

Willis Bond & Co Ltd
PO Box 24137
Wellington 6142

Attention: Rosalind Luxford

Dear Rosalind

Wellington Waterfront Site 10 - Groundwater and Contamination Assessment and Basement Dewatering Effects

1. Introduction

This report summarises the following for the Site 10 development along Wellington waterfront (refer Figure 1):

- Likely hydrogeology of the site based on available information from nearby sites and the recent site investigation;
- Predicted settlement due to groundwater drawdown and the impact to nearby buildings and services;
- Likely volumes of water to be discharged due to dewatering based on results of seepage modelling;
- Potential cofferdam defects;
- Potential that the groundwater to be discharged is contaminated.

The work was done in accordance with our engagement dated 10 December 2014 (Variation V03).



Figure 1. Site location plan



2. Site Hydrogeology

Based on available information, the inferred site ground profile for the purpose of groundwater assessment and seepage is shown in Table 2.1 below. Sampling and testing was undertaken at three piezometer standpipes, P1, P2 and P3 (refer Figure 2 for location plan). Two falling head tests were carried out within the upper zone of the Fill in P1 and P3 and yielded permeability of 3×10^{-4} m/s and 1×10^{-2} m/s respectively. The inferred permeability based on current and historic available data is summarised in Table 2.1.

Continuous groundwater monitoring was carried out in P1 and P3 between 09/01/2015 and 16/01/2015 and groundwater plot is attached in Appendix A. It is clear from the monitoring that there is direct hydraulic connectivity between the site and the sea. The site groundwater variation ranges from 0.5m to 0.7m between the high and low tide. The tide variation ranges from 0.9m to 1.0m. Therefore the groundwater level is slightly higher than the sea level. The highest and lowest measured groundwater level is approximately 1.6m below ground level (mbgl) and 2.4mbgl. For groundwater seepage into excavation assessment, a groundwater level of 1.5mbgl is adopted.



Figure 2. Investigation location plan

Table 2.1 Summary of Ground Hydrogeology

Soil Type	Thickness (m)	Permeability (m/s)
Fill	5	1×10^{-2} to 1×10^{-6}
Beach Deposit	1	1×10^{-2} to 1×10^{-4} (1)
Alluvium	-	1×10^{-6} to 1×10^{-9} (1)

Note:

1. Lower bound represents silty sand beds and upper bound represents clay beds.

3. Seepage Analyses and Groundwater Discharge

Seepage analyses were carried out to assess the amount of inflow into the excavation and an estimate of groundwater discharge may be evaluated. Additionally the seepage models may be used to predict likely groundwater drawdown (and hence settlement – see Section 4.0 below) outside the cofferdam. As the mass permeability of the ground can be highly variable particularly in the Fill and between the sand and clay fractions within the Alluvium, sensitivity analyses were carried out to assess the effects of permeability. Additionally, it is common to expect that the deep soil mixing cofferdam can achieve a permeability in the order of 10^{-8} m/s but the performance of the cut-off wall in the event of possible hydro-fracture (fracturing of cofferdam due to water pressures) and/or

excavation effects is unknown. Therefore sensitivity of the cofferdam permeability was also carried out. Given the relatively small head difference across the cofferdam and the low permeability of the Alluvium, the most likely flow into the excavation will be through the cut-off wall in the event of a fracture although this is likely to be a low risk. The cut-off wall is modelled with a toe level 7.5mbgl to allow 1.5m toe in to the less permeable Alluvium to ensure an adequate cut-off. Also this toe level is likely to be needed for the stability of the wall (to be assessed separately).

The results of the analyses are summarised in Table 3.1 below. It should be noted that the results presented are due to seepage into the cofferdam. The amount of water already present in the basement footprint (i.e. non-seepage effects) to be discharged depends on the porosity of the Fill. Assuming a porosity in the order of 30% to 40%, the amount of water discharge is in the order of 1600m³ to 2200m³ with a basement footprint approximately 2700m² and 2m of groundwater contained within. The perimeter of the basement is approximately 260m.

Table 3.1 Summary of Seepage Analyses

No.	Fill and Beach Deposit Permeability (m/s)	Alluvium Permeability (m/s)	Cut-off Wall Permeability (m/s)	Seepage (m ³ /day) [litres/day]	Drawdown Immediately Behind Wall (m)
1	1 x 10 ⁻²	1 x 10 ⁻⁸	1 x 10 ⁻⁸	4 [4000]	0.0
2	1 x 10 ⁻⁶	1 x 10 ⁻⁸	1 x 10 ⁻⁸	4 [4000]	0.2
3	1 x 10 ⁻²	1 x 10 ⁻⁸	1 x 10 ⁻⁶	300 [300,000]	0.0
4	1 x 10 ⁻²	1 x 10 ⁻⁶	1 x 10 ⁻⁶	360 [360,000]	0.0
5	1 x 10 ⁻⁴	1 x 10 ⁻⁷	1 x 10 ⁻⁷	35 [35,000]	0.0
6	1 x 10 ⁻⁶	1 x 10 ⁻⁷	1 x 10 ⁻⁷	16 [16,000]	0.9

The most onerous scenario in terms of seepage into excavation would be a very high permeability Fill coupled with a high permeability cut-off wall (possibly due to fracture) and this is demonstrated in Analysis 4. A more probable or “average” permeability analysis is shown in Analysis 5. As demonstrated above, the amount of seepage into excavation is highly dependent on the permeability and performance of the cofferdam water tightness. At this stage, it can be assumed that water inflow is likely to be in the region of 35m³/day to 350m³/day (0.4 litres/s to 4 litres/s) and the upper bound related to poor performance of cofferdam in the unlikely event of hydro fracture and/or other unexpected leakage.

Drawdown is highly dependent on the permeability of the soil and in general, the lower the permeability, the higher the drawdown due to the lower rate of recharge. As demonstrated above when the permeability of the Fill is low, drawdown is recorded. In summary, as the head difference is small (approx. 2m), together with fairly permeable Fill, drawdown is expected to be small. In the event that low permeability Fill is encountered with a slightly higher than expected permeability of cofferdam (probably due to defects in cofferdam), drawdown in the order of 1m can be expected.

In view of the seepage results there is no real benefit to increase the length of the cofferdam from groundwater control standpoint. The current toe level is expected to penetrate 1.5m into the less permeable Alluvium to form a good water cut-off. The permeability of the cofferdam wall will be specified to achieve a minimum of 1x10⁻⁸m/s and shall be verified through testing cored samples. Hydro-fracture and cracking of wall due to excavation remains a low risk since the water head difference is small and the depth of excavation is modest. However poor construction of the cofferdam remains a risk and can be mitigated through best practice and quality control on site. Another significant risk is the variability of the Fill material causing local defects in the cofferdam in a

band of highly permeable fill. In such cases, flow rates in the order of 15litres/s to 20litres/s can be expected.

4. Impact Assessment

The effect of basement dewatering is potential groundwater drawdown outside the cut-off wall. As demonstrated in Section 3 above, limited drawdown may be expected. For settlement calculation purposes, effective stresses increase due to 1m groundwater drawdown has been assumed. It is worth noting that this is a conservative estimate as lowest measured groundwater level is approx. 2.4mbgl and excavation level is 3.5mbgl and a 1m drawdown will be on the assumption that the cofferdam is poorly performing.

The settlement due to 1m groundwater drawdown is estimated to be between 10mm and 15mm at the cofferdam position and decreases almost linearly away from the cofferdam to a distance of approximately 10m from the cofferdam. No settlement is expected 10m away from the cofferdam. Minimal impact is expected on services for such magnitude of settlement. Existing buildings are sufficiently far (approx. 10m or more away) to be affected by the predicted settlement.

5. Groundwater quality assessment

Soil testing indicates that fill within the proposed basement excavation at and below groundwater level has elevated concentrations of metals and polycyclic aromatic hydrocarbons (PAH). Therefore there is the potential for elevated concentrations of metals and PAH in groundwater. If the water to be extracted is contaminated, there will be constraints on disposal of the water.

5.1 2014 groundwater testing

Preliminary groundwater testing was undertaken at 2 standpipes (P1 and P2) within the proposed basement footprint in 2014 (refer *Ground contamination assessment, Wellington Waterfronts Sites 8,9,10*, dated October 2014, T&T ref: 85778.001).

All PAH were well below the Australian and New Zealand Environment Conservation Council (ANZECC) 2000 guidelines for protection of 95% of marine species (refer Table 5.1).

All metals were below detection limits (refer Table 5.2). Copper and zinc detection limits were above the ANZECC guidelines for protection of 80% of marine species. The laboratory was unable to achieve lower detection limits for these samples.

Sulphate exceeded the Wellington City Council (WCC) trade waste limits at one standpipe.

Table 5.1: PAH (mg/L)

Sample location	Anthracene	Benzo[a]pyrene (BAP)	Fluoranthene	Naphthalene	Phenanthrene
P1	< 0.00010	0.00014	0.00022	< 0.0005	< 0.0004
P2	< 0.00010	< 0.00010	< 0.00010	< 0.0005	< 0.0004
Guidelines					
ANZECC 95% ¹	0.004 ²	0.0007 ²	0.002 ²	0.07	0.008 ²

Only PAH with ANZECC guidelines are reported in this summary table. **Bold** exceeds ANZECC guidelines.

1. ANZECC 95% species protection for marine water.

2. ANZECC Guidelines Vol 2. Section 8.3.7 - Interim working levels for 99% species protection for marine water.

Table 5.2: Inorganics (mg/L)

Location	pH	Sulphate	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
P1	7.2	750	< 0.10	< 0.005	< 0.05	< 0.05	< 0.010	< 0.05	< 0.10
P2	7.7	<u>3400</u>	< 0.10	< 0.005	< 0.05	< 0.05	< 0.010	< 0.05	< 0.10
Guidelines									
ANZECC 80% ¹	-	-	0.0045 ²	0.036	0.0906	0.008	0.012	0.56	0.043
ANZECC 95% ³	-	-	-	0.0055	0.0274	0.013	0.0044	0.07	0.015
WCC trade waste ⁴	-	1500	-	-	-	-	-	-	-

Bold exceeds ANZECC guidelines. Underline exceeds trade waste guidelines.

1. ANZECC 80% species protection for marine water.
2. ANZECC Guidelines Vol 2. Section 8.3.7 - Interim working levels for 80% species protection for marine water.
3. ANZECC 95% species protection for marine water.
4. WCC (2004). Trade waste bylaw Table 1 – Sulphate with good mixing.

5.2 Follow up groundwater testing

Due to the potential for elevated metals, additional groundwater samples were collected from 3 locations (P1, P2 and P3) on 16 January 2015 (high tide) and 2 locations (P1, P3) on 5 February 2015 (low tide). Tide conditions and times were obtained from the MetService website.

Each standpipe was purged in 2L intervals using a peristaltic pump, until pH and conductivity stabilised for three consecutive readings. P2 was dry at low tide. All groundwater samples were clear and no odour or surface sheen was noted.

All samples were placed into clean sample bottles prepared by the laboratory. The samples were sent to Hill Laboratories under chain of custody documentation. All samples were tested for metals. Given that the 2014 results showed PAH concentrations were well below the guideline values, the follow up samples were not tested for PAH.

The laboratory reports are in Appendix B.

5.3 QA/QC

Two groundwater duplicate samples were tested to check the variability of the samples, one for the high tide sampling (16 January 2015), and one for low tide (5 February 2015). The results are provided in Table 5.3.

In general, the results agreed well, with the exception of total zinc in the high tide sample. This indicates some variability in the total metals results. Dissolved metals are used for the purpose of assessing potential effects of the discharge on the receiving environment. The dissolved metal results compared well with their duplicates.

Table 5.3: QA/QC results (mg/L)

	High Tide (16 January 2015)			Low Tide (5 February 2015)		
	P1	Duplicate	Relative % difference ¹	P3	Duplicate	Relative % difference ¹
pH	7.7	7.7	0.0%	7.6	7.7	1.3%
Dissolved Copper	< 0.0010	0.0012 ²	-	0.001	< 0.0010	-
Total Copper	< 0.0011	< 0.0011	-	0.0012	< 0.0011	-
Dissolved Lead	< 0.0010	< 0.0010	-	< 0.0010	< 0.0010	-
Total Lead	0.0063	0.0051	21%	< 0.0011	< 0.0011	-
Dissolved Zinc	< 0.004	< 0.004	-	0.006	< 0.004	-
Total Zinc	0.0123	< 0.00422	-	0.0046	0.0046	0.0%
Sulphate	178	185	3.9%	2,500	2,600	3.9%

Notes:

1. Where a result is less than the laboratory detection limit, the RPD is not calculated.
2. The copper result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the analysis methods.

5.4 Results

The results of the groundwater testing undertaken in 2015 are included in Table 5.4. The results indicate the following:

- Groundwater quality varies across P1, P2 and P3.
- Groundwater quality varies between high and low tide conditions. Lead and zinc concentrations were higher at high tide than at low tide.
- Metals are mostly adsorbed to sediment.
- For both high and low tide conditions, most metals are within ANZECC guidelines for protection of 95% of marine species. On one occasion at one location, copper exceeds ANZECC guidelines for protection of 80% of marine species.
- Sulphate is within the trade waste limit at P1, however exceeds the limit at P2 and P3.

Table 5.4: Inorganics (mg/L)

Location	Tide	pH	Sulphate	Copper		Lead		Zinc	
				Total	Dissolved	Total	Dissolved	Total	Dissolved
P1	High	7.7	178	< 0.0011	< 0.0010	0.0063	< 0.0010	0.0123	< 0.004
	Low	7.5	230	0.0014	0.0012	0.0018	< 0.0010	0.0057	< 0.004
P2	High	7.7	<u>2700</u>	0.0055	0.0044	0.0018	< 0.0010	< 0.0042	< 0.004
	Low	-	-	-	-	-	-	-	-
P3	High	7.6	<u>2600</u>	0.10	0.08	0.0026	< 0.0010	0.0108	0.005
	Low	7.6	<u>2500</u>	0.0012	0.001	< 0.0011	< 0.0010	0.0046	0.006*
Guidelines									
ANZECC 80% ¹	-	-	-	-	0.008	-	0.012	-	0.043
ANZECC 95% ²	-	-	-	-	0.013	-	0.0044	-	0.015
WCC trade waste ³	-	-	1500	-	-	-	-	-	-

Bold exceeds ANZECC guidelines. Underline exceeds trade waste guidelines. * The zinc result for the dissolved fraction was greater than that for the total fraction, but the laboratory reported this was within analytical error.

1. ANZECC 80% species protection for marine water.
2. ANZECC 95% species protection for marine water.
3. WCC (2004). Trade waste bylaw Table 1 – Sulphate with good mixing.

5.5 Implications

The groundwater in the monitoring wells has variable spatial and temporal quality. Therefore, the composition of the actual bulk water that would be extracted during dewatering is not known. However, the limited data collected to date allow preliminary assessment of the feasibility of potential disposal options.

5.5.1 Discharge to stormwater

If the extracted groundwater is discharged to stormwater, it would then discharge to Wellington harbour.

The groundwater quality measured at P1, P2 (three occasions) and P3 (two occasions) are generally below ANZECC guidelines for protection of 80% of marine species.

Because the metals are largely associated with the sediment (i.e., the total concentrations are higher than dissolved concentrations), good sediment control will help improve the quality of groundwater discharge.

Dilution within the Wellington Harbour would be significant. Based on these limited data, discharge of the dewatering water to the harbour is not expected to have a significant effect on the water quality of the Wellington Harbour.

Discharge to stormwater would require resource consent from GWRC (for discharge of groundwater to stormwater) and a stormwater permit from WCC. GWRC and/or WCC may require additional testing to support an application.

5.5.2 Discharge to trade waste

Sulphate is within WCC trade waste guidelines at P1, however exceeds guidelines at P2 and P3. The bulk concentration of the discharge may meet the trade waste criteria.

Discharge to trade waste will require a permit from WCC. WCC would likely also require assessment of other water quality parameters (e.g., total suspended solids concentration) in order to assess an application for disposal to trade waste. The total suspended solids concentration of the groundwater to be extracted cannot be estimated from the borehole data.

5.5.3 Aggressiveness for concrete design

The exposure classification for concrete piles in soil was assessed in accordance with Table 6.2.4 (c) of the *Australian Standard for Piling – Design and Installation AS 2519 -2009*.

Assuming soil condition A (high permeability soils which are in groundwater), Table 6.2.4 (C) indicates the measured sulphate concentration in samples P2 and P3 may result in a moderate exposure classification. At P1, the measured sulphate concentration may result in a mild exposure classification.

6. Summary

Dewatering requirements

- Estimated discharge volume (non-seepage) = 1600m³ to 2200m³
- Estimated discharge volume (seepage) = 35m³/day to 350m³/day (0.4 litres/s to 4 litres/s) with upper bound related to poor performance of cofferdam in the unlikely event of hydro fracture and/or other unexpected small leakage
- Estimated discharge volume (local major defects in cofferdam) = 15 litres/s to 20 litres/s
- Risk of hydro-fracture of cofferdam = Low
- Risk of cofferdam damage due to basement excavation = Low
- Risk of cofferdam defects due to poor construction = Moderate and can be significantly reduced to Very Low through the use of experience Contractors and implementing strict quality control
- Risk of poor/highly unfavourable ground conditions leading to major local defects in cofferdam = Moderate/High
- Estimated groundwater drawdown outside cofferdam = up to 1m (conservatively)
- Estimated ground settlement due to groundwater drawdown = 10mm to 15mm at outside face of cofferdam and 0mm at 10m distance
- Impact of induced settlement on existing services and structures = Low
- Depth of cofferdam = 7.5mbgl to ensure 1.5m toe in to less permeable Alluvium to ensure water tightness. There is no additional benefit deepening this.

Groundwater quality assessment

Groundwater quality varies spatially and temporally (with tides). Although the bulk composition of groundwater that would be extracted is not known, the preliminary testing indicates:

- Discharge of groundwater to the harbour is not expected to have a significant effect on water quality in Wellington harbour. However, resource consent from and a stormwater permit from WCC would be required, and additional testing may be needed to support an application.
- Good sediment control will help improve the quality of groundwater discharge.

- Discharge to trade waste would require a permit from WCC. WCC may require testing of the actual water to be extracted to confirm sulphate and total suspended solids concentrations are acceptable.
- Groundwater may carry a mild to moderate exposure classification in terms of Table 6.2.4 (c) of the *Australian Standard for Piling – Design and Installation AS 2519 -2009* due to the presence of sulphate.

7. Applicability

This report has been prepared for the benefit of Willis Bond & Co Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

The ground model and design ground parameters have been developed by inferring from nearby sites and actual conditions at the site may vary, particularly in the fill material. Such variations can have a significant impact in the predictions of seepage flow, volumes of water to be discharged and settlements especially when such adverse ground conditions cause major defects in the cofferdam which will null the current predictions.

Recommendations and opinions in this report are based on data from discrete samples. The nature and continuity of subsoil away from the sample locations are inferred but it must be appreciated that actual conditions could vary from the assumed model.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:

Authorised for Tonkin & Taylor Ltd by:

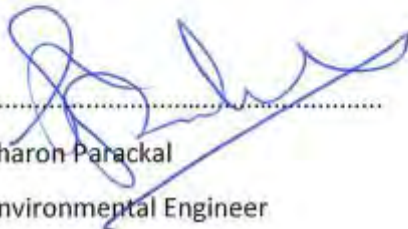



Eng Chin

Stuart Palmer

Senior Geotechnical Engineer

Project Director



Sharon Parackal

Environmental Engineer

Technical review of groundwater quality assessment by: Penny Kneebone (senior environmental scientist).

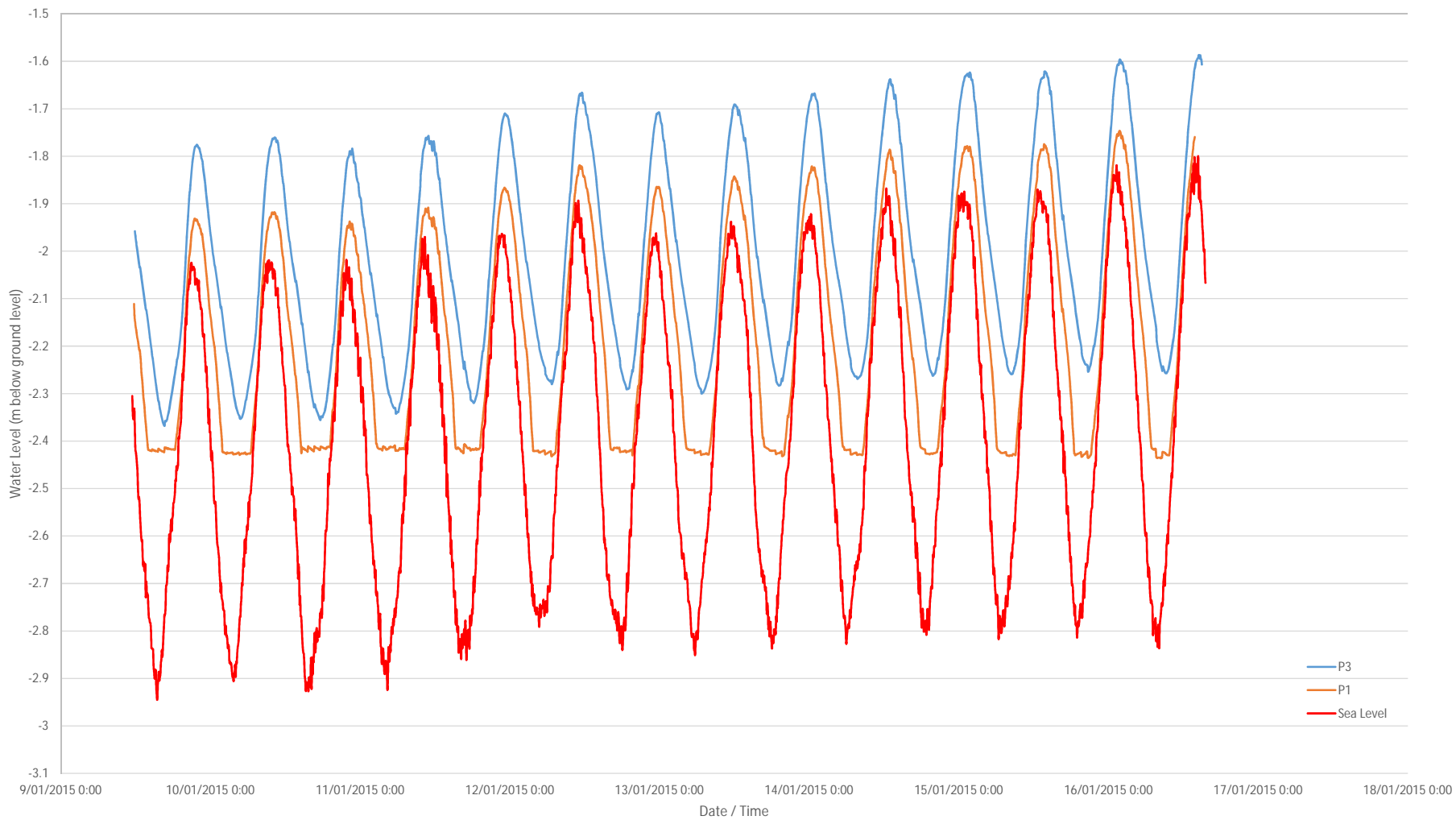
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Appendix A: Groundwater Monitoring Plot

- **Groundwater Monitoring Plot**

Site 10 Water Level P1, P3 and Sea Level Data (9/01/2015 - 16/01/2015)



Appendix B: Laboratory reports

ANALYSIS REPORT

Page 1 of 2

Client:	Tonkin & Taylor	Lab No:	1375764	SPV1
Contact:	Sharon Parackal C/- Tonkin & Taylor PO Box 2083 WELLINGTON 6140	Date Registered:	22-Jan-2015	
		Date Reported:	12-Feb-2015	
		Quote No:	66224	
		Order No:		
		Client Reference:		
		Submitted By:	Sharon Parackal	

Sample Type: Saline

	Sample Name:	P1 Borehole 16-Jan-2015 2:35 pm	P2 Borehole 16-Jan-2015 2:00 pm	P3 Borehole 16-Jan-2015 3:05 pm	Duplicate 16-Jan-2015	
	Lab Number:	1375764.1	1375764.2	1375764.3	1375764.4	
pH	pH Units	7.7	7.6	7.6	7.7	-
Dissolved Copper	g/m ³	< 0.0010	0.0044	0.080	0.0012 #2	-
Total Copper	g/m ³	< 0.0011	0.0055	0.100	< 0.0011 #2	-
Dissolved Lead	g/m ³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Total Lead	g/m ³	0.0063	0.0018	0.0026	0.0051	-
Dissolved Zinc	g/m ³	< 0.004	< 0.004	0.005	< 0.004	-
Total Zinc	g/m ³	0.0123 #1	< 0.0042	0.0108	< 0.0042	-
Sulphate	g/m ³	178	2,700	2,600	185	-

Analyst's Comments

#1 Confirmed by repeat analysis.

#2 It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
Total Digestion of Saline Samples	Nitric acid digestion. APHA 3030 E 22 nd ed. 2012 (modified).	-	1-4
pH	Saline water, pH meter. APHA 4500-H ⁺ B 22 nd ed. 2012.	0.1 pH Units	1-4
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22 nd ed. 2012.	-	1-4
Dissolved Copper	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0010 g/m ³	1-4
Total Copper	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0011 g/m ³	1-4
Dissolved Lead	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.0010 g/m ³	1-4
Total Lead	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.0011 g/m ³	1-4
Dissolved Zinc	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.004 g/m ³	1-4
Total Zinc	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0042 g/m ³	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 nd ed. 2012.	0.5 g/m ³	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental Division

ANALYSIS REPORT

Page 1 of 2

Client:	Tonkin & Taylor	Lab No:	1382012	SPv2
Contact:	Sharon Parackal C/- Tonkin & Taylor PO Box 2083 WELLINGTON 6140	Date Registered:	07-Feb-2015	
		Date Reported:	18-Feb-2015	
		Quote No:	66224	
		Order No:		
		Client Reference:		
		Submitted By:	Sharon Parackal	

Sample Type: Saline

Sample Name:		P1-Low Tide 05-Feb-2015	P3-Low Tide 05-Feb-2015	Dup 05-Feb-2015		
Lab Number:		1382012.1	1382012.2	1382012.3		
pH	pH Units	7.5	7.6	7.7	-	-
Dissolved Copper	g/m ³	0.0012	0.0010	< 0.0010	-	-
Total Copper	g/m ³	0.0014	0.0012	< 0.0011	-	-
Dissolved Lead	g/m ³	< 0.0010	< 0.0010	< 0.0010	-	-
Total Lead	g/m ³	0.0018	< 0.0011	< 0.0011	-	-
Dissolved Zinc	g/m ³	< 0.004	0.006 #1	< 0.004	-	-
Total Zinc	g/m ³	0.0057	0.0046 #1	0.0046	-	-
Sulphate	g/m ³	230	2,500	2,600	-	-

Analyst's Comments

#1 It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-3
Total Digestion of Saline Samples	Nitric acid digestion. APHA 3030 E 22 nd ed. 2012 (modified).	-	1-3
pH	Saline water, pH meter. APHA 4500-H ⁺ B 22 nd ed. 2012.	0.1 pH Units	1-3
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22 nd ed. 2012.	-	1-3
Dissolved Copper	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0010 g/m ³	1-3
Total Copper	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0011 g/m ³	1-3
Dissolved Lead	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.0010 g/m ³	1-3
Total Lead	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.0011 g/m ³	1-3
Dissolved Zinc	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.004 g/m ³	1-3
Total Zinc	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0042 g/m ³	1-3
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 nd ed. 2012.	0.5 g/m ³	1-3

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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