

NHT Funded Project NLP 13188

The effects of waste disposal on groundwater quality in Tasmania



Stieglitz sewage lagoons

**Tasmanian Geological
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Groundwater quality investigations at the Stieglitz sewage lagoons

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Abstract

Groundwater was investigated in the area of the Stieglitz sewage lagoons to determine if the lagoons were affecting groundwater quality. The lagoons are situated close to perched shallow water tables. Further investigations are required to refine the hydrogeological model of the site and preferred pathways of flow from groundwater mounding beneath the lagoons.

INTRODUCTION

Mineral Resources Tasmania (MRT) initiated a project to investigate the effects of waste disposal on groundwater quality in Tasmania. The project was funded by MRT and the Natural Heritage Trust (NHT) and included a number of sites for detailed study. The sewage lagoons at Stieglitz were one of these sites.

The objectives of the investigations at the Stieglitz sewage lagoons were to:

- ☐ Determine the geological nature of the host materials;
- ☐ Identify the depth of the water table;
- ☐ Examine the quality of the groundwater;
- ☐ Determine the permeability of the host materials; and
- ☐ Identify if a potential hydraulic connection exists between the lagoons and the local groundwater system.

SITE DESCRIPTION

The township of Stieglitz is located on the east coast of Tasmania, bordering Georges Bay about four kilometres east of St Helens. The Stieglitz sewage lagoons are located approximately 500 metres southeast of Stieglitz (609 200 mE, 5 423 700 mN) (fig. 1). The lagoons, which have been in operation since about 1983, are currently licensed by the Department of Primary Industries, Water and Environment (DPIWE) while the Break O'Day Council is responsible for maintenance. Engineering

consultants Sinclair Knight Merz have supervised additional engineering works undertaken since the initial construction of the lagoons.

During construction both lagoons had a one metre cement wave wall constructed at surface level to prevent wave erosion damage. Post construction, the southern lagoon was lined with geo-fabric material sprayed with bitumen. This liner has since lifted from the base of the lagoon and can be seen floating at the surface (Plate 1). Both lagoons are located in gravelly sand.

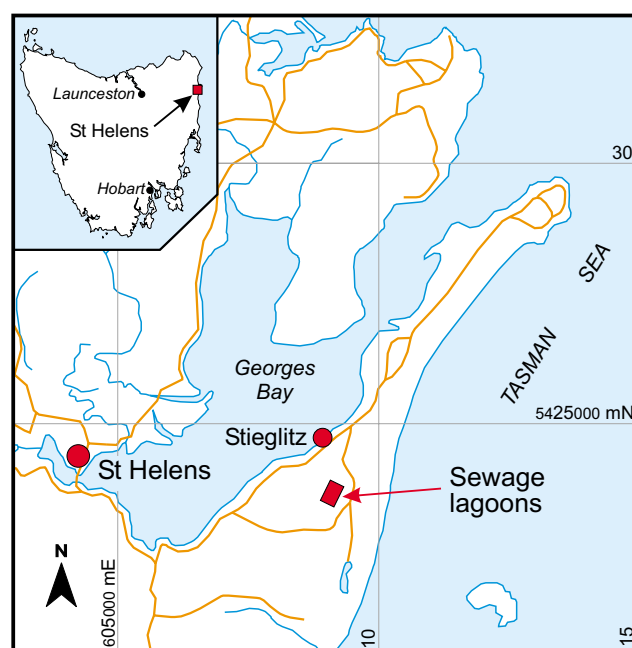


Figure 1

Location of the Stieglitz sewage lagoons.

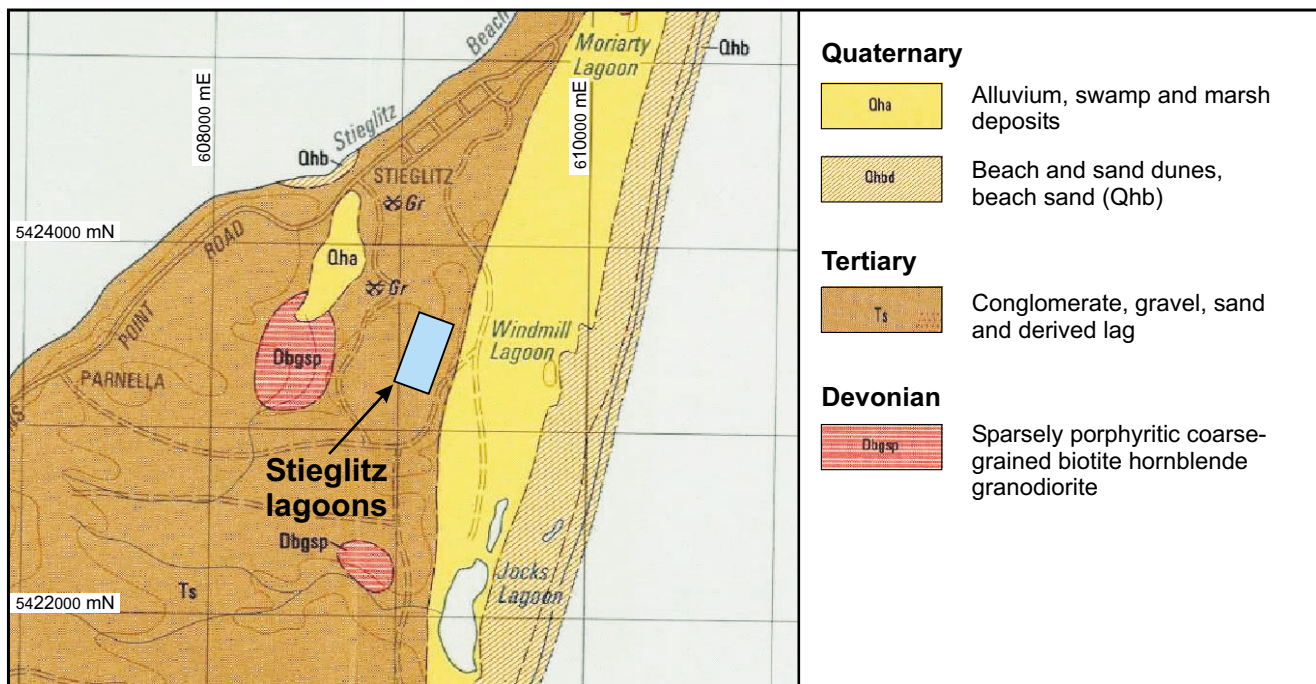


Figure 2

Extract from the St Helens geological map (McClenaghan et al., 1987) of the local area and related geology.



Plate 1

Geo-fabric liner sprayed with bitumen floating in the southern lagoon.



Plate 2

Drainage line west of the sewage lagoons with bore hole SZSL2001/2 in the foreground.

Geology

The Tasmania Department of Mines 1:50 000 scale geological map of the St Helens area (McClenaghan *et al.*, 1987) indicates that the geology of the lagoon footprints comprises Tertiary-aged conglomerate, gravel and sand (fig. 2). Quaternary-aged alluvial, swamp and marsh deposits are indicated to the east of the lagoons.

Geological mapping during the current study indicated that the site is dominated by gravel and sand deposits within 80 m of the lagoons in all directions. Occasional small pods of high plasticity white clay were observed in the area of an old landfill southwest of the lagoons. Dark brown hard pans of iron-enriched material were also observed in the area.

Hydrology

The lagoons are located within 100 m of a drainage line to the west that discharges into Chimneys Lagoon (Plate 2). Windmill Lagoon is located approximately 250 m to the east of the lagoons. Australian Bureau of Meteorology rainfall station 092033 (St Helens Post Office) is the closest rainfall station to the site. The chart of average monthly recorded rainfall (fig. 3) shows that the average annual rainfall of 774.6 mm is evenly distributed over the year. The average annual rainfall is low when regarded in a statewide perspective.

INVESTIGATION METHODS

Borehole drilling and installation

Five 120 mm diameter monitoring bores were auger drilled on 8 March 2001 for this project (fig. 4). All bores (except SZSL2001/4) were drilled to the maximum depth capacity of the drilling rig. Fifty millimetre PVC casing and slotted screens with bentonite seals were installed in each hole. All bores were logged in accordance with AS 1726-1993; engineering logs are presented in Appendix 1.

Groundwater was encountered between 3.2 m (SZSL2001/4) and 7.1 m (SZSL2001/3) depth below

ground level across the site. Flow during drilling indicated that the groundwater in all boreholes was unconfined. Recorded yields of bores ranged between 0.012 to 0.033 l/s. Figure 5 shows a cross-section and the standing water level on 19 August 2001.

Both the unsaturated and saturated zones mainly consist of heterogenous layers of clay, fine to coarse-grained sand and gravel. Layers of low to medium plasticity clay were intercepted in boreholes SZSL2001/2 and SZSL2001/3. A strong organic odour was observed on the returns of SZSL2001/1 between 2.3 and 8.3 metres. Rounded quartzite pebbles were intercepted in bore SZSL2001/4 and indicate reworking and imported material in this area.

SZSL2001/4 was drilled as a potential up-gradient background bore. Several months after the installation of the bores, the Break O'Day Council undertook earthworks to control surface water run off in the vicinity of the southwest corner of the southern lagoon. Hole SZSL2001/4 failed to make water after these earthworks were undertaken.

Engineering logs of the boreholes indicate that the bund walls overlying the Tertiary sediments consist of reworked clayey sandy gravelly material.

In situ permeability testing

A slug extraction test on bore SZSL2001/3 was carried out on 17 August 2001. Data collected during this test is presented in Appendix 2.

The slug extraction test data was analysed in the software package *AquiferWin32* (Version 2.17, Environmental Simulations Inc.). The Bouwer and Rice (1976, Unconfined Aquifer) solution was used to calculate the hydraulic conductivity value for SZSL2001/3 (fig. 6). This method was selected as the most appropriate available within the software package.

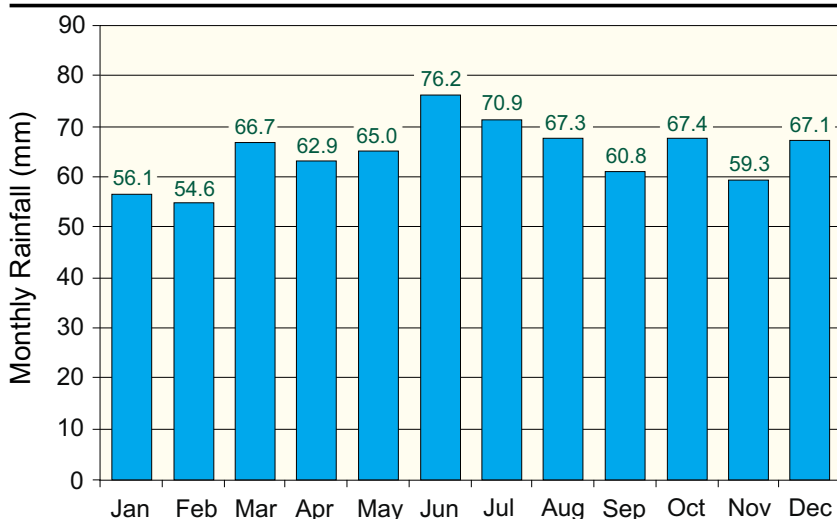


Figure 3
Average monthly rainfall for Australian Bureau of Meteorology rainfall station 092033, St Helens Post Office.

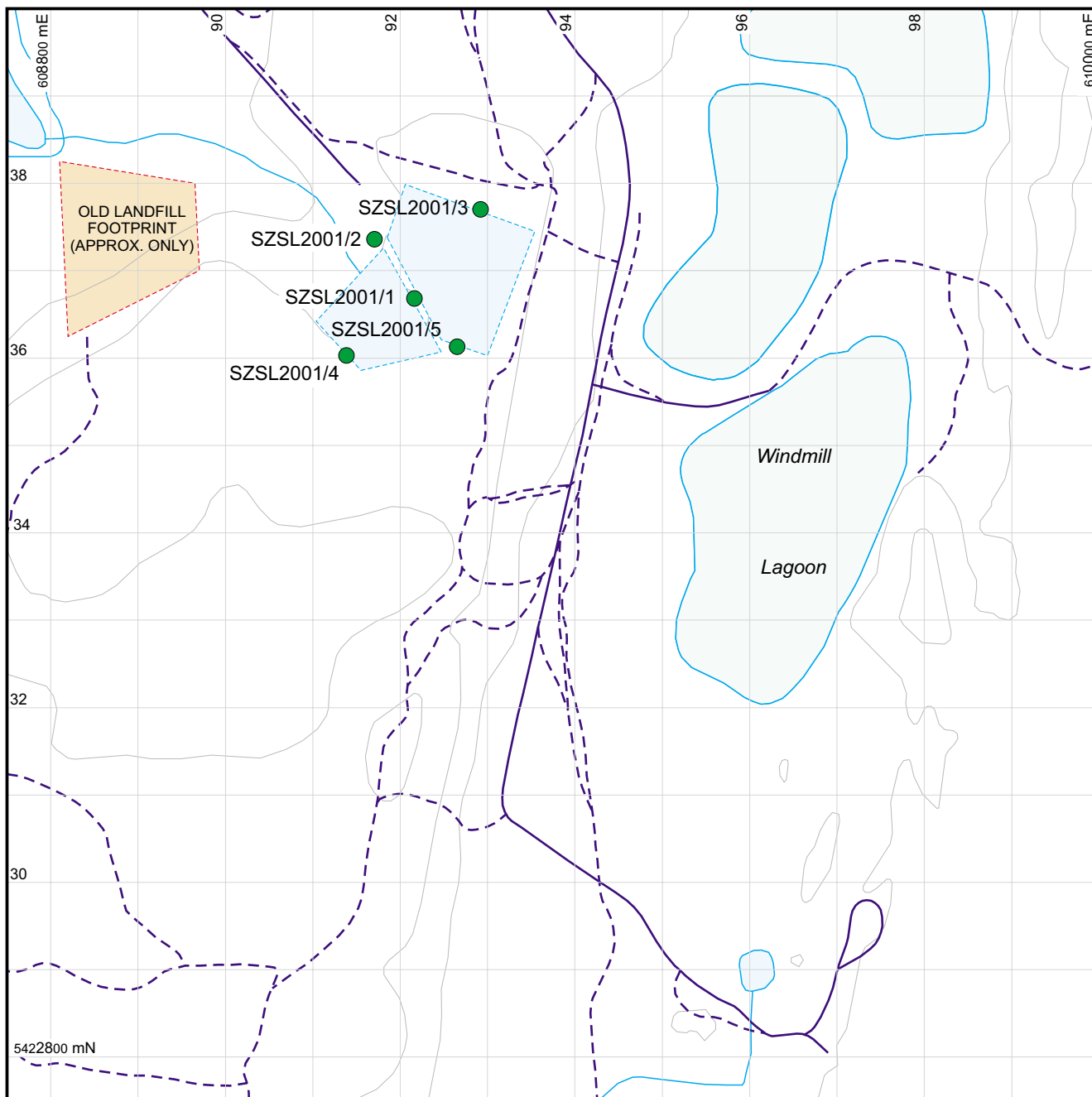


Figure 4
Locations of environmental monitoring bores installed at the Stieglitz sewage lagoons.

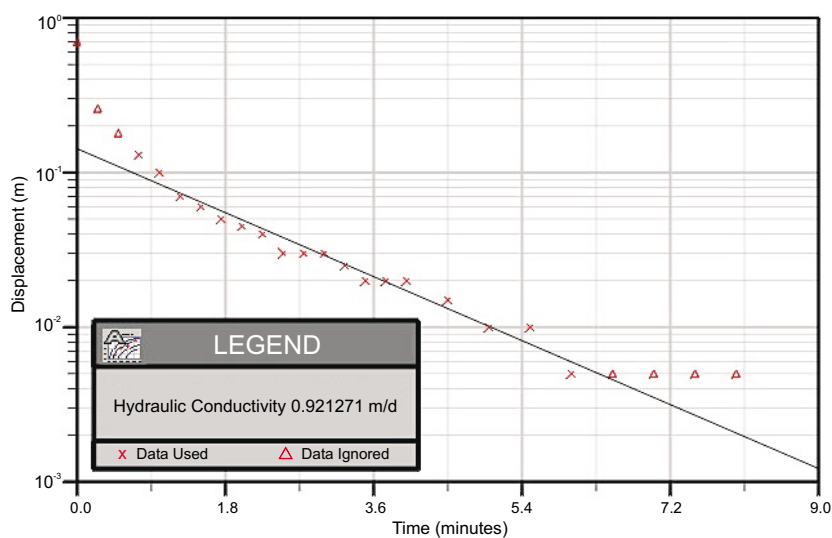


Figure 6
Hydraulic conductivity value for SZSL2001/3 ($K = 0.92 \text{ m/d} = 1.07 \times 10^{-5} \text{ m/sec}$) calculated in AquiferWin32 (Version 2.17, Environmental Simulations Inc.), Bouwer and Rice (1976 Unconfined Aquifer) solution.

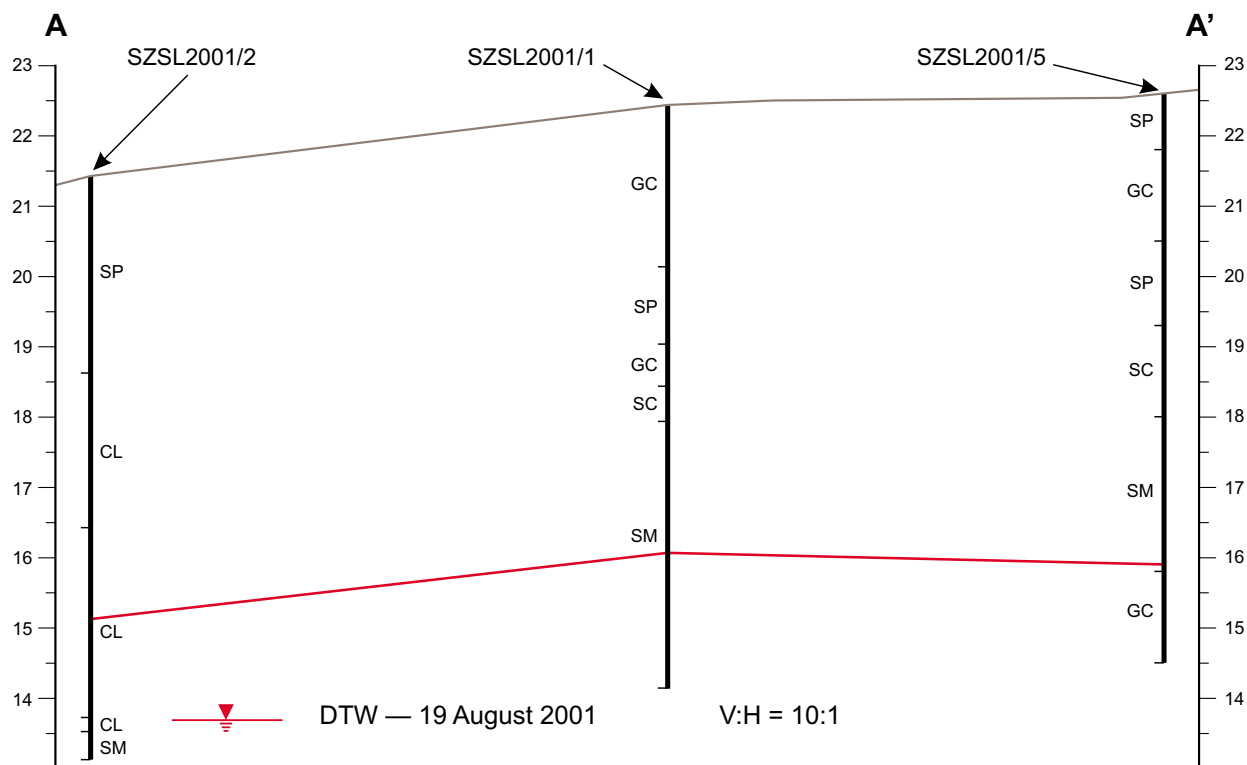


Figure 5

Cross-sections and related standing water levels on 19 August 2001 for bores SZSL 2000/2, 1 and 5 [A-A'].

HYDROLOGICAL MODEL

Constraints related to the drilling contractor's depth capacity did not allow for a complete groundwater flow-regime investigation. Iron pans within the sediments appear to be producing perched water tables. The drying up of borehole SZSL2001/4 (refusal on iron pan) after surface drainage control works supports this comment.

Some of the gravel is clay bound (also demonstrated by low yields), implying the main groundwater storage capacity occurs within the sandy zones. Perched water is also most likely occurring above the clay-enriched layers/lens. It is expected that holes drilled to greater depth would intercept additional groundwater and allow for a more complete interpretation of the groundwater flow regime in the area of the lagoons.

An interpretation of the piezometric surface (based on surveyed heights and groundwater depths of the boreholes in the limited area of the lagoons) is shown in Figure 7. The water table appears to slope towards the northwest and a groundwater mounding effect is also indicated close to and beneath the lagoons.

GROUNDWATER CHEMISTRY

All bores were sampled in accordance with Australian/New Zealand Standard AS/NZS 5667.11:1998 on 15 May 2001. Bore SZSL2001/4 contained no water and therefore was not sampled. Laboratory testing of samples of groundwater extracted from the boreholes was carried out by Analytical Services Tasmania, in accordance with

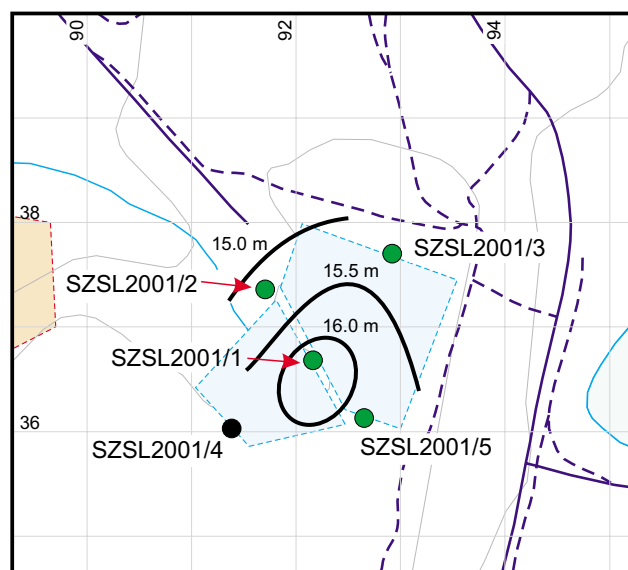


Figure 7

Interpretation of the piezometric surface based on surveyed heights and groundwater depths of the boreholes (RL water surface contours).

relevant Australian and international standards (Appendix 3). Values for pH ranged between 5.0 and 5.5. Conductivity values ranged between 430 and 656 $\mu\text{S}/\text{cm}$. Analytical results are presented on site maps in Appendix 4. Figure 8 is a cation Ternary plot for the results of the groundwater analyses. Tables 1 and 2 compare the analytical results against international standards where a guideline/emission value is stated by the relevant standard.

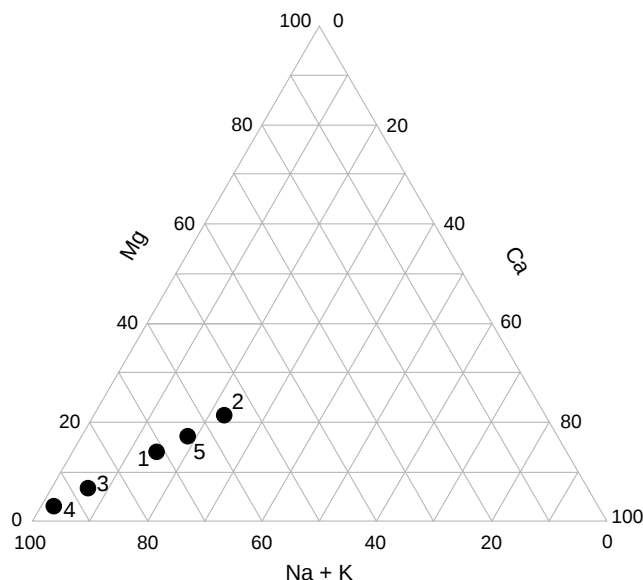


Figure 8

Cation ternary plot for groundwater bores at the Stieglitz sewage lagoons. 1 – SZSL2001/1; 2 – SZSL2001/2; 3 – SZSL2001/3; 4 – SZSL2001/5; 5 – average of all MRT groundwater records for Quaternary coastal sands.

For the water parameters analysed, the groundwater chemistry shows little variation in the area of the lagoons. Groundwater that was interpreted as down-gradient of the lagoons (SZSL2001/2 and 5) had some slightly elevated chemical results for sulphate, magnesium, and iron. The water chemistry of SZSL2001/3 and 5 is dominated by sodium and potassium cations (fig. 8), with the other two bores containing higher levels of magnesium and calcium cations. SZSL2001/3 and 5 are both screened predominantly in clayey gravel, which may account for these differences.

CONTAMINATION ASSESSMENT

The combination of *in situ* permeability testing, the cross section (fig. 5) and piezometric surface map (fig. 7) demonstrate that the Tertiary unconsolidated sedimentary aquifer may potentially transport any leakage from the sewage lagoons. There is a high potential for significant migration of effluent and consequent effects in the coastal sediments and the Tertiary plain area. Transport velocities, based on slug test data, may be as high as one metre per day. This

implies that leakage from the sewage lagoons could reach Chimneys Lagoon or Windmill Lagoon in approximately one year.

There are currently no known users of groundwater in the area.

PRINCIPAL CONCLUSIONS

Layers and/or lens of clayey gravel, clay and iron pans (acting as aquitards) control perched groundwater. Migration of effluent water from the lagoons may follow preferred pathways to a deeper, unconfined unconsolidated aquifer. This aquifer most likely has hydraulic connection to Chimneys and Windmill lagoons. Investigations of groundwater quality in the area should consider potential impacts of the unlined old landfill to the west.

FURTHER WORK

Because of the clay content within the gravel, geophysical investigations may not detect a distinct groundwater plume at the site. A ground conductivity survey may identify potential sand/gravel channels and therefore preferred pathways of flow within the sediments. Any identified channels/pathways may represent future drilling targets.

The drilling of a background bore some distance from the lagoons would enable the determination of local TDS levels. A comparison of background TDS combined with the installation of strategically placed additional bores may indicate the degree of recharge to groundwater from the lagoons.

Future monitoring of microbiological water quality parameters may help to confirm the extent of the degradation of groundwater quality in the local area and the processes associated with potential natural attenuation at the site. Effluent water chemistry from the lagoons should be considered as part of this assessment.

REFERENCE

McCLENAGHAN, M. P.; TURNER, N. J.; WILLIAMS, P. R. 1987. *Geological Atlas 1:50 000 Series. Sheet 41 (8515S). St Helens.* Department of Mines Tasmania.

[30 May 2002]

Table 1
Comparison of analytical results against water quality standards
(guideline value listed when stated by a relevant standard)

<i>Parameter</i>	<i>SZSL 2000/1</i>	<i>SZSL 2000/2</i>	<i>SZSL 2000/3</i>	<i>SZSL 2000/5</i>	<i>Emission limit</i>
pH	5.2	5.5	5.3	5.0	N/A
Conductivity (µS/cm)	430	594	656	587	N/A: note average sea water value 36 000.
TDS (mg/L)	226	324	368	331	N/A
Bromide (mg/L)	0.71	2.7	0.96	0.20	N/A
Chloride (mg/L)	83	110	86	81	250* (mg/L)
Fluoride (mg/L)	<0.02	0.09	<0.02	0.04	1.5* (mg/L)
Sulphate (mg/L)	11	36	150	140	250* (mg/L)
Ammonia (mg-N/L)	<0.05	0.34	0.08	<0.05	0.5* (mg/L) nitrogen (as ammonia)
Nitrate (mg-N/L)	<0.03	<0.03	0.46	0.04	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Nitrite (mg-N/L)	<0.10	<0.10	<0.10	<0.10	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Phosphate (mg-P/L)	<0.10	<0.10	<0.10	<0.10	2.0* as phosphorus
Calcium (mg/L)	10.2	22.4	4.30	2.18	N/A
Potassium (mg/L)	1.13	1.63	0.78	0.98	N/A
Magnesium (mg/L)	5.98	12.9	2.94	2.10	N/A
Sodium (mg/L)	56.3	62.1	68.2	113	N/A
Aluminium (mg/L)	<0.020	<0.020	0.033	0.032	N/A
Arsenic (mg/L)	<0.005	<0.005	<0.005	<0.005	0.05* (mg/L)
Cadmium (mg/L)	<0.001	<0.001	<0.001	<0.001	0.01* (mg/L)
Cobalt (mg/L)	<0.001	0.006	<0.001	<0.001	N/A
Chromium (mg/L)	<0.001	<0.001	<0.001	<0.001	0.5* (mg/L)
Copper (mg/L)	<0.001	<0.001	<0.001	<0.001	1.0* (mg/L)
Iron (mg/L)	<0.020	4.540	<0.020	<0.020	(Combined iron and manganese total) 1.0* (mg/L)
Manganese (mg/L)	0.183	0.850	0.118	0.016	(Combined iron and manganese total) 1.0* (mg/L)
Nickel (mg/L)	0.003	0.009	0.006	0.003	0.1** (mg/L)
Lead (mg/L)	<0.005	<0.005	<0.005	<0.005	0.05* (mg/L)
Zinc (mg/L)	<0.001	0.005	0.003	0.003	5.0* (mg/L)

* *Environment Protection (Water Pollution) Regulations 1974*, emission into inland water.

** *Australian Water Quality Guidelines for Fresh and Marine Waters 1992*.

N/A — no emission limit available.

Table 2
Comparison of analytical results against the Australian and New Zealand Guidelines
for Fresh and Marine Water Quality 2000

Bore hole number	STIEGLITZ SEWAGE LAGOONS				ANZECC 2000		
	SZSL 2000/1	SZSL 2000/2	SZSL 2000/3	SZSL 2000/5	IRRIGATION		LIVESTOCK DRINKING
Analyte					STV (Short-term)	LTV (Long-term)	
Standing Water Level (m)	6.51	6.36	7.55	6.89			
pH (laboratory)	5.2	5.5	5.3	5.0	**6.0-8.5		
Conductivity (µS/cm)	430	594	656	587	(1)(Refer Tables 4.2.3 & 4.2.4)		
TDS (mg/L)	226	324	368	331			(2)2,000-10,000 (Refer Table 4.3.1)
Bromide (mg/L)	0.71	2.7	0.96	0.20			
Chloride (mg/L)	83	110	86	81	(3)MT (Refer Table 4.2.6) MR (Refer Table 4.2.7)		
Fluoride (mg/L)	<0.02	0.09	<0.02	0.04	4	1	
Sulphate (mg/L)	11	36	150	140			
NH ₃ -N (mg/L)	<0.05	0.34	0.08	<0.05			
NO ₃ -N (mg/L)	<0.03	<0.03	0.46	0.04			
NO ₂ -N (mg/L)	<0.10	<0.10	<0.10	<0.10			
PO ₄ -P (mg/L)	<0.10	<0.10	<0.10	<0.10			
Aluminium (µg/L)	<20	<20	33	32	20,000	5,000	5,000
Arsenic (µg/L)	<5	<5	<5	<5	2000	100	500
Cadmium (µg/L)	<1	<1	<1	<1	50	10	10
Cobalt (µg/L)	<1	6	<1	<1	100	50	1,000
Chromium (µg/L)	<1	<1	<1	<1	1,000***	100***	1,000
Copper (µg/L)	<1	<1	<1	<1	5,000	200	400-5,000
Iron (µg/L)	<20	4540	<20	<20	10,000	200	NST
Manganese (µg/L)	183	850	118	16	10,000	200	NST
Nickel (µg/L)	3	9	6	3	2000	200	1,000
Lead (µg/L)	<5	<5	<5	<5	5,000	2,000	100
Zinc (µg/L)	<1	5	3	3	5,000	2,000	20,000
Calcium (mg/l)	10.2	22.4	4.3	2.18			1,000
Potassium (mg/l)	1.13	1.63	0.78	0.98			
Magnesium (mg/l)	5.98	12.9	2.94	2.10			250-2,000
Sodium (mg/l)	56.3	62.1	68.2	113	(2)MT (Refer Table 4.2.8)		

Shaded areas indicate values above relevant guideline levels

Notes: ** set to limit potential for corrosion and fouling of pumping, irrigation and stock watering systems.

*** Chromium (VI)

(1) Suitability depends on salt tolerance of crop & calculation of EC_{se}, the average root zone salinity.
EC_{se} depends on soil type & average root zone leaching fraction.

(2) Depending on animal type, within this salinity range may be reluctance to drink or may be some scouring but stock should adapt without loss of production.

(3) ES = Suits extremely sensitive crops

MT = Suits moderately tolerant crops

MR = Medium risk of increasing crop cadmium concentrations

STV – Short term trigger value for contaminant in irrigation water (<20 years) use

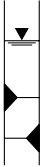
LTV – Long term trigger value for contaminant in irrigation water (100 years) use

Appendix 1

Engineering logs of boreholes

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

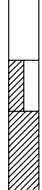
Penetration	Water	Notes — samples and tests		Material classification
		U50	Undisturbed sample 50 mm diameter	Based on Unified Soil Classification System.
	22 Jan, 80 Water level on date shown	D	Disturbed sample	In Graphic Log materials are represented by clear contrasting symbols consistent for each project.
	Water inflow	N	Standard penetrometer blow count for 300 mm	
	Water outflow	N*	SPT + Sample	

Moisture content	Consistency	Density index
D Dry, looks and feels dry	VS Very soft <25 (kPa)	VL Very loose 0 – 15
M Moist, no free water on hand when remoulding	S Soft 25 – 50	L Loose 15 – 35
W Wet, free water on hand when remoulding	F Firm 50 – 100	MD Medium dense 35 – 65
LL Liquid limit	St Stiff 100 – 200	D Dense 65 – 85
PL Plastic limit	VSt Very stiff 200 – 400	VD Very dense 85 – 100
PI Plasticity index	H Hard >400	
e.g. M>PL — Moist, moisture content greater than the plastic limit	Fb Friable	
	Notes: X on log is test result — is range of results	

Fracture description

RP	Rough planar
RL	Rough irregular
SP	Smooth planar
SL	Smooth irregular

Cored borehole log

Case - lift	Fluid loss	Lugeons	Graphic log
		Lugeon units (uL) are a measure of rock mass permeability. For a 46 to 74 mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of 1×10^{-4} mm / sec.	

Weathering	Strength	Significant defects
Fr Fresh	point load strength index 1.5 (50) (MPa)	Significant defects shown graphically
SW Slightly weathered	EL Extremely low < 0.03	
HW Highly weathered	VL Very low 0.03 – 0.1	Joint
EW Extremely weathered	L Low 0.1 – 0.3	Sheared zone
	M Medium 0.3 – 1	Crushed seam
	H High 1 – 3	Infill seam
	VH Very high 3 – 10	Extremely weathered seam
	EH Extremely high >10	
	Notes: X on log is test result.	

ENGINEERING LOG - BOREHOLE

 Borehole no. **SZSL2001/1**
 Sheet 1 of 2

Project		Stieglitz sewage lagoons				Location		St Helens Point Road, Stieglitz			
Co-ordinates		55 609216 mE 5423668 mN		Drill type		Auger		Hole commenced		8 March 2001	
				Drill method		Rotary		Hole completed		8 March 2001	
R.L.				Drill fluid		Nil		Drilled by		T.O. Bresnehan Pty Ltd	
Inclination		Vertical						Logged by		Mr Andrew Ezzy	
Bearing								Checked by		Mr Adrian Waite	
penetration		support		water		notes		metres		material	
1 2 3						samples, tests		R.L.		soil type: plasticity or particle characteristics, colour, secondary and minor components.	
						depth		graphic log		classification symbol	
										moisture condition	
										consistency density index	
										structure, geology	
				</							

ENGINEERING LOG - BOREHOLE

Borehole no.
SZSL2001/1
Sheet 2 of 2

Project		Stieglitz sewage lagoons		Location		St Helens Point Road, Stieglitz	
Co-ordinates		55 609216 mE 5423668 mN		Drill type		Auger	
				Drill method		Rotary	
R.L.				Drill fluid		Nil	
Inclination		Vertical		Hole commenced		8 March 2001	
Bearing				Hole completed		8 March 2001	
				Drilled by		T.O. Bresnehan Pty Ltd	
				Logged by		Mr Andrew Ezzy	
				Checked by		Mr Adrian Waite	

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
			D Sample ID 11	5.5		SP	SAND - coarse, light brown-grey	W	L	Tertiary sediments
										
		No Screen	D Sample ID 12	6.0		SP	SAND - coarse, light brown-grey	W	VL	Tertiary sediments
		7 mm Gravel		6.5						
				7.0						
				7.5						
		1.4 metre Pro Screen		8.0						
		Back in fill								
			Sample ID numbers refer to samples stored in MRT core shed				End of hole at 8.3 m Pumped at 0.4 L/m for 5 minutes.			

ENGINEERING LOG - BOREHOLE

Borehole no.
SZSL2001/2
Sheet 1 of 2

Project			Stieglitz sewage lagoons				Location		St Helens Point Road, Stieglitz					
Co-ordinates			55 609170 mE 5423736 mN		Drill type		Auger		Hole commenced		8 March 2001			
					Drill method		Rotary		Hole completed		8 March 2001			
R.L.					Drill fluid		Nil		Drilled by		T.O. Bresnehan Pty Ltd			
Inclination			Vertical						Logged by		Mr Andrew Ezzy			
Bearing									Checked by		Mr Adrian Waite			
penetration			support	water	notes	metres		graphic log	classification	material		moisture	consistency	structure, geology
1 2 3					samples, tests	R.L.	depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.		condition	density index	
				Cement	D Sample ID 1		0.5		SP	SAND - medium, humic, dark-grey, gravelly		M	L	Fill - Reworked Tertiary sediments
							1.0		SP	SAND - coarse, black, gravelly, strong organic odour		M	L	Fill - Reworked Tertiary sediments
							1.5							
							2.0							
							2.5							
							3.0		CI	CLAY - medium plasticity, mottled dark brown and grey, gravelly		M	F	Fill - Reworked Tertiary sediments
							3.5							
							4.0							
							4.5							

ENGINEERING LOG - BOREHOLE

Borehole no.
SZSL2001/2
Sheet 2 of 2

Project				Stieglitz sewage lagoons				Location		St Helens Point Road, Stieglitz			
Co-ordinates				55 609170 E 5423736 N		Drill type		Auger		Hole commenced		8 March 2001	
						Drill method		Rotary		Hole completed		8 March 2001	
R.L.						Drill fluid		Nil		Drilled by		T.O. Bresnehan Pty Ltd	
Inclination				Vertical						Logged by		Mr Andrew Ezzy	
Bearing										Checked by		Mr Adrian Waite	
penetration		support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology		
1	2	3		samples, tests	R.L.	depth	symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index			
			Bentonite					(As sheet 1)					
			No Screen	D Sample ID 6		5.5	CL	CLAY - low plasticity, light grey-brown	M	F	Tertiary sediments		
						6.0							
						6.5							
			7 mm Gravel			7.0							
			1.4 metre Pro Screen	D Sample ID 7		7.5	CL	CLAY - low plasticity, light yellow, silty	M	F	Tertiary sediments		
				D Sample ID 8			CI	CLAY - medium plasticity, light brown	M	F	Tertiary sediments		
				D Sample ID 9		8.0	SM	SAND - fine, light grey	W	S	Tertiary sediments		
				Sample ID numbers refer to samples stored in MRT core shed				End of hole at 8.3 m					

ENGINEERING LOG - BOREHOLE

 Borehole no.
SZSL2001/3
 Sheet 1 of 2

Project				Stieglitz sewage lagoons				Location		St Helens Point Road, Stieglitz			
Co-ordinates				55 609292 mE 5423770 mN		Drill type		Auger		Hole commenced		8 March 2001	
						Drill method		Rotary		Hole completed		8 March 2001	
R.L.						Drill fluid		Nil		Drilled by		T.O. Bresnehan Pty Ltd	
Inclination				Vertical						Logged by		Mr Andrew Ezzy	
Bearing										Checked by		Mr Adrian Waite	
penetration			support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology	
1 2 3					samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index		
				Cement	D Sample ID 1			SP	SAND - medium, humic, dark grey, gravelly	M	L	Fill - Reworked Tertiary sediments	
						0.5							
					D Sample ID 2			GC	GRAVEL - fine, orange-brown, sandy	M	L	Fill - Reworked Tertiary sediments	
						1.0							
						1.5							
					D Sample ID 3			CL	CLAY - low plasticity, brown, gravelly	M	F	Fill - Reworked Tertiary sediments	
						2.0							
						2.5							
					D Sample ID 4			GC	GRAVEL - fine, orange-brown, sandy	M	L	Fill - Reworked Tertiary sediments	
						3.0							
					D Sample ID 5			GC	GRAVEL - fine, light brown, clayey	M	L	Fill - Reworked Tertiary sediments	
					D Sample ID 6								
						3.5							
					D Sample ID 7			GC	GRAVEL - fine, black, sandy	M	L	Fill - Reworked Tertiary sediments	
						4.0							
					D Sample ID 8			SM	SAND - fine, brown	M	L	Fill - Reworked Tertiary sediments	
						4.5							
					D Sample ID 9			SM	SAND - fine, light brown	M	VL	Tertiary sediments	

ENGINEERING LOG - BOREHOLE

Borehole no.
SZSL2001/3
Sheet 2 of 2

Project		Stieglitz sewage lagoons		Location		St Helens Point Road, Stieglitz	
Co-ordinates		55 609292 mE 5423770 mN		Drill type		Auger	
				Drill method		Rotary	
R.L.				Drill fluid		Nil	
Inclination		Vertical		Hole commenced		8 March 2001	
Bearing				Hole completed		8 March 2001	
				Drilled by		T.O. Bresnehan Pty Ltd	
				Logged by		Mr Andrew Ezzy	
				Checked by		Mr Adrian Waite	

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1	2	3	samples, tests	R.L.	depth	symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
							(As sheet 1)			
					5.5					
					6.0					
					6.5					
					7.0					
					7.5	GC	GRAVEL - fine, light brown	W	VL	Tertiary sediments
					8.0	SM	SAND - fine, light yellow	W	VL	Tertiary sediments
							End of hole at 8.1 m			

ENGINEERING LOG - BOREHOLE

Borehole no.
SZSL2001/4
 Sheet 1 of 2

Project			Stieglitz sewage lagoons			Location		St Helens Point Road, Stieglitz				
Co-ordinates			55 609138 E 5423603 N		Drill type		Auger		Hole commenced		8 March 2001	
					Drill method		Rotary		Hole completed		8 March 2001	
R.L.					Drill fluid		Nil		Drilled by		T.O. Bresnehan Pty Ltd	
Inclination			Vertical						Logged by		Mr Andrew Ezzy	
Bearing									Checked by		Mr Adrian Waite	
penetration		support	water	notes	metres			material				
1 2 3				samples, tests	R.L.	depth	graphic log	classification symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
			Cement	D Sample ID 1		0.5		SP	SAND - medium, grey, 5 % rounded coarse gravel	D	VL	Fill - Reworked Tertiary sediments
			Back fill	D Sample ID 2		1.0		SP	SAND - coarse, grey, 10 % quartzite rounded fine gravel	M	L	Fill - Reworked Tertiary sediments
				D Sample ID 3		2.0		SP	SAND - coarse, light grey, 5% quartzite rounded medium gravel	M	VL	Fill - Reworked Tertiary sediments
				D Sample ID 4		2.5						
			No Screen	S.W.L. 08/03/01		3.0						
				D Sample ID 5		3.5						
			7 mm Gravel	D Sample ID 6		4.0		GC	GRAVEL - fine, grey, sandy	M	VL	Fill - Reworked Tertiary sediments
			1.4 metre Pro Screen	D Sample ID 7		4.5		SP	SAND - coarse, dark brown	W	S	Tertiary sediments
				D Sample ID 7				SP	SAND - coarse, dark brown	W	VL	Tertiary sediments

ENGINEERING LOG - BOREHOLE

Borehole no.
SZSL2001/4
Sheet 2 of 2

Project		Stieglitz sewage lagoons		Location		St Helens Point Road, Stieglitz	
Co-ordinates		55 609138 E 5423603 N		Drill type		Auger	
				Drill method		Rotary	
R.L.				Drill fluid		Nil	
Inclination		Vertical		Hole commenced		8 March 2001	
Bearing				Hole completed		8 March 2001	
				Drilled by		T.O. Bresnehan Pty Ltd	
				Logged by		Mr Andrew Ezzy	
				Checked by		Mr Adrian Waite	

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1	2	3	samples, tests	R.L.	depth	symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
					5.5		(As sheet 1)			
	Back fill	Back fill			6.0	SP	SAND - coarse, black, humic	M	H	Tertiary sediments
			Sample ID numbers refer to samples stored in MRT core shed				End of hole due to auger refusal at 6.2 m Pumped for 10 minutes at 1.1 L/m.			Auger refusal may be due to iron pan?

ENGINEERING LOG - BOREHOLE

Borehole no.
SZSL2001/5
Sheet 1 of 2

Project			Stieglitz sewage lagoons			Location			St Helens Point Road, Stieglitz																							
Co-ordinates			55 609265 E 5423613 N			Drill type			Auger																							
						Drill method			Rotary																							
R.L.						Drill fluid			Nil																							
Inclination			Vertical			Hole commenced			8 March 2001																							
Bearing						Hole completed			8 March 2001																							
						Drilled by			T.O. Bresnehan Pty Ltd																							
						Logged by			Mr Andrew Ezzy																							
						Checked by			Mr Adrian Waite																							
<table><tr><td>penetration</td><td>support</td><td>water</td><td>notes</td><td>metres</td><td>graphic log</td><td>classification</td><td>material</td><td>moisture</td><td>consistency</td><td>structure, geology</td></tr><tr><td>1</td><td>2</td><td>3</td><td>samples, tests</td><td>R.L.</td><td>depth</td><td>symbol</td><td>soil type: plasticity or particle characteristics, colour, secondary and minor components.</td><td>condition</td><td>density index</td><td></td></tr></table>											penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology	1	2	3	samples, tests	R.L.	depth	symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology																						
1	2	3	samples, tests	R.L.	depth	symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index																							
			D Sample ID 1		0.5	SP	SAND - medium, red-orange	M	L	Fill - Reworked Tertiary sediments																						
		Cement																														
			D Sample ID 2		1.0	GC	GRAVEL - fine, orange, sandy	M	VL	Fill - Reworked Tertiary sediments																						
			D Sample ID 3		2.0	SP	SAND - coarse, brown, gravelly	M	L	Fill - Reworked Tertiary sediments																						
			D Sample ID 4		2.5	SP	SAND - coarse, red-orange	M	L	Fill - Reworked Tertiary sediments																						
			D Sample ID 5		3.5	SC	SAND - medium, light brown, mottled orange	M	VL	Fill - Reworked Tertiary sediments																						
			D Sample ID 6		4.5	SM	SAND - fine, light brown	M	VL	Tertiary sediments																						

Project		Stieglitz sewage lagoons			Location		St Helens Point Road, Stieglitz		
Co-ordinates		55 609265 mE 5423613 mN		Drill type	Auger	Hole commenced	8 March 2001		
				Drill method	Rotary	Hole completed	8 March 2001		
R.L.				Drill fluid	Nil	Drilled by	T.O. Bresnehan Pty Ltd		
Inclination		Vertical				Logged by	Mr Andrew Ezzy		
Bearing						Checked by	Mr Adrian Waite		

penetration			support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
1	2	3										
			No Screen	Back fill		5.5			(As sheet 1)			
			Bentonite			6.0						
			Gravel			6.5						
			7 mm		S.W.L. 08/03/01 D Sample ID 7	7.0		GC	GRAVEL - fine, light brown	W	VL	Tertiary sediments
			1.4 metre Pro Screen	Back fill		7.5						
						8.0						
					Sample ID numbers refer to samples stored in MRT core shed				End of hole at 8.1m			

Appendix 2

Raw data collected for slug extraction tests

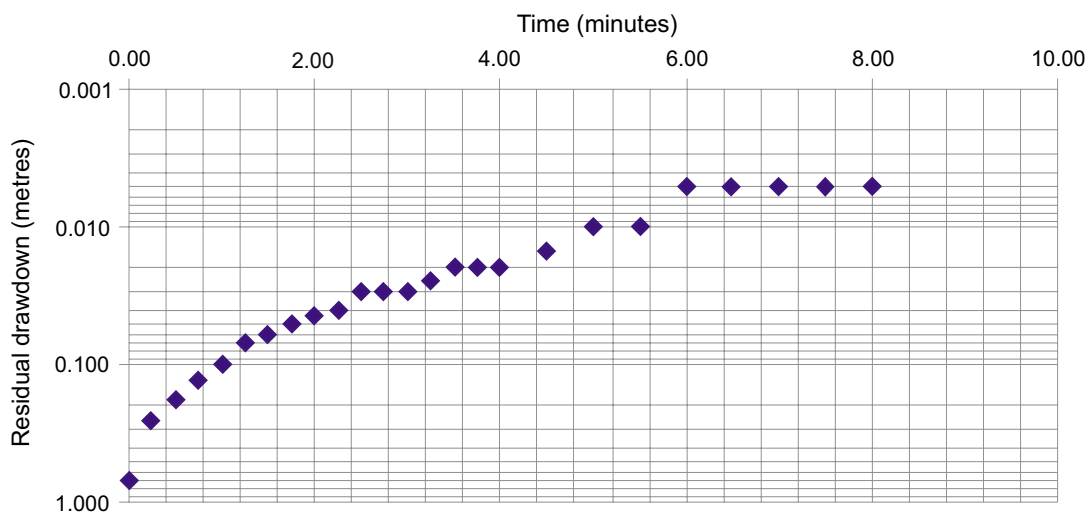
Stieglitz lagoons recovery pump test – Slug extraction recovery data

Date: 17/08/2001
 Bore: SZSL 2001/3
 TD: 8.10 m
 Flow: 2.1 l/m
 SWL: 7.63 m
 Stick up: 0.18 m

Recovery data

<i>Time</i>	<i>Residual drawdown</i>	<i>Measurement</i>
0.00	0.700	8.33
0.25	0.260	7.89
0.50	0.180	7.81
0.75	0.130	7.76
1.00	0.100	7.73
1.25	0.070	7.70
1.50	0.060	7.69
1.75	0.050	7.68
2.00	0.045	7.675
2.25	0.040	7.67
2.50	0.030	7.66
2.75	0.030	7.66
3.00	0.030	7.66
3.25	0.025	7.655
3.50	0.020	7.65
3.75	0.020	7.65
4.00	0.020	7.65
4.50	0.015	7.645
5.00	0.010	7.64
5.50	0.010	7.64
6.00	0.005	7.635
6.50	0.005	7.635
7.00	0.005	7.635
7.50	0.005	7.635
8.00	0.005	7.635

Recovery SZSL 2000/3, 17 August 2001



Appendix 3

Analytical Services Tasmania — Laboratory reports



ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
c/- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005
Telephone: (03) 6226 7175 Fax: (03) 6226 7825
Email: ast.sandybay@dpiwe.tas.gov.au



NATA Accreditation
Number: 5589

Laboratory Report

Report No: 14943 *Please quote this number when making enquiries about this report*
Submitted By: Andrew Ezzy (Mineral Resources Tasmania)
Client: E&P Division MRT Groundwater
Site Description:
Received: 15-May-01 **Client Order No:**
Report Date: 01-Jun-2001 10:18
Report To: Andrew Ezzy (Mineral Resources Tasmania)
Address: Gordons Hill Road Rosny TAS 7018

Test Method(s) :

1001-Water:	pH in Water by APHA Method 4500-H
1002-Water:	Conductivity by APHA Method 2510
1004-Water:	Solids, Total Dissolved by APHA Method 2540C
1103-Water:	Anions by Ion Chromatography APHA Method 4110C
1204-Water:	Ammonia by Ion Selective Electrode APHA Method 4500-NH3 *
1301-Water:	Metals in Water by APHA Method 3030/3120
1302-Water:	Major Cations in Water by APHA Method 3030/3120



NATA Accreditation
Number: 5589

The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to national standards of measurement.

This document shall not be reproduced, except in full.
Samples analysed as received.

* NATA accreditation does not cover the performance of this service.


Mike Johnson
Manager

Page 1 of 2

Report No: 14943

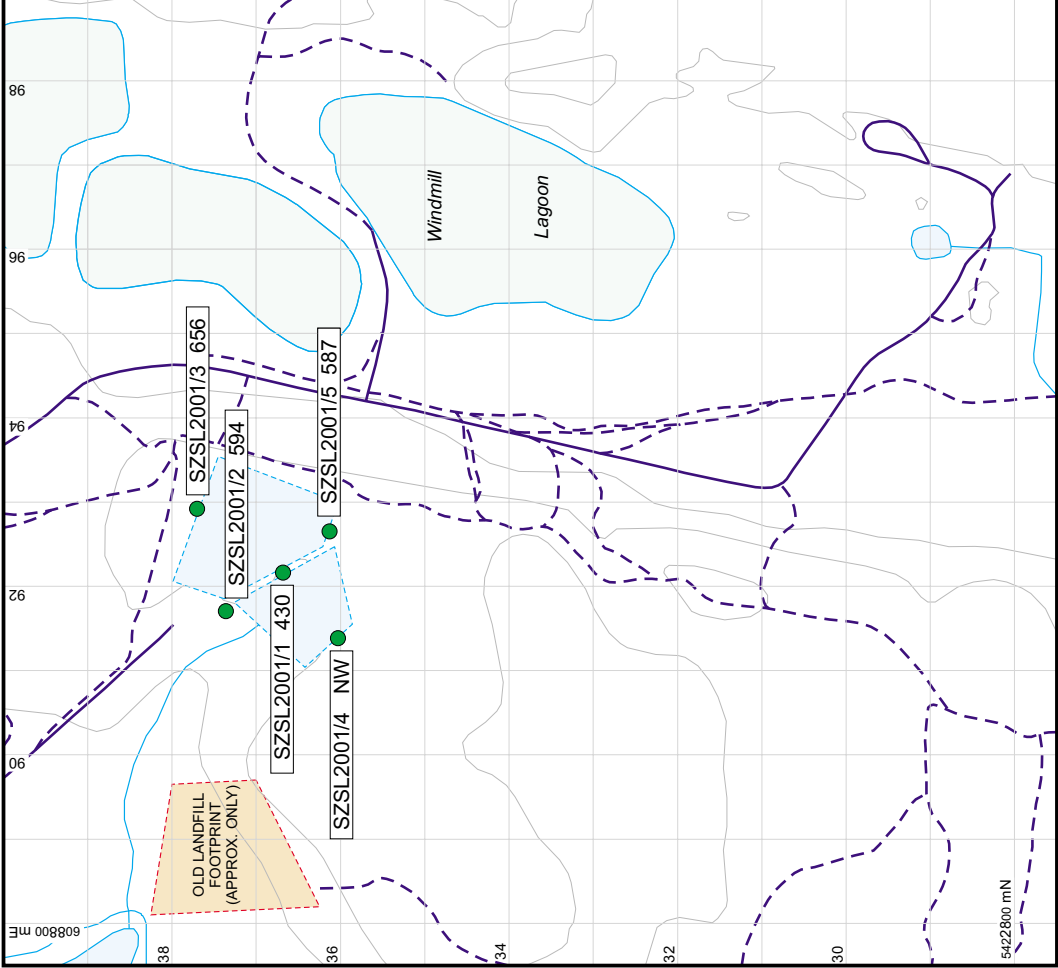
Report Date: 01-Jun-2001 10:14

Method	Analyte	Units / Sampled On :	Lab.No.: 20852	20853	20854	20855
			Sample Id.: SZSL2001/1	SZSL2001/2	SZSL2001/3	SZSL2001/5
			15-05-01 11:20	15-05-01 11:40	15-05-01 10:30	15-05-01 12:15
1001-Water	pH		5.2	5.5	5.3	5.0
1002-Water	Conductivity	µS/cm	430	594	656	587
1004-Water	TDS	mg/L	226	324	368	331
1103-Water	Bromide	mg/L	0.71	2.7	0.96	0.20
	Chloride	mg/L	83	110	86	81
	Fluoride	mg/L	<0.02	0.09	<0.02	0.04
	Nitrate	mg-N/L	<0.03	<0.03	0.46	0.04
	Nitrite	mg-N/L	<0.10	<0.10	<0.10	<0.10
	Phosphate	mg-P/L	<0.10	<0.10	<0.10	<0.10
	Sulphate	mg/L	11	36	150	140
1204-Water	Ammonia	mg-N/L	<0.05	0.34	0.08	<0.05
1301-Water	Al (Dissolved)	µg/L	<20	<20	33	32
	As (Dissolved)	µg/L	<5	<5	<5	<5
	Cd (Dissolved)	µg/L	<1	<1	<1	<1
	Co (Dissolved)	µg/L	<1	6	<1	<1
	Cr (Dissolved)	µg/L	<1	<1	<1	<1
	Cu (Dissolved)	µg/L	<1	<1	<1	<1
	Fe (Dissolved)	µg/L	<20	4540	<20	<20
	Mn (Dissolved)	µg/L	183	850	118	16
	Ni (Dissolved)	µg/L	3	9	6	3
1302-Water	Pb (Dissolved)	µg/L	<5	<5	<5	<5
	Zn (Dissolved)	µg/L	<1	5	3	3
	Ca (Dissolved)	mg/L	10.2	22.4	4.30	2.18
	K (Dissolved)	mg/L	1.13	1.63	0.78	0.98
	Mg (Dissolved)	mg/L	5.98	12.9	2.94	2.10
	Na (Dissolved)	mg/L	56.3	62.1	68.2	113

Appendix 4

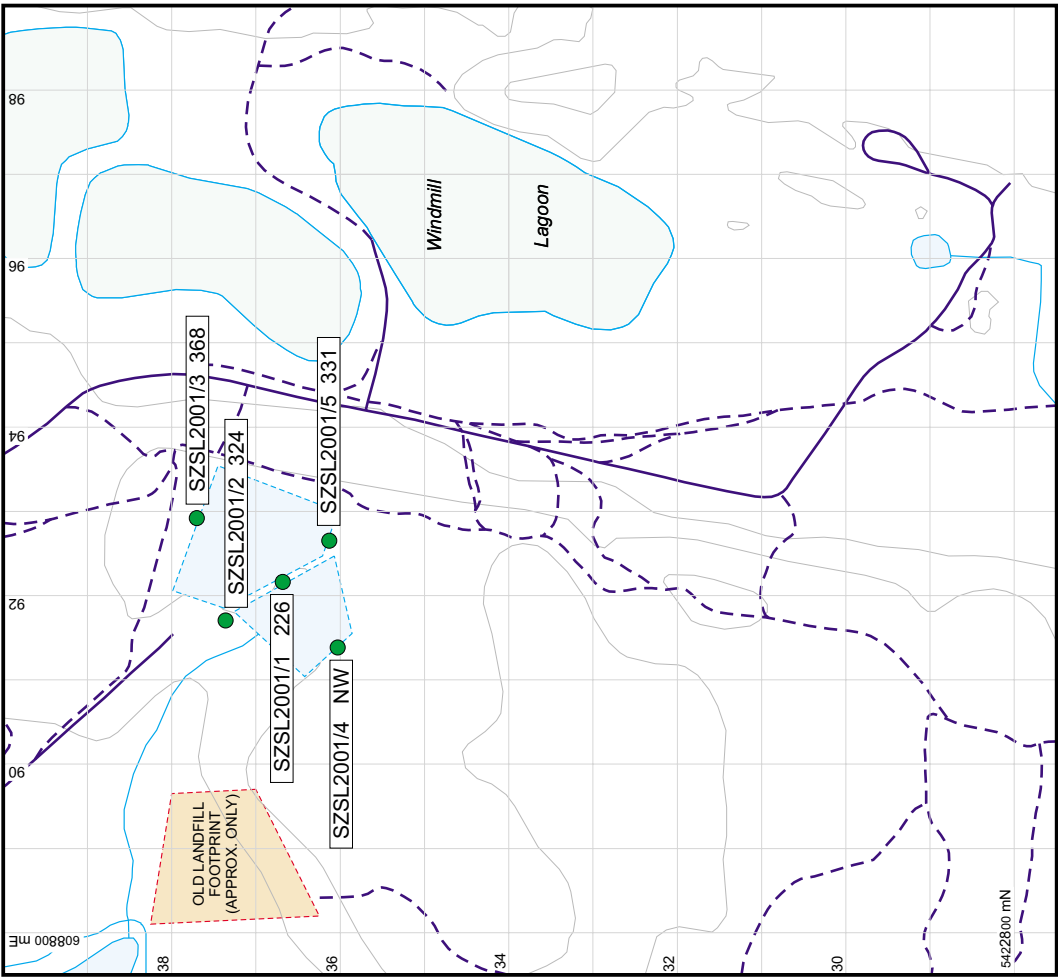
Analytical results on site maps

Stieglitz Sewage Lagoons
May 2001
Conductivity ($\mu\text{S}/\text{cm}$)



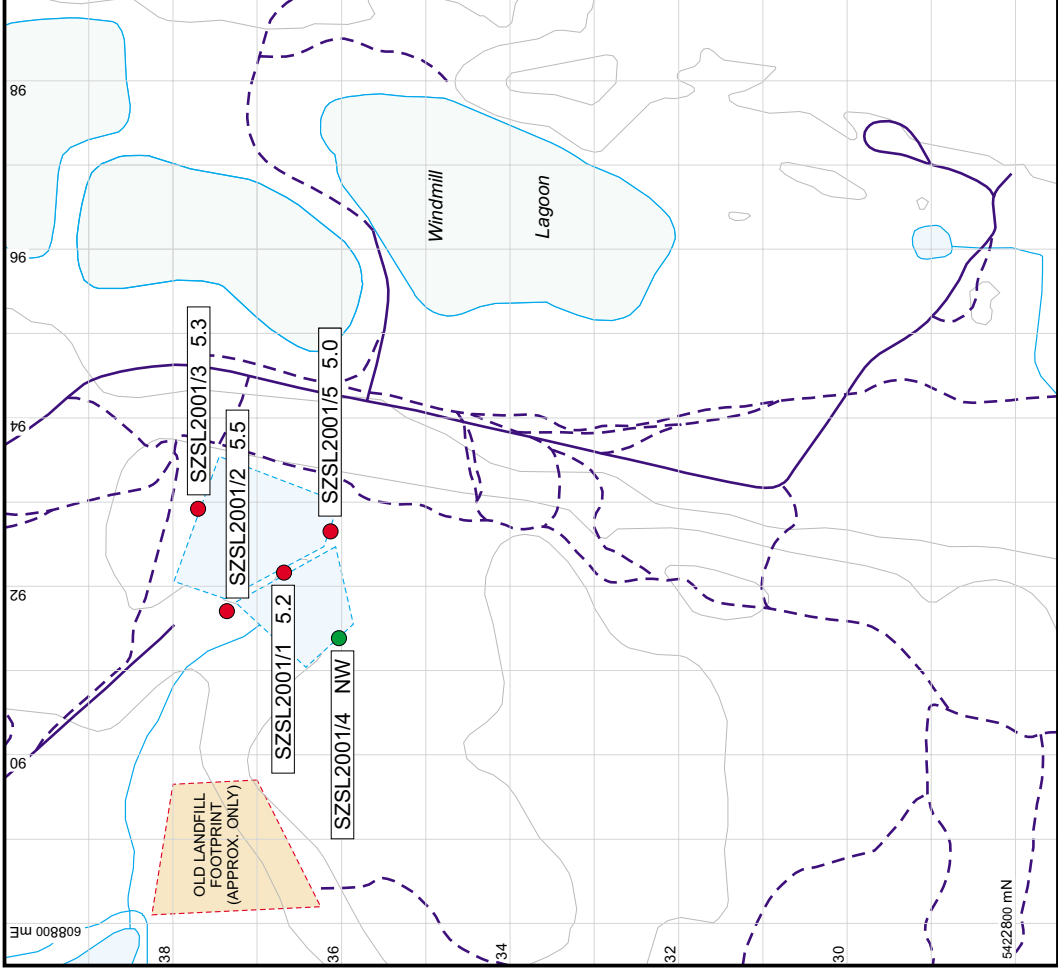
NW = no water

Stieglitz Sewage Lagoons
May 2001
TDS (mg/L)



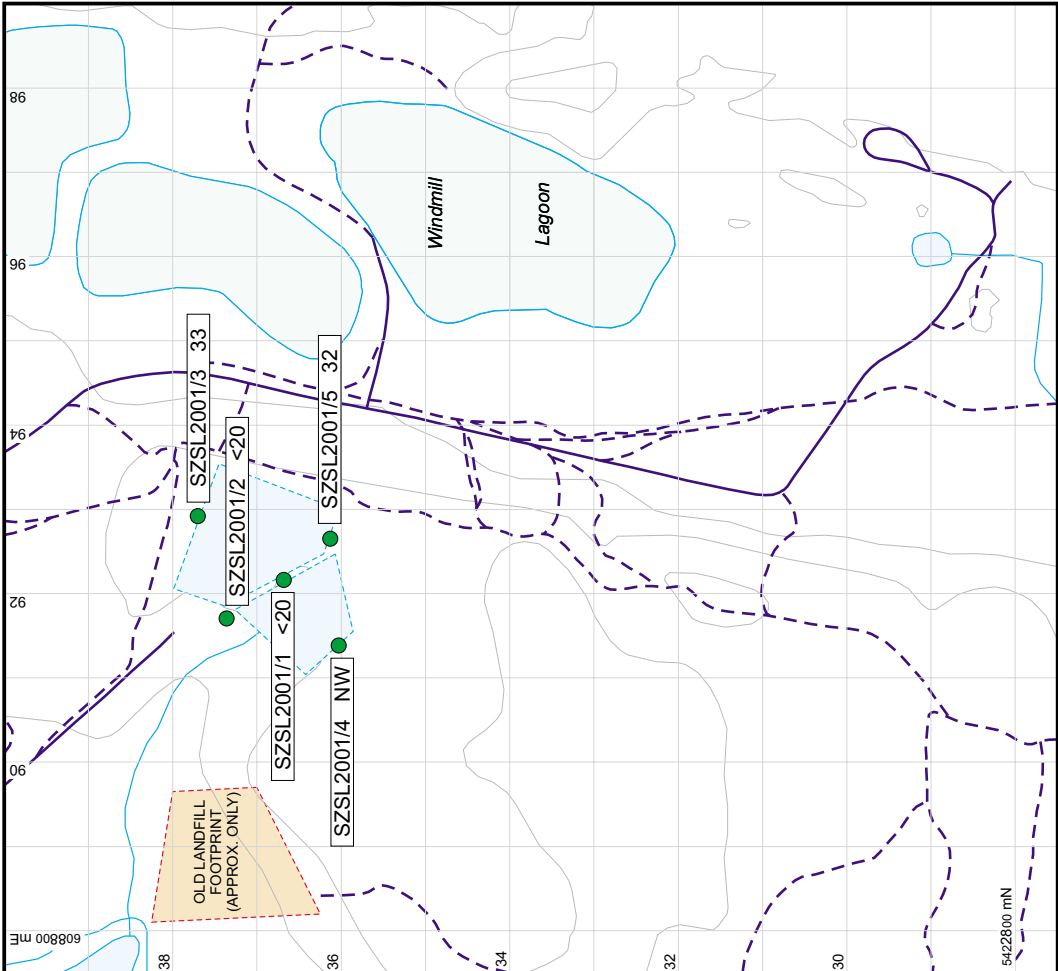
NW = no water

Stieglitz Sewage Lagoons
May 2001
pH



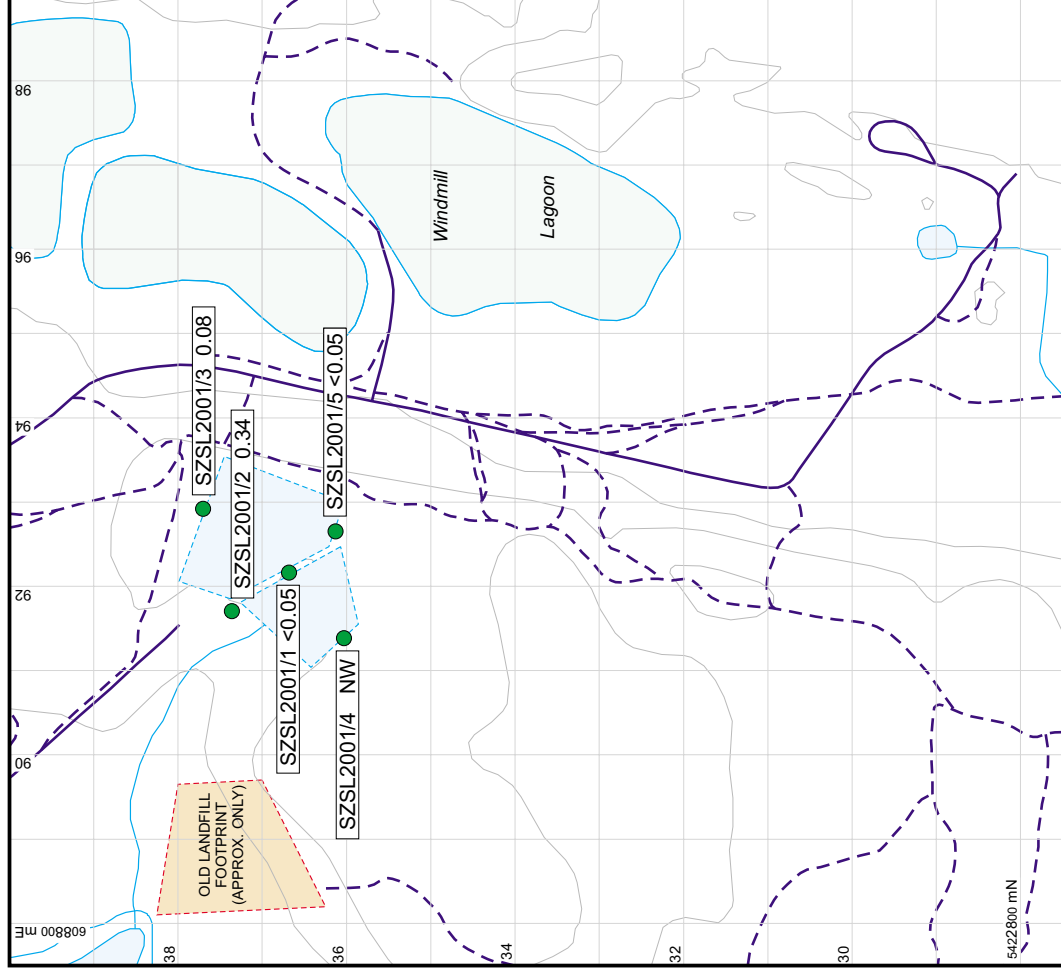
NW = no water

Stieglitz Sewage Lagoons
May 2001
AI ($\mu\text{g/L}$)



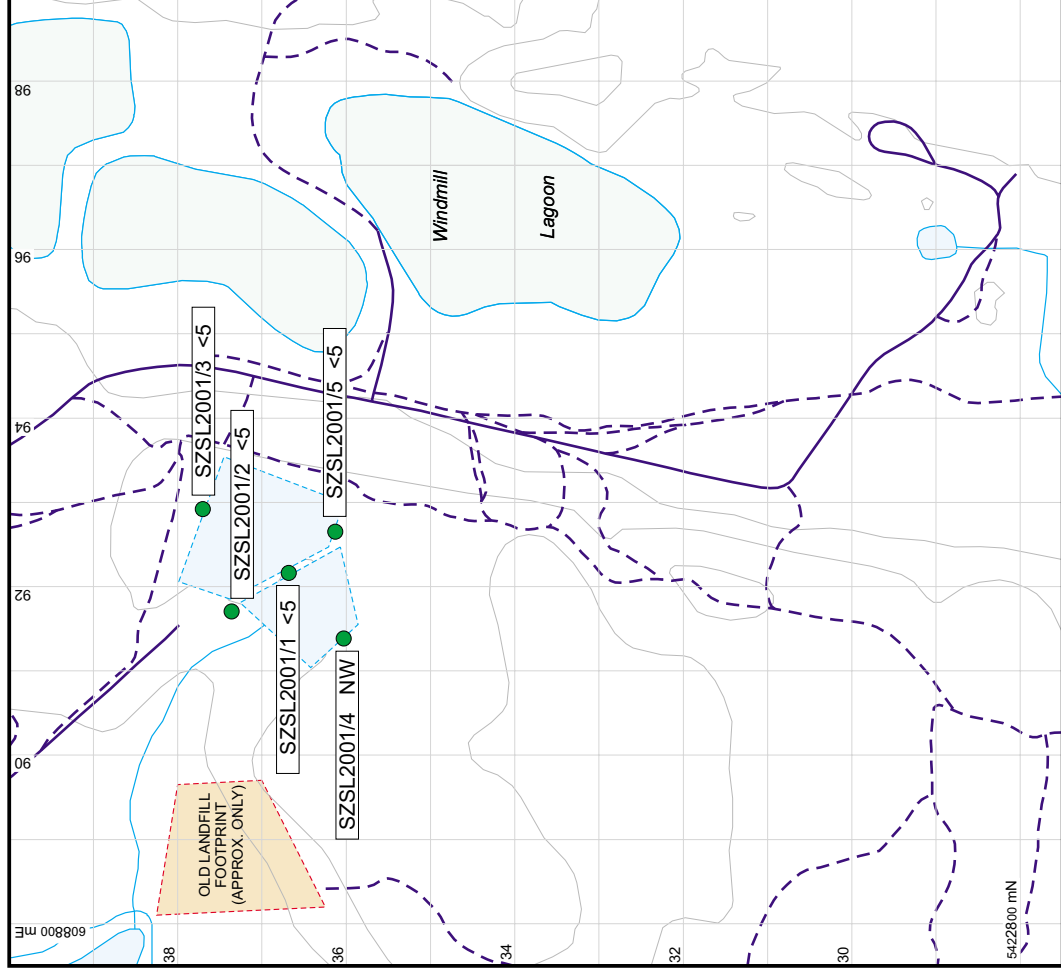
NW = no water

Stieglitz Sewage Lagoons May 2001 Ammonia (mg-N/L)



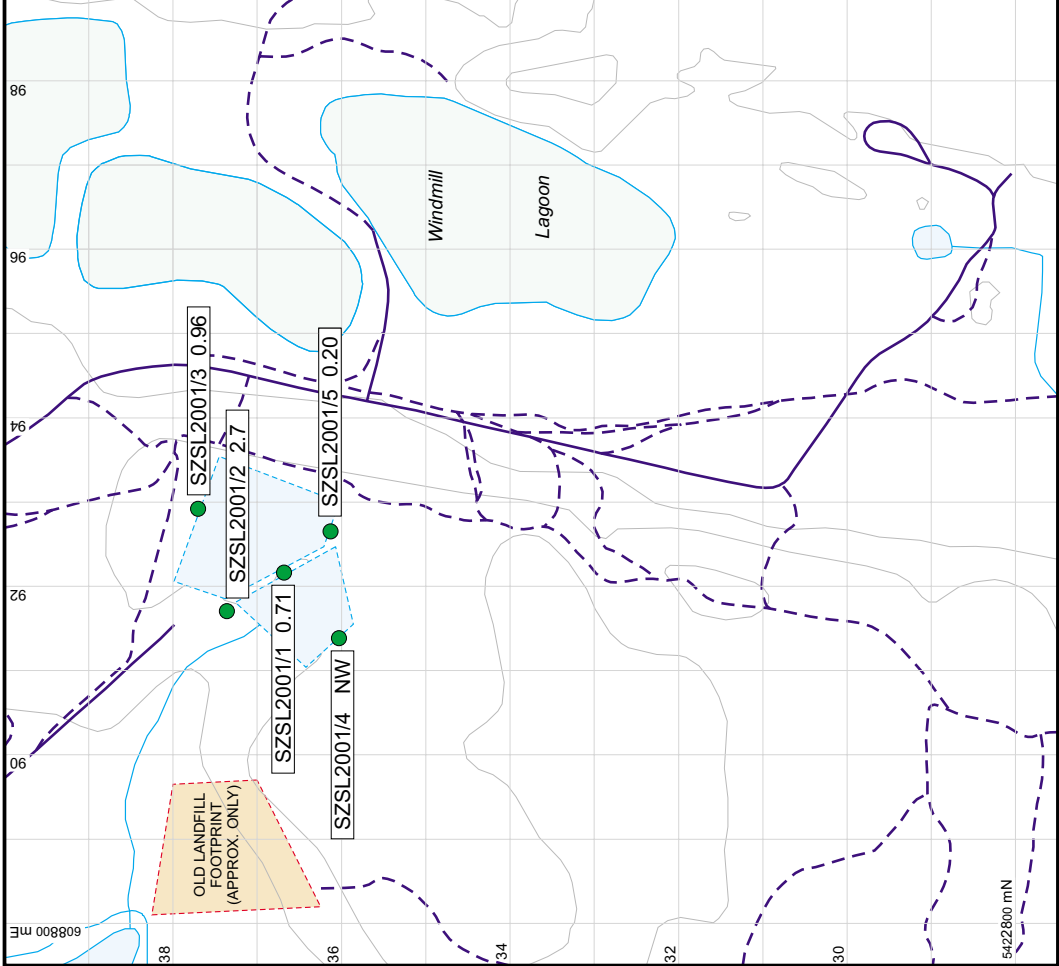
NW = no water

Stieglitz Sewage Lagoons May 2001 As (mg/L)



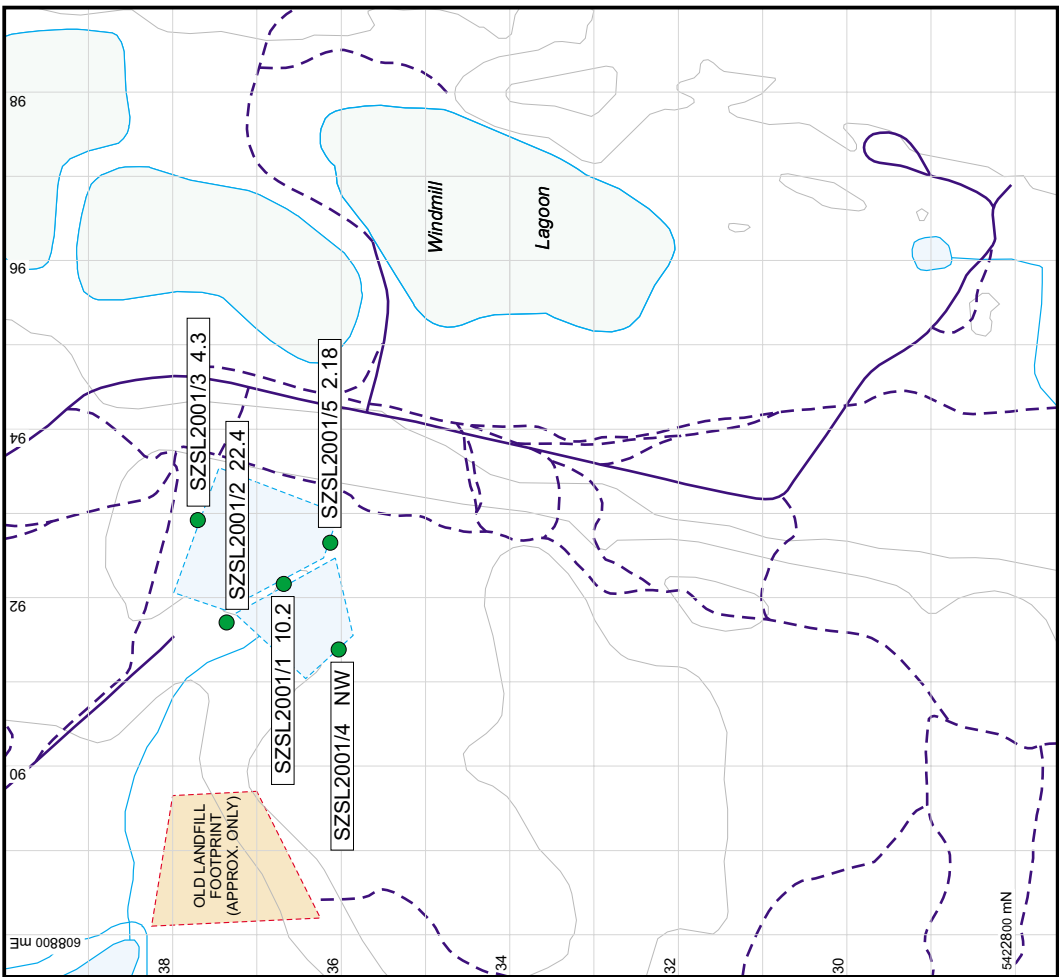
NW = no water

Stieglitz Sewage Lagoons May 2001 Bromide (mg/L)



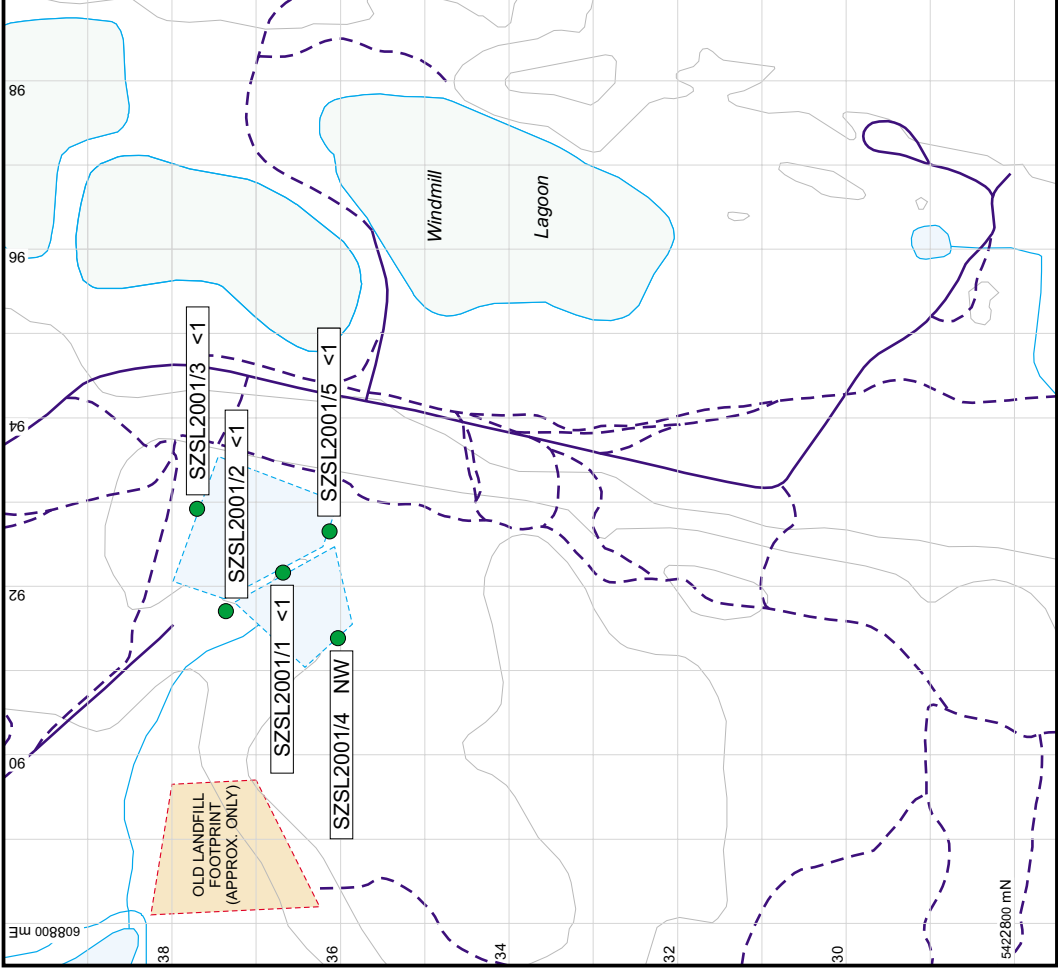
NW = no water

Stieglitz Sewage Lagoons May 2001 Ca (mg/L)



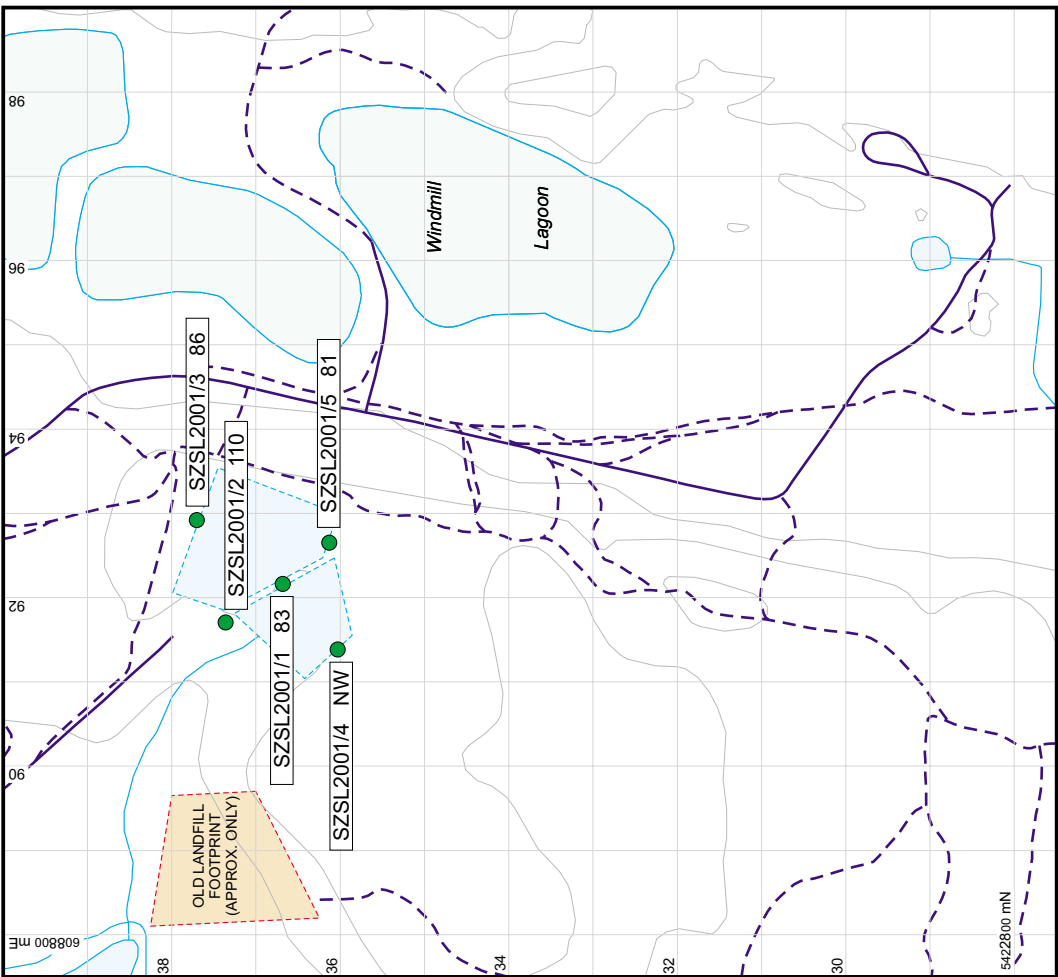
NW = no water

Stieglitz Sewage Lagoons May 2001 Cd ($\mu\text{g/L}$)



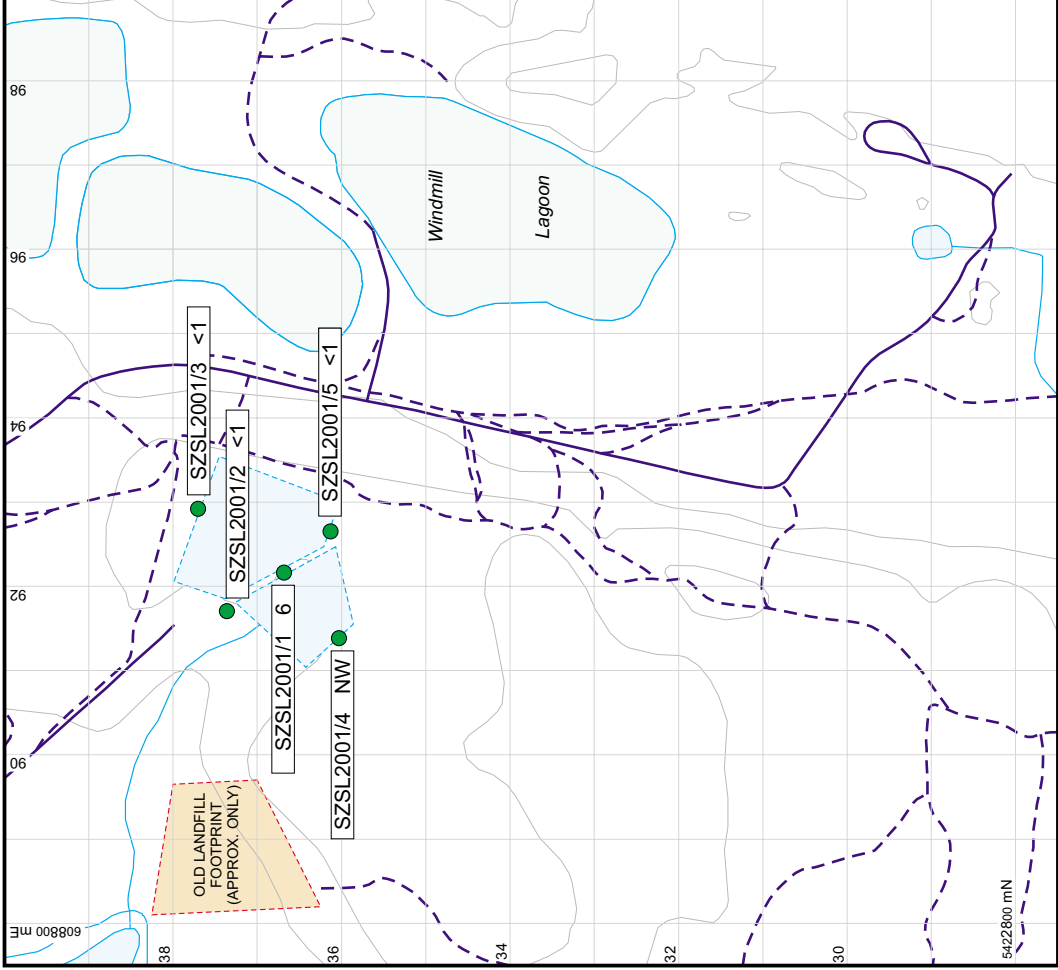
NW = no water

Stieglitz Sewage Lagoons May 2001 Chloride (mg/L)



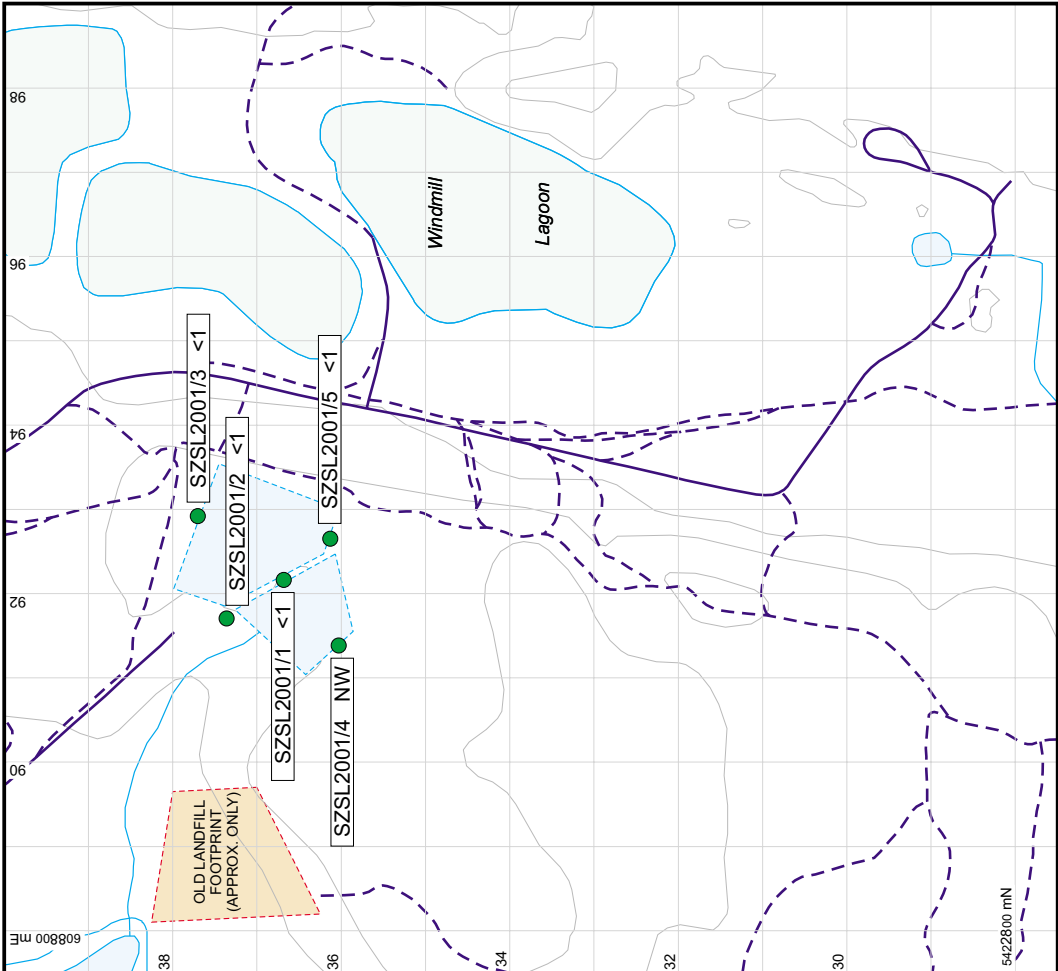
NW = no water

Stieglitz Sewage Lagoons
May 2001
Co (µg/L)



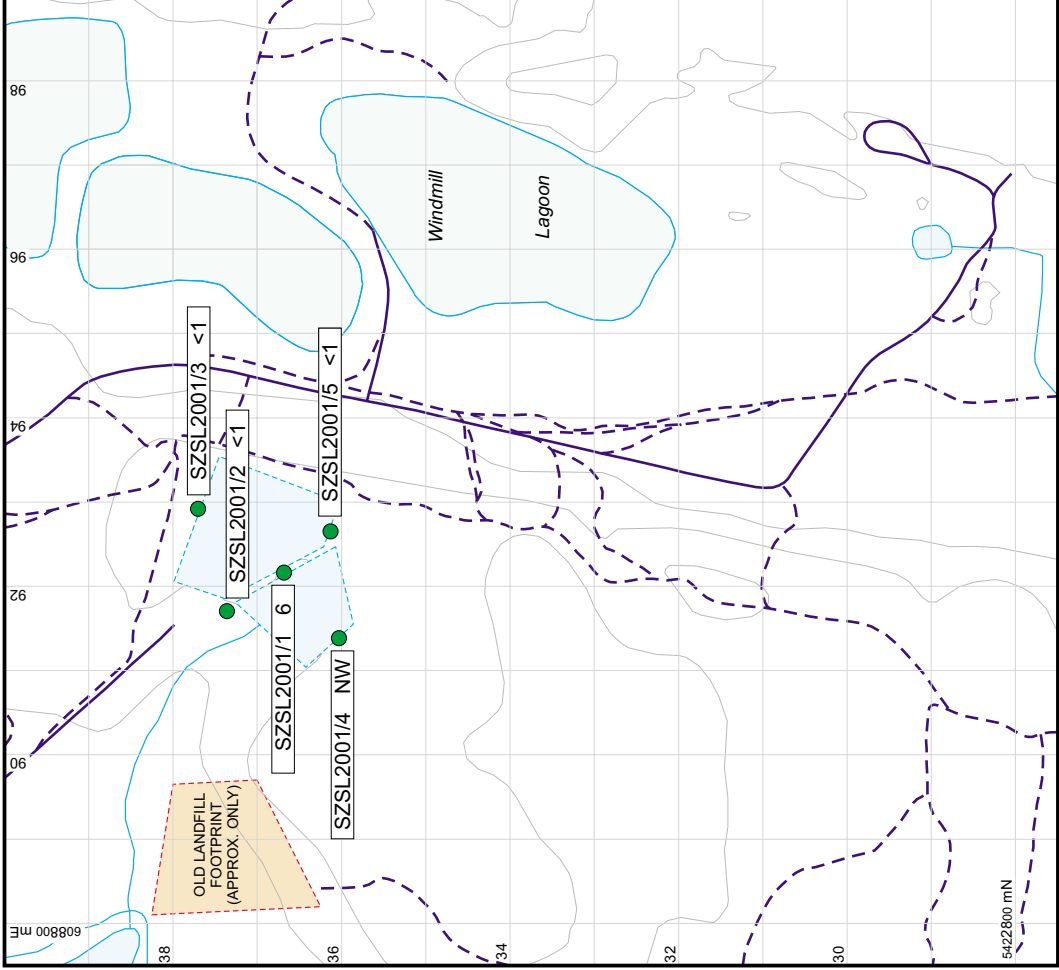
NW = no water

Stieglitz Sewage Lagoons
May 2001
Cr (µg/L)



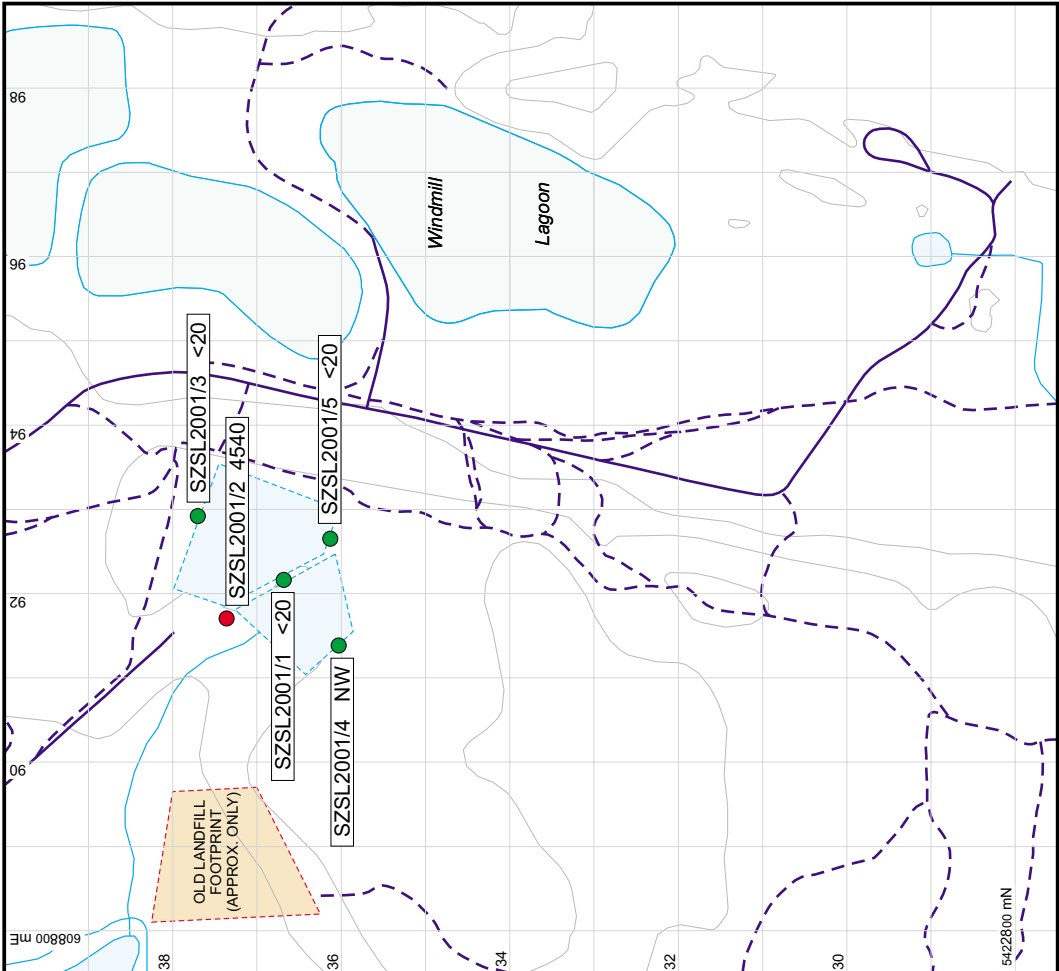
NW = no water

Stieglitz Sewage Lagoons
May 2001
Cu ($\mu\text{g/L}$)



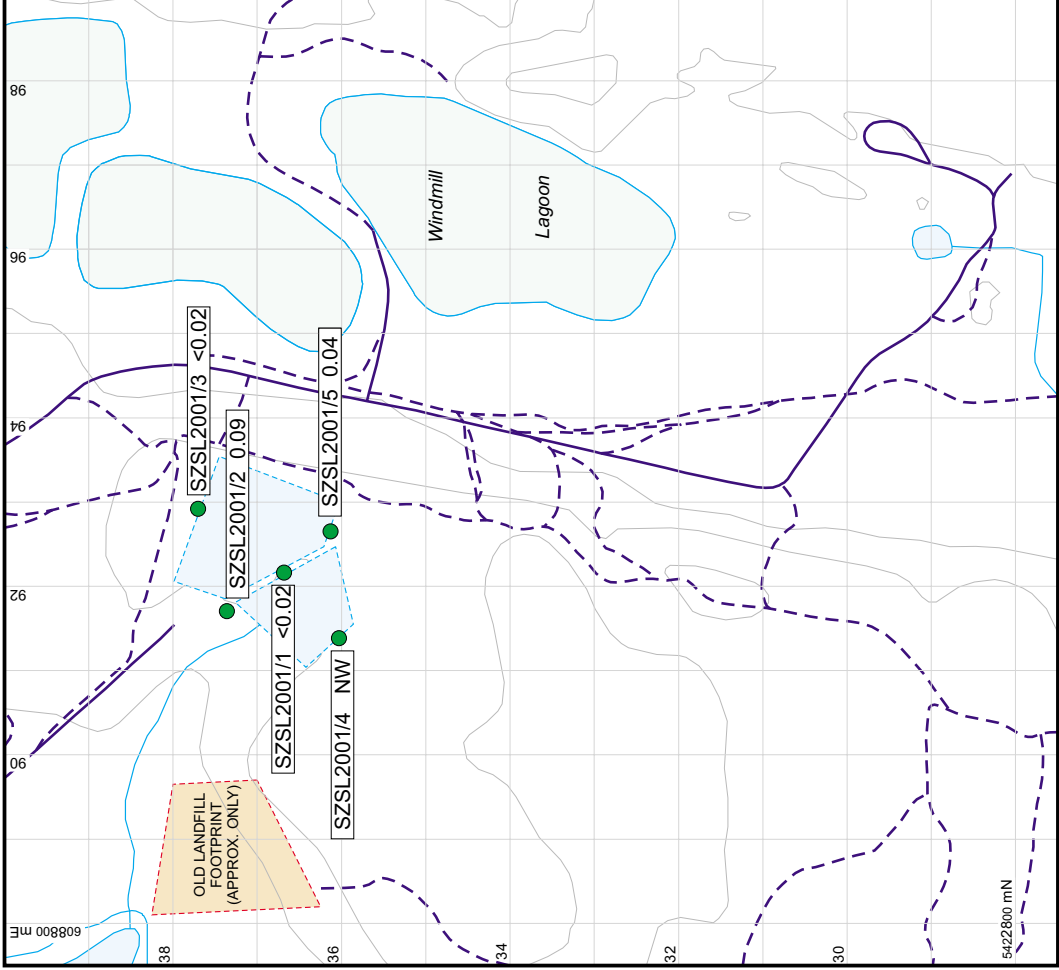
NW = no water

Stieglitz Sewage Lagoons
May 2001
Fe ($\mu\text{g/L}$)



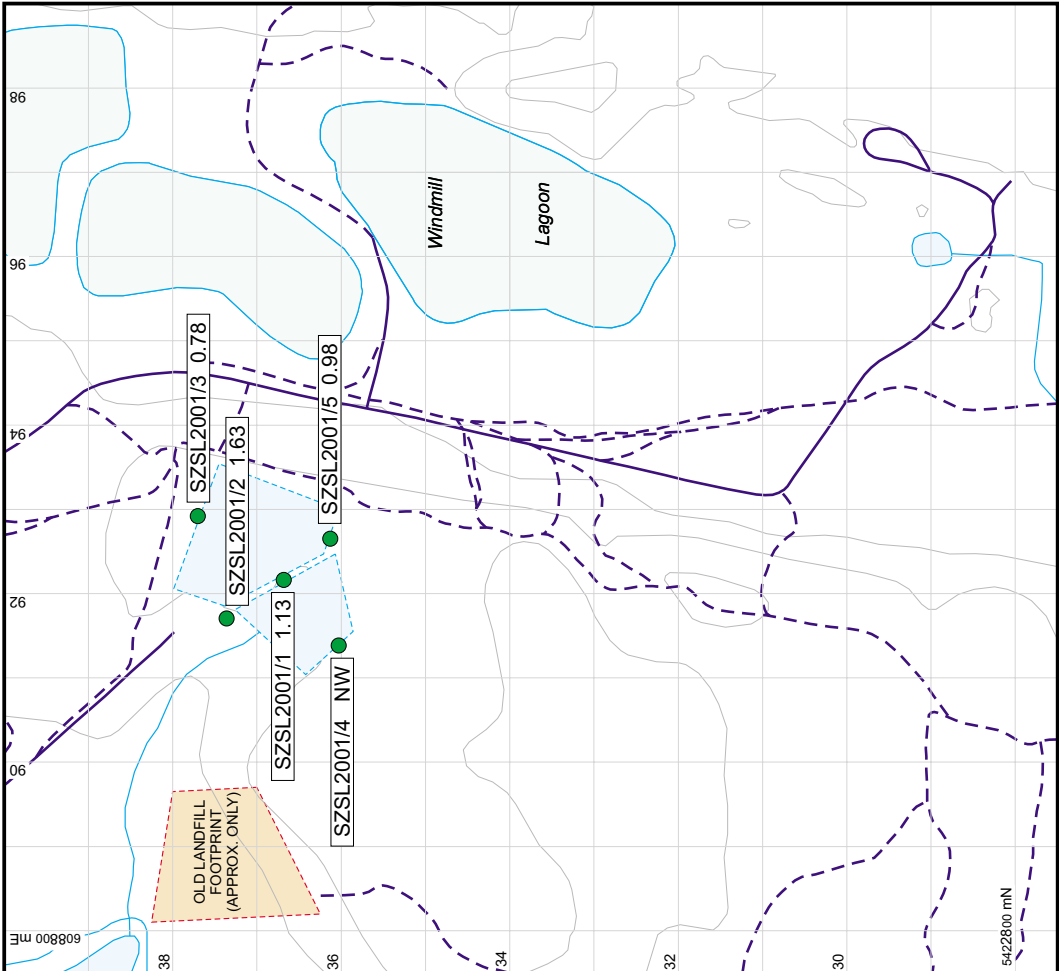
NW = no water

Stieglitz Sewage Lagoons
May 2001
Fluoride (mg/L)



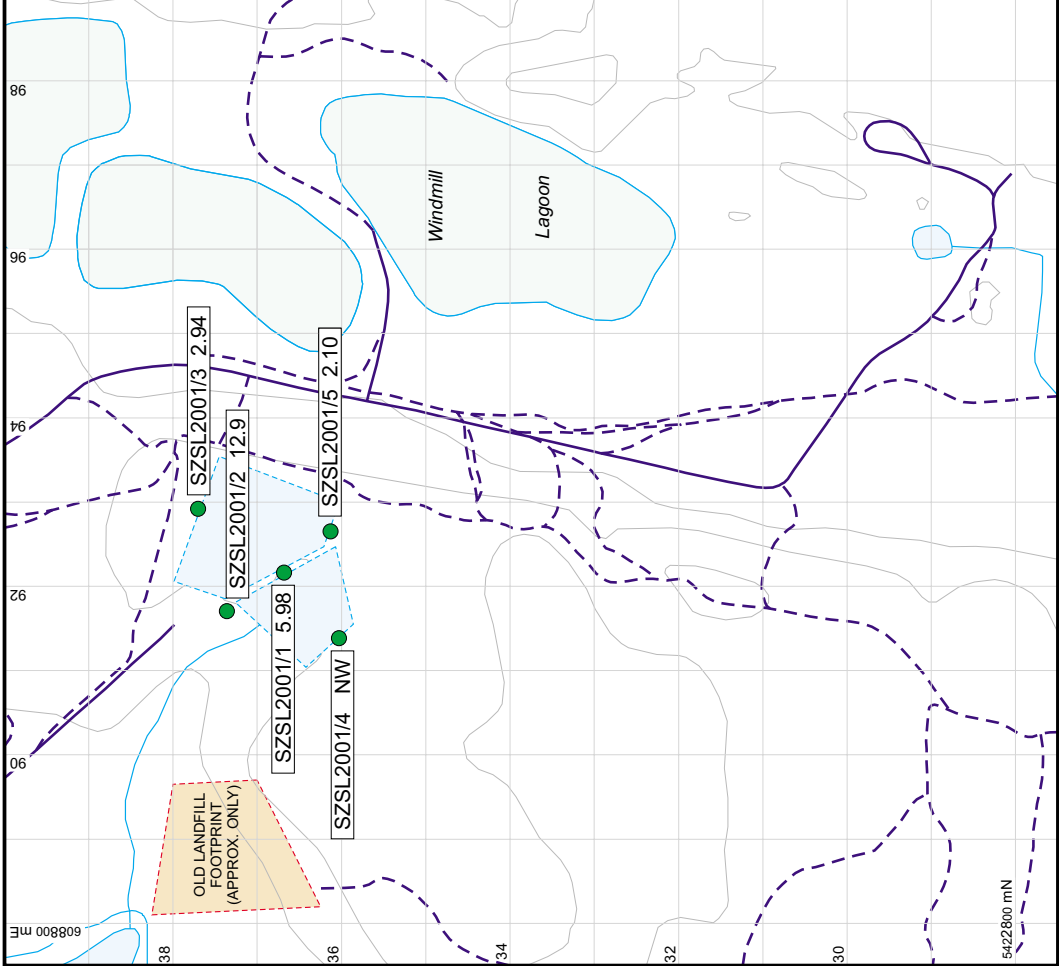
NW = no water

Stieglitz Sewage Lagoons
May 2001
K (mg/L)



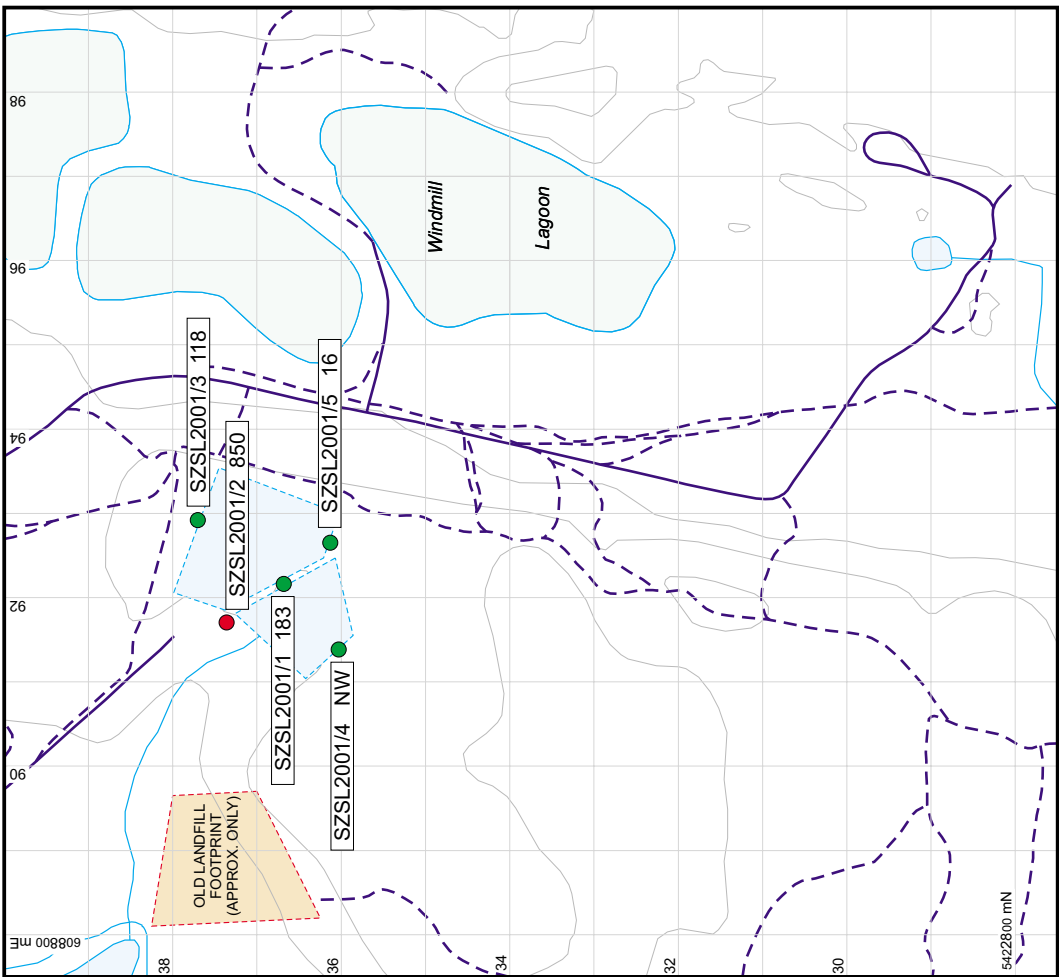
NW = no water

Stieglitz Sewage Lagoons May 2001 Mg (mg/L)



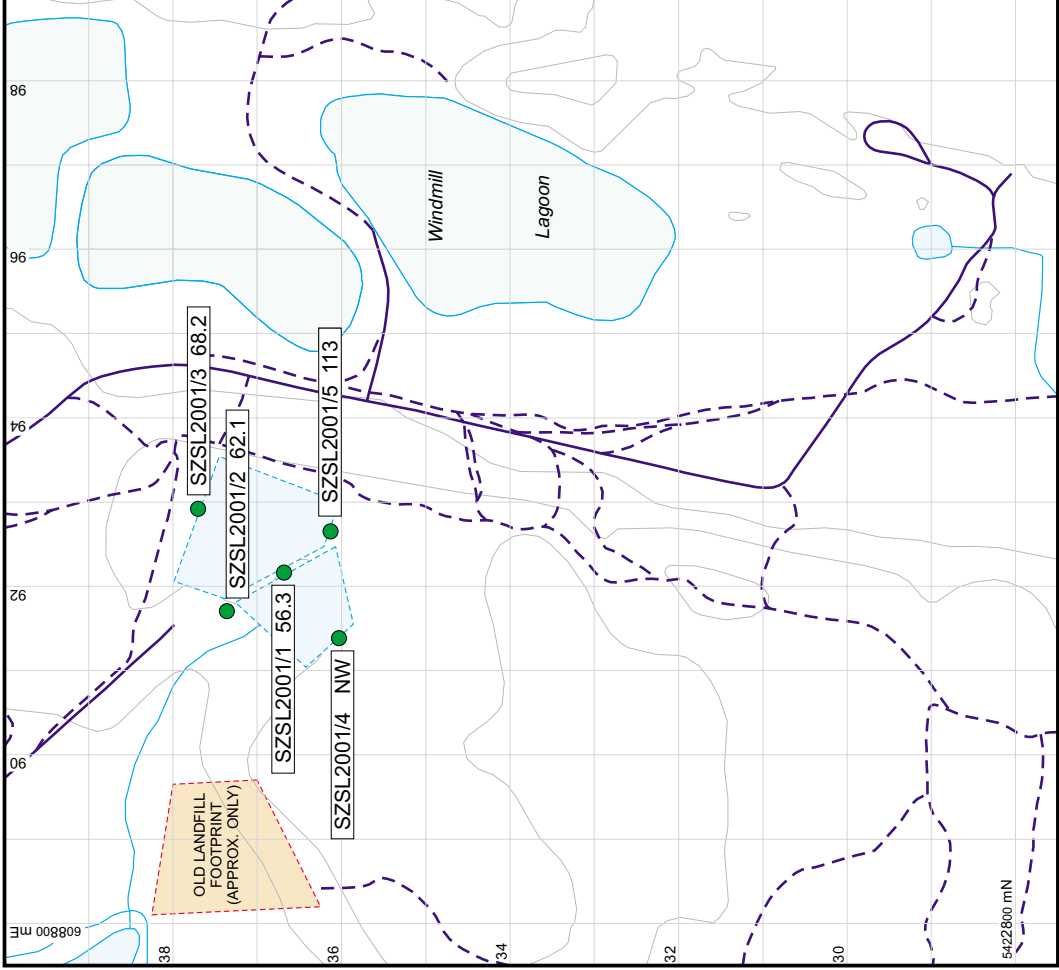
NW = no water

Stieglitz Sewage Lagoons May 2001 Mn (µg/L)



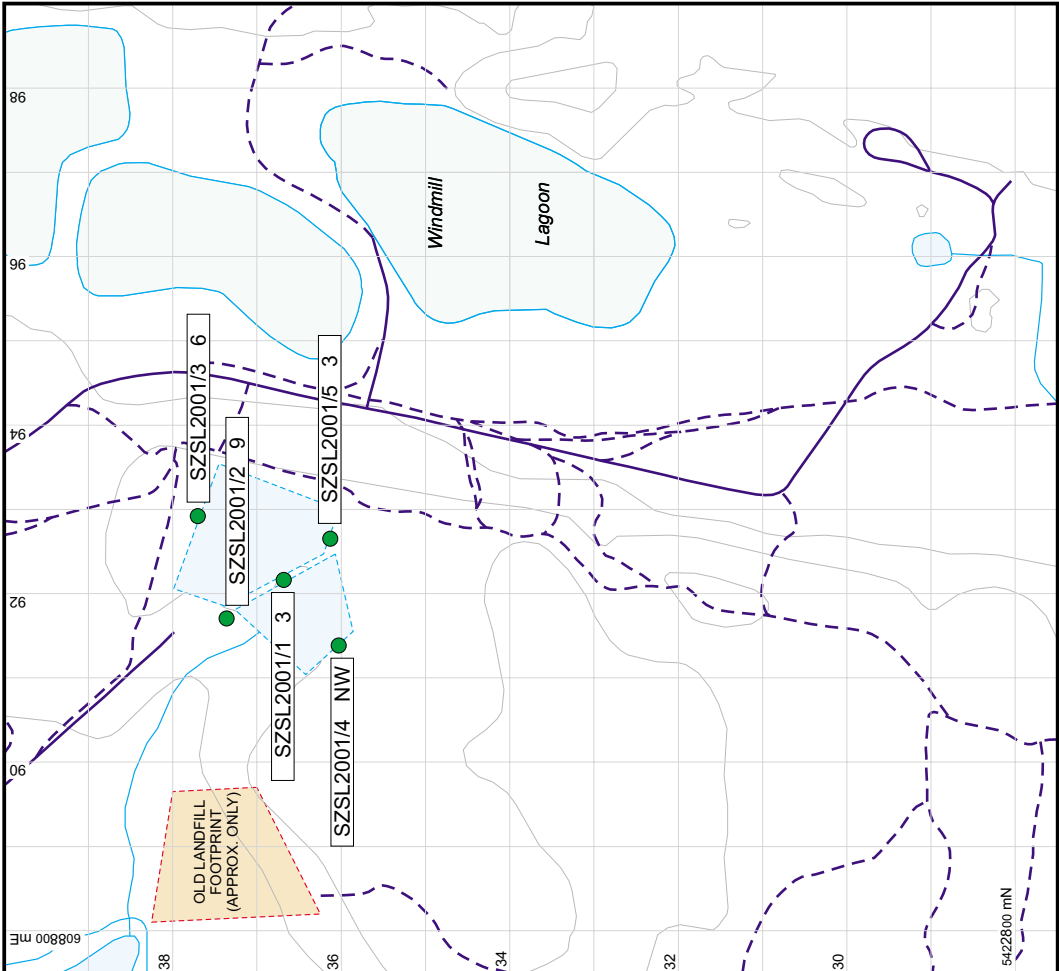
NW = no water

Stieglitz Sewage Lagoons
May 2001
Na (mg/L)



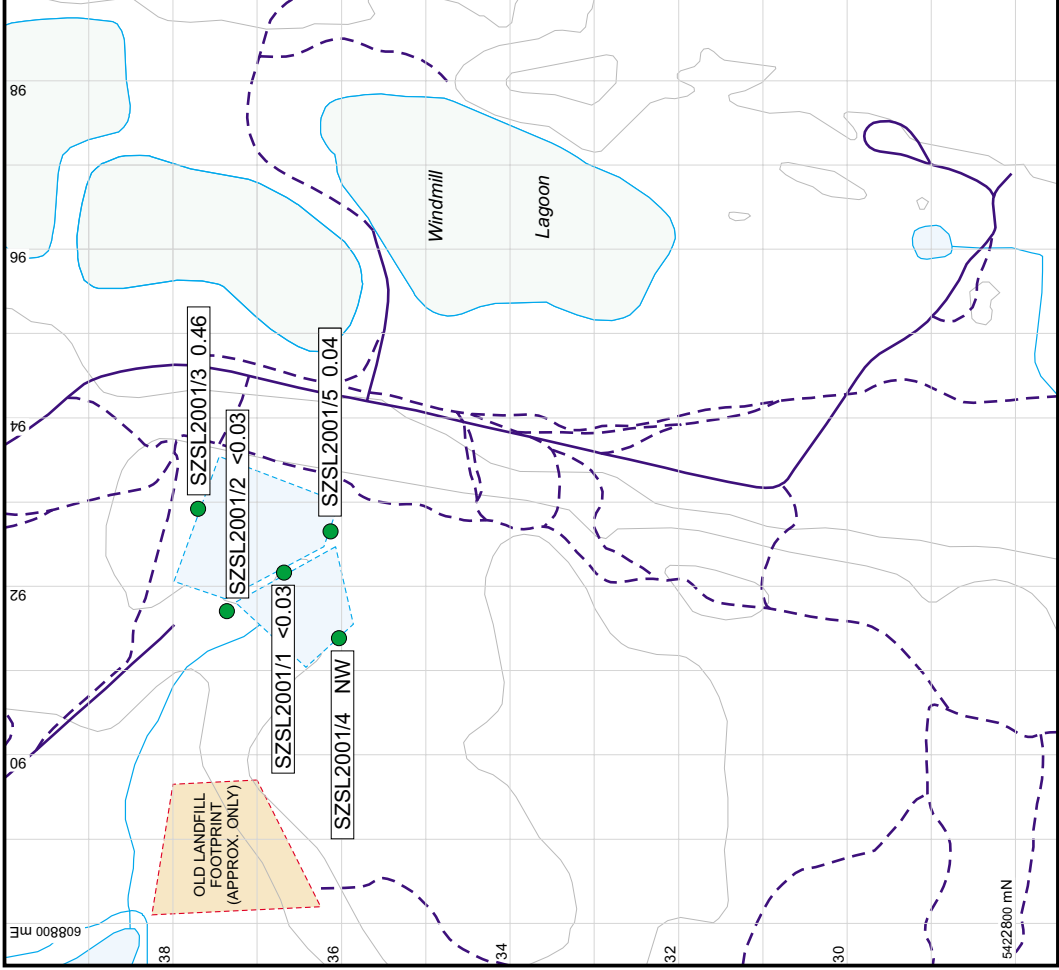
NW = no water

Stieglitz Sewage Lagoons
May 2001
Ni ($\mu\text{g/L}$)

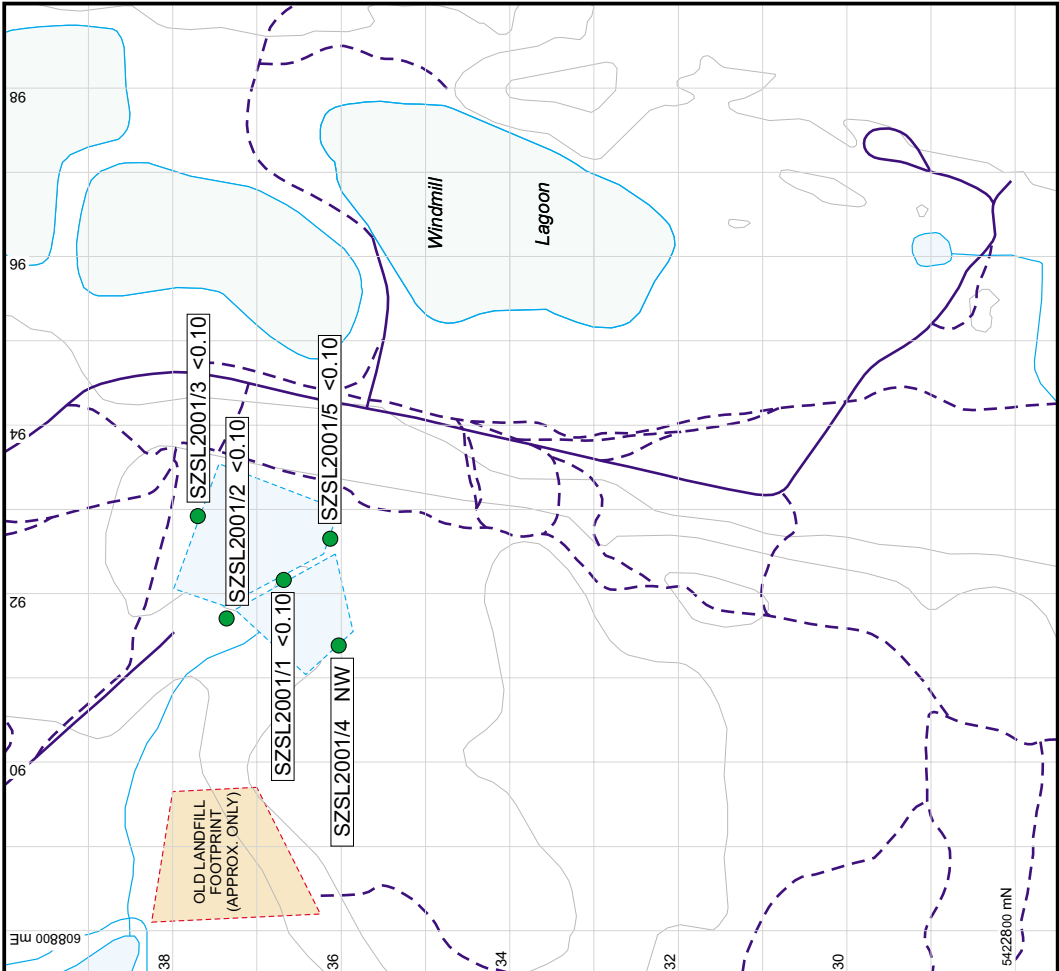


NW = no water

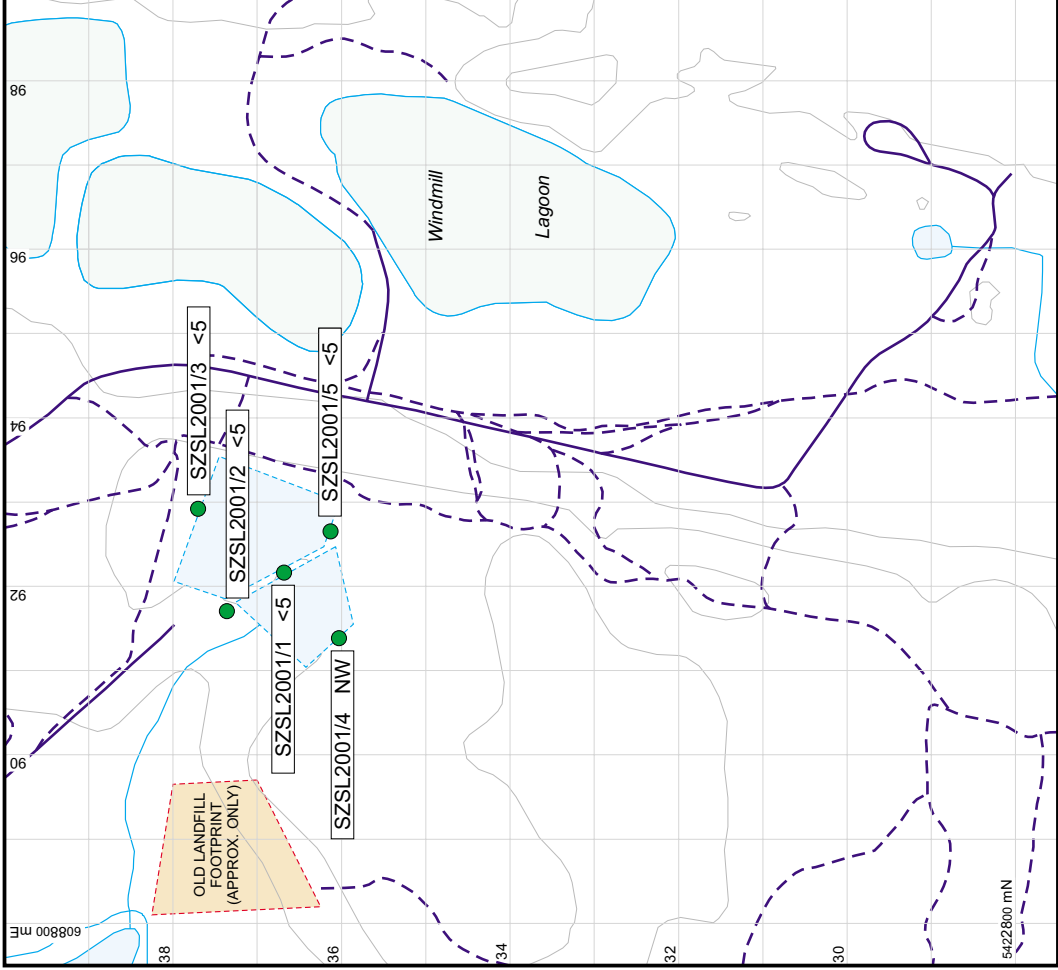
Stieglitz Sewage Lagoons
May 2001
Nitrate (mg-N/L)



Stieglitz Sewage Lagoons
May 2001
Nitrite (mg-N/L)

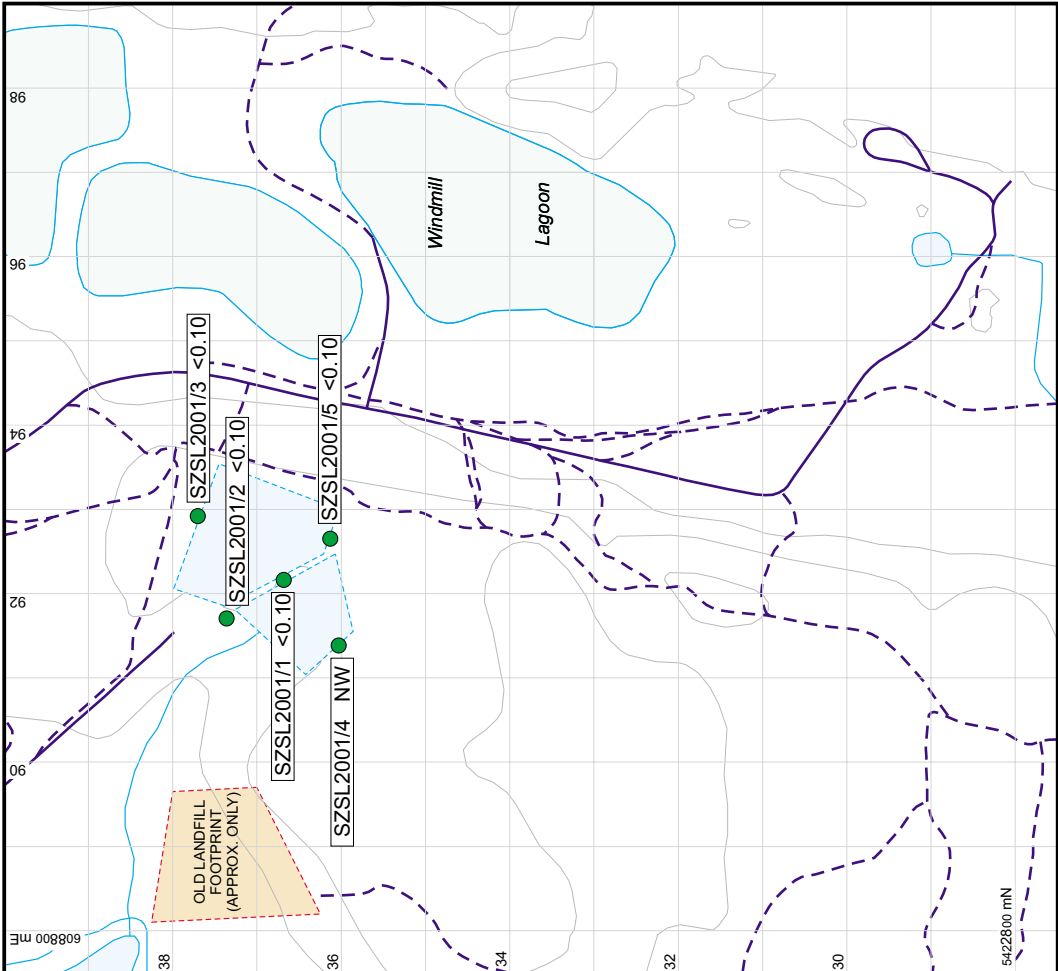


Stieglitz Sewage Lagoons
May 2001
Pb ($\mu\text{g/L}$)



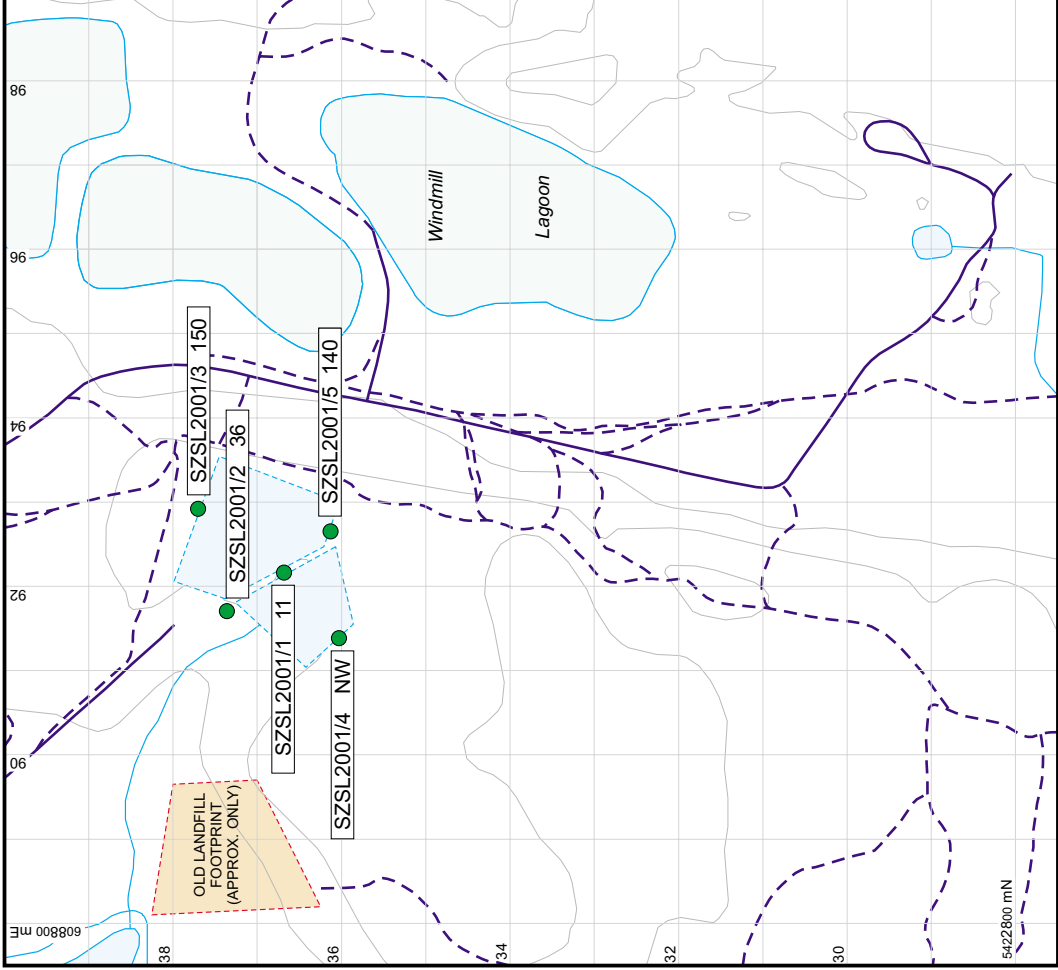
NW = no water

Stieglitz Sewage Lagoons
May 2001
Phosphate (mg-P/L)



NW = no water

Stieglitz Sewage Lagoons
May 2001
Sulphate (mg/L)



Stieglitz Sewage Lagoons
May 2001
Zn ($\mu\text{g/L}$)

