
ADDRESS / COUNTRY	: 300 BEACH ROAD, THE CONCOURSE, #39-00
PROJECT Code / Ref.	: 60596697 Task 1.4
SITE	: MT. PLEASANT
QUOTATION / JOB REQUEST / PO No.	: -
SEND REPORT TO	: JAFON NG, CHENG YI; Jafon.ng@aecom.com
COMMENT / SPECIAL INSTRUCTION	: -
STORAGE / DISPOSAL	: -

MLS LAB USE ONLY

Job No.: R200376/1

PRESERVATION DONE:

☐ On Site

☐ By Lab

Cold Box temp. at receipt: ____°C (if applicable)

☐ Sampling done by MLS

S/N	SAMPLE ID / LOCATION	SAMPLING DEPTH (m)	MATRIX* (Water/Soil/Sand/Sed/Sludge/Air)	DATE (DD/MM/YY)	TIME (HRS)	TOTAL NOs OF CONTAINERS# / SAMPLING MEDIA$	STORAGE CONDITION**	Sample Seal (Y / N) ☐ Tick if all sealed	ANALYSIS PARAMETER (Enter "x" below to indicate Request): TICEBS Suite (Soil)	TICEBS Suite (GW)	Major Ions *	VOCs	REMARKS / OBSERVATION / SAMPLE CONDITION
1	VBH - 02	0.5	S	200120	AM	1		✓	✓	-	-	-	*Major Ions include: - bicarbonate; - carbonate; - calcium; - potassium; - magnesium; - Sodium - chloride; - sulfate; and - Fluoride.
2	VBH - 02	3.0	S	200120	AM	1			✓	-	-	-	
3	VBH - 01	0.5	S	200120	AM	1			✓	-	-	-	
4	VBH - 01	3.0	S	200120	AM	1			✓	-	-	-	
5	TRIP BLANK	-	W	-	-	1			-	-	-	✓	
6	VMW - 01	-	W	220120	AM	5			-	✓	✓	-	
7	VMW - 02	"	W	220120	AM	5			-	✓	✓	-	
8													
9						15							
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													

RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME	RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME	SHIPMENT BY COURIER:
Name: Zafon NG	22/1/2020	Name: A. Vairavan	22-01-2020	Name: A. Vairavan	22-01-2020	Name: LYL	22/1/2020	Courier Co. / Carrier Name:
Sign:	2.00pm hrs	Sign:	3.40pm hrs	Sign:	4.40pm hrs	Sign:	1700 hrs	Consignment Note/Airway Bill:
Company: AECOM Singapore		Company: MLS		Company: MLS		Company: MLS		

* = For Water sample: Please Indicate FW (Fresh Water), SW (Seawater), BW (Ballast Water), DW (Drinking Water), GW (Ground water), WW (Wastewater), OW (Other type of water e.g. canal/storm water)

Type of Sampling Containers/Bottles: G = Glass; P = Plastic; T = Tube; V = VOC vial; S = Steriled bottle/bag; B = Bag.

$ Type of Sampling Media: ST = Sorbent Tube; IM = Impinger solution; F = Filter; RT = Resin Trap; AP = Agar Plate; W = Wipe Sample; Others (PUF, etc. - please specify).

** Storage Condition: C = Refrigerate at 4 °C; R = Room Temperature; P = Preserved as per Lab's instruction.

TEST REPORT

Our Reference No. : **R200376/1B**
Project Code / Ref. : Mount Pleasant

Date Received : 22/01/2020
Date Commenced : 22/01/2020
Date Reported : 05/02/2020

Customer Ref. No. : -
Customer Name : AECOM Singapore Pte Ltd
Customer Address : 300 Beach Road
#03-00 The Concourse
Singapore 199555

Attention To : Mr Albert Payapaya

Sample Description : 2 Water Samples

RESULTS:

Test Parameter	Unit	Test Method	Sample Date: 09/07/2018	
			VMW - 01	VMW - 02
Alkalinity	mg/L	APHA 2320B	201	228
Bicarbonate as HCO^{3-}	mg/L	APHA 4500-CO_2 (D)	245	278
Carbonate as CO_3^{2-}	mg/L	APHA 4500-CO_2 (D)	0.12	0.20
Calcium as Ca^{2+}	mg/L	APHA 3120B	84.5	99.9
Magnesium as Mg^{2+}	mg/L	APHA 3120B	3.20	4.14
Sodium as Na^{+}	mg/L	APHA 3120B	13.2	11.8
Potassium as K^{+}	mg/L	APHA 3120B	5.50	4.92

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.

Tan Thuan Piang
Laboratory Manager

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Main (Office and Laboratory): 116 Tuas South Ave 2, West Point Bizhub Singapore 637163 ☎ : +65 6790 0118 : +65 6790 0091
Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 ☎ : +65 6262 3736 (Lab) ☎ : +65 6262 3726 / 3776 (Site)
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MARCHWOOD LABORATORY SERVICES PTE LTD

22 JAN 2020

MLS-QF 001 Rev (4), Mar 2017
Page 1 of 1

CHAIN OF CUSTODY DOCUMENT / ANALYSIS REQUEST

Priority Queue / Urgent / Report Needed by: 5 Feb 2020

CLIENT	: AECOM SINGAPORE PTE LTD
CONTACT (Name / Tel / email)	: JAFON NG / +65 9825 7919
ADDRESS / COUNTRY	: 300 BEACHROAD, THE CONCOURSE, #39-00
PROJECT Code / Ref.	: 60596697 Task 1.4
SITE	: MT. PLEASANT
QUOTATION / JOB REQUEST / PO No.	: -
SEND REPORT TO	: JAFON.NG,CHENG YI; [illegible]
COMMENT / SPECIAL INSTRUCTION	: -
STORAGE / DISPOSAL	: -

MLS LAB USE ONLY
Job No.: R003761

PRESERVATION DONE:
☐ On Site
☐ By Lab
Cold Box temp. at receipt: ____°C (if applicable)
☐ Sampling done by MLS

S/N	SAMPLE ID / LOCATION	SAMPLING DEPTH (m)	MATRIX* (Water/Soil/Sand/Sed/Sludge/Air)	DATE (DD/MM/YY)	TIME (HRS)	TOTAL NOs OF CONTAINERS# / SAMPLING MEDIA$	STORAGE CONDITION**	Sample Seal (Y / N) ☐ Tick if all sealed	ANALYSIS PARAMETER: TICEBS Suite (Soil)	TICEBS Suite (GW)	Major Ions *	VOCs	REMARKS / OBSERVATION / SAMPLE CONDITION
1	VBH - 02	0.5	S	20/01/20	AM	1			✓	-	-	-	*Major Ions include: - bicarbonate; - carbonate; - calcium; - potassium; - magnesium; and - Sodium - chloride; - sulfate; and - Fluoride.
2	VBH - 02	3.0	S	20/01/20	AM	1			✓	-	-	-	
3	VBH - 01	0.5	S	20/01/20	AM	1			✓	-	-	-	
4	VBH - 01	3.0	S	20/01/20	AM	1			✓	-	-	-	
5	TRIP BLANK	-	W	-	-	1			-	-	-	✓	
6	VMW - 01	-	W	22/01/20	AM	5			-	✓	✓	-	
7	VMW - 02	-	W	22/01/20	AM	5			-	✓	✓	-	
8													
9						15							
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													

RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME	RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME	SHIPMENT BY COURIER:
Name: Jafon Ng	22/1/2020	Name: A. Vairavan	22-01-2020	Name: A. Vairavan	22-01-2020	Name: [illegible]	22/1/2020	Courier Co. / Carrier Name:
Sign: [signature]	2.00pm hrs	Sign: A. Vairavan	3.40pm hrs	Sign: A. Vairavan	4.40pm hrs	Sign:	1700 hrs	Consignment Note/Airway Bill:
Company: AECOM Singapore		Company: MLS		Company: MLS		Company: MLS		

* = For Water sample: Please indicate FW (Fresh Water), SW (Seawater), BW (Ballast Water), DW (Drinking Water), GW (Ground water), WW (Wastewater), OW (Other type of water e.g. canal/storm water)

Type of Sampling Containers/Bottles: G = Glass; P = Plastic; T = Tube; V = VOC vial; S = Steriled bottle/bag; B = Bag.

$ Type of Sampling Media: ST = Sorbent Tube; IM = Impinger solution; F = Filter; RT = Resin Trap; AP = Agar Plate; W = Wipe Sample; Others (PUF, etc. - please specify).

** Storage Condition: C = Refrigerate at 4 °C; R = Room Temperature; P = Preserved as per Lab's instruction.

TEST REPORT

Our Reference No. : **R193228/1**
Project Code / Ref. : -

Customer Ref. No. : -
Customer Name : AECOM Singapore Pte Ltd
Customer Address : 300 Beach Road
#03-00 The Concourse
Singapore 199555

Attention To : Mr Jafon Ng

Sample Description : 1 Water Sample

Date Received : 17/02/2020
Date Commenced : 17/02/2020
Date Reported : 18/02/2020

RESULTS:

S/N	Sample Description	Copper as Cu APHA 3120B	Zinc as Zn APHA 3120B
		mg/L	mg/L
1	WQ3	0.018	0.073

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017).

Tan Thuan Piang
Laboratory Manager

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Website: www.mls.sg

TEST REPORT

Our Reference No.	:	**R194454/1**	Date Received	:	17/02/2020
Project Code / Ref.	:	-	Date Commenced	:	17/02/2020
			Date Reported	:	18/02/2020
Customer Ref. No.	:	-			
Customer Name	:	AECOM Singapore Pte Ltd			
Customer Address	:	300 Beach Road #03-00 The Concourse Singapore 199555			
Attention To	:	Mr Jafon Ng			
Sample Description	:	1 Water Sample			

RESULTS:

S/N	Sample Description	Copper as Cu APHA 3125B	Zinc as Zn APHA 3125B
		mg/L	mg/L
1	WQ3	<0.0015	0.012

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017).

Tan Thuan Piang
Laboratory Manager

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