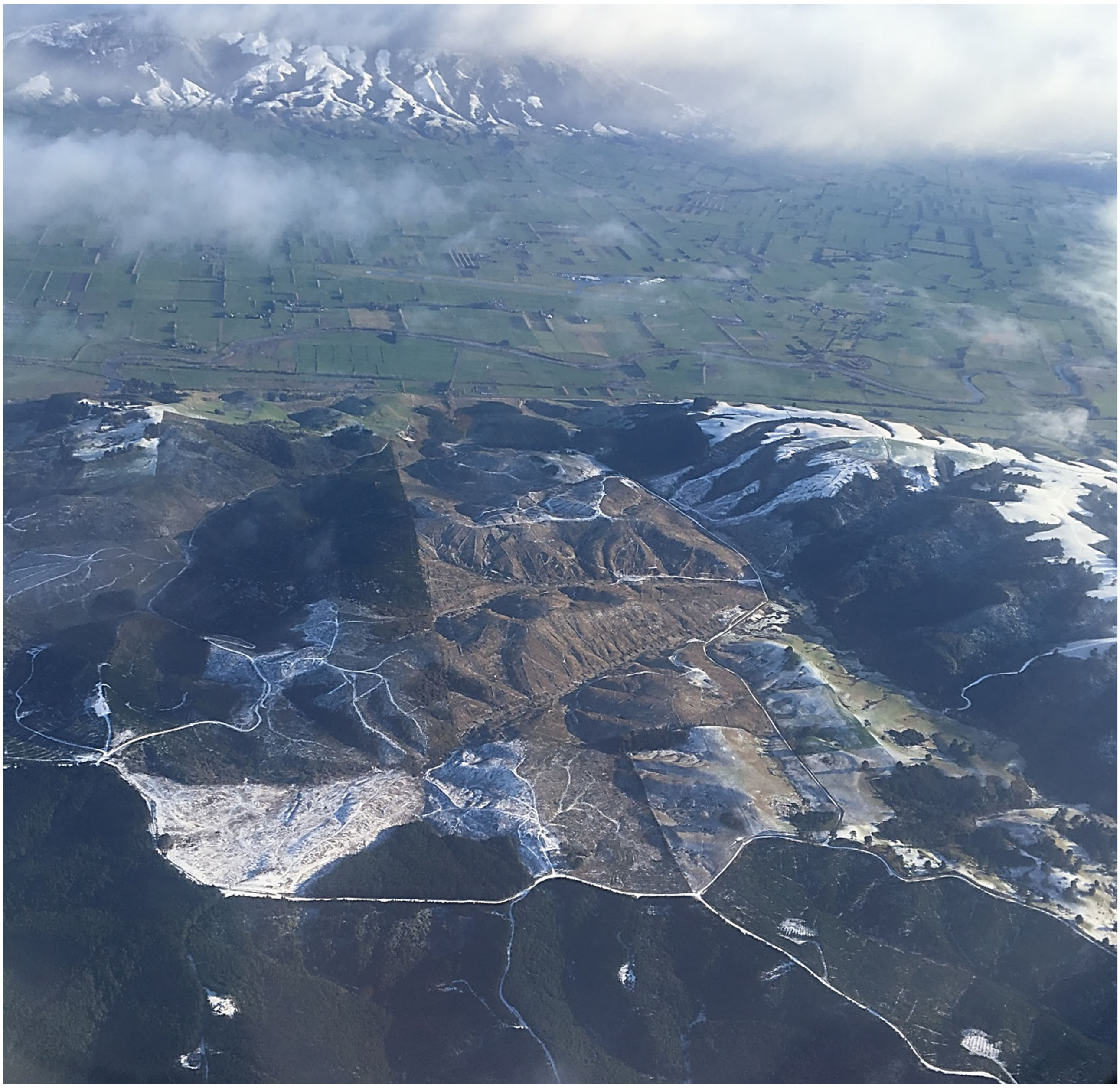
Appendix 9: Surface Water Assessment Report



Dunedin City Council

Waste Futures Phase - Smooth Hill Landfill

Surface Water Assessment

DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

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1. Introduction

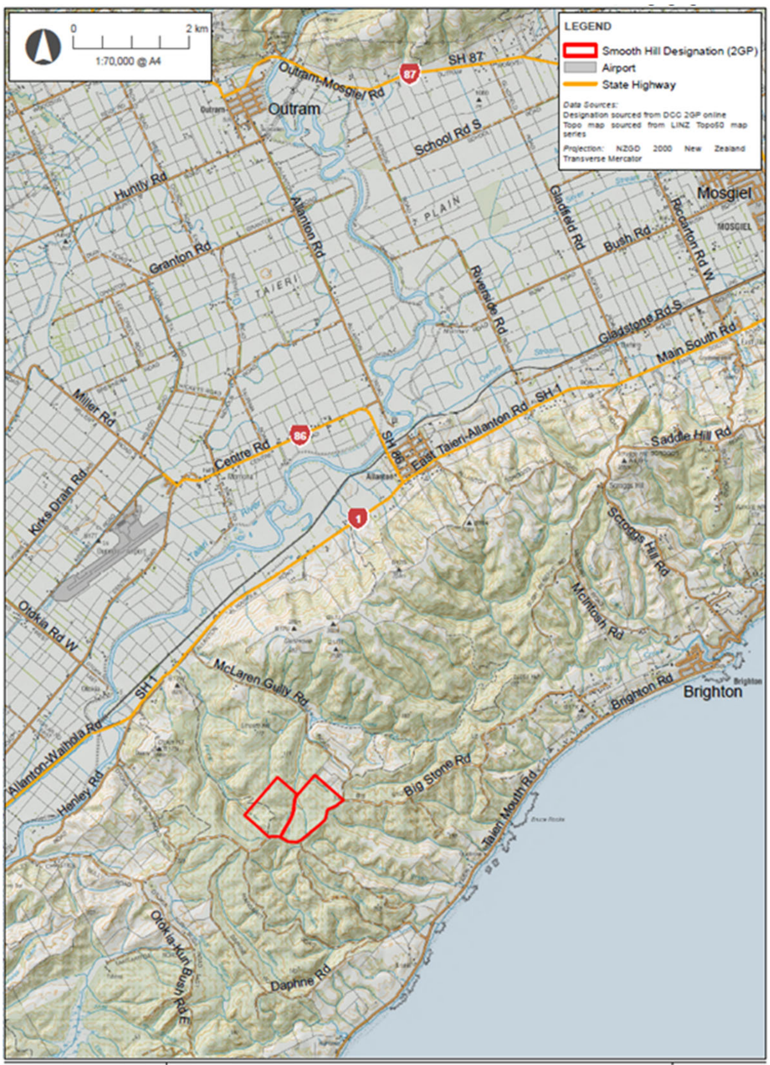
1.1 Introduction

The Dunedin City Council (DCC) collects residential waste and manages the disposal of both residential and majority of commercial waste for the Dunedin City area and environs.

The Council has embarked on the Waste Futures Project to develop an improved comprehensive waste management and diverted material system for Dunedin, including future kerbside collection and waste disposal options. As part of the project, the Council has confirmed the need to develop a new landfill to replace the Council’s current Green Island Landfill, which is likely to come to the end of its functional life sometime between 2023 and 2028..

The Council commenced a search for a new landfill location in the late 1980s and early 1990’s and selected the Smooth Hill site in south-west Dunedin, shown in Figure 1 below, as the preferred option. At that time, the site was designated in the Dunedin District Plan, signalling and enabling its future use as a landfill site. The Council also secured an agreement with the current landowner, Fulton Hogan Ltd, to purchase the land. Over the following period, the Council extended the life of Green Island Landfill and further development of the Smooth Hill site has been on hold.

Figure 1 – Site Location



As part of the Waste Future's Project, the Council has reconfirmed the technical suitability of Smooth Hill for the disposal of waste. The Council has proceeded to develop a concept design for the landfill, and associated road upgrades. The concept design (GHD Landfill Concept Design Report (GHD 2020) and Drawings (GHD 2020)) for the landfill has been developed by GHD with technical input from Boffa Miskell, and represents contemporary good practice landfill design that meets adopted New Zealand landfill design standards. The Council is now applying for the remaining RMA authorisations required to enable the construction, operation, and aftercare of the landfill, and construction of the associated roading upgrades.

The proposal includes the following key components:

- The staged construction, operation, and aftercare of a Class 1 landfill within the existing designated site to accept municipal solid waste. The landfill will have a capacity of approximately 6 million cubic metres (equivalent of 5 million tonnes) and expected life (at current Dunedin disposal rates) of approximately 55 years. The landfill will receive waste only from commercial waste companies or bulk loads.
- Infrastructure to safely contain, collect, manage, and dispose of landfill leachate, landfill gas, groundwater, and stormwater to avoid consequential adverse effects on the receiving environment.
- Facilities supporting the operation of the landfill, including staff and maintenance facilities.
- Environmental monitoring systems.
- Landscape and ecological mitigation, including planting.
- Upgrades to McLaren Gully Road including its intersection with State Highway 1, and Big Stone Road, to facilitate vehicle access to the site.

1.2 Scope of Assessment

The scope of this report is to:

- Provide an overview of the existing site hydrology, water quality and land use.
- Identify erosion and sediment control requirements and surface water monitoring during the development, operation and aftercare for the proposed development.
- Provide an assessment of the potential effects of site storm water and groundwater on surface water flows and quality in the downstream environment and wider catchment.

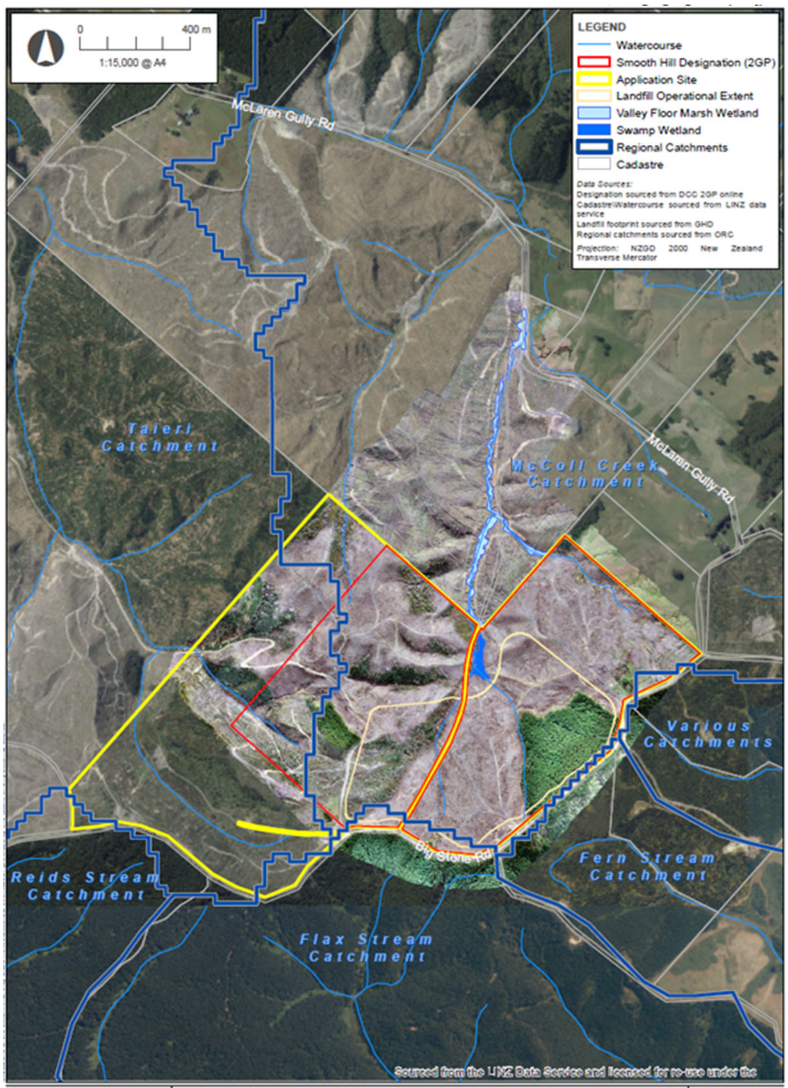
Note the effects on surface water associated with changes to groundwater flows and the effects of leachate leakage are addressed in the Groundwater Assessment Report, (GHD 2020) and referenced in this report. Section 6 of this report considers the combined effects of both storm water and groundwater discharges from the landfill site to the receiving surface water environment.

2. Site Description

2.1 Site Location

The site is located approximately 28 km south-west of central Dunedin in the hills between State Highway 1 (SH1) and the coast. Access from SH1 is via McLaren Gully Road and Big Stone Road to the south-eastern boundary of the site. Both roads are currently unsealed. The site is bounded to the north and west by forestry land and to the north-east by pastoral farmland (Figures 1 and 2). Within the site, access is via a series of forestry roads and tracks. Most of the site has been logged and re-planted in the past 5 years although a large stand of Macrocarpa remains in the south-east part of the site (Figure 1) and areas of remnant native vegetation occur in the gully bottoms.

Figure 2 - Site Hydrology



2.2 Topography and Geomorphology

The landfill site is located in a natural “amphitheatre”, which is bisected by a larger central ridge and a smaller ridge in the south-western corner – both trending south to north – see Drawing 12506381-C103 Existing Contours. The site typically has side slopes of 20%. A south to north system of gullies run through the site, which are dry most of the year with flowing water only after persistent rainfall. The gullies coalesce into a single gully at the northern edge of the site, and join a permanent stream to the north of the site that passes under McLaren Gully Rd via a culvert 1km downstream from the site. The stream then joins the Otokia Creek that ultimately flows to the coast near Brighton, approximately 10 km south-east of the landfill site.

Big Stone Road runs along a ridge on the south-eastern edge of the site and is the catchment divide. To the south of Big Stone Road the land drains directly to the Pacific Ocean via a series of gullies and streams (from north to south Graybrook Stream, Fern Stream, Tutu Stream and Open Stream – Figure 2).

The lowest elevation within the landfill site is the base of the gully at RL 100 rising to the ridgeline on Big Stone Road typically RL 140 to RL 150 and up to RL180 in the southwest corner of the site.

2.3 Climate

General climate data for the area derived from NIWA 2015 "*The Climate and Weather of Otago"* indicates the following for the site.

The climate of this region is temperate. Monthly rainfall is between 63 mm to 96 mm. Annual rainfall for the 2018 to 2019 period has been between 979 mm and 886 mm. The winter period of June to September is slightly dryer with rainfall between 42 mm and 47 mm per month. The wettest months are December and January.

Daily average temperatures across the year vary from 6.7 °C to 7.8 °C. Monthly average wind speeds are between 12.1 to 15.7 km/h.

Soil moisture deficit occurs over the period of October to April. During the winter months there is little evapotranspiration.

Table 1 Mean monthly and annual rainfall at selected Otago locations[1]

Table 6. Monthly and annual rainfall normal (a; mm), and monthly distribution of annual rainfall (b; %) at selected Otago locations, for the period 1981–2010.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Alexandra	a	48	36	29	24	28	31	19	23	19	31	31	47	363
	b	13	10	8	6	8	9	5	6	5	8	8	13	
Balclutha	a	78	68	62	50	68	62	50	43	48	61	53	71	713
	b	11	9	9	7	10	9	7	6	7	9	7	10	
Clyde	a	51	41	33	34	32	33	24	24	26	36	35	49	416
	b	12	10	8	8	8	8	6	6	6	9	8	12	
Cromwell	a	48	33	43	33	33	38	28	27	26	36	41	52	437
	b	11	8	10	8	7	9	6	6	6	8	9	12	
Dunedin (Airport)	a	69	63	56	48	60	47	46	40	42	58	50	72	652
	b	11	10	9	7	9	7	7	6	6	9	8	11	
Dunedin (Btl Gardens)	a	92	88	85	67	89	77	87	78	63	82	73	88	968
	b	9	9	9	7	9	8	9	8	7	8	8	9	

2.4 Existing Hydrology and Surface Water

The landfill site catchment area is approximately 1.5 km^2 (of which the Designation Area is 0.87 km^2 and the landfill footprint is 0.445 km^2). This compares to the total catchment area for Otokia Creek of approximately 27 km^2.

All of the site drains to the Otokia catchment except for a small area along southern edge of landfill embankment– Area 1B shown on Drawing 51-12506381-01-C301). Surface water that

[1] Reproduced from NIWA 2015 "*The Climate and Weather of Otago"*

falls on this small area cannot flow into the landfill swale drain due to gradients. Flows from this area will be diverted from the landfill catchment to the catchment south-east of Big Stone Road (Open Stream catchment). This is discussed further in Section 4.2.2.

As discussed previously, all gullies within the landfill site are ephemeral with flow only occurring following persistent/high rainfall events. Areas of wetland occur within these gullies and at the low point at the northern edge of the landfill site. At some distance to the north of the site the gully transitions from an ephemeral stream to a permanently flowing stream which crosses under McLaren Gully Road via a culvert. Existing site drainage patterns are shown on Drawing 51-12506381-C301.

The upper reaches of the Otokia Creek catchment (including the landfill site) are hilly and the predominant land use is forestry, with some areas of pasture. Aerial photographs indicate that a large percentage of the forest in the area has recently (in the last 5 years) been harvested and replanted (including most of the landfill site) and with further cutting currently occurring.

The landform in the footprint of the proposed landfill is relatively steep with grades of up to 20% and the loess soil covering is relatively erodible. The forestry cover provides interception of rainfall and stabilises soils reducing catchment runoff, flood volumes and limiting erosion and entrainment of sediments in the runoff. During the harvest/replanting cycle of the forestry land use, the removal of the vegetative cover and the associated soil disturbance results in increased runoff and erosion of the surface soils with associated impacts on water quality in receiving watercourses downstream. The increased discharges and reduced water quality will occur until the surface cover is restored which can take several years. As a result, there can be a significant variation in the water quality and runoff volumes from the catchment over time as forestry is cleared, replanted, and grows to maturity.

There are two regionally significant wetlands within the wider vicinity of the site designated on the ORC mapping (2019); Otokia Swamp, located approximately 3.4 km north west of the site adjacent to the Taieri River; and Lower Otokia Creek Marsh, adjacent to McColl Creek approximately 7.6 km north east of the site at Brighton.

Flood flows for various flood events in Otokia Creek, the valley above McLaren Gully Road (including the landfill site) and the upper catchment in the area of the landfill were obtained from the NIWA stream explorer programme[2]. These are provided in Table 2. These are current flows. Climate change is expected to result in an increase runoff in the order of 16% by 2100. The projected flows (increased by 16%) are provided italicised in brackets.

Table 2 Flood Flows

Flood Event	Otokia Creek m^3/s	Valley u/s McLaren Gully Road m^3/s	Landfill Footprint m^3/s
Mean Annual Flood (MAF)	10.7 *(12.4)*	1.0 *(1.16)*	0.33 *(0.38)*
50 year	27.4 *(31.8)*	2.5 *(2.9)*	0.96 *(1.11)*
100 Year	30.9 *(35.8)*	2.8 *(3.2)*	1.08 *(1.25)*

It should be noted that the landfill catchment and the Otokia Creek catchment will have significantly different times of peak runoff during significant rainfall events. The extreme events are unlikely to coincide and flows from the landfill area will contribute no more than approximately 1.5% of flood flows in Otokia Creek.

[2] Stream Explorer is an online flood estimation tool utilizing the regional flood estimation method for individual waterways

2.5 Existing Hydrogeology

The site groundwater system and anticipated effects associated with the landfill development are described in the GHD Groundwater Assessment Report (GHD 2020). A summary is provided below.

Otago Regional Council (ORC) designate water allocation regions by surface water catchment and/or aquifer. As the groundwater resource at the location of the Smooth Hill site is limited, the groundwater resources have been designated as part of the "McColl Creek" surface water allocation catchment. The catchment has no calculated allocation allowance and has no recorded active consents (including surface water or groundwater takes).

Both deep and shallow groundwater systems have been identified at the Smooth Hill site separated by an intermittent semi-confining siltstone layer within the Henley Breccia. The shallow system is located within the bottom of the valleys and comprises relatively permeable alluvium and colluvium and shallow weathered Henley Breccia materials. Groundwater flow directions in the shallow system follow topography, with groundwater anticipated to discharge into the Otokia Creek.

The deep groundwater system within the Henley Breccia has very low permeability due to the presence of unweathered to slightly weathered breccia and conglomerate units.

Groundwater is expected to be recharged by rainfall at different rates across the site due to the varying properties of surficial materials. Very little recharge is anticipated to occur through the low permeability loess materials to the deep groundwater system in the Henley Breccia. The alluvium and colluvium of the shallow groundwater system is likely to receive recharge directly from rainfall, with runoff generated across the loess soils also expected to flow down to the base of the valleys and provide additional recharge.

Groundwater quality appears to be impacted at the site by fertiliser use during forestry operations, with elevated concentrations of nitrate and ammonium recorded within both the shallow and deep groundwater systems. Elevated concentrations of copper, nickel and zinc have also been recorded in a number of on-site monitoring wells, which is likely a result of the reducing groundwater conditions observed at these locations.

3. Landfill Concept Design

3.1 Project Description

In summary, the project comprises the construction of a landfill with a capacity of approximately 6M m^3 (equivalent to 5 million tonnes) to provide for the safe disposal of municipal solid waste for a period in excess of 35 years (up to 55 years). The landfill will be designed to accept municipal solid waste in accordance with acceptance criteria for a Class 1 landfill described in Appendix D of the *WasteMINZ (2018) Technical Guideless for Disposal to Land*. The overall project will comprise:

- All works associated with the development of an operating landfill on the identified footprint area including:
  - Earthworks to construct the required shape;
  - Construction of a low permeability lining system to prevent leachate seepage into the surrounding environment;
  - Construction of a leachate collection system above the low permeability lining system;
  - Stormwater control around the constructed landfill and other areas of the site with appropriate treatment and attenuation of stormwater before it leaves the site;
  - A landfill gas (LFG) collection system to collect LFG from the placed waste; and
  - A leachate management system, including (leachate storage, tanker loading facilities and leachate treatment facilities).
- LFG destruction by a LFG plant (flare and/or engines);
- Provision of water supplies for operational (non-potable) and staff (potable) requirements;
- Provision of overhead power cables capable of HV transmitting electricity generated in future LFG engines;
- Upgrade and sealing of McLaren Gully Road from State Highway 1 and Big Stone Road to the site entrance.
- Heavy vehicle movement on-site to operate the landfill, including excavators and bulldozers;
- Heavy vehicle movements to and from the site;
- Other vehicle movements for staff, contractors and possibly visitors;
- Operational infrastructure such as weighbridges and vehicle wheel wash;
- Facilities for site staff, including on-site wastewater disposal via leachate management systems;
- Maintenance facilities for site plant and equipment;
- Landscaping and tree planting to minimise the visual impact of the facility; and
- Environmental monitoring systems.

The details of these works are described in the Landfill Design Report (GHD, 2020). Development of a landfill is essentially a long term construction project. The landfill will be developed in stages, with one stage being filled with waste while the next stage is constructed.

3.2 Landfill Design Aspects

3.2.1 Final Fill Profile

The final landfill capping landform is shown on Drawing 51-125306-01-C 202.

The lower elevation batter slopes immediately above the 10 m high toe bund will be constructed at 1V:4H with 10 m wide benches every 10 m vertical increase in height. These benches provide maintenance access and with a longitudinal grade of 2% and will include a swale drain to direct surface water flow to the perimeter stormwater drainage. The entire final cap will shed water to the perimeter drainage swale that flows to the stormwater attenuation basin at the northern base of the landfill.

3.3 Landfill Staging

The amphitheatre like setting for the landfill lends itself to phased development progressing in a clockwise fashion from east to west around a toe buttress constructed at the northern base of the amphitheatre. The landfill will be developed in five formal stages (Stages 1 to 5) where Stages 1 and 2 will be in the north-eastern portion of the landfill footprint separated by the natural ridge from Stages 3, 4 and 5 in the south-western portion. Each stage will be the full width of the landfill (from Big Stone Road to the toe buttress). (Refer to Drawing 51-12506381-01-C201).

3.4 Leachate Collection and Stormwater Management

Leachate is the liquid produced through waste degradation and rain water that percolates through the waste to the landfill liner, collecting dissolved and/or suspended matter from the waste as it passes through. A landfill is managed to minimise the volume of leachate that is produced. This is achieved by:

- Redirecting upslope surface water from entering the leachate collection system;
- Minimising the size of the active filling area where waste is exposed to rainfall;
- Covering areas with intermediate or final cover as soon as is practicable so that as much water as possible is shed into a stormwater collection system and minimising percolation of water through these layers into the underlying waste;
- A stormwater collection system that enables monitoring of stormwater from areas of intermediate cover or final cover and ability to redirect that contaminated surface water to the leachate system if found to be contaminated.
- Providing well managed stormwater systems to separate all stormwater flow from areas where waste is placed, and ensuring all site stormwater is diverted away from waste.

All stormwater that comes into contact with waste will be treated as leachate and will not be discharged to the stormwater system. Leachate generated within the landfill will flow to the leachate collection system at the base of the landfill from where it will be removed off site for treatment and disposal.

4. Stormwater Control

4.1 Overall Stormwater Management

Stormwater management and controls will be required during the construction, operation, closure, and aftercare phases of the landfill. Stormwater controls are shown on Drawings 51-12506381-01-C102, C301, C803 and C804. The management and controls are required to mitigate adverse effects on surface water flows and water quality in the downstream receiving environment and wider catchment. The issues and associated control measures are discussed below.

Stormwater systems are required as part of the landfill operation to ensure that:

- Stormwater is diverted and separated from waste to avoid contamination – any stormwater that comes into contact with waste must be treated as leachate.
- To the extent practicable, erosion and transport of sediment from earthworks areas must be minimised. This is achieved through minimising exposed soil surfaces, installing cut-off drains to minimise flow over exposed earth surfaces, installing temporary measures where practicable to minimise the transport of sediment from earthworks areas, and stabilising these areas with vegetation or by other means as soon as practicable.
- Suitable conveyance systems (channels, pipes) are in place to carry the stormwater to suitable treatment devices to remove any sediment carried with the stormwater. These systems may comprise permanent systems (e.g. perimeter channels) or temporary systems as each stage is developed.
- Adequate treatment systems are in place to remove sediment from stormwater at all stages of development and operation of the landfill.

4.1.1 Construction Phase

A key issue during the construction phase is the exposed surface with the potential to generate suspension of sediments in runoff discharging to the downstream valley and Otokia Creek (with a minor contribution to Open Stream - see Section 4.2.2.)

The construction phase controls will include:

- Perimeter swale drain: A cut off channel will be provided around the perimeter of the immediate construction phase to intercept up gradient flows and divert these from entering the construction area. Further description of the swale drain is provided below.
- Attenuation basin: An attenuation basin will be constructed as part of the long-term management for the site managing increased runoff from the landfill site over its lifetime. All stormwater from the landfill (other than the small 9,000 m^2 area on the southern edge of the landfill adjacent to Big Stone Road – see 4.2.2) will drain to this basin. This includes runoff from:
  - The Landfill extents;
  - Gullies outside the landfill footprint – but upslope of the attenuation basin;
  - The landfill facilities area
  - The small area of the catchment upstream of the landfill (via the perimeter cut off drain and existing gullies prior to landfill footprint development);
  - pre-construction areas;
  - areas during construction;

- areas with final cover and/or stormwater diverted from activity areas that has not come into contact with waste.

- The basin will be located at the downstream end of the landfill site and will be constructed at commencement of the landfill development works to manage increased flows associated with the exposed surface and to provide an additional level of treatment of runoff prior to discharge. Further description of the attenuation basin is provided in Section 4.2.1 below (see Drawing 51-12506381-01-C102 for location).
- Sediment control pond in landfill: A sediment control pond will be constructed at the immediate base of the excavation for each phase of the landfill and provide primary treatment of runoff removing sediment from discharges that then flow through to the attenuation basin. The typical anticipated layout of a sediment control pond for Stage 1 development is shown on Drawing 51-12506381-01-C803. These in-landfill sediment control ponds will remain in operation for the life of the various landfill stages until subsequent stage works require the footprint of that sediment control pond. Alternative sediment control ponds will be progressively installed for the subsequent development stage.
- Sediment control for Stockpile: The stockpiles are located in a small sub-catchment to the north of the main site area and the associated attenuation basin (51-12506381-01-C301). Stormwater runoff from the stockpile area will be managed through a separate stormwater control system (51-12506381-01-C206).
- Stage area limitation: Excavation will be carried out as required to limit the area exposed at any one time and following excavation surfaces will be protected as soon as possible. This may take the form of grassing / hydroseeding or the use of protective matting.
- Localised works will be site specific such as management measures for the road upgrade works, which may include the use of filter socks or temporary silt dams in channels while works are under construction and there is potential for elevated sediment concentrations in runoff.

4.1.2 Operation Phase

The operational phase involves the opening of new cells as required, the progressive relocation of access routes over the landfill footprint and application of cover soils once that portion of the cell is full.

The controls for the opening of new cells are similar to those outlined for the construction phase including extension of the perimeter swale drain around the extent of the new works, development of new sediment control ponds and the development of drainage to the attenuation basin.

The key controls for the covering and closure of filled cells are the grading and surface drainage of the impermeable capping to the perimeter swale drain flowing to the attenuation pond and the establishment of a vegetative cover over the surface to reduce runoff volumes and stabilise the surface to control sediment discharges.

4.1.3 Closure/Aftercare Phase

This phase includes the final covering and closure of the landfill and the post-closure aftercare.

The closure phase controls will be similar to those for the cell closure discussed in the operational phase above with the addition of localised short term sediment control measures for the removal of long-term infrastructure such as hardstand areas and building platforms. Landfill capping and therefore closure of the cell will be progressive. It is expected that at any point in time, the final cap will be placed and vegetation established where the design levels are reached.

The closed landfill will have an ongoing stormwater management requirement. This includes the ongoing drainage from the capping and the management of increased flows together with water quality monitoring. While this does not require the construction of additional control measures it does require the ongoing retention and maintenance of the perimeter swale drain and the attenuation basin.

A site specific stormwater management plan will be prepared which will form part of the overall operation plan for the landfill. The stormwater management plan will provide a more detailed assessment of management requirements, the measures to be adopted, and design of the controls. The plan will follow good practice and will utilise relevant guidelines, including Auckland Council GD05 for the sizing of ponds and the Environment Canterbury Erosion and Sediment Control Toolbox, for the identification of the most appropriate control measures taking in to account site specific conditions.

The following sections provide more information on specific aspects of the stormwater control systems.

4.2 Landfill Stormwater Management Systems

The proposed landfill site is bounded by ridges on three sides and drains to the gully at the north end of the site. The site is located at the head of the catchment and there is no significant external catchments that drain to and through the landfill site. This is a significant advantage for the site in terms of stormwater management.

The catchment for the stormwater attenuation basin is 69.2 ha where the current surface at the time of the consent application is mainly recently replanted forestry, with vegetation existing in gullies and 8 ha of exotic macrocarpa forestry.

The stormwater collection and conveyance system at the landfill is based on:

- A perimeter swale drain around the final landfill footprint to collect stormwater flows from the limited land area up gradient of the landfill and the landfill cap and divert all stormwater to the attenuation basin at the toe of the landfill and is designed for a 1% AEP storm event. The perimeter drain will be constructed progressively as the landfill stages are developed. As there is no significant external catchment this drain will primarily be collecting stormwater from the interim and final landfill surfaces.
- A system of temporary stormwater drains on the landfill operational surface, as required to suit the current stage of operation, diverting all stormwater not impacted by contact with waste to the landfill perimeter drain.
- The final cap is graded to the perimeter swale drain. Where final capping slopes exceed 1V:10H, permanent contour drains discharging to the perimeter swale drains will be installed at 50 m centres. Prior to the establishment of the grass stabilised final capping, temporary contour drains will be installed to meet the requirements of the Canterbury Regional Council document Erosion and Sediment Control Guideline.
- During landfill construction and where soils are un-vegetated, clean water diversions will be installed and all sediment laden stormwater will pass through treatment ponds for the removal of sediment. As discussed above, these will be constructed progressively within the landfill footprint and the landfill is progressively developed. An example layout for Stage 1 is shown on Drawing 51-12506381-01-C803.
- All treated (for sediment only – any stormwater found to be contaminated by waste will be diverted to the leachate treatment system for disposal) and diverted stormwater will report

to the attenuation basin at the northern boundary of the landfill. Along with the toe bund, the basin will be constructed at the commencement of the project development. The pond will provide additional water quality polishing as well as attenuate flows to the downstream catchment. In addition, in the event of a spill of leachate or other contaminants the pond will provide some emergency containment.

- Stormwater calculations and catchment flow assessments have utilised rainfall data derived from HIRDS V4 rainfall data and the NIWA Stream Explorer tool (which utilises the Regional Flood Estimation method) with a climate change allowance of 16%, based on prediction scenario RCP6.0 (2081-2100)..

4.2.1 Attenuation Basin Design

The attenuation basin is designed to control flows from the catchment draining to it that currently discharge to the existing gully. As noted previously, drainage is likely to be restricted to persistent or high periods of rainfall. The preliminary design for the basin is shown on Drawings 51-12506381-01-C306 to C307.

The attenuation basin is designed to attenuate up to a 1% AEP storm event with allowance for climate change to the end of the 35 year consent period which provides for 4.6 degree centigrade rise in temperature. Stormwater channels provide 300 mm of freeboard above the 1% AEP. The basin will have less than 20,000 m^3 of stored water during a rain event (and is normally empty) and has a retained height of 4.0 m to the lined spillway crest (internal, downstream height is 4.8m from crest to natural ground). Other than the spillway, the attenuation basin embankment will have 1.0 m freeboard and 5.0 m width at the crest for maintenance access. This will attenuate flows and provide water treatment through a wet forebay and planting on the dry basin base grade.

As added security to mitigate a leachate discharge, the low flow outlet pipe will be provided with an emergency shut off valve that can be closed to provide emergency storage if required. This then allows for water captured in the attenuation basin storage to be tested, monitored, treated or removed off site where necessary. This reduces the risk of discharging leachate contaminated stormwater to the receiving watercourse.

The base of the basin will be unlined to allow seepage of stormwater into the groundwater system. As described in the Groundwater Assessment Report (GHD, 2020), this will assist in mitigating groundwater recharge to the downstream area that will be impacted by the construction of the landfill.

4.2.2 Perimeter Drain Design

The perimeter swale drain is designed to accommodate a 1% AEP storm event. The minimum gradient of the swale drain is 1% (other than on the landfill toe embankment where flow volumes are minimal). Where the 1% AEP flow in the swale would exceed 0.8 m/s, scour protection will be applied to the wetted perimeter of the swale drain. This limiting velocity is based on the use of loess in the channels and the maximum velocity for grassed swales will be confirmed during detailed design. Channel scour protections will vary dependant on the design velocity and will range from grass only channel, through reinforced earth (grass root matting) through to formal rock ballast rip-rap.

The swale drain will have a continuous gradient along the 1.2 km frontage of Big Stone Road from the high point at the south end of the landfill to the facilities area at the north and from there to the attenuation basin. To achieve this, the swale drain will be constructed on engineered fill to raise the swale 8 m above the road at this location (see Drawing 51-12506381-01-C302). Slightly north of this location and where Big Stone Road is higher than the proposed swale drain, the drain will be constructed approximately 5 m lower than Big Stone Road.

While the design directs all stormwater from the landfill and associated catchment to the attenuation basin, a small area of exception exists. Where the swale drain is higher than Big Stone Road (small section along southern edge of landfill – Area 1B shown on Drawing 51-12506381-01-C301), surface water that falls on the batter below the swale drain cannot flow into the swale drain. Flows from this area will be diverted from the landfill catchment to the catchment south-east of Big Stone Road (Open Stream catchment – see Section 2.2). This diversion in catchment has an area of 9,000 m^2 and anticipated flow rates of 67 l/s for a 10% AEP and 101 l/s for a 1% AEP. As the batter in question will be constructed wholly of engineered fill (see Drawing 51-12506381-01-C302), no waste will exist in this sub-catchment thereby avoiding the possibility for leachate to escape to this catchment.

The stormwater from this small sub-catchment will be collected in a swale drain along the base of the embankment and directed to the Big Stone Road swale system and Open Stream catchment via a culvert beneath Big Stone Road. The Open Stream catchment is comparatively large (at least 6 km^2) and the additional diversion catchment of 9,000 m^2 will make a very minor additional contribution (less than 0.01%).

4.2.3 Subsoil Drainage

The Groundwater Assessment Report (2020) estimates that groundwater seepage collected by the underdrain system will be very small reflecting the low permeability of the underlying geology. Groundwater flows could be up to 4 m^3/day (approx. 0.05 litres/second). Groundwater will be collected from the base of the landfill and pumped for either discharge into the attenuation basin or utilised as a non-potable water supply on site. At this time it is anticipated that nearly all the groundwater will be used as a non-potable water supply.

4.3 Ancillary Works

4.3.1 Site Roading

Access Road

Access from SH1 is via the existing McLaren Gully Road to the junction with Big Stone Road (a distance of approximately 4.3 km). Traffic then turns right onto the existing Big Stone Road for 350 m to a proposed landfill access road junction (see Drawings 51-12506381-C702). A new access will be constructed from the junction to the site facilities and landfill – a distance of approximately 200 m.

Upgrades Required to Existing Roads

An evaluation of anticipated traffic has been completed (see Integrated Transport Study, GHD 2020) and based on the study, upgrades to the existing SH1/McLaren Gully Road junction are proposed. These will include:

- Upgrade of the SH1/McLaren Gully Road junction with the inclusion of a south bound left turn lane (Drawing 51-12606381-01-601).
- Inclusion of “flag lighting” for the SH1 junction.

Widening and upgrade of McLaren Gully Road and Big Stone Road will be required up to the proposed landfill access point. The legal roads and access as far as the wheel wash will also be sealed from the SH1 junction.

The upgrade will not significantly affect stormwater volumes and the sealing of the road is likely to result in a reduction in sediment discharges in runoff. The design has therefore assumed that runoff will be managed via discharge to roadside channels similar to existing and that the same discharge points to watercourses will be retained so that the current drainage regime is not altered.

Internal Site Access

Access will be sealed as far as the wheel wash, beyond which internal access roads will be unsealed as landfill operations machinery use this portion of the access and would repeatedly damage a sealed surface.

Surface run off from the access roads south of the intersection within the facilities area will discharge to the stormwater attenuation basin which will also provide a degree of treatment improving the quality stormwater discharges from the site. This attenuation basin also provides for the ability to manage a spill (should this occur) within the site and internal access roads closest to the landfill. Monitoring of water in the attenuation basin will be undertaken.

Tip Area Access and Perimeter Road

An access track will be constructed around the final landfill perimeter next to the perimeter swale drain. The purpose of the track is to provide 4-wheel drive access to the perimeter of the landfill for monitoring and maintenance purposes. The track will have a gravelled surface.

The perimeter track will be progressively constructed along with the perimeter swale drain as the landfill stages are developed. Stormwater from the perimeter access will be directed to the swale drain.

4.3.2 Site Facilities

Two main platforms will be created for the location of facilities: an upper area immediately to the north east of the landfill and west of the Big Stone Road access; and a lower platform to the north of the landfill (see Drawing 51-12506381-01-C702).

Water tanks will be provided to store non-potable water (from roofs or groundwater) for wheel wash, equipment cleaning and dust suppression requirements. Potable water for drinking and showers will be tankered in. Wastewater from the toilets and showers will discharge to the leachate collection storage tanks for removal off site and disposal to the DCC sewerage system.

Wheel Wash

A wheel wash will be provided on the main access road for cleaning the wheels of all vehicles leaving the site as shown on drawing 51-12506381-01-C702. Beyond these points, the access road to the public roads will be sealed. The wheel wash will comprise a pressure under body spray wash with rumble bars through which the vehicles drive. Dirty water from the wheel wash will be captured in coarse sediment traps adjacent to the wheel wash and further treated in flocculation ponds before being recycled back to the wheel wash. Discharges of excess water from the wheel wash recycle system are expected to be minimal and only occur during periods of heavy rainfall. This water will flow into the landfill stormwater system and will pass through the landfill stormwater attenuation basin.

4.3.3 Stockpiles

Stockpiles are required for:

- Surplus excavated materials until they are needed for landfill operations or final capping (largely excavated breccia);
- Low permeability loess material;
- Topsoil

- Unsuitables

The stockpiles will have appropriate sediment control measures which may include the use of soils stabilisers, biodegradable cover or silt fences for the smaller stockpiles or sediment retention ponds and cut off drains for the larger stockpile areas. Stockpiles will be track rolled and trimmed to regular shapes and those not expected to be reworked within 1 month will have mulch or hydroseeding applied.

5. Ongoing Monitoring

On-going monitoring during the construction programme will be required to assist with sediment management. The approach will be an adaptive sediment management strategy where the monitoring can provide feedback on the effectiveness of sediment controls and the need for adaption of those controls.

Monitoring measures will be included in the Landfill Management Plan and will include at least the following:

- Weather forecasting will be required to allow planning of works with a significant potential for sediment generation.
- Daily visual inspection of systems including water clarity or colour downstream of the site when surface discharge is occurring.
- Monitoring at the on-site locations shown on Drawing 51-12506381-01-C309 (Locations SW1-SW6). Monitoring will occur only during periods of surface water discharge from the site. If continued periods of surface water discharge occur then monitoring will occur weekly.
- Monitoring will commence at least 12 months prior to construction to establish baseline conditions.
- Weekly monitoring (while persistent surface water flow occurs) downstream from the landfill at the location where the tributary to the Otokia Creek passes under McLaren Gully Road (SW7).
- At each location samples will be collected and water flow measured. Samples will be analysed for the parameters presented in Table 5 in Section 4.2.4 of the Groundwater Assessment Report (GHD 2020) and compared to trigger levels to determine the presence of any leachate in stormwater or other site contaminants. Samples will also be analysed for suspended solids and turbidity to assess the performance of sediment management. Trigger levels will be detailed in the Landfill Management Plan.

It is recognised that due to the nature of the soils in this area and ongoing forestry activity parts of the Otokia catchment can currently generate significant amounts of sediment during persistent rainfall events. The objective of the sediment management measures will be to ensure that the landfill site contributes, on a proportional basis, no more sediment than the immediate surrounding catchment during any given rainfall event. To determine if this objective is being met the sediment load being discharged from the site will be determined based on flow and analysis of sediment concentrations. This will be compared to the calculated sediment load at SW7. If the site is shown to be contributing a disproportionate sediment load then sediment controls will be reviewed and adapted to address.

It should be noted as the landfill is developed and stages are progressively completed and closed the final form will be a contoured grass covered cap. In terms of sediment discharge the final cap will have significantly lower potential to generate sediment runoff during rainfall events compared to the existing forestry activities.

Evidence of leachate in stormwater runoff from the site will trigger an immediate investigation of the potential source. The multiple sampling sites shown on Drawing 51-12506381-01-C309 will allow the source of any discharge to be narrowed down to a specific part of the site. Contingency actions should trigger levels be exceeded will be detailed in the Landfill Management Plan.

6. Assessment of Effects on the Environment

The construction, operation, and aftercare of the landfill and associated infrastructure including facilities and access roads have the potential to result in effects from site stormwater on surface water flows and quality in the downstream receiving environment and wider catchment, including as a result of discharges of sediment during earthworks.

The Landfill Management Plan will provide a more detailed assessment of stormwater management requirements, the measures to be adopted, design of the controls, and monitoring. The plan will follow good practice and will utilise relevant guidelines, including Auckland Council GD05 for the sizing of ponds and the Environment Canterbury Erosion and Sediment Control Toolbox, for the identification of the most appropriate control measures taking in to account site specific conditions.

The objectives for land disturbances activities under the Landfill Management Plan require land disturbance activities to be undertaken in a manner that protects the safety of people and avoids, remedies and mitigates adverse effects on the environment by minimising sediment generation and controlling land disturbance activities.

The associated effects have been considered and are outlined below. In addition, the effects associated with groundwater and potential leachate seepage from the site have also been considered in the following section. Therefore, the following evaluation represents an overall assessment of the combined effects on the receiving surface water environment.

Downstream Hydrology

- The site is located at the head of the Otokia catchment and very little through flow of stormwater from above the site will occur.
- Surface runoff currently occurs at the site only during and immediately after periods of persistent or high rainfall.
- In this report it is estimated that the site area will contribute no more than 1.6% of flood flows in the Otokia catchment.
- Ongoing construction of the landfill will modify the hydrology of surface water discharges when they occur from the site area to some extent as the site is developed. For example, exposed areas of liner will increase stormwater runoff from those areas compared to existing site conditions (note runoff from exposed areas of liner will only be directed to the stormwater system where contact with waste can be excluded). In contrast aspects of the development such as the establishment of a grassed final cap will result in decreased runoff through increased evapotranspiration
- However, these changes need to be considered in the context of the sites contribution to the wider catchment:
    - As noted in this report, except during extended periods of rainfall no surface runoff occurs from the site. The Groundwater Assessment Report (GHD, 2020) has identified that shallow groundwater from the site contributes to downstream wetlands. Site development may impact shallow groundwater levels by a few metres for a distance of approximately 50 metres downstream from the toe of the landfill. However, the change in seepage rates is estimated to be approximately 0.08 litres/second and is very small in the context of surface water flows when they do occur from the site.

Therefore, no impact on the wider hydrology of the Otokia catchment is anticipated from changes in groundwater.

  - Following periods of persistent or high rainfall surface runoff will occur from the site and contribute to the wider Otokia catchment. As discussed above, during the development of the landfill these surface flows may be modified and increase or decrease depending on the construction activities and status of the site. However, during these events the site makes a small contribution to the overall Otokia catchment during periods of flood (1.6%) and no significant impacts are anticipated on the wider catchment beyond the immediate vicinity of the site.
  - When flows occur, in the environment immediately downstream of the site flows may vary to some extent from those that currently occur. However as flows are already intermittent in nature in this area this is not expected to have a significant impact on the immediate downstream surface water environment.

- Section 2.4 of this report identified two regionally significant wetlands designated on the ORC mapping (2019); Otokia Swamp, located approximately 3.4 km north west of the site adjacent to the Taieri River; and Lower Otokia Creek Marsh, adjacent to McColl Creek approximately 7.6 km north east of the site at Brighton. The Otokia Swamp wetland will not be impacted by the landfill as it is located in the Taieri River catchment rather than the Otokia Creek catchment. The Lower Otokia Creek Marsh is located towards the bottom of the Otokia catchment. At this location the contribution to surface water flows from the landfill site is very small and no significant impacts are likely associated with either creek hydrology or water quality at this location.

Downstream Water Quality - Sediment and Other Water Quality Matters

- The site and surrounding area undergo intermittent clearing of forestry with associated potential for erosion of sediments during periods of rainfall until ground cover can establish.
- Development and operation of the landfill also has the potential to generate sediment loads during rainfall events.
- Considering the implementation of the measures outlined in this report combined with the use of best practice methods, and an adaptive approach including monitoring, the effects from sediment discharges during construction and operation should be able to be appropriately controlled to ensure the risk of effects from sediment discharges are minimal.
- Furthermore, the long-term effects of the landfill in terms of sediment management may be largely beneficial as the sediment discharge from the final cap and swale drains will be minimal compared to the existing forestry operations during periods of cutting, clearing and replanting/re-establishment.
- In addition to sediment the site also has the potential to impact surface water quality for a range of parameters associated with landfill leachate. This is described in detail in the Groundwater and Surface Water Report (GHD, 2020). In summary, no significant downstream effects on surface water quality associated with waste disposal and leachate generation are anticipated as:
  - Surface water runoff will be kept separate from landfill waste. Any surface water that comes into contact with waste will be managed as leachate. Section 5 of this report includes a monitoring plan for surface water flows, when they occur.

- As described in the groundwater and surface water report, shallow groundwater seepage from the site and wider catchment emerges as surface water downstream from the landfill; either as areas of wetland or flowing water north of the landfill toe.
- Groundwater samples collected at the site indicate that the existing environment and forestry practices are contributing nitrogen and a range of other parameters to the shallow groundwater system.
- Analysis presented in the groundwater report assumes these existing effects will largely be removed by the construction of a landfill as they are associated with forestry practices. However, it has also been assumed that a very small amount of leachate leakage will occur through the landfill lining system to the underlying shallow groundwater (up to 1.9 m^3/year).
- The change in land use from forestry to landfill is expected to result in a net reduction in flux of contaminants to the groundwater system beneath the landfill footprint for almost all parameters of concern (Table 7 in the groundwater report). The exception is ammoniacal nitrogen which is expected to increase slightly (total flux increase from approximately 0.17 kg/year to 1.3 kg/year). However, nutrient transformation between nitrogen species, nitrate and ammoniacal nitrogen is dependant upon a variety of environmental conditions. Therefore total inorganic nitrogen is considered to represent a better measure for comparing nitrogen nutrient flux. Table 7 (Groundwater Assessment Report) estimates a significant reduction in total inorganic nitrogen from an existing contribution of 73 kg/year to less than 2 kg/year.
- Given the anticipated reduction in flux of contaminants to the groundwater system the impact on the wider surface water system is anticipated to be an improvement in water quality, albeit very small given the minor contribution groundwater from the site makes to the wider surface water system.
- Baseline and operational monitoring of groundwater quality is proposed in the Groundwater Assessment Report to confirm these expectations.

- Schedule 15.2.2 of the Otago Regional Plan establishes water quality limits for surface water. The relevant limits are:
  - Nitrate –nitrite 0.075 mg/l
  - Dissolved Reactive Phosphorus (DRP) 0.01 mg/l
  - Ammoniacal nitrogen 0.1 mg/l
  - E Coli 260 cfu/100ml
  - Turbidity 5 NTU
- As described in Section 4.6.2 of the Groundwater Assessment Report (GHD, 2020) and in the above sections of this report the total flux contribution for DRP and total nitrogen are expected to decrease in comparison to current shallow groundwater discharges from beneath the landfill footprint. Therefore, on the assumption that shallow groundwater eventually discharges to the surface water system downstream from the landfill, no significant impact is anticipated on these parameters in surface waters.
- A small increase in the total annual flux of ammoniacal nitrogen is expected in the shallow groundwater seepage but the associated groundwater seepage rate is very small (1,200 m^3/year or less than 0.04 l/second). Furthermore, as discussed above the flux of total inorganic nitrogen is estimated to reduce from approximately 73 kg/year to less than

2 kg/year, and considering nutrient transformations between nitrogen species, the impact to groundwater and surface water quality is considered to be less than minor.

- E.Coli is not anticipated to be a contaminant of concern associated with any seepage from the landfill with the underlying groundwater. E coli has a relatively short half–life and the velocity of groundwater seepage will be very slow. Therefore, any E Coli are unlikely to survive within the groundwater system. Furthermore, both the liner system and the underlying natural materials are very fine grained and will filter E Coli from groundwater seepage.
- As discussed in Section 5 of this report, sediment load from the site and turbidity will be monitored to ensure that the landfill site contribution, on a proportional basis, is no more than the immediate surrounding catchment during any given rainfall and runoff event. Monitoring is proposed to confirm this occurs. If the relative contribution is higher than the surrounding catchment the sediment control methodologies on site will need to be adapted to address. It is anticipated that surface runoff from the site will only occur during high intensity or extended rainfall events. At these times it is likely that the wider Otokia catchment will have a significant sediment load and turbidity will generally not meet the plan limits regardless of the contribution of surface water runoff from the site.

7. Limitations

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This report has been prepared in part by Allen Ingles, an associate and civil engineer at GHD Ltd.. Allen has over 20 years experience as a landfill engineer and has the following qualifications and institutional memberships: NZCE (Civil), NZCLS, CPEng and a member of Engineering New Zealand and member of Australasian Land and Groundwater Association and member of the Society of Construction Law The author would also like to acknowledge the assistance of Nick Eldred and Richard Coombe in the preparation of this report.

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