Michael Fowler Centre Carpark Development Structural/Geotechnical Effects & Construction Methodology

Statement of Structural & Geotechnical Effects
Revised to accompany updated design information for RC

The purpose of this report is to identify likely structural hazards and effects relating to the proposed redevelopment of the Michael Fowler Centre Carpark (MFCC)site, and to identify appropriate mitigation, for the purpose of assisting with the Resource Consent application for the site.

The MFCC site has relatively high exposure to potential natural hazards including seismic shaking, liquefaction, lateral spreading, and flooding (arising from local inundation and/or foreseeable sea-level rise).

The structural, geotechnical and architectural design addresses and mitigates the natural hazards, noted above, with a high-performance structure intended to perform in excess of Building Code minimum requirements. In addition, the development will result in some remediation/disposal of existing in-ground (low-level) contamination. [Refer to Tonkin & Taylor *Ground Contamination Assessment* dated November 2016].

Geological profile of site

The site's geological profile (top to bottom) comprises:
- Reclamation Fill
- Marine Deposits
- Alluvium
- Bedrock (varies across the site, possibly between 50-80 metres depth).

The Reclamation Fill and Marine Deposits (below groundwater level) have a potential for widespread liquefaction resulting in lateral spreading towards the Whairepo Lagoon. The upper zones of the Alluvium have a potential for localised pockets of liquefaction but lateral spreading within the Alluvium is unlikely.

Proposed development

The proposed development involves removal of the existing, temporary ballet building and construction of an 9-level office building of irregular plan form. The new building structure will be base-isolated to provide seismic life-safety protection coupled with Low Damage Design, and protection of contents, in excess of Building Code expectations. Above the base isolators the structure will be predominantly

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steel framed. The upper floors will be composite slabs [reinforced concrete on permanent steel formwork] supported on steel beams. Seismic resistance of the superstructure will be provided by a diagrid arrangement of steel bracing that will transmit the lateral loads down to the base-isolation level.

The ground floor slab level of the new building will be set approximately 1m above existing ground levels to mitigate potential local inundation and sea-level rise flooding hazards as recommended in the Aurecon *Civil Engineering Concept Design Report*. Note that the raised floor level also provides space for base-isolation bearings and reduces excavation volumes.

Bulk excavation will be carried out generally as shown on the attached drawings. The volume of excavation is expected to be approximately 3200m^3. Excavation will typically be shallow [approximately 1200mm deep], with localised deeper zones at pilecaps and beneath the liftpits [approximately 2.4m deep, maximum]. The proposed pile solution [bottom-driven steel-tubes] results in minimal spoil for disposal. Excavated material will be treated/disposed as appropriate. Bulk excavation will be carried out prior to piling in order to form a site bund.

All construction phase run-off will be contained and treated on site as appropriate, refer to the LT McGuinness Draft Construction Management Plan [DCMP]. Typical bulk-excavation levels are expected to be above ground-water levels. Localised de-watering may be required to enable formation of lift pits and possibly some of the deeper foundation beams. Deeper, localised excavations will be retained with sheet piling as required and no significant lowering of the water-table is anticipated. Any de-watering effects are expected to be extremely localised.

Along the development's western side (facing the Michael Fowler Centre) and northern side (Jervois Quay) the excavation will typically be battered to meet existing ground levels, within the site boundaries. Along the southern side (Wakefield Street) a mixture of shallow, temporary, vertical cuts and temporary retaining will be required. This will include some areas of temporary encroachment along Wakefield Street, of approximately 300mm into road reserve, with steel sheet piling or steel soldiers and lagging. Any temporary retaining structures that extend beyond the site boundary will be removed to a minimum depth of 800mm below footpath level following completion of the permanent works.

Potentially, at three locations along the Wakefield Street boundary, localised and shallow, permanent encroachments may be necessary to facilitate base-isolation rattle space detailing. The need for this will be confirmed during design development.

Piling strategy

The building structure will likely be founded on driven piles founded in the dense Alluvium at a minimum depth of 12m, expected to range down to 20m below ground. Specialist geotechnical engineering input is being provided by Tonkin & Taylor.

Piles are likely to be bottom-driven steel tubes which are then filled with concrete. These piles will:

a) Transmit the vertical loads from the building, through the potentially liquefiable materials, down to competent founding.
b) Transmit the lateral (seismic) loads from the building into the surrounding supporting soils.
c) Resist the effects of potential liquefaction-induced lateral ground movement including ground lurch and lateral spreading.

Bottom-driven, steel-tube piles have been recently installed at the nearby Tākina (Wellington Convention Centre) site and Victoria Lane Apartments (161 Victoria Street) with the noise and vibration during installation successfully managed. The mitigation of the effects of the pile installation at the MFCC site, including noise and vibration, will be managed in a similar manner. Refer to Appendix A: *MFCC Driven Piling – Rationale & Mitigation,* and also to the Marshall Day Acoustic Assessment Report dated 10 February 2022. The great majority of the new piles will have a good separation from adjacent, occupied buildings.

Protection of existing infrastructure

Within the site are two existing items of public utility infrastructure:
1) A large, underground, sewage storage/detention tank, at the western end of the site; and
2) An old, buried, predominantly concrete, ovoid stormwater culvert running across the south-eastern corner of the site.

The proposed new building structure will be built over 50% of the tank plan area and over the culvert for a length of approximately 16m. Various inspections and assessments have been undertaken to better understand potential risks to the infrastructure.

The design intent for the proposed development is to:
a) Protect the infrastructure from damage during construction.
b) Protect the infrastructure from damage resulting from movement of the new MFCC building during a seismic event.
c) Ensure that permanent building loads transmitted to the infrastructure are minimal.
d) Make provision for future operations and maintenance of the infrastructure.

Refer to Appendix B: *Tank and Culvert – Protection and Access Protocols,* for further details.

Construction Methodology

The Michael Fowler Centre Carpark development permanent foundations will be constructed fully within the site. In-ground construction activities will include demolition, excavation, removal of existing foundations, piling, minor local de-watering and construction of the reinforced concrete foundation beams, concrete slabs and lift pits. The following steps outline, in concept, the construction methodology that will be used. Refer also to the LT McGuinness DCMP.

1. Additional proof-drilling to determine depths for piles.
2. Site establishment, hoardings, protective footpath gantries, site sheds etc.
3. Storm-water protection/diversion etc. Temporary filters, kerbs etc. to prevent construction and excavation materials entering the storm-water system.
4. Pruning (by arborist) and protection of trees to be retained.
5. Designation/marking of ‘light-traffic’ zones over tank and culvert.
6. Removal/demolition of the existing structures on the site. Note this includes the temporary ballet building, the elevated pedestrian bridge across Wakefield Street and an existing sculpture.
7. Site-wide bulk-excavation generally as shown on the bulk excavation plans, attached. This is likely to expose remaining foundations from previously demolished structures on the site. The excavated/demolished material shall be treated if required and disposed to landfill/cleanfill as appropriate.
8. Driving and pouring piles with protection measures and noise/vibration monitoring/management as necessary. Refer also to Appendices A and B.
9. Additional localised excavation together with temporary shoring works, as required, to form the pilecaps and foundation beams. The excavated material shall be assessed, treated if required and disposed to landfill/cleanfill as appropriate.
10. Installation of underground services as required.
11. Construction of concrete tidy slabs under pilecaps and the sub-ground floor slab.
12. Construction of the pilecaps, liftpit, foundation beams and reinforced-concrete sub-ground floor slab.
13. Installation of the base-isolator bearings.
14. Construction of the superstructure.

APPENDIX A - MFCC Driven Piling – Rationale & Mitigation

It is proposed to found the new building on ~150 bottom-driven, steel-tube piles. This technology involves driving hollow steel tubes, typically 450mm or 600mm in diameter, through poor overlying material into dense, competent founding strata at depth. The pile-driving hammer, instead of hitting the top of the pile, runs up and down inside the tube and typically hits a gravel plug at the base of the tube/pile.

The decision to utilise a driven pile type, rather than a drilled/bored pile is based on a comparative pile study carried out by Tonkin & Taylor and Dunning Thornton Consultants and more generally on Recommendation Number 26 issued by the Canterbury Earthquakes Royal Commission (Volume 1) that states: *Because driven piles have significant advantages over other pile types for reducing settlements in earthquake-resistant design, building consent authorities should allow driven piles to be used in urban settings where practical.*

The structural advantages can be summarised as follows:

a) By displacing the surrounding soil as it is driven, it improves the soil around and more importantly below the pile.
b) As it is driven to a ‘set’ (a prescribed maximum penetration for each blow of the driving hammer) it is effectively self-proving.
c) The compaction of the ground through driving improves the overall bearing capacity of the pile. In particular, it improves the end bearing capacity, reduces the length of the pile and provides increased dependability (confidence) in variable soil such as the Alluvium. Additionally, they can be more easily tested, to verify their load carrying capacity, compared to a bored pile.
d) As it is driven, rather than drilled, it does not create large volumes of spoil that has to be disposed of, as occurs with a bored pile. However, it is common to pre-drill a limited depth (typically 3m) to pitch the piles prior to driving. At contaminated sites, the much-reduced soil removal is a particular advantage.
e) The alternative drilled pile solution in these ground conditions is likely to involve a 1.2-1.8m diameter pile in the range of 35-45m deep (instead of 4-600mm diameter driven piles). The drilled option would require approximately 3 times the volume of concrete and the disposal of 50 cubic meters of spoil.
f) Compared to screw-piles in the given founding conditions, the driven pile provides significantly enhanced vertical capacity, lateral capacity, stiffness and dependability. Note that the uncertainty of a screw pile founding condition is the same as a bored pile. Additionally, it is likely that there will be difficulty in advancing screw piles to the required founding depths and consequently augering will be required which increases the volume of contaminated soils excavated.

We do note that, pending developed design, there may also be a need for some drilled piles. They also may be utilised for the contractor’s temporary tower crane foundations.

The perceived disadvantages of driven piles are noise and vibration. Conventionally, driven piles are top driven, precast concrete. The driving (the hammer hitting the top of the pile) occurs above ground creating a high level of noise. For bottom-driven, steel-tube piles the driving impact occurs below ground reducing the audible sound by approximately 10 dB.

In relation to ground-transmitted vibration, the difference between top-driven and bottom-driven piles is not significant. Human perception of ground vibration/acceleration is acute and people may perceive vibration despite it not being of a magnitude which would initiate structural damage. Previous trial piling works within the Te Aro Basin indicate that average vibrations can be limited to around 10-15mm/s when piling is carried out close to a building. According to the German Standard, DIN 4150-3, levels below 20mm/s should not damage a building to the extent which affects the serviceability of a building.

Recent experience of bottom-driven piling in the vicinity of the MFCC has shown that the effects of vibration can be effectively managed. Management protocols will include:

- Identification of surrounding buildings where occupants may feel the vibration.
- Early and ongoing communications with potentially affected occupants.
- Precondition photographic surveys of closely adjacent buildings.
- Attachment of 3-D survey targets to nearby buildings and structures.
- The driving of test piles at different locations around the site coupled with measurement of vibration magnitude in potentially affected surrounding buildings and infrastructure.
- Setting of vibration maximums, measured at neighbouring buildings, that would be prescribed to the piling contractor.
- Pre-augering through upper stiff gravels lavers, if required.
- During production piling, monitoring of vibration magnitude, in the surrounding buildings and infrastructure, on a real-time basis with pile driving energy inputs adjusted as required.
- Regular survey monitoring, of the targets, during production (and test) piling.

Projects where these piling protocols have been successfully implemented include:

- Tākina (Wellington Convention Centre)
- Victoria Lane Apartments

Both projects had close neighbours, both residential and commercial office.

Bottom-driven steel-tube piles were also successfully installed in the John Chambers Building and NZX, sites immediately to the north of the MFCC site.

APPENDIX B - MFCC Tank & Culvert - Protection and Access Protocols

These protocols are intended to establish the principles for protection and maintenance access for the sewage holding tank and the stormwater culvert that will be partially covered by the proposed MFCC development building. Prior to the commencement of construction the contractor shall prepare a detailed site management plan that incorporates these protocols. Refer also to the attached drawings.

Tank

- The new building shall be designed to span across the tank i.e. only minimal, permanent, vertical building loads shall be to be transmitted into the tank.
- A detailed seismic assessment of the tank has been carried out. Findings from the assessment are as follows:
    - The existing tank is generally compliant with current New Zealand loading and material codes, with allowance having been made for future sea-level rise and potential future seismic hazard changes.
    - The base of the tank is sufficiently socketed into the underlying alluviums, below potential liquefaction layers, to prevent more than minimal lateral displacement of the tank.
    - Unbalanced, seismically induced earth pressures may result in minor (50-100mm) settlements across or along the tank. This could result in a small tilt, in the order of 0.5 degrees maximum.
    - With the projected, minimal tank displacements, the proposed clearances to new building piles are satisfactory.
    - Potential flexural demands on the tank's walls and slabs, both out-of-plane and in-plane, are well within the existing tank's capacities.
    - It is apparent that the tank's original design allowed for worst-case buoyancy conditions i.e. ground water-table at ground level.
    - Removal of overburden above the eastern end of the tank (i.e. beneath the proposed new building) may reduce uplift/buoyancy factors-of-safety to nominally below minimum. Anchor piles or ballast could be used to restore the F.o.S. to appropriate levels.
- Based on this assessment, the partial covering of the tank will not pose significant risk either to the performance of the tank or to the future availability of access for maintenance or strengthening of the tank.
- A nominal, minimum pile clearance of 500mm from tank (base slab edge) shall be maintained. This will limit lateral load transference between piles and tank during seismic shaking.
- Piles within 4m of tank shall be pre-augered to 1m below base of tank.
- Existing access point at western end of tank will be covered by the new building footprint. A new access point to be created at western edge of building plinth. This will lie outside of proposed driveway service access to the MFC.
- No heavy construction traffic shall be permitted to pass-over/operate above tank. (Service traffic will continue to drive over tank.)
- Vibration levels at the tank will be monitored during pile driving – refer to *APPENDIX A - MFCC Driven Piling – Rationale & Mitigation*. No vibration issues are anticipated in relation to the tank.

- Existing fill above tank will be excavated, within the area of the new building footprint, to enable easier access to roof of tank for future maintenance. As noted above, some additional resistance to buoyancy uplift, at the eastern end of the tank will be provided, either by way of vertical ground anchors or with the addition of ballast.
- A pre-construction condition/damage survey of the tank shall be carried out. *Note: This has already been completed, refer to Aurecon Civil Engineering Concept Design Report.*
- A post-construction condition/damage survey shall be carried out, following completion of the ground floor of the new building.

Culvert

- The new building structure shall be designed to span across the culvert i.e. only minimal, long-term, vertical building loads shall be transmitted into the culvert.
- Approximately 16m length of culvert will lie beneath the footprint of the new building.
- The extent/dimensions of the culvert shall be confirmed prior to the commencement of piling.
- Options to maintain performance of the culvert include:
  a) Relining the culvert prior to construction of the new building.
  b) Cantilevering the building across the culvert to enable replacement to be carried out at some future date.

For either option, the following protocols will be followed:

- Piles within 4m of culvert centreline shall be pre-augered to 3m below the base of the culvert and shall have permanent casings, larger in diameter than the driven piles, from underside of pilecap to 1m below base of culvert. This will limit lateral load transference between piles and culvert during seismic shaking. Refer to preliminary piling plan, attached.
- A nominal, minimum clearance of 600mm from the face of culvert to the face of the permanent casing shall be maintained.
- Any new building sub-ground floor slab and foundations will be designed to span over the culvert without applying loads to culvert and will be separated with compressible material.
- No heavy construction activities or traffic (i.e. heavier than that permitted over the adjacent road-covered sections of culvert) shall be allowed above the culvert within the MFCC site.
- Vibration levels at the culvert shall be monitored during pile driving (with allowable levels pre-determined through programme of test-driving). Refer to *APPENDIX A - MFCC Driven Piling – Rationale & Mitigation*.
- A pre-construction condition/damage survey of the culvert shall be carried out. *Note: This has already been completed, refer to Aurecon Civil Engineering Concept Design Report.*
- A post-construction condition/damage survey of the culvert shall be carried out, following completion of ground floor of new building.

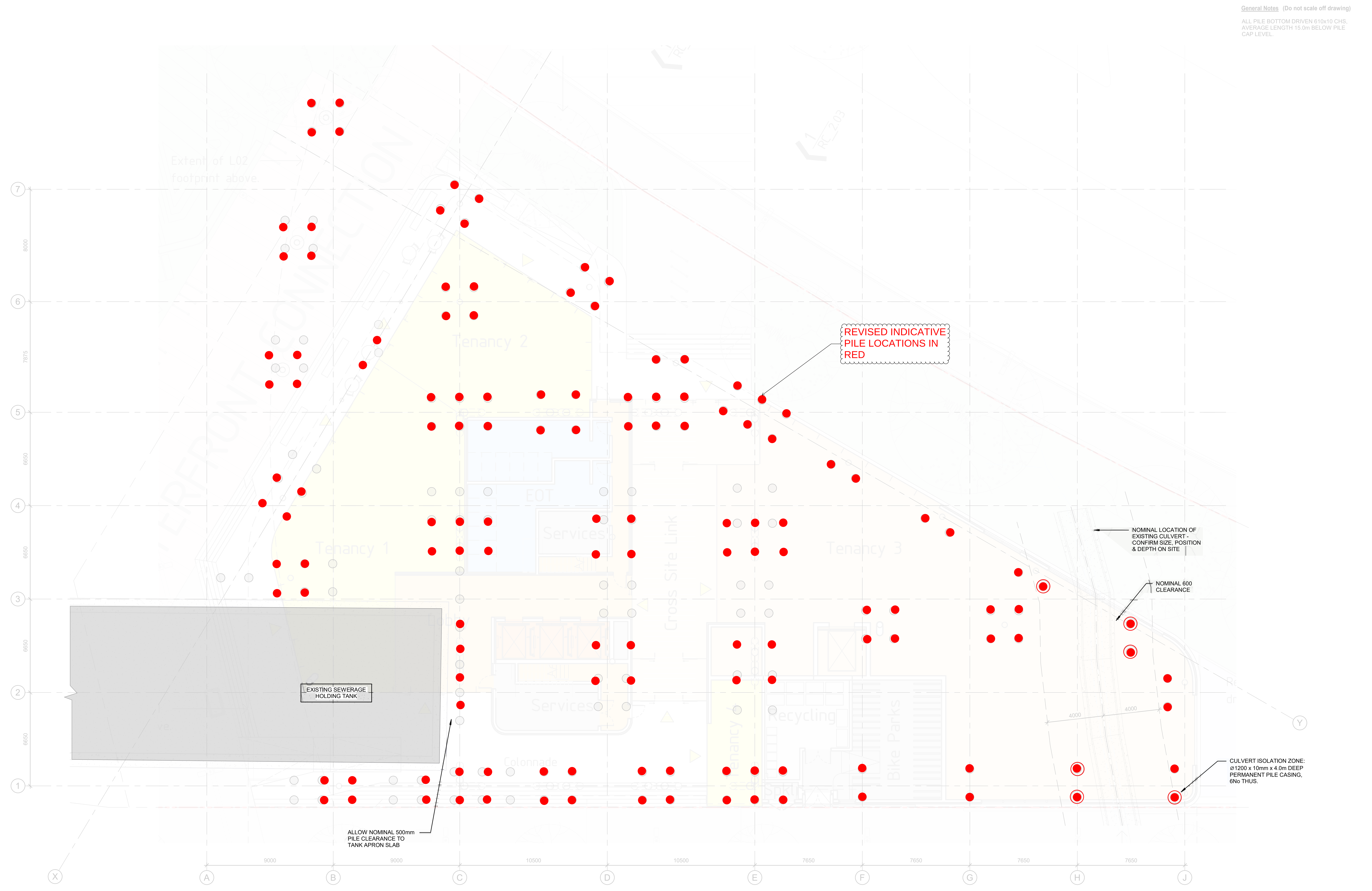
Attachments:

- 7952 Sketch S01-01 Pile Plan – Dated 11-8-2022
- 7952 S02-03 Tank and Culvert Cross Sections – Rev A

Dunning Thornton Consultants Ltd
Tonkin & Taylor
220824 – Revised Final

BIM 360://7952 - MFC Carpark/7952_MFC Carpark.rvt

ORIGINAL SIZE A1



ORIGINAL SIZE A1

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SKETCH			
JOB NAME:	MFC CARPARK OFFICE DEVELOPMENT		
JOB NO:	DRAWN BY:	DATE:	SKT NO:
7952	CRS	11.08.22	SKETCH S01.01

IF IN DOUBT ASK DO NOT SCALE VERIFY ALL DIMENSIONS ON SITE PRIOR TO COMMENCING ANY WORK

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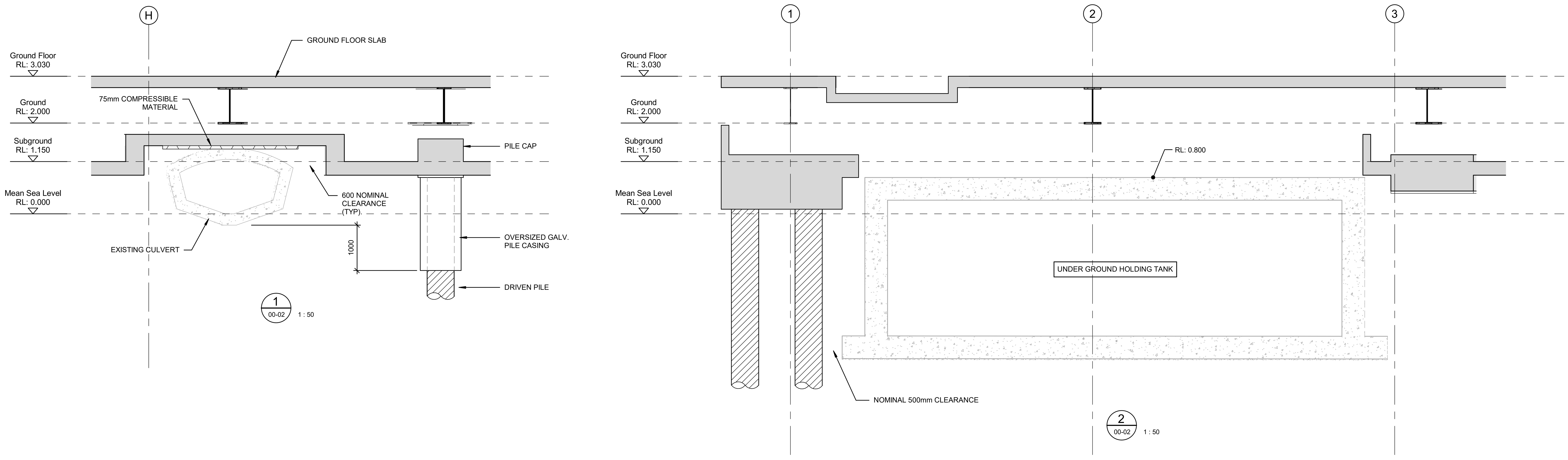
General Notes (Do not scale off drawing)



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Original Scale 100 50 0 10

ORIGINAL SIZE A1

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MFC CARPARK

TANK AND CULVERT CROSS SECTIONS

REVISIONS

A	RESOURCE CONSENT	10/12/2021

Scales	1:50
A3 Scales	1:100
Designed	Chris Speed
Drawn	Maurice Beckers
CAD Reference	

Job Number 7952

Drawing Number S02-03

Rev A

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