Baylink

NZTA

BR05 MGI Underpass Design Philosophy Report

B2B-S-RP-5500 | BA

18 December 2018

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A	17-12-2018	First draft issued to wider team for comment	Various	Various	[redacted] s 9(2)(a)
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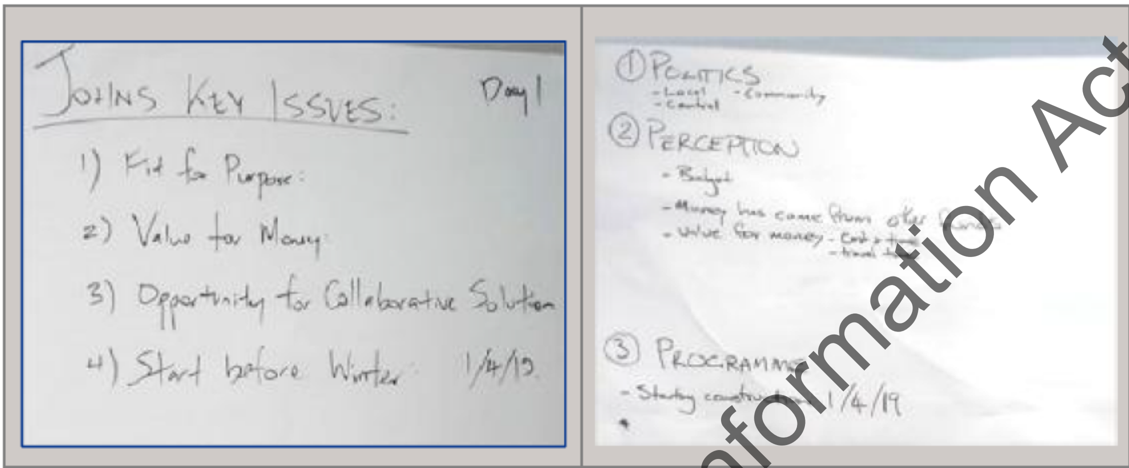
Contents

1. Introduction

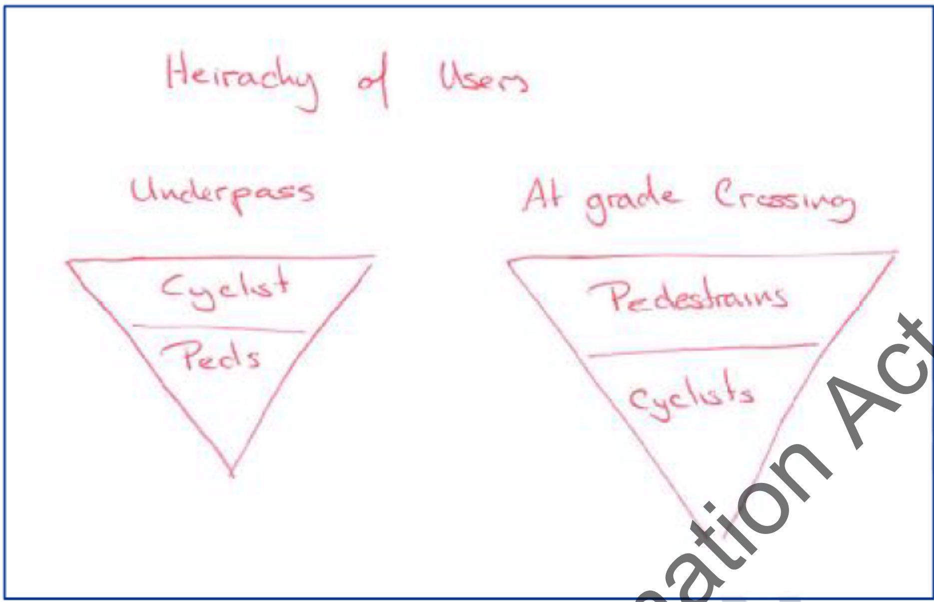
The contents of this report are based upon the workshops held between Monday 10th December and Friday 14th December 2018 in the T&T offices in Auckland. These collaborative workshops were attended by representatives from NZTA, Beca, CPB, Jacobs, T&T, Align and GHD.

The outcomes for the NZTA were best captured on the following charts



This report is intended to capture the Design Philosophy for the design and subsequent construction of the Matapihi Girven interchange (MGI) Underpass that was established during the week starting the 10th December 2018.

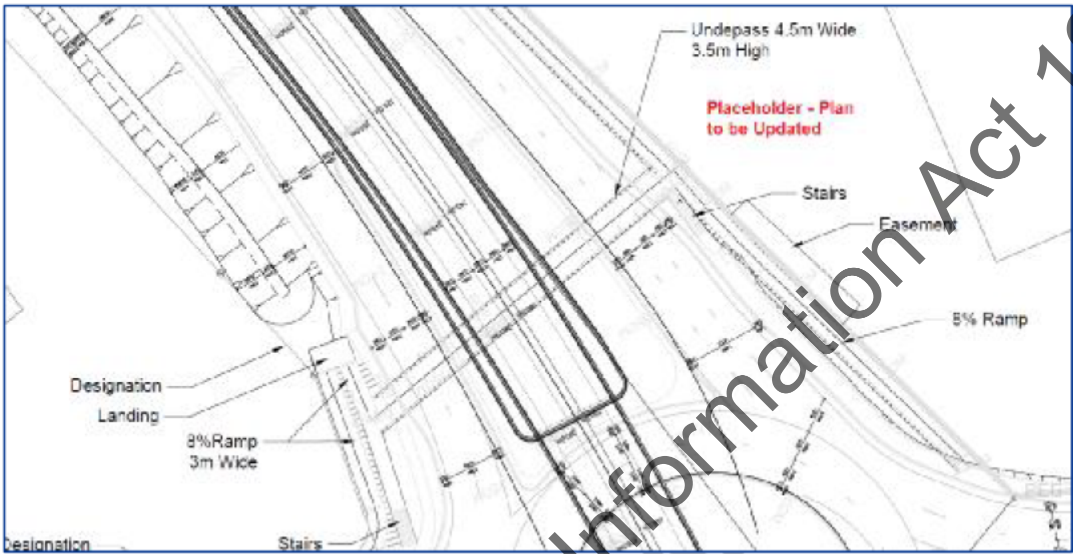
- The underpass will have minimum internal dimensions of 4.5m horizontal by 3m vertical these dimensions.
- It will be located as near as possible to the desire line for users crossing Maunganui road
- The underpass will be located to allow the maximum use of the existing underpass to convey pedestrians and other active modes of travel during construction
- The desirable maximum grade of approach ramps will be 8%. The absolute maximum grade of the ramps will be 9%
- There will be an additional egress from the ramps at each end to provide users with an alternative route should they feel uncomfortable upon entering or exiting the underpass.
- The entrance / egress will include flared approach to be confirmed at detailed design stage, to eliminate blind corners or areas for people to hide
- A key design objective will be to minimise or preferable eliminate standing water in the underpass or on the ramps.
- The desirable hierarchy of users is defined as below with the recognition that either type of user cannot be prohibited from using the underpass or at-grade facilities.

- 
Heirachy of Users
Underpass
Cyclist
Peds
At grade Crossing
Pedestrains
Cyclists

2. Roading Design

2.1 Location

The underpass is located at approx. Chainage 360m and crosses under the full width of SH2.



The new underpass will affect the configuration of the access areas in both sides of the underpass, Bayfair side and in Matapihi side. The space restriction mainly on the Bayfair side will require to modify the adjacent lane and shoulder configurations. .

This new design will require the relocation of the bus stops on both MGI northbound on ramp and southbound off ramps.

2.2 Scope and Principal Elements

This new underpass aims to minimise the impacts of the current Baylink design. I

For that and due to space constraints, such as the designation with Bayfair shopping centre, width to fit the proposed works will be limited, additional width, should it prove to be required will be gained from one or a combination of changes to shoulder and lane widths:

- In the south bound direction space may be reallocated from the three traffic lanes to a minimum lane width of 3.3m.
- In the south bound direction space may be reallocated from the shoulders with a minimum width to be considered of 0.5m.

The actual redistribution of space from the shoulder and lanes will be confirmed early in the detailed design stage. Any reduction in lane width will be carried throughout the ramps / local access road. Shoulder narrowing will be localised at an appropriate distance back from the roundabout.

2.3 Design standards and references

The current Principal's Requirements PR A2.0 regarding lane widths will potentially need to change dependent on the geometrical design development. The location of the bus stops as described in PR A9.3 will potentially need to change, these will be adjusted to accommodate a link to the new underpass for both bus stops.

2.4 Design constraints and assumptions

The main constraints are the designation boundaries existing in both sides, Bayfair and Matapihi and the lane configuration on the Bayfair side.

2.5 Risk/Opportunities

- The risk of reducing the lane width is a potential reduction in performance of the traffic flow but given relatively straight alignment and the approach to traffic signals this loss of performance is considered negligible. Careful consideration will need to be given to the tracking of large vehicles.
- A potential opportunity is that reduce lane widths on the roundabout approaches will reinforce the desired speed reduction
- The risk of reducing the width of the shoulder in the Bayfair side is the interruption in the traffic flow in case of vehicle breakdown, accidents or other incidents.

3. Roading Infrastructure

3.1 General

The new underpass on the Bayfair side will affect the Gantry 04 located in close proximity to the end of the underpass, this gantry will need to be moved approximately 20 m to the north. The gantry, underpass and pedestrian footbridge will require a concrete barrier to provide protection to errant vehicles.

Currently a safety barrier will be required between the footpath at street level and the access ramp (approx. 2m lower) to the underpass to protect from errant vehicles, final decision will be made during detailed design development

On the Matapihi side due to the underpass and the different levels between the carriageway and the access ramp a concrete barrier will be required to prevent errant vehicles leaving the carriageway.

A safety from falling barrier may be required between the footpath and the underpass ramps.

The barrier location will be decided after undertaking the visibility checks in the area.

3.2 Scope and Principal Elements

Barriers help to provide protection to pedestrian, cyclists and drivers from hazards and at the same time help to segregate the space.

On the Matapihi side a TL 4 concrete barrier will provide protection since interaction between vehicles, pedestrian and cyclist is at different level.

3.3 Design standards and references

The current Principal's Requirements are PR A8.3.2 and PR A8.3.3 regarding Bridge Edge Barriers and Pedestrian/Cyclists Barriers departures may be required but will only become known during detailed design.

3.4 Design constraints and assumptions

The design constraints on the Bayfair side are Gantry 04 and the underpass, on the Matapihi side the constraint is the underpass.

3.5 Risk/Opportunities

- The concrete barriers are prominent on both sides of the underpass and consideration could be given to use them as an extra element for urban design.
- During design development there is a risk that the barriers adjacent to the traffic lane will inhibit visibility splays, barriers will be located outside of visibility splays during detailed design.
- There is an opportunity to identify a robust wayfinding strategy that combines the Underpass and the Surface crossings through the signalised interchange.
- Consideration will be made for the impact of gantry and safety barrier footing on existing and new services

4. Urban Design Principles

4.1 Urban Design Principles

- Have an underpass design with a high functionality aspect that focuses on usability, ease of access, comfort and practicality.
- The paths leading to the underpass will take into consideration the planned Tauranga City Council pedestrian and cycle strategy for the Bayfair and Arataki area. Key desire lines and local destinations will be referenced and clearly allowed for in the design of access paths.
- Focus on safety and CPTED, areas for surveillance (both passive and active), providing clear and open sightlines, and alternative routes at exit points (decision nodes).
- Allow for aesthetic treatments that contribute to a high-quality environment that represents the place and integrates with the rest of the B2B urban design approach and features.
- The basis of the waterproofing design shall be a qualitative outcome where the underpass is provided with waterproofing to achieve 'No visible water patches'' under static conditions and following an SLS/minor earthquake.
- Create a hierarchy of user groups for movement through each area, based upon higher speed commuting cyclists mainly using the underpass and slower speed pedestrians mainly using the at grade facility over the roundabout, signal this hierarchy for users.
- Conflict points between higher speed cyclists and lower speed pedestrians will be minimised through the provision of dedicated paths for each of these modes where possible.
- Underpass will provide a non-demarcated shared path that can accommodate the tidal flow and direction of morning and afternoon cycle commuters and allow use by pedestrians.
- Interior environment of the underpass will consider all user senses sight (through natural and artificial lighting when practicable) and smell (through waterproofing and passive ventilation)

4.2 Scope and Assumptions [Implementation of Principles]

- The Bus Stops will need to be relocated for the layouts either side of the underpass to work. Working with the team to establish best location on Golf Course side.
- Levels are currently working pre-emptively from at grade road level traversing 'down' to underpass entrance of 3.4 to [a max of] 4m 'drop'.
- The underpass interior space is 3.0m high to align with the Bridging the Gap guidelines for urban design, (height 2/3 of the width). The underpass will have a 4.5m clear width
- Good urban design needs to consider the existing surrounding fixed and movable elements outside of the designation. The following should be considered and confirmed if they can be relocated i.e. the Bayfair Mall large sign, the golf course putting green, existing and future pedestrian connections to Bayfair etc.
- The underpass interior space is 3.0m high and 4.5m wide to align with the Bridging the Gap guidelines for urban design (height 2/3 of the width).

- Level interface with both ramp and path at grade required. This is a thin area and will need some considered design. Ramps at desirable maximum 8% slope (or absolute 9% maximum). In accordance with use for cyclists (accessible users route is through at grade crossings and paths).

- PS10 Lighting (AS /NZS 1158) along with at least 2x lightwells for areas of both natural and filtered light. Reflectivity and light to be a key feature through the space, where possible.

- Underpass wall surfacing to have painted walls with scope for art work with treatment either through paint or sandblasted to deter graffiti. Walls to be painted in light colour that provides a higher level of reflectance.

- Interaction with the urban designer for art works incorporation is required. Use of an architectural lining to provide a finish will not be pursued.Tiered planting and planter boxes where possible to visually break up and provide relief from the concrete vertical surfaces. see Risks and Opportunities). Look to terrace by creating lower level retaining walls (2m below) then sloped planting. Option for very steep planting and carefully designed boxes (planter boxes) where possible

- Look to terrace by creating lower level retaining walls (2m below) then sloped planting. Option for very steep planting and carefully designed boxes (planter boxes) where possible.

- Feature footbridge crossing over the top of the underpass on the Mall side. To be established over the top of the underpass and potential wingwalls.

- Steps to link pedestrians either into the Mall or into the underpass entrance (decision node). Consider access for ambulant users through steps and an accessible ramp.
- Wingwall 'flare out' where possible to allow for a transition area from dark to light for users exiting the underpass, clear sight lines and a more open entrance (no blind 90-degree corners). This will link into the pedestrian footbridge design.

4.3 Constraints

- The relatively narrow area between the required road geometrics and the designation boundary.

- The designation corners on each side sharply angle into the area creating small pinch point zones and tight corners. Golf course side the angle is very tight. Mall side the angle is over the existing path.

- Existing elements on either side of the designation. For example, signs, carparks, golf course, trees etc.

- Requirements of teams for waterproofing and treatments for the underpass for technical reasons.

- Lightwells to be incorporated into (edges) of overbridge. Location is key and constrained by the driveable maintenance area. Retaining walls and levels required. Interface between Bayfair Mall levels which are currently unknown.

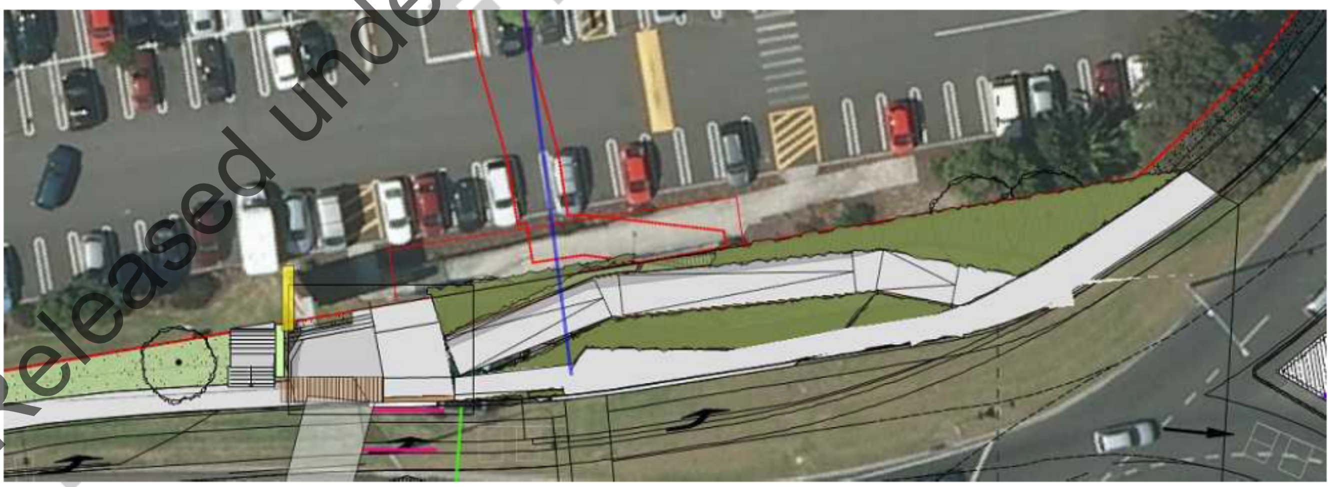
- Offset required for the geometrics and levels – assumed at this stage of 13m minimum from the edge of the northern bridge abutment (at MGI).

- Offset required for the construction staging – assumed for this at a minimum of 6m.

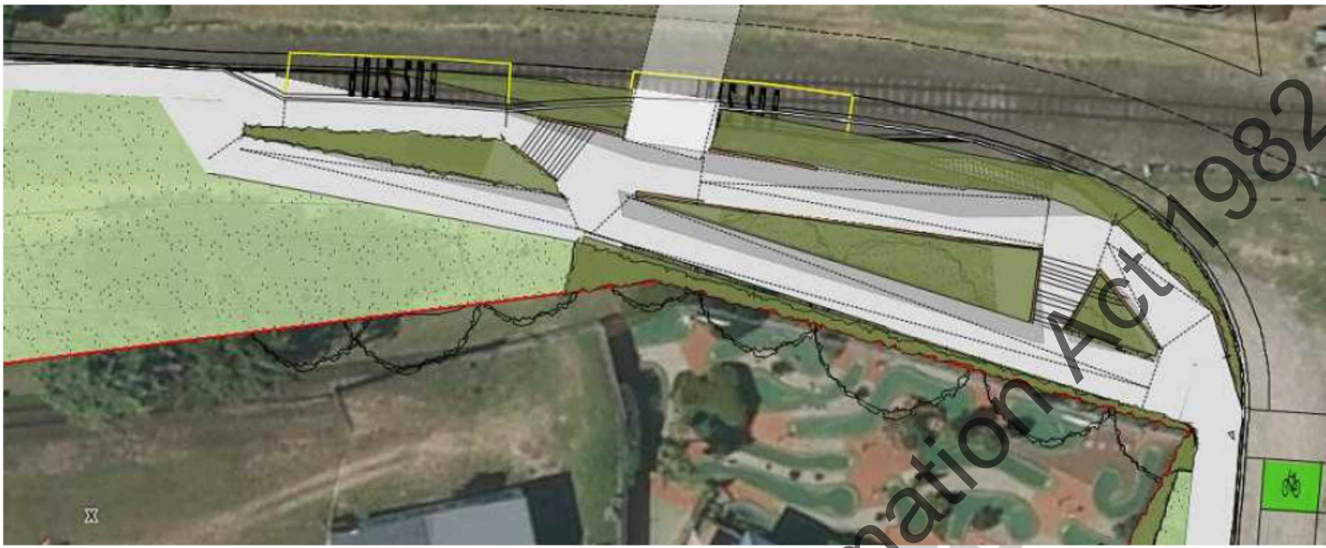
4.4 Risks and Opportunities

- Clear sight lines across these two zones particularly near the golf course – there is no passive surveillance here and is an 'island' – building 'down' not up and also areas where there are flat views across
- Large heavy blank walls provide a target for graffiti / vandalism and the feel of enclosure and over bearing moving through the spaces. These should be avoided.
- It is preferable for us to avoid 4m walls - everywhere except for immediately around the wingwalls of the underpass. This is so we don't create outdoor 'open' tunnels with utilitarian fencing that are cold and hostile. Opportunity to break up with tiered planting zones.Lack of survey data for adjacent land . The survey data on both sides – the Bayfair Mall and the Golf Course
- Fixed at 4m drop maximum. If the level change needs to drop more significantly then this will majorly change the ramps and the current workings of the design of paths / cycleways.
- The easement space on the MGI side presents option for the ramp to 'angle' into this space.
- Staircase into the Mall land prior to going 'back' into the underpass turnaround area.
- Geometrics incorporating elements of urban design principles and CPTED whilst meeting roading requirements for example the gantry location may need to be relocated to properly implement the ramp and stairs arrangement. Aligning this in the appropriate location is key.
- Safety roadside. The concrete barriers required for the 'inside' the space is best directly adjacent to roadside as may not be in accordance with the objectives and principles of urban design. Working through this will be key for a good outcome with offset of levels - likely that a fence and levels treatment that works from an urban perspective will be a better result.

4.5 Design Interpretation- Bayfair Ramps



4.6 Design Interpretation- Matapihi Ramps



5. Geotechnical

5.1 General

This Design Philosophy Statement is an Addendum to Groundworks Design Criteria and Philosophy Statement (B2B-G-RP-6000-C) and relates to the design of the Underpass at the Maunganui/Girven Road Interchange (MGI).

5.2 Scope and Principal Elements

This addendum to the B2B-G-RP-6000-C applies to the geotechnical design including stability, settlement, and foundation design of the underpass structure at MGI and the embankments and off and on ramps for SH2 that overlie the underpass.

5.3 Design Standards and References

The geotechnical design will comply with Appendix A of the Principal's Requirements and the NZTA Bridge Manual. Relevant Principal's Requirements (PR) and Bridge Manual clauses are referenced, where appropriate.

5.4 Design Constraints and Assumptions

5.4.1 Subsurface Conditions

Geology

Refer to the Baypark to Bayfair Geotechnical Interpretative Report (GIR) for a description of the regional geology, individual geological units, engineering properties of the site (and imported) materials and the groundwater model for the Bay Link alignment. Based on current information the geology for the underpass area is presented in drawing B2B-DRG-GT01_6006.

Groundwater

Groundwater monitoring data is available from between June 2011 and September 2016 from nearby piezometers installed in BH05, BH06 and BH312. The data indicates that groundwater level typically fluctuates between RL2.91 and to RL3.65m in the area. However, in June and July of 2011 groundwater levels in BH05 and BH06 were elevated to a maximum of RL 4.83m which is likely to represent a storm event.

The preliminary GWL adopted for general geotechnical design is 3.8m RL or top of wall whichever is lower.

5.4.1.1 Buoyancy Assessment

The invert of the underpass is currently considered to be approximately RL 2.5m.

For assessment of buoyancy the groundwater level will be assumed to be at ground surface level which is RL 6.5m at the currently proposed location of the underpass. A Factor of Safety against uplift of 1.1 will be required for this extreme case. It is noted that the location of the underpass may vary during detailed design and if so a reassessment of groundwater levels may be required.

5.4.1.2 Waterproofing of underpass

It is proposed to waterproof the full depth of the underpass

Seepage from the existing underpass is drained to a sump and then pumped. There is an opportunity to install piezometers around the existing underpass and investigate whether the current level of pumping maintains a lowered groundwater level around the existing underpass.

5.4.2 Seismic Design of Soil Structures relating to Underpass

Seismic design of the embankment over the underpass will be carried out in accordance with Clauses A3.5, A3.6.4 and A3.6.5 of the PRs. Seismic stability analysis of soil structures and bulk earthworks will be undertaken using the seismic parameters summarised in Table 1 1.

Table 1 Design ground accelerations and earthquake magnitudes

Location	Height (m)	Importance Level (IL)	Seismic Event	APE	PGA (g)	Magnitude
Underpass and Embankment over underpass	All	3	Minor	1/100	0.15	5.9
			SLS*	1/100	0.15	5.9
			ULS	1/2500	0.42	5.7
			MCE	N/A	0.46	6.9
Ramp Retaining structures and Base Slabs– providing route security and landing area at end of underpass	All	3	SLS*	1/100	0.15	5.9
			ULS	1/2500	0.42	5.7
Retaining walls supporting ramps and private property (50-year design life)	All	2	SLS	1/50	0.11	5.9
			ULS	1/1000	0.33	5.7

* Operational continuity

Performance criteria for the underpass and embankment immediately above shall be as summarised in Table 5.3 of the DPS B2B-G-RP-6000-C.

Table 5.3(B2B-G-RP-6000-C): Performance criteria of soil structures affecting underpass

Event	Performance Criteria	Displacement Limits (1)	
		Horizontal Displacement (mm)	Vertical Settlement (mm)
Minor (1/100 APE)	As per BM Table 5.1		
ULS / design level	To enable the underpass to meet the performance criteria outlined in BM Table 5.1 as clarified in A4.11.1.	100(2)	300(2) - Total

earthquake			
Major / MCE	To enable the underpass to perform as per BM Table 5.1. In addition: Global Stability: Slope stability Factor of Safety (FoS) > 1.1 for post-seismic stability with residual shear strengths and zero PGA	N/A	

Notes:

1. For these cases the performance of the bridges will also need to satisfy the criteria set out in BM Table 5.1, as clarified in A4.11.1.
2. Provided the minimum clearance to the road / rail below the structure can be reinstated by jacking or similar, refer to A4.11.1

Performance criteria for retaining walls forming the ramps at either end of the underpass shall be in accordance with PR A3.6.4.2.

5.4.3 Other criteria

The approach to the following shall be as per GDPS (B2B-G-RP-6000-C) or as modified and agreed during the detailed design

- Slope Stability and Seismic Displacement
- Static Settlement of Soil Structures
- Ground Improvements
- Foundation Design
- Bulk Earthworks
- Pavements, MSE Walls, Embankment to Bridge

5.5 Design philosophy

5.5.1 Ground improvements

It is envisaged that design of the underpass will require ground improvement like that provided below the BR01 abutment zone to mitigate against liquefaction. This is likely to include stone columns below the footprint of the underpass extending to a depth of RL -8.0m. The ground improvements will extend a minimum of 5m beyond the footprint of the underpass. The extension at the eastern and western edge of the underpass will be 5m where practical and will form the landing areas at the end of the underpass. Where it is not practical to install the stone columns to 5m beyond the landing, a relaxation of PRs will be required. .

5.5.2 Settlements

Static and seismic differential settlement is expected where the underpass goes below the edges of the embankment for the MGI overpass.

Static settlements

It is currently estimated that even with stone columns static settlements may be in the order of 50 to 75mm. These can be mitigated to some extent by preloading the embankment over the underpass area. The settlement would be monitored to establish that preloading time for 90% primary consolidation will be achieved. Preload period is in the order to 6 to 12 weeks. The preload would be expected to be equivalent to the loading from final height of the fill embankment. The preloading will provide a robust assessment of the settlement profile (Immediate and long term) expected below the underpass.

It is possible that the installation of the stone columns may densify the subsoil profile reducing the estimated settlement. This approach will be considered as an opportunity following review of the CPT tests undertaken post ground improvement and the settlement monitoring results for the trial embankment on site. It is noted that to date stone columns have been installed in an area to the south of the underpass location and in a different subsoil profile. Accordingly, only a limited assessment will be able to be inferred from these results. If this opportunity is pursued, it is proposed that additional CPTs be undertaken along the underpass alignment.

There is an opportunity following the installation of the stone columns, a second set of CPT tests would be undertaken to establish the densification of the ground between the stone columns. The settlement at the underpass location would be re-estimated based on these results and the decision as to whether the preloading would be required made at this time. However, the preload option gives the more robust measured settlement for the proposed loading and significantly reduces the risk of equivalent embankment loading from the proposed works

Seismic Settlements

Seismic settlements below the underpass are expected to be like those reported in Table 7.5 of the Geotechnical Design Report for Bridge BR01 (B2B-G-RP-6303-C) and provided below.

Table 7.5 B2B-G-RP-6303-C): Summary of seismic settlements for the BR01 abutments (Similar settlements are expected below the embankment at the Underpass location with Stone column ground improvements to RL-8.0m). This table will need to be amended for any updates.

Earthquake event	Settlement limit (mm)	Abutment A (ground improvement to -6 m RL)			
		S_v (mm)	S_s (mm)	S_r (mm)	S_t (mm)
SLS (100-year APE)	N/A	<1	<1	0	<2
ULS (2500-year APE)	300	<5	<10	0	<15
MCE	N/A	<60	<28	0	<88

5.5.3 Water tightness

It is currently intended that vertical movement joints will be provided in the underpass located at the zones of likely maximum differential movement immediately below the outer edge of the embankment. Water tightness criteria for the underpass under static conditions and following seismic events is as follows:

- SLS and static - The underpass shall remain watertight

- ULS - The underpass including the waterproofing shall be repairable
- MCE - No collapse is permissible.

Further details are provided in the structural section of the DPS.

5.6 Risks and Opportunities

Several construction risks / opportunities have been identified in relation to the proposed ground improvement design:

- Risk: Settlement is greater than expected and excessive cracking occurs in the underpass which damages waterproofing .
- Mitigation: robust design of ground improvement, application of preload and review following results of settlement monitoring of trial embankment. Robust design of joints in underpass located at the edge of the embankment location.
- Opportunity: Re-evaluation of groundwater regime based on groundwater monitoring results to reduce waterproofing requirements.
- Opportunity: Avoid the requirement for preloading by assessment of densification and consequential reduction of settlement due to stone column construction. However, this will still come with a greater risk around settlement estimation.
- Risk: Damage to existing underpass while still in use or new underpass due to stone columns construction. Stone column construction generates vibrations. The vibration must be considered regarding potential damage to neighbouring properties. It is recommended that pre-construction condition assessments are undertaken on the surrounding properties and
- An assessment of the effect of vibration on the existing underpass and partially complete new underpass is undertaken
- Vibration monitoring has been undertaken during the stone column trials to develop site-specific attenuation curve for the Vibroflot plant proposed for the Bay Link Project. This site-specific attenuation curve will be used to assess the likely ground vibration effect of stone column construction on adjacent assets and mitigate these as appropriate to comply with the Bay Link Construction Noise and Vibration Management Plan (CNVMP).

6. Structures - Underpass

6.1 Introduction

This section covers the structural design philosophy for the main structure of the BR05 MGI Underpass on the Baylink Project and covers the design criteria and general design approach that will be used to design the structure.

6.2 Scope and principal elements

It was agreed the location of the Underpass will be such that;

- reasonable separation from the existing underpass is maintained to allow construction of new structure whilst the existing is still in place.
- separation from zone of influence of BR01 MSE abutment is maintained
- the Underpass entrance/exit at the Bayfair end is as close to the desired path for pedestrians accessing the Bayfair shopping mall.
- A positive hydraulic gradient will be maintained through the underpass after Static Settlement and SLS conditions.

It was agreed the clear envelope for the Shared User Path through the Underpass will be 4.5m wide x 3m deep to meet the requirements for shared pedestrians/cyclists' users at the MGI location. A structure with internal dimensions of 4.5m x 3m will therefore be adopted for the Underpass to efficiently utilise the space within the structure. The underpass structure will be approximately 62 metres long and will pass under and support the MGI north approach ramp (SH2 mainline) and the two slip roads on either side of the ramp.

It was agreed the Underpass will comprise of a rigid box concrete structure with internal dimensions of 4.5 metres x 3 metres and an anticipated wall thickness of 400mm. The construction type of the box will be a combination of insitu concrete and/or precast concrete construction with precast units stitched or stressed together and will be driven by the construction programme and temporary traffic management staging. The type of construction will be developed further during the 50% design stage.

It was concluded that the box structure will be founded on spread footing on ground-improved dune sands. Ground improvements comprising of vibrated stone columns will be installed for the entire length of the box structure. Refer to the Geotechnical design philosophy statement for further details on ground conditions and ground improvements.

It is currently envisaged that the construction of the Underpass structure will be carried out in stages, the Construction Sequencing is shown in Section 11 of this report.

Preloading of the ground under the MGI north ramp will be undertaken to reduce the magnitude of the primary consolidation settlements expected at this location. This will significantly reduce the differential settlement between the ground under the ramp and adjacent ground. Settlement monitoring during preloading will be used to confirm estimated differential settlement that will need to be accommodated by the underpass.

It is currently considered the structure will be constructed in 3 no. segments with isolation joints provided at either side of the MGI north overpass embankment to accommodate differential static and seismic settlements between the segment under the ramp and the adjacent segments. It is envisaged segments 1 and 2 will be constructed first during stage 1. Where required, provision will be provided at the end of segment 1 to allow access to the existing underpass (where this is to be utilised for temporary pedestrian traffic management). Segment 3 will be constructed during stage 2. The MGI north overpass embankment will be installed once all the 3 segments are in place.

It was identified that the ground water level at the Underpass location is high. Refer to geo-technical section for ground water levels and therefore measures are required to protect the Underpass from water ingress. It was concluded a water-tight detail for the movement joints will be developed as design progresses.

As the Underpass will be founded below the GWL, buoyancy will need to be considered in the design of the structure. It was envisaged that the box structure wall thickness will be sized such that any expected buoyancy is resisted by the self-weight of the box and backfill on top without resorting to the provision of hold-down mechanisms or wings to the sides of the floor slab for mitigating against uplift. It was envisaged that provision of wings to the sides of the floor slab may complicate wrapping the structure with waterproofing hence should be avoided.

The extreme (surface) GWL will be used for the determination of ULS water pressures for the design of the underpass walls for strength and stability.

Side protection in the form of rigid concrete barrier will be provided at the east end and a TL4 performance level concrete barrier at the west end of the Underpass structure as per BM requirements.

Provision of light-wells will be considered from an Urban Design point of view. Where required, allowances will be made on the roof slab to accommodate the light-wells.

6.3 Design standards and references

The design of the Underpass structure will comply with the current Baypark to Bayfair project Principal's Requirements; Supplementary Principal's Requirements ; the NZTA Bridge Manual Third Edition, 2013 (including Amendment No.1) and other Standards referred to in the NZTA Bridge Manual.

Additional Principal's Requirements will be identified at the 50% design stage where required.

It was concluded that any departure from the PRs and/or standards required will be captured and addressed as a Supplementary Principal's Requirement where practicable.

6.4 Design Constraints and assumptions

Proximity of the Underpass to the proposed BR01 MGI North MSE abutment. It was agreed a buffer of 6m (approximately) should be maintained between the two structures for the Underpass to be outside the zone of influence of the bridge MSE abutment.

It is assumed that the provision of the underpass will have no detrimental impact on the design of Bridge 1.

Construction programme and temporary traffic management staging. The Underpass construction type i.e. whether wholly in situ/precast or a mix of in situ and precast will be dictated by the construction programme and the staging of the temporary traffic management.

Height restrictions due to proximity to Tauranga Airport flight path. The size of cranes required for the installation of precast box/panel units will be restricted by the flight path clearances and it was therefore concluded the options for precast construction of the Underpass will be significantly limited by this.

High ground water levels. Measures will be required to achieve water-tightness of the Underpass to meet the Principal's Requirements. Detailing of the movement joints including sealing the joints to meet water-tightness requirements whilst providing the articulation required.

Differential static and seismic settlements. Structure will require to be designed to accommodate differential movements from static and seismic settlements resulting from the construction of the MGI north ramp. Ground improvements and preloading will be employed to reduce the magnitude of the static settlements.

No water should collect in the Underpass due to future settlement of the structure. No low spots on the underpass floor the vertical alignment design will allow for settlement a maintain a positive hydraulic fall.

For the minor earthquake event, there should be no damage to the structure and the Underpass shall remain water-tight. For the design earthquake event, minor repairs may be required, and the Underpass shall remain water-tight or a feasible repair method shall be identified..

Pavement construction over the Underpass. It was concluded that continuous pavement make-up of the carriageway will be maintained over the Underpass hence the option of having a trafficked deck was discounted. A minimum of 600mm cover will be required over the Underpass roof.

Temporary Traffic management. No tracking curves or geometrical modelling of the works or its interfacing with the MGI roundabout has been undertaken in development of the DPR.

6.5 Risks and opportunities

Failure of waterproofing membrane 'wrap' around the Underpass leading to Underpass not being water-tight. Value Engineering will be undertaken to ensure an appropriate waterproofing type is adopted for the structure including exploring use of waterproofing admixtures to the concrete mix.

Failure of movement joints water-tightness. Appropriate detailing of movement joints will be required to ensure the joints remain water-tight whilst providing required articulation.

There is an opportunity for innovative thinking in formulating an appropriate detail for the movement joints for the Underpass.

Impact of Underpass structure on the BR01 MGI north MSE abutment. A review will be required to confirm there is no detrimental effect on the design of the MSE abutment for the bridge once the final layout of the Underpass is agreed on.

7. Structures – Bayfair Footbridge

7.1 Introduction

This section covers the structural design philosophy for the Bayfair Footbridge on the Baylink Project and covers the design criteria and general design approach that will be used to design the structure.

7.2 Scope and principal elements

Based on the urban design requirements, it was agreed a pedestrian footbridge, 1.8m wide is required to carry the footpath across the entrance to the Underpass at the Bayfair end.

Consideration will be given to supporting the footbridge off the wingwalls or cantilevering off the Underpass headwall depending on the final urban design layout adopted at this location.

Consideration will be given to use a timber or concrete decking for the footbridge, based on an Urban Design opportunity. Timber along with other materials will be considered during detailed design development.

It has been identified that several utilities at the Bayfair end will require relocation to accommodate the construction of the approach ramps. Consideration will be given to the utilities being relocated to run under the pedestrian footpath along the carriageway with the footbridge providing support to the utilities across the Underpass entrance.

7.3 Design standards and references

The design of the Underpass structure will comply with the current Baypark to Bayfair project Principal's Requirements; Supplementary Principal's Requirements; the NZTA Bridge Manual Third Edition, 2013 (including Amendment No.1) and other Standards referred to in the NZTA Bridge Manual.

Additional Principal's Requirements will be identified at the concept design stage where required.

It was concluded that any departure from the PRs and/or standards required will be captured and addressed as a Supplementary Principal's Requirement.

7.4 Design Constraints and assumptions

It is assumed the requirement for the footbridge or the type of footbridge structure may change with the development of the urban design at the entrance to the Underpass at the Bayfair end.

Consideration will need to be given to the differential settlement between footbridge structure and adjacent ground to meet serviceability requirements of the footpath (stepping at ends of footbridge and water ponding).

7.5 Risks and opportunities

There is the opportunity that an appropriate footbridge structure will enhance the urban design features at the entrance to the Underpass.

8. Structures – Ramp Structures

8.1 Introduction

This Design Philosophy Statement covers the structural design philosophy for the ramp structures of the BR05 Pedestrian Underpass on the Baypark to Bayfair Link Upgrade. The report provides information on the design criteria and general design approach that will be used to design the structure.

8.2 Scope and principal elements

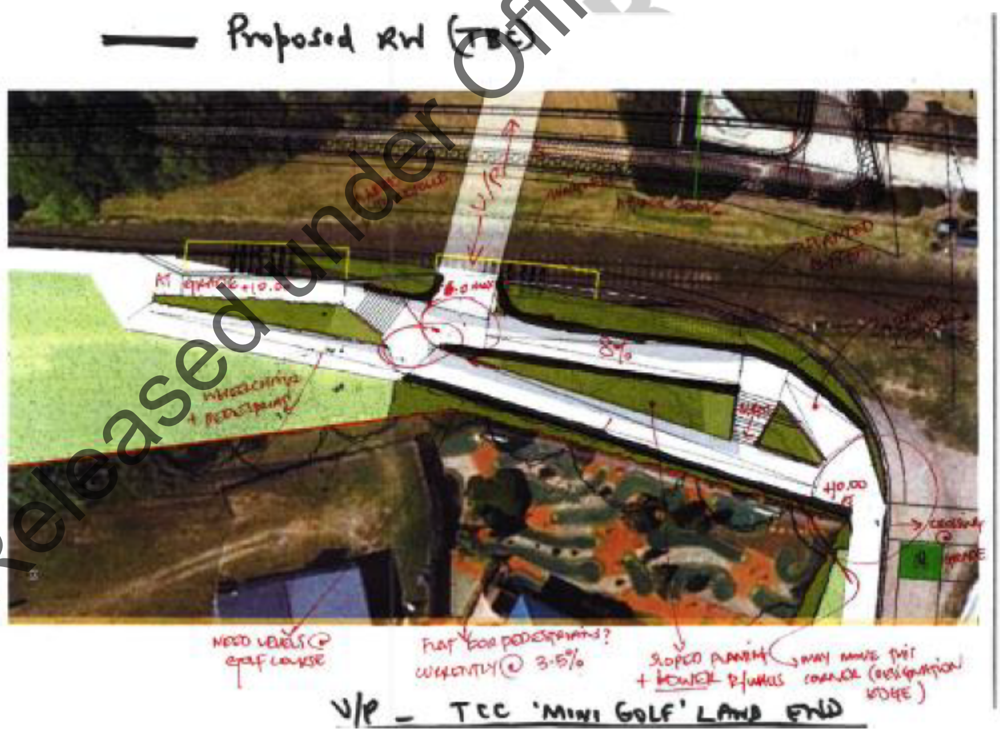
It was agreed the location of the ramp structures will be such that:

- Desired path for pedestrians and cyclists to/from the Underpass from/to the Bayfair shopping centre is maintained where possible at the Bayfair end.
- The ramp structures are within designation in the first instance.

Embedded retaining structures would be unsuitable due to liquefaction of the ground at the ramp structures locations. The conclusion was to utilise U-shaped concrete units wherever possible depending on the ground level differences on both sides of the ramps and gravity walls (modular blocks) where U-shaped concrete units are unsuitable.

The option of lowering the Importance Level and design life for the retaining structures remote from the carriageways was considered and it was concluded that these structures will be designed for IL2 instead of IL3 required by the PRs. The structures forming part of the landing at both ends of the Underpass will however be treated as IL3 as this will need to provide the same performance requirement as the Underpass during the Major seismic event i.e. no structural collapse. A departure from the PR Clause A4.3 will therefore be required. This will be addressed as Supplementary Requirement rather than through the departure process.

It is intended to prove stone columns under the bases slabs at the entrance / egresses of the underpass but not under the ramps themselves.



For the retaining structures along the TCC mini golf property at the west end of the Underpass, the option for using timber poles embedded walls was considered for IL2 and 50 years design life, however this was discounted due to potential problem with graffiti on the wall. Modular block retaining walls was considered as an option as the retained ground at this location is assumed to be approximately 1.5m high.

It was agreed the requirement for water-tightness of the ramp structures will differ to the Underpass structure as the ramps will be exposed to the elements and positively drained. Therefore, some seepage will be acceptable. Appropriate storm water drainage will require to be provided to ensure flows are captured before entering the Underpass.

8.3 Design Constraints and assumptions

Liquefaction of the ground at the ramp locations limiting the choice of retaining structures to be considered for the ramp structures.

Appropriate measures will be required to manage any water ingress from the raised GWL.

Differential static and seismic settlements between underpass and ramp structures at the landings. Structures will require to be designed to accommodate differential movements from static and seismic settlements to meet SLS and ULS requirements at the entrance to the underpass. Ground improvements will be undertaken at the landing locations to reduce the magnitude of the static settlements.

Structures will require to be designed to accommodate differential movements from static and seismic settlements to meet SLS and ULS requirements of the ramps.

8.4 Risks and opportunities

Failure of gravity structures due to ground liquefaction. This will be considered in the design.

Structural collapse of cantilever walls due to ground liquefaction during major seismic event. Where possible U-shaped units or gravity walls will be used in lieu of cantilever walls.

Differential settlements between ramp structures on improved ground and those without ground improvements.

Access restrictions resulting from temporary traffic management programme and constructability constraints.

9. Drainage

9.1 Scope and Principal Elements

- Road surface drainage network near the new underpass to be directed away from the underpass to prevent clash with the underpass and associated infrastructure;
- Manage high groundwater level near the underpass. The existing underpass floods and has a pumped drainage sump to control the ingress of groundwater;
- Provide gravity drains to divert runoff from the access ramps (at possible lowest levels)
- Maximise ground water drainage by gravity. Pump ramp runoff not captured by gravity systems and groundwater;
- Design fully tanked underpass and retaining walls to the design GWL (See 5.4.1)
- Design adequate systems to capture runoff from lower portions of the access ramps and dispose by pumping to prevent flooding of the underpass. Ground water freely drained at the faces of the underpass will be pumped.
- Provide the pipework and chambers only to support potential future requirements for potential ground water lowering.
- Provide high level (at lowest possible level) gravity drains parallel to the underpass.
- The underpass will be protected from a 50- year ARI storm.
- No flood modelling of any nature is not proposed for this work.

9.2 Design standards and references

- For assessment of buoyancy the groundwater level will be assumed to be at ground surface level which is RL 6.5m at the currently proposed location of the underpass.
- The invert of the underpass is currently anticipated to be at approximately RL 2.5m.
- A general ground water level at RL 3.8m will be adopted for design.
- The underpass will be protected from the surface water flooding of 50-year ARI.
- The PRs for the B2B project will be utilised with the following exclusions:
- PR A6.3.6 - No longer applicable no requirement to undertake any flood modelling.
- PR A6.3.5.3 – the minimum pipe diameter of 300mm no longer applies.

9.3 Design Philosophy

The following design philosophy will be adopted for the design of the underpass and associated structures:

- The road surface drainage near the proposed underpass will be directed away from the underpass to prevent clash of drainage pipes with the underpass and associated infrastructure.

- The proposed underpass location has high groundwater level . The existing underpass is located close to the proposed underpass and is on its south. It has an invert level of approximately 3.00 m RL and it floods occasionally. Currently, it has a pumped drainage sump to control ingress of ground water into the underpass.

- The access ramps on the north and south entrances of the new underpass fall from existing ground levels to an anticipated 2.5m RL at the entrances. The road runoff outside of the access ramps will be diverted away from the ramps via re-arranged drainage pipes. However, runoff from the ramps themselves flow down the ramps and collect at the entrances.

- Gravity drains (at lowest possible levels of the access ramps) will be provided to collect surface runoff from ramps and direct to manhole SP1.2 where a gravity drainage systems namely SP1 (1350 mm dia culvert) runs outside to the south of the proposed underpass. It is currently assumed that access ramp areas higher than 3.85 m RL can be directed to Manhole SP1.2 by gravity. The HGL in SP1.2 is 3.75 m RL at a 50-year ARI storm and its invert is at 2.46 m RL. The underpass will be protected from the 50-year ARI surface water flooding. A non -return flap gate will be installed at MHSP1.2 to prevent flood entry into ground from culvert SP1.

- Lower portions of the access ramps (Lower than 3.85 m RL) that cannot be diverted away by gravity will be collected in the sumps located on ramps. The sump at the eastern entrance will be connected to the western sump by a gravity pipe. Other sumps that collect groundwater will also be connected to the central sump located at the western end. The collected surface and groundwater from the central sump will be pumped to the nearest gravity drainage pipe. The downstream piped system will be designed to cater for the additional load from pumping.

- Current proposals are that the underpass will be subjected to a maximum groundwater level of 4.83 m RL (recorded June -July 2011) even though the data indicates that groundwater level typically fluctuates between RL2.91 and to RL3.65m in this area. The SP1 has a hydraulic gradient of 3.75 m RL at MH SP1.2 in a 50-year ARI storm which means that the groundwater higher than 3.75 m RL can be constantly drained to SP1 by gravity. When the culvert is running partially full or has only a base flow, lower groundwater can be drained by gravity. A non- return valve will be installed at MH SP1.2 to prevent flows from SP1 into the ground. It is inevitable as the detailed design progresses that flood values quoted here may change but the philosophy will remain the same.

- Groundwater pumping is an opportunity as risk management or future proofing. Excessive pumping of ground water can have adverse hydrogeological effects in the wider area, the attempt is to maintain a groundwater regime like the existing. Only freely drained groundwater at faces of the underpass will be collected in sumps via perforated pipes and will be pumped. The combination of the gravity and pumped systems are to provide hydraulic relief to the underpass, retaining walls and associated structures.

The surface drainage and groundwater management philosophy concept is as shown on the illustrations below.

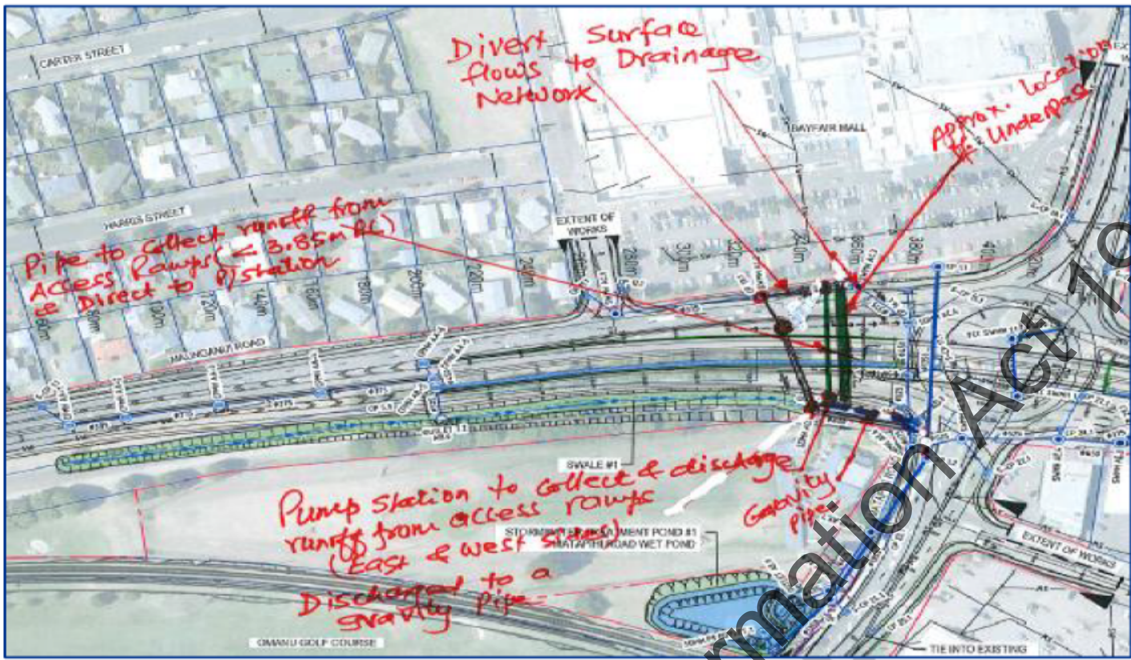


Fig 1- General Drainage Layout

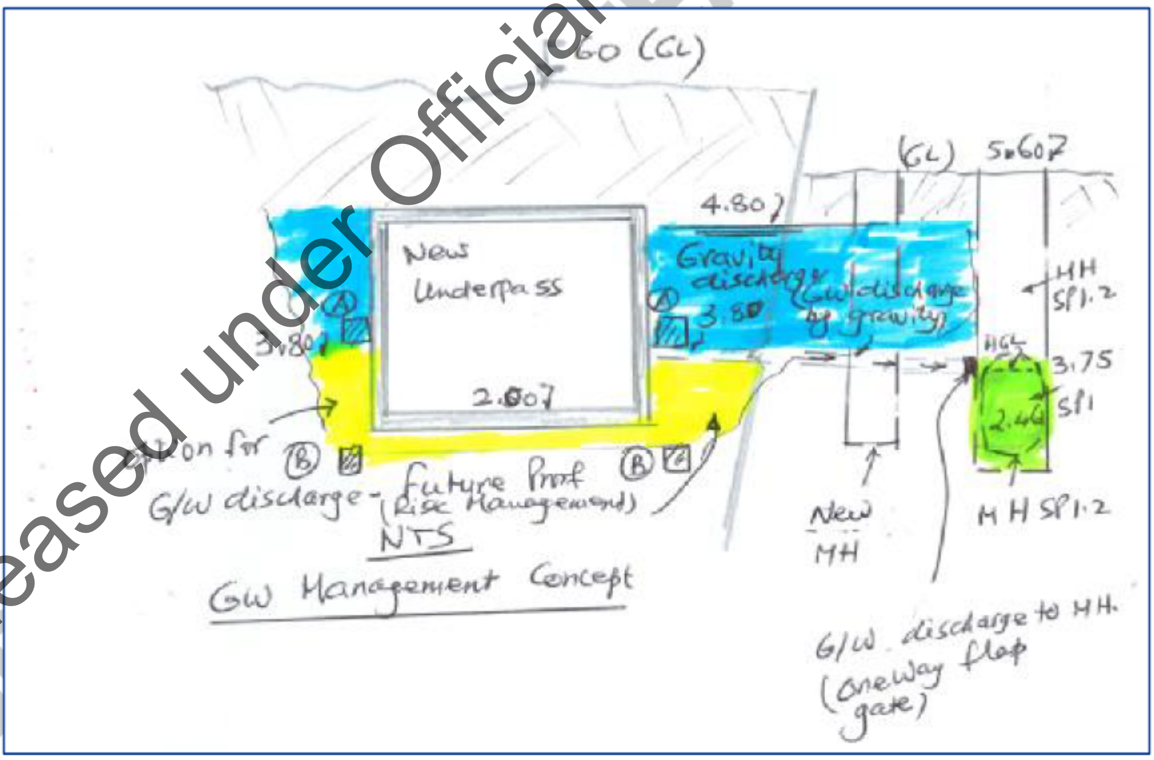


Figure 2- Concept of Groundwater Management

Notes:

1. *Access ramp runoff above 3.8 m RL is captured in sumps (located on ramps) at both entrances and discharged by gravity. Provide a non-return flap gate at the outfall manhole to prevent flood water entry from SP1. Ramp runoff below 3.8 m RL is to be directed to sumps for pumping. Ramp runoff up to a 50 -year ARI is to be managed.*
2. *Groundwater above 3.80m RL may be discharged by gravity to the drainage network leading to the SW wetland. Portions of access ramps lower than 3.8m RL and any ground water lowering below RL 3.80m RL are to be directed to*

the sumps. Surface and ground water collected in these sumps will be pumped to the gravity pipes that lead to the gravity drainage system.

3. *Set Subsoil drains (A) at a height (approx. 3.80m RL) to connect to sumps on ramps that are part of the gravity drainage system.*
4. *As a possible option for future proofing (risk management), set subsoil drain(B) below underpass blanked at ends) to lower groundwater in the future.*

It is to be noted that the design philosophy is for the long- term management of surface and ground water and has not discussed the construction water management. It is expected that significant ground water pumping will be required during construction of the underpass associated infrastructure. and a separate water management methodology will need to be developed for construction.

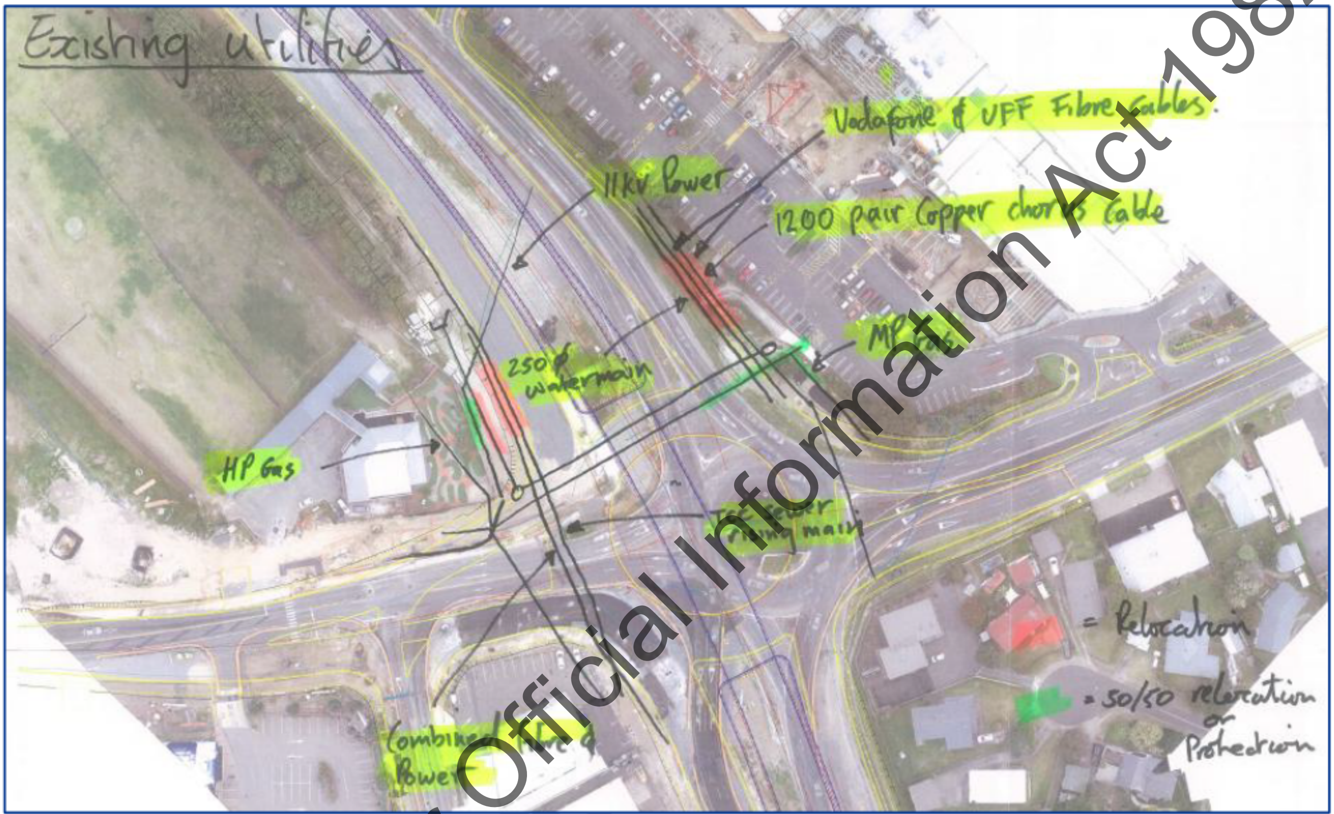
9.4 Risks and Opportunities

- Risk that TCC require flood modelling undertaken during the detailed design, this will impact design delivery, mitigation is that we do not undertake any flood modelling, risk owner is the NZTA.
- VE Opportunity to refine the waterproofing system adopted during detailed design
- Risk that designing underpass, retaining walls and associated infrastructure to control leakage of groundwater can be expensive. Complete sealing between underpass and retaining walls may be difficult to achieve.
- Opportunity that ground water level may be lowered by gravity sufficiently (most of the time SP1 is expected to run part full). The water levels in SP1 and downstream piped systems because of the peak flows can subside early before ground water near the underpass rises allowing groundwater discharge by gravity. Overall a minimal pumping may be required.
- Opportunity to investigate concrete admixtures to resist infiltration of concrete from Ground Water to block pores and cracks in concrete.
- Opportunity to use sumps and pumps at each end for removal of stormwater at each end more effectively.

10. Utilities

10.1 Existing Utilities

The key utilities impacted by the underpass are as shown below.



The decision to either relocate or protect in place those utilities shown green can only be fully determined once the detailed design has particularly the fixing of the major elements of underpass and ramps.

It is currently considered that the 1200 Pair Copper Chorus Cable is the most critical utility impacted and will require diversion, this cable alignment takes it under the existing underpass.

10.2 Risks and opportunities

The key risks and opportunities are:

- Risk – Early on site works to establish the exact location of utilities near the underpass location. Further investigation required to develop the design and confirm design philosophy
- Opportunity - Early development of utility packages within the 50% Design Phase.
- Programme utilities and consider works as enabling packages.
- Opportunity to incorporate utilities on Bayfair side within the new pedestrian bridge passing over the underpass.
- Opportunity to keep pedestrian path at grade on golf course side and keep / provide space for utilities under footpath.

11. Construction Sequencing.

11.1 Construction Sequencing

A preliminary construction sequencing plan has been developed in line with the existing Principle Requirements that maintains two lanes of traffic in each direction.

This methodology maintains a grade separated crossing of SH2 that will assist with maintaining traffic flows and provide the public with a safe route between Matapihi & Girven Road.

An opportunity to introduce an Early Works Package, involving service works, ground improvements and preloading has been identified which will allow works to commence on or before April 1st 2019.

This package would involve commencing works as described below in Stage 1 & Stage 2.

There is opportunity to develop/improve the preliminary staging plans to reduce further the overall programme and additional cost impact.

To provide for future reference and allow further development, the approximate duration (in weeks) and timeline (month-year) is included within the stages below (CPB Dean to provide).

11.1.1 Stage 1 – Pavement widening

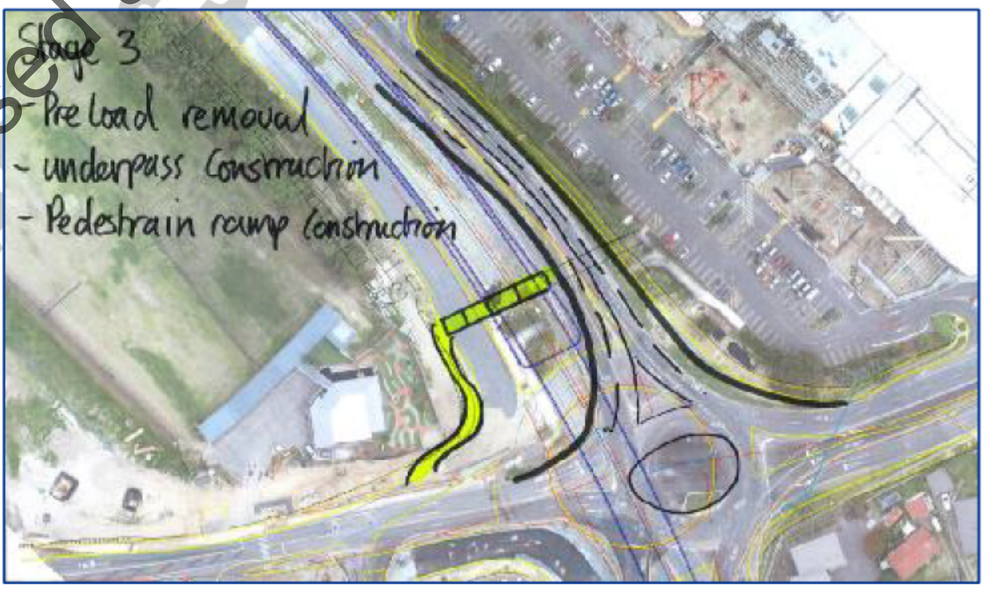
- Removal of kerb & Channel and temporary pavement approximately 2 m wide from Girven Road to the Bayfair entrance/exit on SH2. .
- Relocate TTM barriers and switch traffic.

11.1.2 Stage 2 – Early Works

- Installation of stone columns (SC) to the western and central sections.
- Place and compact preload, using containers as temporary works to support fill adjacent to live carriageways.

11.1.3 Stage 3 – Western Section

- Preload removal.
- Cut and cover with temporary sheet pile retaining walls
- - Underpass construction.
- - Pedestrian ramp & stair construction.
- - Construct pedestrian access between old & new.



11.1.4 Stage 4 – Liven Underpass

- Pedestrian switch.
- MGI northbound off ramp (permanent) pavement construction.

11.1.5 Stage 5 – Middle Section

- Traffic Switch 2.
- Stone column installation.
- Underpass construction.
- Pavement.

11.1.6 Stage 6 – Eastern Section

- Traffic Switch 3.
- Stone column installation.
- Underpass construction.
- Pedestrian ramp & stair installation.
- Switch pedestrians 100% through the new underpass.
- Deconstruct existing underpass.
- Pavement construction from Girven to Bayfair entrance.

11.1.7 Stage 7 – Commence Northern Approach Embankment

- Traffic Switch 4.
- Deconstruct existing underpass and commence construction of the northern approach embankment.

11.2 Risks and opportunities

The key risks and opportunities are:

- Risk – Stone column rig availability doesn't support underpass programme.
- Risk – Preload duration required is greater than planned.
- Risk – Resulting differential settlements on the Underpass cannot be accounted for by the design.

- Opportunity – Stages may be combined to reduce programme.
- Opportunity – Limit traffic to 1 lane for short durations to reduce programme.

12. Project Risks and Opportunities

12.1 R&O Register

The Risk and Opportunity Register is attached in Appendix A.

Appendix A. Risk and Opportunity Register