LEACHATE TREATMENT USING VIBRATORY REVERERSE OSMOSIS

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ABSTRACT

- The North Waikato Regional Landfill (NWRL) is owned and operated by EnviroWaste and is the largest operating landfill in New Zealand. The NWRL was opened in 2005 and comprises of a fully engineered landfill with a footprint of 87 ha contained within a 360ha site.
- Leachate at NWRL is currently tankered off site and disposed of at into the Watercare wastewater network. Current discharge rates are 150 to 300m3/day at a cost of $22.00/m3 with a total cost of more than $1m/year. Operating costs were projected to exceed $2.5m by 2020.
- Several options were investigated into treatment. No local disposal options were available without significant pre-treatment. Options investigated were evaporation, reverse osmosis and local disposal.
- The most viable option chosen was treatment via Reverse Osmosis which gave an attractive removal of contaminants with a proven history of successfully being used at landfills throughout the world. New Logic Research from San Francisco were flown to New Zealand to conduct trials on the leachate. There process uses Vibratory Separation Enhanced Processing (VSEP) which helps mitigate colloidal fouling of RO membranes. The pilot test showed a 60-73% recovery of permeate.
  Construction of the plant commenced in November 2015 and full commissioning in June 2016.

KEYWORDS

Leachate, water treatment, operations

1 INTRODUCTION

The NWRL is a state of the art, modern lined sanitary landfill located at Hampton Downs, 55 kilometres south of Auckland and 3 kilometres south of Meremere, between State Highway 1 and the Waikato River. Situated on 362 hectares of farmland, the landfill proper will cover an area of 87 hectares and be filled to a depth of over 70 metres when completed. .

Currently leachate collected from the landfill is transported by truck to a trade waste discharge facility at the Wiri Transfer Station in South Auckland for disposal to Watercare's Mangere Wastewater Treatment Plant.

In early 2013 investigations were started into options for leachate treatment either on site or local disposal. Three options were chosen to look into for dealing with the landfill leachate. Reverse osmosis, evaporation and local disposal were all investigated with reverse osmosis being the preferred option.

2 TREATMENT OPTIONS CONSIDERED

2.1 OVERVIEW

Leachate Treatment

Landfill leachate may be treated by a wide range of methods including:

• Biological treatment methods (e.g. anaerobic treatment, aerobic treatment, sequencing batch reactors, activated sludge, wetland polishing.).

• Physical/chemical treatment (ammonia stripping, membrane filtration, activated carbon polishing, ozonation.).
• Evaporation using landfill gas as a source of energy.
The critical factor in the selection of an appropriate treatment system for the Hampton downs site is the need to reduce both ammoniacal-nitrogen and boron concentrations to acceptable levels for discharge to surface waters or irrigation onto land.

The VESP multi-stage RO/membrane filtration system was selected based on its ability to achieve this requirement.

Leachate evaporation was not favoured, as it would use up a significant proportion of the landfill gas generated on-site, which is presently being used productively for the generation of electricity for supply to the national grid.

Permeate Disposal
Options considered for permeate disposal included discharge to surface waters, irrigation onto land, off-site disposal to the Te Kauwhata Wastewater Treatment Plant, and use on-site for dust control and other similar operational purposes.

The off-site disposal option was rejected due to the high quality of the permeate, making this option redundant. Permeate may be used for dust control during dry periods. New Logic have advised that the low levels of TDS in the permeate should not be an issue with this use.

Concentrate Disposal
The disposal of the leachate post treatment residual concentrate by tankerage to the Wiri Refuse Transfer Station for discharge into the Watercare sewer, (ie the existing system) was not favoured, due to the high cost of off-site tankerage, and the concentrate essentially comprising threefold stronger leachate, which would not meet the trade waste permit acceptability criteria without further treatment.

Concentrate could also be disposed of by evaporation, with the evaporator being significantly smaller in size than that required for the option of evaporating permeate due to concentrate flows being 34% of leachate flows, along with a similar reduction in evaporation energy requirements.

However, an ammonia stripper unit is also likely to be required to remove ammonia from the evaporated product stream, while this may also need treating to remove other contaminants prior to discharge to air. An air discharge consent is also likely to be required. In contrast, proposed recirculation of the leachate concentrate into the landfill is considered a much simpler system. Concentrate evaporation may be investigated further in the future, if concentrate recirculation proves more difficult than expected.

2.2 METHOD

In August 2013 NLR (New Logic Research) were engaged to conduct a pilot test on the Hampton Downs Landfill leachate. NLR provided a VSEP (Vibratory Separation Enhanced Processing) spiral pilot unit with a reverse osmosis membrane.

The pilot plant was installed with a Reverse Osmosis (RO) membrane called ESPA. This membrane was chosen based on NLR experience with similar applications. The spiral unit was installed with LFC membrane modules and used as a secondary polishing step.

The results of the pilot scale tests are given below.

Table 1: Permeate Quality (Test Results)

Constituent (g/m^3 unless stated)	**Raw Feed**		**VSEP Permeate**		**Spiral Permeate**		**ANZECC 90%**
	24/8	29/8	24/8	29/8	24/8	29/8	
Total Alkalinity g/m3 as CaCO3	4,700	5,800	340	340	74	22	

Bicarbonate g/m3 at 25°C	5,700	7,000	380	370	58	27	
Total Boron	26	23	13.3	12.7	9.6	9.3	0.68
Total Calcium	200	220	< 1.1	< 1.1	< 1.1	< 1.1	
Total Iron	4.7	4.7	< 0.42	< 0.42	< 0.42	< 0.42	
Total Magnesium	120	129	< 0.42	< 0.42	< 0.42	< 0.42	
Total Potassium	450	450	13.1	17.2	1.4	< 1.1	
Total Sodium	1,290	1,470	39	56	5.1	2.4	
Chloride	1,260	1,410	58	73	0.8	1.5	
Total Ammoniacal-N	730	930	66	67	12.2	3.6	1.43
Nitrite-N	0.003	< 0.02	0.007	0.007	< 0.002	< 0.002	
Nitrate-N	0.064	0.03	0.011	0.004	0.004	< 0.002	3.4
Nitrate-N + Nitrite-N	0.067	0.03	0.017	0.011	0.004	< 0.002	
Sulphate	137	95	< 0.5	< 0.5	< 0.5	< 0.5	
Carbonaceous Biochemical Oxygen Demand (cBOD5)	1,420	1,570	8	12	4	5	
Chemical Oxygen Demand (COD)	4,500	4,100	11	21	< 6	< 6	

The actual and calculated results for the permeate from the spiral unit using the LFC membrane indicate that three passes will achieve the NZDWS, ANZECC Irrigation Standard or the ANZECC Criteria for Protection of Freshwater Aquatic Species (90% confidence interval) for all parameters of concern except for boron.

A bench top test was undertaken using a water sample spiked with boron using both an LFC and a Toray membrane. Results of this test are presented in Table 2. This test indicates that the Toray membrane will produce a permeate with boron concentration below the NZDWS, ANZECC Irrigation Standard or the ANZECC Criteria for Protection of Freshwater Aquatic Species (90% confidence interval).

Table 2: Spiral RO Boron Rejection

Sample	LFC	TM810C
Feed	26 mg/L	26 mg/L
VSEP Permeate	13.3 mg/L	13.3 mg/L
Spiral Permeate – Pass #1	9.6 mg/L	4.0 mg/L
Spiral Permeate – Pass #2	6 mg/L	1.2 mg/L
Spiral Permeate – Pass #3	3.6 mg/L	0.4 mg/L
Spiral Permeate – Pass #4	2.2 mg/L	
Spiral Permeate – Pass #5	1.3 mg/L	
Spiral Permeate – Pass #6	0.8 mg/L	

The decision was made based on the results from the pilot test to have NLR design a VSEP RO plant to treat up to 300m3 per day of raw leachate.

3 APPLICATION FOR RESOURCE CONSENTS

3.1 OVERVIEW

Applications for two discharge consents were sought from WRC (Waikato Regional Council) being

- Discharge Consent for the irrigation of treated leachate onto land; and
- Discharge Consent for the discharge of treated leachate into water.

Clune stream which will be the receiving environment for the discharged clean permeate was

3.2 METHODS

The application was lodged in November 2014 with a report into the assessment on the receiving environment for the clean permeate and the ecological values present in the aquatic environment by Kessels Ecology and a Fraser Thomas report on the assessment of environmental effects.

3.2.1 SURFACE WATER

An Ecological Values and Assessment Report for Proposed Changes to Leachate System was prepared by Kessels Ecology. The report provides an assessment of the Pine and Clune Streams, which are the ultimate receiving environments for the permeate from the RO leachate treatment system.

Field surveys were undertaken to assess the aquatic ecological values present at three sites, Pine Stream, Clune Stream and the stormwater treatment wetland at the north of the NWRL site, using:

- aquatic surveys including visual assessment of riparian and aquatic habitat; and
- assessment of macroinvertebrate and fish communities.

The report describes the Clune Stream as being highly modified, situated in pasture and unfenced. Overhanging riparian vegetation is limited to grasses, and banks become progressively steeper and the stream more incised further downstream. The stream is highly channelized and flows in a straight line. It states that though some areas are deeper than others, there is no habitat variability in the form of riffles or pools.

The surveyed reach of Pine Stream is described as situated in pasture and highly modified, but fenced to prevent stock access. Overhanging riparian vegetation comprises grasses and willows. The stream is relatively incised and the bare banks show signs of stream clearance earthworks which were carried out in September 2013. It states that Pine Stream, like Clune Stream, flows in a straight line with almost no habitat variability in the form of pools or riffles.

The report found aquatic vegetation to be more abundant at Clune Stream than at Pine Stream, which was likely due to the stream clearance earthworks undertaken three months previously. The species found were common aquatic plant species found in streams and wetlands.

The report states that macroinvertebrate community metrics at Clune and Pine Streams were indicative of poor water and/or habitat quality and reflect the soft bottom substrates and modified nature of the streams.

Several taxa common in slow-flowing, weedy habitats were found at Clune Stream, including damselflies, the water boatman and cladoceran crustaceans that are usually found in still water habitats. Ostracod crustaceans, another species found in slow flowing waters, were dominant at Pine Stream and highly abundant at Clune Stream.

The following fish were found in the Clune Stream and the stormwater treatment wetland:

- 14 black mudfish (and an additional juvenile black mudfish was caught unintentionally in a bucket when collecting water);
- native species common bully;
- shortfin eel;
- introduced species catfish; and
- mosquitofish.

The black mudfish is a threatened species listed by the Department of Conservation as being At Risk – Relictual, because it's natural wetland habitat has been greatly reduced from its historical extent

The report concludes:

> "Based on the highly modified nature of the receiving environments and low projected contaminant concentrations, discharge from the proposed RO leachate treatment system is not considered likely to have a significant ecological effect on the Clune and Pine Streams. Effects of discharging the effluent

to Clune Stream are expected to be mitigated by passage through the 3.1 ha stormwater treatment wetland. The effect of discharging the effluent into the stormwater treatment system or irrigating onto land is therefore considered to be less than minor, provided that the RO treatment system functions as expected and reduces contaminants to acceptable levels.

Because the black mudfish is a threatened species, it is recommended that monitoring of fish is continued in the stormwater treatment wetland and in Clune Stream. Sampling in autumn or winter 2014 is recommended to confirm that the population in the wetland is self-sustaining. Thereafter, monitoring every three years in autumn or winter is recommended to monitor the health of the population and detect any changes."

3.2.2 DISCHARGE TO LAND

This section addresses potential environmental effects associated with the proposed discharge of treated leachate (permeate) by irrigation onto land during summer months. The initial permeate flow is expected to be 61m3/d and may be irrigated over approximately four months during summer.

The effects of the irrigation of permeate on land were addressed in a Fraser Thomas report (Engineering report and assessment of environmental effects), which concludes:

> "Overall, the irrigation of permeate onto land is considered to have less than minor environmental effects. It may in fact have some benefits, by providing a moderate source of irrigation water during dry times of the year and by providing a consistent source of nitrogen at acceptable loading rates. The land irrigation of permeate is considered to be sustainable."

3.2.3 STATUTORY ANALYSIS

During the preparation of this application, regard was given to the Resource Management Act 1991, and any actual or potential effects on the environment of allowing the activity. Consideration has also been given to the relevant objectives, policies and rules of the Waikato Regional Plan (WRP) and the Waikato District Plan (WDP).

1. Resource Management Act 1991

2. Part II – Purpose and Principles

This part of the Act relates to matters such as the purpose of the Act, matters of national importance, maintenance / enhancement of the quality of the environment and Treaty of Waitangi issues.

The proposed activity is not considered to be contrary to this part of the Act, given that:

- the activity will enable people and communities to provide for their social and economic well-being, while avoiding, remedying and mitigating the adverse effects of the activity on the environment;
- the environmental effects of the proposed works are considered to be minor;
- the proposed activity will promote the efficient use and development of natural and physical resources; and
- the nature of the activity will not be contrary to the principles of the Treaty of Waitangi.

Overall the activity is considered to be consistent with Part II of the Act. The discharge and irrigation of permeate retains water in the landfill catchment rather than removing it off-site and enables irrigation of farm land, including the dry summer months.

The discharge and irrigation of permeate will be undertaken in such a way that ensures that waterways and people in the surrounding environment are not adversely affected.

3. Part III – Duties and Restrictions

Section 9 – Restrictions on the Use of Land

Section 9 (3) states that no person may use land in a manner that contravenes a district rule unless the use-
(a) is expressly allowed by a resource consent.

Section 15 – Discharge of Contaminants into Environment

Section 15 states that no person may discharge any-

(a) contaminant or water into water; or
(b) contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water;

An assessment of the requirements of the Waikato Regional Plan is set out in Section 9.

1. Part IV – Resource Consents

Section 95A Public Notification of Consent Application at Consent Authorities Discretion

A consent authority may, in its discretion, decide whether to publicly notify a consent application (section 95A(1). However, section 95A(2) requires that a consent authority must publicly notify an application if:

(a) It decides that the activity will have, or is likely to have, adverse effects on the environment that are more than minor;
(b) the applicant requests public notification of the application; or
(c) a rule or national environment standard requires public notification.

Section 95A(3) provides that an application must not be publicly notified if a rule or national environmental standard precludes public notification and the applicant has not requested public notification.

Section 95A(3) allows a consent authority to publicly notify an application if it decides there are special circumstances in relation to the application.

Section 95B provides that if an application is not publicly notified, a council must decide if there are any affected persons in relation to the activity. Limited notification of the application must be given to affected persons unless a rule or national environmental standard precludes limited notification.

Section 6 of this AEE confirms that the activity will have no more than minor adverse effects on the environment in respect of:

- discharges to land; and
- discharges to water.

On this basis the effects of the activity will be minor and no person will be adversely affected by the granting of consent.

Section 104 – Decisions

Subject to Part II of the Act, when considering a consent application the consent authority shall have regard to the following relevant matters:

(a) *"Any actual and potential effects on the environment of allowing the activity; and*
(d)(iv) *Any relevant provisions of a plan or a proposed plan; and*
(i) *Any other matters the consent authority considers relevant and reasonable necessary to determine the application".*

An assessment of effects on the environment is contained within Section 6 of this report. An assessment of the relevant plans is outlined in sections 3.6 and 3.7 of this report.

2. National Environmental Standards

The following National Environmental Standard (NES) is relevant to the section 127 application to vary the Land Use Consent:

- National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.

The NES states:

> **5 Application**
> (1) These regulations-
> (a) apply when a person wants to do an activity described in any subclause (2) to (6) on a piece of land described in subclause (7) or (8).
>
> *Activities*
> (4) An activity is disturbing the soil of a piece of land, which-
> (a) means disturbing the soil of a piece of land for a particular purpose:
>
> *Land covered*
> (7) The piece of land is a piece of land described by 1 of the following:
> (a) an activity or industry described in the HAIL is being undertaken on it:
>
> **8 Permitted activities**
>
> *Disturbing soil*
> (3) Disturbing the soil of a piece of land is a permitted activity while the following requirements are met:
> (c) the volume of the disturbance of soil of the piece of land must be no more than 25 m^3 per 500 m^2.

The NWRL site is on the HAIL as it is a landfill. The activities proposed in respect of the development and operation of the RO plant will not disturb more than 25 m^3 per 500 m^2 and are therefore Permitted Activities under the NES.

3. National Policy Statements

The National Policy Statement for Freshwater Management 2014 (NPS FM 2014) is relevant to this application.

The NPS-FM 2014 requires regional councils to recognise the national significance of fresh water for all New Zealanders and Te Mana o te Wai (the mana of the water).

It directs regional councils to, among other things:

- safeguard fresh water's life supporting capacity, ecosystem processes, and indigenous species including their associated ecosystems;
- protect the significant values of wetlands and outstanding freshwater bodies
- implement the national objectives framework by:
    - setting freshwater objectives according to a specified process (i.e., the national objectives framework) and to meet community and tāngata whenua values which include the compulsory values of ecosystem health and human health for recreation
    - using a specified set of water quality measures (attributes) to set the freshwater objectives (an objective can only be set below national bottom lines in specified circumstances)

- set limits which allow freshwater objectives to be met (e.g., a total catchment contaminant-load or a total rate of water take)
- put in place measures to better account for water takes and sources of contaminants, and measure achievement towards meeting objectives
- fully implement the National Policy Statement by 2025.

4. Waikato Regional Policy Statement

The Waikato Regional Policy Statement (2000) has the following relevant objectives in respect of discharges of water to land and water:

3.4.3 Water Quality

Objective
Net improvement of water quality across the Region

3.9.5 Waste Management

Objective
The efficient use of resources and a reduction in the quantities of wastes requiring disposal in the Waikato region, and the adverse effects associated with their generation and disposal.

An assessment of effects on the environment is provided in Section 6. In respect of the relevant objectives in the Waikato Regional Policy Statement (2000):

- the application to discharge permeate to land and the NWRL stormwater system and irrigate permeate onto farmland at the site, as proposed is likely to have less than minor effects on surface water or groundwater quality;
- the irrigation of permeate onto farmland is a beneficial use of a discharge from the waste disposal process;
- the discharge of permeate to land at the site will retain the water in the Clune Stream catchment area..

5. Proposed Waikato Regional Policy Statement

The Proposed Waikato Regional Policy Statement was notified on 3 November 2010. It has the following objectives relevant to the proposed irrigation of permeate.

3.9 Efficient Use of Resources

Use and development of natural and physical resources occurs in a way and at a rate that is efficient and minimises the generation of waste.

3.13 Mauri and Health of Fresh Water Bodies

The mauri and health of **fresh water bodies** are protected by:

(a) recognising and maintaining the following values:

i. natural character and natural functioning;

ii. health and functioning of indigenous biodiversity, ecosystems and habitats;

iii. the relationship of tangata whenua with fresh water;

iv. availability and suitability of drinking water;

v. harvesting of aquatic food species and **mahinga kai** that is safe to eat; and

vi. recreation values including swimming;

(b) restoring or enhancing the values of fresh water bodies where they have been degraded as a result of human activities, with demonstrable progress made by 2030; and

(c) protecting the values of fresh water bodies where they are high; and

(d) while not detracting from the above values, enabling people and communities to provide for their social, economic and cultural wellbeing and for their health and safety.

6. Waikato Regional Plan

7. Objectives

The following objectives in the Waikato Regional Plan are relevant to the proposed irrigation of permeate:

Chapter 3 Water Module

3.1.2 Objective

"The management of water bodies in a way which ensures:

a) that people are able to take and use water for their social, economic and cultural wellbeing

b) net improvement of water quality across the Region

c) the avoidance of significant adverse effects on aquatic ecosystems

f) the range of reasonably foreseeable uses of ground water and surface water are protected

m) ground water quality is maintained or enhanced and ground water takes managed to ensure sustainable yield

o) concentrations of contaminants leaching from land use activities and non-point source discharges to shallow ground water and surface waters do not reach levels that present significant risks to human health or aquatic ecosystems"

3.5.2 Objective

"Discharges of contaminants to water undertaken in a manner that:

a) does not have adverse effects that are inconsistent with the water management objectives in Section 3.1.2

b) does not have adverse effects that are inconsistent with the discharges onto or into land objectives in Section 5.2.2

c) Ensures that decisions regarding the discharge of contaminants to water do not reduce the contaminant assimilative capacity of the water body to the extent that allocable flows as provided for in Chapter 3.3 are unable to be utilised for out of stream uses."

The design, construction and operation of the leachate treatment system will ensure that the permeate is of a quality suitable for irrigation to farmland, use on site roads and discharge into the NWRL site stormwater system, via a land disposal field.

Chapter 5 Land and Soil Module

5.2.2 Objective

"Discharges of wastes and hazardous substances onto or into land undertaken in a manner that:

a) does not contaminate soil to levels that present significant risks to human health or the wider environment

b) does not have adverse effects on aquatic habitats, surface water quality or ground water quality that are inconsistent with the Water Management objectives in Section 3.1.2.

c) does not have adverse effects related to particulate matter, odour or hazardous substances that are inconsistent with the Air Quality objectives in Section 6.1.2 "

The design, construction and operation of the leachate treatment system will be implemented to ensure that the permeate is of a quality suitable for irrigation to farmland, use on site roads and discharge into the NWRL site stormwater system, via a land disposal field. It will not contaminate the land and contaminants will not leach into groundwater, or discharge into water or the air, at levels that present a risk or nuisance to people or the environment.

8. Policies

The following policies in the Waikato Regional Plan are relevant to the proposed activity:

Chapter 3 Water Module

3.2.3 Policies

"Policy 2: Managing Degraded Water Bodies
Enhance the quality of degraded water through improved management of activities that affect water bodies so that:

a. For activities controlled by rules in the Plan:
i discharges to water will not further degrade water quality with respect to those parameters of the relevant class(es) for that water body that are not currently met
ii land-based treatment systems will be promoted where soil type and drainage will allow, and where adverse effects are less than the adverse effects of direct discharges into water"

3.5.3 Policies

"Policy 4: Discharges to Land
Ensure that the discharge of contaminants onto or into land maximises the reuse of nutrients and water contained in the discharge

Advisory Note:
- *The adverse effects of discharges of contaminants onto or into land and soil and subsequent adverse effects on water quality and air are addressed in the policies in Section 5.2.3 of the Plan."*

Chapter 5 Land and Soil Module

5.2.3 Policies

"Policy 2: Other Discharges Onto or Into Land
Manage discharges of contaminants onto or into land not enabled by Policy 1, in a manner that avoids, where practicable, the following adverse effects and remedies or mitigates those effects that cannot be avoided:

a) contamination of soils with hazardous substances or pathogens to levels that present a significant risk to human health or the wider environment.
c) any effect on water quality or aquatic ecosystems that is inconsistent with the purpose of the Water Management Classes as identified by the policies in Section 3.2.3"

9. Rules Relating to Section 15 of the RMA

Rule 3.5.4.5 in the Waikato Regional Plan states that any discharge of a contaminant into water, or onto or into land, in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water, that is not specifically provided for by any rule, or does not meet the conditions of a permitted or a controlled activity rule in this Plan, is a **Discretionary Activity** (requiring resource consent).

Rule 5.2.7.1 states that the discharge of contaminants into or onto land, and any subsequent discharge of contaminants into water or air (excluding discharges to air permitted by Rule 6.1.13.1) as part of the operation of a landfill is a **Discretionary Activity** (requiring resource consent).

Therefore consent is required for the discharge of permeate to land, from where it will discharge to water, and irrigation of permeate onto land on and around the NWRL site and into the site's stormwater system, via a land disposal field, as a **Discretionary Activity**.

3.3 RESULTS

A Section 127 RMA Consent was granted to EnviroWaste for 35 years expiring on the 31st of December 2029 with conditions relating to discharge to the Clune Stream. The main conditions set by WRC relate to monitoring and testing of the following constituents and maximum values:

Table 4: Consent Discharge Parameters

Parameter	Maximum Value
Conductivity (mS/m)	20
Boron (g/m3)	<0.5
Sodium (g/m3)	<1.0
Iron (g/m3)	<0.2
Ammonia(g/m3)	<0.5

4 CONSTRUCTION AND COMISSIONING

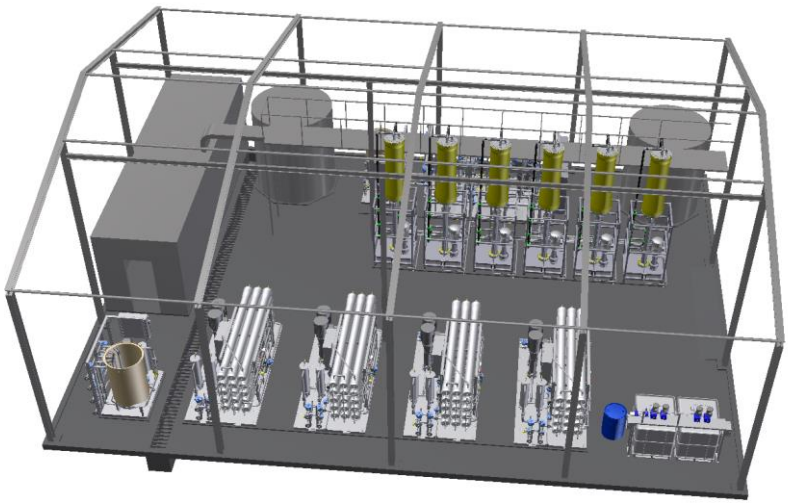
4.1 OVERVIEW

An order was placed on the 15th of December 2014 to start construction of the VSEP plant implementing 6 VSEP modules and 4 RO Spiral enclosures. Earthworks began for the plant enclosure in November 2015 and the building completed in March 2016. Factory Acceptance Testing in San Francisco was attended by myself in January 2016. All plant from NLR was received in March 2016 and Site Acceptance Testing was commenced at the end of June 2016.

4.2 CONSTRUCTION AND COMMISIONING

Preliminary designs were received from ORO Engineering Services who are the Australasian vendors for NLR along with treatment diagrams.

Photo 1: Preliminary Design



Construction commenced in November 2015 based on the above photo and the plant was ready for commissioning on the 22nd June. The plant was initially treating an input of 450m3/day which was well above the design of 300m3/day. Initial samples of the raw leachate and from the VSEP modules and RO spiral units showed effective reduction in all consented constituents apart from Ammoniacal – N.

Table 5: Leachate Treatment Samples

Parameters	**Units**	**Raw Leachate**	**VSEP**	**Spiral 1**	**Spiral 2**	**Spiral 3**	**Spiral 4**
pH	pH Units	8.2	9	9.9	10.1	9.9	10
Electrical Conductivity (EC)	mS/m	1,220	63.1	6.2	4.7	4.4	3.7
Total Boron	g/m3	19.7	10	3.3	0.35	0.0196	< 0.0053
Chloride	g/m3	1,130	45 #1	< 5 #1	< 5 #1	< 5 #1	< 5 #1
Total Ammoniacal-N	g/m3	770	59	16	13	12	11

Because of the high pH running through the final spiral units the Ammoniacal-N reduction was not within consent parameters and was not effectively removing this constituent. The decision was made to lower the pH through the third and fourth spiral after effective boron concentrations were removed. Initial sampling showed dosing with HCL that removal could be achieved of Ammoniacal-N.

Table 6: Leachate Treatment Samples With HCL Dosing

Parameters		Raw Leachate	VSEP	Spiral 1	Spiral 2	Spiral 3	Spiral 4
pH	pH Units	8.1	9.1	10	10.1	9.6	4.2
Electrical Conductivity (EC)	mS/m	1,101	43	6	4.2	1.6	5.6
Total Boron	g/m3	16.7	7.7	2.7	0.63	0.24	0.072
Total Iron	g/m3	9.6	<2.1	<2.1	<0.021	<0.021	<0.021
Total Sodium	g/m3	1,160	33	2.6	0.38	0.046	0.026
Total Ammoniacal-N	g/m3	680	46	21	17.4	3.4	1.85

In order to achieve effective removal of Ammoniacal – N pH dosing was found to be in the range of a Ph of between 7 and 8.

Table 7 : pH Adjusted Through RO Spirals

Parameters		Spiral 3	Spiral 4
pH	pH Units	7.1	6.4
Total Ammoniacal-N	g/m3	0.19	0.37

A pH dosing unit was then installed in the plant directly dosing into the third RO spiral. This was setup to dose for a pH of 7.5 and has proved effective in stripping out of Ammoniacal-N whilst not compromising the overall effectiveness of the removal of other constituents.

5 CONCLUSIONS

The VSEP technology supplied by NLR has proven to be an effective means of leachate treatment and has been effective in treating up to 450m3 per day under optimal operation. 65% recovery has been achieved as clean permeate and discharged to the Clune stream or used on site for dust control.

Removal of all constituents to date has been effective especially for Boron and Ammoniacal-N with latest results putting removal of Boron at 0.015 g/m3 and Ammoniacal-N at 0.11 g/m3. All other constituents are well below trace in samples taken.

With a treatment cost conversion of $5/m3 as opposed to tankering off site with a cost of $22/m3 this as also proved to be a cost effective solution for treatment of landfill leachate.

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REFERENCES