

Appendix 7

Stuarts Point Treated Effluent Management System: Dunal
Discharge Concept Design Report

Beca Hunter H2O (2025)



Report

**Stuarts Point Treated Effluent
Management System**
Dunal Discharge Concept Design Report

Beca HunterH2O

13/10/2025

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Report Details

Project Title	Beca HunterH2O Stuarts Point Treated Effluent Management System : Dunal Discharge Dunal Discharge Concept Design Report
Project No.	16004-004-05 (AU) / 3020134 (NZ)
Document Location	3020134-1737965438-2760
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Beca HunterH2O is committed to the delivery of this project within the timeframes detailed in this proposal, however as HunterH2O would appreciate, the current COVID-19 event may have an impact on these timeframes. Beca HunterH2O values its record of strong delivery of projects and will keep HunterH2O informed of any actual impacts throughout the project’s delivery.

Document History and Status

Revision	Report Status	Prepared By	Reviewed By	Approved By	Issue Date
0	Draft For client review	Nazila Esmaeili, Nick Jowsey Andrew Brough, Stefanie Toemmers, Keith Neill	Reuben Bouman, Mike Thorley, Greg Offer, Peter Greenhalgh	Greg Offer	25/07/2025
1.0	Final with client revisions	Stefanie Toemmers	Rennie Ferguson, Mike Thorley, Greg Offer	Greg Offer	13/10/2025

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Executive Summary

The Stuarts Point Sewerage Scheme is designed to serve the growing communities of Stuarts Point, Grassy Head, and Fisherman’s Reach. The scheme will cater for current needs and future expansion, with infrastructure sized based on robust hydraulic analysis and inflow/infiltration (I&I) studies.

The overall wastewater scheme includes a new sewer collection system for Stuarts Point, a new wastewater treatment plant and treated effluent disposal to land. This report covers the disposal to land scheme only, other overall sewer scheme components have been scoped and costed separately by others.

The design basis flow for the Stuarts Point dune disposal system is to service the Stuarts Point Sewer Scheme to 2047 within growth levels provide by Kempsey Shire Council, Ultimate growth may require future upgrades of the WWTP and Dunal Disposal system.

Based on projected average and peak dry weather flows, with peaking factors of 2.5 for daily and 1.9 for weekly sustained flows, as shown in the table below. Wet weather inflow and infiltration (I&I) will be minimised by using pressure sewer, making improvements to existing onsite sewers.

A conservative wet weather peaking factor of 1.3 has been adopted. The system sensitivity to rainfall and shallow groundwater means ongoing I&I management over time will be essential, including operational strategies to manage network deterioration and associated infiltration.

Parameter	Unit	Existing 2027	Design horizon 2047	Ultimate
Average Dry Weather Flow (ADWF)	kL/day	283	693	731
Peak Day Sustained Dry Weather Flow (PDDWF)	kL/day	707	1,732	1,826
Peak Week Sustained Dry Weather Flow (PWDWF)	kL/day	537	1,316	1,388

The disposal system includes conveyance and disposal on an area of land within sand dunes containing a shallow water table that lie between the McLeay Arm and the sea. At the center of the concept design work is a hydrogeological assessment of the performance of the land disposal system and consideration of several design options. The hydrogeological assessment has found that an area of 6.3 ha (1300m long by 40 metres wide, plus a 10m wide road access track) is required to distribute wastewater to address reduced infiltration capacity due to groundwater mounding and reduce the occurrence of routine surface seepage of applied wastewater directly to the McLeay Arm.

Several options for the design of the land disposal system were assessed including a “lay of the land” minimal earthworks option and another option based on flattening and recontouring the land surface. The lay of the land option has been identified as preferred because it minimizes the risk of surface seepage at the disposal field perimeter. Various treated-effluent disposal to land methods were reviewed. Pressure compensating dripper irrigation (PCDI) was identified as preferred due to the ability to accurately distribute wastewater over the land surface, accommodate local topography and provide a longer service life with less maintenance.

The land disposal system is designed for a maximum dry weather flow of 1,248 kL/day, with application of wastewater cycled between four zones to allow soil recovery. Key features of the disposal field include:

- low-rate effluent application due to shallow water table constraining effective land disposal capacity
- automated hydraulic valves for zone control
- sub-zoning for efficient distribution and flushing
- vehicle and pedestrian access tracks for maintenance
- bunding on the western boundary to prevent runoff to Macleay Arm
- retained vegetation for erosion control

- centralized flow monitoring equipment
- fencing around the entire site and signposting to ensure safety and environmental protection

During heavy rainfall events, the water table rises towards and reaches the land surface, which reduces the capacity of the land to accept wastewater and when it cannot be applied to land, the treated wastewater will need to be stored at the treatment plant site. Modelling indicates that the provision of 3 ML of storage will reduce the frequency of overflows to surface water (i.e. events where wastewater cannot be with applied to land or stored, so must discharge elsewhere) to an average of one overflow event per year for the 2047 design horizon of the plant. Additional tankage can be added in future as flows increase with community growth.

The wastewater treatment plant includes secondary and tertiary treatment, including solids removal via filtration, UV disinfection, and chlorination. Proposed upgrades to previous treatment plant design concepts include pressure media filters upstream of UV disinfection and expanded chlorine dosing/storage for comprehensive pathogen control. Sodium metabisulphite dosing is also included to allow de-chlorination prior to discharge when required. Details of the WWTP upgrades are provided in the document SPWWTP Design Guidance Memo (Beca HunterH2O, 2025).

Cost estimates with -50%/100% (Class 5 AACE, ROM) have been developed for the Stuarts Point disposal field design and the total cost for the system is estimated at \$ **million**. Note: this excludes the tertiary treatment, storage and pumpstation at WWTP as well as the pipeline to the disposal field.

The proposed Stuarts Point treated effluent management system balances reliable wastewater management with environmental protection—using advanced treatment processes, robust automation/monitoring systems, and a carefully engineered disposal field within sensitive coastal dunes. It represents an optimal solution that provides capacity for community growth while protecting local waterways and ecosystems to maximum extent, accepting local limitations posed by shallow groundwater and the low-lying nature of the land across the disposal area.

1 Introduction

Kempsey Shire Council (KSC) is undertaking the design and construction of a sewage collection and disposal scheme for Stuarts Point, Grassy Head, and Fisherman's Reach. The project involves retrofitting a low-pressure sewer system (LPSS) to about 550 existing properties, with capacity for 1,000 future lots, all treated at a new wastewater treatment plant (WWTP) south of Stuarts Point town.

Treated effluent will be discharged via a dunal discharge in the dune area north-east of Stuarts Point. The network and Stuarts Point WWTP (SPWWTP) together form the Stuarts Point Sewerage Scheme. Significant progress has been made on design work, and an Environmental Impact Statement (EIS) is being prepared as the project is classified as State Significant Development.

Beca HunterH2O has been engaged to complete the concept design for the Treated Effluent Management System, supporting both approvals and delivery. KSC requested this work under their procurement process after initial scoping reviews.

The concept design covers infrastructure at the WWTP and discharge site, using an established pipeline route including a horizontal directional drilling (HDD) crossing of Macleay Reach. Additional details of the SPWWTP upgrades are provided in the SPWWTP Design Guidance Memo (Beca HunterH2O, 2025).

The project recently secured Commonwealth funding aimed at housing development, with completion milestones set for 2026. This requires accelerated design progress to support EIS submission and procurement planning.

1.1 Background

Kempsey Shire Council (KSC) is planning to discharge treated effluent from a new wastewater treatment plant inland of Macleay Reach. Initial groundwater modelling by GHD identified potential risks with the original dunal site, particularly regarding its capacity to absorb effluent without surface runoff.

Beca HunterH2O (BecaHH2O) undertook a peer review GHD's work and then developed a 2D seepage model using available data. This assessment found the original site lacked sufficient capacity for the required flows, but suggested that a longer, narrower discharge area could be more feasible—though further site investigation was needed.

After conducting deep bore and infiltration tests, Beca HunterH2O updated the model and developed a preliminary layout with four long irrigation lines and additional storage at the SPWWTP to manage flow during periods when the dunes cannot absorb effluent.

The revised concept includes an extended dunal discharge area (4 x 1,300m irrigation zones), storage at the SPWWTP and controlled pumping schedules that are further refined in this concept design report.

1.2 Stuarts Point Sewer Scheme - Project Timeline

The Stuarts Points Sewer Scheme has been considered since 1984 and for the intervening 40 years various work has progressed, a summary of the work done over that period is provided in Figure 1 below.

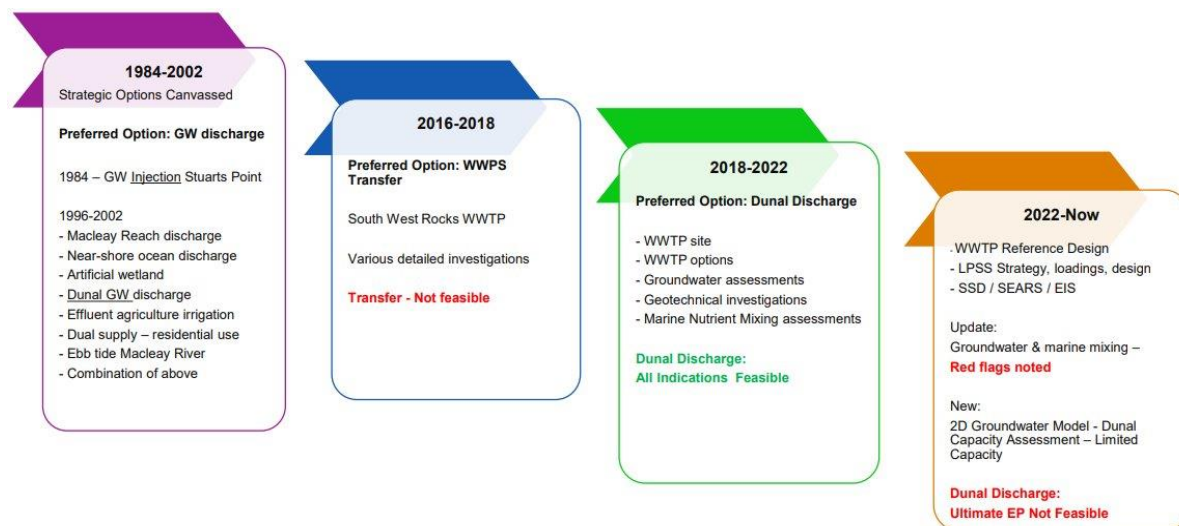


Figure 1 Stuarts Point Sewer Scheme Investigation Timeline.

Feasibility assessments on the dunal discharge site identified a set of site constraints, and these were incorporated into design objectives to assess and develop feasible discharge options to progress to Concept Design, summarised in Table 1 below.

Table 1 Dunal Site Constraints

Constraint	Description
Low Elevation	Site is low lying with a high groundwater table. Approximately 80% of the dunal area is below 2.5m AHD with groundwater at approximately 0.8m below surface
Localised GW System	Localised dunal groundwater system is shallow and highly sensitive to rainfall with seepage present on Stuarts Beach after rainfall
Infiltration rates	Groundwater mounding significantly impacts infiltration for constant duration discharge - initial infiltration rates are higher (~135mm/hr for first 24hrs) - reduces quickly when groundwater has mounded (~34 mm/hr over following 5 days).
Configuration	The site necessitates configuration of narrow discharges (multiple widths modelled - narrow configurations have higher infiltration rates than wider applications)
Coastal Hazard	Site is within the Coastal Vulnerability Area and the more favourable higher elevation barrier dune is within the Coastal Erosion and Recession Hazards Zone and subject to current and future coastal erosion Available area for dunal discharge is within the lower lying central dunal area (coastal erosion/recession zones)
Topography	The dunal terrain is hummocky and variable and exposed to wind erosion and sand drift
Public Use	Stuarts Point Beach and Macleay Reach are popular recreational areas and increasingly so with planned population growth – high traffic 4WD, beach fishing, swimming, kayaking
Wet Weather	Site is highly sensitive to rainfall and application of effluent during wet weather would be very limited, with storage options needed to be considered until groundwater levels reduced.

2 Basis of Design

The Basis of Design has been developed based on the known site constraints (refer to Table 1 above), design objectives and a review of sewer inflows to the Stuarts Point WWTP from the low pressure sewer collection system.

2.1 Design Objectives

A set of design objectives for Stuarts Point Treated Effluent Management System were developed by Kempsey Shire Council and Beca Hunter H2O informed by the site constraints and the requirements of KSC for construction, operation and community expectations. These objectives were developed over the course of the recent feasibility assessments undertaken by Beca HH2O listed in Table 2 below.

Table 2 Dunal Site Design Objectives

Objective	Description
Dry Weather Seepage	No Direct Dry Weather flooding/sheeting/seepage of Effluent Outside of Designated Effluent Application Area (The dunal discharge method selected should be designed to minimise changes in groundwater levels).
Coastal Hazard	Dunal Discharge Infrastructure – located outside Coastal Hazard Zones 1 and 2 (Beach erosion and shoreline recession)
Effluent Distribution	Dunal Discharge Infrastructure to allow for even and constant distribution across the irrigation zone
Long term clogging	Dunal Discharge to avoid longer term clogging of sand from effluent application
Landform	Dunal Discharge to suit natural landform, vegetation and regrowth to minimise sand drift Sensitivity to rainfall and higher groundwater levels limiting discharge at the dunal site requires a systematic approach for management of treatment effluent – comprising: • Dunal Discharge Site • Storage at the Wastewater Treatment Plant
Project Objectives	Supporting full development profile to 2047 without staging and further investment
Operational Feasibility and Reliability	Be within Kempsey Shire Council's operational and maintenance capacity and capability and reliability expectations
Environmental Impact	Minimise the initial construction and ongoing environmental impact at and adjacent to the site
Constructability	Within capability of available construction contractors – clearing, minor earthworks, HDPE pipework, irrigation pipe, simple EIC and comms

2.2 Design Flows

Design basis flows are discussed in the SPWWTP Design Guidance Memo (Beca HunterH2O, 2025). Key output is information on the predicted daily dry weather volumes. The revised SPWWTP Flow Loadings memorandum reflects the updated growth projections on the flow loadings for SPWWTP.

The current and future Average Dry Weather Flow (ADWF) was adopted based on the Stuarts Point Sewer Scheme Project Summary Report on Hydraulic Loadings Analysis and I&I Justification.

The basis of design flow shown in Table 3 below provides a summary of the adopted design basis daily, and weekly peaking factors and flows.

Table 3 Summary of the adopted design basis flows.

Parameter	Unit	Existing 2027	Interim 2047	Ultimate	Comment
Equivalent Tenement	ET	628	1,540	1,624	Off-peak
Equivalent Persons	EP	1,319	3,233	3,409	Off-peak
Average Dry Weather Flow (ADWF)	kL/day	283	693	731	from Summary Report on Hydraulic Loadings Analysis and I&I Justification Report
Peak Day Sustained Dry Weather Flow (PDDWF)	x ADWF	2.5			From Iluka peaking factor (as defined in Revised Stuarts Point STP Flow Loadings – Technical Memorandum)
	kL/day	707	1,732	1,826	As a total daily inflow volume.
Peak Week Sustained Dry Weather Flow (PWDWF)	x ADWF	1.9			From Iluka peaking factor,
	kL/day	537	1,316	1,388	As a total daily inflow volume occurring for at least 7 consecutive days.

3 Hydrogeological Assessment Summary

An assessment of the hydraulic capacity for land-based discharge of treated effluent has been undertaken to inform Stuarts Point dunal discharge scheme development.

The assessment took into consideration the infiltration capacity of the shallow soils, response of the shallow water table to rainfall, and groundwater flow paths. Groundwater flow modelling was undertaken using two-dimensional SEEP/W¹ to provide indications of the infiltration capacity whilst avoiding flooding/sheeting due to the application of treated wastewater to land. The assessed design infiltration capacity is the key factor in determining the land area required to discharge treated effluent across a range of wastewater flow scenarios. The assessment of hydraulic capacity has also indicated key constraints where the infiltration capacity is significantly limited due to rainfall events, which will require mitigation by storage and/or secondary/emergency discharge to surface water. The groundwater modelling and assessment report is included in Appendix C.

3.1 Site Investigations

Ground investigations were carried out in December 2024 to provide more specific site-based information about the infiltration capacity of the near surface soils, groundwater levels and the nature and extent of geologic strata beneath the dunal site. This is covered in BHH2O's Stuarts Point Hydrogeological Factual Report, 2025 (included in Appendix C). The following ground investigations were carried out across the dunal area:

- Drilling of 3 machine boreholes to 30 m depth and 2 piezometer installations at 6 m depth.
- 2 falling head permeability tests, one in each new piezometer.
- 8 infiltration tests in the surficial dune sands.

Data from the ground investigations were used to update and inform the groundwater modelling. The key information from the 2024 field investigations is:

- Update of the hydraulic conductivity of the shallow sands from 1×10^{-4} to 2.7×10^{-4} m/s.
- Indication of horizontal to vertical hydraulic conductivity (K_y'/K_x' ratio) of 0.5 for the dune sand material, 0.01 for the clay, 0.05 for the silty sand, and 0.1 for the estuarine sand.
- Indication of the depth of the clay confining strata at 15 m and extent of estuarine sands beneath the clay strata. Note that the clay layer is extensive but may not be continuous under the entire dunal area. This clay confining unit is at a shallower depth than the previous information had indicated which lessened infiltration capacity compared to it being deeper, due to the reduced thickness of the groundwater flow pathway.
- Static groundwater level of approximately 0.8 m depth below ground level towards the centre of the dunal area (the lower lying parts).
- Tested infiltration of the shallow sands (minimum: 275 mm/hour, average: 1,985 mm/hour, maximum: 6,000 mm/hour). These correspond to hydraulic conductivities of (minimum: 7.6×10^{-5} m/s, average: 5.5×10^{-4} m/s, maximum: 1.7×10^{-3} m/s). The variability in infiltration rates suggest some areas may have more capacity to soak applied wastewater than others, with the low-lying areas closer to the shallow groundwater table having lower infiltration capacity than those with a greater unsaturated thickness.
- The groundwater model was set up based on previous information prepared by GHD^{2,3} and BecaHunterH2O and calibrated to a limited set of monitored groundwater levels at monitoring piezometer BH1 (located near the footbridge at the southern end of the dunal discharge area). These data had been collected from 02/07/2022 to 08/12/2022 and indicated that the water table

¹ <https://www.seequent.com/products-solutions/geostudio-2d/>

² GHD. 2019. Groundwater Modelling: Stuarts Point Wastewater Treatment Plant.

³ GHD. 2022a. Stuarts Point Sewerage System – Effluent Transfer and Disposal Design: Geotechnical Report.

is shallow and highly responsive to rainfall. The key locations, 2D model geometry and transect and hydrograph are shown in Figure 2.

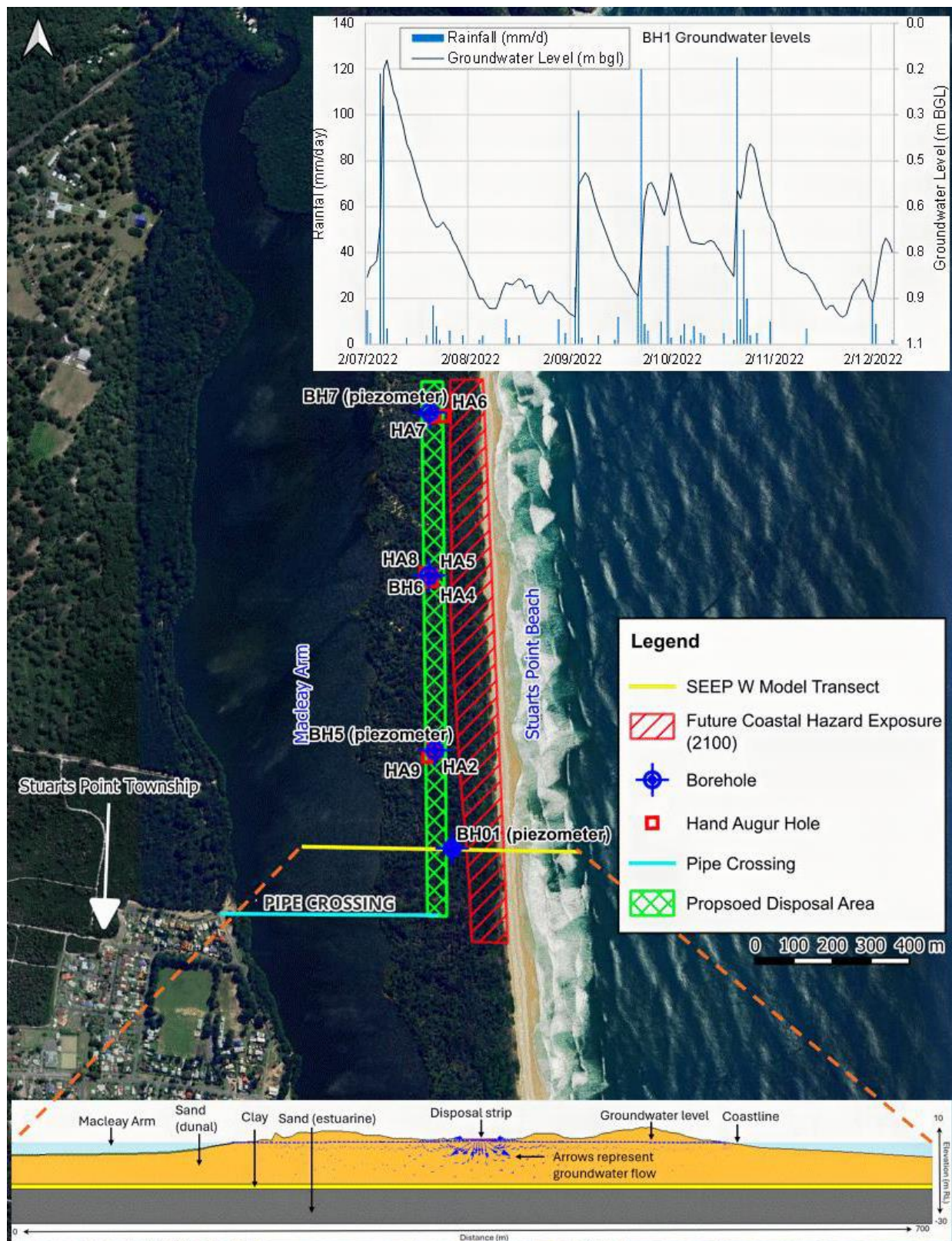


Figure 2 Overview map showing key locations at the dune

In addition, climate and tidal data were input into the model sourced from nearby BOM weather stations, including 2-years of observed rainfall data from the Nambucca Heads Rain Gauge (Station 59150).

During prolonged application of treated effluent, the model indicates that the soakage capacity of the dune site will likely be significantly reduced due to mounding of the water table. Assuming a starting static groundwater level of 0.8 m below ground level (m BGL), the modelled infiltration rate (due to mounding) reduces exponentially after 24 hours of continuous application of treated effluent and after 5 days even further.

Disposal field configuration constraints

A range of discharge field shapes and configurations were analysed and found that the longer duration infiltration capacity is maximised when the treated effluent is applied across narrow strips over longer extents along the dunes. For example, 10 m wide strips oriented over longer lengths north and south have higher capacity than a wider 40 m wide strip that is shorter in the north-south direction. This is due to the improved distribution of wastewater over a wider zone running across the groundwater direction of flow towards the sea. The key indications from the modelling, which represent the ground condition capacity are:

- When applying infiltration across a 10 m wide strip in the model with no rainfall event recharge, mounding of the groundwater table increases, reaching ground level after ~24 hours.
- The early-time infiltration rate over the first 24 hours (while mounding is developing) is approximately 130 mm/hour.
- After 5 days of continuous discharge, the infiltration rate reduces to approximately 40 mm/hour due to the effect of groundwater mounding underneath the disposal area. This represents the maximum mounded infiltration rate while avoiding flooded conditions and overflow.
- When rainfall is applied to the model, the infiltration capacity of the sand reduces quickly, before gradually recovering as the sands drain. During extended periods without rainfall, the maximum flow to the disposal area is ~40 mm/hour. These data, and the relationship between rainfall and infiltration capacity is presented visually in Figure 3 below.

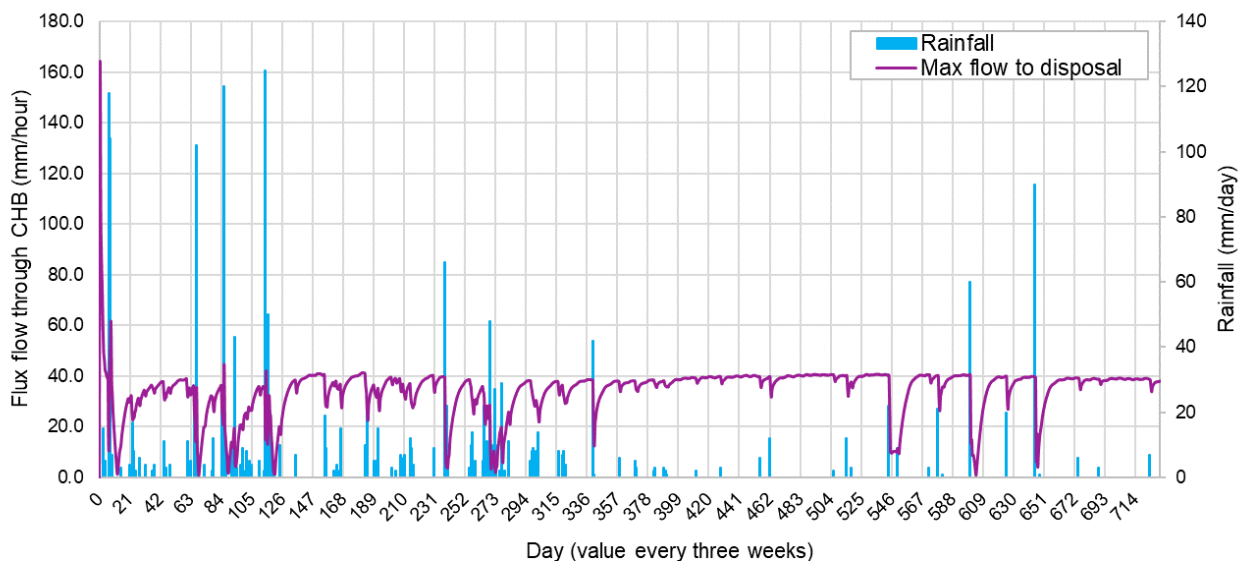


Figure 3 Graph showing the flow rate through the constant head boundary against daily rainfall depth

For the infiltration system design rate, which is used to determine the land area required for the discharge field, a factor of safety (FOS) of 4 -10% is recommended by the *United States Environmental Protection Agency (USEPA) 2006 Process Design Manual for Land Treatment of Municipal Wastewater Effluents* for infiltration to land of treated wastewater. This safety factor considers the reduction in infiltration rate that typically occurs over time due to clogging, longer term infiltration performance and uncertainties in the ground information and conditions.

In this case (due to the high level of treatment and nature of the soils), a FOS of 10% has been applied to the longer duration (>5 day) mounded infiltration rate of 40 mm/hour, and results in a design infiltration rate of **4 mm/hour**.

Total land discharge area requirements also need to have bed rotations and resting areas added. Discharge bed rotations involve periodically shifting the application of treated effluent to different areas of land, while bed resting involves temporarily ceasing effluent application to a specific area to allow for recovery and treatment within the soil. These practices allow the soil to drain, aerate, and recover its treatment capacity, and help prevent issues associated with prolonged soil saturation. Rotations and resting are critical in maintaining the long-term effectiveness and operational life of land application systems by reducing clogging and other issues associated with continuous effluent application to land-based discharge systems.

Section 2 above describes the various design flows and their commensurate populations. Using the design daily treated effluent flow of 1,248 kL/day, the following points can be made to summarise the discharge to land area requirements based on the groundwater modelling assessment:

- Each disposal discharge strip area is to be approximately 1,300 m in length x 10 m wide to accommodate the design flows from the WWTP.
- Four (4) disposal discharge strips are recommended to allow for rotation and resting.
- The overall disposal area should comprise 4 adjacent strips, one of which is operational at any given time (assuming soakage capacity in the dunes is available).
- Each disposal discharge strip is to be run over a minimum period of 18 hours and up to 48 hours before moving to the next (subject to operational requirements and antecedent groundwater/rainfall conditions).

As shown in the hydrograph inset in Figure 3, the water table already reaches near ground surface across parts of the dunal area naturally and in response to rainfall. When the groundwater levels reach close to or at the ground surface, the infiltration capacity will reduce, and could cease entirely, until groundwater levels drain back down. Discharge of treated wastewater when groundwater level is at or near the surface would likely result in additional surface flooding and overflow.

The groundwater model provided indications of the response of the water table to rainfall and the reductions in infiltration capacity across a 2-year period, from 1 July 2022 to 30 June 2024. The modelling indicates that a 1 in 3-month rainfall event of ~54 mm in 24 hours is likely to cause groundwater to rise to the ground surface in low lying areas and reduce discharge capacity to near zero for approximately 1 – 7 days. During a 1 in 6-month rainfall event of >86 mm over 24 hours is likely to cause groundwater levels to reach ground surface for periods of approximately 3 – 7+ days and hence reduces the discharge field capacity significantly or stops.

Over the 2-year period modelled, which coincided with a wetter period, the modelling indicates that approximately 17 rainfall events (several over multiple consecutive days) likely reduce the dunal discharge in order to avoid flooding/overflow issues. The discharge of treated effluent to the dunal area will need to be controlled based on groundwater level monitoring to avoid exacerbating flooding and overflow conditions at the dunal site. Additional measures such as flow buffering, storage and/or alternative overflow to surface water will be required for those periods when groundwater conditions limit or stop the discharge to land.

In summary, the modelling indicates that the dune disposal area presented in this report can accept flows of 1,248 kL/d. However, the infiltration capacity of the soils reduces and potentially ceases during periods of heavy rainfall due to the surrounding water table rising. The application of treated effluent during these periods will likely need to be adjusted/reduced and stored until the groundwater levels drop back to baseline conditions.

Design Considerations

The nature of the dunal environment, hummocky topography, persistent shallow groundwater levels and consequential low design infiltration rate make this site more suitable to a slow-rate (SR) application system involving application of wastewater to the existing land surface via dripper irrigation. Other high-rate application systems that rely on gravity flow to distribute the treated effluent will likely require significant earthworks and a level of accuracy in constructed levels over a large area. This is likely to be a significant challenge to construct and maintain.

The surface topography contains hummocky terrain with natural low points, some of which appear to drain towards the Macleay Arm, not towards the coast. There is a risk that groundwater reaching the surface during certain periods may flow into the Macleay Arm if the land topography remains in its current

state. Hence a bund on the western (landward) side of the dune is recommended and can also be utilised as an access track to the disposal field.

A centrally located groundwater level monitoring bore containing a level sensor connected to the WWTP should be established to indicate when the treated effluent flows should be diverted to storage and/or overflow. Another 3 piezometers that have already been installed and are being equipped with continuous groundwater level monitoring sensors should be actively monitored and utilised to adjust and tune the settings of the central control groundwater level site, at least annually.

4 Treated Effluent Management System – Overall Configuration

The overall configuration of the Treated Effluent management system comprises:

- Stuarts Point Wastewater Treatment Plant
 - Tertiary Treatment and Disinfection
 - Treated Effluent Storage
 - Treated Effluent Emergency Overflow
- Treated Effluent Pipeline

Figure 4 shows the main components of the Stuarts Point Treated Effluent Management System (note the pipe routes are the subject of further development).



Figure 4 SPWWTP Treated Effluent Management System Overview

5 Dune Disposal Options

5.1 Options Overview

With consideration of the site constraints developed through the Feasibility phase and further informed by the hydrogeology investigation in Section 3 the range of options were assessed and summarised. A summary of dunal application methods assessed against the design objective is provided in Table 4 below

Table 4 Long list Options against Design Objectives (KSC, 2025)

Option	Dry Weather Seepage	Coastal Hazard	Effluent Distribution	Long Term Clogging	Project Objectives	Community/ Public Impact	Operational Feasibility	Enviro Impact	Construct
Flooded Distribution	X	X	X	X	X	X	✓	✓	✓
Exfiltration Pond	X	X	X	X	X	X	X	X	X
Elevated Platform	X	X	X	X	X	X	X	X	X
Exfiltration Basin	X	X	X	X	X	X	X	X	X
Low Pressure Effluent Dist.	✓	✓	✓	✓	✓	✓	✓	X	X
PC Drip Irrigation (Preferred)	✓	✓	✓	✓	✓	✓	✓	✓	✓

With the need for effluent to be applied to a long and narrow configuration with a slower application rate on the low lying dunal site was limited to those that were more typically used for land application effluent treatment or irrigation, description each option against the design objectives with further description in Table 5 below.

Table 5 Dunal Discharge Options Summary

Option	Comment	
Flooded Distribution (South West Rocks)	Not Suitable	Uncontrolled ponding and seepage across whole of dunes and shorelines
Exfiltration Pond	Not Suitable	- Varying pond depths assessed – 1m to 4m - Promoted seepage on shoreline - Pond construction at dunal site difficult – construction and maintenance of sand walls for water retention
Elevated Platform	Not Suitable	- Promoted seepage on shoreline - Extensive earthworks - Best location closer to barrier dune – subject to coastal erosion
Exfiltration Basin	Not Suitable	- Width of basins assessed – 10m, 50m, 100m - Long and Narrow configuration required (1300m long x 10m) - Even and consistent distribution of effluent over the long, narrow site very difficult using conventional pipework discharging across surface - Distribution of even pumped flows across the long and narrow configuration requires high level of engineering to prevent areas of high and low discharge - Distribution of low-rate pumped flows and constant pressure very difficult – high engineering required

Option	Comment	
		• Preferential concentrated areas of ponding likely with poor flow distribution (rate and volume) resulting in seepage on shorelines • Extensive earthworks required to construct basins and long-term vegetation removal needed • Longer term clogging of sand and maintenance considerations – limited opportunity for rotation of discharge areas • Vulnerable to sand drift with vegetation removal
Slow Rate Application Systems • Low Pressure Effluent Distribution • Low-Rate Pressure Compensating Drip Irrigation	Suitable	• Methods available for distribution of effluent across long and narrow field • Methods available for large area application of effluent • Slow rate of effluent discharge to suit required application rate • Methods available for engineered or natural landforms • Irrigation methods available allow for vegetation re-growth and management • Methods allow for sand-drift over infrastructure (above and below ground applications) • Methods allow for rotation of application through discharge zones

The option of spray irrigation had not been included in earlier options assessment through the feasibility review, but for completeness has been briefly considered here and not progressed for the reasons outlined below.

The purpose of the discharge is to evenly distribute the effluent across the discharge field to maximise the infiltration and minimise local ponding and groundwater mounding effects. This requires utilising the full length of the discharge field area at any one time. Discharge options such as spray irrigation or large diameter flood discharge pipes cannot achieve the even distribution required in this situation.

To achieve even distribution with spray irrigation will require complete removal, and continued removal of the existing vegetation. In addition, spray irrigation presents a higher human health risk due to spray drift than the options discussed further here. The large diameter pipe discharge options essentially are a flood irrigation model. This will not achieve even distribution due to the free draining nature of the sand dunes.

Taking the above factors into account, the focus has been on methods that achieve an even application across the entire area. Two methods have been investigated - a low pressure effluent distribution system using large diameter pipes using low pressure heads (more commonly referred to as Low Pressure Effluent Distribution [LPED]) and surface laid driplines using pressure compensating drippers (more commonly referred to as Pressure Compensated Drip Irrigation [PCDI]).

5.2 Slow Rate Application Disposal Methods

The two options considered for progression to concept design are both slow rate application systems, Low Pressure Effluent Distribution (LPED) and Pressure Compensated Drip Irrigation (PCDI).

These two options are discussed further in this section.

5.2.1 Low Pressure Effluent Distribution (LPED)

For the application of treated sewage effluent an LPED system generally consists of a small diameter pipe placed within a larger diameter pipe. The small diameter pipe has holes (orifices) drilled into it at intervals along the pipe from which the effluent “squirts”. With careful hydraulic design the flow rate from each hole can be designed to be relatively even (usual working difference is up to 5%). The squirted effluent then pools within the larger pipe and discharges from that larger pipe via slots cut into the pipe along its length. To ensure even discharge flow along the length of the LPED pipe requires the pipe to be laid flat. Any slope on it will result in effluent discharge concentrating at the low end. Therefore, this would require the length of the irrigating area to be levelled. The whole area would not need to be levelled but at 1 m intervals (possible spacing of LPED) the strips down the dunal system would need to be levelled.

An example of the LPED system is shown in Figure 5 below. Generally, a LPED system is used to discharge primary treated effluent and is buried and laid on an engineered sand bed. The orifice diameters are usually around 3 mm located approximately 900 mm to 1,000 mm apart along the pipe. The outside pipe is usually slotted at 300 mm intervals along its length. The internal pipe is generally PE

pressure pipe, and the outside pipe is drainage pipe, although slotted drainage pipe (e.g. Novacoil) is also frequently used. Less frequently the PE pressure pipe is laid directly in a bed of gravel when discharging secondary treated effluent.

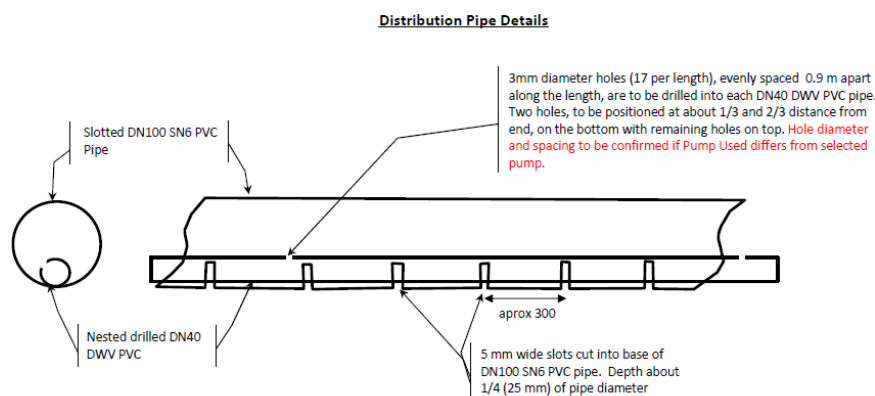


Figure 5 Example details of LPED pipe

5.2.2 Pressure Compensated Drip Irrigation (PCDI)

The irrigation of crops has occurred for many decades using drip irrigation. Traditionally button drippers were push fitted into a small diameter pipe. The flow from the button drippers varied with pressure making even application of water to a row of plants difficult. To overcome this problem pressure compensating drippers were developed, these have a rubber diaphragm built into a dripper body the diaphragm gets compressed as the pressure increases and restricts the flow, these were developed in the early 1970s. Rather than attaching the drippers to the pipe a technique was developed to install the drippers within the pipe. This has been used for many decades for clean water irrigation.

Around 25 to 30 years ago the benefit of using PCDI for the even application of treated effluent was recognised. At first traditional black PE pipe was used but to recognise the application of effluent purple pipe is now used. The typical pressure range over which a dripper is pressure compensating is 0.5 to 4 bar meaning that these can be laid on undulating land without impacting on the flow rate from the dripper.

It has been used throughout the world especially for domestic and small scale systems wastewater treatment systems. In New Zealand it has been used for discharge from municipal sewage treatment plants for over 20 years (e.g. Omaha near Auckland) and for relatively large scale systems. The discharge from the Blenheim STP includes over 100 hectares of irrigation of which approximately 20 hectares is subsurface PCDI. This was installed in 2014.

5.2.3 Comparison of Options

Table 6 shows the comparison of PCDI and LPED for the application in Stuarts Point treated effluent management system in the dunal disposal field.

Table 6 Comparison PCDI and LPED for Stuarts Point Disposal Field Application

	PCDI	LPED
Irrigation Method	Pressure compensated drip irrigation using surface laid Driplines	Low pressure large diameter pressure pipes laid on ground surface
Land contour requirement	Can be laid on undulating ground as long as the height difference is less than the pressure range for pressure compensation of the drippers	Each pipe needs to be laid on a level ground surface to help ensure even distribution of the effluent.
Buried or Surface Laid	Can be buried or surface laid	Can be buried or surface laid, although buried is more common
Landscape/vegetation	Can be laid on the ground surface amongst trees, shrubs or grasses, however access is needed for maintenance. Some growth	Should be kept clear of vegetation along length of distribution pipes to avoid blockages

	PCDI	LPED
	around driplines will not impact on performance	
Design	Pressure compensation of driplines makes selection of a combination of drippers and spacing for required application rate straight forward as application rate is even along the length of each dripline. The pressure compensating function of the drippers enables large subzones to be designed reducing the number of control valves required.	Careful hydraulic design is required to calculate flow rate from each orifice. As a result of pressure drop along a LPED pipe the application rate will drop from the start to the end of the pipe. The pipe lengths are restricted by the acceptable variation in application rate. The loss of pressure and hence flow requires shorter pipe lengths and hence more subzones and more control valves
Operation	The area will be split into zones and subzones and be controlled using irrigation control valves for operation and rotation.	The area will be split into zones and subzones and be controlled using irrigation control valves for operation and rotation.
Maintenance	Requires intermittent flushing dependent on the effluent quality Small emitter size limits intrusion by insects or very small snakes etc. Small risk of root intrusion so occasional lifting of dripline to break rootlets would be useful	Requires intermittent flushing dependent on the effluent quality Larger orifice and slotted pipe sizes present risk of insects and small snakes etc entering the pipe system causing blockages. Root intrusion more likely. Less easy to lift and clear root intrusion than driplines.
Construction	Construct vehicle access track Clear all vegetation of the land, trench and lay pumping mains, submains, collector mains for backflushing and control cabling. Connect driplines to submains and collector mains. Fill trenches, pin driplines to ground surface. Plant selected vegetation	Clear all vegetation of the land, reshape the land (fill in and remove to flatten and shape), built mound with imported fill, create pedestrian tracks and vehicle access along lines, import fill material to create pipe beds, built engineered surface to lay distribution and irrigation pipework (incl pipe supports) to fit hydraulic design,
Hazards	Will depend on effluent quality	Will depend on effluent quality. also risk of bites from spiders/snakes when clearing distribution pipe blockages.
Requirements for Effluent Treatment	Minimum standard is secondary treatment 20 g/m ³ BOD and 30 g/m ³ TSS. Noting that the better the effluent quality the less chance of blockages and backflushing	Minimum standard primary effluent e.g. from septic tank. Higher risk of blockage, Minimum secondary treatment standard 20g/m ³ BOD/30g/m ³ TSS will minimise blockage from effluent.

5.3 Recommended Disposal Method

It is proposed to install an irrigation system that uses pressure compensating driplines to distribute the effluent evenly over the uneven surface of the natural hummocky land (refer to Table 6 in section 5.2.3). Drippers have been chosen for the application at Stuarts Point dunal effluent disposal system as it requires:

- Even distribution over the long stretch (10 m wide and 1300 m long) hummocky land and uneven surface of the dunes at low application rates (slow infiltration)
- Pressure compensating enables dripper to emit the same flow throughout the length of each dripline in each zone
- Minimum of automated control by using one solenoid controlled hydraulic valve to control disposal to one of four 10 m wide and 1,300 m long dispersal zones
- Avoidance of erosion and disruption of natural vegetation by keeping some existing vegetation and dripper pipe laid on a mulch bed made from existing vegetation for dripline
- Dripline spacings to allow for planting between rows of low growing grasses to return dune stability and allow for easy maintenance of the driplines and the plantings
- Driplines are held in place with anchors/pins that can be easily replaced and dripper line location and spacing can be adjusted
- Pathogen, nutrient and solids reduction at the proposed SPWWTP is sufficient to enable dripper lines without the need of additional solids screening or filters (in-line strainer to remove any possible solids added through long pipeline)

6 Disposal Field Concept Design

6.1 Overview

The disposal field is located in the dunes of Stuarts Point between MacLeay Arm and the beach/sea and stretches north of the transfer pipeline crossing located. The disposal field area will be 1,300 m long and 50 m wide and will be divided in four zones (each 1,300 m length and 10 m width) for discharge along the full length of the disposal field at a time. It is proposed to design a disposal field that utilises pressure compensating drippers in a dripline which allows the driplines to be laid along the natural topography of the disposal field site to avoid unnecessary disturbance of the existing dunal system.

Parameters and features included in the concept design of Stuarts Point disposal field are:

- The area designated for the land disposal is 1,300 m long and 50 m wide into that needs to locate the full extent of the field including access and pipework (all civil and mechanical and EI&C structures)
- Maximum acceptable dry weather flow which will fit into the 1,300 m long and 10 m wide dunal disposal strip is 1,248 kL /day based on a factored design infiltration rate of 4 mm/hour, as discussed in Section 3
- The total disposal discharge to land field comprises 4 rotations, each sized for the 1,248 kL/day flow to allow rest and recovery of the soils.
- The disposal field is to be divided into 4 zones of 10 m width and 1300 m length. Distribution lines with flow controlled by actuated hydraulic valves feed one zone at a time for a set duration of time (e.g. change over to the next zone every couple of days).
- Distribution and feed pipework distribute the effluent to subzones of 160m length and 10m width with dripper lines
- Dripper lines are joined into a flushing manifold at the end to allow for flushing of the driplines controlled by using a manually operated flushing valve
- Vehicle access to site is from the beach in the designated area (refer to layout in Appendix B)
- A bund with a vehicle access track along the western boundary of the disposal site for access and to reduce the risk of overland runoff to the McLeay Arm.
- Pedestrian tracks between between the irrigation zones and at the northern and southern end of the field to allow access for maintenance and operating flush valves
- Flowmeter, filter and pressure gauge (refer to P&ID in Appendix A) in central location with main valve pit (manhole) are accessible from main vehicle track
- Hydraulically actuated valves in central location valve pit are accessible from main vehicle track to minimise the use of electrical control cabling due to saline conditions and for ease of maintenance
- Manually operated flushing valves accessible via footpath (pedestrian tracks)
- Some existing vegetation in the disposal area is kept for erosion control. Cut down weeds and prune/trim existing vegetation to create a mulch bed to lay drippers onto.
- Whole site to be fenced off and signage installed

In the design of Stuarts Point disposal field, the public health risk associated with pathogens in treated effluent in surface seepage or ponding has been addressed by:

- Additional treatment barriers at the SPWWTP to reduced pathogens in the effluent as discussed in Section 7.5
- Reduced risk of aerosols and spray hazards through the method of dripline irrigation
- Avoidance of occurrence of surface seepage by balanced and uniform distribution of effluent across the disposal field area, e.g. control of four zones through actuated valves and distribution pipework
- Reduced risk of ponding by pump control based on field monitoring of groundwater levels, rain data and storage levels

- Vehicle track along the length of the disposal field for easier operation and maintenance access and designated pedestrian access to manual valves
- Fencing and signage to create awareness and minimise access to the disposal site and decrease public health risk

Details of civil, mechanical and electrical concept design of the disposal field for Stuarts Point treated effluent management system are described in the following section.

6.2 Mechanical Design

6.2.1 Pumping and Pipelines

6.2.1.1 System

The treated effluent from the WWTP will be pumped into and temporarily stored in 2 x 1.5 ML effluent storage tanks before being pumped to the distribution field (refer to section 7.5 and section 7.5).

Adjacent to the storage tanks, a ground-mounted pump station will be established. This pump station will be equipped with two dry-mounted end-suction pumps arranged in a duty/standby configuration.

The pump station will include a set of non-return valves, gate valves and a flow meter (if so preferred).

6.2.1.2 Pump Selection

The minimum and recommended pressure at the distribution field location before distribution into the various zones, is 3.5 bar. To achieve this, the selected pump, a low-pressure centrifugal 30kW KSB ETN 065-050-250, 241.7 mm impeller diameter has been selected.

This pump delivers a flow rate of 18.7 L/s at a total head of 76.3 metres. This pumped head includes the static & dynamic losses in the 3.7 km rising main (30.2 m), the disposal field pipes (10.4 m) and the 35.7 m (3.5 bar) pressure required at the entry point of the distribution field dripper lines. Air valves will be placed along the rising main at best suited locations.

The maximum impeller size for this pump model & 30kW motor size is 260 mm which allows future proofing by way of simple impeller upsizing in the future to gain more flow, for example during a pump refurbishment, if required.

6.2.1.3 Distribution Piping

For the pressure main, a DN180 PN12.5 pipe with an internal diameter of 153 mm has been chosen to achieve optimal cleansing velocity under ultimate flow conditions. Given the pipeline length of approx. 3,700 metres, it is challenging to maintain velocities above 1 m/s without significantly increasing system pressure, which would impact pump selection and potentially require a higher kW rating.

The four distribution pipelines will be DN125 PE100 PN12.5 from the tee to the first take off to a set of zones. From the first off take to a block of zones, the distribution pipes will be DN90 PE100 PN12.5 to accommodate the reduced flow and maintaining a needed flow velocity. Zone feed pipes and manual valves will be the same size at DN90 PE100 PN12.5. Feed laterals and dripper manifolds have been sized to be DN63 PE100 PN12.5 (refer to Figure 6 below and to the P&ID in Appendix A). Flushing manifolds and manual flush valves will be DN50 PE100.

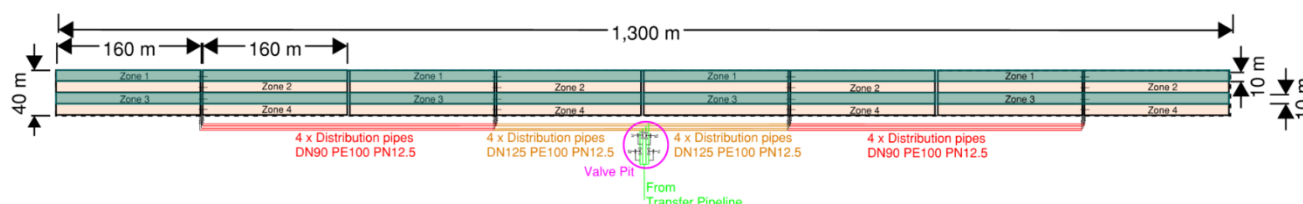


Figure 6 Stuarts Point disposal field plan showing zones, valve pit and distribution pipework.

At the connection of the transfer pipeline to the disposal field, there will be an inline filter (130 micron) to remove any residual solids, a flowmeter and a pressure gauge to control effluent flows to the disposal field. A valve pit with four solenoid controlled hydraulically operated diaphragm valves to control the

sequence of changing over disposal to the zones will be installed in a valve pit. Each actuated valve controls effluent flow to one of the four zones through the four distribution pipes and the feed pipework.

The effluent is split in a tee to distribute the flow to the zones of the disposal field in four distribution pipes that run along the disposal field to the four points of feed pipework (as shown in Figure 7). There is a manual valve on each feed pipe to manually isolate the dripper subzones connected for flushing or emergencies. From the feed pipes, the effluent gets split into flow to two dripper sub-zones (block with dripline of 10 m width and 160 m length) and laterals and dripper manifolds enable distribution to dripper lines. Dripper lines are grouped in three between new vegetation. Each block of driplines is to be joined into an end flush manifold connected to a manually operated flush valve to allow for flushing of the driplines.

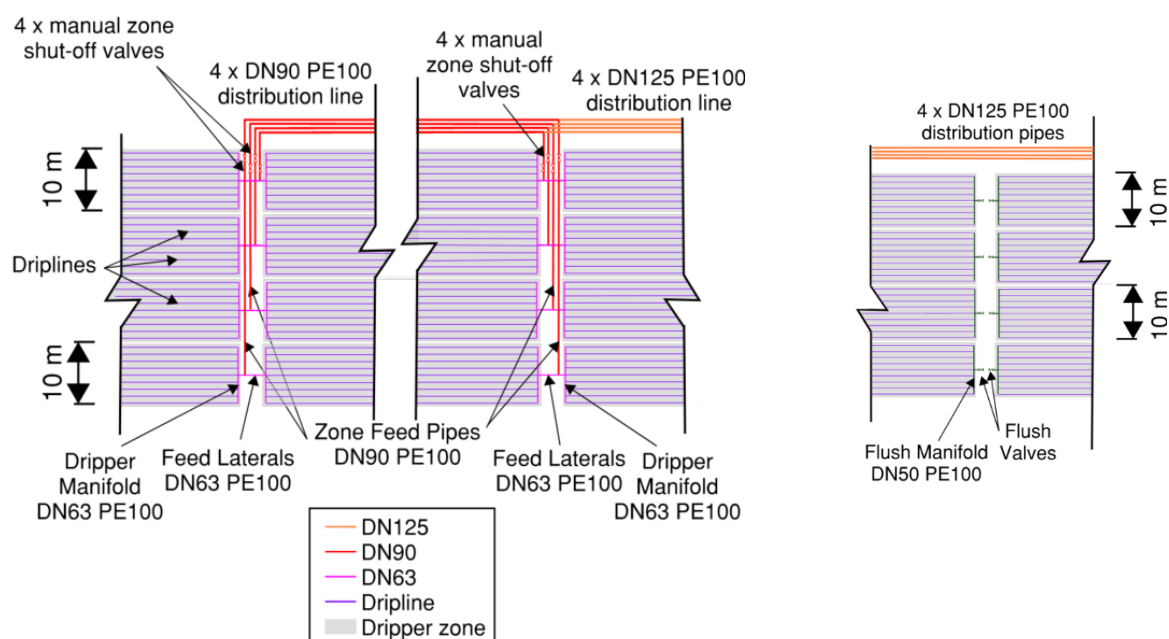


Figure 7 Disposal field pipework and valving details

6.3 Irrigation Design - Driplines

The factored infiltration rate is based on application of effluent over 24 hours. The target duration of irrigation in the 24 hour period to apply the 1248 kL/day should be 18 - 20 hours to enable flexibility in irrigation operation, time for emergency maintenance of the system and to allow draw down of storage after periods when irrigation cannot occur. The actual rate of effluent application will exceed 4 mm/hr.

The selected dripline shall have drippers with a flow rate and spacing which allows for the operation of the drippers under pressure control over the full 160 m of dripline length, i.e. the recommended pressure at the dripline inlet is 3.5 bar and the minimum allowable pipeline pressure at the end of each length of dripline shall be no less than 0.5 bar.

The design parameters for the driplines in the Stuarts Point disposal field are shown in Table 7.

Table 7 Disposal field dripline design parameters

Description	Unit	Details
Total Disposal Area	ha	5.2 ha
Disposal Field Zone Width	m	10
Disposal Field Zone Length	m	1,280
Target Daily Discharge	kL/day	1248

Description	Unit	Details
Disposal Equivalent Application Depth	mm/day	19.2
Max Application Rate	mm/hr	5.83
Laterals/Rows Spacing	m	1
Rows per Zone	No.	10
Emitter Spacing	mm	600
Lateral length	m	160
Min pressure at start of line	bar	3.5
Min pressure at end of the line	bar	0.5
Max operating pressure	bar	4

6.4 Civil Design

6.4.1 Access Track

The elevated access track along the western side of the disposal field is planned to be approximately 1 m above the local low point. The bund provides protection against localised surface flooding into the Macleay arm. A concept Cut/Fill balance has been performed based on the LiDAR information provided with the existing surface profile. Some reference levels to note:

- Field - lowest point 0.98 m RL
- Field - average level 2.16 m RL
- Field - highest point 5.65 m RL
- Dune – average height 5.36 m RL

Setting the height of the bund and access track to 2.0 m RL for the whole length of the section (1m higher than the lowest point 0.98 m RL) provided high net balance and there would be high amount of cut sand that would need to be removed from site.

Another balance has been performed with the cut height following the existing surface and the fill height is set 2.9 m RL including 300 mm of fill for road surface and stabilisation. The 3D model with the result of the access track is shown in Figure 8. The volume summary is shown in Table 8.

Table 8 Cut Fill balance results of 2.9m RL

Name	Cut / fill factor	2D area (m ²)	Cut (m ³)	Fill (m ³)	Net (m ³)	Gravel fill (m ³)
Cut Fill at 2.9m RL Road	1.0 / 1.0	19,157	9404	5323	4080 (Cut)	830

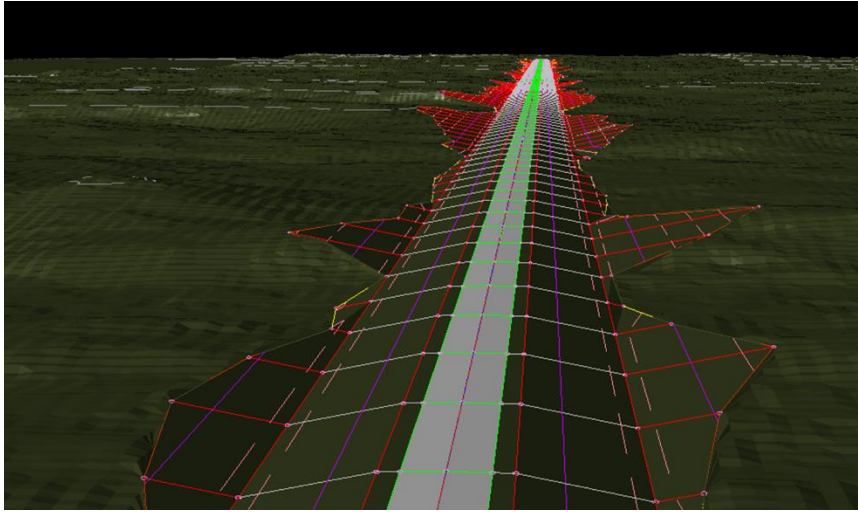


Figure 8 3D model of 2.9m RL access track bund cut/fill design along Stuarts Point disposal field.

This is an initial cut to fill concept issued for discussion purposes. For subsequent design the intention is to refine and reduce the cut by lifting the road level or stepping the back slope from 1:3 to 1:1 or 1:2, this would reduce the extent of earthworks needed to tie into existing ground on either side of the track. There is also potential to use any excess cut to fill in natural hollows in the field (i.e local spreading).

6.5 Automation and Control Design

6.5.1 System Function

Pumping

Effluent from the SPWWTP will be pumped by the effluent pumps and controlled based on the level in the effluent storage tanks at the effluent pump station (refer to P&ID in Appendix A).

A weather station at SPWWTP records rain, wind direction and speed, air temperature and other weather data. Rainfall intensity can be used to control (shut off) the effluent pumps in high rainfall events.

Effluent is pumped via the transfer pipeline to the disposal field for discharge in the dunes.

Irrigation zone distribution

A flowmeter at the dune disposal field captures the discharge volume and a pressure transmitter monitors the delivery pressure at the disposal field. Distribution to each 10 m wide and 1300 m long zone of the disposal field is controlled by solenoid controlled hydraulically actuated valves. It is anticipated to sequence through the zones one to four within 8-12 days, discharging to one zone at a time for 2-3 days.

Effluent is distributed to four zone blocks for one zone via the distribution pipework as shown in Figure 7, each zone block consists of two 160 m long dripper fields connected via zone feed pipes and laterals to the dripper manifold, shown in Figure 6.

Effluent is evenly distributed in each dripper field by PCDI consisting of nine driplines bundled in groups of three over the width of 10m. Several bores with piezometers around the disposal field site detect the groundwater level. A centrally located groundwater level monitoring bore containing a level sensor connected via telemetry to the WWTP will be used to indicate (alarm when groundwater level is too high) and treated effluent flows need to be diverted to storage (refer to section 3).

Flushing

Flushing of the driplines can be performed by opening the manually operated flush valve at the end of each dripper zone using the pumped effluent flow as defined above.

WWTP Infrastructure

Upgrades to enable pumping treated effluent from the WWTP to the dispersal field include:

- New pump station controls with **Duty/Standby pump starters**

- Integration with **HMI/SCADA** systems for remote monitoring and control
- Installation of a **weather station** to inform dispersal operations

6.5.2 Instrumentation, Control and Monitoring

The following instrumentation and equipment would be installed at the dunal site control, monitor and communicate with the SP WWTP:

- **Control panel:** Located at the valve manifold; manages valve operation, monitors pressure and flow, and transmits data back to the WWTP
- **Flow meter:**
 - Triggers a **Low Flow Alarm** if pumps run with no dispersal
 - Triggers a **High Flow Alarm** for events such as pipe breakage or operator error
- **Pressure transmitter:** Monitors delivery pressure and automatically stops pumps on overpressure
- **4x low-power latched piloted solenoid valves:** Used to select active dispersal fields; consume power only during state changes
- **Data gateway:** Collects readings from remote groundwater level sensors
- **Groundwater sensors:** Solar-powered, hydrostatic level sensors reporting approx. every 60 minutes — locations TBD
- **Weather station data integration:** Used to automate dispersal control
 - Stop dispersal when rainfall exceeds threshold (e.g., >XX mm/hr)
 - Resume dispersal after a defined dry period (e.g., XX hours post-rain)



<https://ewsmonitoring.com/service/groundwater-monitoring/>

6.6 Power Supply Design

This section outlines two options for supplying power for automation, control and communications to the dispersal field located more than 700 meters from the nearest mains power source.

6.6.1 Solar Powered Option

A standalone solar installation provides a sustainable solution:

- 1200W solar array to charge batteries supporting:
 - Communication systems
 - Metering equipment
 - Valve actuators

6.6.2 Mains Powered Option

A traditional approach involves running mains electricity across the estuary to the dispersal field, either:

- Along the new pipe run, or
- Via the existing bridge infrastructure

This would provide reliable power but comes with high installation costs due to distance and environmental challenges.

6.6.3 Comparison of Power Supply Options

Table 9 **Error! Reference source not found.** below shows the comparison of mains power and solar power options.

Table 9 Disposal field parameters

Feature	Mains Power Option	Solar Power Option
Power reliability	Consistent and scalable	Weather-dependent; suitable for low loads
Installation cost	High (700m cable run, estuary crossing)	Moderate; self-contained infrastructure
Sustainability	Fossil-fuel based grid connection	Renewable; aligns with low-impact development
Complexity of deployment	Complex trenching and approvals	Simpler minimal environmental impact
System autonomy	Grid-dependent	Autonomous, battery-backed
Maintenance	Low, but long-term asset management required	Battery and panel upkeep required

Costs for Stuarts Point electrical supply have been compared in a high level cost estimate as shown in Table 10.

Table 10 Electrical connection options:

Description	Cost Estimate
Trenched Power (footbridge)	\$ million
Underbored Power (Macleay Reach)	\$ million
Solar	\$

6.6.4 Recommendation

- Establishing a mains connection would involve substantial infrastructure and cost. Therefore, a solar-powered control station is proposed as the primary alternative.
- Given the remote location and environmental sensitivities, a solar-powered control station is recommended.
- It minimizes civil works, supports long-term sustainability, and enables modular expansion with minimal disruption.

6.7 Construction, Operation, and Maintenance

6.7.1 Construction

Site access including construction access will be from Stuarts Point beach as indicated in the designated area on the layout plan in Appendix B. During construction, it is proposed the area will be used for construction site access and laydown area.

Constructing the vehicle access track will require earthworks with moving volumes of sand to cut into high lying areas and fill low points. An initial cut/fill analysis has been performed but need to be refined in the next design stage.

Construction of the disposal field will require the following working steps:

- Clear existing vegetation off the land
- Trench and lay pumping main (transfer pipeline), distribution and feed pipework, and mains for backflushing and control cabling
- Connect driplines to feed lateral and collector mains
- Fill trenches, pin driplines to ground surface
- Plant selected vegetation (short grass species to be advised)

The mulching/removal of vegetation and planting of short grass species may create a risk of sand movement in the irrigation zone. Consideration should be made to provide additional plantings around the irrigation area and across the irrigation area to mitigate this risk.

The mulching/removal of vegetation and planting of short grass species may create a risk of sand movement in the irrigation zone. Consideration should be made to provide additional plantings around the irrigation area and across the irrigation area to mitigate this risk.

6.7.2 Operation

The area will be split into four zones of 10 m width and 1300 m length and dripper subzones (10 m wide and 160 m long). Irrigation zones will be controlled using irrigation control valves for operation and rotation/sequencing of effluent disposal through the four zones.

The design of the disposal system has specified a flow rate and operating pressure for the effluent pumps. The actual operating conditions will be monitored to ensure the system is operating at the design requirements. A flowmeter will record the effluent flow discharged to the disposal field. A pressure gauge and transmitter will be installed downstream of the inline filter to monitor and maintain the required pressure for operation of the driplines. Separately the pressure drop across the filter will be monitored with back flush occurring based on filter operational requirements to avoid the pressure drop causing required downstream pressure to be too low.

Sustained low pressure or increased flow are likely to indicate serious damage/leakage. Loss of flow in individual drippers or damage to a single dripline may not be observable during normal operation so maintenance of the system is required. Regular inspection of the disposal fields is advisable.

6.7.3 Maintenance

Pressure Compensated Drip irrigation (PCDI) when used for the irrigation of treated effluent may lose performance due to a number of factors including:

- Blockage of emitters either from sediment in the wastewater or root intrusion.
- Build-up of slime in driplines (and delivery pipes)
- Breakages of driplines from animals, humans or failure of fittings
- These can be monitored and addressed using following operations and maintenance procedures.
- The pressure compensating function of the drippers enables large subzones to be designed reducing the number of control valves required.

These issues are addressed below.

Driplines

While the proposed normal effluent quality is extremely high and it is recommended that the selected dripline has emitters impregnated with root retardant some slime build-up or root blockage may occur. The driplines need to be inspected regularly to carry out backflushing and check for blockages and damage. Typically, inspections are carried out at 6 monthly intervals.

Initially, at least, it is recommended that at each inspection backflushing of the driplines is carried out, although if the system continues to operate at the design flow and pressure or little to no slime is released during backflushing then the period of backflushing could be extended. Equally if the backflushing shows continual discharge of large amounts of slime, then more frequent backflushing or the injection of higher dose chlorine (using sodium or potassium hypochlorite) or the use of Hydrogen peroxide may be required.

Planting

The recommended planting between the driplines is compact short “grasses” which should have minimal intrusion across the driplines. The intention is to provide sufficient vegetation to control soil and sand erosion, but also to minimise growth and spread of vegetation in order to impede access and maintenance of dripper lines. Some vegetation growth is acceptable and does not interfere with the operation of the driplines, but regular weed control and vegetation maintenance may be required to ensure access to the driplines is maintained and plants are growing in a controlled manner (easy checking of the dripline for breakages/roots etc.).

Boundary and intermediate shelter trees are recommended to minimise wind blow soil erosion. These may require pruning to maintain access, particularly along the footpaths planned to be installed at the end of the driplines.

Velocity checks and flushing

Operating flow velocities (~1.7 m/s at the inlet end down to around 0.4 m/s three quarters of the way down the dripline) in the driplines need to be checked regularly that these are above normal flushing velocities (0.4 to 0.6 m/s) along most of the length of the driplines. Hence the flushing regime will include visiting the site when during normal operation and open the manual flush valve on the flush manifold and flush each subzone individually for a period of around 15 minutes.

Other maintenance tasks

Other site observation tasks to be carried out while in the field and operators walking the lines are to check for line breakages, dripper blockages by sediment and root intrusion, and plant maintenance. It is not recommended that individual emitter blockages caused by sediments are addressed immediately but if a length of dripline is blocked then it could be cut out and replaced with new dripline. In this case, the dripper sub-zone would need to be isolated with the manual valve to stop effluent flow before that replacement can occur. Jointing of driplines can be in a way of using push fittings and clamps. Minor root intrusion could be addressed by lifting the dripline to break the roots (Noting that root intrusion should not be an issue for a number of years with the use of the specified emitters).

Some emitters may fail so that they do not maintain the pressure compensating function. This is usually seen by a jet of water into the air or a strong hissing sound if a dripper is spraying into the ground. Once again replacement can occur by cutting them out and inserting a new length of pipe, shutting the flow off to carry out that task as above.

7 Water Balance and Effluent Storage

7.1 Water Balance and Effluent Storage

The treated effluent management system requires the storage of treated effluent at the SP WWTP to attenuate discharge to the dunal site at times when the dunes are unable to receive flows.

Section 2.2 summarised the design flows to be managed by the system, this section discusses how these flows would be managed at times when the dunal site is unable to receive the flow.

7.2 Synthetic Flow Scenarios

Discharge to the dune disposal system cannot occur whilst the groundwater table in the dunes is high, during and after a rainfall event (further discussion is provided on this below).

An analysis was conducted to calculate the potential number of overflows to the Macleay Reach based on historical rainfall data and varying volumes of effluent storage.

Synthetic daily raw sewage patterns (Figure 10) were developed based on:

- Population growth data provided by Council.
- Per ET flow data sourced from the Stuarts Point Sewer Scheme Project Summary Report on Hydraulic Loadings Analysis and I&I Justification
- Monthly variation in dry weather flow based on Iluka Inflow data (assumed to be similar to Stuarts Point). See Figure 9 for details.
- Rainfall data from Crescent Head for the period from 1982 to 2024 (weather station ID 59047). Crescent Head was identified as the nearest suitable station with sufficient rainfall data.
- A linear correlation between rainfall and the assumed inflow to the new SPWWTP assuming the maximum inflow is capped at 130% of the dry weather inflow.
- A peak dry weather daily inflow of 1.9 x the off-peak dry weather flow was assumed for the first week of January to simulate high flows during the Christmas New Year period.

The inflow patterns shown in Figure 9 and Figure 10 below were used to assess the storage requirements for SPWWTP. Discussion on the storage requirements is provided below.

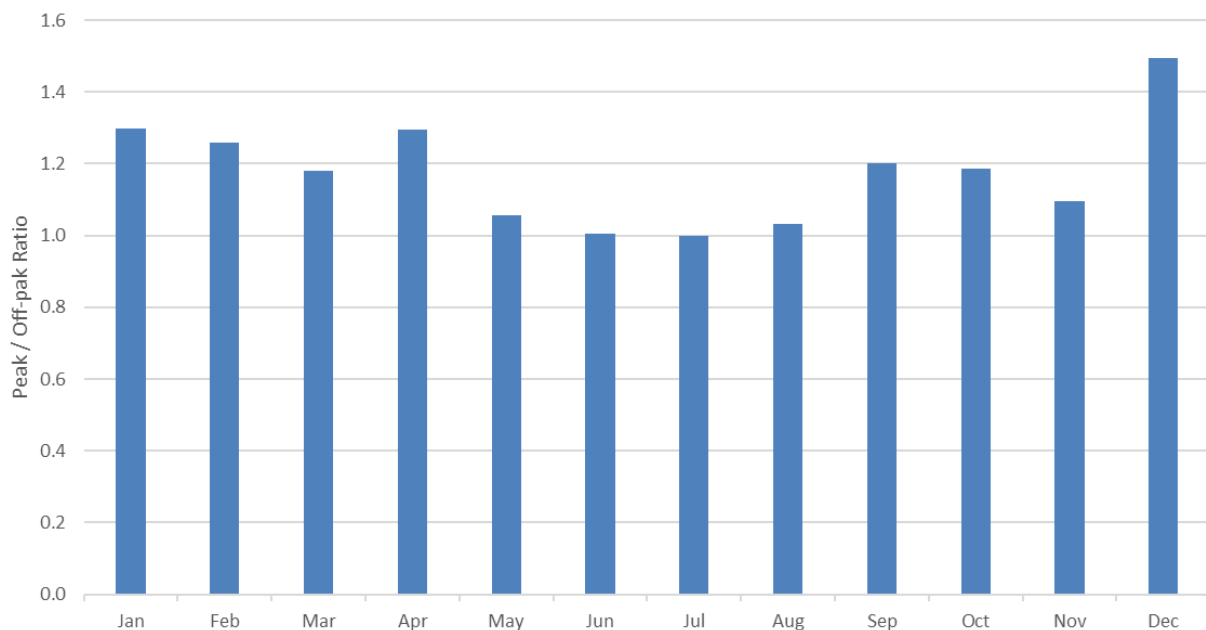


Figure 9 Assumed monthly dry weather inflow for SPWWTP based on inflow data from Iluka STP

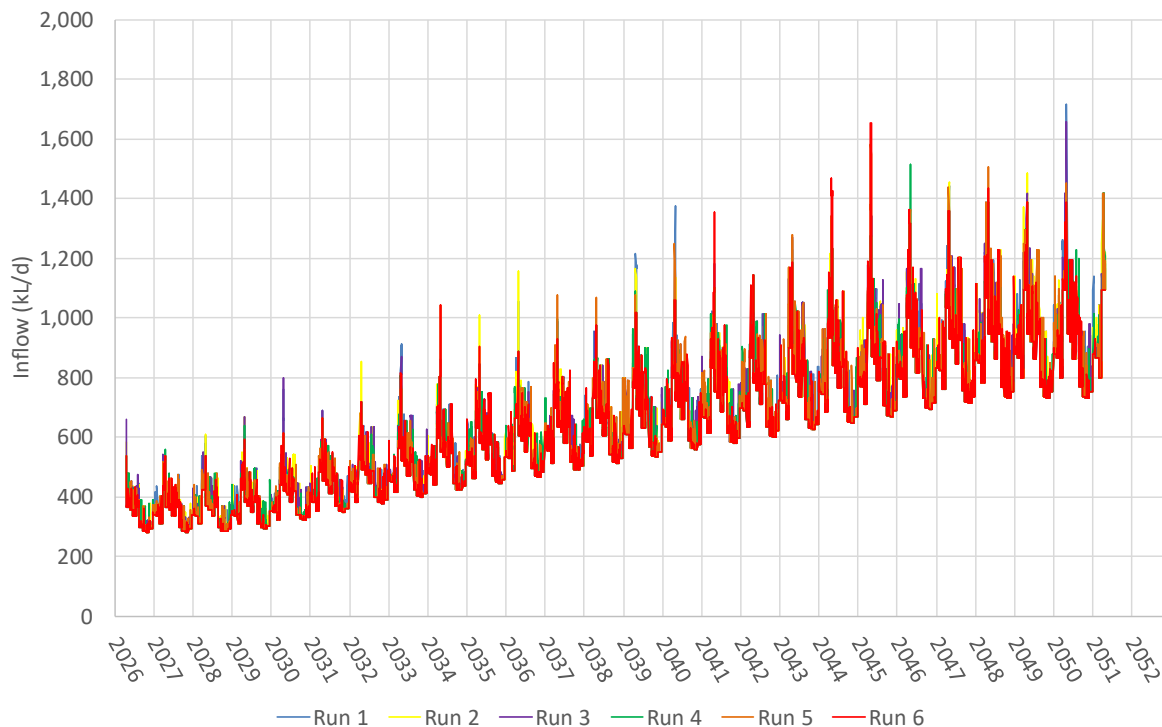


Figure 10 SPWWTP Synthetic inflow patterns

7.3 Methodology

The results of the groundwater modelling (as presented in Section 3) have been used to create a water balance:

- Longer duration unfactored application rate of 40 mm/h (per day) with 10 % factor of safety applied, factored design infiltration rate of 4 mm/hour is used to determine overall land area requirements, as discussed in Section 3
- Disposal field footprint 1,300 m x 10 m each disposal area, 48h disposal time to each area and then move to the next resulting in 2 days on, 6 days off
- Resulting maximum dry weather flow of 1,248 kL/d
- Resting days with no disposal onto dunes have been defined based on days of relationship between rainfall event depth and days of sheeting as shown in GW Modelling section (refer to section 3)
- Inflow and rainfall data per Section 2.

The restrictions to dispose onto the dunal disposal field (out-of-action and resting times) during and after rainfall events have been set into a water balance to calculate volumes of storage needed for the years of rainfall.

7.4 Results

Using the inflow, rainfall and dune disposal capacity, multiple model runs were conducted with varying rainfall patterns and effluent storage volumes at the SPWWTP.

Key considerations in running the scenarios were:

- Noting the future uncertainty with regards to population growth rates, the ability to stage storage over time is important.
- Large storage volumes will be problematic from an operational perspective. The quality of effluent when stored for long periods of time can deteriorate and returning high flows can reduce the performance of the SP WWTP.

- Noting the above, ideally the effluent storage can be drained withing 3-4 days using the residual capacity of the treatment plant.

In consideration of the above constraints, an optimised storage volume of 3 ML (2 x 1.5 ML tanks) up to 2038 loadings and an additional 1.5 ML storage to the ultimate loadings was developed.

Nominally, the proposed storage volume would result in an average of one emergency discharge event per year for the life of the plant. An overflow event is defined as one or more consecutive days in which discharge directly to the Macleay Arm would be required. A graph showing the volume of effluent overflows to the Macleay Arm as well as the average number of events per year is displayed in Figure 11.

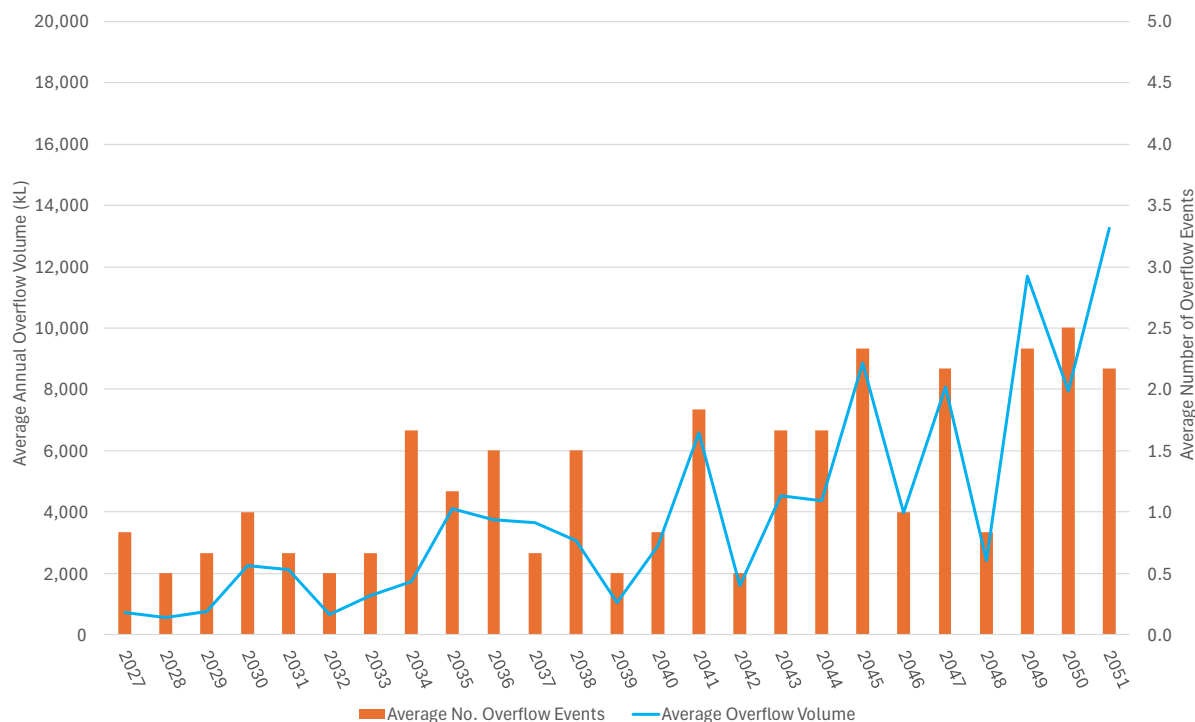


Figure 11 Event number and volume for effluent bypass to the MacLeay Reach.

7.5 Conclusion

The proposed approach based on the modelling conducted is to:

- Provide 2 x 1.5 ML storage tanks to store treated effluent in times when discharge to dune disposal is not feasible.
- Allow space for a third 1.5 ML storage tank to be constructed nominally in 2038 however the timing would be reviewed based on actual loadings to the SP WWTP.

8 WWTP Tertiary Treatment

The design of the dune disposal system as well as the capacity limitation of the dune disposal system impact the required performance and configuration of SPWWTP.

In particular, the following aspects are affected:

- Treated effluent storage at the WWTP and how this storage interacts with other plant processes (e.g. reuse).
- The need to filter effluent to reduce the chance of solids carryover blocking dune disposal infrastructure.
- Disinfection performance requirements related to direct discharge of effluent to the Macleay Arm, particularly in consideration of the presence of the oyster leases. Emergency discharge provisions have been included to address situations where dune disposal system capacity is exceeded.
- Further treatment may be required to meet quality standards for onsite reuse of effluent.

As a result of the factors outlined above, a tertiary treatment process is required to be incorporated into the SPWWTP Design Guidance Memo prepared by Beca HunterH2O.

Details of the changes to the SPWWTP to meet the aforementioned needs are details in a an updated WWTP reference design document. Nominally, the changes to the scope of works for the WWTP include:

- Pressure media filters designed to accept all pumped effluent flows decanted into the IDEAT balance tank. These media filters would be upstream of the inline UV disinfection systems included in the original concept. The media filters would backwash dirty water to the inlet of the IDEAT process.
- Chlorine dosing (using sodium hypochlorite) and chlorine contacting in 2 x baffled tanks which would treat all flows. Chlorine contacting would be downstream of the inline UV disinfection systems included in the original concept.
- Two x 1.5 ML effluent storage tanks which would receive the chlorinated effluent and provide buffer storage for operation of the dune disposal transfer pumps (space will be available for a third). The effluent storage tanks would also provide storage for the onsite reuse (noting the previous concept had a separate effluent balance and reuse storage tank).
- In addition to the pumps used to transfer effluent to the dune disposal system, another set of pumps would be used to transfer effluent from the effluent storage tanks to a new discharge into the Macleay Arm.
- Expansion of the sodium hypochlorite storage and dosing system to enable disinfection of all effluent flows as well as a residual maintenance dose for site effluent reuse and the ability to provide a maintenance dose for discharge to the dune disposal system.
- Provision of a sodium metabisulphite (SMBS) storage and dosing facility to enable de-chlorination of the effluent transferred to the dunes and to the Macleay Reach.

8.1 Process Flows

The main process steps at SPWWTP are shown in the Process Flow Diagram (PFD) in Figure 12. Treated effluent from the SPWWTP will be tertiary treated including filtration for solids removal and UV. The effluent will be chlorinated before being discharged (pumped or stored) and SMBS can be added for de-chlorination. The effluent pump station will be pumping the treated effluent through the main transfer pipeline to the disposal field in the dunes. Effluent storage will be provided at SPWWTP as discussed in Section 7. There will be a weather station at SPWWTP to control the pumping to the disposal field during rain events. Effluent pumps draws from effluent storage tanks and will pump treated effluent to the disposal field when it can receive effluent for dispersal in the dunes.

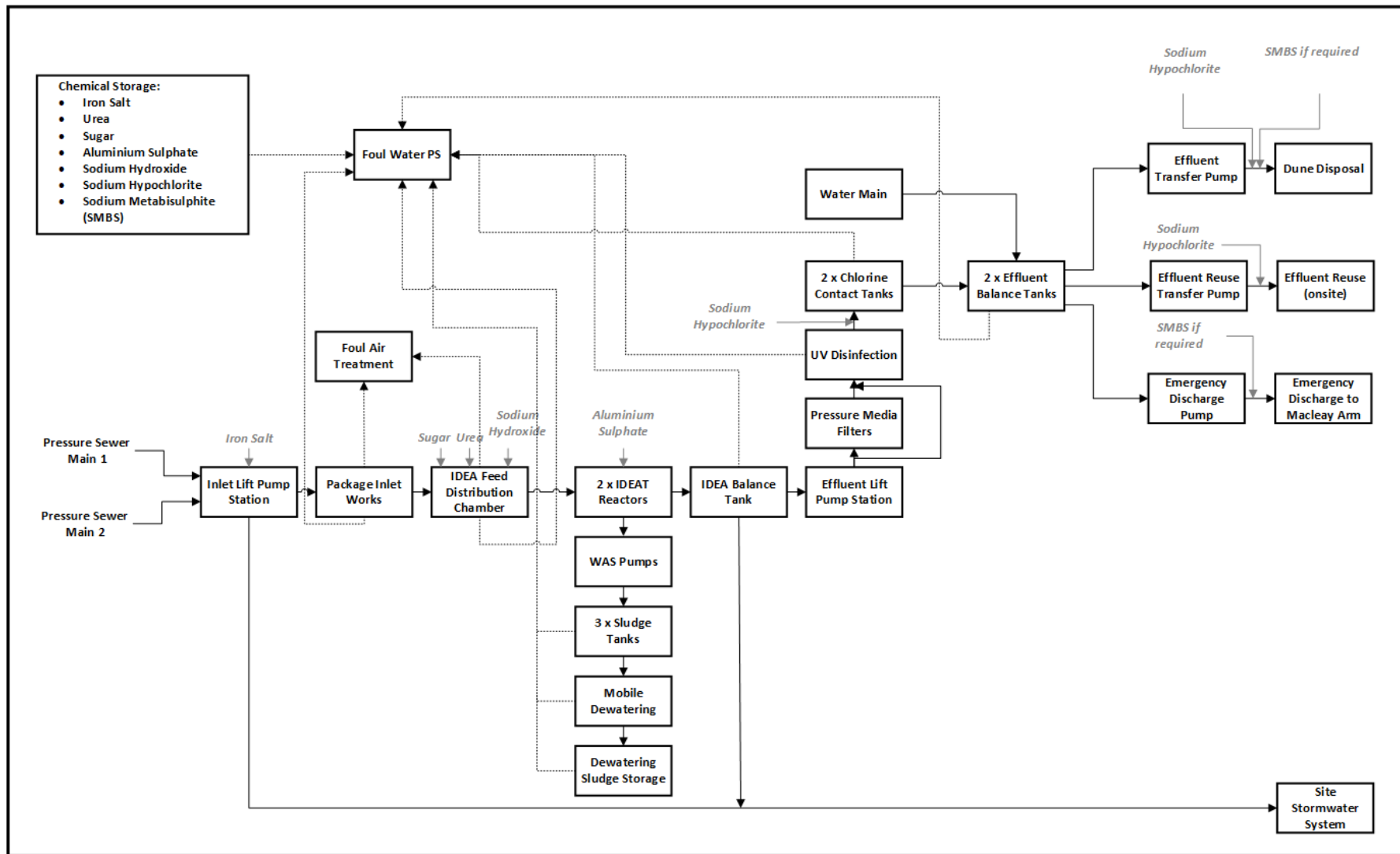


Figure 12 Stuarts Point WWTP Process Block Flow Diagram

9 Cost Estimates

Cost estimates with -50%/100% (Class 5 AACE, ROM) have been developed for the Stuarts Point disposal field design and are shown in Table 11 below.

Table 11 Cost estimates for Stuarts Point Disposal Field

Item	Costs
Subtotal Disposal Field	\$
Detailed Design	\$
Contractor fee incl contingency	\$
Owners' costs	\$
TOTAL	\$

The total projects cost for Stuarts Point treated effluent management system disposal field is \$ million (AUD).

9.1 Assumptions and Clarifications

The cost estimate derived for Stuarts Point effluent disposal field presented in Table 11 are based on the following assumptions:

- Effluent pump station, storage tanks and tertiary treatment process updated at SPWWTP are included elsewhere in the overall budget (i.e. excluded from the cost estimate in this report)
- The transfer pipeline from SPWWTP to the disposal field is designed and scoped elsewhere, including the transfer pipeline alignment underneath MacLeay arm (refer to GHD report (2023) Stuarts Point Sewerage Scheme Effluent Transfer and Disposal Design and Investigations)
- Removal of vegetation for the 6.7ha site: mulching and pruning on the dunes – no removal from site has been included in the costing
- Access to disposal field site from the southern point of the designated area from Stuart point beach (as indicated in the layout drawing in Appendix B). Please note: access from the northern end of Stuarts Point beach, Grassy Head, has not been considered in this concept.
- Elevated Access track alongside the disposal field for vehicle access is based on concept design and initial cut and fill assessment. More detail on the design of the bund and vehicle track will need to be considered for the next level of cost estimates. Further design of the bund and track will require more geotechnical investigations to confirm site conditions.
- Electrical supply is based on remote connections, e.g. solar panels and batteries have been considered in the costing.

10 Safety in Design

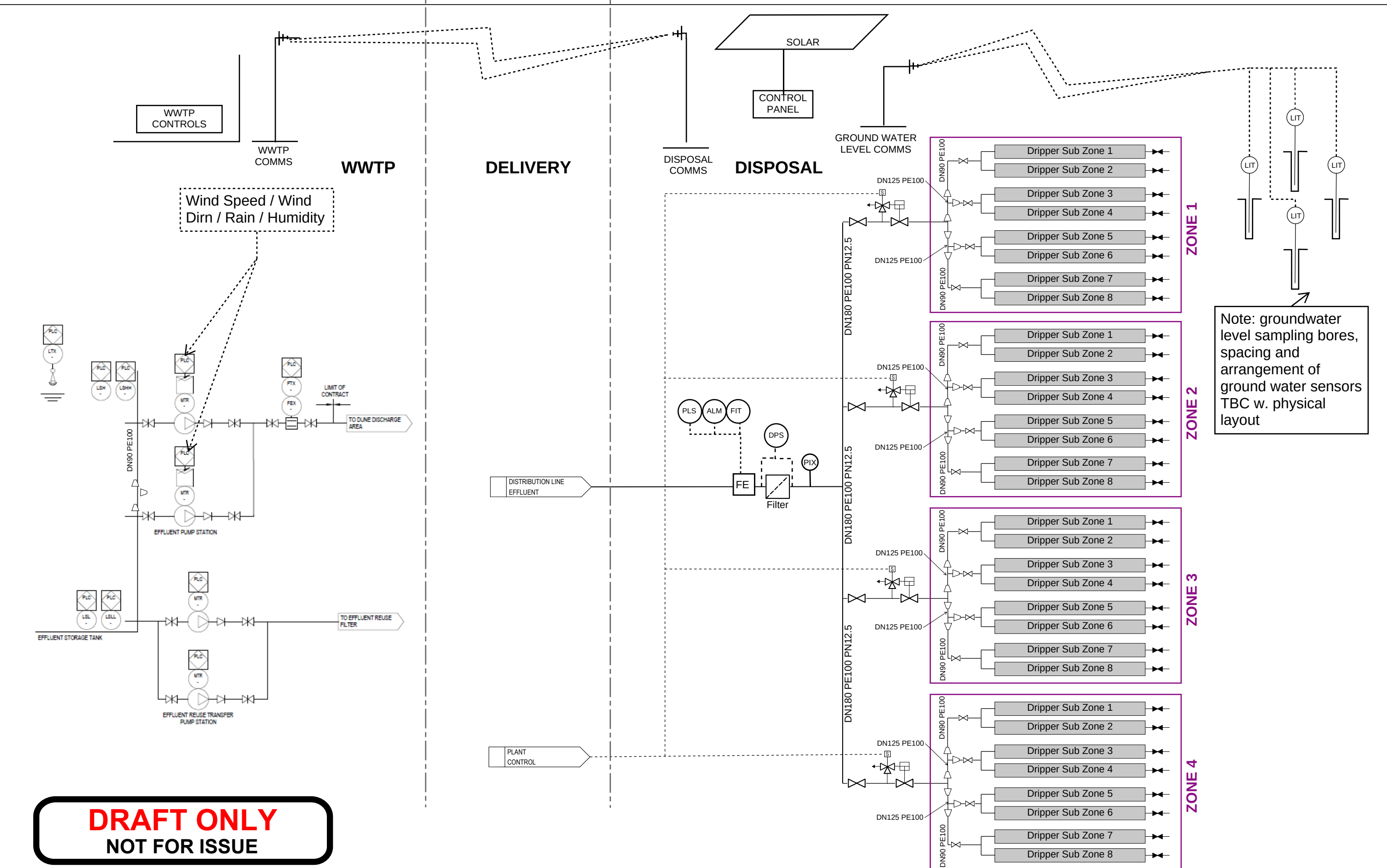
A concept design review and Construction Hazard Assessment and Implications Review (CHAIR 1) workshop was held on 27th August 2025 with Kempsey Shire Council planning project and operations representatives. General feedback, concerns and comments for the Stuarts Pint Treated Effluent Management System were discussed and workshop summary received. These have been captured in the design review register.

The CHAIR workshop covered a high-level risk assessment of:

- dunal discharge site in Module 1
- Tertiary Treatment and disinfection in Module 2
- Treated Effluent Storage in Module 3
- and risks of interaction between the design elements in Module 4.

Risks and controls captured and assessed in the register and will be presented in a Safety in Design Report to be submitted separately

Appendix A. Piping and Instrumentation Diagram (P&ID)

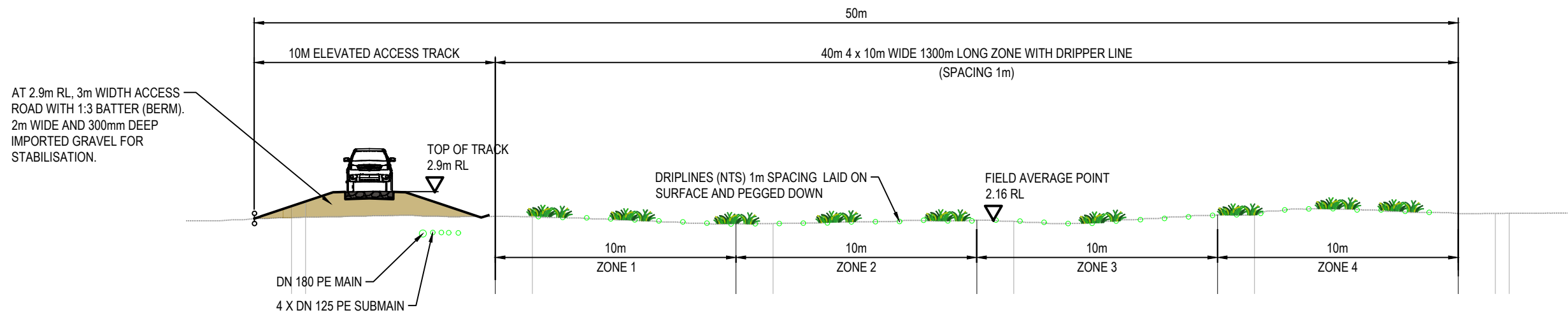


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					Date 20.07.2025												
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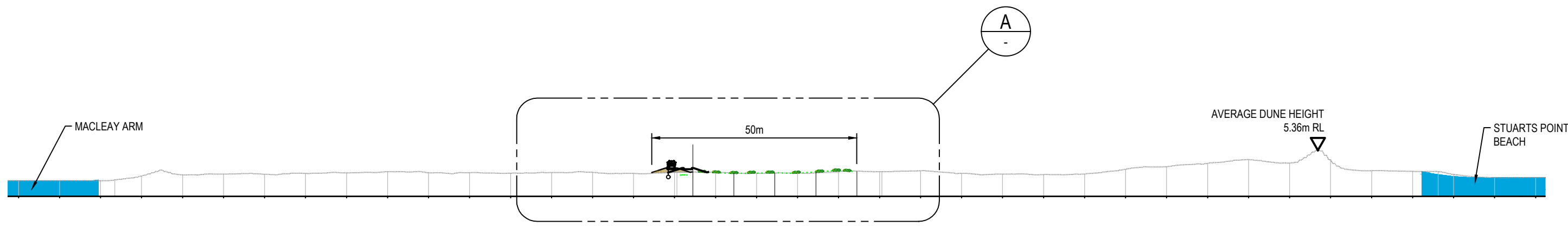
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Appendix B. Layout and Cross Section Drawings



DETAIL VIEW SECTION A

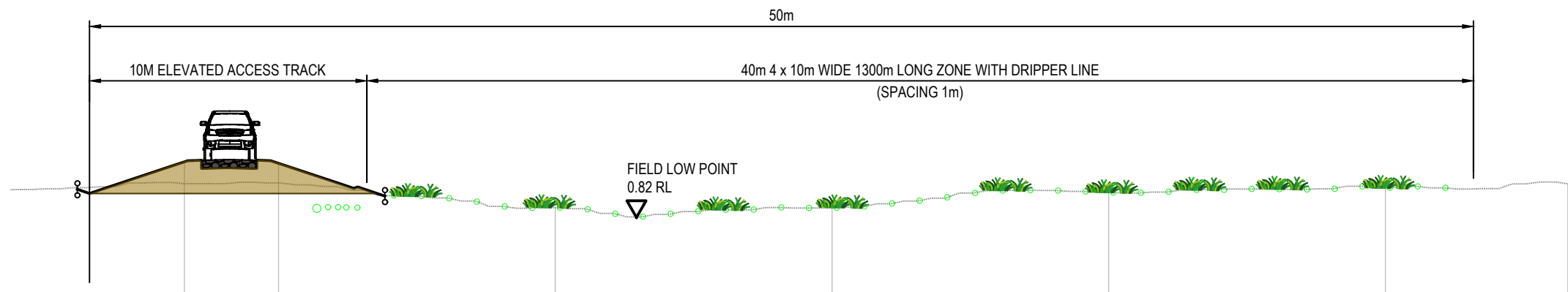
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DISPOSAL FIELD - CROSS SECTION 1

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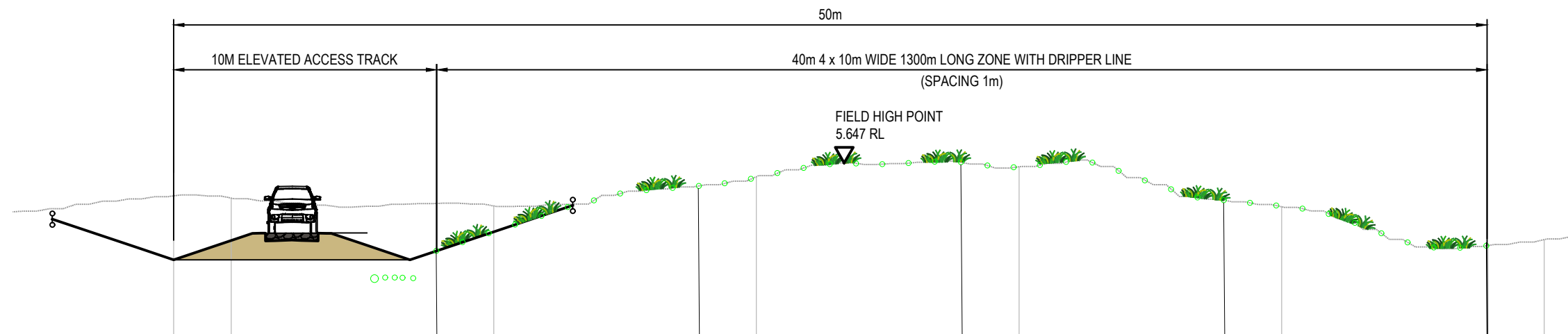
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DISPOSAL FIELD - LOWEST POINT CROSS SECTION

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HIGEST POINT SECTION DETAIL VIEW

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Appendix C. Groundwater Modelling Report

Report

Stuarts Point Groundwater Modelling Report

Dune Wastewater Disposal Concept

Kempsey Shire Council

14/10/2025

Beca HunterH2O | ABN 16 602 201 552

Report Details

Project Title	Beca HunterH2O Report: Dune Wastewater Disposal Concept Design
Project No.	3020134
Document Location	3020134-1737965438-2500
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Document History and Status

Revision	Report Status	Prepared By	Reviewed By	Approved By	Issue Date
01	Draft	Nick Jowsey	Mike Thorley		25/07/2025
02	Final for issue	Nick Jowsey	Mike Thorley	Greg Offer	14/10/2025

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Appendix A. Beca 2025 Hydrogeological Ground Investigation Factual Report

Executive Summary

An assessment of potential capacity for dunal treated effluent discharge was carried out using two-dimensional SEEP/W modelling to support and inform KSC's scheme development decisions. The modelling simulated the dune as a receptor of treated effluent under a range of flow scenarios and rainfall events which indicated the capacity of the dune to soak treated effluent in different conditions and identified some of the key risks of utilising the dune as a disposal site.

In November 2024, a high-level modelling report was issued to KSC based on the results of a 700 m wide east-west section from the inlet through the dunes to the ocean. The model was calibrated to groundwater level changes observed in a monitoring piezometer in the sand dune in response to rainfall. Ground investigations were carried out in December 2024 to provide more site-based input data. The following ground investigations were carried out across the dunal area, spaced across a straight ~1,300 length:

- Drilling of 3 machine boreholes to 30 m depth and 2 piezometer installations at 6 m depth.
- 2 falling head permeability tests, one in each new piezometer.
- 8 infiltration tests in the surficial dune sands.

Data from the ground investigations were used to update the existing SEEP/W model and run refined scenarios to assess the infiltration capacity of the dunal area to discharge treated wastewater to ground. The key updates to the model based on the field information are:

- Update of the hydraulic conductivity (K) of the shallow dune sands from 1×10^{-4} to 2.7×10^{-4} m/s.
- Indication of horizontal to vertical hydraulic conductivity (K_y'/K_x' ratio) of 0.5 for the dune sand material, 0.01 for the clay layer, 0.05 for the silty sand, and 0.1 for the estuarine sand.
- Indication of the depth of the clay confining strata at 15 m and extent of estuarine sands beneath the clay strata. Note that the clay layer is extensive but may not be continuous under the entire dunal area. This clay confining unit is at a shallower depth than the previous information had indicated which lessened infiltration capacity compared to it being deeper, due to the reduced thickness of the groundwater flow pathway.
- Static groundwater level of approximately 0.8 m depth below ground level towards the centre of the dunal area (the lower lying parts).
- Tested infiltration of the shallow sands (minimum: 275 mm/hour, average: 1,985 mm/hour, maximum: 6,000 mm/hour). These correspond to hydraulic conductivities of (minimum: 7.6×10^{-5} m/s, average: 5.5×10^{-4} m/s, maximum: 1.7×10^{-3} m/s). The variability in infiltration rates suggest some areas may have more capacity to soak applied wastewater than others, with the low-lying areas closer to the shallow groundwater table having lower infiltration capacity than those with a greater unsaturated thickness.

The groundwater model was set up based on previous information prepared by GHD and BecaHunterH₂O, and calibrated to a limited set of monitored groundwater levels at monitoring piezometer BH1 (located near the footbridge at the southern end of the dunal discharge area). These data had been collected from 02/07/2022 to 08/12/2022 and indicated that the water table is shallow and highly responsive to rainfall.

In addition, climate and tidal data were input into the model, including 2-years of observed rainfall data, as well as evaporation, air temperature, relative humidity and vegetation functions.

During prolonged application of treated effluent, the model indicates that the soakage capacity of the dune site will likely be significantly reduced due to mounding of the water table. Assuming a starting static groundwater level of 0.8 m below ground level (m BGL), the modelled infiltration rate (due to mounding) reduces exponentially after 24 hours of continuous application of treated effluent and after 5 days even further. A range of discharge field shapes and configurations were analysed and found that the longer duration infiltration capacity is maximised when the treated effluent is applied across narrow strips over longer extents along the dunes. For example, 10 m wide strips oriented over longer lengths north and south have higher capacity than say a wider 40 m wide strip that is shorter in the north-south direction. This is due to the mounding effect on the water table that is more distributed across the groundwater flow of the dunes for the narrow strips. The key indications from the modelling, which represent the ground condition capacity are:

- When applying infiltration across a 10 m wide strip in the model with no rainfall event recharge, mounding of the groundwater table increases, reaching ground level after ~24 hours.
- The early-time infiltration rate over the first 24 hours (while mounding is developing) is approximately 130 mm/hour.
- After 5 days of continuous discharge, the infiltration rate reduces to approximately 40 mm/hour due to the effect of groundwater mounding underneath the disposal area. This represents the maximum mounded infiltration rate while avoiding flooded conditions and overflow (due to excessive wastewater disposal flows).

When rainfall is applied to the model, the infiltration capacity of the sand reduces quickly, before gradually recovering as the sands drain. During extended periods without rainfall, the maximum sustainable flow to the disposal area is ~40 mm/hour.

For the infiltration system design rate, which is used to determine the land area required for the discharge field, a factor of safety (FOS) of 4 -10% is recommended by the *United States Environmental Protection Agency (USEPA) 2006 Process Design Manual for Land Treatment of Municipal Wastewater Effluents* for infiltration to land of treated wastewater. This safety factor considers the reduction in infiltration rate that typically occurs over time due to clogging, longer term infiltration performance and uncertainties in the ground information and conditions.

In this case (due to the high level of treatment and nature of the soils), a FOS of 10% has been applied to the longer duration (>5 day) mounded infiltration rate of 40 mm/hour, and results in a design infiltration rate of **4 mm/hour**.

Total land discharge area requirements also need to have bed rotations and resting areas added. Discharge bed rotations involve periodically shifting the application of treated effluent to different areas of land, while bed resting involves temporarily ceasing effluent application to a specific area to allow for recovery and treatment within the soil. These practices allow the soil to drain, aerate, and recover its treatment capacity, and help prevent issues associated with prolonged soil saturation. Rotations and resting are critical in maintaining the long-term effectiveness and operational life of land application systems by reducing clogging and other issues associated with continuous effluent application to land-based discharge systems.

Using the design daily treated effluent flow of 1,248 kL/day, the following points can be made to summarise the discharge to land area requirements based on the groundwater modelling assessment:

- Each disposal discharge strip area is to be approximately 1,300 m in length x 10 m wide to accommodate the design flows from the WWTP.
- Four (4) disposal discharge strips are recommended to allow for rotation and resting.
- The overall disposal area should comprise 4 adjacent strips, one of which is operational at any given time (assuming soakage capacity in the dunes is available).
- Each disposal discharge strip is to be run over a minimum period of 18 hours and up to 48 hours before moving to the next (subject to operational requirements and antecedent groundwater/rainfall conditions).

The groundwater model provided indications of the response of the water table to rainfall and the reductions in infiltration capacity across a 2-year period, from 1 July 2022 to 30 June 2024. The modelling indicates that a 1 in 3-month rainfall event of ~54 mm in 24 hours is likely to cause groundwater to rise to the ground surface in low lying areas and reduce discharge capacity to near zero for approximately 1 – 7 days. During a 1 in 6-month rainfall event of >86 mm over 24 hours is likely to cause groundwater levels to reach ground surface for periods of approximately 3 – 7+ days and hence reduces the discharge field capacity significantly or stops. Over the 2-year period modelled, which coincided with a wetter period, the modelling indicates that approximately 17 rainfall events (several over multiple consecutive days) likely reduce the dunal discharge in order to avoid flooding/overflow issues.

The discharge of treated effluent to the dunal area will need to be controlled based on groundwater level monitoring to avoid exacerbating flooding and overflow conditions at the dunal site. Additional measures such as flow buffering, storage and/or alternative overflow to surface water will be required for those periods when groundwater conditions limit or stop the discharge to land.

The modelling also indicated that discharging treated effluent to the dunal area in excess of the 1,248 kL/day is likely to further and significantly exacerbate the flooding and overflow risk hence it is recommended that alternative discharges options are considered for flows beyond 1,248 kL/day.

A separate site located directly south of Stuarts Point Township was assessed as a disposal field option, including minor ground investigation works and a groundwater modelling assessment. The results of the assessment indicate that while the ground conditions may be suitable for a land disposal system, the contamination risk associated with disposal of treated effluent into the shallow aquifer was unlikely to be acceptable given:

- The shallow aquifer is used as a water source in the nearby Township, and;
- The deeper aquifer located near the proposed disposal field is used for the municipal drinking water supply.

Design Considerations

The nature of the dunal environment, hummocky topography, persistent shallow groundwater levels and consequential low design infiltration rate make this site more suitable to a slow-rate (SR) application system involving application of wastewater to the existing land surface via dripper irrigation. Other high-rate application systems that rely on gravity flow to distribute the treated effluent will likely require significant earthworks and a level of accuracy over a large area which is likely to be a significant challenge to construct and maintain.

The surface topography contains hummocky terrain with natural low points, some of which appear to drain towards the Macleay Arm, not towards the coast. There is a risk that groundwater reaches the surface during certain periods and flows into the Macleay Arm if the land topography remains in its current state, hence a bund on the western (landward) side of the dune is recommended and could also be utilised as an access track to the disposal field and mitigate floodwater ingress from the Macleay Arm in flood events.

A centrally located groundwater level monitoring bore containing a level sensor connected to the WWTP should be established to indicate when the treated effluent flows should be diverted to storage and/or overflow. The other 3 piezometers that have already been installed and are being equipped with continuous groundwater level monitoring sensors should be actively monitored and utilised to adjust and tune the settings of the central control groundwater level site, at least annually.

1 Introduction

Kempsey Shire Council (KSC) commissioned Beca HunterH2O (BecaHH2O) to assess the capacity of a designated land area (the site) south of Stuarts Point township to soak treated effluent to ground. The assessment was carried out using a two-dimensional groundwater flow modelling software (SEEP/W¹) to indicate potential ground condition constraints and risks for land-discharge at the site.

1.1 Context

KSC is planning to discharge tertiary treated effluent from the proposed Stuarts Point Wastewater Treatment Plant located at Stuarts Point, inland of the Macleay Arm, over a designated area in the sand dunes on the coastal side of the inlet.

An assessment of treated discharge, groundwater mixing, and tidal flushing was modelled by consultants, GHD²³⁴. However, infiltration (disposal) to land capacity analysis had not been specifically considered to indicate the required sizing of the dunal discharge area.

Beca HunterH2O (BecaHH2O) was initially asked to comment on the feasibility of the proposed treated effluent discharge scheme and concluded that because of the low dunal profile, shallow and responsive groundwater conditions, it appeared to be a discharge to land at this location carried considerable feasibility risk.

BecaHH2O was then commissioned by KSC to undertake a preliminary groundwater modelling assessment to assess the potential capacity for treated effluent discharge utilising available data. A two-dimensional groundwater flow model was compiled by BecaHH2O to indicate potential ground condition constraints and risks for land-discharge at the dunal site. During the modelling process, it was identified that certain physical characteristics of the site such as the shallow groundwater, hydraulic conductivity of the surficial dune sand and the depth to underlying low permeability strata were not well understood and would require physical investigations to reduce the uncertainty of the modelling. Site investigations were carried out in December 2024, with the factual site information reported in BecaHH2O (2025⁵). This report summarises the updates to the groundwater model and incorporates land/climate interaction, tidal boundary conditions and three disposal flow scenarios in two-year long transient modelling simulations.

An initial high-level assessment indicated that a disposal area of approximately 1,300 m x 50 m may be suitable for disposal in normal conditions (i.e. without significant rainfall). However, this initial assessment did not account for factors such as rainfall, evaporation, and tides, hence a more detailed modelling assessment was required to more thoroughly assess the concept design.

For initial groundwater model reporting, refer to the Beca's 2025 report *Stuarts Point WWTP Dunal Discharge Report*.

¹ <https://www.seequent.com/products-solutions/geostudio-2d/>

²² GHD. 2019. Groundwater Modelling: Stuarts Point Wastewater Treatment Plant.

³ GHD. 2020. Stuarts Point Sewerage Scheme: WWTP Marine Mixing Modelling.

⁴ GHD. 2022a. Stuarts Point Sewerage System – Effluent Transfer and Disposal Design: Geotechnical Report.

1.2 Purpose

The purpose of this report is to present the outcomes of the groundwater modelling assessment, specifically:

- summarise key aspects of an infiltration (disposal) performance and constraints.
- provide indications for design of the spatial extents that may be required to accommodate infiltration (disposal) discharge of treated wastewater to the dunal area and reduce the likelihood of uncontrolled seepage break-out and/or ponding of treated wastewater.
- Assess the effect of climate (particularly rainfall and evaporation) on disposal performance and provide indications of rainfall magnitudes which are likely to prevent the use of the disposal field due to high groundwater levels or surface flooding/sheeting⁶.

⁶ The terms 'sheeting' and 'surface flooding' and used interchangeably in this report, meaning "a situation in which an area is covered with water."

2 Scope

The scope of the dunal discharge assessment is summarised as follows:

Stage 1 (completed):

Review the existing documentation on the hydraulic capacity of the dunes and comment on the feasibility of the proposed dunal discharge.

Stage 2 (completed):

- Set up a two-dimensional (2D) groundwater model (SEEP/W) across the dunal discharge site near borehole BH01.
- Provide model indications of the capacity of the dunes to infiltrate treated effluent over 100 m, 50 m and 10 m wide footprints.
- Apply the proposed 1.08 ML/day design discharge (dry condition) over the 100 m, 50 m and 10 m wide footprints to the model. Evaluation of a 3 ML/day design discharge flow (wet condition) was not assessed.
- Evaluate the relative effect of different elevation levels of treated effluent application (as a pond depth or constructed/elevated platform representing a higher sand dune).
- Evaluate potential for surface breakout (seepage areas) for various applied treated effluent loading over a 300 m wide disposal area.

Stage 3 (completed):

Stage 3 evolved to provide a technical specification for a field investigation programme to obtain more information about the ground profile underlying the dunes and in-situ measurements for hydraulic soil properties. The site investigations were carried out in December 2024 and were used to update the existing SEEP/W model (Factual Report attached in **Appendix A**). The updated model provides the following information:

- Average infiltration capacity of the sand dunes with static groundwater level ~0.8 m below ground level at the disposal area.
- Modified infiltration rates due to the water table mounding over time (i.e., when groundwater levels rise in response to the infiltration discharge and reach near the ground surface but not breaching the surface). The scenarios involved applying wastewater across a 10 m wide footprint in the groundwater model to assess infiltration rates over time. An additional scenario was run to assess mounding interference between basins, which involved applying wastewater across 4 x 10 m parallel strips with 2 m spaces in between them (~50 m wide area), noting that the operational intention would be to apply wastewater over one strip at a time and rest/rotate them.

Stage 4 (this report):

- Refine the Stage 3 model by including land/climate boundary conditions (e.g. rainfall, evaporation), tidal cycles, and run the model for longer periods of time (i.e. 2 years).
- Run the model with the three different disposal flow scenarios (existing, interim and fully built future populations) and assess the performance of the dune to soak treated effluent under these different conditions.
- Define a factored design infiltration rate and disposal field capacity for the other aspects of concept design to progress. The modelled infiltration rates have been factored in accordance with USEPA (2006) guidelines to provide design infiltration rates.

3 Project Description

The proposed disposal site is a vegetated sand dune located on a spit between the Macleay Arm (tidal river) and Stuarts Point Beach, approximately 10 km north-west of South West Rocks and approximately 18 km south of Nambucca Heads, on the NSW Mid North Coast. It is understood that an approximately 2.5 km long effluent transfer pipeline could extend from the proposed wastewater treatment plant (WWTP) located south of Stuarts Point township, beneath the Macleay Arm to the dunal discharge area to the east of the township. The Macleay Arm is approximately 350 m wide, with a maximum water depth of about 4.5 m.

A site plan showing the proposed pipe crossing, ground investigation sites across the possible 1,300 m disposal length, and coastal hazard extents are shown in **Figure 3-1**. In this area, treated effluent applied at the surface would soak to ground under gravity.

The approximately 380 m wide dunal area is covered in vegetation. The topography of the dunes varies in an irregular hummocky pattern across elevations of 0 to ~8.3 metres above mean sea level (m AMSL), with the higher elevation areas next to Stuarts Point Beach (refer to elevation map in **Figure 3-2**). A significant proportion of the terrain identified for discharge (perhaps up to 80%) is below 2 m elevation. The size and shape of the dunes are dependent on the complex interaction between winds and sediment supply and is possibly active/mobile with potential to change over time. The thick vegetation reduces the rate of wind-borne erosion of the dunes.

The investigation locations were selected to be outside the 2050 and 2100 coastal beach erosion and recession zones mapped in the KSC Coastal Hazards Study (JBP, 2021).

A separate site (Site 2) located directly south of Stuarts Point Township was also assessed as a disposal field option, including minor ground investigation works and a groundwater modelling assessment. The results of the assessment indicate that while the ground conditions may be suitable for a land disposal system at Site 2, the contamination risk associated with disposal of treated effluent into the shallow aquifer was unlikely to be acceptable given:

- The shallow aquifer is used as a water source in the nearby Township from household bores, and;
- The deeper aquifer located near the proposed disposal field is used for the municipal drinking water supply from several bores.

As a result, the decision was made not to proceed with Site 2 and focus wholly on the dune disposal site in this concept design.

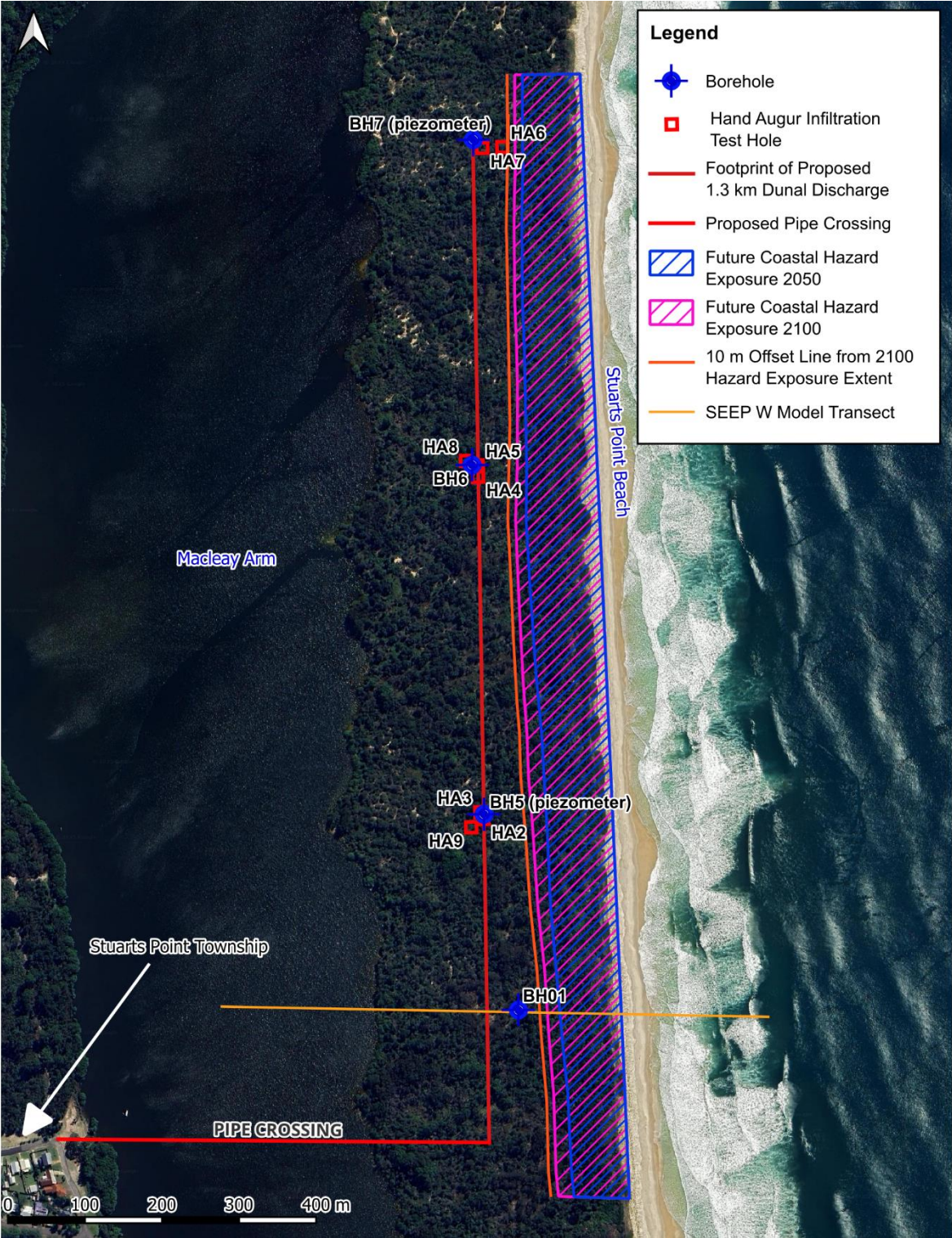


Figure 3-1: Dunal site overview map showing potential disposal site location and key features relevant to groundwater modelling at Stuarts Point.

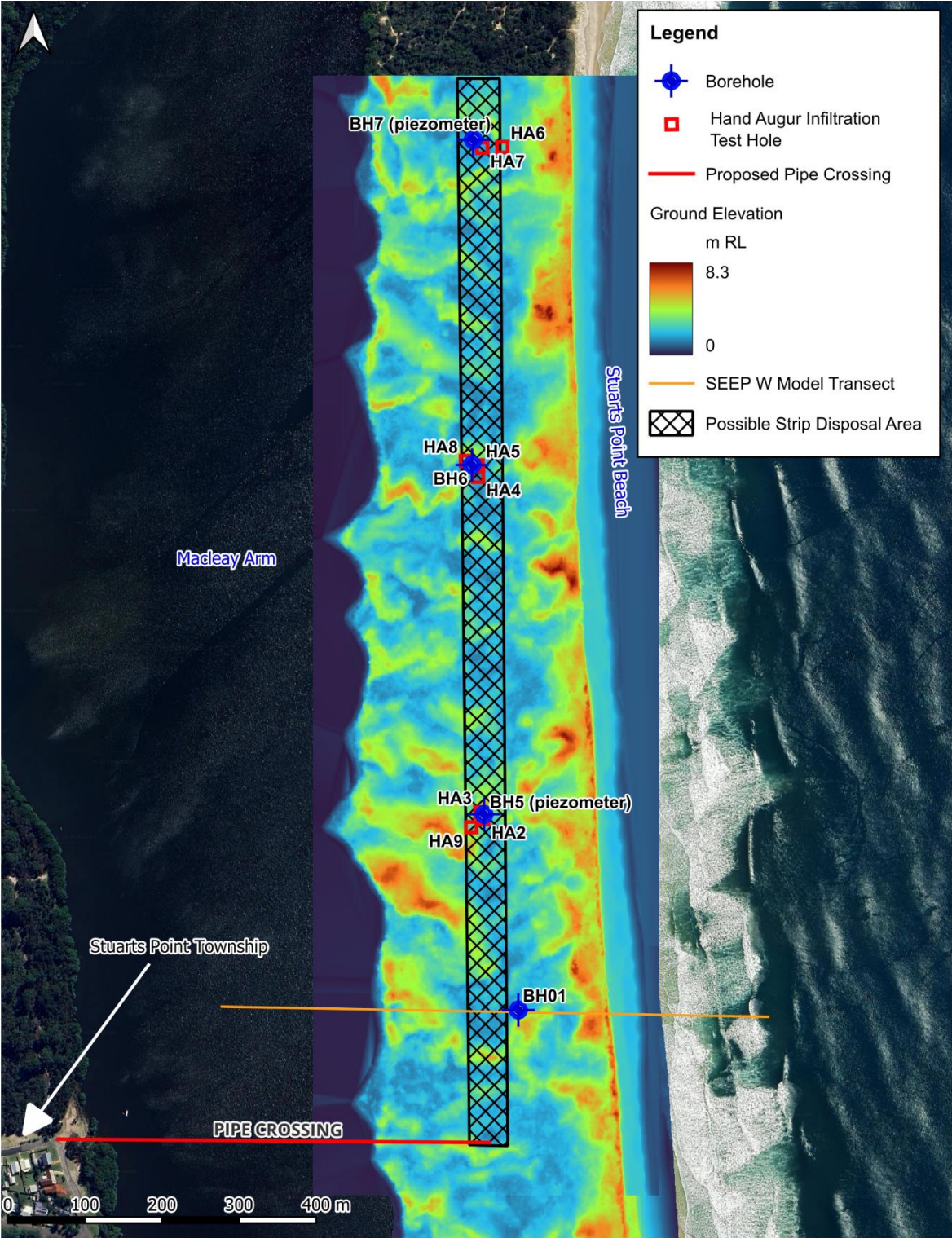


Figure 3-2: Elevation map of sand dune complex showing the possible overall disposal area which is 1,300 m long and 50 m wide, comprised of 4 x 10 m wide strips (not shown) which would have spaces between them.

3.1 Land Discharge Scenarios

KSC currently estimate flows of treated wastewater across three scenarios based on population projects, existing, interim and fully built.

The following land discharge scenarios were considered as part of the groundwater modelling assessment:

- Across a 10 m wide area.
- Across a 50 m wide area made up of 4 x 10 m wide disposal areas with a 2 – 4 m space in-between.

The treated effluent was applied using a constant head boundary (CHB) set slightly below the existing ground surface (7 mm) in all scenarios. The results of the CHB were checked using a water rate boundary condition which applies a rate of water to ground in a particular location. The model set-up is described in more detail in **Section 9**.

The basis of design flows are presented in **Table 3-1** below. The context of the design flows are explained in full in the 2025 report: *Beca HunterH2O_Stuarts Point Effluent disposal Field Concept*.

Table 3-1: Basis of design flows and peaking factors.

Parameter	Unit	Existing 2027	Interim 2047	Ultimate	Comment
Equivalent Tenement	ET	628	1,540	1,624	
Equivalent Persons	EP	1,319	3,233	3,409	
Average Dry Weather Flow (ADWF)	kL/day	283	693	731	from Summary Report on Hydraulic Loadings Analysis and I&I Justification Report
Peak Day Sustained Dry Weather Flow (PDDWF)	x ADWF	2.5			From Illuka peaking factor (as defined in Revised Stuarts Point STP Flow Loadings – Technical Memorandum)
	kL/day	707	1,732	1,826	As a total daily inflow volume.
Peak Week Sustained Dry Weather Flow (PWDWF)	x ADWF	1.9			From Illuka peaking factor,
	kL/day	537	1,316	1,388	As a total daily inflow volume occurring for at least 7 consecutive days.
Average Wet Weather Flow (AWWF)	x PDWF	1.3			from Summary Report on Hydraulic Loadings Analysis and I&I Justification Report
	kL/day	368	901	950	As a total daily inflow volume
Peak Day Wet Weather Flow (PDWWF)	kL/day	919	2,252	2,374	Wet weather peaking factor on Peak Day sustained Flow (as per Revised Stuarts Point STP Flow Loadings – Technical Memorandum)
Peak Week Wet Weather Flow (PWWWF)	kL/day	699	1,712	1,806	Wet weather peaking factor on Peak Week sustained Flow (as per Revised Stuarts Point STP Flow Loadings – Technical Memorandum)

4 Conceptual Ground Model

The proposed dunal discharge area is underlain by poorly graded fine to medium dune sand of windblown origin at the surface, as shown in the borehole logs in **Appendix A**. The dune sands are typically very loose to medium dense. These sands form the Stuarts Point Aquifer.

The dune sands present at the surface are underlain by estuarine deposits, with a distinctive clay layer present at ~15 m BGL. The clay layer was clearly identified in two of the boreholes (BH6 and BH7) at ~15 and ~19 m BGL respectively. A distinctive clay layer was also identified in BH5, but at a depth of ~25 m BGL. The inlet geophysical survey undertaken (GHD, 2022a) showed that the low permeability interface is located at ~18 m depth which was confirmed by the drilling investigations. GHD, 2019 suggest the clay layer is laterally extensive, and forms the confining layer between the surficial aquifer and the lower aquifer from which the Stuarts Point community water supply is abstracted.

Groundwater from rainfall and the applied treated effluent will flow both towards Macleay Arm (against regional flow) and towards the ocean.

Prior ground investigations in the area have identified discontinuous lenses of coffee rock in the upper sand, above the clay layer, but these were not encountered during the drilling investigations in the dunes in December 2024, hence were not included in the model. If the coffee rock layers are present in some areas, this may reduce the infiltration capacity.

A simplified and idealised updated ground model through the modelled dunal area is shown in **Figure 4-1**.

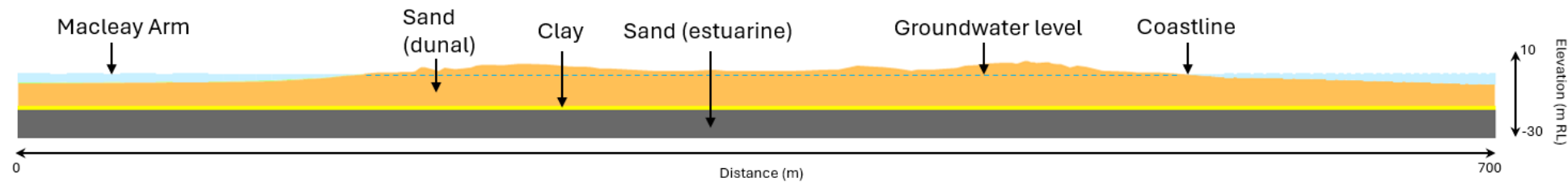


Figure 4-1: Conceptual ground model used in the SEEP/W model of the proposed site from west to east through the sand dune.

5 Groundwater Levels

The ambient groundwater levels on the sand dunes vary significantly in response to rainfall, and are likely affected by tidal, flooding and storm surge events. The proximity of groundwater to the land surface during/ after rainfall events highlights a risk of surface ponding and lesser capacity of the ground for infiltration of treated wastewater discharge to land.

Monitoring of groundwater in BH1 across the period 02/07/2022 to 08/12/2022 is reported in GHD (2022). The groundwater levels recorded in BH1 along with the daily rainfall totals from nearby Nambucca Heads rain gauge (station 59150) are shown in **Figure 5-1**. The location of BH1 on the sand dunes is shown in **Figure 3-1**. These data indicate depth to groundwater ranged from 0.1 m BGL to 1 m BGL and reflect rapid responses to rainfall events. **Figure 5-1** indicates approximately 0.5 m variation in groundwater level following ~100–120 mm in 24-hour rainfall events. It should be noted that BH1 is not located in the lowest elevation part of the dune complex, with a surface RL of 1.5 m (GHD, 2022), therefore lower elevation areas (<1.5 m AMSL) are likely to have groundwater closer to the ground surface or breaching the surface. The groundwater model was positioned to cut across the area containing BH1.

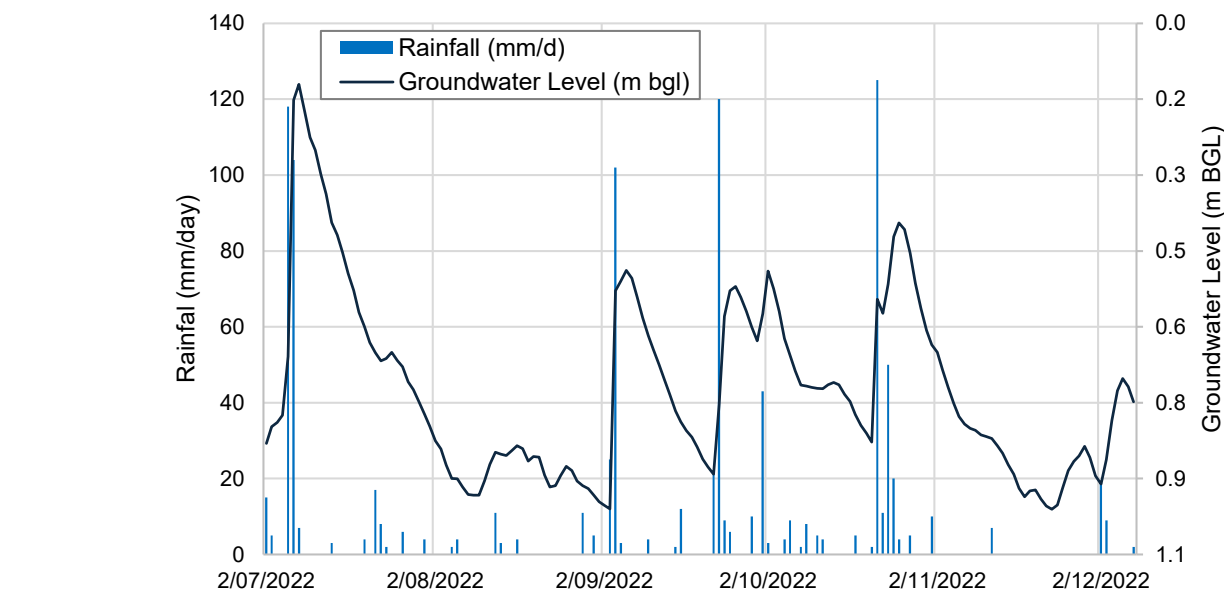


Figure 5-1. Groundwater levels recorded in BH1 on the sand dune along with daily rainfall totals from Nambucca Heads rain gauge (Station 591590).

Groundwater levels were observed in three boreholes (2 of which had 6 m deep piezometers installed in them) to the north of BH1 during the December 2024 ground investigations (detailed in Beca, 2025⁷) and are summarised in **Table 5-1**. These levels were recorded during a long dry spell in the summer of 2024/2025. Note that the borehole drilling had recently been completed before observing groundwater level, hence levels are indicative only and may have been influenced by the drilling process/presence of drilling fluids. A longer-term period of monitoring in the two new piezometers, and the existing BH1 is currently underway using telemetered sensors to gauge the temporal and spatial variation of groundwater level across the dunal area.

⁷ Beca, 2025. Stuarts Point Hydrogeological Factual Report.

Table 5-1. Manual groundwater levels recorded on Stuarts Point sand dune after borehole drilling in December 2024.

Borehole/ Piezometer ID	Easting	Northing	Groundwater Level (m BGL)	Groundwater Level (m AMSL)
BH05 (piezometer)	499892.85	6591156.01	1.13	0.58
BH06	499877.37	6591609.44	0.68	0.39
BH07 (piezometer)	499878.86	6592031.58	1.0	0.24

Notes:

Survey coordinates are given in terms of MGA 2020.

m BGL (metres below ground level)

m AMSL (metres above mean sea level).

6 SEEP/W Model Land Climate Interaction

SEEP/W has a land climate interaction (LCI) function. This allows complex interactions between atmospheric and hydrological systems to be quantified. The atmospheric factors include evapotranspiration, temperature, humidity and rainfall. These interact with the vegetation and soils at the ground surface, ultimately influencing the overall hydrological and hydrogeological system. Each key LCI parameter is described in more detail below, including the dataset incorporated in the groundwater model.

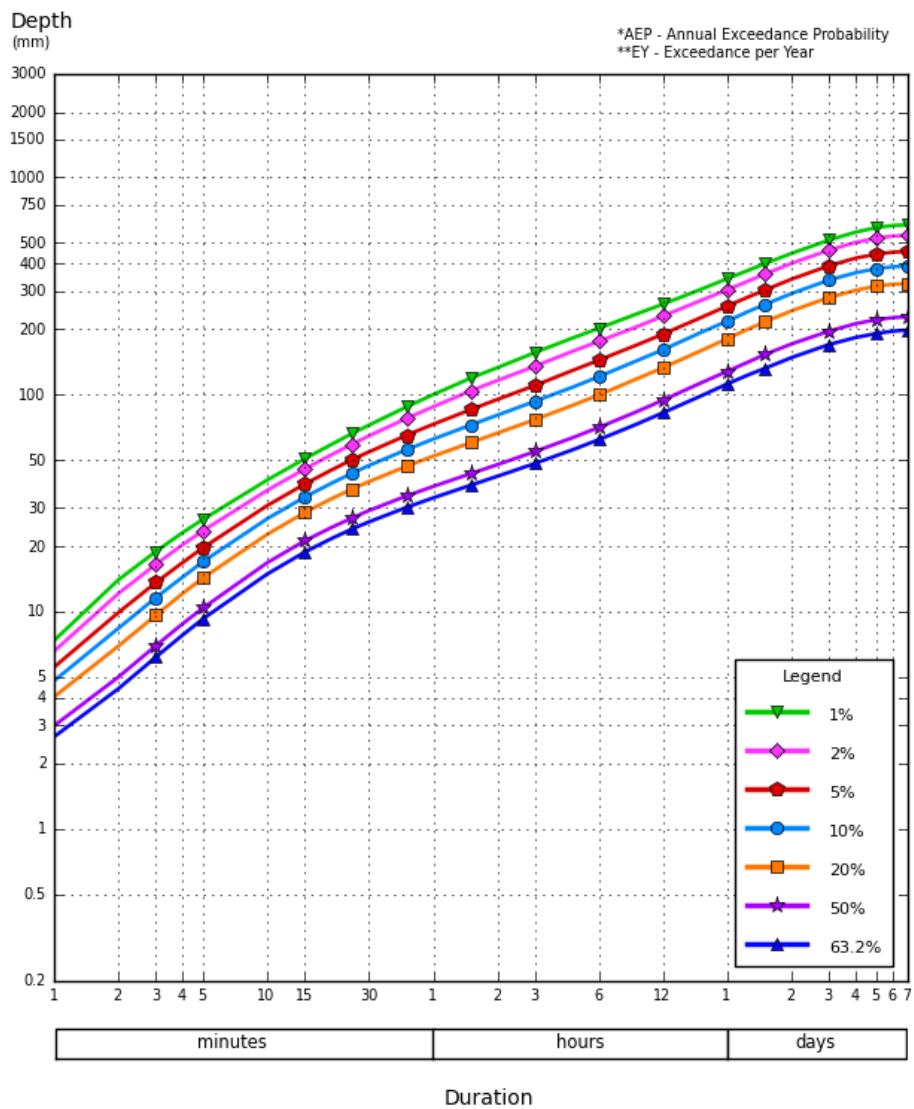
6.1 Rainfall

Rainfall is the main source of groundwater recharge at the site and has highly variable spatial and temporal patterns. Rainfall data from a rain gauge near Stuarts Point at Nambucca Heads (station 59150) over the year 2022 and 2023 (2 years) was used as a model input. Due to the high permeability of the surficial sands, a large portion of rainfall percolates through the sand into the shallow aquifer, causing groundwater levels to increase.

Both **Figure 6-1** and **Table 6-1** show the annual exceedance probability (AEP) of rainfall events of varying magnitudes, with larger rainfall events being rarer (lower probability) than small and moderate rainfall events.

The probability of a rainfall event exceeding 100 mm in 24-hours (1-day) is more than 63.2%, indicating large rainfall events are relatively common in Stuarts Point. The design rainfalls were sourced from the Australian Bureau of Meteorology (BOM) with a coordinate of -30.8125 (S), 152.9875 (E) based in Stuarts Point Township. The BOM model values were compared against statistical data derived from Nambucca Heads rain gauge (Station 59150).

Based on the groundwater level and rainfall data presented in **Figure 6-1**, large rainfall events, for example over 100 mm in 24-hours, will prevent wastewater application on the dune and require storage of effluent, or an alternative discharge location until it stops raining and groundwater levels reduce enough for effluent to be applied on the dunal site again.



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Figure 6-1. Annual exceedance probability (AEP) of rainfall volumes at Stuarts Point, NSW. Source: <http://www.bom.gov.au/water/designRainfalls/revise-ifd/?multipoint>

Table 6-1. Table showing return interval for specific rainfall depths from both the Nambucca Heads Rain Gauge (Station 59150) and design rainfall volumes at Stuarts Point from BOM, 2016, link: <http://www.bom.gov.au/water/designRainfalls/revise-ifd/?multipoint>

Return interval (RI)	Rainfall duration (hours)	Rainfall depth (mm) Nambucca Heads Station 59150	Rainfall depth (mm) BOM, 2016 data
1-3 months	96	91	100
1-6 months	96	131	147
1-1 year	96	186	202
1-1.44year	96	229	233
1-2 year	96	267	
1-4.48 year	96	352	331

Return interval (RI)	Rainfall duration (hours)	Rainfall depth (mm) Nambucca Heads Station 59150	Rainfall depth (mm) BOM, 2016 data
1-5 year	96	363	
1-10 year	96	428	397
1-3 months	72	85	94
1-6 months	72	124	137
1-1 year	72	188	188
1-1.44year	72	209	217
1-2 year	72	241	
1-4.48 year	72	309	308
1-5 year	72	318	
1-10 year	72	367	370
1-3 months	48	74	83
1-6 months	48	112	121
1-1 year	48	158	165
1-1.44year	48	187	190
1-2 year	48	211	
1-4.48 year	48	264	270
1-5 year	48	270	
1-10 year	48	307	324
1-3 months	24	54	63
1-6 months	24	86	92
1-1 year	24	116	124
1-1.44year	24	139	143
1-2 year	24	158	
1-4.48 year	24	201	203
1-5 year	24	206	
1-10 year	24	237	245

Two years of recorded rainfall (1 July 2022 to 30 June 2024) from the nearby rain gauge at Nambucca Heads was applied to the model to assess the groundwater response while discharging wastewater. The rainfall applied included a range of different wet weather events which affect the response of the groundwater and also the ability of the ground to soak the applied treated wastewater.

Rainfall is plotted in **Figure 6-2** below.

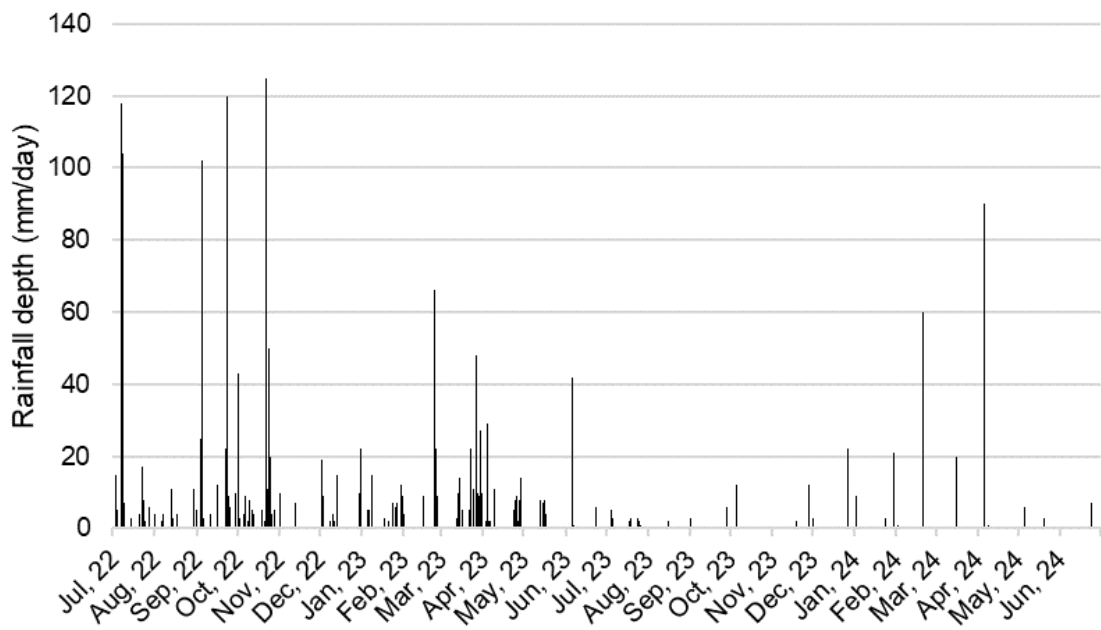


Figure 6-2. Nambucca Heads (Station 59150) daily rainfall totals from 1 July 2022 – 30 June 2024.

6.2 Air Temperature

Air temperature is an important factor influencing evaporation and fluctuates daily and seasonally with generally higher temperatures during daylight hours and over summer, and lower temperatures overnight and in winter. Higher temperatures tend to drive higher evaporation. Air temperature data was sourced through the BOM website from Kempsey Airport AWS (station 059007).

The average minimum and maximum daily air temperature over 21 years of available data is shown in **Figure 6-3** below.

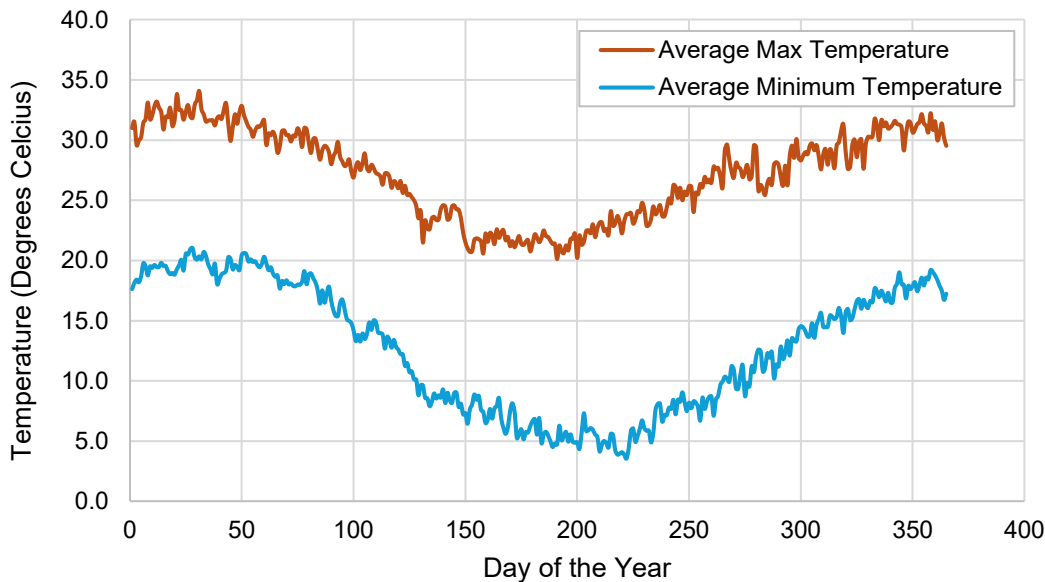


Figure 6-3. Air temperature average minimum and average maximum over 21 years, sourced from Kempsey Airport AWS (Station 059007) through <http://www.bom.gov.au/climate/data/>.

6.3 Relative Humidity

Relative humidity is a measure of how much water vapour is in the air versus how much it could hold at a certain temperature. It tends to be higher in summer and lower in winter at Stuarts Point. The higher the humidity, the closer the air is to saturation, hence the lower the evaporative potential. Dry (low humidity) air can absorb more moisture. Relative humidity data was sourced through the BOM website from South West Rocks (Station 059030).

The monthly average relative humidity from South West Rocks is shown in **Figure 6-4** below.

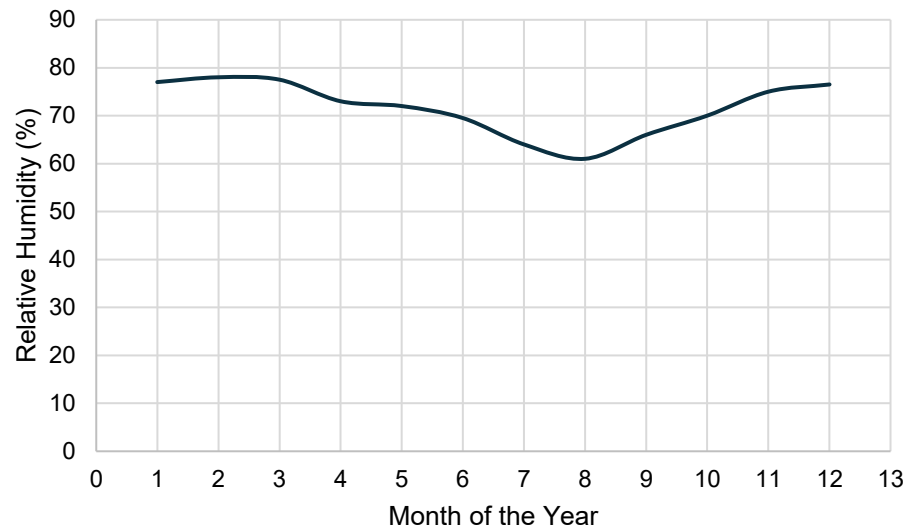


Figure 6-4. Monthly relative humidity data from South West Rocks (Station 059030) through <http://www.bom.gov.au/climate/data/>.

6.4 Evaporation

Evaporation is when water transforms from a liquid into a gas and escapes into the atmosphere. It is a key part of the hydrologic cycle and varies seasonally at Stuarts Point, with higher rates of evaporation in summer and lower rates in winter. Evaporation data was sourced through the BOM website from Coffs Harbour Airport (Station 059151), averaged over the 9 years of available data, and is shown in **Figure 6-5** below.

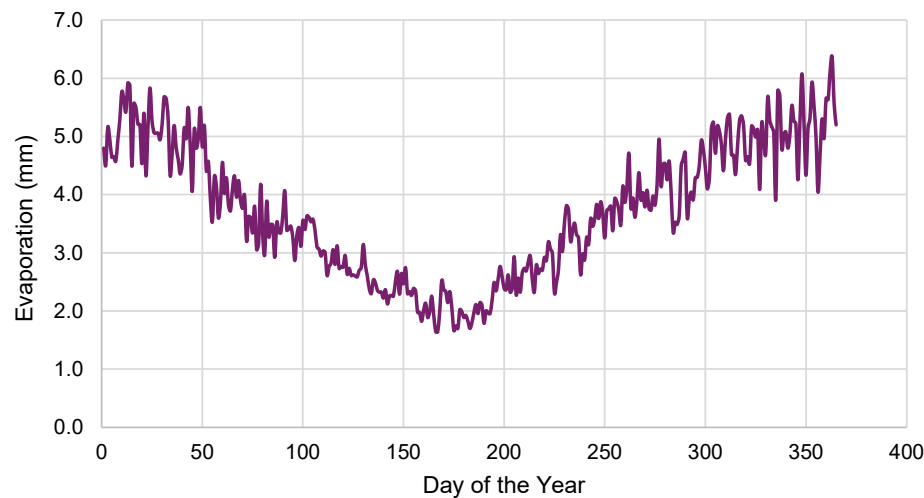


Figure 6-5. Daily evaporation data averaged over 9 years from Coffs Harbour Airport (Station 059151) through <http://www.bom.gov.au/climate/data/>.

6.5 Soil Cover/ Vegetation

The vegetation function allows the user to add information such as vegetation cover, plant root depth, leaf area index and plant moisture limit. These factors contribute to the way water enters, exists and moves through the soil. The values used are estimates based on physical site walkovers observing the vegetation on the site, reviews of site photos, and aerial imagery which shows the spatial distribution of vegetation. The key values used in the model are:

- Land area index (LAI) of 0.6 (-).
- Root depth of 0.5 m.
- Soil cover of 0.6 (-).

7 Tides

Tidal data was sourced from BOM at South West Rocks⁸. An example of the tidal range used in the model is shown in **Figure 7-1**.

The salinity of the two water bodies is expected to differ slightly on average, with more freshwater present in the upper Macleay Reach, hence a lower density. This was accounted for in the modelling by setting the elevation on the Macleay Arm side to 0.05 m lower than on the coastline.

It should also be noted that the tides in the upper estuary on the Macleay Arm side of the dune are expected to be delayed by 30 – 60 minutes due to the geometry, depth and frictional resistance of the Arm, which was not accounted for in the modelling.

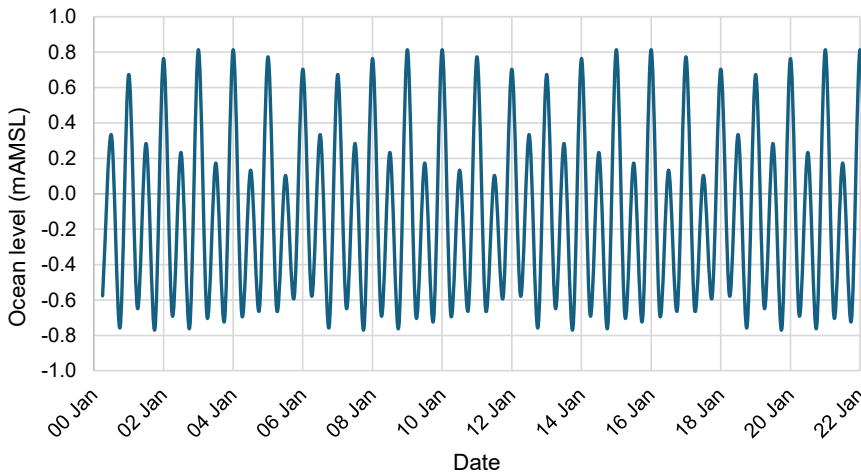


Figure 7-1. Tidal data at South West Rocks. Source: BOM, 2025 'Tide Predictions for Australia, South Pacific and Antarctica.'

8 Surface Topography

As mentioned above in the site description, the surface topography at the site is hummocky with the elevation of the dunes varying from 0 m AHD to ~8.3 m AHD in an irregular pattern. This pattern is largely driven by past wind-blown deposition of sand. The variable elevations can be observed in the coloured elevation map in **Figure 3-2**. The map shows higher elevations adjacent to the coast, and lower elevations mainly in the centre of the dune, and some higher elevation mounds adjacent to the Macleay Arm.

⁸ <http://www.bom.gov.au/australia/tides/#!/nsw-south-west-rocks>

Many of the low points on the dune, particularly in the centre, do not appear to have clear outlets for overland flow. In these areas, if ponding was to occur, the surface water would stay in the natural hollow until it could drain through the sand. However, there are some possible surface runoff pathways which may be able to channel overland flow west towards the Macleay Arm (rather than towards the coast), if the surface water level was high enough. A bund on the Macleay Arm side of the proposed disposal field may reduce the risk of overland flow to the Macleay Arm and have the additional purpose as an access track, and for flood mitigation when the Macleay Arm is in flood.

9 SEEP/W Modelling Approach

The dunal discharge assessment was undertaken by creating a 2D groundwater SEEP/W model of a section through the dunal discharge site. The modelling was undertaken generally in accordance with the NSW Aquifer Interference Policy (NSW Government, 2012) as well as the groundwater assessment toolbox for major projects in NSW (NSW Government, 2022).

The following summarises the key modelling assumptions:

- A thin layer of lower permeability material, representing a clogging layer across the bed of the Macleay Arm.
- A low permeability clay layer underlies the dunal sand deposits at 15 m depth and is laterally extensive across the model.
- Under average weather conditions, the static groundwater level is around 0.8 m BGL directly underneath the modelled disposal area.
- The key hydraulic parameters of the materials in the model are shown in **Table 9-1**.

Note that the volumetric water content function for saturated/ unsaturated zones is not required as a model input in permanently saturated materials such as the lower sand and clay.

Table 9-1. SEEP/W hydraulic parameters for materials in the Stuarts Point dunal groundwater model.

Parameter	Upper sand	Lower sand	Clay	Silty sand
Layer thickness (m)	10.5 – 21.4	13	2	0.5
Hydraulic conductivity, K (m/s)	3.0×10^{-4}	1.0×10^{-4}	1.0×10^{-8}	1.0×10^{-5}
Volumetric water content function for saturated/unsaturated materials (-)	0.4	-	-	0.3
Ky'/Kx' anisotropy ratio	0.5	0.1	0.01	0.05

9.1 Model Calibration

The model was calibrated to 160 days of groundwater level monitoring located at piezometer BH1, roughly in the centre of the dune (midway between the Macleay Arm and the coastline). This is the only time series of groundwater level data available from the dune site currently.

To compare the groundwater level data between the model and what was observed, the rainfall time series covering the monitoring period was applied to the model, and the model parameters adjusted iteratively to achieve the closest match. It should be noted that the rainfall recorded at Nambucca Heads is located approximately 20 km north of the piezometer location, hence the rainfall depths encountered at each site are likely to be similar but not identical. The implication of this is that the recharge into the model versus the site borehole are likely to be slightly different, and therefore an exact groundwater level match is not possible. A graph showing the observed and modelled groundwater levels is shown in **Figure 9-1**.

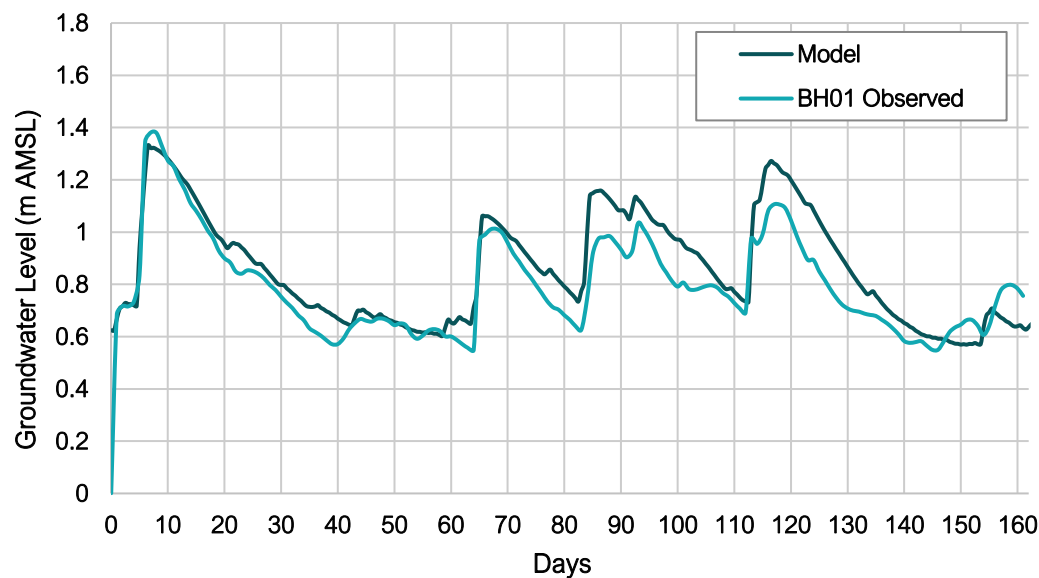


Figure 9-1. Site 1 modelled groundwater level data versus observed groundwater level data from BH1.

9.2 Simulation of Effluent Disposal

The simulations were run testing different magnitudes of effluent flow characterised by current and future population data. The scenarios run accounted for existing, interim and fully built population scenarios as presented in **Section 3.1** above.

The critical case was to assess whether the dunes could soak the large multi-week flows over the December holiday period to ground without surface runoff/ sheeting (not accounting for rainfall events).

9.2.1 Constant Head Boundary

This boundary condition allowed the model to ‘pour in or out’ as much water as necessary to maintain the specified head which was set fractionally below the ground surface in the proposed disposal area. This type of boundary responds dynamically to variations in groundwater level such that when groundwater levels are close to or exceeding the ground surface due to rainfall, less water is required to be ‘poured in’ through the boundary. Conversely, when groundwater levels are low, for example during a long dry-weather spell, the boundary will pour in more water to maintain the specified head. The results of this analysis are presented in **Section 10.2.1** below.

9.2.2 Variable-Rate Flux Boundary

This boundary condition allowed the three different flow scenarios to be input directly into the model to assess soakage performance under different disposal rates and observe the frequency and duration of sheeting events. The results of this analysis are presented in **Section 10.3.3** below.

A zoomed in screenshot of the SEEP/W model result during active discharge to ground across a 10 m wide strip is shown in **Figure 9-2**. The direction of each arrow represents the direction of groundwater flow, and the size of each arrow represents the magnitude of flow, with larger arrows constituting a higher flow rate. The groundwater flow tends to spread out evenly beneath the disposal area, migrating both east towards the coast and west towards the Macleay Arm.

The colours represent the total head, with higher heads immediately below the discharge area and progressively lower heads further out towards the lateral extents of the model (Macleay Arm to the west and Ocean to the east).

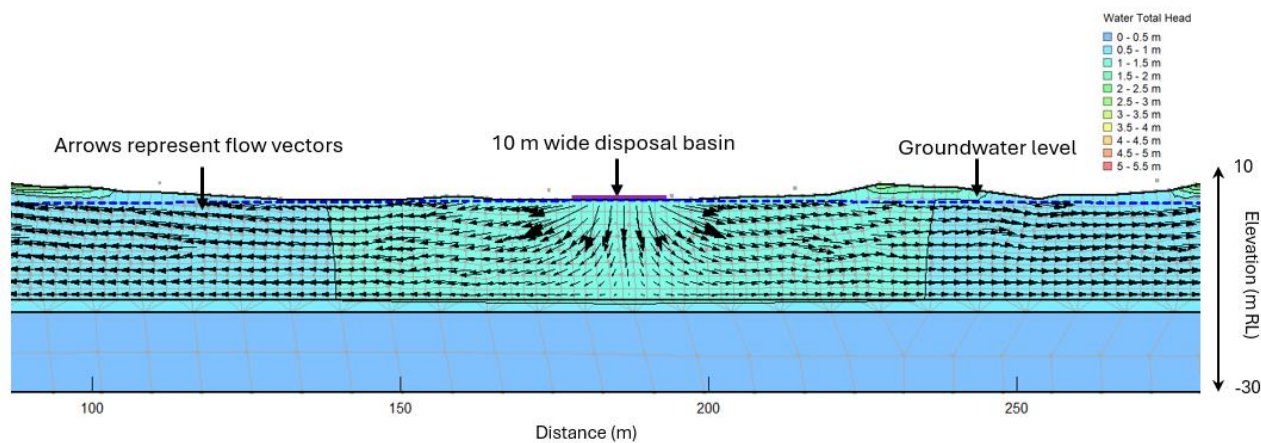


Figure 9-2. Screenshot of the 2D SEEP/W model showing groundwater flow vectors during active disposal to ground.

9.3 Groundwater Mounding

Initially, when water seeps into the ground, it occurs within unsaturated flow conditions above the water table, which is primarily driven by capillarity pressures and the porosity of the soil. Filling of porous soil storage and percolation towards the groundwater table creates a ‘mound’ of saturation onto the water table. This is known as ‘groundwater mounding.’ When the mounding builds up and reaches the disposal surface, the infiltration rates decrease markedly. This is a key consideration for rapid infiltration discharges where the water table is normally near the surface.

Once the infiltration event is stopped, the bulb of saturation will dissipate, and the soil moisture and water table will return towards ambient conditions. The infiltrated water will continue to flow through the underlying soils, moving generally outwards and downward.

The SEEP/W modelling provides a simplified representation of the complex hydrogeological processes occurring across the dunal area and an indication of the effect groundwater mounding on the infiltration rates.

A cross section showing a groundwater mound is shown in **Figure 9-3**.

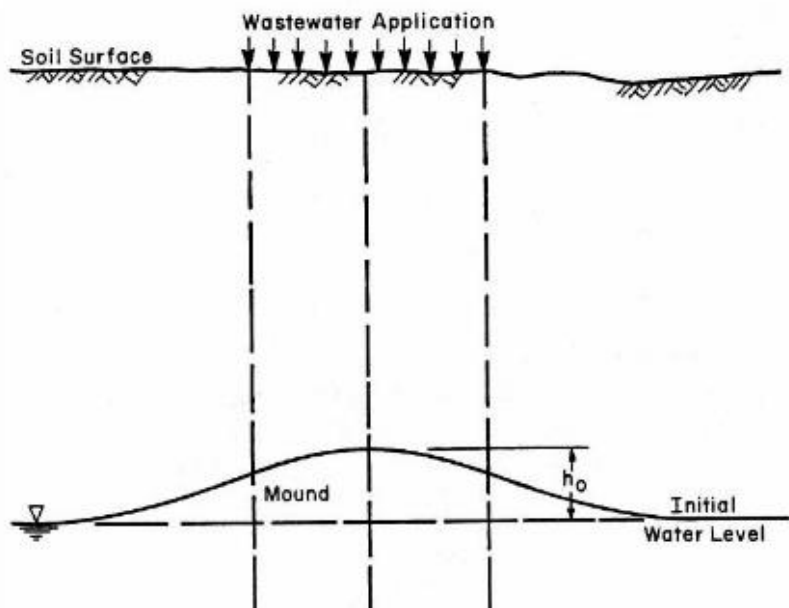


Figure 9-3. Schematic of a groundwater mound. Source: USEPA, 2006.

10 Results

10.1 Field Results

The tested infiltration rates in the dune sands were generally high (BecaHH2O, 2025), with an average tested infiltration rate of 1,985 mm/hour, ranging from a minimum of 275 mm/hour to 6,000 mm/hour. A summary of the results of the infiltration testing are shown in Table 10-1.

These infiltration tests were carried out at the end of a prolonged dry weather spell; hence groundwater levels were comparatively low and the surficial sands relatively dry. A ~1-hour pre-soak was carried out before each test was run to saturate the material around the hole, but it is likely this bulb of saturation was small and would drain rapidly towards the groundwater surface, meaning the infiltration results are likely to be higher than mounded infiltration rates which occur when the groundwater table is close to the ground surface. Some infiltration tests were carried out in lower elevation areas closer to the groundwater table, and other in slightly higher elevation areas with a larger separation from the groundwater table, which is likely to be the cause of some of the difference in measured infiltration rates.

Table 10-1. Infiltration test results in the Stuarts Point dune sands from December 2024 field investigations.

Infiltration Test ID	Depth of hole (m)	Main lithology at base of test	Tested Infiltration Rate (mm/hour) (unfactored)
HA02	1.2	Fine to medium SAND	367
HA03	1.2	Fine to medium SAND	3,267
HA04	1.2	Fine to medium SAND	404
HA05	1.2	Fine to medium SAND	367
HA06	1.2	Fine to medium SAND (groundwater encountered at ~0.6 m BGL)	275
HA07	1.2	Fine to medium SAND	4,800
HA08	1.2	Fine to medium SAND	6,000
HA09	1.2	Fine to medium SAND	400

Note: m BGL represents metres below ground level.

10.2 Modelling Results

10.2.1 Soakage Capacity in Wet and Dry Weather

The capacity of the dune sand to soak treated effluent is significantly influenced by its degree of saturation. In major wet weather during and soon after rainfall, when groundwater levels are at the surface, the dunes will have a soakage capacity of zero. As the groundwater level drains down (gets lower), the infiltration capacity increases. The groundwater flux flow rate and rainfall are plotted together in **Figure 10-1** below. When the treated effluent is applied at the surface of the dunes and allowed to infiltrate under gravity, the modelling indicates the following:

- When a single 10 m wide disposal area was modelled, both the short- and long-term mounded infiltration rates were higher than when 4 x 10 m wide disposal footprints were modelled simultaneously. This indicates each disposal area in the 4 x 10 m scenario has a collateral mounding effect on the adjacent disposal area, resulting in a decrease in infiltration capacity per 10 m wide strip. The most effective infiltration rates can therefore be achieved by applying effluent across one 10 m wide strip at a time, and rotating disposal through parallel strips to allow for resting/drying and reducing unnecessary clogging of the field.
- The infiltration capacity of the sand is highest in the first 24 hours when the starting groundwater levels are >0.8 m BGL and the groundwater mound is building up. Modelling of the 10 m footprint indicated an initial 24-hour average infiltration rate of 130 mm/hour due to the rapid development of the groundwater mound underneath the disposal area.
- Modelling of the 10 m footprint indicated a longer term (after 5 days) average infiltration rate of ~40 mm/hour.
- During prolonged wet weather the soakage capacity of the dune site will be significantly reduced. When the groundwater level reaches the surface, the infiltration capacity will be close to zero.
- With a 10% factor applied, as recommended by USEPA 2006⁹, the mounded, factored infiltration rate is **4 mm/hour**.
- With a 10% factor applied, as recommended by USEPA 2006, the unmounded, factored infiltration rate is **13 mm/hour**, but is only available temporarily, i.e., until the groundwater level rises to near the surface, which is when it reduces to 4 mm/hour.

⁹ United States Environmental Protection Agency (USEPA). 2006. Process Design Manual: Land Treatment of Municipal Wastewater Effluents.

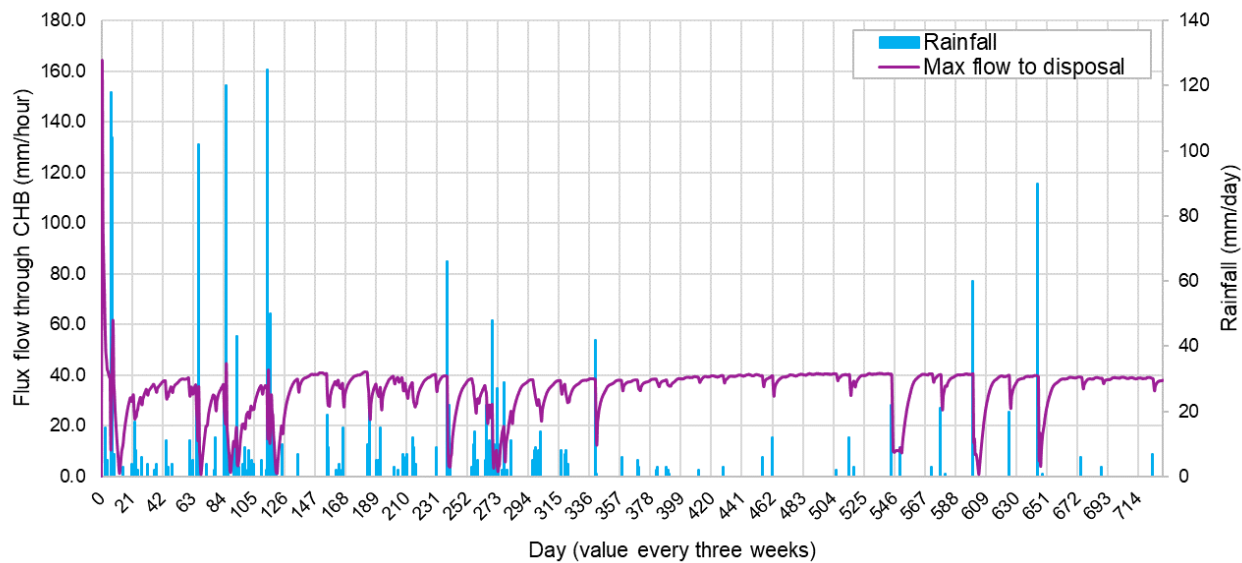


Figure 10-1. Graph showing the flow rate through the constant head boundary against daily rainfall depth. Rainfall data was sourced from Nambucca Heads (Station 59150) through the BOM website.

10.3 Discharge Area

A factor of safety (FOS) should be applied to the infiltration rates to take into account the future clogging and reductions in soil capacity that typically occur over time in land discharge systems. A FOS of 4 -10% is recommended by the *United States Environmental Protection Agency (USEPA) 2006 Process Design Manual for Land Treatment of Municipal Wastewater Effluents for rapid infiltration to land of treated wastewater*.

10.3.1 Longer Duration Infiltration Rate Discharge Area

Based on applying a FOS of 10% on the longer duration (>5 day) infiltration rate, and accounting for mounding, results in a design infiltration rate of 4 mm/hour.

When static groundwater levels are more than 0.8 m BGL, and based on a 10 m wide infiltration strip, the following infiltration areas are indicated to be required to soak 1,248 kL/day of treated effluent:

- Each individual disposal strip would need to be approximately 1,300 m in length x 10 m wide.
- A minimum of 4 parallel disposal strips is recommended to allow for rotation and spelling of each strip. The modelling suggests there will be interference between closely spaced strips (disposal) areas if they were all soaking wastewater simultaneously, because the mounding from one adjacent strip will impact the infiltration capacity of the neighbouring strip, whereas if there is one 10 m strip only receiving wastewater, there will be no interference from another source (discounting rainfall recharge).
- A total disposal field area (4 x strips) of at least 6.4 ha (including an additional 20% site area for access and bunding) is recommended to be further considered in future design stages.

10.3.2 Shorter Duration Infiltration Rate Discharge Area

Based on applying a FOS of 10% on the shorter duration (<1 day) infiltration rate, and accounting for mounding, results in a design infiltration rate of 13 mm/hour.

KSC indicated the Peak Wet Weather Flow (PWWF) for the wastewater scheme at the time of modelling was 3 ML/day. When static groundwater levels are more than 0.8 m BGL, and based on a 10 m wide infiltration strip, the following infiltration areas are indicated to be required:

- Each infiltration (disposal) area would need to be approximately 950 m in length x 10 m wide.

- The PWWF infiltration (disposal) area fits within the ADWF infiltration (disposal) area and therefore the ADWF scenario is the critical design case for area requirements. The ADWF scenario requires a larger area, because the lower, mounded infiltration rate was used to derive the area, while the higher infiltration rate possible in the first 24-hours of disposal was used to size the PWWF area.

Flow buffering, storage and/or alternative disposal measures will also be required for periods when ground conditions limit or stop infiltration capacity to land.

10.3.3 Rainfall Trigger Events

As described in **Section 9.2** above, rainfall events were applied to the model surface in conjunction with the disposal flow series to assess which events induced sheeting, and how many consecutive days the sheeting occurred for. The results are summarised for each scenario below.

Existing Population

- In the existing population flow scenario, the model indicates that sheeting occurs only during rainfall events (i.e. the effluent flows in isolation do not induce sheeting on their own).
- The model indicates that the disposal field cannot be used due to sheeting for ~8 days consecutively across the two-year period modelled (2022-2023).
- The model indicates that the disposal field will be flooded for ~41 days total in 2022, and ~7 days in 2023 (due to rainfall variance between the two years). No effluent can be applied during these days.
- **Figure 10-2** shows the relationship observed between rainfall event depth and days of consecutive sheeting. Note that these events occur over multiple days in some cases.
- There were some cases where sheeting occurred during or soon after small rainfall events. In these instances, the antecedent conditions were characterised as having groundwater close to the surface already, hence the storage capacity in the soil was limited before the rainfall occurred.

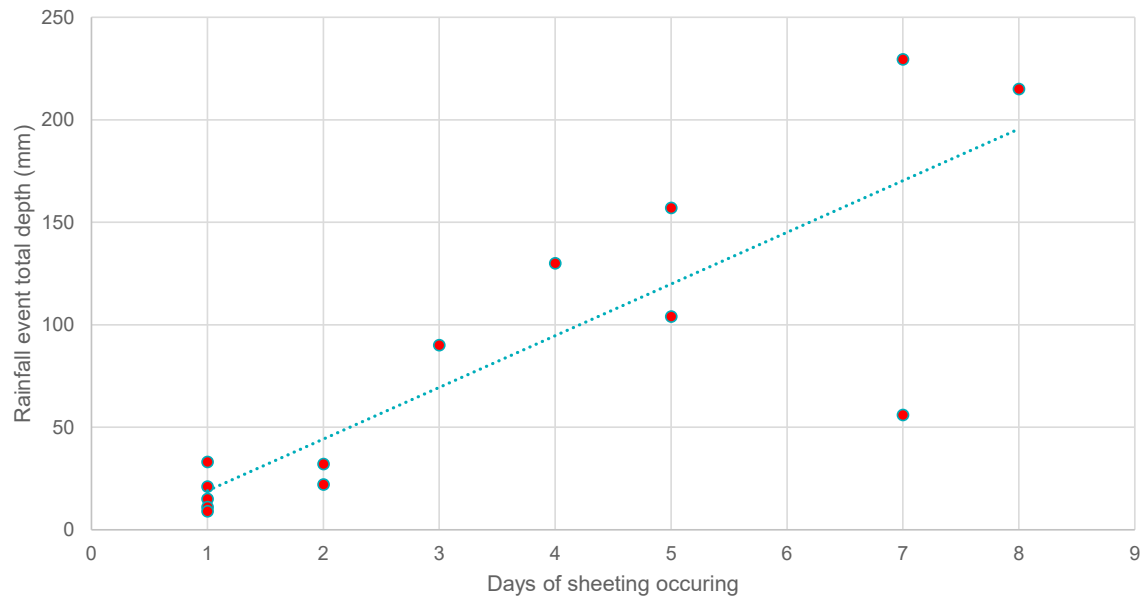


Figure 10-2. Graph showing the relationship between rainfall event depth and days of sheeting for the existing population scenario.

Interim Population

- In the interim population flow scenario, the model indicates that sheeting occurs only during rainfall events, including some very small events when groundwater is close to the surface.
- The model indicates that the disposal field could be flooded up to 13 days consecutively across 2022-2023.
- The model indicates flooding in the basin area during ~61 days in 2022, and ~15 days in 2023.
- **Figure 10-3** shows the relationship observed between rainfall event depth and days of consecutive sheeting. Note that these events occur over multiple days in some cases.

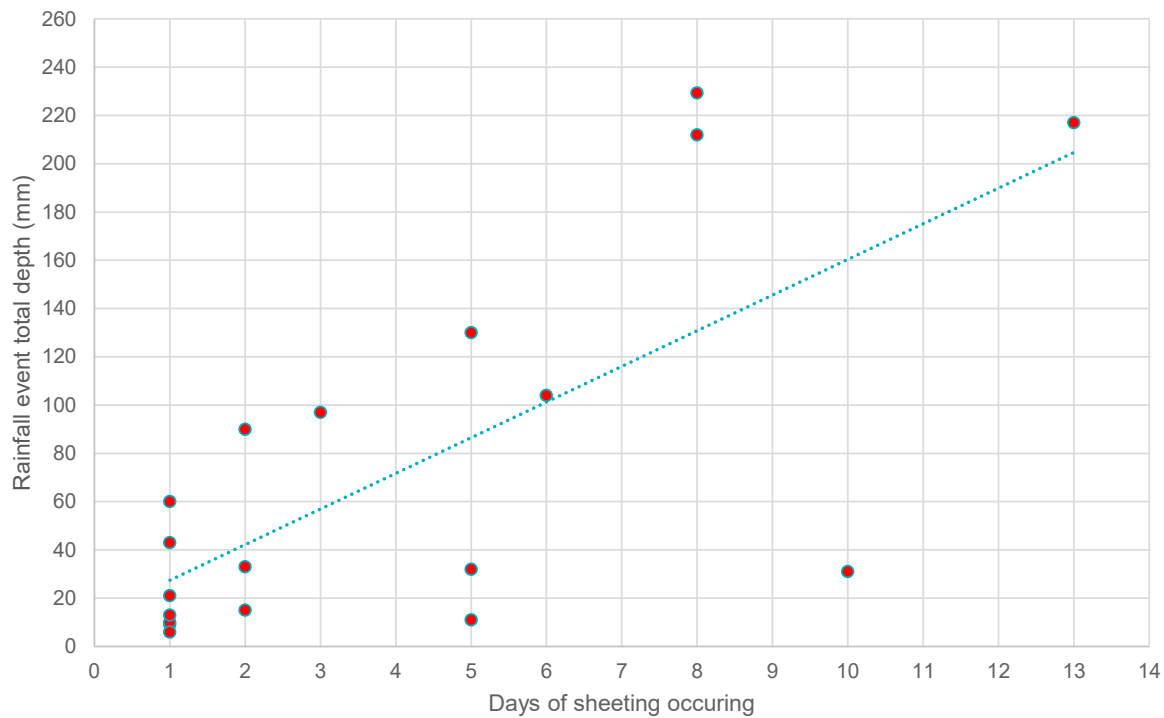


Figure 10-3. Graph showing the relationship between rainfall event depth and days of sheeting for the interim population scenario.

Fully Built Population

- In the fully built population flow scenario, the model indicates that sheeting could occur even in small rainfall events, and occasionally without the contribution of rainfall.
- The model indicates the disposal field could be flooded for ~39 days consecutively during the modelled 2022-2023 period.
- The model indicates that the disposal field may be flooded for ~162 days in 2022, and ~82 days in 2023.
- **Figure 10-4** shows the relationship observed between rainfall event depth and days of consecutive sheeting. Note that these events occur over multiple days in some cases.

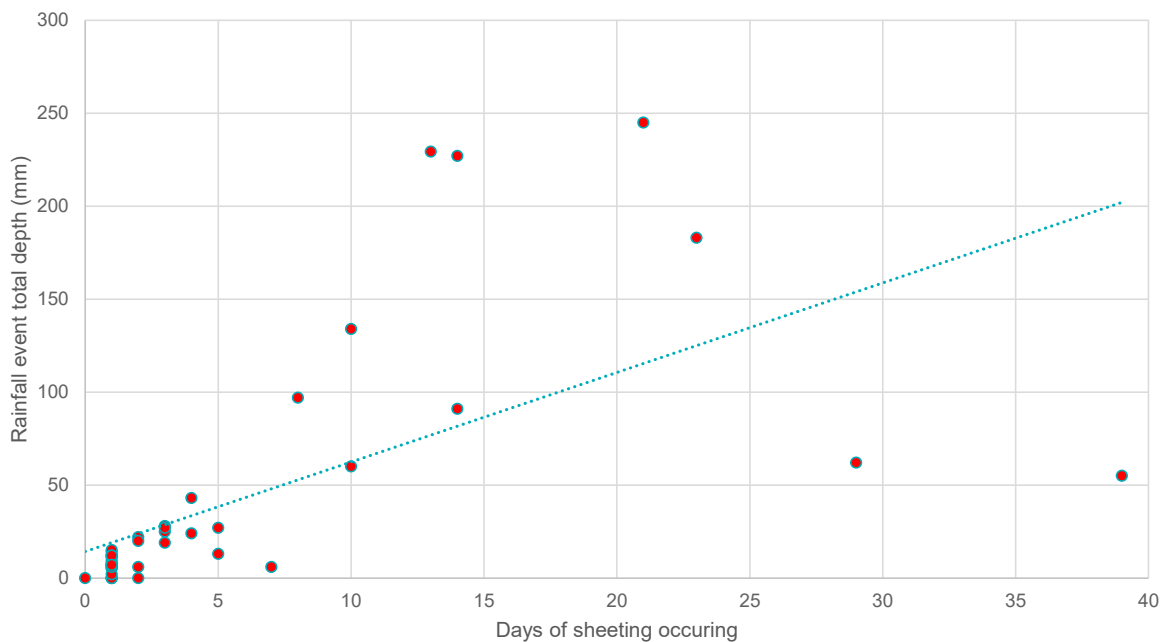


Figure 10-4. Graph showing the relationship between rainfall event depth and days of sheeting for the fully built population scenario.

10.3.4 Ponding / Sheetting

The model indicates that when ponding occurs, it tends to be in the low elevation hollows located in the centre of the dune which are at elevation of ~1.6 m RL or less. The main ponding areas tend to be within or immediately adjacent to the proposed disposal area, and not near the Stuarts Point Coastline. These ‘hollows’ are generally bounded by higher elevation ground, hence ponding, but not overland flow could be expected in these areas.

Due to the higher elevations on the coastal side of the dune, overland flow to the coast is not expected. There are some low-lying patches of ground close to the Macleay Arm which are connected to low lying areas within the disposal field. These areas present a risk of overland flow. A bund/ stop bank with an access track on the surface is proposed on the western side (Macleay Arm side) of the disposal field which would reduce the risk of overland flow to the Macleay Arm. It could also be designed to reduce the risk of floodwater from the Macleay Arm entering the disposal field.

It should also be noted that dune sands can be highly mobile in certain conditions, hence the dune topography could change over time. If the dunes are stabilised by vegetation, the rate of erosion will be lower than in unvegetated conditions.

10.3.5 Assessment of Potential Dunal Seepage Face

A concern raised by KSC is regular seepage from the disposal field out onto Stuarts Point Beach.

The proposed disposal system is not designed to increase the elevation of the groundwater above what it could reach under natural conditions, however, it will keep groundwater levels high on a more consistent basis as the daily treated effluent flows are applied to the field (except when the field is already flooded). In effect, the disposal system is not likely to induce seepage at a level higher up the coastline than what it would do under natural conditions, but it is likely to reach the natural high level more regularly.

The model indicates that when interim effluent flows are discharged to the field, seepage is only likely to occur in the lower portion of the intertidal zone when the tide is approaching or at its lowest. When the tide is high, the head from the ocean retards the groundwater flow from the dune, even when the field is in a flooded condition.

It should be noted that the edge of the proposed disposal field is approximately 150 m from the beach (on average). The treated effluent will have undergone mixing with natural groundwater, and filtering through the soil by the time it meets the coastal water body. Additionally, when groundwater levels are high due to the contribution of rainfall recharge (and seepage corresponding with this), there will more dilution of treated effluent than under dry conditions.

10.3.6 Groundwater Flow Divide and Flow Direction

Groundwater flows from areas of high head to areas of low head. On the dune, the areas of highest head are generally in the centre, grading downwards on either side to the coastline and Macleay Arm. This means the groundwater divide is roughly in the centre of the dunes, approximately where the proposed disposal field will sit, meaning groundwater on the eastern side of the disposal area is generally expected to flow eastwards to the coastline, and groundwater on the western side of the disposal area is generally expected to flow westwards to the Macleay Arm. However, there are additional factors which impact groundwater flow direction. Under normal conditions, the density of the coastal water body will be higher (on average) than in the upper Macleay Arm, hence slightly higher pressure is to be expected from the coast than the Macleay Arm, which may bias the groundwater divide and induce more flow to the Macleay Arm. Counter to this, when the Macleay Arm is in flood, and water levels are elevated above normal, there will be more pressure from the Macleay side, reducing groundwater flow to it.

In the steady state model, a constant head boundary was set to 0.25 m AMSL on the coastal side, and 0.2 m AMSL on the Macleay side, with the difference to account for average density disparity. A constant recharge of 0.17 mm/hour (4 mm/day) was applied to the dune to simulate average daily rainfall. Under this scenario, the flow to the Macleay Arm was 13.7 m³/day over a 1,300 stretch, and 11.9 m³/day over a 1,300 m stretch to the coast, resulting in a 13.7% higher discharge to the Macleay over the coast.

A visual representation of groundwater flow under both natural conditions (no effluent application) and under active effluent application are presented in **Figure 10-5**.

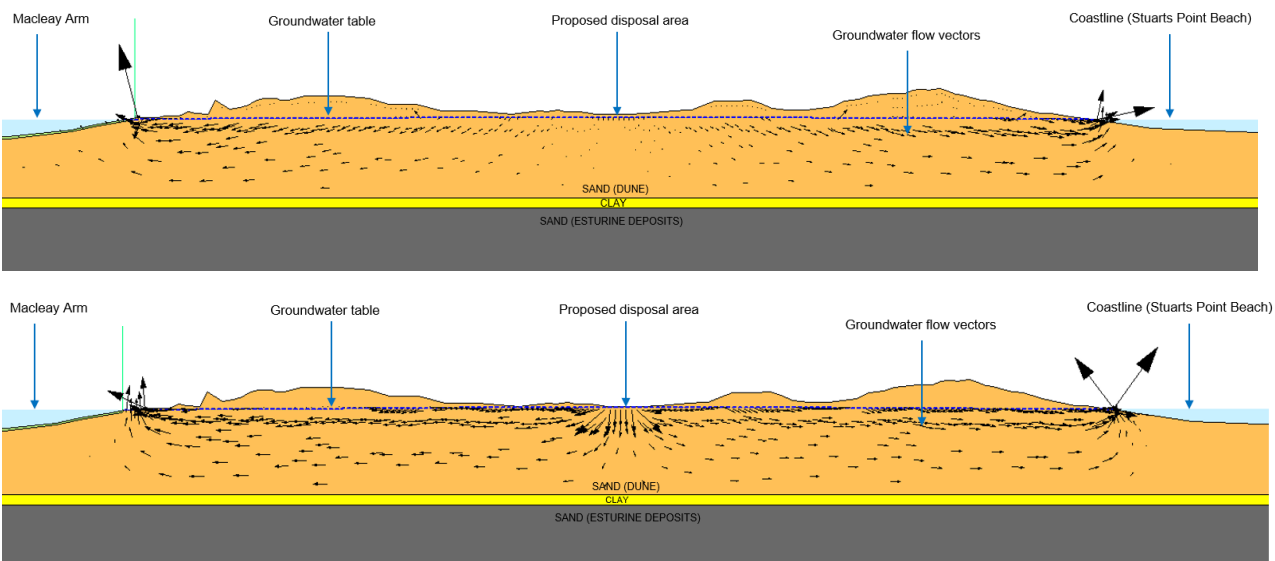


Figure 10-5. Dune model cross section showing groundwater flow direction under natural conditions in the upper image and with active disposal occurring in the lower image.

10.3.7 Particle Transport Assessment

SEEP/W allows particle movements to be tracked and timed as they move through a groundwater system. In this case the objective was to ‘track’ particles from the applied treated effluent to assess their flow path and their travel time to either the Macleay Arm, the coast, or down into the clay confining layer. Three ‘particles’ were tracked in the model, one on the western side of the disposal strip, one in the centre, and one on the eastern side. These three particles are shown in **Figure 10-6** after 6 months, **Figure 10-7** after 1 year, and **Figure 10-8** after 2 years. The particles all moved in different directions initially, one vertically downwards and two laterally and slightly downwards. After 6 months, all three particles had migrated outwards between 20 and 40 m from the base of the disposal strip, with two now migrating towards the Macleay Arm at different depths, and one towards the coastline. The particle which initially tracked vertically downwards changed direction towards the Macleay Arm due to the attenuation (partial barrier) of vertical groundwater flow from the clay confining layer. After 1 year the particles had moved between 55 and 80 m, and after 2 years they had migrated 130 – 160 m from the original starting point at the disposal strip site.

None of the particles seeped out of the groundwater system after the 2-year model run time.

The particles do not always track along a regular pathway, because the groundwater model contains dynamic inputs from rainfall recharge, irregular disposal field flows, and tidal cycles.

The overall rate of movement is slow, which is largely driven by the low hydraulic gradient (difference in total head between the disposal area and the water bodies on either side).

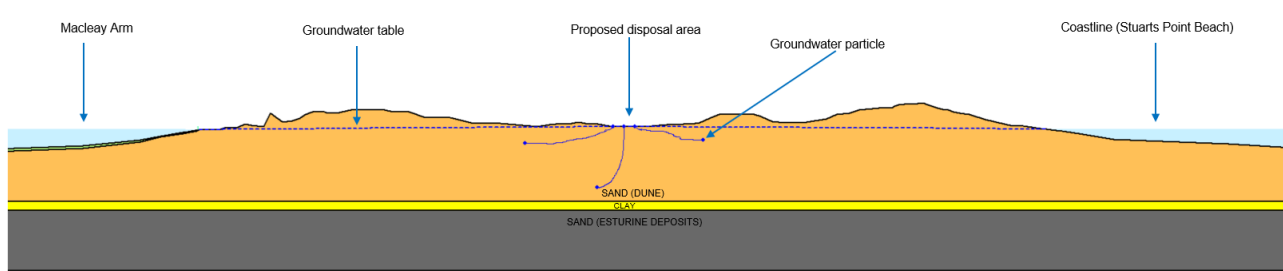


Figure 10-6. Particle transport from disposal area after 6 months.

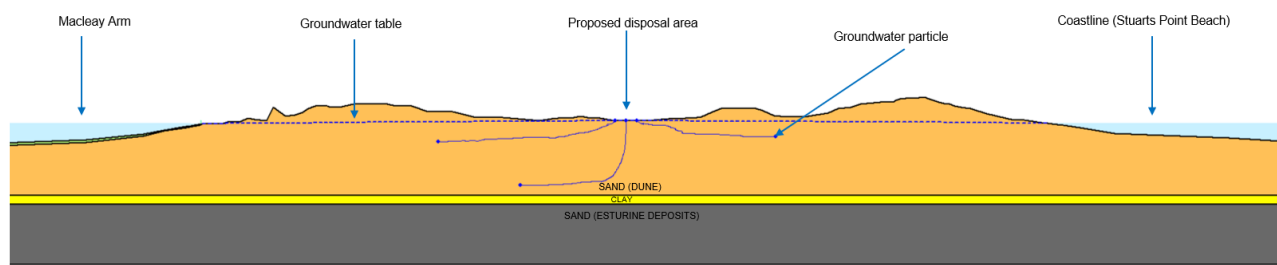


Figure 10-7. Particle transport from disposal area after 1 year.

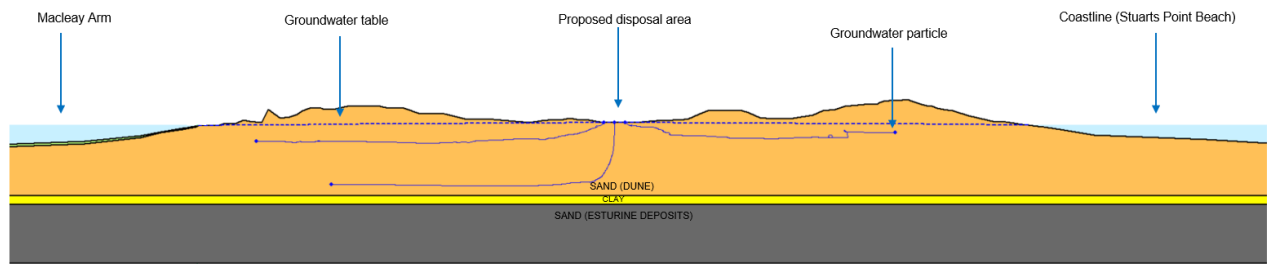


Figure 10-8. Particle transport from disposal area after 2 years.

11 Slow-rate Land Treatment Systems

Slow-rate treatment systems involve the disposal of treated effluent to land via the controlled application of wastewater onto the land surface to achieve a designed degree of treatment through natural physical, chemical and biological processes within the plant-soil matrix (USEPA, 2006).

Slow rate systems can be effective with groundwater depths of 0.6 – 1 m BGL, while rapid infiltration systems require groundwater levels to be no higher than 1 m BGL during the flood cycle, and 1.5 – 3 m BGL during the drying cycle (USEPA, 2006).

Photos of possible slow-rate dripper disposal system designs which could be effective on the dunal site are shown in **Figure 11-1**.



Figure 11-1. Example photos of possible slow-rate disposal systems. Source: Netafim wastewater drip dispersal (2025). Source: <https://www.netafim.com/en/products-and-solutions/>.

12 Risks

This section presents risks that have been identified at this stage of the project based on the work done to date and information available. It is not an exhaustive list of risks and further risks may become apparent as the project is developed further and additional information becomes available.

The following key hydrogeological and modelling assumptions and risks are summarised by the following:

- Limited hydrogeological, geotechnical and hydraulic soil properties characterisation data are available for the current assessment. The nature and hydraulic soil properties and the strata depths may vary from those assumed.
- It is expected that the capacity of the dune sand under the disposal area to receive water would be predominantly consumed by treated effluent discharge, with little further capacity to receive rainwater, hence the additional precipitation loading will result in rapid appearance of uncontrolled surface break-out (seepage faces) and run-off sheeting within the dunes.
- The Kempsey Shire Council Coastal Hazard Mapping (JB Pacific, 2021) shows that the alignment is partially located within a 'coastal vulnerability area', which indicates that the land is subject to coastal hazards. The sensitivity of the assets to the potential impacts should be appropriately considered in selecting design schemes. The selection of an alignment would need to consider the coastal hazard risk and dune growth/recession.
- The risk of wastewater irrigation is that groundwater reaches the surface at these natural low points and flows from there to the Macleay Arm. The ground surface elevation is irregular and varied, and a careful assessment of the topography is critical to optimise the disposal areas and reduce the risk of sheeting towards the Macleay Arm.

13 Recommendations

Should the dunal discharge option progress beyond concept design, then the following is expected to be needed:

- A coastal groundwater mixing assessment.
- Further groundwater monitoring and investigations.
- Suitability and impacts on the coastal environment and ecology.
- Undertake a longer-term period of monitoring in the three dunal piezometers, to gauge the temporal and spatial variation of groundwater across the dunal area.

14 Conclusions

The results of the SEEP/W modelling without rainfall inputs indicate shorter duration infiltration rates (across a 10 m strip) average 130 mm/hour over the first 24-hours of application, with a starting groundwater level of 0.8 m BGL. After 5 days of constant application, and a groundwater mound built-up to near the disposal strip surface, the infiltration rate is reduced to approximately 40 mm/hour. With a factor of safety of 10 applied to these values (as recommended by USEPA), the 24-hour factored design infiltration rate is 13 mm/hour and >24 hours the factored design infiltration rate is 4 mm/hour.

The maximum design flow of 1,248 kL/day will require infiltration discharge (disposal) strips comprising areas of approximately 1,300 m x 10 m. A minimum of 4 parallel infiltration (disposal) strips is recommended to allow for rotation and spelling of each infiltration (disposal) strip within the overall disposal area. The total disposal field area of at least 6.4 ha likely to be required to accommodate 4 infiltration discharge (infiltration) strips, separation space, bunding and access.

The rainfall and groundwater level data indicate that sheeting occurs in some locations on the dunes naturally, particularly in events >100 mm in 24-hours. Therefore, applying additional water (treated effluent) to the ground surface will reduce the time for groundwater to breach the surface, and also reduce the magnitude of the rainfall event required to induce groundwater sheeting.

The persistent high groundwater levels and consequential low mounded infiltration rates make this site suitable for a slow-rate (SR) system involving application to the land surface may be feasible to dispose of a portion of the treated effluent.

Flow buffering, storage and/or alternative disposal measures will also be required for periods when ground conditions limit or stop infiltration capacity to land. Performance of infiltration to land systems are highly sensitive to effluent quality and require solids to be removed and regular maintenance of the soakage areas.

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16 Applicability

This report has been prepared by Beca HunterH₂O (**BecaHH2O**) on the specific instructions of Kempsey Shire Council (**Client**). It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which BecaHH2O has not given its prior written consent, is at that person's own risk.

Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

In preparing this report BecaHH2O has relied on key information including the following:

- Groundwater Modelling: Stuarts Point Wastewater Treatment Plant (GHD, July 2019).
- Stuarts Point Sewerage System – Effluent Transfer and Disposal Design: Geotechnical Report (GHD, August 2022).
- Topographical Survey of Stuarts Point: Drone-LIDAR and Photogrammetry. Aerial orthophoto and high-resolution 3D textured mesh model provided.
- Groundwater monitoring data (raw data file) for BH01 over the period 1 July 2022 to 8 December 2022 (from piezometer and groundwater level logger installed during GHD's 2022 investigation).
- Daily rainfall data (raw data file) from the Nambucca Heads and South West Rocks weather stations for the period 1 January to 31 December 2022.

Unless specifically stated otherwise in this report, BecaHH2O has relied on the accuracy, completeness, currency and sufficiency of all information provided to it by, or on behalf of, the Client, including the information listed above, and has not sought independently to verify the information provided.

This report should be read in full, having regard to all stated assumptions, limitations, and disclaimers. No part of this report shall be taken out of context, and, to the maximum extent permitted by law, no responsibility is accepted by BecaHH2O for the use of any part of this report in any context, or for any purpose, other than that stated herein.

Appendix A. Beca 2025 Hydrogeological Ground Investigation Factual Report



Stuarts Point Hydrogeological Ground Investigations for Potential Treated Wastewater Disposal Site

Factual Report

Prepared for Kempsey Shire Council (KSC)

Prepared by Beca Limited

4 February 2025



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Revision History

Revision N°	Prepared By	Description	Date
1	Nick Jowsey & Henry Foster	For Internal Review	04/02/25

Document Acceptance

Action	Name	Signed	Date
Prepared by	Nick Jowsey		04/02/25
Reviewed by	Mike Thorley		04/02/25
Approved by	Mike Thorley		04/02/25
on behalf of	Beca Limited		

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1 Introduction

1.1 Project Outline

Kempsey Shire Council (KSC) is developing a new wastewater treatment and discharge scheme at Stuarts Point, NSW. Beca Hunter H2O Limited (Beca HH2O) was commissioned by KSC to provide hydrogeological consultancy services including site investigations to provide additional site information at two potential land-based discharge sites. The focus area was on the sand dunes to the east of Stuarts Point, between the Macleay Arm and the Stuarts Point beach (coastline) (Site 1). At Site 1, the treated wastewater may be piped across the Macleay arm and discharged to land via soakage through the near surface soils within the dunes. The second site investigated (Site 2) is located at the KSC owned tract of land south of Stuarts Point Township off Fisherman's Reach Road.

1.2 Object and Scope of the Investigation

1.2.1 Site 1

The objective was to characterise the strata to a depth of 30 m below ground level, measure shallow groundwater levels, and test the permeability and infiltration capacity of the surficial strata along the dune footprint. The data collected will be used to address gaps in the understanding of the ground conditions and inform site feasibility considerations, largely in relation to potential infiltration hydraulic loading rates for the planned volumes of treated wastewater.

The investigation scope consisted of 3 machine boreholes drilled to 30 m BGL, installation of 2 standpipe piezometers to 6 m BGL, and 8 infiltration tests in hand augured holes at 1.2 m depth BGL. Falling head tests were also performed on the piezometers.

1.2.2 Site 2

The objective was to characterise the surficial soils and test their infiltration capacity.

The investigation scope comprised 4 shallow infiltration tests spread out across the available land parcel and tested at 1.2 m BGL.

1.3 Site Location and Description

1.3.1 Site 1

Site 1 is on a long narrow coastal spit which runs from Grassy Head to the north of Stuarts Point, down past Stuarts Point township to South West Rocks, approximately 9 km to the south. The site is along a section of spit approximately 1.3 km long and 350 m wide.

The dunes are low-lying and hummocky, with elevations ranging from ~1 m to ~8 m above mean sea level (m AMSL). The highest elevation areas are located on the coastal side of the spit, and lowest elevation areas closer to the Macleay Arm.

The dunes are mostly covered in thick vegetation with occasional areas of thinner coverage.

Stuarts Point beach is largely unprotected from easterly swells and weather which create a coastal hazard adjacent to the proposed site. A set-back to account for future coastal hazards was accounted for in the site investigation planning and test locations.

A map of site 1 is shown in **Figure 1-1** and photos of the site in **Figure 1-2**.

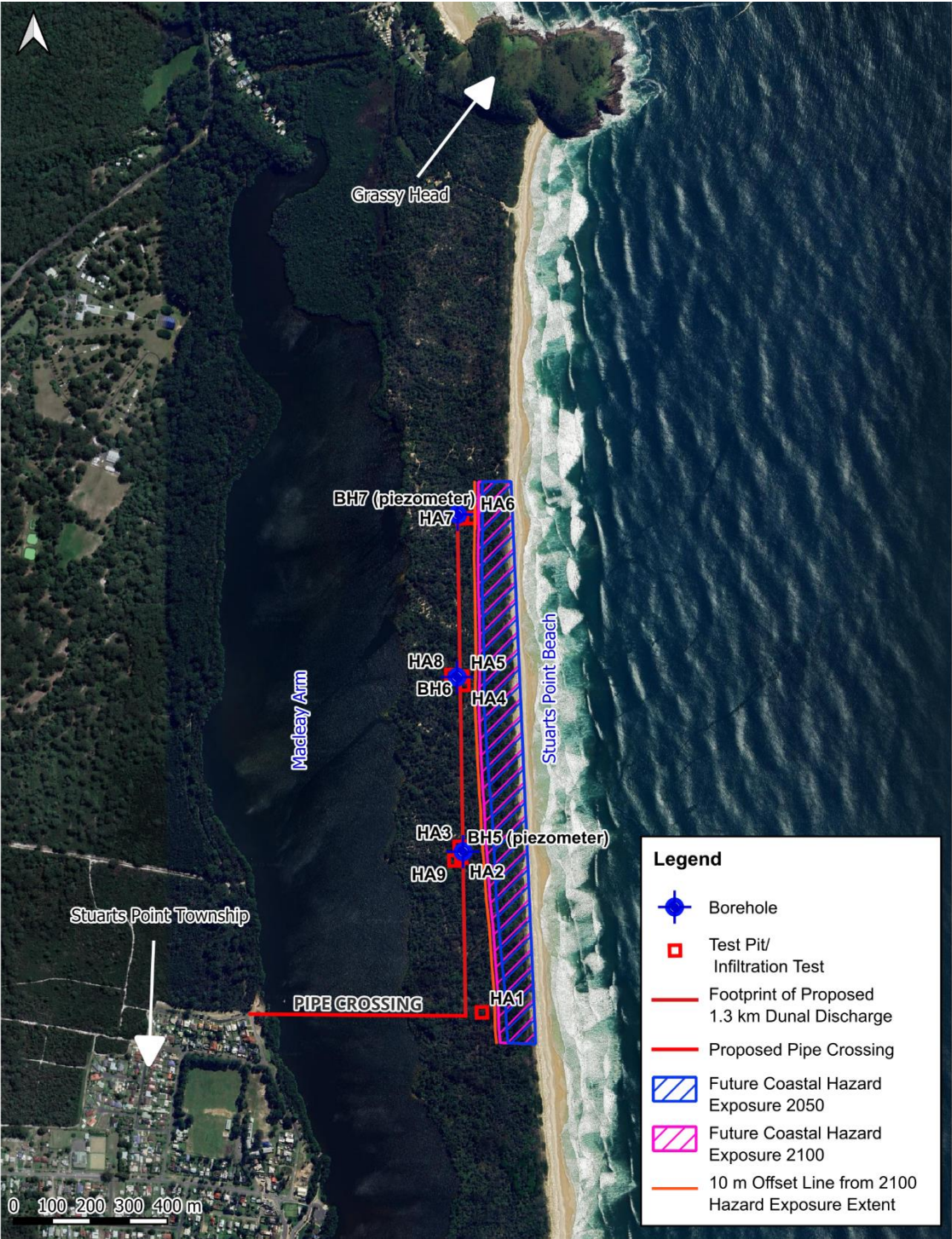


Figure 1-1. Stuarts Point dunal discharge site investigation overview map (Google Satellite Imagery).



Figure 1-2. Annotated photos of Site 1.

1.3.2 Site 2

Site 2 was located south of Stuarts Point township off Fisherman’s Reach Road. The site was flat with relatively consistent fine to medium sand at the surface, occasional trees and thin ground cover plants. The perimeter of the site has large mature trees around it.

The site is also located near the community drinking water supply bores which sit to the southwest of the site, and also borders an active avocado orchard (south).

Photos of the site are shown in Error! Reference source not found. and a map of the site is shown in **Figure 1-4**.



Figure 1-3. Photos of Site 2: Left: Looking east at an excavator preparing to dig TP4. Right: Looking south at the water tanker near TP1.



Figure 1-4. Site 2 ground investigation overview map.

1.4 Proposed Development

KSC indicated that the current basis of design for the wastewater treatment plant (WWTP) and treated effluent discharge flows include 1.08 ML/day Average Daily Dry Weather condition (ADWF) and 3.0 ML/day peak wet weather flow (PWWF). We understand these flows are subject to change and further design considerations.

If a land discharge area at Site 1 were to be constructed, an approximately 2.5 km long effluent transfer pipeline would extend from the proposed WWTP located south of Stuarts Point township, beneath the Macleay Arm to the dunal discharge area to the east of the township.

Site 2 would be less than 500 m from the proposed WWTP.

1.5 Regional Geology

The basement rock in the area is siltstone of the Kempsey Beds Formation which was deposited in a marine environment in the early Permian Period. After which it was deformed and metamorphosed forming fault breccias. When sea level fell in the mid Pleistocene (120,000 years ago), the bedrock was intensely eroded and scoured by energetic rivers and the paleochannels were filled in with alluvial gravels. Alluvial sands and silts were later deposited in a fining upwards sequence as the river lost energy. Sea level reached a low point c. 20,000 years ago, before rising through the late Pleistocene and estuarine deposits filled in the basin (Varcoe et al., n.d).

1.6 Site Geology

The currently active Macleay River system deposits and erodes sediments in the river channel and on the floodplain during flood events (Varcoe et al., n.d).

The sand dunes which form the spit are comprised of uniform fine to medium loose sand with estuarine deposits below.

1.7 Local Hydrogeology

Regional groundwater flow in the Stuarts Point area is primarily eastward, towards the coast (GHD, 2019).

There are three named aquifer units in Stuarts Point according to the Australian Groundwater Explorer, though little publicly available information exists about them, they are the 'upper', 'middle' and 'lower' aquifers.

The upper aquifer is comprised of alluvial sediments (sand) and is used for domestic, industrial and community drinking water supplies. No information could be found on the middle and lower aquifers.

Groundwater at both sites is recharged from rainfall. Shallow groundwater levels on the spit are close to the ground surface; in many low-lying areas the water table sits within 1 m of surface. Groundwater was not encountered at Site 2.

In general, the permeability of the surficial soil (sand) is high due to the lack of fines.

With the community water supply sourced from groundwater bores, and the township reliant on septic tank systems, there is a risk to groundwater quality over the long term until a community WWTP replaces the individual septic systems.

2 Hydrogeological Investigation

2.1 General

The ground investigation commenced on 6 December 2024 and was completed by 13 December 2024. Coordinates and elevations of the testing locations and bores were taken by a professional surveyor using the datum MGA 2020. The site investigations were observed and logged by a Beca Hydrogeologist, and the logs have been verified by a Beca Associate Engineering Geologist.

2.2 Standards

The site investigations were undertaken in general accordance with the following Australian Ground Investigation Guidelines:

- Australian Standard 1289:2000 Methods of Testing Soils for Engineering Purposes.
- Australian Standard 4133: 2005 Methods of Testing Rocks for Engineering Purposes.
- Australian Standard 1726: 2017 Geotechnical Investigations.
- EPA Classification 2015/205 Industrial Waste – Classification for Drilling Mud.

Infiltration testing was carried out in line with the advice set out in:

- CIRIA, 1996. Infiltration Drainage – Manual of Good Practice. Construction Industry Research and Information Association.
- United States Environmental Protection Agency (USEPA), 2006. Process Design Manual for Land Treatment of Municipal Wastewater Effluents

2.3 Machine Boreholes

Three machine boreholes were drilled by Stratacore Limited (Stratacore) using a Massenza M14 drill rig. The first 6 m of each hole was machine augured so that reasonable soil samples could be collected, and drilling muds did not have to be used. Drilling from 6 – 30 m BGL was carried out using mud rotary methodology in order to keep the hole open in the soft, sedimentary material. While this drilling methodology is quick and effective for drilling through unconsolidated materials, it is challenging to log the geology accurately from the cuttings which are brought to the surface in the mud pumping system.

A summary of the borehole information is shown in **Table 2-1**.

Table 2-1. Borehole Investigation Summary Table.

BH ID	Location	Date Drilled	Easting	Northing	Ground level (m RL)	Total Depth (m BGL)
BH05	Southern end of the site	12/12/24	499892.85	6591156.01	1.71	30
BH06	Centre of the site	11/12/24	499877.37	6591609.44	1.07	30
BH07	Northern end of the site	09/12/24	499878.86	6592031.58	1.24	30

Notes:

RL (Relative Level).

Survey coordinates are given in terms of MGA 2020.

m BGL (metres below ground level)

Borehole inclination is 90°.

Core samples were logged on site by a Beca Hydrogeologist. Borehole logs and cutting samples images are presented in **Appendix A**.

2.4 Test Pit Investigations

Test pits at Site 1 and Site 2 were hand augered at 100 mm diameter to depths of 1.2 m BGL. To prevent collapse, the auger holes were cased using an uncapped perforated PVC pipe. The locations of the Site 1 test pits are shown in **Figure 1-1** and the location of the Site 2 test pits are shown in **Figure 1-4**. The logs for the test pits are given in **Appendix A**.



Figure 2-1. Photo of hand auger and perforated PVC pipe ready for infiltration testing.

2.5 Instrumentation

Standpipe piezometers were installed in two of the three boreholes for permeability testing, and to enable groundwater level monitoring in the future, should this be required. A summary of the piezometer installations is provided in Table 2-2. Photographs of the finished piezometers at the surface are shown in Figure 2-2.

Table 2-2-2. Standpipe piezometer summary

Borehole/ Piezometer ID	Piezometer Type	Response Zone Top (m BGL)	Response Zone Bottom (m BGL)	Response Zone Geology
BH05	Single standpipe	2.25	5.25	Quaternary sediments
BH07	Single standpipe	2.25	5.25	Quaternary sediments

The standpipe piezometer installation consisted of 50 mm diameter uPVC pipe with slotted screen section located in the response zone of interest. The borehole below the base of the piezometer and the around annulus of the piezometer screen were backfilled with quartz sand to 2.25 m BGL. The sand was overlain by bentonite to 0.2 m and concrete to the ground surface. BH05 and BH07 were completed with a lockable stand-up toby.



Figure 2-2. Finished piezometer upstands; BH5 to the left and BH7 to the right.

2.6 Groundwater Levels

The depth to groundwater measured within the piezometers (BH05 and BH07) is presented in Table 2-3.

The depth to groundwater within the borehole (BH06) was measured following drilling. Groundwater was measured at 0.68 m BGL (approximately RL 0.39 m). Due to the use of drilling fluids this groundwater level may be higher (i.e. closer to the surface) than in normal ambient conditions.

Table 2-3. Groundwater levels at Stuarts Point Site 1.

Borehole/ Piezometer ID	Easting	Northing	Groundwater Level (m BGL)	Groundwater Level (m RL)
BH05	499892.85	6591156.01	1.13	0.58
BH06	499877.37	6591609.44	0.68	0.39
BH07	499878.86	6592031.58	1.0	0.24

Notes:

Survey coordinates are given in terms of MGA 2020.

m BGL (metres below ground level)

RL (Relative Level).

Groundwater was not encountered during the ground investigation at Site 2.

2.7 Permeability Testing

2.7.1 Falling Head Tests

Falling head permeability tests were conducted in BH05 and BH07. The static water level was recorded and then a volume of water was added to the piezometers. After adding a volume of water, water levels were recorded using an electronic data logger until the water level had fully returned to its static level. The falling head test data has been analysed using the software AQTESOLV. The results are presented in Table 2-4 and the curve fitting plots are presented in Figure 2-3 and Figure 2-4.

Table 2-4: Results of Hydraulic Conductivity Testing (analysed using AQTESOLV).

Borehole/ Piezometer ID	Screened lithology	Static water level (m BGL)	Hydraulic Conductivity (m/s)
BH05	Fine SAND	1.13	2×10^{-05}
BH07	Fine to medium SAND	1.0	5×10^{-05}

Hydraulic conductivity has been analysed using the Bouwer-Rice solution

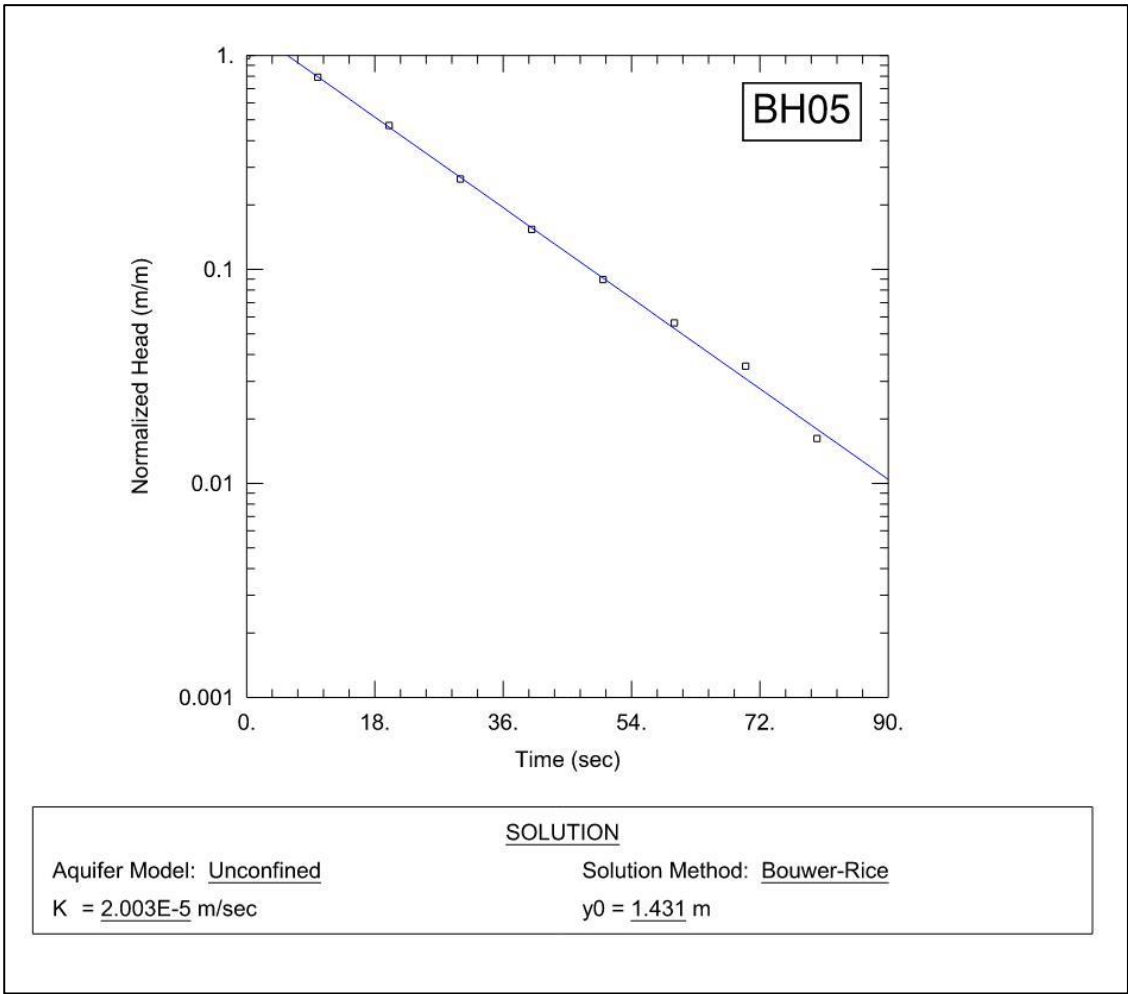


Figure 2-3: BH05 Hydraulic conductivity analysis.

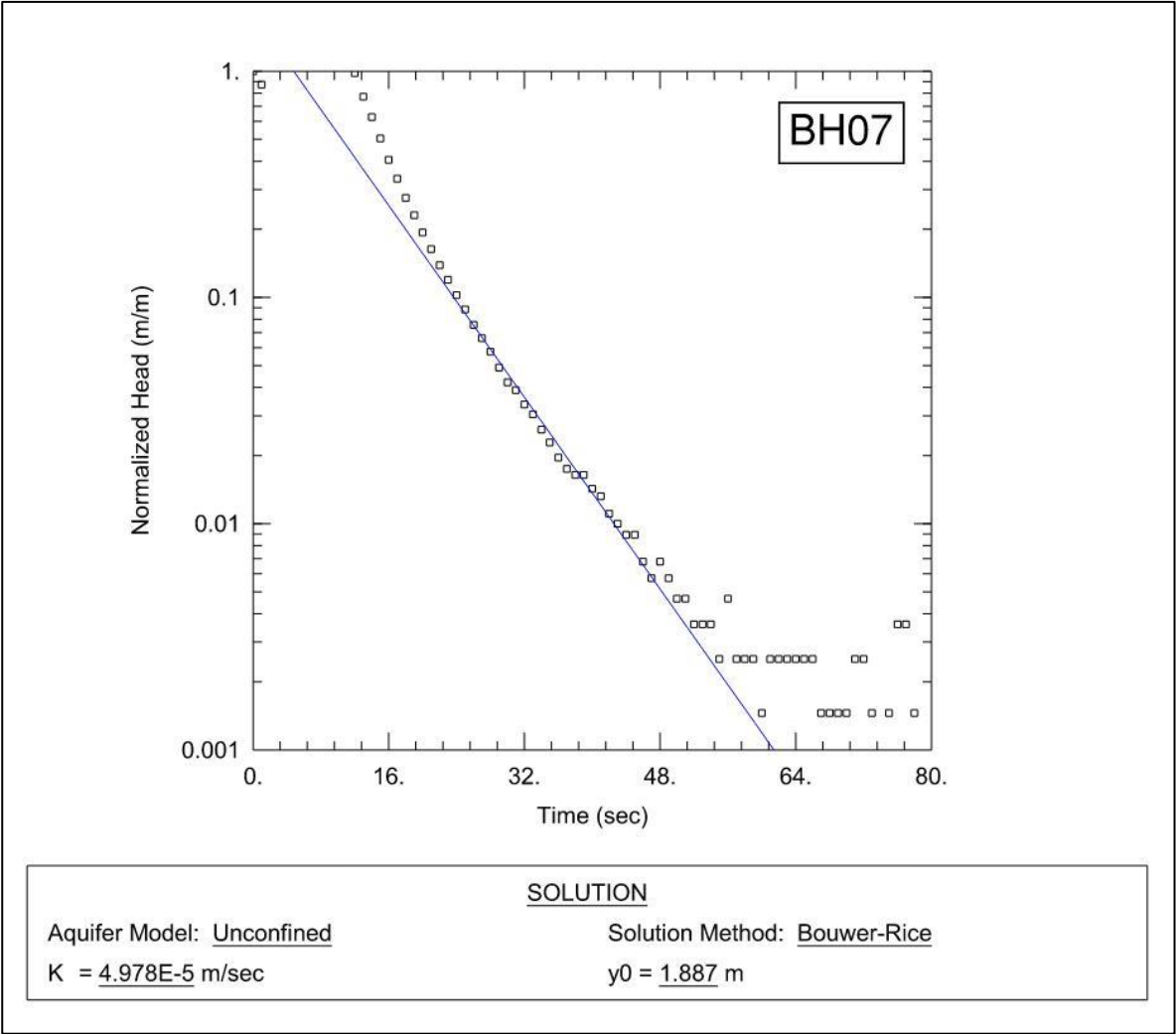


Figure 2-4: BH07 Hydraulic conductivity analysis.

2.8 Infiltration Testing

Infiltration tests were carried out in 8 locations at Site 1 and 4 locations at Site 2.

Each test involved filling a hole with fresh water from a 1,000 L IBC container to ~0.2 m of the surface. Each hole was 1.2 m deep and 100 m in diameter, with a 100 mm diameter perforated pipe installed to the base of the hole to hold it open and prevent the sand from collapsing. The perforated pipe had an open end at the base. The water level in each hole was maintained for ~1 hour by continuously pouring water into the hole, which is known as a ‘pre-soak.’ The presoak is intended to saturate the ground around the test hole immediately before the water supply is stopped and the infiltration test begins. Water level (head) is measured using an electronic logger and manual dipper as it decreases over time until it completely soaks away or returns to the pre-test static water level.

2.8.1 Site 1

Infiltration rates were generally high at Site 1, with an average infiltration rate of 1,985 mm/hour across all the infiltration tests, ranging from a minimum of 275 mm/hour to 6,000 mm/hour. The results of the infiltration testing at Site 1 are shown in Table 2-5 below.

Table 2-5: Results of infiltration tests at Site 1

Infiltration Test ID	Depth of hole (m)	Main lithology at base of test	Tested Infiltration Rate (mm/hour) (unfactored)
HA02	1.2	Fine to medium SAND	367
HA03	1.2	Fine to medium SAND	3,267
HA04	1.2	Fine to medium SAND	404
HA05	1.2	Fine to medium SAND	367
HA06	1.2	Fine to medium SAND (groundwater encountered at ~0.6 m BGL)	275
HA07	1.2	Fine to medium SAND	4,800
HA08	1.2	Fine to medium SAND	6,000
HA09	1.2	Fine to medium SAND	400

2.8.2 Site 2

Site 2 also indicated high infiltration rates, with an average of 7,911 mm/hour across all the infiltration tests, ranging from a minimum of 5,213 mm/hour to 11,637 mm/hour. The results of the infiltration testing at Site 2 locations are shown in Table 2-6 below.

Table 2-6: Results of infiltration testing at Site 2

Infiltration Test ID	Depth of hole (m)	Main lithology at base of test	Measured Infiltration Rate (mm/hour) (unfactored)
ITP01	1.2	Fine to medium SAND	8,039
ITP02	1.2	Fine to medium SAND	6,755
ITP03	1.2	Fine to medium SAND	11,637
ITP04	1.2	Fine to medium SAND	5,213

3 Lab Testing

Soil samples were taken at various depths in each borehole, with the intention to determine the particle size distribution (PSD) of the main stratigraphic units in each borehole. Samples taken within the upper 6 m of each borehole were from the machine auger cutting pile, and samples below 6 m were taken from mud rotary drill cuttings.

The testing was organised by Stratacore Ltd and carried out by Quality Geotechnical Services Limited (QGS). Only dry sieving was carried out and no hydrometer analysis for silts and clays.

The PSD results are included in Appendix D.

5 Applicability Statement

This report has been prepared by Beca on the specific instructions of Kempsey Shire Council (Client). It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above to which Beca has not given its prior written consent is at that own person's risk.

This is a factual report of field investigations and laboratory testing. The field investigations have been undertaken at discrete locations and no inferences about the nature and continuity of ground conditions away from the investigation locations are made. Furthermore, logs are provided presenting description of the soils and geology based on our observation of the samples recovered in the fieldwork and may not be truly representative of the actual underlying conditions.

No interpretation of the results has been made in this report. Should you be in any doubt as to the applicability of this report for the proposed development described herein, it is essential that you carry out independent investigations to satisfy your needs.

References

Beca, 2024. Stuarts Point WWTP Dunal Discharge Assessment Report RF 131124. Beca Limited.

Kempsey Shire Council (KSC). 2022. Topographical Survey of Stuarts Point: Drone-LIDAR and Photogrammetry. Aerial orthophoto and high-resolution 3D textured mesh model provided.

Kempsey Shire Council – Coastal Hazard Mapping (JBPacific, 2021) applied by Ramboll (Ramboll. 2024) to the project site.

Varcoe, Nation, Nunn, Terzaghi.n.d. Application of Modern Ground Investigation Techniques to Characterise Quaternary Sediments in Kempsey, NSW.

A

Appendix A – Borehole and Test Pit Logs

SOIL AND ROCK DESCRIPTIONS

Soil and Rock Descriptions are in general accordance with the Australian STANDARD AS 1726:2017.
Hand-held Vane Shear Strength measurements are in general accordance with the AS1289.

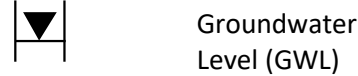
METHOD

BH	Machine Borehole
CPT	Cone Penetration Test
DCP	Dynamic Cone Penetration
HA	Hand Auger
SPT	Standard Penetration Test
IVAN	In-situ Vane Test
MA	Machine Auger
OB	Open Barrel
SNC	Sonic Core Drilling
TP	Test Pit/Trench
TT	Triple Tube
PT	Thin-walled Open Drive Tube
VE	Vacuum Excavation
W	Wash Boring

WEATHERING

RS	Residual Soil
XW	Extremely Weathered
HW	Highly Weathered
DW	Distinctly Weathered
MW	Moderately Weathered
SW	Slightly Weathered
FR	Fresh
SAMPLES	
B	Bulk Disturbed Sample
C	Core Sample
D	Small Disturbed Sample
PT	Thin-wall Open Drive (Push) Tube Sample

WATER



Groundwater
Level (GWL)

IN-SITU TESTS

Shear Vane	
Su	In-situ peak undrained shear strength and remoulded undrained shear strength
UTP	Unable to Penetrate
CB	Pilcon-type vane tested in Core Barrel
DH	Pilcon-type vane tested in-situ (downhole)
GV	Geonor vane, tested in-situ
IcV	Icove vane, tested in-situ
Standard Penetration Test (SPT)	
N	SPTn Sampler (Split-spoon)
Nc	SPTn Solid Cone
HB	SPT Hammer Bouncing

TERMINOLOGY

RL	Relative Ground Level
RQD	Rock Quality Designation

GRAPHIC LOG (1 or a combination of the following)



Clay



Silt



Sandstone
(SST)



Conglomerate



Fine Igneous



Gravel



Sand



Siltstone (ZST)



Limestone



Coarse Igneous



Shells



Organic
Material



Mudstone



Foliated
Metamorphic



Ignimbrite



Cobbles /
Boulders



Wood



Interbedded
SST & ZST



Asphalt



No Core

MONITORING INSTALLATION

Backfill Material



Sand



Grout



Bentonite



Gravel

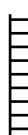


Cement Mixes

Standpipe



Plain



Slotted



Vibrating
Wire

SOIL CLASSIFICATION

Coarse Soils

GW	Gravel/gravel-sand mixture, little to no fines
GP	Gravel/gravel-sand mixture, little to no fines, uniform gravel
GM	Gravel-silt/gravel-silt-sand mixtures
GC	Gravel-clay/gravel-sand-clay mixtures
SW	Sand/gravel-sand mixtures, little to no fines
SP	Sand/gravel-sand mixtures, little to no fines
SM	Sand-silt mixtures
SC	Sand-clay mixtures

Fine Soils

ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity
CL, CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay
OL	Organic silt
MH	Inorganic silt
CH	Inorganic clay of high plasticity
OH	Organic clay of medium to high plasticity, organic silt
Pt	Peat, highly organic soil

Project:Stuarts Point WWTPOutlet

Site location:Southwest Rocks STP, NSW, Australia

Location:Site 1 on Macleay Arm Spit. At the southern end of disposal field.

Project number:3020134/310

Client:Kempsey Shire Council

Coordinate system:LOCAL

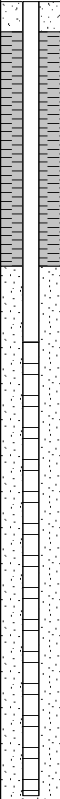
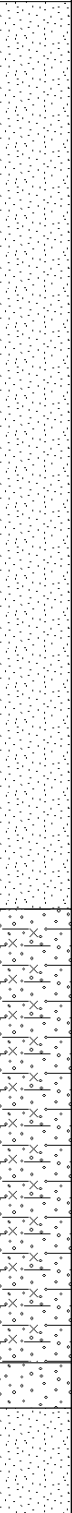
Vertical datum:AHD

Northing:6591156.0

Ground level (mRL): 1.71

Easting:499893.0

Location method:Surveyed

Installations	Drilling					In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	GWL	Fluid Return	Recovery Method	Casing	RQD	Su (kPa)	SPT						
										1.5		SP SAND, fine grained; yellow-brown; dry; marine.	Holocene Coastal Deposits
										0.5			
										1.0			
										0.5		1.15m: wet.	
										1.5			
										0.0			
										-0.5			
										-1.0			
										-1.5			
										-2.0			
										-2.5			
										-3.0			
										-3.5			
										-4.0			
										-4.5		GM/GC clayey silty GRAVEL, fine grained, angular, shell fragments and sandstone; grey; 40% clay/silt; wet.	
										-5.0			
										-5.5			
										-6.0			
										-6.5			
										-7.0			
										-7.5		GP GRAVEL, fine grained, angular, sandstone; grey; wet.	
										-8.0		SP SAND, fine grained; grey; wet.	

Date started:12/12/2024

Logged by:NJ

Vane ID:N/A

Vane type:N/A

Vane width:N/A

SPT No:N/A

SPT efficiency:N/A

Date end:12/12/2024

Drilled by:Stratacore Drilling Pty Ltd

Equipment:Massenza M14

Method:W/MA

Inclination:90°

Diameter:98mm

Fluid type:Polymer

Comments:

Soil description has been interpreted based on disturbed material recovered from machine auger and wash drill cuttings. Coordinates are shown in MGA94. Groundwater measured at 1.13 m below ground level on the 12/12/2024.

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. At the southern end of disposal field.	Coordinate system:	LOCAL
		Northing:	6591156.0
		Easting:	499893.0
		Vertical datum:	AHD
		Ground level (mRL):	1.71
		Location method:	Surveyed

Installations	Drilling					In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	GWL	Fluid Return	Recovery Method	Casing	ROD	Su (kPa)	SPT						

Date started:	12/12/2024	Date end:	12/12/2024	Comments: Soil description has been interpreted based on disturbed material recovered from machine auger and wash drill cuttings. Coordinates are shown in MGA94. Groundwater measured at 1.13 m below ground level on the 12/12/2024
Logged by:	NJ	Drilled by:	Stratacore Drilling Pty Ltd	
Vane ID:	N/A	Equipment:	Massenza M14	
Vane type:	N/A	Method:	W/MA	
Vane width:	N/A	Inclination:	90°	
SPT No:	N/A	Diameter:	98mm	
SPT efficiency:	N/A	Fluid type:	Polymer	

Project number:	3020134/310
Client:	Kempsey Shire Council
LOCAL	Vertical datum: AHD
6591156.0	Ground level (mRL): 1.71
499893.0	Location method: Surveyed

Holocene Coastal Deposits

Comments:
Soil description has been interpreted based on disturbed material recovered from machine auger and wash drill cuttings.
Coordinates are shown in MGA94.
Groundwater measured at 1.13 m below ground level on the 12/12/2024

For Explanation of Symbols and Abbreviations See Key Sheet

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. At the southern end of disposal field.	Coordinate system:	LOCAL
		Northing:	6591156.0
		Easting:	499893.0
		Vertical datum:	AHD
		Ground level (mRL):	1.71
		Location method:	Surveyed



Sample 1 (clayey silty GRAVEL) - 6.50mbgl to 7.50mbgl



Sample 2 (clayey silty GRAVEL) - 7.00mbgl to 9.50mbgl

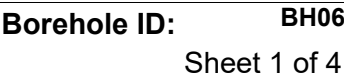
Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. At the southern end of disposal field.	Coordinate system:	LOCAL
		Northing:	6591156.0
		Easting:	499893.0
		Vertical datum:	AHD
		Ground level (mRL):	1.71
		Location method:	Surveyed



Sample 3 (SAND) - 9.50mbgl to 12.00mbgl



Sample 4 (silty CLAY, with sand) - 27.00mbgl to 30.00mbgl



Date started:	11/12/2024	Date end:	11/12/2024	Comments: Soil description has been interpreted based on disturbed material recovered from machine auger and wash drill cuttings. Coordinates are shown in MGA94. Groundwater measured at 0.68 m below ground level on the 11/12/2024. BH06 backfilled with quartz sand.
Logged by:	NJ	Drilled by:	Stratacore Drilling Pty Ltd	
Vane ID:	N/A	Equipment:	Massenza M14	
Vane type:	N/A	Method:	W/PT/MA	
Vane width:	N/A	Inclination:	90°	
SPT No:	N/A	Diameter:	98mm	
SPT efficiency:	N/A	Fluid type:	Polymer	

For Explanation of Symbols and Abbreviations See Key Sheet

Project:

Stuarts Point WWTP

Site location:

Southwest Rocks STP, NSW, Australia

Location:

Site 1 on Macleay Arm Spit. In the center of disposal field.

Project number:

3020134/310

Client:

Kempsey Shire Council

Coordinate system:

LOCAL

Vertical datum:

AHD

Northing:

6591609.0

Ground level (mRL):

1.07

Easting:

499877.0

Location method:

Surveyed

Drilling						In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
GWL	Fluid Return	Recovery	Method	Casing	RQD	Su (kPa)	SPT						
												SP SAND, fine grained; yellow-brown; moist; marine.	Holocene Coastal Deposits
												SC Clayey SAND with gravel, fine grained; grey; 30% clay, high plasticity; 20% gravel, fine to coarse grained, angular, shell fragments; wet; marine.	Holocene Coastal Deposits
												CH CLAY, high plasticity; yellow; wet.	Holocene Coastal Deposits
												SW Gravelly SAND with silt and clay, fine to coarse grained; grey; 20% clay/silt.	Holocene Coastal Deposits

For Explanation of Symbols and Abbreviations See Key Sheet

Project:

Site location:

Location:

Stuarts Point WWTP

Southwest Rocks STP, NSW, Australia

Site 1 on Macleay Arm Spit. In the center of disposal field.

Project number:

Client:

Coordinate system:

Northing:

Easting:

3020134/310

Kempsey Shire Council

LOCAL

6591609.0

499877.0

Vertical datum:

Ground level (mRL):

Location method:

AHD

1.07

Surveyed

Drilling						In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
GWL	Fluid Return	Recovery	Method	Casing	RQD	Su (kPa)	SPT						
												30.00m - End of Borehole, terminated at target depth.	
									30.5	-29.5			
									31.0	-30.0			
									31.5	-30.5			
									32.0	-31.0			
									32.5	-31.5			
									33.0	-32.0			
									33.5	-32.5			
									34.0	-33.0			
									34.5	-33.5			
									35.0	-34.0			
									35.5	-34.5			
									36.0	-35.0			
									36.5	-35.5			
									37.0	-36.0			
									37.5	-36.5			
									38.0	-37.0			
									38.5	-37.5			
									39.0	-38.0			
									39.5	-38.5			

Date started:

Logged by:

Vane ID:

Vane type:

Vane width:

SPT No:

SPT efficiency:

11/12/2024

NJ

N/A

N/A

N/A

N/A

N/A

Date end:

Drilled by:

Equipment:

Method:

Inclination:

Diameter:

Fluid type:

11/12/2024

Stratacore Drilling Pty Ltd

Massenza M14

W/PT/MA

90°

98mm

Polymer

Comments:

Soil description has been interpreted based on disturbed material recovered from machine auger and wash drill cuttings. Coordinates are shown in MGA94. Groundwater measured at 0.68 m below ground level on the 11/12/2024. BH06 backfilled with quartz sand.

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. In the center of disposal field.	Coordinate system:	LOCAL
		Vertical datum:	AHD
		Ground level (mRL):	1.07
		Location method:	Surveyed
		Northing:	6591609.0
		Easting:	499877.0



Sample 1 (SAND) - 0.00mbgl to 7.00mbgl



Sample 2 (fibrous tree root) - 7.00mbgl to 7.30mbgl

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. In the center of disposal field.	Coordinate system:	LOCAL
		Northing:	6591609.0
		Easting:	499877.0
		Vertical datum:	AHD
		Ground level (mRL):	1.07
		Location method:	Surveyed



Sample 3 (gravelly SAND, with silt and clay) - 19.50mbgl to 30.00mbgl

For Explanation of Symbols and Abbreviations See Key Sheet

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. At the northern end of disposal field.	Coordinate system:	LOCAL
		Northing:	6592031.0
		Easting:	499878.0
		Vertical datum:	AHD
		Ground level (mRL):	1.24
		Location method:	Surveyed

Installations	Drilling					In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit	
	GWL	Fluid Return	Recovery	Method	Casing	ROD	Su (kPa)							SPT

Date started:	09/12/2024	Date end:	09/12/2024	Comments: Soil description has been interpreted based on disturbed material recovered from machine auger and wash drill cuttings. Coordinates are shown in MGA94. Groundwater measured at 1.0 m bgl on the 9/12/2024.
Logged by:	NJ	Drilled by:	Stratacore Drilling Pty Ltd	
Vane ID:	N/A	Equipment:	Massenza M14	
Vane type:	N/A	Method:	W/MA	
Vane width:	N/A	Inclination:	90°	
SPT No:	N/A	Diameter:	98mm	
SPT efficiency:	N/A	Fluid type:	Polymer	

Project number:	3020134/310
Client:	Kempsey Shire Council
LOCAL	Vertical datum: AHD
6592031.0	Ground level (mRL): 1.24
499878.0	Location method: Surveyed

Holocene Coastal Deposits

Comments:
Soil description has been interpreted based on disturbed material recovered from machine auger and wash drill cuttings.
Coordinates are shown in MGA94.
Groundwater measured at 1.0 m bgl on the 9/12/2024.

For Explanation of Symbols and Abbreviations See Key Sheet

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. At the northern end of disposal field.	Coordinate system:	LOCAL
		Northings:	6592031.0
		Easting:	499878.0
		Vertical datum:	AHD
		Ground level (mRL):	1.24
		Location method:	Surveyed



Sample 1 (SAND) - 0.00mbgl to 15.50mbgl



Sample 2 (Clay) - 15.50mbgl to 17.50mbgl

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. At the northern end of disposal field.	Coordinate system:	LOCAL
		Vertical datum:	AHD
		Ground level (mRL):	1.24
		Location method:	Surveyed
		Northings:	6592031.0
		Eastings:	499878.0



Sample 3 (Clayey SAND) - 17.50mbgl to 23.00mbgl

Project:	Stuarts Point WWTP	Project Number:	3020134/310
Site Location:	Southwest Rocks STP, NSW, Australia	Client:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. Adjacent to BH05 at the southern end of the disposal field.	Coordinate System: LOCAL	Vertical Datum:
		Northing: 6591105.0	Ground level (mRL):
		Easting: 499919.0	Location Method: Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine grained; yellow-brown; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.2	-1.2		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:	12/12/2024	Vane ID:	N/A	Comments: The material description for HA02 is derived from BH05.
Logged By:	NJ	Vane Width:	N/A	
Diameter:	100mm	Vane Type:	N/A	

Project:Stuarts Point WWTP

Site Location:Southwest Rocks STP, NSW, Australia

Location:Site 1 on Macleay Arm Spit. Adjacent to BH05 at the southern end of the disposal field.

Project Number:3020134/310

Client:Kempsey Shire Council

Coordinate System:LOCAL

Vertical Datum:Ground level (mRL):

Northing:6591208.0

Easting:499923.0

Location Method:Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine grained; yellow-brown; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.2	-1.2		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:12/12/2024

Logged By:NJ

Diameter:100mm

Vane ID:N/A

Vane Width:N/A

Vane Type:N/A

Comments:

The material description for HA03 is derived from BH05.

Project:Stuarts Point WWTP

Site Location:Southwest Rocks STP, NSW, Australia

Location:Site 1 on Macleay Arm Spit. Adjacent to BH06 in the center of the disposal field.

Project Number:3020134/310

Client:Kempsey Shire Council

Coordinate System:LOCAL

Vertical Datum:

Northing:6591544.0

Ground level (mRL):

Easting:499907.0

Location Method:Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine grained; yellow-brown; moist; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.2	-1.2		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:10/12/2024

Logged By:NJ

Diameter:100mm

Vane ID:N/A

Vane Width:N/A

Vane Type:N/A

Comments:

The material description for HA04 is derived from BH06.

Project:Stuarts Point WWTP

Site Location:Southwest Rocks STP, NSW, Australia

Location:Site 1 on Macleay Arm Spit. Adjacent to BH05 in the center of the disposal field.

Project Number:3020134/310

Client:Kempsey Shire Council

Coordinate System:LOCAL

Vertical Datum:

Northing:6591669.0

Ground level (mRL):

Easting:499907.0

Location Method:Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine grained; yellow-brown; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.2	-1.2	1.20m - End of hand auger, terminated at target depth.		
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:10/12/2024

Logged By:NJ

Diameter:100mm

Vane ID:N/A

Vane Width:N/A

Vane Type:N/A

Comments:

The material description for HA05 is derived from BH05.

Project:Stuarts Point WWTP

Site Location:Southwest Rocks STP, NSW, Australia

Location:Site 1 on Macleay Arm Spit. Adjacent to BH07 at the northern end of the disposal field.

Project Number:3020134/310

Client:Kempsey Shire Council

Coordinate System:LOCAL

Vertical Datum:

Northing:6592012.0

Ground level (mRL):

Easting:499905.0

Location Method:Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine to medium grained; pale yellow; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.2	-1.2		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:09/12/2024

Logged By:NJ

Diameter:100mm

Vane ID:N/A

Vane Width:N/A

Vane Type:N/A

Comments:

The material description for HA06 is derived from BH07.

Project:Stuarts Point WWTP

Site Location:Southwest Rocks STP, NSW, Australia

Location:Site 1 on Macleay Arm Spit. Adjacent to BH07 at the northern end of the disposal field.

Project Number:3020134/310

Client:Kempsey Shire Council

Coordinate System:LOCAL

Vertical Datum:

Northing:6592016.0

Ground level (mRL):

Easting:499836.0

Location Method:Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine to medium grained; pale yellow; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.20	-1.20		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:09/12/2024

Logged By:NJ

Diameter:100mm

Vane ID:N/A

Vane Width:N/A

Vane Type:N/A

Comments:

The material description for HA07 is derived from BH07.

Project:	Stuarts Point WWTP	Project Number:	3020134/310
Site Location:	Southwest Rocks STP, NSW, Australia	Client:	Kempsey Shire Council
Location:	Site 1 on Macleay Arm Spit. Adjacent to BH05 in the center of the disposal field.	Coordinate System: LOCAL	Vertical Datum:
		Northing: 6591607.0	Ground level (mRL):
		Easting: 499823.0	Location Method: Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine grained; yellow-brown; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.2	-1.2		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:	10/12/2024	Vane ID:	N/A	Comments: The material description for HA08 is derived from BH05.
Logged By:	NJ	Vane Width:	N/A	
Diameter:	100mm	Vane Type:	N/A	

Project: Stuarts Point WWTP

Site Location: Southwest Rocks STP, NSW, Australia

Location: Site 1 on Macleay Arm Spit. Adjacent to BH05 at the southern end of the disposal field.

Project Number: 3020134/310

Client: Kempsey Shire Council

Coordinate System: LOCAL

Vertical Datum: Ground level (mRL):

Northing: 6591146.0

Easting: 499833.0

Location Method: Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine grained; yellow-brown; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.2	-1.2		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started: 12/12/2024

Logged By: NJ

Diameter: 100mm

Vane ID: N/A

Vane Width: N/A

Vane Type: N/A

Comments:

The material description for HA09 is derived from BH05.

Project:	Stuarts Point WWTP	Project Number:	3020134/310
Site Location:	Southwest Rocks STP, NSW, Australia	Client:	Kempsey Shire Council
Location:	Site 2 - 120 m south of Nineteenth Ave, Stuarts Point Township.	Coordinate System:	LOCAL
		Northing:	6589314.0
		Easting:	499072.0
		Vertical Datum:	Ground level (mRL):
		Location Method:	Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine to medium grained; pale grey; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.2	-1.2		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:	13/12/2024	Vane ID:	N/A	Comments:
Logged By:	NJ	Vane Width:	N/A	The material description for HA09 is derived from BH07.
Diameter:	100mm	Vane Type:	N/A	Groundwater not encountered.

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 2 - 120 m south of Nineteenth Ave, Stuarts Point Township.	Coordinate system:	LOCAL
		Northing:	6589314.0
		Easting:	499072.0
		Vertical datum:	
		Ground level (mRL):	
		Location method:	Surveyed



Test Pit - 0.00mbgl to 1.20mbgl

Project:	Stuarts Point WWTP	Project Number:	3020134/310
Site Location:	Southwest Rocks STP, NSW, Australia	Client:	Kempsey Shire Council
Location:	Site 2 - 200 m south of Nineteenth Ave, Stuarts Point Township.	Coordinate System: LOCAL	Vertical Datum:
		Northing: 6589201.0	Ground level (mRL):
		Easting: 499189.0	Location Method: Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine to medium grained; pale yellow; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.20	-1.20		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:	13/12/2024	Vane ID:	N/A	Comments:	
Logged By:	NJ	Vane Width:	N/A		The material description for HA09 is derived from BH07.
Diameter:	100mm	Vane Type:	N/A		Groundwater not encountered.

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 2 - 200 m south of Nineteenth Ave, Stuarts Point Township.	Coordinate system:	LOCAL
		Northing:	6589201.0
		Easting:	499189.0
		Vertical datum:	
		Ground level (mRL):	
		Location method:	Surveyed



Test Pit - 0.00mbgl to 1.20mbgl

Project:Stuarts Point WWTP

Site Location:Southwest Rocks STP, NSW, Australia

Location:Site 2- 300 m south of Nineteenth Ave, Stuarts Point Township.

Project Number:3020134/310

Client:Kempsey Shire Council

Coordinate System:LOCAL

Vertical Datum:

Northing:6589144.0

Ground level (mRL):

Easting:499069.0

Location Method:Surveyed

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine to medium grained; pale grey; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.20	-1.20		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:13/12/2024

Logged By:NJ

Diameter:100mm

Vane ID:N/A

Vane Width:N/A

Vane Type:N/A

Comments:

The material description for HA09 is derived from BH07.

Groundwater not encountered.

Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 2- 300 m south of Nineteenth Ave, Stuarts Point Township.	Coordinate system:	LOCAL
		Northing:	6589144.0
		Easting:	499069.0
		Vertical datum:	
		Ground level (mRL):	
		Location method:	Surveyed



Test Pit - 0.00mbgl to 1.20mbgl

Project:	Stuarts Point WWTP	Project Number:	3020134/310
Site Location:	Southwest Rocks STP, NSW, Australia	Client:	Kempsey Shire Council
Location:	Site 2 - 400 m south of Nineteenth Ave, Stuarts Point Township.	Coordinate System: LOCAL	Vertical Datum:
		Northing: 6588951.0	Ground level (mRL):
		Easting: 499095.0	Location Method:

Groundwater (m)	In Situ Tests		Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
	Su (kPa)	Scala blows/50mm						
				0.5	-0.5		SP SAND, fine to medium grained; pale yellow; dry; marine.	Holocene Coastal Deposits
				1.0	-1.0			
				1.2	-1.2		1.20m - End of hand auger, terminated at target depth.	
				1.5	-1.5			
				2.0	-2.0			
				2.5	-2.5			
				3.0	-3.0			
				3.5	-3.5			
				4.0	-4.0			
				4.5	-4.5			

Date Started:	13/12/2024	Vane ID:	N/A	Comments:	
Logged By:	NJ	Vane Width:	N/A		The material description for HA09 is derived from BH07.
Diameter:	100mm	Vane Type:	N/A		Groundwater not encountered.

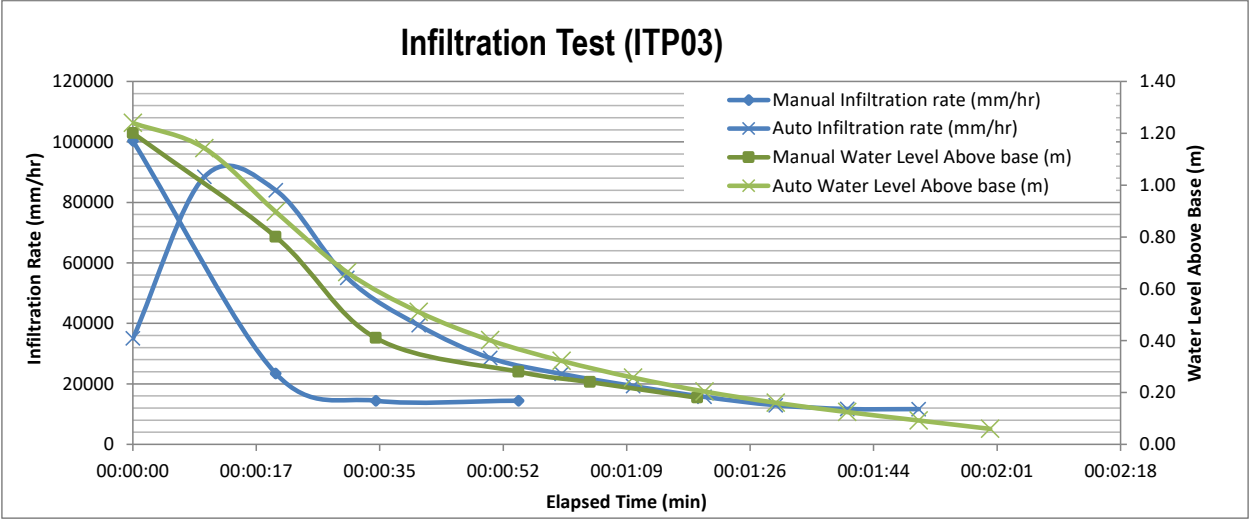
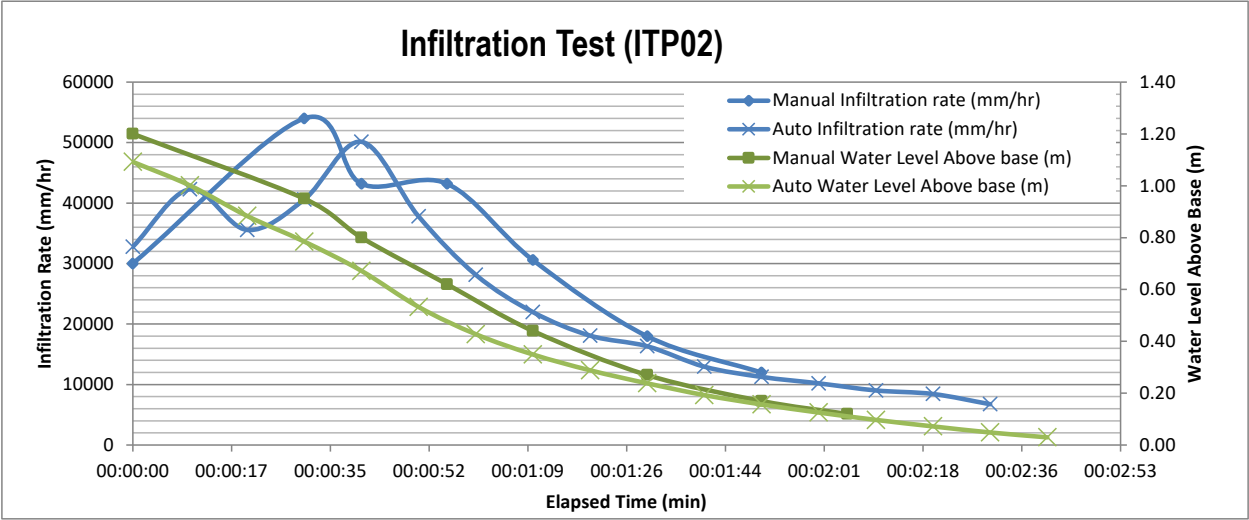
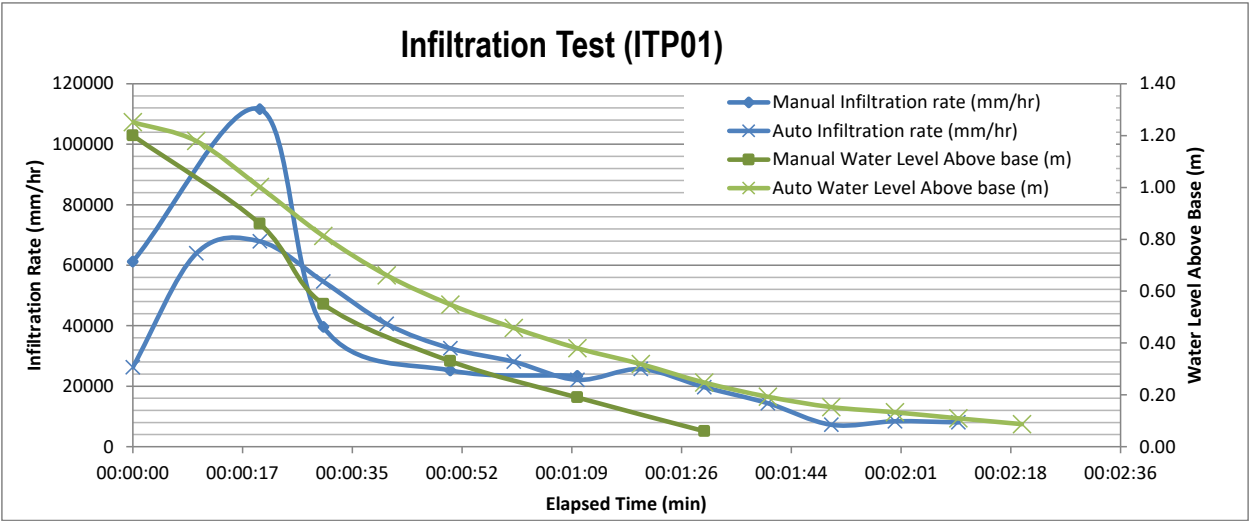
Project:	Stuarts Point WWTP	Project number:	3020134/310
Site location:	Southwest Rocks STP, NSW, Australia	Client Name:	Kempsey Shire Council
Location:	Site 2 - 400 m south of Nineteenth Ave, Stuarts Point Township.	Coordinate system:	LOCAL
		Northing:	6588951.0
		Easting:	499095.0
		Vertical datum:	
		Ground level (mRL):	
		Location method:	

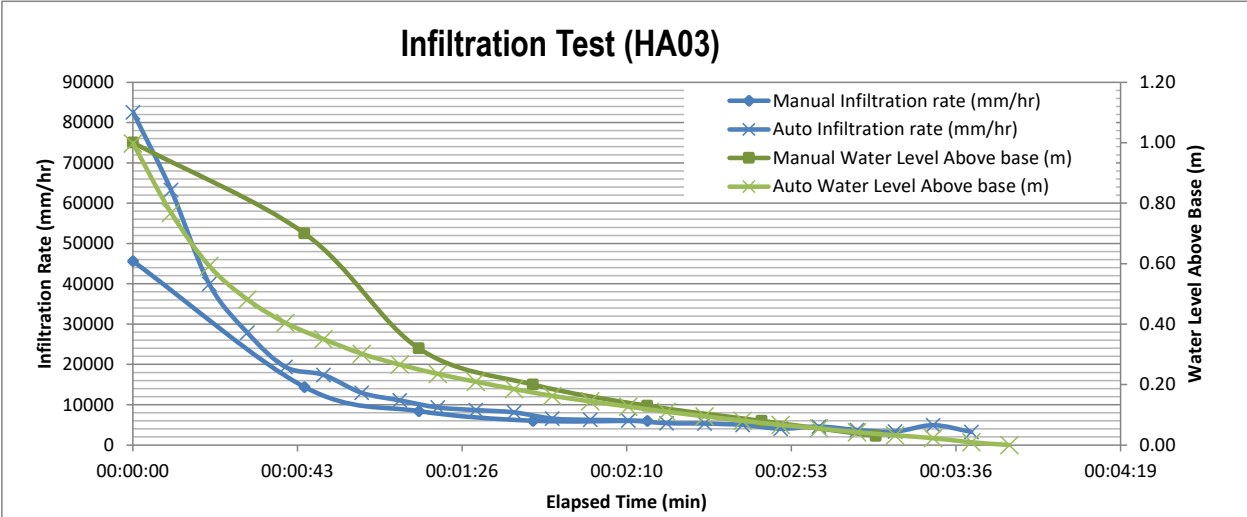
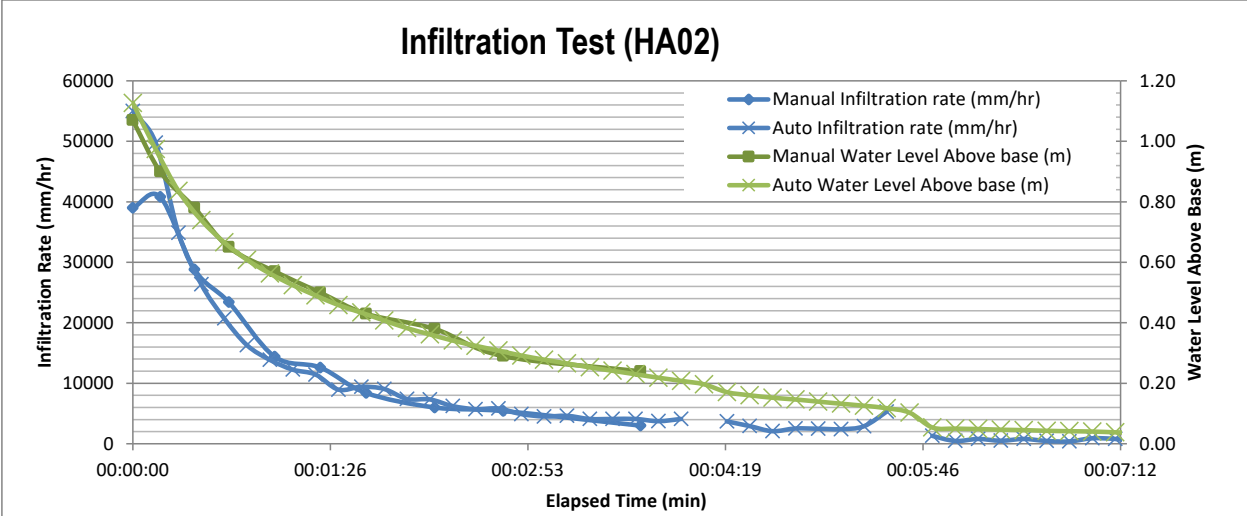
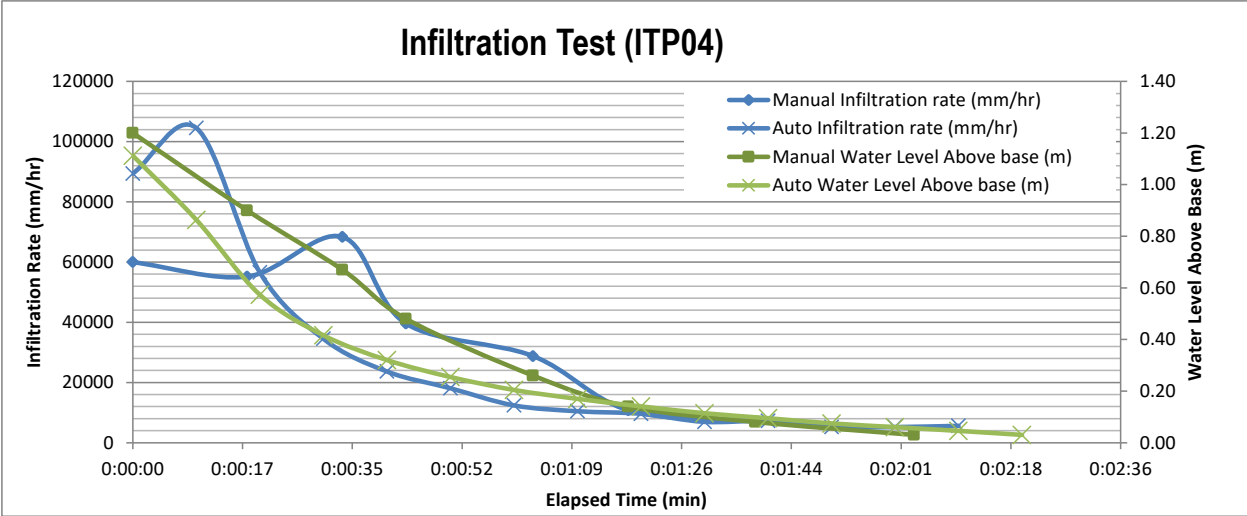


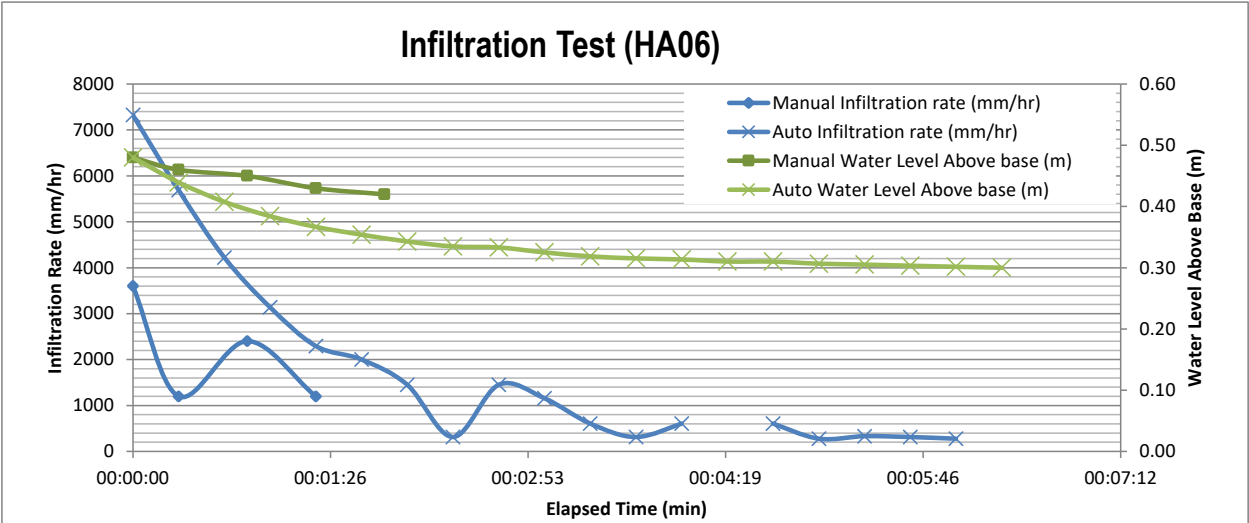
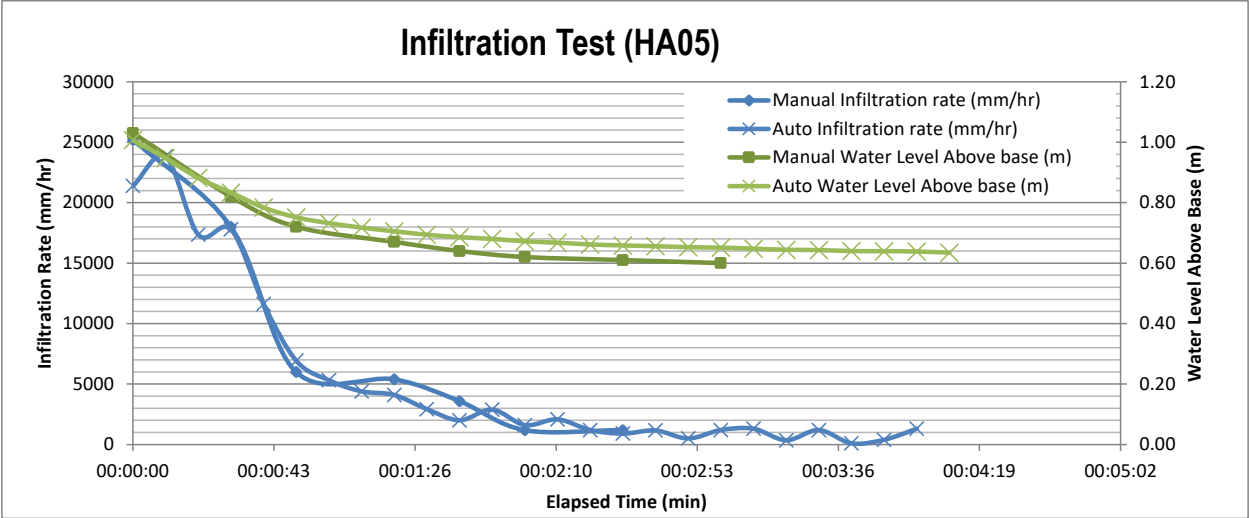
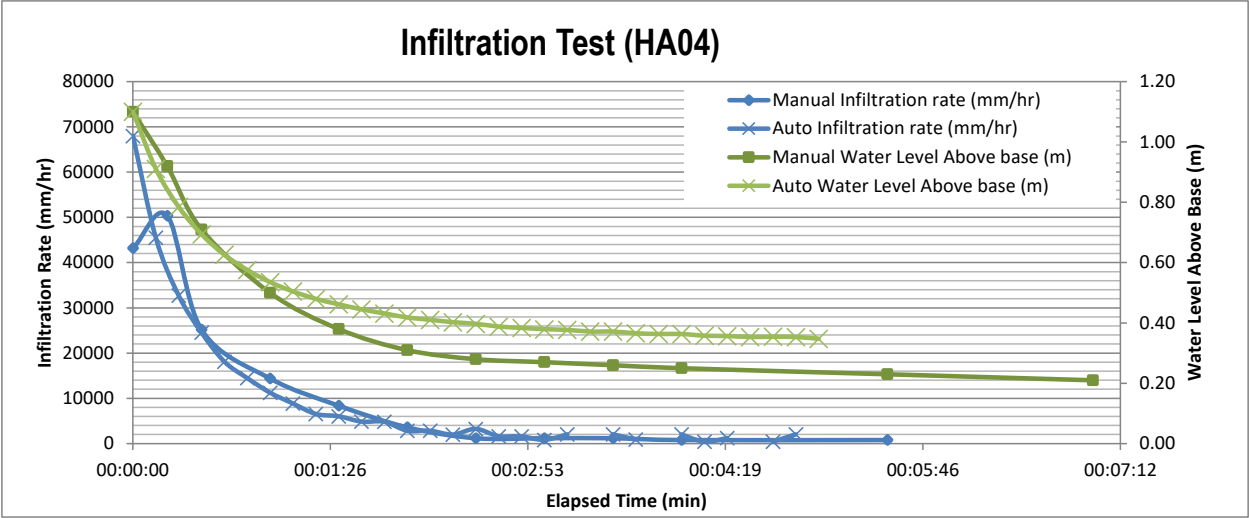
Test Pit - 0.00mbgl to 0.40mbgl

B

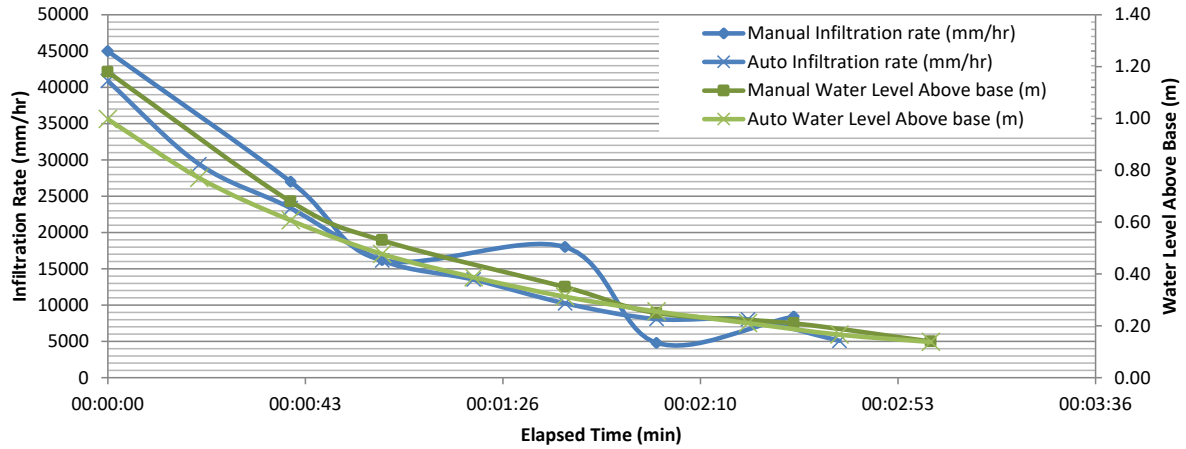
Appendix B – Infiltration Test Results



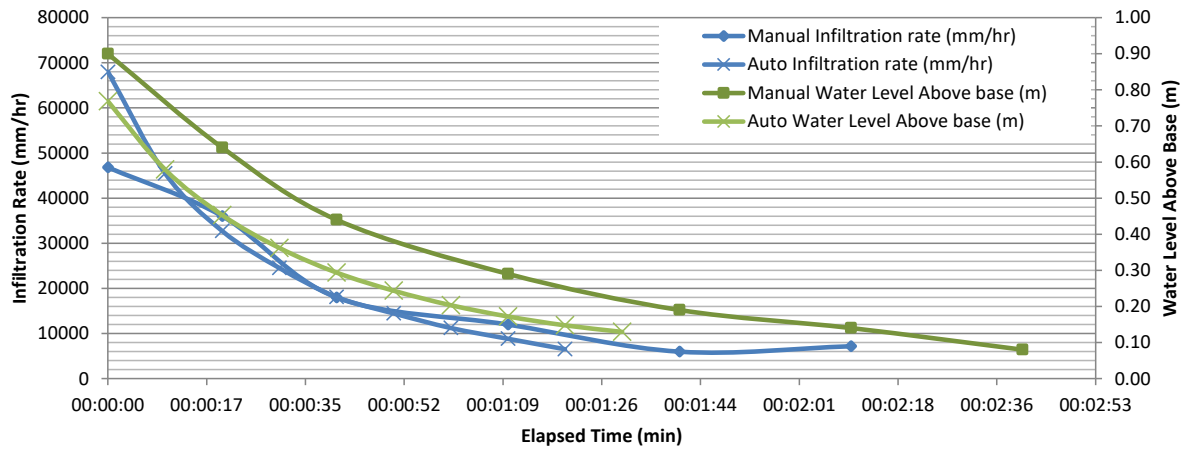




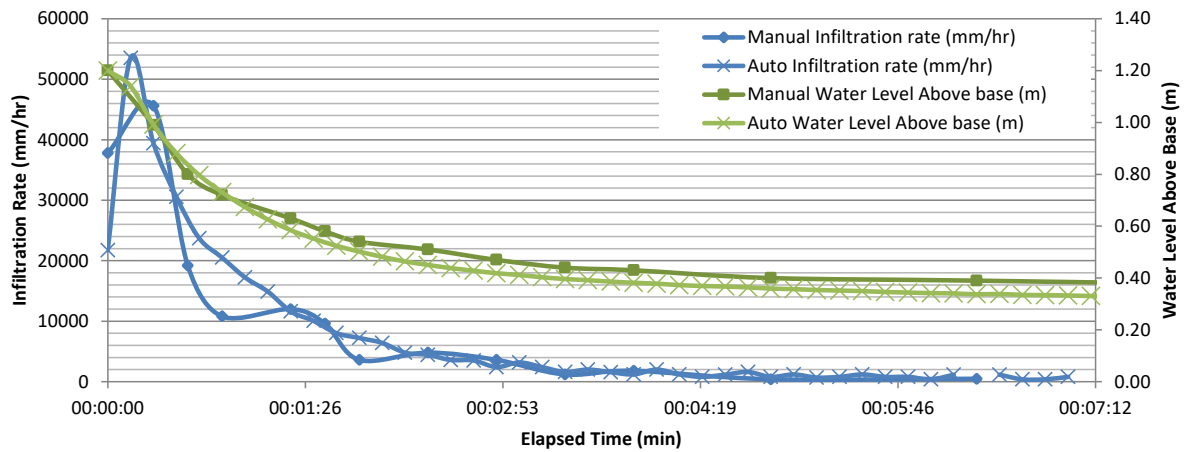
Infiltration Test (HA07)



Infiltration Test (HA08)

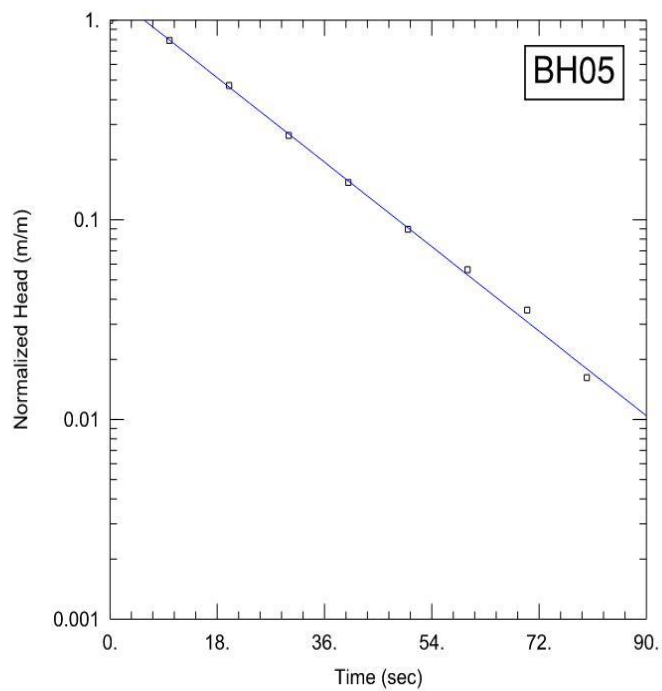


Infiltration Test (HA09)



C

Appendix C – Piezometer Falling Head Test Results



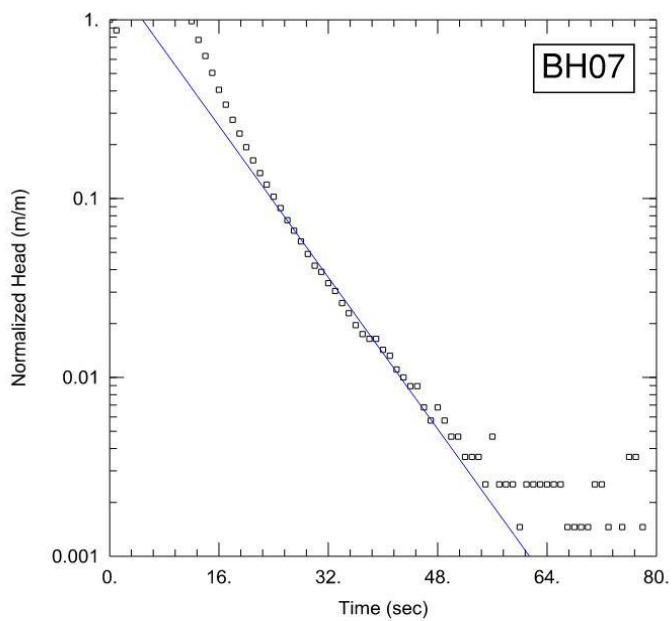
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bouwer-Rice

K = 2.003E-5 m/sec

y0 = 1.431 m



SOLUTION

Aquifer Model: Unconfined

Solution Method: Bouwer-Rice

K = 4.978E-5 m/sec

y0 = 1.887 m

D

Appendix D – PSD Results

Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045A
Date Sampled: 12/12/2024
Dates Tested: 08/01/2025 - 14/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH5 (15-25m)
Material: Refer to Client logs



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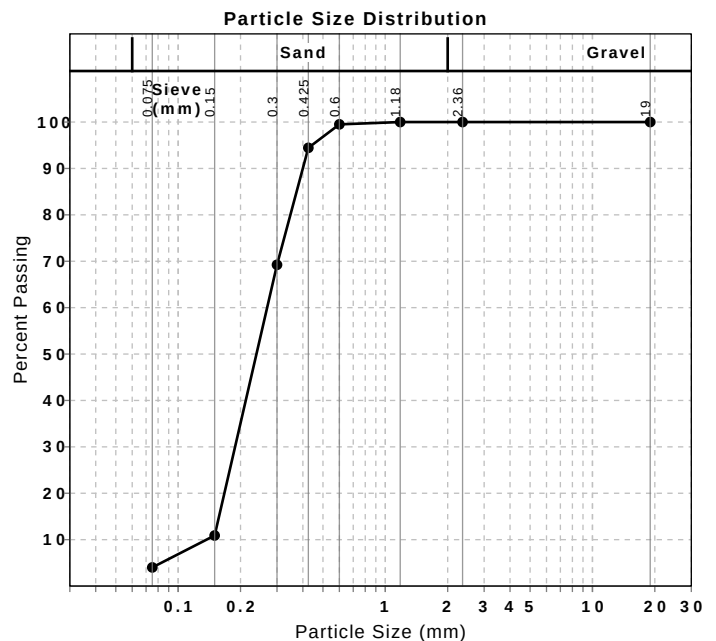


Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)					
Sieve	Passed %	Passing Limits	Retained %	Retained Limits	
19 mm	100		0		
2.36 mm	100		0		
1.18 mm	100		0		
0.6 mm	100		0		
0.425 mm	94		5		
0.3 mm	69		25		
0.15 mm	11		58		
0.075 mm	4		7		



Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045B
Date Sampled: 12/12/2024
Dates Tested: 08/01/2025 - 14/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH5 (0-6m)
Material: Refer to Client logs



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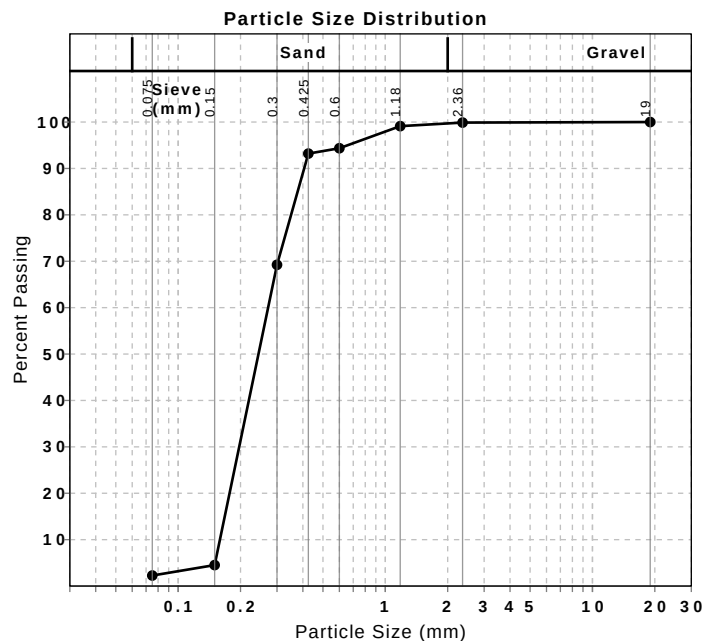


Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)				
Sieve	Passed %	Passing Limits	Retained %	Retained Limits
19 mm	100		0	
2.36 mm	100		0	
1.18 mm	99		1	
0.6 mm	94		5	
0.425 mm	93		1	
0.3 mm	69		24	
0.15 mm	5		65	
0.075 mm	2		2	



Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045C
Date Sampled: 09/12/2024
Dates Tested: 08/01/2025 - 14/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH7 (15.5-23m)
Material: Refer to Client logs



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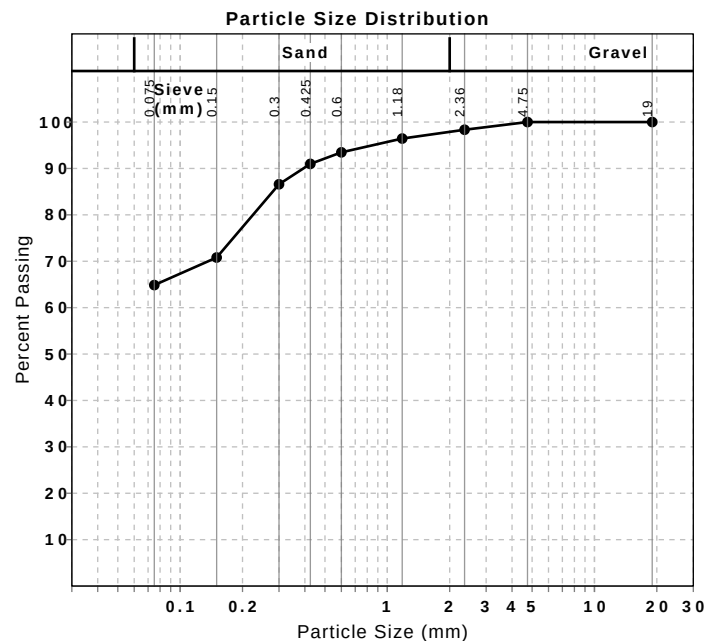


Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)				
Sieve	Passed %	Passing Limits	Retained %	Retained Limits
19 mm	100		0	
4.75 mm	100		0	
2.36 mm	98		2	
1.18 mm	96		2	
0.6 mm	93		3	
0.425 mm	91		2	
0.3 mm	87		4	
0.15 mm	71		16	
0.075 mm	65		6	



Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045D
Date Sampled: 11/12/2024
Dates Tested: 08/01/2025 - 14/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH6 (19.5-30m)
Material: Refer to Client logs



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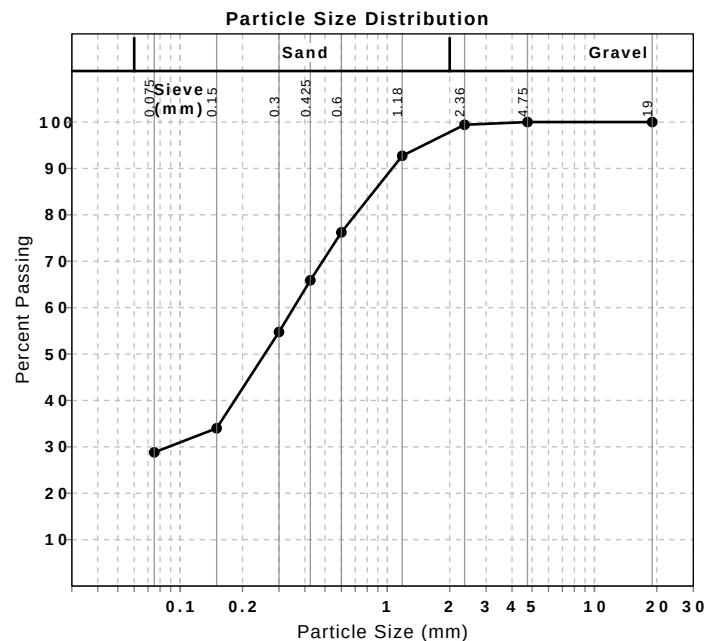


Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)				
Sieve	Passed %	Passing Limits	Retained %	Retained Limits
19 mm	100		0	
4.75 mm	100		0	
2.36 mm	99		1	
1.18 mm	93		7	
0.6 mm	76		16	
0.425 mm	66		10	
0.3 mm	55		11	
0.15 mm	34		21	
0.075 mm	29		5	



Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045E
Date Sampled: 11/12/2024
Dates Tested: 08/01/2025 - 14/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH6 (9.5-13)
Material: Refer to Client logs



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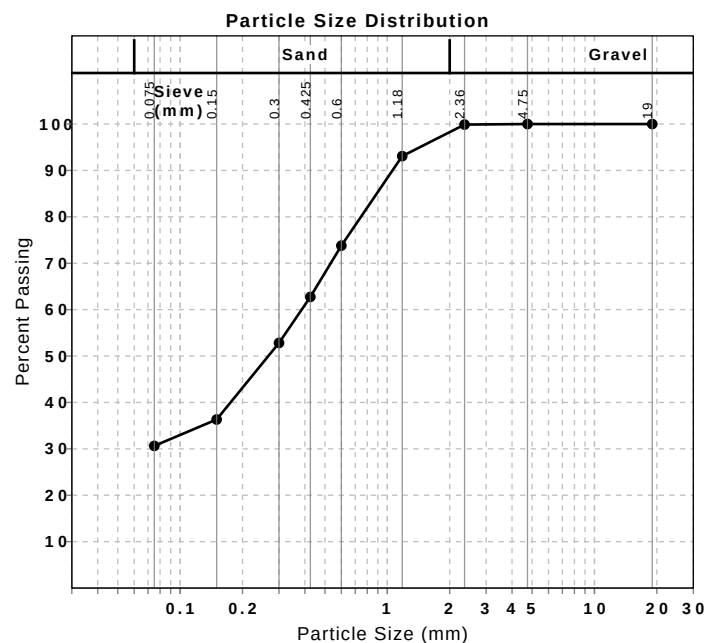


Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)				
Sieve	Passed %	Passing Limits	Retained %	Retained Limits
19 mm	100		0	
4.75 mm	100		0	
2.36 mm	100		0	
1.18 mm	93		7	
0.6 mm	74		19	
0.425 mm	63		11	
0.3 mm	53		10	
0.15 mm	36		17	
0.075 mm	31		6	



Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045F
Date Sampled: 11/12/2024
Dates Tested: 08/01/2025 - 14/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH6 (0-6m)
Material: Refer to Client logs



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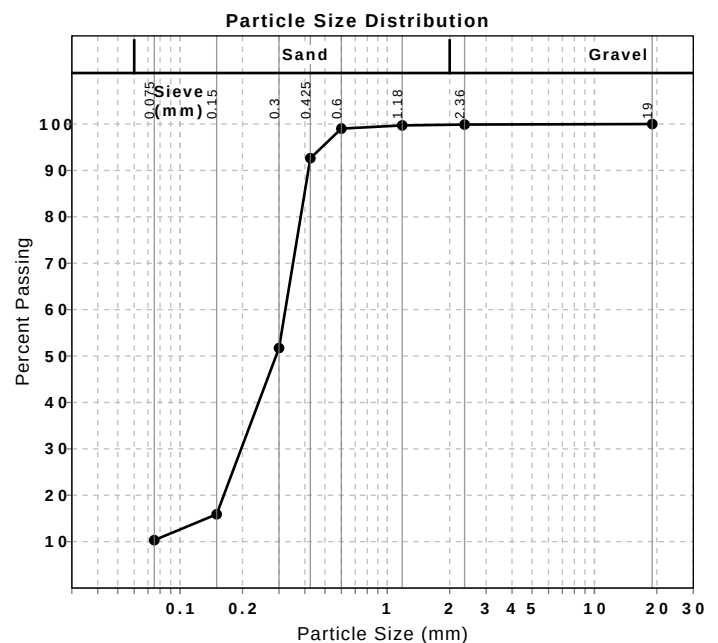


Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)					
Sieve	Passed %	Passing Limits	Retained %	Retained Limits	
19 mm	100		0		
2.36 mm	100		0		
1.18 mm	100		0		
0.6 mm	99		1		
0.425 mm	93		6		
0.3 mm	52		41		
0.15 mm	16		36		
0.075 mm	10		6		



Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045G
Date Sampled: 12/12/2024
Dates Tested: 08/01/2025 - 14/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH5 (12m)
Material: Refer to Client logs



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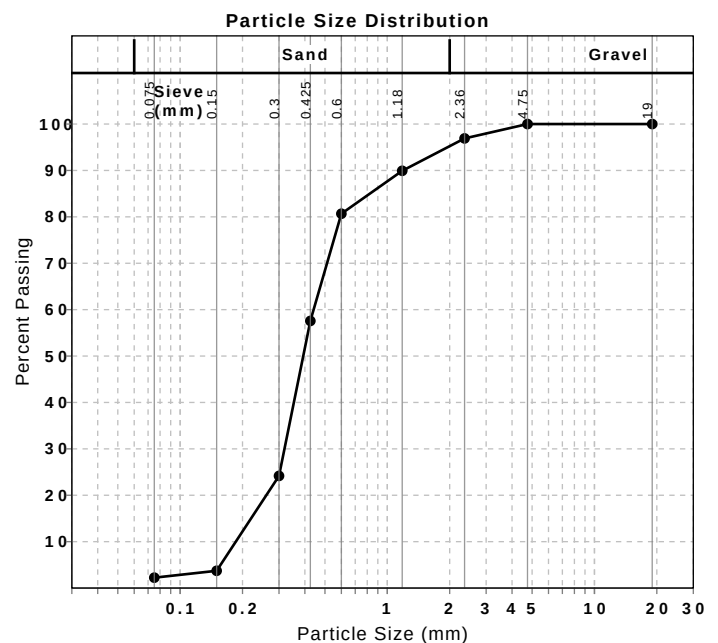
Steve Waugh

Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)					
Sieve	Passed %	Passing Limits	Retained %	Retained Limits	
19 mm	100		0		
4.75 mm	100		0		
2.36 mm	97		3		
1.18 mm	90		7		
0.6 mm	81		9		
0.425 mm	58		23		
0.3 mm	24		33		
0.15 mm	4		20		
0.075 mm	2		1		



Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045H
Date Sampled: 12/12/2024
Dates Tested: 08/01/2025 - 15/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH6 (18m)
Material: Refer to Client logs



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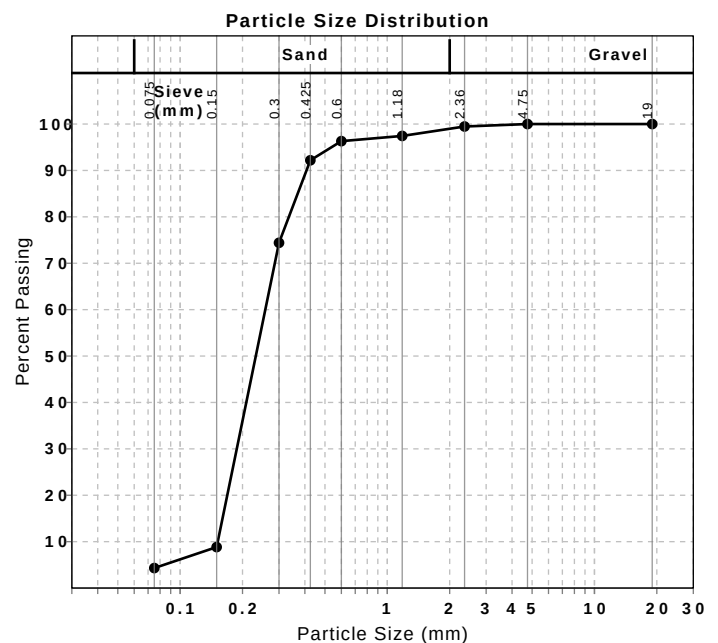


Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)				
Sieve	Passed %	Passing Limits	Retained %	Retained Limits
19 mm	100		0	
4.75 mm	100		0	
2.36 mm	99		1	
1.18 mm	97		2	
0.6 mm	96		1	
0.425 mm	92		4	
0.3 mm	74		18	
0.15 mm	9		66	
0.075 mm	4		5	



Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045I
Date Sampled: 10/12/2024
Dates Tested: 08/01/2025 - 16/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH7 (24m)
Material: Refer to Client logs



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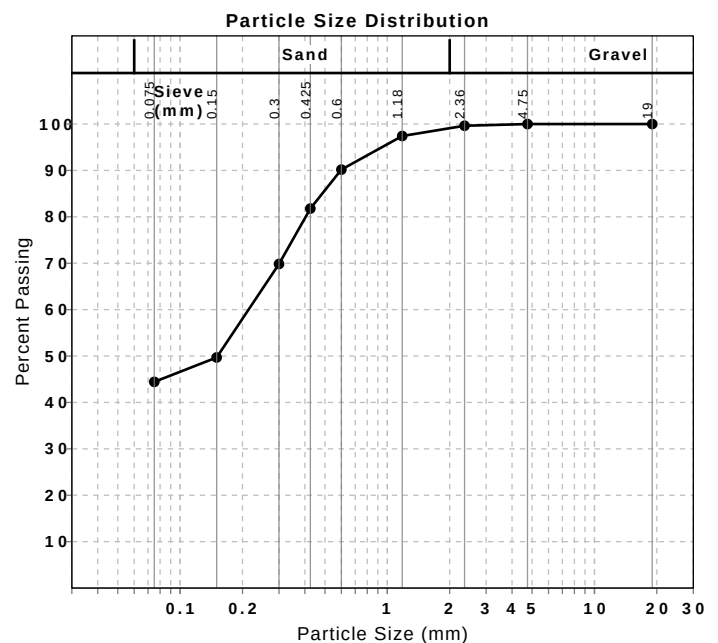


Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)				
Sieve	Passed %	Passing Limits	Retained %	Retained Limits
19 mm	100		0	
4.75 mm	100		0	
2.36 mm	100		0	
1.18 mm	97		2	
0.6 mm	90		7	
0.425 mm	82		8	
0.3 mm	70		12	
0.15 mm	50		20	
0.075 mm	44		5	



Material Test Report

Report Number: SC25359-1
Issue Number: 1
Date Issued: 17/01/2025
Client: Stratacore Drilling Pty Ltd
2 James Graham Lane, Ourimbah NSW 2258
Contact: Todd Redman
Project Number: SC25359
Project Name: Materials Testing
Project Location: Stuarts Point Feasibility
Work Request: 10045
Sample Number: M25-10045J
Date Sampled: 09/12/2024
Dates Tested: 08/01/2025 - 15/01/2025
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: BH7 (0-7m)
Material: Refer to Client logs



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Approved Signatory: Steve Waugh

Managing Director

NATA Accredited Laboratory Number: 21234

Particle Size Distribution (AS1289 3.6.1)				
Sieve	Passed %	Passing Limits	Retained %	Retained Limits
19 mm	100		0	
4.75 mm	100		0	
2.36 mm	100		0	
1.18 mm	100		0	
0.6 mm	99		1	
0.425 mm	94		5	
0.3 mm	58		36	
0.15 mm	3		55	
0.075 mm	1		1	

