Kōmanawa Solutions Ltd



Westland Mineral Sands Co. Ltd

Report No: Z20019_01_R2

Hydrological Impact Assessment for Westland Mineral Sands Quarry

Summary

Westland Mineral Sands proposes to excavate and mechanically separate mineral sands from the Cape Foulwind area over a five-to-seven-year operational period. The proposed activity includes:

- Construction of access roads
- Excavation of dune sand deposits
- Abstraction of water from Blind River for use in the mineral separation process
- On-site minerals processing
- Discharge of minerals processing water to infiltration ponds
- Progressive rehabilitation of the excavation areas

The water take consent has been addressed separately and is not part of this effects assessment. The potential hydrological impacts associated with the proposed quarrying operation are therefore:

- Modification of local drainage pathways due to road construction and reprofiling of the land surface during rehabilitation works.
- Groundwater quantity impacts associated with excavation below the water table.
- Water quality impacts associated with discharge of mineral separation process water to land and groundwater.
- Water quality impacts due to sediment discharges to waterways.

Drainage pathway modification can be further avoided by reinstatement of existing drainage pathways during road construction and reinstatement of the existing topographic divide when rehabilitating the mining area immediately west of Silverstream Swamp.

Any significant reduction in groundwater levels associated with sand excavation below the water table could potentially result in a groundwater level decline and associated impact on the local wetlands. The two mechanisms by which impacts could occur are as follows:

1. Water level depression due to groundwater and sediment removal when excavating below the water table.
2. Increase or decrease in the hydraulic conductivity of the sediments replaced in the excavated area following minerals processing.

Excavation of material from below the water table will involve some removal of water along with the excavated sediment. Analysis presented in this report shows that if the rate of mineral sand excavation from below the water table is limited to 100 m^3/d, the excavation is very unlikely to have a significant hydrological impact.

The hydraulic conductivity of the material replaced in the excavation areas may temporarily differ from the hydraulic conductivity of the undisturbed materials due to changes in the degree of compaction of the sediments. This could increase or decrease the rate of westerly groundwater flow from Silverstream Swamp through the dune sand deposits.

The results of my analysis indicate that there is some potential for a small temporary increase in the rate of groundwater flow from the Silverstream Swamp to the Blind River tributary to the west if the hydraulic conductivity of the return material was higher. A Water Management Plan should be developed to document the material testing process that will be undertaken to ensure that a suitable degree of compaction is achieved in the sediment returned to the proposed excavation area west of the swamp.

Minerals processing discharge water may contain slightly elevated concentrations of iron, manganese and trace elements. The proposed Water Management Plan (WMP) should include a suitable water quality monitoring programme to ensure that any seepage from the settling ponds has no adverse impact on local water quality. The WMP should document actions to be undertaken if the discharge water quality is likely to breach suitable environmental standards, e.g. lining of the settling ponds and/or more detailed monitoring.

CONTENTS

1. INTRODUCTION

1.1. Background

Westland Mineral Sands proposes to excavate and mechanically separate mineral sands from the Cape Foulwind area over a five-to-seven-year operational period.

Komanawa Solutions Ltd (KSL) has been engaged to assess the hydrological impact of these proposed activities and to work with the project team to develop a quarrying approach which avoids, remedies and mitigates any hydrological effects that might otherwise occur.

1.2. Activity description

The main elements of the proposed quarrying operation are as follows:

- Construction of access roads
- Excavation of dune sand deposits
- Abstraction of water from Blind River for use in the mineral separation process
- On-site minerals processing
- Discharge of minerals processing water to infiltration ponds
- Progressive rehabilitation of the excavation areas

The water take consent has been addressed separately and is not part of this effects assessment.

1.3. Report scope

The scope of work for this report comprises:

- Collate data on the local environmental setting.
- Describe those aspects of the proposed activity with the potential for hydrological impacts.
- Assess the hydrological impacts of the quarrying operation and evaluate options to avoid, remedy or mitigate these effects where appropriate.
- Provide advice on conditions that could be included in a resource consent to minimise the potential for hydrological impacts.

2. SITE SETTING

2.1. Site location

The site comprises vegetated sand dunes utilised for grazing pasture and is located east of Okari Road, south of Cape Foulwind and south west of Westport per Figure 2-1 and Figure 2-3 respectively below. The elevation of the proposed mining area ranges from approximately 5 m to 30 m asl.

Figure 2-1 Vegetated dunes looking south

2.2. Hydrological setting

2.2.1. Climate

Macara (2013) describes the West Coast climate as follows:

West Coast is New Zealand's wettest region, and this may be attributed to its exposure to the predominant westerly airflow over the country, combined with the orographic effect of the Southern Alps. Annual rainfall totals at relatively high elevations regularly exceed 10,000 mm, with low elevation coastal locations typically recording between 2,000 and 3,000 mm of rainfall annually. Temperatures in lowland areas remain mild *throughout the year, with temperatures less than 0°C and greater than 25°C occurring infrequently compared to most other regions of New Zealand*.

Rainfall in Westport averages approximately 2500 mm/year, with October being the wettest month (average 260 mm) and February being driest (averaging 142 mm).

2.2.2. Geology

The geology of the site has been described by Hardie Pacific Ltd as follows:

The general geomorphology of the Nine Mile project area is characterised by two shore parallel coastal paleodunes separated by a lowlying area of lagoonal sediments. The area is presently pasture grasslands with small pockets of scrub and gorse.

The Nine Mile project geology consists of Holocene postglacial (<10ka) coastal sediments deposited on a flat wave cut marine platform during shoreline progradation. The eastern boundary of the deposit is delineated by a post glacial Holocene shoreline/cliff, found throughout Westland and known as the Nine Mile shoreline. The sediments were deposited during westward progradation from the shoreline towards the present shoreline.

Adjacent to the shoreline cliff sits the Ferry Member Dune ridge, that is ~150m wide and up to 28m high. The Ferry dune placer deposit consists of shoreline interlayered sands with heavy mineral (HM) strandline accumulations and aeolian well sorted sands. The Ferry member is the target ore body for the project.

To the west of the Ferry Dune is a 200m wide flat area of lagoonal sediments. These sediments are thin (1-4m thick) low-lying lagoonal sands, silts and muds. The lagoonal deposits can be subdivided into two end members; Sand or Mud (swampy) dominated. The sand dominated areas generally contain only minor HM <5%.

To the west of the lagoonal sediments, and east the modern shoreline, sits the Shetland Member dune, that is ~200m wide and less than 20m high. This ridge forms a continuous North - South trending belt along most of the Nine Mile North beach. The dune ridge is separated from the present-day beach by a belt of vegetation and active dune systems about 100m wide and less than 15m high. The upper portion of the Shetland dune is dominated by aeolian sands that overlie shoreline deposited interlayer sands.

The Ferry member ore body within the consent area consists of free flowing to slightly indurated dunal sands that contain elevated heavy mineral content notably garnet and ilmenite. The average mineable thickness of the sands is approximately 12.5 metres, in a range of 3 to 20 metres (Figure 2-2). The mining basement directly underlying the dunal sand is a blueish marine calcareous mudstone referred to by locals as "Papa". The sand, or ore component generally contains minor amounts of oversize material (i.e. 4% + 300µm) and up to 10% - 53µm or "slimes". The average ilmenite grade within the consent area is ~5% but ranges between 3-25%. The average heavy mineral content is ~15%. There is also fine gold, zircon, monazite, rutile and magnetite contained in the sands. The deposit is well characterised with over 500 historic drill holes which have been digitised and using in project evaluation.

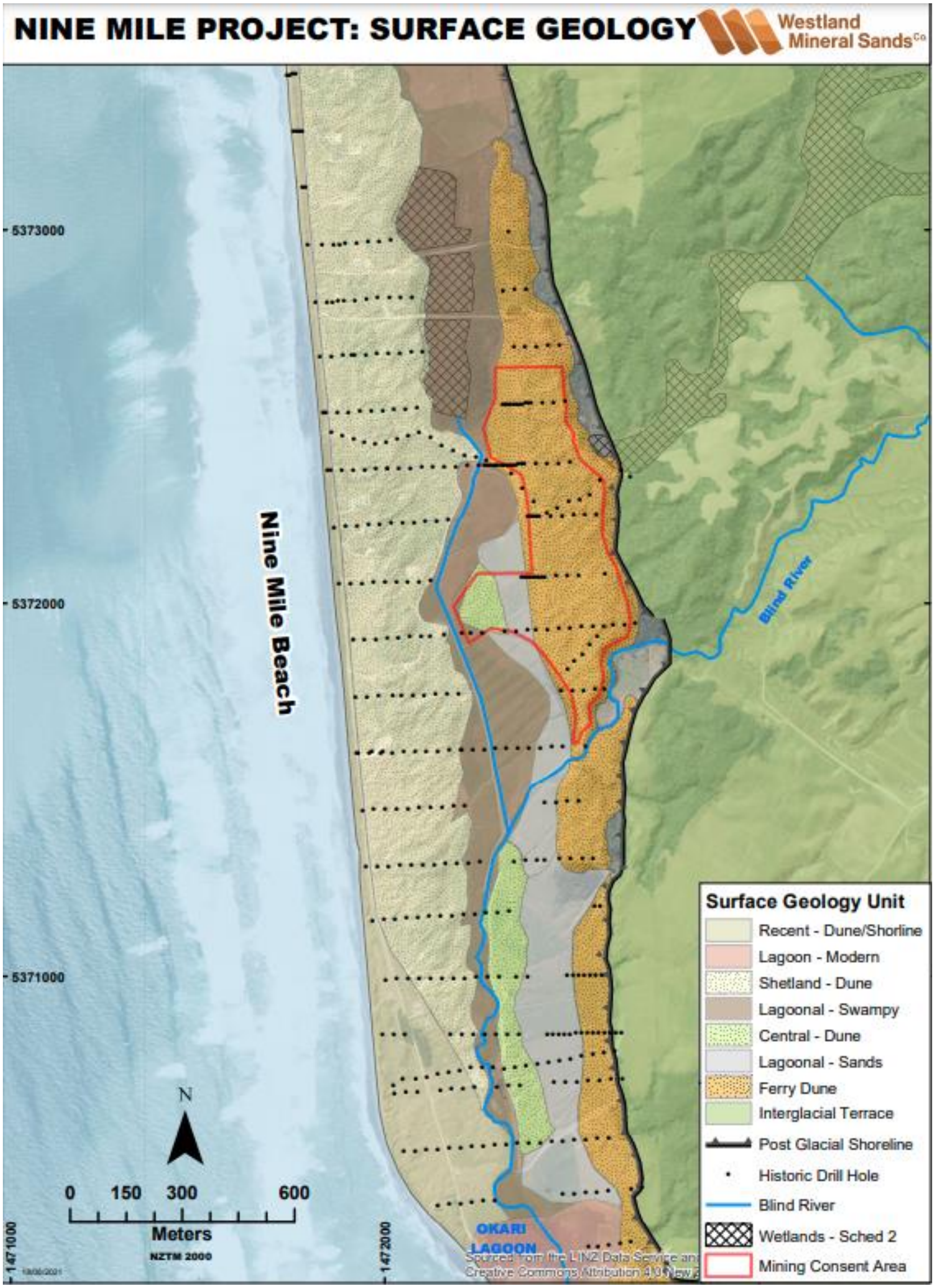


Figure 2-2 Geology

2.2.3. Hydrology

The Cape Foulwind area is drained by Blind River to the south and Gibsons Creek and Bradshaw River to the north. The proposed mining area is located in the Blind River catchment, as per Figure 2-3 below.

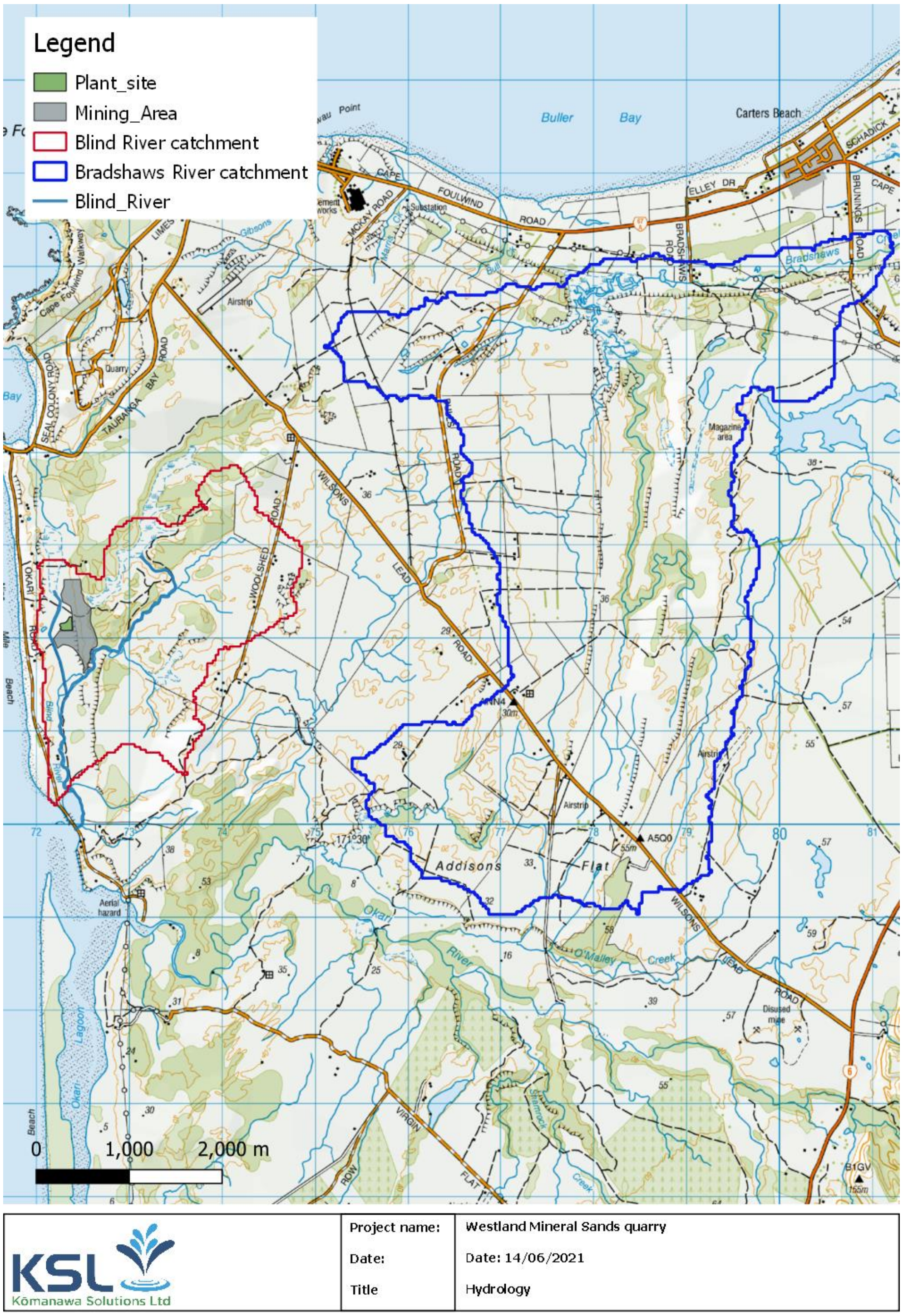


Figure 2-3 Site location and area hydrology

The proposed mining area is located adjacent to two wetlands listed within Schedule 2 of the 2014 (including Plan Change 1, operative 22 October 2020) West Coast Regional Council Regional Land and Water Plan (RLWP): Okari Road Swamp and Silverstream Swamp, as shown in Figure 2-4 and Figure 2-5. Silverstream Swamp straddles the hydrological divide between the Blind River catchment and Gibsons Creek catchment.

The RLWP defines Schedule 2 wetlands as:

wetlands that either are, or are likely to be, ecologically significant. A wetland in Schedule 2 is considered to be significant if it meets any one of the ecological criteria in Schedule 3. Wetlands identified in Schedule 2 require an assessment using the ecological criteria on Schedule 3 during any resource consent process.

It is noted that the wetland description above refers to resource consent processes where consent is required for a rule breach in relation to a Schedule 2 wetland, not any resource consent that has a Schedule 2 wetland in the vicinity. There are no breaches of RLWP rules in relation to wetlands from the proposed activity.

Figure 2-4 Okari Rd swamp looking north

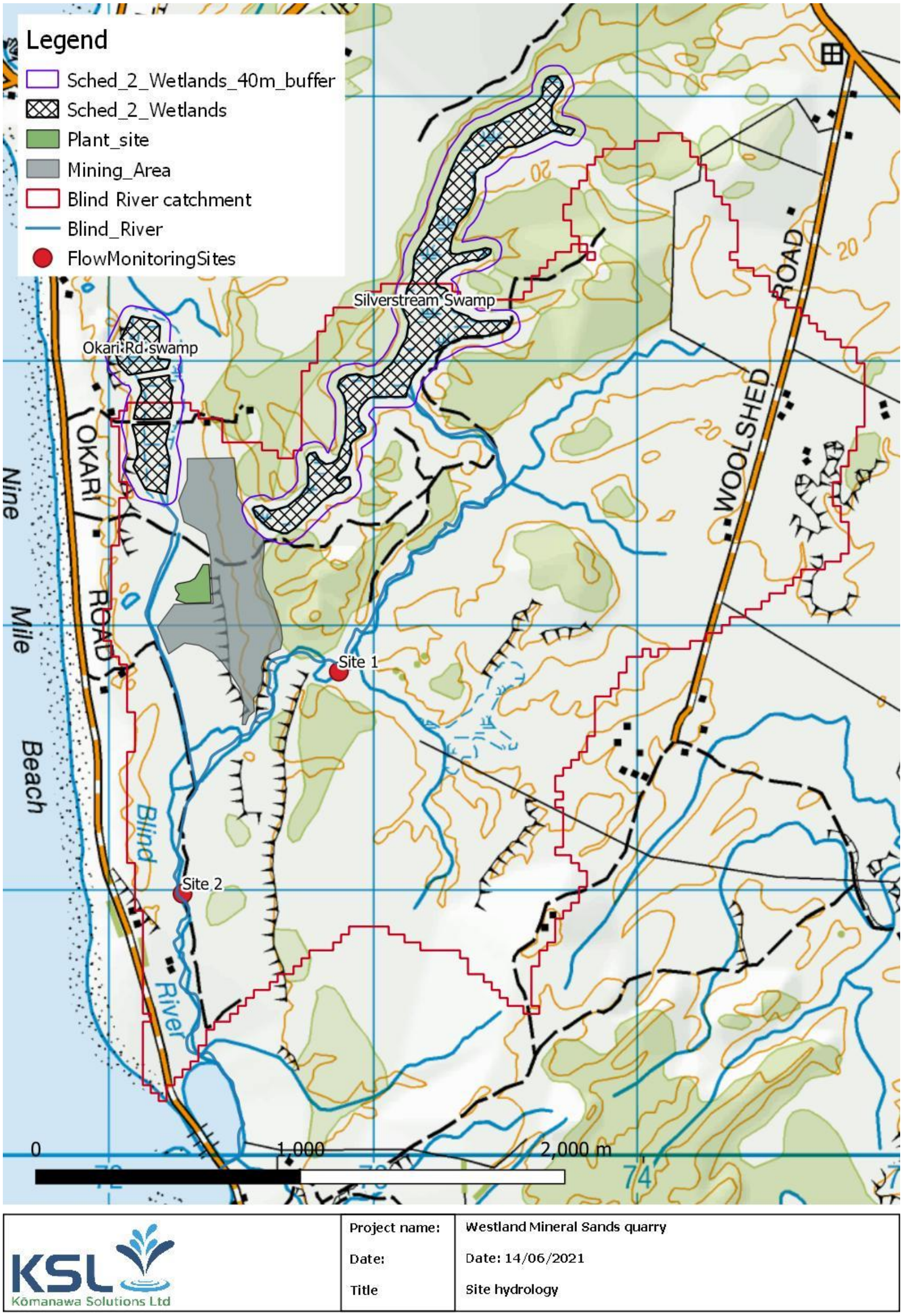


Figure 2-5 Site hydrology

Figure 2-6 Blind River looking upstream of Site 1

A series of flow gaugings were undertaken in Bradshaws River at the Brunnings Rd bridge between 1989 and 1991 as per Figure 2-7 below. The minimum flow recorded over this period was 162 L/s; the median flow was 620 L/s.

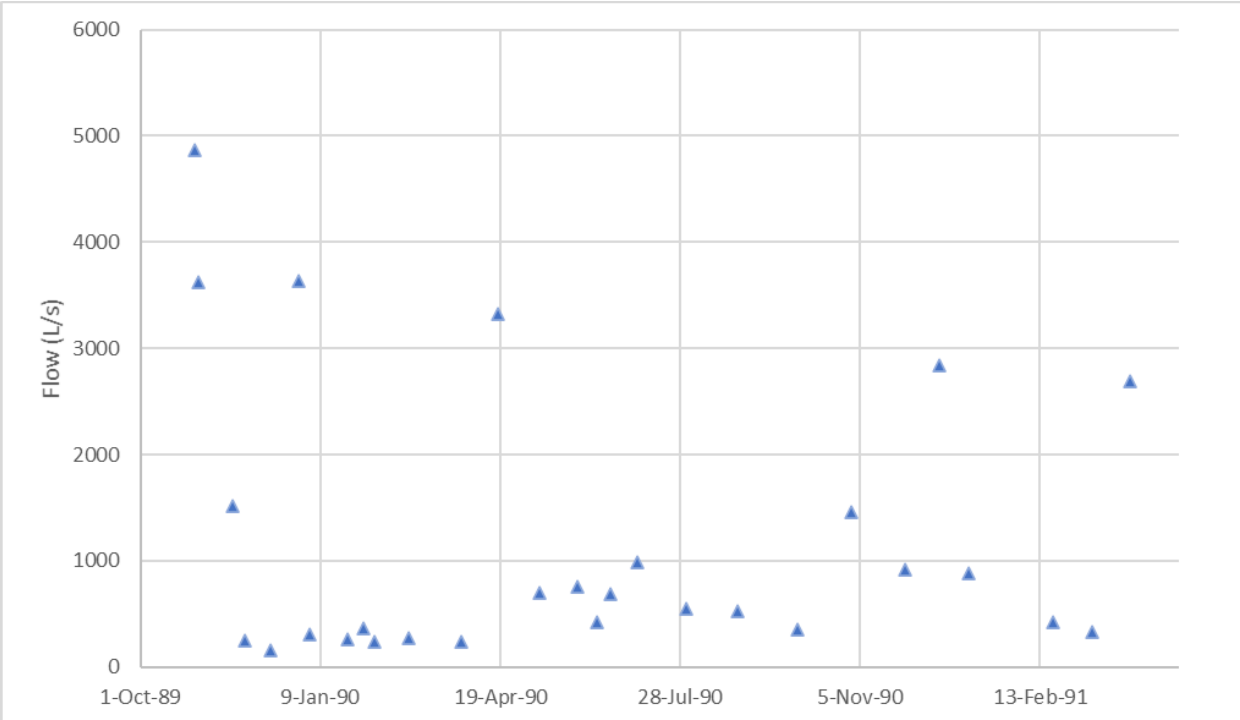


Figure 2-7 Bradshaws River flow gauging data

Westland Mineral Sands engaged NIWA to undertake flow gaugings at two locations in Blind River (see Figure 2 4 for locations) and in at the Brunnings Road site as part of this project. Flows recorded on 26/5/21 were:

- Blind River Site 1: 230 L/s
- Blind River Site 2 248 L/s
- Bradhsaws River at Brunnings Rd 594 L/s

2.2.4. Groundwater quantity

The site is underlain by a dune sand and coastal sediment Holocene period aquifer overlying low permeability mudstone basement strata in the form of a wave cut platform.

Water table elevation contours presented in Figure 2-9 and ground surface, water table and geological basement cross section plots shown in Figure 2-10 derived from an extensive resource investigation drilling programme show the following:

- The water table slopes towards the coast, from a maximum of 9 m asl at the eastern edge of the proposed mining area to 2 m asl at Okari Road.
- The vast majority of the mineral resource is found above the water table. The maximum saturated thickness of mineral sands is approximately 4 m and is generally less than 2 m.

This second point is key because it means that most of the local mineral sand resource can be excavated under dry conditions.

Although the dune sand aquifer is relatively thin and is not utilised for groundwater abstraction in the site area, the groundwater resource supports baseflows in Blind River and water levels in the Okari Road Swamp and Silverstream Swamp and is therefore key to the health of the local hydro-ecological system.

The aquifer is recharged by local rainfall, with relatively high infiltration rates expected given the sandy soils present here. The modelled Blind River median flow at Site 1 equates to an annual average yield of 0.7 m over the 400 ha catchment, equivalent to ~30% of mean annual rainfall.

A 1995 Tonkin and Taylor report entitled *Westport Titanium Project – Assessment of environmental effects* provides some additional information in the local hydrogeology as follows:

> A groundwater study (Tonkin & Taylor, 1994) describes the aquifer as unconfined, with its level at the coast controlled by sea level. Drains and the Blind River control the groundwater levels in the low lying plains in the central part of the North Nine Mile mine area. The thickness of the aquifer varies between about 1 m and 10 m as the underlying bedrock varies in depth. The aquifer thickness is generally less under the inland dunes than the seaward dunes. Aquifer recharge is likely to be from a combination of surface infiltration, and inflow from the upstream aquifer. A conceptual model of the groundwater system, based on a typical west-east cross-section through the proposed mining area, is illustrated on Figure 6.
>
> Hydraulic conductivity is the parameter which describes the speed at which water moves through an aquifer, and is necessary to calculate the rate of seepage into, or discharge from, the mine pond. The hydraulic conductivity of the groundwater systems is between 1×10^{-5} and 1×10^{-6}m/s in the upper 1 to 2m, and 1×10^{-5}m/s or higher than 1×10^{-5}m/s below a depth of 2 m.
>
> The logs from the piezometer boreholes and the prospecting holes carried out by Buller Minerals Ltd in 1971, indicate that there is a general trend for the lower layers of the sand deposit to included coarser sands, and that there is a layer of coarse gravels/boulders overlying the bedrock in places. This indicates that the hydraulic conductivity of the aquifer is likely to increase with depth.

We have been unable to obtain a copy of the 1994 report cited above. A schematic hydrogeological cross section through the site is provided below.

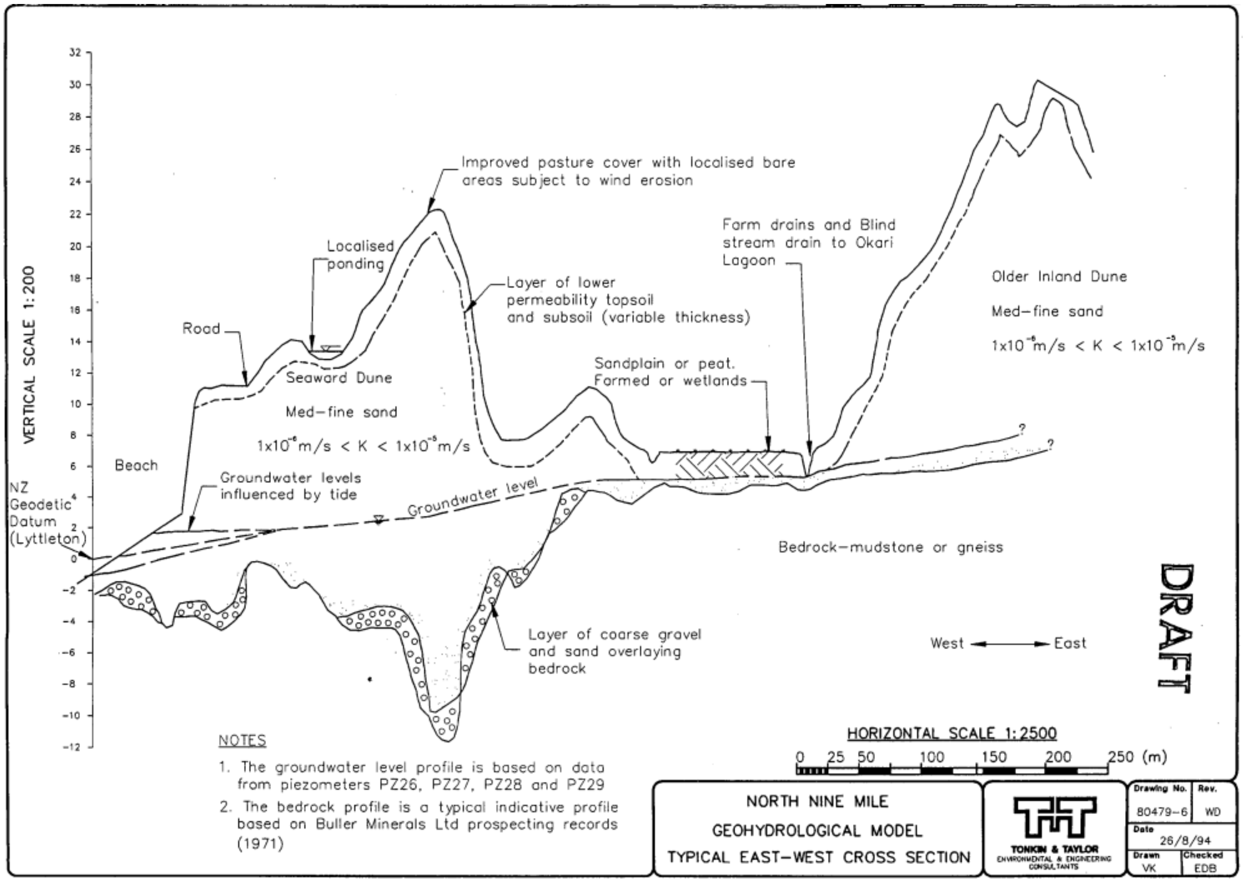


Figure 2-8 Conceptual hydrogeological section through the site (from Tonkin & Taylor, 1995)

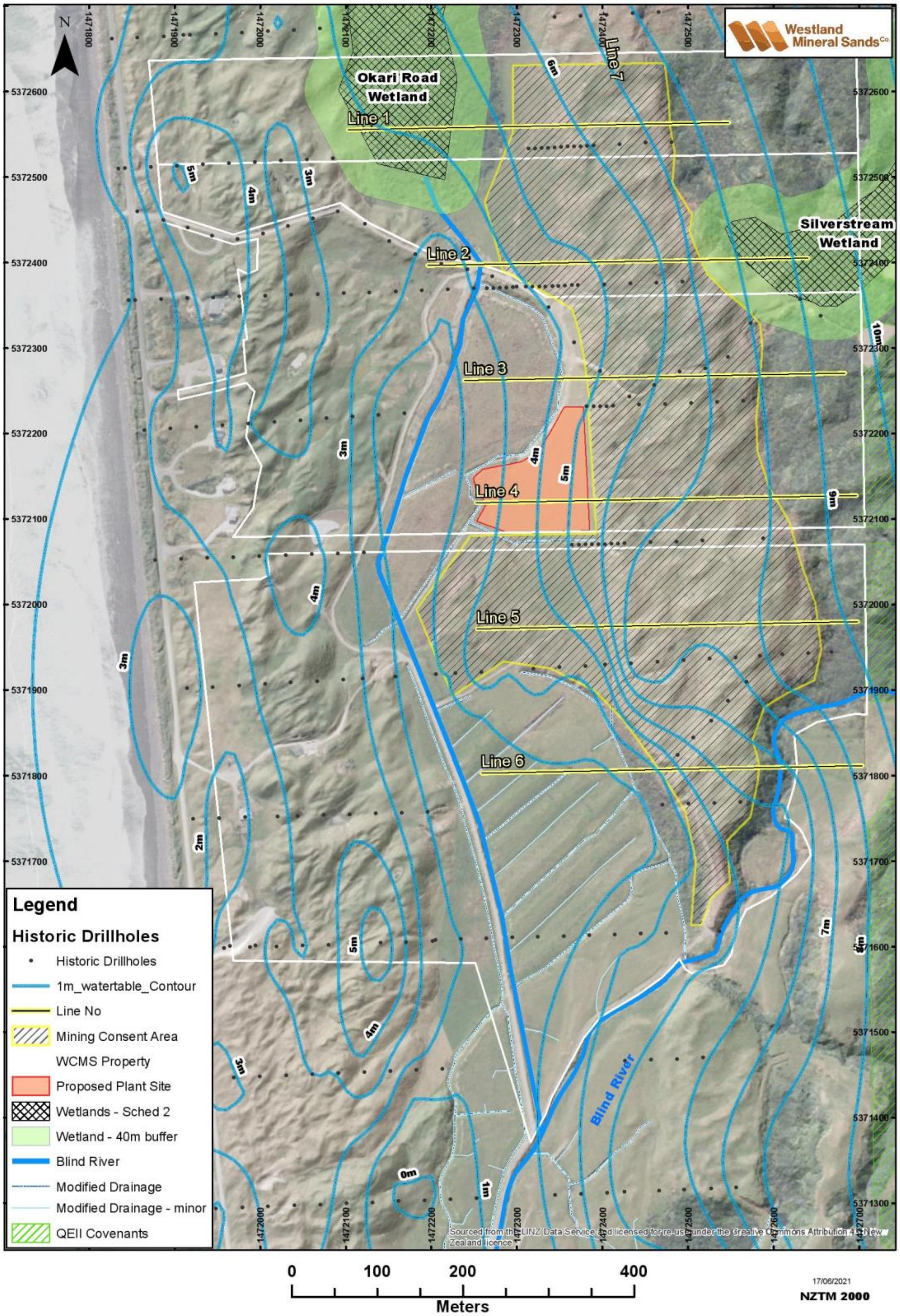


Figure 2-9 Water table elevation contours and cross section locations

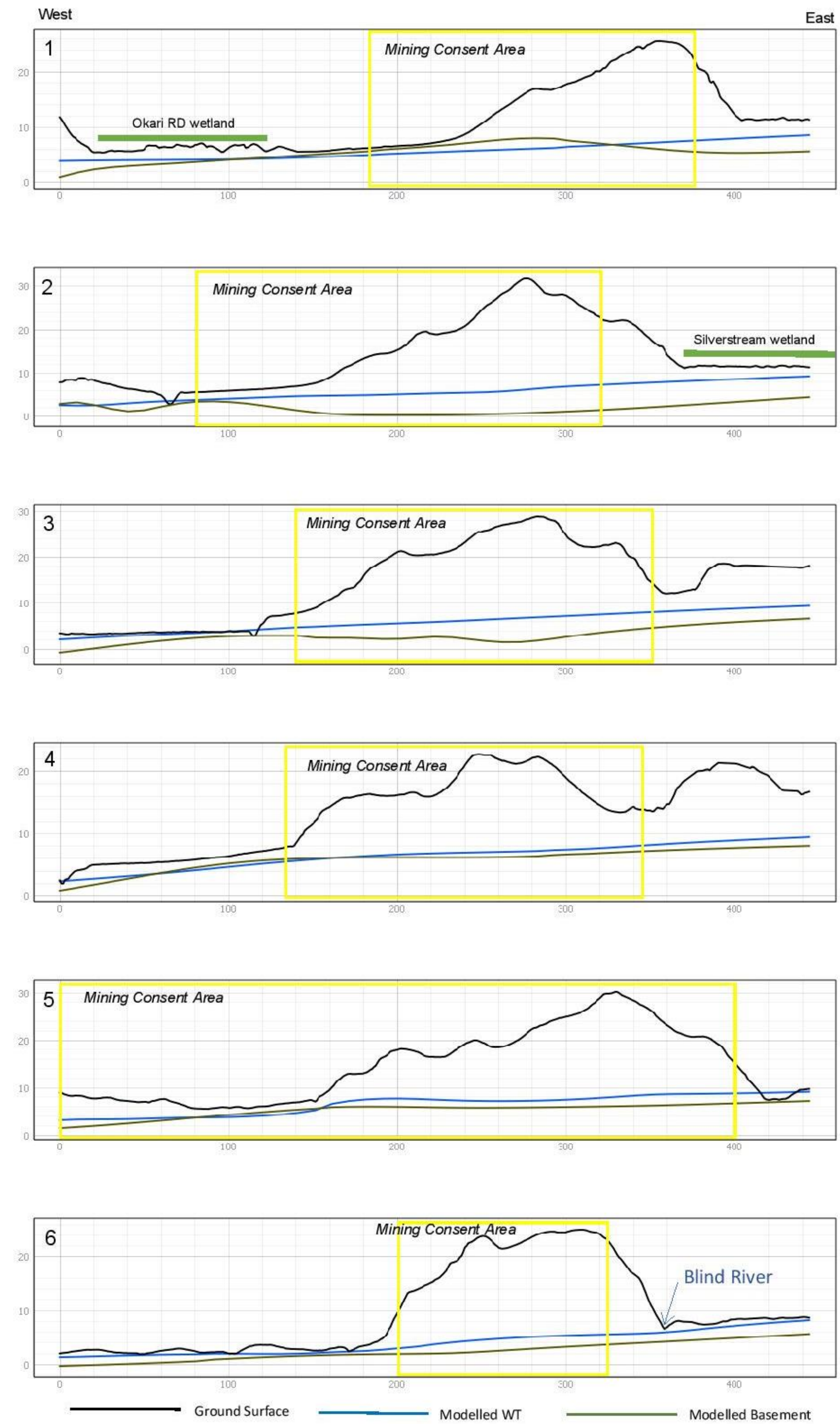


Figure 2-10 Cross sections

2.3. Water quality

Although no local data are held by WCRC, water quality was sampled as part of a resource investigation in the early 1990's, the findings of which are presented in Tonkin and Taylor (1995). Groundwater quality was monitored at four sites; locations and extracts of the monitoring results are provided in Appendix A. The water quality in Blind River was also monitored as part of this work, results are provided in Appendix A.

The measured groundwater quality can be summarised as follows:

- Moderately acidic (pH 5.2 – 6.0)
- Low dissolved solids (max EC = 35 ms/m), equivalent to 224 ppm TDS
- Elevated dissolved iron in some locations (up to 1.8 mg/L)
- Detectable trace elements (max arsenic = 0.001 mg/L, max titanium = 0.01 mg/L)
- Detectable zinc (max 0.05 mg/L)

The Tonkin and Taylor (1995) report also included laboratory testing (referred to as MP1) to evaluate metals and trace element concentrations in the proposed mine pond. The testing process, summarised in the report extract below, provides a reasonable proxy for the proposed minerals processing on site and hence the results of this testing can be used to infer the potential water quality of the minerals processing effluent.

The MP1 series of samples were taken at the same time as the GW1 series in August 1994 and 20% of the sample bottle volume was filled with loose sand excavated from below the soil horizons near the well. The samples were then transported to the laboratory where they were shaken for 24 hours, and allowed to settle for 24 hours, before the water was analysed using the same procedures as for the GW1 series. This allowed comparison between natural groundwater quality (GW1 series) and the simulated mine pond results (MP1 series). The analysis results are presented in Table 5.

The MP1 testing results (See Appendix A) can be summarised as follows:

- Elevated dissolved iron (up to 0.87 mg/L)
- Detectable trace elements (max arsenic = 0.002 mg/L, max titanium = 0.21 mg/L)
- Detectable zinc (max 0.07 mg/L)

Water quality samples were taken from Blind River on four occasions between 1989 and 1990. The following points are noteworthy:

- Slightly acidic pH (6.5 – 7.1)
- Low TDS
- Elevated dissolved iron (max 0.83 mg/L)
- Detectable zinc (max 0.016 mg/L)
- Detectable cadmium (max 0.0005 mg/L)

3. HYDROLOGICAL IMPACT ASSESSMENT

3.1. Impact potential of proposed activities

The potential hydrological impacts associated with the proposed quarrying operation are:

- Modification of local drainage pathways due to road construction and reprofiling of the land surface during rehabilitation works.
- Groundwater quantity impacts associated with excavation below the water table.
- Water quality impacts associated with discharge of mineral separation process water to land and groundwater.
- Water quality impacts due to sediment discharges to waterways.

We discuss each of these in turn below. As noted previously, the water take for mineral sands processing is not part of this effects assessment.

3.2. Drainage pathway modification

The quarrying process will involve topsoil removal, excavation of dune sand deposits, mechanical separation of the mineral component and infilling of the excavation with the residual sand. The mineral content of the sand is 10% on average, so 90% of the excavated material will be replaced in the excavated area. This means that sufficient material is available to reinstate the existing topography and hence drainage pathways during the rehabilitation process.

Drainage pathway modification can be further avoided by reinstatement of existing drainage pathways during road construction and reinstatement of the existing topographic divide when rehabilitating the mining area immediately west of Silverstream Swamp.

The upgrade of the access road into the mining and plant area will require minimal earthworks and resurfacing and will not modify current drainage pathways. An existing culvert across the unnamed tributary of Blind River may need replacing to cater for heavy vehicles. If this occurs the existing drainage profile will be retained.

3.3. Groundwater quantity impacts

As discussed in Section 2.2.3, Blind River and the two Schedule 2 wetlands on the site are groundwater-fed. Mining operations should therefore be undertaken to avoid significant impacts on the local groundwater system. No dewatering operations are proposed and removal of minerals sands from below the water table will be undertaken via excavator. Any minerals sands that cannot be excavated without dewatering will be left in place.

Figure 3-1 provides a schematic cross section through Silverstream Wetland under present conditions and during mining operations. The potential hydrological impacts associated with mining and actions that will be undertaken to avoid these are discussed below.

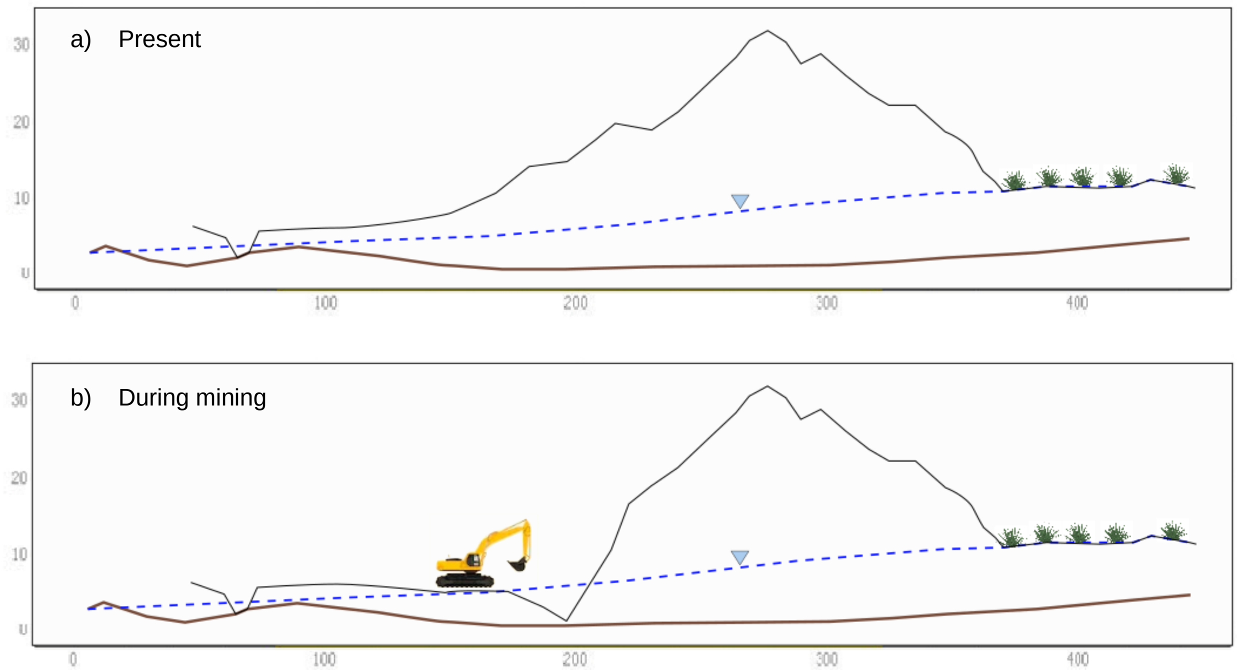


Figure 3-1 Schematic cross section through Silverstream Wetland

Any significant change in groundwater levels associated with sand excavation below the water table could potentially impact on the local wetlands. The two mechanisms by which impacts could occur are:

- Water level depression due to groundwater and sediment removal when excavating below the water table.
- Increase or decrease in the hydraulic conductivity of the sediments replaced in the excavated area following minerals processing.

I discuss these in turn below.

3.3.1. Effects of sediment and water removal

Excavation of this material from below the water table will create a temporary void into which groundwater will flow to replace the sand and that proportion of the water that has been removed. In parallel to this, material will be placed back into the void and displace water in that part of the void. Noting that the porosity of the dune sand deposits is likely to be in the order of 35-50% (see Atkins & Mcbride, 1991), the net rate of water removal (Q) can be estimates as follows:

$Q = X(Mc_o - Mc_r)$

Where X = excavation rate, Mc_o = moisture content of the excavated material and Mc_r= moisture content of the returned material

I have assumed that the moisture content of excavated material (Mc_o) is in the order of 30%, noting that some drainage of the water within material excavated from below the water table will occur prior to conveyance to the minerals processing plant.

The return material moisture content (Mc_r) is expected to be around 10%

The net water removal rate in areas of excavation below the water table therefore = excavation rate x 20%.

An excavation rate of 100 m^3/d would therefore equate to 20 m^3/d of net water removal. This very low rate of water removal is unlikely to have any hydrological or hydro-ecological effect.

3.3.2. Effects of potential changes in hydraulic conductivity

The hydraulic conductivity of the material replaced in the dune sand excavation areas could potentially differ from the hydraulic conductivity of the undisturbed materials due to changes in the grain size and/or compaction of the sediments. This could increase or decrease the rate of westerly flow through the dune sand deposits.

The minerals separation process is not expected to result in any significant change in the average grain size of the replaced material and hence the hydraulic conductivity of the dune sand is unlikely to be affected by this aspect of the operation.

Material replaced in the excavation below the water table will be compacted by excavators and further compacted by the weight of overlying (dry) sediments. Over time the material will naturally consolidate to achieve the same level of compaction as the status quo. The proposed excavation work is therefore not expected to have any long-term effect on the rate of local groundwater flow.

If material replaced in the excavation below the water table is not immediately compacted to achieve a similar hydraulic conductivity to that of the undisturbed material, it is possible that the rate of groundwater flow through that part of the aquifer could temporarily increase until natural consolidation occurs.

Groundwater flow in the Okari Rd swamp area is likely to be to the south and to the west and hence the proposed mineral sand excavation to the east of this wetland is unlikely to affect the wetland hydrology, even on a temporary basis.

I have evaluated the potential magnitude of temporary changes in groundwater flow rates through the dune sand aquifer west of Silverstream Wetland for a scenario in which the material is not immediately compacted to achieve the status quo hydraulic conductivity.

The current rate of westward groundwater flow through the dune sand aquifer adjacent to Silverstream Swamp can be estimated via Darcy's Law based on:

- The hydraulic gradient and wetland length adjacent to the proposed mining area shown in Figure 2-9 (5 m/400 m = 0.013);

- The maximum proposed excavation depth of 2 m below the water table and the length of proposed excavation area adjacent to the wetland (200 m); and
- The hydraulic conductivity value noted in Section 2.2.4 (>=1E-5 m/s, i.e. 1 m/d or above). I have used two values: 1 m/d and 10 m/d.

The possible temporary increase in groundwater flow rates in the event that the undisturbed hydraulic conductivity was not immediately restored have been estimated in Table 3-1 below via a sensitivity analysis which assumes a 100% increase in hydraulic conductivity. These calculations could potentially overestimate the possible temporary change in flow rates because they do not account the undisturbed sediments between the proposed excavation area and the likely groundwater discharge location in the creek to the west. All else being equal, this means that the change in average hydraulic conductivity over the flow path length would be less that these calculations show. A degree of conservatism of this nature is appropriate, however, given the uncertainty over the possible short-term changes in hydraulic conductivity.

Table 3-1 Estimated westerly groundwater flow rates

Scenario	Length (m)	Thickness (m)	Gradient	Hydraulic conductivity [k](m/d)	Groundwater flow (m^3/d)
Status quo – low k	200	2	0.013	1	5
Post mining – low k	200	2	0.013	2	10
Status quo – high k	200	2	0.013	10	50
Post mining – high k	200	2	0.013	20	100

The results of this analysis indicate that there would be some potential for a temporary increase in groundwater flow through the aquifer between Silverstream Swamp and the Blind River tributary to the west if the hydraulic conductivity of the return material was significantly higher than the undisturbed sediment. This could be avoided by:

a) undertaking site testing during an excavation trial to determine the pre- and post-excavation hydraulic conductivity;

b) compacting the replaced material with the excavator if this is necessary to avoid a significant increase in hydraulic conductivity; and

c) testing the hydraulic conductivity of the replaced material (e.g. via variable head tests in temporary piezometers) to confirm that the hydraulic conductivity is not increased significantly.

A Water Management Plan should be developed for the proposed activity to document this testing process.

3.4. Water quality impacts

Minerals processing discharge water may contain slightly elevated concentrations of iron, manganese and trace elements as discussed in Section 2.3. These elements are naturally present in the local groundwater and surface water to some degree, however, and sorption to clay minerals within the settling ponds and underlying aquifer is likely to result in significant removal. Nonetheless, I recommend that a Water Management Plan (WMP) should be developed for the site to include a suitable water quality monitoring programme to ensure that any seepage from the settling ponds has no adverse impact on local water quality. The WMP should document actions to be undertaken if the discharge water quality is likely to breach suitable environmental standards, e.g. lining of the settling ponds and/or more detailed monitoring.

Sediment discharges to waterways can be avoided by:

- Implementation of appropriate erosion and sediment control actions (e.g. silt fences) to manage runoff from access/haul roads
- Diversion of runoff away from active working areas
- Containment of runoff from active excavation areas within the excavation

An Erosion and Sediment Control Plan (ESCP) will be developed for the site prior to the start of mining operations to provide specific details of the actions that will be undertaken to prevent sediment discharge to waterways. Because infiltration rates into the excavation areas are likely to be high, runoff volumes are expected to be low and containment of water within the excavation is likely to be possible. Natural seepage to this runoff to the water table is likely to happen relatively quickly. Details of the excavation design measures that will be used to ensure no sediment discharge to surface waterways from the excavation areas will be provided in the ESCP.

4. PROPOSED CONDITIONS OF CONSENT

We propose the following conditions:

i. A Water Management Plan shall be developed for the site prior to the start of mining operations to include:
   a. A maximum rate of excavation (e.g. 100 m^3/d) for material below the water table in the area adjacent to Silverstream Swamp (see Figure 6-1, appended)
   b. Documentation of the trial excavation hydraulic conductivity testing process (see Section 3.3.2); and
   c. Actions and associated monitoring to avoid water quality impact associated with seepage from the proposed settling ponds to the underling aquifer and downgradient surface waters.

ii. An Erosion and Sediment Control Plan shall be developed for the site prior to the start of mining operations to provide specific details of the actions that will be undertaken to prevent sediment discharge to waterways.

iii. Suspended sediment, iron and manganese discharges from the operational mine site shall not result in conspicuous change in visual clarity or colour beyond the zone of reasonable mixing in surface watercourses.

iv. Iron and manganese discharges from the operational mine site shall not result in conspicuous increases in iron and manganese precipitates in surface waters.

5. REFERENCES

Atkins, J. & Mcbride, Earle. (1991). Porosity and packing of Holocene river, dune, and beach sands. Aapg Bulletin - AAPG BULL. 75.

Booker, DJ; and Whitehead, A L. 2017. NZ River Maps: An interactive online tool for mapping predicted freshwater variables across New Zealand. National Institute of Water & Atmospheric Research Ltd, Christchurch.

Kingett Mitchell & Associates Ltd, 1991. Westport Titanium Project – Summary of environmental and licensing impacts

Tonkin and Taylor, 1995. Westport Titanium Project – Assessment of environmental effects

Macara, G R. 2016. The Climate and Weather of West Coast. NIWA Science and Technology Series, Report Number 72, 2nd edition, SSN 1173-0382, NIWA, Wellington, pp38.

West Coast Regional Council Regional Land and Water Plan 2014

6. LIMITATIONS

Kōmanawa Solution Ltd (KSL) has prepared this Report in accordance with the usual care and thoroughness of the consulting profession for the use of Westland Mineral Sands Co. Ltd.

This Report has been prepared in accordance with the scope of work and for the purpose outlined at the start of this report and is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

Where this Report indicates that information has been provided to KSL by third parties, KSL has made no independent verification of this information except as expressly stated in the Report. KSL assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between 30/04/2021 and 12/07/2021 and is based on the conditions encountered and information reviewed at the time of preparation. KSL disclaims responsibility for any changes that may have occurred after this time.

This Report should be read in full. No responsibility is accepted for use of any part of this Report in any other context or for any other purpose. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This Report has been prepared for the exclusive use of Westland Mineral Sands Co. Ltd and their authorised agents. Except as required by law, no third party may use or rely on this Report unless otherwise agreed in writing by KSL.

To the extent permitted by law, KSL expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by any third party relating to or resulting from the use of, or reliance on, any information contained in this Report. KSL does not admit that any action, liability or claim may exist or be available to any third party.

APPENDICES

APPENDIX A – WATER QUALITY DATA

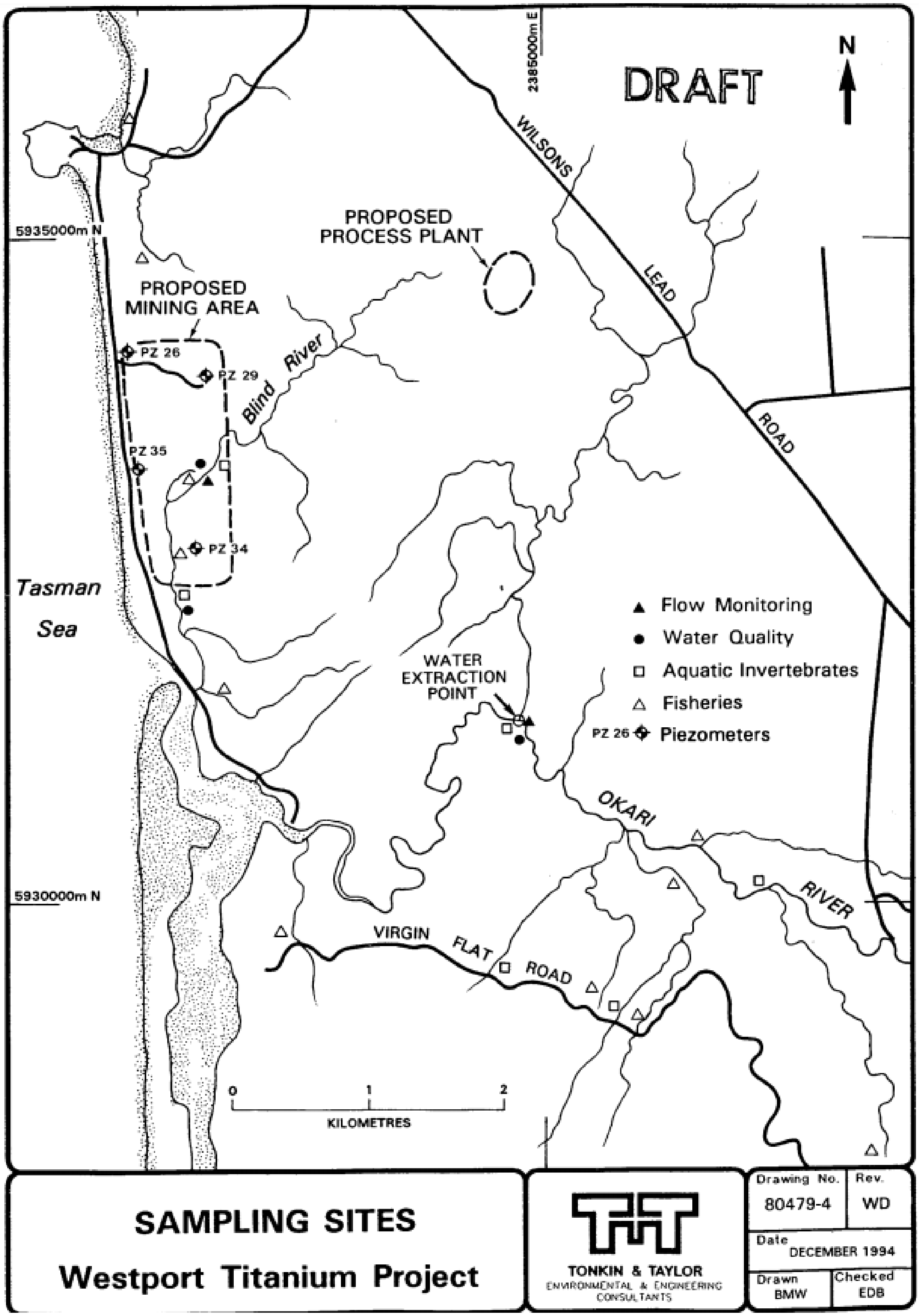

DRAFT
N
2385000m E
5935000m N
5930000m N
WILSONS
LEAD
ROAD
PROPOSED PROCESS PLANT
PROPOSED MINING AREA
PZ 26
PZ 29
PZ 35
PZ 34
Blind River
Tasman Sea
WATER EXTRACTION POINT
Flow Monitoring
Water Quality
Aquatic Invertebrates
Fisheries
PZ 26 Piezometers
OKARI
RIVER
VIRGIN FLAT ROAD
0 1 2
KILOMETRES
SAMPLING SITES
Westport Titanium Project
TONKIN & TAYLOR
ENVIRONMENTAL & ENGINEERING CONSULTANTS
Drawing No. 80479-4
Rev. WD
Date DECEMBER 1994
Drawn BMW
Checked EDB

Table 5 Natural Groundwater and Simulated Mine Pond Chemistry Analysis Results For North Nine Mile (Source: Tonkin & Taylor Ltd, 1994)

Parameter	Unit	Sample No. & date		Sample No. & date		Sample No. & date		Sample No. & date		Revised Dutch Quality Guidelines		NZDWS
		PZ26-GW1 Aug 94	PZ26-MP1 Aug 94	PZ29-GW1 Aug 94	PZ29-MP1 Aug 94	PZ34-GW1 Aug 94	PZ34-MP1 Aug 94	PZ35-GW1 Aug 94	PZ35-MP1 Aug 94	"A" Target	"C" Intervention	Highest desirable
pH (lab.)		5.9		5.2		5.9		6.0				7.4-8.5
pH (field)												
Conductivity (lab.)	mS/m	29		16		35		23				
Conductivity (field)												
Sodium	g/m³	31		16		20		20				100
Potassium	g/m³	3.6		2.4		1.5		4.8				
Calcium	g/m³	11		6.5		47		10				
Magnesium	g/m³	6.3		2.9		5.8		5.6				
Carbonate ($CaCO_3$)	g/m³	<1		<1		<1		<1				
Bicarbonate (HCO_3)	g/m³	31		12		84		18				100
Chloride	g/m³	70		28		200		40				
Sulphate	g/m³	9.0		6.0		30		20				
Lead (dissolved)	g/m³	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	.015	.075	.05
Zinc (dissolved)	g/m³	0.04	0.05	0.05	0.01	0.04	0.04	0.03	0.07	.065	.80	5
Chromium (dissolved)	g/m³	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	.001	.03	.05
Copper (dissolved)	g/m³	<0.01	0.03	<0.01	<0.01	<0.01	0.02	<0.01	0.07	.015	.075	N/A
Iron (dissolved)	g/m³	<0.05	0.78	0.13	<0.05	1.8	0.45	<0.05	0.87	-	-	1.0
Iron (total recov.)	g/m³											
Cadmium (dissolved)	g/m³	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	.0004	.006	.005
Arsenic (dissolved)	g/m³	<.001	<.001	<.001	<.001	0.001	0.001	<.001	0.002	.01	.06	.05
Titanium (dissolved)	g/m³	0.002	0.013	0.002	0.002	0.010	0.21	0.002	0.007	N/A	N/A	N/A
Suspended Solids	g/m³	780	73,000	3,100	33,000	590	77,000	5,400	34,000			
COD	g/m³	<50	5,600	64	1,200	110	2,100	62	2,400			

Notes: NZDWS = New Zealand Drinking Water Standards "Highest Desirable" category

* The Carters Beach sludge pond samples were analysed for COD & suspended solids using a different methodology to the GW1 and MP1 samples

** The slightly elevated Arsenic concentration in the Carters Beach sludge pond is consistent with higher background levels in the Carters Beach groundwater.

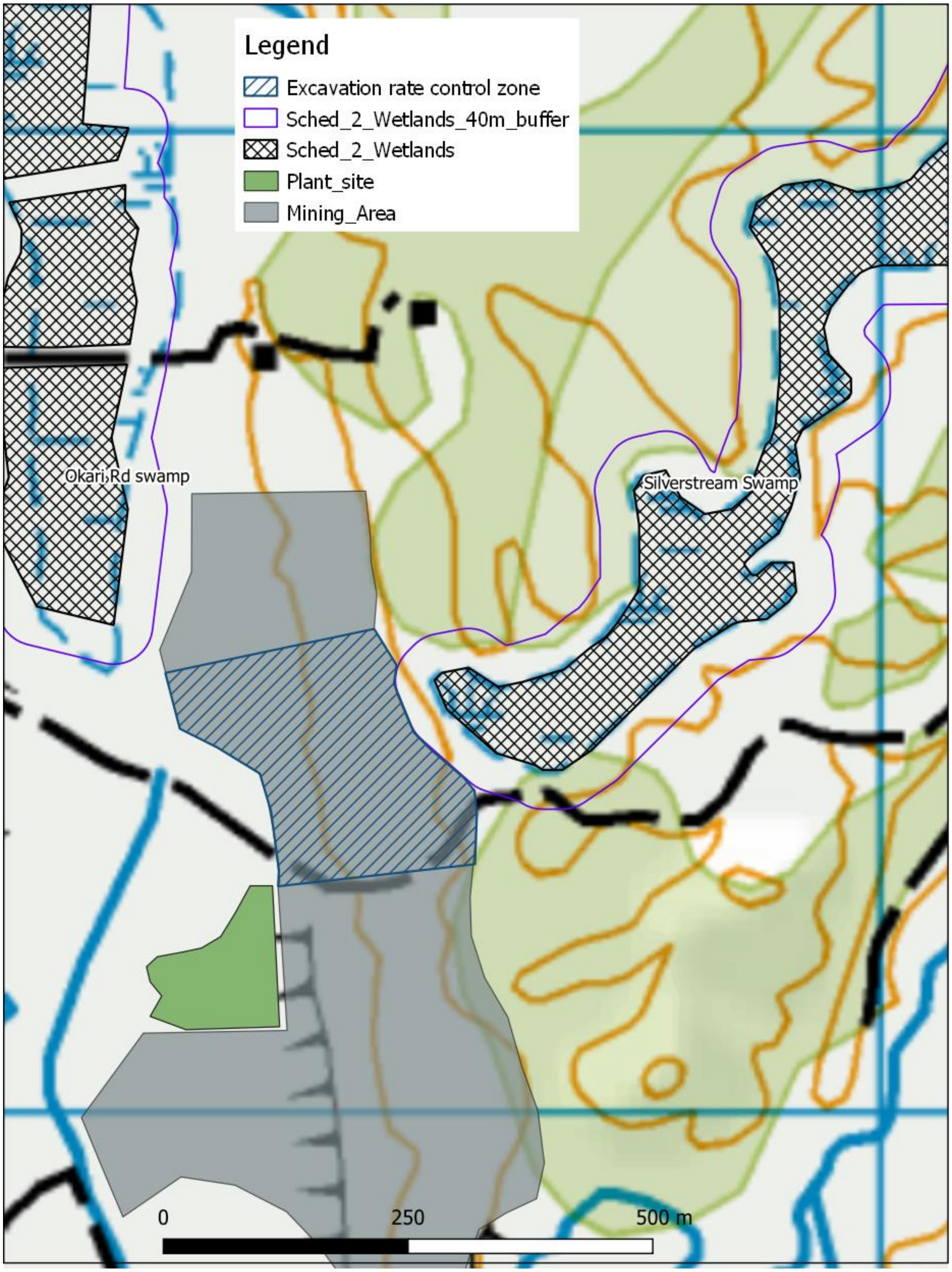
Table 7: Blind River (400 m upstream of river mouth)
Water Quality Sampling Results
(all units as g/m^3 unless otherwise stated)

Parameter	Date of Sampling 26-10-89	Date of Sampling 27-11-89	Date of Sampling 16-01-90	Date of Sampling 06-02-90
Field Measurements				
pH	6.9	6.5	6.5	7.1
Temperature (°C)	14.5	17.8	19.5	19.4
Dissolved oxygen	8.25	9.6	9.0	7.4
Conductivity (umbos cm^{-1})	100	110	107	110
Laboratory Measurements				
pH	6.6	6.5	6.6	6.7
Conductivity (mS m^{-1})	12.7	12.6	11.9	13.0
Alkalinity (as $CaCO_3$)	17	15	12	19
Hardness (as $CaCO_3$)	25	25	24	26
Calcium	6.3	6.2	6.0	6.4
Magnesium	2.2	2.2	2.1	2.3
Sodium	13.7	14.6	12.0	15.2
Potassium	0.74	0.64	1.50	0.65
Sulphate	6	2	2	4
Chloride	24	24	22	26
Suspended solids	<6	<6	<6	<6
Turbidity (NTU)	2.8	2.3	2.6	2.6
Colour (Hazen units)	40	40	100	40
Absorbence (270nm)	0.257	0.196	0.515	0.173
Absorbence (420nm)	0.031	0.023	0.061	0.022
COD	22	16	41	<6
Boron	0.08	0.06	<0.05	<0.05
Fluoride	0.09	0.14	0.32	0.14
Nitrate-nitrogen	0.052	0.024	0.027	0.018
Ammonium-nitrogen	<0.01	<0.01	<0.01	<0.01
TKN	0.25	0.33	0.48	0.28
DRP	0.012	0.004	0.019	0.011
Total phosphorus	0.021	0.017	0.049	0.026
Total iron	0.65	0.45	0.83	0.56
Soluble iron	0.29	0.37	0.52	0.35
Total manganese	0.5	0.03	0.05	0.04
Soluble manganese	0.3	0.03	0.05	0.04
Total Aluminium	<0.5	0.5	-	<0.5
Soluble Aluminium	<0.5	<0.5	<0.5	
Acid-soluble Aluminium			0.23	
Cadmium (mg m^{-3})	0.5	0.5	<0.5	<0.5
Chromium (mg m^{-3})	-	<3	<3	<3
Copper (mg m^{-3})	<2	<2	<2	<2
Nickel (mg m^{-3})	3*	<2	<2	<2
Lead (mg m^{-3})	3*	<2	<2	<2
Zinc (mg m^{-3})	<1	<1	<1	16
Arsenic (mg m^{-3})	<1	<1	<1	<1

Note: COD Chemical Oxygen Demand
DRP Dissolved Reactive Phosphorus
TKN Total Kjeldahl Nitrogen

* Nickel of 1 mg m^{-3}) recorded from field blank

APPENDIX B – PROPOSED EXCAVATION RATE CONTROL ZONE



Kōmanawa Solutions Ltd	Project name:	Westland Mineral Sands quarry
	Date:	Date: 112/07/2021
	Title	Proposed control zone for excavation below water table

Figure 6-1 Proposed excavation rate control zone