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Flood Hazard Assessment

Queen Street Wastewater Diversion Project (Part 3-Part 4 Connector)

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CONFIDENTIAL

wsp

150 YEARS IN AOTEAROA

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Abbreviation and Definitions

AC	Auckland Council
AEE	Assessment of Environmental Effects
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
AT	Auckland Transport
AUP	Auckland Unitary Plan
BPO	Best Practicable Option
CRLL	City Rail Link Limited
CSA	Construction Support Area
ESC	Erosion and Sediment Control
DCS	Design and Construction Statement
TBM	Tunnel Boring Machine
NES	National Environmental Standard
NPS	National Policy Statement
TMPs	Traffic Management Plans
WSL	Watercare Services Limited
WSP	WSP New Zealand Limited

1 Executive Summary

Watercare Services Limited ('Watercare') proposes to construct a new wastewater mainline under Queen Street in Auckland's City Centre. As part of its design and consenting commission, WSP has been engaged by Watercare to assess the stormwater and natural hazards associated with the Part 3 / Part 4 Connector Tunnel stage of the Queen Street Wastewater Diversion Project. This Flood Hazard Assessment should be read in conjunction with the Part 3 Flood Hazard Assessment (refer to Appendix I of the Part 3 application). Additionally, this assessment should be read in conjunction with the Erosion and Sediment Control Plan prepared for this Project (refer to Appendix H of this application).

Stormwater and natural hazards have been assessed in accordance with the requirements of the Auckland Unitary Plan (Section E36.9). The desktop review of existing natural hazards within the Auckland City Centre catchment found that an overland flow path ('OLFP') passes through the project area.

The proposed tunnelling services for the Part 3 / Part 4 Connector Tunnel are entirely underground. This means that during its operational phase, the tunnelling service is not expected to interfere with the operation of the existing overland flow paths and floodplains along or near the alignment, provided any excavations associated with the works are reinstated to existing ground levels.

The construction support area (CSA) located on Greys Ave intersects an existing overland flow path (OLFP) and flood plain. The CSA lies in a pronounced gully from which it will be very difficult to divert flow. Instead, using a combination of concrete barriers and hot mix bunds, the site will be divided into three areas; one "clean water" corridor, and two "dirty water areas" either side. It will be important to manage the site so that only flood-resilient activities take place in the "clean" OLFP corridor (i.e. no earthworks or stockpiling of spoil) and so that the flow path is not obstructed. While the hazard associated with overland flow can't be fully eliminated, this will minimise environmental risk arising from uncontrolled sediment discharge during storm events.

The proposed tunnelling service shaft at Greys Ave will sit 3 metres away from the boundary of the constructed clean water corridor, so it is not expected to obstruct any overland flow during a storm event. Using a simple Manning's calculation, it was found that the upstream interface of the dirty water areas should be protected by 700mm high concrete training barriers. These will be used to mitigate the potential overtopping of stormwater into the dirty areas resulting from the flow constriction. Similar barriers will be placed along the walls of the clean water corridor between the flow entry and vehicle crossing. From this point to the downstream end of the corridor, only hot mix bunds will be needed.

The Greys Ave CSA will require a strict management regime to monitor weather forecasts and limit activities within the clean water corridor when a storm is forecast.

2 Introduction

Watercare Services Limited ("Watercare") is a lifeline utility providing water and wastewater services to a population of 1.7 million people in Auckland. Its services are vital for life, keep people safe and help communities to flourish. More specifically, Watercare is the council-controlled organisation of Auckland Council responsible for municipal water supply and wastewater treatment within Auckland, and the provider of bulk water and wastewater services to Pokeno and Tuakau in the Waikato District.

Watercare are proposing to upgrade the wastewater network within the upper catchment (southern) of Auckland City Centre. It has been established by Watercare that the existing network does not have sufficient capacity to meet future demands. WSP New Zealand (WSP) has been engaged by Watercare to design and consent a new wastewater mainline through Auckland city centre (the Project).

This report provides an assessment of stormwater and natural hazards in relation to the service tunnel which will connect Parts 3 and 4 of the Queen Street Wastewater Diversion Project. Resource consent for Parts 3 and 4[1] of the wider programme of works has been sought separately from these connecting works.

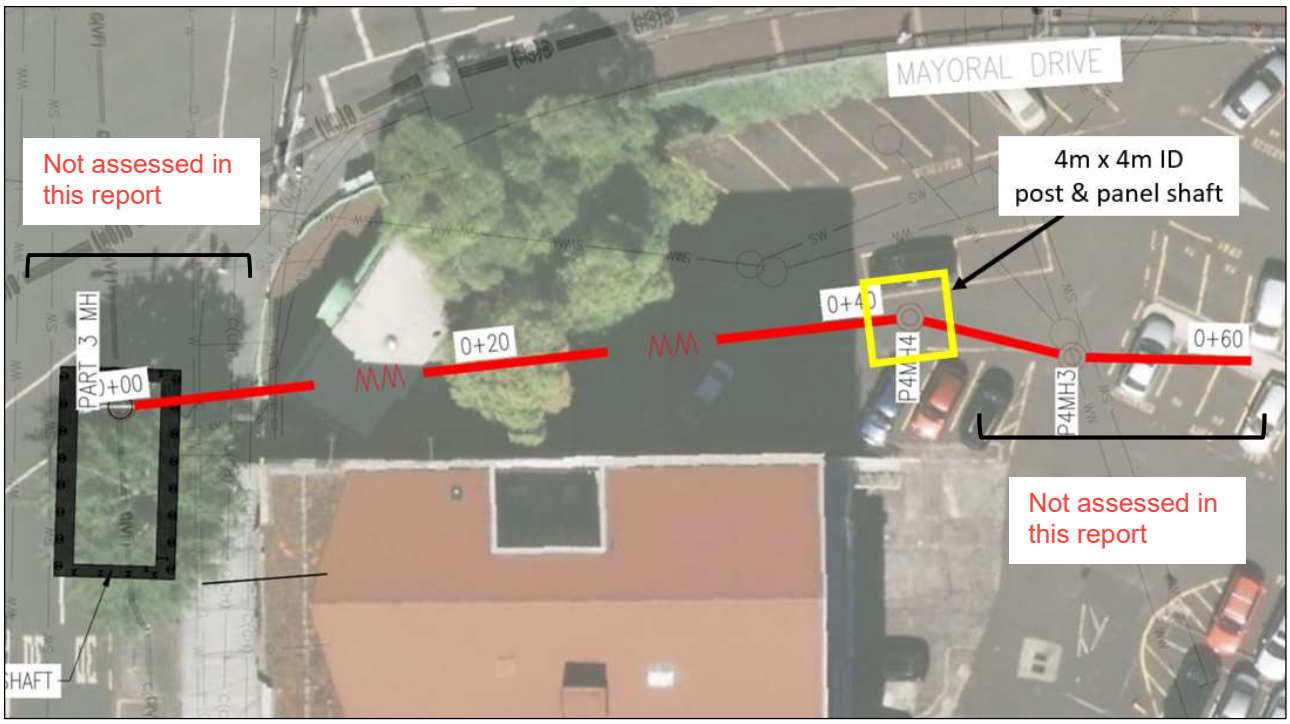

Figure 2-1: Site plan of the P3-P4 connector tunnel and shaft

This project involves the early construction of a section of pipeline to enable the tunnelling works required for the Part 3 wastewater pipeline. These works will consist of constructing one shaft (P4MH4), shown as the yellow square at the Greys Avenue carpark in Figure 2-1, and a 43m length of tunnel from this shaft to the Part 3 launch shaft at the intersection of Mayoral Drive and Queen Street (Mayoral Shaft). The Mayoral Drive shaft will not be assessed for flood effects within this report, as this has already been done in the Part 3 assessments. The 17m of pipeline and singular manhole following the shaft at Greys Ave are also not being assessed within this report, as they will form part of a separate resource consent application. This is indicated in Figure 2-1.

[1] Part 4 of the project sits within the 'Mayoral Drive' alignment consent, which will be consented as a separate package of works.

The purpose of this tunnel is to service the Tunnel Boring Machine (TBM) which will be used to construct the Part 3 alignment of pipeline from the Mayoral Drive Shaft down Queen Street. During the Part 3 construction phase, the P3-P4 connector tunnel will carry all required power, hydraulic and other cables and hoses from the staging area in the Greys Avenue Carpark into the bottom of the Mayoral Shaft to support the operation of the TBM.

Upon completion of the Part 3 construction works, the P3-P4 connector tunnel will no longer be needed to service the TBM. The tunnel will then assume it's primary role as the section of wastewater pipe which will convey wastewater from the new Mayoral Drive wastewater pipe (Part 4) into the newly installed Queen Street wastewater pipe (Part 3).

3 Description of Existing Environment

The following provides a description of the existing environment applicable to the application.

3.1 Location and Physical Environment

The project is located within Auckland City Centre in the surface carpark at 329 Queen Street and a portion of the road reserve(footpath) below ground on Queen Street. The tunnel to be constructed will connect to the Construction support Area (CSA) in the adjacent carpark at 34 and 36-38 Greys Avenue. Figure 3-1 below shows the wider environment in which the connector tunnel will be constructed. The green box represents the location of the shaft/manhole while the purple line shows the path of the underground tunnelling.

Figure 3-1: P3-P4 link tunnel existing environment

The land use around the intersection of Mayoral Drive and Queen Street is a mixture of retail, commercial, hospitality, civic, residential, and represents a highly developed urban environment. For the most part, retail activity is provided at street level with other uses provided above. The buildings along Queen Street are multi-levelled with a mixture of heritage structures and more modern high-rises.

4 Project Works

Establishment of the P3-P4 connector tunnel comprises of two main construction activities, being the post and panel shaft and the 43m length of tunnel below ground. The temporary shaft will then be backfilled to become a manhole on the Part 4 wastewater alignment.

The shaft construction is expected to take 15 days followed by tunnelling operations which will last 20 days. Once the tunnel has finished being used as a duct, the shaft will be converted into a manhole, which is expected to take 10 days.

4.1 Shaft Construction Details

The shaft (P4MH4) will be constructed within the carpark at 329 Queen Street to a depth of 5.5m. The necessary plant equipment for this construction has been included in Table 1 below.

Table 1: Plant list for shaft works

Activity	Plant List
Drilling and installing steel posts	10-20t excavator and/or GEAX EK-40
Excavating shaft	10-20t excavator
Spoil removal	6-wheeler or artic truck
Concrete base	Concrete truck, pump truck

The major components of constructing the temporary post and panel shaft are outlined below and shown in the plan in Figure 4-1:

- An auger attachment on a 10 – 20t excavator or small piling rig (GEAX EK-40) will be used to drill 300 to 400mm diameter holes and steel H beams will be set into each with sand or concrete backfill.
- The shaft will be excavated from the top using an excavator at surface level to a depth of 5.5 metres, approximately 1m below pipe invert. Six-wheeler trucks will be used to remove spoil off site. The approximate shaft spoil volume will be 100m^3 (20 return truck trips).
- Steel road plates or timber lagging will be installed between H beams as the excavation advances.
- The shaft base will be lined out with 500mm of aggregate or blinding concrete to provide a solid and level working platform.
- If dewatering is required, a 50-100mm submersible pump will be used to remove water from excavation. The water will be pumped into clarifying tanks for treatment before discharging. The pumps will run continuously while the trench is open and will be powered by a diesel generator or grid power from the CSA.

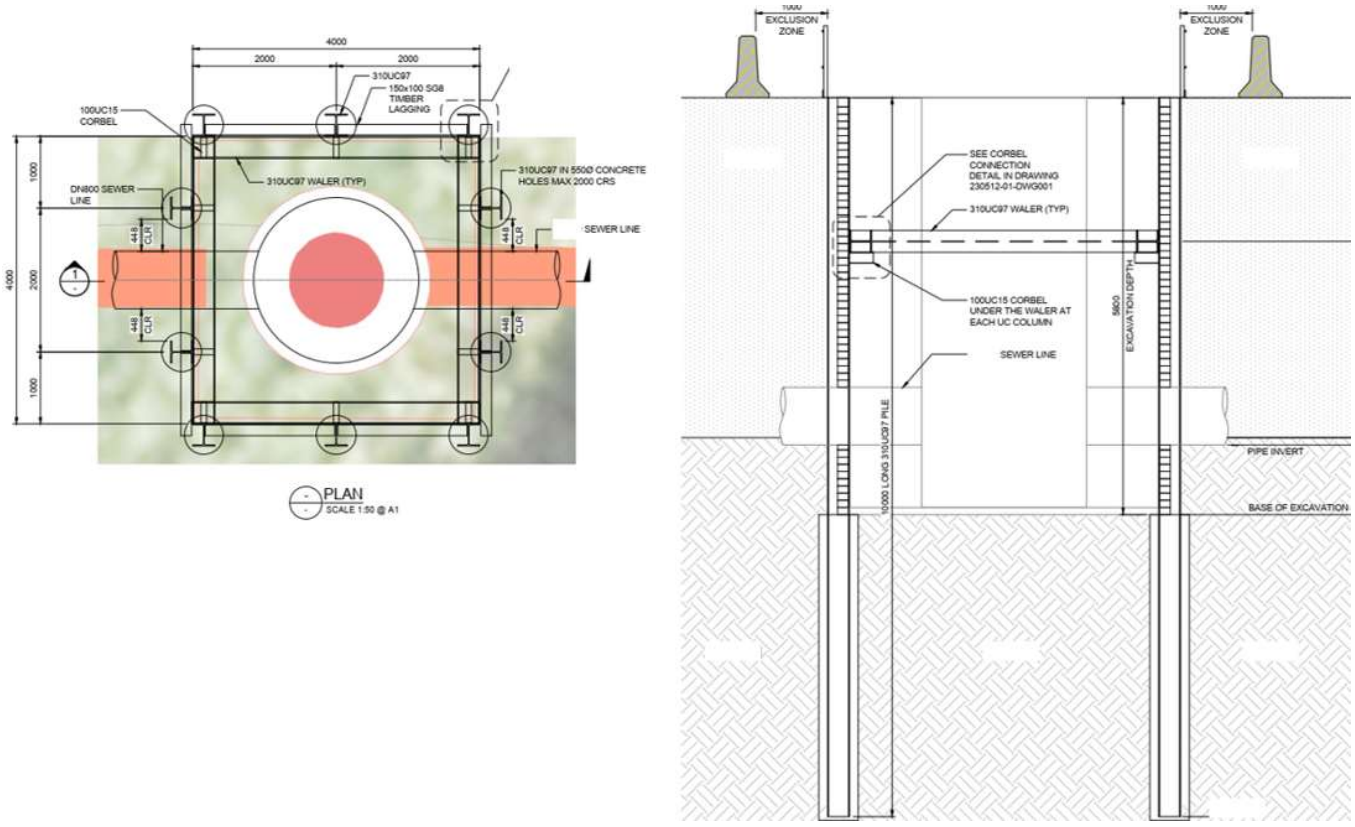

Figure 4-1: Post and panel shaft details

Following completion of the tunnelling required for the P3-P4 connector and the Part 3 construction works, the shaft will be backfilled with GAP65 or low strength concrete and will become a manhole for any necessary servicing of the pipeline in future.

4.2 Trenchless Tunnel Construction Details

A trenchless laser guided pilot bore construction methodology will be followed to create the tunnel from the P4MH4 shaft to the Mayoral Drive Shaft. The plant equipment list for tunnelling works is included in Table 2 below.

Table 2: Plant list for tunnelling works

Activity	Plant List
Tunnelling – P4MH4 Launch shaft	Crane truck, power pack container, thrust boring machine, sucker truck or 6 wheeler, tool truck.
Tunnelling – Mayoral Receiving shaft	Crane truck, power pack container, thrust boring machine, tool truck.

The major components of this methodology are outlined below:

- Setup of power pack, pump and water tank on surface adjacent to launch pit
- Lift pilot bore rig into pit and survey into position
- Drill pilot hole to reception pit using laser guided steering head
- Install cutting reamer and pull back to launch pit
- An auger or vacuum with sucker truck will be used to remove spoil from drive to be disposed offsite using 6 wheelers or sucker trucks. The approximate wet tunnel spoil volume will be 20m^3 (8 return truck trips).

- Simultaneously jack GRP pipes between pits
- Clean up and flush drill slurry out of pipe by jetting and vacuum truck
- CCTV inspection and low pressure air test upon completion

5 Assessment Methodology

Chapter E36 of the Auckland Unitary Plan (AUP) outlines the requirements for assessing development impacts on existing natural hazards. Section E36.9(1) requires a hazard risk assessment report where the developments requiring a resource consent is proposed on land subject to (among other things) 1 per cent annual exceedance probability (AEP) flood plain or overland flow paths. This assessment must address the following:

(a) the type, frequency and scale of the natural hazard and whether adverse effects on the development will be temporary or permanent;
(b) the type of activity being undertaken and its vulnerability to natural hazard events;
(c) the consequences of a natural hazard event in relation to the proposed activity;
(d) the potential effects on public safety and other property;
(e) any exacerbation of an existing natural hazard risk or the emergence of natural hazard risks that previously were not present at the location;
(f) whether any building, structure or activity located on land subject to natural hazards or near the coast can be relocated in the event of severe coastal erosion, inundation or shoreline retreat;
(g) the ability to use non-structural solutions, such as planting or the retention or enhancement of natural landform buffers to avoid, remedy or mitigate hazards, rather than hard protection structures;
(h) the design and construction of buildings and structures to mitigate the effects of natural hazards;
(i) the effect of structures used to mitigate hazards on landscape values and public access;
(j) site layout and management to avoid or mitigate the adverse effects of
(k) natural hazards, including access and exit during a natural hazard event;
(l) the duration of consent and how this may limit the exposure for more or less vulnerable activities to the effects of natural hazards including the likely effects of climate change; and
(m) any proposed measures to mitigate the natural hazards and its effects.

The assessment has been based on the requirements listed under the AUP (E36.9), industry best practice, and desktop review of available information about existing natural hazards provided by Auckland Council's GeoMaps.

6 Technical Analysis

The receiving environment is the Waitemata Harbour, with flow reaching it via the piped stormwater system. No natural watercourses exist within or downstream of the project area.

The City Centre is heavily urbanised and is highly impervious, with extremely limited absorption capacity for rainwater. Project works include early construction of a tunnelled pipe that links the Mayoral Drive shaft to the Greys Ave CSA. If unmitigated, significant rainfall events could generate flows that may potentially breach the allocated sites and become hazardous to site personnel and equipment, as well as possibly mobilising stored equipment, materials, or spoil. Flow diverted around the work sites could spread onto neighbouring commercial properties, causing or increasing flooding. Section 8 describes the effects of such unmitigated events in further detail.

The Greys Ave CSA is directly intersected by an overland flow path (OLFP). This site also contains significant flood plains within its boundary. It is expected that concrete training walls and hot mix bunds will be configured to divert flood flows around or through the area such that it causes as little complications as possible. To divert the flows through the site, two lines of bunds will need to be constructed in a way that cuts through the site in the same direction as the OLFP, which is south to north. A vacant gap, or "corridor" should remain in between the newly formed compound halves, with a flow entry at the southern end of the corridor and a flow exit at the northern end. Figure 6-1 illustrates what this corridor may look like. A width of 5m for the corridor is deemed necessary to withstand the flow demands of a 1% storm event.

Proposed tunnelling works indicate the placement of a tunnelling shaft around 6 metres away from the centre of the major OLFP running through the site, and 2-3 metres away from the corridor boundary. Certain measures are required to be taken so that flow will not be obstructed by the shaft, equipment or vehicles, otherwise flood related hazards are a likely consequence. Effects will be discussed in Section 8. Measures to mitigate these effects will be discussed in Section 9.

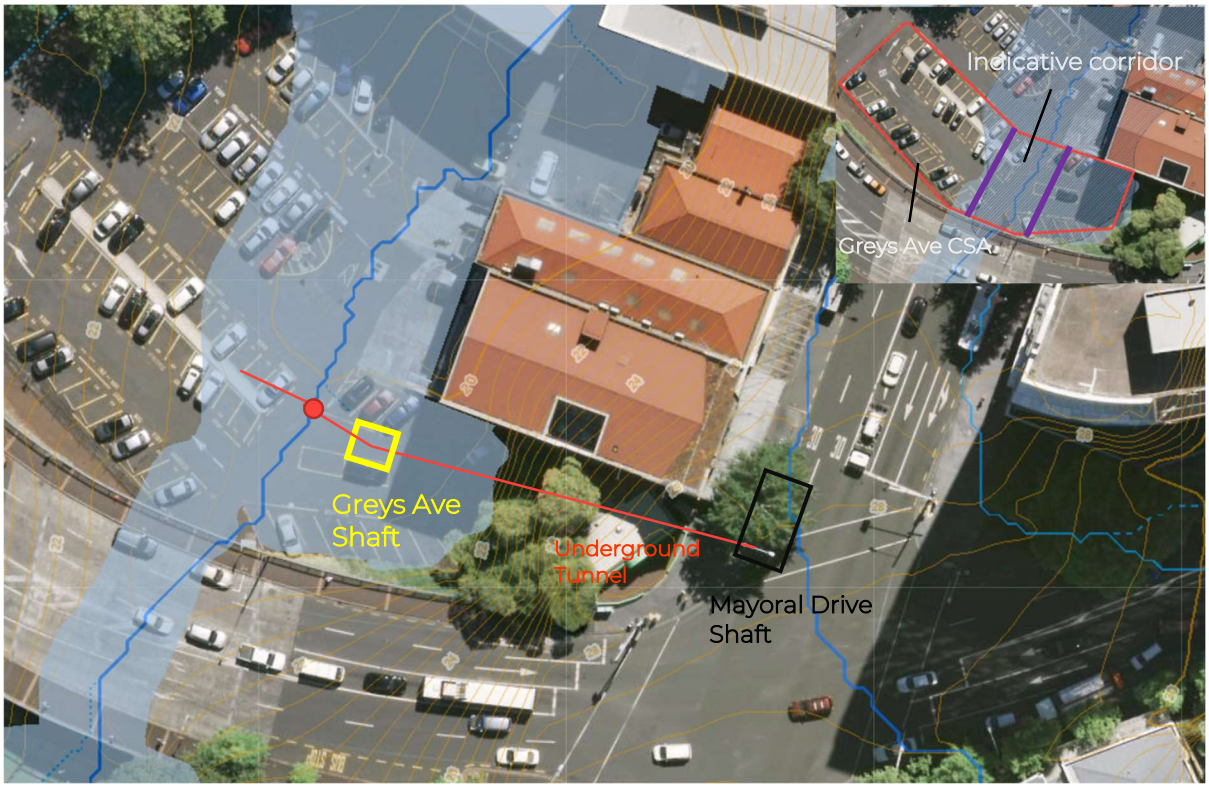

Figure 6-1: Proposed works in relation to stormwater behaviours

7 Proposed Activity/s and Triggered Rules

7.1 Auckland Unitary Plan (AUP) – Chapter E36 Natural Hazards

The following activities are relevant to the proposed works:

> ***E36.4.1 (A28)*** *Permitted Activity*
> *Storage of goods and material in the 1 per cent annual exceedance probability (AEP) floodplain.*
>
> ***E36.4.1 (A56)*** *Restricted Discretionary Activity*
> *All other Infrastructure in areas listed in the heading above (1 per cent AEP floodplain) not otherwise provided for.*

The following permitted standards relate to Rule E36.4.1 (A28):

> *(1) Goods and materials stored in the 1 per cent annual exceedance probability (AEP) floodplain for longer than 28 consecutive days must:*
> - *a. not impede flood flows; and*
> - *b. where capable of creating a safety hazard by being shifted by floodwaters, be contained and secured in order to minimise movement in times of floods; and*
> - *c. be stored in watertight containers if they are hazardous substances.*

Because the work sites are likely to involve the storage of goods and materials, and because the duration, nature and location of those materials is currently unknown, we recommend that compliance with the permitted standards of activity E36.4.1 (A28) is addressed in the Construction Management Plan.

No permitted standards relate to Rule E36.4.1 (A56).

8 Effects Assessment

Relevant stormwater/flood information retrieved from Auckland Council's GeoMaps is shown in Figure 8-1:

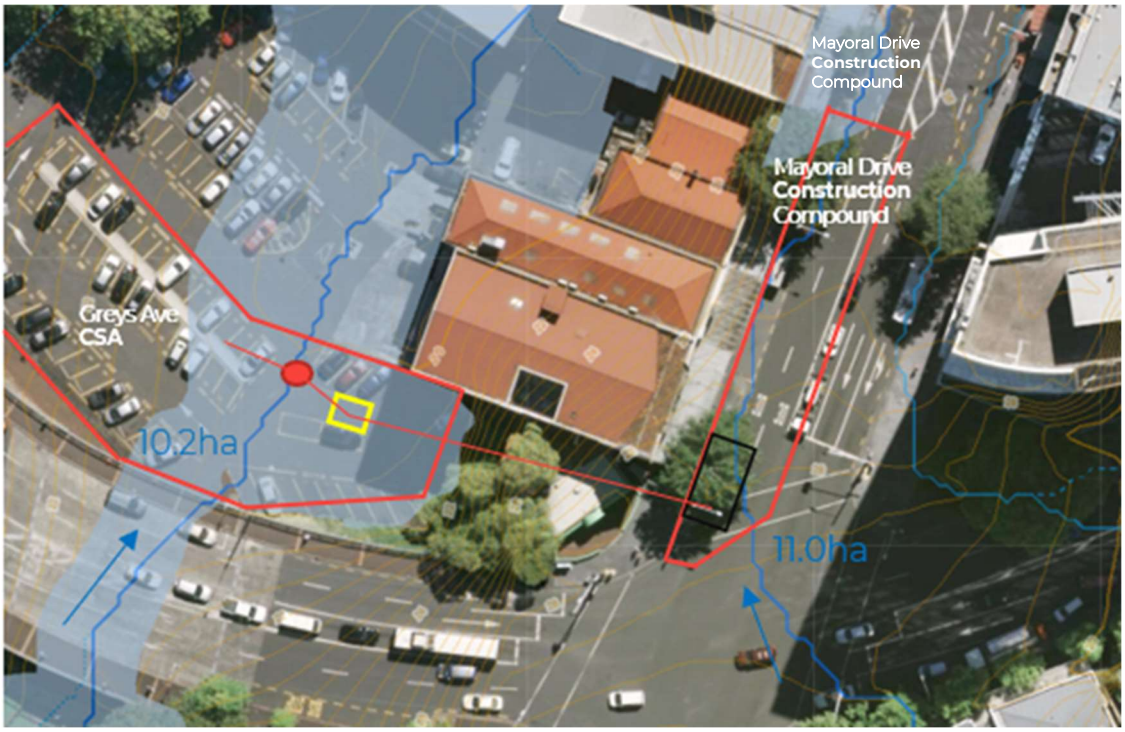

Figure 8-1: Stormwater and Flood Data Retrieved from Auckland Council's GeoMaps

The Part 3-4 Connector Project involves a tunnelled services pipe between the Mayoral Drive shaft and the Greys Ave post and panel shaft. In its future life as a wastewater pipe, the new pipe will exist entirely underground, which means it will not interfere with any existing OLFPs and floodplains provided the works associated with the tunnel maintains existing ground level. During the construction phase at the Greys Ave CSA however, surface features such as equipment, storage facilities, vehicles, materials and the shaft could constrict or obstruct the major OLFP running through the site. Consequentially this would create hazardous site circumstances such as site personnel endangerment and threatening the integrity of important assets and materials.

The Erosion and Sediment Control Plan (ESCP) addresses this issue for the Greys Ave shaft by creating a 5m wide flow corridor through the middle of the Greys Ave CSA. Parking and vehicle movements will be permitted within this corridor, but no materials storage or "dirty" activities will be permitted. Providing this corridor is created and maintained, effects on the OLFP should be negligible and effects on the floodplain should be limited to only slight constriction and a small possibility of local backflow into the reserve upstream. Mitigation measures are to be adopted so that this possibility can be minimised.

8.1 1% AEP Overland Flow Paths (OLFP)

As seen on Auckland's GeoMaps, the Greys Ave CSA has a 10.2ha OLFP running through the middle of the site and heading northbound. A clean water corridor has been proposed as part of the ESCP that allows this water to flow directly through the site without any possible obstruction or blockage.

The passage of the OLFPs must be maintained throughout the duration of the project. The Greys Ave CSA is scheduled to be operational for the entire construction period, thus having probability of at least 0.16% of experiencing a 1% event and overland flows through the site.

8.2 1% AEP Flood Plain

Auckland Council's GeoMaps suggest the central part of the Greys Ave CSA is within the 1% AEP flood plains. In reality, these flood plains are simply modelled and mapped versions of the overland flow paths described above (i.e. flowing rather than ponded areas), showing a more realistic indication of flow width. Therefore, comments above relating to flow paths are also applicable to flood plains.

The Greys Ave CSA will be an active site across the entire project construction period. The creation of a 5m wide flow corridor through the Greys Ave CSA will form a constriction to flow, and accompanying heading-up upstream, however we have demonstrated via simple analysis that this headwater pond will be entirely contained within the Myers Park reserve and will not impact on any buildings.

9 Mitigation Measures

9.1 Construction Phase

This flood hazard assessment anticipates minor disruption with no alteration to the overland flow paths/flood plains. It is recommended that the construction methodology provides for safe evacuation of personnel and critical equipment in the event that OLFPs are triggered.

Site personnel should monitor weather forecasts to stay informed about potential flood events. This allows for proactive measures to be taken, such as relocating stored goods and materials temporarily if there is an imminent risk of flooding.

Goods and materials should be stored outside of the 1% AEP floodplain areas, preferably in designated storage facilities or secure locations away from flood-prone zones.

9.1.1 Greys Ave

The Greys Ave CSA lies within a major gully containing an overland flow path and flood plain. The OLFP is unable to be diverted due to the orientation and location of the site relative to the flow path, so a “clean water corridor” allowing flow to pass directly through the site is to be implemented as indicated in the ESCP (refer to Appendix H - ESCP of the application).

The CSA is to be divided into 3 areas, one “clean water” corridor, and two “dirty water areas”. The section where the OLFP passes through the site is to be isolated using concrete barriers and/or hot mix bunds to create a 5m minimum width overland flow corridor. Analysis using Manning’s Formula found that the 10-year event flow would reach a depth of approximately 500mm through the upstream constructed cross section.

Additionally, a desired freeboard of 200mm was found using a simple velocity head calculation. By combining these two factors, it was found that the upstream interface of the dirty water areas will need 700mm high concrete training walls to prevent the pooling from flow constriction from overtopping into the dirty water areas. These concrete walls are also to be adopted along the walls of the clean water corridor until the point where trucks or other vehicles are expected to pass over the corridor. Here and beyond this point there is only to be a hot mix bund separating the dirty water areas from the clean water corridor.

Any pipes or services linking the two parts of the CSA must not block the 5m flow path. They must be either buried or at least 700mm above ground level.

A strict advisory program is to be implemented on the site with focus on limiting activities within this bunded section over the period of time leading up to and during a forecasted storm event.

9.2 Operational Phase

The proposed tunnel is entirely underground and will have no impact on flooding. No provisions are required to address flood hazards in the operational phase provided the existing ground level is reinstated after the excavations associated with the pipeline are completed.

10 Identification of affected parties

Provided the diverted flow paths are managed as intended, the effects on other parties should be negligible.

As such, no affected parties have been identified.

11 RMA s104 Assessment

11.1 Assessment Criteria

While the proposal is a restricted discretionary activity under Chapter E36 of the AUP, there are no assessment criteria provided for the activity of "All other infrastructure in the 1 per cent annual exceedance probability (AEP) floodplain. However, Assessment Criteria E36.8.2 (17) is considered to be a useful comparison, and an assessment is provided below.

Table 3: Assessment against E36.8.2

(17) for operation, maintenance, renewal, repair and minor infrastructure upgrading of infrastructure in the coastal erosion hazard area; or in the coastal storm inundation 1 per cent annual exceedance probability (AEP) area; or in the coastal storm inundation 1 per cent annual exceedance probability (AEP) plus 1m sea level rise area; or in the 1 per cent annual exceedance probability (AEP) floodplain; or in overland flow paths; or on land which may be subject to land instability:	
(a) the long-term management, maintenance and monitoring of any mechanisms associated with managing the risk of adverse effects resulting from the placement of infrastructure within a hazard area to other people, property and the environment including the management of hazardous substances;	Provided that the existing ground levels are maintained and the manhole construction does not alter the surface contours, there should be no adverse effects resulting in the hazards spreading to more people, property and environments as a result of the works.
(b) the extent to which residual risks to people, property and the environment resulting from any mitigation measures implemented to manage the hazard	Proposed diversion bunds and the constructed flow corridor are not expected to divert flows anywhere which will cause residual risks for people, property or the environment.
(c) the extent to which an existing hazard is exacerbated or a new hazard is created as a result of the structure	The existing flood hazards relating to the flood plain and overland flow path will not be exacerbated by the works, as the temporary shaft is not within the constructed flow corridor and the permanent manhole following the works will exist entirely underground.
(d) the extent to which the proposal includes non-structural solutions to protect infrastructure from the hazard and resulting adverse effects; and	The proposal does not include implementation of non-structural solutions to protect surrounding infrastructure.
(e) the extent to which landscape values and/ or public access are affected by the proposed structure or structures associated with the mitigation of the hazard	All permanent infrastructure proposed in the works is expected to be underground. The proposed infrastructure does not permanently affect access or landscape aspects provided that the original ground levels are restored.

11.2 Special Information Requirements

As stated in Section 5, Chapter E36.9 of the AUP provides a list of requirements to be met when assessing the effects of an activity taking place in a flood plain. This flood hazard assessment addresses these requirements through the technical analysis, effects assessment and mitigation measures report sections.

12 Conclusion and Recommendations

A short section of tunnel adjacent to Mayoral Drive will be constructed early to serve as a conduit for services associated with the Queen St wastewater upgrade project, connecting a new shaft within 329 Queen Street to the Mayoral Draft shaft established under the 'Part 3' consent.

The proposed tunnel for the Queen Street Part 3 / Part 4 Connector Tunnel is not significantly constrained by the existing flood hazards in its operational phase. Moreover, the construction of the tunnel is not expected to create or worsen flood effects for any other party. Diversion bunds proposed in the ESCP will divert flows through the sites and prevent early inundation. General mitigative measures include the constant monitoring of weather forecasts and ensuring that goods and materials are stored outside of the 1% AEP floodplain area. Activities within the gully flow path must be strictly managed to avoid sediment release and dangerous circumstances in the event of an overland flow event. Maintaining a 5m minimum width flow corridor will be a key factor in managing flooding.

It is recommended that the Construction Management Plan to be provided to Auckland Council addresses compliance with the relevant permitted standards of Chapter E36 relating to the storage of goods and materials within the 1% AEP floodplains.

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