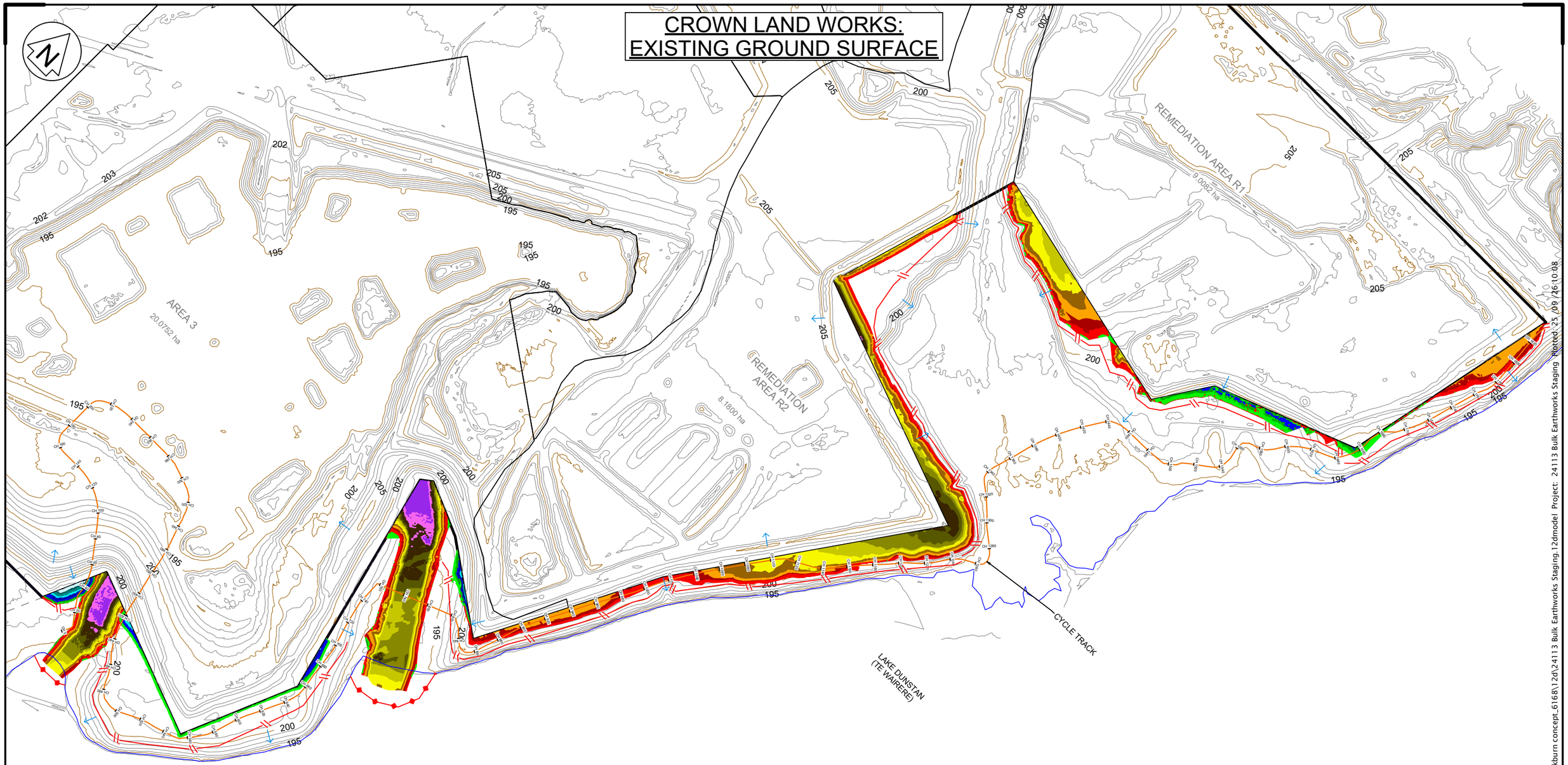
CROWN LAND WORKS: EXISTING GROUND SURFACE



0 100 200 metres

1:3000 Scale Bar

ISSUED FOR CONSENT

LEGEND

- CLEAN WATER DIVERSIONS
- EXISTING CLEAN WATER DIVERSIONS
- DIRTY WATER DIVERSIONS
- TRAFFICABLE CONTOUR BUND
- HAUL ROAD
- SILT FENCE
- SILT CURTAIN
- INFILTRATION BASIN
- SPILLWAY
- STABILISED CONSTRUCTION ENTRANCE
- GENERALISED OVERLAND FLOW DIRECTION

Folder Location: c:\12d5\data\SERVER2008R2\24113-Parkburn concept_6168\12d\24113 Bulk Earthworks Staging.12dmodel Project: 24113 Bulk Earthworks Staging Plotted: 25/09/26 10:08

LANDPRO.
OFFICES IN CROMWELL, WANAKA, AND NEW PLYMOUTH - www.landpro.co.nz

Client: FH LAND DEVELOPMENT LTD

NOTES
- All dimensions shown are in metres unless otherwise shown
- Copyright on this drawing is reserved
- Check any electronic data against the hardcopy plan to ensure it is the latest version
-If this plan is being used as part of sale and purchase agreement then it is done so on the basis that it is preliminary only, final dimensions and areas may vary on final survey

EROSION AND SEDIMENT CONTROL - CROWN LAND WORKS

PARKBURN DEVELOPMENT PROJECT

922 LUGGATE - CROMWELL ROAD

Rev.	Date	Revision Details	By
A	09 2026	EWK Area Interface linework added	KA

Designed: WN	Date: 04 2026	Job No.: 24113	Drawing No.: 114_07
Drawn: KA	Date: 05 2026	Scale: 1:3000 @ A3	
Checked: NKA	Date: 06 2026	Datum & Level: LP2000 & NZVD16	Rev.: A

N

Cut/Fill Depths

Lower_value		Upper_value		Colour
-10	to	-9	m	
-9	to	-8	m	
-8	to	-7	m	
-7	to	-6	m	
-6	to	-5	m	
-5	to	-4	m	
-4	to	-3	m	
-3	to	-2	m	
-2	to	-1	m	
-1	to	0	m	
0	to	1	m	
1	to	2	m	
2	to	3	m	
3	to	4	m	
4	to	5	m	
5	to	6	m	
6	to	7	m	
7	to	8	m	
8	to	9	m	
9	to	10	m	

CUT

FILL

NOTE: CUT & FILL DEPTHS ARE PRELIMINARY ONLY AND ARE SUBJECT TO DETAILED DESIGN.

FISH BARRIER

EARTHWORKS SUB-AREA 3

EARTHWORKS SUB-AREA 2

EARTHWORKS SUB-AREA 1

DIVERSION DAM

REINSTATED CREEK CHANNEL TO BE STABILISED WITH CLEAN GRAVEL AND COBBLES

CLEAN WATER DIVERSION BUND

STREAM DIVERSION (INDICATIVE ONLY - FINAL ALIGNMENT TBC VIA DETAILED DESIGN)

CREEK FLOODPLAIN AND BANKS TO BE TOPSOILED, HYDROSEEDED, AND STABILISED WITH EROSION CONTROL BLANKET/MAT

APPROX. EXISTING ACTIVE BED

AREA 9

3.5684 ha

AREA 8

5.3405 ha

REMEDIATION AREA R1

9.0082 ha

205

200

CWB

LEGEND

- CLEAN WATER DIVERSIONS
- EXISTING CLEAN WATER DIVERSIONS
- DIRTY WATER DIVERSIONS
- TRAFFICABLE CONTOUR BUND
- HAUL ROAD
- SILT FENCE
- SILT CURTAIN
- INFILTRATION BASIN
- SPILLWAY
- STABILISED CONSTRUCTION ENTRANCE
- GENERALISED OVERLAND FLOW DIRECTION

ISSUED FOR CONSENT

PARK BURN CHANNEL: EXISTING GROUND SURFACE

Folder Location: c:\12d5\data\SERVER2008R2\24113-Parkburn concepts 6168\12d\24113 Bulk Earthworks Staging\12dmodel Project: 24113 Bulk Earthworks Staging Plotted: 25 /09 /26 10.08

LANDPRO.

OFFICES IN CROMWELL, WANAKA, AND NEW PLYMOUTH - www.landpro.co.nz

Client: FH LAND DEVELOPMENT LTD

NOTES
- All dimensions shown are in metres unless otherwise shown
- Copyright on this drawing is reserved
- Check any electronic data against the hardcopy plan to ensure it is the latest version
-If this plan is being used as part of sale and purchase agreement then it is done so on the basis that it is preliminary only, final dimensions and areas may vary on final survey

EROSION AND SEDIMENT CONTROL - PARK BURN CHANNEL

PARKBURN DEVELOPMENT PROJECT

922 LUGGATE - CROMWELL ROAD

Rev.	Date	Revision Details	By
A	09 2026	EWK Area Interface linework added	KA

Designed: WN	Date: 04 2026	Job No.: 24113	Drawing No.: 114_08
Drawn: KA	Date: 09 2026	Scale: 1:1500 @ A3	
Checked: NKA	Date: 09 2026	Datum & Level: LP2000 & NZVD16	Rev.: A

Appendix E: ESC design details

CWBs/CWDCs – GD05 pgs 38-43

Also referred to as clean water diversions (CWDs), clean water diversion channels (CWDCs) are to be constructed as maintained as per the below GD05 typical detail, unless indicated otherwise – in some cases, CWDs may be existing and not necessarily designed to GD05 standards, but it is preferable to leave these vegetated and undisturbed rather than re-work them and expose potentially clean upslope water to contamination.

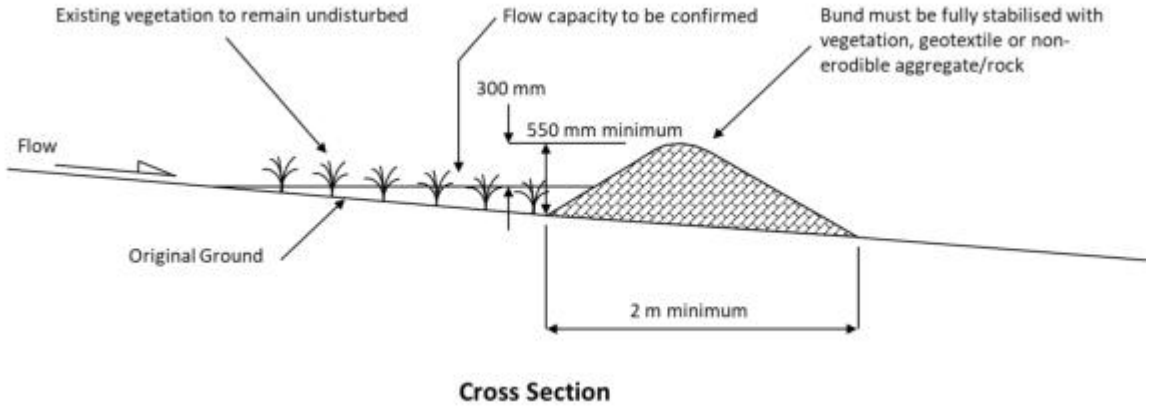


Figure 24: Clean water diversion typical detail (GD05)



Figure 25: Clean water bund with grass establishing



Figure 26: Clean water bund with established grass stabilisation

Key design criteria for CWDs are as follows:

- Ensure bunds are compacted and immediately stabilised – this may require erosion control blankets or a thick layer of hay mulch until grass can establish.
- Ensure bunds roughly follow the contour, to avoid steep gradients and runoff velocities.
- CWDs must have a stabilised outlet to prevent scour, such as riprap.

DWBs/DWDCs – GD05 pgs 43-46

Dirty water diversion channels (DWDCs; DWBs; DWDs) are to be constructed and maintained as per the below GD05 typical detail unless the attached calculations indicate otherwise. Where DWDC longitudinal grade exceeds 2%, they should be lined (preferably with HDPE) or stabilised with either a thick coating of polymer or topsoil and hydroseed, to prevent scour. Unlined DWDCs should be monitored for scour, and may require retrospective lining where scour risks undermining the integrity or shape of the channel as shown below.

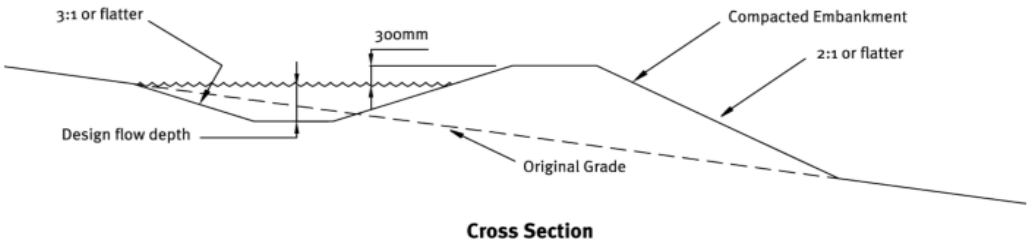


Figure 27: GD05 DWDC typical detail



Figure 28: DWDC with establishing direct-drilled grass. When all of the catchment and the channel itself is fully stabilised, it will become a clean water diversion



Figure 29: DWDC with rock check dams

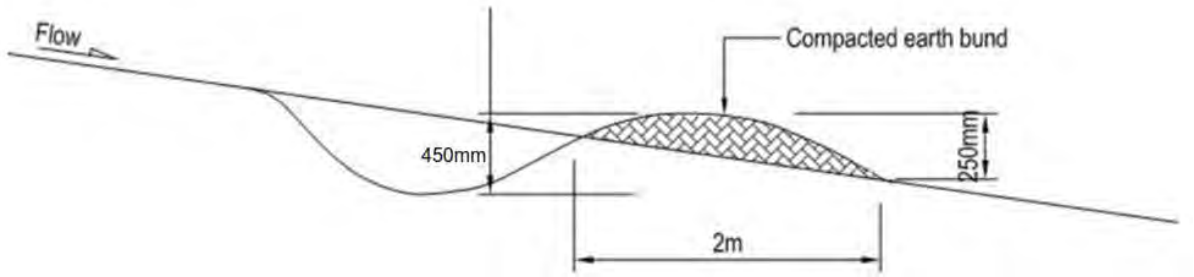
Key design criteria for CWDs are as follows:

- Ensure bunds are compacted and a shallow grade – at least 2:1 or flatter
- The upslope batter into the channel needs to be 3:1 or flatter – the flatter the channel batters are, the less likely they are to scour or fail

- Formally design diversion channels where catchments exceed 5 ha, ensuring they have capacity to carry the 5% AEP storm plus 300 mm freeboard
- Consider lining channels where gradients exceed 2% - however check dams can also help reduce flow velocities and scour in steeper drains.

Trafficable contour bund – GD05 pgs 47-50

Contour drains or contour bunds are constructed parallel to the contour to break up flowpaths, reduce slope catchments and minimise runoff velocities. Bunds need to be well-compacted, low and wide, to ensure heavy machinery can track over the bunds without damaging them. A shallow drain it to be formed on the upslope side of the bund.



Cross-section

Due to the virtually flat gradient of most of earthworks Areas 1-3, contour bunds can be installed every 50 to 100 m, and adjusted to suit vehicle movements and site needs.

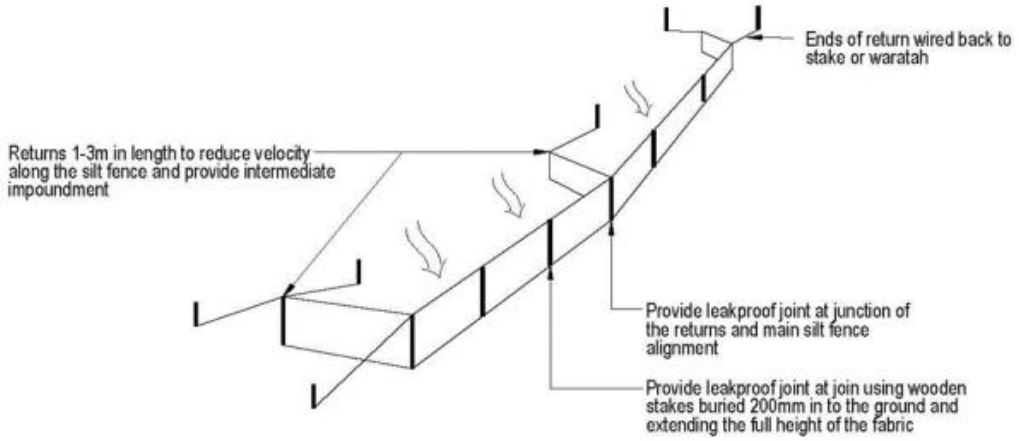
Silt fencing GD05 pgs 111-118

Silt fences are very effective perimeter sediment controls when installed correctly, however they are not designed to treat concentrated flows, and should only be relied on as a final element in a runoff treatment train – not a standalone ESC solution. For larger catchments, super silt fences provide more robust sediment control.

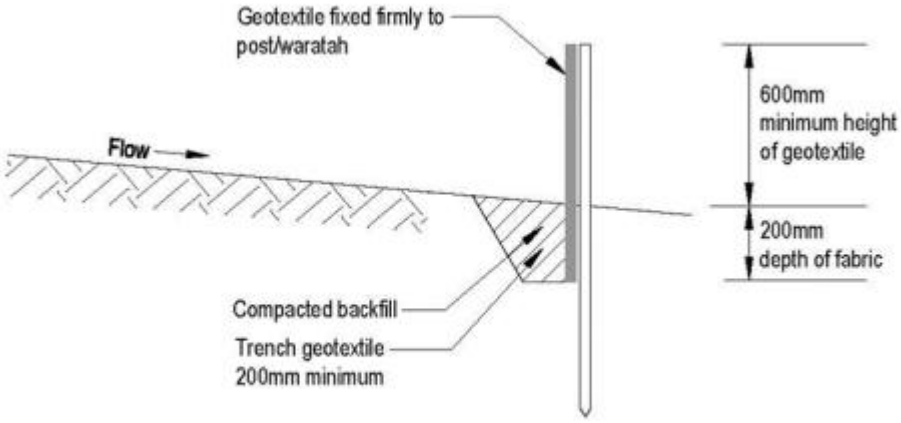
Key design criteria for installing silt fencing is as follows:

- Ensure silt fence height is 600 mm above ground level and 200 mm below ground level.
- Install silt fence **parallel to contours** to avoid formation of low points, where runoff can collect and destabilise the fence.

- Locate supporting posts/waratahs for silt fences 2-4 m apart with support provided by a tensioned wire (2.5 mm HT) along the top of the silt fence.
- Join lengths of silt fence by doubling over fabric ends around a waratah or by stapling the fabric ends to a batten and butting the two battens together.



Silt fence with returns and support wire



Cross-section

- For standard silt fences, use Table 13 (below) to determine maximum slope length, return spacing and maximum silt fence length based on contributing slope steepness.
- For super silt fences, use Table 14, below, for slope length, return spacing and max fence length.

Table 13: Silt fence design criteria

Slope steepness %	Slope length (m) (maximum)	Spacing of returns (m)	Silt fence length (m) (maximum)
Flatter than 2%	Unlimited	N/A	Unlimited
2 – 10%	40	60	300
10 – 20%	30	50	230
20 – 33%	20	40	150
33 – 50%	15	30	75
> 50%	6	20	40

Table 14: Super silt fence design criteria

Slope steepness %	Slope length (m) (maximum)	Spacing of returns (m)	Super silt fence length (m) (maximum)
0 – 10%	Unlimited	60	Unlimited
10 – 20%	60	50	450
20 – 33%	30	40	300
33 – 50%	30	30	150
> 50%	15	20	75



Figure 30: Super silt fence treating dirty upslope water

Silt socks – GD05 pgs 125-129

Silt socks are a tubular runoff sediment control consisting of either a mesh tube filled with filter material (e.g. compost, sawdust) or a log composed entirely of coconut fibre (coir log). They are used to intercept and slow sediment-laden runoff for smaller catchments, and (in the case of completely biodegradable products like coir logs) can be left to degrade into soil over time and/or be directly seeded to provide vegetated filtration bunds or check dams.







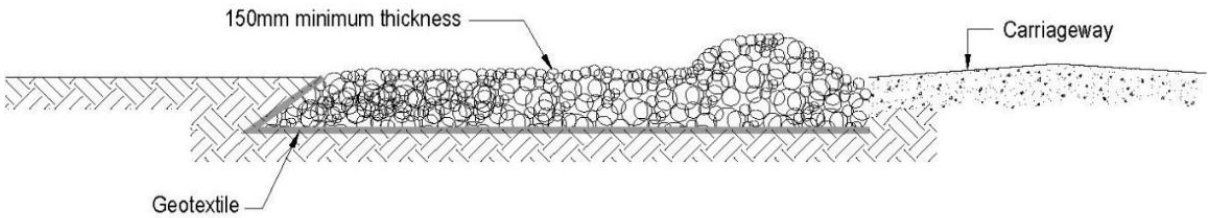
Key design criteria for installing silt socks includes:

- install socks/logs flush with the ground, to prevent runoff from flowing under the device. Where necessary, prepare the ground first to ensure 100% contact.
- similar to silt fencing, socks/logs should be installed parallel to the contour
- for perimeter control, ensure there is sufficient overlap with the next sock so that runoff can't flow in between the socks
- for 300 mm diameter silt socks, install as indicated below:

Slope steepness (%)	Maximum slope length (m)	Spacing of returns (m)
Flatter than 2%	100	N/A
2% - 10%	40	30
10% - 20%	30	25

Stabilised construction entrance – GD05 pgs 60-64

SCEs provide a stabilised access and egress point for construction/earthworks sites that is designed to vibrate/shake mud and dirt off wheels and minimise the amount of dirt tracked onto public roads, along with keeping dust to a minimum. To be effective, they must be regularly maintained/refurbished as mud begins to accumulate between the aggregate. For sites with mud issues or a high volume of traffic entering and exiting the site, combining an SCE with a series of trackout mats can be effective.



Side elevation

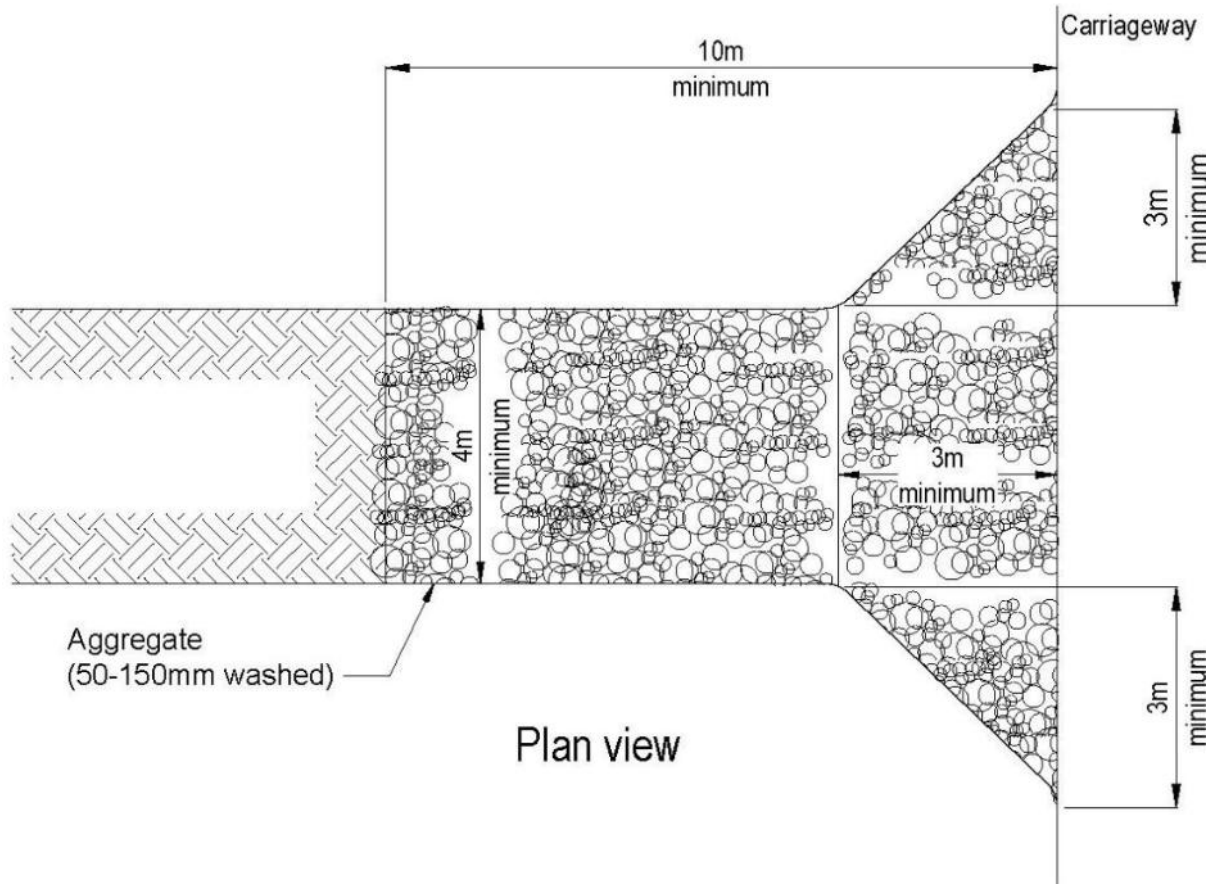


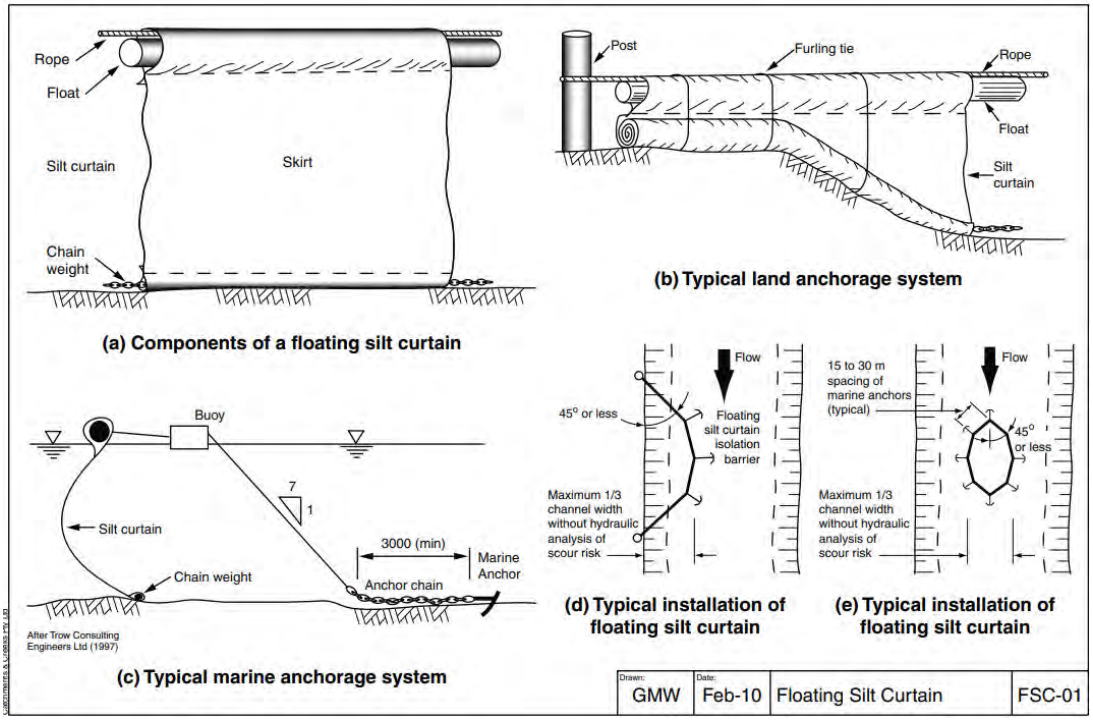
Figure 31: SCE design - section (above) and plan view (below)



Figure 32: Combination of trackout mats and SCE at site entrance

<u>Silt curtains</u>

A specification for silt curtains in relation to the cove construction in-water works will be developed in association with a domestic supplier of this specialised equipment. The below specification is taken from the IECA's Best Practice Erosion and Sediment Control (BPESC) manual, and is provided for indicative purposes only – noting that the specific design for the proposed applications will likely vary from that specified below.





Appendix F: Infiltration basin and diversion drain calculations

Infiltration basin Identifier: **IB1**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	1.8			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	220			m	Longest flow path within contributing catchment
Slope gradient (longest)	**6.36**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel	Sloping gravel			
% cover	92%	8%			Flat gravel interspersed with small areas of sloping gravel at quarry level interfaces.
Runoff coefficient (C)	0.15	0.25			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	1.66	0.14		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0018	0.0003		m^3/s	
IB design calculations					
Hourly volume required	6.4	0.9	**7.4**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	154.5	22.4	**176.9**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	36.8	5.3	**42.1**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (hrs)
Top length (A)			45.00	m	
Top width (B)			11.25	m	
Basal length (a)			38.00	m	
Basal width (b)			4.25	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			228.0	m^3	
Actual basal infiltration area			161.5	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			28.9	%	~29% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	1:5 batters with 1 m wide forebay flat bottom
Length			11.25	m	Full width of basin
Level spreader					
Width			11.25	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			4.25	m	Full width of the IB base

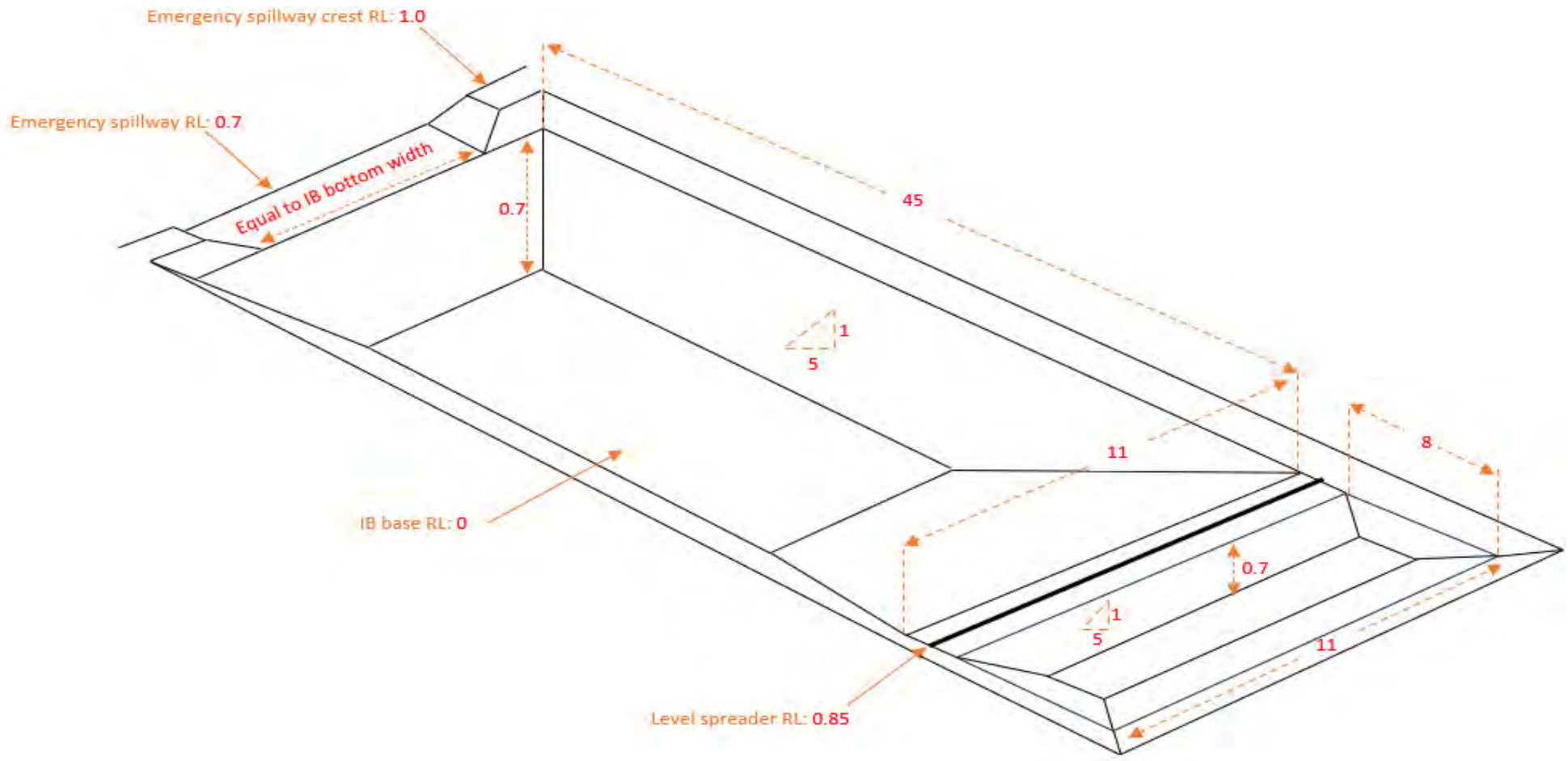
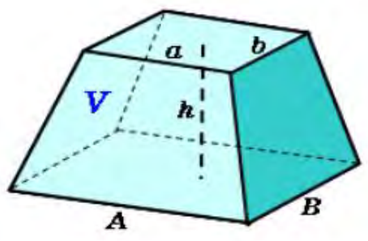


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	45	m	Pond volume calc:
B	11.25	m	**228.00**
a	38.00	m	
b	4.25	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB2**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	4.41			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	220			m	Longest flow path within contributing catchment
Slope gradient (longest)	**6.82**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel	Sloping gravel			
% cover	87%	13%			Flat gravel interspersed with small areas of sloping gravel at quarry level interfaces.
Runoff coefficient (C)	0.15	0.25			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	3.83	0.58		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0041	0.0010		m^3/s	
IB design calculations					
Hourly volume required	14.9	3.8	**18.6**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	357.4	90.2	**447.6**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	85.1	21.5	**106.6**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (hrs)
Top length (A)			60.00	m	
Top width (B)			15.00	m	
Basal length (a)			53.00	m	
Basal width (b)			8.00	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			457.7	m^3	
Actual basal infiltration area			424.0	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			2.3	%	~2% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	1:5 batters with 1 m wide forebay flat bottom
Length			15.00	m	Full width of basin
Level spreader					
Width			15.00	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			8.00	m	Full width of the IB base

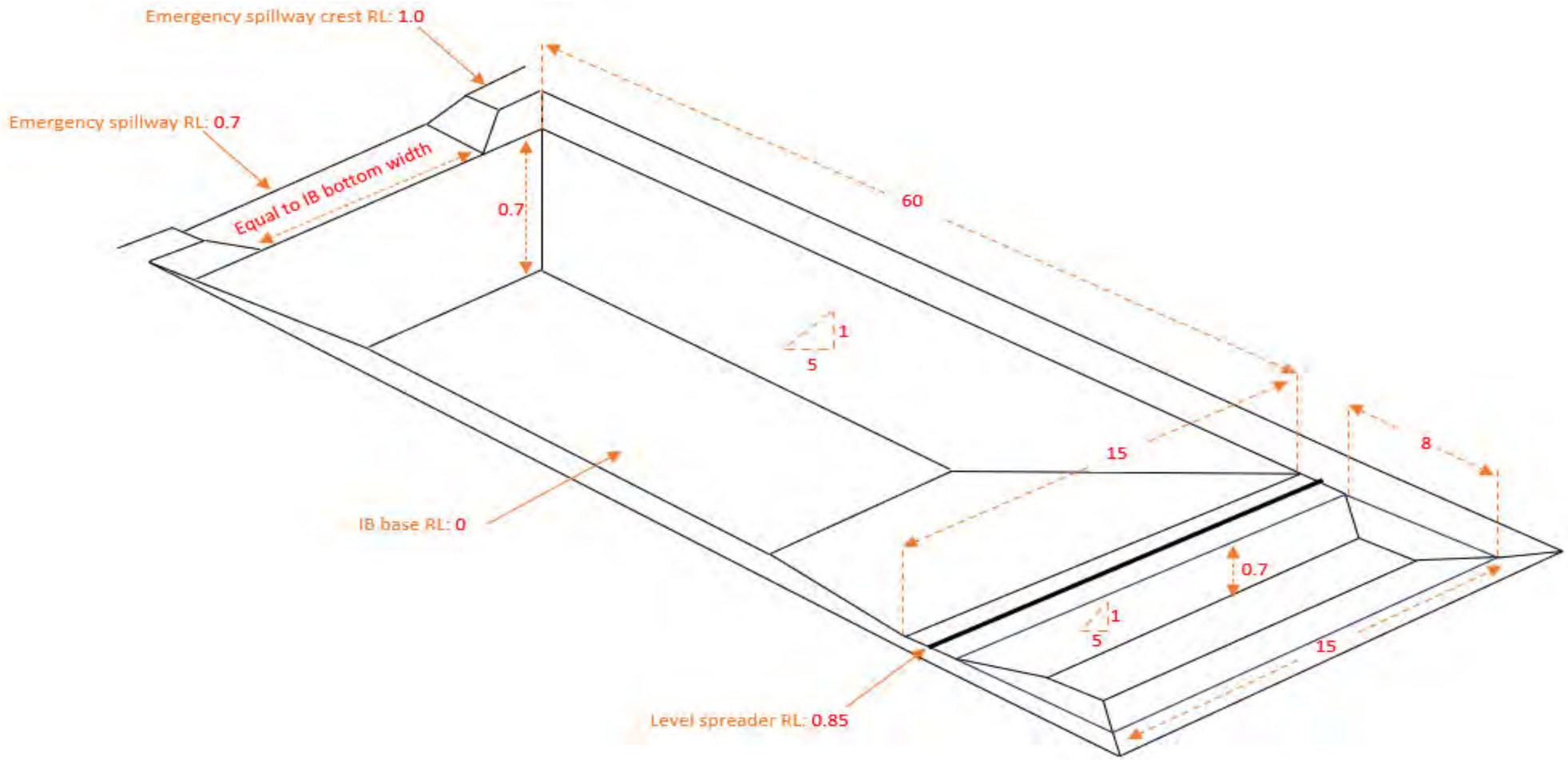
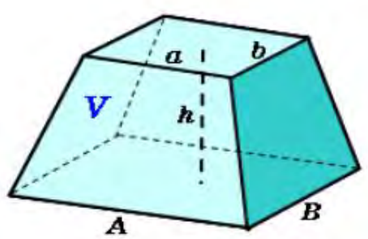


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	60	m	Pond volume calc:
B	15.00	m	**457.68**
a	53.00	m	
b	8.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB3**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	13.68			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	482			m	Longest flow path within contributing catchment
Slope gradient (longest)	**3.73**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel	Sloping gravel			
% cover	66%	34%			
Runoff coefficient (C)	0.15	0.25			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	8.97	4.710677196		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0097	0.0085		m^3/s	
IB design calculations					
Hourly volume required	34.9	30.5	**65.4**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	837.0	732.6	**1569.6**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	199.3	174.4	**373.7**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (24 hrs)
Top length (A)			104.00	m	
Top width (B)			26.00	m	
Basal length (a)			97.00	m	
Basal width (b)			19.00	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			1585.7	m^3	
Actual basal infiltration area			1843.0	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			1.0	%	~1% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	
Length			26.00	m	Full width of basin
Level spreader					
Width			26.00	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			19.00	m	Full width of the IB base

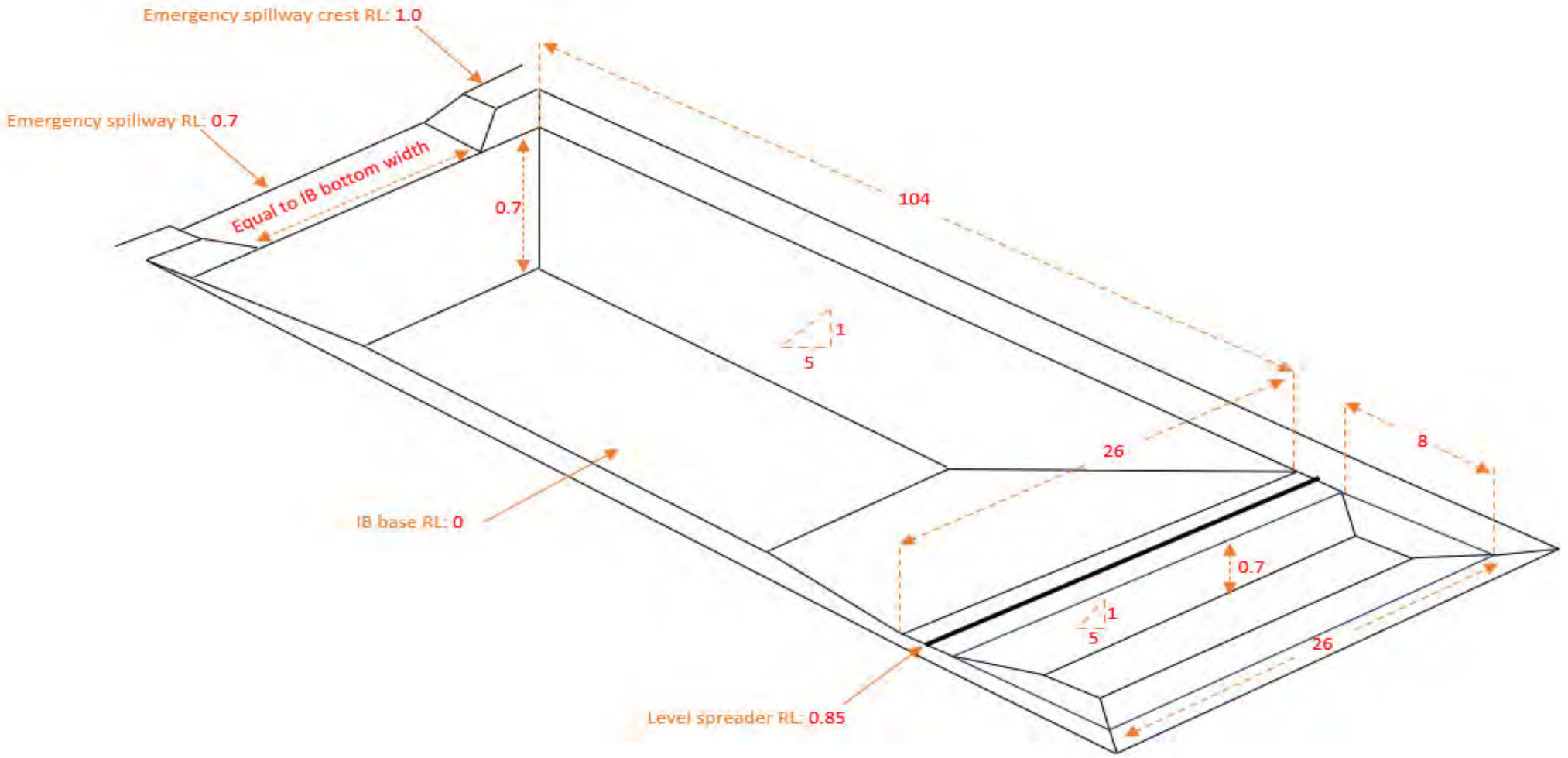
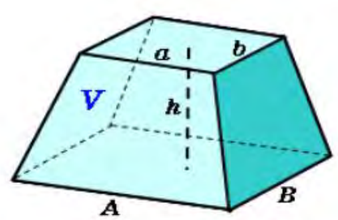


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	104	m	Pond volume calc:
B	26.00	m	**1585.73**
a	97.00	m	
b	19.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB4**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	4.63			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	284			m	Longest flow path within contributing catchment
Slope gradient (longest)	**1.41**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel				
% cover	100%				
Runoff coefficient (C)	0.15				From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59			mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	4.63			ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0050			m^3/s	
IB design calculations					
Hourly volume required	18.0		**18.0**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	432.0		**432.0**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175		**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	102.9		**102.9**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (24 hrs)
Top length (A)			60.00	m	
Top width (B)			15.00	m	
Basal length (a)			53.00	m	
Basal width (b)			8.00	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			457.7	m^3	
Actual basal infiltration area			424.0	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			5.9	%	~6% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	
Length			15.00	m	Full width of basin
Level spreader					
Width			15.00	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			8.00	m	Full width of the IB base

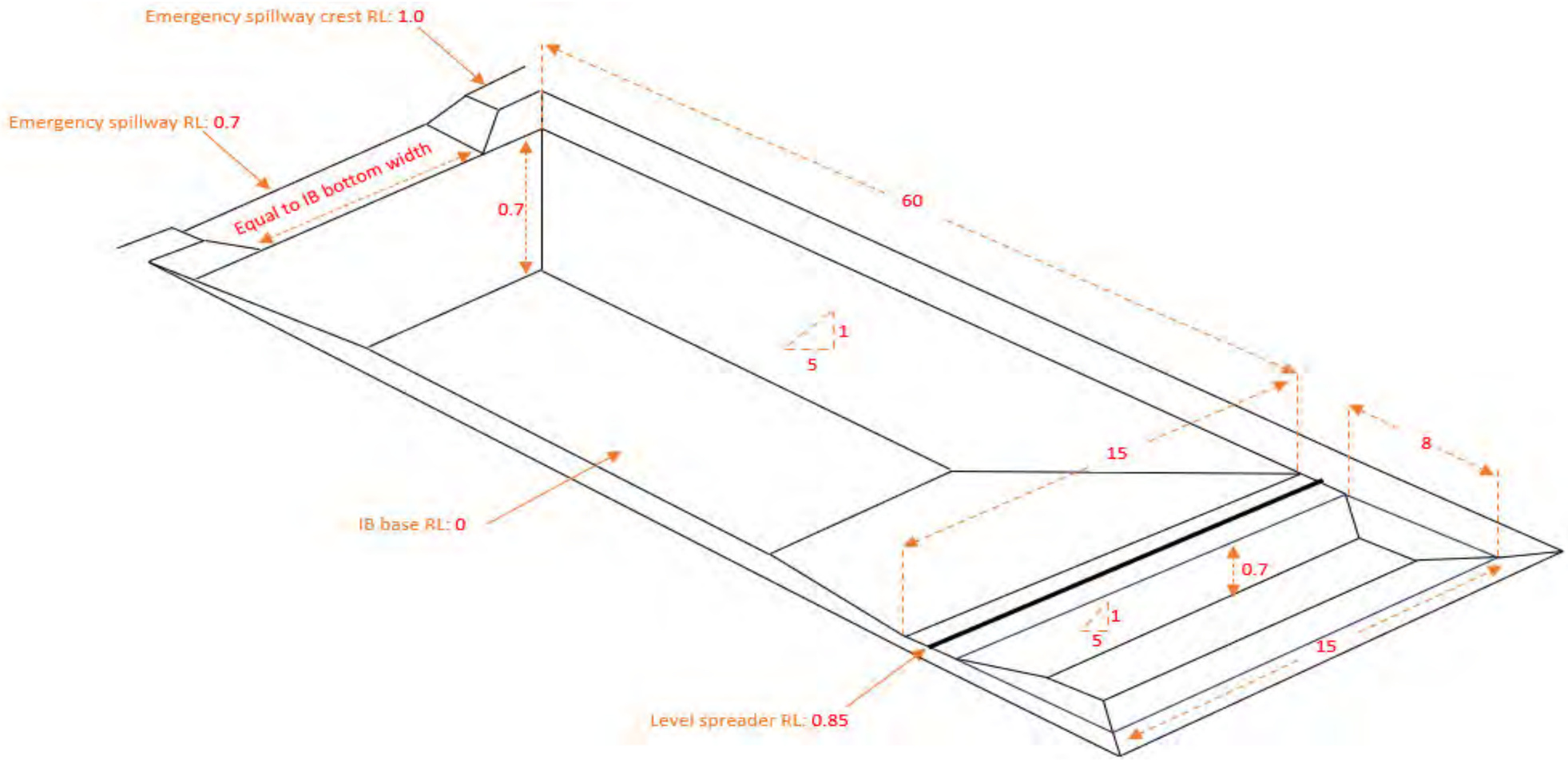
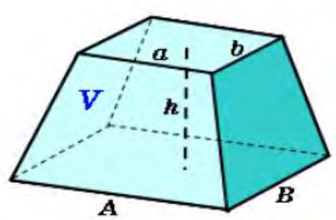


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	60	m	Pond volume calc:
B	15.00	m	**457.68**
a	53.00	m	
b	8.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB5**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	6.03			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	311			m	Longest flow path within contributing catchment
Slope gradient (longest)	**0.32**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel				
% cover	100%				
Runoff coefficient (C)	0.15				From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59			mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	6.03			ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0065			m^3/s	
IB design calculations					
Hourly volume required	23.4		**23.4**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	562.7		**562.7**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175		**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	134.0		**134.0**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (24 hrs)
Top length (A)			66.00	m	
Top width (B)			16.50	m	
Basal length (a)			59.00	m	
Basal width (b)			9.50	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			571.6	m^3	
Actual basal infiltration area			560.5	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			1.6	%	~2% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	
Length			16.50	m	Full width of basin
Level spreader					
Width			16.50	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			9.50	m	Full width of the IB base

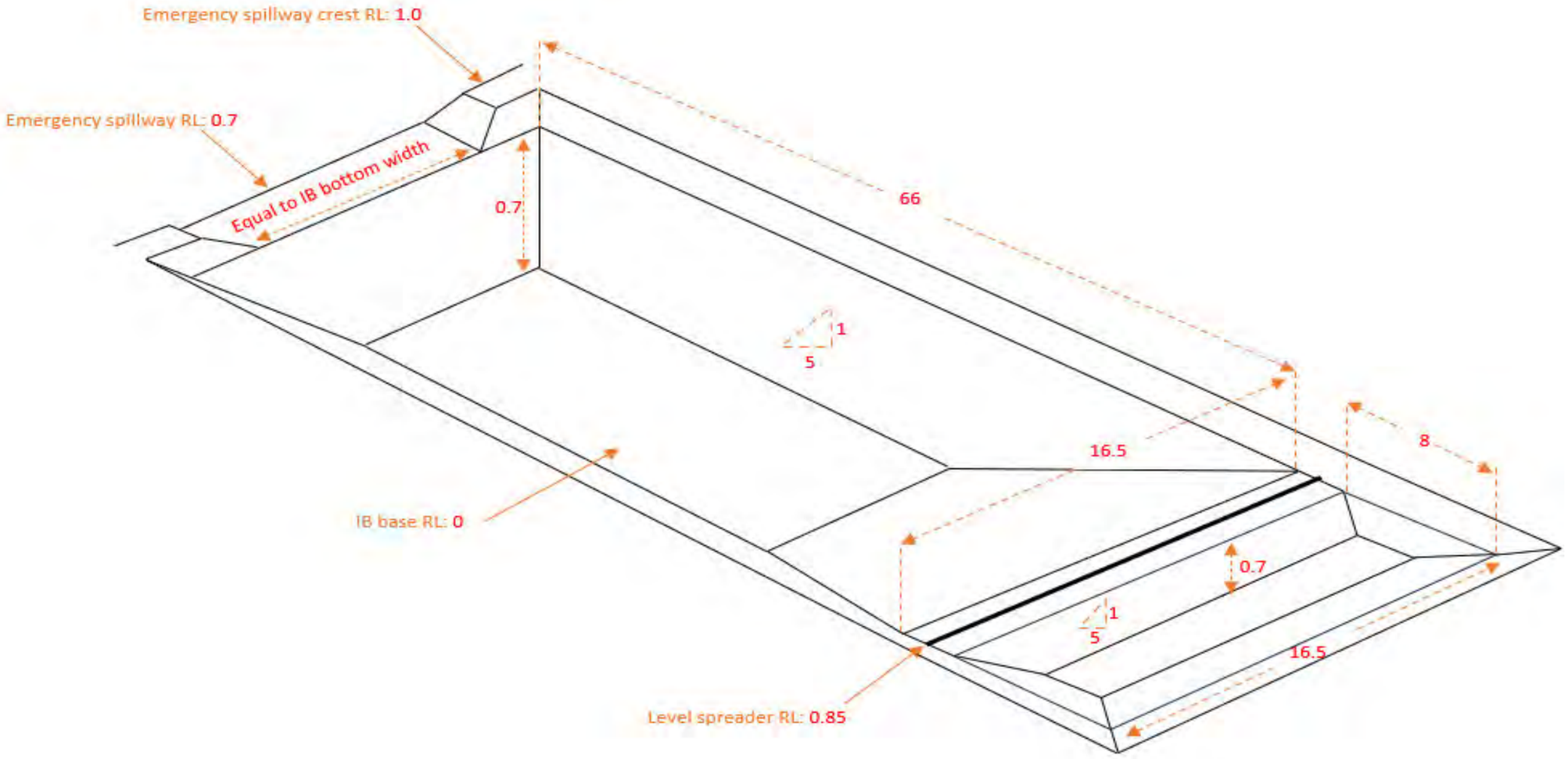
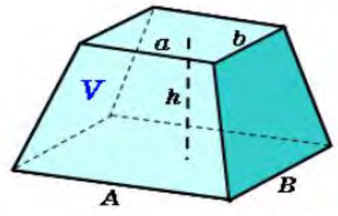


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	66	m	Pond volume calc:
B	16.50	m	**571.61**
a	59.00	m	
b	9.50	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB6**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	36.09			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	650			m	Longest flow path within contributing catchment
Slope gradient (longest)	**0.46**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel	Flat grass			
% cover	25%	75%			Flat gravel within the active works area; flat grass underlain by topsoil and then compacted fill for rest
Runoff coefficient (C)	0.15	0.2			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	8.91	27.18		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0096	0.0391		m^3/s	
IB design calculations					
Hourly volume required	34.6	140.9	**175.5**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	831.4	3381.7	**4213.2**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	198.0	805.2	**1003.1**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (hrs)
Top length (A)			166.00	m	
Top width (B)			41.50	m	
Basal length (a)			159.00	m	
Basal width (b)			34.50	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			4325.4	m^3	
Actual basal infiltration area			5485.5	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			2.7	%	~3% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			10.00	m	1:5 batters with 3 m wide forebay flat bottom
Length			41.50	m	Full width of basin
Level spreader					
Width			41.50	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			34.50	m	Full width of the IB base

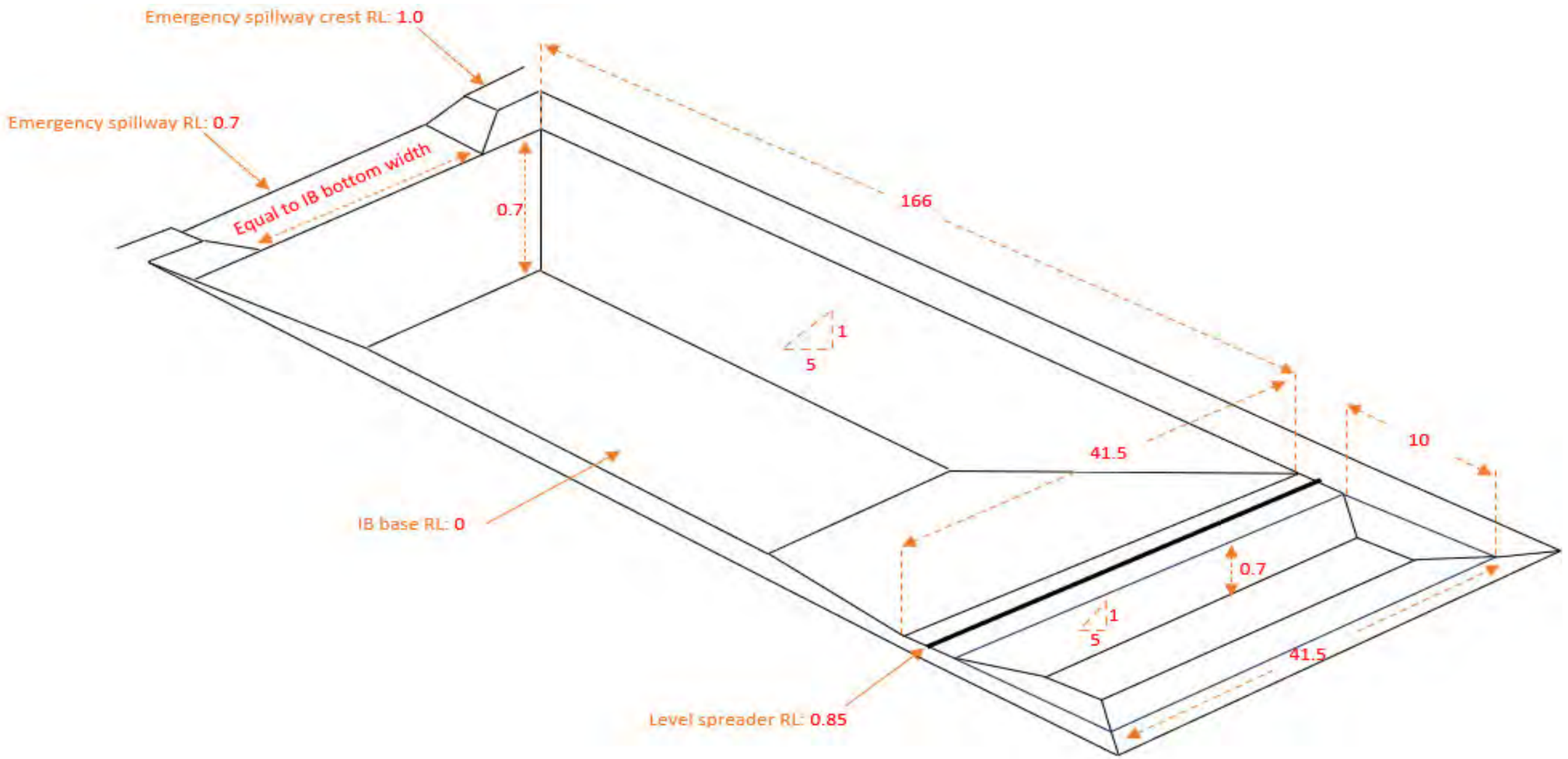
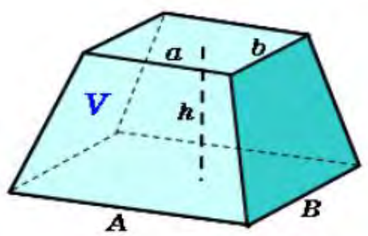


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	166	m	Pond volume calc:
B	41.50	m	**4325.36**
a	159.00	m	
b	34.50	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB7**

Input	Value 1	Value 2		Total/design	Units	Notes / Reference
Catchment information						
Contributing catchment	12.58				ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	800				m	Longest flow path within contributing catchment
Slope gradient (longest)	**1.88**				%	
Slope gradient (immediately upslope)	0.50				**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24				months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation						Q = 0.00278CiA
Catchment ground cover	Flat gravel	Sloping gravel	Flat grass			
% cover	58%	12%	30%			Flat gravel within the active works area; flat grass underlain by topsoil and then compacted fill for rest
Runoff coefficient (C)	0.15	0.25	0.2			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	7.27	1.51	3.80		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0079	0.0027	0.0055		m^3/s	
IB design calculations						
Hourly volume required	28.3	9.8	19.7	**48.0**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	678.4	234.8	472.8	**1386.0**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	161.5	55.9	112.6	**330.0**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (hrs)
Top length (A)				100.00	m	
Top width (B)				25.00	m	
Basal length (a)				93.00	m	
Basal width (b)				18.00	m	
Depth (h)				0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio				1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)				1455.2	m^3	
Actual basal infiltration area				1674.0	m^2	
Length-width ratio				4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer				5.0	%	~5% additional storage above minimum storage required (not including infiltration capacity)
Forebay						
Depth				0.7	m	
Width				8.00	m	1:5 batters with 1 m wide forebay flat bottom
Length				25.00	m	Full width of basin
Level spreader						
Width				25.00	m	Must span full width of basin
Height above emergency spillway invert				0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient				1:5	rise/run	
Emergency spillway						
Spillway invert depth from crest				0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width				18.00	m	Full width of the IB base

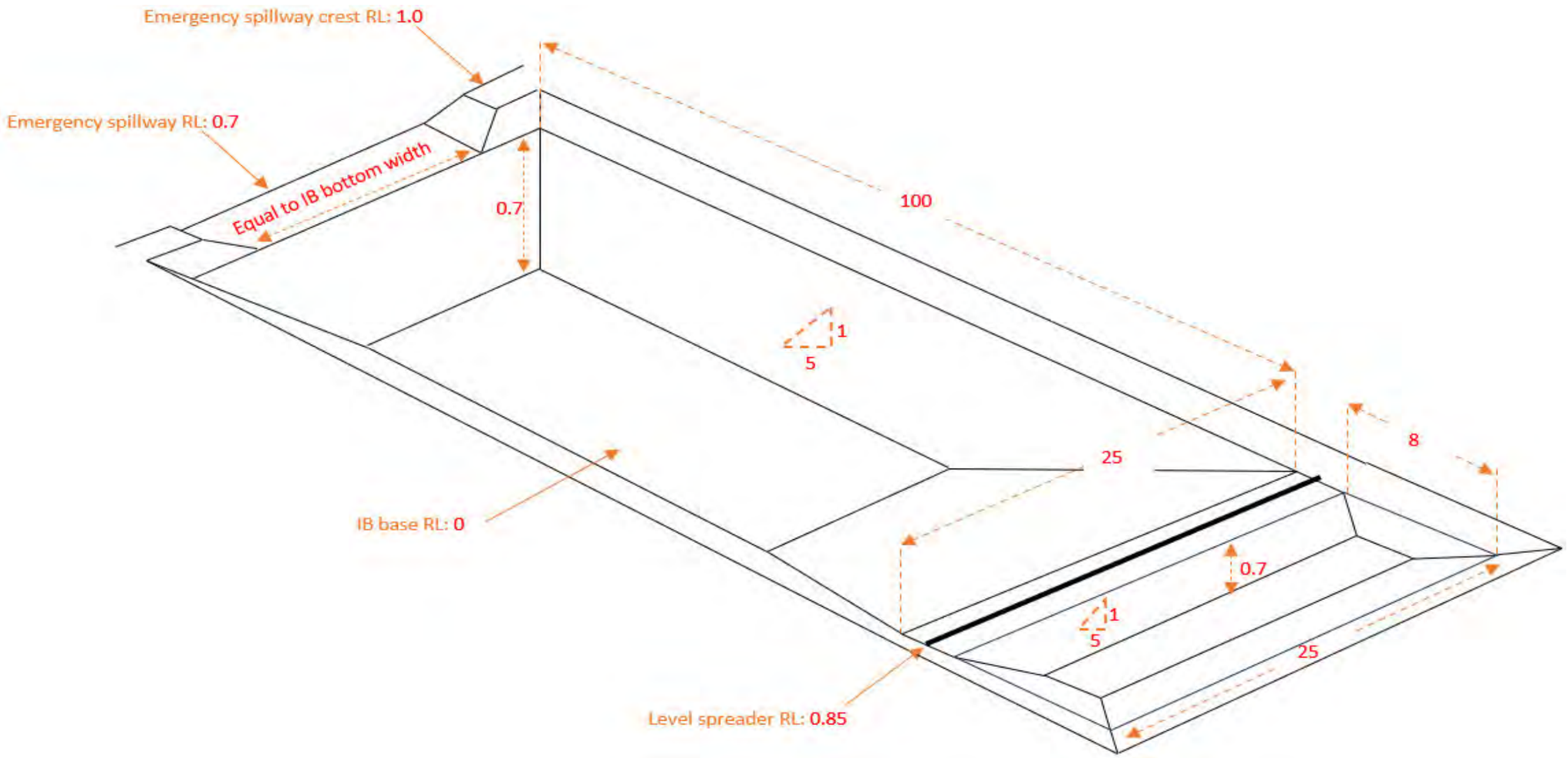
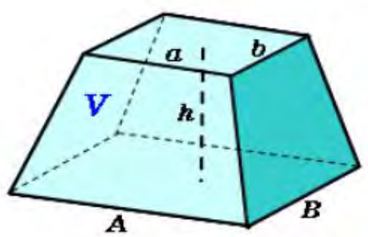


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	100	m	Pond volume calc:
B	25.00	m	**1455.18**
a	93.00	m	
b	18.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB8**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	2.11			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	141			m	Longest flow path within contributing catchment
Slope gradient (longest)	**0.71**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel				
% cover	100%				
Runoff coefficient (C)	0.15				From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59			mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	2.11			ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0023			m^3/s	
IB design calculations					
Hourly volume required	8.2		**8.2**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	196.9		**196.9**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175		**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	46.9		**46.9**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (24 hrs)
Top length (A)			44.00	m	
Top width (B)			11.00	m	
Basal length (a)			37.00	m	
Basal width (b)			4.00	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			215.5	m^3	
Actual basal infiltration area			148.0	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			9.4	%	~9% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	1:5 batters with 1 m wide forebay flat bottom
Length			11.00	m	Full width of basin
Level spreader					
Width			11.00	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			4.00	m	Full width of the IB base

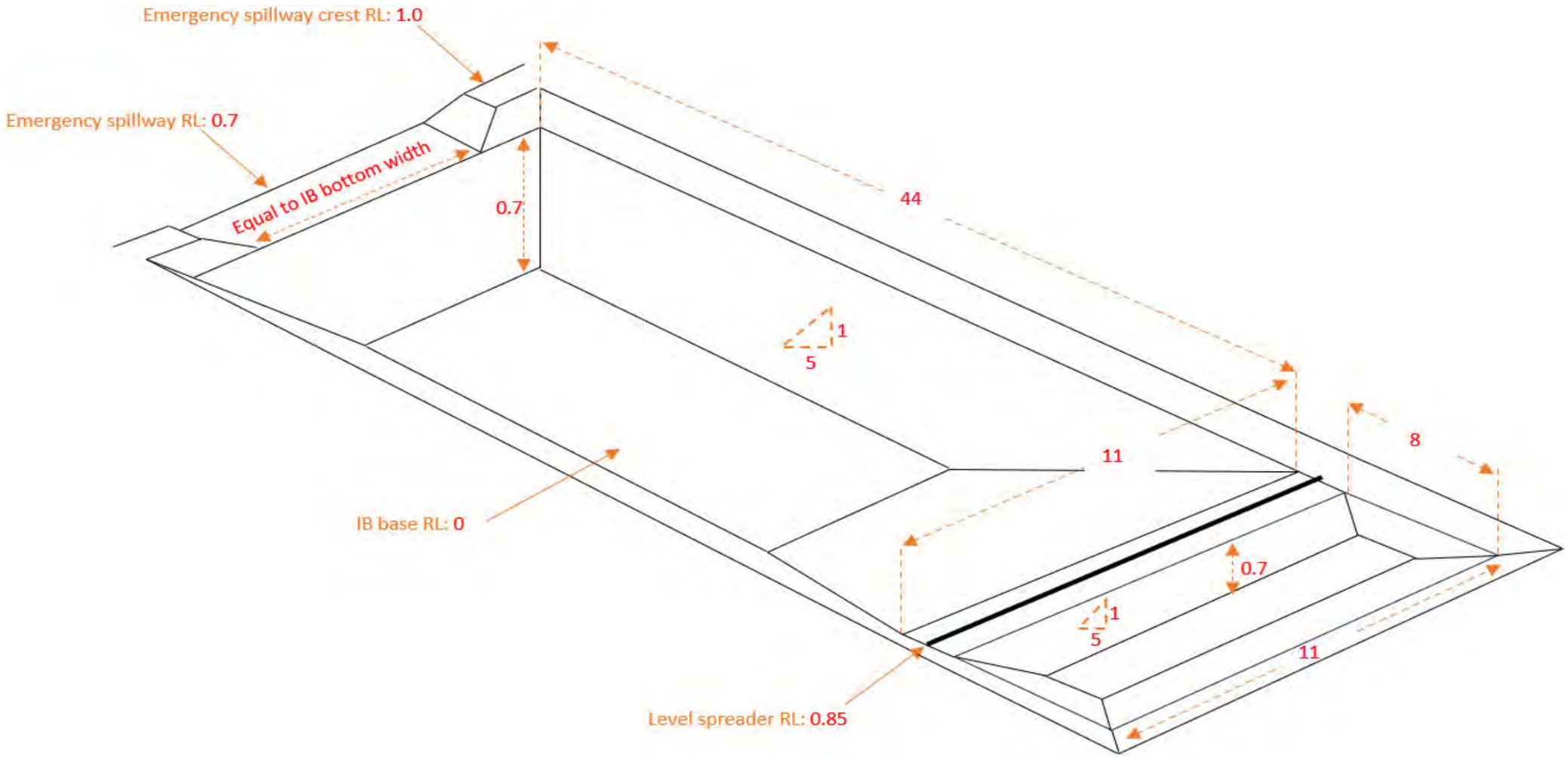
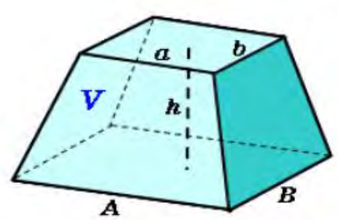


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	44	m	Pond volume calc:
B	11.00	m	**215.48**
a	37.00	m	
b	4.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Indicative DWDC and CWDC design

Swale drains to: IB6 (DWDC) & Area 4c & 4b southern (CWDC)

	DWDC	CWDC
Catchment area (ha)	36.09	6.00
Catchment flowpath length (m)	450	229
Catchment elevation fall (m)	4	6
Gradient (%)	0.9	2.6
Retardance coefficient (N)*	0.01	0.01

*Representative of smooth, packed gravel

Conveyance capacity requirements: 5% AEP storm plus 300 mm freeboard (assumed)

5% AEP rainfall intensity calculations

DWDC catchment	DWDC	CWDC	Unit
Area	36.09	6	ha
Rainfall intensity (10 min duration)*	44.5	44.5	mm/hour

*Based on hirds.niwa.co.nz for Site ID: NORTHBURN

source: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/appendixa.pdf

Peak runoff calculations

Using Rational Method: Q = CiA/360

	DWDC	CWDC	Unit
C (runoff coefficient)	0.55	0.55	N/A
i (rainfall intensity)	44.5	44.5	mm/hour
A (catchment area)	36.09	6	ha
Q (peak flow)	2.4536	0.4079	m^3/s

Generally flat, compacted gravels

Calculate channel design

Using Manning's Formula Trapezoidal Channel Flow calculator

Roughness coefficient (n): 0.025 (Earth, gravelly)

	DWDC	CWDC	Unit
Channel flow path (length)	360	548	m
Elevation fall	2	4	m
Slope	0.6	0.7	%

Source: https://www.engineeringtoolbox.com/mannings-roughness-d_799.html

RUNOFF COEFFICIENTS FOR THE RATIONAL FORMULA

Typical Composite Runoff Coefficients by Land Use		Normal Range of Runoff Coefficients	
Area Description	C-value	Surface Characteristic	C-value
Business		**Lawns**	
Downtown Areas	0.70-0.95	Sandy Soil, Flat (2%)	0.05-0.10
Neighborhood Areas	0.50-0.70	Sandy Soil, Ave. (2-7%)	0.10-0.15
		Sandy Soil, Steep (>7%)	0.15-0.20
Residential		Heavy Soil, Flat (2%)	0.13-0.17
Single Family Areas	0.30-0.50	Heavy Soil, Ave. (2-7%)	0.18-0.22
Multi-Units (detached)	0.40-0.60	Heavy Soil, Steep (>7%)	0.2500.35
Multi-Units (attached)	0.60-0.75		
Suburban	0.25-0.40	**Agricultural**	
Apartments	0.50-0.70	Bare Packed Soil	
		Smooth	0.30-0.60
Industrial		Rough	0.20-0.50
Light Use	0.50-0.80	Cultivated Rows	
Heavy Use	0.60-0.90	Heavy Soil, no crop	0.30-0.60
Railroad Yards	0.20-0.35	Heavy Soil, with crop	0.20-0.50
Unimproved Areas	0.10-0.30	Sandy Soil, no crop	0.20-0.40
		Sandy Soil, with crop	0.10-0.25
Park		Pasture	
Park/Cemeteries	0.10-0.25	Heavy Soil	0.15-0.45
Playgrounds	0.20-0.35	Sandy Soil	0.05-0.25
Pavement		**Woodland**	0.05-0.25
Asphalt and Concrete	0.70-0.95		
Brick	0.70-0.85		
Roof	0.75-0.95		

The presented C-values are typical for return periods of 2-10-year storms with the higher values for the larger design storms. Judgement must be used to select the appropriate C-value within the range for the land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have the lower C-value; and smaller areas with low permeability soils, steep slopes and sparse vegetation should be assigned higher a C-value.

Surface Material	Manning's Roughness Coefficient - *n* -
Asbestos cement	0.011
Asphalt	0.016
Brass	0.011
Brick and cement mortar sewers	0.015
Canvas	0.012
Cast or Ductile iron, new	0.012
Clay tile	0.014
Concrete - steel forms	0.011
Concrete (Cement) - finished	0.012
Concrete - wooden forms	0.015
Concrete - centrifugally spun	0.013
Copper	0.011
Corrugated metal	0.022
Earth, smooth	0.018
Earth channel - clean	0.022
Earth channel - gravelly	0.025
Earth channel - weedy	0.030
Earth channel - stony, cobbles	0.035
Floodplains - pasture, farmland	0.035
Floodplains - light brush	0.050
Floodplains - heavy brush	0.075
Floodplains - trees	0.15
Galvanized iron	0.016
Glass	0.010
Gravel, firm	0.023
Lead	0.011
Masonry	0.025
Metal - corrugated	0.022
Natural streams - clean and straight	0.030
Natural streams - major rivers	0.035
Natural streams - sluggish with deep pools	0.040
Natural channels, very poor condition	0.060
Plastic	0.009
Polyethylene PE - Corrugated with smooth inner walls	0.009 - 0.015
Polyethylene PE - Corrugated with corrugated inner walls	0.018 - 0.025
Polyvinyl Chloride PVC - with smooth inner walls	0.009 - 0.011

Sizing calculations for DWDC:

Inputs

Bottom width, b	2	m	X
Side slope 1 (horiz./vert.)	3		X
Side slope 2 (horiz./vert.)	3		X
Manning roughness, n ? ○Strickler ○B/B (See notes)	0.025		X
Channel slope, S	1	% rise/run	X
Flow depth, y	0.43	m	X

Results

Flow area, a	1.4147	m^2	X
Wetted perimeter, P_w	4.7196	m	X
Hydraulic radius, R_h	0.2998	m	X
Velocity, v	1.7916	m/s	X
Flow, Q	2.5345	m^3/s	X
Velocity head, h_v	0.1637	m	X
Top width, T	4.5800	m	X

Thus with a bottom width of 2m, side slopes of 3:1, and a design flow depth of 0.43 m,
flow capacity of 2.53 m^3/s is achieved. This exceeds the 2.45 m^3/s design flow for the DWDC.

Sizing calculations for CWDC:

Inputs

Bottom width, b	1	m	X
Side slope 1 (horiz./vert.)	3		X
Side slope 2 (horiz./vert.)	3		X
Manning roughness, n ? ○Strickler ○B/B (See notes)	0.025		X
Channel slope, S	1	% rise/run	X
Flow depth, y	0.25	m	X

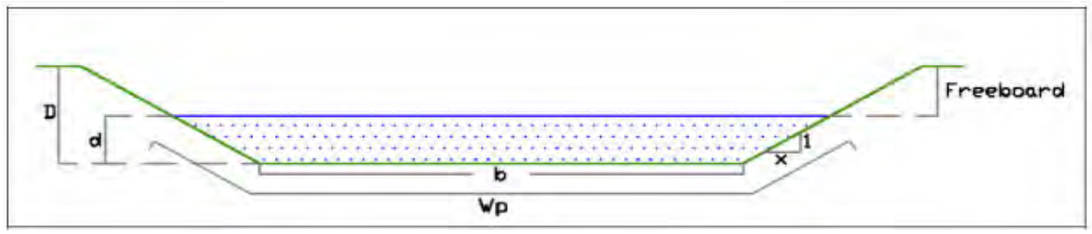
Results

Flow area, a	0.4375	m^2	X
Wetted perimeter, P_w	2.5811	m	X
Hydraulic radius, R_h	0.1695	m	X
Velocity, v	1.2251	m/s	X
Flow, Q	0.5360	m^3/s	X
Velocity head, h_v	0.0765	m	X
Top width, T	2.5000	m	X

Thus with a bottom width of 1m, side slopes of 3:1, and a design flow depth of 0.25 m,
flow capacity of 0.54 m^3/s is achieved. This exceeds the 0.41 m^3/s design flow for the DWDC.

Summary of dimensions for all swales

	Swale 1	Swale 2	Unit
Bottom width (b)	2	1	m
Side slope gradient	3	3	H:V
Effective depth (d)	0.43	0.25	m
Depth + 300 mm freeboard (D)	0.73	0.55	m
Average channel slope	0.6	0.7	%
Flow capacity (Q)	2.5300	0.5400	m^3/s
Q (peak flow)	2.4536	0.4079	m^3/s



Appendix G: Accidental Discovery Protocol

APPENDIX 4: HERITAGE NEW ZEALAND POUHERE TAONGA ARCHAEOLOGICAL DISCOVERY PROTOCOL

HERITAGE NEW ZEALAND
POUHERE TAONGA

Heritage New Zealand Pouhere Taonga Archaeological Discovery Protocol

Under the Heritage New Zealand Pouhere Taonga Act (2014) an archaeological site is defined as any place in New Zealand that was associated with human activity that occurred before 1900 and provides or may provide, through investigation by archaeological methods, evidence relating to the history of New Zealand. For pre-contact Maori sites this evidence may be in the form of bones, shells, charcoal, stones etc. In later sites of European/Chinese origin, artefacts such as bottle glass, crockery etc. may be found, or evidence of old foundations, wells, drains or similar structures. Burials/koiwi tangata may be found from any historic period.

In the event that an unidentified archaeological site is located during works, the following applies;

1. Work shall cease immediately at that place and within 20m around the site.
2. The contractor must shut down all machinery, secure the area, and advise the Site Manager.
3. The Site Manager shall secure the site and notify the Heritage New Zealand Regional Archaeologist. Further assessment by an archaeologist may be required.
4 If the site is of Maori origin, the Site Manager shall notify the Heritage New Zealand Regional Archaeologist and the appropriate iwi groups or kaitiaki representative of the discovery and ensure site access to enable appropriate cultural procedures and tikanga to be undertaken, as long as all statutory requirements under legislation are met (*Heritage New Zealand Pouhere Taonga Act*, *Protected Objects Act*).
5. If human remains (koiwi tangata) are uncovered the Site Manager shall advise the Heritage New Zealand Regional Archaeologist, NZ Police and the appropriate iwi groups or kaitiaki representative and the above process under 4 shall apply. Remains are not to be moved until such time as iwi and Heritage New Zealand have responded.
6. Works affecting the archaeological site and any human remains (koiwi tangata) shall not resume until Heritage New Zealand gives written approval for work to continue. Further assessment by an archaeologist may be required.
7. Where iwi so request, any information recorded as the result of the find such as a description of location and content, is to be provided for their records.
8. Heritage New Zealand will determine if an archaeological authority under the *Heritage New Zealand Pouhere Taonga Act* 2014 is required for works to continue.

It is an offence under S87 of the *Heritage New Zealand Pouhere Taonga Act 2014* to modify or destroy an archaeological site without an authority from Heritage New Zealand irrespective of

Appendix H: Parkburn soil permeability testing report

29 April 2026

Fulton Hogan Land Development Ltd
C/- Tim James
Via email: [redacted]
CC: [redacted]

Re: Soil Permeability Testing, Parkburn Quarry

Our Reference: 24019_4

1 Introduction and Scope of Report

JKCM Ltd, trading as Insight Engineering (IE), was requested to arrange and observe three soil permeability tests at the Parkburn Quarry (herein referred to as 'the site'). The tests were requested to inform the erosion and sediment control plans for the future land development earthworks proposed to be carried out at the site.

This letter presents a brief description of the tests, calculations and a summary of results.

2 Soil Permeability Tests

2.1 Methodology

Three soil permeability tests were completed at the site on 24 April 2026. As the tests were arranged with short notice, we opted to use test pits, rather than boreholes or standpipes to complete the tests.

The test pits were excavated using a 1.8T excavator. Due to the relatively dense ground conditions, the test pits were all terminated at a depth of 0.6 m. The sides and base of the test pits were squared and cleaned as much as practicable prior to commencing the tests.

Each test pit was filled with water to approximately 100-150 mm below the top, with the water level measured from a fixed point.

It was not possible to pre-soak the test pits, however at Test 1, where the water drained away rapidly (in less than 10 minutes), the test was repeated three times. At Test 2 the rate at which the water drained was significantly slower than Test 1, and therefore the test was terminated after an hour when the remaining water depth was less than 0.25 m above the base of the pit.

At Test 3, the base of the test pit was approximately 0.5 to 1 m above the lake level (as estimated from information provided by Fulton Hogan quarry operators). The water was not observed to drain for a period of 45 minutes and therefore the test was terminated and no calculations were performed.

2.2 Test Pits

The locations of the three test pits are shown on the attached plan.

2.2.1 Test 1

The soil conditions encountered at Test 1 included 100mm of topsoil overlying dry, brown sandy, fine to coarse GRAVEL with some cobbles and trace silt. The gravel was observed to be loosely packed, well graded and sub-rounded to sub-angular.

2.2.2 Test 2

No topsoil was present at the location of Test 2. The test pit exposed dry, brownish-grey sandy, fine to coarse GRAVEL with some cobbles and trace silt and boulders. The gravel was observed to be tightly packed, well graded and sub-rounded to sub-angular.

2.2.3 Test 3

No topsoil was present at the location of Test 3. The test pit exposed dry, brownish-grey sandy, fine to coarse GRAVEL with some cobbles and trace silt and boulders. The gravel became wet at a depth of 0.3 m and was observed to be loosely to tightly packed, well graded and sub-rounded to sub-angular.

3 Results

3.1 Percolation/Infiltration Rates

Percolation/infiltration rates were calculated for Test 1 and Test 2 using two methods. The more conservative result for each are presented below. As discussed in the preceding section, no results were able to be calculated for Test 3 as the water did not soak away.

Calculation worksheets are attached to this letter.

Test 1

The calculated infiltration rate is 3.85 x 10^{-4} m/s or 1,380 mm/hr.

Test 2

The calculated infiltration rate is 4.9 x 10^{-5} m/s or 175 mm/hr.

3.2 Erodibility Factor K

We attempted to assess the erodibility factor K for the typical site materials based on observations in the field, as well as making some assumptions on the material properties. It must be noted that our assessment of this factor is limited and based on several assumptions of the soil properties. Therefore further laboratory or field testing may be required (noting that an emersion test and a specific sieve and hydrometer analysis has not been carried out yet).

Erodibility factor K is estimated using the Wischmeier and Smith nomograph.

$$100K = 2.1M^{1.14}(10^{-4})(12-a) + 3.25(b-2) + 2.5(c-3)$$

Where:
M = (%silt + %sand) x (100 - % clay)
a = % organic
b = soil structure code (taken as 2 in this case, fine granular)
c = soil permeability class (taken as 5 in this case, slow materials exposed by deep excavation of the quarry).

In this case, we estimated the percentage sand, silt and clay from a prior grading curve for pit run material sampled from the quarry (attached). Taking the percentage of sand as 13%, and assuming 1% for silt and clay respectively, the calculated M value is 1,287.

Therefore, the calculated K factor is 0.14 (US units) or 0.0182 (SI units).

We reiterate again that this factor is based on several assumptions and we strongly advise that this factor should be reviewed once further laboratory and/or field test data is available.

4 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Fulton Hogan Land Development Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground and material conditions indicated from published sources, inspections and tests described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site and material characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

Report prepared by



Jana Kruyshaar, CMEngNZ, MIPENZ
Principal Geotechnical Engineer

Appendix 1: Test Location Plan

Appendix 2: Soil Permeability Calculation Worksheets

Appendix 3: Laboratory Particle Size Distribution Result (Pit Run)

Appendix 1

Test Location Plan



Description	Soil Permeability Test Locations (Not to scale, for information only)		
Project	Parkburn Development	Date drawn	24/04/2026
Client	Fulton Hogan Land Development Ltd	Drawn by	JK
Reference Number	24019	Approved by	CM

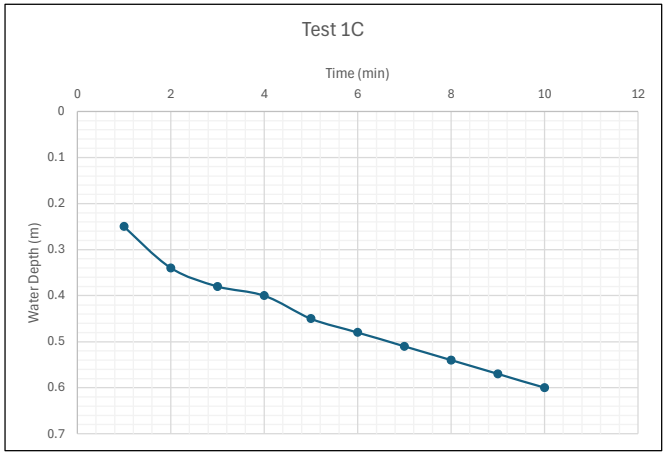
Appendix 2

Soil Permeability Calculation Worksheets

Measurements

Test 1C

Time (min)	Difference in depth (m)
0	
1	0.25
2	0.34
3	0.38
4	0.4
5	0.45
6	0.48
7	0.51
8	0.54
9	0.57
10	0.6
	empty



Calculations

Percolation Rate Calculation (Method 1):

$P = V_y/(AT \times X)$

Length pit	1.2	m
width pit	1	m
y*	0.03	m
d**	0.045	m
water vol V_y	0.036	m^3
wall area A1	0.06	m^2
wall area A2	0.072	m^2
base area AB	1.2	m^2
total area AT	1.332	m^2
Percolation rate P	0.027	m/min
Percolation rate P	27.027	mm/min
Percolation rate P	**1621.622**	**mm/hr**
Percolation rate P	**4.50E-04**	**m/s**

*y is the depth difference btw the last 2 points
**d is the distance btw the midpoint of the last 2 readings and the base of the pit
X is the time interval between the last two points in minutes

BRE Digest Method:

$$f = \frac{V_{p75-25}}{a_{p50} \times t_{p75-25}}$$

Length	1.2	m
Width	1	m
Depth	0.6	m
Area Base Abase	1.2	m^2
H eff storage depth	0.4	m
*V_{p75-25}	0.24	m^3
75% depth	0.3	m
25% depth	0.1	m
50% depth	0.2	m
**A_{p50}	2.08	m^2
***Tp75	1.5	min
****Tp25	6.5	min
T_{p75-25}	5	min
	300	s
Infiltration rate f	**3.846E-04**	**m/s**
Infiltration rate f	**1384.615**	**mm/hr**

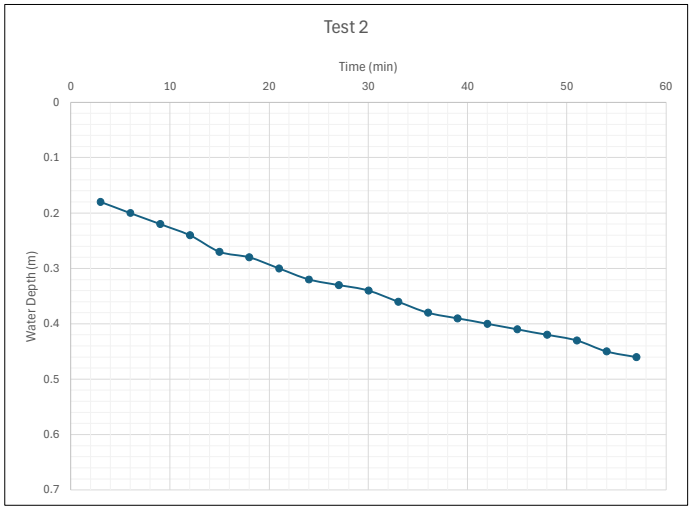
*Vol lost btw 75% and 25% of effective depth
**Mean surface area at 50% depth (incl base)
***Time at 75% depth of effective depth
****Time at 25% depth of effective depth

Measurements

Test 2

Time (min)	Difference in depth (m)
0	
3	0.18
6	0.2
9	0.22
12	0.24
15	0.27
18	0.28
21	0.3
24	0.32
27	0.33
30	0.34
33	0.36
36	0.38
39	0.39
42	0.4
45	0.41
48	0.42
51	0.43
54	0.45
57	0.46

Base of TP is 0.6m



Calculations

Percolation Rate Calculation (Method 1):

$P = V_y/(AT \times X)$

Length pit	1.2	m
width pit	1.1	m
y*	0.01	m
d**	0.145	m
water vol V_y	0.0132	m^3
wall area A1	0.022	m^2
wall area A2	0.024	m^2
base area AB	1.32	m^2
total area AT	1.366	m^2
Percolation rate P	0.003	m/min
Percolation rate P	3.221	mm/min
Percolation rate P	**193.265**	**mm/hr**
Percolation rate P	**5.37E-05**	**m/s**

*y is the depth difference btw the last 2 points
**d is the distance btw the midpoint of the last 2 readings and the base of the pit
X is the time interval between the last two points in minutes

BRE Digest Method:

$$f = \frac{V_{p75-25}}{a_{p50} \times t_{p75-25}}$$

Length	1.2	m
Width	1.1	m
Depth	0.6	m
Area Base Abase	1.32	m^2
H eff storage depth	0.45	m
*V_{p75-25}	0.297	m^3
75% depth	0.3375	m
25% depth	0.1125	m
50% depth	0.225	m
**A_{p50}	2.355	m^2
***Tp75	14	min
****Tp25	57	min
T_{p75-25}	43	min
	2580	s
Infiltration rate f	**4.888E-05**	**m/s**
Infiltration rate f	**175.974**	**mm/hr**

*Vol lost btw 75% and 25% of effective depth
**Mean surface area at 50% depth (incl base)
***Time at 75% depth of effective depth
****Time at 25% depth of effective depth

Appendix 3

Laboratory Particle Size Distribution Result (Pit Run)

Work Order ID: CTS25W1915

Central Testing Services
18 Ngapara Street, Alexandra 9340, Central Otago
P.O Box 397, Alexandra, Central Otago
Telephone: +64 3 4487644
www.centraltesting.co.nz

Material Test Report

Report No: MAT:CTS25S-01765
Issue No: 1

Client:
Cant Land Resource
Corner Main South & Halswell Junction Rd
Hornby

Christchurch 8042
NZ

Project: Parkburn Investigations

The tests reported herein (unless otherwise indicated) have been performed in accordance with the laboratory's scope of accreditation. Samples are tested as received, in natural condition, unless stated otherwise in the comments. This report may only be reproduced in full.

The results in this report relate only to the items / samples that were tested

Approved Signatory: Carl Julius
(Laboratory Technician)
IANZ Accreditation No:434
Date of Issue: 6/06/2025

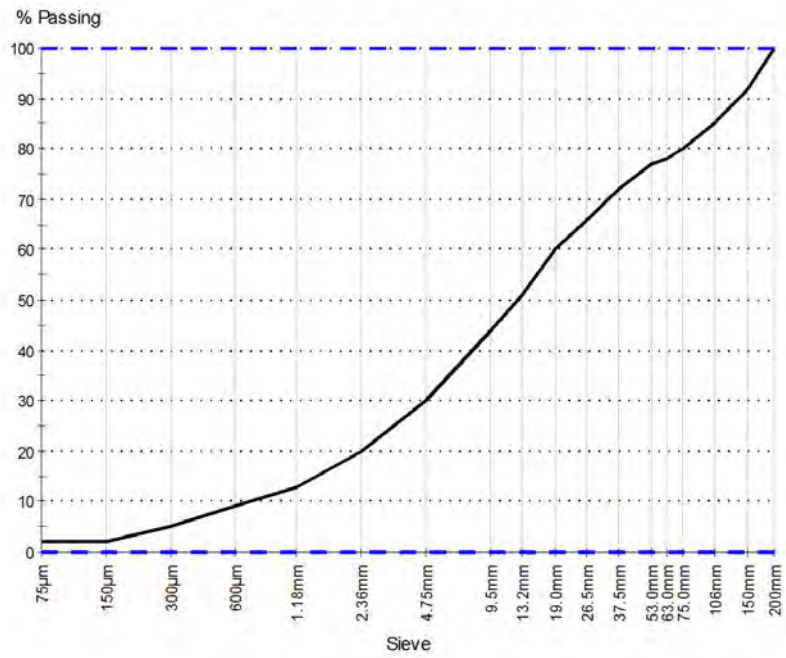
Sample Details

Sample ID: CTS25S-01765
Client Sample ID: 09674
Material: Pit Run - Cobbly GRAVEL with minor sand and trace of silt
Sample Source: Central - Parkburn Quarry
Site/Sampled From: Stockpile
Date Sampled: 26/05/2025
Specification: No Specification
Sampled By: Cam Maxwell
Sampling Method: NZS 4407:2015 2.4.6.3.2 (SP/WG/MACHINE)
Technician: Adam Rowe
Sampling Endorsed?: Yes

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: NZS 4407:2015 Test 3.8.1
Drying By: Oven
Date Tested: 30/05/2025
Tested By: Adam Rowe
Note: [a] Obtained by difference.

Sieve Size	% Passing	Limits
200mm	100	0 – 100
150mm	92	0 – 100
106mm	85	0 – 100
75.0mm	80	0 – 100
63.0mm	78	0 – 100
53.0mm	77	0 – 100
37.5mm	72	0 – 100
26.5mm	66	0 – 100
19.0mm	60	0 – 100
13.2mm	51	0 – 100
9.5mm	44	0 – 100
4.75mm	30	0 – 100
2.36mm	20	0 – 100
1.18mm	13	0 – 100
600µm	9	0 – 100
300µm	5	0 – 100
150µm	2	0 – 100
75µm	2[a]	0 – 100

Comments

Date Received: 27-May-25

© 2000-2025 QESTLab by SpectraQEST.com

Appendix I: Draft Cove Dewatering Management Plan

1. Purpose and status

This Dewatering Management Plan (DMP) describes the preliminary methodology for managing groundwater encountered during landward (i.e. prior to connecting to the lake) excavation of the two proposed coves adjacent to Lake Dunstan/Te Wairere.

This DMP has been prepared at a preliminary design stage to demonstrate a practicable framework for dewatering and managing associated discharges. It is based on currently available geotechnical and permeability information, preliminary cove geometry and conservative assumptions regarding groundwater conditions.

The final groundwater inflow rates, pumping requirements and treatment capacity cannot presently be determined with sufficient confidence for detailed design. Accordingly, the estimates and methodologies presented in this DMP will be verified through site-specific investigations, including groundwater monitoring, saturated permeability testing and/or trial pumping.

The results of those investigations will inform an updated DMP incorporated into the final CEMP submitted to Otago Regional Council (ORC) for review and acceptance before cove excavation below groundwater level begins.

The primary objectives of the DMP are to:

- minimise the volume of groundwater requiring pumping and treatment;
- maintain safe and practicable working conditions within the cove excavations;
- minimise the generation of sediment-laden dewatering water;
- provide sufficient treatment capacity for the anticipated dewatering flow;
- prevent the discharge of potentially sediment-laden water to Lake Dunstan/Te Wairere; and
- provide monitoring and contingency measures that enable the dewatering system to respond to changing groundwater and construction conditions.

This approach is consistent with the general dewatering principles in Auckland Council's Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region (GD05), which emphasises minimising dewatering volumes, appropriately treating sediment-laden pumped water, monitoring discharges and preparing a specific dewatering plan where dewatering is required. This

management plan is also consistent with Section 6.7 (Dewatering) of the ORC Guidelines.

2. Site and groundwater conditions

The proposed works include formation of two coves extending inland from the existing Lake Dunstan/Te Wairere shoreline. The northern cove is approximately 29 m long and up to approximately 40m wide, while the southern cove is approximately 200 m long and up to approximately 30m wide (Viridis Environmental Consultants, 2026).

The site is predominantly underlain by Late Pleistocene outwash deposits. These generally comprise sandy gravels with cobbles and occasional boulders, with quarrying having exposed these materials across substantial parts of the site. Previously quarried areas also contain various fill materials, including loose pea gravel (Insight Engineering, 2026a; Geotago, 2022).

Groundwater has previously been encountered within test pits on the lower quarry floor at approximately 1.1–1.6 m below ground level. The existing geotechnical information indicates that groundwater beneath the quarry is reasonably static and hydraulically connected with Lake Dunstan/Te Wairere. The lake has a normal operating range of approximately 193.5–194.5 m AOD (Geotago, 2022; Landpro, 2026).

For the purposes of this preliminary assessment, 194.5 m AOD has therefore been adopted as the assumed maximum groundwater elevation.

Based on the current cove earthworks model, the approximate excavation volumes below 194.5 m AOD are presented in the following table.

Cove	Approx. excavation below 194.5 m AOD
Southern cove	21,900 m^3
Northern cove	30,800 m^3
Total	**52,700 m^3**

The northern cove has an approximate overall excavation footprint of 1.4 ha. The 30,800 m^3 below the assumed maximum groundwater level therefore represents an average below-groundwater excavation depth of approximately 2.2 m across this footprint, although the maximum excavation depth below groundwater may locally approach approximately 5 m.

3. Available permeability information

Insight Engineering undertook three shallow permeability tests at Parkburn Quarry in April 2026. The tests were undertaken in 0.6 m deep test pits and were intended to inform erosion and sediment control planning rather than detailed groundwater or dewatering design (Insight Engineering, 2026b).

The calculated infiltration rates were:

- Test 1: 3.85×10^{-4} m/s, equivalent to approximately 1,380 mm/hr; and
- Test 2: 4.9×10^{-5} m/s, equivalent to approximately 175 mm/hr.

Test 3 was located closer to Lake Dunstan/Te Wairere, with the test pit base estimated to be approximately 0.5–1 m above lake level. No measurable drainage occurred during the 45-minute test period.

The tested materials generally comprised sandy fine-to-coarse gravel with cobbles and trace silt. Laboratory grading of representative pit-run material describes cobbly gravel with minor sand and trace silt, with approximately 2% passing the 75 μm sieve (Insight Engineering, 2026b).

The measured infiltration rates have not been directly adopted as saturated horizontal hydraulic conductivity values. The tests were shallow, predominantly within initially unsaturated materials, were not pre-soaked, and were not undertaken as groundwater pumping tests. Insight Engineering (2026b) also identifies the limited nature of the investigation and potential for conditions to vary between investigation locations.

Nevertheless, the results provide useful site-specific information regarding the likely order of magnitude of permeability. For preliminary dewatering assessment, the following values have therefore been adopted:

Scenario	Preliminary hydraulic conductivity (K)
Lower	5×10^{-5} m/s
Representative	1×10^{-4} m/s
Upper	5×10^{-4} m/s
Conservative sensitivity case	1×10^{-3} m/s

These values are preliminary screening assumptions rather than design values and will be replaced or refined following the detailed groundwater investigations described in Section 5.

4. Preliminary dewatering assessment

A preliminary screening assessment has been undertaken using the available permeability information, cove geometry and an assumption that groundwater is hydraulically connected to Lake Dunstan/Te Wairere.

For the northern cove, which represents the larger dewatering area, indicative sustained groundwater inflows for the full excavation footprint are estimated as follows:

Assumed K	Indicative groundwater flow
5×10^{-5} m/s	approximately 3–11 L/s
1×10^{-4} m/s	approximately 6–22 L/s
5×10^{-4} m/s	approximately 26–110 L/s
1×10^{-3} m/s	approximately 52–220 L/s

These estimates are order-of-magnitude screening values only. Actual inflow will depend on saturated hydraulic conductivity, groundwater and lake levels, excavation geometry, distance from the lake, local geological variability, effectiveness of hydraulic isolation and the size of the active excavation cell.

On the information presently available, groundwater inflow in the order of approximately 20–100 L/s is considered a reasonable preliminary central range for planning purposes. Approximately 200–250 L/s is retained as a conservative sensitivity range pending field verification.

Actual operational flows may be appreciably lower because the full cove footprint will not be dewatered simultaneously. The staged-cell methodology described in Section 6 is intended specifically to reduce the active drawdown footprint and resulting pumping requirement.

The estimates in this section are not intended to establish the design capacity of the final dewatering system. That capacity will be established following the investigations described below.

5. Detailed investigation and final dewatering design

Before significant excavation below groundwater level begins, targeted groundwater investigations will be undertaken by a suitably qualified and experienced person (SQEP).

The investigation programme will include, as appropriate:

- installation of groundwater monitoring points within and around the proposed cove excavation areas;
- monitoring of groundwater and Lake Dunstan/Te Wairere levels;
- saturated permeability testing within representative materials at relevant excavation depths;
- trial pumping within or immediately adjacent to the proposed cove excavations; and
- monitoring of groundwater response during trial pumping to assess hydraulic connectivity with Lake Dunstan/Te Wairere.

Trial pumping will be particularly important because the existing shallow infiltration tests do not establish the rate at which the saturated gravel aquifer and Lake Dunstan/Te Wairere may replenish an excavation under sustained drawdown.

The investigation results will be used to:

- verify or revise the preliminary hydraulic conductivity assumptions;
- determine representative and conservative groundwater inflow rates;
- establish appropriate excavation cell dimensions;
- determine required pumping and standby capacity;
- establish required treatment capacity; and
- determine whether temporary hydraulic cut-off measures are necessary or beneficial.

An updated DMP incorporating the investigation results, supporting calculations and final dewatering design will form part of the final CEMP submitted to ORC for review before any dewatering associated with cove excavation begins.

6. Excavation staging and inflow minimisation

Only one cove will be actively excavated below groundwater level at any one time, with cove excavation to be substantially completed on the landward side of Lake Dunstan prior to "breaking through" into the wetted bed of the lake. Note that, at this stage, it is assumed that cove formation/excavation on the lake bed can occur within the water column (therefore no dewatering is expected to be required for this aspect of the works).

Each cove will also be divided into a series of smaller excavation cells. Dewatering will be limited to the active cell or cells required for the immediate construction activity rather than attempting to lower groundwater across the entire cove footprint.

This approach is consistent with the general principle in GD05 that erosion and source controls that reduce the volume requiring dewatering are preferable to relying solely on downstream sediment treatment.

The number, dimensions and sequence of excavation cells will be determined during detailed construction planning following completion of the groundwater investigations.

The excavation sequence will seek to:

- minimise the area and duration of excavation below groundwater level;
- retain undisturbed material between Lake Dunstan/Te Wairere and the active excavation for as long as practicable;
- progressively complete excavation before moving to subsequent cells;
- avoid unnecessary groundwater drawdown outside the active work area; and
- minimise the pumping and treatment capacity required at any one time.

Completed cells may be allowed to re-wet where this does not interfere with subsequent construction.

If groundwater inflow exceeds the practical capacity of the proposed pumping and treatment system, the construction methodology will be reviewed before simply increasing pumping capacity. Responses may include reducing excavation cell size, modifying excavation sequencing, installing temporary sheet piling or another hydraulic cut-off, limiting the duration or depth of drawdown, or undertaking suitable components of the excavation in the wet.

7. Dewatering collection

Groundwater will be collected using appropriately positioned sumps, wells, wellpoints, gravel collection trenches or a combination of these methods. The final collection system will be determined following the detailed groundwater investigation and confirmation of excavation staging.

Where practicable, relatively clean groundwater will be intercepted before it passes through active earthworks. Water collected directly from active excavation areas will be treated as potentially sediment-laden unless monitoring demonstrates otherwise.

Pumps will be positioned and operated to minimise disturbance of exposed soils and entrainment of fine sediment. Pump intakes will be appropriately screened and elevated above accumulated sediment where practicable.

Clean surface runoff will be diverted around the active excavation in accordance with the ESCP so that rainfall runoff from surrounding areas does not unnecessarily increase the volume requiring dewatering and treatment.

8. Dewatering treatment

Dewatering water that does not meet the applicable discharge criteria will be treated before discharge.

GD05 identifies settlement, sediment retention devices and flocculant treatment as potential management measures where pumped water does not meet the required discharge standard. It also emphasises that treatment devices receiving pumped flows need to be appropriately sized and that dewatering discharges require close monitoring.

Given the potentially significant pumping rates associated with excavation of the coves, conventional sediment retention ponds or infiltration basins are not proposed as the primary treatment or disposal method for cove dewatering. Instead, the principal treatment system is anticipated to comprise modular high-rate clarification, with chemical treatment where required.

The indicative treatment train is:

Dewatering pumps → equalisation/buffer storage → chemical dosing and flocculation → lamella clarification → water-quality monitoring → discharge

Multiple lamella clarification units will be installed and operated in parallel as necessary to provide the required treatment capacity. This modular arrangement will enable treatment capacity to be matched to the pumping rates established through field investigation and adjusted during construction where required.

The number and rated capacity of the lamella units will not be prescribed until the field investigation and trial pumping programme has established an appropriate design flow.

Chemical treatment will be confirmed through bench testing using representative dewatering water. The treatment chemical and dose will be selected based on treatment performance, actual suspended sediment characteristics, water chemistry and suitability for discharge to the receiving environment.

The treatment system will incorporate sufficient buffer/equalisation capacity to accommodate short-term fluctuations in pumping rate and treatment performance. Buffer storage is not intended to provide long-term storage of the entire dewatering flow.

9. Discharge of treated water

Subject to the relevant resource consent requirements and confirmation that applicable water-quality criteria are achieved, treated dewatering water is expected to be returned to Lake Dunstan/Te Wairere.

This is considered preferable to attempting large-scale infiltration within the site because groundwater beneath the lower quarry is understood to be hydraulically connected to the lake (Geotago, 2022; Landpro, 2026). Large-scale infiltration within highly permeable lake-margin materials could potentially recycle pumped groundwater towards the active excavation and increase the overall dewatering requirement.

The final discharge location and outlet arrangement will be confirmed during detailed design. The discharge system will:

- avoid erosion and scour of the lake bed or margins;
- provide appropriate energy dissipation;
- minimise the potential for discharged water to recirculate towards the active excavation;
- avoid unnecessary disturbance of aquatic habitat; and
- enable representative monitoring of discharge water.

Untreated sediment-laden dewatering water will not be discharged directly to Lake Dunstan/Te Wairere.

10. Water quality monitoring

The final DMP will establish discharge performance criteria consistent with the relevant resource consent conditions and final CEMP.

As a minimum, monitoring is expected to include:

- discharge flow rate;
- turbidity;
- pH; and
- visual assessment of the discharge and receiving environment.

Additional parameters will be included where warranted by the selected treatment chemicals, baseline water-quality monitoring or consent conditions.

Monitoring frequency, trigger levels and response requirements will be confirmed in the final DMP.

Where monitoring identifies that treated water does not meet the applicable discharge criteria, discharge to Lake Dunstan/Te Wairere will cease and water will be redirected to buffer storage or recirculated through the treatment system until acceptable treatment performance is restored.

11. Treatment residuals

Sediment and sludge accumulated within sumps, tanks and lamella clarification units will be removed as required to maintain treatment performance.

Clarifier sludge will be directed to an appropriately contained dewatering system, which may include geotextile dewatering bags, a bunded drying area or a proprietary sludge-management system.

Dewatered sediment may be reused within the site where it is demonstrated to be geotechnically and environmentally suitable. Material unsuitable for reuse will be disposed of at an appropriately authorised facility.

12. Monitoring and adaptive management

Groundwater conditions, pumping rates and treatment performance will be monitored throughout dewatering.

Records will include, as appropriate:

- groundwater and Lake Dunstan/Te Wairere levels;
- pumping rates and cumulative pumping volumes;
- treatment plant flow rates;
- chemical dosing rates;
- treated-water quality;
- observations of groundwater ingress and excavation conditions;
- treatment system maintenance and desludging activities; and
- incidents, exceedances and corrective actions.

Actual groundwater inflows will be compared with the values used to design the system. The treatment system and excavation methodology will be adapted where actual conditions differ materially from those predicted.

If inflow approaches available treatment capacity, consideration will first be given to reducing the active dewatering footprint or groundwater inflow through changes to cell size, sequencing or hydraulic isolation rather than relying solely on increased pumping and treatment capacity.

13. Contingency measures

Standby pumping and treatment capacity will be provided appropriate to the final design flow and consequences of equipment failure.

The final DMP will establish trigger levels and response measures for circumstances including:

- groundwater inflow approaching pumping or treatment capacity;
- unexpected rapid groundwater ingress;
- treatment plant malfunction;
- treated water exceeding discharge criteria;
- chemical dosing failure;
- significant rainfall;
- material changes in Lake Dunstan/Te Wairere level; and
- instability or erosion associated with groundwater inflow or discharge.

Responses may include reducing or temporarily stopping excavation, reducing excavation cell size, installing additional hydraulic isolation, increasing treatment capacity, recirculating water through the treatment system, adjusting chemical treatment or temporarily ceasing discharge.

Where compliant discharge cannot be maintained, excavation below groundwater level will cease until adequate dewatering and treatment capacity is restored.

14. Dewatering pit decommissioning

At the completion of dewatering, any dewatering pits or bores that have been constructed to enable cove works below the water table will be decommissioned by backfilling with clean, inert material. The fill material is to be placed and compacted so as to avoid the formation of a preferential contaminant pathway to groundwater.

15. Review and finalisation

This DMP establishes the preliminary management framework for cove dewatering. It reflects the level of design and groundwater information currently available and is not intended to represent the final construction-level dewatering design.

The preliminary assessment via the available information indicates a hydraulic conductivity range of approximately 1×10^{-4} to 5×10^{-4} m/s for planning purposes, with 1×10^{-3} m/s retained as a conservative sensitivity case. The existing permeability testing was not designed to determine saturated aquifer hydraulic

conductivity or sustained groundwater inflow to a dewatered excavation and therefore does not provide an appropriate basis, in isolation, for final system design (Insight Engineering, 2026b).

Before excavation below groundwater level begins, the preliminary assumptions and estimates in this DMP will be verified or validated through detailed groundwater investigation and dewatering assessment. The DMP will then be updated to incorporate:

- measured groundwater and Lake Dunstan/Te Wairere levels;
- site-specific saturated hydraulic conductivity;
- trial-pumping results and observed groundwater response;
- refined groundwater inflow calculations;
- final cove excavation staging and cell dimensions;
- design pumping rate and standby capacity;
- final lamella clarification capacity and number/configuration of treatment units;
- chemical-treatment selection and bench-testing results (if required);
- buffer and contingency storage requirements;
- final discharge location and outlet design;
- discharge performance criteria;
- monitoring requirements; and
- trigger and response procedures.

The updated DMP will form part of the final CEMP provided to ORC for review and acceptance before cove dewatering activities commence.

16. References

Auckland Council. 2016. Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region. Guideline Document GD2016/005 (GD05). Knowledge Auckland

Geotago Ltd. 2022. Geotechnical Assessment for Proposed Residential Development, Parkburn.

Insight Engineering. 2026a. Geotechnical and Earthworks Assessment for Proposed Residential Subdivision at Parkburn Quarry, 922 Luggate-Cromwell Road (SH6), Cromwell.

Insight Engineering. 2026b. Soil Permeability Testing, Parkburn Quarry.

Landpro Limited. 2026. Parkburn Subdivision Environmental Management Plan.

Viridis Environmental Consultants. 2026. Parkburn, Luggate-Cromwell Road: Ecological Impact Assessment.

Appendix J: Dust Management Plan

(to be provided in Final EMP)

Appendix K: Noise and Vibration Management Plan

(to be provided in Final EMP)

Appendix L: Draft Lizard Management Plan

VIRIDIS
Environmental Consultants

Parkburn, Luggate-Cromwell Road

Draft Lizard Management Plan

Prepared for: Fulton Hogan Land Development Limited

July 2026



DOCUMENT CONTROL AND REVISION HISTORY

Document title	Parkburn, Luggate-Cromwell Road
	Draft Lizard Management Plan
Prepared for	Fulton Hogan Land Development Limited
Version	Draft B
Date	16 July 2026
Document number	10418-003-B

Version	Issue date	Document number
Draft A	12 May 2026	10418-003-A
Draft B	16 July 2026	10418-003-B

Author(s)	
	Annabelle Coates
	[redacted]
Reviewer(s)	
	Mark Delaney
	[redacted]

Reference: Viridis 2026. Parkburn, Luggate-Cromwell Road Draft Lizard Management Plan. A report prepared for Fulton Hogan Land Development Limited by Viridis Limited. July 2026.

Cover photo: Lizard habitat within the Parkburn site, February 2026

© Viridis Limited 2026

This document has been prepared by Viridis Limited for Fulton Hogan Land Development Limited and is intended solely for the purpose for which it was commissioned. It may not be used or relied upon by any third party without the express written consent of Viridis Limited. Unauthorised use, reproduction, or distribution of this document, in whole or in part, is strictly prohibited.

TABLE OF CONTENTS

1 Introduction 1
1.1 Purpose of this Lizard Management Plan 1
1.2 Project Background 1
2 Site Context, Ecological Values, and Potential Effects 3
2.1 Site Description 3
2.2 Species Potentially Present 4
2.3 Lizard Habitat 4
2.4 Lizard Densities 5
2.5 Proposed Site Works 5
2.6 Description of Impacted Habitat 7
2.7 Potential Effects on Lizards 7
3 Herpetofauna Management 8
3.1 Objectives 8
3.2 Statutory Context 8
3.3 Project Herpetologist and Methodology Finalisation 9
3.4 Lizard Search and Capture Methodology 9
3.5 Release Site 13
3.6 Pest Control 16
3.7 Post Release Monitoring 20
3.8 Completion Reporting 20
3.9 Contingency measures 20
3.10 Incidental discovery protocol 22
3.11 Checklist 23
References 24

List of Tables

Table 1. Summary of release site suitability 14
Table 2. Recommended pest control methods for the lizard release site. 18
Table 3. Proposed contingency measures for lizard management. 21
Table 4. Lizard Management Checklist 23

List of Figures

Figure 1. Site location as indicated by blue polygon (map source: LINZ NZ Topo 50). 3
Figure 2. Examples of potential lizard habitat within the proposed works area scrubby vegetation and woody debris. 5
Figure 3 - Lizard survey results 6
Figure 4. Lizard habitat and lizard records 11
Figure 5. a) a funnel trap, b) an ACO. 12
Figure 6 - Proposed lizard release locations 15
Figure 7. Lizard release site pest control 19

1 INTRODUCTION

1.1 Purpose of this Lizard Management Plan

This Lizard Management Plan (LMP) has been prepared to identify and manage the actual and potential adverse effects of the proposed Parkburn residential subdivision development on indigenous lizards and lizard habitat at 922 Luggate-Cromwell Road, Cromwell.

The LMP outlines procedures and management measures relating to:

- pre-construction lizard salvage;
- vegetation clearance supervision;
- lizard capture, handling, and relocation;
- release-site establishment and habitat enhancement;
- pest animal management;
- post-release monitoring; and
- completion reporting.

The overall objective of this LMP, and the purpose of the activity with regard to Schedule 7 of the Fast Track Approvals Act 2024 (FTAA), is to avoid, minimise, and mitigate adverse effects on indigenous lizards and achieve no net loss of lizard populations associated with the development. This will be achieved by salvaging and relocating any individuals present within suitable habitat before and during vegetation clearance, earthworks and associated habitat removal.

This draft LMP accompanies the FTAA application and associated Wildlife Act Authorisation (WAA) application and will be finalised following confirmation of construction methodologies, detailed design, and consultation with the Department of Conservation (DoC).

1.2 Project Background

Fulton Hogan Land Development (FHLD) Limited has applied for resource consent through the Fast Track Approvals Act (2024) (FTAA) to develop a residential subdivision on the property at 922 Luggate-Cromwell Road (State Highway 6), Cromwell.

The proposed development includes:

- earthworks;
- vegetation clearance;
- installation of stormwater infrastructure;
- quarry rehabilitation; and
- associated residential development works.

The site has been heavily modified through historical agricultural use and more recent quarrying activities. However, areas of indigenous lizard habitat remain within portions of the site, particularly within areas of rank grassland, woody debris, scrub vegetation, and the Park Burn riparian corridor. As a result, there is potential for indigenous lizards to be adversely affected by vegetation clearance and habitat disturbance associated with the proposed works.

This LMP should be read in conjunction with the Parkburn Ecological Impact Assessment Report ('EcIA')[1], which assesses the ecological values of the site and the potential effects of the proposed works.

[1] Viridis. 2026. Parkburn, Luggate-Cromwell Road, Ecological Impact Assessment. Prepared for Fulton Hogan Land Development Limited.

2 SITE CONTEXT, ECOLOGICAL VALUES, AND POTENTIAL EFFECTS

2.1 Site Description

The site is located in the Pisa Ecological District (ED) of the Central Otago Region. The Pisa ED is characterised by mid to high elevation ranges and flats in some locations. The climate is generally dry, with cold winters and some small snowbanks that persist through summer. Tussocklands would have predominated historically, however now much of the district is modified by pastoral farming. Very small remnants of native forest remain. Fauna habitat has been degraded and reduced over time as agricultural and urban development expanded.

The site represents a highly modified area of the ecological district. While not currently urbanised, the site contains an active gravel quarry and has been heavily modified over the past 40 years. Prior to the quarry being established, the site was used for agricultural purposes. The neighbouring property to the north is formed by another active gravel quarry, while to the south is an existing residential development of Pisa Moorings. The western boundary is Luggate-Cromwell Road (SH6) with horticultural land beyond. The hydroelectric Lake Dunstan is located on the site's eastern boundary. Further afield is the township of Cromwell.

Historically (pre-human) the site likely comprised scrub and/or tussockland. The wider area has been farmed since the 1860s and therefore it is likely it has been devoid of any significant native vegetation for more than 150 years. Lake Dunstan, on the site's eastern boundary, was first filled between 1992 and 1993. Prior to this, the Clutha River was located approximately 500 m beyond the site's boundary.

Currently the site is occupied by an operational gravel quarry, with various buildings associated with the quarry and the manufacture of products such as paving blocks.

The location of the site is shown in Figure 1.

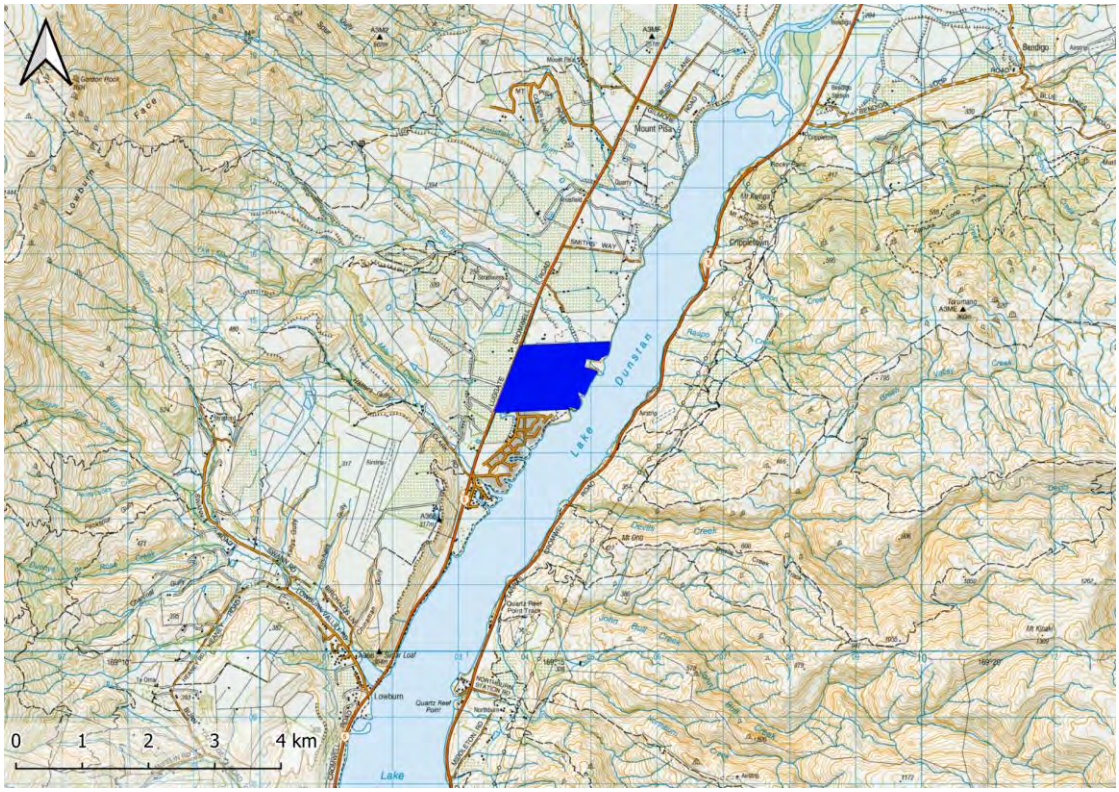


Figure 1. Site location as indicated by blue polygon (map source: LINZ NZ Topo 50).

2.2 Species Potentially Present

Viridis (2026) contains the results of a desktop review of lizard data, a site assessment to assess the presence of suitable habitat on the site, and results of a survey completed by Lizard Expert NZ within the site. The results of the findings are summarised below.

A review of Department of Conservation's (DoC) Herpetofauna database (accessed November 2024) for records within 10 km of the site identified nine lizard species. Two species of lizard have been recorded – McCann's skink (*Oligosoma maccanni*; Not Threatened) and Kawarau gecko (*Woodworthia* "Cromwell"; At Risk – Declining (nationally) and Regionally Declining (regionally)).

Lizard habitat within the site was mostly limited to areas of moderate and long grass that had not been subject to quarrying (Figure 3). Additionally, habitat was also present within the Park Burn riparian area between the site and the lake margins. Some areas of debris were present within the site, including dead trees and wood, which provided refugia and basking habitat for skinks. Habitat typically associated with Kawarau gecko was not identified within the site, and geckos are therefore considered highly unlikely to be present.. No lizards are expected to be present in the actively quarried area, and as such, values associated with lizard habitat are not attributed to these areas.

A lizard survey was undertaken in December 2025. One hundred baited Gee's minnow traps were distributed throughout the site (Figure 3), and this was complemented by manual hand searches in other suitable habitats. The areas were focused around areas where lizard habitat values were present, i.e. not within the actively quarried area. A total of 80 McCann's skink and one tussock skink (*Oligosoma chionochloescens*; At Risk – Declining; Regionally Declining) were captured in traps and by hand searches during the survey. An additional 38 separate observations of skink presence (guano, skins) were also noted. These observations were attributed to McCann's skink due to their locations and the habitat they were found in. An additional two observations were attributed to tussock skink, however these observations were outside of the site on the lake margin.

2.3 Lizard Habitat

McCann's skink are likely to be present throughout the site where habitat is suitable, i.e. not within the actively quarried areas. It is possible tussock skink may be present, predominantly in the Park Burn riparian corridor, although the survey did not detect any tussock skink in this area. The site contained areas of long grass that provides low-moderate skink habitat. These areas were within a wider quarry area and are subject to period mowing to prevent grass getting too long. Where grass was regularly cut or mown, habitat values were considered low. Where grass was in close proximity to trees or shrubs, it was considered to be low-moderate. Where fallen debris was present amongst grass, lizard habitat was considered to be moderate.

Examples of these habitats present on the site are shown in Figure 2.



Figure 2. Examples of potential lizard habitat within the proposed works area scrubby vegetation and woody debris.

2.4 Lizard Densities

Native lizard density estimates vary by habitat type and quality, and factors such as predation, historical site disturbance and population dynamics. It is not possible to reliably estimate population sizes and densities without detailed mark–recapture data. Given the very common nature of McCann's skink, the heavily dominant species within the site, mark and recapture was not considered necessary.

Regardless, densities of lizards expected to be present within the works footprint have been estimated based on existing information and based on the survey effort (number of traps, number of survey days) undertaken as part of the baseline survey of the site. Density estimates are available for McCann's skink (Wilson et al. 2017), and also for southern grass skink which has been used as a proxy for tussock skink given their very similar habitats and recent classification as two separate species. In high quality habitat, southern grass skink can reach up to ~9,200 skinks per ha while McCann's skink can reach up to ~2,250 skinks per ha.

The works area comprises approximately 1.7 ha of moderate value habitat (long grass with basking debris), approximately 11 ha of low-moderate (maintained grass in proximity to trees/shrubs) and 33 ha of low quality habitat (periodically mown grass).

Given the low to moderate habitat quality with no pest mammal management, and the results of the preliminary survey, a rough estimate of 25 skinks per ha could be expected across the site. This would equate to approximately 1,150 McCann's skinks in the project footprint.

Tussock skink habitat is largely unimpacted. A conservative estimate of approximately 0.6 ha of tussocks skink habitat is within the earthworks footprint. Given the low to moderate habitat quality with no pest mammal management, and the limited detection during the survey, a rough estimate of 10 skinks per ha could be expected. This would equate to <10 tussock skink within the project footprint potentially affected by the works.

2.5 Proposed Site Works

The majority of the vegetation within the site is proposed to be removed. However, the bulk of the site comprises managed grass or active quarry. Lizard habitat is concentrated in long grass around trees, shrubs and in proximity to debris forming basking habitat. Figure 3 illustrates areas where lizards were detected during a targeted survey of the site.

2.6 Description of Impacted Habitat

The ecological values of the habitat on the site are assessed and described in Viridis (2026). The vegetation on the site affected by the proposed clearance is described as:

- Long grass around trees and shrublands.
- Woody debris forming basking habitat.
- Scrubby vegetation within the Park Burn corridor and around the edge of Lake Dunstan.

2.7 Potential Effects on Lizards

If indigenous lizards are present within the areas of vegetation clearance, potential adverse effects on lizards may include:

Direct effects:

- Mortality during vegetation clearance or habitat disturbance
- Injury during physical clearance works

Indirect effects:

- Loss of habitat
- Habitat fragmentation
- Temporary noise disturbance

Managing direct effects on lizards requires mitigation through a salvage and relocation programme. The riparian revegetation planting proposed as part of the development will help to mitigate for the loss of indigenous lizard habitat.

Avoidance of lizard habitat is not possible. However, given the ongoing quarrying activities occurring on the site, the values of the habitat at the time construction of this project commences are likely to be lower than they are currently. The impact on lizards is therefore proposed to be minimised through salvage and relocation of lizards that remain within the site when construction commences. The contents of this plan set out methods for minimisation.

3 HERPETOFAUNA MANAGEMENT

3.1 Objectives

The objectives of the herpetofauna management measures proposed are to minimise potential adverse effects on native lizards within the construction footprint by way of capturing and relocating any native lizards prior to and during vegetation removal, and providing habitat enhancement and pest control, where appropriate. Further, the proposed herpetofauna management aims to achieve the following:

- The population of each species of native lizard present on the site where works are to occur shall be maintained or enhanced on site; and
- The habitat(s) that lizards are transferred to on the site will support viable native lizard populations for all species present pre-development.

These objectives will be achieved by:

a. Using current best practice to capture native lizards from vegetation and other potential habitats in the construction footprint prior to and during vegetation clearance, and relocate any captured individuals to safe and suitable habitats (avoid and minimise mortality of wildlife protected by the Wildlife Act);

b. Setting out standard surveying and monitoring protocols that are to be followed, using the DoC Natural Heritage Management System's Herpetofauna Inventory & Monitoring Toolbox (DoC, undated) and/or using new advances in tools and techniques not yet incorporated into the toolbox;

c. Meeting requirements of the Wildlife Act and Resource Management Act.

Section 3 of the LMP addresses the following:

- Lizard capture, vegetation clearance supervision and relocation methodologies;
- A summary of the recommended on site release site;
- Post works management and monitoring (where required).

3.2 Statutory Context

Herpetofauna (reptiles and amphibians) comprise a significant component of New Zealand's terrestrial fauna. There are currently 147 native herpetofauna taxa recognised in New Zealand (Hitchmough et al., 2021; Burns et al., 2024), 88% of which are considered 'Threatened' or 'At-Risk'. All indigenous reptiles and amphibians are legally protected under the Wildlife Act 1953, and vegetation and landscape features that provide significant habitat for native herpetofauna are protected by the Resource Management Act 1991.

Statutory obligations require management of resident lizard populations where they or their habitats are threatened by disturbance or land development. This draft LMP is a site-specific plan prepared to avoid or minimise adverse construction effects and to ensure that all necessary measures for successful relocation of lizards are identified and implemented to protect and/or enhance their habitats.

Capture, handling and relocation of indigenous lizards may only be undertaken under a valid Wildlife Act Authorisation (WAA) issued by DoC.

3.3 Project Herpetologist and Methodology Finalisation

A suitably qualified herpetologist or ecologist ('project herpetologist') is required to implement this LMP, and a WAA to capture and relocate indigenous lizards is required.

Prior to undertaking lizard relocation work, the project herpetologist will review the methodologies outlined within this LMP and may amend or refine the methodologies where necessary to respond to site conditions, habitat changes, weather conditions, construction staging, or updated ecological information available at the time works commence.

The project herpetologist will have authority to modify salvage methodologies, trapping effort, search methodologies, release procedures, and timing of activities where necessary to improve salvage outcomes, minimise adverse effects on indigenous lizards, or address health and safety considerations, provided the overall intent of this LMP and any conditions of the WAA continue to be met.

Any material amendments to the methodologies outlined in this LMP will be documented by the project herpetologist and communicated to the relevant contractors and regulatory authorities where required.

3.4 Lizard Search and Capture Methodology

3.4.1 Timing of activities

Revegetation activities associated with the release site should be completed prior to commencing lizard salvage activities. Pest control should be in place within the release site prior to commencing lizard salvage activities.

Vegetation clearance should occur between October and April (inclusive). Lizard salvage activities are confined to warmer months when lizards are the most active and likely to be detected if present.

All lizard management activities are required to be undertaken during fine, calm, and dry weather. If weather is marginal, the project herpetologist will have the ultimate say on whether management activities can occur on that day.

Trapping and day searches are to be undertaken in the fortnight leading up to vegetation removal, as well as destructive searches immediately prior to and during vegetation clearance. Seven days of lizard trapping, hand searching and destructive searches of habitat will be completed in the two weeks leading up to vegetation removal. If weather conditions are unsuitable (e.g. too cold, raining) salvage will continue until seven days of salvage have been completed.

3.4.2 Trapping and habitat searches

Salvage shall occur in all areas of moderate and low-moderate value (red and orange areas) lizard habitat within the earthworks footprint (Figure 4). Salvage in low value areas will occur at the discretion of the project herpetologist depending on habitat values at the time. It is understood quarrying activities are still ongoing and therefore areas of suitable habitat at the time of works commencing are likely to be different compared to what was present during investigations for the EcIA. Areas of salvage will be confirmed by the project herpetologist prior to works commencing.

A minimum seven-day trapping period using a combination of artificial cover objects (ACOs), baited pitfall traps and/or baited funnel traps (Figure 5) will be undertaken prior to vegetation removal at a density deemed suitable by the project herpetologist. Additional trapping days may be required depending on numbers of lizards captured. Additional days will be undertaken at the discretion of the project herpetologist. Key points for this trapping are:

- All traps shall be embedded in and furnished with vegetation to protect any captured lizards from heat and exposure during confinement.
- ACOs and pitfall traps shall be installed at least four weeks prior to the commencement of trapping to allow them to 'bed in' to the environment.
- Each trap will be baited with fruit (e.g. canned pear).
- Traps are to be placed in shaded areas (as far as practicable) away from potential inundation with water and checked once per day while active to limit adverse effects on lizards (stress, desiccation, drowning, etc.).
- When not in use, all pitfall traps shall be deactivated (sealed closed or furnished to the upper rim so that lizards may escape).
- Captured lizards will be held temporarily (up to two hours) to allow traps to be cleared either in their entirety or in sections. Lizards will be stored as described in 3.4.4 below.
- All native lizards shall be released at the designated release sites following capture.

During trap checks, the project herpetologist shall hand search all vegetation, logs, rocks and debris to capture lizards and identify important areas that should be targeted for destructive searching.

a)



b)



Figure 5. a) a funnel trap, b) an ACO.

3.4.3 Destructive habitat searches

After trapping and active searches are complete, destructive habitat searches will be carried out in conjunction with the vegetation clearance or works contractor. This will involve systematic manual searches of suitable habitat (e.g. rank grass) and destruction of habitat where practicable. Leaf litter, ground cover vegetation, and small debris may be hand-raked where practicable, and larger debris overturned to search for refuging lizards.

Where vegetation growth means an area cannot practically be searched by hand, machine-assisted searches will be undertaken. This involves the project herpetologist working alongside an excavator operator as the top layer of vegetation is scraped away to reveal bare soil underneath and expose concealed lizards. The excavation methodology and bucket type used during machine-assisted searches will be determined by the project herpetologist and contractor based on site conditions and the need to effectively expose concealed lizards while minimising the risk of injury..

Machine-assisted searches will follow until all habitat for lizards have been removed and there is no suitable habitat for native lizards remaining within the affected area, as assessed by the project herpetologist.

At the conclusion of the trapping, machine-assisted searches and vegetation clearance, the suitably qualified ecologist would undertake a final site walk over to detect any remaining lizards.

3.4.4 Lizard handling and containment

All lizards will be handled as specified by the methodologies within the New Zealand Lizard Conservation Toolkit (Anderson et al., 2012).

Native lizards will only be captured and handled by or under the supervision of the DoC-authorised, suitably qualified ecologist. Hands should be sterilised before and after handling lizards, along with all field equipment that indigenous lizards may come into contact with.

Lizards will be held individually in cloth bags in a secure, vented container or in temporary containment box(es) filled with vegetation matter and leaf litter and misted with water out of the sun. Lizards will be held temporarily for the period of the active searches or trap inspections and then transported to the release site as soon as possible.

It is not anticipated that lizard taxa with conservation statuses higher than 'At Risk' would be encountered on-site. However, if 'Threatened' lizard species were encountered, the individual(s) would be captured and temporarily contained, and the local DoC office contacted for further instruction.

3.4.5 Inadvertent lizard injury or death

The following steps will be implemented should any injured or dead indigenous lizards be found during the vegetation clearance activities:

- The project herpetologist will notify DoC as soon as possible (within 24 hours);
- Any lizard death of 'Threatened', 'At Risk' or 'Data Deficient' species shall be sent to Massey University Wildlife post-mortem service for necropsy. The body should be chilled if it can be delivered within 24 hours or frozen if delivery will take longer than 24 hours;
- Appropriate measures shall be undertaken to minimise further lizard deaths;
- Injured lizards found during salvage will be taken to a suitably qualified vet as soon as possible for assessment and treatment. Injured lizards will be kept in an appropriate portable enclosure (i.e., a clean, well-ventilated (plastic container) under the direction of the project herpetologist to ensure the lizard is handled appropriately until it can be treated;
- Lizards assessed by the vet or alternative specialist as uninjured or otherwise in suitable condition for release would be transported to the relocation site in the portable enclosure and released; and

Euthanasia of an injured lizard is only to be undertaken under the direction of DoC.

3.5 Release Site

3.5.1 Selection of release site

Factors that should be considered when selecting a site to release salvaged indigenous lizards include ecological appropriateness, long-term security, habitat suitability, and protection from predators and future human disturbance (DoC Lizard Technical Advisory Group, 2019). Key considerations include, but are not limited to, the following:

- It is important that the release site is an appropriate distance from the project footprint to prevent the lizards from re-entering the works area. However, the release site should be located as close as possible to the salvage site to ensure resemblance of microhabitats and environmental conditions.
- The habitat within the release site should be representative to or of higher ecological value than the salvage site.
- Areas with long-term protection should be favoured, such as reserves managed by DoC or Council, vegetation covenants or areas protected by regional and local council overlays.
- Potential existing species composition and density at the release site should be considered as far as practicable to limit potential adverse effects of intra- and inter-species competition at the release site.

3.5.2 Proposed release site

The proposed release site is illustrated in Figure 6. The site has been selected as it meets the key criteria for a suitable lizard release area. The location is sufficiently separated from the works area to minimise, as far as practicable, salvaged lizards from re-entering the construction footprint, while remaining close

enough to provide comparable microhabitats and environmental conditions. Separation will be further supported by a lizard fence being installed around the release site which will be left in place for as long as works are being undertaken. The fence will consist of silt fencing, partially buried in the ground, held in place by waratahs and wire. The fencing will be inspected weekly for the duration the fence is in place for, and any holes repaired as soon as identified. Fencing will only be removed once all works on site have been completed.

The habitat within the release site is currently of equal value to the salvage site. It is in an area of the site that has not been quarried and will not be subject to quarrying works between now and when construction of the subdivision commences. It has remained undeveloped for at least 20 years, and contains a small number of shrubs and trees providing low levels of refugia. The area will be enhanced through removal of weeds, revegetation with appropriate native species, installation of additional basking habitat, and pest control.

The release location will be protected in perpetuity via consent notices or covenants preventing additional development and requiring vegetation to be maintained and pest control.

Release site suitability is summarised in Table 1.

Table 1. Summary of release site suitability.

Component	Assessment
Suitability of existing habitat	The release site contains habitat of similar quality and value to the rest of the site. It will be enhanced, protected and subject to predator control further increasing its suitability. These actions will be in place before lizards are released to it.
Proximity of the site from the salvage	The release site is immediately adjacent to the development site, within the same property.
Long-term protection of the site	The release site will be protected via a consent notice or covenant.
Accessibility for release	The site is readily accessible for lizard release, pest control, and monitoring.
Size of the release site and its connectivity to other habitat	The size of the release site has been calculated based on a conservative estimate of the number of lizards to be salvaged and expected carrying capacities for enhanced, protected and pest managed habitat (i.e. the release site). Approximately 1,150 skinks are expected. The release site was sized to accommodate 1 skink per square metre. The release site is 4,560 m² providing significant redundancy.
Existing lizard populations	McCann's skink are known to be present in the release site in low numbers. Given the proposed habitat enhancements, pest control and larger than necessary area, the relocated lizards will have no measurable influence on existing lizard populations (e.g., overcrowding).
Habitat enhancement opportunities	The release site will be subject to revegetation and habitat enhancement and pest control.
Existing predator control or opportunities to enhance predator control	Predator control, planting and habitat enhancements will be established in the release site prior to lizards being released.

3.5.3 Habitat enhancement of release site

Introducing new individuals into an already occupied environment could lead to competition and/or resource availability issues. Displaced lizards have a lower likelihood of survival where the carrying capacity of adjacent habitats is stressed through increased competition for fewer resources. Further, displaced animals have a higher probability of risk of predation and a rapid increase in lizard numbers in a given area is likely to result in a corresponding increase in predators.

Revegetation of the release location will be undertaken as part of the development of the site. Beyond the revegetation, specific lizard centric planting will occur in the release site and this will be completed prior to lizard salvage commencing. Silver tussock (*Poa cita*), creeping pohuehue (*Muehlenbeckia axillaris*), scrub pohuehue (*Muehlenbeckia astonii*) and mingimingi (*Coprosma propinqua*) should be planted in patches around the site to create a mosaic of lizard habitat (e.g. refugia and foraging).

Creeping pohuehue and silver tussock should be sized at PB3, while the other species should be sized at PB5. Larger plant sizes reduces the time needed for plants to establish and provide effective habitat.

Plants should be maintained until 80% ground/canopy coverage is achieved. Monitoring will be undertaken as part of general landscape planting monitoring. If plants have died and left gaps of 1 m^2 or larger, infill planting should be undertaken during the first growing season following gap identification. Dead plants should be replaced with individuals of the same species. Weed maintenance should preferentially occur by hand. Targeted spraying should only occur for significant infestations, however providing weed maintenance occurs regularly (every three months) significant infestations should not establish. The use of weed whackers or similar should be avoided.

The planting will be complemented by installation of eco piles. Eco piles are created by piling woody debris and rocks together to form complex three dimensional structures. Eco piles are used by lizards for cover, basking and foraging. The branches of exotic tree species removed during works on the wider site should be split into small sections and retained for use as lizard enhancement. Willows should not be used due to their ability to propagate from branches, unless the trees are already dead prior to clearance. A total of 40 to 50 eco piles should be located within the area at roughly equidistant separation.

3.6 Pest Control

Predator control will be undertaken in the release site before lizards are released, and for five years post release to reduce predation pressure while lizards establish within the release site. FHLD or suitably qualified individuals action on FHLD's behalf, will carry out the pest control.

Trapping will commence at least two months prior to planned release of lizards. Earlier commencement is acceptable and may be timed with lizard habitat enhancement planting. Control will be conducted over a four week period with traps baited only in week one, then actively set (with baits) in weeks two to four. At the end of week four, traps should be left *in situ*, but all baits removed.

The sections below set out recommended methods and spacing for pest control. While cats represent a significant threat to lizards, the proximity of the site to current and proposed residential areas means cats present are highly likely to be domestic.

3.6.1 Rats and mice

Four bait stations per hectare is recommended for sufficient control of rats while higher densities are generally needed for mice. For the release site, two bait stations will be installed.

Lockable (e.g., Philproof) or run through bait stations will be used where possible, these will be spaced 50 m apart in a location that are easily accessible (Figure 7). As plants establish, bait station locations should be revised as appropriate and should be placed near any trees that produce large volumes of fruits.

Philproof stations have a pin fixture which bait blocks slot onto, to prevent rats from taking the bait and storing it rather than eating it. DoubleTap (diphacinone and cholecalciferol) bait is recommended for use in these stations as it is effective for rats, mice, and for possums.

3.6.2 Mustelids and hedgehogs

One trap is recommended for every 20 hectares of land for mustelid control (i.e., stoats, weasels). DOC 200 traps inside wooden tunnels are recommended (Figure 7). Due to the size of the release area, only one trap is recommended for this site.

DOC 200s will also catch rodents and small hedgehogs. Alternatively, a GoodNature A24 self-resetting trap may be used. Ensure the entrance and inside of the wooden tunnel are kept free of debris and cobwebs so it looks like other animals have used the tunnel. The tunnel should be embedded so the base is level with the ground surface.

Placing the trap under existing tree canopy is typically recommended wherever possible. However, vegetation on the site is currently limited and therefore unlikely to provide sufficient canopy cover. Traps should be placed on edges of features (e.g. close to the lizard fence) as these provide pathways mustelids are likely to utilise. Placing the trap near a possum trap may attract mustelids when a possum is caught.

DOC 200s require regular maintenance checks and servicing to ensure the trap is firing well.

It is recommended traps are baited with fresh rabbit meat or eggs. Alternatively, salted or freeze-dried rabbit, or egg may be used, however these may be less effective.

3.6.3 Possums

One trap per hectare is generally recommended for sufficient control of possums (Figure 7) and therefore one trap will be installed within the release site.

Flipping Timmy traps or Trapinator traps will be used for simple and humane control of possums. Traps should be installed at least 1.5 m off the ground and attached firmly to a wooden surface (e.g., a wooden post) so they remain sturdy when sprung.

The traps will be baited with a food source that is not common in the area, such as a piece of freshly cut apple sprinkled with cinnamon in a Flipping Timmy trap or peanut butter in a Trapinator. Other possum lures may include citrus peel, carrots, or vegemite. Regularly alternating bait types may increase success rates as possums may learn to avoid certain lures over time. Due to the proximity to residential areas, the use of meats, fish or pet food as bait will be avoided to minimise the risk of non-target capture.

3.6.4 Lagomorphs

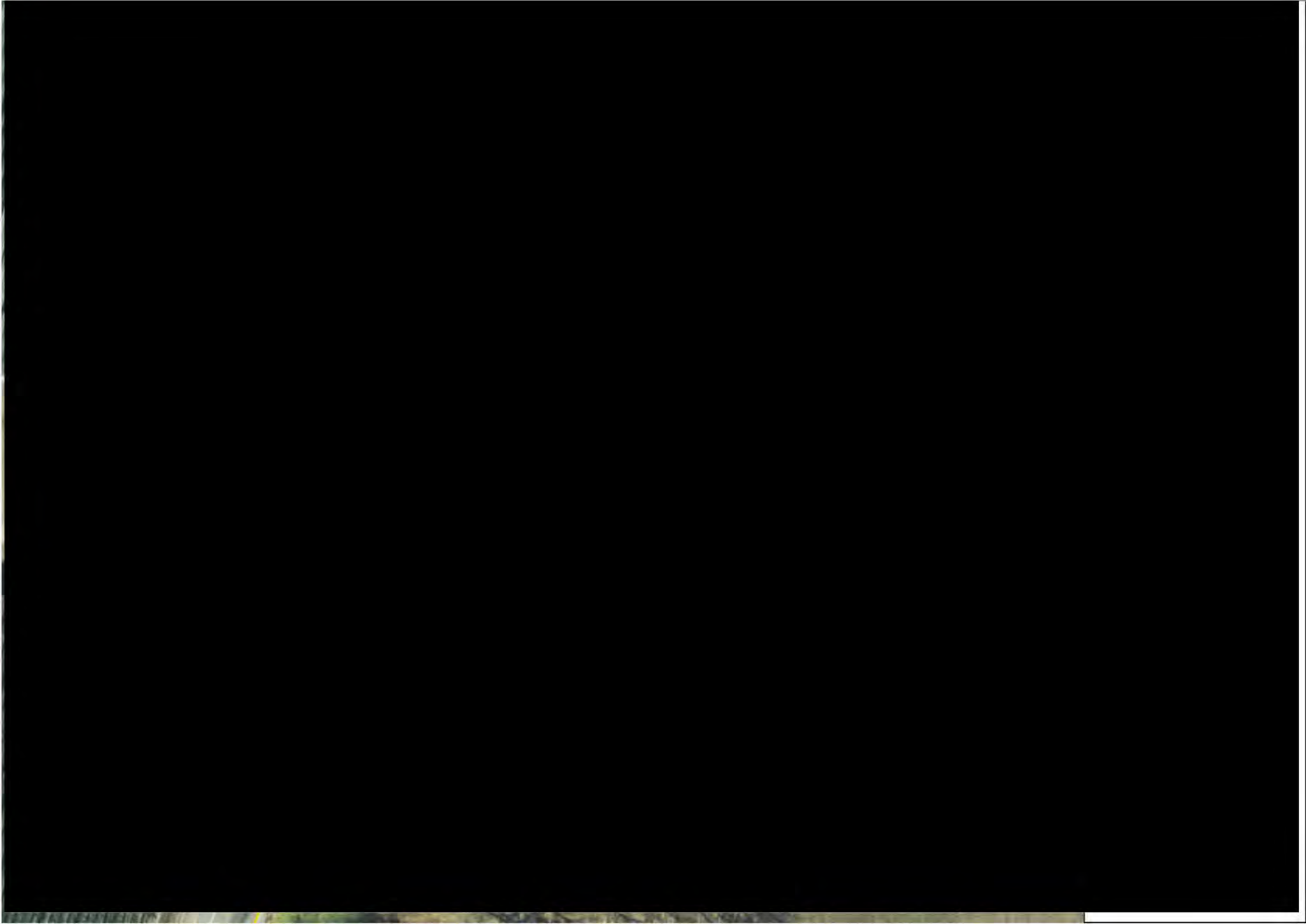
One Philproof bait station will be installed within the relocation area, along a fenceline. Pindone pellets will be used within the bait station as this type of poison bait does not require pre-feeding. Stations will be baited with Pindone for two weeks before being emptied and rebaited for another two weeks. Lagomorph control should occur two months before commencement of enhancement planting to ensure the population is low and will not damage newly planted native vegetation.

3.6.5 Pest control summary

The table below summarises the recommended methods and spacing for pest control.

Table 2. Recommended pest control methods for the lizard release site.

Pest	Method	Density	Bait / Lure	Maintenance / Notes
Rats and mice	Philproof or run-through bait stations	Two bait stations within the release site, spaced approximately 50 m apart	DoubleTap bait blocks (diphacinone and cholecalciferol)	Traps to commence at least two months prior to release. Bait stations to remain in situ and be re-baited as required. Locations may be adjusted as vegetation establishes.
Mustelids and hedgehogs	DOC 200 trap in wooden tunnel or GoodNature A24 self-resetting trap	One trap per 20 ha (one trap proposed for the site)	Fresh rabbit meat or eggs preferred; salted/freeze-dried alternatives may be used	Tunnel entrances to remain clear of debris and cobwebs. Trap to be checked and serviced regularly to ensure effective operation.
Possums	Flipping Timmy or Trapinator traps	Approximately one trap per hectare (one trap proposed within the release site)	Apple with cinnamon, peanut butter, citrus peel, carrot, vegemite, or alternative possum lures	Bait types should be rotated periodically to maintain effectiveness. Meat- or fish-based baits should be avoided due to proximity to residential areas.
Lagomorphs	Philproof bait station	One bait station within the release area, positioned along a fence line	Pindone pellets	Bait stations to be baited for two weeks, rebaited, and maintained for a further two weeks. Control to occur prior to enhancement planting.



3.7 Post Release Monitoring

Post release monitoring of the lizard population in the release site is recommended if a substantial number of lizards (>100 Mcann's skink or any other species) are salvaged from the works area. Monitoring is necessary to determine the success of the salvage and enhancement works at the release site. Monitoring will be carried out during the first season post salvage. If multiple salvages occur across seasons, the same triggers will apply, i.e. if two separate seasons salvage more than 100 lizards, monitoring will be required following both salvage seasons. The monitoring will be commissioned by FHLD Limited, and completed by a suitably qualified herpetologist/s.

The monitoring of translocated lizards to measure survivorship and population establishment is difficult without physically marking the lizards as McCann's skink are very difficult to identify to an individual level as their markings are not distinctive enough between individuals. Methods such as toe clipping are effective, but are not widely used due to ethics. Post release monitoring will therefore be focused on determining if population/s of lizards are persisting in the release site/s following salvage and release.

Standard survey techniques (i.e ACOs, baited pitfalls, baited gee's minnow traps) will be employed at the release site. The number and location of traps will be determined at the time depending on the number of lizards salvaged. Traps will be checked every day for one week during appropriate weather between November and February when lizards are at their most active. All lizards captured will be measured (snout-vent, tail-vent length), sexed, photographed, and marked with an ID number using a non-toxic marker. Survey results may be used to provide an indication of occupancy and persistence within the release site.. These results will provide an indication of how lizards are persisting in the release site/s.

The herpetologist undertaking the post-release survey may recommend additional monitoring if survey results do not indicate a healthy population. Reporting of results of the post release monitoring will specify this. The post release monitoring report, along with recommendations, will be provided to DoC. Additional habitat enhancement, pest control, or other measures may be recommended at the discretion of the project herpetologist.

3.8 Completion Reporting

A completion report would be prepared by the project herpetologist and submitted to DoC/Queenstown Lakes District Council/Otago Regional Council within **one month** of the completion of all vegetation removal. The report should detail the number of lizards captured, the locations they were captured from and the release site/s. The report would also detail whether any post-release monitoring (and timing) is recommended based on the number of lizards salvaged. An Amphibian/Reptile Distribution Scheme (ARDS) Card will be sent to the Council and DoC.

3.9 Contingency measures

Management of lizards for any project comes with some level of risk and uncertainty. While this document is intended to be a 'live' document, and subject to updates if/when necessary, Table 3 below sets out the most likely risks and uncertainties associated with management options, and includes measures to minimise or address these risks.

Table 3. Proposed contingency measures for lizard management.

Risk	Details	Likelihood	Management	Residual risk
Additional lizard species encountered	Additional species other than those listed in this LMP	Very low	Stop works, notify DOC for further instructions. Follow incidental discovery protocol.	Very low
Unsuitable weather conditions for salvage	Weather during salvage needs to be suitable for lizard activity, i.e. not cold or raining	Low	The lizard salvage season generally extends from October to April. Seven working days of salvage are still required as per sections 3.4.1 and 3.4.2. Project planning will ensure sufficient time is available prior to vegetation clearance to meet objectives if adverse weather occurs.	Very low
Relocation site failure	Failure of revegetation plantings	Very low	Planting and enhancement of the release site will be undertaken prior to lizard works commencing. If vegetation not established appropriately, lizard salvage cannot commence until alternative release site confirmed or revegetation plantings established.	Very low
Pest control failure	Failure of pest control measures to reduce/manage pest abundance	Low	Revisit pest control measures, extra pulses of pest control. Provide additional habitat features, e.g. log/rock piles.	Very low
More lizards than expected captured and relocated	It is not possible to know exactly how many lizards will be captured, best efforts to estimate have been made based on the survey results. If 10% more than the anticipated numbers are captured, the following measures will be implemented.	Low-moderate	Salvage will continue until a decreasing trend in lizard numbers is established, for a minimum of three additional days, up to a maximum of five additional days. Additional relocation habitat may be necessary if more than 4,500 lizards are captured. Once 3,500 lizards have been captured contact DOC to discuss the requirement fo alternative release sites.	Very low
Residual lizard populations remaining following habitat clearance	It is unlikely every lizard will be captured from the works areas. The Wildlife Permit application includes the application for 'incidental killing' of lizards that elude salvage.	Moderate	Follow incidental discovery protocol.	Low

3.10 Incidental discovery protocol

The following protocols are to be followed if lizards are encountered on site during works, after lizard salvage has been completed. The protocol will be distributed to the construction team, including plant operators.

Lizards could be present in and on vegetation that has either not been cleared, or has established following initial clearance. Vegetation could include long grass, scrub and weedy vegetation. They may also bask in sunny exposed spots, such as in/on wood or rock piles, and may be found underneath debris. They may be uncovered when disturbed.

Following discovery of a lizard after salvage has occurred, the following steps will be taken:

- Immediately (as soon as discovery of a lizard is made) stop any activities within five metres of the discovery. If the species encountered is a species with a Threat Classification status of 'Threatened' then all works must cease immediately within 100 m, until an assessment is made of the risk for that species by the works, and any specific management identified, including avoidance.
- If possible, catch the lizard and place in a container with grass/leaf litter. Useful containers include clean lunch boxes or clean materials boxes. Ensure to create breathing holes in the container if the container is airtight. Store the lizard in the container in a safe, cool, shady location out of sun until a decision is made.
- Immediately inform the Project Herpetologist and site manager.
- Note the date, time, name of person who observed the lizard and the person who caught the lizard (if caught). Photograph the lizard/s and the habitat where it was found and record GPS location (e.g. a pin on Google Maps). A cell phone photo will be sufficient providing it is in focus. If the lizard was not captured, note any details possible (e.g. colour, body markings, size, body shape in order to describe to the Project Herpetologist or DOC.
- If the lizard is injured immediately (within one hour) contact the Project Herpetologist and a local veterinarian and arrange for the lizard to be transported to the veterinarian. Treatment by the veterinarian will likely require payment. Photograph the injury.
- If a dead lizard is found note the location it was found, the time it was found, and the approximate time of death if this can be determined (e.g. time materials where a lizard was found were moved). Notify the Project Herpetologist and DOC. If DOC require arrange for the carcass to be sent to Massey University Wildlife Postmortem Service, Massey University, in Palmerston North. If the carcass can be delivered within 72 hours, chill it, or if delivery will take longer, freeze it.

3.11 Checklist

Table 4 contains a checklist summarising the responsibilities for lizard management within the site.

Table 4. Lizard Management Checklist

Task	Required of:	Completed
Project start-up		
Appointment of project herpetologist	FHLD / Consent holder	
Finalisation of lizard management techniques and LMP	Project herpetologist	
Submission of final LMP to DoC / Council	Project herpetologist / FHLD	
Approval of LMP	DoC / Relevant authority	
Pre-works management prior to vegetation clearance		
Contractor induction regarding lizard management requirements	Project herpetologist / Site manager	
Installation of release-site pest control	FHLD or suitably qualified contractor	
Release-site enhancement planting and eco pile installation	FHLD / Landscape contractor	
Installation of lizard exclusion fencing around release area	Contractor under supervision of project herpetologist	
Deployment of ACOs, pitfall traps and / or funnel traps	Project herpetologist	
Pre-works lizard trapping and active searches	Project herpetologist	
Works phase lizard management		
Confirmation of salvage areas and habitat suitability	Project herpetologist / Site manager	
Machine assisted lizard capture	Project herpetologist, clearance contractor	
Post works		
Works completion report to client, Council and DoC	Project herpetologist	
Post completion monitoring (where required)	Project herpetologist	
Post-release monitoring (if triggered)	Project herpetologist	

REFERENCES

Anderson, P., Bell, T., Chapman, S., and Corbett, K. 2012. New Zealand Lizard Conservation Toolkit. Society for Research on Amphibians and Reptiles of New Zealand.

Burns RJ, Armstrong DP, Bell BD, Haigh A, Germano J, Rawlence NJ, Thurley T, Hitchmough RA, Makan T, Michel P 2025. Conservation status of amphibians in Aotearoa New Zealand, 2024. Department of Conservation, Te Papa Atawhai. 2025.

DoC, undated. Natural Heritage Management System's Herpetofauna Inventory & Monitoring Toolbox. Available: https://www.doc.govt.nz/our-work/biodiversity-inventory-and-monitoring/.

DoC Lizard Technical Advisory Group, 2019. Key principles for lizard salvage and transfer in New Zealand. Department of Conservation, Wellington.

Hitchmough, R., Barr, B., Knox, C., Lettink, M., Monks, J., Patterson, G., Reardon, J., van Winkel, D., Rolfe, J., and Michel, P. 2021. Conservation status of New Zealand reptiles. New Zealand Threat Classification Series 35. Department of Conservation, Wellington.

Towns, D. R., Elliott, G., & Reese, A., 2007. Reptile conservation in New Zealand. New Zealand Journal of Ecology, 31(1), 1–2

Wilson, D. J., Mulvey, R. L., Clarke, D. A., & Reardon, J. T.,2017. Assessing and comparing population densities and indices of skinks under three predator management regimes. New Zealand Journal of Ecology, 41(1), 84-97.

Viridis 2026. Parkburn, Luggate-Cromwell Road. Ecological Impact Assessment. A report prepared for Ridgeburn Limited by Viridis Limited.

Appendix A
Assessment against the key principles for lizard salvage and transfer in New Zealand

Table 5. Assessment of the proposed works against the key principles for lizard salvage and transfer in New Zealand.

Principle		Discussion
1	Lizard species' values and site significance must be assessed at both the development and receiving sites	Surveys have been undertaken of the salvage site and relocation site confirming the presence of McCann's skink in the salvage and release sites (Figure 3), and the likely presence of tussock skink around the lake edge. The values of the release site were confirmed through surveys and hand searching. The release site currently has low-moderate values, in line with the majority of the lizard habitat in the rest of the site. Values will be increased through planting, enhancements and pest control, increasing the significance of the habitat as well. The significance of the site as a whole (salvage and relocation areas) was considered moderate to moderate due to the presence of Not Threatened McCann's skink. At Risk tussock skink were only present around the lake edge. The value of the site was considered to be lower due to the lack of native vegetation, and pressure from agriculture. McCann's skink is very common in the wider area, and eastern South Island.
2	Actual and potential development-related effects and their significance must be assessed	Section 2.7 of this report and section 4.2.2 of the EcIA discuss actual and potential effects. Direct effects include injury and mortality during physical works. Indirect effects include loss of habitat, habitat fragmentation, disturbance during works as a result of noise and machinery/vehicle movement and other construction activities, and changes in habitat due to application of treated wastewater. The significance of the wider site is not expected to change At Risk species are most likely to be present around the lake margins. The value and significance of areas to contain houses and commercial areas is likely to be reduced.
3	Alternatives to moving lizards must be considered	There are no areas of high value habitat in the site. The ongoing quarrying activities continue to impact habitat values. Development of the site means lizards must be moved out of harms way. Compensation in the form of enhancement elsewhere was not considered to address actual effects on site.
4	Threatened lizard species require more careful consideration than less-threatened species	The species expected to be encountered most is Not Threatened McCann's skink. Tussock skink habitat is minimal and mostly located outside of the site. It has been avoided as far as possible when it comes to development of the coves through minimising the number of coves and locating these in areas where there is already natural inlet topography. Where avoidance is not possible works have been minimised. Only very small numbers of tussock skink are expected to be encountered in very discrete areas (cove excavation).
5	Lizard salvage, transfer and release must use the best available methodology	Best practice methodologies have been proposed as per section 3.4 of this document. The LMP is considered to be a 'live' document, and can be updated if evidence requires alternative methodologies be considered. The release site will be subject to habitat enhancement, revegetation, pest control and ongoing protection in line with best practice.

6	Receiving sites and their carrying capacity must be suitable in the long term	The release site will not be subject to development. It will be protected via consent notices or covenants. It has been sized conservatively to accommodate expected numbers of lizards with significant redundancy. It is four times larger than the minimum size needed, and will be subject to habitat enhancements and pest control, increasing the carrying capacity significantly over and above what it would currently support.
7	Monitoring is required to evaluate the salvage operation	Post release monitoring is proposed as per section 3.7 of this LMP. The monitoring of translocated lizards to measure survivorship and population establishment is difficult without physically marking the lizards. Post release monitoring will therefore be focused on determining if population/s of lizards are persisting in the release site/s following salvage and release.
8	Reporting is required to communicate outcomes of salvage operations and encourage process improvements	Reporting regarding post release monitoring, and completion reporting, are proposed as per section 3.7 and 3.8 of this LMP.
9	Contingency actions are required when lizard salvage and transfer activities fail	The enhancement, revegetation and pest control of a larger area of habitat within the site than is necessary will support resident lizards in these areas and are expected to result in growth of the resident population even in the absence of lizards being released to these areas. Significant revegetation and landscape enhancements are occurring as part of the wider project, including around the lake margin. These activities will significantly increase habitat values for lizards beyond the site boundaries and will create new habitat opportunities in the site for lizards to move into of their own accord.

Appendix M: Draft Fish Management Plan

VIRIDIS
Environmental Consultants

Parkburn, Luggate-Cromwell Road

Draft Fish Management Plan

Prepared for: **Fulton Hogan Land Development Limited**

May 2026



DOCUMENT CONTROL AND REVISION HISTORY

Document title	Parkburn, Luggate-Cromwell Road
	Draft Fish Management Plan
Prepared for	Fulton Hogan Land Development Limited
Version	Draft A
Date	12 May 2026
Document number	10418-004-A

Version	Issue date	Document number
Draft A	12 May 2026	10418-004-A

Author(s)	
	Annabelle Coates
	[redacted]
Reviewer(s)	
	Mark Delaney
	[redacted]

Reference: Viridis 2026. Parkburn, Luggate-Cromwell Road Draft Fish Management Plan. A report prepared for Fulton Hogan Land Development Limited by Viridis Limited. May 2026.

Cover photo: Upland bully (*Gobiomorphus breviceps*).

© Viridis Limited 2026

This document has been prepared by Viridis Limited for Fulton Hogan Land Development Limited. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

TABLE OF CONTENTS

1 Introduction 1
1.1 Purpose of this Fish Management Plan 1
1.2 Project Background 1
1.3 Site description 2
1.4 Fish Values and Species Potentially Present 3
1.5 Objectives of Fish Salvage and Relocation 4
1.6 Roles and Responsibilities 4
2 Methodology 6
2.1 Timing 6
2.2 Exclusion devices 6
2.3 Fish capture 7
2.4 Handling of fish 9
2.5 Relocation site 9
2.6 Biosecurity 11
2.7 Adaptive Management 11
2.8 Contingency Measures 11
3 Reporting 12
4 Permits 12

List of Figures

Figure 1. Site location as indicated by blue polygon (map source: LINZ NZ Topo 50). 2
Figure 2. Park Burn within the site. 3
Figure 3. Lake Dunstan adjacent to the site. 3
Figure 4. Freshwater features 5
Figure 5. Example of a fish barrier installed in a stream to prevent passage into or out of an area. 7
Figure 6. Proposed fish release sites 10

1 INTRODUCTION

1.1 Purpose of this Fish Management Plan

This Fish Management Plan (FMP) has been prepared to manage the actual and potential adverse effects of the proposed works on freshwater fish and fish habitat associated with the Parkburn residential subdivision development at 922 Luggate-Cromwell Road, Cromwell.

The FMP outlines procedures for:

- the installation and maintenance of fish exclusion devices;
- fish salvage and relocation;
- fish handling and transportation;
- relocation site selection;
- biosecurity measures;
- monitoring and reporting requirements; and
- adaptive management during works.

The purpose of these measures is to minimise adverse effects on freshwater fish during instream works within Park Burn and excavation works associated with the proposed Lake Dunstan coves.

This draft FMP accompanies the Fast-track Approvals Act 2024 (FTAA) application and will be finalised following confirmation of the detailed construction methodology and any relevant consent conditions.

1.2 Project Background

Fulton Hogan Land Development (FHLD) Limited has applied for resource consent through FTAA to develop a residential subdivision on the property at 922 Luggate-Cromwell Road (State Highway 6), Cromwell.

The proposed development includes:

- replacement of the existing triple-arch culvert with a bridge crossing;
- excavation of two coves along the margin of Lake Dunstan; and
- associated earthworks and infrastructure works.

As these works will occur within or adjacent to freshwater habitats, there is potential for adverse effects on freshwater fish and aquatic habitat..

This FMP should be read in conjunction with the Parkburn Ecological Impact Assessment Report ('EcIA')[1], which assesses the ecological values of the site and the potential effects of the proposed works.

[1] Viridis. 2026. Parkburn, Luggate-Cromwell Road, Ecological Impact Assessment. Prepared for Fulton Hogan Land Development Limited.

1.3 Site description

The site contains two freshwater environments relevant to this FMP:

- Park Burn, an intermittent stream flowing through the site; and
- the margins of Lake Dunstan adjacent to the proposed cove excavation areas.

The location of the site is shown in Figure 1.

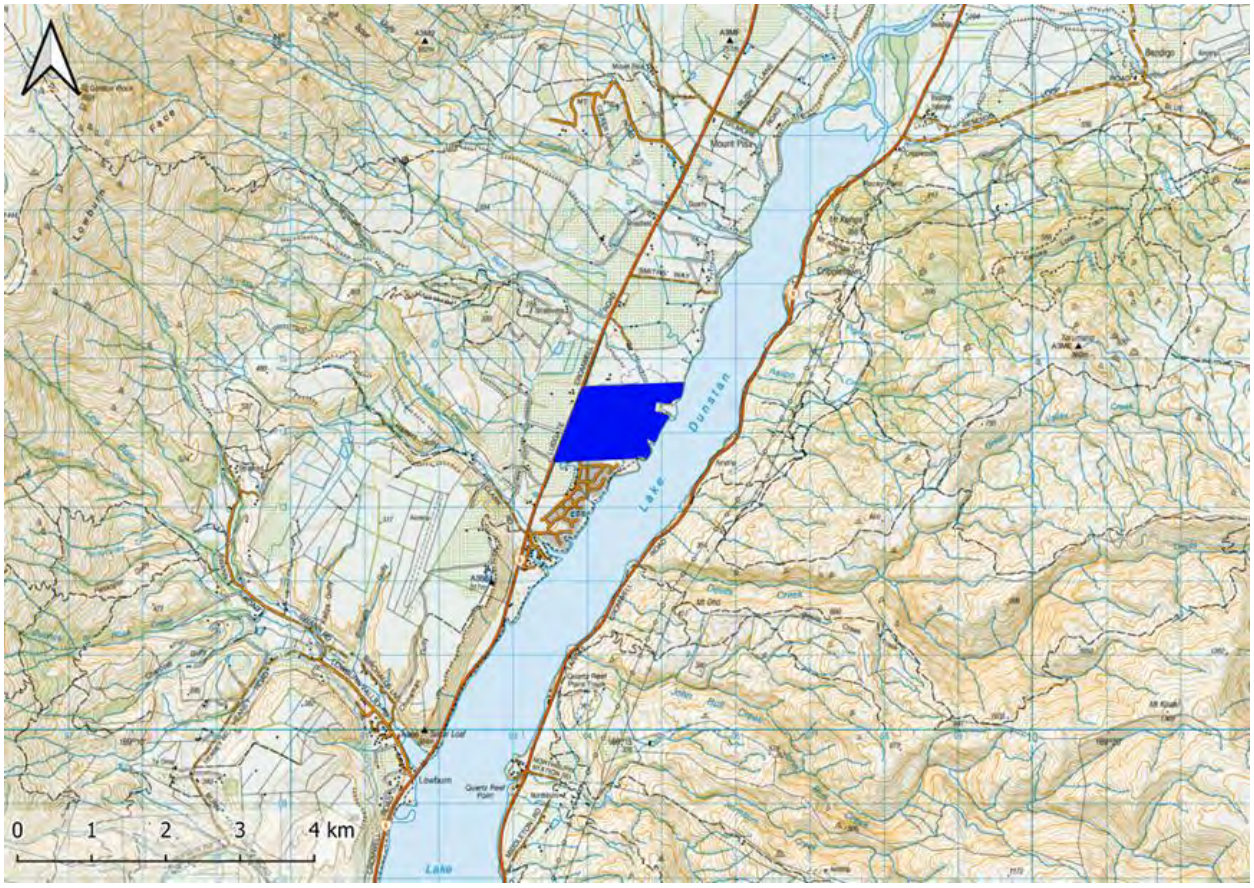


Figure 1. Site location as indicated by blue polygon (map source: LINZ NZ Topo 50).

1.3.1 Park Burn

One intermittent stream, Park Burn, flows through the site. It originates northwest of the site, on the Lowburn Face of the Pisa Range. The upper reaches flow through extensive agricultural land, while the lower reaches (on the river flats) flow through horticultural land. It flows into Lake Dunstan immediately to the east of the site.

Within the site, the Park Burn is contained within a small gully, approximately 30 m wide, that has not been subject to quarrying. Substrates were dominated by gravels with smaller areas of fine sediment, and given sufficient flow, small braids can form (Figure 4). It periodically runs dry, therefore it has been classified as intermittent.

Park Burn is considered to have moderate ecological values. Despite its modified nature, there is the potential for At Risk fish species to be periodically present.

a)



b)



Figure 2. Park Burn within the site.

1.3.2 Lake Dunstan

Lake Dunstan is an approximately 26 km^2 hydroelectric lake, formed in the 1990s following the construction of the Clyde Dam. Prior to the lake being filled, the moderately braided Clutha River flowed in its place. The lake is long, narrow and relatively shallow, occupying a river valley.

The lake is considered to have high ecological value due to it providing habitat for a number of Threatened and At Risk fish and bird species.

a)



b)



Figure 3. Lake Dunstan adjacent to the site.

1.4 Fish Values and Species Potentially Present

A survey of Park Burn within the site yielded a single common bully (*Gobiomorphus cotidianus*, Not Threatened). Records for the Park Burn in the New Zealand Freshwater Fish Database have only recorded brown trout (*Salmo trutta*; Introduced and Naturalised) to date. Records for Lake Dunstan, and for its tributaries record the presence of various species.

The presence of hydroelectric dams downstream means any eels present in Park Burn or Lake Dunstan have been present since prior to the installation of the dams. Numbers are expected to be low, if any in Park Burn, but they are expected to be present in the lake. Clutha flathead galaxias have been recorded in a tributary of the Low Burn, southwest of the site. It is considered unlikely they are present in the site itself due to their non-migratory status and they do not reside in lakes. Koaro populations have also

likely been impacted by the hydro dams as they are a migratory species requiring a period in the sea for reproduction. However, there are landlocked koaro populations, including in the Central Otago lakes.

Species expected to be present within Park Burn or Lake Dunstan include:

- Longfin eel (*Anguilla dieffenbachii*, At Risk - Declining)
- Shortfin eel (*Anguilla australis*, Not Threatened)
- Common bully
- Upland bully (*Gobiomorphus breviceps*; At Risk – Naturally Uncommon)
- Brown trout (*Salmo trutta*, Introduced and Naturalised)
- Koaro (*Galaxias brevipinnis*; At Risk – Declining)
- Rainbow trout (*Oncorhynchus mykiss*; Introduced and Naturalised)
- Perch (*Perca fluviatilis*; Introduced and Naturalised)

1.5 Objectives of Fish Salvage and Relocation

The objectives of fish salvage and relocation are to:

- minimise injury and mortality to freshwater fish during works;
- prevent fish entering active work areas;
- safely capture and relocate fish from affected habitats;
- relocate fish to suitable habitat within the same catchment;
- minimise stress during capture, handling, transport, and release;
- ensure works are undertaken in accordance with relevant permits and industry best practice; and
- maintain appropriate biosecurity controls.

1.6 Roles and Responsibilities

The roles and responsibilities associated with implementation of this FMP are outlined in Table 1.

Table 1. Roles and responsibilities

Role	Responsibility
Supervising freshwater ecologist	Oversee implementation of the FMP; undertake fish salvage and relocation; determine salvage effort requirements; supervise fish handling and release; implement adaptive management measures where necessary; record fish capture data; and prepare post-salvage reporting.
Contractor	Install and maintain fish exclusion devices as directed by the freshwater ecologist; provide safe access to work areas; comply with directions provided by the freshwater ecologist; and ensure works are undertaken in accordance with this FMP.
Project manager / consent holder	Ensure relevant permits and approvals are in place prior to works commencing; coordinate timing of salvage works; ensure resource consent conditions are complied with; and provide required reporting to Otago Regional Council where applicable.

2 METHODOLOGY

The methodology outlined below describes the procedures that will be implemented to minimise adverse effects on freshwater fish during works within Park Burn and Lake Dunstan.

2.1 Timing

Fish salvage and relocation will be undertaken immediately prior (within 2-3 days) to the commencement of any instream works or cove excavation. Ongoing maintenance of any temporary fish barriers by the contractors will be undertaken until stream and cove excavation works are complete within the area. Fish salvage should preferentially occur during the drier summer months when weather is generally more settled. No salvage should occur if moderate or higher rainfall is forecast for the salvage period.

2.2 Exclusion devices

Prior to commencing works on Park Burn barrier(s) will be installed to prevent fish moving up and downstream through the area of works. Exclusion devices are still required on Park Burn if it is dry as a period of rain may set the stream flowing again.

Isolation devices are considered impractical for the cove excavation due to the size of the area and depth of the lake.

Exclusion devices will be constructed from steel warratahs and shade cloth, or similar. Shade cloth, or a similar material, allows water to continue to flow downstream while preventing fish passage. The exclusion screen will extend at least one metre past the wetted width of the aquatic habitat and will be embedded into the dry ground or the banks (Figure 5).

Waratahs will be securely hammered into the ground and evenly spaced across the stream to support the shade cloth. Where extra support is necessary, i.e. if the flow is very swift, wire will be threaded horizontally through the waratahs. Shade cloth will be fastened to the waratahs and wire supports (where applicable) using zip ties or similar mechanism. The shade cloth will extend approximately 0.5 m above the water level. Along the stream bed the shade cloth will either be embedded and pinned or securely weighted down, or an apron of the shade cloth will be formed and pinned. This creates a pocket, preventing fish from passing under the barrier.

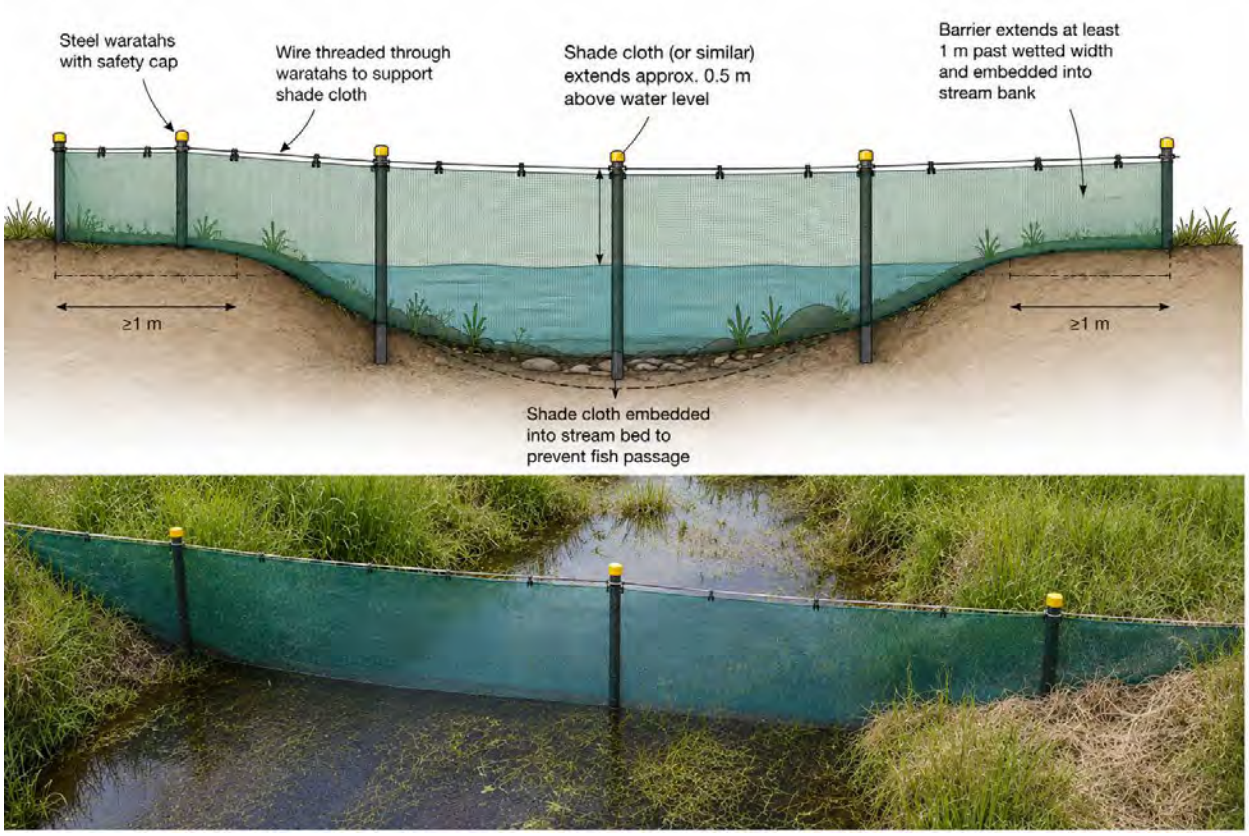


Figure 5. Example of a fish barrier installed in a stream to prevent passage into or out of an area.

2.3 Fish capture

2.3.1 Park Burn

If the Park Burn is dry at the time of works, no fish salvage is necessary.

A combination of electric fishing and netting/trapping is proposed within the Park Burn if water is present. If water is not present, but saturated mud/sediment is present in the Park Burn, this should be searched for eels.

The *New Zealand Freshwater Fish Sampling Protocols* (Joy *et al*. 2013) will be followed unless specified within this plan.

Electric fishing will be undertaken in the works reach prior to setting any nets. Several passes may be undertaken depending on fish capture rate. Following electric fishing and providing water levels allow, baited Gee's minnow traps and fyke nets will be placed at intervals over the stream works areas and left in place overnight. Fine meshed fykes with a separator grill will be used if depth allows. All nets and traps will be set with an airspace to provide trapped fish access to atmospheric oxygen and will be set in general accordance with Joy et al. (2013). Floats will be placed in the fyke nets if required to ensure an airspace is available. The traps will be checked the following morning, prior to 9 am, with any captured fish recovered.

Trapping densities will be set, at minimum, at least one fyke net and two Gee's minnow traps over 25 m, in accordance with Joy et al., (2013). However, if sufficient length and depth of water is present, the densities of traps and nets may be increased if deemed appropriate by the supervising freshwater ecologist. Where water depth prevents fykes being set, the densities of Gee-minnow traps will be

increased and hand-netting of any aquatic habitat (e.g. pools, overhanging vegetation, woody debris) will be undertaken. Hand netting will occur moving up the impact reach to sweep for any fish present within the channel which may not be able to move into the traps due to the shallow water depth. Hand netting will cease when less than two indigenous fish are captured. If water depths are not suitable for Gee's minnow traps, hand netting will still occur.

If more than 20 native fish are caught during a single trapping effort within the target area, trapping will continue until numbers are depleted to the satisfaction of the supervising freshwater ecologist (using an 80% removal rate as a target, based on the Hayne's (1949) regression method). A single trapping effort is considered to be one night of trapping. Target removal rates will be adjusted to 95% if any Threatened or At Risk species are captured. Electric fishing will be undertaken again following clearance of the nets.

While a streamworks methodology has not yet been confirmed, it is expected works within Park Burn will be required to occur 'in the dry'. At this point, bunding or sheet piling or similar will be installed to isolate the works area. Complete dewatering of the works area will commence provided capture rates have declined to the appropriate thresholds. All pumps used for dewatering will be appropriately screened to prevent fish being entrained in the pump. Screens will have gaps no larger than 3 mm. Native fish, such as eels (*Anguilla* spp.), will burrow into silt substrates when they are disturbed or as water levels decrease. As a result of this, during the dewatering stage, the supervising freshwater ecologist will be present to search through drained habitat, rocks/debris, remaining pools or thick sediment for any remaining fish. Once dewatering is completed an excavator will be used to carefully scrape out any thick layers of sediment, if necessary. A toothed bucket will not be used on the excavator. In our experience it is more effective to use a non-toothed bucket. Providing a minimum depth of approximately 200 mm of sediment is scraped, any eels buried within the mud will be scooped up unharmed. Toothed buckets are inefficient for 'muck outs' as the teeth mean a shallower depth is scraped.

2.3.2 Cove excavation

While a works method for excavation of the coves has not yet been confirmed, it is expected some level of excavation within the lake itself will be required. It is not feasible to completely isolate the works area due to the size of the excavation area, depth of Lake Dunstan, and the open connectivity of the lake environment. Fish are also able to freely move into and out of the excavation area, meaning pre-construction salvage would likely result in only temporary and incomplete removal of fish from the area. The works area represents a very small proportion of the lake habitat and effects of works are considered to be very low.

As a result, salvage associated with excavation of sediments during works is considered the best practicable method to minimise adverse effects on fish within the lake environment. This approach focuses on recovering fish that may become entrained within excavated sediment, particularly benthic species and burrowing species such as eels.

The supervising freshwater ecologist will be on site for all excavation works that are in direct contact with the waters of Lake Dunstan. Excavated material will be deposited on the banks of the lake to allow any eels present to naturally move back into the lake. In addition, the ecologist will manually search through all excavated sediment for any fish entrained within the sediment.

A toothed bucket will not be used on the excavator. In our experience it is more effective to use a non-toothed bucket. Providing a minimum depth of approximately 200 mm of sediment is scraped, any eels buried within the mud will be scooped up unharmed. Toothed buckets are inefficient for 'muck outs' as the teeth mean a shallower depth is scraped.

2.4 Handling of fish

Fish handling will be in accordance with Section 3.9 of the *New Zealand Freshwater Fish Sampling Protocols* (Joy *et al.* 2013) and the Viridis MPI Special Permit (875) and Native Fish Transfer Authorisation (NFT420).

All fish captured in traps/nets or via electric fishing, will be immediately transferred to water-filled, lidded containers of an appropriate volume for the number of fish captured. Multiple containers will be used if necessary. Containers will be stored in the shade. Fish will be stored in the containers for no more than one hour. If storage for longer is required, water will be changed at least once per hour and/or a battery powered air pump will be placed in each container to ensure oxygen levels are sufficient. A water conditioner, such as API Stress Coat may be added to the water to reduce fish stress. Water conditioner will be added as per manufacturer instructions.

If any individual captured fish shows signs of stress (loss of righting response, exuding excessive mucus, gulping air, and/or mouth gaping) the water will be changed to provide more oxygen, or the fish will be moved to the relocation site immediately.

Fish will be visually examined for general health (visual skin lesions or heavy fungal burdens) and if considered unhealthy by the supervising freshwater ecologist, they will be humanely euthanised in accordance with condition 14 of the MPI Native Fish Transfer Authorisation (420).

Large eels (> 500 mm) will be contained individually to avoid injury to other smaller captured fish. Kōura (*Paranephrops sp.*), if present, will also be separated into their own containers.

Captured fish will be securely transported to the relocation site and gently transferred into the stream within two hours of being captured. If large numbers of fish are captured, they will be distributed across multiple release points in the general area to avoid short term overstocking and predation risks.

2.5 Relocation site

2.5.1 Park Burn

Fish captured within the Park Burn will be released back to the Park Burn upstream of the works area (Figure 6). Access is readily available from Luggate-Cromwell Road. Keeping fish within the same system they are salvaged from removes the risk of increased population densities, unsuitable habitats and biosecurity risks. There is sufficient upstream habitat to support additional fish species for the short period works will occur.

2.5.2 Lake Dunstan

Any fish captured from the Lake Dunstan will be returned to the lake (Figure 6). Whether they are returned to the lake to the north or south of the site will depend on any sediment released into the lake environment. Access is readily available to both the north and south of the works sites.

2.6 Biosecurity

All equipment will be thoroughly cleaned and dried prior to use. Equipment includes, but not limited to: electric fishing machine, waders, fyke nets, Gee's minnow traps, stop and dip nets and transfer buckets.

Any pest fish caught will be humanely euthanised and all euthanised pest fish will be disposed of in a biosecure manner to land, in accordance with condition 20 of MPI Special Permit 875 and 16(d) of Native Fish Transfer Authorisation 420.

2.7 Adaptive Management

Due to the high level of intrinsic variability in any fish recovery and relocation, this plan may be slightly modified by the supervising freshwater ecologist to ensure fish are recovered in a safe and professional manner, as well as in accordance with the *New Zealand Freshwater Fish Sampling Protocols* (Joy et al. 2013).

2.8 Contingency Measures

Unexpected conditions may arise during fish salvage, relocation, dewatering, or excavation works. The following contingency measures will be implemented where necessary to minimise adverse effects on freshwater fish and aquatic habitat.

2.8.1 Rainfall events

Fish salvage and relocation will not be undertaken during periods of moderate or heavy rainfall, or where such conditions are forecast during the proposed salvage period. Elevated flows and reduced water clarity can reduce salvage effectiveness and increase risks to both fish and personnel.

If significant rainfall occurs during salvage or instream works, activities will cease until flows and water quality have stabilised to a level considered suitable by the supervising freshwater ecologist. Following any significant rainfall event, fish exclusion devices and isolated work areas will be inspected to confirm they remain functional and secure.

2.8.2 Fish mortality

If unexpected fish mortality occurs during salvage, handling, dewatering, or excavation works, the supervising freshwater ecologist will investigate the likely cause and determine whether modifications to salvage methods, handling procedures, work practices, or fish holding arrangements are required.

Any significant fish mortality event, including mortality of Threatened or At Risk species, will be recorded and reported to the relevant regulatory authority where required by resource consent conditions or permit requirements.

2.8.3 Discovery of Threatened or At Risk species

If Threatened or At Risk fish species are captured in greater numbers than anticipated, salvage methodologies and effort may be modified by the supervising freshwater ecologist to increase capture efficiency and reduce adverse effects on the affected species.

Where necessary, additional salvage effort, increased trap densities, or revised handling and relocation procedures may be implemented. Works within the affected area may be temporarily delayed if considered necessary by the supervising freshwater ecologist to ensure appropriate management of the species.

2.8.4 Equipment failure

In the event of equipment failure during salvage or dewatering activities, works will cease until the equipment is repaired or replaced, where failure may compromise fish salvage effectiveness, fish safety, or environmental protection measures.

Backup equipment, including spare nets, buckets, aeration devices, and dewatering pumps (where practicable), will be available during salvage operations to minimise delays and risks to fish.

3 REPORTING

Following completion of fish salvage and relocation works, a short report will be prepared detailing the fish captured (species and number of fish) during the recovery, as well as details on the relocation site. Otago Regional Council shall be provided with a copy of the report within five days of completion of all fish relocation works. Data can be made available following the completion of stages if works are to be staged.

Fish records will also be sent to NIWA to be included in the New Zealand Freshwater Fish Database.

Reporting will be in accordance with any resource consent conditions.

4 PERMITS

Viridis holds an MPI Special Permit (875) and Native Fish Transfer Authorisation (420) that allows Viridis Limited, and their agents, representatives, and employees to take and relocate aquatic life to a suitable habitat where this is necessary or required to mitigate adverse effects of habitat modification on the aquatic life.

As the capture and relocation sites are not within a conservation area and since any fish captured will be relocated within the same catchment, no other permits are considered necessary.

Appendix N: Construction Traffic Management Plan

(to be provided in Final EMP)

APPENDIX D – Insight Engineering Geotechnical Report

Geotechnical and Earthworks Assessment for Proposed Residential Subdivision at Parkburn Quarry, 922 Luggate-Cromwell Road (SH6), Cromwell

Prepared for:	Fulton Hogan Land Development Ltd
Date:	29/10/2026
Our Reference Number:	24019_3 V7

Report prepared by:	Jana Kruyshaar CMEngNZ, CPEng
Reviewed by:	Joe Gray CMEngNZ, CPEng

Record of Distribution

Sent to	Date	Report Status	No. of Copies
Daniel Thorne (via Sharepoint)	17/04/2026	Draft V1	1 (electronic)
Daniel Thorne (via Sharepoint)	7/05/2026	Draft V2	1 (electronic)
Daniel Thorne (via Sharepoint)	21/06/2026	Final V3	1 (electronic)
Daniel Thorne (via Sharepoint)	16/07/2026	Final V4	1 (electronic)
Daniel Thorne (via Sharepoint)	28/09/2026	Final V5	1 (electronic)
Daniel Thorne (via Sharepoint)	23/10/2026	V6 for review	1 (electronic)
Daniel Thorne (via Sharepoint)	28/10/2026	Final V6	1 (electronic)
Daniel Thorne (via Sharepoint)	29/10/2026	Final V7	1 (electronic)

Author Credentials

Jana Kruyshaar Statement of Qualifications and Experience

I am a Director of JKCM Ltd t/a Insight Engineering.

I hold a Bachelor of Engineering from the University of Stellenbosch, completed in 2004. I am a Chartered Professional Engineer and a chartered member of Engineering New Zealand and have held this status since 2012.

I have 19 years professional experience in Geotechnical Engineering for land development projects, including preliminary and detailed geotechnical investigations, geotechnical numerical analyses for slopes, deep excavations and liquefiable land, design of retaining structures and ground improvement systems as well as earthworks monitoring and certification.

I have acted as lead Geotechnical Engineer for a wide variety of land development projects, ranging from single sites to large, multi-lot residential, commercial and industrial properties in Auckland, Canterbury, Southland and Otago.

In my role as author of this report, I confirm that I have read and comply with the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Contents

List of Figures 5
List of Tables 5
List of Appendices 5
1 Introduction and Scope of Report 6
2 Site Description 6
3 Development Proposals 9
4 Desktop Review 10
4.1 Geology 10
4.1.1 Geological Setting 10
4.1.2 Mapped Geology 10
4.2 Regional and Local Council Reports and GIS Maps 11
4.2.1 Active Faults 11
4.2.2 Seismic Shaking Intensity 12
4.2.3 Liquefaction 12
4.2.4 Seismic Ground Class 12
4.2.5 Alluvial Fans 12
4.3 Groundwater and ORC Well Records 13
4.4 Review of New Zealand Geotechnical Database 15
4.5 Review of Related Geotechnical Reports 15
4.6 Aerial Photograph Review 17
5 Preliminary Ground Model 19
6 Fieldwork: Gravel Crushing and Compaction Trials 21
6.1 Overview of the Trials 21
6.2 Summary of Results 21
6.2.1 Trial 1 21
6.2.2 Trial 2 21
6.2.3 Discussion on Results 21
7 Discussion on Geotechnical Considerations 22
7.1 Seismicity 23
7.1.1 Ground Shaking 23
7.1.2 Fault Rupture 23
7.1.3 Liquefaction 24
7.1.4 Lateral Spreading 25
7.2 Alluvial Fan and Overland Flows 25
7.3 Existing Uncontrolled Fill and Pea Gravel Backfill 25
7.4 Future Earthworks 26

7.4.1 General Excavations 26
7.4.2 General Filling and Local Borrow Materials 26
7.4.3 Remediation of Existing Filled Areas 27
7.4.4 Fill Settlement and Consolidation 27
7.4.5 Finished Gradients and Slope Angles 28
8 Conclusions and Geotechnical Recommendations 29
8.1 General 29
8.2 Bulk Earthworks 29
8.2.1 General 29
8.2.2 Site Preparation 30
8.2.3 Fill Materials 30
8.2.4 Fill Stabilisation and Sloping Ground 31
8.2.5 Fill Placement and Compaction Testing 31
8.2.6 Fill Settlement 32
8.2.7 Excavations and Batter Slope Angles 32
8.2.8 Erosion Controls 32
8.2.9 Formation of Coves 33
8.2.10 Cleanfill Containment Cells 33
8.3 Settlement Monitoring 34
8.4 Preliminary Retaining Structures 34
8.4.1 General Design Considerations 34
8.4.2 Seismic Design Considerations 34
8.5 Future Subgrade, Foundation and Set Back Conditions 34
8.6 Preliminary Pavement Design CBR 35
8.7 Stormwater and Surface Water Management 35
8.8 Landscaping Areas 35
8.9 Further Assessments and Reporting 35
9 References 37
10 Limitations 38

List of Figures

Figure 1: Site Location Plan

Figure 2: Simplified Site Layout

Figure 3: Published Geological Mapping

Figure 4: Published Alluvial Fan Mapping

Figure 5: Well Locations

Figure 6: Preliminary Ground Model

Figure 7: NPS Risk Assessment Matrix

List of Tables

Table 1: ORC Well Records Summary

Table 2: Historical Aerial Photograph Summary

List of Appendices

Appendix 1: Peer Review Response Letter dated 16 July 2026

Appendix 2: Well Lithology Records

Appendix 3: Geotago Ltd Site Plans and Test Pit Logs

Appendix 4: Crushed Pea Gravel Compaction Trial Report (2025)

Appendix 5: Crushed Pea Gravel Compaction Trial Test Results (2026)

Appendix 6: Draft Fill Specifications

1 Introduction and Scope of Report

JKCM Ltd, trading as Insight Engineering (IE), was requested to undertake a geotechnical assessment 922 Luggate-Cromwell Road, Cromwell (herein referred to as 'the site').

We understand that the site is proposed to be subdivided and developed for residential use, as per the development and scheme plans included in the Fast Track application (refer also to Section 3 of this report). Therefore, IE was requested to undertake a geotechnical assessment of the site as well as the proposed earthworks that will be required to facilitate the development of the site.

Our scope of work for this geotechnical assessment included:

- Review and summarise publicly available information for the site, including published geological maps, local authority GIS webmaps and records, the existing geotechnical reports for the site, the NZGD and historical aerial photographs, as well as our own geotechnical records;
- Assessment of general geotechnical considerations for the proposed residential development at the site, including mapped or observed hazards and bulk earthworks considerations;
- Observe field compaction trials to inform the earthworks methodologies and specifications, and;
- Preparation of this geotechnical report, presenting the findings of our review and recommendations for the proposed subdivision to accompany a Resource Consent application.

Assessment of the Park Burn flooding potential and likely effects on the proposed development is outside of the scope of this report, and it is our understanding that this is being assessed by others (Refer to Sections 4.2.5 and 7.2 below).

This report is not intended to express an opinion on the suitability or otherwise of any future lots or to provide detailed geotechnical information, for example, as might be required to accompany a Building Consent application. It is IE's expectation that a series of Geotechnical Completion Reports will be prepared following completion of each stage of earthworks, and these reports will present lot specific geotechnical information for the design of future structures, and identify any areas requiring further geotechnical assessment.

This assessment is an updated version to that which was lodged as part of the original Parkburn Substantive Application lodged 4 August 2026. It takes into account the revised scheme plan and incorporates peer review comments received from Local Authority expert/s to date along with a response to the peer review matters. For completeness, our prior response to the Peer Review dated 16 July 2026 has been presented as Appendix 1.

2 Site Description

The site is located at 922 Luggate-Cromwell Road (SH6), Cromwell (legal description PT SEC 63 BLK IV WAKEFIELD SD). Figure 1 below shows the site outlined in red.

The site is located on the western side of Lake Dunstan/Te Wairere and is approximately 8 km north of Cromwell. It is bound by rural resource land to the north and west (beyond SH6). The Park Burn creek flows through the site in a roughly NW to SE direction and it discharges into Lake Dunstan/Te Wairere.

Most of the site is zoned as low and medium density residential following Plan Change 21 in 2024. The northern strip is zoned as industrial; however we understand that another Private Plan Change application is currently in progress to re-zone this portion of the site to residential. Approximately 4.2 ha near the eastern side is zoned as Business Area 1-2.

The Parkburn Quarry, which was established in the 1980s and is still operational at the time of writing, currently occupies about half of the site area. Also, present are offices and yards for the quarry operators (Fulton Hogan Ltd), a concrete plant, and an asphalt plant. The area to the east of the Park Burn is used as a “cleanfill” disposal area (for imported materials), and general materials and machinery storage.

Part of the site to the north of the quarry area and south of the offices is generally undisturbed and is considered as “greenfield” land. Areas that were previously quarried have been backfilled with pea gravel in places which is generally a by-product of the quarry operations. These areas are typically either flat or gently sloping, with the surface stabilised with topsoil and vegetation.

The north-eastern end of the site is designated for “cleanfill” disposal and general storage, and contains a stockpile of “cleanfill” with volume indicated as 130,800 m^3. This area, as well as the land containing the concrete and asphalt plants, are verified on the HAIL register.

It should be noted that some areas within the operational quarry area shown on Figure 2 have been previously quarried and backfilled with pea gravel, however currently contain ponds or are otherwise used by the quarry operator. The “cleanfill” area at the north-eastern end was also previously quarried and backfilled with pea gravel to varying extents, with uncontrolled imported fill overlying the pea gravel.

There are bunds located at the western side of the site adjacent to SH6 that act as a visual barrier. These are understood to be formed from mixtures of topsoil and silty overburden soils scraped from the quarry. Similar bunds are located at the eastern sides of the site.

The existing (undisturbed) surface elevations are typically around 205 mRL, with the cleanfill area being around 200 mRL. The base of the quarry is generally around 195 mRL or 1 m above the lake level.

The site location and general site layout are presented as Figures 1 and 2 below.

Figure 1: Site Location Plan (not to scale)



Images sourced from Central Otago District Council GIS and Google

Figure 2: Simplified Site Layout (at time of writing)



Base image sourced from Central Otago District Council GIS

3 Development Proposals

The proposed development includes bulk cut to fill earthworks to form ground surfaces to support future residential and commercial properties as indicated by the plans prepared by LandPro Ltd. Associated roading, green spaces and reserves are also proposed, including a 50 m wide exclusion zone proposed at the western boundary adjacent to SH6. Two coves are proposed, with the northern cove being up to 4 m deep and the southern cove being no more than 1.5 m deep.

The earthworks plans indicate cut to fill activities to maximum depths of 15 m. The earthworks are proposed to be staged, commencing at the south-western end of the site and gradually progressing north and eastwards. The bulk earthworks staging methodology is described and depicted on the drawings numbered 24113_113_01 to 19.

Remediation areas R1-R3 are shown on the earthworks plans. This refers to previously quarried areas that are known to have been backfilled with pea gravel, which is not a suitable engineered fill material. Geotechnical remediation is proposed to involve over-excavation and sorting of the existing materials, removal of unsuitable materials, crushing of pea gravel, and replacement of uncontrolled fill with engineered, crushed materials. Further discussion on this process is presented in Sections 6 and 7 below.

The fill depths indicated on the earthworks plans have been estimated based on an assumed worst-case scenarios for the various remediation areas where the assumed depth of prior quarry activities was to ~ 195 mRL.

Remediation area R1 contains existing pea gravel backfill, as well as other imported fill materials. These materials have been placed in an uncontrolled manner, and therefore, geotechnical remediation of this area is also required. Due to the HAIL status of this portion of the site, it is proposed that these works be carried out in conjunction with a Suitably Qualified Environmental Practitioner (SQEP).

The finished site gradients are indicated to be gently sloping (<10%). Some steeper slopes up to 50% are proposed around the lakeside edges of the development. We understand that these slopes are likely to be retained, or depending on the ground conditions, height of the slopes and distance to buildings/infrastructure, they may be regraded, reinforced with geogrids or left unsupported.

The proposed coves are likely to be formed by excavation and filling to form the batters adjacent to the waterways, once the temporary stormwater and sediment works are completed. Excavation below ~195 mRL is required to achieve the design depth below the water line for both coves. This is likely to involve combination of excavation with staged sump pumping, until the design configuration is achieved. Breaking through to the lake will be the final step in the formation of the coves.

4 Desktop Review

4.1 Geology

4.1.1 Geological Setting

The Otago region is predominantly underlain by metamorphic basement rocks that have been folded and uplifted by continental plate boundary tectonic processes. Glacial and fluvial processes have shaped landforms in much of the western Central Otago area where the site is located.

During the Miocene period, Central Otago was a large river and lake environment resulting in deposited sediment which were carried from mountain ranges to the north. The Miocene terrestrial sediments and basement rock are almost exclusively covered by Quaternary sediments (Pleistocene glacial till and outwash deposits) as well as more recent (Holocene) alluvium and fan deposits in the Cromwell Basin.

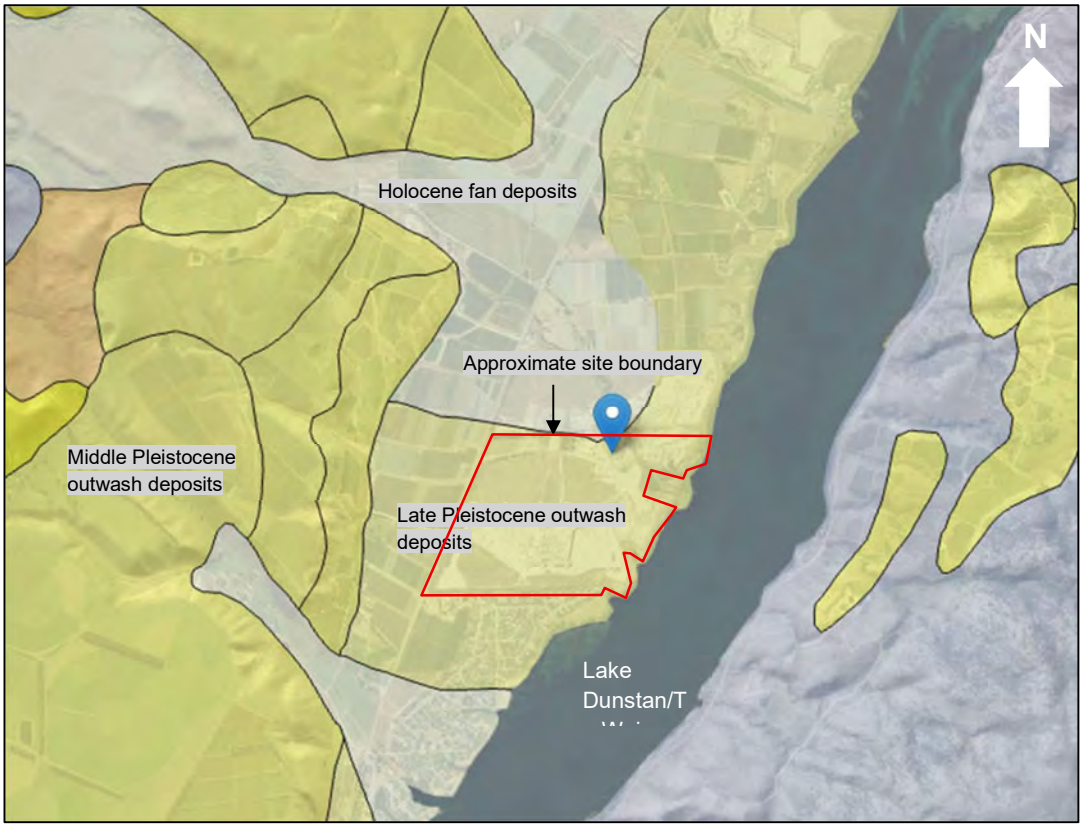
4.1.2 Mapped Geology

The majority of the site is mapped[1,2] as being underlain by Late Pleistocene outwash deposits of Albert Town Advance, described as "*Unweathered to slightly weathered, loose, sandy to silty, well rounded gravel usually on large outwash plains*".

Holocene Fan deposits, broadly described as "*Loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree (upslope) and valley alluvium*", are mapped extending over a small portion of the site at the northern boundary.

The published mapping is reproduced as Figure 3 below.

Figure 3: Published Geological Mapping



Base image sourced from GNS Science

4.2 Regional and Local Council Reports and GIS Maps

Mapped hazards from the Otago Regional Council (ORC) natural hazards portal are discussed in the following sections.

4.2.1 Active Faults

The characteristics and potential effects of local active faults are discussed in two reports[3,4] prepared by GNS for ORC.

The nearest mapped fault zone to the site is the Pisa Fault Zone, located approximately 1.4 km to the west of the site. The Pisa Fault Zone is reported by GNS as having "*definite, likely and possible active fault and fold strands*" with a calculated recurrence interval (RI) of 22,000 years.

Fault Awareness Areas (FAAs) have recently been developed by ORC. The following text is extracted from a 2025 ORC Committee report[5] relating to FAAs: "*The intent of a Fault Awareness Area is that it is sufficiently large to encompass the full range of plausible locations of the active fault, to account for the inaccuracies involved in mapping at 1:250,000 scale, and to accommodate the possibility that future fault ruptures and associated ground deformation may not coincide exactly with mapped areas of previous fault rupture deformation*".

The FAA around the Pisa Fault Zone is 500 m wide, approximately 1.1 to 1.6 km from the western site boundary.

The Dunstan Fault Zone, also mapped as "*definitely*" active is located approximately 18 km to the south-east and has a reported recurrence interval of 8,200 years. FAA around the Dunstan Fault Zone is also 500 m wide.

The GNS report discusses that the faults in the Upper Clutha region are generally assessed as low-activity faults, with many calculated recurrence intervals being more than 10,000 years. However, the faults are capable of generating large, locally damaging earthquakes in the future decades to centuries. Accordingly, severe ground shaking and permanent deformation of the land are possible primary effects in the event of rupture of these faults.

The Alpine fault, located approximately 100 km to the west of the site, also presents a seismic hazard to the Otago region. The Alpine Fault is assessed as having a shorter (more frequent) recurrence interval and capable of generating earthquakes of Mw8.1. Research completed by Howarth *et al*.[6], reports a 75% likelihood for magnitude 7 or greater rupture of the Alpine Fault over the next 50 years.

4.2.2 Seismic Shaking Intensity

The ORC hazards portal provides estimates of ground shaking intensity for various fault rupture scenarios and exceedance for given recurrence intervals. Shaking intensity is presented using the Modified Mercalli Intensity (MMI) scale which is composed of increasing levels of intensity that range from imperceptible shaking to catastrophic destruction. The version of the scale presented on the ORC database goes from MM1 up to MM12.

The source report[7] for the seismic shaking intensity mapping can be found on the ORC website and contains additional detail regarding specific event shaking intensity and the MMI scale.

At the site, MM6 shaking is expected to be exceeded 1/100 years. This level of ground shaking would be felt by all. Effects of MM6 shaking include difficulty walking steadily, objects falling from shelves, slight damage to some types of buildings, trees and bushes shake and loose material may be dislodged from sloping ground.

MM9 shaking is expected to be exceeded 1/2500 years at the site. This level of ground shaking can heavily damage or destroy many buildings, houses not secured to foundations can slide off, ground cracking is conspicuous, and landsliding is possible on steep slopes.

4.2.3 Liquefaction

The site is mapped within a region indicated to have a low to nil risk of liquefaction (A Domain) on the Otago Regional Council (ORC) hazards database. The mapping is based on the report[8] compiled by GNS Science.

4.2.4 Seismic Ground Class

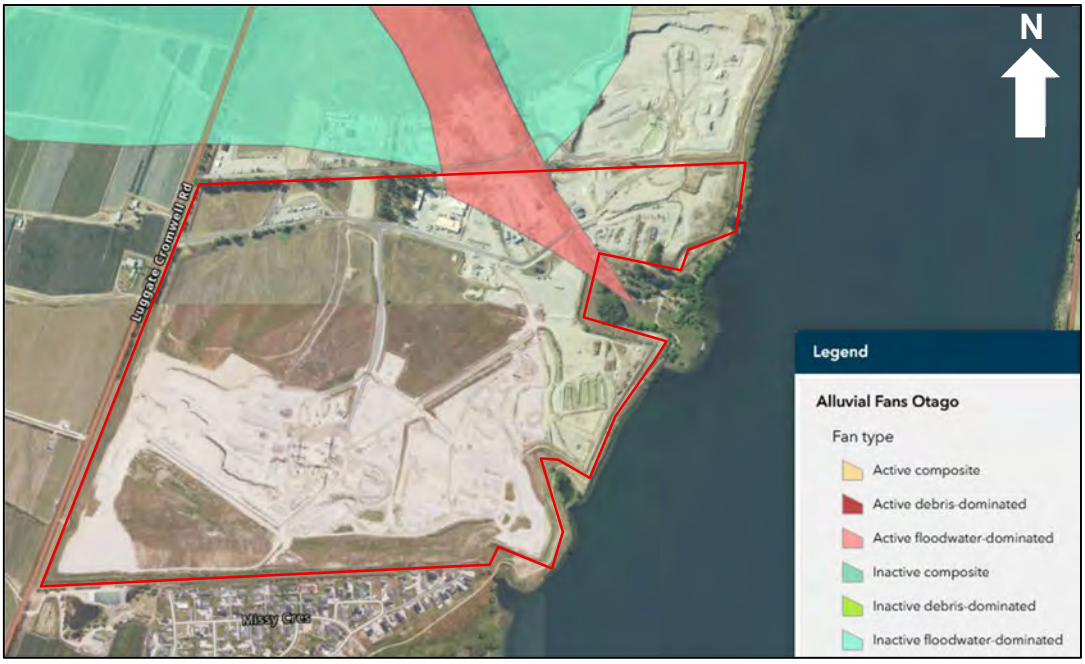
The seismic ground classification appears to be based on the mapped geology and NZS1170.5:2004. The site is mapped by ORC as Class D (deep or soft soil). It should be noted that NZS1170.5 was updated in 2025 and now includes a slightly different site classification system from the prior version.

4.2.5 Alluvial Fans

Regional scale alluvial fan mapping, reproduced as Figure 4 below, extends into the site boundaries. The mapping indicates that an approximately 200 m wide strip of land adjacent to the Park Burn, tapering to practically zero at the creek outlet, is potentially subject to floodwater dominated fan activity. The remainder of the site is excluded from mapped alluvial fan activity, although inactive fan is mapped to the north of the site.

The mapping is based on the Otago Alluvial Fans Project report[9] dated 2009 prepared by Opus Consultants Ltd.

Figure 4: Published Alluvial Fan Mapping



Base image sourced from GNS Science

4.3 Groundwater and ORC Well Records

A report[10] prepared by the ORC dated October 2012 discusses that the depth to the water table in the Cromwell basin can vary between 2 m to 34 m, primarily due to variances in the ground surface topography, with the mean depth being approximately 20 m below the ground surface. The report further discusses that the depth to the water table is likely to be shallower closer to the edge of Lake Dunstan/Te Wairere, and that the elevation of the water table "*tends to conform to a surface less than a metre above the mean lake water level of 194.2 m AMSL*".

A review of the Wells Aotearoa New Zealand database[11] has yielded information for several water bores located at and around the site. This information is summarised in Table 1, and the well locations are presented as Figure 5 below.

Table 1: ORC Well Records Summary

Well Identifier	Driller Name	Well Status	Elevation (datum)	Static Water Level (Elevation)	Well Depth	Date Drilled
G41/0113	McNeill Drilling	Existing	202.7 (NZVD 2016)	16.47 m (186.29)	24.89 m	12/08/1992
G41/0125	McNeill Drilling	Not recorded	203.154 (Dunedin 1958)	Not recorded	10 m	1/01/1990
G41/0115	Mc Neill Drilling	Existing	210.5 (Dunedin 1958)	12.6 m (197.9)	23.49 m	06/01/1994
G41/0301	McNeill Drilling	Existing	~204.8 (NZ Vertical)	10.6 m (~194.2)	28 m	09/01/2003
G41/0459	McNeill Drilling	Existing	202.641 (Dunedin 1958)	9.86 m (~192.8)	30.17 m	17/11/2015
G41/0199	McNeill Drilling	Existing	214.72 (Dunedin 1958)	16.42 m (~198.3)	27.95 m	25/11/1999
G41/0004	Not recorded	Decommissioned	~198.7 (Dunedin 1958)	Not recorded	205 m	1/10/1978
G41/215	McNeill Drilling	Existing	212.16 (Dunedin 1958)	15.47 m (~196.69)	28.44 m	05/05/2000

Figure 5: Well Locations



Base image sourced from Wells Aotearoa

Lithology records for seven wells are available and are presented as Appendix 2 of this report.

In broad terms, the lithology records indicate that the subsoils below and around the site are primarily comprised of silty and sandy gravel (alluvial or fluvial deposits) extending to approximately 28 m depth below the original ground surface. Glacial deposits or outwash deposits are indicated between depths of 28 m and 124 m, below which are reportedly tertiary lacustrine deposits. Completely weathered Schist rock was reported at a depth of 198 m.

4.4 Review of New Zealand Geotechnical Database

We have reviewed the New Zealand Geotechnical Database in preparation of this report, however we did not find additional subsurface investigation records that were relevant to this site.

4.5 Review of Related Geotechnical Reports

IE have reviewed the preliminary geotechnical assessment report[12] prepared by Geotago Ltd for the prior plan change application.

Where relevant, the findings and conclusions of that report have been taken into consideration in the preparation of this report.

Geotago's scope of work included a desktop review of publicly available information, and a limited subsurface investigation at site comprised of 14 test pit excavations to a maximum depth of 2.2 m. It should also be noted that the proposed subdivision scheme plan has evolved since Geotago's preliminary report was prepared, and therefore not all the conclusions and recommendations presented by Geotago apply to the current development plans.

Key information from that report is summarised as follows:

- Geotago's assessment identified typical native alluvial deposits as well as areas of uncontrolled fill and pea gravel backfill. The natural ground not affected by the quarry activities is reported as loess overlying native sandy gravels with some cobbles and boulders.
- The cleanfill stockpile is described by Geotago as "*Sandy silty GRAVELS with cobbles and occasional extraneous materials (wood, plastic, concrete)".*
- Geotago have divided the property at 922 Luggate-Cromwell Road into various areas to represent the land use at the time of their assessment (2022) and potential geotechnical constraints relevant to each.
  We have reproduced Table 2 from their report below. A copy of their plan showing the locations of these areas is presented as Appendix 3 of this report:

Table 2: Site Areas & Potential Constraints

Site area	Land Use	Potential Constraints
1	*Administration, plant and equipment*	*Low risk area in terms of ground conditions. Area likely to be maintained as industrial / commercial use*[a]
2	*Current settling pond*	*This will be backfilled at some point, with residual silt and fine sands having accumulated at the base of the pond. Backfilling likely to be with pea gravels in line with other backfilled areas. Poor ground conditions will likely result from backfilling*[b]*.*
3	*Operational quarry area*	*Quarry activities have exposed natural gravel sequence. Low risk in terms of ground conditions. Groundwater is shallow*
4	*Backfilled areas*	*Former quarry areas backfilled with uncontrolled but clean fill. This includes pea gravel to depths of up to 5m. Likely to be geotechnically constrained due to the free-running nature of the pea gravel.*
5	*Former settling ponds*	*Fill and sediment within the former pond areas are likely to be soft sand and silts, with a high moisture content and low bearing capacity. Remainder of fill will be pea gravels, with their inherent constraints*
6	*Quarry floor*	*Current exposed natural gravels on the quarry floor where operations have ceased. Groundwater is shallow at this level, but the natural soils have few geotechnical constraints.*
7	*Southern Batter (Reinstated)*	*This area is the current southern batter and boundary to the site. The former quarry wall has effectively been buttressed with coarse quarry scrapings and pea gravel, mantled with site won topsoil and superficial soils from the quarry extension. The slope is approximately 1V:5H or 11- 12 degrees. The fill is not engineered. Excavation of test pits in this area demonstrated the free running nature of the pea gravels. This would impact on any future earthworks in order to develop the slope area. It is understood that the backfilled area is at a maximum of some 11m.*
8	*Southern Batter (in process of reinstatement))*	*Pea gravels currently being deposited in this area as part of the quarry reinstatement as per Area 7. Some partial revegetation using quarry scrapings and topsoil for the quarry extension areas. The fill is nonengineered and will present similar constraints to those identified for Area 7.*
9	*Future quarry Extension*	*Natural ground yet to be quarried. The ground conditions present as the natural sequence of topsoil over loess over sandy gravels. Groundwater is at depth in these locations (i.e. >10m from current ground level).*

- Broadly, Geotago concluded that there were no significant natural hazards likely to affect the proposed development, with the exception of a minor risk of lateral spreading potentially affecting future waterfront properties and liquefaction affecting the former settling ponds.
- They further concluded that the ground conditions would be generally conducive to the proposed development but noting that specific engineering design "*will be required for the waterfront properties, and the larger commercial, industrial and retail type structures, particularly where these coincide with areas of historical fill*."

[a] This area is no longer planned to remain zoned Industrial and will be changed to allow residential use.
[b] In this case, Geotago assumed that backfilling will be completed by the quarry operator using uncontrolled pea gravel.

- Geotago identified the areas backfilled with pea gravel and the pea gravel slopes as being problematic for the development, and suggested that ground improvement or deep foundations would likely be required for development in those areas.

- Geotago concluded that there were "*no seismic conditions or constraints that negate the development of any building, regardless of its Building Importance Category*". IE interprets this statement as being related to the proximity of the site to the Pisa Fault Zone, noting that the potential for seismic ground shaking exists for the site.

As noted previously, not all of Geotago's conclusions and recommendations are relevant to the current Scheme Plan and development proposals. We also note that some of Geotago's conclusions and recommendations assume that remedial earthworks (or ground improvement) will not be undertaken, for example in their discussions regarding liquefaction potential at prior settling ponds and foundation options at areas of historical fill.

Copies of the relevant site plans from Geotago's report and their test pit logs are presented as Appendix 3 of this report.

4.6 Aerial Photograph Review

Limited publicly available aerial and historical photographs reviewed as part of this investigation include:

- Aerial photographs dated between 1958 and 2003 sourced from retrolens.nz[13]; and

- Aerial photographs dated between 2007 and 2021 sourced from Google Earth;

The following table broadly summarises the geotechnically relevant features visible in selected photographs. Photographs with poor resolution or scale were not assessed, and not all details are discussed.

Table 2: Historical Aerial Photograph Summary

Date	Description
1958	The site appears as undeveloped land on the western side of the Clutha River (pre-Lake Dunstan/Te Wairere). There are signs of what appears to be overland flow or meanders of the Park Burn at the site.
1976	The site appears to be used for agricultural/ crop growing purposes. Flood irrigation appears to have occurred, as well as flooding of the Park Burn.
2001	The Parkburn Quarry has been established at the northeastern side of the site. The existing offices, concrete and asphalt plants are not yet established, but three structures are visible in the approximate location of the asphalt plant. The topsoil has been stripped, and excavations and stockpiles are apparent near the eastern site boundary, as well as in the area currently containing the asphalt and concrete plants. What appears to be ponded water (~350 m^2) is visible near the northeastern boundary.
2003	The quarry extents are generally similar to 2001 and excavations appear to be ongoing. Ponded water (~5,600 m^2) is visible near the northeastern boundary.
2007	The concrete plant has been established by 2007, and ground clearance activity has occurred at the location of the weighbridge. Quarry activities appear to be ongoing at the northeastern side and areas of ponded water are no longer visible at the northeastern boundary. Stockpiles are visible at the cleanfill area. Operational quarry areas are visible in the approximate centre of the site and extending to the southern boundary. Settling ponds appear to have been formed to the south of the Park Burn outlet.
2010	The operational quarry areas have extended to the west and east along the southern boundary.
2011	The weighbridge area is constructed and the asphalt plant also appears to be constructed. Quarry activities are ongoing along the southern boundary. Quarry activities at the northeastern side appear to have ceased.
2015	Stockpiles are visible at the cleanfill area, and the access road to this area appears dark compared with previous photographs. The extents of the operational quarry area at the southern boundary continue to expand to the west and east.
2017-2019	Quarry activities continue at the southern side of the site, and ponded water is visible in places in the quarry floor, suggesting that the maximum practical excavation depth has been achieved. The settling ponds to the south of the Park Burn outlet are gradually being filled in during this period. Surficial changes occur around the weighbridge, concrete and asphalt plants over this time, including roading, stockpiling, minor construction etc.
2019-2024	Quarry activities continue and gradually expand towards the north along the western boundary. By 2021, formation of the pea gravel backfilled slope at the southern boundary has commenced. By 2023, most of the pea gravel slope at the southern boundary has been completed and quarry activities continue northwards.
2024	There are no significant changes, apart from stripping a portion of land to the north of the concrete plant, dark coloured stockpiles in that area, and changes in vegetation.

5 Preliminary Ground Model

From the results of our desktop review described herein and observations of the site, we infer that the native site soils are generally in keeping with the mapped geology.

The undisturbed greenfield portions of the site are indicated to be covered by a layer of topsoil that is typically 0.2 to 0.3 m thick.

Pleistocene outwash deposits are mapped by GNS for the majority of the site area, and are generally anticipated to underlie most of the site below the surficial Loess/alluvium, as indicated by the well records, Geotago's test pit findings (TP101-107, and TP111-112) and our observations of the quarry. These gravels are anticipated to extend to depths of at least 20 m. Geotago reported that the outwash gravels they identified were typically loose to tightly packed. Therefore, variation in density and consistency may be expected.

Geotago reported encountering a surficial layer of Loess (SILT) at some test pit locations within undisturbed areas. The thickness of Loess ranged from 0.0 to 0.9 m (in TP112) and IE have observed the Loess layer up to 2 m thick in places within the greenfield area during quarry stripping operations. It is possible that the silt may also be the result of alluvial processes, given that GNS have mapped more recent Holocene alluvial/fan deposits to the north of the site.

At the eastern side of the site are areas that have previously been quarried and reportedly backfilled with pea gravel, which is generally a by-product of the quarrying activities. At the cleanfill area, a surficial layer of uncontrolled fill is anticipated to be present over the pea gravel backfill, based on the findings of TP108 by Geotago. This fill is likely to be comprised of variable materials that have been imported to the site over a number of years in a relatively uncontrolled manner, and may contain anthropic and organic inclusions. The thickness of this fill layer is unknown however it is likely to vary over the cleanfill area.

Additionally, from our review of historical aerial photographs, it is possible that some localised areas may have been quarried and backfilled prior to the establishment of the existing concrete and asphalt plants.

The previously quarried areas along the southern boundary and in places on the eastern side of the quarry (south of the Park Burn) have been backfilled with pea gravel, overlying native outwash deposits.

The settling ponds have not been investigated in great detail however we concur with Geotago's assumptions that these are likely to contain soft, silty depositions to varying depths.

The depth and extent of the fill, including imported materials and pea gravel backfill, is not fully quantified as detailed records were not kept, and there are gaps in between historical aerial photographs. Explorations to obtain this information would likely be cost-prohibitive, as well as impractical due to the ongoing quarry activities and scale of the site. Therefore, we conservatively concur with the assumptions made by LandPro when preparing the earthworks plans. Landpro have estimated the thicknesses of the pea gravel and existing fill based on assumed quarry floor elevations of ~195 mRL. Similarly, we have conservatively assumed the "worst-case' extents of various areas of backfill at the site based on historical aerial photographs and discussions with the quarry operators.

The preliminary ground model is summarised on Figure 6 below, however it should be accepted that variations could exist and these may only become apparent once bulk excavations are underway. The three primary areas requiring geotechnical remediation are highlighted in red (Remediation Areas R1 to R3).

Groundwater depths based on published information show a static water level between 186 mRL to 198mRL. We expect that groundwater level will on average be in keeping with and approximately conform to lake levels (~194 mRL), although some variations could exist from time to time.

Figure 6: Summary of Preliminary Ground Model



Base image sourced from Central Otago District Council GIS

6 Fieldwork: Gravel Crushing and Compaction Trials

6.1 Overview of the Trials

IE was requested to arrange two field compaction trials using crushed pea gravels sourced from Parkburn Quarry. The purpose of the trials was to assess whether or not it was feasible to crush unsuitable pea gravel to create a material suitable for reuse as a bulk structural fill.

To this end, two trials were completed. The first trial was carried out in October 2025 at the Fulton Hogan Miners Road quarry in Christchurch, and used a high pressure grinding roll crusher. A hardfill plateau density test procedure was carried out on a series of trial fill platforms. The trial is fully described in our letter[14] dated 3 November 2025 (reference 24019_1) which is presented as Appendix 4 of this report, and therefore those details will not be reiterated herein.

The second trial was completed at an earthworks site in Wanaka, using pea gravel crushed by a vertical shaft impact (VSI) crusher. The test procedure was generally the same as the first trial, except that the fill platforms were formed in a shallow excavation rather than upon the ground surface. This allowed for survey measurements to estimate the compression/compaction factor of the crushed gravel, as the sides of the fill platforms were confined. Therefore, lateral deformation of the fill platform did not contribute to the compaction factor estimations. A specific summary report for the second trial was not prepared, however the plateau test results are presented as Appendix 5 of this report.

6.2 Summary of Results

6.2.1 Trial 1

The crushed product was described as a sandy, fine to medium GRAVEL, from the particle size distribution test. Laboratory standard compaction testing carried out on a sample of this material resulted in a Maximum Dry Density (MDD) of 2.06 t/m^3 with an optimal water content of 6%.

The MDD resulting from the plateau density trial was 2.07 t/m^3 with average moisture content values of 3.1% to 5.3 %.

CBR values of at least 7% were correlated from Impact Hammer testing.

The trial results indicated that crushed pea gravel would be suitable for use as bulk structural fill, and that densities of 95% and 98% of the MDD would likely be able to be achieved during bulk earthworks. The outcome of Trial 1 is discussed in full in Appendix 4.

6.2.2 Trial 2

The crushed product was described as a fine gravelly SAND with some silt from the particle size distribution test. Laboratory standard compaction testing carried out on a sample of this material resulted in a Maximum Dry Density (MDD) of 2.06 t/m^3 with an optimal water content of 9%.

The MDD resulting from the plateau density trial was 1.96 t/m^3. Moisture contents ranged between 2.6 % and 5.1 %.

CBR values of greater than 7% were correlated from Impact Hammer testing.

6.2.3 Discussion on Results

Both trials indicated that crushing pea gravel results in an aggregate that is suitable for use as bulk structural fill. Either crushing method is likely to be suitable, noting that slightly differing materials are produced by each machine and production rates are likely to vary.

From Trial 2, the compacted crushed pea gravel was able to be adequately compacted, however the MDD resulting from the plateau testing is around 95% of the laboratory results. It should be noted that the typical water contents of the second trial were approximately half of the optimum water content from the laboratory, and we anticipate that this is a likely contributing factor to the difference. Therefore, a greater application of water during compaction is likely to be required to achieve higher densities.

Fill constructed from crushed pea gravel is indicated to be suitable for supporting future buildings and roads, and further recommendations are presented in Section 8 of this report.

7 Discussion on Geotechnical Considerations

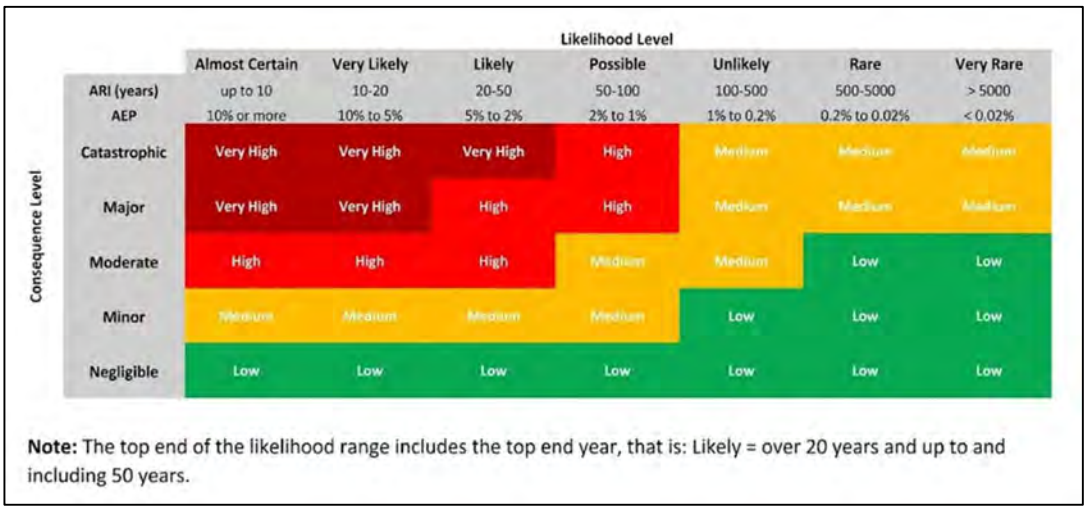
The following geotechnical considerations are either mapped or identified for the site as a result of our desk top review and fieldwork. Discussions on the perceived implications are presented below and specific recommendations are presented in Section 8 of this report:

- Seismicity;
- Alluvial Fan and overland flow;
- Existing Uncontrolled Fill and Pea Gravel Backfill;
- Future Earthworks:
    - General Excavations;
    - General Filling;
    - Remediation of Existing Fill Areas;
    - Fill Settlement and Consolidation;
    - Finished gradients and slope angles.

We also present a National Policy Statement (NPS) Natural Hazard risk assessment where relevant in the following sections. Natural hazards identified by our assessment relate to seismicity, and alluvial fan and overland flow. As the assessment of the alluvial fan/overland flow flooding potential is outside of the scope of our work, we have excluded this hazard from the assessment.

The NPS risk matrix is reproduced as Figure 7 for ease of reference.

Figure 7: NPS Risk Assessment Matrix



7.1 Seismicity

Seismic effects may be considered as follows:

- Primary effects – ground shaking
- Primary effects – fault rupture
- Secondary effects – liquefaction and lateral spreading

7.1.1 Ground Shaking

A future significant earthquake is likely to result in moderate to severe ground shaking (as discussed in Section 4.2.1 and 4.2.2 of this report), which may lead to deformations in the ground surface.

Ground shaking has been excluded from the NPS as it is already regulated under the Building Act 2004 and the New Zealand Building Code.

7.1.2 Fault Rupture

The risk of fault rupture (directly affecting built structures or infrastructure) relates to the Pisa Fault Zone being the closest mapped feature to the site. The likelihood level of this event is “very rare” as the current understanding of the Pisa Fault Zone recurrence interval is 22,000 years (>5000 years).

The consequence level at the site is considered to be negligible. This is due to the distance of the site to the current mapped extents of the Pisa Fault Zone (including Fault Awareness Area) ranging between approximately 1.1 and 1.4 km, meaning that the development will not overlap these zones.

Therefore, the assessed matrix risk level for this hazard is *Low*.

Additionally, fault rupture is unlikely to be a consideration for this proposed development according to the report[15] prepared by GNS for the Ministry for the Environment for planning land development close to active faults, due to the distance of the site to the fault zone.

7.1.3 Liquefaction

The soil types that are typically susceptible to liquefaction include normally consolidated, relatively young deposits of poorly graded sands, sandy silts, silty sands and fine gravels. Older deposits of well graded, medium dense to dense sands and gravels tend be less susceptible.

Additionally, unsaturated soils above the water table are generally not at risk of liquefaction. Sites with a non-liquefiable crust of at least 3 m[16] deep are generally understood to be less susceptible to liquefaction induced damage at the surface than those with shallower groundwater tables or weak surficial soils.

The site is mapped by ORC as generally being unlikely to be susceptible to liquefaction, and this agrees with our observations and the subsurface materials indicated by the available well records. Geotago have identified that a minor risk of liquefaction exists at the locations of the settling ponds which are assumed to be infilled with soft, moist sediments (from quarrying activities, not natural processes). These areas may experience liquefaction if they remain unchanged. However, the settling ponds are proposed to be mitigated before any dwellings or infrastructure are built over them, therefore removing the potential for liquefaction of these man-made features. Mitigation is anticipated to involve removal of all soft sediments from the existing and prior settling ponds (contained within Remediation Area RA2), and backfilling with engineered materials to the design surface elevations.

However, variations in natural soil deposits cannot be fully discounted, and recommendations are presented in Section 8.1 if loose materials are encountered close to the lake elevations during the earthworks.

Taking the above into account, as well as the proposed finished ground surface elevations which will be at least 4 m above the lake level, local geology and future engineered fill to be placed at the site, the overall potential for widespread liquefaction occurring at the site is considered to be low.

For the NPS risk assessment, we have considered the potential and likely consequences for liquefaction at the site resulting from three potential seismic events, taking the above considerations into account:

- **Alpine Fault Rupture**

The annual exceedance probability of the Alpine Fault is taken as between 0.33% and 2.7%. Therefore, this event is taken as being between *Unlikely* and *Likely* on the Likelihood Table.

Shaking intensity at the site is indicated to be MM6 using the Modified Mercalli Intensity scale according to the Otago Regional Council natural hazards portal. This level of ground shaking would be felt by all. Effects of MM6 shaking include difficulty walking steadily, objects falling from shelves, slight damage to some types of buildings, trees and bushes shake and loose material may be dislodged from sloping ground. However, considering the site conditions, widespread liquefaction damage is not expected.

Therefore, the consequence level is considered to be minor. The highest assessed matrix risk level is therefore *Medium*, for unmitigated site conditions.

For mitigated site conditions, including engineered fill to replace the settling pond materials and to increase the ground surface elevation above the lake level, the assessed matrix risk level is *Low*.

- **Pisa Fault Zone Rupture**

As the Pisa Fault Zone has a long recurrence interval (>22,000 years) it is taken as *Very Rare* on the Likelihood Table.

Shaking intensity is not mapped on the ORC natural hazards portal for the Pisa Fault Zone, but MM9 shaking is expected to be exceeded for 1 in 2,500 year events. This level of ground shaking can heavily damage or destroy many buildings, houses not secured to foundations can slide off, ground cracking is conspicuous, and landsliding is possible on steep slopes. However, as the site is generally not susceptible to widespread liquefaction, the consequence level is considered to be minor.

The assessed matrix risk level is therefore *Low*.

- **Dunstan Fault Rupture**

As for the Pisa Fault Zone, the Dunstan Fault Zone has a long recurrence interval of 8,200 years (>5,000 years). Therefore, this event is taken as *Very Rare* on the Likelihood Table.

Shaking intensity is indicated to be MM9. Therefore, anticipated effects are similar to those indicated for the Pisa Fault Zone.

The assessed matrix risk level is therefore *Low*.

7.1.4 Lateral Spreading

Lateral spreading is associated closely with liquefaction, and it is not expected to occur unless soil liquefaction is also occurring at areas with unsupported banks or slopes. Therefore, we conclude that the assessed risk of lateral spreading may be taken as the same as liquefaction.

It should be noted that Geotago discussed some risk of lateral spreading in their prior report, however this related to future waterfront properties on peninsula, which are no longer proposed. Their conclusions were based on a prior scheme plan and did not account for geotechnical remedial works that are being now being proposed to be undertaken. Any land adjacent to future coves is likely to be constructed of engineered fill, which may be reinforced (by retaining or incorporation of geogrids), if necessary, to mitigate potential lateral displacements that may result from a seismic event. Such areas will be subject to specific engineering design and further discussion, and recommendations are presented in Sections 7.4.5 and 8.

For a scenario where an Alpine Fault rupture results in localised soil liquefaction, the assessed risk matrix level is *Medium* for unmitigated conditions. For mitigated site conditions, including engineered earthworks, slope stabilisation, retaining structures and set-back distances (as necessary), the assessed risk level is *Low*.

7.2 Alluvial Fan and Overland Flows

Part of the site including the Park Burn is mapped as active alluvial fan (floodwater dominated, refer to Figure 4 of this report). Detailed assessment of the Park Burn flooding potential and active fan effects are outside of the scope of this report.

We understand that specific assessment has been carried out by a suitably qualified consultant to assess potential flooding of the Park Burn Creek and effects on the proposed development.

7.3 Existing Uncontrolled Fill and Pea Gravel Backfill

Three primary areas containing existing uncontrolled fill and pea gravel backfill have been identified at the site (Remediation Areas R1 to R3). These areas are outlined in red on Figure 6 of this report. Additionally, the area highlighted in yellow on Figure 6 potentially also contains localised areas of existing uncontrolled fill.

Potential issues associated with the existing fill and pea gravel backfill include unstable building areas leading to differential settlement below future buildings, unstable slopes in a future seismic event,

ongoing consolidation settlement in areas containing wet, soft sediments (settling ponds). The filled and pea gravel areas are unsuitable for future development in their current condition. Therefore, mitigation measures are required to be implemented.

The proposed mitigation measures involve remediation of these areas by:

- Over-excavation of existing fill;
- Sorting and disposal of unsuitable materials;
- Crushing of pea gravel; and
- Replacement of uncontrolled fill with engineered, crushed materials or local borrow materials to the design surface elevation.

Further discussion is presented in Section 7.4.3 below, and in Section 8 of this report.

7.4 Future Earthworks

From the earthworks plans, we understand that all of the site area will be affected by future earthworks, involving either excavation or filling (or both in the remediation areas) to achieve the design subgrade elevations. Therefore, actual foundation bearing and other geotechnical design parameters (e.g. for retaining wall and pavement design) would be assessed upon completion of the earthworks.

7.4.1 General Excavations

Maximum excavations heights are indicated to be up to 15 m, and are generally expected to expose native materials like those visible in the quarry sides. Native deposits could include surficial Loess, layers and lenses of silts, and fine to coarse sands and gravels that are typical of Pleistocene outwash deposits.

The subgrade conditions exposed by the excavations could be variable (in density and type), subject to the actual materials present.

7.4.2 General Filling and Local Borrow Materials

Fill using local borrow materials is indicated to a maximum depth of around 12 m. No overly steep fill batters are proposed within the site boundaries, however if required consideration can be given to retaining or mechanically stabilised earth (MSE) structures.

Fill is generally expected to be relatively straightforward as most of the borrow materials are anticipated to comprise silty and sandy GRAVEL, however based on our knowledge of the locality, some of the following challenges may be experienced:

- Variable, weak or loose subgrade conditions in places may lead to challenges with compaction of the fill;
- Earthworks adjacent to the Park Burn Creek will require specific erosion and sediment controls; and
- Engineering quality control of potentially variable fill materials.

These challenges should be able to be mitigated with normal engineering practices and management.

7.4.3 Remediation of Existing Filled Areas

Geotechnical remediation of the existing filled areas should be managed separately from the general earthworks. As discussed in a preceding section the remedial works are likely to involve:

- Over-excavation of existing fill;
- Sorting and disposal of unsuitable materials;
- Crushing of pea gravel; and
- Replacement of uncontrolled fill with engineered, crushed materials or local borrow materials to the design surface elevation.

Geotechnical remediation should not be required in areas that do not contain existing fill or pea gravel backfill. Therefore, the actual extents of remediation may be less than indicated by the earthworks plans and this report.

Geotechnical challenges that might be encountered during the remediation work may include compaction of crushed materials near the groundwater surface (subject to the depth of over-excavation), quality control (including water content) and logistical matters, however these should be able to be mitigated with normal engineering practices and management. Deep fill embankments should be well constructed to mitigate settlement of fill due to self weight, and potential differential settlement between filled and unfilled areas (see Section 7.4.4 below).

At the cleanfill area and the existing concrete and asphalt plants (shown in orange and yellow on Figure 6) the geotechnical remediation is required in conjunction with environmental/contamination controls. Geotechnical remediation will involve the management of pea gravel as discussed in the preceding paragraphs as well as appropriate disposal of the existing cleanfill stockpile. Disposal of the cleanfill is proposed to involve the formation of underground containment cells in at least two locations at the site, where cleanfill materials that are deemed to be suitable to remain on site will be placed. The conceptual designs for the containment cells are presented on Landpro's drawings numbered 24113_120_01 to 02. Reference should be made to the Remediation Action Plan[17], which presents the description of the environmental/contamination remedial works. Specific geotechnical controls are proposed to manage the containment cell areas such that the resulting ground surface is suitable from both geotechnical and environmental perspectives, and these are presented in Section 8.2.10.

7.4.4 Fill Settlement and Consolidation

From NZS4431:2022:

> *"One of the most important factors in ensuring satisfactory performance of stable fills is the limiting of post-construction differential settlements. Acceptable differential settlements should be identified and documented."*

Settlement considerations include settlement within in the fill itself and (consolidation) settlement of the native materials below the fill. Additionally, fill may also settle differentially to any adjacent non-filled or excavated areas.

Soils that are susceptible to consolidation settlement typically include normally consolidated fine-grained soils (or otherwise compressible materials) and any soil type that experiences a slow release of excess pore water pressure generated from the placement of new loads.

Post construction settlement of the fill itself may occur due to self weight or poor construction methods. Additionally, collapse compression is defined by NZS4431 as:

> "*Settlements developing in partially saturated and low to medium dense soils because of fluid infiltration. Collapse compression settlements can be rapid or develop over an extended period*."

Generally, well constructed, well graded fills with appropriate drainage and stormwater management should be at relatively low risk of collapse compression. Settlement of granular materials tends to occur over relatively short periods and should be largely expressed during earthworks or construction. Fine grained type soils may experience settlement over longer periods of time.

Monitoring of settlement during and post construction of the fills is a measure that will assist in evaluating the total and differential settlement, as well as timeframes over which settlement occurs.

7.4.5 Finished Gradients and Slope Angles

The finished surface gradients are depicted on a plan prepared by LandPro (reference 114_01)

Most of the site area is generally indicated to be very gently sloping (< 10 %) with no overly steep excavation batter angles proposed.

A 7 m tall and 50 m wide slope battered at between 16 and 20 % (up to 1(V):5(H)) is proposed at the western side of the site. This slope is to be formed by excavation of the native outwash gravels. Preliminary slope stability analysis was completed for this slope. The results indicate acceptable factors of safety under assumed normal, static conditions (minimum FoS ~2.8). Under modelled seismic conditions, resulting yield accelerations range between 0.3 and 0.4 g, suggesting that some slope movement is possible in a 1 in 500 year seismic event for Cromwell (where the design peak ground acceleration for a 1 in 500 year event is 0.35g). Calculated deformations for this scenario do not exceed 10 mm.

At the eastern side and adjacent to the proposed coves, the ground surface is generally around 4 m above the lake level with slope angles ranging between 20 and 50 % (up to 1(V):2(H)). Some slopes adjacent to the lake edge are existing, and some will be engineered during the earthworks. Slope stability analyses have not been carried out for these slopes yet. For slopes to be constructed by engineered filling, we anticipate that future measures such as slope stability analysis would be carried out leading to any required mitigation measures. These may include fill reinforcement (e.g. with geogrids or retaining walls) if necessary, appropriate set back distances and specific foundation design as necessary may be applied to protect future structures and infrastructure. Existing slopes are likely to be managed by either re-grading if possible or applying set-back distances.

The coves are generally understood to be formed with 33% (1(V):3(H)) slopes below the water line (in native alluvium). The northern cove is proposed to be 4 m deep and the southern cove is proposed be no greater than 1.5 m deep. Such slope gradients are generally acceptable for permanent unsupported batters in the local materials. Additionally, edge protection involving rock liners/reno mattresses, gabions etc are proposed for the sides of the coves, which should be suitable based on similar conditions at Pisa Moorings to the south of the site. It is our further understanding that retaining walls (likely to be mass block or similar) are proposed for the southern edge of the Northern Cove as a minimum.

8 Conclusions and Geotechnical Recommendations

8.1 General

Based on the information presented herein and our knowledge of the area, it is our opinion that the site is geotechnically suitable for future residential development, subject to the recommendations of this report.

From the prior subsurface investigations completed by Geotago and our knowledge of the locality, we anticipate that the native subsurface conditions should be generally in keeping with published mapping.

Areas containing existing fill (pea gravel backfill and imported cleanfill) have been broadly quantified based on assumed worst case conditions. This approach has been taken to ensure that the geotechnical remediation can be appropriately budgeted, managed and implemented. However, it is possible that other areas containing existing fill have not yet been identified. The Geotechnical Engineer should be consulted in the event that such areas are identified during the earthworks, so that appropriate remediation measures can be extended to these areas as well. Geotechnical and environmental remediation is required to be carried out concurrently in the cleanfill areas, as well as potentially at the areas around the existing concrete and asphalt plants.

Potential seismic effects at the site could include moderate to severe ground shaking (as discussed in Section 4.2 of this report), which may lead to deformations in the ground surface. Appropriate engineering design of structures and underground services, as well as appropriate construction of cut and fill embankments (where relevant). The site is not anticipated to be subject to earthquake induced liquefaction based on the subsurface conditions indicated by the well records, and providing that settling ponds etc. are appropriately remediated to mitigate any such potential. However, if loose, sandy deposits are encountered close to or below the lake level then the liquefaction and lateral spreading potential should be reassessed so that appropriate mitigation measures can be implemented. Fault rupture of mapped faults is considered unlikely to adversely affect the site.

Assessment of alluvial fan activity and flooding that may result from the Park Burn Creek are beyond the scope of this report. We understand that an assessment has been carried out for the neighbouring property to the north and the results may be applicable to the site. If the outcome of that assessment indicates that the proposed development could be adversely affected by potential flooding of the Park Burn Creek, then further specific assessment to inform appropriate mitigation measures may be required.

Groundwater levels are likely to conform to the existing lake levels, and should be taken into account if geotechnical remediation works are likely to come close to or contact groundwater. Methods to manage and control water inflow during excavations for the coves should be allowed for.

8.2 Bulk Earthworks

8.2.1 General

Bulk earthworks should be undertaken in accordance with NZS4431:2022 Engineered Fill for Lightweight Structures, Good Practice Guidelines for Excavation Safety published by Worksafe (July 2016) and the recommendations of the Geotechnical Engineer.

Remedial earthworks in the “cleanfill’ areas should be carried out in conjunction with the recommendations of the Geotechnical Engineer and a Suitably Qualified Environmental Practitioner (SQEP). Recommendations relating to the cleanfill containment cell areas are presented in Section 8.2.10.

It is the responsibility of the contractor to ensure that all earthworks are undertaken in accordance with the relevant Health and Safety legislation, implement environmental and erosion controls and to protect neighbouring properties from adverse impacts potentially resulting from the earthworks.

The following sections provide geotechnical recommendations in addition to those presented in NZS4431 which are specific to the proposed earthworks.

8.2.2 Site Preparation

Generally, fill areas should be prepared by stripping all topsoil, vegetation, loose surficial materials, existing fill and overly coarse materials (e.g. boulders) where present to expose competent native deposits.

Similarly, excavation areas should be cleared of unsuitable materials to expose acceptable borrow materials for use as bulk fill.

Remediation areas should be prepared by excavating all existing fill and pea gravel and compacting the exposed subgrade if necessary, prior to replacement with engineered fill materials. Excavations adjacent to site boundaries should be controlled/staged such that neighbouring properties are not adversely affected.

Topsoil stockpiles should be sited well clear of the works to avoid contamination with bulk fill materials. Stockpiles of unsuitable materials should be sited well clear of the works on stable areas or disposed in an appropriate manner off site.

If any areas of weaker soil are identified during the site clearance activities, then further localised excavation and backfilling may be required. Advice should be sought from the Geotechnical Engineer in the event that this work is necessary.

The Geotechnical Engineer shall view all stripped areas and undertake testing as necessary to verify the stiffness of the subgrade prior to placement of new fill materials.

8.2.3 Fill Materials

Fill specifications should be prepared for all the materials to be used as fill at the site. Draft specifications are presented as Appendix 6 of this report, however these should be reviewed prior to works commencing subject to actual materials used.

Fill materials are generally expected to be comprised of either local borrow materials (Loess, and sandy GRAVEL alluvium/outwash deposits) or re-purposed pea gravel that is crushed to form a suitable fill material.

Borrow Materials

Borrowed fill materials may vary, and further assessment of these soils may be required to inform compaction specifications. From our limited observations, the materials identified to date at the site should be able to be used as engineered fill subject to the appropriate controls and methods being implemented for the various soil types. Further field compaction trials, such as plateau testing, may be carried out on local borrow materials to further inform the fill specification and compaction methodologies, and to assess the actual performance of the site materials. Where a material change is identified, additional acceptance testing shall be carried out as per NZS4431.

Boulders (typically particles in excess of 200 mm length) should ideally be removed from the fill materials.

Crushed Pea Gravel

IE have observed two compaction trials using crushed pea gravel specifically to inform the geotechnical remediation strategies to be implemented at Parkburn. It is our opinion that crushed pea gravel should be suitable to be used as engineered fill providing it is crushed with appropriate machinery, conditioned with respect to water content and compacted with suitably heavy, vibrating plant.

The crushed gravel is likely to be produced as a uniform, consistent product which allows for more efficient on-site quality controls during bulk earthworks. The addition of water must be allowed for, both for compaction and for dust control.

Other Materials

Other existing fill materials that may be proposed to be re-used as engineered fill (e.g. crushed concrete, other aggregates etc.) will be subject to approval by the Geotechnical Engineer and potentially also a SQEP.

Any existing fill materials are that deemed to be unsuitable for re-use as engineered fill (e.g. due to excessive unsuitable inclusions, contaminants or compressible materials) should be disposed of in an appropriate manner and not be incorporated into the engineered fill.

8.2.4 Fill Stabilisation and Sloping Ground

Some areas may require fill compaction upon weak/unfavourable native subgrades. Specific design may be required for these areas, involving either earthworks methods or incorporation of geotextiles and grids which may assist to stabilise unfavourable subgrades, such that the design requirements can be achieved. These areas should be assessed and mitigated once identified (should they exist).

Fill placed on sloping ground steeper than 1(V):4(H) should be appropriately keyed and benched into the slope to avoid downward migration of fill materials. Typical depths for shear keys and bench heights are between 0.6 m and 1 m, however this may vary slightly in different parts of the site. The width of the shear keys and benches will be determined by the size of machinery on site, and the quantity of the benches will be dependent on the actual slope geometry.

In broad terms, fill embankments with batter slopes steeper than 1(V):3(H) may require stabilisation, subject to the type of fill materials, height of the batter slopes and proposed development near to the batter. Stability of the proposed filled batters should be assessed and appropriate retaining structures designed as necessary. Mechanically stabilised earthfill using geogrid reinforcement may be considered as an alternative to retaining structures, if necessary.

8.2.5 Fill Placement and Compaction Testing

Fill placement and compaction methods for local borrow materials should be confirmed prior to bulk earthworks commencing, by conducting a fill compaction trial. Compaction methods for the crushed pea gravel have been largely determined by the trials completed to date, and will be verified once the actual crushing machinery etc. is confirmed.

Field compaction testing should be carried out by Nuclear Density testing (as per the specification) to verify that the appropriate degree of compaction has been achieved. A minimum target dry density of 95% of the maximum dry density (MDD) is typically recommended for normal residential development. However, in areas where the height of fill exceeds 3 m at this site, we recommend a minimum target dry density of 98% of the MDD should be aimed for. This recommendation may be reviewed subject to the performance of actual materials used and outcomes of further field trials.

Supplementary testing using a Scala penetrometer and/or Impact Hammer may be carried out as directed or by the Geotechnical Engineer. If continuous compaction control methods are used then field compaction testing as above should be undertaken periodically to verify results.

Field compaction testing shall be carried out by an independent testing company or the Geotechnical Engineer. Test results shall be forwarded to the Geotechnical Engineer (when completed by others) for review as soon as completed and on an ongoing basis during the earthworks programme.

If any tests indicate failure to comply with the earthworks specification, then the contractor is required to rework the area in question as necessary to achieve compliance. The reworked area shall be retested and return a satisfactory result before further fill placement can continue.

8.2.6 Fill Settlement

Fill settlement due to self-weight could lead to differential settlement occurring between adjacent filled and excavated areas, as well as within areas of deep fill itself.

Settlement of fill due to self weight is a potentially complex issue that could affect fill greater than 6 m thick. Estimated settlements could range between 0.5 and 2 % of the total fill thickness[18], subject to the quality and type of the fill, and time taken to construct. Fill constructed of primary granular materials, such as is the case for this site, is most likely to experience immediate settlement during a relatively short time frame. Long term, creeping settlements are usually anticipated for cohesive clays and silts, and not for the site materials, however creeping settlement due to self weight cannot be discounted given the proposed fill heights of up to 12 m.

Mitigation methods include specific construction methods and timing for such fill embankments to ensure high quality of earthworks, appropriate benching, and a sufficient period of settlement monitoring of completed areas. Subject to the outcomes of these methods, additional methods such as temporary over-filling/pre-loading to induce most settlements could be carried out prior to construction of permanent structures and pavements.

8.2.7 Excavations and Batter Slope Angles

Excavation safety on site is responsibility of the contractor, and the recommendations of Worksafe should apply.

Permanent, unsupported excavation and fill batter slopes should not be formed any steeper than 1(V):2(H). As discussed in Section 8.2.4 above, batter slopes steeper than 1(V):3(H) may require stabilisation, subject to the type of fill materials, height of the batter slopes and proposed development near to the batter. Stability of the proposed batters should be assessed and appropriate retaining structures designed as necessary.

Temporary batters may be formed at steeper angles subject to approval by the Geotechnical Engineer, depending on the height of the temporary slope and other work area conditions. This is best addressed on site at the time of construction. The Geotechnical Engineer should be contacted immediately if any temporary or permanent slopes display signs of instability, particularly if any personnel, neighbouring properties, infrastructure or other assets are potentially at risk of harm or damage.

8.2.8 Erosion Controls

Fine grained materials, such as the surficial silt (Loess) identified at the undisturbed parts of the site, are potentially dispersive and subject to erosion when exposed to water, and dust generation in windy conditions. Crushing operations are also likely to produce fine grained materials that will form sediment and dust.

Appropriate controls should be implemented during bulk earthworks to minimise these effects. The design of short term erosion, sediment and dust control during earthworks is undertaken by others and is excluded from this report.

Permanent measures such as vegetating, hydro-seeding and/or the placement of proprietary erosion control mats, should be carried out to stabilise the surface of any unsupported batters and bunds to protect against long term erosion and the formation of dust. This recommendation may also apply to temporary batters, where the batters are to remain exposed for prolonged periods of time (i.e. months rather than weeks).

8.2.9 Formation of Coves

The proposed coves are likely to be formed by excavation and filling to form the batters adjacent to the waterways, once the temporary stormwater and sediment works are completed. Therefore, we anticipate that cove formation will be towards the end of the earthworks programme.

Excavation below ~195 mRL to achieve the design depth below the water line will require management of water inflows. We anticipate that water inflow management will be by staged sump pumping methods. A draft Cove Dewatering Management Plan has been prepared by LandPro Ltd, which presents more specific information relating to the staged dewatering approach, including the preliminary design (and limitations thereof), further investigation and detailed design, excavation methodologies, monitoring, treatment and discharge of pumped water. Contingency measures for the dewatering, treatment and discharge processes are also presented by LandPro.

The sides of the coves are proposed to be battered at 1(V):3(H), and edge protection to reduce erosion is likely to be by means of rock armour.

8.2.10 Cleanfill Containment Cells

Geotechnical controls for the containment cell areas will vary slightly depending on the proposed end use of the land. Each of the containment cell areas will be capped by a layer of compacted engineered fill, likely to be comprised of crushed pea gravel. The intent is to form a stiff crust over the encapsulation cell that limits stormwater infiltration (through compaction) and meets the Geotechnical requirements for construction of NZS3604:2011 type dwellings, where relevant.

Potential issues associated with the containment cell from a Geotechnical perspective are future differential settlements. For the containment area below the stormwater corridor, the fill will not support future structural loads. Therefore, a 1 m thick capping layer is considered to be sufficient from a Geotechnical perspective.

Where the containment area is within a future residential area, the capping layer is proposed to be 1 to 2 m thick. Additional Geotechnical measures, such as incorporation of geotextiles and geogrid reinforcement may be included within the containment cell material and capping material, subject to the type and condition of actual materials placed in the containment cell. Other measures that are proposed to be implemented include screening and exclusion of large and organic inclusions (e.g. timber, wood fragments and topsoil) from the containment cell. Settlement monitoring, also proposed to be incorporated as part of the greater bulk earthworks, is recommended to be carried out at the containment cell areas. Finally, subject to the condition, type and extent of compaction achieved, the containment cell area may be pre-loaded to express any unwanted settlement prior to allowing installation of services and building construction.

Quality control measures to verify compaction of the containment cell materials will likely need to be altered from the rest of the bulk earthworks, subject to the actual type of materials. Suitable methods of testing, such as nuclear densometer, Scala Penetrometer, Impact hammer, or a combination of these, may be used to verify compaction targets are achieved during fill placement.

The requirement for geotextiles and geogrids, preloading and testing methods are best assessed on site during construction by the Geotechnical Engineer, once the materials to be encapsulated are exposed and able to be assessed.

8.3 Settlement Monitoring

Monitoring of completed filled areas using accurate survey measurements is recommended to be carried out.

Monitoring should continue until a trend in the data shows that primary settlements have been expressed, and that creeping settlements are either non-existent or negligible. Further it is recommended that areas containing the maximum height of fill should be constructed first, so that adequate monitoring periods can be allowed for in the development programme.

8.4 Preliminary Retaining Structures

The following broad recommendations may apply for the design of retaining structures, however we recommend that designers verify the geotechnical conditions and type of support prior to designing any structures with the Geotechnical Engineer.

8.4.1 General Design Considerations

The designer should allow for any other relevant surcharges that are likely to be imposed on the wall, including any relevant building, vehicle, backslope, toeslope and seismic loads.

Depending on the style of wall, toe drainage is likely to be required. Toe drainage should be connected into an approved stormwater disposal system.

We anticipate that the retained and foundation soils around future retaining walls will be engineered local materials or crushed pea gravel fill. The following moderately conservative geotechnical parameters are assessed for typical sandy gravel materials:

- Cohesion c’ 0 kPa
- Internal friction φ’ 32 degrees
- Unit weight γ 19 kN/m^3

8.4.2 Seismic Design Considerations

Reference should be made to the Ministry of Business, Innovation and Employment (MBIE) / New Zealand Geotechnical Society (NZGS) Earthquake Resistant Retaining Wall Design (Module 6 version 1) guidance issued in November 2021.

Seismic design calculations should be carried out for any walls that meet the criteria outlined in Module 6.

The site may be taken as Class IV and the topographic amplification factor may be taken as 1.0 in this case. The appropriate wall displacement factor (W_d) should be selected from Table 5.2 of Module 6.

The maximum peak ground acceleration (PGA) for various return periods for Cromwell is given in NZS1170.5:2025 Table 3.1 (part 49).

8.5 Future Subgrade, Foundation and Set Back Conditions

Final foundation recommendations for future dwellings are subject to developed/final design plans and the actual extent of earthworks. Factors to consider include excavation and fill depths, successful bulk earthworks construction, potential for settlement, proximity to slopes and material types.

Based on the findings of Geotago's preliminary investigations, the compaction trials completed to date and our understanding of the proposed earthworks, we anticipate the site conditions to be generally suitable for shallow foundation types for most light weight residential buildings and specifically designed commercial buildings, following successful bulk earthworks and remediation of currently unsuitable areas.

Any filled areas requiring specific design should be identified and documented upon completion of the earthworks. Similarly, excavated areas will need to be assessed following completion of earthworks such that appropriate foundation and pavement design recommendations can be made.

Any lots with unsupported batter slopes or retaining walls on the boundaries may be subject to foundation set-back distances. Set back distances should be applied to the crest of unsupported slopes, top of retaining walls and from the base of retaining walls to allow access for any future maintenance that may be required.

8.6 Preliminary Pavement Design CBR

Based on the field compaction trials completed to date, we consider that preliminary pavement design may be based on a CBR of at least 7, however some variation should be expected given the scale of the development.

Some stabilisation measures or specific pavement design may be needed where the final CBR values are lower than 7. These measures may involve additional compaction, aggregate or the use of geotextiles and/or geogrids incorporated into the roading basecourse and are best assessed on site during the earthworks programme.

8.7 Stormwater and Surface Water Management

Finished platform surfaces should be positively graded with appropriate slopes at all times to provide for efficient removal of surface water runoff and discharge to the approved stormwater disposal system. Therefore, finished grades should be sustained after completion of earthworks and areas potentially susceptible to minor slumping should be finished at slightly steeper gradients (such as 2.5 to 5%)

For future building reference, ponding of water should not be permitted near or under the future building areas, as well as foundation excavations and filled batters, at any time during or after construction. As a guide, surface gradients of 1 in 25 (4%) for a minimum distance of 1 m around the building perimeter are specified in NZS3604 for buildings with concrete slab foundations.

Additionally, to prevent surface runoff from entering building areas, perimeter berms or swales may be constructed as necessary at the top and bottom of slopes or across depressions to re-direct surface water into approved drainage systems.

8.8 Landscaping Areas

Landscaping areas that are proposed to be vegetated with trees etc., may require a different approach with respect to earthworks to facilitate proper growth and allow the survival of plants, as tightly compacted crushed gravel may not provide optimal growing conditions.

Therefore, consideration should be given to a more relaxed earthworks specification for the surficial layers at such areas.

8.9 Further Assessments and Reporting

Any areas that are identified as requiring further geotechnical assessment during the earthworks programme should be assessed by the Geotechnical Engineer of record prior to issuance of

S223/S224 certificates so that the appropriate scope of remedial work can be determined and implemented. Examples may potentially include, but are not limited to, areas with finished gradients greater than 1(V):3(H), areas requiring retaining walls that are likely to extend beyond single lot boundaries, areas containing loose, saturated silts and sands and areas containing previously unidentified existing fill.

Future lot specific geotechnical information is to be presented in a series of Geotechnical Completion Reports (publication of completion reports is likely to be staged in accordance with the earthworks stages). Any areas requiring further geotechnical assessment upon completion of earthworks will also be identified in these reports, as well as other lot specific geotechnical constraints, such as set back distances, retaining requirements, foundation types, CBR etc.

9 References

1. Turnbull, I.M 2000. Geology of the Wakatipu area. Institute of Geological and Nuclear Sciences1:250 000 geological map 18. 1 sheet plus 72 p. Lower Hutt, New Zealand: Institute of Geological and Nuclear Sciences Ltd.

2. GNS Webmap Institute of Geological and Nuclear Sciences 2013: 1:250,000 Geology. Viewed at: http://data.gns.cri.nz/geology/

3. Barrell DJA. 2019. General distribution and characteristics of active faults and folds in the Queenstown Lakes and Central Otago districts, Otago. Lower Hutt (NZ): GNS Science. 99 p. Consultancy Report 2018/207

4. Barrell DJA. 2025. Review and update of active geological fault and fold characterisation in the Otago region. Lower Hutt (NZ): Earth Sciences New Zealand. 55p. GNS Science Consultancy Report 2025/48. Prepared for Otago Regional Council.

5. Van Woerden, T., Welsh, A., Payan, J.L. 2025. Otago Active Fault Mapping and Fault Awareness Areas. Report No. HAZ2506 Prepared for the Science and Resilience Committee (ORC).

6. Howarth, J. D., Barth, N. C., Fitzsimons, S. J., Richards-Dinger, K., Clark, K. J., Biasi, G. P., Langridge, R. M., & Villamor, P. (2021). Spatiotemporal clustering of great earthquakes on a transform fault controlled by geometry. Nature Geoscience, 14(5), 314–320.

7. Opus Consultants Ltd 2005. Seismic Risk in the Otago Region, Report No. SPT:2004/23

8. Barrell DJA. 2019. Assessment of liquefaction hazards in the Queenstown Lakes, Central Otago, Clutha and Waitaki districts of the Otago Region. Lower Hutt (NZ): GNS Science. 99p. Consultancy Report 2018/67.

9. Grindley, J., Cox, S., Turnbull, I. 2009. Otago Alluvial Fans Project. Dunedin (NZ). Opus International Consultants Ltd. 64p Report No. 1205 – Version 2.

10. Rekker, J. 2012. Cromwell Terrace Aquifer Study. Dunedin (NZ). Resource Science Unit, Otago Regional Council.

11. Wells Aotearoa New Zealand. Viewed at https://wellsnz.teurukahika.nz/

12. Geotago Ltd. 2022. Preliminary Geotechnical Assessment for Proposed Residential Development. Report reference GL21-022.1. Prepared for Fulton Hogan Ltd.

13. Retrolens Historical Image Resource. Viewed at retrolens.nz.

14. Insight Engineering. 2025. Crushed Pea Gravel Compaction Trial, Parkburn Quarry. Report reference 24019_1. Prepared for Fulton Hogan Land Development Ltd.

15. Kerr, J., Nathan, S., Van Dissen, R., Webb, P., Brunsdon, D. and King A. 2003. Planning for Development of Land on or Close to Active Faults. Wellington (NZ). Institute of Geological & Nuclear Sciences client report 2002/124.

16. Ishihara, K. (1985). Stability of natural deposits during earthquakes. *Proceedings of the 11th International Conference on Soil Mechanics and Foundation Engineering*, San Francisco, CA, Vol. 1, 321–376. A.A. Balkema, Rotterdam, the Netherlands.

17. Insight Engineering. 2026. Remediation Action Plan for the Parkburn Quarry at 922 Luggate-Cromwell Road (SH6), Cromwell. Report reference 24019_RAP. Prepared for Fulton Hogan Land Development Ltd.

18. Look, BG., (2023). Earthworks Theory to Practice – Design and Construction. First Edition. CRC Press Taylor and Francis Group

10 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Fulton Hogan Land Development Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground conditions indicated from published sources, site assessments and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

Appendix 1

Peer Review Response Letter dated 16 July 2026

16 July 2026

Fulton Hogan Land Development Ltd
C/- Town Planning Group
Distributed via Sharepoint: Gregory Dewe
Daniel Thorne
Melanie Foote

Re: FHL Parkburn Development – Substantive Application Response to Geotechnical Peer Review

Our Reference: 24019_6

This letter is presented in response to the Geotechnical Peer Review which was completed by WSP New Zealand Ltd (WSP). Their review is presented in a letter dated 24 June 2026, reference number NZL-WSP-6-XH078.00.0215.

This document should be read in conjunction with our prior assessment report entitled *Geotechnical and Earthworks Assessment for Proposed Residential Subdivision at Parkburn Quarry, 922 Luggate-Cromwell Road (SH6), Cromwell*, our reference number 24019_3 V4. It should be considered as an addendum to our prior report.

We note that WSP are in general agreement with the geotechnical findings and conclusions presented in our assessment report, apart from the fact that a National Policy Statement (NPS) Natural Hazard risk assessment was not included. This assessment is therefore presented below, along with some clarifying remarks relating to the design of earthworks.

1 NPS Natural Hazard Risk Assessment

Natural hazards identified by our prior assessment related to seismicity, and alluvial fan and overland flow. As the assessment of the alluvial fan/overland flow flooding potential is outside of the scope of our work, we have excluded this hazard from the assessment.

A copy of the risk matrix from the NPS is presented as Appendix 1 of this letter.

1.1 Seismicity

Seismic effects may be considered as follows:

- Primary effects – ground shaking
- Primary effects – fault rupture
- Secondary effects – liquefaction and lateral spreading

Ground shaking has been excluded from the NPS as ground shaking is already regulated under the Building Act 2004 and the New Zealand Building Code. Therefore, we will consider only active faults/fault rupture, and liquefaction and lateral spreading.

1.1.1 Active Faults/Fault Rupture

The risk of fault rupture (directly affecting built structures or infrastructure) relates to the Pisa Fault Zone being the closest mapped feature to the site. The likelihood level of this event is “very rare” as the current understanding of the Pisa Fault Zone recurrence interval is 22,000 years (>5000 years).

The consequence level at the site is considered to be negligible. This is due to the distance of the site to the current mapped extents of the Pisa Fault Zone (including Fault Awareness Area) ranging between approximately 1.1 and 1.4 km, meaning that the development will not overlap these zones.

Therefore, the assessed matrix risk level for this hazard is *Low*.

1.1.2 Liquefaction

The soil types that are typically susceptible to liquefaction include normally consolidated, relatively young deposits of poorly graded sands, sandy silts, silty sands and fine gravels. Older deposits of well graded, medium dense to dense sands and gravels tend be less susceptible.

Additionally, unsaturated soils above the water table are generally not at risk of liquefaction. Sites with a non-liquefiable crust of at least 3 m deep are generally understood to be less susceptible to liquefaction induced damage at the surface than those with shallower groundwater tables or weak surficial soils.

Taking the above into account, as well as the proposed finished ground surface elevations which will be at least 4 m above the lake level, local geology and future engineered fill to be placed at the site, the overall potential for widespread liquefaction occurring at the site is considered to be low. Localised areas such as the settling ponds, which contain wet and soft deposits, may experience liquefaction if these areas remain unchanged. However, the settling ponds are proposed to be mitigated by earthworks and engineered fill before any dwellings or infrastructure are built over them, therefore removing the potential for liquefaction of these man-made features. Reference should be made to Section 7.1 of our prior report for similar discussion on potential seismic impacts and perceived liquefaction issues.

We have considered the potential and likely consequences for liquefaction at the site resulting from three potential seismic events, taking the above considerations into account:

Alpine Fault Rupture

The annual exceedance probability of the Alpine Fault is taken as between 0.33% and 2.7%. Therefore, this event is taken as being between *Unlikely* and *Likely* on the Likelihood Table.

Shaking intensity at the site is indicated to be MM6 using the Modified Mercalli Intensity scale according to the Otago Regional Council natural hazards portal. This level of ground shaking would be felt by all. Effects of MM6 shaking include difficulty walking steadily, objects falling from shelves, slight damage to some types of buildings, trees and bushes shake and loose material may be dislodged from sloping ground. However, considering the site conditions, widespread liquefaction damage is not expected.

Therefore, the consequence level is considered to be minor. The highest assessed matrix risk level is therefore *Medium*, for unmitigated site conditions.

For mitigated site conditions, including engineered fill to replace the settling pond materials and to increase the ground surface elevation above the lake level, the assessed matrix risk level is *Low*.

Pisa Fault Zone Rupture

As the Pisa Fault Zone has a long recurrence interval (>22,000 years) it is taken as *Very Rare* on the Likelihood Table.

Shaking intensity is not mapped on the ORC natural hazards portal for the Pisa Fault Zone, but MM9 shaking is expected to be exceeded for 1 in 2,500 year events. This level of ground shaking can heavily damage or destroy many buildings, houses not secured to foundations can slide off, ground cracking is conspicuous, and landsliding is possible on steep slopes. However, as the site is generally not susceptible to widespread liquefaction, the consequence level is considered to be minor.

The assessed matrix risk level is therefore *Low*.

Dunstan Fault Rupture

As for the Pisa Fault Zone, the Dunstan Fault Zone has a long recurrence interval of 8,200 years (>5,000 years). Therefore, this event is taken as *Very Rare* on the Likelihood Table.

Shaking intensity is indicated to be MM9. Therefore, anticipated effects are similar to those indicated for the Pisa Fault Zone.

The assessed matrix risk level is therefore *Low*.

1.1.3 Lateral Spreading

Lateral spreading is associated closely with liquefaction, and it is not expected to occur unless soil liquefaction is also occurring. Therefore, we conclude that the assessed risk of lateral spreading may be taken as the same as liquefaction.

For a scenario where an Alpine Fault rupture results in localised soil liquefaction, the assessed risk matrix level is *Medium* for unmitigated conditions. For mitigated site conditions, including engineered earthworks, slope stabilisation, retaining structures and set-back distances (as necessary), the assessed risk level is *Low*.

2 Further Geotechnical Assessment

It is our understanding that detailed geotechnical review, analysis and design of earthworks will be undertaken on a Stage by Stage basis before bulk earthworks commence. This is likely to include the design of benching, excavation and regrading of existing quarry walls, any incorporation of geotechnical reinforcement (e.g. geotextiles), construction methods (subject to fill materials) and planning of settlement monitoring.

It is our further understanding that specific geotechnical investigations will be undertaken to inform the detailed structural design of the Parkburn bridge, as a minimum.

We confirm that settlement monitoring is recommended in our prior report to be undertaken, and the results of the monitoring programme should be used to inform the suitability of filled land for future residential construction, or alternatively, other engineering measures to appropriately mitigate potential settlement impacts on the future development.

3 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Fulton Hogan Land Development Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground and material conditions indicated from published sources, inspections and tests described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site and material characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

Report prepared by



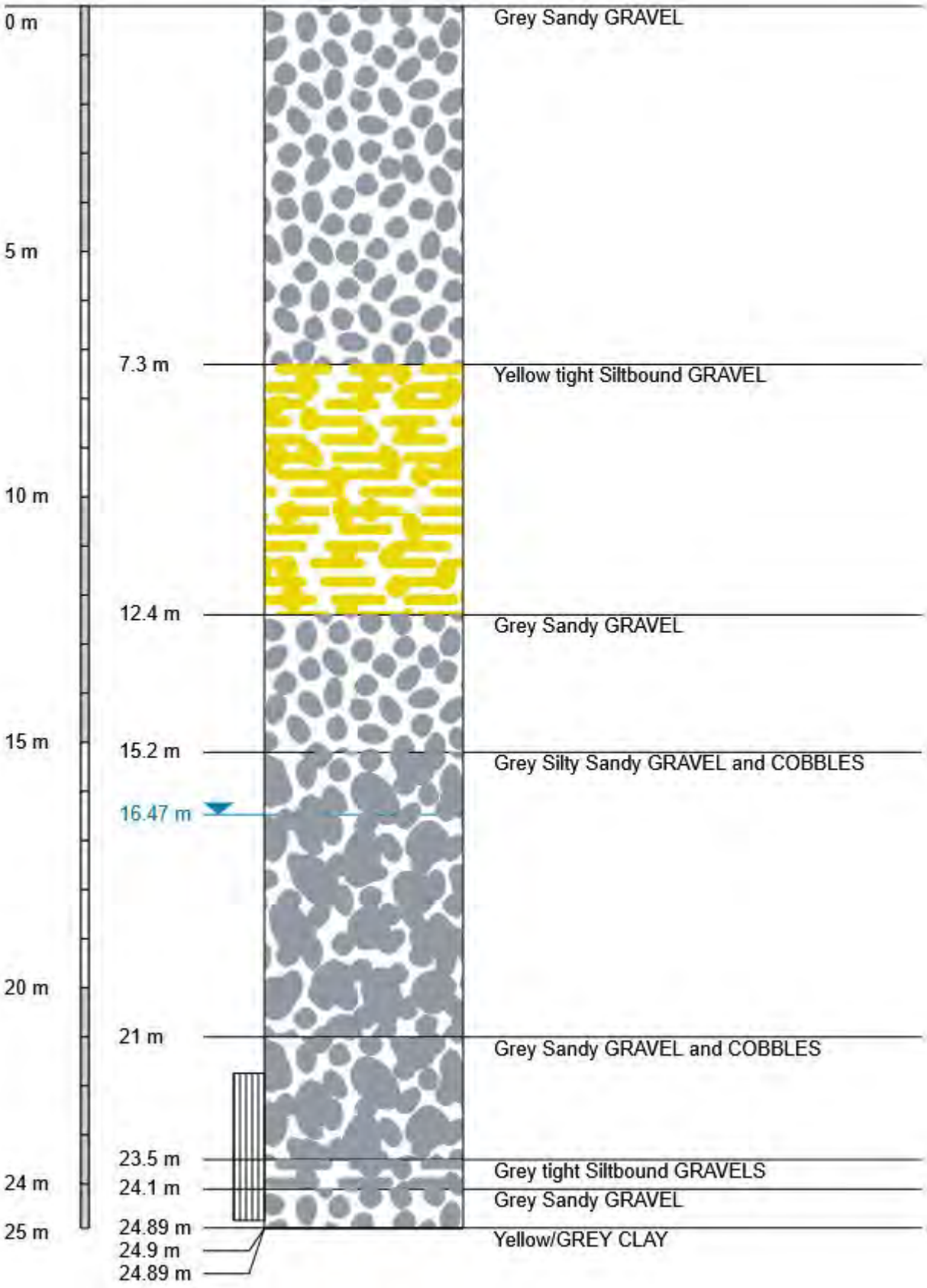
Jana Kruyshaar, CMEngNZ, MIPENZ
Principal Geotechnical Engineer

Appendix 1 – Copy of NPS Natural Hazards Risk Matrix

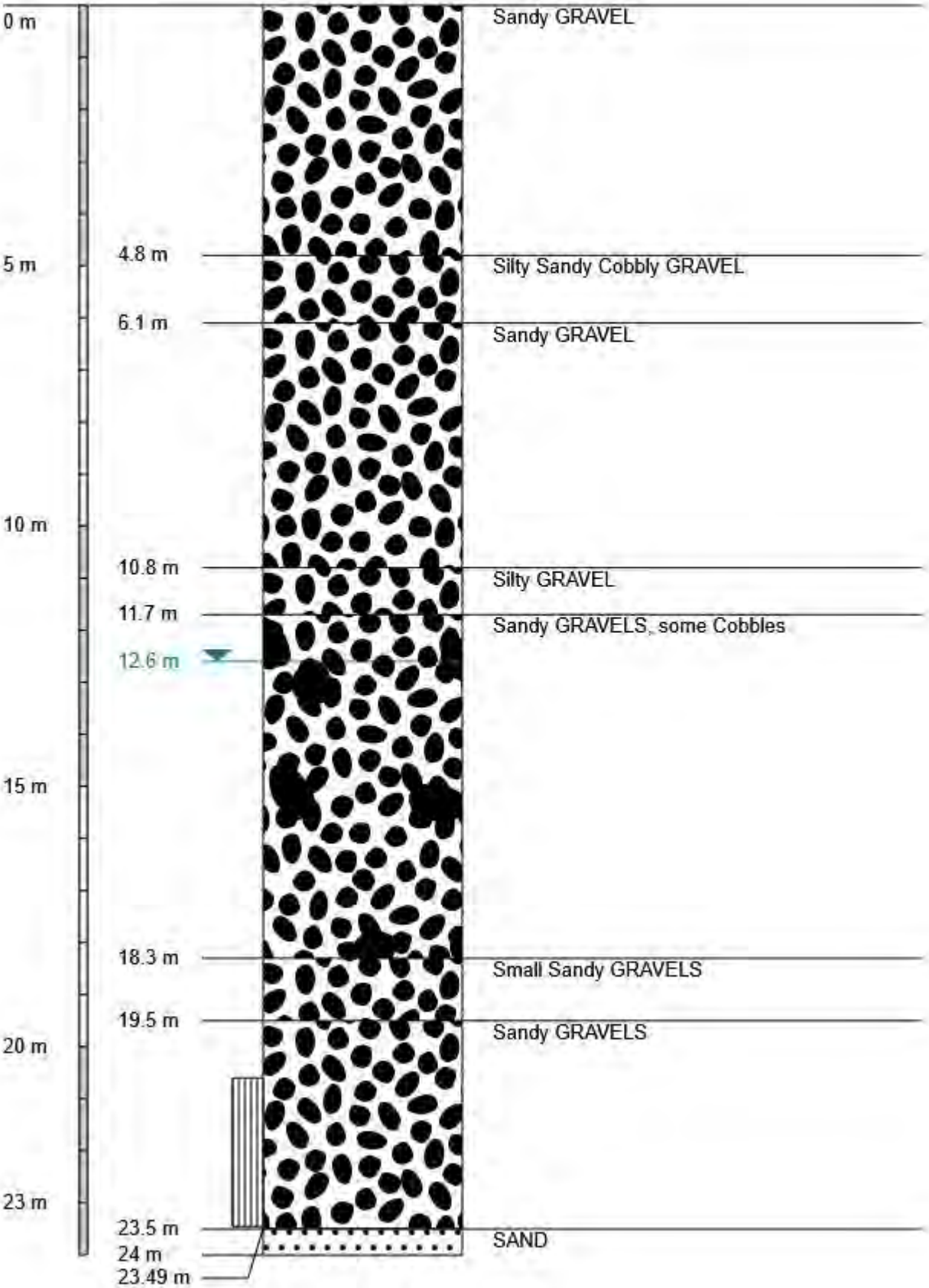
Appendix 2

Well Lithology Records

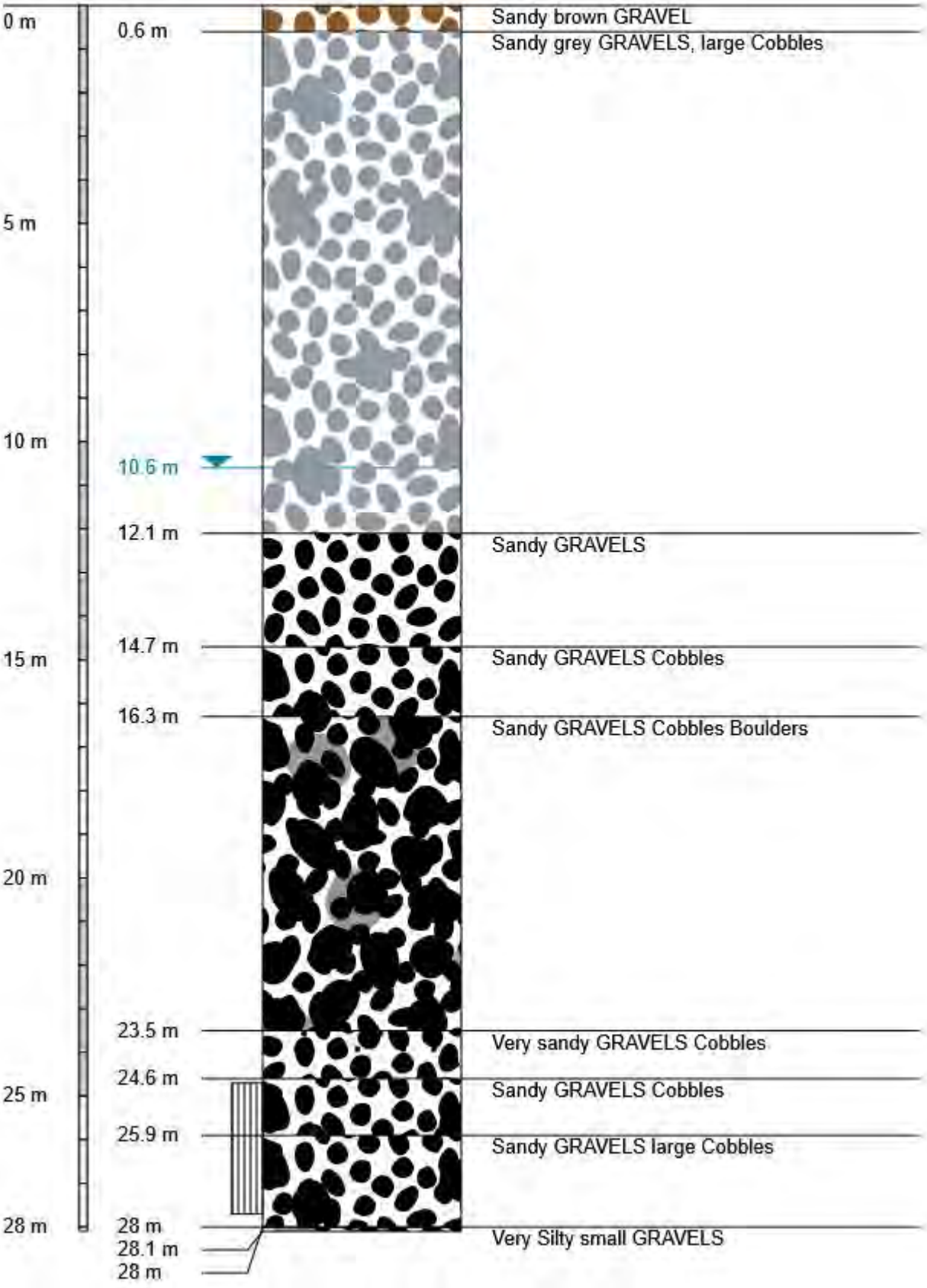
Council well number : G41/0113
Well name : -
Drilling company : McNeill Drilling
Drilling date : 12/08/1992
Drilling method : Rotary/Percussion
Locality : -
Total depth drilled : 24.89m
NZTM : 1304746 : 5014765



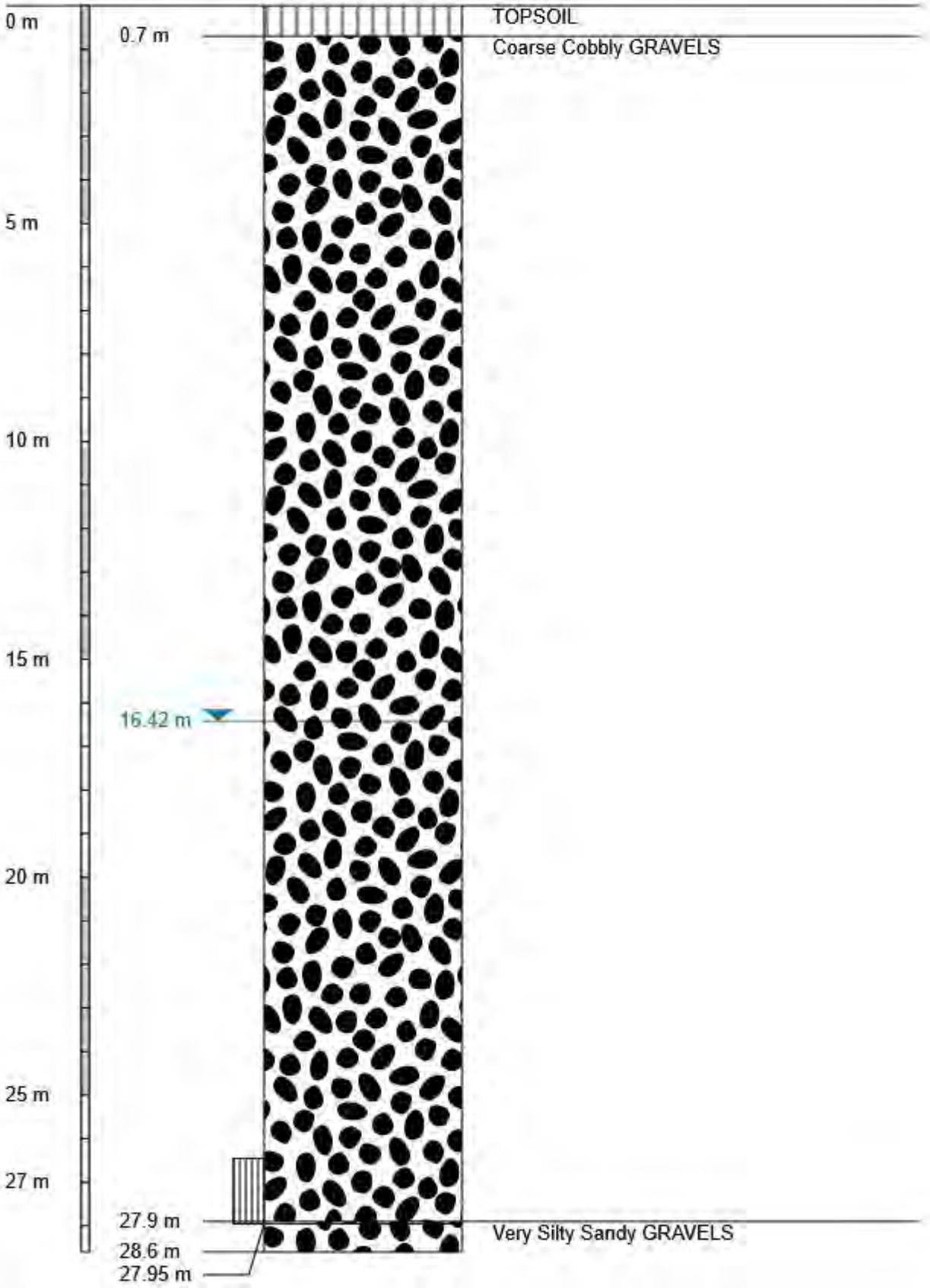
Council well number : G41/0115
Well name : -
Drilling company : McNeill Drilling
Drilling date : 06/01/1994
Drilling method : (unknown)
Locality : -
Total depth drilled : 23.49m
NZTM : 1303935 : 5014058



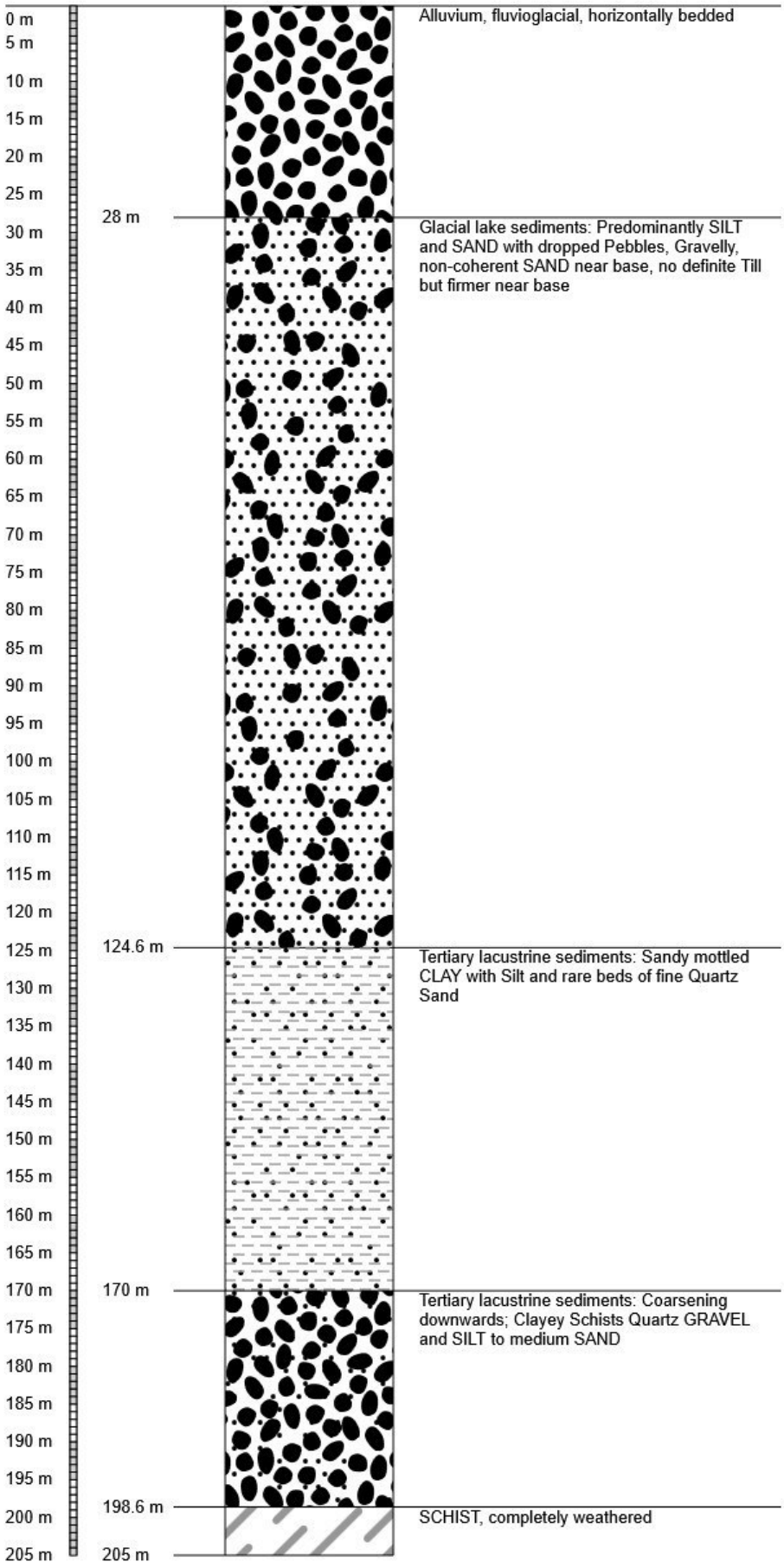
Council well number : G41/0301
Well name : -
Drilling company : McNeill Drilling
Drilling date : 09/01/2003
Drilling method : Cable Tool
Locality : Mount Pisa
Total depth drilled : 28m
NZTM : 1304283.33 : 5013954.88



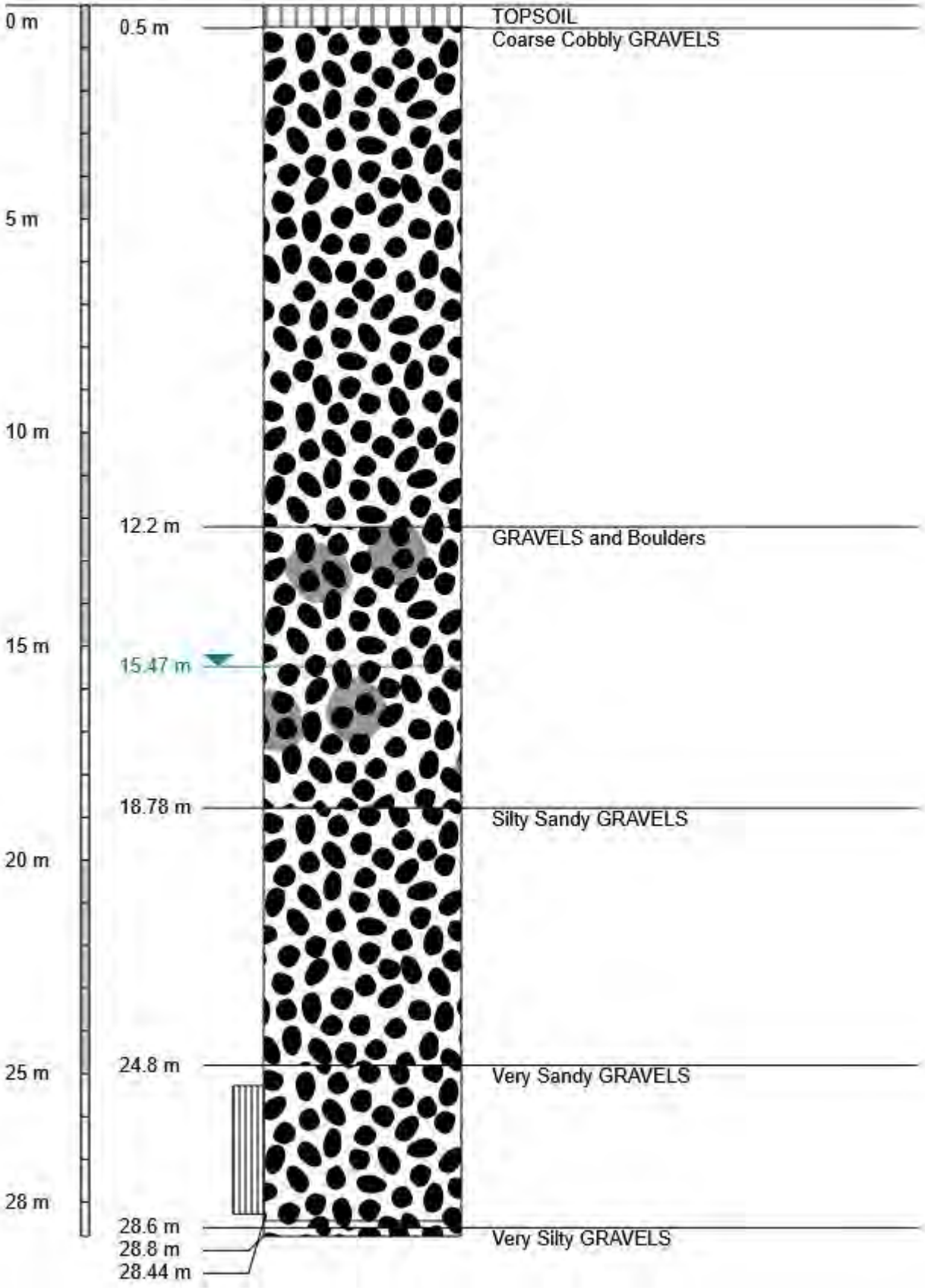
Council well number : G41/0199
Well name : -
Drilling company : McNeill Drilling
Drilling date : 25/11/1999
Drilling method : (unknown)
Locality : -
Total depth drilled : 27.95m
NZTM : 1303799.63 : 5014325.75



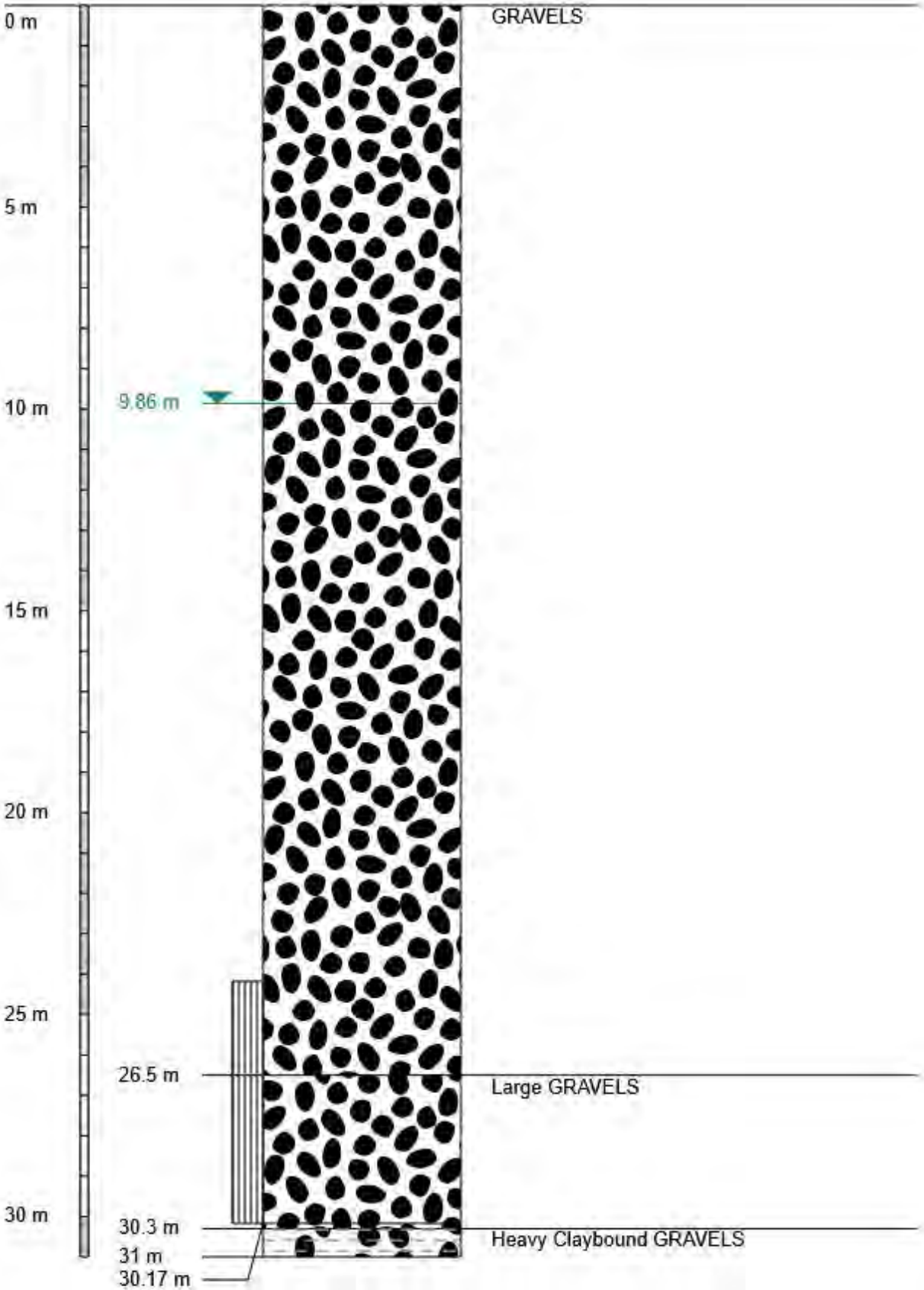
Council well number : G41/0004
Well name : -
Drilling company : -
Drilling date : 01/10/1978
Drilling method : (unknown)
Locality : -
Total depth drilled : 205m
NZTM : 1304801.37 : 5014369.66



Council well number : G41/0215
Well name : -
Drilling company : McNeill Drilling
Drilling date : 05/05/2000
Drilling method : (unknown)
Locality : -
Total depth drilled : 28.44m
NZTM : 1303615.91 : 5013834.2



Council well number : G41/0459
Well name : -
Drilling company : McNeill Drilling
Drilling date : 17/11/2015
Drilling method : Dual Rotary
Locality : -
Total depth drilled : 30.17m
NZTM : 1304356 : 5013954



Appendix 3

Geotago Ltd Site Plans and Test Pit Logs



geotago
Engineering Geology & Geotechnics

FULTON HOGAN

PARKBURN QUARRY, MOUNT PISA

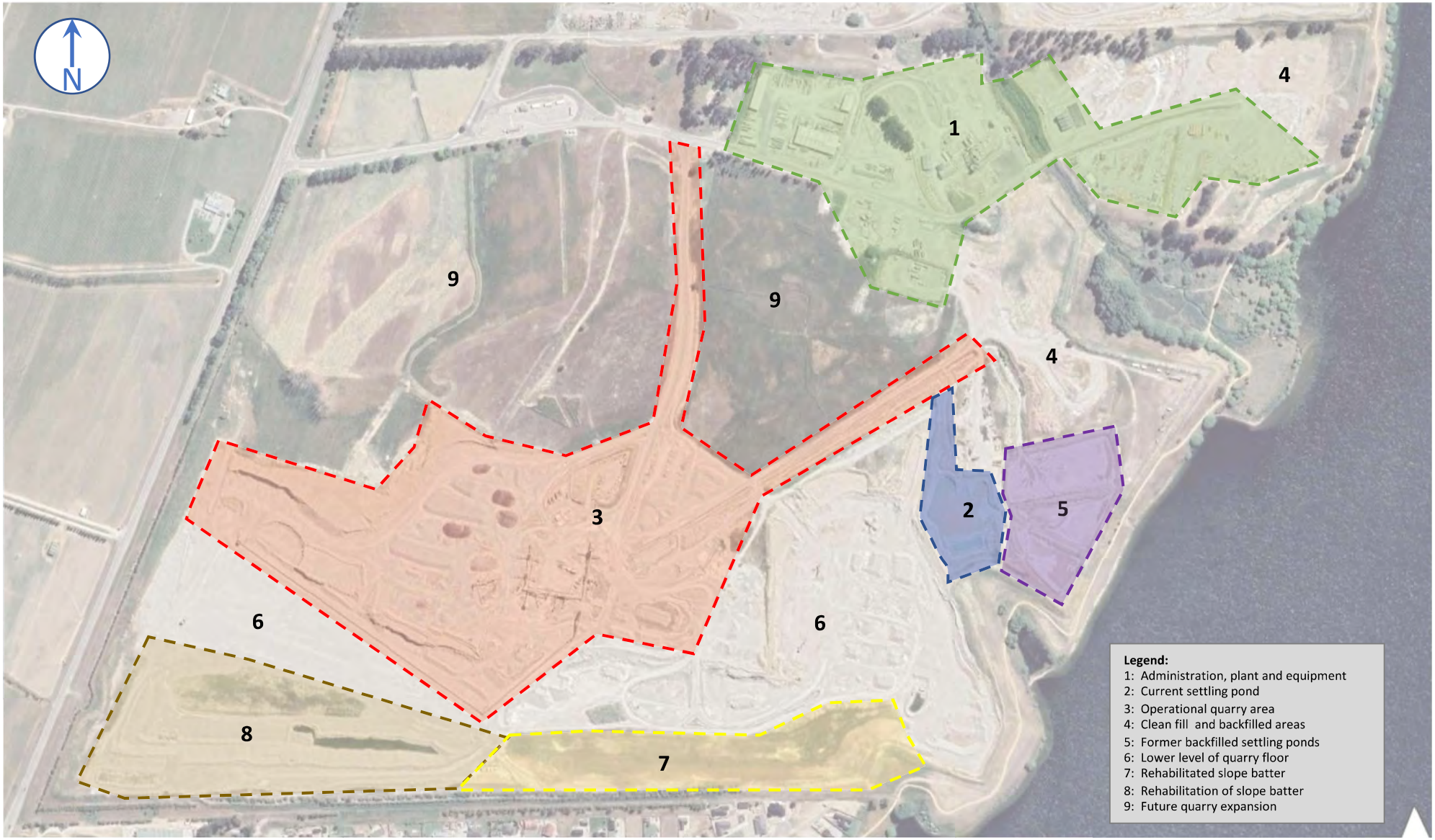
SITE INVESTIGATION PLAN

SCALE: 1:7000 APPROX

0m 280m

REF: 21-022.1 DRW002

DATE: 23 FEBRUARY 2022



geotago
Engineering Geology & Geotechnics

FULTON HOGAN

PARKBURN QUARRY, MOUNT PISA

SITE MODEL

SCALE: 1:7000 APPROX

0m 280m

REF: 21-022.1 DRW003

DATE: 23 FEBRUARY 2022

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP101		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		FILL		Sand with gravels, light brown. Tightly packed, dry. Sand coarse grained, gravels fine grained subangular to subrounded (CRUSHER DUST)		
0.5		OUTWASH DEPOSITS		Sandy GRAVEL with cobbles and occasional small boulder, greyish brown. Loose to tightly packed, dry. Sand coarse grained, gravels well graded subangular to subrounded. Cobble subrounded. Strong water ingress from 1.0m depth.		0.5
1.0	▽					1.0
				End of pit due to water table.		
1.5						1.5
2.0						2.0
2.5						2.5
3.0						3.0
3.5						3.0

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T:
E:
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP102		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		TOPSOIL		Sandy SILT, with organic content, roots and rootlets.		
0.5		FILL		Sand with gravels, light brown. Tightly packed, dry. Sand coarse grained, gravels fine grained subangular to subrounded (CRUSHER DUST)		0.5
1.0		OUTWASH DEPOSITS		Sandy GRAVEL with cobbles and occasional small boulder, greyish brown. Loose to tightly packed, dry. Sand coarse grained, gravels well graded subangular to subrounded. Cobble subrounded. Storng water ingress at 1.8m.		1.0
1.5	▽					1.5
2.0				End of pit due to water table		2.0
2.5						2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T:
E:
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP103		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		FILL		Sand with gravels, light brown. Tightly packed, dry. Sand coarse grained, gravels fine grained subangular to subrounded (CRUSHER DUST)		
0.5		OUTWASH DEPOSITS		Sandy GRAVEL with cobbles and occasional small boulder, greyish brown. Loose to tightly packed, dry. Sand coarse grained, gravels well graded subangular to subrounded. Cobble subrounded. Water ingress at 1.6m.		0.5
1.0						1.0
1.5	▽					1.5
2.0				End of pit due to water table		2.0
2.5						2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T:
E:
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP104		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		TOPSOIL		Sandy SILT, with organic content, roots and rootlets.		
0.5		LOESS		SILT, light brown. Tightly packed, dry.		0.5
1.0		OUTWASH DEPOSITS		Sandy GRAVEL with cobbles and occasional small boulder, greyish brown. Loose to tightly packed, dry. Sand coarse grained, gravels well graded subangular to subrounded. Cobble subrounded.		1.0
1.5						1.5
2.0						2.0
2.5				End of pit - Stable		2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T: [redacted]
E: [redacted]
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP105		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		TOPSOIL		Sandy SILT, with organic content, roots and rootlets.		
0.5		OUTWASH DEPOSITS		Sandy GRAVEL with cobbles and occasional small boulder, greyish brown. Loose to tightly packed, dry. Sand coarse grained, gravels well graded subangular to subrounded. Cobble subrounded.		0.5
1.0						1.0
1.5						1.5
2.0						2.0
2.5				End of pit - stable		2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T:
E:
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP106		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		TOPSOIL		Sandy SILT, with organic content, roots and rootlets.		
0.5		OUTWASH DEPOSITS		Sandy GRAVEL with cobbles and occasional small boulder, greyish brown. Loose to tightly packed, dry. Sand coarse grained, gravels well graded subangular to subrounded. Cobble subrounded.		0.5
1.0						1.0
1.5						1.5
2.0						2.0
2.5				End of pit - stable		2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T: [redacted]
E: [redacted]
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP107		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		TOPSOIL		Sandy SILT, with organic content, roots and rootlets.		
0.5		LOESS		SILT, light brown. Tightly packed, dry.		0.5
1.0		OUTWASH DEPOSITS		Sandy GRAVEL with cobbles and occasional small boulder, greyish brown. Loose to tightly packed, dry. Sand coarse grained, gravels well graded subangular to subrounded. Cobble subrounded.		1.0
1.5						1.5
2.0						2.0
2.5				End of pit - stable		2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T:
E:
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP108		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
0.5		UNCONTROLLED FILL		Sandy silty GRAVELS with cobbles and occasional extraneous materials (wood, plastic, concrete). Grey brown. Tightly packed, dry.		0.5
1.0				Sandy silt with roots, rootlets and decaying plant matter		
1.5				Sandy GRAVEL, light browish grey. Very loosely packed, dry. Gravels 5-8mm in diameter. ('PEAS')		1.0 1.5
2.0						2.0
2.5				End of pit - collapsing in due to pea gravel		2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T:
E:
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP109		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		TOPSOIL		Sandy SILT, with organic content, roots and rootlets.		
0.5		UNCONTROLLED FILL		Sandy GRAVEL, light browish grey. Very loosely packed, dry. Gravels 5-8mm in diameter. ('PEAS')		0.5
1.0						1.0
1.5						1.5
2.0						2.0
2.5				End of pit - collapsing in the pea gravel		2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T: [redacted]
E: [redacted]
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP110		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		TOPSOIL		SILT, light brown. Tightly packed, dry.		
0.5		UNCONTROLLED FILL		Sand with gravels, light brown. Tightly packed, dry. Sand coarse grained, gravels fine grained subangular to subrounded (CRUSHER DUST)		0.5
1.0				Sandy GRAVEL, light browish grey. Very loosely packed, dry. Gravels 5-8mm in diameter. ('PEAS')		1.0
1.5						1.5
2.0						2.0
2.5				End of pit - collapsing in pea gravels		2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T: [redacted]
E: [redacted]
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP111		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		TOPSOIL		Sandy SILT, with organic content, roots and rootlets.		
0.5		LOESS		SILT, light brown. Tightly packed, dry.		0.5
1.0		OUTWASH DEPOSITS		Sandy GRAVEL with cobbles and occasional small boulder, greyish brown. Loose to tightly packed, dry. Sand coarse grained, gravels well graded subangular to subrounded. Cobble subrounded.		1.0
1.5						1.5
2.0						2.0
2.5				End of pit - stable		2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T:
E:
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Test Pit Log

Project:	Parkburn Masterplan	Project Number:	GL21-022
Site Location:	Parkburn Quarry, Mount Pisa	Client:	Fulton Hogan
Test Pit Number:	TP112		Sheet 1 of 1

Depth (m)	Water Level	Geological Unit	Sample	Soil Rock Description	Legend	Depth
		TOPSOIL		Sandy SILT, with organic content, roots and rootlets.		
0.5		LOESS		SILT, light brown. Tightly packed, dry.		0.5
1.0						1.0
1.5		OUTWASH DEPOSITS		Sandy GRAVEL with cobbles and occasional small boulder, greyish brown. Loose to tightly packed, dry. Sand coarse grained, gravels well graded subangular to subrounded. Cobble subrounded.		1.5
2.0						2.0
2.5				End of pit - stable		2.5
3.0						3.0
3.5						3.5

Date Excavated: 22 February 2022	Equipment: 35T tracked excavator with 1200mm tooth bucket
Logged By: PF	Contractor: Fulton Hogan

Geotago Ltd
Arrow Junction
Queenstown 9371
New Zealand

T: [redacted]
E: [redacted]
W: www.geotago.nz

geotago
Engineering Geology & Geotechnics

Notes:

Appendix 4

Crushed Pea Gravel Compaction Trial Report (2025)

3 November 2025

Fulton Hogan Land Development Ltd
C/- Tim James
Via email: [redacted]
CC:

Re: Crushed Pea Gravel Compaction Trial, Parkburn Quarry

Our Reference: 24019_1

1 Introduction and Scope of Report

JKCM Ltd, trading as Insight Engineering (IE), was requested to arrange a field compaction trial of crushed pea gravels sourced from Parkburn Quarry, using a hardfill plateau density test procedure.

This letter presents the methods used to complete the trial and results including relative compaction and water content, as well as estimations of volumetric compression of the crushed pea gravel. We also present our opinion on the use of this material as a bulk fill material, based on the trial and test results.

2 Methodology

2.1 Location and Operators

The field compaction trial was carried out at the Fulton Hogan Miners Road Quarry in Christchurch. Machinery and operators used in the trial were supplied by Fulton Hogan, and field density testing was carried out by Fulton Hogan Canterbury Laboratory.

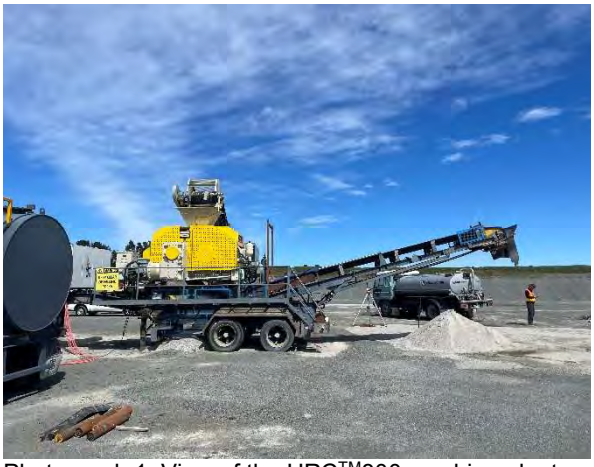
2.2 Hardfill Materials

The materials used in the trial were comprised of pea gravel which was transported from Parkburn Quarry. The pea gravel was crushed using a high pressure grinding roll crusher (HRC^{TM}800), operating at a rate of approximately 90 ton/hour. The crushed gravel product is represented by the Particle Size Distribution plot presented as Appendix 1 to this letter. Based on this plot, the crushed product can be described as sandy, silty, fine to medium GRAVEL.

The sand and gravel fragments were observed to be typically sub-rounded to angular following crushing.

The crushed gravel was generally dry to moist when taken from the stockpile, and water had to be added prior to compacting. Water was sprayed from a water truck for around 5-10 seconds for each trial hardfill pad.

Figure 1: Materials Photographs



Photograph 1: View of the HRC^{TM}800 crushing plant and showing a small stockpile of crushed gravel.



Photograph 2: View of a sample of crushed gravel

2.3 Base Preparation

The ground surface within the quarry where the trial pads were to be formed was very hard. Therefore, to simulate less favourable base conditions, the subgrade was excavated to a depth of approximately 0.4 m. Crushed pea gravel was used to backfill the excavation. The crushed gravel was lightly compacted using 4 single passes of a 15.5T vibrating drum roller.

This resulted in a relatively firm base with a dry density of 1.64 t/m^3.

Figure 2: Base Preparation Photographs



Photograph 3: Over-excavation of the base.



Photograph 4: View of the prepared base prior to formation of the trial hardfill pads.

2.4 Trial Hardfill Pads

The trial hardfill pads were constructed on top of the prepared base. Due to the limited quantity of crushed gravel available, only one hardfill pad could be constructed and tested at a time. The width and length of each pad was approximately 3 m and 5 m respectively.

Trial pad 1 was formed using a 0.4 m thick loose layer of crushed gravel.

Trial pad 2 was formed using a 0.5 m thick loose layer of crushed gravel.

Trial pad 3 was formed using a 0.6 m thick loose layer of crushed gravel.

2.5 Compaction and Testing

Each pad was prepared, compacted and testing following the same methodology.

Compaction was achieved with a 15.5T vibrating drum roller. Initial compaction involved four single passes of the roller (i.e. a pass was recorded as one way, not back and forth). Nuclear Density testing (NDM) on backscatter mode was carried out after the initial four single passes, and then after every two single passes until a plateau was achieved for each hardfill pad. Static rolling was then carried out with testing completed at the same intervals until a plateau was again achieved.

Additional NDM testing using the Direct Transmission method was carried out upon completion of compaction on each trial pad to measure the dry density at depths of 250mm, 150mm and 100mm below the surface of the hardfill pads.

Supplementary testing to correlate the *insitu* CBR was undertaken using an Impact Tester (Clegg Hammer).

Additionally, upon completion of the plateau testing on the third trial pad (600 mm thick loose layer), we completed two Light Weight Deflectometer tests (LWD) to estimate the stiffness of the compacted hardfill layer.

Figure 3: Compaction and Testing



Photograph 5: Trial pad 1 prior to compaction.



Photograph 6: Testing of Trial pad 3.

3 Results

The plateau test results are presented as Appendix 2 of this letter. The laboratory Standard Compaction test result is presented as Appendix 3.

3.1 Dry Density

The laboratory compaction test indicates a maximum dry density (MDD) of 2.06 t/m^3 with an optimal water content of 6%.

The plateau tests give the field maximum dry density (field MDD) of the crushed gravel as used in the trial. The field MDD is taken as 2.07 t/m^3 from the Plateau Test #2 result, which relates to 18 single passes of the compactor (or 9 passes back and forth). The water content of the hardfill pad was recorded as 3.7% during the trial.

Dry density results from the direct transmission tests for all three trial pads were equal to or exceeding 95% of the laboratory MDD, which equates to 1.96 t/m^3.

3.2 CIV and CBR

The impact value (CIV) was generally returned as 10 to 15 following 10 single passes of the roller. This value correlates[1] to an estimated CBR of 7%.

3.3 Light Weight Deflectometer

The dynamic modulus is indicated by the LWD, and for the trial hardfill pad the modulus values were returned as approximately 24 and 26 MN/m^2.

3.4 Compression of the hardfill pads

Compression of the hardfill following compaction was estimated by recording pre-compaction elevations of each trial pad using a dumpy level. The elevations were recorded again once the compaction and plateau testing of each trial pad was completed.

Trial pad 1 was compressed by an estimated 100 to 150mm.

Trial pad 2 was compressed by an estimated 140 to 200 mm.

Trial pad 3 was compressed by an estimated 150 mm.

It should be noted that these quantities are estimates only and lateral displacement may have also contributed to the overall vertical compression. It was not possible to estimate lateral displacement with any accuracy during the trials.

4 Discussion on Results

The field MDD obtained from the plateau tests is greater than the laboratory MDD. This is likely due to the field machinery being able to provide a higher compactive effort than the standardised laboratory equipment. However, the difference between the field and laboratory MDD is not considered to be significant in this case, and therefore minimum target dry densities of 95% or 98% (subject to fill volume, thickness and final land use) should be achievable in the production of bulk fill using crushed pea gravel.

From the trials, we consider that the optimal case for compaction is likely to be achieved using loose layers of 500 mm (as indicated by plateau test #2), providing that similar sized compaction machinery is used. Our reasoning for this conclusion is based on the number of passes to achieve the field MDD and water content, as well as the results of the direct transmission tests. Note that the plateau test indicated 18 single passes which can also be taken as 9 passes back and forth.

It is our opinion that adequate compaction is also likely to be achievable using loose layers of 600 mm thick. However, more water and suitably heavy (greater than 15T) compaction machinery moving at low speeds is likely to be required to achieve consistent results, which may be less efficient.

It is interesting to note that the results from plateau test # 1 (for the 400 mm thick loose layer) are less optimal than for #2. We anticipate that this is likely due to the prepared base, which had stiffened up during plateau test # 1, therefore providing slightly more favourable conditions for plateau test # 2. Therefore, for future areas where the bulk fill is placed over less favourable subgrade, thinner loose layers may be more appropriate to ensure adequate compaction is achieved throughout the fill layer.

[1] CBR = 0.07 x (CIV)^2 and CBR = (0.24 x CIV+1)^2

Volumetric compression of the hardfill pads were typically indicated to be around 25% but potentially up to 40%. However, as indicated above we are unclear how much lateral displacement has contributed to the compression.

The Impact Test results indicated that a CBR of 7 is likely to be achievable where the appropriate degree of compaction is carried out. The laboratory soaked CBR tests results indicate significantly higher values, however in this case we consider it is prudent to refer to the field test results over the laboratory results.

The LWD indicated dynamic modulii of 24 and 26 MN/m^2 for the third hardfill pad (600 mm loose layer thickness). This result indicates a moderately stiff subgrade is likely to be achieved, which is generally in keeping with our assessment of the field CBR from the Impact Test and the achieved dry density values.

5 Other Considerations

The crushed gravel is likely to be produced as a uniform, consistent product which allows for more efficient on site quality controls during bulk earthworks. Gravel processed at Parkburn Quarry is likely to be drier than materials used for the trials, and addition of water must be allowed for, both for compaction and for dust control.

Wet weather conditions are unlikely to significantly disrupt fill placement activities using crushed pea gravel.

Larger compaction machinery could be more efficient, requiring fewer passes and potentially allowing for thicker loose layers. Further trials to refine the earthfilling specification could be carried out at Parkburn in the future with actual machinery proposed to be used, as was done for Pembroke Heights.

In addition to the volumetric compression, settlement of fill due to self weight is a potentially complex issue that should require further assessment, particularly given the large volumes of fill proposed to be greater than 6 m thick. This is estimated to potentially range between 0.5 and 2 % of the total fill thickness, subject to the quality of the fill and time taken to construct. Potential options to mitigate effects of fill settlement may involve temporarily over-filling fill areas to induce settlement, prior to constructing pavements, services and final surfaces etc. It should also be noted that the trial was carried out at a water content that is less than optimal, based on the laboratory compaction test. This may have an impact on the overall air voids after compaction, which may also contribute to settlement.

The pea gravel is expected to be relatively durable and chemical or other weathering in the long term, that could potentially compromise the material as a fill product is not anticipated to be an issue. However, for confirmation, we recommend that mineralogical and aggregate testing is carried out on a representative sample of pea gravel.

Landscaping areas that are proposed to be vegetated with trees etc., may require a different approach to facilitate proper growth and allow the survival of plants, as tightly compacted crushed gravel may not provide optimal growing conditions.

6 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Fulton Hogan Land Development Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground and material conditions indicated from published sources, inspections and tests described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site and material characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

Report prepared by



Jana Kruyshaar, CMEngNZ, MIPENZ
Principal Geotechnical Engineer

Appendix 1: Laboratory Particle Size Distribution Test Result

Appendix 2: Plateau Testing Results

Appendix 3: Laboratory Standard Compaction Test Result

Appendix 1

Laboratory Particle Size Distribution Test Result

Work Order ID: CAN25W7644

Canterbury Laboratory
24 Miners Road, Templeton, Christchurch
PO Box 16-064, Christchurch 8441
Telephone: +64 3 349 9142
www.fultonhogan.com
0800 LABORATORY

Material Test Report

Report No: MAT:CAN25S-21825
Issue No: 1

Client:
Cant Land Resource
Corner Main South & Halswell Junction Rd
Hornby

Christchurch 8042
NZ

Project: 251706 Parkburn Quarry-Cant Land Resource SWO INT

The tests reported herein (unless otherwise indicated) have been performed in accordance with the laboratory's scope of accreditation. Samples are tested as received, in natural condition, unless stated otherwise in the comments. This report may only be reproduced in full.

The results in this report relate only to the items / samples that were tested

Approved Signatory: Liam Brennan
(Laboratory Operations Manager)
IANZ Accreditation No:200
Date of Issue: 29/10/2025

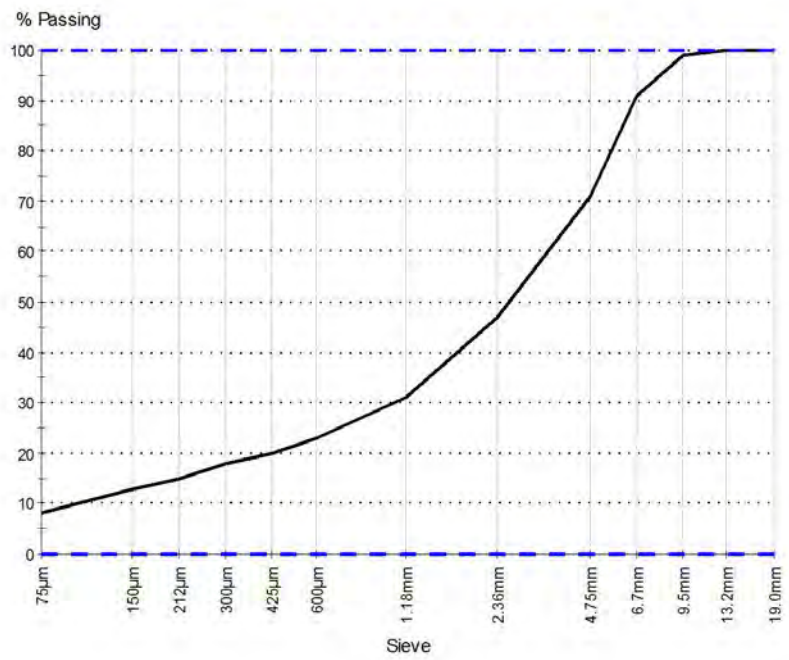
Sample Details

Sample ID:	CAN25S-21825
Client Sample ID:	QA Testing
Material:	Crusher Dust
Sample Source:	Miscellaneous Material Source
Site/Sampled From:	Miners Rd West ,ex Parkburn Quarry Trial Pad
Date Sampled:	22/10/2025
Specification:	No Specification
Sampled By:	Liam Brennan
Sampling Method:	NZS 4407:2015 2.4.6.3.2 (SP/WG/MACHINE)
Technician:	Amanda Ryan
Sampling Endorsed?:	Yes

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: NZS 4407:2015 Test 3.8.2
Drying By: Oven
Date Tested: 27/10/2025
Tested By: Amanda Ryan

Sieve Size	% Passing	Limits
19.0mm	100	0 – 100
13.2mm	100	0 – 100
9.5mm	99	0 – 100
6.7mm	91	0 – 100
4.75mm	71	0 – 100
2.36mm	47	0 – 100
1.18mm	31	0 – 100
600µm	23	0 – 100
425µm	20	0 – 100
300µm	18	0 – 100
212µm	15	0 – 100
150µm	13	0 – 100
75µm	8	0 – 100

Comments

N/A

© 2000-2025 QESTLab by SpectraQEST.com

Appendix 2

Plateau Test Result

Canterbury Laboratory
24 Miners Road, Templeton
PO Box 16 064, Hornby
Christchurch
Phone (03) 349 9142
Email:
cantlab@fultonhogan.com
0800 LABORATORY

Plateau Test Report

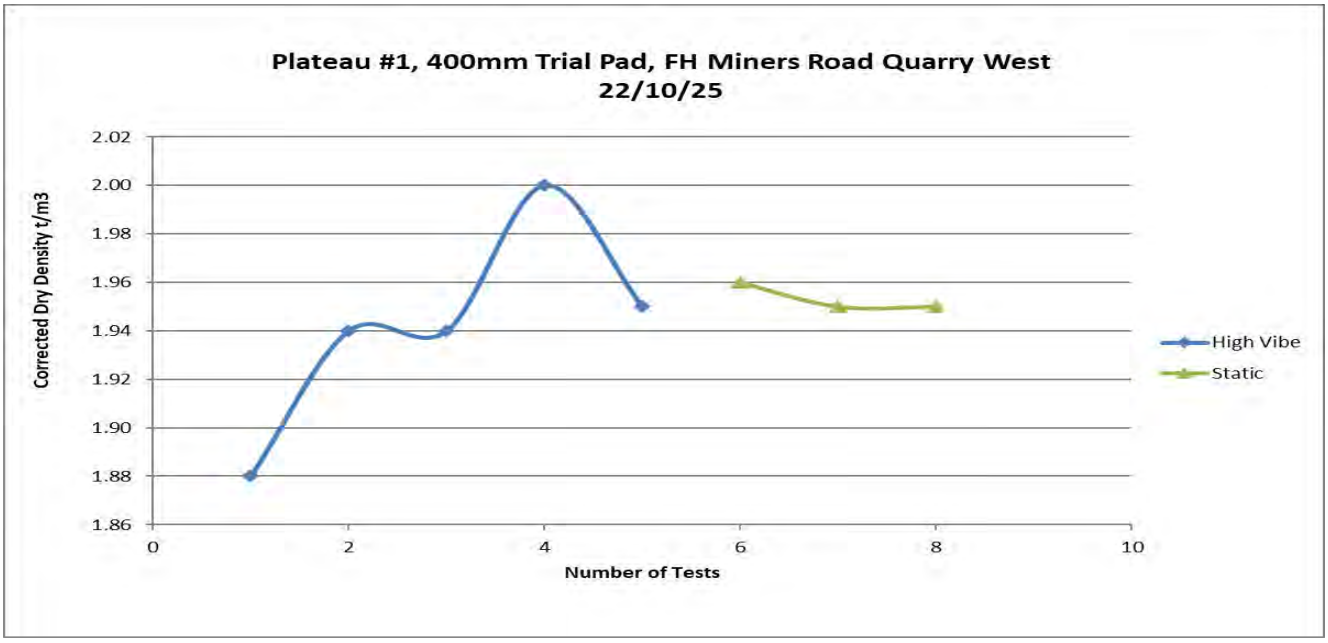
Client:	Cant Land Resource	**Report No:**	**CAN25W7541**
Project:	**2500173W3017512**	**Issue No:**	**1**

Testing Details	
Site Tested:	400mm Trial Pad, FH Miners Road Quarry West
Tested by:	Liam Brennan
Date:	22/10/25
Time Tested:	09:00am
Material:	Crushed Parkburn Quarry Pea Gravel
Field Method:	NZS 4407:2015 Test 4.3
Lab Method:	NZS 4407:2015 Test 3.1

Plateau Test #1

Test Results					
Test No.	**Passes**	**Roller Used**	**Compaction Stage**	**Dry Density (t/m³)**	**Average Moisture Content (%)**
1	**4**	**15.5T Construction Roller**	**High Vibe**	1.88	**3.1**
2	**2**			1.94	
3	**2**			1.94	
4	**2**			**2.00**	
5	**2**			1.95	
6	**2**		**Static**	1.96	
7	**2**			1.96	
8	**2**			1.95	

Please note: One pass is in a single direction over the test spot.



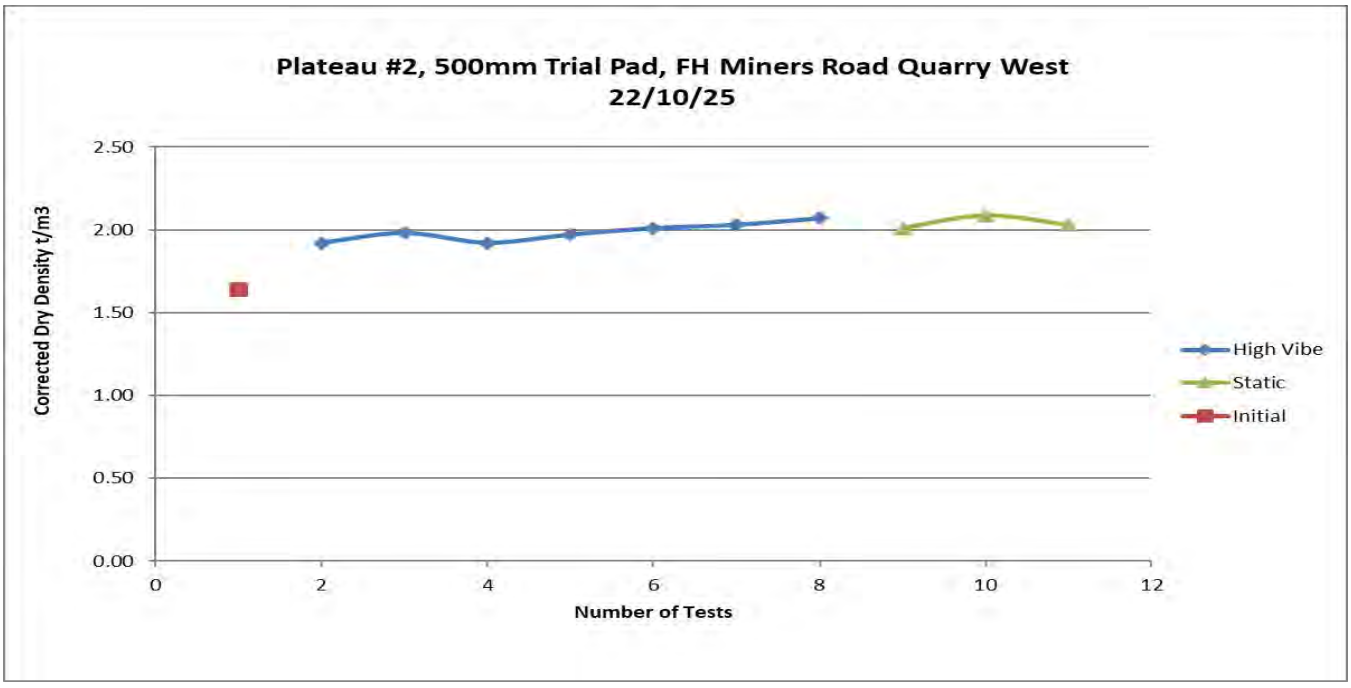
Canterbury Laboratory
24 Miners Road, Templeton
PO Box 16 064, Hornby
Christchurch
Phone (03) 349 9142
Email:
cantlab@fultonhogan.com
0800 LABORATORY

Testing Details	
Site Tested:	500mm Trial Pad, FH Miners Road Quarry West
Tested by:	Liam Brennan
Date:	22/10/25
Time Tested:	10:00am
Material:	Crushed Parkburn Quarry Pea Gravel
Field Method:	NZS 4407:2015 Test 4.3
Lab Method:	NZS 4407:2015 Test 3.1

Plateau Test #2

Test Results					
Test No.	**Passes**	**Roller Used**	**Compaction Stage**	**Dry Density (t/m³)**	**Average Moisture Content (%)**
1	**0**	**N/A**	**Initial - Laid**	1.64	
2	**4**	**15.5T Construction Roller**	**High Vibe**	1.92	
3	**2**			1.98	
4	**2**			1.92	
5	**2**			1.97	
6	**2**			2.02	**3.7**
7	**2**			2.03	
8	**2**			2.07	
9	**2**		**Static**	2.01	
10	**2**			**2.08**	
11	**2**			2.04	

Please note: One pass is in a single direction over the test spot.



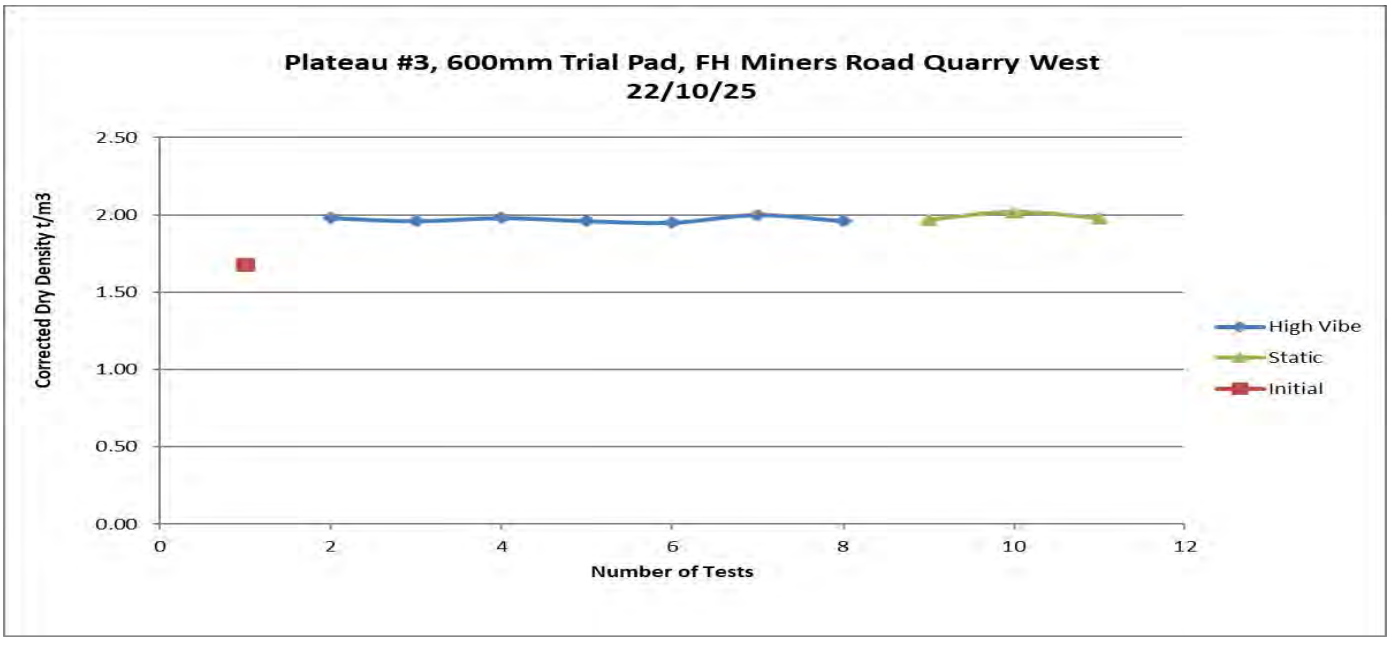
Canterbury Laboratory
24 Miners Road, Templeton
PO Box 16 064, Hornby
Christchurch
Phone (03) 349 9142
Email:
cantlab@fultonhogan.com
0800 LABORATORY

Testing Details	
Site Tested:	600mm Trial Pad, FH Miners Road Quarry West
Tested by:	Liam Brennan
Date:	22/10/25
Time Tested:	10:45am
Material:	Crushed Parkburn Quarry Pea Gravel
Field Method:	NZS 4407:2015 Test 4.3
Lab Method:	NZS 4407:2015 Test 3.1

Plateau Test #3

Test Results					
Test No.	**Passes**	**Roller Used**	**Compaction Stage**	**Dry Density (t/m³)**	**Average Moisture Content (%)**
1	**0**	**N/A**	**Initial - Laid**	1.68	**5.3**
2	**4**	**15.5T Construction Roller**	**High Vibe**	1.98	
3	**2**			1.96	
4	**2**			1.98	
5	**2**			1.96	
6	**2**			1.95	
7	**2**			2.00	
8	**2**			1.96	
9	**2**		**Static**	1.97	
10	**2**			**2.01**	
11	**2**			1.98	

Please note: One pass is in a single direction over the test spot.



Canterbury Laboratory
24 Miners Road, Templeton
PO Box 16 064, Hornby
Christchurch
Phone (03) 349 9142
Email:
cantlab@fultonhogan.com
0800 LABORATORY

Direct Transmission NDM Test Results:

Test method used: NZS 4407:2015 Test 4.2

Test Results at the conclusion of Plateau Test – 400mm Trial Pad				
Test	**Probe Depth (mm)**	**Dry Density (kg/m³)**	**Wet Density (kg/m³)**	**Moisture Content (%)**
1	**250**	2.016	2.089	3.6
2	**150**	2.051	2.116	3.2
3	**100**	2.007	2.089	4.1
4	**0**	1.939	2.006	3.4

Test Results at the conclusion of 8th High Vibe pass in the Plateau Test – 500mm Trial Pad				
Test	**Probe Depth (mm)**	**Dry Density (kg/m³)**	**Wet Density (kg/m³)**	**Moisture Content (%)**
1	**250**	1.988	2.047	2.7
2	**150**	1.961	2.028	3.4

Test Results at the conclusion of 10th High Vibe pass in the Plateau Test – 500mm Trial Pad				
Test	**Probe Depth (mm)**	**Dry Density (kg/m³)**	**Wet Density (kg/m³)**	**Moisture Content (%)**
1	**200**	1.982	2.055	3.7
2	**150**	2.002	2.068	3.3

Test Results at the conclusion of 2nd Static pass in the Plateau Test – 500mm Trial Pad				
Test	**Probe Depth (mm)**	**Dry Density (kg/m³)**	**Wet Density (kg/m³)**	**Moisture Content (%)**
1	**250**	2.025	2.097	3.6
2	**150**	2.026	2.098	3.6
3	**100**	2.006	2.076	3.5

Test Results at the conclusion of Plateau Test – 600mm Trial Pad				
Test	**Probe Depth (mm)**	**Dry Density (kg/m³)**	**Wet Density (kg/m³)**	**Moisture Content (%)**
1	**250**	1.999	2.108	5.5
2	**150**	2.009	2.113	5.2
3	**100**	2.026	2.129	5.0
4	**50**	2.051	2.153	5.0

Canterbury Laboratory
24 Miners Road, Templeton
PO Box 16 064, Hornby
Christchurch
Phone (03) 349 9142
Email:
cantlab@fultonhogan.com
0800 LABORATORY

Site Tested:



Report Checked By:	Liam Brennan	23/10/2025
Report Issued By:	Liam Brennan	23/10/2025

* This report may not be reproduced except in full

Appendix 3

Laboratory Standard Compaction Test Result

Work Order ID: CAN25W7644

Canterbury Laboratory
24 Miners Road, Templeton, Christchurch
PO Box 16-064, Christchurch 8441
Telephone: +64 3 349 9142
www.fultonhogan.com
0800 LABORATORY

Maximum Dry Density Report

Report No: MDD:CAN25S-21826
Issue No: 1

Client:
Cant Land Resource
Corner Main South & Halswell Junction Rd
Hornby

Christchurch 8042
NZ

Project: 251706 Parkburn Quarry-Cant Land Resource SWO INT

The tests reported herein (unless otherwise indicated) have been performed in accordance with the laboratory's scope of accreditation. Samples are tested as received, in natural condition, unless stated otherwise in the comments. This report may only be reproduced in full.

The results in this report relate only to the items / samples that were tested

Approved Signatory: Liam Brennan
(Laboratory Operations Manager)
IANZ Accreditation No:200
Date of Issue: 29/10/2025

Sample Details

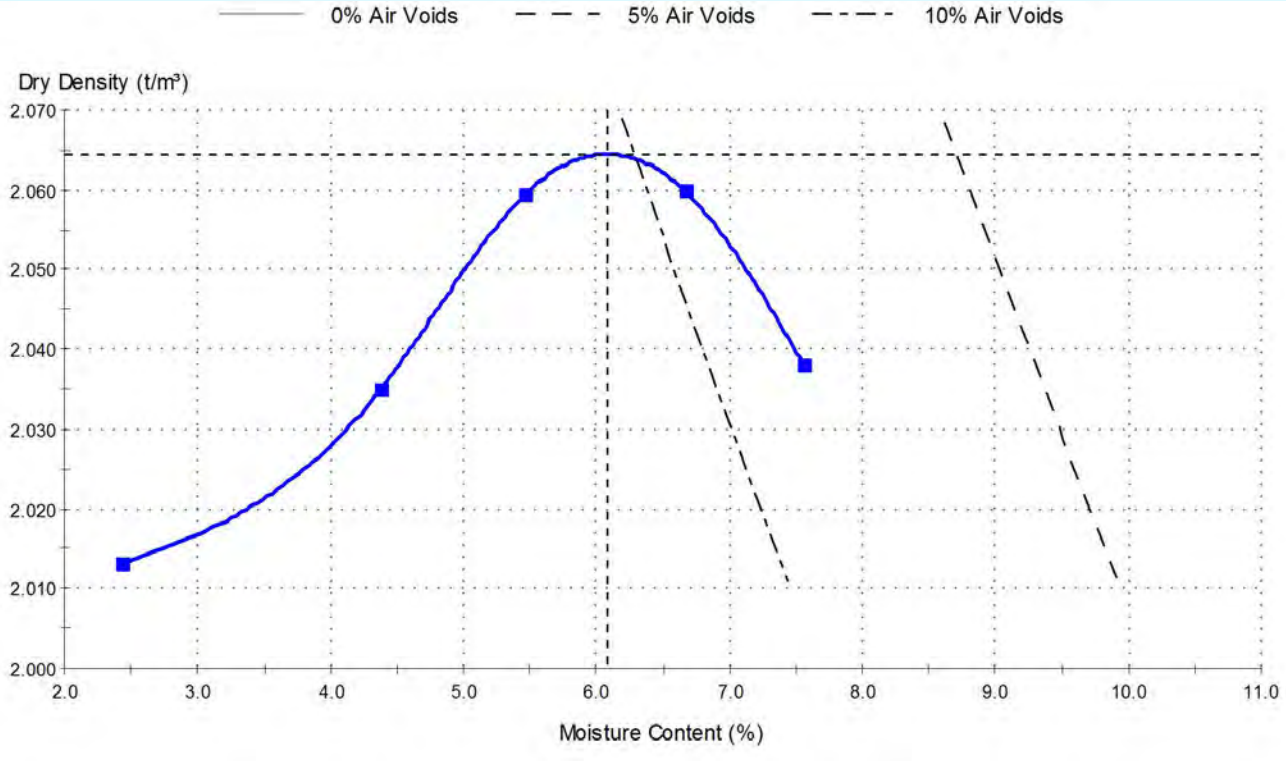
Sample ID:	CAN25S-21826	**Client Sample ID:**	QA Testing
Material:	Crusher Dust	**Sample Source:**	Miscellaneous Material Source
Site/Sampled From:	Miners Rd West ,ex Parkburn Quarry Trial Pad	**Date Sampled:**	22/10/2025
Specification:	Standard Compaction Test	**Sampled By:**	Liam Brennan
Sampling Method:	NZS 4407:2015 2.4.6.3.2 (SP/WG/MACHINE)	**Date Tested:**	27/10/2025
Tested By:	Amanda Ryan	**Sampling Endorsed?:**	Yes

Test Results

NZS 4402:1986 Test 4.1.1 - 1986

Maximum Dry Density (t/m³):	**2.06**	**Optimum Moisture Content (%):**	**6.0**
Solid Density (t/m³):	2.680 assumed	**Oversize Sieve (mm):**	19.0
Oversize Material (%):	0	**Sample History:**	Natural

Dry Density - Moisture Relationship



Comments

© 2000-2025 QESTLab by SpectraQEST.com

Appendix 5

Crushed Pea Gravel Compaction Trial Test Results (2026)

Work Order ID: CTS26W0576

Central Testing Services
18 Ngapara Street, Alexandra 9340, Central Otago
P.O Box 397, Alexandra, Central Otago
Telephone: +64 3 4487644
www.centraltesting.co.nz

Material Test Report

Report No: MAT:CTS26S-00605
Issue No: 1

Client:
Central Testing Cash Sales
PO Box 397

Alexandra 9340
NZ

Project: Insight Engineering

The tests reported herein (unless otherwise indicated) have been performed in accordance with the laboratory's scope of accreditation. Samples are tested as received, in natural condition, unless stated otherwise in the comments. This report may only be reproduced in full.

The results in this report relate only to the items / samples that were tested

Approved Signatory: Carl Julius
(Laboratory Technician)
IANZ Accreditation No:434
Date of Issue: 17/03/2026

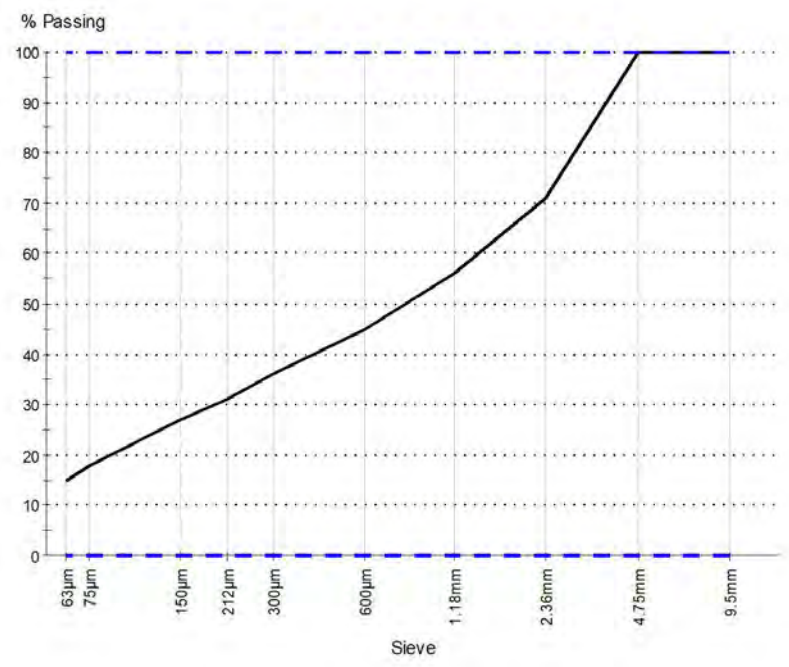
Sample Details

Sample ID:	CTS26S-00605
Client Sample ID:	09698
Material:	Crushed Pea Gravel
Sample Source:	Central - Parkburn Quarry
Site/Sampled From:	Pembroke Heights, Wanaka
Date Sampled:	20/02/2026
Specification:	No Specification
Sampled By:	Nevan Danischewski
Sampling Method:	NZS 4407:2015 2.4.8.3 (EX PAVEMENT/SEL)
Technician:	Henry Clatworthy
Sampling Endorsed?:	Yes

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: NZS 4402:1986 Test 2.8.1 - Modified
Drying By: Oven
Date Tested: 11/03/2026
Tested By: Henry Clatworthy

Sieve Size	% Passing	Limits
9.5mm	100	0 – 100
4.75mm	100	0 – 100
2.36mm	71	0 – 100
1.18mm	56	0 – 100
600µm	45	0 – 100
300µm	36	0 – 100
212µm	31	0 – 100
150µm	27	0 – 100
75µm	18	0 – 100
63µm	15	0 – 100

Comments

Date Received: 20-Feb-26

© 2000-2026 QESTLab by SpectraQEST.com

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: CTS26W0575-1

Date: 7 April 2026

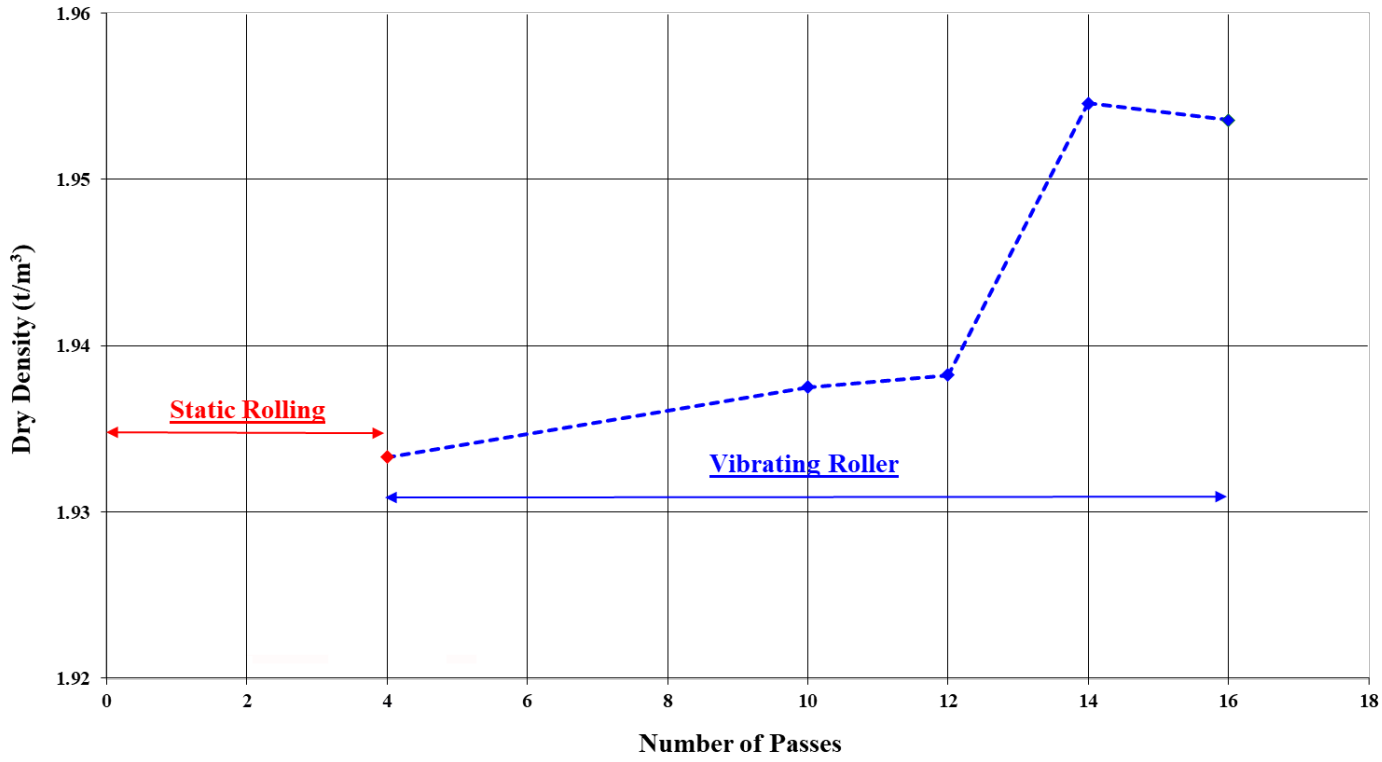
TEST REPORT – PLATEAU DENSITY & WATER CONTENT

Client Details:	**Insight Engineering, P.O. Box 456, Cromwell**	**Attention:**	**J. Kruyshaar**
Job Description:	**Pembroke Heights, Wanaka – Compaction Trial #2, Layer 1**		
Sample Description:	**Crushed Pea Gravel**	**Sample Source:**	**Parkburn**
Sample Method:	**NZS 4407:2015, Test 2.4.8.3**	**Sampled By:**	**N.P. Danischewski**
Test Methods:	**Field Density - NZS 4407:2015, Test 4.2 (Direct transmission - 250mm probe depth); Water Content - NZS 4402:1986, Test 2.1**		

Compaction Used (13T Bomag)	Total Passes	Wet Density (t/m³)	Dry Density (t/m³)	Corrected Water Content (%)	Relative Compaction (%)	Air Voids (%)	Total Voids (%)
4 Passes Static	4	1.99	1.93	3.1	94	22	28
4 Passes Static + 6 Passes Vib	10	2.01	1.94	3.9	94	21	28
4 Passes Static + 8 Passes Vib	12	2.01	1.94	3.8	94	21	28
4 Passes Static + 10 Passes Vib	14	2.04	1.95	4.1	95	19	28
4 Passes Static + 12 Passes Vib	16	2.04	1.95	4.2	95	19	28

Note: The density results reported above are the mean of 3 individual NDM probes (excluding 4 passes static – one reading only). 1 pass = 1 direction.

PLATEAU DENSITY



General Notes:

- *Relative Compaction values have been calculated using a maximum dry density of 2.06 t/m³. Voids have been calculated using an assumed solid density of 2.70 t/m³ (See Reference No. CTS26W0577 for NZ standard compaction details).*
- *A water content correction based on comparative laboratory water contents has been applied to this data.*
- *This report may not be reproduced except in full.*

Tested By: N.P. Danischewski & A. Rowe **Date:** 20 to 22-Feb-26 **Checked By:** A. Rowe

Approved Signatory

A. Rowe

A. Rowe
Key Technical Personnel

ACCREDITED IANZ TESTING LABORATORY No. 444

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: CTS26W0575-2

Date: 7 April 2026

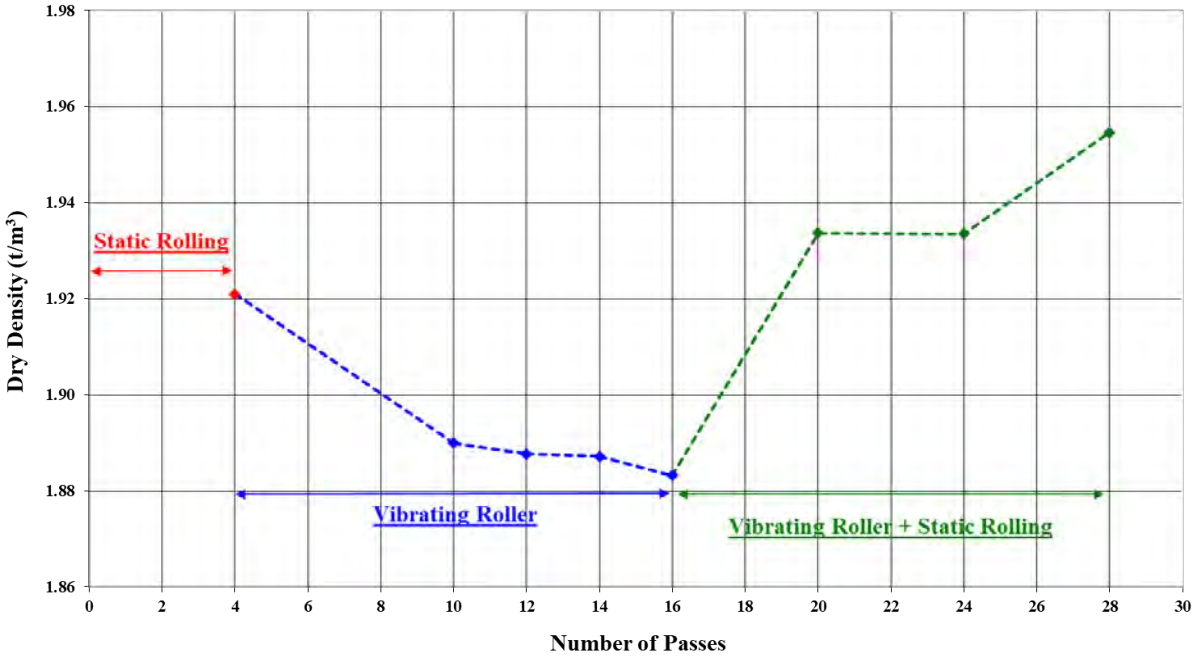
TEST REPORT – PLATEAU DENSITY & WATER CONTENT

Client Details:	**Insight Engiueering, P.O. Box 456, Cromwell**	**Attention:**	**J. Kruyshaar**
Job Description:	**Pembroke Heights, Wanaka – Compaction Trial #2, Layer 1**		
Sample Description:	**Crushed Pea Gravel**	**Sample Source:**	**Parkburn**
Sample Method:	**NZS 4407:2015, Test 2.4.8.3**	**Sampled By:**	**N.P. Danischewski**
Test Methods:	**Field Density - NZS 4407:2015, Test 4.3 (backscatter method); Water Content - NZS 4402:1986, Test 2.1**		

Compaction Used (13T Bomag)	Total Passes	Wet Density (t/m³)	Dry Density (t/m³)	Corrected Water Content (%)	Relative Compaction (%)	Air Voids (%)	Total Voids (%)
4 Passes Static	4	1.99	1.92	3.6	93	22	29
4 Passes Static + 6 Passes Vib	10	1.98	1.89	4.7	92	21	30
4 Passes Static + 8 Passes Vib	12	1.98	1.89	4.7	92	21	30
4 Passes Static + 10 Passes Vib	14	1.97	1.89	4.6	92	22	30
4 Passes Static + 12 Passes Vib	16	1.97	1.88	4.5	91	22	30
8 Passes Static + 12 Passes Vibe	20	2.03	1.93	4.9	94	19	28
12 Passes Static + 12 Passes Vibe	24	2.03	1.93	5.1	94	19	28
16 Passes Static + 12 Passes Vibe	28	2.05	1.95	4.8	95	18	28

Note: The density results reported above are the mean of 3 individual NDM probes (excluding 4 passes static – one reading only).
1 pass = 1 direction.

PLATEAU DENSITY



General Notes:

- *Relative Compaction values have been calculated using a maximum dry density of 2.06 t/m³. Voids have been calculated using an assumed solid density of 2.70 t/m³ (See Reference No. CTS26W0577 for NZ standard compaction details).*
- *A water content correction based on comparative laboratory water contents has been applied to this data.*
- *This report may not be reproduced except in full.*

Tested By: N.P. Danischewski & A. Rowe **Date:** 20 to 22-Feb-26 **Checked By:** A. Rowe

Approved Signatory

A. Rowe

A. Rowe
Key Technical Personnel

ACCREDITED IANZ TESTING LABORATORY №434

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: CTS26W0575-3

Date: 7 April 2026

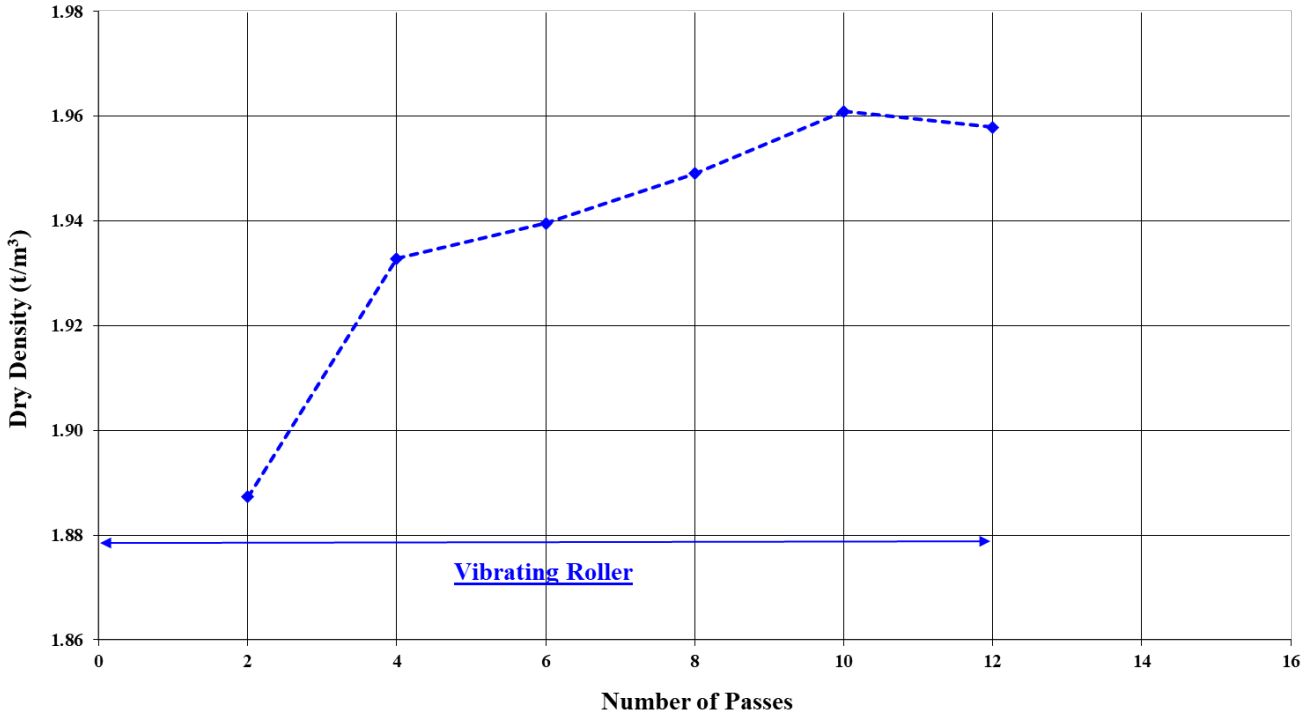
TEST REPORT – PLATEAU DENSITY & WATER CONTENT

Client Details:	**Insight Engineering, P.O. Box 456, Cromwell**	**Attention:**	**J. Kruyshaar**
Job Description:	**Pembroke Heights, Wanaka – Compaction Trial #2, Layer 2**		
Sample Description:	**Crushed Pea Gravel**	**Sample Source:**	**Parkburn**
Sample Method:	**NZS 4407:2015, Test 2.4.8.3**	**Sampled By:**	**N.P. Danischewski**
Test Methods:	**Field Density - NZS 4407:2015, Test 4.2 (Direct transmission - 250mm probe depth); Water Content - NZS 4402:1986, Test 2.1**		

Compaction Used (13T Bomag)	Total Passes	Wet Density (t/m^3)	Dry Density (t/m^3)	Corrected Water Content (%)	Relative Compaction (%)	Air Voids (%)	Total Voids (%)
2 Passes Vib	2	1.95	1.89	3.4	92	24	30
4 Passes Vib	4	2.01	1.93	3.7	94	21	28
6 Passes Vib	6	2.01	1.94	3.9	94	21	28
8 Passes Vib	8	2.02	1.95	3.7	95	21	28
10 Passes Vib	10	2.03	1.96	3.6	95	20	28
12 Passes Vib	12	2.03	1.96	3.7	95	20	27

Note: The density results reported above are the mean of 3 individual NDM probes.
1 pass = 1 direction.

PLATEAU DENSITY



General Notes:

- *Relative Compaction values have been calculated using a maximum dry density of 2.06 t/m^3. Voids have been calculated using an assumed solid density of 2.70 t/m^3 (See Reference No. CTS26W0577 for NZ standard compaction details).*
- *A water content correction based on comparative laboratory water contents has been applied to this data.*
- *This report may not be reproduced except in full.*

Tested By: N.P. Danischewski & A. Rowe **Date:** 20 to 22-Feb-26 **Checked By:** A. Rowe

Approved Signatory

A. Rowe

A. Rowe
Key Technical Personnel

ACCREDITED IANZ TESTING LABORATORY 1434

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: CTS26W0575-4

Date: 7 April 2026

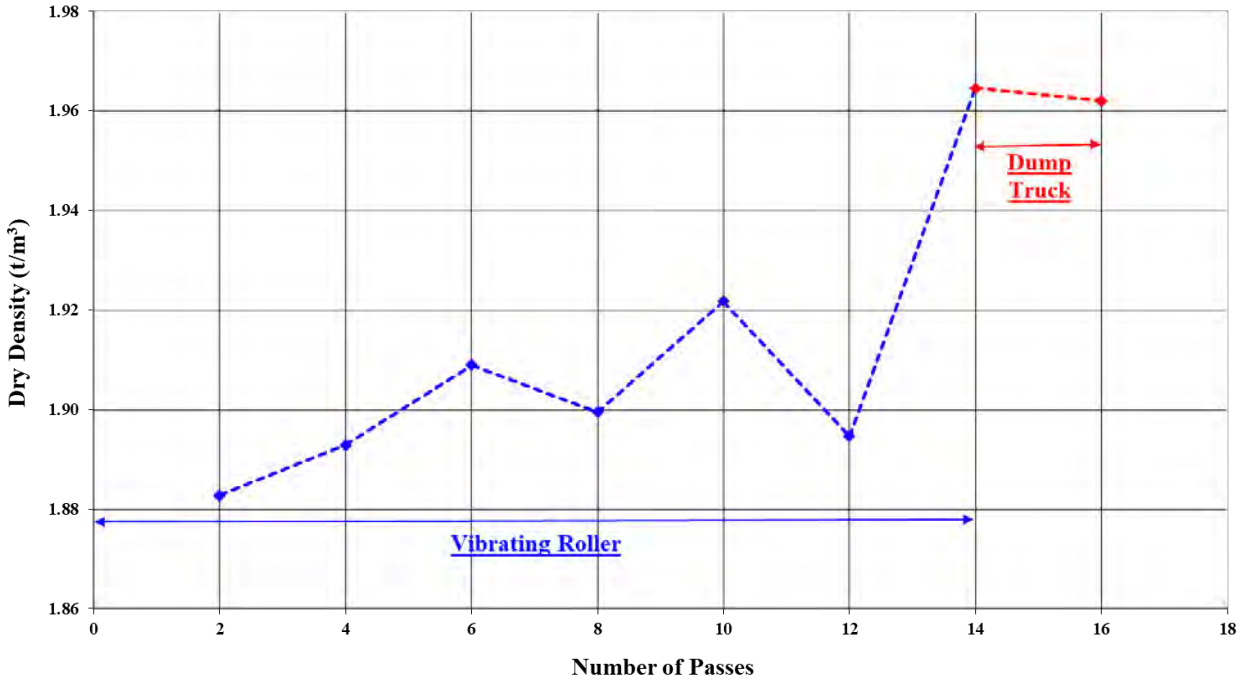
TEST REPORT – PLATEAU DENSITY & WATER CONTENT

Client Details:	**Insight Engiueering, P.O. Box 456, Cromwell**	**Attention:**	**J. Kruyshaar**
Job Description:	**Pembroke Heights, Wanaka – Compaction Trial #2, Layer 2**		
Sample Description:	**Crushed Pea Gravel**	**Sample Source:**	**Parkburn**
Sample Method:	**NZS 4407:2015, Test 2.4.8.3**	**Sampled By:**	**N.P. Danischewski**
Test Methods:	**Field Density - NZS 4407:2015, Test 4.3 (backscatter method); Water Content - NZS 4402:1986, Test 2.1**		

Compaction Used (13T Bomag)	Total Passes	Wet Density (t/m^3)	Dry Density (t/m^3)	Corrected Water Content (%)	Relative Compaction (%)	Air Voids (%)	Total Voids (%)
2 passes vibe	2	1.93	1.88	2.6	91	25	30
4 passes vibe	4	1.95	1.89	2.9	92	24	30
6 passes vibe	6	1.97	1.91	3.2	93	23	29
8 passes vibe	8	1.95	1.90	2.8	92	24	30
10 passes vibe	10	1.98	1.92	3.0	93	23	29
12 passes vibe	12	1.95	1.89	2.9	92	24	30
12 passes vibe + 2 passes dump truck	14	2.03	1.96	3.4	95	21	27
12 passes vibe + 4 passes dump truck	16	2.03	1.96	3.4	95	21	27

Note: The density results reported above are the mean of 3 individual NDM probes.
1 pass = 1 direction.

PLATEAU DENSITY



General Notes:

- *Relative Compaction values have been calculated using a maximum dry density of 2.06 t/m^3. Voids have been calculated using an assumed solid density of 2.70 t/m^3 (See Reference No. CTS26W0577 for NZ standard compaction details).*
- *A water content correction based on comparative laboratory water contents has been applied to this data.*
- *This report may not be reproduced except in full.*

Tested By: N.P. Danischewski & A. Rowe **Date:** 20 to 22-Feb-26 **Checked By:** A. Rowe

Approved Signatory

A. Rowe

A. Rowe
Key Technical Personnel

ACCREDITED IANZ TESTING LABORATORY №434

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: CTS6W0577

Date: 7 April 2026

TEST REPORT - NZ STANDARD COMPACTION

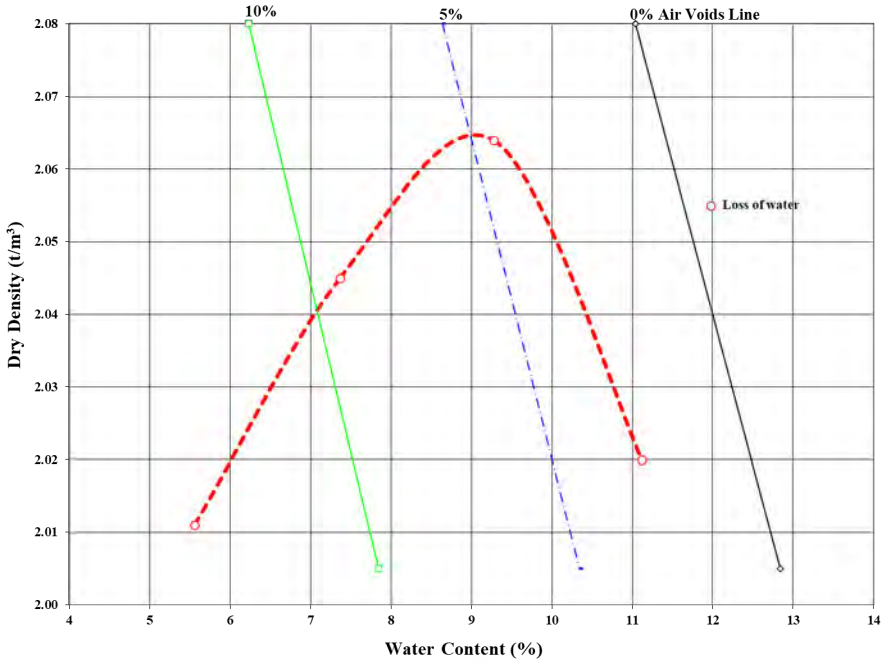
Client Details:	**Insight Engineering, P.O. Box 456, Cromwell**	**Attention:**	**J. Kruyshaar**
Job Description:	**Pembroke Heights**		
Sample Description:	**Crushed Pea Gravel**	**Order No:**	**N/A**
Sample Source:	**Parkburn**	**Sample Label No:**	**09698**
Date & Time Sampled:	**20-Feb-26**	**Sampled By:**	**N.P. Danischewski**
Sample Method:	**NZS 4407:2015, Test 2.4.8.3**	**Date Received:**	**20-Feb-26**

NZ STANDARD COMPACTION - NZS 4402:1986, Test 4.1.1

% Retained (+19.0mm Fraction)	**0.0 %**
Maximum Dry Density:	**2.06t/m^3**
Optimum Water Content:	**9.0 %**

Notes:

- *The sample was received in a natural state.*
- *The material tested in the NZ Standard Compaction test was whole soil.*
- *The air voids lines were calculated from an assumed solid density of 2.70 t/m^3.*



General Notes:

- *This report may not be reproduced except in full.*

Tested By: M. Duncan **Date:** 27 to 31-Mar-26

Checked By:

Approved Signatory

N.P. Danischewski
Key Technical Personnel

ACCREDITED IANZ TESTING LABORATORY №434

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Appendix 6

Draft Fill Specifications

Draft Bulk Earthworks Specification for Park Burn

Specification for Local Borrow materials

The bulk earthworks shall be undertaken in accordance with NZS4431:2022 unless noted otherwise in this report and specification.

Material definition	**Fill use type**	Bulk 4431 fill		
	Source material type	C-A (coarse-grained – acceptable, GAP100 pit run)		
	Typical use description	General fill for residential/commercial earthworks using site-won materials		
Source material acceptance testing[3]	**Test and method**	**Minimum test frequency**	**Normal acceptance criteria**	**Notes**
	Particle size distribution (NZS4407 3.8 or NZS4402 2.8.1)	1 for each source and 1 for each change in material	Refer to Table A2 NZS4431:2022	Completed before works begin and during the works if material changes
	Dry density/water content relationship (NZS 4402 4.1.3 or 4.2.1, 4.2.2 and 4.2.3)	1 for each source and 1 for each change in material	OMC and MDD determined for compaction acceptance testing	Completed before works begin and during the works if material changes. Not required for coarse-grained soils where continuous compaction control will be used to assure compaction quality.
	Water Content (NZS4402 3.1)	1 for each source and 1 for each change in material	Between OMC -2% and OMC +4%	Ongoing during the works confirm conditioning requirements. Not use if there is no well-defined density/water content relationship
	Solid density of soil particles (NZS4402 test 2.7)	1 for each source and 1 for each change in material	Solid density determined for in-situ density testing	Can be omitted where the geotechnical engineer can provide a reliable estimate for the specific source material or where alternative compaction acceptance testing is proposed.
Placement requirements[1]	Loose layer thickness < 250 mm Wetting as necessary			
Compaction acceptance testing	**Test and method**	**Minimum test frequency**	**Normal acceptance criteria**	**Notes**
	For coarse grained soils with max particle size <65mmm: Field water content and density (NZS4402 2.1 NZS4407 4.1,4.2 & 4.3)	1 per 1,000 m^3 (minimum 2 per lift[4])	≥95% MDD where fill height is <3 m ≥98% MDD where fill height is >3m <15% air voids	**Acceptance criteria is subject to Dry Density/Water content test method. 92% is acceptable for Vibrating Hammer method.**
	For coarse grained soil with max particle size 65-250mm, proof roll to target calibrated dynamic response modulus or relative density (CEN/TS 17006)	Ongoing continuous compaction control	Target minimum calibrated compaction machine specific dynamic response modulus or minimum 80% relative density	Target minimum modulus set by correlation with plate load test(s) or as otherwise defined by the certifier
	Dynamic Cone Penetrometer	2 per 1,000 m^3 for full depth of lift (minimum 2 per lift)	≥ 5 blows per 100 mm	The DCP is indicative only and should not be used alone for compaction compliance.
	Impact test – 4.5 kg hammer (ASTM D5874)	1 per 50 m3 on each compacted layer (min 2 for each lift of fill)	IV>25	This test is indicative only and should not be used alone for compaction compliance.
	Plate load test (DIM 18134)	As specified by the certifier	≥300 kPa ultimate bearing capacity <25 mm settlement at 300 kPa	Typical frequency 1 per lot at completion of final lift

[3] Refer to Laboratory test results (attached)
[4] For this project the maximum height of a lift is taken as no greater than 750 mm or three compacted layers

Draft Bulk Earthworks Specification for Park Burn

Specification for Crushed Pea Gravel (Impact crusher)

The bulk earthworks shall be undertaken in accordance with NZS4431:2022 unless noted otherwise in this report and specification.

Material definition	**Fill use type**	Bulk 4431 fill		
	Source material type	F-D (fine-grained – dry)		
	Typical use description	General fill for residential/commercial earthworks using crushed pea gravel		
Source material acceptance testing[5]	**Test and method**	**Minimum test frequency**	**Normal acceptance criteria**	**Notes**
	Particle size distribution (NZS4402 2.8.1)	1 for each source and 1 for each change in material	Refer to Table A2 NZS4431:2022	Completed before works begin and during the works if material changes
	Dry density/water content relationship (NZS 4402 2.1 & 4.1.1)	1 for each source and 1 for each change in material	OMC and MDD determined for compaction acceptance testing	Completed before works begin and during the works if material changes
	Water Content (NZS4402 2.1)	1 for each source and 1 for each change in material	Between OMC -2% and OMC +4%	Ongoing during the works confirm conditioning requirements
	Liquid and plastic limit (NZS4402 2.2, 2.3 & 2.4)	1 for each source and 1 for each change in material	Plasticity index < 25% Liquid limit <50%	Completed before works begin and during the works if material changes. Only if high silt content.
Placement requirements[1]	Loose layer thickness < 500 mm Wetting as necessary			
Compaction acceptance testing	**Test and method**	**Minimum test frequency**	**Normal acceptance criteria**	**Notes**
	Field water content and density (NZS4402 2.1 NZS4407 4.1,4.2 & 4.3)	2 per 1,000 m3 (minimum 2 per lift[6])	≥95% MDD where fill height is <3 m ≥98% MDD where fill height is >3m <15% air voids	Nuclear Density Meter on direct transmission or backscatter mode.
	Dynamic Cone Penetrometer	As specified by the certifier (maximum depth of test is 2 m)	≥ 5 blows per 100 mm	The DCP is indicative only and should not be used alone for compaction compliance.
	Impact test – 4.5 kg hammer (ASTM D5874)	1 per 50 m3 on each compacted layer (min 2 for each lift of fill)	IV>25	This test is indicative only and should not be used alone for compaction compliance.

[5] Refer to Compaction Trial Plateau test results (attached)
[6] For this project the maximum height of a lift is taken as no greater than 1000 mm or three compacted layers

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: CTS25W2031

Date: 16 June 2025

TEST REPORT - NZ VIBRATING HAMMER COMPACTION

Client Details:	**Fulton Hogan Land Development Ltd, Level 1 Annex, 152 Oxford Street, Christchurch**	**Attention:**	**T. James**
Job Description:	**Parkburn Investigations**		
Sample Description:	**Pit Run - Cobbly GRAVEL with minor sand & trace of silt**	**Client Order No:**	**N/A**
Sample Source: (cs)	**Central – Parkburn Quarry**	**Sample Label No:**	**05510**
Date & Time Sampled: (cs)	**3-Jun-25**	**Sampled By:** (cs)	**G. Marsh & J. Ford**
Sample Method: (cs)	**NZS 4407:2015, Test 2.4.6.3.2 (machine stockpile)**	**Date Received:**	**3-Jun-25**

MAXIMUM DRY DENSITY, OPTIMUM WATER CONTENT & DRY DENSITY RESULTS

% Retained: (+37.5mm Fraction)	**28.0 %**
Dry Density: (+37.5mm Fraction)	**2.68 t/m^3**
Absorption: (+37.5mm Fraction)	**0.5 %**
Maximum Dry Density: (-37.5mm Fraction)	**2.34 t/m^3**
Optimum Water Content: (-37.5mm Fraction)	**2.6 %**

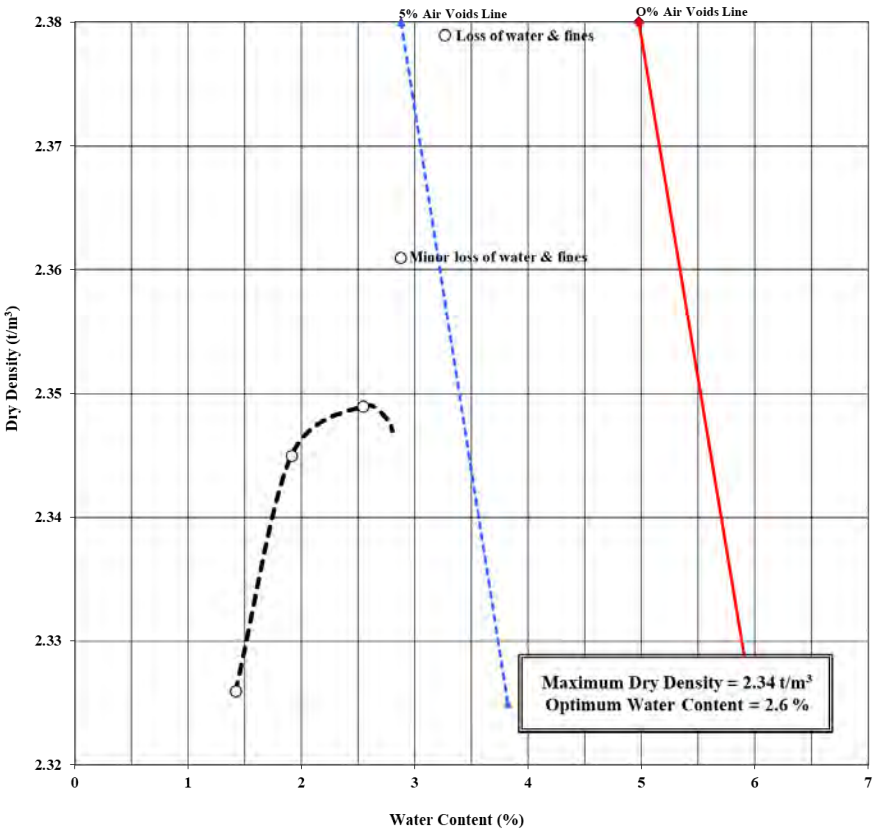
Test Methods:

Dry Density: NZS 3111:1986, Test 12

Maximum Dry Density: NZS 4402:1986, Test 4.1.3

Notes:

- *The material was received in a natural state.*
- *NZS 4402:1986, Test 4.1.3 states the maximum dry density is to be reported to the nearest 0.02 t/m^3. The maximum dry density reported to the nearest 0.01 t/m^3 = 2.35 t/m^3 (Not IANZ Accredited).*
- *The sample tested was the fraction passing a 37.5mm test sieve.*
- *The air voids lines were calculated from an assumed solid density of 2.70 t/m^3.*



Additional Notes:

- *Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.*
- *This report may not be reproduced except in full.*

Tested By: J. Smith **Date:** 9 & 10-Jun-25 **Checked By:**

Approved Signatory

C. Julius
Key Technical Personnel `

ACCREDITED IANZ TESTING LABORATORY
№ 434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Work Order ID: CTS25W1915

Central Testing Services
18 Ngapara Street, Alexandra 9340, Central Otago
P.O Box 397, Alexandra, Central Otago
Telephone: +64 3 4487644
www.centraltesting.co.nz

Material Test Report

Report No: MAT:CTS25S-01765
Issue No: 1

Client:
Cant Land Resource
Corner Main South & Halswell Junction Rd
Hornby

Christchurch 8042
NZ

Project: Parkburn Investigations

The tests reported herein (unless otherwise indicated) have been performed in accordance with the laboratory's scope of accreditation. Samples are tested as received, in natural condition, unless stated otherwise in the comments. This report may only be reproduced in full.

The results in this report relate only to the items / samples that were tested

Approved Signatory: Carl Julius
(Laboratory Technician)
IANZ Accreditation No:434
Date of Issue: 6/06/2025

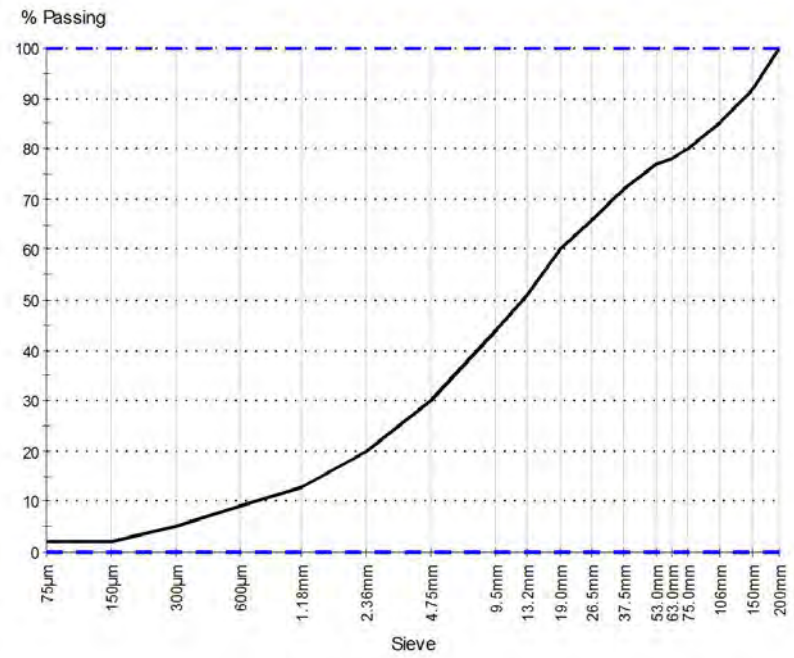
Sample Details

Sample ID: CTS25S-01765
Client Sample ID: 09674
Material: Pit Run - Cobbly GRAVEL with minor sand and trace of silt
Sample Source: Central - Parkburn Quarry
Site/Sampled From: Stockpile
Date Sampled: 26/05/2025
Specification: No Specification
Sampled By: Cam Maxwell
Sampling Method: NZS 4407:2015 2.4.6.3.2 (SP/WG/MACHINE)
Technician: Adam Rowe
Sampling Endorsed?: Yes

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: NZS 4407:2015 Test 3.8.1
Drying By: Oven
Date Tested: 30/05/2025
Tested By: Adam Rowe
Note: [a] Obtained by difference.

Sieve Size	% Passing	Limits
200mm	100	0 – 100
150mm	92	0 – 100
106mm	85	0 – 100
75.0mm	80	0 – 100
63.0mm	78	0 – 100
53.0mm	77	0 – 100
37.5mm	72	0 – 100
26.5mm	66	0 – 100
19.0mm	60	0 – 100
13.2mm	51	0 – 100
9.5mm	44	0 – 100
4.75mm	30	0 – 100
2.36mm	20	0 – 100
1.18mm	13	0 – 100
600µm	9	0 – 100
300µm	5	0 – 100
150µm	2	0 – 100
75µm	2[a]	0 – 100

Comments

Date Received: 27-May-25

© 2000-2025 QESTLab by SpectraQEST.com

Work Order ID: CTS25W2032

Central Testing Services
18 Ngapara Street, Alexandra 9340, Central Otago
P.O Box 397, Alexandra, Central Otago
Telephone: +64 3 4487644
www.centraltesting.co.nz

Material Test Report

Report No: MAT:CTS25S-01793
Issue No: 1

Client:
Cant Land Resource
Corner Main South & Halswell Junction Rd
Hornby

Christchurch 8042
NZ

Project: Parkburn Investigations

The tests reported herein (unless otherwise indicated) have been performed in accordance with the laboratory's scope of accreditation. Samples are tested as received, in natural condition, unless stated otherwise in the comments. This report may only be reproduced in full.

The results in this report relate only to the items / samples that were tested

Approved Signatory: Carl Julius
(Laboratory Technician)
IANZ Accreditation No:434
Date of Issue: 18/06/2025

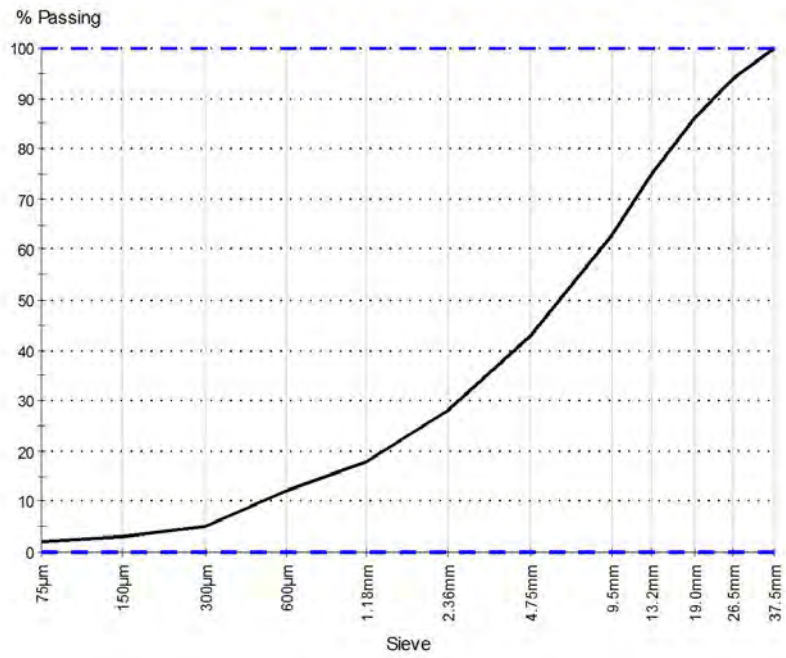
Sample Details

Sample ID:	CTS25S-01793
Client Sample ID:	05510
Material:	Pit Run - GRAVEL with some sand and trace of silt
Sample Source:	Central - Parkburn Quarry
Site/Sampled From:	Parkburn
Date Sampled:	03/06/2025
Specification:	No Specification
Sampled By:	Gary Marsh
Sampling Method:	NZS 4407:2015 2.4.6.3.2 (SP/WG/MACHINE)
Technician:	Adam Rowe
Sampling Endorsed?:	No

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: NZS 4407:2015 Test 3.8.1
Drying By: Oven
Date Tested: 13/06/2025
Tested By: Adam Rowe
Note: [a] Obtained by difference.

Sieve Size	% Passing	Limits
37.5mm	100	0 – 100
26.5mm	94	0 – 100
19.0mm	86	0 – 100
13.2mm	75	0 – 100
9.5mm	63	0 – 100
4.75mm	43	0 – 100
2.36mm	28	0 – 100
1.18mm	18	0 – 100
600µm	12	0 – 100
300µm	5	0 – 100
150µm	3	0 – 100
75µm	2[a]	0 – 100

Comments

Note: Material is estimated to have 35% all in Pea Gravel.
Date Received: 3-Jun-25

© 2000-2025 QESTLab by SpectraQEST.com

Work Order ID: CTS25W2033

Central Testing Services
18 Ngapara Street, Alexandra 9340, Central Otago
P.O Box 397, Alexandra, Central Otago
Telephone: +64 3 4487644
www.centraltesting.co.nz

Material Test Report

Report No: MAT:CTS25S-01797
Issue No: 1

Client:
Cant Land Resource
Corner Main South & Halswell Junction Rd
Hornby

Christchurch 8042
NZ

Project: Parkburn Investigations

The tests reported herein (unless otherwise indicated) have been performed in accordance with the laboratory's scope of accreditation. Samples are tested as received, in natural condition, unless stated otherwise in the comments. This report may only be reproduced in full.

The results in this report relate only to the items / samples that were tested

Approved Signatory: Carl Julius
(Laboratory Technician)
IANZ Accreditation No:434
Date of Issue: 18/06/2025

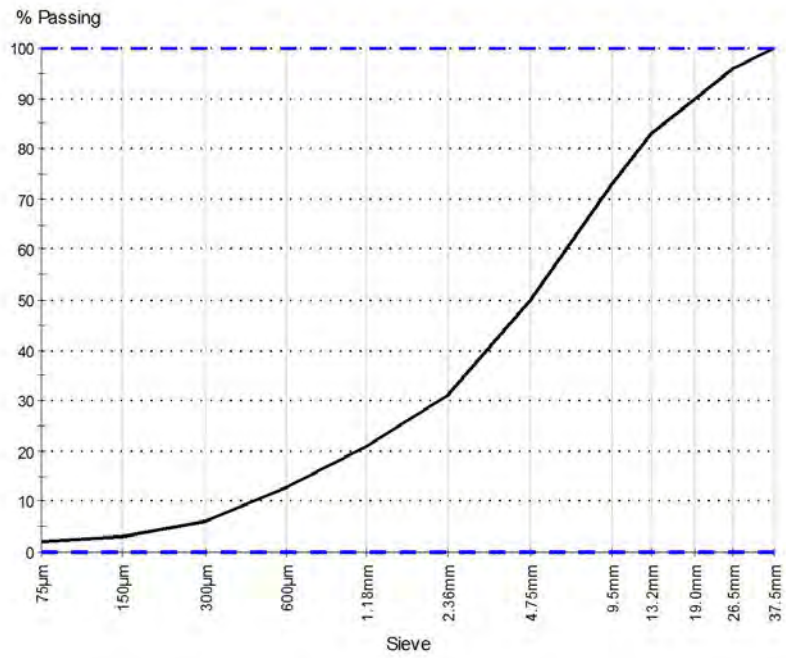
Sample Details

Sample ID:	CTS25S-01797
Client Sample ID:	05510
Material:	Pit Run - GRAVEL with some sand and trace of silt
Sample Source:	Central - Parkburn Quarry
Site/Sampled From:	Parkburn
Date Sampled:	03/06/2025
Specification:	No Specification
Sampled By:	Gary Marsh
Sampling Method:	NZS 4407:2015 2.4.6.3.2 (SP/WG/MACHINE)
Technician:	Adam Rowe
Sampling Endorsed?:	No

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: NZS 4407:2015 Test 3.8.1
Drying By: Oven
Date Tested: 13/06/2025
Tested By: Adam Rowe
Note: [a] Obtained by difference.

Sieve Size	% Passing	Limits
37.5mm	100	0 – 100
26.5mm	96	0 – 100
19.0mm	90	0 – 100
13.2mm	83	0 – 100
9.5mm	73	0 – 100
4.75mm	50	0 – 100
2.36mm	31	0 – 100
1.18mm	21	0 – 100
600µm	13	0 – 100
300µm	6	0 – 100
150µm	3	0 – 100
75µm	2[a]	0 – 100

Comments

Note: Material is estimated to have 50% all in Pea Gravel
Date Received: 3-Jun-25

© 2000-2025 QESTLab by SpectraQEST.com

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: CTS6W0577

Date: 7 April 2026

TEST REPORT - NZ STANDARD COMPACTION

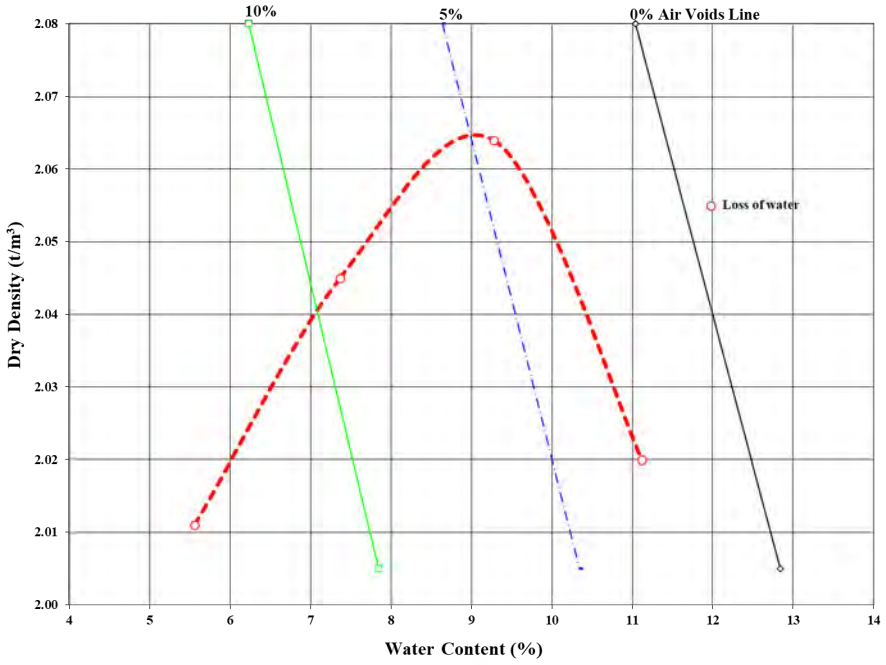
Client Details:	**Insight Engineering, P.O. Box 456, Cromwell**	**Attention:**	**J. Kruyshaar**
Job Description:	**Pembroke Heights**		
Sample Description:	**Crushed Pea Gravel**	**Order No:**	**N/A**
Sample Source:	**Parkburn**	**Sample Label No:**	**09698**
Date & Time Sampled:	**20-Feb-26**	**Sampled By:**	**N.P. Danischewski**
Sample Method:	**NZS 4407:2015, Test 2.4.8.3**	**Date Received:**	**20-Feb-26**

NZ STANDARD COMPACTION - NZS 4402:1986, Test 4.1.1

% Retained (+19.0mm Fraction)	**0.0 %**
Maximum Dry Density:	**2.06t/m^3**
Optimum Water Content:	**9.0 %**

Notes:

- *The sample was received in a natural state.*
- *The material tested in the NZ Standard Compaction test was whole soil.*
- *The air voids lines were calculated from an assumed solid density of 2.70 t/m^3.*



General Notes:

- *This report may not be reproduced except in full.*

Tested By: M. Duncan **Date:** 27 to 31-Mar-26

Checked By:

Approved Signatory

N.P. Danischewski
Key Technical Personnel

ACCREDITED IANZ TESTING LABORATORY №434

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

APPENDIX E – Insight Engineering Contaminated Land Report

Remediation Action Plan for the Parkburn Quarry at 922 Luggate-Cromwell Road (SH6), Cromwell

Prepared for:	Fulton Hogan Land Development
Date:	23/10/2026
Our Reference Number:	24019_RAP
Report prepared by:	Claude Midgley MSc, CEnvP
Reviewed by:	Jana Kruyshaar CMEngNZ

Record of Distribution

Sent to	Date	Report Status	No. of Copies
Daniel Thorne (Town Planning Group)	11/04/2026	Draft for Comment	1 Electronic
Melanie Foote (Town Planning Group)	19/06/2026	Final	1 Electronic
Melanie Foote (Town Planning Group)	16/07/2026	Updated Final	1 Electronic
Melanie Foote (Town Planning Group	24/09/2026	Updated Final	1 (electronic)
Melanie Foote (Town Planning Group	28/09/2026	Updated Final	1 (electronic)
Melanie Foote (Town Planning Group	23/10/2026	Updated Final	1 (electronic)

Record of Report Version

Date	Version Number
11/04/2026	24019_RAP
19/06/2026	24019_RAP
16/07/2026	24019_RAP
24/09/2026	24019_RAP
28/09/2026	24019_RAP
23/10/2026	24019_RAP

Table of Contents

1 Introduction 5
1.1 Background 5
1.2 Purpose 5
1.3 Objectives 5
2 Site Description 5
2.1 Contaminants of Concern 6
2.2 Contaminant Distribution 7
2.3 Volume of Contaminated Soil 7
3 Assessment of Remedial Options 8
4 Discussion 10
5 Remediation Methodology 11
5.1 Introduction 11
5.2 Description of Remedial Works 11
5.3 Site Establishment 12
5.3.1 Procedures 12
5.3.2 Site Supervision 13
5.3.3 Health and Safety 13
5.4 Validation of Works 13
5.4.1 Selection of Remedial Goals 13
5.4.2 Validation Methodology 14
5.5 Timescales 14
5.6 Post Remediation 14
6 Assessment of Environmental Effects 15
6.1 Introduction 15
6.2 Dust Control 15
6.3 Noise 16
6.4 Stormwater Control 16
6.5 Site Access 16
6.6 Decontamination 16
6.7 Unforeseen Conditions / Circumstances 17
7 Reporting 17
8 Statutory considerations 17
8.1 Introduction 17
8.2 Central Otago District Plan and the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health 18

8.3 Regional Policy Statement for Otago 19
8.3.1 Overview 19
8.3.2 Assessment of Relevant Objectives and Policies 19
8.4 Regional Plan: Waste for Otago 20
8.4.1 Overview 20
8.4.2 Assessment of Relevant Objectives and Policies 20
8.4.3 Assessment of rule applicability 21
8.5 Summary of Statutory Considerations 21
9 References 21
10 Limitations 22

Tables

Table 1: Site Description

Table 2: Assessment of Remedial Methods for Impacted Soil

Table 3: Potential effects of remediation works and proposed mitigation measures.

1 Introduction

1.1 Background

JKCM Limited, trading as Insight Engineering (IE), was contracted by Fulton Hogan Land Development to prepare this Remediation Action Plan (RAP), including an assessment of available remedial options, for the property (herein referred to as 'the site', refer to Appendix 1) at 922 Luggate-Cromwell Road, Cromwell.

Potentially contaminated areas were identified by e3scientific Limited (e3) during completion of a preliminary environmental site investigation (PSI) in 2021[1]. Contamination impacts were then confirmed by IE during completion of a preliminary and detailed environmental site investigation (PSI/DSI) in 2026[2]. Although some information is summarised in this RAP, it is recommended that this document is read in conjunction with the PSI[1] and PSI/DSI[2] for completeness (Appendix 2).

Figure 1 indicates the location of The Project and Figure 2 highlights the areas requiring remediation. Additional figures provided in Appendix 1, prepared by LandPro, provide detailed designs of the containment cells.

1.2 Purpose

This purpose of this document is to assess and conclude on the suitability of various options available to remediate the impacted portions of the site, in accordance with the MfE *Contaminated Land Management Guideline No. 1: Reporting on Contaminated Sites in New Zealand*[3] (CLMG#1) and Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations[4] (herein referred to as the NES-CS) and then to provide procedures to enable implementation of the recommended remedial strategy / strategies.

1.3 Objectives

The RAP has the following specific objectives:

- Review past site investigation report(s) to assess contaminant distribution;
- Produce a report identifying the possible remedial options available, the method of risk reduction associated with each option, and the estimated positive and negative aspects associated with each remedial method;
- Recommend one, or several, methods that could adequately reduce the risk to human health at the site; and
- Provide procedures required to complete the remedial work in a safe and sustainable manner.

The limitations of this document are outlined in Section 10.

2 Site Description

The site information is summarised in Table 1.

Table 1: Summary of Site Information and Description

Location	922 Luggate-Cromwell Road (SH6), Cromwell
Legal Description	Part Sections 62-63 Block IV Wakefield Survey District, Part Section 63 Block IV Wakefield Survey District, Section 1 Survey Office Plan 365897, Section 4 Survey Office Plan 557380 and

Table 1 (cont.): Summary of Site Information and Description

Legal Description (cont.)	Sections 64-65 Block IV Wakefield Survey District.
Property Owner	Fulton Hogan Limited
Former Site Use	A large proportion of the property is used for gravel quarrying purposes. Other isolated parts of the site are used for administration (offices), a concrete plant, an asphalt plant, a glass recycling area, equipment storage areas and for storage of a large stockpile of imported cleanfill. The remainder of the site is not used.
Proposed Site Uses	Residential, commercial and recreation areas are proposed.
Property Area	Approximately 118 ha
Territorial Authorities	Central Otago District Council Otago Regional Council
Zoning	80.1 ha of Low Density Residential Zone, 10.1 ha of Medium Density Residential Zone, 4.7 ha of Business Resource Area 3, 2.3 ha of Industrial Resource Area 2, and 22.3 ha of Industrial Resource Area 3
Geology	The GNS New Zealand Geology Webmap[5] indicates that the site contains two geological units: The majority of the site is located within Late Pleistocene outwash deposits of Albert Town Advance, described as "*Unweathered to slightly weathered, loose, sandy to silty, well rounded gravel usually on large outwash plains*". A small area located near to the northern boundary is underlain by Holocene fan deposits, broadly described as "*Loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree (upslope) and valley alluvium*".
Hydrogeology	Information provided in support of Private Plan Change 21, prepared by e3Scientific[1], confirms that the site is located within the Pisa Groundwater Management Zone. Groundwater flows from the Holocene river deposits, west of the site, through the highly permeable Late Pleistocene river deposits, comprised of sandy gravel or sandy cobbles and gravel, underlying the site. Groundwater ultimately reaches Lake Dunstan, east of the site. ORC data[6] indicates that several water bores are located at and around the site. Groundwater depths in those wells ranged between 10.6 m below ground level (bgl) and 16.47 m bgl.

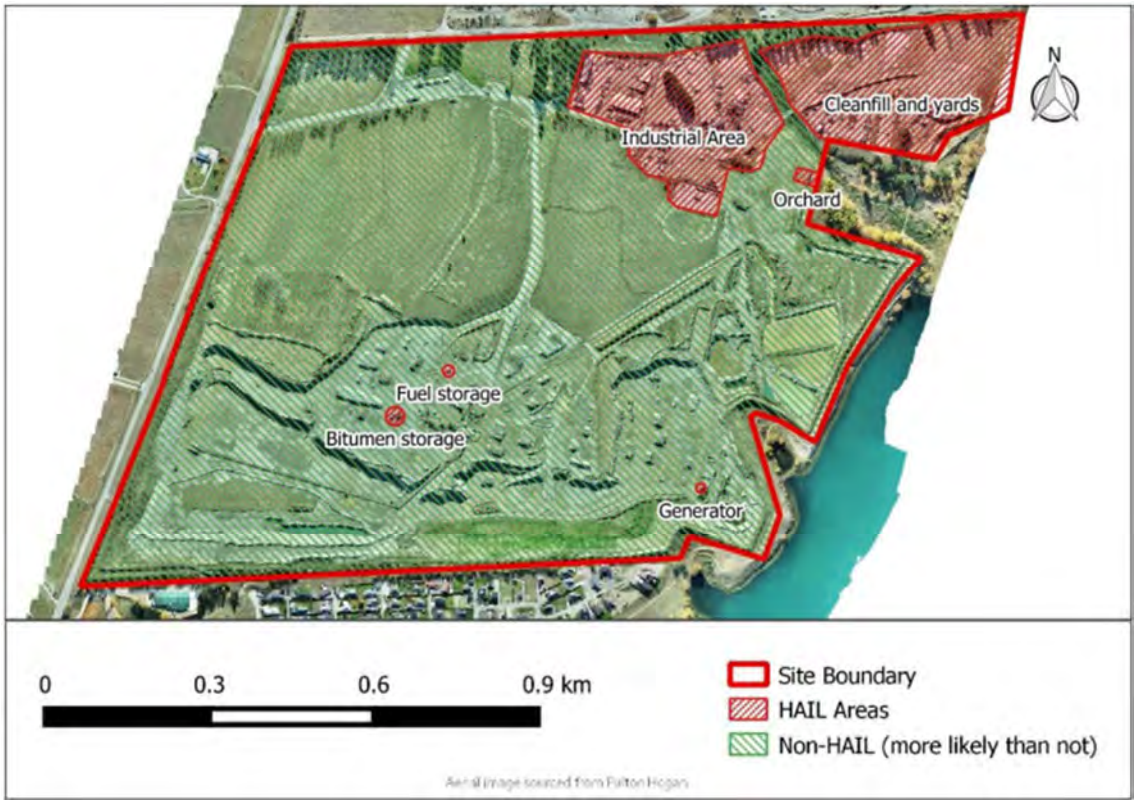
2.1 Contaminants of Concern

e3 identified[1] petroleum hydrocarbons, heavy metals and possible persistent pesticides as contaminants of concern in various isolated parts of the site.

2.2 Contaminant Distribution

Contamination impacts are primarily located within the north eastern portion of the site, in the vicinity of the asphalt plant, the concrete block manufacturing facility, equipment storage areas / yards and the cleanfill stockpile.

Additionally, isolated areas of potential impact were identified by e3 within the quarry area in the central and southern portions of the site.



The map above courtesy of e3 (Appendix 2) shows the areas within which contaminants are located. The locations of specific hazardous activities within the north eastern portion of the site are outlined in Figure 2.

2.3 Volume of Contaminated Soil

Cleanfill Stockpile

Due to the variability of the material observed by e3[1] and IE[2], a small percentage the cleanfill stockpile is conservatively considered to contain contaminants at concentrations marginally exceeding the relevant SCSs.

However, statistical analysis of laboratory results[2] confirmed that the 95% upper confidence limits for heavy metals concentrations are below the current background criteria for Otago and Southland[7].

The stockpile volume has been estimated by LandPro, based on survey data collected in December 2025, at approximately 130,800 m^3.

Asphalt plant

The volume of impacted material cannot be quantified until the plant and other operations on site have ceased. It is conservatively estimated that up to 100 m^3 could be impacted with various petroleum hydrocarbon products in the vicinity of the asphalt plant.

Fuel storage areas

Above-ground fuel storage activities generally result in negligible surface impacts from drips during refilling of machinery. However, underground fuel storage tanks and associated pipework can result in more significant impacts. Those impacts will only become apparent when removing the fuel tank(s).

It is conservatively anticipated that the volume of impacted soil associated with fuel storage areas could total up to 50 m^3.

Other areas

The contractors' yards, used for storing machinery and treated timber poles, are conservatively estimated to contain up to 100 m^3 of impacted material.

The former orchard area is considered unlikely to contain significant concentrations of persistent pesticides, due to the significant length of time since they could have been applied to the site. However, if present, the conservative estimate for the volume of impacted material is 70 m^3, based on impacts within the upper 100 mm across an area of approximately 700 m^2.

3 Assessment of Remedial Options

The following section identifies potential remedial options that are considered suitable for remediating soil contaminated with heavy metals, petroleum hydrocarbons and persistent pesticides that have been successfully conducted at field scale level and that have been documented at contaminated site case studies both nationally and internationally.

Table 2 provides a brief description of the remedial method and an assessment of whether this method is applicable to this site given its setting, proposed land use, contaminant volume, and distribution across the site and throughout the soil profile, as well as the required timeframe to complete the work.

Table 2: Assessment of Remedial Methods for Impacted Soil.

Remedial method	Description	Applicable and feasible at the site?
Electrokinetics	Electrokinetics is the application of low intensity current between electrodes placed in the soil (in-situ or ex-situ) to mobilise the contaminants towards the polarised electrodes thereby concentrating them and allowing their subsequent removal in a smaller volume of soil[8].	Not considered applicable or financially viable at the site given the nature of the majority of the contamination on site, which is not considered to be particularly mobile in soil.
Phytoremediation	Involves the planting of certain grasses and tress which uptake the contaminants from the soil root zone into above ground plant tissue. Plants are removed after a sufficient period and disposed of at an appropriate facility[8].	Not considered applicable or feasible at the site given the length of time taken to remediate the site compared with the available timeframe to enable residential development.

Table 2 (cont.): Assessment of Remedial Methods for Impacted Soil.

Solidification/ stabilisation	Solidification refers to a process that involves binding contaminated soil with a reagent such as lime or cement, thereby changing its physical properties by increasing the strength, decreasing its permeability and encapsulating the contaminants to form a solid material[9]. The stabilisation process refers to a chemical reaction that reduces the leachability of contaminated soil, immobilising the waste and reducing its solubility; thus making the soil less harmful or less mobile. Solidification/stabilisation treatment typically involves mixing a binding agent into the contaminated soil. These techniques are done either *in-situ*, by injecting the binder agent into the contaminated media, or *ex-situ* by excavating the materials and machine mixing them with the agent.	Remediation technique is considered applicable to the site, especially the material within the cleanfill stockpile, but the process requires specialised equipment to enable uniform mixing of the impacted material and the binding agent. The approach is therefore not considered to be economically viable.
Soil washing	This method would typically involve physical and chemical separation of the majority of the contaminants into a smaller volume which is then disposed of or treated further. The washed or processed soil is then returned to the site. Physical separation typically involves standard mineral processing equipment to remove the finer particles which are likely to contain the majority of the contaminants. Chemical washing involves transferring the contaminants from the soil into solution which is subsequently treated[10].	Given the time and associated costs to design and set up the soil washing process, this remedial approach is considered not a financially viable option. This option would also produce other waste streams (liquid reagents) that would require further treatment/disposal.
'Do nothing' approach	Continue with the residential development without undertaking any prior remedial activities.	Not considered applicable given the restrictions of the NES-CS which prohibit the residential use of sites that contain contaminants at concentrations that exceed the SCSs. Furthermore, earthworks are required for geotechnical purposes and the opportunity to re-work the impacted material therefore exists.
Offsite disposal	This involves the physical excavation of the contaminated soil and offsite disposal at an appropriate waste disposal facility.	Considered applicable, but given the total volume of impacted material to be removed the cost of disposal is considered a significantly limiting factor. However, off-site disposal is considered likely to be selected as the remedial option for the most significantly impacted material on site e.g. bituminous residue, or significant petroleum hydrocarbon impacts.

Table 2 (cont.): Assessment of Remedial Methods for Impacted Soil.

Containment / Encapsulation	This remedial approach would involve excavating the impacted soil identified at the site and placing within a containment cell. A suitable containment cell for the site could be positioned 1 m below finished ground level within the stormwater corridor in the central portion of The Project. Furthermore, space is available beneath 2 m of engineered fill within residential properties in north eastern portion of The Project.	Considered applicable given the abundance of available containment space in certain parts of The Project. The cleanfill stockpile is required to be moved to enable excavation of the underlying pea gravels which are not geotechnically suitable for use as engineered fill. Therefore, the opportunity to screen the cleanfill stockpile and remove large inclusions will be incorporated into the remediation works. The screened cleanfill can then be placed beneath the engineered fill layer in the stormwater channel in the central portion of The Project, as well as beneath a few residential properties in Stages 14 and 15 of The Project. Once all cleanfill stockpile material has been placed and compacted, back-filling to the finished design levels can continue, using clean material from other parts of the property. Once buried, the cleanfill would not interact with the environment to a measurable degree.
Capping	This remedial method involves capping the site with a sufficient thickness of clean soil.	The geotechnical constraints of the underlying pea gravel layer means that excavation of the pea gravel beneath the cleanfill stockpile is required to enable the construction of 'good ground' in that part of The Project, therefore the stockpile cannot be capped in its current state. However, the containment / encapsulation approach is proposed to be supplemented by capping the cleanfill with at least 1 m of clean engineered fill from other parts of the property.

Of the available options, on-site containment / encapsulation of the impacted material, supplemented by capping with at least 1 m of engineered fill, is considered to be the most effective way to eliminate risks to human, environmental and ecological health for small amount of contaminated material within the cleanfill stockpile.

Significantly contaminated material, such as petroleum hydrocarbon-impacted soil, will be disposed of off-site at an appropriate facility such as Victoria Flat landfill in Gibbston, or the Taiko Landfill near Timaru.

4 Discussion

Excavation, screening and encapsulation of the cleanfill stockpile can be easily achieved during the bulk site earthworks phase. Excavation of the cleanfill stockpile is required regardless of which

remediation method is selected, because the underlying pea gravels must be removed prior to back-filling with competent material for geotechnical purposes.

Once constructed, the potential for stormwater infiltration through the 1 m thick engineered fill crust, to be able to reach the marginally impacted pockets within the compacted cleanfill, is considered to be low under normal Central Otago climate conditions.

IE has undertaken a soakage test to estimate the rate of infiltration through a test layer of compacted crushed pea gravel that will form the engineered fill crust / encapsulation layer over the cleanfill. The results confirmed that stormwater infiltration is limited by the generally low hydraulic conductivity of the crust, which is assessed as ranging between 4 x 10^{-6} m/s and 5.5 x 10^{-6} m/s. Infiltration through the crust would require sustained moderate intensity rainfall for periods up to 20 hours (typically). Such rainfall events are rare at the site. Additionally, the fill within the containment cell is also to be compacted. While it was not possible to perform soakage testing on a representative sample of this material, the compaction is expected to reduce the hydraulic conductivity, further limiting the transmission of water through the fill.

If a significant rainfall event does occur, the generation of leachate from the small pockets of marginally impacted of soil within the compacted cleanfill layer is likely to be minimal even without the 1 m layer of engineered fill crust, due to the fact that contaminant concentrations are expected to be at, or below, background in the majority of the compacted cleanfill layer[2].

Off site disposal will be reserved for the most significantly contaminated material, due to the unsustainability of disposing of contaminated material at landfills intended for household refuse and industrial waste.

The encapsulation approach does result in minor risks to worker health or the wider environment, but only during the earthworks phase. Therefore, implementation of the approach should be under a remediation action plan (RAP) and environmental management plan (EMP) detailing the health and safety, environmental and regulatory considerations.

5 Remediation Methodology

5.1 Introduction

IE has developed the following methodology to complete the remediation of the impacts identified by e3[1].

5.2 Description of Remedial Works

The extent of the proposed remedial work is limited to the areas highlighted in Figure 2.

The remedial works will be undertaken in the following order:

- A site meeting will be held with the individuals responsible for physical works, to ensure that the methodology and requirements of this RAP have been communicated and understood;
- Physical works will be completed by the designated remediation contractor and periodically observed by IE staff;

The potential risks associated with the chosen remedial method to be employed at this site are considered negligible. However, to ensure that there are no adverse environmental effects beyond the immediate vicinity of the remediation areas, the earthwork activities shall be undertaken in

accordance with the protocols outlined in this RAP, as well as under a robust EMP to ensure stormwater, sediment and dust are controlled to the maximum possible extents.

Potential risks associated with contaminants identified on site relate to dermal contact, ingestion and inhalation of soil particles (dust). These risks will be kept to a minimum through the use of controlling site access, dust mitigation measures, and the control of stormwater. Information relating to minimising such risks is outlined in Section 6.0.

This RAP should not be used as a standalone document but should supplement the earthwork operators own health and safety protocols for their employees and contractors.

While some tasks may overlap during the remediation, the following outline indicates the proposed sequencing of works:

- Site establishment and kick-off meeting;
- Excavation and stockpiling of impacted material from the areas identified by e3[1];
- Confirmation of the significance of contamination impacts in material from the asphalt plant, fuel storage locations and former orchard area through laboratory testing;
- Screening of the cleanfill material to remove large inclusions, for geotechnical purposes;
- Placement and compaction of the cleanfill, and marginally impacted material from other parts of the site, beneath the stormwater corridor in the central portion of The Project and beneath residential properties in the north eastern corner of The Project;
- Capping the cleanfill material with at least 1 m of engineered fill generated by crushing pea gravel;
- Off-site disposal of the significantly impacted material (if any) from other parts of the site; and
- Production of a Works Completion Report, to summarise the remediation activities undertaken for each area identified by e3[1].

These works are described in further detail in the following sections.

5.3 Site Establishment

5.3.1 Procedures

Prior to the remedial works commencing at the site, the remediation supervisor will outline all relevant Health and Safety requirements to personnel working on site during the remediation works. Such requirements will be documented within a detailed Health and Safety Plan (HASP) which will be kept in the site file. In general, the following procedures will be adhered to, to ensure that the health and safety, and environmental measures are achieved:

- Personal safety equipment and procedures associated with the contaminants will be explained to the individuals responsible for physical works;
- The identification and marking out of the proposed remediation areas by the remediation supervisor prior to commencement of the remediation program. ‘Clean’ and ‘dirty’ areas will be identified.

5.3.2 Site Supervision

To provide control and validation of the proposed remedial works it is recommended that a designated, suitably trained site supervisor is present to oversee the works on a part-time basis. The site supervisor would address field changes as necessary should unanticipated conditions arise.

Prior to earthworks activities commencing, all employees and contractors associated with the remedial work shall also be briefed by the individuals responsible for physical works with respect to any potential hazards on the site relevant to their role.

5.3.3 Health and Safety

This RAP identifies potential hazards associated with the presence of contaminants in site soils and recommends procedures to mitigate these risks. Risks associated with elevated concentrations of petroleum hydrocarbons, heavy metals and persistent pesticides relate to dermal contact, ingestion and to inhalation of impacted soil particles during earthwork activities.

Prior to the commencement of the remediation works a HASP will be prepared for the proposed activities. All site personnel will be required to review this document. At the start of each day, a brief "tool box" meeting shall be held to review the HASP and the proposed work for the day, discuss potential perceived health and safety risks as well as environmental management procedures and communicate these issues to the remediation team.

To prevent the unintended transfer of any contamination off site, or to other areas within site boundaries, and to minimise exposure to site remediation workers the following risk mitigation measures will be followed:

- To minimise exposure to airborne dust, the excavator and truck driver shall keep cab windows closed and use air conditioning when excavating and loading soil during remediation earthworks;
- Contractors working outside shall wear a half face disposable mask or filter type particulate respirator, if dust is generated during completion of remedial works; and
- Eating, drinking, smoking, use of mobile phones and applying cosmetics / sunscreen should only occur outside of the remediation areas and after face and hands have been thoroughly washed with potable water.

5.4 Validation of Works

The extents of the encapsulation / containment cells will be professionally surveyed as part of the site development works. The relative levels and extents of the base, sides and top of the compacted layer of cleanfill material will be recorded. Furthermore, the survey data for the finished ground level above the encapsulated material will be recorded to confirm the thickness of the engineered fill crust.

5.4.1 Selection of Remedial Goals

The remedial goals are proposed to make the site suitable for residential use[4].

Given the fact that marginally impacted material will be encapsulated deep below the finished site surface, no laboratory testing of that material is considered necessary. Instead, periodic XRF scans will be undertaken to assess whether any heavy metals are present at concentrations that could be considered significant.

Furthermore, laboratory testing of material from areas used for asphalt production or fuel storage will be undertaken to quantify the significance of the impacts (if present).

For this site, significant contamination impacts are conservatively set at twice the applicable criteria for the protection of human health (such as SCSs, or equivalent) on residential land.

If any contaminants are identified to be present at concentrations exceeding the remedial goals, the material will be diverted away from the containment cells and will be disposed of off-site at an appropriately licensed facility.

5.4.2 Validation Methodology

IE will supervise the excavation and off-site disposal of material from significantly contaminated areas, where impacts are visually obvious, such as the areas covered with a bituminous product near to the asphalt plant and south east of the cleanfill stockpile.

Material surrounding the obviously contaminated areas, where petroleum hydrocarbons are present, will be screened on site using a photoionization detector (PID). If the vapour concentration exceeds 100 ppm, samples will be collected for laboratory analysis to confirm whether the material is suitable to be retained on site within the containment cells, or whether off-site disposal is required. If the vapour concentrations are below 100 ppm, no further excavation will be undertaken unless required for geotechnical purposes. Any excess spoil from those areas, with vapour concentrations below 100 ppm, will be placed into the containment cells prior to the cells being capped with clean material.

Validation samples will be collected from the residual material where impacts associated with engine oil stains and treated timber storage have been remediated.

If any material is required to be excavated from the former orchard area, it will be placed and compacted into the containment cells. Samples will be collected from the soil remaining in the former orchard area, after excavation works have been completed, for laboratory testing of persistent pesticide concentrations. If pesticides are found at concentrations above the laboratory limits of detection, additional excavation will be undertaken until the remaining soil does not contain detectable concentrations of persistent pesticides.

5.5 Timescales

It is expected that site development earthworks could continue for up to 10 years.

IE understands that the site development will be undertaken in a staged approach, with the north eastern portion of the site being developed last of all. That provides abundant time to ensure that the remediation works are completed well before bulk earthworks commence in that part of the site.

The remedial works are expected to take up to two years, for the excavation, screening, placement and compaction of the cleanfill stockpile. Remediation of the remaining areas could be completed within 3 months at any time during the site development process.

A Works Completion Report will be presented to CODC within three months following completion of all remediation earthworks.

5.6 Post Remediation

Other than areas of currently unknown sources of contamination, surface soil remaining at the site will not exceed criteria designed to be protective of human health during normal residential use.

It is not expected that disturbance of the compacted cleanfill material within the containment cells would be required in the future. However, if excavation depths reach that material it is conservatively recommended that a Contaminated Site Management Plan be prepared to control those works.

6 Assessment of Environmental Effects

6.1 Introduction

This section of the RAP details the potential environmental effects that could occur from conducting the remediation outlined previously. Table 3 summarises the potential effects associated with the proposed remedial works and the management measures that are recommended to mitigate these.

Table 3: Potential effects of remediation works and proposed mitigation measures.

Potential Effects	Receptor	Mitigation Measures
The potential for dust generation is high during the stockpiling and placement of soil on site.	Site workers and members of the public on neighbouring properties are the primary receptors.	When wind speed is high enough to cause visible dust, the site surface and excavations will be dampened to suppress dust generation. Stockpiles of soil will be covered or stabilised with dust suppressant spray, as necessary.
Excavator and truck noise will be generated during the remedial activities.	None, because surrounding residential properties are located over 800 m from the activities.	All work will be conducted during regular daytime business hours.
Contaminated surface water, stormwater and sediment discharge from site during rainfall events.	Neighbouring properties and Lake Dunstan / *Te Wairere*.	All works will be completed under a robust EMP to ensure that surface water, stormwater and sediment are controlled appropriately.
Exposure to impacted materials (direct contact with contaminated soil).	Site personnel.	Control site access, no public access to be allowed. Instruction on site rules and site induction to site workers. Appropriate dust suppression. Good hygiene practices (hand washing, no smoking). Use of appropriate PPE. Suitable decontamination procedures.

6.2 Dust Control

The inhalation of contaminated dust on site during earthworks is considered to be a hazard to earthwork contractors and staff present within the site.

The following activities may generate dust during the remedial works:

- Excavation of contaminated material.
- Placement of fill onto the containment cells.

It is recommended that the following control methods are implemented to ensure that dust levels generated by earthwork activities are kept to a minimum:

- Any material temporarily stockpiled should be covered as soon as possible.
- Avoid working or standing in areas down-wind of earthwork activities.
- Limit drop heights from excavator buckets.
- Keep windows / doors on excavators and trucks closed when parked in the earthworks area.
- Apply water by a cart or sprinkler prior to commencement of works. The site shall be regularly damped down to reduce any airborne dust. This should prevent visible dust emissions beyond the site boundary.

Weather reports will be checked at the beginning of each day and if high wind speeds are expected the above mitigation measures will be prepared. When wind speed exceeds such a level that dust is noted to be airborne, operations shall cease. The site health and safety officer or site foreman will be responsible for ensuring that the dust mitigation measures are implemented when necessary.

Site practices to reduce worker exposure to contaminated dust should also include the designation of exclusion zones, such as the excavation area(s), where the provision and use of particulate dust masks is required. Such controls should be outlined within the contractors HASP.

6.3 Noise

The following protocols will be employed to ensure that noise levels are kept to acceptable standards:

- Earthwork activities will be restricted to the hours of 7:00 am to 6:00 pm Monday to Friday and 7:30 am to 5:30 on Saturdays. No work shall be permitted on Sundays or Public Holidays.
- These remedial works will be required to comply with the New Zealand Standard NZS 6803: 1999 “Acoustics – Construction Noise”[11].

6.4 Stormwater Control

Where applicable, the site surface will be graded to divert stormwater away from site boundaries.

Any temporary stockpiled soil will not be placed adjacent to drainage areas and will not contain contaminated soils. Runoff from the stockpiles will be mitigated by covering stockpiles with tarpaulins, or other sediment management methods specified in the EMP.

6.5 Site Access

The remediation contractor will use appropriate means to ensure that members of the public are not able to enter the site during completion of remedial works. This may be through the use of fences, barrier tape, signs and / or personal observation and communication.

6.6 Decontamination

No decontamination of equipment is expected to be required upon completion of the remedial works within the containment cells.

Decontamination of equipment used to excavate petroleum hydrocarbon-impacted soil will be undertaken by rinsing excavator buckets with water in a way that the wash water is contained within the bed of the truck used to dispose of the material off-site.

If bitumen remains attached to the excavator bucket(s) or truck bed(s), those parts of the machines will be scrubbed using degreaser to dissolve the bitumen. The waste liquid will then be placed into the next load of contaminated material being disposed of off-site. Liquid from the final rise will be collected in an appropriate receptacle for off-site disposal, such as an empty 44 gallon drum that can be sealed for transport.

6.7 Unforeseen Conditions / Circumstances

Other potentially hazardous conditions which have not been identified may exist at the site, including discovery of additional contamination during remedial works. In the event of any unforeseen circumstances the remediation supervisor should be consulted. Assessment of the contamination will be determined using the remediation supervisors judgement and knowledge of industry best practise.

7 Reporting

At the completion of the remediation and validation works a Works Completion Report will be prepared outlining the remediation works undertaken and presenting the laboratory results of the soils tested during the remedial works.

8 Statutory considerations

8.1 Introduction

The Resource Management Act 1991 (RMA), and associated statutory planning documents, establish the framework for the management of all activities that utilise New Zealand's natural and physical resources. The remediation of the site is assessed against the requirements of these documents in the following sections of the RAP.

In relation to the proposed remediation, the relevant statutory documents are:

- Resource Management Act 1991 (RMA)[12].
- Central Otago District Plan and the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NES-CS)[3].
- Regional Policy Statement for Otago 1998 (RPS)[13].
- Regional Plan: Waste for Otago 2022 (Waste Plan)[14].

Part 2 of the RMA outlines the purpose and principles of the RMA. Section 5 states:

> *"(1) The purpose of this Act is to promote the sustainable management of natural and physical resources.*
>
> *(2) In this Act, "sustainable management" means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while –*
>
> *(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> *(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
>
> *(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment."*

The proposed remediation of the site is intended to ensure that the site can be used for residential purposes. The ability to use the land resource safely, into the future, means that people and communities can provide for their social, economic and cultural well-being. In relation to the land, water and air resources of the area, the proposed remediation approach will ensure that, except for a relatively small volume of soil impacted with petroleum hydrocarbons, valuable landfill space (land) will not be taken up by impacted material, the generation of dust and sediment discharge will be managed to minimise or eliminate the potential adverse effects on air and surrounding land / water.

Section 6 sets out the matters of national importance which shall be recognised and provided for while Section 7 identifies matters for which regard shall be had under the RMA. There are no section 6 matters which are considered to be of relevance to this proposal. However, the following section 7 matters are considered to be relevant:

"(b) the efficient use and development of natural and physical resources:

(c) the maintenance and enhancement of amenity values:

(f) maintenance and enhancement of the quality of the environment"

The proposed remediation method, as detailed in this RAP, will enable the efficient use of the land into the future, in so doing achieving the intent of Section 7(b)).

In addition, the management measures incorporated into the proposed remediation approach will ensure that the land, air and water resources of the area will not be adversely affected during the remediation process and into the future. This ensures that the quality of the surrounding environment is enhanced (section 7(f)), which in turn provides for enhancement of amenity values in the area (section 7(c)).

Section 8 of the RMA requires specific regard to be had to the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).

Lake Dunstan / Te Wairere is of significant cultural importance to mana whenua. Lake Dunstan / Te Wairere is a Statutory Acknowledgement Area and formally recognises the deep cultural, spiritual, historical, and traditional association of Ngāi Tahu with the lake and surrounding section of the Clutha River.

Given the above assessment, the proposed remediation approach, as outlined in this RAP, will promote the sustainable management of natural and physical resources and is therefore consistent with Part 2 of the RMA.

8.2 Central Otago District Plan and the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health

Land contamination is dealt with under the Central Otago District Plan through the implementation of the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NES-CS). All local territorial authorities (district and city councils) are required to give effect to and enforce the requirements of the NES-CS.

The NES-CS[4] came into effect on 1 January 2012. The objective of the NES-CS is to ensure that land affected by contaminants in soil is appropriately identified and assessed at the time of being developed and if necessary remediated, or the contaminants contained, to make the land safe for human use.

Regulation 5 sets outs the land and the activities to which the NES-CS applies. The NES-CS applies if it is on land described under Regulation 5(7), and if the activity proposed is described in any of subclauses (2) to (6) of Regulation 5.

Regulation 5(7), applies to any land on which an activity or industry described in the current edition of the Hazardous Activities and Industries List (HAIL) is being undertaken, is suspected to have been, or has been undertaken. Activities undertaken at the site are included on the HAIL (refer to the site investigation reports[1, 2]). Therefore, Regulation 5(7) applies.

The activities described in subclauses (2) to (6) of Regulation 5 include subdivision, land-use change, significant earthworks, soil sampling or removing fuel storage systems. The remedial approach involves disturbing the soil of the piece of land for a particular purpose, therefore the NES-CS applies to this activity.

The proposed remediation of the site does not meet the requirements of Regulation 8(3) and the remedial work can therefore not be undertaken as a Permitted Activity. The activity is not Controlled, being that it does not meet Regulations 9(1)(b) and 9(3)(b). As a result, the activity would, under normal circumstances, require consent under the NES-CS for a restricted discretionary activity pursuant to Regulations 10(1) and 10(2). However, given the fact that certain areas of contamination impact cannot be assessed while the site is operational, the activity would need to be undertaken as a Discretionary Activity pursuant to Regulation 11.

8.3 Regional Policy Statement for Otago

8.3.1 Overview

The RPS[13] became operative on 1 October 1998. Since becoming operative changes were notified in May 2015 and a decision was made in October 2016. Changes to the RPS went through an appeals process and a partially operative RPS was issued in 2019, including the changes resulting from the appeals process.

The RPS 1998 is now deemed to be only partially operative and the provisions of Chapter 13 – Wastes and Hazardous Substances in this version of the document have been fully revoked. Accordingly, for the purposes of this assessment, it is the provisions of the Partially Operative RPS 2019 in Part B Chapter 4, that address contaminated land that are relevant to the consideration of this proposal.

The RPS provides an overview of the resource management issues within the Otago region. It then developments a policy framework (i.e., objectives and policies), and associated methods for delivering on that policy, aimed at achieving integrated management of the region's natural and physical resources. Regional Plans, including the Waste Plan, and district plans cannot be inconsistent with the RPS.

8.3.2 Assessment of Relevant Objectives and Policies

Part B Chapter 4 of the Partially Operative RPS addresses issues, and develops an associated policy framework, in relation to 'hazardous substances, contaminated land and waste materials'. This includes contaminated sites. Therefore, the policy framework of relevance to the proposed remediation, as outlined in Section 13 of the RPS, is:

- *To minimise the risks, to people and the environment, arising from existing contaminated sites (Objective 13.4.4).*
- *To address the adverse effects from past waste disposal, including identified contaminated sites, by remedying and mitigating any adverse effects arising from such sites (Policy 13.5.7).*

The proposed remediation approach, as outlined in this RAP, has been developed to minimise the future risks to people and the environment. This is to be achieved by encapsulating and capping the contaminated soil within portions the property that are unlikely to be disturbed in the future. In so doing, the removal of the majority of impacted fill from the site is eliminated. On this basis, the proposed remediation approach is consistent with the relevant policy framework of the Partially Operative RPS.

8.4 Regional Plan: Waste for Otago

8.4.1 Overview

The Waste Plan[14] became operative on 9 July 2022.

The Waste Plan seeks to provide for the integrated management of waste (solid, liquid and gaseous) through the implementation of a waste strategy which addresses all stages of the waste life cycle.

Chapter 4 of the Waste Plan covers Waste Minimisation to enable the most efficient use of resources and energy.

Chapter 5 of the Waste Plan covers Contaminated Sites, and includes the discharge of hazardous substances or wastes onto or into land or water, and the issues associated with remedying or mitigating the adverse effects of those contaminant discharges. Therefore, Chapter 5 is of relevance to the proposed remediation of the site.

Chapter 7 of the Waste Plan covers Landfills, which includes the disposal of solid wastes onto or into land. As the remediation method eliminates the requirement to dispose of impacted material at a landfill, Chapter 7 is also of relevance to the proposed remediation.

8.4.2 Assessment of Relevant Objectives and Policies

The policy framework within Chapters 4 and 5 of relevance are:

- *To encourage, support and facilitate integrated waste management by minimising the effects on the environment by reducing the quantity and / or toxicity of material entering the waste stream; reusing materials, recycling materials, where practicable, that cannot be reused; recovering resources from materials in the waste stream and disposing of the residual waste in an environmentally safe manner (Objective 4.4.2).*
- *To avoid, remedy or mitigate any adverse effects of contaminated sites (Objective 5.3.1).*
- *To avoid further site contamination. (Objective 5.3.2).*
- *To contain and remediate contaminated sites, to the extent that is practicable, and having regard to the land's future use (Policy 5.4.3).*
- *To apply the Australia and New Zealand Conservation Council's "Guidelines for the Assessment and Management of Contaminated Sites" (January 1992) to determine, for a particular contaminated site, the most appropriate course of action (Policy 5.4.4).*

The proposed remediation of the site has been designed utilising the current relevant guidelines (i.e., guidelines that have superseded those specified in Policy 5.4.4 above), to ensure that the land can be utilised in a manner consistent with its proposed future use (i.e. residential land use). This means that the adverse effects of contamination at site will be avoided, remedied and mitigated as a result of the proposed remediation.

Given the above assessment, the proposed remediation approach is consistent with objectives 4.4.2, 5.3.1, 5.3.2 and policies 5.4.3 and 5.4.4 of the Waste Plan.

The policy framework within Chapter 7 – Landfills, is mostly relevant to typical landfills, and not the proposed remediation activity. However Objective 7.3.1 (*to avoid, remedy or mitigate the adverse environmental effects arising from the discharge of contaminants at and from landfills*) is of relevance to the remediation method, as disposal of the vast majority of impacted material is actively avoided by the on-site containment and encapsulation strategy. The potential negative effects that could occur, if impacted spoil was disposed of at a landfill, are therefore eliminated to the maximum practicable extent.

8.4.3 Assessment of rule applicability

The Waste Plan contains only one rule (Rule 5.6.1) covering activities in and around contaminated land as follows:

> *"5.6.1 Hazardous wastes at contaminated sites (discretionary activity).*
>
> 1. *The disturbance of land; or*
> 2. *The discharge of hazardous waste into water; or*
> 3. *The discharge of hazardous waste onto or into land in circumstances that may result in that hazardous waste (or any other hazardous waste emanating as a result of natural processes from that hazardous waste) entering water; or*
> 4. *The deposit of any hazardous waste, in , on or under land; or*
> 5. *The discharge of hazardous waste into air at or from a contaminated site;*
>
> *is a discretionary activity."*

The excavation, containment and encapsulation of the cleanfill stockpile and other marginally impacted soil requires the disturbance of land and a discharge of hazardous waste to land (within the containment / encapsulation area). As such, resource consent would be required for the proposed remediation pursuant to Rule 5.6.1.

The rules covering the discharges of waste onto or into land are contained in Section 7.6 of the Waste Plan and these will be applicable to the operator of the receptor site where some waste will be disposed of.

8.5 Summary of Statutory Considerations

Remediation of the site by excavation and on-site capping of marginally impacted soils, as well as off-site disposal of more significantly impacted soil, as outlined in this RAP, is consistent with the requirements of Part 2 of the RMA[12] and the policy framework of the relevant statutory plans (i.e., the RPS[13], the Waste Plan[14]).

Resource Consent is required from the ORC, according to Rule 5.6.1., as the remediation method results in a disturbance of land containing hazardous waste at a contaminated site[13]. Resource Consent is also required from CODC, under NES-CS Regulation 8(3)[4], to disturb soil on a site where hazardous activities or industries have occurred.

9 References

1. e3scientific Limited 2021: Parkburn Quarry Preliminary Site Investigation. Report reference #21085

2. Insight Engineering 2026: Preliminary and Detailed Environmental Investigation at 922 Luggate-Cromwell Road (SH6), Cromwell. Report reference 24019_3
3. Ministry for the Environment 2011: Contaminated Land Management Guidelines No.1: Reporting on Contaminated Sites in New Zealand.
4. Ministry for the Environment 2012: Users' Guide National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.
5. GNS Webmap Institute of Geological and Nuclear Sciences 2013: 1:250,000 Geology. Viewed at: http://data.gns.cri.nz/geology/
6. Otago Regional Council 2025: Otago Regional Council Resource Consent Database. Viewed at: https://maps.orc.govt.nz/OtagoMaps/
7. The New Zealand Institute for Bioeconomy Limited 2025: Determination and use of background concentrations of trace elements in soil in Otago and Southland.
8. US Environmental Protection Agency 1997: Recent Developments for In Situ Treatment of Metal Contaminated Soils. USEPA Contract Number: 68-W5-0055.
9. US Environmental Protection Agency 2009: Technology Performance Review: Selecting and Using Solidification / Stabilization Treatment for Site Remediation.
10. Contaminated Land: Applications in Real Environments 2007: Understanding Soil Washing, Technical bulletin TB13.
11. Standards New Zealand 1999: NZS 6803:1999 Acoustics – Construction Noise.
12. Ministry for the Environment 1991: Resource Management Act.
13. Otago Regional Council 1998: Regional Policy Statement for Otago.
14. Otago Regional Council 2022: Regional Plan: Waste for Otago.

10 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Fulton Hogan Land Development, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground conditions indicated from published sources, site assessments and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

v. This ROA is not to be reproduced either wholly or in part without our prior written permission.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on [redacted] if you require any further information. The author is a Certified Environmental Practitioners (CEnvP) under the Environment Institute of Australia and New Zealand (EIANZ) accreditation system.

Prepared by





Claude Midgley, CEnvP
Principal Environmental Scientist

Appendix 1

Figures



Note: Map and aerial photograph courtesy of Google



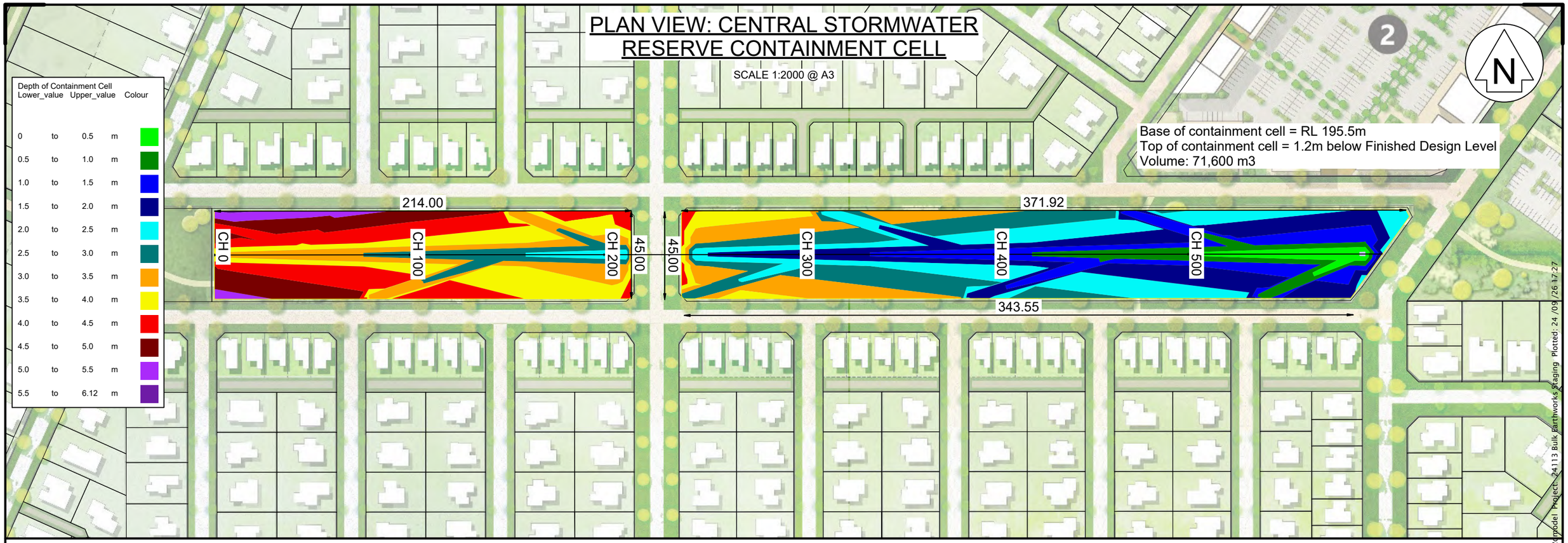
Description	Site Location Plan	**Figure Number**	1
Project	Remediation Action Plan for the Parkburn Quarry at 922 Luggate-Cromwell Road (SH6), Cromwell	**Date**	Sept-26
Client	Fulton Hogan Land Development Limited c/- Tim James Limited	**Drawn by**	CM
Project Number	24019_RAP	**Approved by**	JK

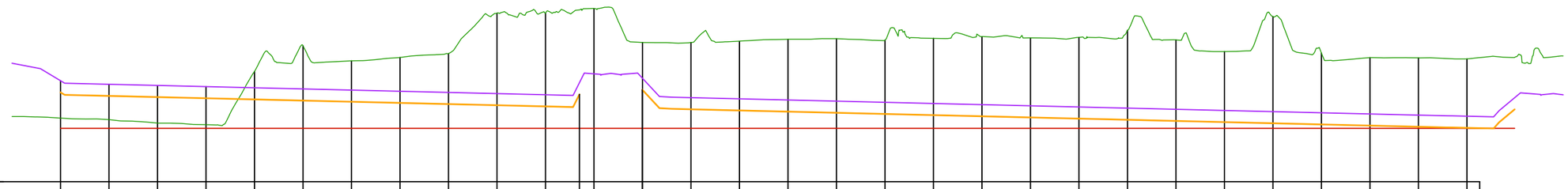


Description	Areas Potentially Requiring Remedation	**Figure Number**	2
Project	Remediation Action Plan for the Parkburn Quarry at 922 Luggate-Cromwell Road (SH6), Cromwell	**Date**	Sept-26
Client	Fulton Hogan Land Development Limited c/- Tim James Limited	**Drawn by**	CM
Project Number	24019_RAP	**Approved by**	JK

PLAN VIEW: CENTRAL STORMWATER RESERVE CONTAINMENT CELL

SCALE 1:2000 @ A3





DATUM = 190.00

CHAINAGE	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540	560	580
BASE OF CONTAINMENT CELL	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50
TOP OF CONTAINMENT CELL	199.21	198.84	198.72	198.60	198.48	198.36	198.24	198.12	198.00	197.88	197.76	199.92	199.46	197.46	197.34	197.22	197.10	196.98	196.86	196.74	196.62	196.50	196.38	196.26	196.14	196.02	195.90	195.78	195.66	195.55
DESIGN FINISHED SURFACE LEVEL	200.41	200.04	199.92	199.80	199.68	199.56	199.44	199.32	199.20	199.08	198.96	201.12	200.66	198.66	198.54	198.42	198.30	198.18	198.06	197.94	197.82	197.70	197.58	197.46	197.34	197.22	197.10	196.98	196.86	196.75
NATURAL GROUND SURFACE LEVEL	196.56	196.39	196.04	195.88	201.36	204.00	202.45	202.80	203.20	207.36	207.36	207.84	204.35	204.35	204.48	204.68	204.74	204.59	204.77	204.95	204.82	204.87	205.61	204.61	203.41	207.01	203.25	202.78	202.76	202.65

A3 SCALE: H 1:2000, V 1:500

LONGITUDINAL SECTION: CENTRAL STORMWATER RESERVE CONTAINMENT CELL

Folder Location: c:\12d5\data\SERVER2008R2\24113-Parkburn concept_6168\12d\24113 Bulk Earthworks Staging 12dpdel Project: 24113 Bulk Earthworks Staging Plotted: 24/09/26 17:27

LANDPRO.
OFFICES IN CROMWELL, WANAKA, AND NEW PLYMOUTH - www.landpro.co.nz

Client: FH LAND DEVELOPMENT LTD

NOTES
- All dimensions shown are in metres unless otherwise shown
- Copyright on this drawing is reserved
- Check any electronic data against the hardcopy plan to ensure it is the latest version
-If this plan is being used as part of sale and purchase agreement then it is done so on the basis that it is preliminary only, final dimensions and areas may vary on final survey

CONTAINMENT CELL DETAIL - SHEET 1 OF 2

PARKBURN DEVELOPMENT PROJECT

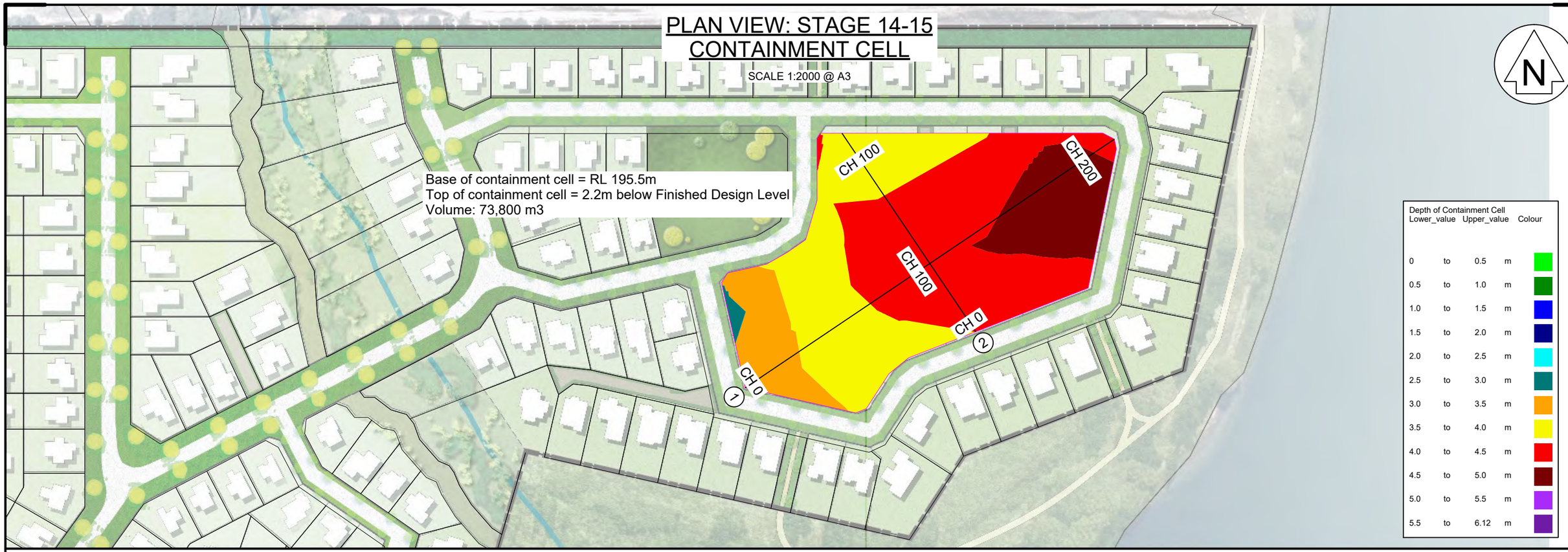
922 LUGGATE - CROMWELL ROAD

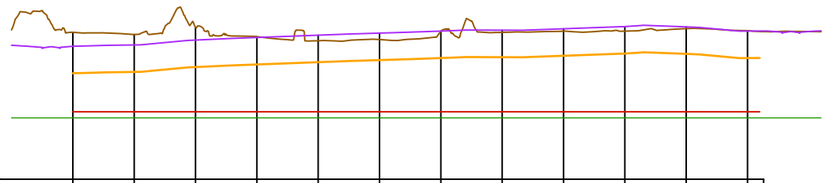
Rev.	Date	Revision Details	By

Designed: CM	Date: 09 2026	Job No.: 24113	Drawing No.: 120_01
Drawn: KA	Date: 09 2026	Scale: AS SHOWN	
Checked: NKA	Date: 09 2026	Datum & Level: LP2000 & NZVD16	Rev.: -

PLAN VIEW: STAGE 14-15 CONTAINMENT CELL

SCALE 1:2000 @ A3



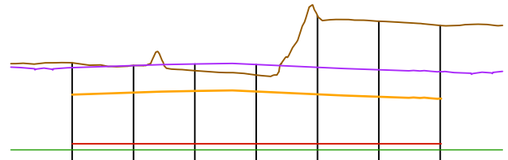


DATUM = 190.00

	0	20	40	60	80	100	120	140	160	180	200	220	
BASE OF CONTAINMENT CELL	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	195.50	
TOP OF CONTAINMENT CELL	198.64	198.74	199.14	199.35	199.54	199.71	199.87	199.95	200.06	200.24	200.22	199.87	
DESIGN FINISHED SURFACE LEVEL	200.84	200.94	201.34	201.55	201.74	201.91	202.07	202.15	202.26	202.44	202.42	202.07	
NATURAL GROUND SURFACE LEVEL	195.00	195.00	195.00	195.00	195.00	195.00	195.00	195.00	195.00	195.00	195.00	195.00	
QUARRY MATERIAL SURFACE LEVEL	201.97	201.80	202.38	201.62	201.28	201.39	202.04	201.97	202.07	202.07	202.27	202.11	
CHAINAGE	0	20	40	60	80	100	120	140	160	180	200	220	

A3 SCALE: H 1:2000, V 1:500

LONGITUDINAL SECTION 1: STAGE 14-15 CONTAINMENT CELL



DATUM = 190.00

	0	20	40	60	80	100	120	
BASE OF CONTAINMENT CELL	195.50	195.50	195.50	195.50	195.50	195.50	195.50	
TOP OF CONTAINMENT CELL	199.50	199.67	199.80	199.76	199.53	199.33	199.18	
DESIGN FINISHED SURFACE LEVEL	201.70	201.87	202.00	201.96	201.73	201.53	201.38	
NATURAL GROUND SURFACE LEVEL	195.00	195.00	195.00	195.00	195.00	195.00	195.00	
QUARRY MATERIAL SURFACE LEVEL	202.10	201.88	201.46	201.10	205.93	205.49	205.14	
CHAINAGE	0	20	40	60	80	100	120	

A3 SCALE: H 1:2000, V 1:500

LONGITUDINAL SECTION 2: STAGE 14-15 CONTAINMENT CELL

Folder Location: c:\12d5\data\SERVER2008R2\24113-Parkburn concept_6168\12d\24113 Bulk Earthworks Staging 12dmodel Project: 24113 Bulk Earthworks Staging Plotted: 24/09/26 17:27

LANDPRO.
OFFICES IN CROMWELL, WANAKA, AND NEW PLYMOUTH - www.landpro.co.nz

Client: FH LAND DEVELOPMENT LTD

NOTES
- All dimensions shown are in metres unless otherwise shown
- Copyright on this drawing is reserved
- Check any electronic data against the hardcopy plan to ensure it is the latest version
-If this plan is being used as part of sale and purchase agreement then it is done so on the basis that it is preliminary only, final dimensions and areas may vary on final survey

CONTAINMENT CELL DETAIL - SHEET 2 OF 2

PARKBURN DEVELOPMENT PROJECT

922 LUGGATE - CROMWELL ROAD

Rev.	Date	Revision Details	By

Designed: CM	Date: 09 2026	Job No.: 24113	Drawing No.: 120_02
Drawn: KA	Date: 09 2026	Scale: AS SHOWN	
Checked: NKA	Date: 09 2026	Datum & Level: LP2000 & NZVD16	Rev.: -

Appendix 2

Insight Engineering Preliminary and Detailed Site Investigation Report

Preliminary and Detailed Environmental Investigation at 922 Luggate-Cromwell Road (SH6), Cromwell

Prepared for:	Fulton Hogan Land Development
Date:	23/10/2026
Our Reference Number:	24019_3
Report prepared by:	Claude Midgley CEnvP, MSc.
Authorised by:	Jana Kruyshaar CMEngNZ, CPEng

Record of Distribution

Sent to	Date	Report Status	No. of Copies
Daniel Thorne (Town Planning Group	11/04/2026	Draft for comment	1 (electronic)
Melanie Foote (Town Planning Group	19/06/2026	Final	1 (electronic)
Melanie Foote (Town Planning Group	16/07/2026	Updated Final	1 (electronic)
Melanie Foote (Town Planning Group	24/09/2026	Updated Final	1 (electronic)
Melanie Foote (Town Planning Group	23/10/2026	Updated Final	1 (electronic)

Contents

List of Tables 4
List of Appendices 4
1 Introduction and Scope of Report 5
2 Objectives of the Investigation 5
2.1 Approach 5
2.1.1 Review of Site Information 6
2.1.2 Intrusive Investigation 6
3 Site Description 7
3.1 Current Site Conditions 9
3.2 e3scientific Preliminary Site Investigation 10
3.3 ORC Property Database 14
3.4 CODC NES Records Search 14
3.5 Review of Historical Maps and Aerial Photographs 15
3.6 Summary of Identified Hazardous Activities and Industries 19
4 Intrusive Investigation 20
4.1 Data Quality Objectives 20
4.2 Methodology 20
4.2.1 Quality Assurance / Quality Control 21
4.3 Investigation Criteria 21
4.3.1 Soil Criteria 21
4.4 Results 22
4.4.1 Soil Encountered 22
4.4.2 Laboratory Test Results 22
5 Discussion 24
6 Conceptual Site Model 24
7 Conclusions 25
8 Recommendations 27
9 References 27
10 Limitations 28

List of Tables

Table 1: Site Information

Table 2: Site Setting

Table 3: Current Site Conditions

Table 4: Historical Maps and Aerial Photographs

Table 5: Laboratory Results Compared with Human Health Criteria, Ecological Health Criteria and Background Concentrations

Table 6: Conceptual Site Model

List of Appendices

Appendix 1: Response to Peer Review Matters

Appendix 2: Proposed Subdivision Plan

Appendix 3: Figures

Appendix 4: Site Photographs

Appendix 5: e3scientific PSI Report

Appendix 6: CODC NES Records Search

Appendix 7: Laboratory Results and Chain of Custody Documentation

Appendix 8: Qualifications and Experience

1 Introduction and Scope of Report

This assessment is an updated version to that which was lodged as part of the original Parkburn Substantive Application lodged 4 August 2026. It takes into account the revised scheme plan and incorporates peer review comments received from Local Authority expert/s to date along with a response to the peer review matters (Appendix 1).

JKCM Ltd, trading as Insight Engineering (IE), was requested to undertake a preliminary and detailed environmental site investigation (PSI and DSI) at the northern portion of 922 Luggate-Cromwell Road, Cromwell (herein referred to as 'the site'). IE understands that the report will form part of an application for subdivision and use of the land for urban development via the Fast Track Approvals Act 2024 process.

The Parkburn Development Project (herein referred to as 'the Project') involves the staged subdivision (Appendix 2) and development of land at 922 Luggate-Cromwell Road (State Highway 6), Cromwell, located approximately 8 kilometres north of the Cromwell township and adjoining Lake Dunstan / *Te Wairere*.

The property includes part of the existing Parkburn Quarry. The Project provides for the establishment of a mixed-use urban development, including quarry rehabilitation, residential development, supporting commercial and community activities, open space, and associated infrastructure. Works are also proposed within the State Highway 6 (SH6) road reserve.

Figure 1 (Appendix 3) indicates the location of the Project and the relevant portion of that property that was investigated as part of this report (herein referred to as 'the site').

Private Plan Change 21, approved in 2025, provides for future residential development over the majority of the Project. As part of that rezoning, the land in the northern portion of the Project (the site) was zoned for industrial land use. The proposed subdivision and development plans have since evolved and it is now proposed to undertake residential development at the site.

The purpose of this investigation was to assess the suitability of the site for residential subdivision, development and use, from the perspective of the Resource Management (*National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health*) Regulations[1] (herein referred to as the NES-CS). This investigation was undertaken in general accordance with the Ministry for the Environment (MfE) *Contaminated Land Management Guidelines No. 1: Reporting on Contaminated Sites in New Zealand* [2].

Potential risks to ecological receptors were assessed according to the criteria provided in the *Determination and use of background concentrations of trace elements in soil in Otago and Southland*[3].

2 Objectives of the Investigation

The objective was to determine if potentially contaminating historical activities pose an unacceptable risks to human health, or the health of ecological and environmental receptors, during and post site development.

2.1 Approach

IE completed the following scope of work to satisfy the investigation objectives:

2.1.1 Review of Site Information

Several sources were contacted for information relating to the past and present uses of the site and to identify any other environmental issues which may be on record. This consisted of:

- Review an existing PSI report[4] prepared by e3scientific as part of the 2022 Private Plan Change application, which was approved in 2025;
- Undertaking a site walkover to describe current site conditions and assess whether any visual or olfactory evidence of contamination is present;
- Review of publicly available data describing the local geology and hydrogeology;
- Review of the Otago Regional Council Selected Land Use Sites (SLUS) database to identify property specific records of hazardous activities or industries at the site and in the surrounding area;
- Reviewing the CODC NES Records Search statement to determine whether any records of contamination at the site are held in their database; and
- Reviewing publicly available historical aerial photographs and maps of the site and surrounding area.

2.1.2 Intrusive Investigation

The following scope of work was undertaken upon completion of the review of site information:

- Collect 8 soil samples from 8 locations within the cleanfill stockpile area;
- Visual and olfactory inspection of soil samples in the field;
- Submit 8 soil samples to Hill Labs for analysis of either a suite of common heavy metals (As, Cd, Cr, Cu, Pu, Ni and Zn) or a suite of common heavy metals and mercury;
- Collect 26 additional soil samples from 26 locations within the cleanfill stockpile area;
- Visual and olfactory inspection of soil samples in the field;
- Submit 26 soil samples to Hill Labs for analysis of a suite of common heavy metals (As, Cd, Cr, Cu, Pu, Ni and Zn) and asbestos presence / absence;
- Assess laboratory results for the soil samples against the adopted human health criteria for residential land use, as well as commercial / industrial land use, which serves as surrogate values for land development / excavation activities / future maintenance of underground services;
- Assess laboratory results for the soil samples against the expected naturally occurring concentrations, as well as the adopted ecological health criteria for residential land use; and
- Present a combined PSI and DSI report outlining the suitability of the site for land development earthworks and ongoing maintenance of underground services, as well as the post-development residential land use.

Site information is summarised in Table 1.

Table 1: Site Information

Location	922 Luggate-Cromwell Road (SH6), Cromwell
Legal Description	PT Secs 62 and 63 BLK IV WAKEFIELD SD and Sec 1 SO 365897

Table 1 (cont.): Site Information

Property Ownership	Fulton Hogan Limited
Current Site Use	Parts of the site are used for administration (offices), a concrete plant, an asphalt plant, a glass recycling area, equipment storage areas and a large stockpile of imported cleanfill. The remainder of the site is not used.
Proposed Site Use	Residential
Site Area	Approximately 24.280 ha (242,800 m²) refer to Appendix 3
Territorial Authorities	Central Otago District Council (CODC) Otago Regional Council (ORC)
Zoning	Industrial Area

3 Site Description

The site is located on the western side of Lake Dunstan / *Te Wairere* and is approximately 8 km north of Cromwell. Lake Dunstan / Te Wairere is of significant cultural importance to mana whenua. Lake Dunstan / Te Wairere is a Statutory Acknowledgement Area and formally recognises the deep cultural, spiritual, historical, and traditional association of Ngāi Tahu with the lake and surrounding section of the Clutha River.

The site is bound by horticultural (viticulture) and rural residential land towards the west (beyond SH6) and industrial land (quarry and contractors' yards) to the north. The land south of the site contains areas used for quarrying gravel, which was operational at the time of writing, as well as previously undisturbed, disused land vegetated with turf.

The quarry activities do not currently extend into the site and are limited to areas towards the north and south. However, the quarry areas are accessed by tracks extending through the site and it is understood that quarrying activities were historically undertaken within the site boundaries.

The Park Burn creek (herein referred to as the Park Burn) flows through the site in a roughly NW to SE direction. It discharges into Lake Dustan in the area directly south east of the site.

The site also contains offices for the quarry operators (Fulton Hogan Limited), a concrete plant, an asphalt plant, a glass recycling area, equipment storage areas and a large stockpile of imported cleanfill.

The remainder of the site can be referred to as a "greenfield" areas because no industrial activities have occurred there.

The site setting is summarised in Table 2.

Table 2: Site Setting

Nearest Surface Water & Use	The Park Burn flows through the site in a roughly NNW to SSE direction. It discharges into Lake Dustan in the area directly south east of the site. Lake Dunstan / *Te Wairere* is used as a source of potable water as well as for recreational and irrigation purposes, as well as for electricity generation.
Geology	The GNS New Zealand Geology Webmap[5] indicates that the site contains two geological units:

Table 2 (cont.): Site Setting

Geology (cont.)	The majority of the site is located within Late Pleistocene outwash deposits of Albert Town Advance, described as "*Unweathered to slightly weathered, loose, sandy to silty, well rounded gravel usually on large outwash plains*". The remainder of the site, located near to the northern boundary, is underlain by Holocene fan deposits, broadly described as "*Loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree (upslope) and valley alluvium*". According to a geotechnical investigation completed by Geotago[6], including test pits excavated in the cleanfill stockpile and the south eastern corner of the site, the cleanfill stockpile consists of uncontrolled fill described as "*Sandy silty GRAVELS with cobbles and occasional extraneous materials (wood, plastic, concrete)*" overlying "*sandy silt with roots, rootlets and decaying plant matter*" over a 1 m thick layer of pea gravel. Material in the south eastern corner of the site was described as topsoil overlying pea gravel. Both test pits were terminated at approximately 2 m below surface, due to the pea gravel causing the sides of the test pits to collapse.
Hydrogeology	Information provided in support of Private Plan Change 21, prepared by e3Scientific[4], confirms that the site is located within the Pisa Groundwater Management Zone. Groundwater flows from the Holocene river deposits, west of the site, through the highly permeable Late Pleistocene river deposits, comprised of sandy gravel or sandy cobbles and gravel, underlying the site. Groundwater ultimately reaches Lake Dunstan / *Te Wairere*, east of the site. ORC data[6] indicates that several water bores are located at and around the site. Groundwater depths in those wells ranged between 10.6 m bgl and 16.47 m bgl.
Groundwater Abstractions [7]	Three groundwater abstraction consents are active at, or within 250 m of the site: • Consent 2010.042.V1 was issued to HWR Property Limited to take and use groundwater from well number G41/0113 located approximately 1.5 km southeast of the intersection of the Luggate−Cromwell Road (State Highway 6) and Smiths' [sic] Way. The Consent was originally issued to Downer New Zealand Limited in April 2010 and was transferred to HWR Property Limited in August 2022. The Consent expires on 31 March 2030. • Consent RM14.064.01 was issued to Number 925 Water Company Limited to take and use ground water for the purpose of irrigation, stock water and domestic supply from a location approximately 2 kilometres north northeast of the intersection of Luggate−Cromwell Road (State Highway 6) and Pisa Moorings Road in May 2014. The Consent was transferred The Consent expires on 12 May 2044. • Consent RM17.106.01 was issued to Skeggs Group Limited to take and use groundwater for the purpose of vineyard irrigation and domestic supply from a location approximately 1965 metres north east of the intersection of the Luggate−Cromwell Road (State Highway 6) and Clark Road. The Consent was originally issued to Akarua Limited in May 2017 and was transferred to Skeggs Group Limited in June 2024. The Consent expires on 15 May 2052.

Table 2 (cont.): Site Setting

Discharge Consents [7]	Three discharge to land consents, and four discharge to air consents are active at, or within 250 m of the site: • Consent 99664 was issued to Fulton Hogan Limited – Alexandra to discharge solid fill to land within an operating gravel quarry beside Lake Dunstan / *Te Wairere* at the location where the Parkburn flows into the Lake for the purpose of backfill at a quarry site. The consent was issued on an unknown date and it expires on 6 November 2026. • Consent 2004.600 was issued to Fulton Hogan Limited – Alexandra to discharge dust to air for the purpose of quarrying, crushing and screening aggregate. The consent was issued on an unknown date and it expires on 31 March 2041. • Consent 2010.043.V1 was issued to HWR Property Limited to discharge water and contaminants to land for the purpose of gravel washing at a location approximately 1.5 km southeast of the intersection of the Luggate−Cromwell Road (State Highway 6) and Smiths' [sic] Way. The Consent was originally issued to Downer New Zealand Limited in April 2010 and was transferred to HWR Property Limited in July 2022 and reissued in August 2022. The Consent expires on 31 March 2030. • Consent RM15.050.01.V1 was issued to Downer New Zealand Limited to discharge contaminants to air for the purpose of an operating an asphalt plant from a location approximately 1.4 km south of the intersection of the Luggate−Cromwell Road (State Highway 6) and Smiths Way in April 2016. The discharge of total suspended particulate matter shall not exceed 50 milligrams per cubic metre of air. The Consent expires on 13 May 2050. • Consent RM15.108.02.V2 was issued to Fulton Hogan Limited to discharge silt, sediment and water to land for the purpose of aggregate washing, processing aggregate, asphalt and concrete, truck washing and dust suppression at the asphalt plant sediment ponds and soakage areas located within the eastern half of the site, as well as south of the south eastern portion of the site, in November 2015. The Consent expires on 13 November 2050. • Consent RM18.376.01.V2 was issued to Fulton Hogan Limited to discharge contaminants to air for the purpose of an operating an asphalt plant from a location approximately 1.6 km south of the intersection of the Luggate−Cromwell Road (State Highway 6) and Smiths Way in March 2019. The discharge of total suspended particulate matter must not exceed 50 milligrams per cubic metre of air and the discharge of arsenic, cadmium, chromium, lead, cobalt, manganese and nickel must not exceed 10 grams per hour (combined). The Consent expires on 6 March 2044. • Consent RM24.364.02 was issued to Southern Transport Company Limited to discharge contaminants to air for the purpose of operating a worm farm at 922A Luggate-Cromwell Road in July 2024. The Consent expires on 31 July 2039.

3.1 Current Site Conditions

Claude Midgley of IE completed a site walkover inspection on 6 November 2025. Observations made at that time are summarised in Table 3 and photographs are presented in Appendix 4.

Table 3: Current Site Conditions

Visible signs of contamination	Bitumen residue, engine oil stains and waste asphalt millings were observed in the eastern half of the site.
Surface water appearance	Water in the Park Burn was clear and free flowing, with no evidence of contamination impacts such as chemical odours, discolouration or hydrocarbon sheen.
Current surrounding land use	Horticultural, rural residential and industrial land surrounds the site.
Local sensitive environments	The Park Burn, Lake Dunstan / *Te Wairere* and the associated riparian zones are considered sensitive environments.
Visible signs of plant stress	No significant signs of plant stress were noted.

3.2 e3scientific Preliminary Site Investigation

e3scientific produced a PSI report[4] that was submitted as part of Private Plan Change 21 in 2022. Their scope of work included assessment of the site and the areas south of the site. The full report is included as Appendix 5, but this summary contains relevant information related only to the land within the current site boundaries.

Site History

Fulton Hogan acquired the lease for the site in December 1985, after Robert and Charles Perriam had leased the land for farming purposes earlier in 1985. Prior to that, the site was leased by several private individuals (unnamed) since Robert Davidson acquired the initial lease in 1894. Fulton Hogan obtained a mining license for the site and surrounding area towards the south by July 1987.

Regional Council information confirmed that an underground petroleum storage system (UPSS), associated with Z Energy, was removed and the removal was reported to ORC in 2015. The contamination investigation associated with the removal of the UPSS confirmed that the residual contamination was acceptable for commercial / industrial land use.

The report about the removal of the UPSS provides information related to the removal of a 10,000L underground kerosene storage tank and a 10,000L underground diesel storage tank, as well as the associated pipework from a single pit where the tanks had been positioned end to end, undertaken in October 2014. The results of laboratory analyses confirmed that residual petroleum hydrocarbon concentrations were below the human health criteria for commercial / industrial land use and for the protection of groundwater quality. A 7 m long section of pipeline and a fuel bowser within a building were not removed as part of the site works at that time. The former tanks were replaced with above-ground fuel storage tanks.

On-Site Observations

e3scientific completed a walkover assessment that included inspection of the general site conditions, including the condition of the buildings and the ground surface across the site. They noted visible signs of contamination such as stains associated with leaks or spills, odours, plant stress, areas of fill or stockpiled material / waste, ground disturbance, former building foundations, incineration areas, chemicals storage and discharges from those areas, as well as the locations of former buildings, processes or activities undertaken on site.

The site was found to contain three separate areas, referred to as the "*weighbridge and offices*", "*industrial area*" and "*cleanfill and yards*".

No evidence of hazardous substance use or storage was found in the "*weighbridge and offices*" area, but the "*industrial area*" was used for asphalt and concrete manufacturing activities. The following excerpts describe the specific findings associated with those activities:

"*The Firth Concrete block manufacturing facility is located on the western end of the industrial area. The gravel yard was generally tidy and well kept. A 10,000 L diesel tank is located to the east of the manufacturing building. An open storage shed is located along the western boundary of this area. A small, waste oil 'igloo' was present to the south of the open shed. There was no staining around the waste oil tanks. Several empty drums of concrete retardant (Sika Retarder) were stored behind (west of) the open shed. Hardfill, consisting of broken concrete tiles and blocks was deposited over the landscape bund, north of the factory.*

East of the Firth Concrete block manufacturing facility, an open yard is used as a parking area by Fulton Hogan Transport. An above ground diesel tank (4) associated with the nearby asphalt plant, was removed from the site in September 2021. Evidence of disturbed ground beneath the removed tank, including some soil on a plastic sheet, was still present. There was no evidence of staining or odour in this area. Underground fuel lines, running to the asphalt plant are reportedly still present.

The asphalt plant itself is located down an embankment to the east of the parking area. The plant is comprised of aggregate feeder bins, bitumen storage tanks, mixing drum, conveyor belt feeding, asphalt storage silos, a bag house and an operations office. The asphalt plant can produce up to 120 tonnes per hour (tph) of asphalt but will typically run at a production rate of approximately 80 tph. Bitumen and kerosene are stored in a bunded above ground tank at the base of the terrace. Bitumen is also stored in a shed near the plant. The ORC resource consent specifies that the plant can be run on used oil; however, to date only diesel fuel has been used.

The Allied Concrete batching plant is located on the opposite side of the main access road from the transport yard. The batching plant appears to be located at the repurposed weighbridge, where diesel fuel storage was noted in plans with several of the building consent applications. Immediately south of the batching plant, there is a gravel yard which was used by a company to produce concrete panels for the construction of the Frankton Marina in 2018. These areas appeared generally tidy.

A truck wash is located on the south side of the main access road. Run-off from the truck wash flows down the site of the access road into an infiltration pond. This is one of the discharge points authorised by ORC consent RM15.108.02. There was no oily sheens or hydrocarbon odour associated with the run-off water or sediment at the truck wash."

The "*cleanfill and yards*" area, located on the eastern side of the Park Burn, was described as a former quarry area that was repurposed for cleanfill disposal and for "*outdoor yards used by JCL Asphalt Limited and several divisions of Fulton Hogan."*

The following excerpts describe the specific findings associated with those activities:

"*A new shed, which will be used for crushing and storage of recycled glass, has been constructed. This building was consented under RC210112. During the site inspection, drainage work was being completed, but storage and crushing of glass had not yet commenced.*

Beyond the new glass processing shed, an excavation is used for disposal of surplus concrete. Further to the east, there are two active (1-2 m high) faces used for cleanfill disposal. A concrete bay just east of the weighbridge at the entrance to the site is used for drop-off of small loads of cleanfill by Fulton Hogan and their sub-contractors. This material is then relocated to the cleanfill face. Visible material was predominantly soil, rock, and gravel, with occasional loads of cured asphalt, and some scattered broken glass across the surface of the cleanfill. A separate area is used for disposal of

hardfill, including concrete, tile, bricks, and cured asphalt, as well as soil, gravel and rock. Disposal of material at the cleanfill is authorised by ORC resource consent 99664.

A Cleanfill Management Plan prepared by Fulton Hogan outlines the procedures required to achieve environmental best practice. Visual inspections of the quality of the fill material coming to the site are completed to ensure the material is consistent with resource consent requirements. If a non-complying load is identified, the cleanfill operator is to isolate the load and advise the Quarry Manager immediately. Signage is in place at the entrance to the cleanfill, providing a clear description of acceptable materials. Material is not to be accepted from any Hazardous Activities and Industries List (HAIL) sites unless it has been suitably analysed.

A partially buried skip is used for temporary storage of waste from high pressure water cutting used during roading maintenance work. The skip is covered and sealed, with waste periodically taken to landfill when full. To the east of the hardfill disposal area, finished areas of the cleanfill have been capped with gravel for use as open yards for other divisions of Fulton Hogan, as well as JCL Asphalt.

At the JCL Asphalt yard, there is a moveable above ground diesel tank located in the corner of the container shelter (1). Some soil staining was also visible. In this area, there were also 4 x 1,000 L IBC of concrete additive (Sika Viscacrete), with some visible product on the ground below the IBCs. The Fulton Hogan civil engineering and construction yards were predominantly used for the storage of building supplies and equipment. There were two small steel explosive storage containers (2) used by the Fulton Hogan geotechnical team. There was also a stack of CCA treated telephone poles (3) in the construction yard. Otherwise, there was no evidence of hazardous substance storage or use in these areas, and surface gravels were free of staining."

e3scientific used a portable X-Ray Fluorescent Spectrophotometer (XRF) to estimate the concentrations of heavy metals at 40 locations within the active faces of the cleanfill / hardfill disposal area. Additional scans were undertaken in a previously undisturbed part of the site, to compare the results from the fill with results representing natural ground conditions. The results indicated that one or more of the heavy metals concentrations in 14 of the 40 samples exceed the naturally occurring concentrations at the site, but 4 of those samples may have been included due to the precision level of the XRF. They concluded that "*three samples exceeded the Manaaki Whenua Landcare Research (2015) predicted background concentration by more than 35%, indicating that there is a higher likelihood that contaminants in excess of the local natural background were present in these samples*."

A preliminary conceptual site model was developed, to provide an overview of the potential interactions between contaminants and sensitive receptors. The following excerpts describe the potential risks associated with the relevant identified sources of contamination:

"Concrete manufacture - Commercial concrete manufacture has taken place on site since 2005. Contaminants associated with concrete manufacture may affect soil pH and stormwater quality; however, risks to human health are generally not considered significant.

In addition to the contaminants listed in Table 4, small quantities of concrete retarding admixture are used within the concrete block manufacturing plant. The active ingredient in this product is tetrapotassium pyrophosphate. Tetrapotassium pyrophosphate is a common food additive, and not considered particularly toxic. The material safety data sheet (MSDS) does not list any special environmental protections required and does not identify the product as toxic to people.

A 10,000 L diesel tank and waste oil igloo are also known to be present within the concrete block manufacturing facility, and it is suspected diesel storage also occurred at the Allied Concrete batching plant in the past.

Asphalt manufacture - The asphalt manufacturing plant has operated on site since 1987. Asphalt manufacture involves the storage and handling of petroleum hydrocarbons including diesel, kerosene, and bitumen. Once manufactured and cured, asphalt is relatively stable, and unlikely to leach significant quantities of contaminants.

Fuel storage - Outside of the asphalt and concrete block plants, there are four known areas of relatively small-scale fuel storage. These include a diesel tank, waste oil storage, and generator at the quarry plant and diesel storage at the JCL asphalt yard.

Treated timber storage - A relatively small area within the Fulton Hogan construction yard has been used for storage of treated timber poles. Although this activity has only occurred recently, and appears to be for relatively short duration, leaching of copper, chromium and arsenic from tanalised timber can impact soils directly under the poles. Although leaching from treated timber stacks can pose a risk to human health under residential land use, results from previous investigations suggest that exceedance of commercial/industrial soil contaminant standards is unlikely (Marlborough District Council, 2016).

Waste disposal to land - Backfilling of the north-eastern portion of the site with cleanfill has taken place since the 1980's.

This activity was consented by the Otago Regional Council in November 2000, and the cleanfill generally appears to be well managed. ORC compliance reports in 2009 and 2020 identified minor non-compliance associated with reporting, but both inspections found the site to be tidy with no evidence of unconsented fill types or adverse environmental effects. A cleanfill management plan for the Parkburn Quarry was prepared by Fulton Hogan in 2018. The management plan provides clear direction on consent and unconsented fill types and confirms that material from HAIL sites is not to be accepted without prior sampling.

Field readings of heavy metal concentrations with an X-Ray Fluorescent Spectrophotometer (XRF) indicates that heavy metal concentrations within most of the soil within the cleanfill surface and tipping faces are consistent natural background concentrations. A small number of readings returned results that indicate some contaminated fill material has been received."

The report provided the following conclusions related to contamination risks within the site boundaries:

"*Within the future industrially zoned area, the identified HAIL activities include concrete manufacturing and batching, asphalt production, fuel storage, persistent pesticide use, treated timber storage, and disposal of cleanfill. We consider that it is highly unlikely that contaminants in soil associated with concrete manufacture, persistent pesticide use, and treated timber storage would pose a risk to human under the proposed commercial/industrial land use.*

It is possible that contaminants associated with asphalt production, fuel storage and cleanfill disposal could result in soil contamination that could pose a risk to long term outdoor workers using the site in the future without appropriate investigation, remediation and/or management during development. The greatest risks are associated with hydrocarbon storage, particularly around any underground fuel storage infrastructure (e.g. fuel supply pipelines). Risks associated with the disposal of cleanfill appear relatively low; however, given the long history of filling, it is possible that localised areas of contaminated fill material may be present.

Given the on-going use of the site for these HAIL activities, it would be appropriate to complete additional investigation upon decommissioning of any potentially contaminating land uses. These investigations may also be better able to assess risks to human health as plans for the proposed development become more detailed."

It should be noted that e3scientific report includes assessment of the remainder of the Project area. Three other activities (fuel storage, bitumen storage and a generator) that could have resulted in contamination impacts were identified within the boundaries of the Project. Those areas could not be assessed as part of this report, due to the ongoing quarrying operations.

3.3 ORC Property Database

IE reviewed the ORC Hazardous Activities, Industries and Bore Search database[8] on 5 November 2025. The search confirmed that the site is not recorded on the database.

The site contains the only record (HAIL.00359.01) in the database within approximately 1.75 km of the site boundaries.

HAIL.00359.01 is recorded in the eastern portion of the site as the "*Fulton Hogan Asphalt Plant Parkburn*". The summary notes state "*Consented asphalt plant location. Z Energy tank removal report rec'd in 2015 confirmed residual contamination from diesel tank was acceptable.*"

The site is recorded as "*Partially Investigated*" for verified hazardous activities and industries list (HAIL)[9] Category E2 activities (Asphalt or bitumen manufacture or bulk storage (excluding single-use sites used by a mobile asphalt plant).

3.4 CODC NES Records Search

The CODC NES Records Search (Appendix 6) was prepared by Adam Vincent, Planning Officer – Consents, on 26 November 2025. The records search contained various records related to Building Consents and Resource Consents associated with the site.

The Resource Area is listed as Medium Density Residential Zone, Low Density Residential Zone, Industrial Resource Area (2), Industrial Resource Area (3), with the Industrial zoning being relevant to the site and the other zones relating to the remainder of the property towards the south.

The following Building Consents were issued for the site: Erect an office building at a quarry (1988), erect a bitumen storage shed (1990), relocate a storage building (1995), erect a new Portacom building (2004), erect all new buildings / platforms for a new industrial plant (2005), relocate a building onto site for staff facilities (2006), additions to an existing shed (2015), erect a new storage shed (2015), foundations and site works for relocated office / smoko room (2016), foundations and site works for relocated office (2018, 2019 and 2020), install a Smart Shelter container roof (2020), foundations, water supply, drainage and site works for unisex Portacom ablution block (2020), a new 20 mx 26 m storage shed (2021), foundations and site works for a relocated Portacom (2022), new foundations and construction of portal frame gantry (2022) and change in the location for the relocated Portacom (2022).

The following Resource Consents were issued for the site: Backfill against quarry pit faces with solid fill (2000), land use to build and operate a concrete block manufacturing plant (2005), land use to extract and convey sand aggregate from the upper terrace (2007), land use to establish Portacom offices (2019), change of conditions of a Resouce Consent to allow establishment of two further Portacoms (2020), land use to construct a shed to house a glass crushing plant (2021), land use to install 2 20,000L diesel fuel tanks to replace one diesel tank with was to be removed (2022), change of conditions of Consent to change a building location (2022) and change of conditions of a Consent to allow the installation of a Smart Shelter on site.

Council aerial photographs, dating back to 2006, confirmed that an asphalt plant and a concrete block plant was present in the eastern portion of the site. The outdoor storage of unknown materials was also confirmed to have occurred in the south eastern portion of the site.

The records search also confirmed that a preliminary environmental site investigation was undertaken at the site in support of Plan Change 23. Extracts of the e3scientific report[4], showing the locations of areas where hazardous activities were undertaken, are included in the records search.

HAIL[9] activities associated with Council's records are A17 (storage tanks or drums for fuel, chemicals or liquid waste), A18 (storage tanks or drums for fuel, chemicals or liquid waste), E2 (Asphalt or bitumen manufacture or bulk storage), E4 (commercial concrete manufacture or commercial cement storage), G4 (scrap yards) and G5 (waste disposal to land).

3.5 Review of Historical Maps and Aerial Photographs

Photographs in the Crown Collection[10] and Google Earth[11], as well as topomaps on the MapsPast[12] website, have been reviewed to obtain information on the past uses of the site. Aerial photographs taken between 1958 and 2024, as well as maps created between 1939 and 2019, have been reviewed.

Table 4 summarises the features visible in each image.

Table 4: Historical Maps and Aerial Photographs

1939 [12]	The site is part of a block of land that is split by two parallel lines representing a road in the north western corner. The road crosses through the site from just south of the north western corner to just east of the north western corner. The site is labelled with "9" and "148,1,17". An overland water flow path is marked with curved black lines from near to the centre of the northern site boundary, to the south eastern corner of the site. Two parallel dashed lines, representing a vehicle track, as well as a dashed line with a single dot between each dash, representing a walking track, are located along a south west / north east axis in the area beyond the eastern site boundary. Another smaller property is located beyond the eastern site boundary and the Clutha River / *Mata Au* is marked in blue at the eastern side of that property. No other significant features are visible on the map.
1949 [12]	No significant changes are visible at the site, or in the surrounding area, compared with the 1939 map.
1958 [10]	In the surrounding land, dwellings and border dykes are visible on the neighbouring property towards the west. A track extends along the southern site boundary, from Luggate – Cromwell Road to a small orchard on the southern bank of the Park Burn located just beyond the south eastern portion of the site. Another dwelling is visible towards the south east of that area. The remainder of the surrounding area appears to be used for agriculture in the same way as the site, with flood irrigation supplying water to various areas via water races. No other significant features are visible at the site or in the surrounding area.
1964 [10]	The majority of the site is visible, but the eastern edge of the site is not covered by this photograph. A few water races are visible in the western portion of the site, west of the Park Burn. The trees near to the centre of the site and in the eastern portion of the site have grown. A small rectangular object, surrounded by a roughly triangular portion of cleared land, is visible just west of the trees near to the centre of the site. In the surrounding land, linear features representing border dykes for flood irrigation purposes, arranged along a north east / south west orientation, are visible towards the north east and south west. A large stack of hay bales is visible south west of the stand of trees near to the centre of the site. No other significant changes are visible at the site, or in the surrounding area.

Table 4 (cont.): Historical Maps and Aerial Photographs

1968 [10]	Apart from a stack of hay bales is visible on the western bank of the Park Burn in the eastern portion of the site, the site remains unchanged compared to the 1964 photograph. In the surrounding land, new border dykes are visible in the south western corner and the eastern portion of the neighbouring property towards the north. No other significant changes are visible at the site or in the surrounding area.
1976 [10]	Apart from the stack of hay bales no longer being present in the eastern portion of the site, the site appears unchanged compared with the 1968 photograph. In the surrounding land, new border dykes have been constructed on the neighbouring property towards the north of the site. No other significant features are visible at the site or in the surrounding area.
1978 [10]	No significant changes are apparent at the site, or in the surrounding land.
1979 [12]	Symbols indicating the presence of trees are visible on the eastern side of the Park Burn near to the northern site boundary. Symbols indicating the presence of embankments or terraces are visible in the eastern portion of the site. The creek crosses through the eastern portion of the site and extends past a neighbouring property towards the east, which is labelled "*Rahoy*". Two blue lines with arrows pointing southwards indicate the presence of water races that cross through the central portion of the site and terminate just beyond the southern site boundary. The Clutha / *Mata Au* is marked in blue further east of the eastern site boundary. In the surrounding land, a track is marked along the southern site boundary from Luggate – Cromwell Road to the area marked "*Rahoy*". Symbols indicating the presence of a shelter belt are visible along the south western boundary of the neighbouring property towards the north. Black squares, representing buildings, are marked in the south west and east of the neighbouring property towards the north, as well as on the neighbouring properties towards the west, south and east. No other significant features are visible at the site or in the surrounding area.
1982 [10]	No significant changes are apparent at the site, or in the surrounding land.
1983 [10]	No significant changes are apparent at the site or in the surrounding land.
1984 [10]	With the exception of a new light-coloured, square-shaped object in the area west of the stand of trees near to the centre of the site, no significant changes are apparent at the site or in the surrounding land.
1989 [12]	No significant changes are apparent, compared with the 1979 map.
1999 [12]	A black circle is labelled "*Tank*" is visible in the area just south east of the eastern edge of the shelter belt marked along the north western site boundary. New water races that extend towards the south east and south are marked in the central portion of the site. Symbols indicating the presence of trees are visible in the central and eastern portions of the site. In the surrounding land, the black squares are no longer present on the neighbouring properties towards the north and south. The area east of the site now has alternating diagonal blue and white lines and the aera is labelled "*Bed of proposed Lake Dunstan*". No other significant changes are apparent, compared with the 1989 map.
2001 [10]	A large quarry has been established in the eastern half of the site. Two new buildings are visible in the western portion of the quarry area. A small dam is visible near to the north eastern corner of the site. In the surrounding land, the areas directly east and west of the Park Burn in the

Table 4 (cont.): Historical Maps and Aerial Photographs

2001 (cont.) [10]	southern half of the neighbouring property towards the north have been quarried and the ground surface in those areas is grey. Another area has been stripped of topsoil directly east of the eastern quarry area and the stripped topsoil appears to have been stockpiled further east of that area. Stripped topsoil from the eastern quarry appears to have been stockpiled at the eastern side of the main excavated area in that part of that property. Lake Dunstan / *Te Wairere* is visible at the eastern edge of the site. The buildings that had been present in the area labelled "*Rahoy*" have been removed and that area is now part of Lake Dunstan / *Te Wairere*. A vineyard appears to have been established on the neighbouring property towards the west. No other significant changes are apparent at the site or in the surrounding area.
2003 [10]	The quarry has been extended towards the south, beyond the south eastern site boundary. A new, larger dam is visible north east of the small dam in the north eastern corner of the site. Another dam is visible directly east of the large dam. In the surrounding land, quarried portions of the neighbouring property towards the north appear to cover the same footprints, with the exception of the eastern extent, which has extended towards the east in the area south east of the stockpile of stripped topsoil. Another relatively small area has been stripped of topsoil on the neighbouring property towards the south, in the area south west of the central portion of the site. No other significant changes are visible at the site or in the surrounding area.
2005 [11]	Only the eastern quarter of the site is covered by this image. The original small dam is no longer visible are visible in the north eastern corner of the site. Instead, the large dam appears to have been mostly filled in and only the south eastern corner remains. The dam directly east of that dam remains. In the surrounding area, the quarry has been extended towards the east in the area east of the stripped topsoil stockpile on the eastern side of the Park Burn on the neighbouring property towards the north. No other significant changes are visible at the site or in the surrounding area.
2007 [11]	Two large new buildings have been constructed in the western portion of the quarry area. Another small rectangular building has been constructed further west, between a parking area and the road that extends from Luggate – Cromwell Road to the quarry area. The dams in the north eastern corner of that property are no longer visible. No other significant changes are visible at the site or in the surrounding area. In the surrounding land, a large new quarry has been established in the southern portion of the neighbouring property towards the south. On the neighbouring property towards the north, the eastern quarry area has been extended towards the east in the area east of the stripped topsoil stockpile. The western topsoil stockpile area on that property has been stripped of topsoil and developed with three buildings, consisting of a large rectangular building in the north western portion of that area, as well as a small rectangular building east of the large building and an L-shaped building half-way along the western boundary of the newly stripped area.
2009 [12]	The water races are no longer marked on the site. Three black squares are visible in the eastern half of the site and the tank is no longer labelled, but the circular symbol remains. A quarry is labelled in the eastern portion of the site and the outline, marked as a dashed black line, extends across the south eastern portion of the neighbouring property towards the north. A small dam is marked in the area between the quarry and Lake Dunstan / *Te Wairere* in the north eastern corner of the site. Lake Dunstan / *Te Wairere* is now labelled as "Lake Dunstan" directly east of the

Table 4 (cont.): Historical Maps and Aerial Photographs

2009 (cont.) [12]	eastern site boundary. “Rahoy” is no longer labelled in the area south east of the site. Symbols indicating the presence of horticultural land are visible on the neighbouring properties towards the west of the site. No other significant changes are visible at the site or in the surrounding area compared with the 1999 map.
2011 to 2019 [11]	New stockpiles of dark grey material are visible near to the western bank of the Park Burn near to the northern site boundary. A new road connects the site to the south western portion of the neighbouring property towards the north. Three new relatively small new buildings have been constructed in the area east of the new road. A large new light-coloured structure is constructed in the area south of the original buildings located on that property. In the surrounding land, quarrying activities continue to extend towards the east, north and west in the southern portion of the neighbouring property towards the south. The new quarry eventually connects to the original quarry in the eastern portion of the site. Quarrying continues to extend towards the east on the neighbouring property towards the north and stripped topsoil from the new quarry areas is stockpiled along the north eastern boundary of that property. The western portion of the area south east of the Park Burn is slowly back-filled towards the east after 2015. Equipment and machines, as well as dark grey stockpiles of unknown material, are stored in the area west of the Park Burn. Additional buildings are constructed in the area west of the equipment storage area. No other significant changes are apparent at the site or in the surrounding area during this timeframe.
2019 [12]	A new track is marked in the western portion of the site and it extends from the existing track on site to the north western site boundary, where it continues towards the east. Another track extends southwards from the area near to the symbol representing a tank. Three additional black squares are marked in the central portion of the site. A new quarry area is visible on the neighbouring property towards the south. A black square is visible in the south western portion of the neighbouring property towards the north. No other significant changes are apparent compared with the 2009 map.
2021 to 2023 [11]	Bulk fill placement is visible in the north eastern corner of the site . The light-coloured structure is removed and a new dark grey structure is constructed in the area north east of the original buildings on the site. Two additional new structures are constructed east of that building, on the eastern side of the Park Burn and west of the bulk filling activities. One new building is removed from the area between the Park Burn and the area being filled. The area directly west of the stand of trees located near to the centre of the site has been stripped of topsoil. In the surrounding land, the quarry in the southern western portion of the neighbouring property towards the south also becomes back-filled and vegetation is established over that area. The quarry on the neighbouring property towards the north is extended towards the north east and the western side of the quarry is slowly back-filled. No other significant changes are apparent at the site or in the surrounding land.
2024 [11]	Bulk fill placement has continued in the north eastern corner of the site. In the surrounding land, quarrying activities continue to extend towards the north in the eastern portion of the neighbouring property towards the north, with topsoil still being stockpiled along the north eastern property boundary. A new area is stripped and developed with three new buildings in the south western corner of that property. No other significant changes are apparent at the site or in the surrounding land.

3.6 Summary of Identified Hazardous Activities and Industries

The following activities noted on the MfE HAIL[9] have been identified during review of the history of the site:

Category A2 – Chemical manufacture, formulation or bulk storage.

- This category is represented by the presence of waste oil tanks and bitumen storage tanks at the asphalt plant. The risks to human health from these sources are likely to be low, due to the chemicals being contained in tanks that did not show signs of leakage, except in the areas where bitumen residue was visible on the ground surface.

Category A17 – Storage tanks or drums for fuel, chemicals or liquid waste.

- This category is represented by the presence of above-ground fuel, kerosene, bitumen, waste oil, concrete additive and concrete retardant storage tanks or drums. The risks to human health are considered likely to be low, except in the areas where bitumen residue was visible on the ground surface.

Category A18 – Wood treatment or preservation including the commercial use of anti-sapstain chemicals during milling, or bulk storage of treated timber outside.

- This category is represented by the presence of stacks of treated timber telephone poles noted by e3scientific in the JCL Asphalt yard. The risks to human health from that area is considered likely to be significant from a residential land use perspective, due to the high toxicity of arsenic which leaches from the poles during rainfall events.

Category E2 – Asphalt or bitumen manufacture or bulk storage (excluding single-use sites used by a mobile asphalt plant).

- This category is represented by the presence of the asphalt plant which poses significant risks to human health in areas where bitumen residue is visible on the ground surface.

Category E4 – Commercial concrete manufacture or commercial cement storage.

- This category is represented by the presence of the concrete block manufacturing facility which is not considered likely to pose significant risks to human health.

Category G5 – Waste disposal to land.

- This category is represented by the cleanfill stockpile in the eastern portion of the site which consists of imported fill. Additionally, engine oil stains, waste asphalt and bitumen residue on the ground are considered to represent waste disposal to land. The risks to human health from engine oil, waste asphalt and bitumen residue in those areas are considered to be significant, but the risks to health from the cleanfill stockpile in the eastern part of the site are unknown.

Category F8 – Transport depots or yards including areas used for refuelling or the bulk storage of hazardous substances.

- This category is represented by the yards in the south eastern portion of the site. The risks to human health from oil stains and treated timber poles in those areas are considered to be significant.

According to Regulation 5 of the NES[1], the Regulations apply if a HAIL[9] activity has been undertaken, or currently is being undertaken on the property.

4 Intrusive Investigation

Under the NES-CS[1], the soil disturbance required for the proposed residential development of the site, as well as the subdivision and change of land use required to enable the development, are considered to meet the definitions provided under Regulations 5(4) disturbing the soil of the piece of land, 5(5) subdividing land and 5(6) changing the use of a piece of land that has had a HAIL[9] activity undertaken on it.

The Fast Track application does not require an exhaustive assessment of the extents of contamination impacts at the site, but rather a high-level assessment to identify activities that could have resulted in significant contamination impacts and conclusions related to the potential for the site to be made suitable for the proposed residential development and use.

Therefore, a limited detailed environmental investigation was undertaken to assess whether certain activities have resulted in unacceptable risks to human health. Where other activities have resulted in obvious contamination impacts that pose significant risks to human health, detailed assessment of the extents of those impacts are considered more appropriate to be undertaken when commercial / industrial activities at the site have concluded. This approach is consistent with the conclusions of the e3scientific PSI report[4].

Therefore, eight discrete soil samples were collected from the cleanfill stockpile in the eastern portion of the site, where the significance of contamination impacts (if any) could not be confirmed by visual observation. The samples were submitted to Hill Labs for analysis of a suite of common heavy metals (As, Cd, Cr, Cu, Pu, Ni and Zn). One sample (CF8) was also tested for mercury, in addition to the suite of common heavy metals.

Additional sampling was undertaken within the cleanfill stockpile area, based on a preliminary review of this DSI by CODC. Twenty-six samples were collected from the stockpile surface and submitted to Hill Labs for analysis of a suite of common heavy metals (As, Cd, Cr, Cu, Pu, Ni and Zn) and asbestos presence / absence.

Sample locations are displayed in Figure 2.

4.1 Data Quality Objectives

The data quality objectives (DQO) of this assessment were:

- To assess the presence and concentrations of contaminants in near surface and stockpiled soil; and
- To assess the risks to human health posed by contamination at the site.

4.2 Methodology

The following was undertaken during the soil sampling works:

- Samples were given individual names that corresponded to specific locations recorded on a site plan (refer to Figure 2);
- Visual and olfactory inspection of soil samples in the field;
- Collect 8 soil samples from 8 locations along the edge of the cleanfill stockpile. Samples were compressed directly into laboratory supplied containers using a new pair of nitrile gloves for each sample. Prior to sampling, the equipment (hand trowel) was decontaminated using a triple wash procedure with potable water, Decon 90 solution and deionised water;
- Placement of samples into a chilly bin and transportation, under standard IE chain of custody procedures, to Hill Labs; and

- Request that Hill Labs analyse the samples for a suite of common heavy metals (As, Cd, Cr, Cu, Pu, Ni and Zn), or a suite of common heavy metals and mercury.
- Visual and olfactory inspection of soil samples in the field;
- Collect 26 additional soil samples from 26 locations at the surface of the cleanfill stockpile. Samples were compressed directly into laboratory supplied containers using a new pair of nitrile gloves for each sample. Prior to sampling, the equipment (hand trowel) was decontaminated using a triple wash procedure with potable water, Decon 90 solution and deionised water.;
- Placement of samples into a chilly bin and transportation, under standard IE chain of custody procedures, to Hill Labs; and
- Request that Hill Labs analyse the samples for a suite of common heavy metals (As, Cd, Cr, Cu, Pu, Ni and Zn) and asbestos presence / absence.

4.2.1 Quality Assurance / Quality Control

The quality assurance / quality control (QA / QC) procedures employed during the works included:

- Standard sample registers and chain of custody records have been kept for all samples;
- The use of Hill Labs, accredited by International Accreditation New Zealand (IANZ), to conduct laboratory analyses; and
- During the site investigation every attempt was made to ensure that cross contamination did not occur through the use of the procedures outlined within this document.

4.3 Investigation Criteria

4.3.1 Soil Criteria

The investigation criteria referenced in this report have been selected from the NES-CS to assess risks to human health. Where a soil contaminant standard (SCS) was not available, the hierarchy detailed in the MfE *Contaminated Land Management Guidelines No. 2: Hierarchy and Application in New Zealand of Environmental Guideline Values*[13] was used to select applicable criteria.

Human Health

SCSs[1], or other appropriate criteria for residential land use and commercial / industrial use have been presented to assess the risks to human health during the disturbance of soil associated with construction works required as part of the site development, as well as to assess the health risks during residential activities.

Ambient Concentrations of Contaminants

The New Zealand Institute for Bioeconomy Science Limited produced a report[3] for ORC and Environment Southland titled *Determination and use of background concentrations of trace elements in soil in Otago and Southland*.

The report provides new criteria that are proposed to be adopted as standardised background / ambient concentrations for Otago and Southland, because the current national database of predicted background concentrations is too variable and has resulted in an unnecessarily complex situation when determining whether soil can be reused at other sites.

Therefore, laboratory results below the proposed '*risk-based background concentrations or soil re-use criteria for the management of contaminated land and soil relocation*' can be considered to qualify as 'cleanfill' according to the MfE definition[14].

Ecological Health

Due to the standardisation of the background concentrations for heavy metals within Otago and Southland, criteria for the protection of ecological receptors (Eco-SVGs) are now standardised as well. For ease of use, the recently published report[3] includes Eco-SVGs that were calculated using the new background criteria.

Laboratory results below the Eco-SVGs provided in the report[3] are considered acceptable for the protection of ecological receptors at the site.

4.4 Results

4.4.1 Soil Encountered

Soil encountered in the cleanfill stockpile was extremely variable and included silty sandy gravel with bricks, metal, plastic, textile, waste asphalt millings and concrete inclusions. Compacted hardfill was present at the surface of the remainder of the potentially contaminated areas.

4.4.2 Laboratory Test Results

Table 5 compares soil contaminant concentrations in the samples with the adopted investigation criteria described in Section 4.3. The full analytical results are included in Appendix 7.

Table 5: Laboratory Results Compared with Human Health Criteria, Ecological Health Criteria and Background Concentrations

Analyte	Investigation Criteria				Investigation Results																
Land Use	Predicted Background Concentrations [A]	Ecological Soil Guideline [A] Residential	Soil Contaminant Standards (SCSs) [B] Residential	Soil Contaminant Standards (SCSs) [B] Commercial / Industrial (Excavation Activities)	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8	PQA	PQB	PQC	PQD	PQE	PQF	PQG	PQH	PQI
Heavy Metals																					
Arsenic	12	20	20	70	***32***	8	7	7	10	13	9	5	9	10	8	5	11	***25***	7	13	8
Chromium	120	200	460 [C]	6,300	6	8	12	7	15	5	12	8	11	9	8	6	8	11	10	8	11
Copper	80	95	>10,000	>10,000	17	16	14	12	13	18	17	9	14	13	12	12	17	15	19	18	14
Lead	150	290	210	3,300	16	10	11	14	23	15	21	13	14.8	16.8	11.6	15.8	15.7	13	12.4	18.1	11
Nickel	30	200 [D]	400 [F]	6,000 [F]	11	10	12	8	13	9	14	7	11	8	8	8	11	11	10	10	11
Zinc	180	180	7,400 [F]	400,000 [F]	57	39	51	32	53	23	54	28	43	42	35	25	42	49	56	36	41
Heavy Metals					**PQJ**	**PQK**	**PQL**	**PQM**	**PQN**	**PQO**	**PQP**	**PQQ**	**PQR**	**PQS**	**PQT**	**PQU**	**PQV**	**PQW**	**PQX**	**PQY**	**PQZ**
Arsenic	12	20	20	70	6	10	11	7	9	8	6	8	9	5	6	8	6	9	9	7	8
Chromium	120	200	460 [C]	6,300	6	10	9	11	12	10	5	10	10	6	7	9	8	10	11	11	8
Copper	80	95	>10,000	>10,000	11	16	21	13	9	13	12	18	16	9	10	12	13	16	9	17	16
Lead	150	290	210	3,300	8.3	12.3	10.2	12.2	13.3	11.2	13.1	12.4	15.2	11.1	13.5	13.9	11.9	15.5	14.2	15	10.6
Nickel	30	200 [D]	400 [F]	6,000 [F]	7	11	12	10	11	10	7	11	11	7	6	9	9	12	10	8	9
Zinc	180	180	7,400 [F]	400,000 [F]	25	46	40	51	58	43	39	44	45	26	32	40	37	56	63	58	38

Notes:

All values in mg/kg. Only detected analytes are presented. Full laboratory certificates are included in Appendix 5.

Underlined text indicates concentration exceeds the background concentration[3].

Italics text indicates that the concentration exceeds the Ecological SGV for Residential Land Use [3].

Bold text indicates that the concentration exceeds the SCS for Residential land use[1].

Highlighted cell indicates that the concentration exceeds the SCS for Commercial / Industrial Land Use which serves a surrogate for excavation activities and maintenance of underground services[1].

- Indicates that the tests was not completed on the sample.

A The New Zealand Institute for Bioeconomy Limited: Determination and use of background concentrations of trace elements in soil in Otago and Southland[3].

B The National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health[1].

C Criteria for Cr6 presented as criteria for Cr3 are non limiting[1].

D Australian National Environmental Protection Council (NEPC) National Environmental Protection (Assessment of Site Contamination) Measure Schedule B(1): Guideline on the investigation levels for soil and groundwater. Calculation: Added Contaminant Limited (ACL) for urban residential and public open space (CEC = 10) + background concentration[15].

E Australian National Environmental Protection Council (NEPC) National Environmental Protection (Assessment of Site Contamination) Measure Schedule B(1): Guideline on the investigation levels for soil and groundwater[15].

5 Discussion

The arsenic concentrations in sample CF1, located at the north eastern side of the cleanfill stockpile and sample PQF, located at the north eastern side of the stockpile surface, exceed the SCS for residential land use, as well as the expected background concentration and the Eco-SVG for residential land.

None of the concentrations of contaminants measured in other samples from the cleanfill stockpile pose significant risks to human health or ecological receptors. Furthermore, no asbestos was detected in the 26 additional samples.

IE calculated the 95% upper confidence limits (UCLs) for the heavy metals (n=34) and the results (refer to Table 6) were below the background concentrations of trace elements in soil in Otago and Southland[3].

Table 6: 95% UCLs for Heavy Metals Concentrations in the Cleanfill Stockpile

Analyte	Predicted Background Concentrations[3]	95% UCL (n=34)
Arsenic	12	11.2
Chromium	120	9.8
Copper	80	15.2
Lead	150	14.7
Nickel	30	10.4
Zinc	180	46.2

However, significant contamination impacts consisting of engine oil stains, soil beneath treated timber poles and spilled bitumen were visually confirmed at the site. Laboratory analysis of those impacts is not required, due to visual and olfactory confirmation of the significance of the impacts. The below-ground extents of those impacts can be ascertained during the site remediation process, when excavation and disposal of the impacted material is proposed to occur.

6 Conceptual Site Model

A contamination conceptual site model, presented in Table 7, consists of three primary components to allow the potential for risk to be determined. These are:

- Source of contamination;
- Pathway to allow the contamination to mobilise; and
- Sensitive receptors which may be impacted by the contamination.

Table 7: Conceptual Site Model

Source	Pathway	Receptor
Heavy metals (naturally occurring and treated timber posts), Petroleum hydrocarbons (underground and above-ground tanks, surface engine oil and bitumen spills), Polycyclic aromatic hydrocarbons (surface engine oil and bitumen spills).	Inhalation of dust; Dermal absorption (direct contact); Ingestion of soil and / or produce grown in the soil; Wind-blown dust; Sediment migration via stormwater; Leaching to groundwater via stormwater infiltration.	Maintenance / Excavation workers; Site workers; Future residents and visitors; Soil microbes; Soil invertebrates; Plants; Wildlife; Groundwater; Surface water.
Acceptable risk to human health	Earthworks Associated with Land Development Yes: The contamination impacts that could pose significant risks to human health are located in well defined areas and can be easily remediated prior to, or as part of the bulk subdivision earthworks. **Future Residential Land Use** No: Contamination impacts that pose significant risks to human health are located within the site boundaries. Remediation is required prior to residential development in those areas.	
Acceptable risk to ecological health	**Future Residential Land Use** No: Contamination impacts that pose significant risks to ecological receptors are located in the north eastern portion of the site	

7 Conclusions

Site History

Information obtained as part of this investigation (refer to Section 3) indicates that the site was used for agricultural purposes, likely as grazing for livestock and / or production of hay prior to establishment of a quarry and associated contractors' yards during the late 1980s.

Evidence was found that HAIL activities (refer to Section 3.6) have occurred in certain parts of the site. Soil samples were therefore collected from areas where significant contamination impacts could not be confirmed by visual or olfactory assessment. Soil samples were not required in areas where visual and olfactory indicators of contamination impacts were obvious, including engine oil stains, stacked treated timber poles and spilled bitumen.

Intrusive Investigation

Eight soil samples were collected from the eastern and southern sides of the cleanfill stockpile (Figure 2), then dispatched to Hill Labs under standard chain of custody documentation. IE requested that Hill Labs analyse the samples for a suite of common heavy metals and mercury was added to the suite of analyses at one sample location (CF8).

Additional sampling was undertaken within the cleanfill stockpile area, based on a preliminary review of this DSI by CODC. Twenty-six samples were collected from the stockpile surface and submitted to Hill Labs for analysis of a suite of common heavy metals (As, Cd, Cr, Cu, Pu, Ni and Zn) and asbestos presence / absence.

The arsenic concentrations in sample CF1, located at the north eastern edge of the cleanfill stockpile and sample PQF, located at the north eastern side of the stockpile surface, exceed the SCS for residential land use, as well as the expected background concentration and the Eco-SVG for residential land.

None of the concentrations of contaminants measured in other samples from the cleanfill stockpile pose significant risks to human health or ecological receptors. Furthermore, no asbestos was detected in the 26 additional samples.

Statistical analysis of the heavy metals concentrations confirmed that the 95% UCLs are below the background concentrations of trace elements in soil in Otago and Southland[3]. It is therefore considered likely that, even though small amounts of soil containing heavy metals exceeding the background concentrations may exist, the stockpile can be considered to qualify as cleanfill.

Significant Contamination Impacts

Visual and olfactory confirmation of significant contamination impacts in various parts of the eastern portion of the site are not considered suitable for residential use until the impacted areas have been remediated. Additional investigation of those areas is proposed to be undertaken upon decommissioning of the operational areas.

Remediation of the impacted areas is considered likely to be relatively straightforward[16] and the success of the remediation works would be validated upon completion, through laboratory analysis of the soil remaining in those areas.

This investigation has therefore confirmed that contaminants in soil, within the parts of the proposed residential use areas, pose significant risks to human health, environmental health or ecological health until such time that remediation earthworks are completed and validated.

Non-HAIL areas

No evidence of HAIL activities was found in the western portion of the site. The non-HAIL area is delineated in Figure 2.

NES Applicability

Contamination impacts identified in isolated parts of the Project confirm that the soil contamination exceeds the applicable standard in Regulation 7. Therefore, the proposed activities of subdividing land, changing land use and disturbing soil do not qualify as Controlled Activities pursuant to Regulation 9[1].

Consent will be required under the NES-CS for Restricted Discretionary Activities (Regulation 10) or Discretionary Activities (Regulation 11), to enable the remediation of the impacted areas prior to the change of land use, subdivision and development of the site for residential purposes.

8 Recommendations

It is recommended that this report be read in conjunction with the e3scientific PSI included as Appendix 5.

Furthermore, it is recommended that the soil contamination aspects of the Fast Track application be approved, because contamination impacts at the site appear to be relatively isolated and should be easily remediated prior to, or during bulk subdivision earthworks occurring.

Finally, it is recommended that the Remediation Action Plan (RAP)[16] provided as part of this application be accepted, to enable all parts of the Project to be made suitable for residential purposes.

These conclusions and recommendations are considered to be consistent with those presented by e3scientific[4].

9 References

1. Ministry for the Environment 2012: Users' Guide National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health
2. Ministry for the Environment 2021: Contaminated Land Management Guidelines No.1: Reporting on Contaminated Sites in New Zealand
3. The New Zealand Institute for Bioeconomy Limited 2025: Determination and use of background concentrations of trace elements in soil in Otago and Southland.
4. e3scientific Limited 2021: Parkburn Quarry Preliminary Site Investigation. Report reference #21085
5. GNS Webmap Institute of Geological and Nuclear Sciences 2013: 1:250,000 Geology. Viewed at: http://data.gns.cri.nz/geology/
6. Geotago Limited 2022: Junction Terraces (Parkburn Quarry), Mount Pisa Preliminary Geotechnical Assessment for Proposed Residential Development. Report Reference: GL21-022.1
7. Otago Regional Council 2026: Otago Regional Council Resource Consent Database. Viewed at: http://data.orc.govt.nz/
8. Otago Regional Council 2026: Mapping Resource Hazardous Activities, Industries and Bores Search. Viewed at: https://maps.orc.govt.nz/portal/apps/MapSeries/index.html?appid=052ba04547d74dc4bf070e8d97fd6819
9. Ministry for the Environment 2011: Ministry for the Environment Hazardous Activities and Industries List
10. Local Government Geospatial Alliance 2026: Retrolens - Historical Image Resource Project. Viewed at: http://retrolens.nz
11. Google Earth v7.3.6.10441. Mount Pisa, Central Otago, New Zealand. -44.960981°lon, 169.253345° lat, Eye alt 1.87 km. http://www.earth.google.com. [November 2025]
12. Mapspast 2026: Current and Historical Topographic Maps (Topomaps) of New Zealand. Viewed at: http://www.mapspast.org.nz/
13. Ministry for the Environment 2011: Contaminated Land Management Guidelines No.2 - Hierarchy and Application in New Zealand of Environmental Guideline Values.
14. Ministry for the Environment 2002: A Guide to the Management of Cleanfills.
15. Australian National Environmental Protection Council 2013: National Environmental Protection (Assessment of Site Contamination) Measure Schedule B(1): Guideline on the investigation levels for soil and groundwater.
16. Insight Engineering 2026: Remediation Action Plan for 922 Luggate-Cromwell Road (SH6), Cromwell. Reference #24019_RAP

10 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Fulton Hogan Land Development Ltd C/- Tim James Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground conditions indicated from published sources, site assessments and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

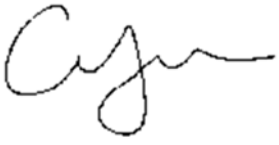
We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on [redacted] if you require any further information. The author is a Certified Environmental Practitioner (CEnvP) under the Environment Institute of Australia and New Zealand (EIANZ) accreditation system.

I, Claude Midgley of JKCM Limited, certify that this report meets the requirements of the Resource Management (National Environmental Standard for assessing and managing contaminants in soil to protect human health) Regulations (2011)[1], because it has been:

- Done by a suitably qualified and experienced practitioner (SQEP);
- Reported on in accordance with the current edition of Contaminated Land Management Guidelines No 1: Reporting on contaminated sites in New Zealand; and
- Certified by a SQEP.

Evidence of the qualifications and experience of the suitably qualified and experienced practitioner who has undertaken this investigation and certified this report is included in Appendix 8

Report prepared and certified by



Claude Midgley
CEnvP, MSc.
Principal Environmental Scientist

Appendix 1

Response to Peer Review Matters

Memorandum

From:	Claude Midgley (Insight Engineering)	Date:	25 September 2026
To:	Melanie Foote (Town Planning Group)	Project No.	24019
Cc:	Greg Dewe (Fulton Hogan) and Will Nicholson (LandPro)		
Subject:	Unresolved Issues Regarding the Remediation Action Plan for Parkburn Quarry		
Total Pages:	7		

1 Introduction

JKCM Ltd, trading as Insight Engineering (IE), was requested by Melanie Foote to provide comment on issues raised by CODC's peer reviewer regarding the approach to the site assessment and remediation required for the proposed subdivision at Fulton Hogan's Parkburn Quarry, located at 922 Luggate-Cromwell Road (SH6) directly north of Pisa Moorings.

Insight Engineering (IE) undertook a limited detailed site investigation (DSI) of the cleanfill stockpile at the site in 2025 and reported on the findings in 2026. IE also prepared a remediation action plan (RAP) to demonstrate how contamination impacts, identified visually by IE and e3Scientific, could be managed or removed from the site after the quarry operations and other industrial activities at the site had ceased.

The proposed approach, to "*complete additional investigation upon decommissioning or closure of any potentially contaminating land uses*" and "*develop a number of feasible strategies for remediation and/or site management if necessary*" was originally part of the conclusions reached by e3Scientific in their preliminary site investigation (PSI) completed in 2021. IE concurs with this approach.

2 Summary of Issues Raised

IE has been provided with the following list of issues to be resolved:

"*Overall, the expert review concludes that the documents are not sufficient to fully characterise contamination, assess risk, or justify the final remediation approach for residential development.*

The review recommends that the following additional information be obtained:

- *Investigation of all identified contaminant source areas, including further, more detailed, investigation of the cleanfill stockpile at depth, or justification as to why this is not considered necessary.*

  - *Additional contaminant testing (asbestos, PAHs, hydrocarbons and other HAIL-specific contaminants).*
  - *Updated risk assessment and conceptual site model incorporating additional investigation data.*
- *Off-site HAIL screening assessment.*
- *Better assessment of groundwater and surface water risks.*
- *Revised RAP based on improved site characterisation from additional DSI.*
- *Incorporation of laboratory-based validation into remediation strategy.*
- *Long-term containment and management controls including geotechnical assessment of retained fill and containment proposals.*

Further investigation is requested and refinement is required through consent conditions."

3 Detailed Response to Issues Raised

Initial statement

"*Overall, the expert review concludes that the documents are not sufficient to fully characterise contamination, assess risk, or justify the final remediation approach for residential development*"

The intent of the DSI was not to fully characterise the contamination. However, the locations of likely contamination impacts have been well established and full characterisation of the impacts is part of the proposed development strategy. This is consistent with the approach proposed by e3Scientific.

The final remediation approach, based on the assessment of available options in the proposed RAP, is limited to off-site disposal or on-site encapsulation of impacted soil.

- Where soil is demonstrated to exceed twice the residential soil contaminant standards, the impacted material will be disposed of at a facility licensed to accept it.
- All other material will be compacted and encapsulated beneath a crust of engineered fill that will provide a barrier between the future residents, visitors and workers at the site. The crust of engineered fill will also provide a barrier to stormwater infiltration, thereby significantly reducing the interaction between small pockets of impacted material within the cleanfill and the surrounding environment. The average concentration of contaminants within the encapsulation cells are expected to be below background, even if small amounts of contaminated soil exceeding the residential soil contaminant standards are included.

Further characterisation of the contamination impacts at this phase in the development does not change the fact that the, under the proposed RAP, the most contaminated material will no longer be present at the site and the remaining marginally impacted material will be isolated in a way that it effectively be inert.

Recommended Additional Information

"Investigation of all identified contaminant source areas, including further, more detailed, investigation of the cleanfill stockpile at depth, or justification as to why this is not considered necessary"

As stated in the introduction, it is not considered practicable to complete additional investigations in the majority of the operative areas at the site until they are decommissioned. However, those areas will be fully investigated as part of the proposed development strategy. A remediation plan has been prepared to demonstrate how the contamination impacts will be addressed, once fully characterised.

Further investigation of the cleanfill stockpile surface has been undertaken as part of the resolution of issues raised through the peer review process. However, samples were not collected at depth within the stockpile because it would interrupt the site operation and could lead to instability within the trafficked areas. Investigation at significant depth would require benching of the test pits, which could result in large areas of disturbance.

For a stockpile consisting of individual truckloads of imported material, the likelihood of uncovering significant unexpected contamination is considered to be very low due to the limitations on material that is allowed to be disposed of in the stockpile. The quarry manager (Matt Goulding *pers. comm.*) has provided the Contractors Agreement (Appendix 1) which formalises the type of material allowed to be placed in the cleanfill stockpile. Mr Goulding has also confirmed that the loads are inspected prior to acceptance into the quarry and that some have been rejected due to unsuitable material, such as organic inclusions, being identified in the fill.

Deeper layers in the stockpile were, at some point in the past, the former surface of the stockpile, therefore the visual indicators of unacceptable material would have been obvious to the site operator. Unsuitable material would have been removed at that time, therefore the material currently at the surface of the stockpile is considered to be sufficiently representative of the deeper layers because the method by which the stockpile has been created has not changed.

- ***Additional contaminant testing (asbestos, PAHs, hydrocarbons and other HAIL-specific contaminants).***

As stated, additional samples have been collected from the stockpile surface. No visual or olfactory indicators of PAHs or hydrocarbons that could interact with the environment were noted. Small amounts of asphalt millings were present, however the nature of that material is such that it can be considered inert even though PAHs are present. Laboratory testing is not considered necessary to confirm that asphalt millings contain PAHs and the results would not be representative of the risks to the environment.

Leaching tests have consistently confirmed that old asphalt millings remain well below hazardous waste and groundwater safety thresholds:
https://www.researchgate.net/publication/245336179_Leaching_of_Pollutants_from_Reclaimed_Asphalt_Pavement

https://faculty.eng.ufl.edu/timothy-townsend/wp-content/uploads/sites/210/2022/06/A-critical-analysis-of-leaching-and-environmental-risk-assessment.pdf

https://asphalt-materials.com/napa-helps-answer-what-is-the-environmental-impact-of-asphalt/

This is because volatile compounds (hydrocarbons) have long since evaporated, the bitumen binder has undergone oxidation that effectively locks the remaining hazardous compounds in place and PAHs are hydrophobic, which significantly reduces the potential for them to leach into groundwater via stormwater infiltration.

Real risks associated with PAHs from asphalt millings are associated with dust generation and sediment discharge via surface water flows. These pathways will not exist when the material has been encapsulated beneath a crust of engineered fill.

- ***Updated risk assessment and conceptual site model incorporating additional investigation data.***

The DSI has been updated to incorporate the results of additional stockpile samples. The findings can be summarised as: The 95% upper confidence limits for the concentrations of heavy metals are below the cleanfill criteria / background concentrations and no asbestos was detected in the samples.

- ***Off-site HAIL screening assessment.***

An off-site HAIL screening assessment is not considered practicable. The number of sites which have contributed to the cleanfill stockpile is considered likely to fall in the hundreds or even thousands. Fulton Hogan does not record the addresses of the source sites and contractors who have disposed of the loads are not likely to spend the time to provide this information.

What can be confirmed is that the contractors were aware that only cleanfill from non-HAIL sites may be disposed of at the facility (Appendix 1) and that it would not be in their financial best interests to dispose of contaminated material at the cleanfill stockpile.

- ***Better assessment of groundwater and surface water risks.***

The following risk matrix has been prepared to better demonstrate the likely risks to groundwater and surface water prior to, during and post remediation:

Risk Matrix

		Likelihood Level						
		Almost Certain	Very likely	Likely	Possible	Unlikely	Rare	Very Rare
Consequence Level	Catastrophic	Very High	Very High	Very High	High	Medium	Medium	Medium
	Major	Very High	Very High	High	High	Medium	Medium	Medium
	Moderate	High	High	High	Medium	Low	Low	Low
	Minor	Medium	Medium	Medium	Medium	Low	Low	Low
	Negligible	Low	Low	Low	Low	Low	Low	Low

The risks to groundwater and surface water are summarised in Table 1.

Table 1: Risk of contamination migration from source to receptor

	Before remediation	During remediation	After remediation
Surface water	Medium Uncontrolled releases of contaminated soil via surface water flow could reach the Park Burn. Bunding prevents this along the majority of the riparian zone. The occurrence is possible, but the consequence level is minor because the volume of sediment discharge is likely to me low. Had significant volumes of contaminated sediment been discharged during the quarry's operational lifespan, environmental impacts within the Park Burn would currently be evident.	Low Implementation of controls prescribed in the environmental management plan will ensure that surface water flows, which could contain contaminated soil, are diverted away from the Park Burn. The potential for contaminated sediment discharges is consider unlikely, but if they occurred the volumes would be low and the impacts would therefore be minor.	Low No contaminated soil will remain at the site surface, therefore the potential for uncontrolled discharges into the Park Burn are eliminated. The potential for contaminated sediment discharge is not possible once the material is encapsulated. In terms of the risk matrix, the occurrence would be rare and the consequence level minor.
Groundwater	High - Medium Stormwater infiltration through contaminated soil can currently result in discharge of contaminants to groundwater, the occurrence is almost certain. Natural soil at the site is characterised by high hydraulic conductivity, enabling contaminant migration through the soil column. Given the large volume of water flowing through the underlying aquifer, the consequence level is moderate to minor due to the likely dilution effect.	High - Medium Stormwater infiltration through contaminated soil could result in discharge of contaminants to groundwater. The occurrence is almost certain. Given the large volume of water flowing through the underlying aquifer, the consequence level is moderate to minor due to the likely dilution effect. Risk reduces with time as contaminated soil is removed from site or compacted within the containment cells.	Low The material within the encapsulation cells will be compacted for geotechnical stability, which will significantly limit the hydraulic conductivity. The material will be covered by a 1 to 2 m thick crust of engineered fill which also has significantly limited hydraulic conductivity, ensuring surface water does not reach the material within the containment cell, thereby reducing the potential for leaching of contaminants to groundwater to a high degree. The occurrence is therefore rare and the likely small volume of water results in negligible consequences.

- ***Incorporation of laboratory-based validation into remediation strategy.***

Laboratory-based validation was always part of the remediation strategy. Refer to Section 5.4.2 of the RAP. It is impossible to confirm whether material meets the threshold to be considered significant (twice the residential soil contaminant standards) or not, without laboratory-based validation.

The laboratory results obtained during the detailed investigation of the currently operative parts of the site will be used to inform the remediation of each area. Laboratory testing of the residual material will be undertaken to confirm that no contaminants remain at significant concentrations.

- ***Long-term containment and management controls including geotechnical assessment of retained fill and containment proposals.***

Geotechnical Controls

Geotechnical controls for the containment cell areas will vary slightly depending on the proposed end use of the land. Each of the containment cell areas will be capped by a layer of compacted engineered fill, likely to be comprised of crushed pea gravel. The intent is to form a stiff crust over the encapsulation cell that limits stormwater infiltration (through compaction) and meets the Geotechnical requirements for construction of NZS3604:2011 type dwellings.

Potential issues associated with the containment cell from a Geotechnical perspective are future differential settlements. For the containment area below the stormwater corridor, the fill will not support future structural loads. Therefore, a 1 m thick capping layer is considered to be sufficient from a Geotechnical perspective.

Where the containment area is within a future residential area, the capping layer is proposed to be 1 to 2 m thick. Additional Geotechnical measures, such as incorporation of geotextiles and geogrid reinforcement may be included within the containment cell material and capping material, subject to the type and condition of actual materials placed in the containment cell. Other measures that are proposed to be implemented include screening and exclusion of organic inclusions (e.g. timber, wood fragments and topsoil) from the containment cell. Settlement monitoring, also proposed to be incorporated as part of the greater bulk earthworks, are recommended to be carried out at the containment cell areas. Finally, subject to the condition, type and extent of compaction achieved, the containment cell area may be pre-loaded to express any unwanted settlement prior to allowing installation of services and building construction.

Quality control measures to verify compaction of the containment cell materials will likely need to be altered from the rest of the bulk earthworks, subject to the actual type of materials. Suitable methods of testing, such as nuclear densometer, Scala Penetrometer, Impact hammer, or a combination of these, may be used to verify compaction targets are achieved during fill placement.

The requirement for geotextiles and geogrids, preloading and testing methods are best assessed on site during construction by the Geotechnical Engineer, once the materials to be encapsulated are able to be assessed.

Long-term Management

The compaction of the cleanfill and engineered fill crust, described in the Geotechnical Controls, are expected to eliminate the requirement for long-term management, because the potential for stormwater infiltration and differential settlement is negligible.

IE has undertaken a soakage test (Appendix 2) to estimate the rate of infiltration through a test layer of compacted crushed pea gravel that will form the engineered fill crust / encapsulation layer over the cleanfill. The results confirmed that stormwater infiltration is limited by the generally low hydraulic conductivity of the crust, which is assessed as ranging between 4 x 10^{-6} m/s and 5.5 x 10^{-6} m/s. Infiltration through the crust would require sustained moderate intensity rainfall for periods up to 20 hours (typically). Such rainfall events are rare at the site. Additionally, the fill within the containment cell is also to be compacted. While it was not possible to perform soakage testing on a representative sample of this material, the compaction is expected to reduce the hydraulic conductivity, further limiting the transmission of water through the fill.

If a significant rainfall event does occur, the generation of leachate from the small pockets of marginally impacted of soil within the compacted cleanfill layer is likely to be minimal even without the 1 m layer of engineered fill crust, due to the fact that contaminant concentrations are expected to be at, or below, background in the majority of the compacted cleanfill layer[2].

Further investigation is requested and refinement is required through consent conditions

Limited further investigation has been undertaken, but the following Consent Conditions are proposed to ensure that the currently inaccessible portions of the site are investigated and remediated to the appropriate standard:

1. After the industrial activities at the quarry have permanently concluded, a supplementary detailed site investigation must be undertaken to investigate the parts of the site identified as being likely to contain contamination impacts by e3Scientific and Insight Engineering.

2. Applicability of the Remediation Action Plan, prepared by Insight Engineering, must be confirmed, based on the additional investigation results. The plan must be approved by the relevant territorial authority prior to commencement of remedial earthworks.

3. Remediation of the contamination impacts must be undertaken concurrently with the bulk subdivision earthworks, in accordance with the approved Remediation Action Plan.

4. A Site Validation Report must be prepared within 3 months of completion of the remediation earthworks. Details of the remediated areas, residual contamination concentrations, off-site disposal and on-site encapsulation works must be provided.

Appendix 1

Fulton Hogan Contractors Agreement including Fill Acceptance Criteria

CONTRACTORS FORMAL AGREEMENT

FILL ACCEPTANCE CRITERIA

Fulton Hogan requires that no contractor, or their sub-contractors shall deposit fill at their approved sites without having signed a formal agreement within the previous 12 months[1]. By signing this agreement, your business is confirming that the material being deposited meets the acceptance criteria outlined below:

Class 3 & 4[2] Fill Materials Restricted To:

- Glass (less than 1% by volume per load [e.g., incidental bottle]).
- Masonry Blocks
- Pavers, pipes and tiles that are made out of clay, concrete, and ceramic (nil asbestos content)
- Dry asphalt (cured)
- Bricks
- Ceramics
- Chip seal (cured)
- Concrete, un-reinforced (including dried concrete slurry)
- Concrete, reinforced (provided that there are no exposed reinforcing rods)
- Soils, rocks, gravel, sand, clay and other natural materials that are not virgin excavated natural materials, but are at or below local background concentrations at the disposal site.

AND

Class 5 Fill:

- Virgin excavated natural materials including soils, rocks, gravel, sand, clay and other natural material that are at or below local background concentrations at the disposal site.
- Inert manufactured materials (e.g., concrete, brick, tiles) less than 5% by volume per load.

No coal tar, road sweepings or hydro-excavated waste will be accepted

No material will be accepted that has been identified on Otago Regional Councils Land Use Register (https://maps.orc.govt.nz/portal/apps/MapSeries/index.html?appid=052ba04547d74dc4bf070e8d97fd6819) **as originating from a site where hazardous activities and industries have been located (HAIL).** This excludes any site where a detailed site investigation has been completed and reported which demonstrates that any contaminants in or on the site or the material to be deposited from that site, are at or below, background concentrations for the site at which the material is being deposited.

If it's discovered that material deposited is not listed on the acceptable materials list above, all testing and remediation costs will be passed back to the Contractor responsible.

This agreement requires annual renewal to allow continuation of this service.

Signed by (please print): _____ Date: _____

On behalf of: _____ Signature: _____

[1] This agreement has been developed to ensure compliance with Fulton Hogan's Resource Consents, and manage restrictions under the Waste Disposal Levy.

[2] Class descriptors in this document are as described by WasteMINZ Technical Guidelines for Disposal to Land – Revision 3.

Appendix 2

Fill Permeability Test Results

17 September 2026

Fulton Hogan Land Development Ltd
C/- Town Planning Group

Re: Fill Permeability Testing, Parkburn Development

Our Reference: 24019_7

1 Introduction and Scope of Report

JKCM Ltd, trading as Insight Engineering (IE), was requested to complete a permeability test within a test area of certified fill. The test was intended better understand the potential for stormwater to soak through fill to reach underlying layers.

This letter presents a brief description of the test and our calculations of the likely infiltration rate.

2 Soil Permeability Test

2.1 Objectives

Our brief was to assess the likely permeability of the future engineered fills that will be placed at the Parkburn Development, specifically fill that will overlie a future subsurface containment cell. This fill is to be comprised of crushed pea gravel.

Gravel crushing and compaction trials have been previously carried out to inform this aspect of the project, and these are described in detail in our Geotechnical Assessment Report dated 16 July 2026 (Version 4). Not all the information from our prior report will be reiterated herein, however one of the trials resulted in a fill pad being constructed at an earthworks site in Wanaka. This trial pad is considered to be representative of future fills at Parkburn and was a practical option for the permeability test.

2.2 Methodology

The soil permeability tests was completed on 14 September 2026. The test was completed within an area containing a trial pad constructed of crushed pea gravel fill. The trial pad was at least 1 m deep and was overlain by approximately 0.5 m of engineered fill sourced from local materials.

The test was carried out in a pit excavated using a 1.8T excavator, which extended through the local engineered fill and into approximately 200 mm into the crushed pea gravel pad. The sides and base of the test pit was squared and cleaned as much as practicable prior to filling with water.

The pit was filled with water to approximately 100-200 mm of the ground surface. The drop in water level was initially recorded every 5 minutes from a fixed point. The time intervals were gradually extended to 10, 20 and 30 minutes over a period of 4 hours as the water level dropped very slowly.

The test was terminated after a period of 4 hours and the observed drop in water level was 80 mm.

3 Results

Percolation/infiltration rates were calculated as per the attached worksheet.

Therefore, the calculated infiltration rates range between 4 x 10^{-6} m/s and 5.5 x 10^{-6} m/s (or 15 to 20 mm/hr).

4 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Fulton Hogan Land Development Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground and material conditions indicated from published sources, inspections and tests described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site and material characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

Report prepared by



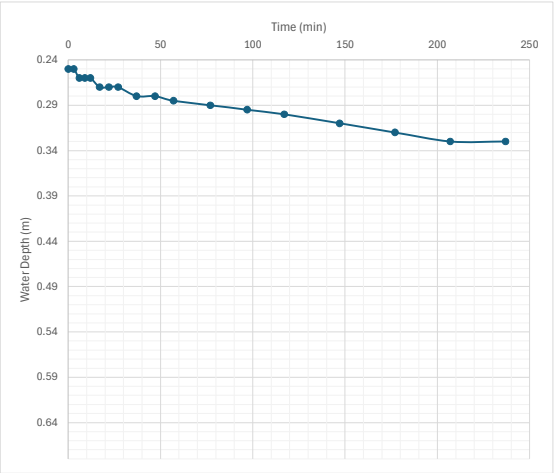
Jana Kruyshaar, CMEngNZ, MIPENZ
Principal Geotechnical Engineer

Attachment: Soil Permeability Calculation Worksheet

Measurements

Test 1

Time (min)	Difference in depth (m)
0	0.25
3	0.25
6	0.26
9	0.26
12	0.26
17	0.27
22	0.27
27	0.27
37	0.28
47	0.28
57	0.285
77	0.29
97	0.295
117	0.3
147	0.31
177	0.32
207	0.33
237	0.33



Calculations

Percolation Rate Calculation (Method 1):

$P = V_y/(AT \times X)$

Length pit	1.05	m
width pit	1	m
y*	0.01	m
d**	0.355	m
water vol V_y	0.0105	m^3
wall area A1	0.02	m^2
wall area A2	0.021	m^2
base area AB	1.05	m^2
total area AT	1.091	m^2
Percolation rate P	0.000321	m/min
Percolation rate P	0.321	mm/min
Percolation rate P	**19**	**mm/hr**
Percolation rate P	**5.35E-06**	**m/s**

*y is the depth difference btw the last 2 points
**d is the distance btw the midpoint of the last 2 readings and the base of the pit
X is the time interval between the last two points in minutes

BRE Digest Method:

$$f = \frac{V_{p75-25}}{a_{p50} \times t_{p75-25}}$$

Length	1.05	m
Width	1	m
Depth	0.68	m
Area Base Abase	1.05	m^2
H eff storage depth	0.43	m
*V_{p75-25}	0.22575	m^3
75% depth	0.3225	m
25% depth	0.1075	m
50% depth	0.215	m
**A_{p50}	1.9315	m^2
***Tp75	237	min
****Tp25	unknown	min
T_{p75-25}	480	min
	28800	s
Infiltration rate f	**4.058E-06**	**m/s**
Infiltration rate f	**15**	**mm/hr**

*Vol lost btw 75% and 25% of effective depth
**Mean surface area at 50% depth (incl base)
***Time at 75% depth of effective depth
****Time at 25% depth of effective depth. This is unknown in this case.
T_{p75-25} is conservatively assumed to 8 hours i.e. double the total test time.

Steady State Percolation Rate (Empirical Curve-Flattening Method)
From Gemini:
20 mm/hr (base only)

Recommended Percolation Rate

Most conservative result:
5.5 x 10-6 m/s
20 mm/hr

Appendix 2

Figures



Note: Map and aerial photograph courtesy of Google



Description	Site Location Plan	**Figure Number**	1
Project	Preliminary and Detailed Site Investigation 922 Luggate-Cromwell Road, Cromwell	**Date**	Sept-26
Client	Fulton Hogan Land Development Limited c/- Tim James Limited	**Drawn by**	CM
Project Number	24019_3	**Approved by**	JK



Description	Sample Location Plan	**Figure Number**	2
Project	Preliminary and Detailed Site Investigation 922 Luggate-Cromwell Road, Cromwell	**Date**	Sept-26
Client	Fulton Hogan Land Development Limited c/- Tim James Limited	**Drawn by**	CM
Project Number	24019_3	**Approved by**	JK

Appendix 3

Proposed Subdivision Plan

NOTES:
- All roads to vest as legal road in the Central Otago District Council

AREAS AA-BR subject to Covenants

SUPER LOTS - See Sheet 6 Diagram A

SUPER LOTS - See Sheet 6 Diagram B

SUPER LOTS - See Sheet 6 Diagram C

Sheet 4

LUGGATE - CROMWELL ROAD

Sheet 2

Sheet 5

Sheet 3

Lake Dunstan
(Te Wairere)

Digital map data sourced from Land Information New Zealand (LINZ). Licensed under the Creative Commons Attribution 4.0 International licence https://creativecommons.org/licenses/by/4.0/ It is made available in good faith but its accuracy or completeness is not guaranteed. Landpro accepts no responsibility for incomplete or inaccurate information. If the information is relied on in support of a resource consent it should be verified independently.

ISSUED FOR CONSENT

WyNOCpyC~l~rpbosboOMMUoOyOQNNPJm=êâAlêâ=ÅçaAEêi|SNSUy^ayOQNNPJNMMbnbnr|EQ05=OPKNMKOMOS

LANDPRO.

OFFICES IN CROMWELL, WANAKA AND NEW PLYMOUTH - www.landpro.co.nz

Client: FH LAND DEVELOPMENT LTD

NOTES
- All dimensions shown are in metres unless otherwise shown
- Copyright on this drawing is reserved
- Check any electronic data against the hardcopy plan to ensure it is the latest version
-If this plan is being used as part of sale and purchase agreement then it is done so on the basis that it is preliminary only, final dimensions and areas may vary on final survey

SCHEME PLAN- OVERVIEW - SHEET 1 OF 7
PARKBURN DEVELOPMENT PROJECT
922 LUGGATE - CROMWELL ROAD

Rev.	Date	Revision Details	By
A	16.09.26	Road Widths updated	SLM
B	23.10.26	All Road Widths updated to CODC Standard	SLM

Designed	Date	Job No.	Drawing No.
TJ	02.26	24113	100_01
Drawn	Date	Scale	
SLM	12.06.26	1:5000@ A3	
Checked	Date	Datum & Level	Rev.
NKA	12.06.26	LP 2000	B



Digital map data sourced from Land Information New Zealand (LINZ). Licensed under the Creative Commons Attribution 4.0 International licence https://creativecommons.org/licenses/by/4.0/ It is made available in good faith but its accuracy or completeness is not guaranteed. Landpro accepts no responsibility for incomplete or inaccurate information. If the information is relied on in support of a resource consent it should be verified independently.

ISSUED FOR CONSENT

WyNOÇpyÇ~[~ypbosboOMMUoOyOQNNPJm~êàA\êà=ÂçàAÉéjlSNSUÿ^ayOQNNPJNMMpdnaçJÉÇ=OPKNMKOMOS

LANDPRO.

OFFICES IN CROMWELL, WANAKA AND NEW PLYMOUTH - www.landpro.co.nz

Client

FH LAND DEVELOPMENT LTD

NOTES
- All dimensions shown are in metres unless otherwise shown
- Copyright on this drawing is reserved
- Check any electronic data against the hardcopy plan to ensure it is the latest version
-If this plan is being used as part of sale and purchase agreement then it is done so on the basis that it is preliminary only, final dimensions and areas may vary on final survey

SCHEME PLAN - QUARRY AERIAL 2025 - SHEET 8 OF 8
PARKBURN DEVELOPMENT PROJECT
922 LUGGATE - CROMWELL ROAD

Rev.	Date	Revision Details	By
A	16.09.26	Road Widths updated	SLM
B	23.10.26	All Road Widths updated to CODC Standard	SLM

Designed	Date	Job No.	Drawing No.
TJ	02.26	24113	100_08
Drawn	Date	Scale	
SLM	12.06.26	1:5000 @ A3	
Checked	Date	Datum & Level	Rev.
NKA	12.06.26	LP 2000	B

Appendix 4

Site Photographs



Photo 1: Above-ground diesel storage tank at the asphalt plant.



Photo 2: No evidence of petroleum hydrocarbons in the bunded area.



Photo 3: Above-ground bitumen storage tank at the asphalt plant.



Photo 4: Bitument disposed to ground near the asphalt plant.



Photo 5: Waste bitumen disposed to ground south east of the cleanfill stockpile, facing west.



Photo 6: Waste bitumen disposed to ground south east of the cleanfill stockpile, facing south.

Description	Site Photographs	**Photos**	1 to 6
Project	Preliminary and Detailed Site Investigation 922 Luggate-Cromwell Road, Cromwell	**Date Taken**	6/11/26
Client	Fulton Hogan Land Development Limited c/- Tim James Limited	**Taken by**	CM
Project Number	24019_2	**Approved by**	JK



Photo 7: Southern face of the cleanfill stockpile at the eastern end, viewed from the east facing west.



Photo 8: Relatively small stockpile in the cleanfill area at the north eastern corner of the site, facing south west.



Photo 9: Eastern face of the cleanfill stockpile, viewed from the east facing north west.



Photo 10: Example of non-soil inclusions in the cleanfill stockpile.



Photo 11: Southern face of the cleanfill stockpile at the western end, facing east.

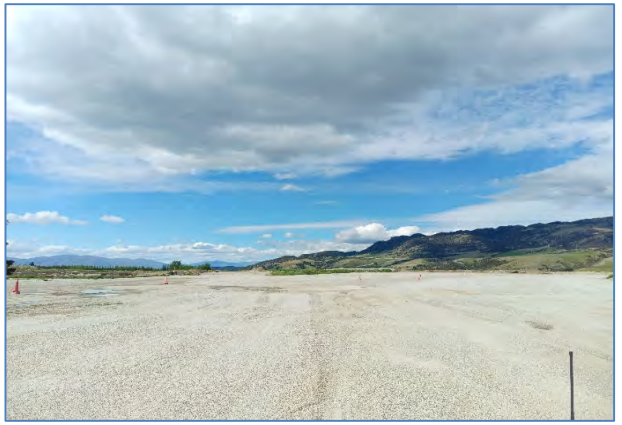


Photo 12: Surface of the cleanfill stockpile, facing north east.

Description	Site Photographs	**Photos**	7 to 12
Project	Preliminary and Detailed Site Investigation 922 Luggate-Cromwell Road, Cromwell	**Date Taken**	6/11/26
Client	Fulton Hogan Land Development Limited c/- Tim James Limited	**Taken by**	CM
Project Number	24019_2	**Approved by**	JK

Appendix 5

e3scientific PSI Report

Parkburn Quarry Preliminary Site Investigation

Fulton Hogan Limited

December 2021

Arrow Lane Arrowtown 9302
www.e3scientific.co.nz

Parkburn Quarry
Preliminary Site Investigation

Document Status

Version	Purpose of Document	Prepared By	Reviewer	Review Date
0.1	Draft for internal review	L. Salemink Waldren & S. Beardmore	G. Davis	20/10/21
0.2	Draft for client review	S. Beardmore	G. Davis	20/10/21
1.0	FINAL	S. Beardmore	G. Davis	6/12/21

TABLE OF CONTENTS

1 Introduction 6

1.1 Purpose 6

1.2 Proposed Development 6

1.3 Scope of Work 7

1.4 Limitations 8

2 Site Location and Description 10

2.1 Site Location 10

2.2 Topography 11

2.3 Geology 11

2.4 Hydrogeology 12

3 Site History 15

3.1 Historical Certificates of Title, Maps and Surveys 15

3.2 Historic Aerial Photography 15

3.3 District Council Information 17

3.4 Regional Council Information 20

3.5 Previous Investigation Reports 21

4 Site Inspection 22

4.1 Weighbridge and offices 24

4.2 Industrial Area 24

4.3 Cleanfill and Yards 26

4.3.1 Cleanfill and Hardfill XRF Results 28

4.4 Quarry Area 29

4.5 Balance of the site 31

5 Summary of HAIL Activities 32

5.1 Identified HAIL Activities 32

5.2 Non-HAIL Areas 33

5.3 Integrity Assessment 35

6 Preliminary Conceptual Site Model 36

6.1 Sources 36

6.1.1 Concrete manufacture 37

6.1.2 Asphalt manufacture 37

6.1.3 Fuel storage 38

6.1.4 Persistent pesticide use 38

6.1.5 Treated timber storage 38

6.1.6 Waste disposal to land 38

6.2 Receptors and Pathways 39

	6.3	**Preliminary Risk Assessment**	**39**
7		**Activity Status under the NESCS**	**42**
8		**Summary and Conclusions**	**44**
9		**Report Certification**	**46**
10		**References**	**47**

LIST OF FIGURES

Figure 1: Draft concept plans 7
Figure 2: Site Location (topographic) 10
Figure 3: Site location (aerial) 11
Figure 4: Registered bores within 1 km of the site 13
Figure 5: Site Layout 23
Figure 6: Weighbridge and offices 24
Figure 7: Industrial area activities 25
Figure 8: Cleanfill and yards area 27
Figure 9: Quarry layout 30
Figure 10: Approximate spatial extent of HAIL areas 35

LIST OF TABLES

Table 1: Summary of Site Location and Description 14
Table 2: Summary of Aerial Images and Maps 16
Table 3: Identified HAIL Activities 33
Table 4: HAIL activities and potential contaminants 36
Table 5: Preliminary conceptual site model 41

LIST OF APPENDICES

Appendix A: e3Scientific Limited Contaminated Land Experience
Appendix B: Historic Certificates of Title
Appendix C: Historic Aerials
Appendix D: Otago Regional Council Supporting Information
Appendix E: Site Photographs
Appendix F: XRF Screening Results

Executive Summary

Fulton Hogan Limited (FHL) operate Parkburn Quarry, immediately north of Pisa Moorings. The quarry was developed by FHL in the 1980s and has been in operation since this time. The quarry produces a range of aggregates, from sealing chip to construction and concrete aggregates. As the site is nearing the end of its operational lifespan, Fulton Hogan are seeking a plan change to rezone the site so that it can be redeveloped for a range of future land uses upon closure.

Currently, a range of activities associated with quarry operation take place on site, including asphalt production, concrete batching and block manufacture, disposal of cleanfill, and fuel storage. These activities are listed on the Ministry for the Environment's Hazardous Activities and Industries List (HAIL) and therefore any subdivision, change of use, or soil disturbance where these activities occur will be subject to the provisions of the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NESCS).

To assist Fulton Hogan in managing the risks associated with contaminants in soil, e3Scientific has undertaken a Preliminary Site Investigation (PSI) to identify the areas of potential contamination within the site, consider the risks to human health associated with the proposed development, consider the activity status of the future development under the NESCS, and assess the need for further investigation.

Based on the review of site history information and a site inspection, six discrete HAIL activities were identified. HAIL activities identified during this investigation include commercial concrete manufacture, asphalt manufacture, fuel storage, persistent pesticide use associated with the orchard, bulk storage of treated timber and waste disposal to land associated with the cleanfill. These HAIL activities are predominantly located in the industrial area on the northern portion of the property. Within the quarry itself, fuel and bitumen storage were the only HAIL activities identified.

Based on the proposed plan change and eventual development of the site, there is potential for workers and residents to be exposed to contaminants associated with the existing HAIL activities.

Within the future residential area, the identified HAIL activities include relatively small-scale hydrocarbon storage associated with the bitumen spray plant, a diesel tank and waste oil storage, and a diesel generator. It is possible that these activities could leave localised areas of hydrocarbon contamination. Although topsoil will need to be imported to this part of this site, there is a relatively low risk that inhalation of volatile contaminants would remain an open exposure pathway. Any topsoil imported to the site should be certified as meeting the appropriate human health and environmental criteria.

Within the future industrially zoned area, the identified HAIL activities include concrete manufacturing and batching, asphalt production, fuel storage, persistent pesticide use, treated timber storage, and disposal of cleanfill. We consider that it is highly unlikely that contaminants in soil associated with concrete manufacture, persistent pesticide use, and treated timber storage would pose a risk to human under the proposed commercial/industrial land use.

It is possible that contaminants associated with asphalt production, fuel storage and cleanfill disposal could result in soil contamination that could pose a risk to long term outdoor workers using the site in the future without appropriate investigation, remediation and/or management during development. The greatest risks are associated with hydrocarbon storage, particularly around any underground fuel storage infrastructure (e.g. fuel supply pipelines). Risks associated with the disposal of cleanfill appear relatively low; however, given the long history of filling, it is possible that localised areas of contaminated fill material may be present.

Given the on-going use of the site for these HAIL activities, it would be appropriate to complete additional investigation upon decommissioning of any potentially contaminating land uses. These investigations may also be better able to assess risks to human health as plans for the proposed development become more detailed.

1 Introduction

1.1 Purpose

Fulton Hogan Limited (FHL) operate Parkburn Quarry, immediately north of Pisa Moorings. The quarry was developed by FHL in the 1980s and has been in operation since this time. The quarry produces a range of aggregates, from sealing chip to construction and concrete aggregates. As the site is nearing the end of its operational lifespan, Fulton Hogan are seeking a plan change to rezone the site so that it can be redeveloped for a range of future land uses upon closure.

Currently, a range of activities associated with quarry operation take place on site, including asphalt production, concrete batching and block manufacture, disposal of cleanfill, and fuel storage. These activities are listed on the Ministry for the Environment's Hazardous Activities and Industries List (HAIL) and therefore any subdivision, change of use, or soil disturbance where these activities occur will be subject to the provisions of the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NESCS).

To assist Fulton Hogan in managing the risks associated with contaminants in soil, e3Scientific has undertaken a Preliminary Site Investigation (PSI) to identify the areas of potential contamination within the site, consider the risks to human health associated with the proposed development, consider the activity status of future development under the NESCS, and assess the need for further investigation.

1.2 Proposed Development

Fulton Hogan are proposing to rezone the quarry through a private plan change. Draft concept plans provided by Fulton Hogan indicate that the site could potentially accommodate a wide range of uses, including residential (standard and high density), commercial, retail commercial, childcare / education, green space, and industrial (Figure 1).



Figure 1: Draft concept plans

The residential areas will be located towards the south of the property, where the current quarry operations are located, adjacent to the existing Pisa Moorings development. The residential areas could be located around man-made waterways and inlets, as found in the southern area of Pisa Moorings. The commercial and industrial areas will be located towards the northern boundary of the site, where these types of activities currently take place.

As the developed areas of the quarry have been stripped, topsoil for residential areas will need to be imported, either from off-site or from stockpiles of soil stripped during quarry operations.

1.3 Scope of Work

The scope of work completed during the investigation included the following:

- Review of land use history from historic aerial photographs, certificates of title, Central Otago District Plan (CODC) property files, and information available from the Otago Regional Council (ORC).
- Completion of a site inspection and review of existing physical environment.

- Development of a conceptual site model identifying potential contaminant sources, the possible routes of exposure to contaminants that may be present in soils on the site, and critical receptors.
- Consideration of risks to human health, the need for any further investigation, and the status of the development under the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (the NESCS).
- Preparation of a Preliminary Site Investigation report in accordance with the requirements of the Contaminated Land Management Guidelines (CLMG) No. 1: Reporting on Contaminated Sites in New Zealand (Ministry for the Environment, 2021).

e3Scientific's experience in the provision of contaminated land services is provided in Appendix A.

1.4 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. Subject to the Scope of Work, e3s's assessment is limited strictly to identifying the risk to human health based on the historical activities on the site. The confidence in the findings is limited by the Scope of Work.

The results of this assessment are based upon site inspections conducted by e3s personnel, information from interviews with people who have knowledge of site conditions and information provided in previous reports. All conclusions and recommendations regarding the properties 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.

Observations and assessments of the site are relevant to the time of inspection and the scope of this assessment. Investigations were limited to the site

investigation area. e3Scientific notes that the continued operation of the site could result in contamination that may alter the status of the site under the NESCS.

2 Site Location and Description

2.1 Site Location

The area under investigation (the site) is located at 922 and 922A Luggate-Cromwell Road (SH6) (see Figures 2 and 3). The site is situated between Lake Dunstan and the state highway, approximately 8 km north of Cromwell.

The property to the immediate north of the site is owned by Downer EDI Limited, and accommodates a quarry, associated support buildings and infrastructure associated with civil construction and road maintenance. Beyond the Downer EDI quarry, the land is primarily agricultural (pastoral) with some rural residential use. The southern boundary backs onto the Pisa Moorings residential housing development. The land west of the site, opposite SH6, is used for a combination of lifestyle, grazing and viticulture. Lake Dunstan lies immediately to the east of the site. A public walkway/cycleway traverses the lakeside marginal strip along the lake edge. From the southern boundary, the site extends approximately 980 m to the north and covers an area of approximately 120 ha.

The central coordinates of the site are E: 1304358 N: 5014130 (NZTM)

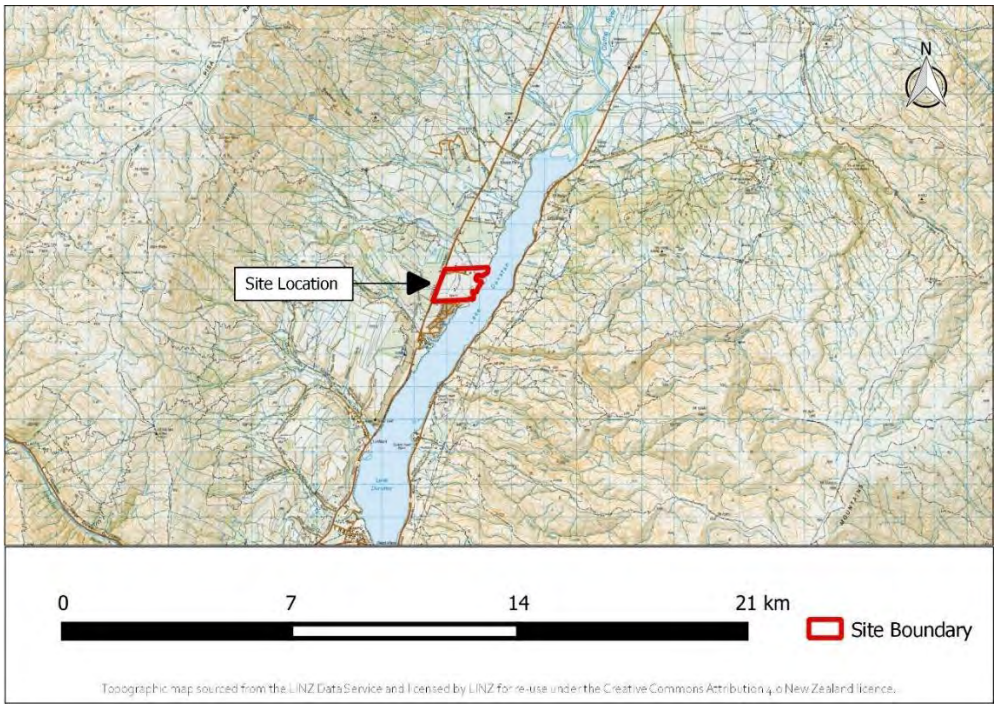


Figure 2: Site Location (topographic)

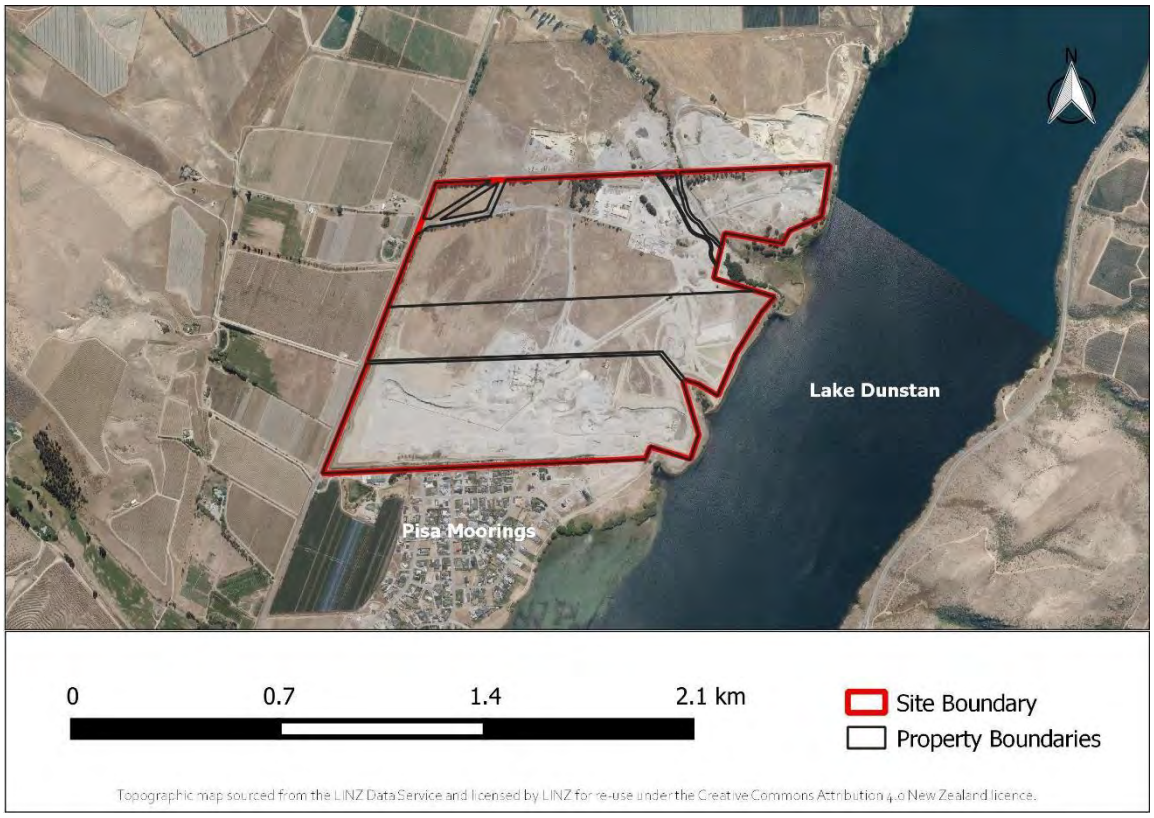


Figure 3: Site location (aerial)

The site is zoned Rural in Central Otago District Council District Plan, and eastern portion of the site is subject to Scheduled Activity notation SA25A – 'Gravel Pit Parkburn.'

2.2 Topography

Natural ground at the site slopes gently in a southward direction with an elevation 220 m above mean sea levels in the northwest corner to 199 m above mean sea level in the southeast corner. The local topography is highly influenced by the operation of the quarry, with active faces approximately 10 m high in the southern part of the site.

2.3 Geology

Based on the 1:250,000 Geological Map of New Zealand, the site is situated primarily on Late Pleistocene River deposits consisting of unweathered to slightly weathered, loose, sandy well-rounded gravel usually on the large outwash plains. There is a small section on the central northern boundary of the site that is situated on Holocene River deposits. These consist of loose commonly angular, boulders,

gravel, sand and silt forming alluvial fans; grades into scree (upslope)and valley alluvium (GNS Science, 2021).

2.4 Hydrogeology

The site overlies the Pisa Groundwater Management Zone. This zone is not identified in the current Regional Plan: Water or any of its schedules but has been identified in the draft/recommended aquifers on the ORC Water Allocation for Consultants webpage. The Groundwater Management Zone extends through the Late Pleistocene River deposits east of SH6 and Holocene river deposits that extend up the valleys of the foothills that run west of SH6. Groundwater beneath the site flows east through the alluvial terraces towards Lake Dunstan. The aquifer is unconfined with generally highly permeable sediments that are comprised of sandy gravel or sandy cobble gravel and is likely to be hydraulically connected to Lake Dunstan.

There are four bores on site, with reported depths to water ranging from 9.9 to 12.6 metres below ground level (mbgl). e3s examined the bore logs from nearby bores to assess the likely aquifer thickness and permeability. No basement rock was found in nearby bores; however, there was clay at the base of G41/0319 and clay-bound gravels at 30 mbgl in G41/0465 at 40 mbgl, which may function as the base of the aquifer. This indicates the saturated thickness of the aquifer may be 10-15 m.

There are 36 recorded bores within a 1km radius of the site's location (Figure 4). Of these bores, the primary usages are: 14 for Irrigation, 16 for domestic use, 3 for community supply, 2 for commercial/industrial, 1 for investigation, and 1 is unknown.

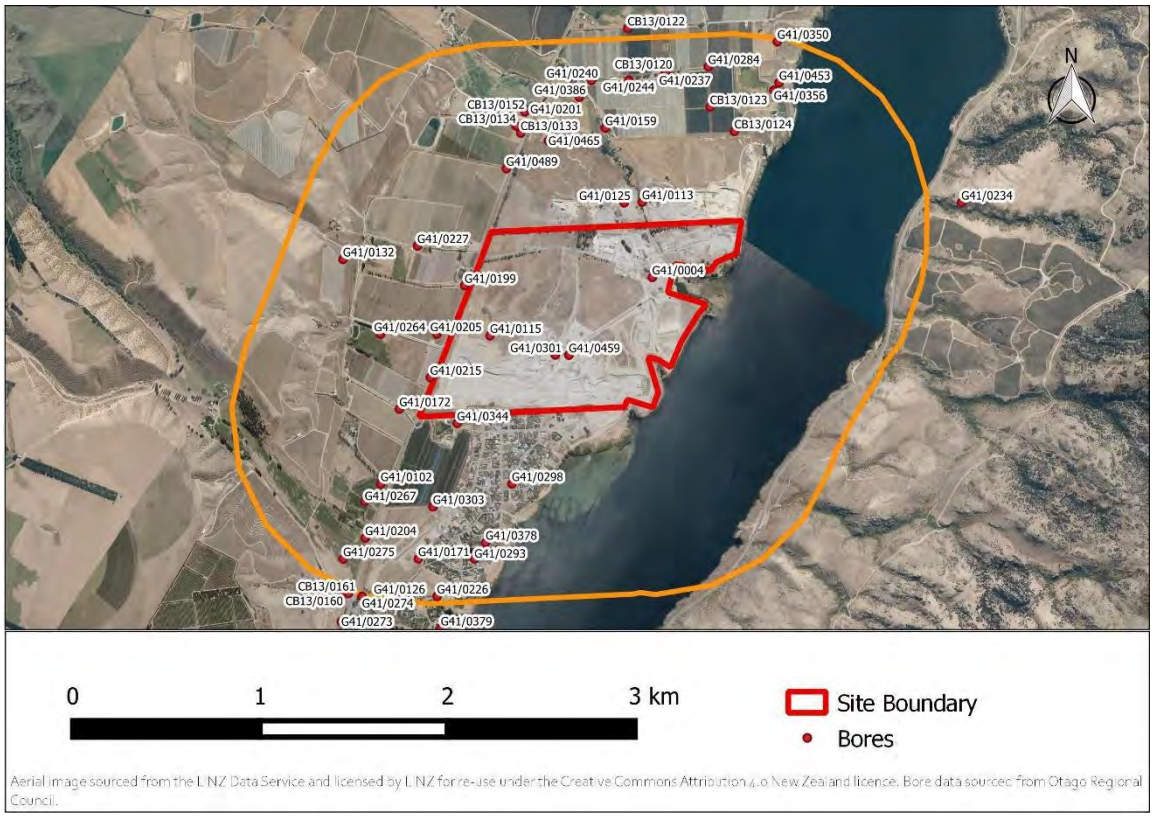


Figure 4: Registered bores within 1 km of the site

Lake Dunstan borders the site's eastern boundary. The lake is utilised for a wide range of water related pursuits including swimming, fishing and boating. To enable these pursuits, access is provided throughout the length of the Lake, including roads to the north and south of the Quarry. The Park Burn, and associated marginal strip, passes through the north-eastern corner of the site. Visible water races can be seen across the pastoral land in the north of the site. There are also several channels and ponds within the quarry site.

Table 1: Summary of Site Location and Description

Address	922 & 922A Luggate Cromwell road, Mount Pisa, 9393
Legal Descriptions	Section 64-65 Block IV Wakefield Survey District, Part Section 62-63 Block IV, Part Section 63 Block IV Wakefield survey District and Section 1 Survey Office Plan 365897.
Location	North of Pisa Moorings residential area, West of lake Dunstan, East of SH6 and approximately 1.5 km south of Smiths Way.
NZTM Coordinates	E: 1304358 N: 5014130 (NZTM)
Owners	Fulton Hogan Limited
Site area	120 ha
Surrounding Land Uses	North: Agricultural farming, commercial/industrial. East: Lake Dunstan South: Residential housing West: Viticulture
Regulatory Authorities	Regional Authority: Otago Regional Council Local Authority: Central Otago District Council
Zoning	Rural Resource Area
Topography	Sloping from south-east to the north-west corner, but heavily influenced by quarry operations
Geology	Late Pleistocene River deposits
Hydrogeology	Pisa Groundwater Management Zone
Nearest Surface water	Lake Dunstan directly to the east, Park Burn passing through the north-east corner and small water races running through the site.
Current Land Use	Industrial and commercial
Future Land Use	Residential, industrial, and commercial

3 Site History

3.1 Historical Certificates of Title, Maps and Surveys

Online available historical maps and images of the area available from the 1800's to present day were accessed via the National Library Cartographic Collection on 23 September 2021 and MapsPast.org.nz on 19 August 2021.

A perpetual lease for what is now Sections 62 and 63 was issued to Robert Davidson in 1894. The lease was transferred to a series of private owners (some of which are illegible on the scanned copy of the deed) in 1905, 1940, and 1947. In 1983, the eastern portion of the site was acquired by the Crown for electricity generation so that it could be inundated by Lake Dunstan. In 1985, the lease was transferred to Robert and Charles Perriam, farmers, and a new certificate of title (10B/738) was issued. In December 1985, the title was transferred to Fulton Hogan Limited, and a mining license commenced on 20 July 1987. In 2008, two sections were declared to be road and vested with Central Otago District Council, and an adjoining road was stopped and amalgamated with the adjoining land to create the current title (407414).

The land that is now Sections 64 and 65 was also appears to have been leased for agricultural use until it was transferred from the Perriams to Fulton Hogan Limited in 1985.

Historic surveys and certificates of title are provided in Appendix B.

3.2 Historic Aerial Photography

Aerial images sourced from retrolens.nz, the National Library, and from Google Earth Pro and Google maps street view have been reviewed. A summary of notable observations is presented in Table 2. Selected images are included in Appendix C.

The review of aerial photographs was completed using digital copies of the images, which provide higher resolution than those provided in the appendix.

Table 2: Summary of Aerial Images and Maps

Date	Source	Site Observations
07.03.1958	Retrolens	An unsealed driveway runs from SH6, approximately 150 m south of the northern site boundary, across the site, to a house, just beyond the eastern boundary of the site. A small orchard is visible between the driveway and the Park Burn. Most of this orchard lies outside of the site boundary to the east; however, approximately 1000 m^2 is within the site. The remainder site is flood irrigated pasture, with several farm tracks and water races visible. The Clutha Mata-Au is approximately 450 m east of the site.
01.03.1975	Retrolens	An irrigation pond has been created south of the orchard visible in the previous image. Four rectangular shapes/structures are visible on the site, two located together within the central parcel and two separated on the southern parcel. The balance of the site continues to be used for flood irrigated pasture. Stacks of felled trees are visible in the central northern portion of the site.
14.11.1976	Retrolens	The majority of the site is similar to the previous image. The rectangular structures visible in the previous image have been removed, with no sign of soil disturbance, suggesting these were most likely bales of hay/feed. Felled trees can still be seen in the central northern section of the site.
20.02.1978	Retrolens	There are no significant changes from the previous image.
17.02.1983	Retrolens	There are no significant changes from the previous image.
19.02.2001	Retrolens	Lake Dunstan has been filled, up to the eastern site boundary. Gravel extraction in the northern portion of the site, on both sides of the Park Burn, has commenced. Two structures associated with present day asphalt plant are visible to the west of Park Burn. There is a small pond visible in the north-east corner of the site. The southern portion of the site remains largely unchanged.
27.02.2003	Retrolens	Quarrying extends further south along the eastern site boundary. The ponds in the north-eastern corner of the site are much larger. The southern portion of the site remains largely unchanged.

Table 2 (continued)

Date	Source	Site Observations
02.2007	Google Earth (c)	A second area of quarrying along the southern boundary, connected to the main driveway by two haul roads, is visible. The ponds in the north-east corner of the site have been filled, and series of small ponds can be seen in pits on the eastern side of the site. In the centre of the northern section, two additional buildings, parking area, and material storage associated with the concrete block manufacturing plant has been established. A gate house and weighbridge has been established near the entrance to the site from SH6. South of the site, Pisa Moorings has been established, with several house and roading infrastructure in place.
10.2011	Google Earth (c)	The layout of the site remains largely the same as the previous image. The quarry to the south has been extended further east and west. The series of ponds in the central/eastern portion of the site have extended further south, and these are in various stages of being filled, with discrete loads of material visible in three of the ponds. The banks of the Park Burn have more vegetation.
12.2015	Google Earth (c)	The overall layout of the site remains unchanged, and the progression of quarrying and filling has continued through the site.
11.2019	Google Earth (c)	The overall layout of the site remains unchanged, and the progression of quarrying and filling has continued through the site. Two more locations have been setup as work yards with infrastructure in place. Both are within the north-eastern section of the site.
06.2021	Fulton Hogan	A recent drone image shows the site in its current configuration. Again, the overall layout of the site remains unchanged, and the progression of quarrying and filling has continued through the site. South of the site, Pisa Moorings is fully developed.

3.3 District Council Information

e3s was provided resource consent and building consent documentation for the site from the Central Otago District Council.

The following information was found in the property file:

- A 1988 building permit (F037756) to erect an office building at the existing weighbridge.

- A 1990 building permit (H056122) to erect a relocated bitumen storage shed. Plans provided with the application show diesel storage at the weighbridge and asphalt plant, and kerosene near the bitumen shed. The weighbridge is located approximately 120 m southeast of the asphalt plant.

- A 1995 building consent application (BC950406) and associated processing information for the installation a shed at the asphalt plant. Plans provided with the application show diesel storage at the weighbridge and asphalt plant.

- A 2004 building consent application (BC040935) and associated processing information for the installation of a prefabricated Portacom building near a new weighbridge, approximately 250 m from the site entrance. The Portacom building was used as an office and washroom and included a single chamber septic tank and wastewater disposal field.

- 2005 building consent and resource consent applications (BC050850 RC050211) and associated processing information for the construction of concrete block processing facility, capable of producing a range of concrete products including masonry, paving stones, landscaping, and other associated building products. The facility is constructed from pre-cast concrete block building and includes a single chamber septic tank and wastewater disposal field. Information in the file also indicates that a 10,000 L diesel tank is used to provide fuel for a boiler, and cement is stored in silo adjacent to the main building. Wash water is channelled into a collection area and settling ponds, after which the water is to be recycled or directed to a soak pit.

- A 2006 building consent application (BC060538) to relocate a Portacom for staff facilities at the weighbridge.

- A 2007 resource consent application (RC070216) and associated processing information for a land use consent to extract and convey sand and gravel. The purpose of the consent was to allow extraction outside of the Scheduled Area provided in the district plan, and to convey these products to the existing processing plant.

- A 2015 building consent application (BC150440) to add an extension to the side of a shed to allow for the installation of a 40,000 L vertical bitumen tank. Plans for the consent show the layout of the asphalt plant, including diesel and kerosene tanks, loading bins, and bitumen spray release.

- A 2015 building consent application (BC150689) and associated processing information for a single pitch storage shed at the concrete block processing facility.

- A 2016 building consent application (BC160880) and associated processing information for the installation of a transportable office on piles near the weighbridge.

- A 2018 building consent application (BC180636) and associated processing information for the foundations and site works for a Portacom office near the weighbridge.

- A 2019 resource consent application (RC190341) and associated processing information to construct three additional relocatable offices/amenities buildings near the weighbridge. The is consent was later amended (RC200046) to allow two further Portacom buildings to be established. There are three subsequent building consents (BC200395, BC190440, BC190726) associated with these structures.

- A 2020 resource consent application (RC210112) and associated processing information to build a commercial shed for a glass crushing plant. Power for the crushing plant is provided by a standalone generator. The fuel source for the generator is not described in the application. There is a subsequent building consent (BC210205) to install a recycled glass materials shed.

- A 2020 building consent application (BC200568) and associated processing information to install a Smart Shelter container roof.

- A 2020 building consent application (BC200771) and associated processing information for foundation and drainage works to install an ablution block. Wastewater is discharged to an existing septic tank.

- A 2021 resource consent application (RC210129) and associated processing information to install two 20,000 litre diesel fuel tanks to replace

one 30, 000 litre diesel fuel tank, located approximately 20 m WSW of the asphalt plant. The tank is noted to be scheduled to be removed mid-2021.

None of the Project Information Memoranda for the above consents identified the likely presence of any hazardous substances, and available plans did not specify the use of any asbestos containing materials (ACM). Supporting documentation from the district council is too large to append but can be provided upon request.

3.4 Regional Council Information

e3Scientific reviewed Otago Regional Council's Hazardous Activities and Industries List (HAIL) Register and consent information on 23 September 2021 and requested information on any Resource Management Act incidents or complaints related to the site.

Part of the site is currently recorded on the Otago Regional Council's HAIL database. This piece of land is registered as site number HAIL.00359.01, as verified HAIL site under the category E2: Asphalt or Bitumen Manufacture. The site is noted as a consented asphalt plant. An underground petroleum storage system (UPSS) removal report was received by the ORC from Z Energy in 2015. The investigation confirmed that residual contamination was acceptable for commercial/industrial land use. However, because of the on-going use as an asphalt plant and other areas of hazardous substance storage, this site is recorded with a contamination status of 'partially investigated.' The UPSS removal report is discussed further in section 3.5.

With regards to the balance of the site, the ORC notes that the database is continually under development and should not be regarded as a complete record of all properties in Otago. The absence of available information does not necessarily mean that the property is uncontaminated; rather no information exists on the database.

There are 25 resource consents associated with the site. Of these, thirteen are expired, five are surrendered, and six are current. Eight of the 25 consents are associated with construction of bores or groundwater takes, Seven are associated with discharges to air from an asphalt plant, six are associated with discharges of water, silt and/or sediment to land for processing aggregate, dust suppression, and truck washing, one is associated with a crossing over the Park

Burn, one is to discharge dust from the quarry operation, and one is to discharge solid fill to land for the purpose of backfilling the quarry.

The Otago Regional Council confirmed that there are four Resource Management Act incidents or complaints recorded for the site. Three of these are associated with dust. The fourth was a complaint regarding odour associated with stockpiles of broken glass.

Supporting documentation from the regional council is provided in Appendix D

3.5 Previous Investigation Reports

The only contaminated land investigation report available for the site is a 'Site Assessment for the Removal of an Underground Petroleum Storage System at the Fulton Hogan Asphalt Plant, Parkburn Quarry, 922 Luggate-Cromwell Road, Cromwell, Central Otago' prepared by Pattle Delamore Partners for Z Energy in 2015.

The report describes the results of soil benchmarking and Tier 1 risk assessment following the removal of a 10,000 L kerosene tank, 10,000 L diesel tank, and associated pipework in October 2014. The two tanks were located end to end in a single tank pit. All thirty samples collected from the tank pit, fuel pipelines and vent risers contained petroleum hydrocarbons below the relevant tier 1 soil acceptance criteria for commercial/industrial land use and for the protection of groundwater quality.

A dispenser within the bituminous emulsion manufacturing building and a 7 m section of pipeline were not removed at the time, and two new aboveground tanks replaced the removed UPSS.

4 Site Inspection

e3s staff conducted a site walkover on the 28th of September 2021. e3s staff were accompanied by Matt Goulding, Fulton Hogan's Central Quarries Operations Manager.

The site inspection was conducted in accordance with the Contaminated Land Management Guidelines No. 5: Site investigation and analysis of soils (revised 2021) (Ministry for the Environment, 2021).

Information gathered during site inspections included:

- General site condition, current use, local topography, and surrounding environmental setting.
- The condition of the buildings.
- The nature of the ground surface across the site.
- The location and condition of surface watercourses, drainage systems, and any groundwater wells.
- Visible signs of contamination or potential contamination, such as evidence of spills or leaks, surface staining, absent or stressed vegetation, and odours.
- Visible signs of areas of fill, stockpiled material, waste, ground disturbance, burnt areas, and former building foundations.
- The location of any chemical storage and transfer areas, bunding, waste storage areas, and discharges.
- The land use of neighbouring properties that have the potential to have an impact on the site or be affected by contamination from the site.
- The location of former buildings, processes or activities undertaken on the site.

The wider site layout is shown in Figure 55, and descriptions of the main parts of the site are provided in the following sections. Site photographs and observations are provided in Appendix E.

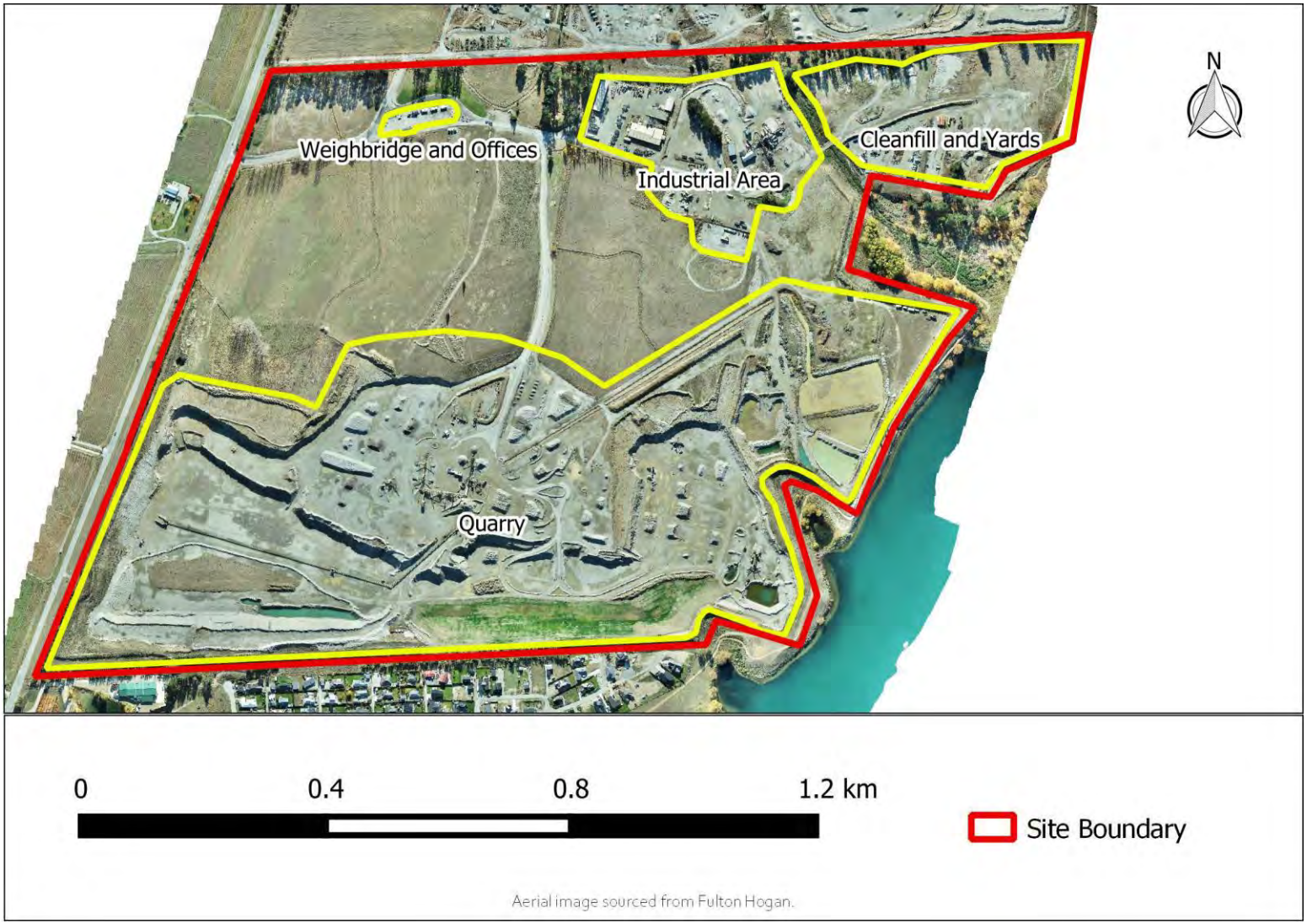


Figure 5: Site Layout

4.1 Weighbridge and offices

The weighbridge and site offices are located approximately 250 m from the SH6 entrance to the property.

There are five Portacom style buildings in addition to the weighbridge. All buildings appeared to be in good condition. The surface cover is predominantly hard stand, gravels, and landscaped areas (Figure 66).

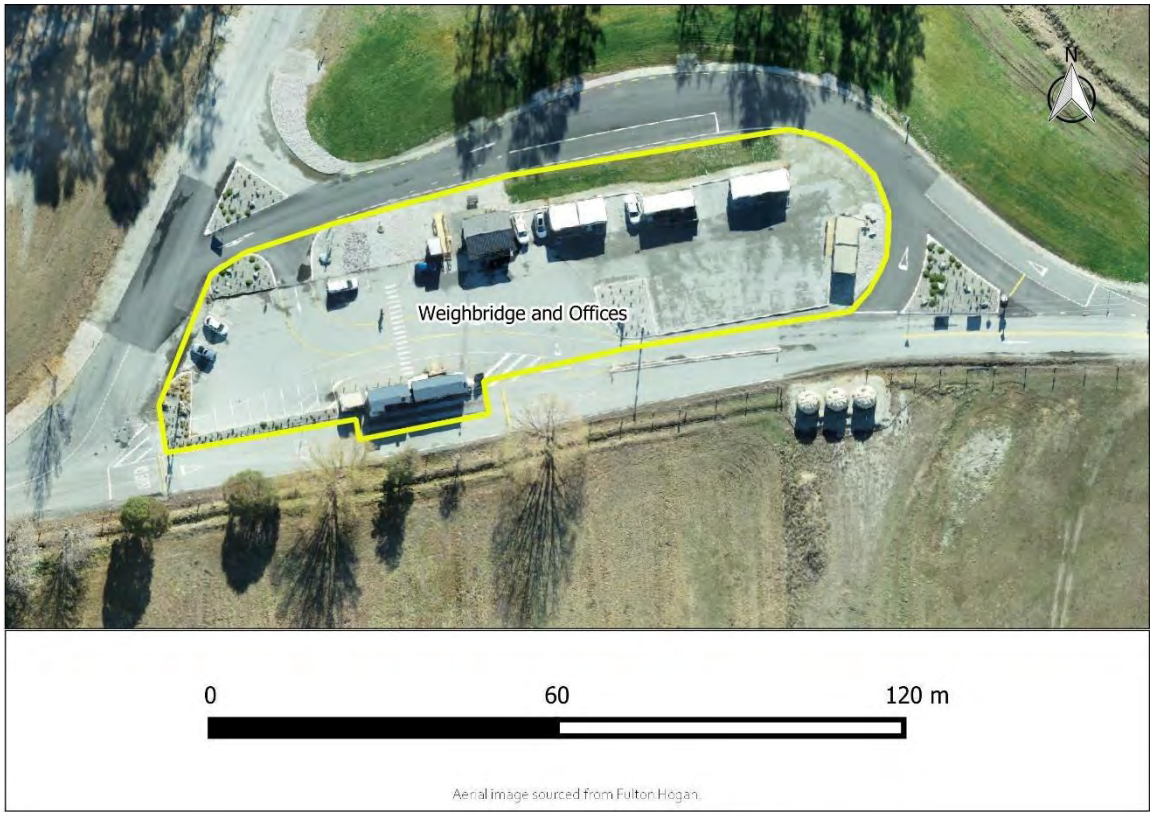


Figure 6: Weighbridge and offices

There was no evidence of any hazardous substance use or storage in this area.

4.2 Industrial Area

Approximately 200 m east of the weighbridge, approximately 7.5 ha of land is used for industrial activity, predominantly related to asphalt and concrete manufacturing.

Activities in this area include: the Firth Concrete block manufacturing facility, the Fulton Hogan asphalt plant, the Allied Concrete batching plant, a yard formerly

used for producing pre-cast concrete panels for the Frankton Marina, a truck wash, and truck parking area (Figure 77).

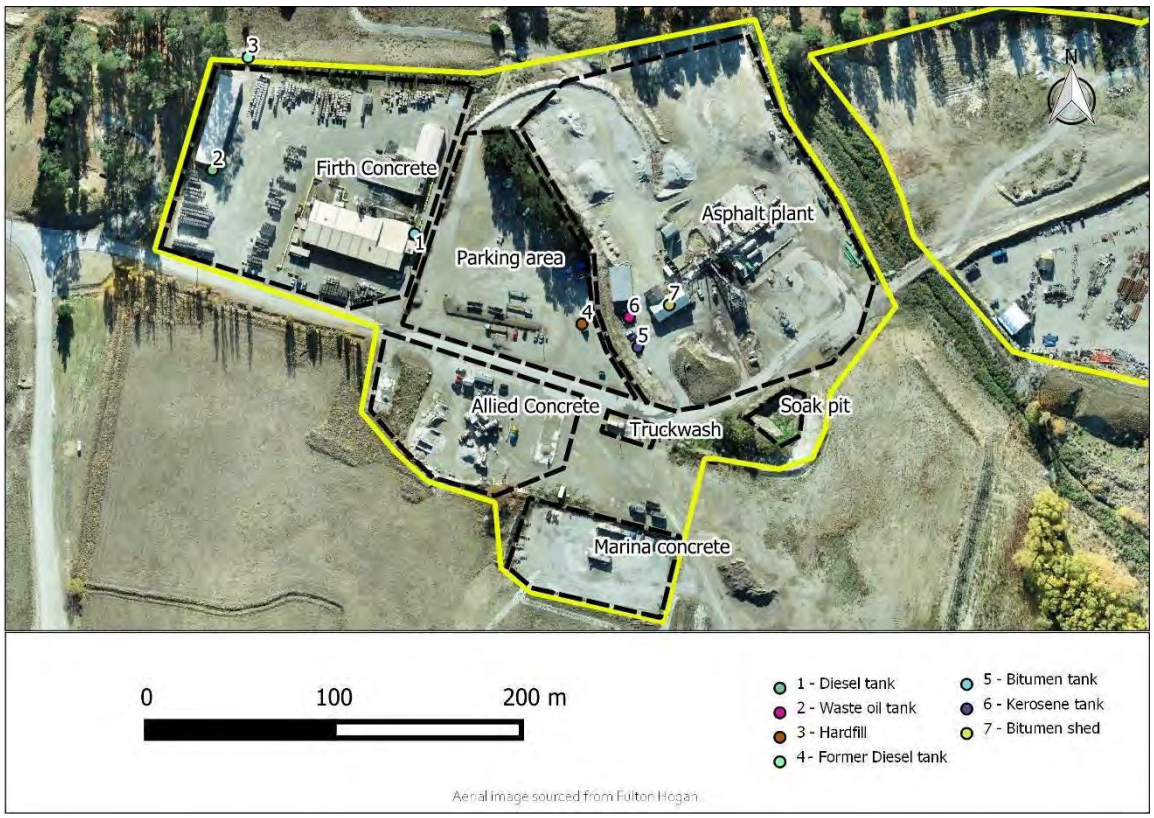


Figure 7: Industrial area activities

The Firth Concrete block manufacturing facility is located on the western end of the industrial area. The gravel yard was generally tidy and well kept. A 10,000 L diesel tank is located to the east of the manufacturing building (1). An open storage shed is located along the western boundary of this area. A small, waste oil 'igloo' was present to the south of the open shed (2). There was no staining around the waste oil tanks. Several empty drums of concrete retardant (Sika Retarder) were stored behind (west of) the open shed. Hardfill, consisting of broken concrete tiles and blocks was deposited over the landscape bund, north of the factory (3).

East of the Firth Concrete block manufacturing facility, an open yard is used as a parking area by Fulton Hogan Transport. An above ground diesel tank (4) associated with the nearby asphalt plant, was removed from the site in September 2021. Evidence of disturbed ground beneath the removed tank, including some soil on a plastic sheet, was still present. There was no evidence of staining or odour in this area. Underground fuel lines, running to the asphalt plant are reportedly still present.

The asphalt plant itself is located down an embankment to the east of the parking area. The plant is comprised of aggregate feeder bins, bitumen storage tanks, mixing drum, conveyor belt feeding, asphalt storage silos, a bag house and an operations office. The asphalt plant can produce up to 120 tonnes per hour (tph) of asphalt but will typically run at a production rate of approximately 80 tph. Bitumen and kerosene are stored in a bunded above ground tank at the base of the terrace. Bitumen is also stored in a shed near the plant. The ORC resource consent specifies that the plant can be run on used oil; however, to date only diesel fuel has been used.

The Allied Concrete batching plant is located on the opposite side of the main access road from the transport yard. The batching plant appears to be located at the repurposed weighbridge, where diesel fuel storage was noted in plans with several of the building consent applications. Immediately south of the batching plant, there is a gravel yard which was used by a company to produce concrete panels for the construction of the Frankton Marina in 2018. These areas appeared generally tidy.

A truck wash is located on the south side of the main access road. Run-off from the truck wash flows down the site of the access road into an infiltration pond. This is one of the discharge points authorised by ORC consent RM15.108.02. There was no oily sheens or hydrocarbon odour associated with the run-off water or sediment at the truck wash.

4.3 Cleanfill and Yards

On the opposite side of the Park Burn, an area of past quarrying is now used for cleanfill disposal and for outdoor yards used by JCL Asphalt Limited and several divisions of Fulton Hogan (Figure 8).

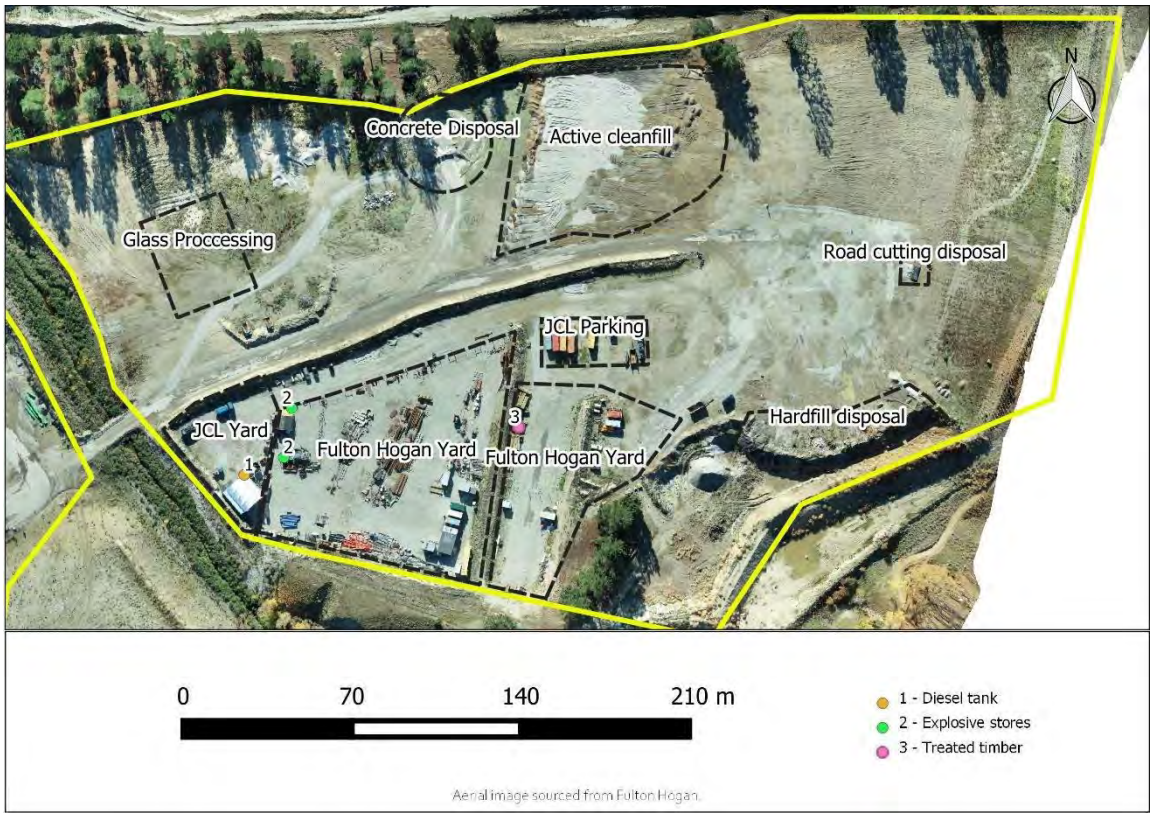


Figure 8: Cleanfill and yards area

A new shed, which will be used for crushing and storage of recycled glass, has been constructed. This building was consented under RC210112. During the site inspection, drainage work was being completed, but storage and crushing of glass had not yet commenced.

Beyond the new glass processing shed, an excavation is used for disposal of surplus concrete. Further to the east, there are two active (1-2 m high) faces used for cleanfill disposal. A concrete bay just east of the weighbridge at the entrance to the site is used for drop-off of small loads of cleanfill by Fulton Hogan and their sub-contractors. This material is then relocated to the cleanfill face. Visible material was predominantly soil, rock, and gravel, with occasional loads of cured asphalt, and some scattered broken glass across the surface of the cleanfill. A separate area is used for disposal of hardfill, including concrete, tile, bricks, and cured asphalt, as well as soil, gravel and rock. Disposal of material at the cleanfill is authorised by ORC resource consent 99664.

A Cleanfill Management Plan prepared by Fulton Hogan outlines the procedures required to achieve environmental best practice. Visual inspections of the quality of the fill material coming to the site are completed to ensure the material is consistent with resource consent requirements. If a non-complying load is

identified, the cleanfill operator is to isolate the load and advise the Quarry Manager immediately. Signage is in place at the entrance to the cleanfill, providing a clear description of acceptable materials. Material is not to be accepted from any Hazardous Activities and Industries List (HAIL) sites unless it has been suitably analysed.

A partially buried skip is used for temporary storage of waste from high pressure water cutting used during roading maintenance work. The skip is covered and sealed, with waste periodically taken to landfill when full.

To the east of the hardfill disposal area, finished areas of the cleanfill have been capped with gravel for use as open yards for other divisions of Fulton Hogan, as well as JCL Asphalt.

At the JCL Asphalt yard, there is a moveable above ground diesel tank located in the corner of the container shelter (1). Some soil staining was also visible. In this area, there were also 4 x 1,000 L IBC of concrete additive (Sika Viscacrete), with some visible product on the ground below the IBCs. The Fulton Hogan civil engineering and construction yards were predominantly used for the storage of building supplies and equipment. There were two small steel explosive storage containers (2) used by the Fulton Hogan geotechnical team. There was also a stack of CCA treated telephone poles (3) in the construction yard. Otherwise, there was no evidence of hazardous substance storage or use in these areas, and surface gravels were free of staining.

4.3.1 Cleanfill and Hardfill XRF Results

An Olympus Vanta field portable X-Ray Fluorescent Spectrophotometer (XRF) was used to collect in-situ field readings of heavy metal concentrations at 40 locations within the active faces of the cleanfill and hardfill disposal area, and across the finished cleanfill surface. For comparison, 10 readings were also taken from undisturbed ground under the pine trees, north of the cleanfill area to provide an estimate of naturally occurring background concentrations. Although not as precise as laboratory analysis, use of an XRF enables a rapid screening-level assessment of soil contaminant concentrations. A table of XRF screening results is provided in Appendix F, and raw results exported from the instrument are available upon request.

XRF instrument checks were undertaken in accordance with e3Scientific's XRF standard operating procedure. These included checking the functionality of the XRF, performing an energy calibration and checking the calibration of the XRF with a certified reference material (NIST 2711a) and a silicon dioxide blank, monitoring analysis time, and ensuring the integrity and cleanliness of the XRF sampling window throughout the sampling.

To collect readings, samples were checked for large non-representative debris, e.g. large pebbles or roots, and these were removed from the sample prior to analysis with the XRF. Soil was gently tamped down to provide a uniform surface for the instrument window. One reading was taken from each location, using two beams, with analysis times of 30 seconds and 3 seconds.

All instrument blank readings returned results of 0.0 parts per million (ppm), with the exception of one zinc reading, which measured at 7.0 ppm. This reading may have been associated with dust within the instrument. Given the range of concentrations detected on site (53 to 385 ppm), this is not considered significant.

One or more heavy metals in 14 out of the 40 samples exceeded the background concentration established using the XRF; however, for 4 of these, the exceedance was by less than 35%, within the expected precision of the XRF. Three samples exceeded the Manaaki Whenua Landcare Research (2015) predicted background concentration by more than 35%, indicating that there is a higher likelihood that contaminants in excess of the local natural background were present in these samples.

4.4 Quarry Area

The active quarry occupies approximately 60 hectares over the southern half of the site. Extraction of sand and aggregate within the eastern two-thirds of the site is allowable under the Scheduled Activity designation in the district plan. Quarrying in the western third of the site is authorised by RC070216, which was issued in 2007. The current layout of the quarry is shown in Figure 99 below.

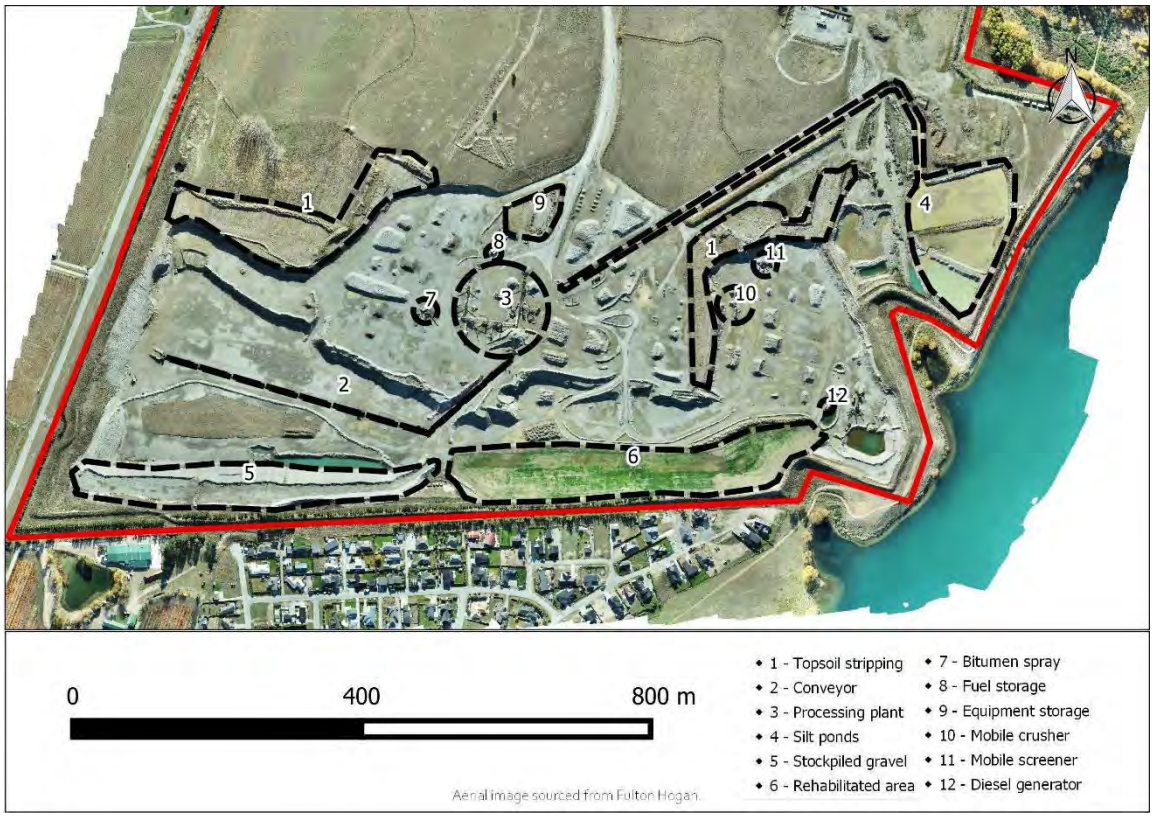


Figure 9: Quarry layout

Topsoil and overburden are stripped from the natural ground surface in advance of the active quarry faces (1). Within the consented quarry area, the extracted material is transported, using a conveyor belt system (2), to the crushing plant (3). Water is sprayed over aggregate as it passes through the plant on a screened conveyor. Debris and sediments are washed off the gravels, and wash water from the processing plant is discharged through a sludge channel to a series of silt ponds (4), which remove sediment from the water. No flocculants are used in this process. Water evaporates or infiltrates through gravels at the base of the ponds. After processing, the sorted material is stored at the site prior to dispatch.

Surplus pea gravel (4.5 to 8 mm gravels) from processing is used for reclamation within the quarry. These gravels are currently being used to form a 1V:3H batter along the southern face of the quarry (5). Topsoil stripped from the site is then placed over the pea gravels and grassed (6).

Roading chip produced at the processing plant is sprayed with a bitumen emulsion at a processing plant in the quarry (7). Bitumen is stored in a 30,000 L tank. The bitumen-coated chip is stored in separate stockpiles at the quarry.

North of the processing plant, there is a small fuel storage area, which includes a moveable double skinned diesel tank, and a bunded waste oil storage area (8). A storage area (9) near the shed is used for miscellaneous equipment and parts.

Mobile crushing (10) and screening (11) plants are used within the eastern portion of the quarry. These machines are periodically refuelled by a mobile diesel delivery service.

A small generator (12) with an in-built diesel tank is located within this part of the quarry. The diesel powers a generator used to supply power to pump for dust suppression. There was no evidence of soil staining or spills near the generator.

4.5 Balance of the site

The balance of the site is predominantly undeveloped pasture. The land is not currently grazed and there was no evidence of contaminating activities.

In the forested area to the west of the Firth Concrete plant, there was some old equipment and occasional surface litter, but not to the extent that soil contamination is likely.

The area occupied the orchard visible in the early aerial images was vacant land, and partially occupied by a bund. Topsoil from this area appeared to have been stripped in the past.

5 Summary of HAIL Activities

5.1 Identified HAIL Activities

The Ministry for the Environment's Hazardous Activities and Industries List (HAIL) is a compilation of activities and industries that have the potential to cause land contamination resulting from hazardous substance use, storage, or disposal. The HAIL is intended to identify most situations in New Zealand where use and storage of hazardous substances could cause, and in some cases have caused, land contamination.

Based on the review of site history information and a site inspection, several separate HAIL activities were identified. HAIL activities identified during this investigation include commercial concrete manufacture, asphalt manufacture, fuel storage, persistent pesticide use associated with the orchard, bulk storage of treated timber and waste disposal to land associated with the cleanfill. The identified HAIL activities are summarised in Table 3.

Table 3: Identified HAIL Activities

HAIL Activity	Dates	Comment	Likelihood
E4. Commercial concrete manufacture or commercial cement storage	2005 - present	Concrete block manufacturing facility	Certain
E2. Asphalt or bitumen manufacture or bulk storage (excluding single-use sites used by a mobile asphalt plant)	1987 - present	Asphalt plant	Certain
A17. Storage tanks or drums for fuel, chemicals or liquid waste	<1990-2004	Various fuel storage	Possible
A10. Persistent pesticide bulk storage or use including sport turfs, market gardens, orchards, glass houses or spray sheds	<1958-~1985	1000 m^2 of orchard	More likely than not
A18. Wood treatment or preservation including the commercial use of anti-sapstain chemicals during milling, or bulk storage of treated timber outside	~2020 - present	250 m^2 of treated timber storage	Certain
G5. Waste disposal to land (excluding where biosolids have been used as soil conditioners)	1987 - present	Cleanfill	Likely

5.2 Non-HAIL Areas

Based on a review of site history information and observations on site, it is more likely than not those activities listed on the HAIL have *not* been undertaken on the site outside of those areas identified in section 5.1.

There is no evidence of HAIL activities having occurred through the balance of pastoral land through the site. There is no evidence of stock yards, sheep dips, woolsheds, farm landfills or other rural HAIL activities on the site in any historic aerial photographs.

It is likely that routine applications of superphosphate and DDT would have occurred during the period of low intensity productive use as farmland. These agrichemicals were commonly used to fertilise soil and control pests such as grass grub. e3Scientific has assessed Organochlorine Pesticides (such as DDT) and

cadmium (a contaminant associated with superphosphate) concentrations in soils throughout Otago and Southland. In all investigations, contaminants have only been encountered at elevated concentrations approaching NESCS soil contaminant standards in the vicinity of sheep dips, sheep footbaths, dusting yards and areas of historic agrichemical storage. It is highly unlikely the broadacre application of agrichemicals over the farm have occurred at a rate and intensity that would result in an accumulation of contaminants in concentrations that could present a risk to human health or the environment. As such, this activity is not considered a HAIL activity.

It is known that several on-site wastewater treatment and disposal systems have been used to treat domestic-type effluent from small offices and ablution blocks. These small-scale systems are considered as being of sufficient size or risk to be interpreted as HAIL sites under category HAIL category *G6: Waste recycling or waste or wastewater treatment*. Hazardous substances associated with wastewater effluent primarily come from commercial and industrial trade wastes that discharge to the sewer network. The primary risk to human health from domestic wastewater is associated with biological hazards, such as viruses and bacteria. These pathogens fall outside the scope of hazardous substance and contaminated land regulation but should be considered a matter for worker health and safety if excavation into the disposal fields were to be necessary.

Although mining industries are listed under HAIL Category E7, gravel extraction is explicitly excluded from this category, and the extraction and processing of aggregate at the Parkburn Quarry is not considered a HAIL activity.

Within the Fulton Hogan civil engineering yard, two small steel containers were used for storing explosives. Although HAIL Category C1 includes '*explosive or ordinance production, maintenance, dismantling, disposal, bulk storage or re-packaging,'* we do not consider the quantity stored to be considered of sufficient scale to be considered a HAIL activity.

Although waste recycling is listed under HAIL Category G6, we consider that the storage and crushing of glass should not be considered a HAIL activity, as it does not involve the storage, use or disposal of hazardous substances.

Prior to the development of the quarry, the only identified HAIL activity was the presence of a small (1,000 m^2) orchard. Topsoil within the former orchard may have contained concentrations of organochlorine or heavy metal persistent

pesticides. Topsoil stripped from the site is typically used for reclamation and creating bunds on site, and it is possible that soil from the orchard has been reused or relocated on site. However, the volume of topsoil from this area, perhaps 200 m^3, is relatively small compared to the volume of soil that has been stripped throughout life of the quarry, perhaps 150,000 m^3. With incidental mixing of soils as they are stockpiled and moved around site prior to and during reclamation, we do not consider the reuse of topsoil to be a HAIL activity.

Outside the areas identified in Section 5.1, it is more likely than not that *no* activities or industries listed on the HAIL have occurred. The approximate spatial extents of HAIL and non-HAIL areas are shown in Figure 10.

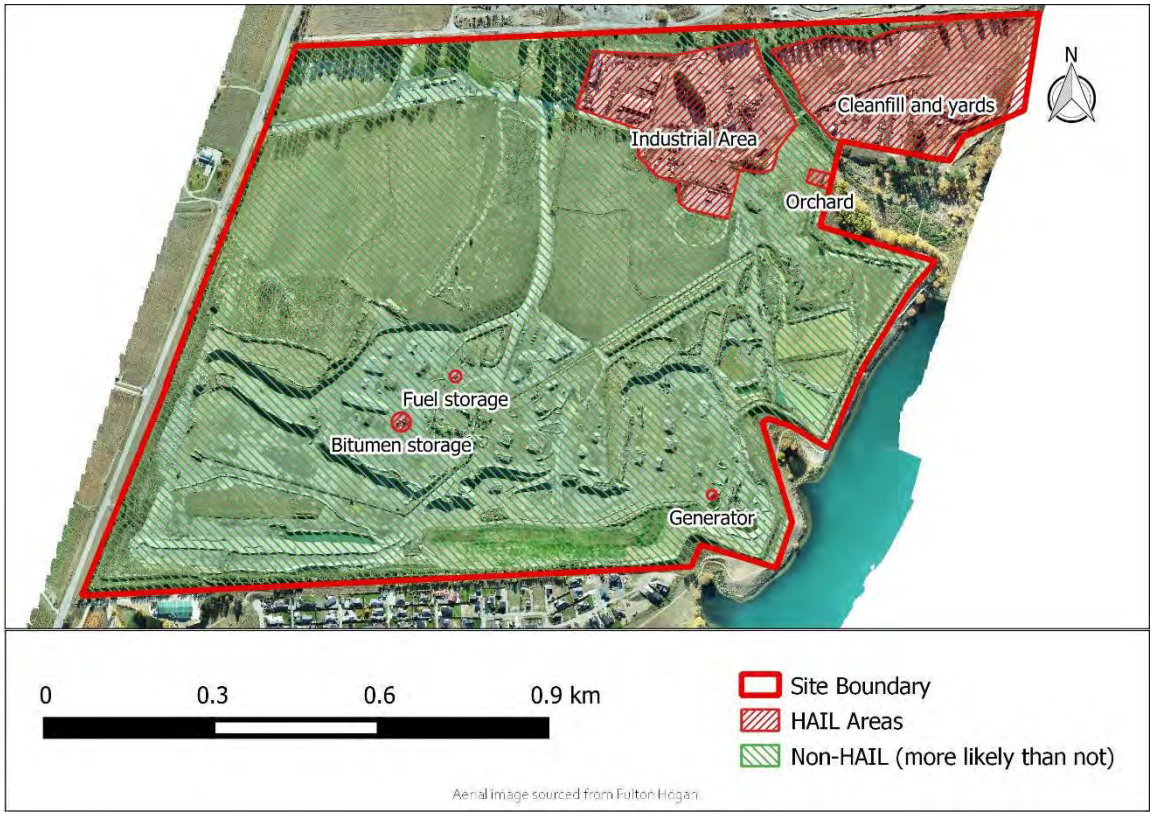


Figure 10: Approximate spatial extent of HAIL areas

5.3 Integrity Assessment

Overall, the established site history spans a period of approximately 120 years. Information obtained from the historic certificates of title and maps, historic aerial images (with a maximum interval of 18 years between 1983 and 2001), local authorities, and a site walkover has provided a reasonable understanding of the site history.

6 Preliminary Conceptual Site Model

A conceptual site model (CSM) for assessing site contamination provides an overview of the interaction between contaminants on site and potential receptors. Also referred to as the pollutant linkage model, the conceptual site model consists of three components (source-pathway-receptor), which if linked, indicate a risk may be present.

The following section sets out a preliminary conceptual site model. This preliminary conceptual site model is based on the collated information including an understanding of the possible contaminant sources, the possible routes of exposure to contaminants that may be present in soils on the site, and critical receptors.

6.1 Sources

A summary of the hazardous activities that have occurred on the site and the contaminants that may be associated with these activities is presented in Table 4 and described in the following sections. The contaminant list in Table 4 is based on site-specific observations and Appendix C of the NESCS User's Guide (Ministry for the Environment, 2012).

Table 4: HAIL activities and potential contaminants

HAIL Activity	Locations	Potential Contaminants
Concrete manufacture	Firth Concrete Block Plant Allied Concrete Batching Plant Frankton Marina Concrete Plant	Cement, calcium hydroxide, alkalis, ammonia, additives
Asphalt manufacture	Fulton Hogan Asphalt Plant	Total petroleum hydrocarbons (TPH) Polycyclic Aromatic Hydrocarbons (PAH)
Fuel storage	Diesel generator, bitumen spray, diesel and waste oil storage	Total petroleum hydrocarbons (TPH) Polycyclic Aromatic Hydrocarbons (PAH)

Persistent pesticide use	Former orchard	Heavy metals Organochlorine Pesticides
Treated timber storage	Fulton Hogan construction yard	Copper, chromium, arsenic
Waste disposal to land	Cleanfill area	Heavy metals

6.1.1 Concrete manufacture

Commercial concrete manufacture has taken place on site since 2005. Contaminants associated with concrete manufacture may affect soil pH and stormwater quality; however, risks to human health are generally not considered significant.

In addition to the contaminants listed in Table 4, small quantities of concrete retarding admixture are used within the concrete block manufacturing plant. The active ingredient in this product is tetrapotassium pyrophosphate. Tetrapotassium pyrophosphate is a common food additive, and not considered particularly toxic. The material safety data sheet (MSDS) does not list any special environmental protections required and does not identify the product as toxic to people.

A 10,000 L diesel tank and waste oil igloo are also known to be present within the concrete block manufacturing facility, and it is suspected diesel storage also occurred at the Allied Concrete batching plant in the past.

6.1.2 Asphalt manufacture

The asphalt manufacturing plant has operated on site since 1987. Asphalt manufacture involves the storage and handling of petroleum hydrocarbons including diesel, kerosene, and bitumen. Once manufactured and cured, asphalt is relatively stable, and unlikely to leach significant quantities of contaminants.

6.1.3 Fuel storage

Outside of the asphalt and concrete block plants, there are four known areas of relatively small-scale fuel storage. These include a diesel tank, waste oil storage, and generator at the quarry plant and diesel storage at the JCL asphalt yard.

6.1.4 Persistent pesticide use

Approximately 1,000 m^2 of orchard was present on the site from at least 1958 until 1985. During this period, organochlorine and heavy metal pesticides are likely to have been used on site. These contaminants typically bind strongly to soils and are not readily leached through the soil profile.

Topsoils from within the footprint of the former orchard were stripped as part of quarry development, and it is unlikely that pesticide residues are still present within this area. As discussed in section 5.2, topsoil stripped from the site is typically used for reclamation or creating bunds on site, and it is possible that soil from the orchard has been reused or relocated on site. However, the volume of topsoil from this area, perhaps 200 m^3, is relatively small compared to the volume of soil that has been stripped throughout life of the quarry, perhaps 150,000 m^3. With incidental mixing of soils as they are stockpiled and moved around site prior to and during reclamation, it is unlikely that detectable concentrations of pesticides could be found on site.

6.1.5 Treated timber storage

A relatively small area within the Fulton Hogan construction yard has been used for storage of treated timber poles. Although this activity has only occurred recently, and appears to be for relatively short duration, leaching of copper, chromium and arsenic from tanalised timber can impact soils directly under the poles. Although leaching from treated timber stacks can pose a risk to human health under residential land use, results from previous investigations suggest that exceedance of commercial/industrial soil contaminant standards is unlikely (Marlborough District Council, 2016)

6.1.6 Waste disposal to land

Backfilling of the north-eastern portion of the site with cleanfill has taken place since the 1980's.

This activity was consented by the Otago Regional Council in November 2000, and the cleanfill generally appears to be well managed. ORC compliance reports in 2009 and 2020 identified minor non-compliance associated with reporting, but both inspections found the site to be tidy with no evidence of unconsented fill types or adverse environmental effects. A cleanfill management plan for the Parkburn Quarry was prepared by Fulton Hogan in 2018.

The management plan provides clear direction on consent and unconsented fill types and confirms that material from HAIL sites is not to be accepted without prior sampling.

Field readings of heavy metal concentrations with an X-Ray Fluorescent Spectrophotometer (XRF) indicates that heavy metal concentrations within most of the soil within the cleanfill surface and tipping faces are consistent natural background concentrations. A small number of readings returned results that indicate some contaminated fill material has been received.

6.2 Receptors and Pathways

Based on the proposed plan change and eventual development of the site, potential receptors will vary throughout the site. Because HAIL activities have been identified in areas proposed to be used for industrial and residential purposes, potential receptors will include:

- Construction workers involved in the development of the site.
- Outdoor workers in the industrial or commercially zoned areas.
- Adults and children living on the site in the residential and childcare areas.

Exposure pathways for contaminants to these potential receptors include:

- Incidental ingestion of contaminated soil.
- Inhalation of contaminants entrained in dust or volatile contaminants.
- Dermal absorption of contaminants.
- Consumption of produce grown in soils on site.

6.3 Preliminary Risk Assessment

A conceptual site model, based on the identified sources, pathways and receptors above is described in Table 5.

Based on the proposed plan change and eventual development of the site, there is potential for workers and residents to be exposed to contaminants associated with the existing HAIL activities.

Within the future residential area, the identified HAIL activities include relatively small-scale hydrocarbon storage associated with the bitumen spray plant, a diesel tank and waste oil storage, and a diesel generator. It is possible that these activities could leave localised areas of hydrocarbon contamination. Although topsoil will need to be imported to this part of this site, there is a relatively low risk that inhalation of volatile contaminants would remain an open exposure pathway. Any topsoil imported to the site should be certified as meeting the appropriate human health and environmental criteria.

Within the future industrially zoned area, the identified HAIL activities include concrete manufacturing and batching, asphalt production, fuel storage, persistent pesticide use, treated timber storage, and disposal of cleanfill. We consider that it is highly unlikely that contaminants in soil associated with concrete manufacture, persistent pesticide use, and treated timber storage would pose a risk to human under the proposed commercial/industrial land use.

It is possible that contaminants associated with asphalt production, fuel storage and cleanfill disposal could result in soil contamination that could pose a risk to long term outdoor workers using the site in the future without appropriate investigation, remediation and/or management during development. The greatest risks are associated with hydrocarbon storage, particularly around any underground fuel storage infrastructure (e.g. fuel supply pipelines). Risks associated with the disposal of cleanfill appear relatively low; however, given the long history of filling, it is possible that localised areas of contaminated fill material may be present.

Given the on-going use of the site for these HAIL activities, it would be appropriate to complete additional investigation upon decommissioning of any potentially contaminating land uses. These investigations may also be better able to assess risks to human health as plans for the proposed development become more detailed.

Table 5: Preliminary conceptual site model

Area	Source	Exposure Pathway	Possible Receptor	Pathway Linkage Assessment
Future Industrial Zoned Areas	Contaminants associated with asphalt manufacture, fuel storage and disposal of cleanfill	Ingestion of contaminated soil	Long term Outdoor workers and Construction workers involved in development of the site	**Potentially complete** – Site remains to be occupied and utilised by various commercial/industrial businesses.
		Dermal contact with contaminated soil and dust		
		Inhalation of volatile contaminants or contaminated dust		
Future residential zoned areas	Contaminants associated with hydrocarbon storage	Ingestion of contaminated soil	Residents	**Incomplete** – Residential development will require topsoil to be imported, either from off-site or from stockpiles of soil stripped during quarry operations. As such, direction exposure is unlikely.
		Dermal contact with contaminated soil and dust		
		Consumption of home grown produce		
		Inhalation of volatile contaminants or contaminated dust		**Potentially complete (volatile contaminants)** – Inhalation of volatile contaminants may be a potentially complete pathway, even after topsoil has been imported.
		Ingestion of contaminated soil	Construction workers involved in development of the site	**Potentially complete** – Construction workers involved in earthworks on site may be exposed to contaminants associated with fuel storage.
		Dermal contact with contaminated soil and dust		
		Inhalation of volatile contaminants or contaminated dust		

7 Activity Status under the NESCS

Preliminary investigation of the site has identified areas of HAIL activity on discrete pieces of land throughout the site. As such, the NESCS will apply to subdivision, change of use, and soil disturbance associated with the development of the site if the plan change is approved.

7.1 Subdivision and Land Use Change

Regulation 8(4) of the NESCS states that subdividing land or changing the use of a piece of land is a permitted activity while the following requirements are met:

(a) A preliminary site investigation of the land or piece of land must exist

(b) The report on the preliminary site investigation must state that it is highly unlikely that there will be a risk to human health if the activity is done to the piece of land.

(c) The report must be accompanied by a relevant site plan to which the report is referenced.

(d) The consent authority must have the report and the plan.

In this case, we do not consider that the requirements of Regulation 8(3) are currently fully met. We consider the proposed zoning associated with the plan change to be generally suitable; however, given the on-going use of the site for HAIL activities, it would be appropriate to complete additional investigation upon decommissioning of any potentially contaminating land uses. These investigations may also be better able to assess risks to human health as plans for the proposed development become more detailed.

7.2 Soil Disturbance and Removal

Regulation 8(3) states that disturbing the soil of the piece of land is a permitted activity while the following requirements are met:

a) Controls to minimise the exposure of humans to mobilised contaminants must:
   i) be in place when the activity begins.
   ii) be effective while the activity is done.
   iii) be effective until the soil is reinstated to an erosion-resistant state.

b) The soil must be reinstated to an erosion-resistant state within 1 month after the serving of the purpose for which the activity was done.

c) The volume of the disturbance of the soil of the piece of land must be no more than 25 m^3 per 500 m^2.
d) Soil must not be taken away in the course of the activity, except that,—
e) For the purpose of laboratory analysis, any amount of soil may be taken away as samples.
f) For all other purposes combined, a maximum of 5 m^3 per 500 m^2 of soil may be taken away per year.
g) Soil taken away in the course of the activity must be disposed of at a facility authorised to receive soil of that kind:
h) The duration of the activity must be no longer than 2 months:
i) The integrity of a structure designed to contain contaminated soil or other contaminated materials must not be compromised.

Based on disturbance over the entire area of HAIL activity (160,000 m^2) a maximum of 8000 m^3 could be disturbed in any one year, and 1600 m^3 can be removed.

Any soil disturbance or removal within the identified HAIL areas that do not meet the permitted activity criteria outlined in Regulation 8(3) would be a discretionary activity under Regulation 11 unless a Detailed Site Investigation (DSI) to quantify contaminant concentrations is completed.

8 Summary and Conclusions

Fulton Hogan Limited (FHL) operate Parkburn Quarry, immediately north of Pisa Moorings. The quarry was developed by FHL in the 1980s and has been in operation since this time. The quarry produces a range of aggregates, from sealing chip to construction and concrete aggregates. As the site is nearing the end of its operational lifespan, Fulton Hogan are seeking a plan change to rezone the site so that, upon closure, it can be redeveloped for a range of future land uses, including residential (standard and high density), commercial, retail commercial, childcare / education, green space, and industrial.

To assist Fulton Hogan in managing the risks associated with contaminants in soil, e3Scientific has undertaken a Preliminary Site Investigation (PSI) to identify the areas of potential contamination within the site, consider the risks to human health associated with the proposed development, consider the activity status of the future development under the NESCS, and assess the need for further investigation.

Based on a detailed review of site history information, HAIL activities identified during this investigation include commercial concrete manufacture, asphalt manufacture, fuel storage, persistent pesticide use associated with the orchard, bulk storage of treated timber and waste disposal to land associated with the cleanfill.

We consider that it is highly unlikely that contaminants in soil associated with concrete manufacture, persistent pesticide use, and treated timber storage would pose a risk to human under the commercial/industrial land use proposed for these areas.

It is possible that contaminants associated with asphalt production, fuel storage and cleanfill disposal could result in soil contamination that could pose a risk to long term outdoor workers using the site in the future without appropriate investigation, remediation and/or management during development. The greatest risks are associated with hydrocarbon storage, particularly around any underground fuel storage infrastructure (e.g. fuel supply pipelines). Risks associated with the disposal of cleanfill appear relatively low; however, given the

long history of filling, it is possible that localised areas of contaminated fill material may be present.

Given the on-going use of the site for these HAIL activities, it would be appropriate to complete additional investigation upon decommissioning or closure of any potentially contaminating land uses. At that stage, we consider that it would be appropriate to develop a number of feasible strategies for remediation and/or site management if necessary.

9 Report Certification

I, Simon Beardmore of e3Scientific, certify that:

1. This preliminary site investigation meets the requirements of the Resource Management (National Environmental Standard for assessing and managing contaminants in soil to protect human health) Regulations 2011 because it has been:
    a. done by a suitably qualified and experienced practitioner, and
    b. reported on in accordance with the current edition of Contaminated land management guidelines No 1 – Reporting on contaminated sites in New Zealand, and
    c. certified by a suitably qualified and experienced practitioner.

2. This preliminary site investigation does **not** conclude:
    a. it is highly unlikely that there will be a risk to human health if the subdivision and/or land use change described in Section 1.2 is done to the piece of land.

Evidence of the qualifications and experience of the suitably qualified and experienced practitioner(s) who have done this investigation and have certified this report is included in Appendix A.



Signed and dated: ……06/12/21……

10 References

GNS Science. (n.d.). *New Zealand Geology Web Map*. Retrieved from http://data.gns.cri.nz/geology/

Landcare Research Manaaki Whenua. (2015). *Background soil concentrations of selected trace elements and organic contaminants in New Zealand.* .

Ministry for the Environment. (1999). *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand Module 4- Tier 1 Soil Screening Criteria (revised 2011).* Ministry for the Environment.

Ministry for the Environment. (2003). *Contaminated LandManagement Guidelines No. 2: Hierarchy and Application in New Zealand of Environmental Guideline Values* .

Ministry for the Environment. (2003a). *Contaminated Land Management Guidelines No. 1: Reporting on Contaminated Sites in New Zealand (revised 2011).* Wellington: Ministry for the Environment.

Ministry for the Environment. (2004). *Contaminated Land Management Guidelines No. 5: Site Investigation and Analysis of Soils (Revised 2011).*

Ministry for the Environment. (2004). *Module 2: Hazardous Waste Guidelines - Landfill Waste Acceptance Criteria and Landfill Classification.* Wellington: Ministry for the Environment.

Ministry for the Environment. (2011). *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health.* Wellington: Ministry for the Environment.

Ministry for the Environment. (2011). *Soil Contaminant Standards in the Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health.* Ministry for the Environment.

Ministry for the Environment. (2012). *Users' Guide: National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.* Wellington: Ministry for the Environment.

NEPC. (1999). National Environment Protection (Assessment of Site Contamination) Measure 1999, amended 2013.

US EPA. (2018). *Regional Screening Levels.* US Environmental Protection Agency.

Appendices

Appendix A:

e3Scientific Limited Contaminated Land Experience

Contaminated Land Services

e3Scientific Limited (e3Scientific) is a New Zealand owned and operated environmental science consultancy. Our team delivers technical, innovative science; practical solutions; and expert advice to assist our clients in the smart management of the environment.

e3Scientific provides a range contaminated land services, including:

- Due Diligence Investigations.
- Preliminary Site Investigations.
- Detailed Site Investigations.
- Soil and groundwater remedial advice and management.
- Peer review and regulator support.

Our Contaminated Land team has a sound understanding of New Zealand's regulatory environment with respect to the assessment and management of contaminated land and has been a major supplier of contaminated land services in Otago and Southland since 2012.

Simon Beardmore is the Technical Director of the Contaminated Land team at e3Scientific. Simon has over 12 years post graduate experience working as an Environmental Scientist, specialising in the investigation and management of contaminated land. Simon developed contaminated land management strategy and standard operating procedures at the Otago Regional Council and has completed and supervised the delivery of preliminary and detailed site investigations, and site remediation projects throughout Otago and Southland. Simon is responsible for technical oversight of projects and certifying contaminated land investigations as a suitably qualified and experienced practitioner. Simon is supported by Team Leader Fiona Rowley, Senior Environmental Scientists Carrie Pritchard, Jodi Halleux and Simon Bloomberg, and Environmental Scientist and Geospatial Specialist Jessie Lindsay.

The e3Scientific team has completed many Preliminary Site Investigations, Detailed Site Investigations and remedial projects across New Zealand and regularly provides peer review of site investigations for district and regional councils. Projects have involved investigations into the impact on soil quality associated with operational and historic timber treatment plants, fuel storage and distribution facilities, substations, sheep dips and yards, orchards, vineyards, agricultural activities, gasworks, service stations, and operational and closed landfills.

The following provides a summary of key contaminated land work e3Scientific is involved in or has completed:

- Hundreds of Preliminary Site Investigations and Detailed Site Investigations to support subdivision, landuse change and earthworks consent applications.
- Support Environment Southland's Selected Landuse Register including the identification of Hazardous Activities on properties across Southland and the registration of HAIL sites.
- Review of groundwater contamination associated with the former Invercargill gasworks site including the completion of a groundwater investigations and an environmental risk assessment to support a discharge consent application.
- Large scale remedial works of former timber treatment plants and sheep dips including the completion of detailed investigations to delineate the extent of contaminated soils, design of remedial action plans, project management of remedial works and completion of site validation and council close out reports.
- Investigations into an area of arsenic impacted soils in Frankton including the completion of detailed investigations to delineate the horizontal extent, consideration of the source of the arsenic, liaison with property owners and council.
- Project management of a bioavailability study of arsenic impacted soils in Gibbston Valley to support a Tier 2 risk assessment associated with a residential development.
- Oversight of the removal of multiple underground fuel storage systems for private residences, schools and oil and gas clients.

The e3Scientific team is committed to professional development, and employing new technologies in the prevention, assessment and remediation of contaminated land. e3Scientific is an active member of the Australasian Land & Groundwater Association and WasteMINZ.

Appendix B:

Historic Certificates of Title

RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier **407414**

Land Registration District **Otago**

Date Issued 07 February 2008

Prior References

GN7705203.1 OT10B/738

Estate	Fee Simple
Area	50.1065 hectares more or less
Legal Description	Part Section 62-63 Block IV and Part Section 63 Block IV Wakefield Survey District and Section 1 Survey Office Plan 365897

Registered Owners

Fulton Hogan Limited

Interests

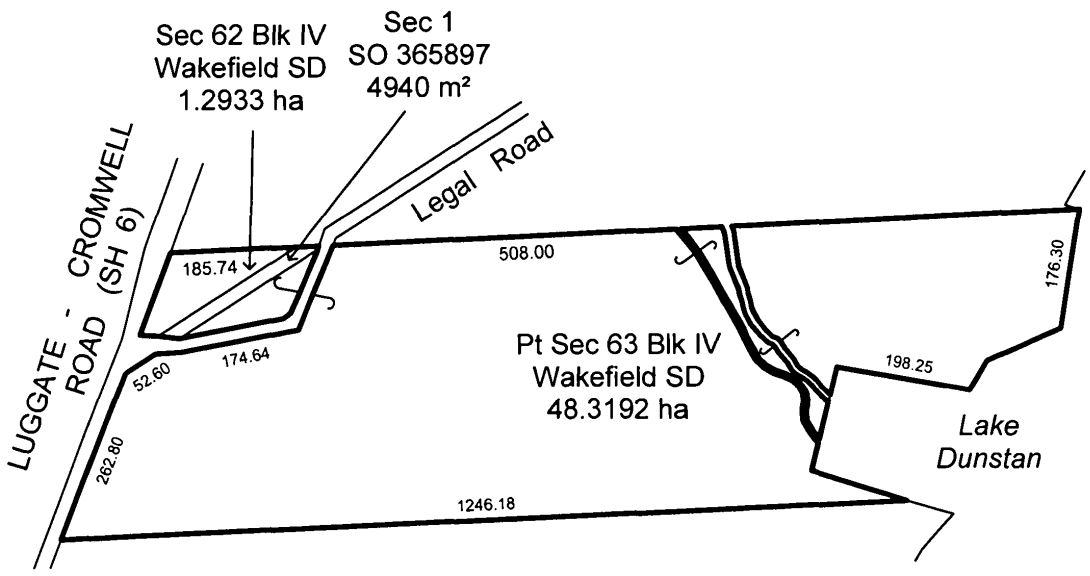
Subject to Section 8 Mining Act 1971(affects part formerly in CT OT10B/738)

Subject to Section 5 Coal Mines Act 1979(affects part formerly in CT OT10B/738)

5041663.1 Gazette Notice (2001/1044) declaring adjoining road (S.H.No. 6) to be limited access road - 11.5.2001 at 9:31 am

5057376.2 Notice pursuant to Section 91 Transit New Zealand Act 1989 - 10.7.2001 at 2:30 pm

Title Diagram ct 40741
Cpy – 01/01, Pgs – 001, 22/02/08, 09:06
DocID: 212144396



Total area: 50.1065 ha
For further dimensions see SO 365897 & SO 20808

L & S – B 1 NEW ZEALAND

Entered in the Register-book, the 23rd *day of* November *1984, at* 10.24 *o'clock*

No. 10A / 748

Former Ref. Vol 179 fol 75
L & S Ref. No. RLF 1409

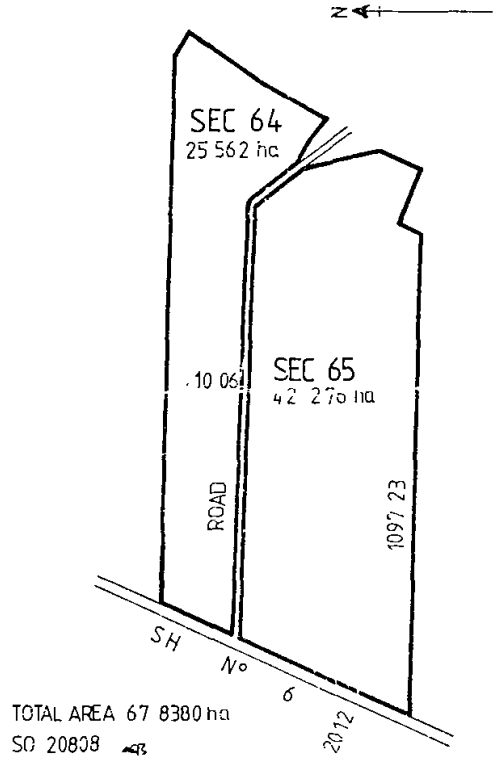
CANCELLED REGISTER

Land Registrar

Renewable Lease under the Land Act 1948

This Deed, made the 1st day of July 19 82, between HER MAJESTY THE QUEEN (hereinafter referred to as "the Lessor"), of the one part, and CHARLES ROBERT [illegible] of Lawrence Farmer

(hereinafter referred to as "the Lessee"), of the other part WITNESSETH that, in consideration of the rent hereinafter reserved, and of the covenants, conditions, and agreements herein contained and implied, and on the part of the Lessee to be paid, observed, and performed, the Lessor doth hereby demise and lease unto the lessee, all that parcel of land containing by admeasurement 67.8380 hectares more or less, situated in the Land District of Otago, and being Sections 64 and 65 Block IV Wakefield Survey District



as the same is more particularly delineated with bold black lines on the plan hereon, together with the rights, easements, and appurtenances thereto belonging. TO HOLD the said premises intended to be hereby demised unto the Lessee for the term of 33 years, commencing on the 1st day of July 19 82 ~~together with the period between the date of this Lease and the aforesaid 1st day of 19~~, YIELDING and paying therefor for the first 11 years of the said term unto the Department of Lands and Survey at Dunedin the annual rent of $ 792.00 calculated on a Rental Value of $ 17600.00 payable without demand by equal half-yearly payments in advance on the 1st day of January and the 1st day of July in each and every year during the said period of 11 years, and for the next two successive periods of 11 years of the said term a rent determined in respect of each of those periods in the manner provided in section 132A of the Land Act 1948. ~~AND also paying in respect of the improvements specified in the Schedule hereto the sum of $ by a deposit of $ (which has already been paid), together with interest thereon at the rate of =per centum per annum and thereafter by half-yearly instalments of $ =on the 30th day of June and the 31st day of December in each and every year subject to variation of the rate of interest and the amount of the half-yearly instalments in the manner hereinafter provided. The first such instalment shall be payable on the 31st day of December 1982. Interest on the balance of the purchase money from the day of 19, to the day of 19, shall be payable on the said day of 19~~

AND it is hereby declared and agreed (1) That these presents are intended to take affect as a renewable lease of Farm land under section 63 of the Land Act 1948 and of any enactments passed in amendment or substitution thereof and the provisions of the said Act and of the regulations made thereunder applicable to such leases shall be binding in all respects upon the parties hereto in the same manner as if such provisions had been fully set out herein.

~~(2) That the Land Settlement Board, pursuant to its powers under section 170B of the Land Act 1948, reserves the right to review the rate of interest payable by the Lessee in the respect of the improvements specified in the Schedule hereto for the second and each ensuing period of 5 years of the term hereof, and the provisions of that section shall apply to any such review, and any necessary adjustments to the instalments payable.~~

IN WITNESS whereof the Assistant Commissioner of Crown Lands for the said Land District, on behalf of the Lessor, has hereunto set his hand, and these presents have also been signed by the said Lessee

No. 10A/748

Signed by the said Assistant Commissioner, on behalf of the Lessor, in the presence of—

Witness ..... A. Clemo .....

Occupation Clerk, Dept. Lands & Survey

Address ..... Dunedin .....

J R Glaze

Assistant Commissioner of Crown Lands

Signed by the above-named Lessee in the presence of—

Witness: .....

Occupation: .....

Address: .....

T R Perriam

Lessee

Interests at date of Issue:

X20543 Irrigation Agreement under Part X1 of the Public Works Act 1928 with Her Majesty the Queen - 9.12.1958 at 2.40 pm.

DUPLICATE DESTROYED
11/3/1986

X20544 Irrigation Agreement under Part X1 of the Public Works Act 1928 with Her Majesty the Queen - 9.12.1958 at 2.41 pm.

394308 Mortgage to Bank of New Zealand - 2.11.1972 at 11.09 am.

506156 Compensation Certificate pursuant to Section 17 of the Public Works Amendment Act 1948 - 1.11.1978 at 11.59 am.

A.L.R.

638087/2 Transfer to Robert Stanley Perriam of Lowburn Farmer - 2.7.1985 at 10.37am

A.L.R.

638087/3 Mortgage to Charles Robert Perriam - 2.7.1985 at 10.37am

A.L.R.

648690 Cancelled and new C.T. 10B/1452 issued for the within land
13.12.1985

A.L.R.

DISTRICT LAND REGISTRAR
CANCELLED
OTAGO NEW ZEALAND

44578E—2,000/3/80 MK

10.24 23.NOV 84 626107

PARTICULARS ENTERED IN REGISTER L
LAND REGISTRY OTAGO

ASST. LAND REGISTRAR .....

COMPUTER FREEHOLD REGISTER
UNDER LAND TRANSFER ACT 1952

Historical Search Copy

R.W. Muir
Registrar-General
of Land

Identifier **OT10B/738**

Cancelled

Land Registration District **Otago**

Date Issued 26 August 1985

Prior References
OT115/31

Estate Fee Simple

Area 50.2450 hectares more or less

Legal Description Section 62-63 Block IV Wakefield Survey District

Original Proprietors
Fulton Hogan Limited

Interests

Subject to Section 8 Mining Act 1971

Subject to Section 5 Coal Mines Act 1979

Mining Licence embodied in register 9D/212 - 3.8.1987 at 9.08 am

5041663.1 Gazette Notice (2001/1044) declaring adjoining road (S.H.No. 6) to be limited access road - 11.5.2001 at 9:31 am

5057376.2 Notice pursuant to Section 91 Transit New Zealand Act 1989 - 10.7.2001 at 2:30 pm

5879308.1 Expiry of Mining Permit 684068 - 29.1.2004 at 9:00 am

7705203.1 Gazette Notice (2008 page 360) declaring Section 3 SO 365897(317m2) and Section 4 SO 365897 (6009m2) to be road and vested in the Central Otago District Council on 31.1.2008 and stopping the adjoining road (Section 1 SO 365897 -4940m2) and amalgamating it with the within land CT 407414 issued- 7.2.2008 at 9:00 am

CANCELLED

Land and Deeds 72

Reference:
Certificate No. 641455
P.R. Vol. 115 Folio 31
Transfer No.

REGISTER

No. 10B/738

CERTIFICATE OF TITLE UNDER LAND TRANSFER ACT

This Certificate dated the 26th day of August one thousand nine hundred and eighty five under the seal of the District Land Registrar of the Land Registration District of O T A G O being a Certificate in lieu of Grant, **WITNESSETH** that ROBERT STANLEY PERRIAM of Lowburn, Farmer

is seised of an estate in fee simple (subject to such reservations, restrictions, encumbrances, liens, and interests as are notified by memorial underwritten or endorsed hereon) in the land hereinafter described, delineated with bold black lines on the plan hereon, be the several admeasurements a little more or less, which said land was originally acquired by the abovenamed

as from the 17th day of December one thousand nine hundred and eighty four
under Section 124A Land Act 1948
that is to say: All that parcel of land containing 50.2450 hectares more or less being Sections 62 and 63 Block IV WAKEFIELD DISTRICT

DISTRICT LAND REGISTRAR OTAGO NEW ZEALAND

ASSISTANT LAND REGISTRAR

Interests at date of issue:

Subject to the reservations and conditions imposed by Section 8 Mining Act 1971 and Section 5 Coal Mines Act 1979

X20543 Irrigation Agreement under Part XI Public Works Act 1928 - 9.12.1958 at 2.40pm

DISCHARGED 12 JUN 1995 ALR.

X20544 Irrigation Agreement under Part XI Public Works Act 1928 - 9.12.1958 at 2.41pm

DISCHARGED 12 JUN 1995 ALR.

638087.3 Mortgage to Charles Robert Perriam - 2.7.1985 at 10.37am

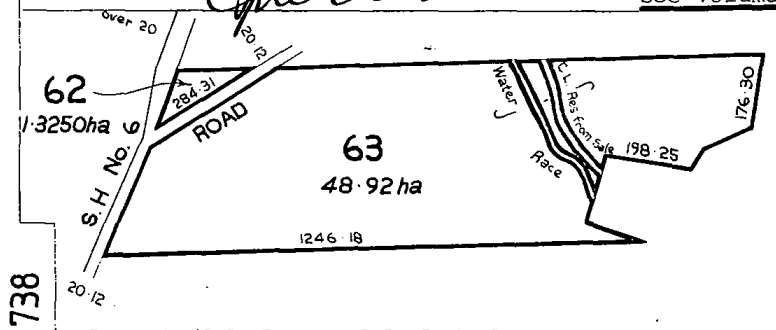
A.L.R.

649433 Transfer to Fulton Hogan Limited - 23.12.1985 at 1.43pm

A.L.R.

684068 Mining Licence under the Mining Act 1971 affecting part of the within land in favour of Fulton Hogan Limited for a term of 21 years commencing on 20 July 1987 - 3.8.1987 at 9.08 am
See Volume 9D Folio 212

A.L.R.



10B/738

Scale 1 : 12500 S.O. 20808
Total Area : 50·2450ha
Measurements are Metric

Register copy for L. & D. 69, 71, 72

RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General of Land

Identifier **OT10B/1452**

Land Registration District **Otago**

Date Issued 13 December 1985

Prior References
OT10A/748

Estate Fee Simple

Area 67.8380 hectares more or less

Legal Description Section 64-65 Block IV Wakefield Survey District

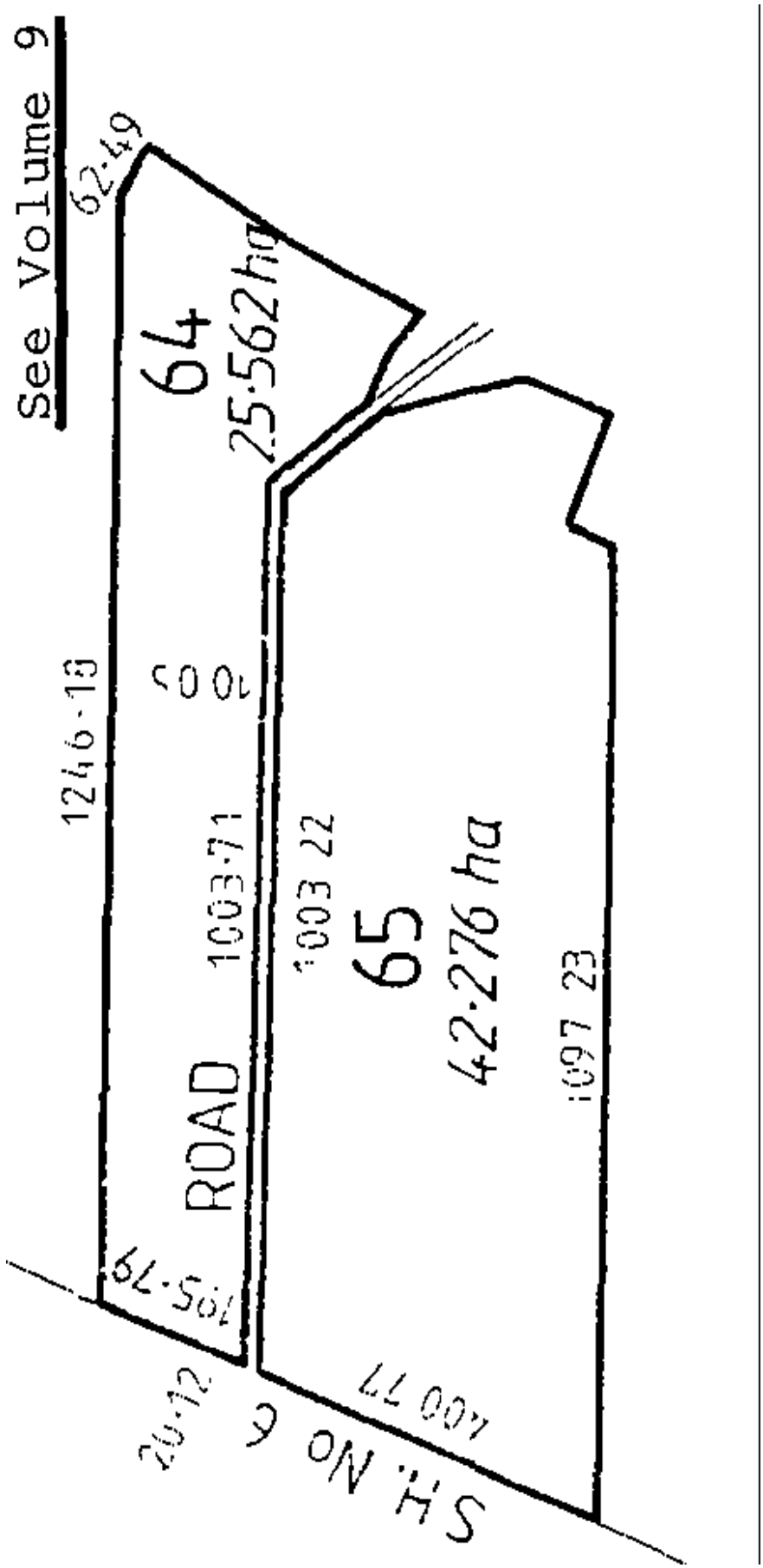
Registered Owners
Fulton Hogan Limited

Interests

Subject to Section 8 Mining Act 1971

Subject to Section 5 Coal Mines Act 1979

5041663.1 Gazette Notice (2001/1044) declaring adjoining road (S.H.No. 6) to be limited access road - 11.5.2001 at 9:31 am


See Volume 9
62.49
64
25.562ha
1246·13
1003·71
1003 22
65
42.276 ha
1097 23
ROAD
195·79
20·12
S.H. No 6
400 77

NEW ZEALAND.

CANCELLED

(Crown Lands Form No. 512

Register-book.

Vol. 115 *fol.* 31

Application No.

115/31

Image Quality due to Condition of Original

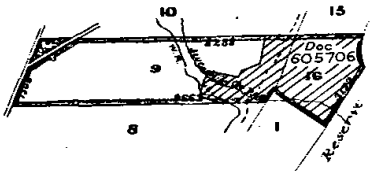
Clutha LAND DISTRICT.

LEASE IN PERPETUITY UNDER PART III. OF "THE LAND ACT, 1892," AND SECTION 7 OF "THE MINING ACT AMENDMENT ACT (No. 2), 1893."

No. 829.

This Deed, made the 6th day of October, 1897, between Her Majesty the Queen (who with her heirs and successors is hereinafter termed "the Lessor"), of the one part, and Robert Davidson of Lawrence Ferry in the Land District of Clutha in the Colony of New Zealand (hereinafter, with his executors, administrators, and permitted assigns, referred to as and included in the term "the Lessee"), of the other part, Witnesseth that, in consideration of the rent hereinafter reserved, and of the covenants, conditions, and agreements herein contained and implied and on the part of the Lessee to be paid, observed, and performed, the Lessor doth hereby demise and lease unto the Lessee All that piece or parcel of land, containing by admeasurement One hundred and ninety nine (199) acres roods and twenty five (25) perches, a little more or less, situated in the Land District of Clutha aforesaid, and being Sections numbered 9 and 16, Block IV, Survey District of Wakefield, as the same is more particularly delineated and described in the plan drawn hereon, and therein coloured red in outline; together with the rights, easements, and appurtenances to the same belonging: To hold the said several premises intended to be hereby demised unto the Lessee for the term of nine hundred and ninety-nine years, commencing from the 1st day of January next Yielding and paying therefor unto the Receiver of Land Revenue for the said District of Clutha the annual rent of Three pounds nineteen shillings and eight pence (£ 3 : 19 : 8), payable half-yearly in advance on the 1st day of January and 1st day of July in each and every year during the said term, free from all deductions whatsoever.

Block IV Wakefield District
199 acres 25 perch
EQUIVALENT METRIC AREA IS 80·5957 ha
605706 31·4080 ha
49·1877 ha
611 832/4 50·2450 ha



Scale: 30 chains to an inch.

And it is hereby declared and agreed that these presents are intended to take effect as a lease in perpetuity under Part III. of "The Land Act, 1892"; and the provisions of that statute applicable to such leases, so far as the same apply to the term, estate, or interest hereby granted or created, and to the relations between the Lessor and Lessee from time to time, shall, subject to the provisions of section 7 of "The Mining Act Amendment Act (No. 2), 1893," be binding in all respects upon the parties hereto in the same manner as if such provisions had been fully set out herein: And it is hereby further declared that if any dispute or disagreement shall arise between the parties hereto touching the construction of these presents, or in anywise relating hereto, such dispute or disagreement shall be referred to arbitration in the manner set forth in section 79 of the said Act; and neither of the said parties shall take or cause to be taken any steps or proceedings to set aside or call in question any award or decision which may have been given upon any such reference as final:

In Witness whereof the Commissioner of Crown Lands for the Land District of on behalf of the Lessor, hath hereunto set his hand, and these presents have been also executed by the said Lessee,

Signed by the said Commissioner, on behalf of the said Lessor, in the presence of—

Signed by the above-named Robert Davidson as Lessee, in the presence of—

Robert Davidson

C.T. 115/31

Transfer No 40562 Robert Davidson to Donald Macpherson of Lowburn Farmer Entered 2nd September 1905 at 11 o'c

Abstract A.S.L. 1/

Transmission No 13211 to Susan Hill Macpherson of Wanaka Road, Lowburn Widow Entered 2nd February 1926 at 10 o'c

H.C. Mowbray A.R.

Mortgage No 56614 Susan Hill Macpherson to The Bank of New Zealand produced 8th DISCHARGED 1931 at 10 o'c

Transmission 32692 to Ernest Jolly of Cromwell Merchant as Executor Entered 26th June 1940 at 11.30 o'c

Transfer 132214 Ernest Jolly to William Henry Perriam and Charles Robert Perriam both of Lowburn Farmers produced 1st November 1940 at 11 o'c

Mortgage 109136 William Henry Perriam and Charles Robert Perriam to the Bank of New Zealand DISCHARGED produced 1st November 1940 at 12 o'c

Transfer No 155697 William Henry Perriam of the undivided 1/2 of his interest and Charles Robert Perriam to the said Charles Robert Perriam produced 30th May 1947 at 11 o'c

X20543 Irrigation Agreement under Part XX of the Public Works Act 1928 between Her Majesty the Queen and Charles Robert Perriam entered 9th December 1958 at 2 p.m.

X20544 Irrigation Agreement under Part XX of the Public Works Act 1928 between Her Majesty the Queen and Charles Robert Perriam entered 9th December 1958 at 2 p.m.

394308 Mortgage to Bank of New Zealand - DISCHARGED 2-11-1972 at 10.09 a.m. A.L.R.

503342 Certificate of Charge under Section 280(1) Public Works Act 1928 - 13.9.1978 at 11.42 pm A.L.R.

506156 Compensation Certificate pursuant to section 17 of the Public Works Amendment Act 1948 - 1.11.1978 at 11.59 am A.L.R.

115/31

605706 Gazette Notice declaring parts of Sections 9 (7.95 ha, 2.42 ha, 4800 m²) and 16 (205580 ha) shown hatched black on the diagram hereon are acquired for the generation of electricity and shall vest in the Crown from and after the 27th day of October 1983 - 21.11.1983 at 10.56 am A.L.R.

The within land is now known as Sections 62 (1.3250 ha) and 63 (48.92 ha) Block IV Wakefield S.D. - 20.3.1984 at 11.51 am See Re-appellation 611832/4 A.L.R.

626107/1 Certificate of alteration with effect from 27.10.1984 reducing the rental value to $118.94 and annual rent to $4.76 - 23.11.1984 at 10.24 am. A.L.R.

of balance 638087/2 Transfer to Robert Stanley Perriam of Lowburn Farmer - 2.7.1985 at 10.37am A.L.R.

of balance 638087/3 Mortgage to Charles Robert Perriam - 2.7.1985 at 10.37am A.L.R.

641455) 26.8.1985) Cancelled and new C.T. 103/738 issued. A.L.R.

THIS REPRODUCTION (ON A REDUCED SCALE) CERTIFIED TO BE A TRUE COPY OF THE ORIGINAL REGISTER FOR THE PURPOSES OF SECTION 215A LAND TRANSFER ACT 1952. A.L.R.

DISTRICT LAND REGISTRAR CANCELLED OTAGO NEW ZEALAND

DUPLICATE DESTROYED 9 19 1985

No. 829.

DATED 6th October 1897.

Her Majesty the Queen

to

Robert Davidson

Otago Land District.

LEASE

Of Section 5 9 & 16, Block II

Wakefield Survey District.

Under "The Land Act, 1892."

Nine hundred and ninety-nine years from 1st January 1898.

Entered at 10 o'clock on the 22nd day of October, 1897.

District Land Registrar.

SECTIONS 141 TO 147 OF "THE LAND ACT, 1892."

Compulsory Residence.

141. Residence on any land, not being land purchased for cash, selected under this Part of this Act shall be compulsory, and shall commence in bush-lands or on swamp-lands within four years, and in open or partly open land within one year, from the date of selection; and thereafter such residence shall be continuous—

(1.) On lands occupied with right of purchase, for six years on bush-lands or on swamp-lands, and for seven years on open or partly open land:

(2.) On lease-in-perpetuity lands, for a term of ten years.

But these conditions of residence shall not apply to any person who has acquired an interest in any lease or license under an intestacy or by virtue of a will.

142. The Board may dispense with residence if the lessee or licensee reside and continue to reside on lands contiguous to the lands held under lease or license. Lands shall be deemed to be contiguous to each other if only separated by a road or stream, or by such interval of space as the Board may determine in each case.

The Board may also dispense with residence for four years after the commencement of the term where residence is otherwise compulsory in cases where the lessees or licensees are youths or unmarried women living within the land district, and residing with their parents or near relatives.

In case of the death of either or both parents of a child or children, residence may be dispensed with until such child or one of such children respectively attain the age of seventeen years.

143. Personal residence may also be dispensed with by the Board in the cases hereinafter mentioned:—

(1.) Whenever any two persons, being licensees with right of purchase or lessees in perpetuity, have lawfully intermarried at some period not sooner than twelve months after the issue of the last of such licenses or leases, such persons may reside on such one of the selections of land made by them as they may think fit.

(2.) Whenever any two persons, one of whom has become a selector of land with right of purchase or a lessee in perpetuity, and the other is an owner or occupier of freehold land, have lawfully intermarried at some period not sooner than twelve months from the issue of the license or lease held by such selector, such selector may reside on such freehold.

(3.) Residence on such selection or on such freehold, as may be the case, shall be deemed a compliance with the conditions of section one hundred and forty-one in respect of residence by such several persons.

(4.) The Board, however, shall have a discretionary power to dispense with personal residence on sufficient and satisfactory grounds being shown for non-residence.

Improvements.

144. Every selector of lands under this Part of this Act, whether for occupation with right of purchase or for lease in perpetuity, shall put on the land comprised in his license or lease, as the case may be, substantial improvements—

(*a.*) Within one year from the date of his license or lease, to a value equal to ten per centum of the price of the land;

(*b.*) Within two years from the date of his license or lease, to a value equal to another ten per centum of the price of the land;

(*c.*) And thereafter, but within six years from the date of his license or lease, to a value equal to another ten per centum of the price of the land;

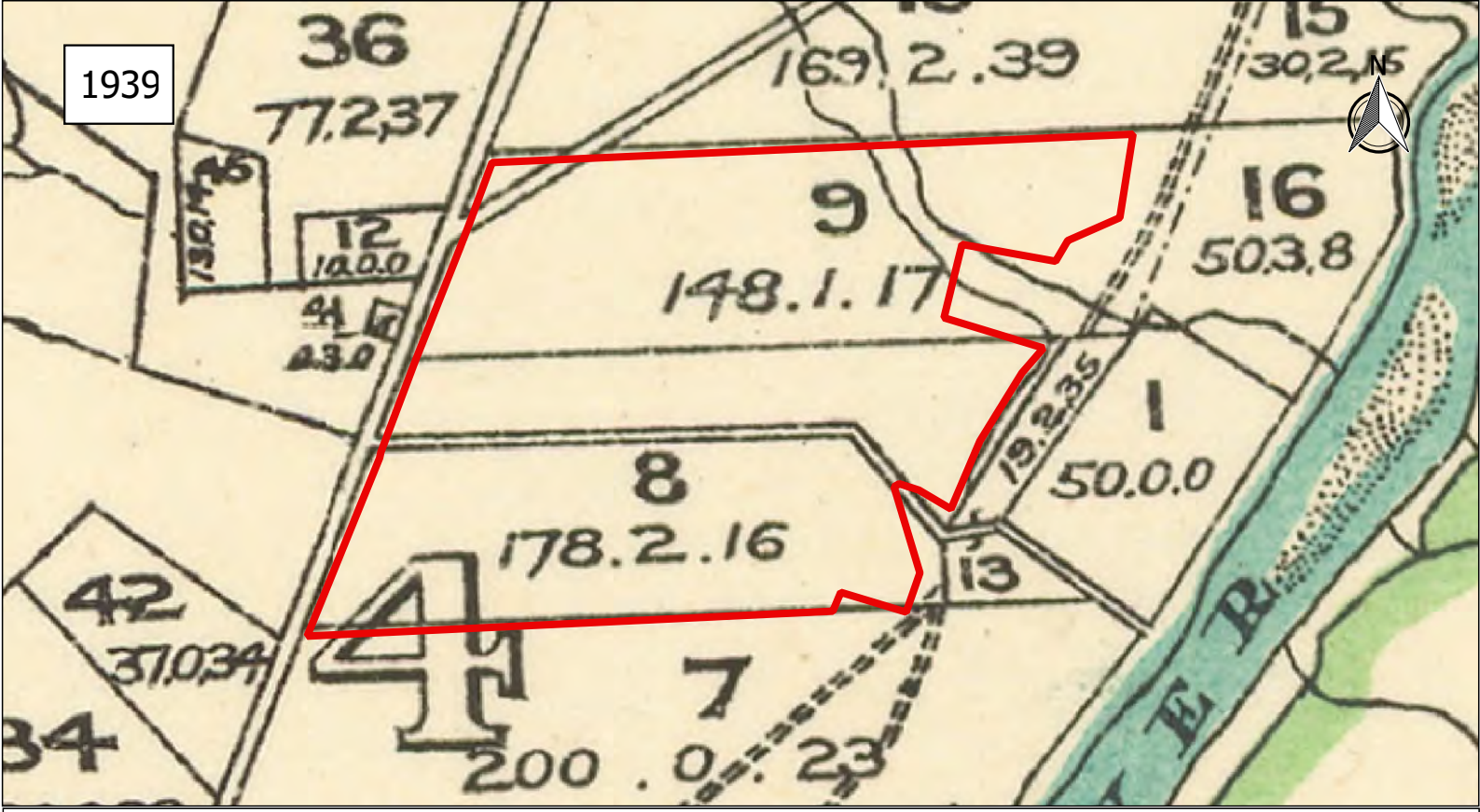
And in addition thereto shall, within six years from the date of his license or lease, put substantial improvements of a permanent character on first-class land to the value of one pound for every acre of such land, and on second-class land to an amount equal to the net price of every acre of such land: Provided that in no case shall the additional improvements required on second-class land be more than ten shillings per acre.

And every selector shall be bound at any time when so required by the Board to make and sign a statutory declaration as to his fulfilment of the conditions of occupation and improvement of the land in his occupation up to the time of making the said declaration.

145. Any holder of bush-lands or swamp-lands on deferred payments under section one hundred and fourteen of "The Land Act, 1885," or in any special settlement under regulations made before the twenty-seventh day of February, one thousand eight hundred and ninety-one, under Part V. of such Act, and any holder of a perpetual lease of any land under section one hundred and forty-eight of such Act, shall be deemed to have complied with the requirements of section twenty-one of "The Land Act Amendment Act, 1887," if within six years from the date of his license or lease he has brought or shall bring into cultivation twice the amount of land required by the herein first above-mentioned sections or regulations respectively, and in addition thereto has put or shall put substantial improvements of a permanent character on the land in his occupation to the value of one pound for every acre of such land.

146. In the case of suburban lands the Board in its discretion may dispense with conditions as to improvements of special monetary value, where such substantial improvements have been effected as in the opinion of the Board are reasonable in the circumstances.

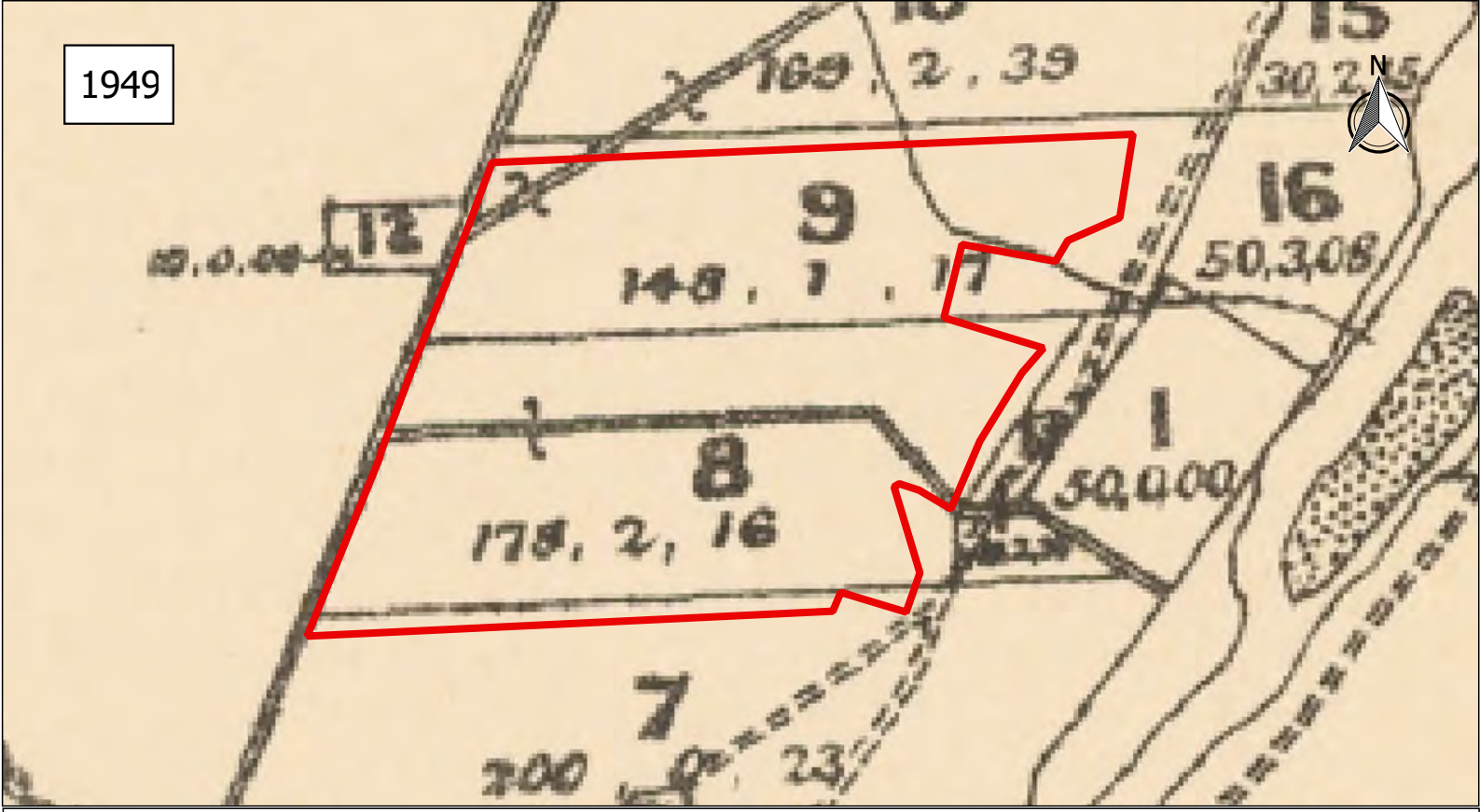
147. The Board, on compliance with the provisions of section eighty-three, or on their being satisfied by a statutory declaration that the transferor is unable or not in a condition to make the improvements on the land required by this Act, may sanction a transfer, either by way of mortgage or otherwise, of land other than such land, or of any interest in such land, held under this Part of this Act, at any time after the first selection thereof, to any person not disqualified who shall make the declaration under the particular system under which the land is held, as given in the Schedules to this Act.



0 500 1000 1500 m

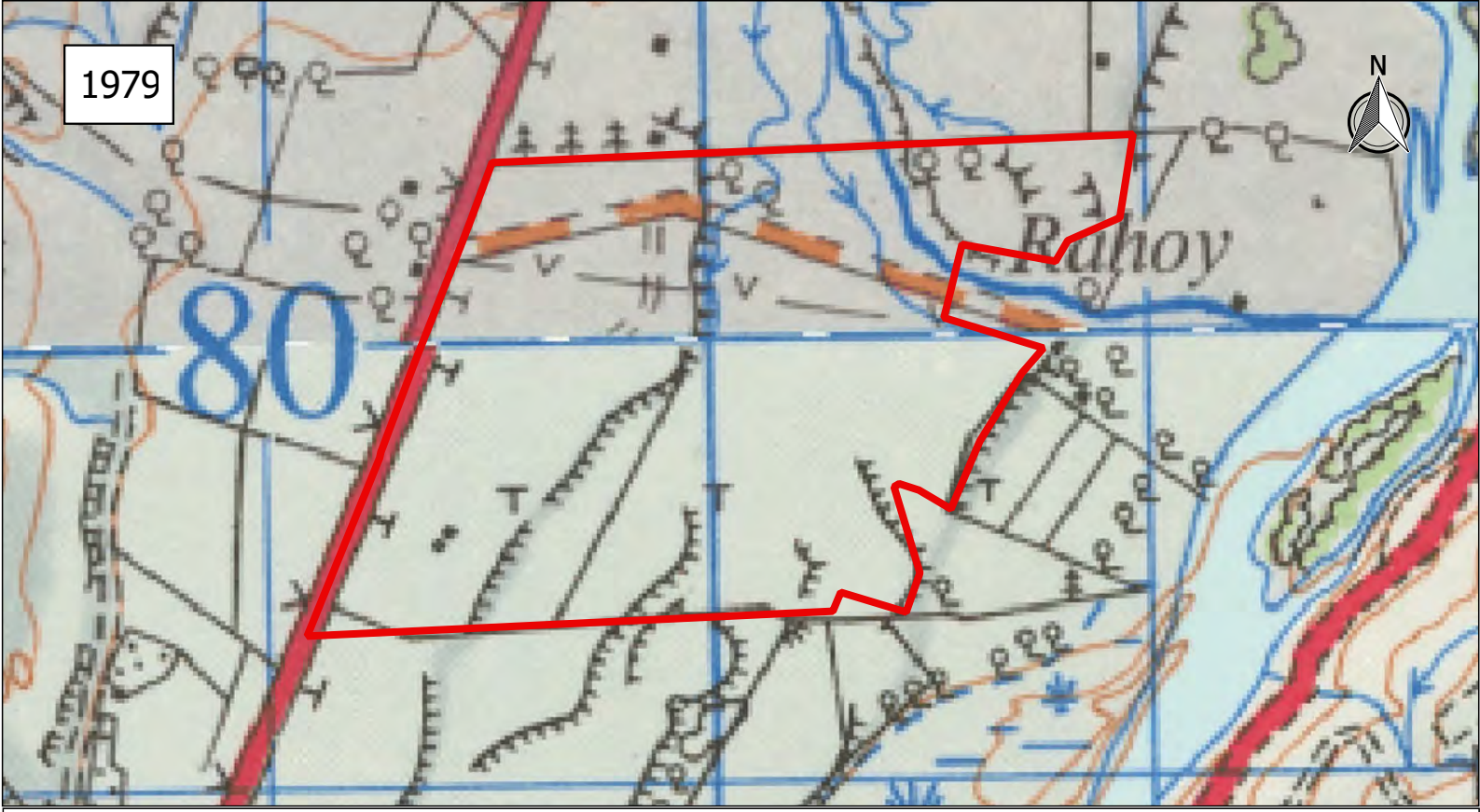
Site Boundary

Cartography sourced from http://mapspast.org.nz which includes data licensed by LINZ for reuse under the CC-BY 3.0 license.



e3 Scientific

Cartography sourced from http://mapspast.org.nz which includes data licensed by LINZ for reuse under the CC-BY 3.0 license.

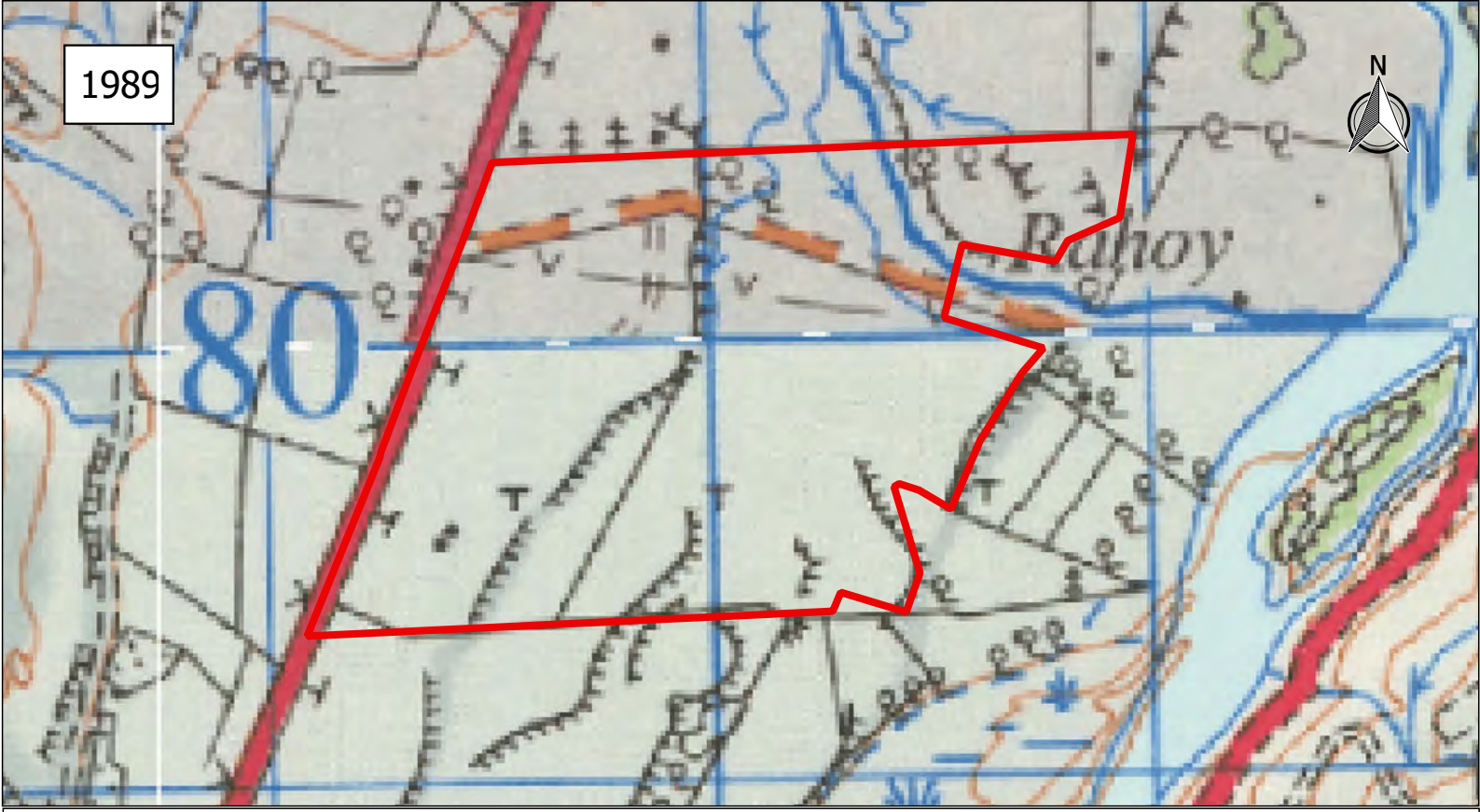


e3 Scientific

0 500 1000 1500 m

Site Boundary

Cartography sourced from http://mapspast.org.nz which includes data licensed by LINZ for reuse under the CC-BY 3.0 license.

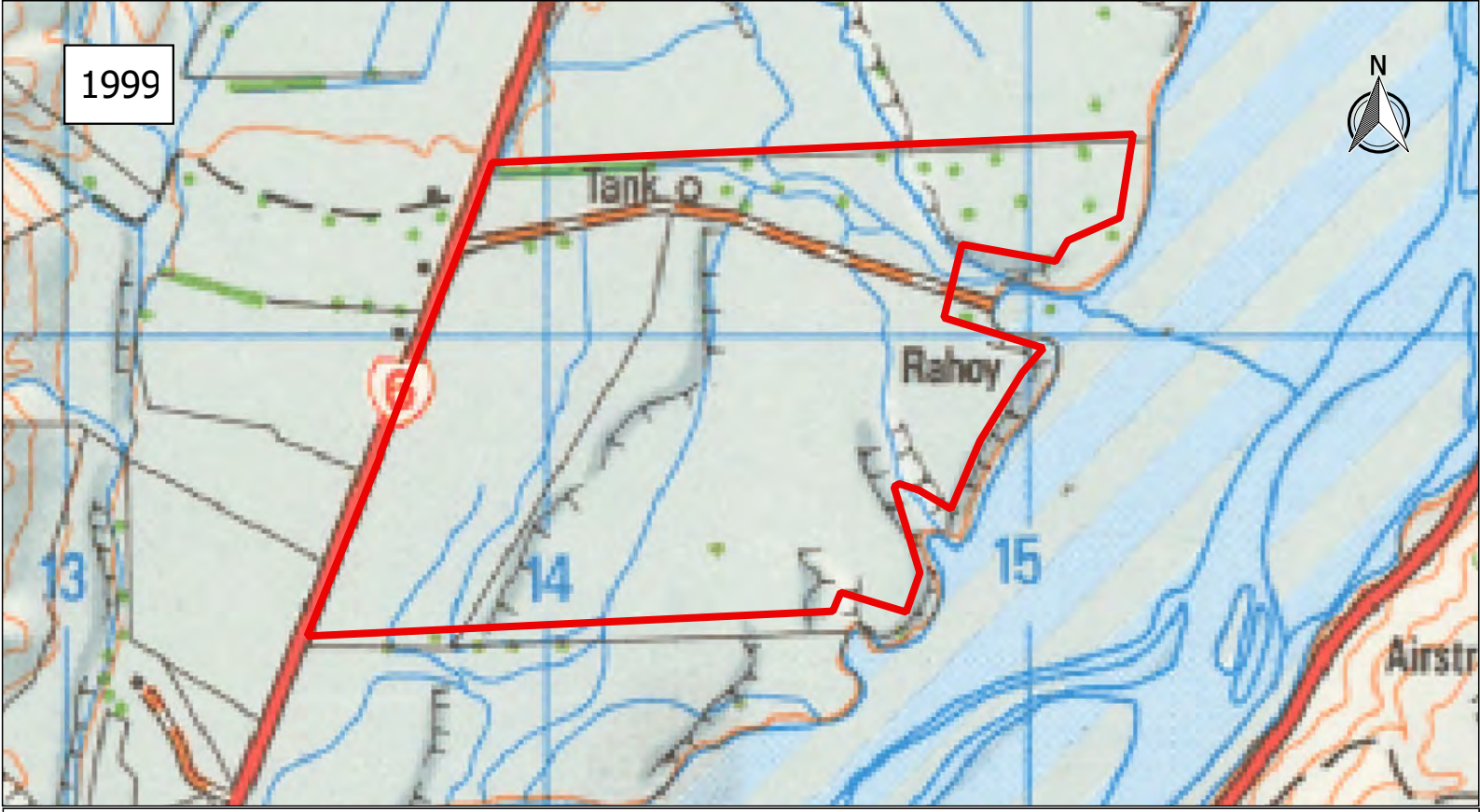


e3 Scientific

0 500 1000 1500 m

Site Boundary

Cartography sourced from http://mapspast.org.nz which includes data licensed by LINZ for reuse under the CC-BY 3.0 license.

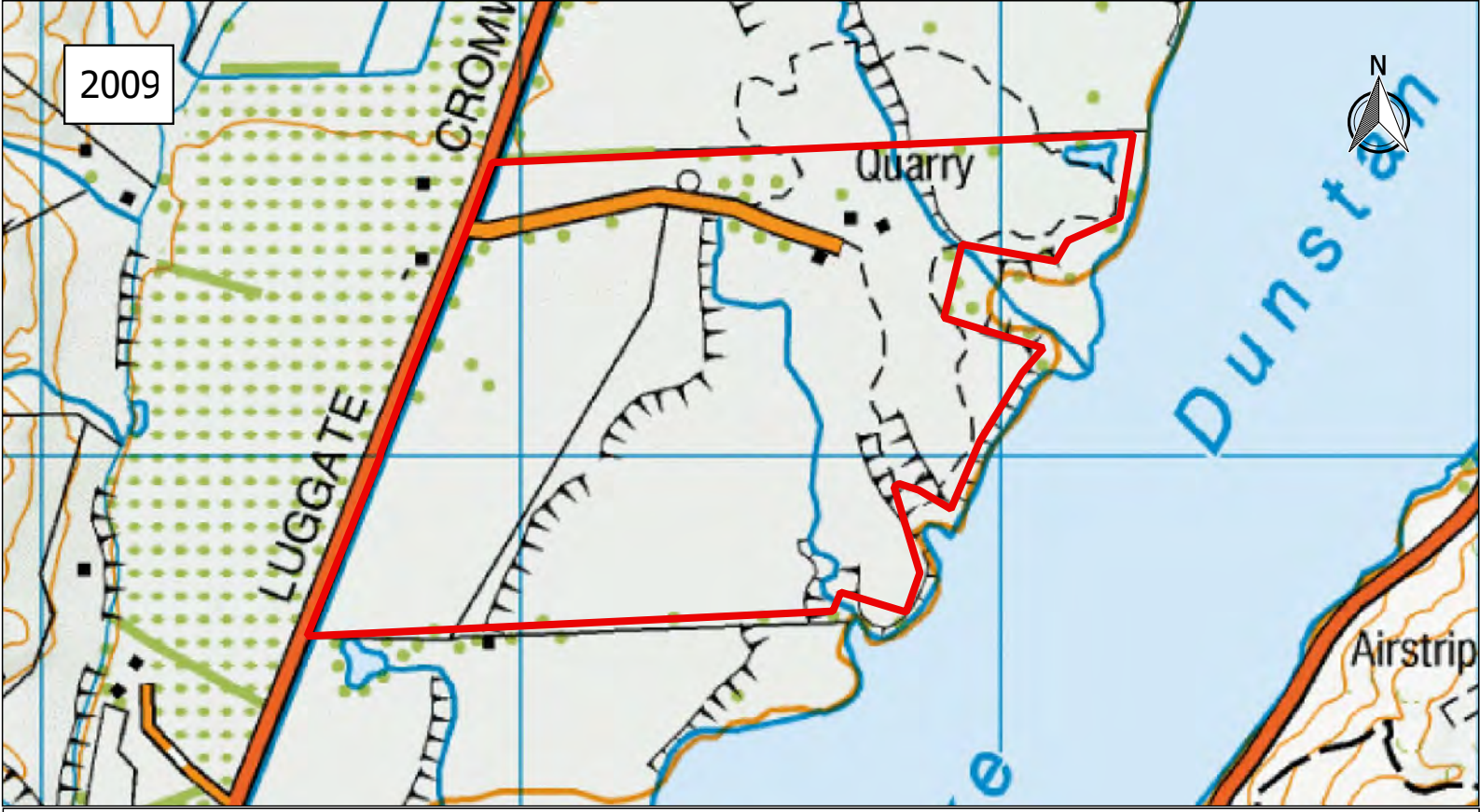


e3 Scientific

0 500 1000 1500 m

Site Boundary

Cartography sourced from http://mapspast.org.nz which includes data licensed by LINZ for reuse under the CC-BY 3.0 license.



e3 Scientific

0 500 1000 1500 m

Site Boundary

Cartography sourced from http://mapspast.org.nz which includes data licensed by LINZ for reuse under the CC-BY 3.0 license.

Appendix C:

Historic Aerials



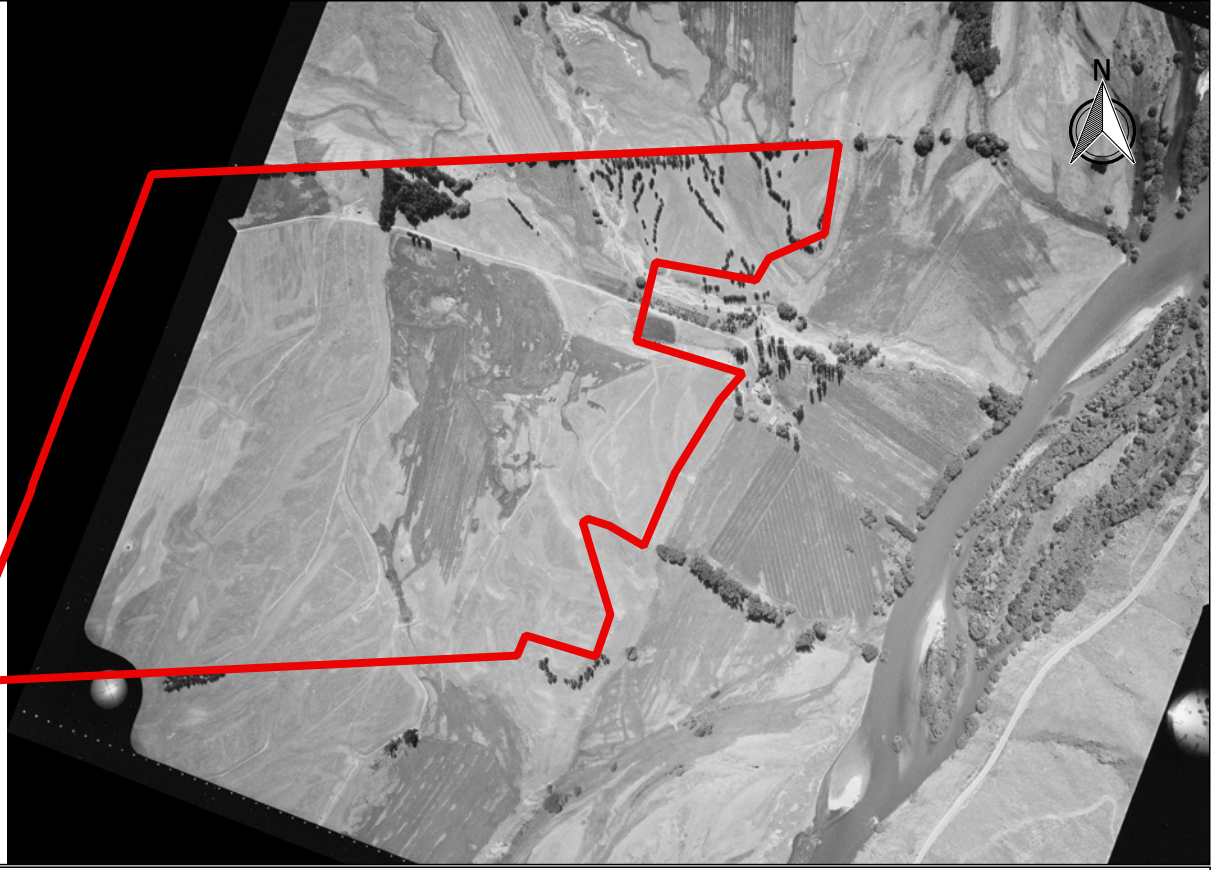
e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from http://retrolens.nz and licensed by LINZ for reuse under the CC-BY 3.0 license.

1975



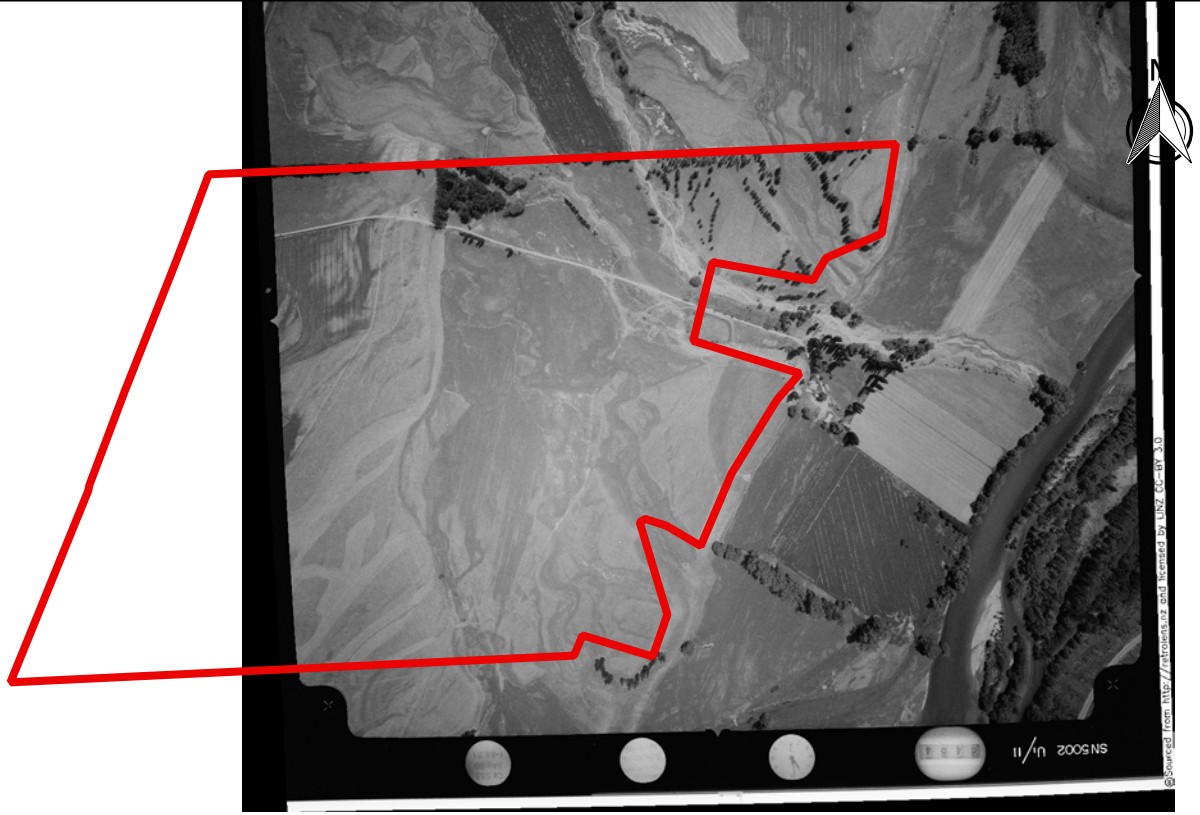
e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from http://retrolens.nz and licensed by LINZ for reuse under the CC-BY 3.0 license.

1976



e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from http://retrolens.nz and licensed by LINZ for reuse under the CC-BY 3.0 license.

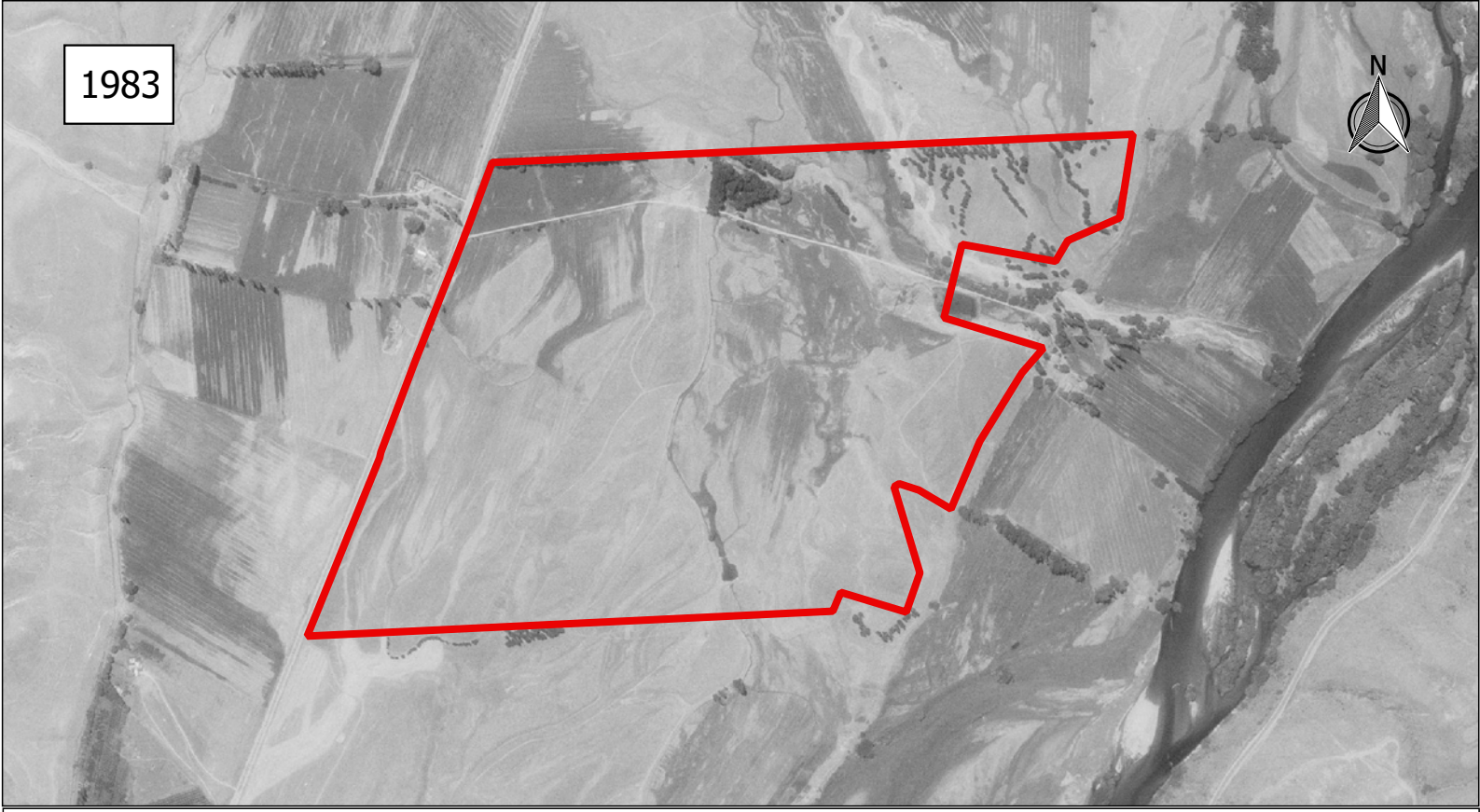


e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from http://retrolens.nz and licensed by LINZ for reuse under the CC-BY 3.0 license.



e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from http://retrolens.nz and licensed by LINZ for reuse under the CC-BY 3.0 license.



e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from http://retrolens.nz and licensed by LINZ for reuse under the CC-BY 3.0 license.



e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from Google Earth Pro, Maxar technologies.



e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from Google Earth Pro, Maxar technologies.

2011



N

e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from Google Earth Pro, Maxar technologies.



e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from Google Earth Pro, Maxar technologies.



e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from Google Earth Pro, Maxar technologies.

2021



N

e3 Scientific

0 400 800 1200 m

Site Boundary

Aerial image sourced from Fulton Hogan

Appendix D:

Otago Regional Council Supporting Information