PROPOSED PLAN CHANGE 11 WATER ASSESSMENT REPORT

Report

Bardowie Investments Ltd

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EXECUTIVE SUMMARY

Bardowie Investments Ltd are proposing Private Plan Change (PC11) to the Waipa District Plan. This seeks to rezone approximately 56.7ha of land zoned Deferred Industrial Zone and Rural Zone to an Industrial Zone at Hautapu. The following report provides technical support to PC11 in respect of water supply, wastewater discharge, stormwater management and hydrogeology.

The rezoning will change the quantity and nature of runoff in the catchment. With an increase in impermeable surfaces, there will be a significant increase to the runoff generated from storm events. There will be an increase in both the total volume, and also the peak rate of discharge. Depending on the activities within the catchment it is likely there will be an increase in heavy metals, suspended sediments, and an increase in temperature. Conversely there is likely to be a decrease in nutrients, BOD and bacteria.

Proposed methods will seek to improve and enhance the current landform, and use water sensitive principles integrated into the built form and proposed landscape to mitigate the adverse effects of the change in land use. Methods proposed are consistent with the regulatory framework of the Waipa District Council (WDC) Development Manual, Regional Infrastructure Technical Standard (RITS), and Regional Stormwater Guidance.

Solutions will seek to replicate existing drainage patterns, including:

- High frequency events – pre-treatment followed by infiltration to ground, or ponded temporarily followed by soakage; and
- Low frequency events – overland flow to the Mangaone Stream.

Both Water and Wastewater assessments have drawn on existing capacity research that was completed initially by WDC in 2012-13, and on more recent re-modelling subsequent to recent changes in development patterns.

Discussions with WDC on both these services have confirmed their availability, and subject to timing of proposed upgrades, may necessitate interim development solutions, and/or longer term joint solutions with WDC.

For water supply, the current supply suffers from dips in network pressures during high demand. Ultimately, additional bulk mains to the industrial area together with changes to network operation will solve current issues, and enable sufficient supply for wider industrial development. The timing of this upgrade will need to be advanced to service the first stage of the PC11 development.

Firefighting flow requirements will depend on the ultimate nature and size of developments. It is proposed that once the network upgrade is complete (2020), the internal network will achieve an FW2 fire rating.

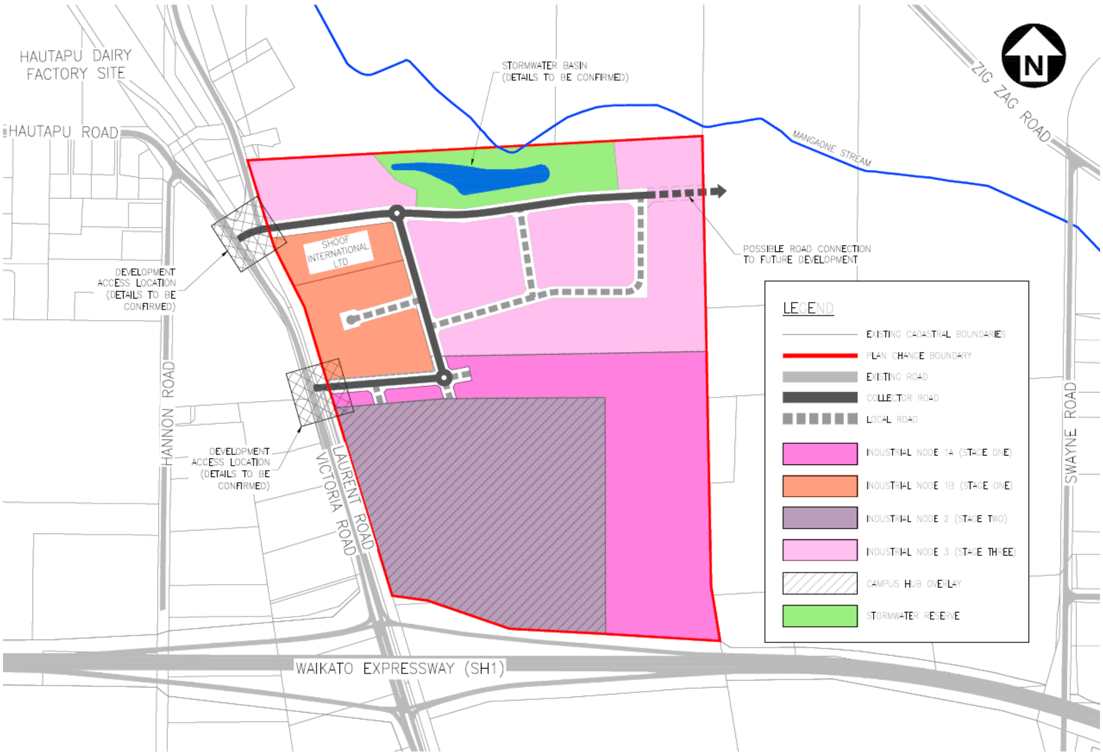
For wastewater, there is a proposed pump station and rising main to be constructed for the adjacent industrial area. A similar proposal is recommended for the PC11 area. As both these areas will take time to develop and to avoid septicity issues in the network, it is proposed that whilst both rising mains will be constructed simultaneously, that initially only one will be used to serve both areas.

Our discussions with WDC have concluded that there are no other off-site restrictions that will impact the proposed plan change area.

1.0 INTRODUCTION

1.1 BACKGROUND AND PURPOSE – 3 WATERS ASSESSMENT SCOPE

The Bardowie Plan Change area covers 57.6ha including all development land and areas potentially available for stormwater management. The area is referred to as the Bardowie Industrial Precinct. 30 ha is currently zoned as ‘Deferred Industrial Zone’ under the operative Waipa District Plan with the balance zoned Rural Zone requiring a private plan change (PC11) to allow the development to proceed. The following diagram shows an initial concept layout for the development area.



This 3 waters assessment provides guidance on the best practicable approach to manage increases in stormwater runoff as well as water and wastewater demands in the short and longer term.

Previous reports for adjacent residential and industrial growth areas have also been evaluated in order to ensure alignment and consistency with the wider 3 waters objectives for the Upper Mangaone Catchment and Cambridge Infrastructure Improvements. These reports include the:

- Draft BECA Stormwater Report to support the Hautapu Structure Plan, December 2017
- Stormwater modelling work undertaken by T+T for the Cambridge North Residential Area in 2011
- Opus report for water upgrading, July 2013
- WDC wide Water Supply Strategy 2014, Beca, November 2014

- Wastewater Issues Report – Opus 2013 and C7 Growth Cell Wastewater Assessment – Opus March 2017

The 57.6ha of the plan change area is proposed to change from primarily rural use to primarily industrial use. This will involve the development of roads and infrastructure to service the various parcels of land, and ultimately the businesses that will establish within the area. The WDC District Wide Water Supply Strategy 2014 sets out water demand criteria, whilst the RITS is silent on industrial water demand, but sets out the discharges for wastewater. Whilst some businesses may use less water than stipulated it is important to analyse the infrastructure capacity based on these higher criteria. This will ensure long term future users will be catered for.

The RITS along with the Waikato Regional Council, Regional Stormwater Management Guidelines, provide guidance on the best practice methods for stormwater management.

One objective of this report is to promote an overall water sensitive design approach to be adopted by each future tenant. The approach for this plan change seeks to provide multifunctional benefits for the plan change area; for example, green infrastructure for amenity and ecology. In doing so this assessment outlines best practical options to deliver a robust water sensitive design outcome.

2.0 CATCHMENT DESCRIPTION

2.1 RECEIVING ENVIRONMENT

The Mangaone Stream is typical of many lowland streams cutting through the Hinuera surface in the Waikato. The stream can be described as modified taking the form of a rural drain as it passes immediately north of the plan change area. Similarly, straightened sections of channel are observed downstream of the Hautapu Dairy Factory through Peake Road and beyond. Approximately 1km west of Bruntwood village (about halfway along its entire length), the rural drainage alignment begins to transition into a more incised natural gully as it continues to widen and deepen and then meander until its confluence with the Mangaonua Stream prior to its connection with the Waikato River.

A site walkover of the stream identified a medium to coarse sand substrate with relatively clear water which is surprising given the inspection was following a number of small winter rain events. This suggests good ground fed spring sources along its length. No significant erosion hotspots, bank slumps or mass wasting was observed during the visit. Some minor scour and bank failure was observed at the outlet to the farm track culverts. The bank and bed materials however are considered vulnerable to erosion from increases in flow and volume due to the typically non-cohesive nature of the sand/gravel bank sides and stream bed.

2.2 SOIL TYPES

Understanding the surface soil types is important from a stormwater modelling perspective in order to estimate accurately the existing runoff rates from the area. The existing runoff rates in turn then determine the on-site attenuation requirements which has a major influence on the amount of area required for flood management.

A preliminary soil survey report was undertaken by Dr Richard Chapman for the Plan Change area to support the hydrology assumptions in the stormwater model. The survey is based on a combination of local knowledge and desktop assessment of the topography. The study revealed 3 soil types all of which are underlain by the Hinuera Formation - silts, sands, gravels laid down by the ancestral Waikato River about 15,000 years ago. The Hinuera formation at the site is reported to be about 60m in thickness.

The distinctive lower lying swales, roughly 2m lower than the terrace areas, support largely Te Kowhai silty/clay loam soils which are generally poorly drained. Te Kowhai soil is very prone to livestock pugging during winter and early spring. Horotiu soils including gravel and sandy loam phases are located on the higher terrace areas and linear ridges. These soils make up approximately 80% of the plan change area and they are generally well drained. The full soil report can be found in Appendix 3.

2.3 SUB CATCHMENTS

There are a series of depression areas following the ancestral channel network flowing in a north westerly direction. Generally, the higher runoff areas in the depressions are separated by the linear ridges and higher terrace areas. The existing flood maps (Appendix 3) show clearly these depression areas taking the form of diagonal striations of deeper flood water flowing towards the Mangaone Stream. It was noted during the site visit that the farm tracks cut off several overland flow paths. No connecting culverts were seen under the farm tracks in these areas. Flows are therefore interrupted by the farm tracks acting like dams to overland flow. These farm tracks are likely to therefore impede the existing peak flows to the Mangaone Stream.

On a catchment wide scale, the Plan Change area is located within what can be described as the upper catchment of the Mangaone Stream. The headwaters are generated by spring feeds a few hundred meters southeast of the St Kilda development. The rainfall recharge area is typically the Cambridge Hills. The mid and lower catchment is characterised by a more incised gully with natural alignment passing through the Tauwhare and Tamahere lifestyle block areas before joining with the Mangaonua Stream prior to discharge - through the Riverlea Industrial Area - to the Waikato River.

2.4 GROUNDWATER

A key objective of this study is to understand the potential to provide for soakage as an integral component of the stormwater management solution. Recognising the regional stormwater guidance and RITS places a strong emphasis on volume retention and disposal to ground as the preferred option for removing runoff from the Mangaone Stream. In doing so, the potential adverse effects of increased stream erosion and sedimentation is removed or mitigated. Although the substrate materials (sands, silts and gravels) are considered favourable for infiltration it is the seasonal groundwater level across the site which presents a potential limiting factor for soakage disposal.

A separate report has therefore been prepared by BECA to assess the existing groundwater conditions and potential for soakage disposal. The key finding of the BECA report is that disposal to ground is a feasible option for the Plan Change area. Winter high groundwater levels do vary across the site (between 2m-4m). Additional on-site testing (in the locations of proposed soakage devices) will be required to support detailed design but, in general, the assumption can be drawn that disposal to ground up to the 2yr ARI, 72hrs duration rainfall event is achievable.

3.0 STORMWATER MANAGEMENT PROPOSED OPTIONS

3.1 STORMWATER MANAGEMENT PROVISIONS (PERFORMANCE CRITERIA)

The following provisions in Table 1 are drawn from the RITS and the Regional Stormwater Management Guidance including a revised rainfall runoff approach for estimating 100yr flows and relate to the criteria that must be met to satisfy these compliance documents.

TABLE 1: STORMWATER MANAGEMENT PROVISIONS

STORM EVENT (ARI)	PROVISION	GUIDANCE
All events	First flush – pre-treatment	Regional SW Guidance
1/3 2yr	Water Quality Treatment	TP 10, RITS and SW guidance
2yr	Soakage Disposal up to 72hrs	RITS
10yr	Primary drainage conveyance through the site	RITS
10yr	Restrict total runoff volume	WRC Drainage Board
100yr	Secondary conveyance through the site – no people or property at risk	RITS and Regional rainfall runoff guidance
100yr	Attenuate to 100% of existing peak flow to the Mangaone Stream	HCC ITS + Regional Stormwater Guidance

3.2 STORMWATER DESIGN CONCEPT

A summary of the Plan Change area stormwater concept design follows, in accordance with the provisions in Section 3.1:

- First flush events will be managed at source via a series of pre-treatment devices prior to discharge to ground soakage. Pre-treatment will improve the long-term performance of soakage devices by removing the coarse grain fragments and any large litter items. Examples include catch pit inserts, grass filter strips, swales, rain water harvesting and basin fore bays.

- Water quality treatment (1/3 of 2yr rain event) will be required for high risk contaminant areas such as carparks and road(s). Treatment can be provided by a range of options such as bio-retention or swale systems.

- Ground soakage devices (on-site or communal basins) will be required to accommodate 100% of the 2yr ARI storm event up to 72hrs. Soakage up to 2yr event will remove the adverse impacts of increased scour, erosion and sedimentation within the Mangaone Stream receiving environment.

- Primary flows up to the 10 yr ARI design event will be managed within the site so as to manage surface flooding and minimise threat to people or property within the Plan Change area. 10 yr ARI flows can be conveyed using pipes or swales.

- Total runoff volume from the 10yr ARI event must be managed and accommodated within the plan change area so as to not impact on the Waikato Regional Council rural drainage scheme. This scheme has its own primary performance standard of alleviating flooding of farmland in no more than 3 days from a 10yr storm event. Discharge from the plan change area cannot adversely impact that objective.

- Secondary flows up to the 100yr ARI + climate change (CC) event must be managed and conveyed within the plan change area so as to not put pedestrians, road users and property floor levels (meeting freeboard requirements) at risk. This requirement also covers New Zealand Building Code 50yr ARI design standard to protect buildings from flood inundation.
- 100yr ARI + CC peak flows must not exceed existing 100yr peak flows to the Mangaone Stream unless the increased flood risk downstream can be managed to acceptable levels. Analysis will consider the existing environment along with the effect of the proposed overland Cambridge North Residential Subdivision (CBN) pipeline which is planned to discharge downstream of the Plan Change area.
- An initial stormwater concept for the development can be found in Appendix 2 supported by a preliminary "Post Development" 2D flood model in Appendix 3.
- Development of the final stormwater solution will focus on the requirements of the Plan Change area and identify any opportunities to integrate stormwater assets with future development where practical.

3.3 DISCUSSION ON PREFERRED APPROACH

The relevant guidance specifically requires that post-development hydrology remains as close to pre-development hydrology as possible.

Maintenance of groundwater levels is required to protect base flow to the Mangaone Stream and the regional aquifer to the Waikato River. Pre-treatment and retention (complete volume loss) of stormwater at source within the Plan Change area is considered best practice to promote recharge and maintain groundwater levels. The effect on the water table of increased runoff volumes to ground is addressed in the BECA report.

A tool box approach for pre-treatment prior to ground soakage is recommended. Pre-treatment options could include first flush diverters on building downpipes, catch pit inserts, grass filter strips and porous surfacing for carpark areas.

Maintenance of base flow and removal of rapid surface flows to the Mangaone Stream is required to maintain habitat for a range of fish species and is currently not subject to adverse active bank or bed erosion. Peak flows from the 10yr ARI up to the 100yr ARI will be directed to attenuation basins or wetland which will in themselves also provide a further degree of polishing treatment and provide an opportunity to enhance the local ecology.

Soakage in the Plan Change area is feasible with suitable sub soils and winter groundwater levels of sufficient depth to allow separation distance between soakage devices and the saturated layer. Soakage can be achieved close to source with a range of distributed units fitted under car parks areas for example and also within the swale network (with underdrains) and/or communal basin areas.

It is noted that the RITS and regional stormwater management guidance requires on-site soakage wherever possible. The soakage testing to date and supporting assessment by BECA (Appendix 4) concludes there are favourable conditions to meet this requirement. Overflows from soakage areas will be directed to the swale network or internal road networks.

The geology on site is variable. The piezometer and borehole survey shows that the water table is lithological controlled with potential for some perched zones, but overall the water table in winter is, at its highest, approximately 2m below ground level.

3.4 WATER EFFICIENCY BENEFITS

Where possible water efficiency measures can be considered to reduce demand on the water and wastewater networks. The entirety of the area is planned for industrial development, therefore there will be no residential properties contributing to the water and wastewater demands. It is expected that potable water usage will be relatively low. Even still, low flow fixtures can be considered for all industrial land uses. This should reduce water consumption, and ultimately wastewater flows. This philosophy will be promoted within the development with the aim of creating a sustainable industrial precinct. However, being an industrial development, there are limitations to the benefits that this type of approach will achieve.

3.5 INITIAL CATCHMENT FLOOD MODELLING

The predeveloped catchment is relatively flat agricultural land. 1D/2D modelling has been undertaken (ICM software) to establish the pre-development and post development flows and volumes within the overall Mangaone catchment. The results for the existing catchment can be seen in the flood maps and model build report in Appendix 3 and in the Table 2 below:

TABLE 2: 1D/2D EXISTING FLOOD MODELLING RESULTS

LOCATION	100YR ARI PEAK FLOW (M3/S)	100YR ARI PEAK LEVEL (MRL)
Peake Road Culvert	6.70	55.21
Victoria Road Culvert	5.11	59.76
Swayne Road Culvert	4.44	64.57

The Plan Change area is located within what can be described as the upper Mangaone catchment. The stormwater model therefore captures runoff from the St Kilda and Cambridge North urban areas as well as existing rural areas.

Pre-development peak flows have been estimated using detailed 2D modelling (with a limited number of 1D elements to represent major culverts under roads and the rail line through the Hautapu Dairy Factory site). The model is a catchment wide model to ensure continuity of flow and volumes through the site. The intention is to capture the existing discharge rates for comparison with the post development impervious coverage discharge rates. Understanding in detail the existing situation is key to developing a robust stormwater management solution for the entire plan change area. This work will support a future application for a Discharge Permit which will be lodged with WRC at a later date.

A model build memo is provided in Appendix 3. The 100yr ARI pre-development flood maps are produced using 2D modelling software to understand maximum flood flows. A 10yr scenario will be undertaken in the future to support the application to WRC for a discharge permit. The 10yr simulation will provide information on primary conveyance as well as test solutions to achieve runoff volume reduction in order to meet the WRC board drain level of service.

4.0 WATER SUPPLY

4.1 BACKGROUND REVIEW

The following documents were reviewed during the preparation of this report:

- The Waikato Regional Infrastructure Technical Specifications (RITS)
- The Waipa District Development and Subdivision Manual
- The Hamilton Infrastructure Technical Specifications (HITS)
- Opus Water Masterplan, 2013
- Opus Waipa District Wide Water Supply Strategy (DWWSS), 2014
- Beca Hautapu Structure Plan, 2017

Consultation with WDC staff (Robin Walker) has also been undertaken regarding existing infrastructure and programmed upgrades.

4.2 EXISTING NETWORK

There are two existing 200mm diameter water mains that run adjacent to Laurent Road and feed the existing WDC reservoir south of Fonterra's Hautapu Dairy Factory. The DWWSS identified that a new 375mm diameter dedicated trunk main extension from Watkins Road to the WDC reservoir is required. WDC have advised that this is planned for construction in 2020. It is intended that existing connections and the Hautapu Industrial Plan Change area will be supplied from the existing network, while Fonterra, and the PC11 area will be supplied from a new feed off the WDC reservoir.

The peak water supply flow rate available to the PC11 area is constrained by the following factors:

- Peak flow rate able to be delivered to the reservoir by the new 375mm diameter trunk main;
- Fonterra peak water demands, and
- Peak flow rate able to be delivered by the reservoir booster pump station (although there is the option to upgrade these pumps if required)

WDC are seeking confirmation from Opus of the peak flow rate able to be delivered to the reservoir by the new 375mm diameter trunk main.

WDC have advised that the peak daily demand during the Fonterra season is 6,000 m^3/day, although this is 5,000 m^3/day to 5,500 m^3/day on average. The season is indicatively from mid-July to the following mid-April (8 months).

The current network operates on network pressures, delivered from the Watkins Road Reservoir, until the increasing demand reduces the line pressure to a set level. Once that low level pressure is reached, one, or both pumps at the WDC Victoria Road Reservoir will start. This then redirects the bulk supply into the reservoir only, with the supply network fed directly by the pump(s).

The limitation on supply is therefore a combination of pump capacity to meet the downstream demand, bulk supply main capacity to deliver a high rate, and the reservoir capacity to balance the peak demand over the short term.

Information obtained from the pump manufacturers is inconclusive about the peak capacity of the existing pump arrangement, however that is not critical, as further investigations may identify that the pumps need upgrading. As surface mounted end suction centrifugal pumps are not particularly expensive, changing the existing pumps is not a fatal flaw to this plan change should that ultimately be required. The key issue is the ability of the 375mm main to replenish what is used from the reservoir.

4.3 DESIGN FLOWS

The DWWSS, which supersedes the 2013 masterplan report, states that WDC use a rate of 0.4l/s/ha for industrial development. The RITS, HITS and Waipa District Development and Subdivision Manual do not give specific guidance on industrial water demands.

It is noted that the Beca Hautapu Industrial Structure Plan document based demands on a population density of 30 persons/ha with a usage of 200 litres/person/day, and a peaking factor of 5 (0.34 l/s/ha).

4.3.1 NORMAL PEAK DEMAND

Water supply design flows based on 0.4 l/s/ha to align with the DWWSS are summarised in Table 3 below.

TABLE 3: DESIGN WATER SUPPLY FLOWS

DEVELOPMENT STAGE	AREA (HA)	DUE FOR COMPLETION	FLOW (L/S)	CUMULATIVE FLOW (L/S)
Stage 1	12.5	Feb 2020	5.0	5.0
Stage 2	16.3	Oct 2022	6.5	11.5
Stage 3	27.9	Oct 2024	11.2	22.7
TOTAL	**56.7**		**22.7**	

The development has already secured a major industrial tenant that will occupy a large 29ha section in the southern part of the site (i.e. Stages 1 &2). An initial assessment of water usage for this company's operations indicate the actual demand may be lower than values listed in the above table. However, it is recommended that the reticulation network is based on the higher design flows to provide flexibility for future development.

4.3.2 FIRE FIGHTING DEMAND

The WDC Water Supply Bylaw 2013 states that Council is under no obligation to provide an on demand supply for fire protection purposes at any particular flow or pressure, or maintain existing pressures or flows. It is noted that this is in contradiction to Section 6.2.3.3 of the RITS which states that Council's standard design meets FW2 firefighting requirements at the street boundary for residential areas and provides FW3 for other zones.

It is aspirational to supply a minimum of an FW 2 Water Supply Classification within the reticulated network. The feasibility of this will be tested once the outstanding information about the existing network has been provided. PAS NZS 4509:2008 states that FW 2, 25 l/s to be provided from a maximum of 2 fire hydrants. The fire demand should be applied on top of 60% of the peak flow.

The practical reasoning for providing an FW 2 supply is that if a building is fitted with sprinklers, then those may be supplied by the network, and subsequently the fire service upon attendance at the fire, also from the network. For larger buildings, such as those proposed by primary tenant, it would be more practical to store water for sprinkler water, but still run an internal potable and hydrant network that would meet the fire service requirements for no less than two hydrants within 135m/270m of the fire. Given also that such a building is likely to require internal charged riser system, then an FW 2 supply in the street is desirable to meet fire service requirements.

Individual lot owners will need to make their own assessment as to the required Water Supply Classification for their site and if this is higher than that provided by the reticulated network adequate on-site storage in suitable reservoirs, tanks, or ponds will need to be provided in accordance with PAS NZS 4509:2008. Alternatively, a specific fire design would need to be provided to demonstrate compliance.

4.3.3 WATER SUPPLY NETWORK ALLOCATION

WDC have advised that based on current modelling assumptions there is 10 l/s available for the PPC11 area. However, an additional 16.7 l/s, that was previously allocated to the C7 residential growth cell, will also be made available (refer email Richard Bax – Abbie Fowler 24/07/2018). A total of 26.7 l/s is therefore available and there is sufficient capacity within the public water reticulation network to provide the PPC11 area with the design water supply flows (0.4 l/s/ha) as noted in Table 3 above.

Further discussion and co-ordination with WDC will be required to better understand how the existing network performs and confirm any reservoir and/or pump upgrades that may be required to improve level of service, and peak demand supply confidence.

4.4 IMPACTS OF STAGING AND TIMING

WDC have advised that the 375mm diameter dedicated trunk main extension is programmed for construction during the 2019/2020 season. The PC11 area will be developed in stages, with Stage 1 (an initial 12.5 Ha site) programmed for completion in February 2020. The next stage, Stage 2, is due for completion in October 2022.

Therefore, based on the current programme, the planned WDC 375mm diameter trunk main extension will need to be advanced to avoid additional temporary supply and storage within the first stage of the development.

4.5 PROPOSED WATER SUPPLY NETWORK

An initial draft reticulation concept to service the development is included in Appendix 2.

The PC11 area will be serviced by a new connection from the existing WDC reservoir. Water mains will run within road corridors and sufficient space provision will be made within the road corridors to allow for servicing the adjacent potential future industrial area (located to the east of the PC11 area).

It is quite likely some upgrade to the existing pumps will be necessary to ensure peak demands are catered for. Information sourced on site and referred to the manufacturers suggests either a limited flow rate (from the 22kW pump) or a mismatched pump and motor resulting in only small flows at low head (5.5kW pump). For such a system we would also expect to see variable speed drives and a pressure tank to control instantaneous fluctuations in demand and pressures.

4.6 LONG TERM WATER DEMAND

It is well recognised that as growth continues, the demand for water will also increase, sometimes reaching close to the limits of sources of supply.

To mitigate this and to aid in promoting best practice in water sensitive design, water reuse, where appropriate should be considered. Many of the buildings likely to be built in the Industrial Zone will have large roof areas. If some, or all, of that water can be harvested and stored, then it can be used to offset the treated potable demand. In particular this water can be used for washdown processes, non-potable building water services such as toilets, urinals, garden irrigation, and possibly some non-consumable industrial processes.

The most economic time to introduce the infrastructure to enable harvesting and reuse is at the initial building development point.

5.0 WASTEWATER

5.1 BACKGROUND REVIEW

The following documents were reviewed during the preparation of this report:

- The Waikato Regional Infrastructure Technical Specifications (RITS)
- The Waipa District Development and Subdivision Manual
- The Hamilton Infrastructure Technical Specifications (HITS)
- Opus Wastewater Issues Report, 2013
- Opus C7 Growth Cell – Wastewater Assessment, 2017
- Beca Hautapu Structure Plan, 2017

Correspondence with WDC staff (Robin Walker) was also had regarding existing infrastructure and proposed upgrades.

5.2 EXISTING NETWORK

The PC11 area is currently un-serviced for wastewater. The existing Shoof International site discharges to on-site treatment with infiltration fields.

WDC have advised that a new 375mm diameter rising main between the Hautapu Industrial Area and the Taylor St pump station is programmed for construction in 2019.

An upgrade to the pipe bridge over the Waikato River is currently under construction. WDC have advised that there is no additional spare capacity within this new pipe, therefore it becomes the long term primary constraint to development on the north side of the Waikato River.

5.3 DESIGN FLOWS

Section 5.2.4.2 of the RITS sets out the following criteria for the calculation of wastewater flows:

- Domestic average daily flow is 200 litres per person per day.
- Infiltration allowance is 2,250 litres per hectare per day.
- Surface water ingress allowance is 16,500 litres per hectare per day.
- Peaking factor based on Table 5.2.
- Population equivalent as per Table 5.3. For industrial this is 45 persons per hectare.
- Gross contributing land area upstream of the wastewater pipe is defined as the total catchment area, excluding reserve land, but including land within legal road boundaries

Average daily flow

ADF = (infiltration allowance x catchment area) + (water consumption x population equivalent)

Peak Daily Flow

PDF (l/s) = ((infiltration allowance x catchment area) + (peaking factor x water consumption x population equivalent))/86400

Peak inflow and infiltration factor

PIIF (l/s/ha) = infiltration allowance + surface water ingress

Peak wet weather flow

PWWF (l/s) = ((infiltration allowance x catchment area) + (surface water ingress x catchment area) + (peaking factor x water consumption x population equivalent))/86400

The Opus December 2013 Wastewater Issues Report used flow assumptions consistent with the RITS. The Beca March 2017 Hautapu Structure Plan document assumes a lower population density of 30 persons/ha.

The wastewater design flows have been based on the RITS and are summarised in Table 4 below.

TABLE 4: WASTEWATER DESIGN FLOWS

DEVELOPMENT STAGE	AREA (HA)	DUE TO COMPLETION	AVERAGE DAILY FLOW (M3/DAY)	PEAK DAILY FLOW (L/S)	PEAK WET WEATHER FLOW (L/S)	CUMULATIVE PEAK WET WEATHER FLOW (L/S)
Stage 1	12.5	Feb 2020	140.6	4.0	6.4	6.4
Stage 2	16.3	Oct 2022	183.4	4.8	8.0	14.3
Stage 3	27.9	Oct 2024	313.9	7.7	13.0	27.3
TOTAL	**56.7**		**637.9**	**16.5**	**27.3**	

An initial assessment of wastewater discharge for the first major industrial tenant that will occupy ~ 29Ha of the site indicate that actual demand may be lower than the values listed in the above table.

However, it is recommended that the reticulation network is based on the higher design flows to provide flexibility for future development.

5.3.1 WASTEWATER NETWORK ALLOCATION

WDC have advised that based on current modelling assumptions there is a 5 ha allowance for the PPC11 area in the model. However WDC have confirmed that the 130 ha currently allocated for the C7 residential growth cell will be reallocated to PPC11 (refer email Richard Bax – Abbie Fowler 24/07/18). There is therefore sufficient capacity in the public wastewater network (both at the Taylor St pump station and the Cambridge pipe bridge) to provide the PPC11 area with the required downstream capacity allocation as noted in Table 4 above.

5.4 IMPACTS OF STAGING AND TIMING

WDC have advised that the new 375mm diameter rising main to service the Hautapu Industrial Structure Plan area is also due for construction during the 2019/2020 season.

Therefore, based on the current programme, it is recommended that the rising main construction is advanced to enable construction at the same time as the proposed new rising main to service the PPC11 area.

5.5 PROPOSED WASTEWATER NETWORK

An initial wastewater network concept to service the development can be found in Appendix 2.

On-site wastewater treatment and soakage is not considered to be feasible based on the anticipated volume of wastewater generated. Due to the topography of the site it is also not possible to drain the whole area by gravity. Therefore, pump stations will be required. The final number and locations of these will be confirmed at later stages.

There will be a single delivery rising main from the development to the Taylor St pump station which is the closest point of connection to the existing wastewater network. There is an opportunity for this rising main to be constructed at the same time as the rising main for the Hautapu Industrial Structure Plan area. WDC has previously identified that pump upgrades will be necessary.

To avoid issues with septicity during the initial stages of both the Hautapu Industrial and PC11 areas, it is envisaged that both developments will discharge into one rising main initially. The second rising main will be brought into service as required.

6.0 SUMMARY AND RECOMMENDATIONS

A summary of the recommendations from this report in respect of servicing the Plan Change site for stormwater, water and wastewater follows:

- Our recommendation for stormwater is to adopt a water sensitive design approach whereby the stormwater solutions are integrated within the built form and landscape. For example, soakage basins can be designed to provide for a variety of functions such as lower wetter areas planted with native species which can take the form of a wetland, as well as potentially slightly higher areas which could be grassed and used for recreational and amenity benefits.
- Soakage potential across the Plan Change site can be maximised either by way of larger scale soakage basins with an array of underdrains or under hardstand areas using 'milk crate' systems with close to 100% void space to reduce footprint and increase storage.
- Although the existing and planned trunk water and wastewater infrastructure can provide for development, water efficiency measures such as rain water harvesting and grey water recycling are well established technologies in New Zealand and can provide benefits in the form of reduced demand on water supply and wastewater treatment.
- To ensure no adverse impacts on the WRC rural drainage network, 10yr ARI runoff volumes will be contained within the communal basins using a combination of live storage and infiltration.
- 10yr and 100 ARI flows will be managed safely within the site so as to ensure no unacceptable risk to people, property and road users.
- The existing 100yr ARI flows to the Mangaone Stream will not be exceeded post development using a series of attenuation basins and swale conveyance and storage.
- Water supply to the PC11 area will be satisfied by the proposed works of WDC in the 2019/2020 construction season. That is, the splitting of the existing reticulation from a dedicated supply into the Fonterra and C8 areas. For normal

supply, demand can be met from the proposed network, and in periods of high daily demand, the supply will be supplemented by a pumped system.

- Based on the current programme Stage 1 of the development (an initial 12.5ha site) is due for completion in February 2020 therefore the planned WDC 375mm diameter trunk main extension will need to be advanced to avoid additional temporary supply and storage within the first stage of the development.

- Wastewater generated around the development will drain to one of at least two wastewater pump stations. These will pump through a dedicated rising main to the Taylor St pump station. WDC have confirmed that there is capacity in the town network to convey the extra flow.

- Initially, both the Bardowie Industrial Precinct and the Hautapu Industrial area will have low flows which may generate septicity issues. To minimise this risk, it has been proposed that both pump stations pump through a single rising main initially until there is sufficient flows to utilise both mains.

7.0 LIMITATIONS

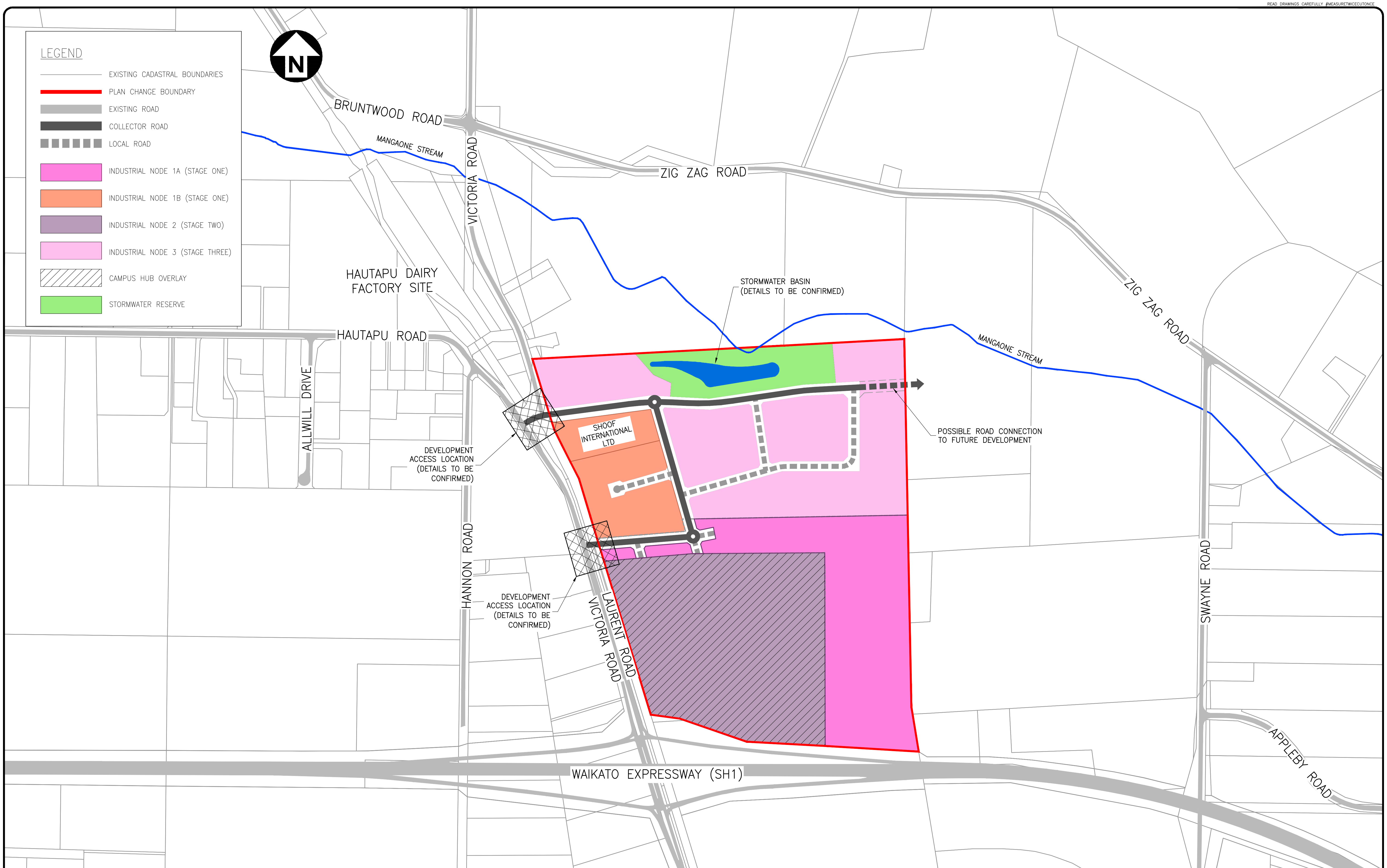
7.1 GENERAL

This report is for the use by Bardowie Investments Ltd only and should not be used or relied upon by any other person or entity or for any other project.

This report has been prepared for the particular project described to us and its extent is limited to the scope of work agreed between the client and Harrison Grierson Consultants Limited. No responsibility is accepted by Harrison Grierson Consultants Limited or its directors, servants, agents, staff or employees for the accuracy of information provided by third parties and/or the use of any part of this report in any other context or for any other purposes.

APPENDIX 1 PLAN CHANGE GENERAL ARRANGEMENT

READ DRAWINGS CAREFULLY #MEASURETWICECUTONCE



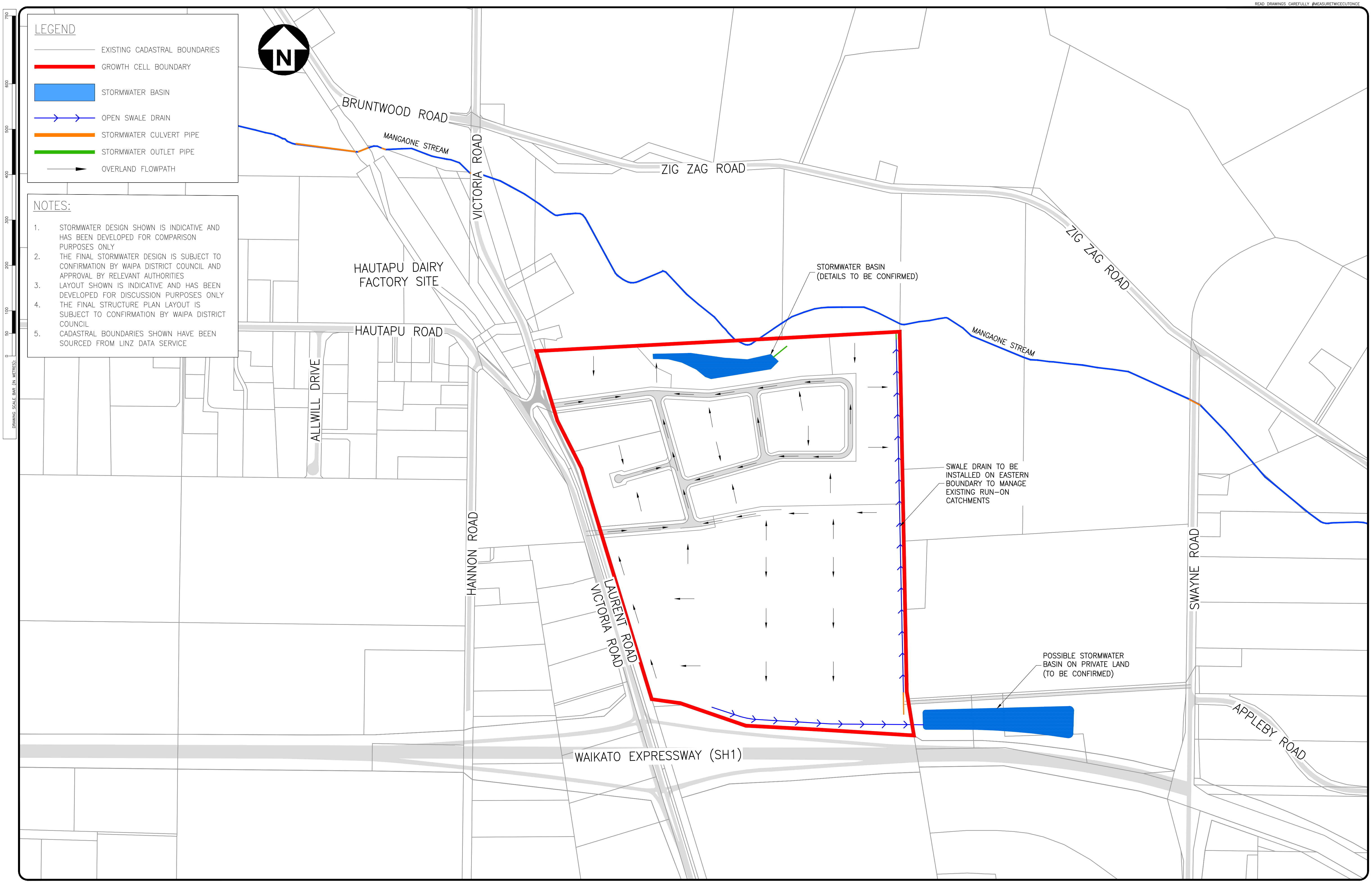
PROPOSED PLAN CHANGE 11 TO THE WAIPA DISTRICT PLAN
BARDOWIE INDUSTRIAL PRECINCT

STRUCTURE PLAN
GENERAL ARRANGEMENT

DRAWING REVISION: 0

DATE PRINTED: 18 July 2018 FILE NAME: 17002-C-0002.dwg

APPENDIX 2 THREE WATERS LAYOUT CONCEPTS



NOTES:

1. STORMWATER DESIGN SHOWN IS INDICATIVE AND HAS BEEN DEVELOPED FOR COMPARISON PURPOSES ONLY
2. THE FINAL STORMWATER DESIGN IS SUBJECT TO CONFIRMATION BY WAIPA DISTRICT COUNCIL AND APPROVAL BY RELEVANT AUTHORITIES
3. LAYOUT SHOWN IS INDICATIVE AND HAS BEEN DEVELOPED FOR DISCUSSION PURPOSES ONLY
4. THE FINAL STRUCTURE PLAN LAYOUT IS SUBJECT TO CONFIRMATION BY WAIPA DISTRICT COUNCIL
5. CADASTRAL BOUNDARIES SHOWN HAVE BEEN SOURCED FROM LINZ DATA SERVICE

READ DRAWINGS CAREFULLY #MEASURETWICECUTONCE

REV	DESCRIPTION	BY	DATE
A	FOR INFORMATION	ABC	08.07.18

APPROVAL STATUS: FOR INFORMATION

		DATE
DESIGNED BY	L. MCCAFFREY	08.07.18
DRAWN BY	A. CONTRERAS	08.07.18
APPROVED BY	–	–

CLIENT NAME: BARDOWIE INVESTMENTS LTD (BIL)

PROJECT NAME: BARDOWIE INDUSTRIAL PRECINCT

DRAWING TITLE: STORMWATER NETWORK GENERAL ARRANGEMENT

PRODUCED BY: MCCAFFREY ENGINEERING CONSULTANTS

DATE PRINTED: 8 July 2018

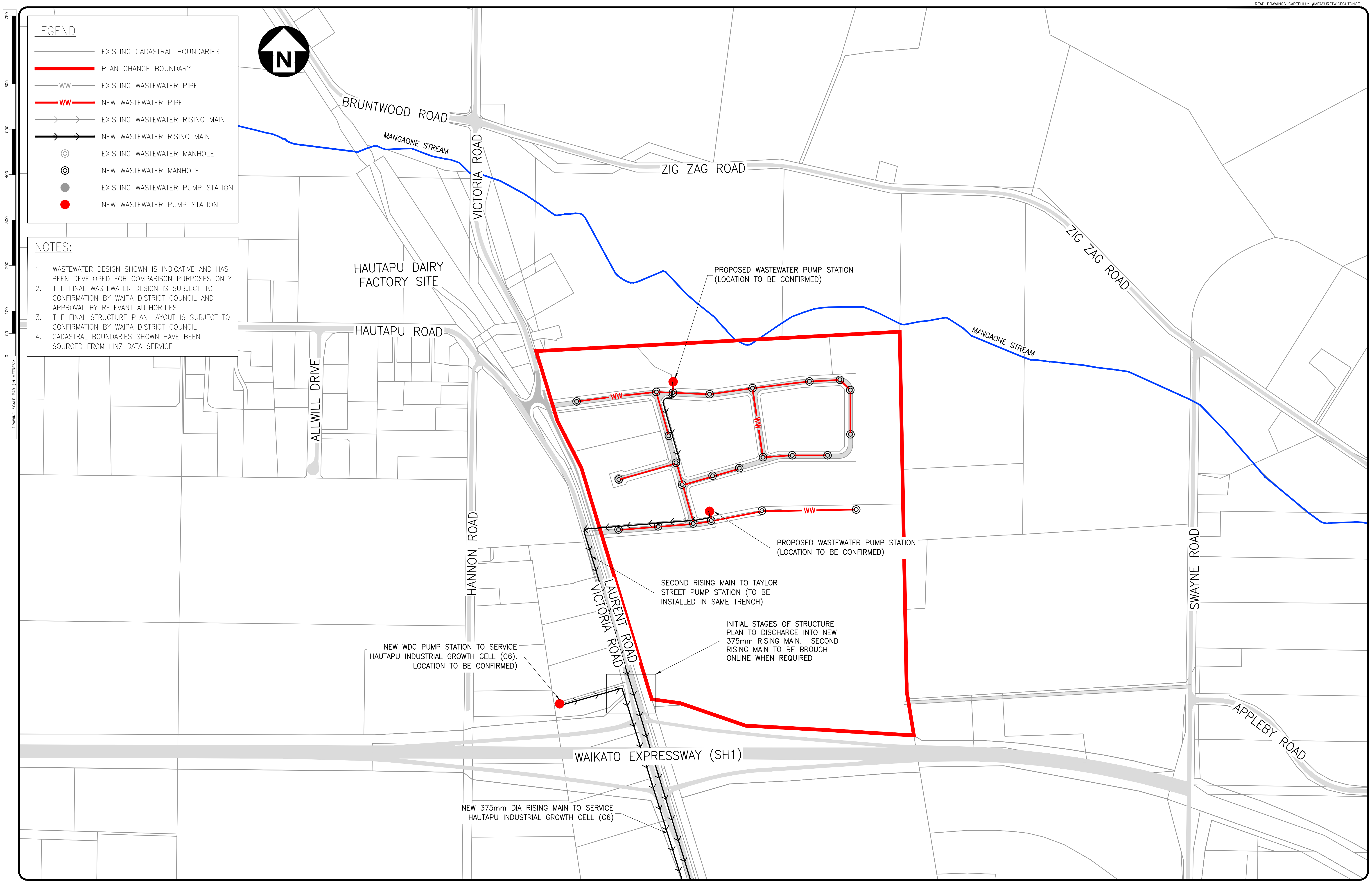
DRAWING SCALE: 1:7500

REVISION No.: A

DISCIPLINE: CIVIL ENGINEERING

DRAWING No.: 17002-C-0040

FILE NAME: 17002-C-0040.dwg



REV	DESCRIPTION	BY	DATE
A	FOR INFORMATION	ABC	08.07.18

APPROVAL STATUS: FOR INFORMATION

		DATE
DESIGNED BY	L. MCCAFFREY	08.07.18
DRAWN BY	A. CONTRERAS	08.07.18
APPROVED BY	–	–

CLIENT NAME: BARDOWIE INVESTMENTS LTD (BIL)

PROJECT NAME: BARDOWIE INDUSTRIAL PRECINCT

DRAWING TITLE: WASTEWATER NETWORK GENERAL ARRANGEMENT

PRODUCED BY: MCCAFFREY ENGINEERING CONSULTANTS

DATE PRINTED: 8 July 2018

DRAWING SCALE: 1:7500

REVISION No.: A

DISCIPLINE: CIVIL ENGINEERING

DRAWING No.: 17002–C–0050

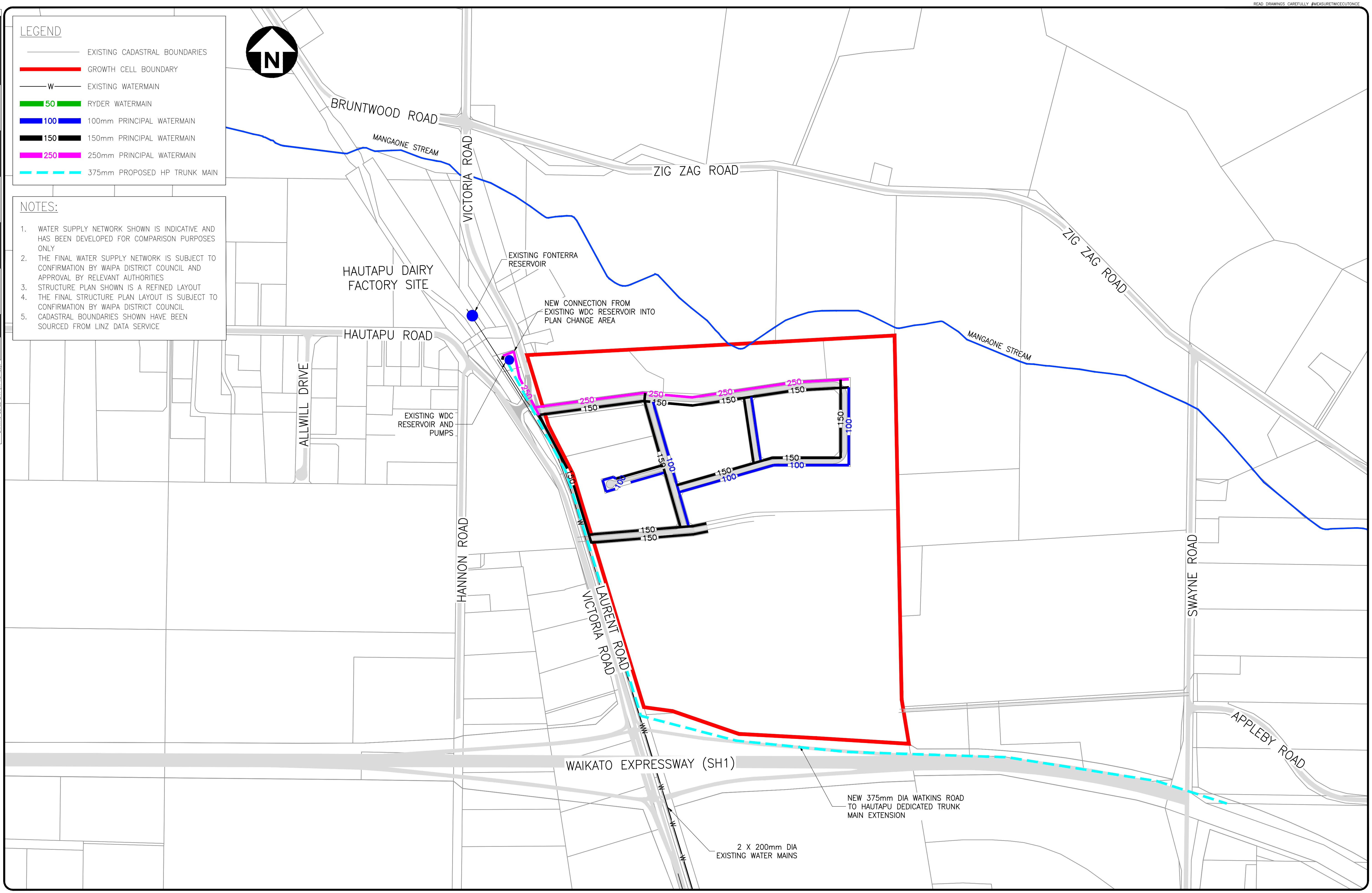
FILE NAME: 17002–C–0050.dwg

LEGEND

(line)	EXISTING CADASTRAL BOUNDARIES
(red line)	GROWTH CELL BOUNDARY
—W—	EXISTING WATERMAIN
50	RYDER WATERMAIN
100	100mm PRINCIPAL WATERMAIN
150	150mm PRINCIPAL WATERMAIN
250	250mm PRINCIPAL WATERMAIN
(dashed line)	375mm PROPOSED HP TRUNK MAIN

NOTES:

1. WATER SUPPLY NETWORK SHOWN IS INDICATIVE AND HAS BEEN DEVELOPED FOR COMPARISON PURPOSES ONLY
2. THE FINAL WATER SUPPLY NETWORK IS SUBJECT TO CONFIRMATION BY WAIPA DISTRICT COUNCIL AND APPROVAL BY RELEVANT AUTHORITIES
3. STRUCTURE PLAN SHOWN IS A REFINED LAYOUT
4. THE FINAL STRUCTURE PLAN LAYOUT IS SUBJECT TO CONFIRMATION BY WAIPA DISTRICT COUNCIL
5. CADASTRAL BOUNDARIES SHOWN HAVE BEEN SOURCED FROM LINZ DATA SERVICE



REV	DESCRIPTION	BY	DATE
A	FOR INFORMATION	ABC	08.07.18

APPROVAL STATUS: FOR INFORMATION

DESIGNED BY: L. MCCAFFREY — DATE: 08.07.18

DRAWN BY: A. CONTRERAS — DATE: 08.07.18

APPROVED BY: – — DATE: –

CLIENT NAME: BARDOWIE INVESTMENTS LTD (BIL)

PROJECT NAME: BARDOWIE INDUSTRIAL PRECINCT

DRAWING TITLE: WATER SUPPLY NETWORK GENERAL ARRANGEMENT

PRODUCED BY: MCCAFFREY ENGINEERING CONSULTANTS

DATE PRINTED: 8 July 2018

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REVISION No.: A

DISCIPLINE: CIVIL ENGINEERING

DRAWING No.: 17002-C-0060

FILE NAME: 17002-C-0060.dwg

APPENDIX 3 FLOOD MODEL BUILD REPORT AND SOIL ASSESSMENT

Technical Memo

BARDOWIE PLAN CHANGE 11

Preliminary Flood Assessment

Modelling Assumptions

TO:	Liam McCaffrey	**HG PROJECT NO :**	1610-143918-01
FROM:	Mike Chapman & Saeed Ghavidelfar	**DATE:**	10 July 2018

An InfoWorks ICM 1D/2D model was developed to perform an initial flood assessment on the post development design surface for the Bardowie Industrial Plan Change 11 area. A model of the existing scenario also was developed in order to assess the impact of proposed earthworks on the Mangaone stream flow rate and level.

The rain-on-grid approach was used to estimate the 100yr ARI flood using ICM software. In the 2D rain on grid approach, the entire catchment contributes to generating runoff from a net rainfall directly applied on the flexible mesh elements.

All the major culverts/orifices upstream and downstream of the site in the Mangaone stream have been modelled in ICM as the 1D components (based on survey). However, some of the minor rural culverts are modelled in 2D by opening up the rural road crossing the streams. This simplification should not have any significant bearing on the flood assessment since all those rural culverts are overtopped in a 100yr ARI event. Table 1 below summarises the hydrologic parameters used in this model.

TABLE 1: CATCHMENT HYDROLOGY

PARAMETERS	VALUE
Rainfall depth	221 mm (from High Intensity Rainfall Design Systems (HIRDS) Version 3, adjusted for a climate change temperature increase of 2.1˚C)
Rainfall pattern (design storm)	It is based on Ruakura design storms, incorporating 2.1 degrees Celsius climate change (obtained from ITS-Section4-Stormwater-Dec2016, table 4-11)
Impervious percentage	The catchment encompassing the Bardowie industrial site is consist of two major land uses including urban and rural (Figure 1). For the urban area the imperviousness of 50% was considered since the majority of the urban area are residential with the large lots. For the Rural area it was assumed that 5% of land is impervious.
Composite CN	For the previous area a CN of 69 and for the impervious area a CN of 98 was used. Taking into account the percentage of pervious/impervious surfaces, the composite CN for the urban and rural areas were calculated as 83.5 and 70.5, respectively. It should be noted that the CN of 69 is relatively conservative for this catchment which is dominated by soil type B. A CN of 61 for pervious surface can be used for the final run. It also worth

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	mentioning that for this preliminary assessment, the increase in imperviousness of site for the post development scenario was not considered. This can be refined in the final run.
Initial abstraction (Ia)	Initial abstraction for each land use was calculated using composite CN according to a method outlined in the Draft Waikato Stormwater Runoff Modelling Guideline. In this way, the initial abstractions of 10.0 mm and 21.3 mm were considered for the urban and the rural area, respectively.
Surface roughness (manning n)	0.05

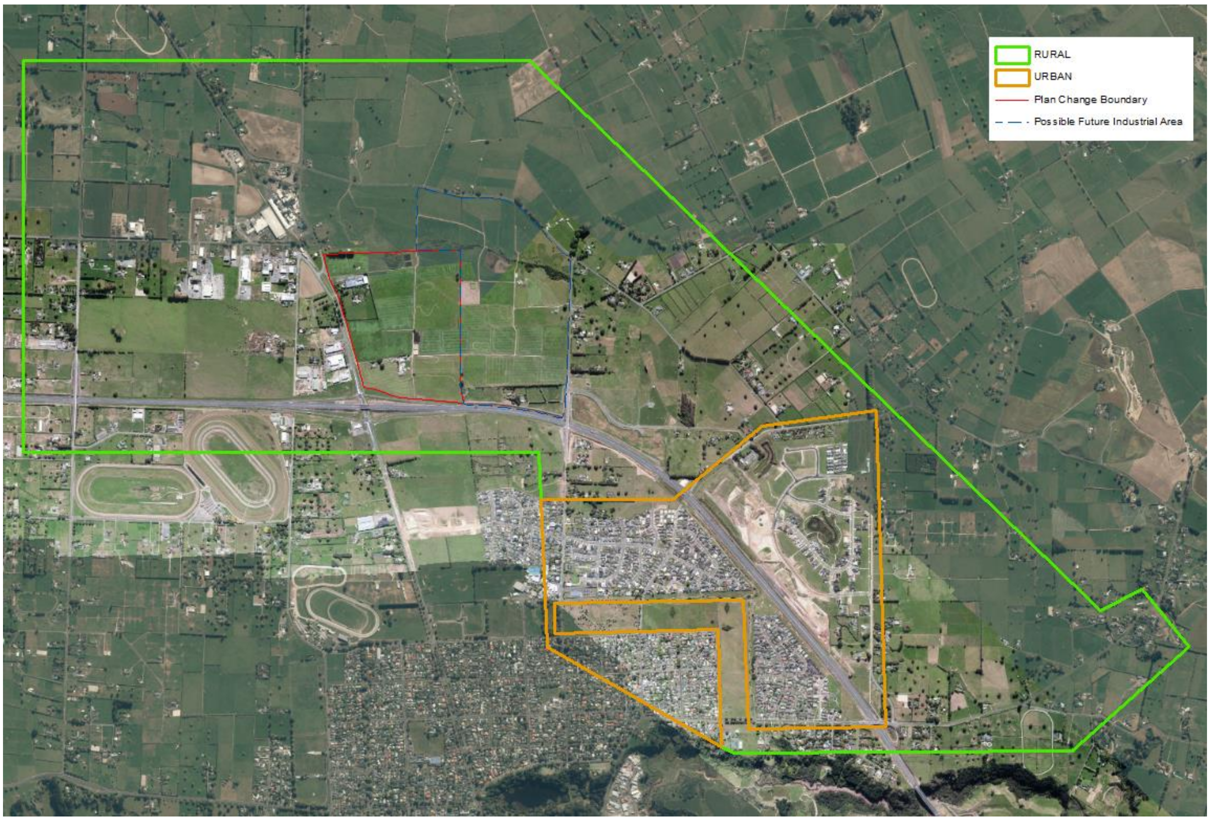
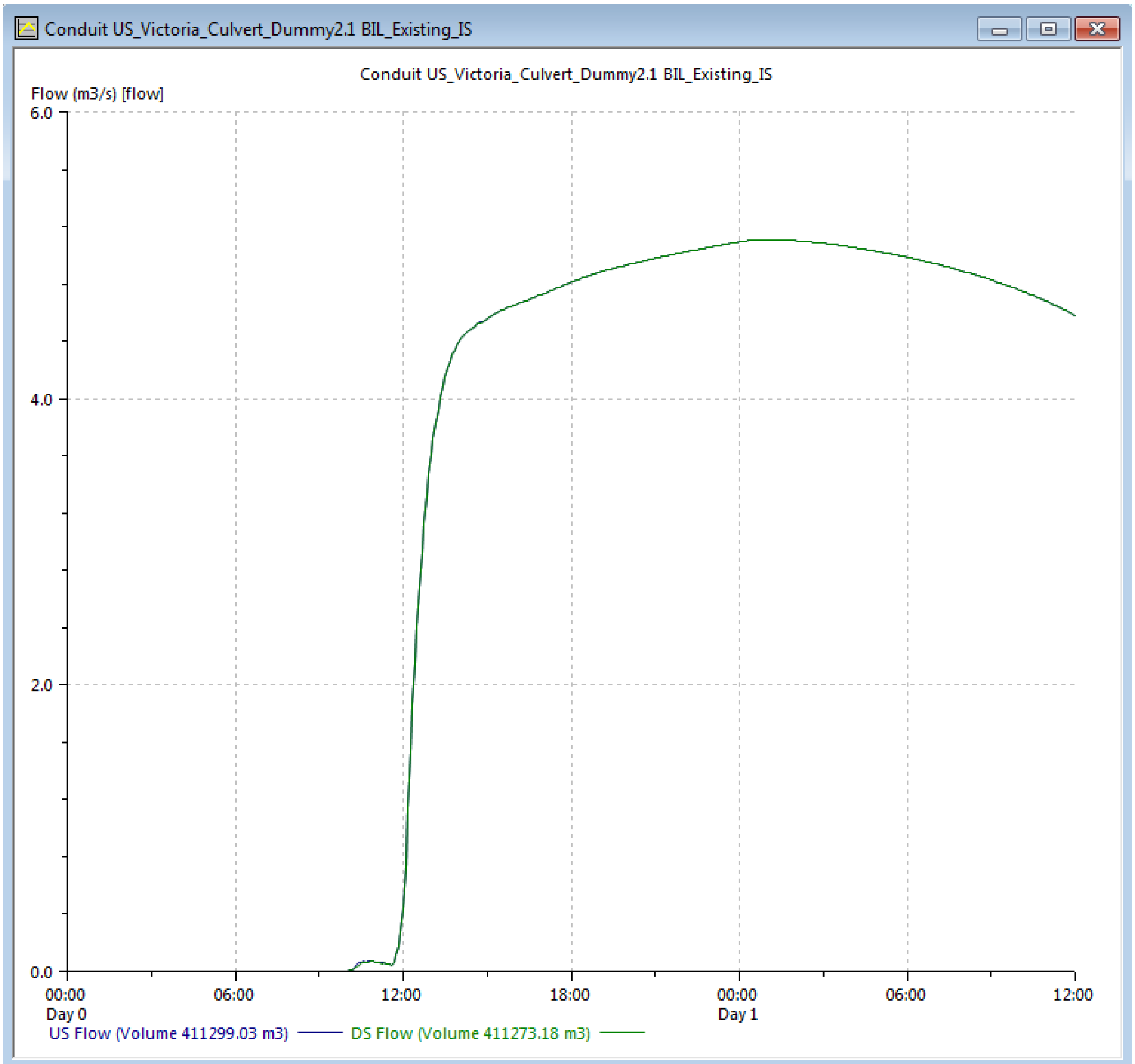


Figure 1. Existing Land Use – Rural/Urban Impervious Zones

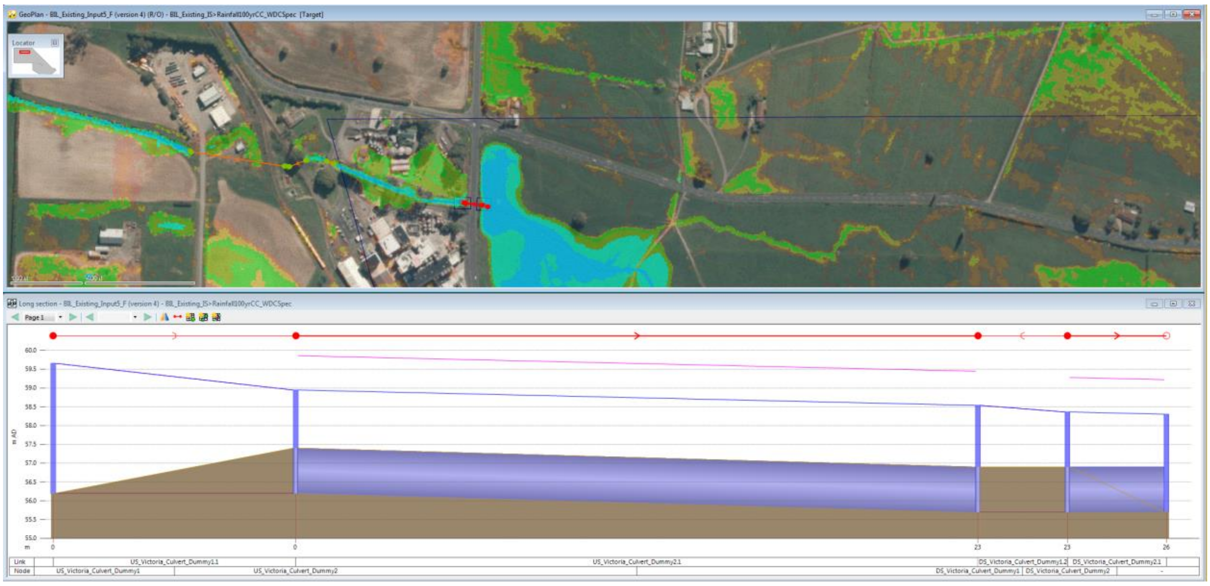
1.0 PRELIMINARY RESULTS – VICTORIA ROAD CULVERT

The existing 100yr ARI velocity and flow hydrographs and long section from upstream of Victoria Road culvert to downstream of the rail line are shown below. Erosive flows (channel forming) are typically storm events up to the 2yr ARI and perhaps to a lesser extent the 10yr ARI flow (depending on stream morphology). It is the intention of the stormwater solution to accommodate all storm events up to the 10yr ARI on site. Potential erosion impacts, over and above those that would result during the existing 100yr ARI, are considered to be negligible if the solutions in the 3 waters assessment are implemented.

The intention of the flood model is to understand the existing 100yr ARI peak flows from the site, into the site and within the Mangaone Stream.

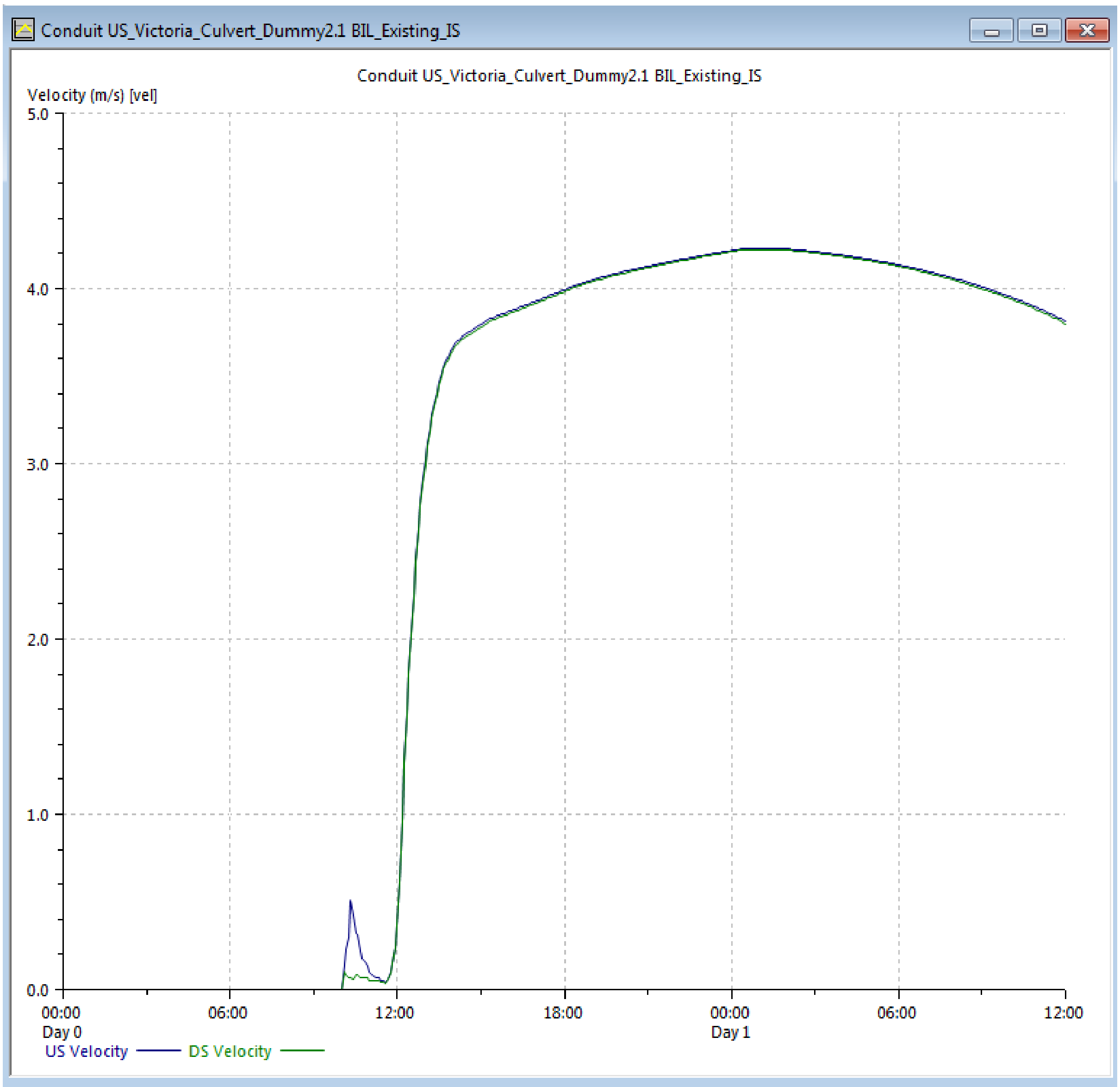


Peak Flow 5.11m³/s

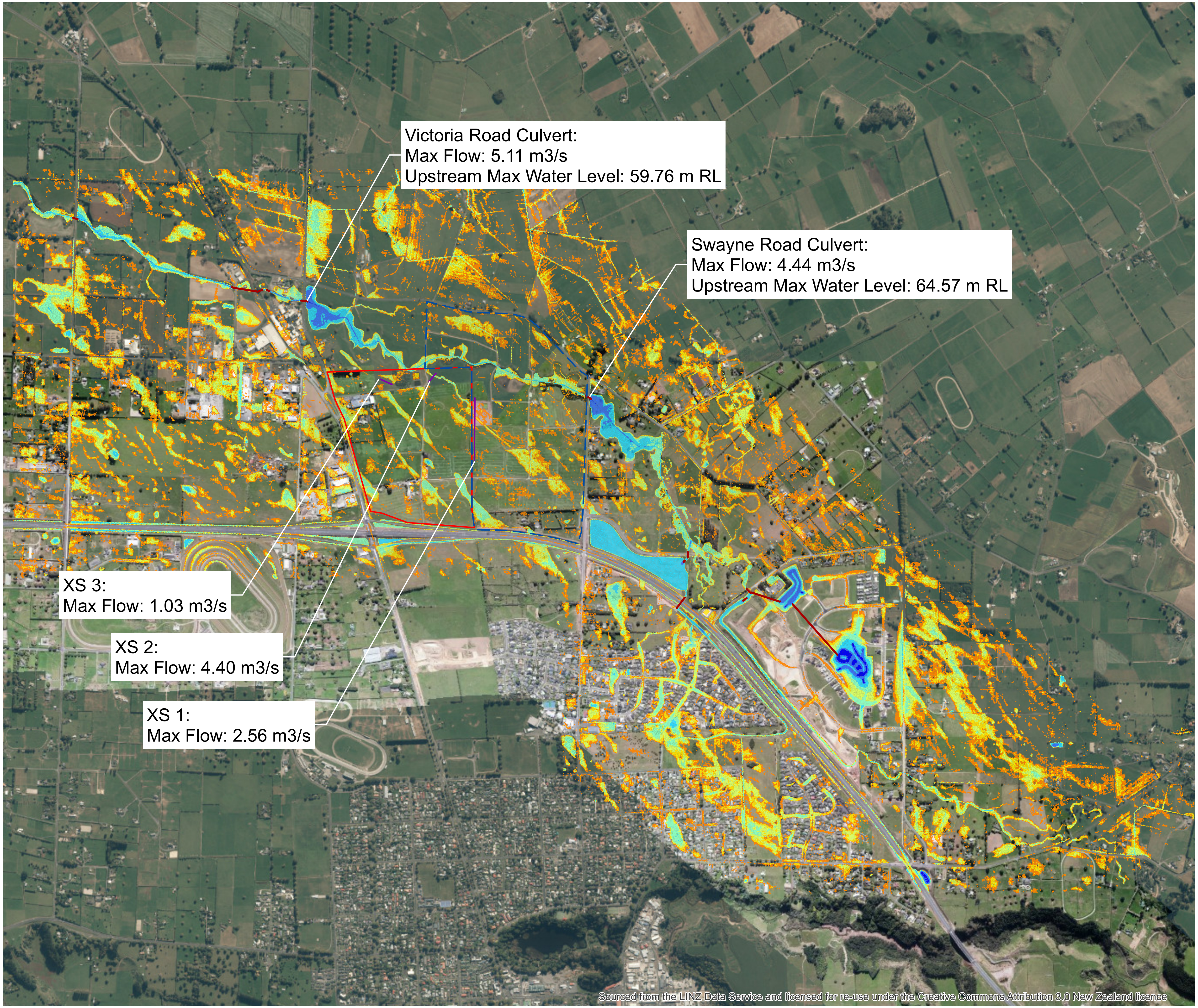


Floodplain u/s of culvert

Hautapu Factory Road



Peak Velocity 5.20m/s



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Legend

- XS
- Plan Change Boundary
- Possible Future Industrial Area
- Existing Culverts

DEPTH2D

- 0.11 - 0.20
- 0.21 - 0.30
- 0.31 - 0.50
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 10.00

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REV	ISSUE STATUS	DATE
Rev1	DRAFT FOR INFORMATION	180705

DESIGNED:	SXG	DATE:	5/07/2018
DRAWN:	SXG	DATE:	5/07/2018
CHECKED:	MYL	DATE:	5/07/2018
APPROVED:	MHC	DATE:	5/07/2018

N

Scale: 1:20,000 (A3 Size)

0 0.15 0.3 0.6 0.9 Kilometers

Bardowie Investments Ltd
Flood Assessment

100yr CC Flood Map
Existing scenario

DRAFT

MAP NO:

143918_01_001

esri

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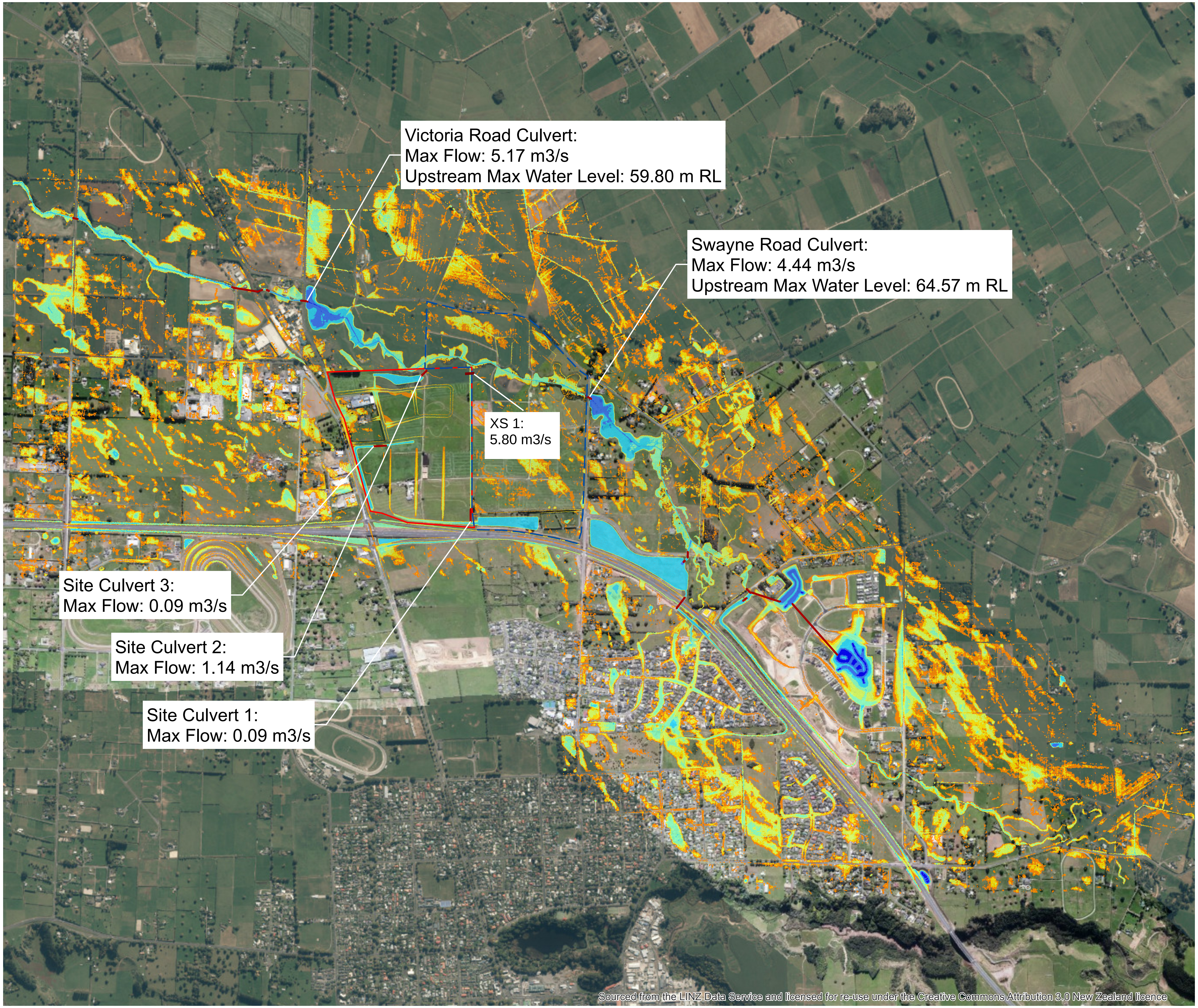

HARRISON GRIERSON

Legend

- Plan Change Boundary
- Possible Future Industrial Area
- Existing/PostDevelopment Culverts

DEPTH2D

- 0.11 - 0.20
- 0.21 - 0.30
- 0.31 - 0.50
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 10.00

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REV	ISSUE STATUS	DATE
Rev1	DRAFT FOR INFORMATION	180705

DESIGNED:	SXG	DATE:	5/07/2018
DRAWN:	SXG	DATE:	5/07/2018
CHECKED:	MYL	DATE:	5/07/2018
APPROVED:	MHC	DATE:	5/07/2018

N

Scale: 1:20,000 (A3 Size)

0 0.15 0.3 0.6 0.9 Kilometers

Bardowie Investments Ltd
Flood Assessment

100yr CC Flood Map
Post Development scenario

DRAFT

MAP NO:

143918_01_002

esri

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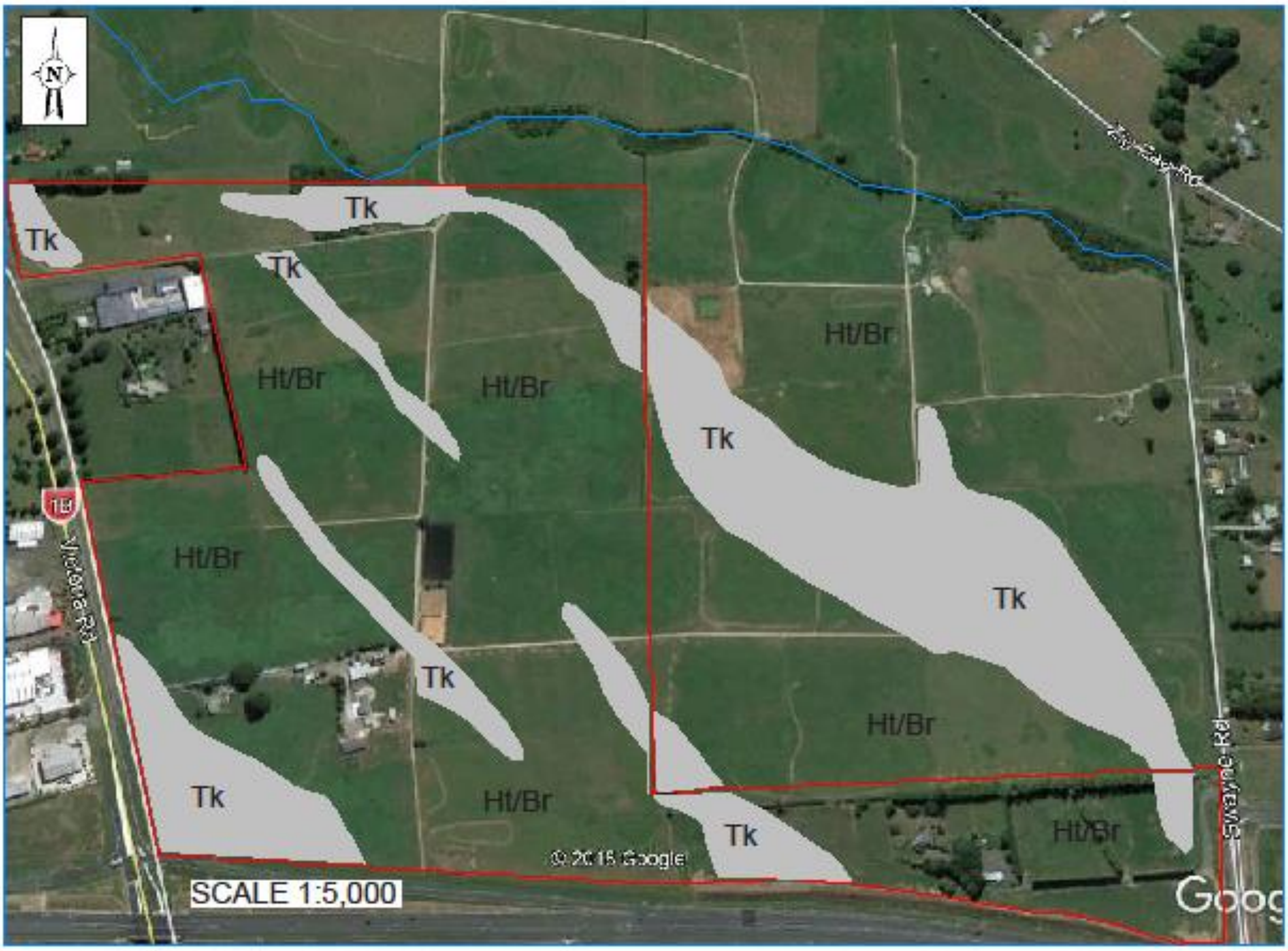

A soil survey of the site revealed three soil types and possibly a fourth (Eureka sands), all of which are underlain by The Hinuera Formation (silts,sands & gravels laid down by the ancestral Waikato River about 15,000 years ago). The Hinuera Formation at this site is reported to be about 60 m in thickness.

About 80% of the site supports Horotiu and Bruntwood soils, which are located on the broad elevated free draing terrace land.

Distinctive lower lying swales (about 2 m down from the terrace land) support largely Te Kowhai soil, which at places could be replaced by Eureka soils (they account for about 20% of the site)

The soils and their characteristics are described in Section 2 below.

Figure 1 – Soil map – showing soil types and areas

Section 2 - Soil Survey, including soil descriptions and photos

A soil survey based on local knowledge and a desk study comprising topographic and flood maps, was completed to produce a reasonably detailed soil map at a scale of about 1:5,000 – see Figure 1 above.
About 80% of the farm supports largely Horotiu sandy loam with some Bruntwood sandy/silt loam, both are versatile free draining soils and occupy the broad elevated terrace land.
The remaining 20% of the site comprise largely Te Kowhai silty/clay loams found on the lower land within the swales. A few areas of the swale may support Eureka soils described below as poorly drained as a consequence of iron pans and perched water tables.

Horotiu sandy loam

Horotiu soils including the gravely and sandy loam phase are located on the terraces/low linear ridges of alluvium, their topsoil is 15 to 20 cm thick dark brown sandy loam with a crumb to granular structure that overlies gravely sands of the Hinuera Formation. **These soils are well drained**, the highest category according to Milne's classification.

Bruntwood silt loam

Bruntwood soils have formed on the flanks of the low ridges upon which the Horotiu soils are found. They occur slightly above the lower, poorly drained areas (swales). The topsoil is a 15 cm thick dark greyish brown and is moderately well structured (nut to crumby). The subsoil is yellow to grey in colour with yellow brown mottles. **The soil is moderately well drained**

Te Kowhai silt/clay loams

Te Kowhai soils are poorly drained gleyed soils, which can be saturated at the ground surface for long periods over the winter months. Te Kowhai soils are poorly drained with slow permeability and a shallow rooting depth. Topsoils are dark greyish brown silt or clay loam. Subsoils are light grey clay loams with a coarse blocky sometimes massive compacted structure with many mottles. The main soil limitation is very poor drainage resulting from water trapped on compact slowly permeable subsoil layers. The soil is very prone to livestock pugging during the winter and early spring.

Eureka soils

Eureka soils are located on the topographic lows where ancient rivers flowed and are characterised by a layer of coarse gravel found at varying depths. The gravels in many cases are cemented by layers (pans) of iron concretions/stones. They are gleyed soils and are poorly drained, especially if the water tables are perched. Where the gravels are within 40 cm of the ground surface the soils are sandy. Where the gravels are deeper say 60 cm depth the overlying subsoils are clayey and compacted and are very poorly drained.

Soil risk categories in relation to irrigation of dairy effluent - according to Dairynz Guidelines – see appendix 2

Horotiu sandy loam – Category D
Bruntwood sandy loam – Category D

Te Kowhai silt/clay loam – Category B
Eureka silt/sandy loam – Category B
Hamilton clay loam – Category C

Note – the figure below describes **effluent considerations related to the risk categories above**

Category	A	B	C	D	E
Soil and landscape feature	Artificial drainage or coarse soil structure	Impeded drainage or low infiltration rate	Sloping land (>7°) or land with hump & hollow drainage	Well drained flat land (<7°)	Other well drained but very light flat land (<7°)
Risk	High	High	High	Low	Low
Application depth (mm)	< SWD[1]	< SWD	< SWD	< 50% of PAW[2]	≤ 10 mm & < 50% of PAW[2]
Storage requirement	Apply only when SWD exists	Apply only when SWD exists	Apply only when SWD exists	24 hours drainage post saturation	24 hours drainage post saturation
Max depth: High rate tool	10 mm	10 mm	10 mm[3]	25 mm[4] (10 mm at field capacity)	10 mm
Max depth: Low rate tool	25 mm	25 mm	10 mm	25 mm	10 mm

1 SWD is the soil water deficit

2 PAW is the plant available water in the top 300 mm of soil

3 Only applicable when instantaneous application rate from the irrigator is less than the infiltration rate

4 Suggested maximum application depths when a suitable SWD exists (> 15 mm). For all the risk categories the application rate should always be less than the soil infiltration rate otherwise you will get ponding (on sloping land the instantaneous application rate needs to be less than the soil infiltration rate or you will get run-off).

Dr Richard Chapman

Suitably Qualified Soil Practioner

APPENDIX 4 HYDROGEOLOGICAL ASSESSMENT

21 Pitt Street
PO Box 6345, Auckland 1141, New Zealand
T: +64 9 300 9000 // **F:** +64 9 300 9300
E: info@beca.com // **www.beca.com**

Bardowie Investments Ltd
1871 Cambridge Road
Cambridge
New Zealand

10 July 2018

Attention: Matt Smith

Dear Matt Smith

Proposed Plan Change 11 to the Waipa District Plan - Bardowie Industrial Precinct Hydrogeological Assessment

Executive Summary

Beca Ltd has been engaged by Bardowie Investments Ltd to undertake a desktop review of the current state of knowledge of the hydrogeological conditions across the Bardowie Industrial Precinct (“the site”) in order to provide an assessment of potential implications for the management of stormwater on the site. It is intended that the stormwater system will be designed to maximise the soakage potential within the site; soakage will deal with the frequent storm events and, where possible, will remove additional runoff volume completely from the Mangaone Stream.

Previous ground investigations on and around the site encountered topsoil and Hinuera Formation comprising predominantly alluvial rhyolitic sands and gravel, with some layers of silt. Information on hydraulic conductivity across the site has been inferred from soakage testing and rising head permeability tests undertaken on adjacent sites (Beca, 2016; Beca, 2018), preliminary soakage testing on the site (BCD, 2018), qualitative interpretation of the trickle irrigation system currently being used by Fonterra on the site and review of the WRC soil runoff risk map. Review of the tests indicates hydraulic conductivities ranging from 10^{-5} m/s to 10^{-3} m/s. These permeabilities are of the order of that which is required for stormwater soakage to the ground.

Groundwater levels for the site have been compiled from a number of sources, and have been interpolated to provide a contour plan of winter groundwater level across the site. The shallowest winter groundwater levels in the wider project area are reported in the Cambridge North area; soil maps indicate that this area has soils that are of “high runoff risk”. This implies low permeability soils that will inhibit soakage deeper into the subsurface, resulting in shallower, possibly perched, groundwater levels. There is some possibility that these soils extend across the eastern boundary of the proposed site where winter water levels are of the order of 64 m to 65 m RL (0.3 m to 2.8 m bgl).

Groundwater levels lower in an overall south-westerly direction, with winter groundwater levels of 60 m RL to 63 m RL (2.5 m to 4.8 m bgl) along the southern and western boundaries of the site. In these areas, where the winter groundwater is > 2.5 m bgl, and, with consideration of the overall groundwater gradient, the ground is likely to be suitable for some soakage of stormwater.

The data available is sufficient for plan change purposes and indicates that the Bardowie Industrial Precinct site will be able to accommodate some disposal of stormwater via soakage to the ground, though further investigation and analysis will be required to support developed design and confirm in more detail the likely infiltration rates and design storm volumes that can be accommodated (and over what area). Additional work should also consider the long term impacts of cumulative discharges to stormwater from this site and from the Hautapu Structure Plan (industrial) area, Cambridge North and Cambridge C1 areas (which are downgradient from the site).

1 Introduction

Bardowie Investments Ltd (BIL) is developing a new 55 Ha industrial subdivision in Hautapu, Cambridge called the Bardowie Industrial Precinct (herein referred to as “the site”). Beca Ltd has been engaged by BIL to undertake a desktop review of the current state of knowledge of the hydrogeological conditions at the site, and, to provide an assessment of potential implications for the management of stormwater on the site.

The site, located at Laurent Road, is currently owned by Fonterra who are understood to be using a trickle irrigation system. On this basis it is anticipated that the site may be able to utilise soakage as an on-lot means of managing stormwater.

This letter report presents the findings of the desktop assessment and provides an initial review of the suitability of the site for the disposal of stormwater to ground as part any future development.

2 Stormwater Design Option

The overall approach to stormwater management is outlined in the accompanying stormwater design report (Harrison Grierson, 2018); however, a summary of the philosophy is provided below.

It is intended that the stormwater system will be designed to maximise the soakage potential within the site. Soakage will deal with the frequent storm events and remove additional runoff volume completely from the Mangaone Stream. Following pre-treatment, soakage could be achieved via on-lot systems (i.e. under parking areas) or within communal soakage basins which could also provide for flood attenuation. Designed correctly, it is anticipated that these larger basins could provide for high visual amenity and recreational functions as well providing an additional level of pre-treatment within a planted base.

Attenuated flood flows and overflows from the soakage system will be conveyed to the Mangaone Stream within open channel/swales which could potentially connect with existing wetland features adjacent to the stream, or a separate connection may also be appropriate.

Full details of the locations of all soakage features is not yet determined however for the purpose of this assessment we have considered that there are likely to be three main components to the stormwater system:

- A conveyance channel(s), possibly with some soakage that will be used to transport stormwater from the impervious areas of the site to the southeast where a large basin will be constructed.
- This basin will likely be the primary location for soakage and storage of stormwater for Stage One development of the site.
- If the basin storage volume is exceeded (e.g. more water enters than can be soaked into the subsurface) then a second conveyance channel will divert water from the swale to the north towards the Mangaone Stream at the northern boundary of the site.

The design philosophy described above can only be finalised once the soakage potential of the site (e.g. the hydrogeological setting) is fully understood and hence the following hydrogeological assessment has considered the full extent of the Bardowie Industrial Precinct.

3 Hydrogeological Setting

3.1 Geology

The site is located within the Hamilton Basin, which is a large graben flanked by greywacke ranges (Pakaroa to the east and Hakarimata to the west) (Edbrooke, 2005). The basin is infilled with a thick sequence of largely alluvial Tauranga Group sediments, which are comprised of pumiceous silts and sands. The Tauranga Group sediments have been distributed by the paleo-Waikato River (Hadfield, 2001) resulting in a complex distribution of lithologies of varying hydraulic conductivities.

The subsurface in the immediate vicinity of the site has been investigated by a number of Beca studies, and, a pre-purchase geotechnical investigation of the site itself has been undertaken by BCD Group (2018). Figure 1 shows the locations of borehole data that has been used to inform this assessment.

Investigations on and around the site intersected topsoil and Hinuera Formation alluvial rhyolitic sands and gravel with layers of silt and clay. The lithology of the site generally consists of a topsoil layer which overlies stiff silt with minor clay or loose sandy silt, which is in turn underlain by loose to dense sands (BCD Group, 2018). There is variability in the depth to and grainsize of the sand layer, varying between 0.8 to 2.5 m bgl and ranging from fine to coarse sand and fine gravel. The sand layer is anticipated to be between 10.4 to 17.5 m thick based on CPTs undertaken across the site (BCD, 2018).

At least three topsoil types are identified on the site (Harrison Grierson, 2018). About 80% of the site is Horotiu and Bruntwood soil types which comprise free draining gravelly and sandy loam. The remaining 20% of the site is comprised of Te Kowhai soil, commonly found in in lower lying swales and composed of silt and clay, which results in poorly drained soils. The areas where Te Kowhai soils are mapped on the site broadly correlate to where Fonterra site staff have anecdotally identified surface flooding and “boggy conditions” after heavy rainfall.

3.2 Groundwater Levels

Groundwater levels for the site have been compiled from a number of sources:

- Previous Beca reports for the Hautapu Structure Plan area and Cambridge C1-C3 growth cells (Beca, 2016; Beca, 2018);
- Fonterra groundwater monitoring bores;
- On-site Stormwater Soakage Guidelines: Cambridge North Residential Zone (2014);
- Interpretation of surface water bodies; and
- Waikato Regional Council bore database.

The groundwater levels measured during winter (e.g. the shallowest measured groundwater levels over the measurement period, where available) have been used, and, for some sites are compiled over multiple winters. Where periodic groundwater level measurements have not been given (e.g. the WRC database) only measurements that are taken during the winter season have been used (e.g. between August to October).

Winter groundwater levels for the site are presented in Table 1 and the interpolated and contoured winter groundwater levels for the site (and the wider area) are presented in Figure 2.

Table 1: Winter groundwater levels for boreholes on the site.

Borehole	Easting (NZTM)	Northing (NZTM)	Groundwater level (m bgl)	Groundwater level (m RL)
BA2	1816514.84	5808987.13	2.55	63.02
BA4	1817123.9	5806217.23	1.01	64.86
BA8	1816762.11	5806444.56	0.27	64.27
BA11	1816305.67	5806427.99	3.56	61.08
BA12	1816056.32	5806808.58	4.46	60.04
BA25	1816148.32	5806345.57	4.75	60.09
BA14	1816509.86	5806381.99	2.49	63.39
BA16	1816629.95	5806217.69	3.10	63.10
BA24	1817393.16	5806060.39	2.10	64.22

The overall trend of the groundwater levels is shallowing (i.e. coming closer to ground level) to the northeast and deepening (i.e. getting further from ground level) to the southwest.

The shallowest groundwater levels are reported in the Cambridge North area. This areas does correlate to where soil maps indicate soils that are of “high runoff risk”. This implies low permeability soils that will inhibit soakage deeper into the subsurface, resulting in shallow, possibly perched, groundwater levels. There is some possibility that these soils extend across the eastern boundary of the proposed Bardowie Industrial Precinct site. There is currently limited site investigation data in this area; however, winter groundwater levels of 64 m to 65 m RL are recorded in the eastern most bores (BA4, BA8 and BA24), and, the areas described by Fonterra staff as being subject to “wet” winter conditions tend to be in the eastern half of the site.

It is anticipated that groundwater level will locally lower towards the level of the Mangaone Stream to the north of the site, however, there is currently not enough data to fully support this assumption.

Towards the western and southern boundaries of the site the winter groundwater levels are in the range of 60 m to 63 m RL (2.6 to 4.8 m bgl). This is consistent with winter water levels measured in the adjacent Hautapu Structure Plan (industrial) area and Cambridge C1 growth cell and likely reflect overall drainage towards the Waikato River some 3 km to the south of the site.

Perched groundwater levels are reported for the Cambridge C2 growth cell (2 km southwest of the site) and are considered to occur as a result of an iron pan in the upper 1.5 m to 2.0 m of the soil profile. No such iron pan has been encountered on the Bardowie Industrial Precinct site; however there remains some risk of localised perched groundwater levels on the site should lower permeability soils occur near surface.

Groundwater levels are expected to vary seasonally (i.e. be deeper in summer) by typically between 1 m to 3 m, but up to 6 m, based on quarterly monitoring of the Fonterra bores between 2015 and 2017. This is consistent with shorter duration, but near-continuous monitoring of bores for the Hautapu Structure Plan (industrial) area (Beca, 2016) and Cambridge C1 growth cell (Beca, 2018)

3.3 Hydrogeological Properties of Soils

Information on hydrogeological properties across the site has been inferred from soakage testing (Beca, 2018; BCD Group, 2018), rising head testing in piezometers (Beca, 2016), qualitative interpretation of the trickle irrigation system currently being used by Fonterra and the WRC soil runoff risk map. Variable testing methodologies have been undertaken across the different projects. For the purpose of having a consistent measure across the data sets, this report has converted all of the results to hydraulic conductivity (in SI units i.e. m/s) and based on late time test data.

3.3.1 Hydraulic Conductivity Measurements

A summary of the raw (un-factored) hydraulic conductivity measurements is given in Table 2, and displayed in Figure 3.

Table 2: Summary of hydrogeological properties of soil on and nearby site.

ID	Easting	Northing	Depth (m bgl)	Test Type	Dominant Lithology	Hydraulic Conductivity (unfactored) (m/s)	Site
TP01	1816050	5805715	6.2	Test pit soakage vertical hydraulic conductivity	Fine sand	1.50E-05	Cambridge C1-C3 (Beca, 2018)
TP02	1816114	5805179	7.3		Silty fine sand	8.31E-05	
TP03	1815592	5804574	5.1		Fine to coarse sand	2.39E-04	
TP04	1815167	5804128	2.9		Fine to medium sand	1.00E-05	
TP05	1814598	5804925	5.0		Fine to coarse sand	7.89E-05	
BH101	1815363	5806084	5.0 – 8.0	Piezo rising head test horizontal hydraulic conductivity	Fine to medium sand	6.52E-05	Hautapu Structure Plan (Beca, 2016)
BH102	1815344	5806482	5.0 – 8.0		Fine to coarse sand	9.25E-05	
BH103	1815694	5806492	5.0 – 8.0		Fine to medium sand	9.25E-05	
BH104	1814647	5806776	5.0 – 8.0		Fine gravelly to coarse sand	2.75E-05	
BH105	1814582	5806571	5.0 – 8.0		Fine sand and sandy silt	6.52E-07	
SH01	1816354	5806694	2.0	Test hole soakage vertical hydraulic conductivity	Sand	7.33E-04	Bardowie Industrial Precinct (BCD Group2018)
SH03	1816291	5806270	2.0		Sand and sandy silt	8.41E-04	
SH04	1816493	5806267	1.7		Sand with trace of gravel	2.90E-03	
SH05	1816694	5806257	1.9		Gravelly sand	3.33E-03	
SH06	1817081	5805983	1.8		Sand with some silt	5.67E-04	
SH07	1817197	5805979	1.7		Gravelly sand	2.00E-03	

The soakage tests performed by BCD Group (2018) have been reanalysed by Beca in order to allow a consistent measure across the various tests. The reanalysed soakage rates are slightly lower than the values reported by BCD Group (2018), as a result of adopting the later time data. We note that the above values are raw test results and a factor of safety should be applied to determine the longer term infiltration rate for design purposes

Overall the tests undertaken on site indicate that the vertical hydraulic conductivity of the shallow soils around the site is generally high, and likely to be suitable for soakage. However, there is some variability between tests on individual sites, with results ranging over 1 - 2 orders of magnitude (a factor of 10 to 100). This is to be expected given the depositional history of the soils, but could have implications for soakage.

Specific testing of the horizontal hydraulic conductivity is also required. Ultimately, the horizontal hydraulic conductivity will dictate how readily the disposed stormwater is transported away from the site (and hence what degree of mounding could occur beneath soakage areas). Results from testing of piezometers in the adjacent Hautapu Structure Plan area indicate that the saturated horizontal hydraulic conductivity may be 5x to 10x lower than that indicated by the shallow soakage testing undertaken on Bardowie Industrial Precinct site; however, this is still likely to be of the order required for soakage.

3.3.2 Soil Risk Map

Waikato Regional Council (WRC) have prepared a map showing the risk that soil will impede infiltration of effluent into the subsurface. Soils marked as high risk have an increased risk of effluent runoff to waterways, whereas soils marked as low risk will drain liquid more evenly through the soil profile as a result of their porosity and soil structure. Figure 3 shows the distribution of high risk, i.e. inferred low permeability soils in the vicinity of the site. The WRC have identified that soil risk for the site is low, with the soil being allophanic, well drained and having slight erosion potential. Soils with high risk for soil run off are mapped in the northeast of Cambridge North (located to the southeast of the site), and correspond to areas of shallow groundwater level and poor soakage. Although not mapped there is some risk that these soils could extend across the eastern boundary of the site.

Three key soil types have been identified which can be divided into two main facies: freely draining sandy soil (80% of site), and poorly drained silty/clayey soil (20% of site). The WRC soil risk map is mapped at a larger scale than soil type map described in Harrison Grierson (2018), and does not show any low permeability soils at the site. However, the northwest / southeast oriented spatial trend of the poorly draining soil facies mapped by Chapman (2018) roughly matches that of the WRC high risk soils and as noted above could extend into the site.

3.3.3 Trickle Irrigation System

Fonterra have been distributing treated process water onto the site at an average rate of 1.3×10^{-5} m/s (range 1.9×10^{-7} to 4.0×10^{-5} m/s) over a large area of the site (Table 3).

Whilst there is no formal reporting of the system, all communication with Fonterra suggests that there has been no runoff from the surface to nearby water bodies when irrigating at these rates. This indicates that the soil where irrigation takes places is conducive to soakage at those rates.

Whilst this is indicative of potential for soakage it is emphasized that the trickle irrigation is widely distributed and at a low infiltration rate. By contrast, soakage basins will be localised and require infiltration at a much higher rate. Hence, soakage will be most effective where it is located in areas of high hydraulic conductivity soils and relatively deep groundwater levels.

Table 3: Fonterra trickle irrigation rates for various locations.

Date	Bardowle (11, 12) *(Horotiu Soil)* (m/s)	Bardowle (18, 19, 20) *(Te Kowhai Soil)* (m/s)
2003/04	2.3E-05	2.0E-06
2004/05	1.1E-05	8.0E-06
2005/06	5.3E-06	1.8E-06
2006/07	4.8E-06	1.2E-05
2007/08	3.6E-05	1.9E-05
2009	1.7E-05	3.9E-06
2010	3.3E-05	3.1E-05
2011	3.0E-06	2.2E-05
2012	4.0E-05	1.9E-05
2013	2.6E-06	1.1E-06
2014	1.9E-07	5.6E-06
2015	2.2E-05	7.5E-06
2016	5.6E-06	1.2E-05
2017	2.0E-05	1.5E-05

4 Potential Hydrogeological and Geotechnical Constraints for Stormwater Design

4.1 Stormwater Options

The proposed stormwater design is likely to comprise a series of conveyance/soakage channels and a primary storage/soakage basin. The channels will convey surface run-off from the built up area of the site to the primary basin. An overflow channel will divert any volume that cannot be soaked away to the Mangaone Stream at the north of the site.

The dimensions and locations of these features has not yet been finalised, hence the statements below are typically generalised across the site. Specific commentary is however provided for the southern boundary of the site, where it is anticipated that the primary soakage basin will be located.

4.2 Hydrogeological Constraints

4.2.1 Depth to Groundwater

Figure 2 and Table 1 show the depth to groundwater based on the current Fonterra piezometers on the site and previous monitoring by Beca in the wider area. It can be seen from this that the groundwater level is likely to be encountered at depths greater than 2.5 m across the southern and western parts of the site during winter. However there is some uncertainty that will need to addressed, regarding site specific groundwater levels at the locations of soakage features, and, of groundwater levels in the north-eastern quadrant of the site.

4.2.2 Infiltration Rates and Groundwater Mounding

Whilst there is infiltration data available (e.g. Fonterra “trickle irrigation” system and nearby Beca hydraulic conductivity measurements), the spatial variability of soil types and therefore potential for variation in hydraulic conductivity, necessitates further investigation. Even where more permeable layers are present at the surface they may be underlain by lower permeability layers which could constrain the long term rate of infiltration.

There is a risk that where stormwater is able to infiltrate through the base or sides of a channel or basin, it could lead to elevated groundwater levels (localised mounding) that reach or exceed the groundwater surface and result in surface flooding. Mounding of the groundwater levels will impede further soakage of water into the subsurface and it may be necessary to restrict groundwater infiltration in areas with shallow depths to water and limited freeboard in order to avoid excessive mounding.

The magnitude and extent of groundwater mounding will be dictated by the saturated horizontal hydraulic conductivity which requires further testing.

4.2.3 Cumulative Effects of Multiple Sites Discharging to Groundwater

Discharge of stormwater to the ground is also proposed for the Hautapu Structure Plan (industrial) area, Cambridge C1 and C2 growth cells and Cambridge North Residential , all of which are along or down-gradient from the site and hence could limit the long term discharge from the Bardowie Industrial Precinct site. Consideration of the cumulative effects of multiple discharges will be required.

4.3 Geotechnical Constraints

4.3.1 Stability of Cuts

A shallow depth to groundwater (and the potential for seepage to reduce the stability of batter slopes) may require lower slope angles which would increase the area of the channels or basin. This is likely to be most significant across the northern and eastern parts of the site where the groundwater levels are closer to the surface but could also be significant where deep excavations are planned (if they are located below the groundwater level and in more permeable layers).

4.3.2 Lateral Spreading

Lateral spreading, or lateral movement, occurs when earthquake shaking induces soil to lose cohesion and move. The loss of cohesion may be caused by liquefaction, which is caused by earthquakes increasing pore water pressures such that grain on grain contact is reduced, resulting in the soil mass acting like a fluid. Three key elements are all required for liquefaction, and thus lateral spreading, to occur:

1. Loose non-plastic soil (typically sands and silts)
2. Saturated soil
3. Sufficient ground shaking

While a geotechnical evaluation is required to understand the liquefaction potential of the site (and this is the scope of BCD group), the soil types that are present at the site are considered potentially susceptible to liquefaction (MBIE, 2017) e.g. quaternary aged sandy soils that are below the groundwater table or are saturated.

Where a wetted base occurs in a swale or basin (either due to ponded or stored water in the base, or, due to being excavated close to or below the groundwater level) the side slopes may be susceptible to lateral spreading, as the underlying material may be saturated and liquefy during an earthquake. This will require specific consideration during further design phases.

5 Summary

The data available is sufficient to inform the plan change and indicates that generally the site is suitable for the disposal of stormwater via soakage to the ground. However, further investigation and analysis will be required for developed and detailed design in order to confirm infiltration rates, the stormwater volumes can be disposed, the required area for stormwater soakage, and, the magnitude and extent of any groundwater mounding.

Yours sincerely

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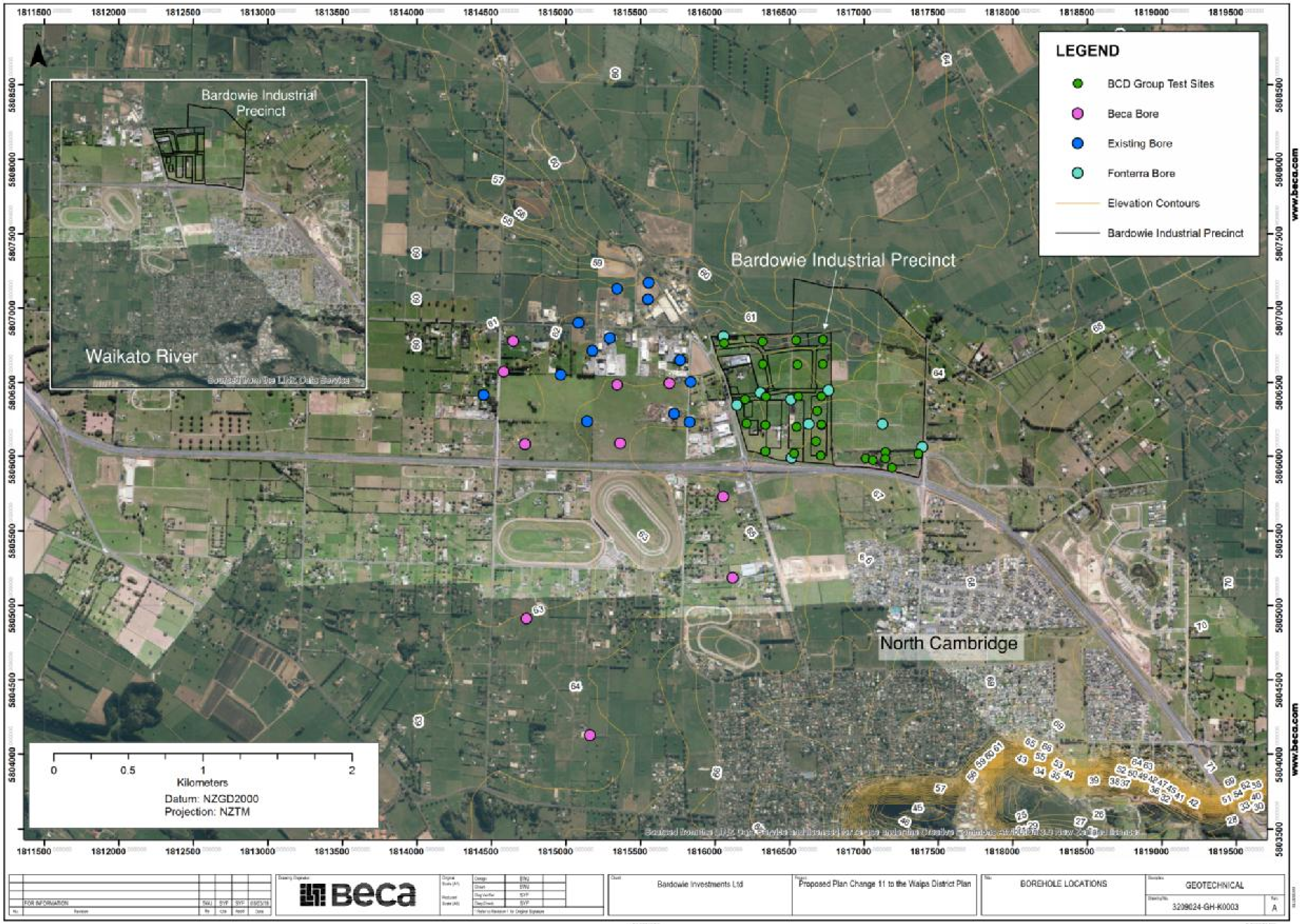

Figure 1: Overview of the site and borehole locations.

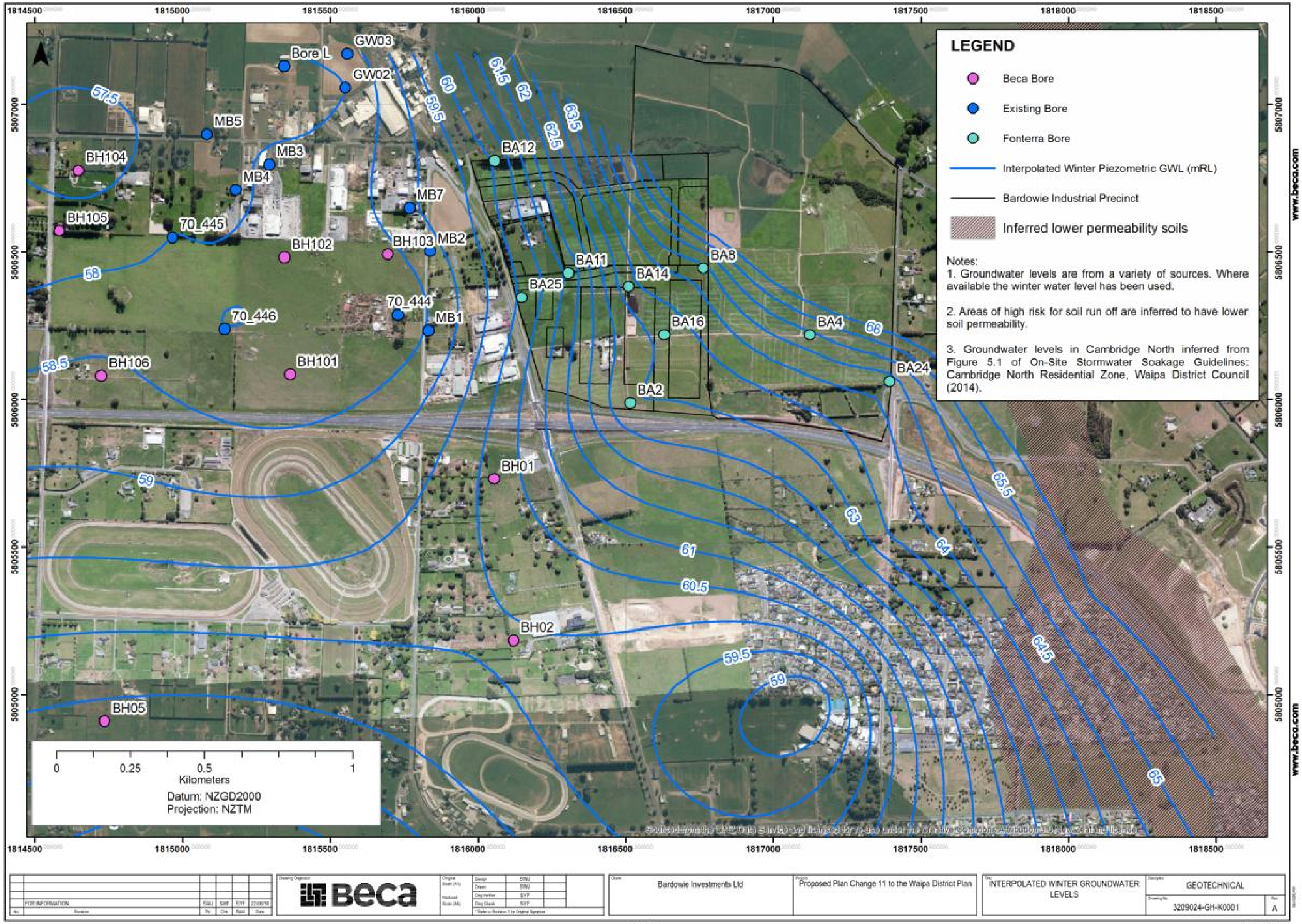

Figure 2: Interpolated winter groundwater levels.

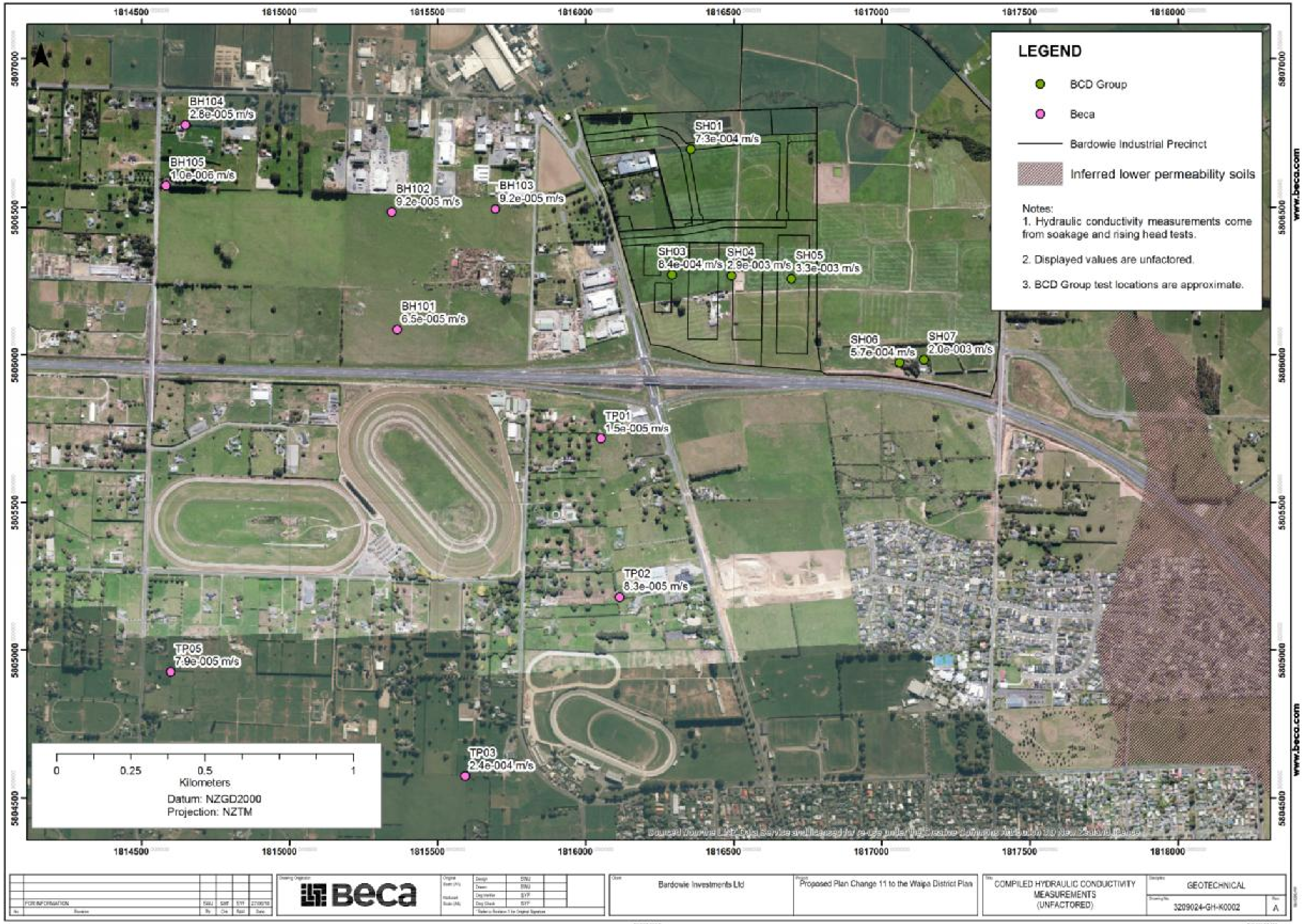

Figure 3: Compiled hydraulic conductivity measurements.