BROCKMAN RESOURCES LIMITED

MARILLANA PROJECT
WASTE WATER TREATMENT EFFLUENT DISPOSAL

1872-RPT-004
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REVISION STATUS

REVISION	DATE	DESCRIPTION	AUTHOR		APPROVED	
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A	15/07/09	First draft	Owen Horton Study Manager			
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1 INTRODUCTION

The proposed admin/processing facility and the camp at Marillana will have sewage treatment requirements. A packaged sewage treatment facility will be installed at each site, sized to suit the expected load. This document describes the conceptually-proposed waste water treatment system, and waste water disposal methodologies.

2 WASTE WATER TREATMENT PLANT (WWTP)

The selection of the actual waste water treatment system is normally performed through a competitive tender during the definitive feasibility study (DFS). The prefeasibility study (PFS) has just been completed for the Marillana Project, and hence the actual system has yet to be selected. Ausenco has used information from previous projects to determine the cost estimates for the PFS, and has proposed the use of a system comparable to the TBR™ system marketed by Chatoyer Water Treatment of Perth. This system is described below.

2.1 Waste Water Treatment Plant Description

Influent (grey and black water) is gravity fed from the camp facilities and amenity blocks to a wet well which incorporates alternating duty/standby macerator pumps.

Influent from the wet well is then pumped to balance tanks located adjacent to the WWTP for primary solids settling and for balancing the inlet flow which will be quite variable through each day, with peaks in the mornings and evenings.

Stored influent from the balance tanks is then transferred at a constant flow rate via a duty/standby feed pump to the inlet of the packaged sewage treatment unit. The wastewater is fed to the different stages of the bioreactors for organic matter removal and nitrogen reduction. The treated wastewater from the bioreactor flows into a clarifier (settling tank) for biomass removal. In addition, chemicals (e.g. alum) will be added into the wastewater for phosphorus removal.

The overflow from the clarifier is collected in a supernatant tank where chlorine (e.g. sodium hypochlorite) will be injected using a chemical dosing pump.

The treated effluent is then filtered through a multimedia filter for removal of fine particulate followed by disinfection and re-chlorination to achieve the desired treated effluent quality. It is then transferred to a storage tank prior to discharge to disposal as required.

2.2 Waste Water Treatment Plant Specifications

Table 1 shows the specifications proposed as typical of a WWTP as described above.

Table 1 Waste Water Treatment System Specifications

Parameter	Abbrev	Units	Raw Sewage Quality	Treated Water Specification
Biochemical Oxygen Demand	BOD_5	mg/L	300 - 400	< 20 (ave)
Total Suspended Solids	TSS	mg/L	200 - 250	< 30 (Ave)
Total Nitrogen	TN	mg/L	30 - 40	<20
Total Phosphorous	TP	mg/L	5 – 15	<8
pH			6.5 – 7.2	6.5 – 8.5
Faecal Coliforms		cfu/100mL		< 1,000
Residual Free Chlorine		mg/L		> 0.5

3 WASTE WATER DISPOSAL METHODOLOGY

It is proposed to use surface irrigation as the primary methodology for disposal of treated waste water, designed to facilitate the evaporation of the sprayed water.

3.1 Regulatory Control

3.1.1 Relevant Legislation

Operation of a waste water treatment plant, and disposal of the waste water treatment is controlled by the Health Act 1911, with particular reference to:

- Section 98 – prohibits sewage being put anywhere unless it is authorized.
- Section 107 – prohibits the use of any apparatus for the treatment of sewage unless approved by the Executive Director of Public Health.
- Section 129 – prohibits the pollution of any water supply.

The disposal of treated waste water from commercial-scale operations is normally evaluated on a case-by-case situation. However, the regulators are also guided by regulations and guidelines that cover residential use of treated greywater, and recycled water originating from sewage and other sources. These include:

- The Metropolitan Water Supply, Sewerage and Drainage By-laws 1981 contain details on several provisions for the supply of alternate water:
  - Section 3 - Protection of water against pollution.
  - Section 4 - Protection of catchment areas and water reserve.
  - Section 5 - Protection of public water supply areas and underground water pollution control areas.
- The Water Services Licensing Act 1995 contains a number of provisions that regulate the use of recycling water sources.

- The Department of Environment and Conservation also regulates the use of recycled water on land under Part V of the Environmental Protection Act 1986.

3.1.2 Approval Process – Local Government

The East Pilbara Shire has an approval process for the installation of sewage treatment facilities up to 540 L/d. These are based on the South Australia Department of Health guidelines, which, in turn, are based on Australian Standard AS/NZS 1547:2000 *On-site domestic – wastewater treatment*, published in July 2000. Whilst the requirements for a commercial-scale waste water treatment plants are likely to be different to those of a domestic system, there are some requirements that are likely to be appropriate to both. These include:

- Aerobic or other manufactured wastewater treatment products must be located above the 10 year ARI event, at least 1.5 m from the irrigation disposal area, at least 10 m from a bore and at least 3 m from a building.

- The SA guideline gives setbacks from coastal water, inland water, and water protection areas. These range between 50 m and 100 m.

- Primary effluent is not permitted anywhere near water protection areas. Secondary effluent must be a minimum of 50 m setback from a water protection area.

The systems installed will be designed to comply with all these parameters.

Surface irrigation systems are currently in use at multiple locations in the Pilbara, and in numerous commercial applications. AS/NZS 1547:2000 Section 4.2A10 deals with the design constraints on domestic surface irrigation systems. These constraints have been considered in the site selection process, and will be built into the final design parameters, as appropriate, for the final surface irrigation system.

3.1.3 Approval Process – State Government

Implementation of the proposed WWTP and surface irrigation system for the treated waste water will need to be approved by the Executive Director, Public Health, based on the application to construct or install apparatus for treatment of sewage and a report from the Local Government authority.

The Department of Health (DoH) requires that recycled water schemes are assessed in accordance with the National Water Quality Management Strategy document "Australian Guidelines for Water Recycling: Managing Health and Environmental Risks" (Phase 1) 2006 (known as the National Guideline) as published by the Natural Resource Management Ministerial Council, Environmental Protection and Heritage Council and the Australian Health Ministers Conference, November 2006. Proponents for recycled water schemes are now required to develop a Recycled Water Quality Management Plan (RWQMP) as per the National Guidelines.

As it is not planned to recycle water at Marillana, a RWQMP will not be required. However, the design guidelines incorporated in the supporting documentation for the RWQMP process are relevant.

Table 2 shows how the water quality parameters vary according to the potential end uses.

Table 2 Recycled Water Schemes Quality Parameters

Exposure Risk Level	Potential End Uses	E. coli (cfu/100 mL)	BOD (mg/L)	SS (mg/L)	pH	Turbidity (NTU)	Disinfection (Cl: mg/L)
High level of human contact	- residential dual use - urban irrigation, unrestricted access - communal use	< 1	< 10	< 10	6.5-8.5	< 2	0.2 – 2.0
Medium level of human contact	- Urban irrigation, restricted access - Fountains and water features - Industrial use	< 10	< 20	< 30	6.5-8.5	< 2	0.2 – 2.0
Low level of human contact	- residential dual use - urban irrigation, enhanced restricted access	< 1000	< 20	< 30	6.5-8.5	< 2	0.2 – 2.0
Extra Low level of human contact	- woodlots - subsurface reticulation	<10,000					

In April 2009, DoH released the document *Draft Guidelines for the Use of Recycled Water in Western Australia.* These guidelines promote the use of management techniques for irrigation systems such as:

- access control to the irrigation area is required when a non-potable supply of recycled water is used for irrigation purposes
- irrigation pipes should be able to be drained or flushed to remove obstructions from the system
- spray drift should be minimised when using a recycled water supply for irrigation purposes to prevent the risks associated with human exposure. Techniques recommended include
  - buffer zones
  - tree/shrub screens
  - selection of large droplet design sprays
  - lower spray height
  - anemometer switching systems
  - irrigating in weather conditions that would not cause spray drift.

3.2 Surface Irrigation

The concept of surface irrigation is to use conventional irrigation equipment to spray the effluent over a large area, such that the effluent evaporates quickly. Nutrients (Nitrogen and Phosphorous) in the waste water can lead to an increase in nutrient levels known as eutrophication.

To achieve effective disposal, a high surface area is required. The actual surface area required is dependant on the nutrient load in the effluent, the volume of effluent to be disposed of, the regional evaporation rate and the eutrophication risk.

The soils at the surface irrigation disposal sites are fine grained, and are believed to be classified as belonging to the eutrophication risk category D (defined in *Water Quality Protection Note 22*, Department of Water, July 2008). This does need to be verified through soil testing during the next phase of the project. Table 3 shows the expected parameters required for treated waste water to be disposed of through a surface irrigation disposal system over soils of eutrophication risk category D.

Table 3 Surface Irrigation Quality Parameters

Parameter	Units	Treated Water Specification*
Discharge rate to spray field	mm/day	<6
Spray Field Nitrogen Loading	kg/ha/year	<480
Spray Field Phosphorous Loading	kg/ha/year	<120

The mean average evaporation rate at Marillana has been estimated to be of the order of 3,600 mm/y[1], compared to a mean average rainfall of 300 mm. In the absence of actual recorded evaporation data from Marillana, Aquaterra have extrapolated average potential evapotranspiration data to form a prediction of local evaporation rates (Table 4).

Table 4 Average Evaporation Data - Newman

Month	Evaporation (mm)
January	380
February	290
March	290
April	200
May	137
June	105
July	115
August	170
September	230
October	320
November	380
December	410

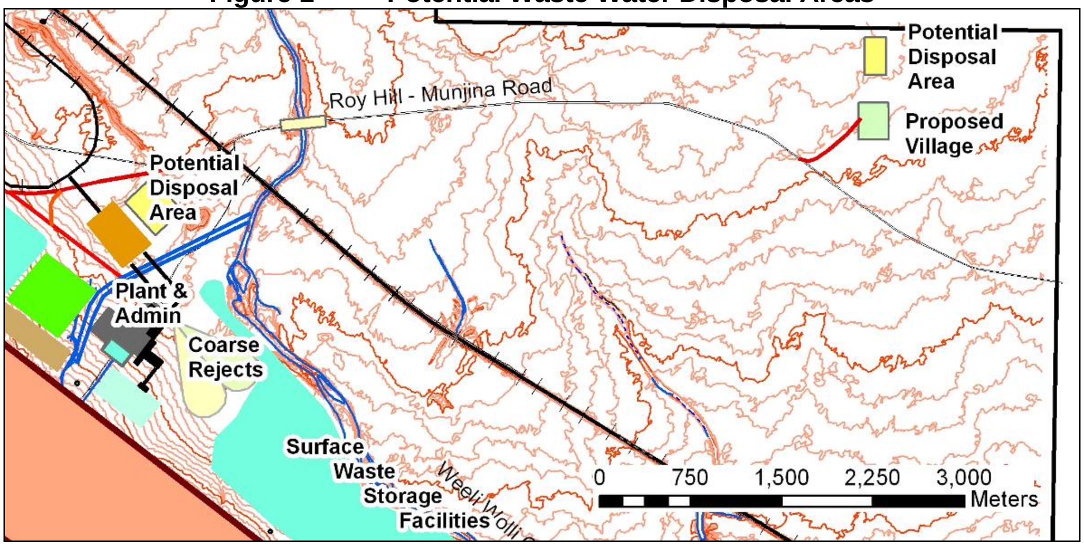
Using the average of the lowest three months (May – July), Aquaterra have calculated (Appendix 2) that an area of 1.72 ha would be required for a 200 room village, based on an assumed eutrophication risk category D and a daily water usage of 300 litres per person. The current Marillana village is sized at 550 rooms, so the likely active irrigation area is expected to be of the order of 5 ha for disposal of 165 kl/d. Additional WWTP irrigation area will be required during the construction phase, when a larger village is anticipated. Aquaterra anticipate that the nutrient loading to the disposal areas will be less that 30% of the expected maximum loading, though this will be dependant on the capabilities of the actual WWTP selected during the next phase of the project.

[1] *"An inventory and condition survey of the Pilbara Region, WA"* A.M.E. Van Vreeswyk, A.L. Payne, K.A. Leighton and P. Hennig Technical Bulletin No. 92 Department of Agriculture, December 2004

3.3 Location of Surface Irrigation Disposal Area – Accommodation Village

The accommodation village has been tentatively sited some 800m north of the Roy Hill – Munjina Road. Figure 1 shows that the topography in the area slopes very gently away to the north-west. The Fortescue Marches lie to the north, and the regional drainage trends in that direction.

Figure 1 Potential Waste Water Disposal Areas



The hydrologeological assessment[1] conducted by Aquaterra notes that the groundwater also flows to the north.

It is proposed to locate the accommodation village surface irrigation disposal area on the northern side of the proposed village site, at a distance of around 500 m.

There are no recorded weather data for the Marillana Project. The closest historical weather stations are Redmont to the NNW and Sand Hill to the SSE, while Newman Aerodrome is the closest active weather station. Average annual wind roses from these sites are included in Appendix 1. These indicate that the predominant winds are from the E and SE. The siting of the surface irrigation disposal area to the north will ensure that any potential odour issues at the camp will be minimised.

Table 5 shows the selected site's compliance with the design guidelines proposed by Aquaterra in their 2008 memo on Effluent Irrigation at Marillana (Appendix 2).

[1] "*Marillana Groundwater Prefeasibility Report"*, Aquaterra, 3 July 2009

Table 5 Accommodation Village Site - Compliance with Design Guidelines

Design Guideline	Compliance
Locate remote from areas where odours or spray drifts may cause nuisance	Site is 500m N of village, predominant wind direction is from S-SE
Locate where depth to water table exceeds two metres	The nearest observation bore, 3000m ESE, has a water table 14 m below the surface
Locate where surface slopes are less than one in twenty	Slope is 1 in 250 m
Locate in areas not subjected to seasonal flooding	Pre-development, this site would have been on the edge of the 1 in 10 Year ARI flood event. Flood protection bunding for the village itself will ensure that the Primary Effluent in the WWTP is protected from the 10 Year ARI flood event.
Locate away from natural waterways and water sources	Site is 2.2 km from Weeli Wolli Creek

There is the potential that a significant flood event (10 year ARI or more) may result in the surface irrigation disposal area becoming inundated.

Aquaterra have carried out an assessment of the impact of inundation on the surface irrigation areas and determined that the risk of mobilising nutrients and coliforms is low, and that any impacts associated with inundation would be negligible on the receiving environment.

Aquaterra's report on the assessment of inundation of the spray fields is included in appendix 3.

The Fortescue Marshes to the north of the project area has been identified as a Wetland of National Significance (DIWA listing), and has been classified as an Environmentally Sensitive Area (ESA) under the Environmental Protection Act 1986.

The proposed surface irrigation disposal area is 12.4 km south of the closest edge of the Fortescue Marshes ESA, and consequently there is not anticipated to be any surface run-off for the surface irrigation disposal area to the ESA. Aquaterra have evaluated the impact of a 1 in 10 year ARI flood event inundating the surface irrigation fields (Appendix 3), and have concluded that with dilution and the likely limited mobilisation of nutrients from the soil profile into the surface water, that the effects of such an event would be limited.

Aquaterra have also estimated that any nutrients reaching the water table would take 25-30 years to reach the Fortescue Marshes, far longer than the lifespan of the nutrients in the system.

3.4 Location of Surface Irrigation Disposal Area – Processing Plant

A provisional site layout has been developed for the processing plant, and the associated admin and mining admin areas. These are shown in Figure 1. An area has provisionally been set aside for the surface irrigation disposal area, at a distance of about 500 m from the main office facilities, and immediately north of the final product stockpiles. This site is also 500 m from Weeli Wolli Creek, and separated from it by a minor dune system, so as to prevent overflow from the surface irrigation system impacting on the creek-based ecosystem.

As with the accommodation village, the surface irrigation disposal area is sited to the north of the main office area, placing it downwind of the predominant wind direction, and hence minimising the potential impact of odours.

Based on a workforce of 550 over two shifts at 60 l/person/d, the likely irrigation area would be 1 ha for the disposal of 33 kl/d. Additional surface irrigation disposal area will be provided to cover the peak construction manning.

Table 6 shows the selected site's compliance with the design guidelines proposed by Aquaterra in their 2008 memo on Effluent Irrigation at Marillana (Appendix 2).

Table 6 Process Plant Site - Compliance with Design Guidelines

Design Guideline	Compliance
Locate remote from areas where odours or spray drifts may cause nuisance	Site is 500m N of offices, predominant wind direction is from S-SE
Locate where depth to water table exceeds two metres	The nearest observation bore, 500m south, has a water table 13 m below the surface
Locate where surface slopes are less than one in twenty	Slope is 1 in 1000
Locate in areas not subjected to seasonal flooding	This site would have been on the edge of the 1 in 10 Year ARI flood event. Flood protection bunding similar to that required for the accommodation village will ensure that Primary effluent in the WWTP remains above the post-development 10 Year ARI flood event.
Locate away from natural waterways and water sources	Site is 0.6 km from Weeli Wolli Creek The location of the potable water bores for the plant site have yet to be determined, but will be placed at a location that Aquaterra's hydrogeological modelling indicates will not be impacted by any potential seepage from the surface irrigation area

3.5 Management of Surface Irrigation Disposal Area

The surface irrigation disposal system shall be operated in such a manner as to prevent spray drift, misting, pooling and run-off from the surface irrigation disposal area. The area should also be fenced, with appropriate signage, to prevent accidental access by unauthorised personnel.

3.6 Targeted Approval Level

The proposed surface irrigation system, as described in the preceding sections, has been designed to the protection levels similar to those of an Exposure Risk Level of Low (as in Table 2), in that the sites chosen are isolated, will have restricted access, and the proposed effluent specifications fall within the required range for Low Exposure Risk Level.

An assessment of the soil type and eutrophication risk will be carried out to determine the key design parameters for the treated waste water disposal spray fields, including nutrient loading and discharge rates. This information will be a key input into discussions with the relevant authorities, to ensure the treated waste water quality parameters selected are appropriate, and to refine the design criteria for the WWTP and for the surface irrigation disposal areas.

Once the design has been suitably developed, an "Application to Construct or Install Apparatus for Treatment of Sewage" can be submitted to the Shire of East Pilbara and the Department of Health.

4 RECOMMENDATIONS

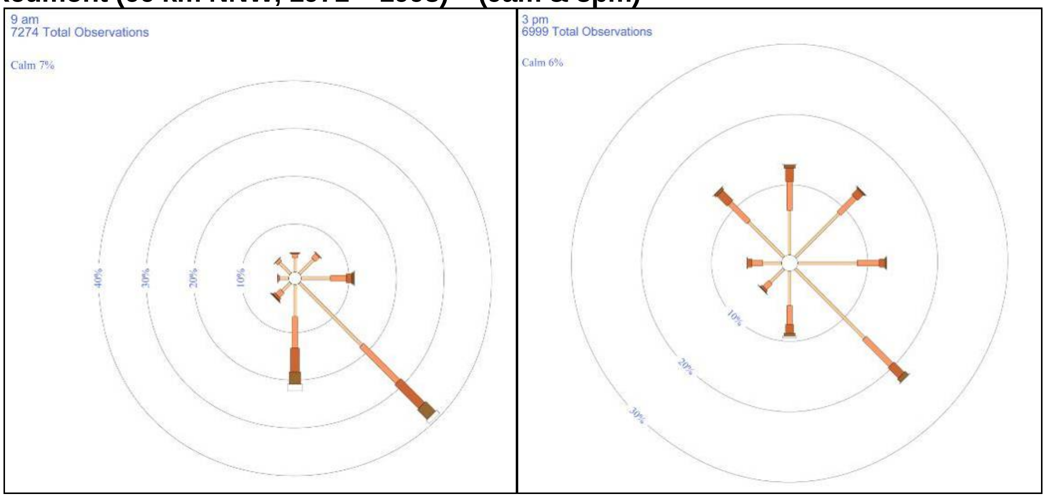
This document has summarised the methodology proposed to dispose of treated water from the WWTP in a manner such that it does not impact on the adjacent environment. Further investigations will be required during the next phase of the project, to determine the actual WWTP to be installed. Detailed design of the surface irrigation disposal areas will be conducted to ensure that potential potable water aquifers of environmentally sensitive areas will not be impacted during normal operations or during flood events.

It is recommended that

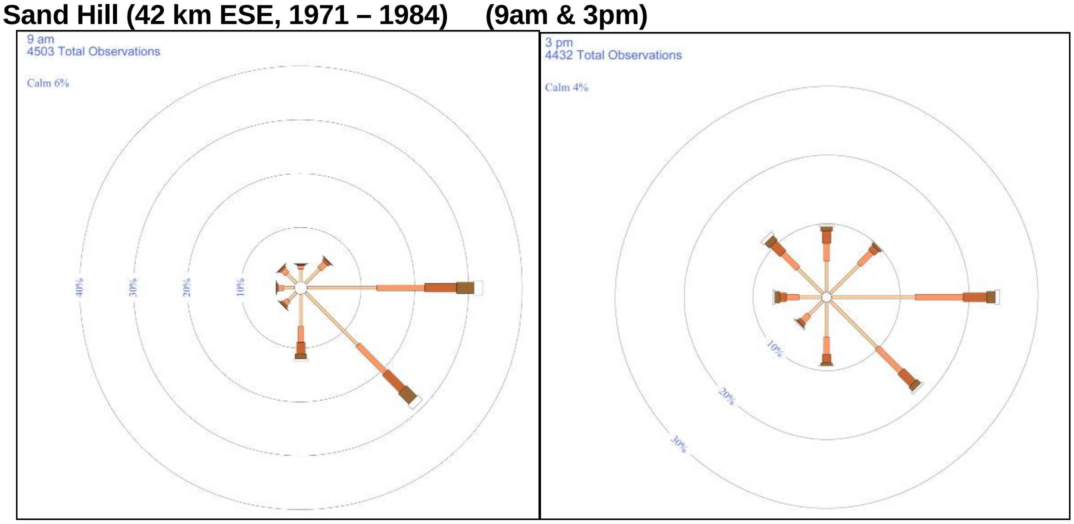
- An assessment of the sites proposed for location of the surface irrigation disposal areas be conducted to confirm the eutrophication risk and key design parameters for the WWTP and surface irrigation spray fields.
- Hydrogeological modelling of the aquifer in the vicinity of the accommodation village be conducted to determine the drawdown predicted from the water supply bore/s for the accommodation village, and use this information to ensure that the surface irrigation fields be sited outside the potential area of influence.
- Negotiations be conducted with the Departments of Health and Water, the East Pilbara Shire Council and other relevant statutory bodies to ensure that design parameters and effluent qualities meet all required standards

APPENDIX 1
AVERAGE ANNUAL WIND ROSES

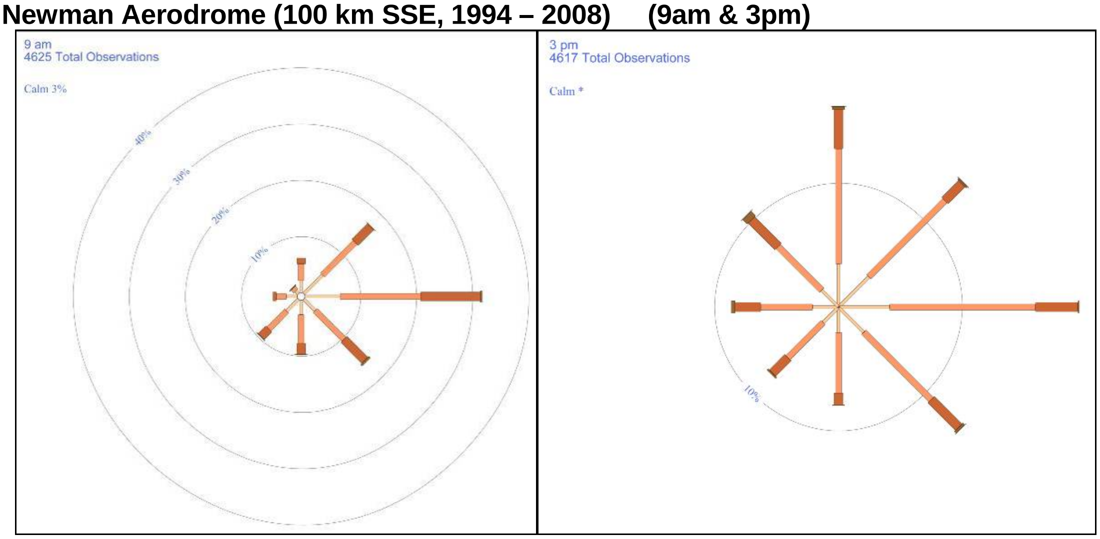
Redmont (66 km NNW, 1971 – 1993) (9am & 3pm)



Sand Hill (42 km ESE, 1971 – 1984) (9am & 3pm)



Newman Aerodrome (100 km SSE, 1994 – 2008) (9am & 3pm)



APPENDIX 2
AQUATERRA MEMO ON SPRAY FIELD DESIGN

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Memo

To	Brendan Hynes	**Company**	Brockman Resources Ltd
From	Vince Piper	**Job No.**	832F/F1
Date	21 November 2008	**Doc No.**	015a
Subject	Marillana Village & Mine Site: Effluent Irrigation		

With development of the Brockman mine site and associated Marillana village, sewerage treatment facilities will be installed and it is proposed to discharge the treated effluent by spray irrigation over a selected area of native vegetation. An assessment of the areas required for the effluent disposal has been undertaken and the details of this assessment are given below.

Discharge Volumes

The estimated discharge volumes to the treatment plants (provided by Engenium) are 60KL/d from the village and 2.5KL/d from the mine site. It is assumed that these same volumes will require disposal by spray irrigation to separate areas. It is understood that the project is under review and hence it is unlikely that these quoted volumes will be the final volumes. However the areas calculated will be able to proportioned to the updated discharge volumes.

Evaporation Area Requirements

The design aim when discharging effluent by irrigation is to ensure that the average evaporation rate equals or exceeds the irrigation rate so not to waterlog the discharge area or promote runoff. Based on data published by the Bureau Of Meteorology (Climatic Atlas of Australia, Evapotranspiration, 2001), point potential evapotranspiration can be used as a preliminary estimate for evaporation from small storages. From this reference, the monthly average point potential evapotranspiration rates for the Brockman mine area are given in Table 1. This data has been conservatively adopted as the average monthly evaporation applicable for sprayed effluent. In reality, spray evaporation would be higher than that from a water storage surface.

Table 1: Average Evaporation

Month	Evaporation (mm)
January	380
February	290
March	290
April	200
May	137
June	105
July	115
August	170
September	230
October	320
November	380
December	410

As shown in Table 1, evaporation in the Pilbara region is relative high for most of the year with the highest rates typically in November, December and January and the lowest rates typically during May, June and July. These lower average evaporation rates are appropriate for sizing the minimum area required for spray irrigation, with the lowest average monthly evaporation rate of 105mm (June) being the control.

Based on 105mm/month evaporation, the village (60KL/d) would require a minimum effluent irrigation area of 1.72ha and the mine site (2.5KL/d) would require a minimum effluent irrigation area of 0.07ha.

Nutrient Area Requirements

The treated sewerage effluent water will contain nutrients which when irrigated over vegetation will be taken-up by the vegetation and promote growth, plus be consumed by soil microbial action. Guidelines on the acceptable rates of nutrient application to native vegetation are not available, though some design guidance on the application of irrigated wastewater and the maximum nutrient application rates are given in the publication "Department of Water - Water Quality Protection Note (WQPN 22, July 2008), Irrigation with Nutrient-Rich Wastewater". This reference has been prepared for stabilised nutrient-rich wastewater from industries such as abattoirs, animal holding yards, aquaculture, breweries and food processors and specifically comments that it does not apply to treated municipal wastewater (sewerage) which requires specific approval under the Health Act 1911. However in the absence of a more pertinent guideline, criteria from this publication (WQPN 22) have been used to provide design guidance and to assess the minimum irrigation areas required.

Pertinent design guidance recommendations for the Brockman effluent irrigated sites include:

- Locate remote from areas where odours or spray drifts may cause nuisance
- Locate where depth to water table exceeds two metres
- Locate where surface slopes are less than one in twenty
- Locate in areas not subjected to seasonal flooding
- Locate away from natural waterways and water sources
- Locate away from conservation zones and wetlands
- Ensure vegetative buffer zones between the irrigation site and sensitive areas
- Ensure irrigation is applied uniformly and avoid waterlogging
- Implement a water quality monitoring programme

Assuming that the irrigation sites have fine grained surface soils and that the eutrophication risk to surface water within 500m of irrigation site is low, then the WQPN 22 guideline ranks the effluent irrigation sites with a eutrophication Risk Category D being the lowest risk category. Adopting this risk ranking, the guideline provides a maximum recommended application rate for Inorganic Nitrogen (as N) at 480kg/ha/yr (assuming a concentration less than 30mg/L) and for reactive Phosphorus (as P) at 120kg/ha/yr (assuming a concentration less than 7.5mg/L).

Typical treated sewerage effluent has an Inorganic Nitrogen (as N) of 10mg/L and Phosphorus (as P) of 2mg/L. Using these application rates, the village (60KL/d) would require a minimum effluent irrigation area of 0.46ha and the mine site (2.5KL/d) would require a minimum effluent irrigation area of 0.02ha. These minimum application areas are less than 30% of the areas required for effluent disposal by evaporation of 1.72ha and 0.07ha respectively.

Adopting the minimum irrigation areas required for effluent disposal by evaporation, the nutrient loadings to the disposal zones would be less than 30% of the maximum recommended application rates given in WQPN 22 guideline for Inorganic Nitrogen (as N) and for reactive Phosphorus (as P). In the absence of more specific application guidelines, these application rates are considered acceptable with the condition that the sites are appropriately monitored.

Summary

When determining the area required to discharge effluent by irrigation, evaporation and nutrient loading should be considered. Adopting evaporation during the month with the lowest evaporation and providing no allowance for spray or seepage losses results in a required area of 1.72ha for the village (60KL/d) and 0.07ha for the mine site (2.5KL/d). These areas can be adjusted proportionally when updated discharge volumes are available. Dependent on the treatment process and design of the irrigation system, nutrient loading is unlikely to be a limiting factor on the irrigated area.

We trust this memo is adequate for you current project needs, should you require any additional information please do not hesitate to contact the undersigned.

Yours sincerely
Aquaterra

Vince Piper

Vince Piper
Principal Civil/Water Resources Engineer

Iain Rea

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Senior Water Resources Engineer

APPENDIX 3
AQUATERRA MEMO ON INUNDATION OF SPRAY FIELDS

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Memo

To	Brendan Hynes	**Company**	Brockman Resources
From	Damien Janssen	**Job No.**	832G
Date	18 August 2009	**Doc No.**	175b
Subject	Effluent Irrigation - 1 in 10 year ARI Flooding Considerations		

Brendan,

As requested, we present here a discussion of the likely effects of inundation as it relates to the two proposed effluent irrigation disposal areas.

1. INTRODUCTION

With development of the Marillana mine site and associated Marillana village, sewage treatment facilities will be installed. It is proposed to discharge the treated effluent by spray irrigation over selected areas of vegetation. Aquaterra provided Brockman with a brief report (Aquaterra, 2008) outlining the requirements of such a system. Here we look at the potential effects that inundation of such spray-fields, at the locations selected for the Project (Ausenco, 2009), may have on the receiving environment.

2. RELEVANT DESIGN CRITERIA

We list here several of the design criteria (outlined in more detail in Aquaterra 2008) which are pertinent to the discussion of potential impacts in the event of inundation of effluent irrigation disposal areas:

- Effluent discharged by irrigation should ensure that the average evaporation rate equals or exceeds the irrigation rate so as not to waterlog the discharge area or promote runoff. All calculations for the required disposal area were undertaken with this consideration.
- The treated sewage effluent water will contain nutrients which when irrigated over vegetation will be taken-up by the vegetation and promote growth, while also being consumed by soil microbial action. Therefore the nutrients have relatively limited residence times within the soil profile rather than accumulating over time.
- By adopting the minimum irrigation areas required for effluent disposal by evaporation, the nutrient loadings to the disposal zones would be less than 30% of the maximum recommended application rates (Department of Water, 2008). This will allow increased opportunities for microbial action and vegetation pick-up to reduce the nutrient load in the soil profile.

3. INUNDATION OF SURFACE IRRIGATION DISPOSAL AREA

The locations of the potential disposal areas are shown and discussed in Ausenco (2009).

In a 1 in 10 year ARI flood event, the village disposal area would be inundated by less than 1m of water (Aquaterra, 2009a), which would drain away to the northeast as sheet flow. Without the use of flood protection bunding, the mine site disposal area would be inundated by 1 to 2m of water, and would tend to drain internally and pond in an area to the southwest of the disposal site.

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However flood protection bunding is proposed to extend from the sand dune located immediately north of the proposed areas southwards past the eastern edge of the proposed area, connecting into higher ground. Consequently, this area will not be impacted by flooding during events up to the bund design ARI.

Groundwater levels have been measured at 11-12 metres below ground level (mbgl) at these locations (Aquaterra, 2009b).

3.1 SURFACE WATER EFFECTS

In terms of the likely surface water effects, the risk to Weeli Wolli Creek and the Fortescue Marsh are deemed to be low. With the low floodwater velocities and the absence of surface water ponding associated with the irrigation (a design aim of a well-managed effluent irrigation disposal system), it is anticipated that only minor mobilisation of nutrients into the surface water would occur. The processing plant location area would be protected from flooding by bunding incorporating an appropriate freeboard during a 1 in 10 year event. Also, due to the drainage directions at the selected sites, little to none of this flood water would make its way directly to Weeli Wolli Creek.

At both of these locations, when flooding does occur; it occurs as a combination of overland and channel flow. Floodwater velocities at the proposed locations area are low (calculated to be less than 1m/second) and overland flow would ensure rapid dilution. When combined with the likely limited mobilisation of nutrients from the soil profile into the surface water, this suggests that the effects of a 1 in 10 year ARI event would be limited.

3.2 GROUNDWATER EFFECTS

In a 1 in 10 year ARI flood event, there is potential that any residual nutrients and coliforms present in the soil profile may be mobilised downward, and perhaps reach the local groundwater system. In the event of these nutrients reaching the water table, the general groundwater flow (and any suspended nutrients) is towards the north at approximately 0.1 to 1.0m/d. With this low groundwater gradient groundwater takes at least 25 years (up to hundreds of years) to reach the Fortescue Marsh (approximately 12km to the north), far longer than the anticipated lifespan of the nutrients in the system, and the potential for effect upon the Marsh is deemed low to negligible.

Future potable water supplies (camp and offices) would be located up-gradient of the proposed spray-fields to ensure that they are not at risk of any mobilised nutrients entering the potable supply. It is important to note that, to the north of the proposed spray-fields, the groundwater becomes progressively more saline with proximity to the Fortescue Marsh. Just to the north of the project tenement, the groundwater is brackish, and is suitable only as a stock water supply, so any potential down gradient effects would not be upon a potable water supply.

It is also worth noting the lack of other receptors down gradient of these locations, with the only groundwater users between the project and the Fortescue Marsh being sparsely located stock watering points of brackish quality (the closest of which is approximately 3km to the northeast – and therefore across gradient). It is deemed unlikely that there would be any effect on the beneficial use of groundwater at these locations associated with the spray-fields.

4. FURTHER WORK

As part of ongoing investigations, numerical groundwater modelling is being undertaken. This will be utilised to target potable water supply bores for both the village and the mine site at locations where the nutrient loading of effluent irrigation disposal areas will not affect the source potable supply.

Prior to submission of application for installation of such a system, soil testing should be undertaken at both spray-field locations to confirm the soil category and subsequent nutrient load limitations. This should be undertaken upon confirmation of spray-field locations, to ensure that soil samples will be representative of the actual receiving soils.

5. CONCLUSIONS

In summary, the effects that inundation of proposed effluent irrigation disposal areas is anticipated to be minimal for the following reasons:

- A correctly operated spray field will not have any ponding or run-off, so there will be no liquids that could be easily mobilised in the event of inundation. Low floodwater velocities will also contribute to the limited mobilisation of nutrients and coliforms from the soil profile.
- Any nutrients and coliforms that may be mobilised by inundation will be significantly diluted by the large volumes of water associated with such an inundation event, and will tend not to flow towards the Weeli Wolli Creek channel.
- Any nutrients introduced to groundwater would move only slowly towards the north, as the underlying aquifer has low flow gradients and increasing salinity towards the Fortescue Marsh, therefore potential for impacts upon the Marsh or the beneficial use of the groundwater are deemed low to negligible.

6. REFERENCES

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We trust this memo is adequate for your current requirements, should you require any additional information please do not hesitate to contact the undersigned.

Yours sincerely
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