Table 1 Summary of relevant site investigation

Type	Specified by	Provided by	Latest date / version	Notes
Light Detection and Ranging (LiDAR) data	NA	LINZ	2019	1m contours
Computer Aided Design (CAD) masterplan for property boundary, lot boundaries, planting areas, riparian protection corridor, building platforms, road layout, and contour levels	Maestro Projects	Baxter Design	18/02/2020	See Master Plan
Road alignment and geometry	Maestro Projects	Bartlett Consulting	31/08/19	
Geotechnical Report	Maestro Projects	Geosolve Ltd	Geotechnical Report for Resource Consent – July 2019	
Ecological Assessment	Maestro Projects	E3 Scientific	Ecological Assessment v1 June 2019	Pongs Creek is a known, secure population of the Clutha flathead galaxias (Galaxias “species D”) (DOC, 2016), which has a conservation status of Threatened. This species is currently protected from other fish species by the presence of a perched culvert.
Onsite Wastewater Management Site Assessment Report	Maestro Projects	E3 Scientific	Version C, 23/09/2019	• Wastewater application areas based on site permeameter testing • Primary, secondary and tertiary wastewater treatment requirement
Permitted and Consented water off-take volumes	Maestro Projects	Environmental Associates Ltd	Certificate of Compliance Application 16 August	See Table 1 permitted and Consented Water Takes: • 0.5 L/s & 25,000 L/day (domestic + animal) • 10 L/s & 100,000 L/day (not for irrigation) • 0.5 L/s & 25,000 L/day (any use) • 1 L/s & 3,000 L/day (any use)

4 DESIGN PERFORMANCE, STANDARDS AND CRITERIA

The Section outlines the standards and requirements of particularly relevant to this design.

4.1 Wastewater

The wastewater system should be designed to convey the peak wet weather flow without surcharge and an asset life of at least 100 years. Some components such as pumps, metering, control valves, and control equipment may require earlier renovation or replacement but should have a minimum 20yr design life.

The following relevant standards and performance requirements apply:

- QLDC Land Development Code of Practice 2017 (Dated 17/04/18)
- AS-NZS 1547-2012 On-site domestic wastewater management
- IS-OSW-Onsite-Wastewater-Disposal-Guidance-Rev-2
- NZ Building Code Clause G13 Foul Water Amendment 8
- Guideline Document: On-Site Wastewater Management in the Auckland Region Sept 18 (2018/006)

4.2 Stormwater

The primary piped SW system should be designed to convey flow from the critical 5% AEP storm event, with climate change allowance, without surcharge and an asset life of at least 100 years. Some components such as pumps, metering, control valves, and control equipment may require earlier renovation or replacement but should have a minimum 20yr design life.

The secondary over land stormwater system should be designed to convey flow from the 1% AEP storm event without increasing the risk of flooding to downstream properties and maintaining relevant freeboard.

The following relevant standards and performance requirements apply:

- NZ Building Code Clause E1 Surface Water Amendment 10
- QLDC Land Development Code of Practice 2017 (Dated 17/04/18) – 'QLDC LDSC'

4.3 Water Supply

The water supply system should be designed to provide sufficient capacity to meet peak demand while maintaining minimum pressure and ensuring the appropriate firefighting flows and pressure can be achieved. Backflow prevention must be suitable for the hazard rating of the system.

The following relevant standards and performance requirements apply:

- QLDC Land Development Code of Practice 2017 (Dated 17/04/18)
- NZ Building Code Clause G12 Water Supplies Amendment 12
- SNZ PAS 4509-2008 NZ Firefighting Water Supplies Code of Practice (CoP)

The proposed design meets the design requirements bar the following deviations:

- It is common practice for consents in the Queenstown area to specify a 20,000 L static firefighting reserve within a 30,000 L tank for on site water storage. This 20,000 L firefighting supply is not consistent with Table 2 of SNZ PAS 4509:2008 which specifies 45,000 L for a fire classification of FW2. This is discussed in a recent hearing:
https://www.qldc.govt.nz/assets/Uploads/Planning/District-Plan/Hearings-Page/Memorandums/S0438-NZFS-Commission-T02-memorandum-of-counsel.pdf

4.4 Other Services

The assessment and provision of other services is by others, but the following relevant standards and performance requirements apply to their coordination:

- National Code of Practice for Utility Operators' Access to Transport Corridors

4.5 Pavements

Pavements, roads and footpaths shall be designed to resist the expected design loads and achieve an asset life.

The following relevant standards and performance requirements apply:

- QLDC Land Development Code of Practice 2017 (Dated 17/04/18)

4.6 Sustainable design

- QLDC Land Development Code of Practice 2017 (Dated 17/04/18)

5 WASTEWATER

5.1 Existing Infrastructure

Based on available infrastructure Assessments and local knowledge of the Cardrona Valley, there is currently no capacity within the existing reticulated wastewater infrastructure to service the new development.

It is assumed that the existing dwelling within the project boundary and the adjacent Pringles Creek Subdivision utilise traditional on-site wastewater treatment and disposal systems.

5.2 Proposed Development Flows

It is assumed that the future dwellings will have 4 bedrooms each. In accordance with AS/NZS 1547:2012 this equates to a design population equivalent of 6-7 people, producing the wastewater demand and required all waste tank size presented in Table 2. If the final owners of the property choose to have additional or fewer bedrooms, then a refinement of this initial wastewater sizing can be carried out during the Building Consent phase.

Table 2 Wastewater demand estimation per dwelling (from Table J1 of AS/NZS 1547:2012)

No. of bedrooms	Population equivalent (people)	Design flow (L/day)	All waste tank capacity requirement per dwelling (L)
4	6 - 7	1,000 - 1,400	3,500

Equating the design flow in Table 2 with the population equivalent gives a wastewater design flow of approx. 200 L/person/day (1,400 L/day / 7 people). Section 5.3.5 of QLDC LDSC states that, based on three people per dwelling, the average Dry Weather Flow (DWF) is 250 L/person/day with a diurnal peaking factor of 2.5 and a dilution / infiltration factor of 2, see Table 3. Table 3 shows a single property would have a daily DWF of 0.75m^3/day (750 L/day) which is significantly less than the proposed 1,400 L/day. The 1.5m^3/day (1,500 L/dwelling/day) in Table 3 is similar to the proposed 1,400 L/dwelling/day flow and includes an allowance for groundwater infiltration and stormwater flows. Groundwater infiltration and incorrect stormwater connections should be minimal on the proposed network involving a small number of private wastewater connections from lots with dedicated stormwater management discharging to a sealed low pressure main.

Table 3 Wastewater demand estimation based on Section 5.3.5 of QLDC LDSC

Number of dwellings	Dry Weather Flow (DWF) (m^3/day)	Daily peak DWF (L/s)	Wet Weather Flow (WWF) (m3/day)	Daily peak WWF (L/s)
1	0.75	0.022	1.5	0.043
16	12	0.347	24	0.694

Combined with the use of water efficient appliances, the design values presented in Table 2 are considered appropriate. Further details are provided in E3's documentation.

5.3 Wastewater Management

Due to the current unavailability of a public wastewater connection, treated wastewater effluent must be discharged to land. Considering the variable topography of the site, this could be achieved by subsoil drip irrigation utilising a UniRam, or similar, pressure compensating emitter system that can be laid at a variable grade. In accordance with QLDC's Onsite Wastewater Disposal Application Form, drip lines would be installed at a minimum depth of 300mm below the surface to minimise the risk of damage resulting from freezing. Further frost protection is achieved through specification and design of the drip lines to be free of effluent between application doses.

The wastewater application area is located and sized in accordance with Section M7 of AS/NZS 1547:2012. Desk study identifies the predominant soil type to consist of moderately structured light clays which is a category 5 soil to Table M1 of AS/NZS 1547:2012 with an indicative permeability rate of 0.06-0.12 m/day; the recommended design irrigation rate of secondary treated effluent in this soil is 0.003 m/day (3mm/day).

This desk study was confirmed following site investigations. E3 Scientific has undertaken constant head permeameter field tests on possible application areas to assess the design irrigation rate, see Section 3.1.2 of E3's Onsite Wastewater Management Site Assessment Report. Testing showed much of the property to be unsuitable for disposal via shallow irrigation due to a perched water table, but the ground that was suitable had measured permeability rates consistent with the 3mm/day from the desk study. The property is also constrained because of the desire to maintain a 50m offset to surface water which is a resource consent trigger for Otago Regional Council (ORC); this requirement is considered to be best practice rather than a site constraint as resource consent will be required in any event for this development due to the volume of effluent being discharged to land (>2000 L/day). Suitable application areas have been identified by E3 on the western side of Pringles Creek, largely between the 50m offsets of Pringles and Pongs Creeks. It should be noted that wastewater discharge of 2,000 L/day is a permitted activity with larger discharges requiring Resource Consent. There is an intention to stage the development in accordance with the staging plan. As the daily discharge from each dwelling of 1,400 L/day (Table 2) is less than 2,000 L/day, there is opportunity to have individual lots discharge to their own area of the communal application area as a permitted activity. A condition on this may be the need to have a dedicated reserve to that lot's application area and for that lot to discharge to a dedicated individual, rather than communal, distribution main.

The possible wastewater application areas are shown in Figure 1. The required size of the application areas is shown in Table 4 which assumes a 100% reserve area is required in accordance with Section 5.5.3.4 of AS/NZS 1547:2012. However, with the provision of secondary and tertiary treatment the need for 100% reserve can be challenged. Section B5.5 of Auckland Council Guideline Document 2018/006 provides guidance about how a reduced reserve area can be justified where secondary effluent is being discharged and where conservative estimates for wastewater flow generation can be demonstrated.

Table 4 Total wastewater drip irrigation estimation

Application area	Design drip irrigation rate[1] (mm/day)	Number of dwellings [1]	Design flow (L/day)	Base application area (ha)	Total application area including reserve (ha)
Communal	2.0	16	22,400	1.12	2.24

[1] *From E3 Onsite Wastewater Management Site Assessment Report including 20% reduction due to 10-20% sloping site as advised in Table M2 of AS/NZS 1547:2012*

Options for domestic wastewater management are presented in Table 5 – each would be sized to meet the design flows presented in Table 4, or adjusted to suit the actual dwelling size. Option 1 is not viable, whilst Options 2 to 4 are viable subject to a cost assessment. The required level of wastewater treatment is to be assessed at detailed design to meet the required discharge consent conditions. E3's 'Onsite Wastewater Management Site Assessment Report' states tertiary treatment is required due to the sensitive nature of the receiving environment. Options 2 to 4 require a low pressure main to collect flows from the lots and convey to the upslope end of the communal application area shown on the master plan, this is where any communal treatment facility would be located.

Table 5 Domestic wastewater management options

Option	Description	Assessment	Decision
1	On-site full treatment + on-site disposal	Except for lot 16 (existing consent) on-site disposal not possible due to limited lot size and a perched water table across much of the site	Unviable
2	On-site full treatment + communal disposal	Dependent on individual lot owners maintaining their treatment units or paying into body corps with rights of access. Allows staged development of lots with construction of communal treatment facility	Viable, subject to cost assessment
3	Communal full treatment + communal disposal	Likely to be most cost-effective option but requires treatment for entire development to be operational prior to any lots being occupied. Likely location to be immediately upstream of communal application area with access taken from the existing access road	Viable, subject to cost assessment
4	On-site partial (primary) treatment, communal partial (secondary, tertiary) treatment + communal disposal	Possibility to stage development with some additional on-site treatment costs required until communal treatment online. May provide good balance of costs with majority of solids retained at source	Viable, subject to cost assessment

The on-site treatment (options 2 and 4) arrangement would involve a septic tank effluent pump (STEP) system involving primary, secondary and potentially tertiary treatment within the lot before the treated effluent is pumped into a low-pressure community main that conveys flows to the communal wastewater application area. The effluent would be applied to the land via subsoil drip irrigation.

The communal treatment (options 3 and 4) arrangement would involve flows to be collected via a low-pressure community main that conveys flows to the communal wastewater treatment plant providing the required level of treatment before the effluent is discharged to the application area via subsoil drip irrigation.

On-site wastewater treatment options are presented in QLDC Onsite Wastewater Disposal Guidance. Options for communal wastewater treatment are presented in Table 6.

Table 6 Communal (centralised) wastewater treatment options from MFE (Table 8.4 of https://www.mfe.govt.nz/publications/waste/sustainable-wastewater-management-handbook-smaller-communities-part-3-options-2)

Wastewater conditioning	Primary treatment	Secondary treatment	Tertiary treatment
Screening and grit removal	Imhoff tank Clarigester	Activated sludge: • standard aeration • extended aeration • oxidation ditches • sequencing batch reactors	Sand filters (following activated sludge, biofilter or pond systems)

Wastewater conditioning	Primary treatment	Secondary treatment	Tertiary treatment
	Sedimentation (large capacity septic tank) Sedimentation with chemical addition	Biofilters: • trickling filter (biological filter) • rotating biological contactor • recirculating Packed bed Reactor	Disinfection (pathogen removal): • chlorination • UV • ozone
	Oxidation ponds (primary treatment)	Sand filters: • intermittent sand filter • recirculating sand filter	Oxidation ponds (maturation treatment)
		Oxidation ponds (secondary treatment)	Overland flow / land application

The wastewater application areas would have limited above ground impact in the form of fences, marker posts and potentially some bunding to control stormwater runoff or fluvial flooding. Controlled grazing could take place in the form of sheep (cattle / horses will be too heavy).

There is likely to be a desire by lot owners to install spas or swimming pools. If swimming pools / spas are to be installed there would need to be dedicated on-lot treatment for the backwash wastewater which cannot be treated using conventional domestic wastewater treatment devices. Considering the sensitivity of the receiving environment, this treatment could also be applied to pool overflow water or the entire body of water if it is being drained. A de-chlorination device may form part of the treatment required for draining the pool, although leaving the pool for a week would allow chorine to dissipate. The treated swimming pool water would then discharge to soakage / land application which could be the same discharge used for the stormwater (see Section 6.3), although there would be some design and operational requirements to limit capital cost such as draining the pool only in dry weather and via a restriction.

There is expected to be expansion within the Cardrona Valley with a new public wastewater treatment plant. Allowance for a future point of connection to this wastewater treatment plant, from upstream of the communal wastewater application area, should be considered during detailed design. Consideration should also be given to how on-site treatment could be decommissioned should a downstream connection to the wastewater treatment be made. Provision for a direct gravity connection to a grinder pump discharging to the small bore community pressure main would be one option.

5.4 Assessment of Infrastructure Effects

Based on site investigation the development has sufficient capacity to facilitate the communal disposal of effluent to land via a STEP system or a small community wastewater treatment plant using sub-soil drip irrigation. The permanent effects of the proposed systems on the environment are considered to be minor.

6 STORMWATER

6.1 Existing Infrastructure

The existing site is dominated by grassed surfaces and generally slopes from the south to the north, with some existing swales, hills, gullies, and creeks within the site boundary. There are two races crossing through the site and overland flow routes through the property drain to either Pongs or Pringles Creek.

The site is located outside of the QLDC stormwater drainage scheme boundary. There is no integrated stormwater infrastructure or management plan for the Cardrona area. The existing dwelling within the site disposes of stormwater via soakage to ground.

Stormwater drainage is generally conveyed via roadside swales, ephemeral gullies and culverts towards Pongs and Pringles Creek, under the Cardrona Valley Highway and ultimately draining to the Cardrona River.

There are a few existing culverts which currently convey stormwater beneath the local roads bordering the development.

6.2 Proposed Stormwater Flows

The Landscape Architect's design of the proposed development has aimed to maintain as much of the existing rural character and hydrology as possible. Maintaining the existing hydrology involves mimicking natural stormwater runoff and infiltration regimes and not creating new dedicated discharge points to watercourses. E3's Environmental Assessment Report establishes the sensitivity of Pongs Creek and so the design approach to stormwater management is to allow water to move through and across the land as it currently does. The development primarily consists of natural grass lands. Thus, the only increase in impervious area will be from the building roofs, new roadways, driveways and on-lot hard landscaping.

6.3 Stormwater Management

Because the nature of the new dwellings is unknown it is difficult to quantify the additional runoff associated with the development. Rainwater harvesting will reduce the demand on the proposed reticulated water supply system for irrigation whilst also offsetting any potential increase in impermeable area resulting from the buildings. The aim of the stormwater management for the development is to replicate the pre-development hydrological regime. Rainwater falling on new impermeable surfaces will partly:

- Be retained via rainwater harvesting, mimicking the retention of stormwater on the surface
- Discharge to ground via soakage, mimicking natural infiltration
- Discharge to surface via above ground dispersal, mimicking run off following saturation

When discharging to a primary stormwater drainage system it is a requirement under Section 4.3.5.1 of QLDC LDSC to limit post-developed peak discharge to pre-development rates for a given AEP storm event. For this development, there will be no discharge to a piped stormwater system and so there is no requirement to restrict peak discharge. Rather, the proposed approach will naturally mitigate any potential local increase in peak flow through the low impact design measures outlined. Calculating pre and post-development peak runoff in this instance will do nothing to achieve the primary aim of replicating the pre-development hydrological regime, instead a pragmatic and intuitive approach is taken.

In accordance with Section 4.3.7.9 of QLDC LDSC, soakage devices are to be sized to accommodate the 5% AEP storm event with a 50% reduction factor applied to the soakage rate determined on site. Section 7.3 of Geosolve's Geotechnical Report presents test data from across the development suggesting a long-term infiltration rate of 0.1 $L/m^2/min$ at a minimum of 1m depth. All soakage is required to be at 1m below ground level due to the perched water table across much of the site. Applying the 50% reduction factor gives a design infiltration rate of 0.05 L/m^2/min (mm/hr). This is not a viable infiltration rate for soakage along meaning storage is required to contain stormwater until it has time, post storm event, to infiltrate into the ground. For buildings, it is advised that any rainwater tank harvesting system be linked to the soakage system via an overflow such that water is retained before overflowing to soakage. Table 7 presents required soakage pit sizes for 100m^2 impermeable areas based on the 5% AEP storm (HIRDS v4 data including 2.1degree climate change in accordance with C4.3.5.1 of QLDC LDSC).

Table 7 Soakage pit sizes for 100m^2 impermeable areas based on the 5% AEP storm

Impermeable area type	Runoff coefficient[1]	Required soakage pit storage volume (m^3) / 100m^2 of impermeable area
Roof	0.9	8.0
Asphalt and paving	0.85	7.4

1 From NZ Building Code Clause E1

Based on Table 7:

- A 250m^2 building roof would require a soakage pit of 20.0m^3
- A 25m length of Type E3 Road (6m seal width) would require a soakage pit of 11.1m^3

Road runoff could be managed by an adjacent swale on the downslope side with soakage pits or above ground dispersal installed intermittently along its length. Alternatively, new discharge connections to Pongs Creek could be made, although this is not advised upstream of an existing culvert due to the sensitivity of the receiving environment, particularly with respect to the protected Galaxias fish; see E3's Environmental Assessment report for details. Depending on the topography, swales could include check dams to retain flow, potentially reducing the size of the required soakage device.

Overflows from soakage devices, particularly from buildings, could be managed using above ground dispersal pipes installed around landscaped areas. This would mimic the natural hydrology of the site whereby stormwater infiltrates into the ground until saturated, at which time it runs off overland to the watercourse.

There is a myriad of green infrastructure, low impact, options to manage stormwater flows across the development, to complement the approach of retention, soakage and above ground disposal, listed in Section 4.3.7.3 of QLDC LDSC. Selection and placement of these devices, if appropriate, will be undertaken at detailed design. So as not to destabilise building platforms, soakage devices should be located at least 10m away from new permanent slopes.

Existing races running through the site will largely be maintained although some slight alteration / re-routing around lots 11 and 12 may be required depending on how the design develops. The proposed wastewater application areas will also require cut off drains (as shown in E3's Onsite Wastewater Management Site Assessment Report). Where possible, intercepted or diverted flow paths will be reconnected to their current downstream path to maintain the current flow regime of the area. Detailed design of these aspects will require a detailed site survey, for example via a drone.

The majority of the proposed infrastructure works will be outside of the Pongs Creek Clutha Flathead preservation corridor although there is a risk of flooding to Lots 11 and 13 from the Creek. As proposed in

Geosolve's Geotechnical Report, the risk of flooding to property could be mitigated through nominally 1m high bunding and ensuring Finished Floor Levels (FFLs) provide adequate freeboard. Downstream culvert extensions are required to facilitate upgrade of the existing access to Figure E3 where it crosses Pongs and Cringles Creeks. These culvert extensions will take place on the downstream side so as not to impact on sensitive upstream environments. Barriers could be installed to limit the road width at these crossings, but earthworks negating the need for barriers has been provided for in the earthworks drawings.

6.4 Assessment of Infrastructure Effects

Water sensitive design principles will be applied to mimic the existing hydrology of the area, namely soakage and runoff to the creeks. This will be achieved through a combination of on-site rainwater harvesting for reuse, soakage to ground and above ground dispersal.

Stormwater discharge to land and water is authorised by ORC's 'Water for Otago Regional Plan' which was prepared to manage the water resources of Otago in accordance with the Resource Management Act of 1991. Stormwater discharge from roads and overland flow not connected to a reticulated system to land or water is a permitted activity, subject to the rules set out in Section 12.B.1.9.

The discharge of stormwater from any road not connected to a reticulated stormwater system to water, or onto or into land, is a permitted activity, providing the discharge does not cause flooding of any other person's property, erosion, land instability, sedimentation or property damage.

The permanent effects of the proposed systems on the environment are considered to be minor.

7 WATER SUPPLY

7.1 Existing Infrastructure

The closest water supply infrastructure to the development is owned by a private water company, Cardrona Water Supply Ltd., but due to spatial separation and lack of adequate supply this is not a suitable connection option for this development.

Existing dwellings within and around the site currently utilise an existing surface water take from Pringles Creek, see Environmental Associates Ltd's Permitted and Consented water off-take volumes letter 16 August 2019.

7.2 Proposed Development Flows

The proposed development will create a new demand for both domestic and fire-fighting water supply which will principally be catered for via a new surface water take from Pringles Creek in conjunction with suitably sized storage tanks. Water derived from this surface water source will require a high level of treatment before it can be considered suitable for human consumption. Bacteriological content, nutrient levels, colour, pH and mineral content must be tested to determine the treatment required to comply with the Drinking Water New Zealand Standards. Above ground infrastructure would be required to treat the water with above ground pump enclosures across the distribution network to ensure the treated water reaches all parts of the development. The sizing and specification of the above ground infrastructure will be undertaken at detailed design to suit the development requirements.

E3 Scientific has advised that the proposed on-site planting will not require irrigation, so no specific allowance for irrigation flow is being made. Furthermore, non-potable demand could be partly met by the provision of on-site rainwater harvesting – this has not been specifically considered in the demand estimates.

Section 6.3.5.6 of QLDC's LDSC states that a minimum residential water demand of 700 litres/person/day should be provided. This volume allows for both indoor and outdoor use include landscape watering, external cleaning, and all internal uses. This development is proposing to use rainwater collection for irrigation use, thus reducing the volume of water required. Section 6.3.5.6 of NZS 4404:2010 advises there should be provision for 250 L/person/day which could still be considered conservative considering modern water saving appliances – approval of this 250 L/person/day figure is at the discretion of the Council.

Proposed water demand should be seen in the context of the 200 L/person/day wastewater demand presented in Section 5.2. In the absence of irrigation and with an allowance for leakage in the water distribution network, the majority of the water supplied will go to waste. Provision of a domestic water supply based on 250 L/person/day is therefore considered proportionate. Leakage from this small private scheme is likely to be lower than would occur in a much larger network such as in Queenstown.

A suitable static firefighting water volume will be required to meet QLDC requirements.

Estimates for the required water supply can be assessed in the following ways with respect to Table 8:

1. Based on on-site storage
2. Based on communal storage
3. Based on a combination of onsite and offsite storage

Table 8 Peak water supply demand comparing 250 and 700 L/person/day demand for single and 16 lots

Population equivalent (people)	Domestic water demand / person (L/person/day)	No. of dwellings	Average Daily Demand (L/day)[1]	Mean Day Max Month (L/day)[2]	Peak day (L/day)[3]	Peak hour (l/s)[4]	Firefighting demand (L/s)	Total required flow (L/s)
7	250	1	1,750	2,625	3,500	0.08	22	22.08
7	250	16	28,000	42,000	56,000	1.30	23	24.30
7	700	1	4,900	7,350	9,800	0.23	24	24.23
7	700	16	78,400	117,600	156,800	3.63	25	28.63

1. *The operational storage requirement are based on assumptions within WSA 03-2002:*
2. *1 Average Daily (AD) demand is people x L/person/day x No. of dwellings*
3. *2 Mean Day Max Month is 1.5 times AD*
4. *3 Peak Day (PD) is 2 times AD*
5. *4 Peak hour is 1/12th of PD*

Option 1 considers each dwelling having its own on-site storage tank for domestic and firefighting water supply. Experience within QLDC shows that a static firefighting water supply of 20,000 L within a 30,000 L tank is normally acceptable although a smaller domestic demand volume than 10,000 L could be admissible based on 250 L/person/day average demand; Table 8 Shows that peak day volume for a single property is 3,500 L based on 250 L/person/day compared to 9,800 L based on 700 L/person/day. On-site booster pumps would provide the required minimum 250kPa pressure for domestic use. On-site tanks could be above or below ground and would negate the need for a communal storage facility. The 20,000 L firefighting volume negates the need for hydrants with the on-site tanks being drip-fed by a small-bore line distributing potable water from the communal treatment facility. On-site tanks also provide a degree of resilience and flexibility because water can be tankered in to individual lots which may assist with the staged development of the site. Combined on-site domestic and firefighting water storage would need to be carefully designed to ensure water quality is not compromised considering average daily turnover would likely be less than 2,000 L/day.

Option 2 considers communal storage adjacent to the communal treatment facility with a water main supplying each lot for both domestic and firefighting. There may be opportunities to have parallel mains, one with untreated raw water for firefighting and a second with treated potable water for domestic use. Separate storage tanks would increase the turnover of the domestic water that would be beneficial from a water quality perspective. This arrangement would incur the extra capital cost of the second pipe in a slightly wider trench whilst potentially saving operational cost on the amount of water to be treated – this saving would only be realised in the event the fire supply was used. Such an arrangement would require fire hydrants to be located in accordance with SNZ PAS 4509:2008 (Table 2): two fire hydrants will be required at a maximum distance of 135m and 270m from each lot, with each of the two hydrants providing a minimum of 12.5 L/s, a total of 25 L/s. Booster pumps would be required along the distribution main to provide a minimum 100kPa of pressure at hydrants and 250kPa at buildings.

The required storage for domestic water could be based on the 10,000 L / dwelling capacity implied by the typically consented on-site storage option presented in Option 1, or the 3,500 peak day flow based on 250 L/person/day, 160,000 L or 56,000 L respectively.

Based on a water supply classification of FW2 to SNZ PAS 4509:2008 (Table 2), 45m^3 of storage is deemed to be an appropriate amount of static firefighting reserve water considering the need to supply two hydrants, although it could be argued the 20m^3 based on what is typically consented for on-site firefighting storage is sufficient. For the purposes of the communal firefighting water storage, only one building is assumed to be on fire at any time – this is appropriate considering the size of the lots and the separation distances between buildings. A conservative estimate of leakage from the new water reticulation main is 5% of the domestic + firefighting storage. Based on 250 L/person/day, this would give a total communal storage volume of approx. 110,000 L (56,000 + 45,000 + 5,050).

Option 3 would involve some hybrid of Options 1 and 2.

A new water take from Pringles Creek is proposed in the northern side of the development. This would take water in accordance with the permitted and consented water take from Environmental Associates Ltd's Permitted and Consented water off-take volumes letter 16 August 2019, shown in Table 9.

Water would be collected from Pringles Creek at the average daily demand which is, based on 250 L/person/day and 100% site occupancy, 0.32 L/s. The permitted and consented water take is presented in Table 9 with the maximum 30 day month take equating to 0.41 L/s (based on max 106,5000 L/month presented in 'Permitted and Consented water off-take volumes letter 16 August 2019') which means there is adequate permitted and consented water supply to service the development. In the event of drought and surface water take restrictions implemented by ORC, potable water will need to be tankered to site and community restrictions implemented to minimise water usage.

Table 9 Permitted and Consented Water Takes for the Roberts Family Trust Landholding (from Environmental Associates Ltd's Permitted and Consented water off-take volumes letter 16 August 2019)

Rule and Consent rate, volume and use	12.1.2.1[1] 0.5 L/s and 25,000 L/day	12.1.2.4[1] 10 L/s and 100,000 L/day Not for irrigation	12.1.2.5 0.5 L/s and 25,000 L/day For any use	RM17.212.01 1 L/s[2] and 3,000 L/day For any use
Maximum daily volume	25,000	100,000	25,000	3,000
Maximum monthly volume (30 day month)	750,000	300,000	750,000	90,000
Maximum potential daily water use	750,000	300,000	750,000	90,000
Maximum potential irrigation water use	0	0	750,000	90,000
Subject to suspension	0	300,000	750,000	90,000[3]

[1] Permitted activity not subject to per-landholding requirement
[2] Cumulative instantaneous rate of take
[3] Subject to suspension if utilised for irrigation purposes

7.3 Water Supply Management

Although water will be sourced from Pringles Creek and treated locally to Drinking Water New Zealand Standards there are two principal options for the storage and distribution of this water. Storage of some kind is required because the peak instantaneous demands presented in Table 8 cannot be met based on the permitted and consented water take. The three Options for water supply management, introduced in Section 7.2, are summarised in Table 10. All three options require communal treatment at the water take with storage volumes being verified during detailed design based on a calculate water balance taking account of seasonal flow variations in Pringles Creek and a cost / risk assessment of more storage versus tankering supply in times of water scarcity.

Table 10 Example water storage and distribution options (excluding storage associated with the communal water treatment plant)

Option	Description with min storage volumes	Assessment	Decision
1	Based on on-site storage: • 20,000 L firefighting • 3,500 L domestic	A single onsite tank for each lot, potentially compartmentalised to retain firefighting flow and provide good turnover of domestic supply. Low pressure drip feed from communal main would keep tanks topped up	Preferred option, results in most resilient and flexible supply
2	Based on communal storage: • 45,000 L firefighting • 110,000 L domestic	A series of tanks to be provided local to the water take treatment facility supplying a pressure main (or possibly two if raw / treated water is segregated) that supplies each lot, including hydrants across the development	Viable, although larger main with hydrants and more communal booster pumps necessary to maintain required pressure
3	Based on a combination of onsite and offsite storage • 45,000 L firefighting • 3,500 L onsite domestic	Option to retain onsite storage tank for resilience / flexibility of supply with communal raw water firefighting storage	Possible advantages separating raw firefighting water from treated domestic, although largely incurring the disadvantages of both Options 1 and 2.

A variant of Option 1 could involve lots sharing a local water tank. The reality is that a single tank within 90m of two properties would need to be approx. 40,000 L to accommodate the firefighting demand and 10,000 L domestic demand / property. Providing storage this way may mean standard size tanks aren't available and costs shift from the property owner to the developer. The sharing of water tanks is not deemed to provide any significant benefits over individual lot storage.

Raw and treated water storage would be required at the communal water treatment plant to buffer demand and to allow for pump operating volumes; these volumes would be additional to those shown in Table 10 and would be determined at detailed design to ensure adequate storage for the operation of the water supply system.

The proposed water take is near the high point of the development and all options will require a suitably sized distribution main and booster pumps as needed. Detailed design shall ensure that the required residual pressures are met in accordance with QLDC LDSC and other relevant standards in order to provide reliability and quality of supply.

Future expansion within Cardrona Valley is forthcoming and there may be an opportunity to recognise some synergies with this development. A future point of connection should be considered during detailed design and incorporated.

7.4 Assessment of Infrastructure Effects

The proposed surface water take can meet the required water demand of the development with storage providing the required buffer to accommodate peak domestic and firefighting demands. Potable water treatment methodology will be implemented to ensure the water supply meets NZ Drinking Water Standards. The permanent effects of the proposed systems on the environment are considered to be minor.

8 ACCESS

8.1 Existing Infrastructure

Curtis Road is a private road that takes access from the public Cardrona Valley Road via approx. 200m of private Pringles Creek Road. Only the first approx. 50m of Curtis Road, from its junction with Pringles Creek Road, is chip sealed with the rest of the road being gravel.

Existing culverts convey Pringles and Pongs Creeks respectively beneath Curtis Road. General stormwater drainage is accomplished via crossfalls and roadside swales.

8.2 Proposed Access

Access to the proposed development will continue to be via the sealed section of Curtis Road, as proposed in the subdivision masterplan. All roads within the development will remain private but will be upgraded to suit the number of lots served in accordance with Table 3.2 of QLDC LDSC. The proposed upgrades have been specified by Bartlett Consulting.

The road upgrades are summarised in Figure 3, as follows, see Bartlett Consulting documentation for details:

- The unsealed section of Curtis Road, just past its junction with Pringles Creek Road to the main residential cluster, will be upgraded to a Type E3 road – the max gradient of this road will be approx. 14.2%
- The upgrade of Curtis Road will also require minor changes to the layout of the intersection with Pringle Creek Road. To meet design guidance the intersection would include the installation of appropriate signs and markings as well as creating an intersection layout to meet the minimum requirements of Austroads guidance.
- The initial section of roading within the main residential cluster will be road type E2 road.
- The other internal roads which serve less than 6 dwellings would be a type E1 road.
- Stormwater drainage of roads will generally be managed using swales with stormwater disposal in accordance with Section 6.3.
- All road pavement details and geometry will be developed at detailed design and shall conform to the requirements of LDSC. Typical sections for the different classes of road are shown in Figure 4.

Where Curtis Road crosses Pringles and Pongs Creeks the roadway will be widened to accommodate recoverable slopes and eliminate safety barriers. Reduced speed curves will be required in an effort to minimise changes to the road alignment. This will require earthworks within these creeks and the extension of the existing culvert. Care will need to be taken to ensure the ecological quality of the creeks is maintained as well as the vertical separation of the downstream culvert on Pongs Creek; to mitigate possible effects on the sensitive upstream sections of watercourse, culvert extensions will be made on the downstream side, with barriers being installed as required.

In order to accommodate the proposed road upgrades, the road reserve may exceed the current right of way easement, as shown on the earthworks drawings. This impact could be mitigated through the installation of new retaining walls and refinements made following a detailed survey at the next design stage.

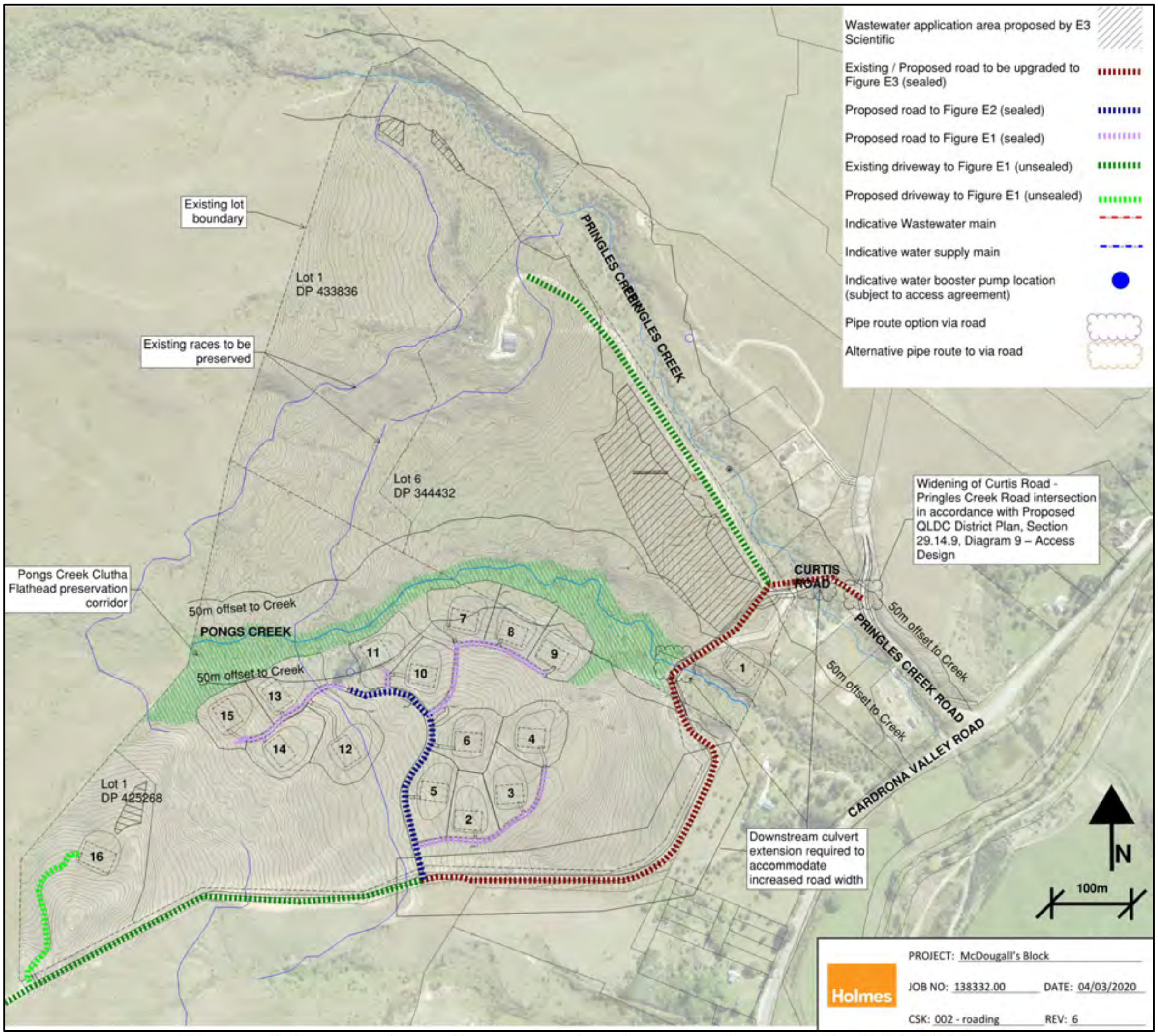


Figure 3 Proposed roading upgrades in accordance with QLDC LDSC

8.3 Assessment of Infrastructure Effects

The proposed development access will be formed to generally fit the existing site constraints, meet QLDC LDSC and achieve compliance with the QLDC District Plan Transport Rules.

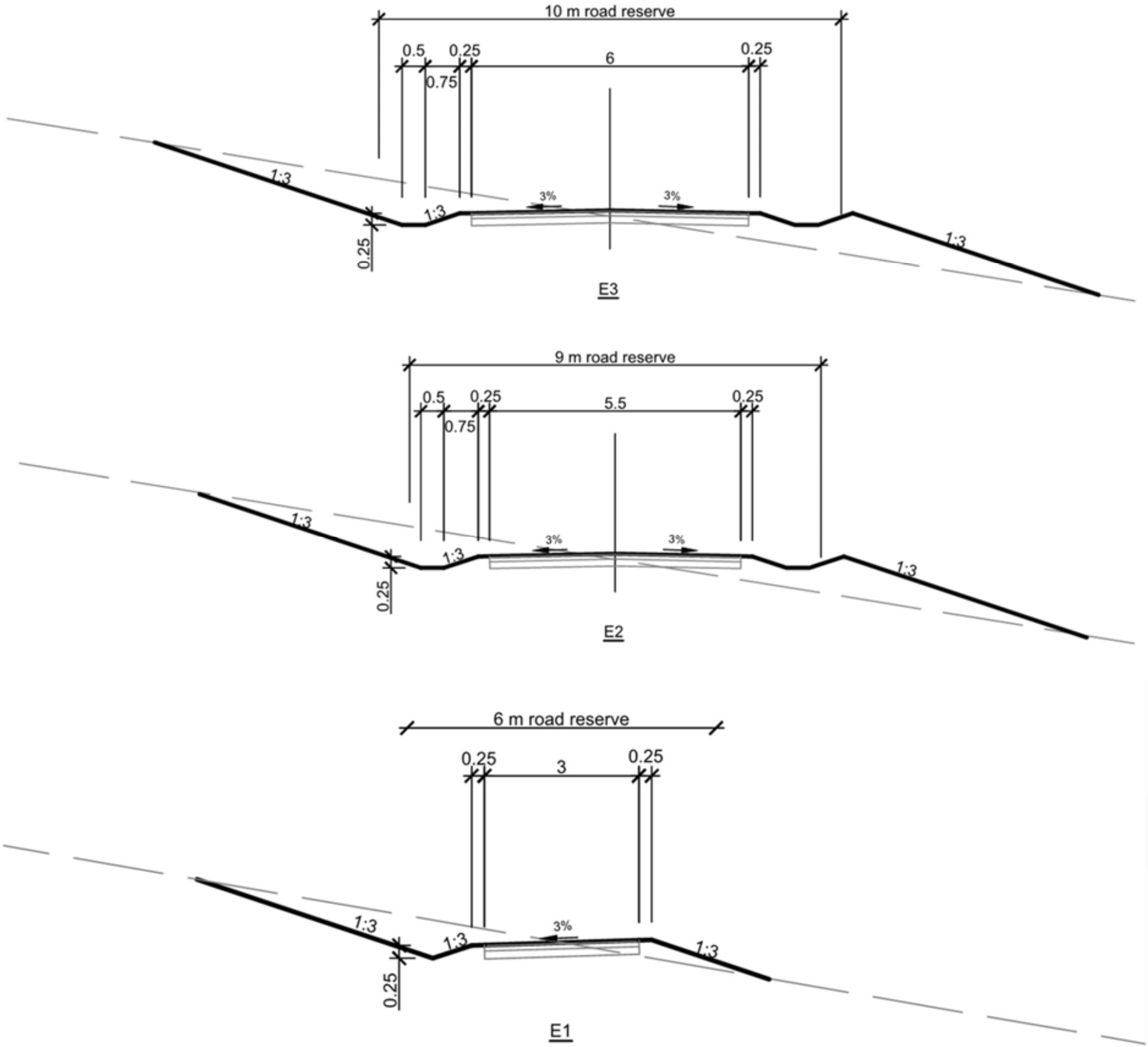


Figure 4 Typical sections for type E1, E2 and E3 roads complying with QLDC LDSC

9 BULK ENABLING EARTHWORKS

Site investigations into soil conditions have been undertaken in the vicinity of the proposed building platforms with the findings summarised in the Geotechnical Report. These investigations indicate that soils in the area are typified by topsoil, overlying softened fan alluvium overlying fan alluvium.

The proposed development will require earthworks to be completed to prepare the site for construction to include access roads and building platforms.

The development is embracing a low impact design philosophy to maintain its inherent rural and rustic character. The associated earthworks shall be sympathetic to the natural environment limiting visual impacts where possible

Cut and fill volumes have been estimated comparing a conceptual bulk earthwork cut model with the existing site surface, see Table 11 and Appendix 01. All cut and fill volumes have been taken from the current to proposed finished ground / surface levels with no allowance being made for pavement or building platform build up at this stage.

A crude assessment of topsoil strip can be done by taking the total earthworks area (55,000m^2) less the existing road area (6,000m^2) = 49,000m^2 and multiplying this by a 200mm deep cut = 9,800m^3. This would need to be verified at the next design stage to be used with any degree of confidence.

Table 11 Estimation of earthworks volumes from drawing C20-01, see Appendix 01

Earthwork	Volume
Cut	20,880 m^3
Fill	17,600 m^3
Total	+3,334 m^3

The earthworks drawings show the potential disturbance areas associated with the possible wastewater application and fill areas. The existing right of way easement is also shown. It should be noted that the E3 upgrade to Curtis Road extends outside of the current easement, based on the 1:3 batter slopes advised by the geotechnical engineer. At the next design stage the extent of the permanent works associated with this upgrade can be reviewed with options to reduce the extent including retaining walls or steeper slopes, potentially utilising ground reinforcement.

All earthworks will be undertaken under the supervision of a Geotechnical Engineer and in accordance with Geotechnical recommendations to ensure that stability of the site and adjacent sites is maintained, and adequate compaction of fills is achieved during construction. All batters will be constructed in accordance with the recommendations set out in Geosolve's Geotechnical Report, presented in Table 12 – the permanent cut slope values have been used as part of the conceptual earthworks modelling.

Table 12 Recommended maximum batter angles for cut slopes up to 3m high in site soils, taken from Table 2 of Geosolve Geotechnical Report

Material Type	Recommended Maximum Batter Angles for Temporary Cut Slopes Formed in Soil (horizontal to vertical)		Recommended Maximum Batter Angles for Permanent Cut Slopes Formed in Soil (horizontal to vertical)
	Dry Ground	Wet Ground	
Topsoil and Softened Fan Alluvium	2H : 1V	3H : 1V	3H : 1V
Fan Alluvium	1.5H : 1V	3H : 1V	2.5H : 1V

An erosion and sediment control plan prepared in accordance with 'Queenstown Lakes District Council's Standard for Environmental Management Plans' will be prepared by the contractor. This will detail specifically how erosion and sediment control will be managed with the construction layout and be submitted to QLDC for approval prior to the commencement of works. This will prevent dust and contaminated soil running into the creeks.

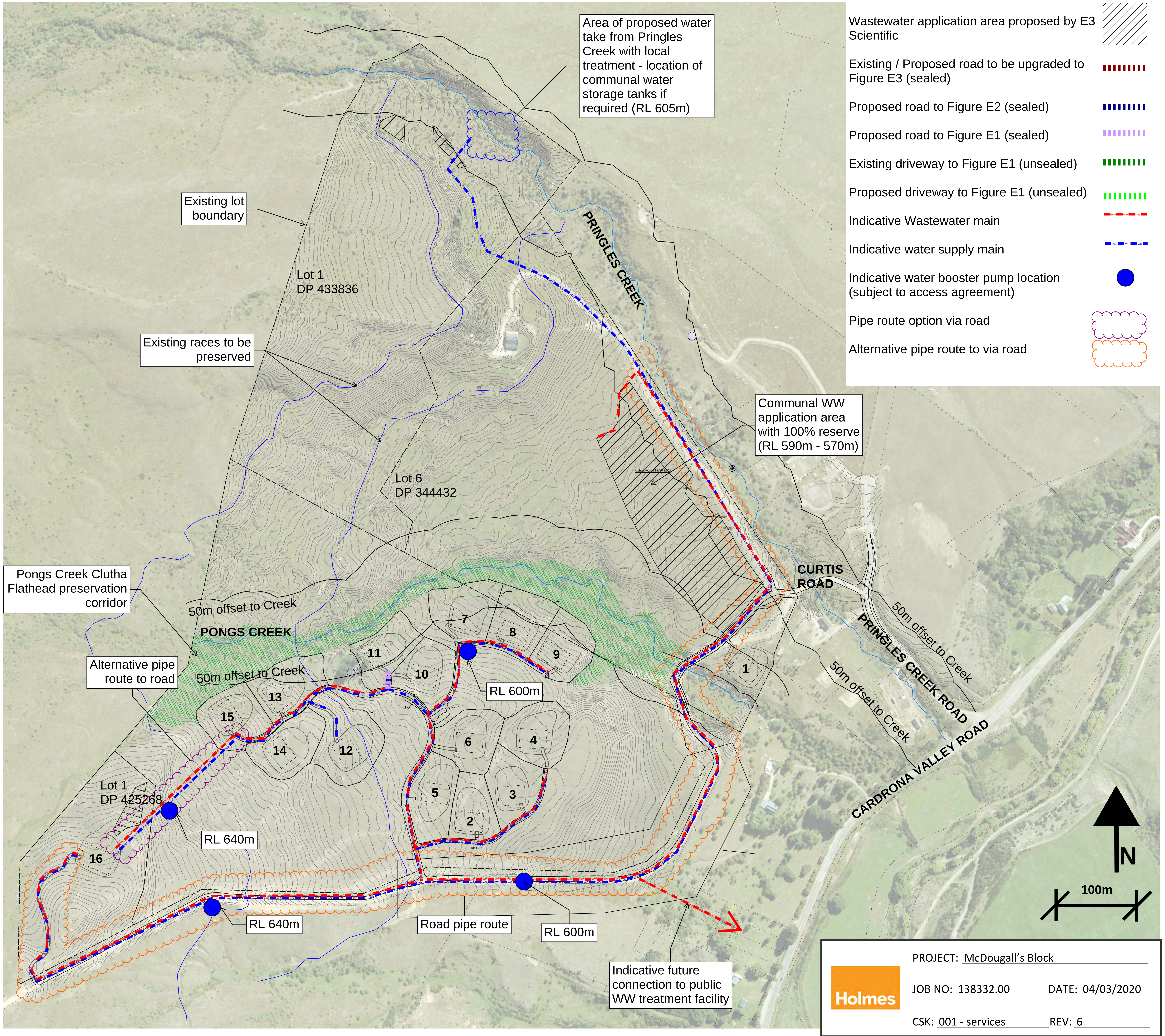
The permanent effects of the proposed earthworks on the environment are considered to be minor.

10 OTHER SERVICES

Gas infrastructure does not extend to the development boundary and any gas use on site will require individual gas bottle supply.

The existing site is currently supplied with power from Aurora Energy. Aurora Energy have confirmed via email, enclosed in Appendix 02, that a point of supply is available for this development.

The existing site is currently supplied with a telecommunication connection from Chorus Network Services. Chorus has provided a provisioning letter via email, enclosed in Appendix 03, stating the development can be supplied with the required infrastructure.


Wastewater application area proposed by E3 Scientific
Existing / Proposed road to be upgraded to Figure E3 (sealed)
Proposed road to Figure E2 (sealed)
Proposed road to Figure E1 (sealed)
Existing driveway to Figure E1 (unsealed)
Proposed driveway to Figure E1 (unsealed)
Indicative Wastewater main
Indicative water supply main
Indicative water booster pump location (subject to access agreement)
Pipe route option via road
Alternative pipe route to via road
Area of proposed water take from Pringles Creek with local treatment - location of communal water storage tanks if required (RL 605m)
Existing lot boundary
Lot 1 DP 433836
Existing races to be preserved
Lot 6 DP 344432
PRINGLES CREEK
Communal WW application area with 100% reserve (RL 590m - 570m)
CURTIS ROAD
Pongs Creek Clutha Flathead preservation corridor
50m offset to Creek
PONGS CREEK
50m offset to Creek
Alternative pipe route to road
50m offset to Creek
PRINGLES CREEK ROAD
50m offset to Creek
CARDRONA VALLEY ROAD
RL 600m
Lot 1 DP 425268
RL 640m
RL 640m
Road pipe route
RL 600m
Indicative future connection to public WW treatment facility
1
2
3
4
5
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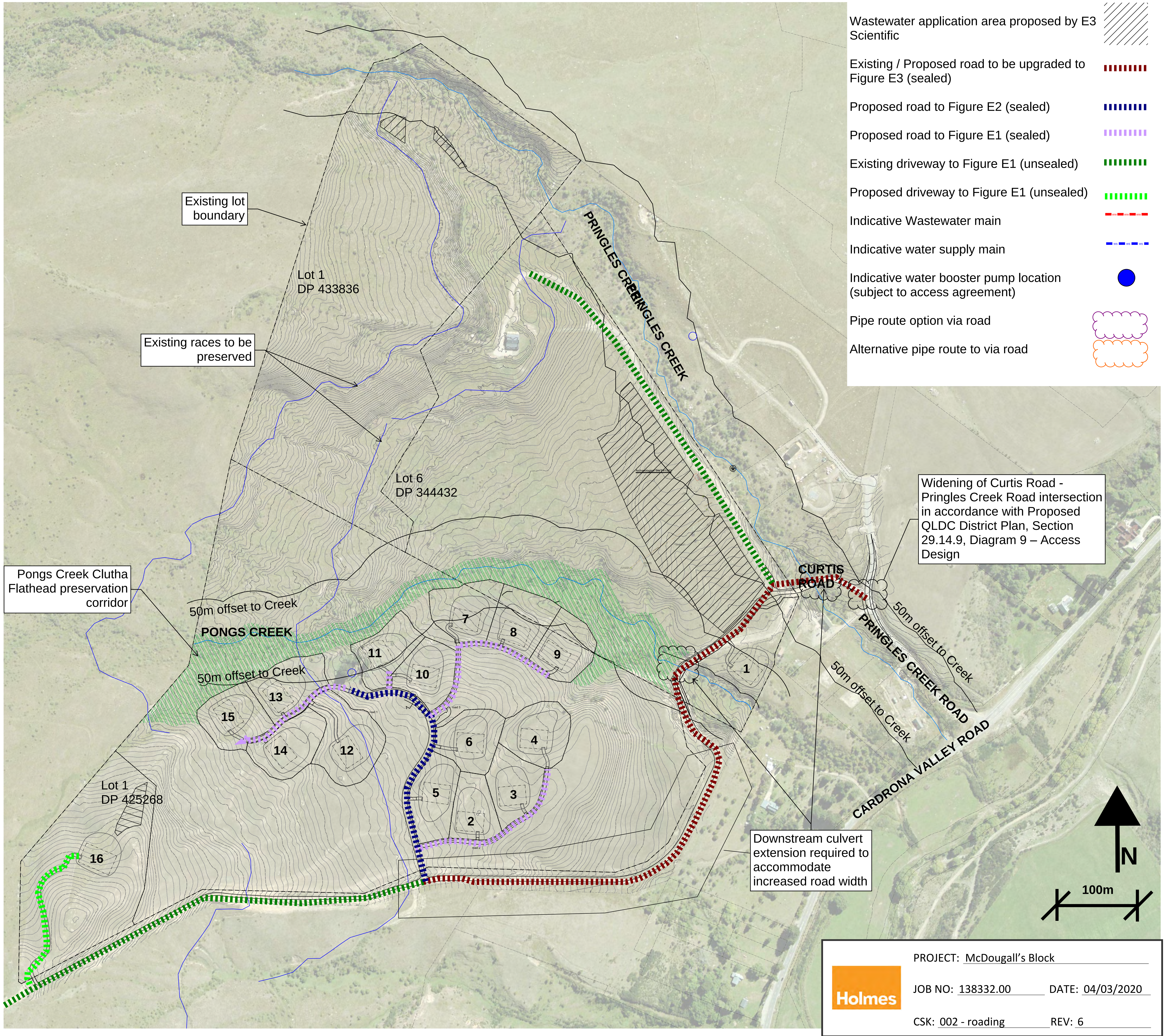
8
9
10
11
12
13
14
15
16
N
100m
PROJECT: McDougall's Block
JOB NO: 138332.00
DATE: 04/03/2020
CSK: 001 - services
REV: 6
Holmes



Document Set ID: 6467037
Version: 1, Version Date: 20/03/2020

Thomas Shenton

From:	Chorus Property Developments <develop@chorus.co.nz>
Sent:	Thursday, 5 September 2019 2:57 PM
To:	Thomas Shenton
Subject:	Chorus Development, WNK53864, 10 Curtis Road, Cardrona
Follow Up Flag:	Flag for follow up
Flag Status:	Completed
Categories:	Filed by Newforma

Hello Thomas,

Thank you for providing an indication of your development plans in this area. I can confirm that we have infrastructure in the general land area that you are proposing to develop. Chorus will be able to extend our network to provide connection availability. However, please note that this undertaking would of course be subject to Chorus understanding the final total property connections that we would be providing, roll-out of property releases/dates and what investment may or may not be required from yourselves and Chorus to deliver the infrastructure to and throughout the site in as seamless and practical way as possible.

The cost involved would be a minimum of our current standard fee of $1600 per lot excluding GST. This cost can only be finalised at the time that you are ready to proceed.

Chorus is happy to work with you on this project as the network infrastructure provider of choice. What this ultimately means is that the end customers (business and home owners) will have their choice of any retail service providers to take their end use services from once we work with you to provide the physical infrastructure.

Please reapply with a detailed site plan when you are ready to proceed.

We're here to help – so please let us know if you need any further information.

Kind regards,

Aimee Smith
Property Development Coordinator

T 0800 782 386 opt1
M
E develop@chorus.co.nz
PO Box 9405
Hamilton
www.chorus.co.nz

CHORUS

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McDougall's Block Proposed Onsite Wastewater Management System

Site Assessment Report

January 2020

Arrow Lane Arrowtown 9302
www.e3scientific.co.nz

Document Set ID: 6467039
Version: 1, Version Date: 20/03/2020

McDougall's Block Proposed Onsite Wastewater Management System
Site Assessment Report

For Roberts Family Trust

Document Status

Version	Purpose of Document	Prepared By	Reviewer	Review Date
A	Draft for internal review	SB	SB	24/07/19
B	Draft for client review	SB	GD	1/08/2019
C	FINAL	SB	AB	15/01/2020

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1 Introduction

Maestro Projects are project managing a proposed 16 lot subdivision at 10 Curtis Road, Cardrona. The sites are expected to house families of six with a peak resident load of 119 people. As there is currently no community wastewater treatment facility for Cardrona, on-site wastewater treatment and management is required. Two treatment systems are proposed: single systems for early stage satellite Lots 1 and16; and a communal treatment facility for all lots 1 – 16. Maestro Projects engaged e3Scientific Limited (e3s) to investigate the suitability of the site for wastewater disposal and review the potential environmental effects of the proposed wastewater discharge to fulfil the consenting requirements of both Queenstown-Lakes District Council and Otago Regional Council.

1.1 Planning Context

Queenstown-Lakes District Council (QLDC) requires a site and soil investigation to support an application for an Onsite Wastewater System for Building Code compliance (G13) and Environmental and Public Health requirements. The site and soil assessment requires the assessor to use the methodology of AS/NZS 1547:2012, as per the QLDC AF OSW Onsite Wastewater Disposal Application Form. The following report provides the required information for sections 4, 5, and 6 of the form.

Otago Regional Council Regional Plan: Water (RPW) sets out a volume threshold and range of conditions that must be achieved for the activity to be permitted. The proposed community wastewater disposal field will discharge a volume in excess of the 2000 L threshold and also encroaches into the 50 metre set back from a surface water body. The communal facility is therefore a discretionary activity under Rule 12.A.2 of the RPW. Single system disposal fields for Lot 1 is a permitted activity. Lot 16 has previously been granted resource consent (RM090876, condition 31.C) for an onsite wastewater disposal field.

1.2 Scope of Work

e3s completed the following scope of work to prepare this site assessment report:

- Review the existing information; including a review of the QLDC OWS Application Form and the existing consent for Lot 16 (RM090876);
- Desktop review of the receiving environment and climate information;
- Complete a site visit to examine the location of two potential wastewater discharge fields and carry out site and soil evaluations including constant head permeameter tests;
- Review of the environmental risks associated with the proposed wastewater discharge;
- Preparation of Site and Soil assessment report suitable for lodgement to Queenstown Lakes District Council with the OWS application Form and for ORC resource consent under Rule 12.A.2 of the RPW.

1.3 Limitations

The findings of this report are based on the Scope of Work outlined above. e3scientific Limited (e3s) performed the services in a manner consistent with the normal level of care and expertise exercised by members of the environmental science profession. No warranties, express or implied, are made. The confidence in the findings is limited by the Scope of Work.

The results of this assessment are based upon a site inspection conducted by e3s personnel, information from discussions with people who have knowledge of site conditions and information provided in publicly available reports. All conclusions and recommendations regarding the proposed wastewater discharge are the professional opinions of e3s personnel involved with the project, subject to the qualifications made above. While normal assessments of data reliability have been made, e3s assumes no responsibility or liability for errors in any data obtained from regulatory agencies, statements from sources outside e3s, or developments resulting from situations outside the scope of this project.

2 Site Characteristics

2.1 Site Details and Surrounding Landuse

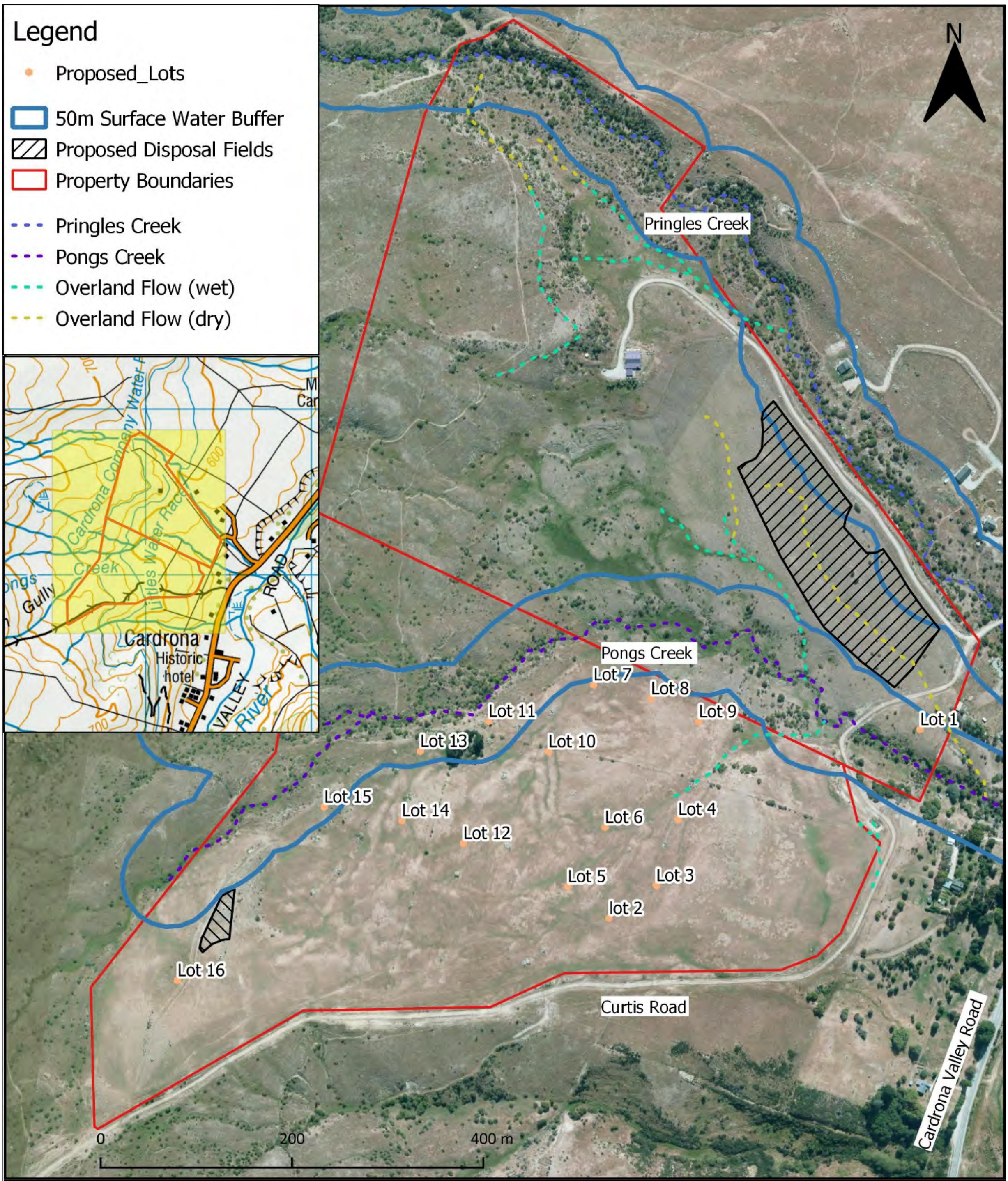
The site (Figure 1) is located within the Cardrona township rural residential area, adjacent to an active agricultural area (Mt Cardrona Station). The surrounding land-use is pastoral and residential. Entrance to the site is via Curtis Road and Pringles Creek Road, off the Cardrona Valley Road. The site is gently sloping (< 15%) terrace and alluvial fans with steep faces separating each terrace. Two natural drainage catchments characterise the site, Pongs Creek in the south and Pringles Creek in the north. Overland flow paths on the terraces are common and connect to these two drainage catchments. Property details are summarised in Table 1.

Table 1. Site details

Site Location	10 Curtis Road, Cardrona Valley
Legal Description(s)	Lot 1 Deposited Plan 433836, Lot 6 Deposited Plan 344432 & Lot 1 Deposited Plan 425263
Development status	Planning
Property area (m^2)	54.4 Ha (however sites in question are 2.5 ha combined)
District Council	Queenstown Lakes District Council
Regional Council	Otago Regional Council

The proposed Onsite Waste Management System (OWS) is comprised of a sewage treatment system and land application site. The land application site options were identified based on soil conditions during site visits in July 2019. The communal site is located on a terrace on the north side of Pongs creek, northwest of Lot 1. The Lot 1 single system disposal field would be located within the proposed communal disposal field. These areas are gently sloping paddocks which are used for stock grazing.

Note that the two satellite lots, Lot 1 and Lot 16 may be commissioned initially but that they are still included in the design of the Communal disposal field and the assessment reflects this.



NZ Property Titles sourced from the LINZ Data Service http://data.linz.govt.nz/ and licensed by LINZ for re-use under the Creative Commons Attribution 4.0 New Zealand licence. Aerial Imagery sourced from the the QLDC Data Service (https://qldc.maps.arcgis.com/home/) and licensed by QLDC for re-use under the Creative Commons Attribution 4.0 New Zealand licence.

Figure 1. Location of site and soil assessment for a site specific disposal field for lot 16 and a communal disposal field for lots 1-16.

2.2 Regional Climate and Soils

Climate data was sourced from NIWA's Climate of Otago (2015) and from their CliFlo database. Table 2 presents average seasonal and annual climate data collected from an automatic weather station in Wanaka, 28 km north east of the site and from the Cardrona Village rain gauge. We note the average total annual rainfall at Wanaka is moderate at 739 mm while Cardrona reported slightly less at 685.5 mm.

Table 2. Annual & seasonal climate data from the nearby Wanaka Airport station and rainfall averages from Cardrona rain gauge (1981 – 2010). (NIWA 2015, 2019)

Parameter	Dec - Feb	Mar - May	Jun - Aug	Sept - Nov	Annual
Cardona Total Rain (mm)	184.8	182.1	160.6	158	685.5
Wanaka Total Rain (mm)	166	164	180	190	739
Mean Temp (°C)	13	11	9	12	11.2
Mean daily grass minimum (°C)	8	2	-3	2	2.4
Mean number of ground frosts (per month)	1	7	21	8	9.3
Mean Vapour Pressure (hPa)	11	9	6	8	8.5

Table 3 presents average monthly rain days where at least 0.1 mm of rain is recorded and average monthly wet days where at least 1 mm is recorded. Table 3 shows the average number of wet days (with at least 1 mm of rainfall) is relatively consistent throughout the year. Wet days occur at least 1 in every 5 days throughout the year.

Table 3. Average monthly rain days and wet days at Wanaka Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
a	8	7	8	8	11	13	11	10	10	11	8	11	114
b	6	5	6	6	7	7	6	7	7	8	6	8	78

a) Days where at least 0.1 mm rainfall is measured; b) days where at least 1 mm (NIWA 2015).

Table 4 presents soil moisture and runoff data. The table shows a significant soil moisture deficit during the summer months and high runoff during winter. Due to higher rates of evapotranspiration and irradiance in summer, there is a significant reduction in days where surface runoff occurs. Conversely, during the winter months lower rates of evapotranspiration and irradiance and increased wet days allow soils to remain saturated, leading to higher rates of surface runoff.

Table 4. Mean monthly and annual water balance summary for a soil moisture capacity of 150 mm at Wanaka Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
DE	107	86	47	21	3	0.2	0	0	2	23	86
ND	20	19	15	13	3	0.3	0	0	1	7	19
RO	0	0	0	0.2	2	12	13	18	10	3	0
NR	0	0	0	0.1	0.3	2	2	3	1	0.4	0

DE: average amount of soil moisture deficit in (mm) ND: average number of days on which a soil moisture deficit occurs RO: average amount of runoff (mm) NR: average number of days on which runoff occurs. (NIWA 2015).

S-Map (Table 5) does not have the site soils mapped, but the nearest soils are Mataura*f* – on the terrace below Curtis Road, which is a 'Typic Fluvial Recent Soil'.

Table 5. S-Map derived Soil classification for Curtis Road site. Manaaki Whenua/Landcare Research, 2018.

Soil Name	Mataura*f* (Matra_5a.4)
Soil Type	Typic Fluvial Recent Soil
Top Soil Clay Range	8 - 15 %
Topsoil P retention	Low (19%)
Bypass flow	Low
N Leaching Vulnerability	Medium
Relative Runoff Potential	Very Low
Pore Available Water (0-100cm or root barrier)	Moderate to High (122 mm or 12%)

The New Zealand Soil Classification 'Soilsmapviewer' however does cover the field area; The disposal field is within a 'Fluvial Recent soils' map unit and are noted as '*Fluvial Recent Soils are Recent Soils containing sediments deposited by water. Recent Soils are weakly developed, showing limited signs of soil-forming processes. A distinct topsoil is present but a 'B' horizon is either absent or only weakly expressed. They occur throughout New Zealand on young land surfaces, including alluvial floodplains, unstable steep slopes, and slopes mantled by young volcanic ash. Their age varies depending on the environment and soil materials, but most are less than 1000 to 2000 years old*.' The soils are further listed as Weathered Fluvial Recent Soils - soils that have a weathered-B horizon with its lower boundary at 30 cm or more from the mineral soil surface.

Note that the Wanaka Airport site is located on the loamy gibbston*f*, a 'Pallic Orthic Brown Soil' whereas the soils in Cardrona are generally siltier. This difference in dominant soil texture would mean the soils in Cardrona are less well drained and less stony. Consequently, runoff days may significantly increase, and soil moisture deficit days may decrease. However, as an actual water balance for Cardrona has not been measured, it may be assumed to be similar to the Wanaka Airport data. Runoff is most likely to occur during the winter months May – October.

3 Soil and Site Assessment

This site and soil investigation report provides the required information for sections 4, 5, and 6 of the QLDC AF OSW Onsite Wastewater Disposal Application Form.

3.1 Soil assessment

Two disposal sites were assessed against the criteria set out in both the QLDC OWS assessment form and the AS/NZS 1547:2012 Standard (Figure 2). In most cases, the QLDC OWS assessment form refers to the Standards methodology of site assessment. Samples were taken from three sites within the communal disposal field with additional test pits and associated soil logs were completed at the communal site. GeoSolve (2019) have also completed test pits and falling head soakage testing near the proposed disposal field (GS_SP4/GS_TP2; Appendix B).

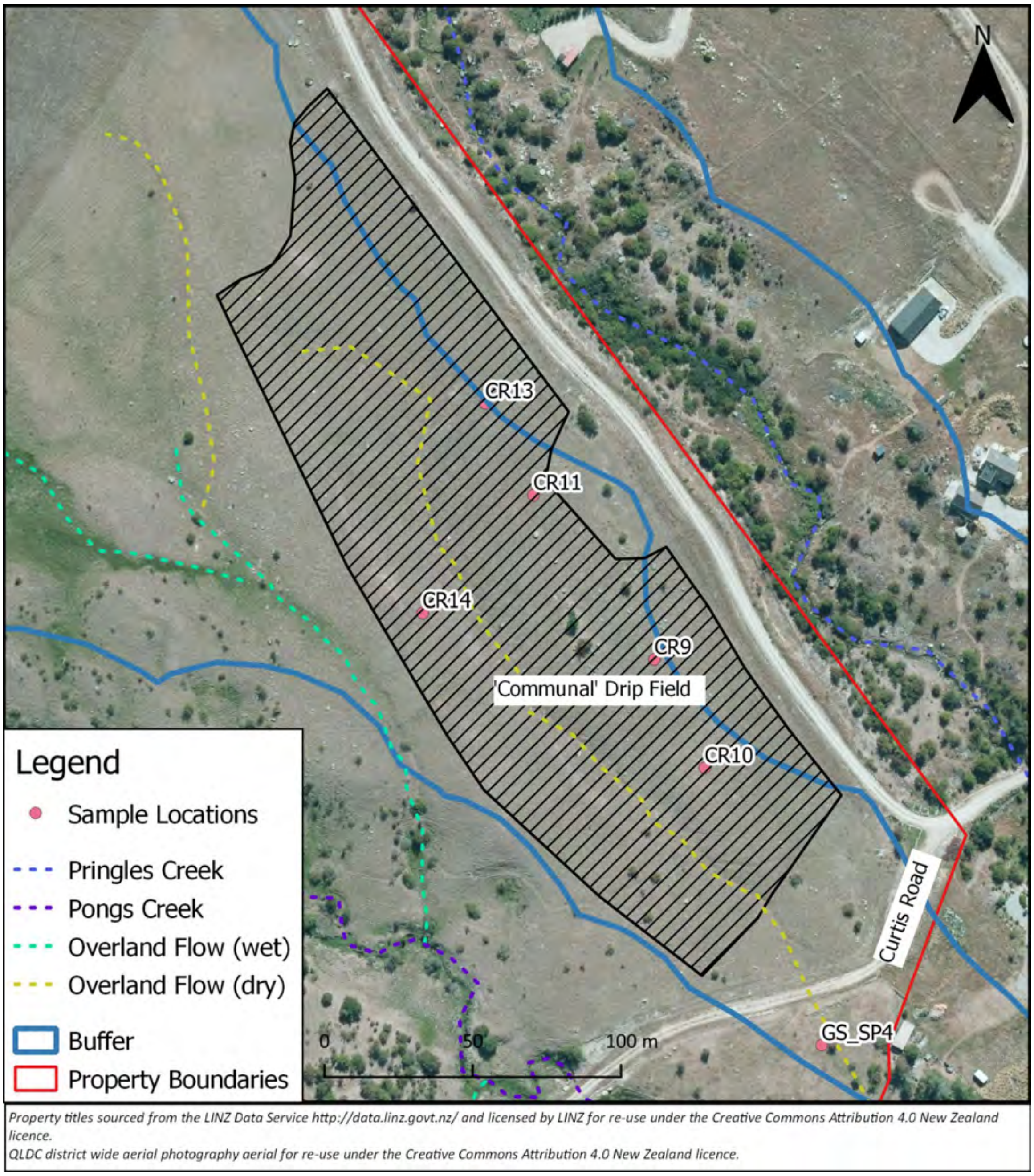


Figure 2. Sample locations at Curtis Road.

3.1.1 Site Specific Soil Investigations

Detailed soil logs were recorded by e3s at the proposed communal disposal field. Generally, S-Map soil units (see Table 5) match the soil encountered on site, however clay content is slightly higher than the S-Map units. The GeoSolve (2019) test pits indicate the soil profile around the site are generally more than 0.2 m thick before transitioning into SILT and SAND fan deposits with gravels and larger cobbles/boulders with depth. The general description for the topsoil at the communal field it is a moist, light greyish brown Clayey Silt LOAM. Full soil logs are available in Appendix A. Table 6 presents the soil logs between 0.3 and 0.4 m deep, the interval required for a buried low-pressure effluent irrigation system.

Table 6. Soil log for constant head test holes at 0.3 - 0.4 mbgl

Site	Soil Colour	Coarse Frag. abundance	Coarse Frag. Size	Fe Mottling	soil moisture	Sandy?	Soil Texture	Soil Category
CR9	Light Brown	Very Few	Fine	5%	Moist	Yes, trace	'Silty CLAY'	5
CR13	Light Brown	Very Few	Fine	5%	Moist	Yes, trace	'Silty CLAY'	5
CR14	Light Brown	Very Few	Fine	5%	Moist	Yes, trace	'Silty CLAY'	5

Soil dispersion tests (E7 of the standard) were undertaken for 24 hrs and all 'worked' samples completely slaked but did not show signs of dispersal (Appendix B). Most 'aggregate' samples had minor slaking but did not show signs of dispersal, hence the soils are not 'dispersive' (AS/NZS 1547:2012, pp109).

3.1.2 Hydraulic Conductivity

e3s completed a constant head permeameter test at CR9, CR13, and CR14 (Figure 2) in order to calculate the saturated infiltration rate (K_{sat} or Ks) across the disposal field. The K_{sat} was calculated using the prescribed test in the AS/NZS 1547:2012 (Table 7).

Ks values at the communal field fell within the expected indicative permeabilities for soil category 5. Sample sites CR9 and CR13 are on the north side of the dry drainage feature that bisects the area and CR14 is on the south side. GeoSolve (2019) excavated a test pit (TP2) and completed a soakage test (SP4) near Lot 1, to the south of the proposed area. The infiltration rate at SP4 for a depth of 1.4 mbgl was initially ~0.5 m/d but then reduced to ~0.3 m/d which is a higher rate than measured during this study.

Table 7. Hydraulic conductivity results of constant head tests.

Site	Soil Category	Soil Texture	Structure	Indicative Permeability[1] (K_{sat}) (m/d)	Measured permeability (K_{sat}) (m/d) Mean	Measured permeability (K_{sat}) (m/d) Median	Design Irrigation Rate (DIR) (mm/day) - for drip irrigation
CR9	5	Light CLAY	Weak to moderate	0.06 – 0.12	0.06	0.06	2.5
CR13	5	Light CLAY	Weak to moderate	0.06 – 0.12	0.07	0.06	2.5
CR14	5	Light CLAY	Weak to moderate	0.06 – 0.12	0.12	0.12	2.5

[1] AS/NZS 1547:2012

For Category 5 soils, the standard recommends that low pressure effluent distribution (LPED) irrigation systems need to be installed in an adequate depth of topsoil (on the order of 150 – 250 mm of *in situ* or imported good quality topsoil) to slow the soakage and assist with nutrient reduction. In addition to this, the QLDC OWS application form requires sub-surface dripper irrigation systems to be buried 300 mm below ground level due to the effects of ground frosts in the district. Therefore, the assessment of the soil was at a depth of between 0.3 and 0.4 mbgl.

3.2 Site Assessment

3.2.1 Site Conditions

The site is a mixture of gently sloping terrace flats and steeper terrace faces with in-cut ephemeral drainage gullies and active creeks. There are few windbreaks with most areas exposed to moderate mountain valley wind patterns. The most common wind is from the southwest. The site has reduced daylight hours in the summer and winter due to the surrounding Criffel and Cardrona ranges, however a soil moisture balance has not been undertaken.

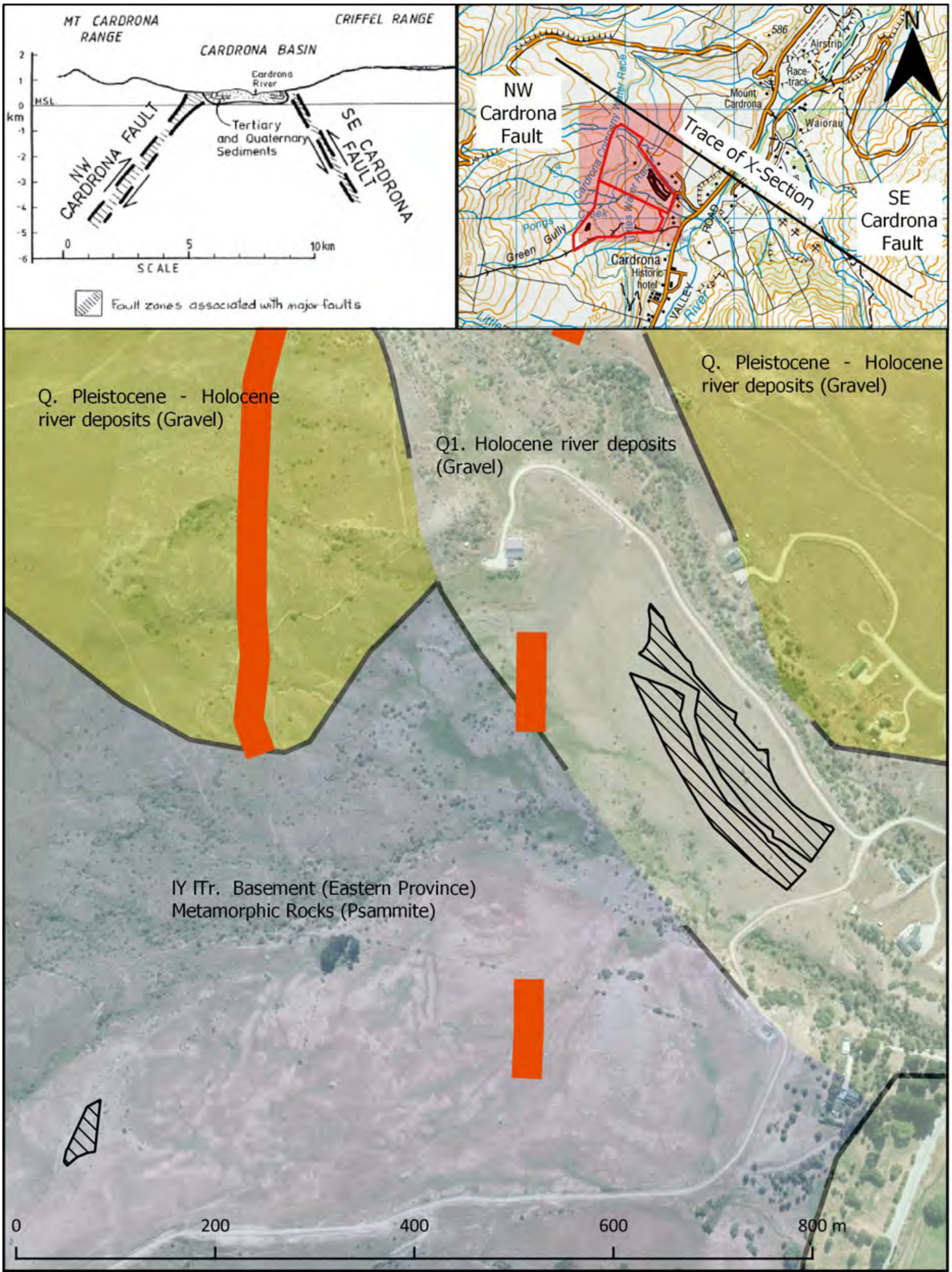
3.2.2 Geology

The site is located on recent alluvial terraces above the Cardrona River (Figure 3). The deposits are therefore pre- and post-glacial alluvial and fluvial sands and gravels mantling underlying basement schist (Rakaia Terrane). QMAP describes the geology as Holocene fan deposits of loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree (upslope) & valley alluvium. The site is bisected by the Cardrona section of the north-east trending Nevis-Cardrona Fault System. The fault is active with a reverse orientation and a recurrence of 4-9k years (Beanland and

Barrow-Hurlbert, 1988). A pair of faults occur on the edges of the Cardrona basin in a typical graben setting; of the two faults the north-west arm is active and south-east arm is inactive.

QMAP shows two fault traces of the north-west arm crossing the western side of the field site, the well-defined 'Skifield Road' trace and the uncertain 'north-west Cardrona' trace. The ORC (2010) state that 'An earthquake on the Nevis-Cardrona Fault System will potentially cause ground deformation along the length of the rupture. This may incorporate surface cracking, tilting, warping or folding. Ground deformation can impact on the functionality of buildings, infrastructure and natural or engineered drainage systems along or near the fault.' Both fault traces are more than 20 m from the proposed disposal field.

The alluvial fans on site were identified as recently active alluvial fans by GNS Science but were not identified during their assessment of the most at risk fans in Otago (ORC, 2010). The site was identified as having a liquefaction risk due to the presence of saturated topsoils and a high silt content. Infrastructure associated with the wastewater treatment facility and disposal fields should thus consider the implications of both the location of the active fault traces and the potential for liquefaction during large earthquakes. GeoSolve (2019) have addressed these concerns in their geotechnical site assessment.



Topo, 1:50k sourced from the LINZ Data Service http://data.linz.govt.nz/ and licensed by LINZ for re-use under the Creative Commons Attribution 4.0 New Zealand licence. Aerial Imagery sourced from the QLDC for re-use under the Creative Commons Attribution 4.0 New Zealand licence. QMAP licensed by GNS Science for re-use under the Creative Commons Attribution 4.0 New Zealand licence.

Figure 3. Geology of the Cardrona Basin and Curtis Road Site. (Geology from QMAP and cross section from Officers, 1984).

3.2.3 Flood Hazards

ORC have undertaken a natural hazard assessment of the Cardrona Valley (ORC, 2010). Flood risk has relevance to the Curtis Road site due to the combination of proximity to active creeks and sluffing in the saturated topsoil, as noted by Geosolve (2019). Additionally, rainfall in the region is expected to rise by 10% over the coming century (ORC, 2010) however the river morphology is stable between catastrophic flood events.

The communal disposal field is located on a gently sloping terrace flat between Pongs Creek and Pringles Creek, elevated above the watercourses by up to 8 metres.

While the risk of direct inundation flooding of the field during heavy rainfall is low, surface water runoff is likely. A proposed cut-off drain recessed 0.5 m from the surface should capture and divert any significant surface water runoff event from entering the disposal field. This drain will need to be designed to limit sluffing of the upslope batter face.

3.2.4 Groundwater

GeoSolve (2019) intersected perched groundwater tables at 0.2 – 0.4 mbgl and 0.9 – 1.0 mbgl across the site during their site assessment. e3s also intersected multiple perched groundwaters on the southern side of Pongs Creek, but only surficial perched waters north of Pongs Creek. Deeper groundwater levels are unknown at the site, however e3s completed an auger hole to 1.5 mbgl and did not intersect groundwater. Similarly, GeoSolve (2019) dug pits to depths of 3.5 mbgl at TP2 and did not intersect groundwater. The proposed communal field is 8 m above both Pongs and Pringles Creek.

3.2.5 Surface Waters

Surface waters near the proposed site are the two identified creeks, Pongs and Pringles, which are located more than 50 m from the disposal field site option (Figure 2). The soils around the proposed lots south of Pongs Creek were all waterlogged - with surface water observed in rabbit holes and hollows. No suitable sites for disposal were located on the south side of Pongs Creek. On the north side of Pongs Creek – to the south and west of the proposed communal disposal field – there are still some areas of surface ponding and waterlogged soils. These areas were not considered suitable for testing. Several overland flow paths were mapped during the field work. The dry and wet flow paths were distinguished and are mapped on Figure 2. These flow paths are ephemeral (i.e. dependent on rainfall and runoff events).

There are several surface water usages of Pringles Creek;

- Mount Cardrona Station surface water take upstream of Property boundary;
- Proposed surface water take for the development;
- H2O surface water take at 6 Gin & Raspberry Lane; and
- 13 Pringles Creek Road surface water take.

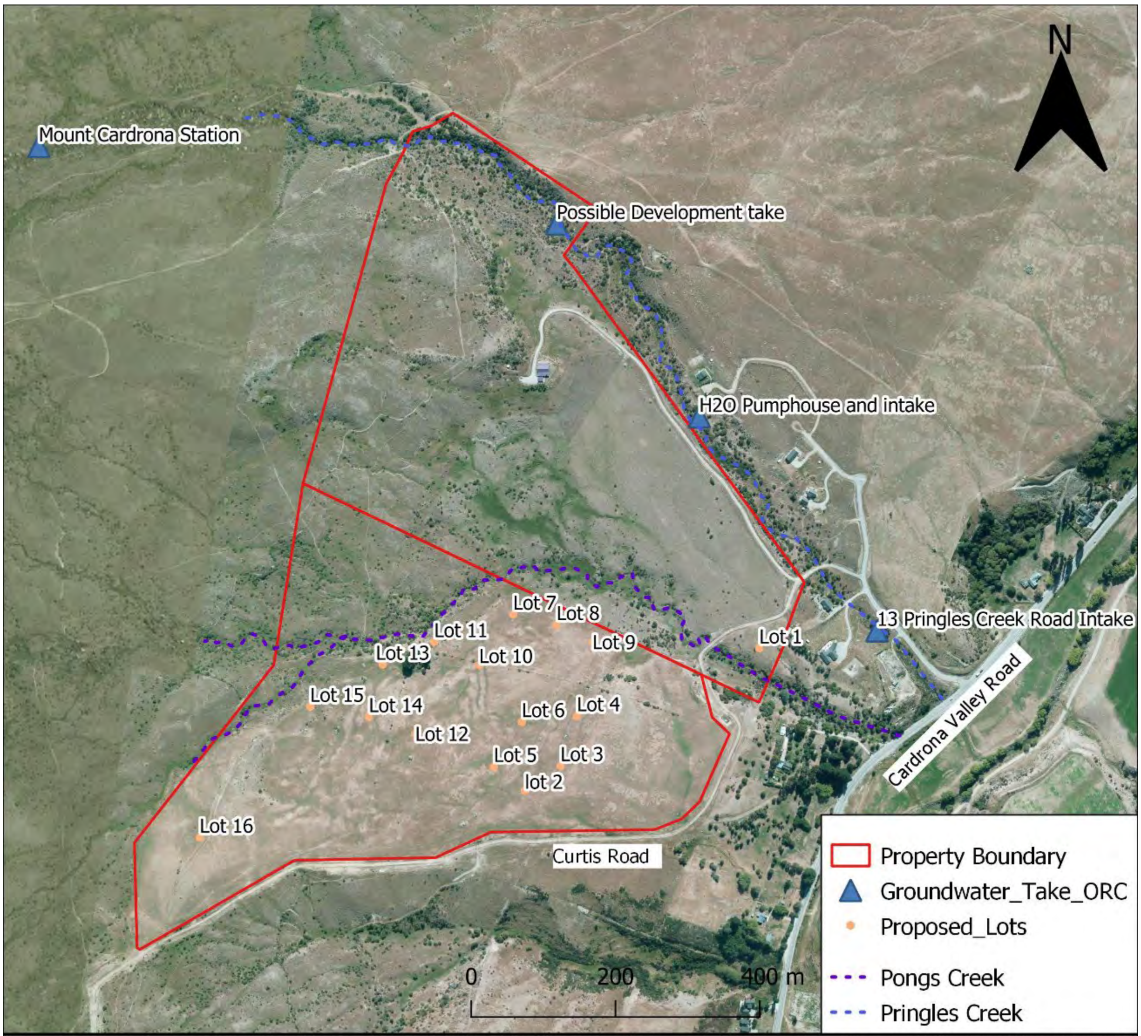


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Figure 4. Surface water takes from Pringles Creek.

4 Proposed Wastewater Treatment System

4.1 Design Flow and Loading Rates

The land application system has been designed for category 5 soils based on a peak load of 200 L of black and grey water per occupant, 6 occupants per household, and

16 households with a peak capacity of 112 occupants (16 additional 'guest' occupants across the communal site and one additional 'guest' occupant for Lots 1 and 16). The design parameters are provided in Table 8.

Table 8. Land application area design parameters for an LPED irrigation system

<table>
<tr><th>Site</th><th>Peak Design Flow</th><th>Design Irrigation rate[1]</th><th>Primary Area Required</th><th>Total Area Required</th><th>Drip line Spacing</th><th>Lineal Length</th></tr>
<tr><td>Communal</td><td>22,400 L/day</td><td rowspan="3">2 L/m²/day</td><td>11,200 m²</td><td>22,400 m²</td><td>1.0 m</td><td>11.2 km</td></tr>
<tr><td>Lot 1</td><td rowspan="2">1,400 L/day</td><td rowspan="2">700 m²</td><td rowspan="2">1,400 m²</td><td rowspan="2">1.0</td><td rowspan="2">700 m</td></tr>
<tr><td>Lot 16[2]</td></tr>
<tr><td colspan="7">[1]Design Irrigation rates are the from table M1 AS/NZS 1547:2012, reduced by 20% to account for slopes of 10-12%
[2]Based on Site and Soil Assessment completed for Approved Consent RM090876</td></tr>
</table>

The long-term acceptance rate (LTAR) of soil within a disposal field is dependent on two factors: Firstly, the standard recommends design irrigation rates (DIR) that are an order of magnitude less than the field measured permeability. Secondly, the drip lines are only used for a short period of time each day and are controlled by management practices such as line sequencing (using an automatic sequencing valve). The combination of the reduced irrigation rate and line sequencing ensures the field never becomes saturated.

The peak effluent soil DIR to the disposal field are 80% of the recommended standard value for a category 5 soil type (2.5 L/m²/day; AS/NZS 1547:2012) to take into account the 10-12% slope at the communal field. The disposal field size and soil loading rate will allow the soil (0.3 – 0.6 mbgl) to assimilate the effluent via plant uptake, soil biota activity, as well as evapotranspiration. We note that the disposal field will be sown in grass and could be grazed with low stock units or a cut and carry system which would remove nitrogen from the system.

Note that Lot 16's approved consent RM090876 'Suitability for On-Site Wastewater Treatment' by Clark Fortune McDonald & Associates (2009) specified the use of an evapotranspiration seepage trench (ETS) disposal system. The land application design parameters for Lot 16 in Table 8 were calculated using the recommended DIR for an LPED disposal system. The disposal method approved in consent RM090876 was subject to additional implementation design by a suitably qualified wastewater engineer. e3s noted that the DIR recommended in the approved consent had not been modified to account for slope.

Tertiary disinfection will be required at the communal site in order to discount the lack of a 100% reserve area outside of the 50m surface water buffer. There is more available land on the south side of Pongs creek, east of Lot 4, however at the land was observed to be unsuitable as it was saturated. There is, however, plans to use this land for cut and fill activities which could lead to the land becoming suitable as a reserve area. The main consideration for these two sites is that they maintain their low moisture levels so that the effluent can be readily absorbed by the soils. Cut-off drains down to 0.5 mbgl along boundaries and especially on the upslope side are necessary to maintain the LTAR.

4.2 Options Assessment

The development required the assessment of a disposal field servicing only Lot 1, and a communal disposal field servicing all lots (1 – 16). The two sites are considered in the following sections. Note that Lot 16's disposal field has already been approved but is discussed in this section.

4.2.1 Lot 1

The proposed disposal field for Lot 1 is situated within the communal disposal field. No specific sites were assessed for Lot 1 and instead it was determined that any suitable area within the communal field that satisfied the permitted activity requirements would be appropriate. For this reason, lot 1 is not further discussed here and the site assessment is deferred to the communal site.

4.2.2 Communal disposal field (and Lot 1)

The proposed Communal disposal field is located on a terrace between Pongs and Pringles Creek (Figure 5). The terrace gently slopes from the base of a terrace face, below the existing residential property, and falls consistently towards the Cardrona Valley floor. The disposal field is adjacent to the access road to the existing residential property and part of the field lies within 50 m of Pringles Creek. Ground and surface waters within the proposed Communal disposal field drain downslope along the dry drainage gully and east towards the Cardrona Valley.

The area converges gently around this central drainage gully with an elevation difference of around 2 metres from the terrace flats to the gully bottom. There is a significant amount of land on both sides of this dry gully which is suitable for use as a disposal field. Land further west and upslope towards the toe of the terrace face is damper. A cut-off drain connecting the existing southern and northern overland flow paths to the access road ditch would reduce surface flow and soil water throughflow from upgradient of the disposal field - and ensure the disposal field soils have the ability to absorb effluent even during prolonged wet periods.

The dry drainage gully that bisects the proposed disposal field could be addressed in the following ways;

- Topsoil and subsurface sediment from cut and fill activities could be used to infill the drainage gully and shape the disposal field into a consistent slope which sheds water. This activity would provide enough suitable land for both the primary disposal field and a 100% reserve.
- The gully is left as is and filled with native plantings which reduce runoff, polish nutrients, and control soil moisture from excessively draining into the gully. In this scenario there is enough land for the primary but not enough for a 100% reserve.

An option of using land on the south side of Pongs Creek for reserve (that is set aside for receiving cut and fill material from the subdivision earthworks) was proposed but could not be tested due to being over saturated at that time. The area would require significant boundary drainage ditches given the soils are prone to periods of saturation, even at depth. Note that the area east of sample location CR11 has been left outside of the disposal field due to sites of archaeological importance. A buffer of 5 metres has been used to define the area of exclusion from the disposal field.

If Lot 1 is commissioned as a satellite lot, a small area (1200 m^2) of the communal disposal field would be required for use. It is also noted that QLDC may commission a community wastewater treatment facility for the Cardrona village and surrounding dwellings in the future. This site is well positioned to be connected to a municipal system.

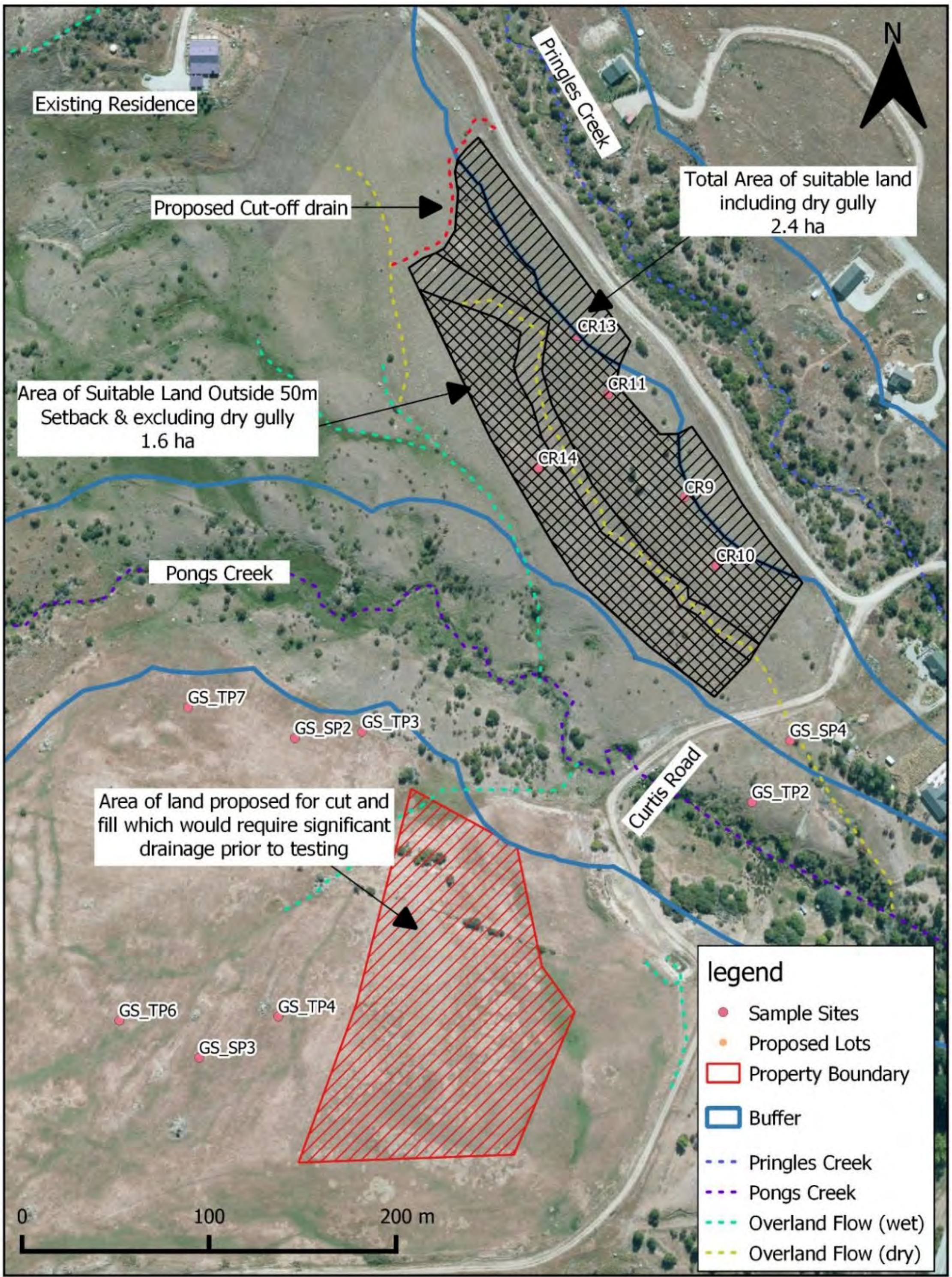

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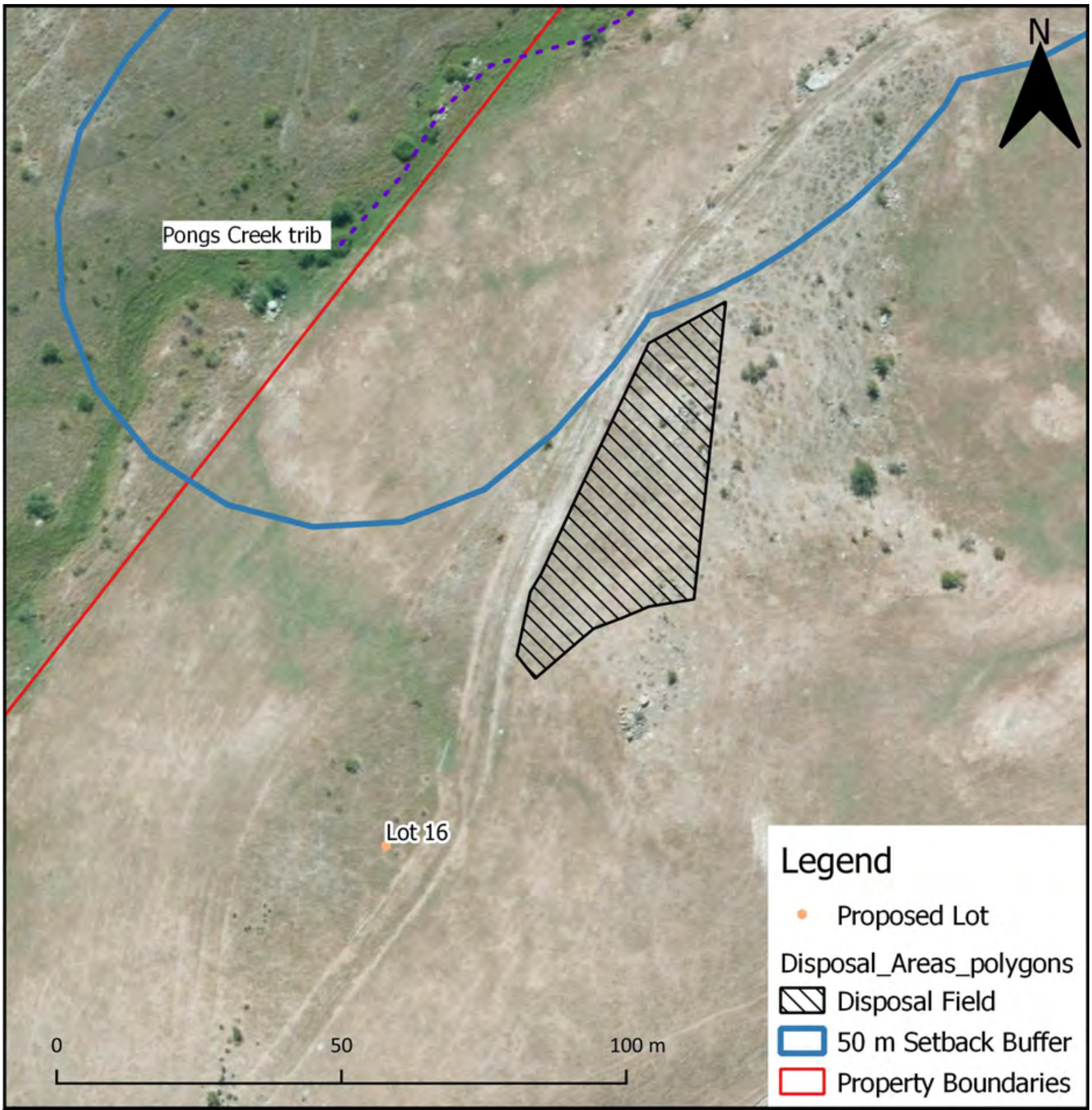
Figure 5. Communal Disposal Field Options

4.2.3 Lot 16

Approved consent RM090876 contains a site and soil assessment undertaken by Clark Fortune McDonald & Associates in November 2009. The approved disposal field is located north east of proposed lot 16 and covers an area of approximately 1200 m^2.

The report was approved with a recommended DIR of 5 mm/day in accordance with the ANZS 1547:2012 for category 5 soils and an ETS disposal system.



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Aerial Imagery sourced from QLDC (http://qldc.maps.arcgis.com) and licensed by QLDC for re-use under the Creative Commons Attribution 4.0 New Zealand licence.

Figure 6. Approved Disposal Field for Lot 16

4.3 Effluent Quality

The effluent quality for the site has not been characterised. Expected influent and effluent were therefore derived from test data and real data from QLDC in order to assess the potential effects on the environment of the discharge of treated domestic wastewater to land.

'Water New Zealand' undertake testing of commercially available on-site wastewater treatment systems on behalf of the wastewater treatment industry. The treatment capabilities of these systems are available through the OSET (On-site Effluent Treatment) national testing programme which assesses the capabilities of treatment systems over a test period of 35 weeks (Appendix C). Influent and effluent data from QLDC wastewater treatment facilities from 2018 is compared to the Water New Zealand test conditions in Table 9 and Table 10. QLDC influent values are comparable to the OSET testing conditions and therefore the test results should provide a reasonable estimate of effluent quality.

Table 9. OSET vs QLDC Influent data

Influent (g/m^3)	**AS1546.3:2017 Requirement**		**RLC measured influent quality (Trial 12)**		**Project Pure (Wanaka)**	**Project Shotover**
	Range	*Average*	*Range*	*Average*	*2018*	*2018*
cBOD	150-750	>300	55-262	145	n/a	249.6
TSS	150-750	>300	120-615	229	354.3	280.1
Total Nitrogen (TN)	20-150	>60	34-73	56	56.3	
Ammonium Nitrogen (NH4-N)	20-80	n/a	22-55	n/a	n/a	39.3
Total Phosphorus (TP)	6 - 25	>8	3-10	6	n/a	n/a
pH	6 - 9	n/a	7 - 8	n/a	n/a	7.5
***E.coli* (cfu/100mL)**	n/a	n/a	1,900-18,000	n/a	n/a	n/a

Data from two systems is presented as a model for effluent treatment quality AdvanTex® AX-20 Mode 3 and the AES-38 R & R/UV (see Appendix C for OSET results). Both systems were tested at a flow rate of 1,000 L/day (equivalent to servicing a 3-bedroom, 5 to 6 person household) over a 35 week period followed by a 5 week high load period of 5 days at 2,000 L/day then 1,000 L/day over the following 4 weeks. Note that the Advantex system was not tested with a tertiary disinfection unit but does have the capability for this to be included. In its place the AES-38 R/UV system was assessed for tertiary disinfection capabilities.

The effluent quality leaving the two OWS is compared in Table 10 and shows the range of capabilities as set out in the OSET testing programme. The effluent quality restrictions are different for municipal wastewater systems and domestic onsite wastewater systems however both Project Pure and Project Shotover are achieving effluent quality similar to the two domestic treatment units test by OSET (Table 10).

Table 10. OSET vs QLDC effluent data

Effluent (g/m^3)	AdvanTex AX-20 Mode 3/3B	AES-38 R/UV	Project Pure (Wanaka)	Project Shotover
cBOD	2.0	2	5.8	6
TSS	2.5	1	8.8	8.5
Total Nitrogen (TN)	12.3	7.7	9.6	19.4
Ammonium Nitrogen (NH_4-N)	0.6	0	4.5	10.1
Total Phosphorus	n/a	3.5	2.8	4.4
***E. coli* (cfu/100mL)**	n/a	2	65	19.9
Energy (kWh/d)[i]	0.92	2.1	n/a	n/a

[i]Note that the difference in energy consumption between the AdvanTex and the AES system is solely dependent on the tertiary disinfection unit which doubles the energy consumption

Bacteria reduction by tertiary disinfection was tested on the AES-38 R/UV system. The OSET test influent contained 1,900-18,000 cfu/100mL, while the effluent contained a median of 2cfu/100mL and 80% <3cfu/100mL (Appendix C). Drinking water standards require less than 1 cfu/100mL *E.coli*.

Nutrient reduction (nitrogen and phosphorus) from influent to effluent is also considerable with both OWS units achieving significant reductions in total nitrogen and modest reductions in total phosphorus. The Cardrona Ribbon Aquifer is not listed in the RWP’s sensitive nitrogen zones and therefore the allowable nitrogen leaching limit is 30 kg TN per hectare per year across a property (ORC, 2014). As the Proposed development has been retired from intensive agricultural activity it is expected that the effluent disposal to land will be the only significant source of nitrogen losses for the site.

Table 11 shows the estimated nitrogen loading resulting from the effluent disposal to land with a total effluent nitrogen concentration of 20 mg/L. The loading is modelled over the communal field, Lot 1, as well as over the whole property.

Table 11. Nitrogen loading estimates for 10 Curtis Road's wastewater disposal to land.

Site Nutrient losses	Peak Design Flow (L/year)	TN (kg/L)	Annual Total Nitrogen Load (Kg TN/yr)	Area (ha)	Annual Total Nitrogen Load per hectare (kg TN/ha/yr)
Full Property	8,687,000	0.00002	173.74	54.4	3.2
Communal Disposal Field	8,687,000	0.00002	173.74	1.058	164.2
Lot 1 Disposal Field	511,000	0.00002	10.22	0.12	85.2

The nitrogen losses from the disposal fields can be managed by cut and carry or low stock unit grazing (Table 12). It is therefore expected that despite the high point source load of total nitrogen in the proposed disposal fields, the nitrogen uptake of the suggested management systems can service that nitrogen load. Some losses are expected due to the required burial depth of the LPED lines (0.3 mbgl) however these are expected to be limited in nature due to the observation of rootlets to depths of 0.35 mbgl from test pits within the proposed Communal disposal field.

Table 12. Nitrogen uptake of varying management systems.

Crop / Land use	N uptake (kg/ha/year)	Reference
Pasture – irrigated, cut and carry	500 - 600	Morton *et al.* (2000)
Ryegrass - cut and carry	390	Sunich and MacDonald, (2014)
Pastoral – irrigated grazed system	200 - 240	Williams and Haynes (1990)

5 Review of Receiving Environment

The site is situated on river valley alluvial fans and terraces with sand and gravel deposits over schist bedrock. The gravel deposits are likely to be thick and extend to depths beyond the water table (up to 30 m), while some schist outcrops are present on site near Lot 16. The land is comprised of gently sloping (<15°) terrace flats, steep terrace faces, bedrock spurs, and active creek systems with historic and active channels flats, and eroded scarps.

Disposal fields are to be located on the gently sloping terrace flats so that any drip line irrigation will drain vertically/sub-vertically and not be subject to horizontal throughflow. These areas are also typified by scattered boulders which would need to be removed during the earthworks to install the irrigation lines.

During the site walkover, a significant area of the site's soils were found to be waterlogged, however the two areas (lot 16 and communal/lot 1) proposed for disposal were dry upon inspection. The risk of ingress of surface and seepage water into the land application area shall be minimised with cut-off trenching up-slope of the disposal fields. Existing drainage networks can be leveraged to reduce the downstream effects of any sediment, nutrient, or pathogen releases.

Runoff is most likely in the winter. By using the design irrigation rates derived from the LTAR, reduced from the field measured permeability by an order of magnitude, the receiving environment will have significant storage available to account for rainfall events. During heavy rainfall events, Pongs and Pringles Creeks are not considered to be an active risk to the disposal field. Flood risk and runoff is considered minor due to the low frequency of these events, the short time duration, and the ability to temporarily store effluent within the OWS during extreme weather events.

Groundwater was not encountered during any test pitting by GeoSolve (2019) or deeper auger holes (e.g. CR9) by e3s, thus groundwater is likely to be at a depth >3.5 mbgl. Disposal fields are proposed in locations with no direct connections to surface water (Pringles or Pongs Creek), risks to neighbouring property nor water takes.

Soil observations indicate that good drainage is available when soils are dry, the depth of organic matter and rootlets extend to 0.3 mbgl, and that some cobbles/boulders are present in the surface and subsoils. These observations should be considered when constructing and designing the disposal field irrigation plans. As biota activity decreases beyond a depth of 0.45 mbgl, burying the low-pressure effluent distribution network at 0.3 mbgl not only protects the system from ground frosts, but also provides additional polishing of the effluent by soil biota and other organic activity.

The design irrigation rate of 2 L/m^2/day at the Communal field reduces the risk of overland/bypass flow of the effluent. The daily load rate was calculated using a maximum per lot occupancy of 7 persons, however the most likely scenario is that of a maximum of 6 full-time occupants. The design therefore has two redundancies built into it; designed for a maximum occupancy of 7 persons (or 6 occupants and 365 additional guest nights over the year) and using 80% of the standard design irrigation rate due to the gentle slope of the terrace flat and creek bed.

Land disposal of domestic effluent will result in a low risk discharge to land that may enter groundwater. Any groundwater then entering surface water downgradient of the effluent field may be expected to carry a minor contaminant load. The effects of this contaminant load to surface water quality is expected to be less than minor - in part due to dilution and attenuation of contaminants but also due to the high level of treatment achieved by modern wastewater treatment systems with tertiary treatment.

6 Recommendations and Conclusions

The proposed pressure-fed disposal field irrigation system utilises tertiary disinfection capabilities and the inherent properties of soil, soil biota, and flora to polish contaminants in the wastewater. The design has been adapted to the environmental characteristics of the proposed disposal fields.

This site and soil assessment report has been provided to the landowner as supporting information for an ORC resource consent application and QLDC OWS application. The report includes information about the sites receiving environment, including a site and soil evaluation as recommended by AS/NZ 1547:2012. The report provides evidence that the potential adverse effects on the environment from the proposed discharge to land are likely to be no more than minor if the recommended sites are used and tertiary disinfection is adopted.

7 References

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Appendix A Soil Logs, photographs, and ribbon tests

SOIL PROFILE LOG

PROJECT NUMBER:	**19059**	WEATHER:	**Mild**
SITE NAME:	**Curtis Road**	METHOD:	**Auger**
SAMPLING AREA:	Communal	TOTAL DEPTH (mbgl):	**1.5**
SAMPLING LOCATION ID:	**CR9**	REFUSAL (Y/N):	**N**
SCIENTIST(S):	**AB & SB**	FILL PRESENT (Y/N)	**N**
DATE:	**17/07/2019**	DEPTH TO WATER (mbgl)	**N/A**
TIME:			
QA/QC SAMPLE IDs:			

SOIL PROFILE		**SAMPLE DATA**	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0-0.35	O/A: Dark Brown Clayey Silt Loam with rootlets/organics, moist, low plasticity, soft		
0.35 - 0.6	B: Brownish Grey Clayey Silt, moist, low plasticity, soft	CR9	0.3 - 0.4
0.6 - 1.5	Bw: Brownish Grey mottled orange Clayey SILT, moist, Firm		

FURTHER COMMENTS:

Several large boulders nearby at the surface (upto 2m^3)

GPS: 5023269.9184 1284345.1974

Photos:

SOIL PROFILE LOG

e3 Scientific

PROJECT NUMBER:	**19059**	WEATHER:	**Mild**
SITE NAME:	**Curtis Road**	METHOD:	**Auger**
SAMPLING AREA:	Communal	TOTAL DEPTH (mbgl):	**0.8**
SAMPLING LOCATION ID:	**CR10**	REFUSAL (Y/N):	**Y**
SCIENTIST(S):	**AB & SB**	FILL PRESENT (Y/N)	**N**
DATE:	**17/07/2019**	DEPTH TO WATER (mbgl)	**N/A**
TIME:			
QA/QC SAMPLE IDs:			

SOIL PROFILE		**SAMPLE DATA**	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0-0.3	O/A: Dark Brown Clayey Silt Loam with rootlets/organics, moist, low plasticity, soft		
0.3 - 0.6	B: Brownish Grey Clayey Silt, moist, low plasticity, soft		
0.6 - 0.8	Bw: Brownish Grey mottled orange Clayey SILT, moist, Firm		

FURTHER COMMENTS:

refused at 0.8, dug down with spade an intercepted cobbles (100 - 200mm) between 0.4 and 0.8. Site not sampled or tested.

GPS: 5023233.3410 1284362.2029

Photos:

SOIL PROFILE LOG

e3 Scientific

PROJECT NUMBER:	**19059**	WEATHER:	**Mild**
SITE NAME:	**Curtis Road**	METHOD:	**Auger**
SAMPLING AREA:	Communal	TOTAL DEPTH (mbgl):	**0.9**
SAMPLING LOCATION ID:	**CR11**	REFUSAL (Y/N):	**N**
SCIENTIST(S):	**AB & SB**	FILL PRESENT (Y/N)	**N**
DATE:	**17/07/2019**	DEPTH TO WATER (mbgl)	**N/A**
TIME:			
QA/QC SAMPLE IDs:			

SOIL PROFILE		**SAMPLE DATA**	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0-0.3	O/A: Dark Brown Clayey Silt Loam with rootlets/organics, moist, low plasticity, soft		
0.3-0.9	B/Bw: Brownish Grey Clayey Silt, moist, low plasticity, soft		

FURTHER COMMENTS:

test pit and augered extension to 0.9 after noticing minor seepage. Left over night and returned next day, noted 5cm of water in bottom of extended hole indicating drainage at similar rate to infiltration.

GPS: 5023325.2550 1284304.3836

Photos:

SOIL PROFILE LOG

e3 Scientific

PROJECT NUMBER:	**19059**	WEATHER:	**Mild**
SITE NAME:	**Curtis Road**	METHOD:	**Auger**
SAMPLING AREA:	Communal	TOTAL DEPTH (mbgl):	**0.4**
SAMPLING LOCATION ID:	**CR13**	REFUSAL (Y/N):	**N**
SCIENTIST(S):	**SB**	FILL PRESENT (Y/N)	**N**
DATE:	**18/07/2019**	DEPTH TO WATER (mbgl)	**N/A**
TIME:			
QA/QC SAMPLE IDs:			

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 0.3	O/A: Dark Brown Clayey Silt Loam with rootlets/organics, moist, low plasticity, soft		
0.3 - 0.4	B: Brownish Grey Clayey Silt, moist, low plasticity, soft	CR13	0.3 - 0.4

FURTHER COMMENTS:

NW of CR11, undertook permeabiltiy test and soil sample.

GPS: 5023356.1902 1284288.1308

Photos:

SOIL PROFILE LOG

e3 Scientific

PROJECT NUMBER:	**19059**	WEATHER:	**Mild**
SITE NAME:	**Curtis Road**	METHOD:	**Auger**
SAMPLING AREA:	Communal	TOTAL DEPTH (mbgl):	**0.4**
SAMPLING LOCATION ID:	**CR14**	REFUSAL (Y/N):	**N**
SCIENTIST(S):	**SB**	FILL PRESENT (Y/N)	**N**
DATE:	**18/07/2019**	DEPTH TO WATER (mbgl)	**N/A**
TIME:			
QA/QC SAMPLE IDs:			

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 0.3	O/A: Dark Brown Clayey Silt Loam with rootlets/organics, moist, low plasticity, soft		
0.3 - 0.4	B: Brownish Grey Clayey Silt, moist, low plasticity, soft	CR14	0.3 - 0.4

FURTHER COMMENTS:

SW of CR11, undertook permeabiltiy test and soil sample.

GPS: 5023285.5503 1284266.9879

Photos:

Test Pit for CR9. Depth of hole dug to 0.4 mbgl and extended to 1.5 mbgl with auger.

Test Pit for CR10. Depth of hole dug to 0.4 mbgl and extended to 0.9 mbgl with auger.

Test Pit for CR11. Depth of hole dug to 0.4 mbgl

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