TNG Darwin Processing Facility

Stormwater Management Plan

TNG Limited

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PROJECT 301001-02135: TNG Darwin Processing Facility - Stormwater Management Plan

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Executive summary

Advisian has been commissioned by TNG Limited to prepare a Stormwater Management Plan (SBSMP) for the proposed magnetite concentrate processing facility.

The scope of work for the surface water and watercourses assessments was based upon the need to address the Terms of Reference (ToR), as set out by the Northern Territory Environment Protection Authority, and comments received following assessment of the Draft Environmental Impact Statement for the Project. To support the EIS process and address requirements of the ToR, the scope of this assessment is to:

- Develop a conceptual Site Based Stormwater Management Plan (SBSMP) for the site, and
- Develop a conceptual Erosion and Sediment Control Plan (ESCP).

Stormwater Management

A high-level assessment of potential stormwater management options has been undertaken to mitigate potential adverse waterway impacts relating to the on-going operation of the proposed facility. The addition of reagents, mineral concentrates, sediments, litter, nutrients, hydrocarbons and other pollutants to stormwater runoff may decrease environmental values of downstream receiving environments, if primary management and containment infrastructure was to fail. These impacts can be minimised by implementation of stormwater management measures specified in this conceptual SBSMP (e.g. Stormwater Quality Improvement Devices (SQUIDs), bioretention pods and basins etc.).

Much of the proposed project site is located on unconstrained areas requiring no diversion of stormwater runoff from upstream catchments, however there is a small catchment upstream of the central hub on the southern peninsula that will require diversion around the site. Additionally, the catchment upstream of a section of the road reserve between the southern and northern peninsulas will need to be conveyed through the site's road reserve into the East Arm.

Generally, stormwater flow from the site will be conveyed in an open channel system. The system will need to cater for the minor storm event of 20 year Average Recurrence Interval (ARI) and major storm event of 100 Year ARI.

Generic design intents have been used for this Environmental Impact Statement and hence final design of the minor and major stormwater systems, minor diversion systems and stormwater quality management features (e.g. SQUIDs, bioretention basins etc) will need to be undertaken during the detailed design phases of the project. As a minimum this would involve detailed engineering hydraulic design / modelling to ensure that the major and minor drainage systems achieve the required performance standards and water quality modelling to ensure that the treatments recommend achieve the desired water quality objectives for the site. Additionally, water balance modelling should be undertaken to determine the optimised stormwater harvesting design for the site.

Operational management, monitoring and maintenance plans should be developed with clear responsibilities assigned to relevant site personnel to ensure successful operation of all stormwater systems.

Conceptual Erosion and Sediment Control

Most of the site has a low to moderate erosion risk due to the low gradients of the natural topography, with soil testing nearby classifying soils as non-dispersive. However, catchments S2 and S3 (Southern Peninsula) potentially have a high erosion risk. The extent of construction activity will generally require Type 1 sediment control (e.g. sediment basins). However, due to the seasonality of rainfall at the project location, only Type 3 sediment controls (e.g. sediment fencing) are required in cases where defined works can be completed between May and September inclusive (or May to October inclusive for catchments N1, N2 and R3).

Sufficient space is available for the construction of sediment basins required for the site, assuming conservative design parameters. Detailed design and specification of erosion and sediment control techniques will be required in the final Construction Erosion and Sediment Control Plan (ESCP).

Groundwater levels on site have been considered during the design of the sediment basins with an impermeable liner included.

Additional sampling is recommended to inform the Construction Erosion and Sediment Control Plan. Existing data from the area indicates soils are non-dispersive (specifically results showed Emerson Class 5 or 6 (URS, 2009)). Additional site-specific Emerson Class sampling is required. In addition, further sampling will be undertaken following consideration of Section 3.5 of the BPESC. Jar testing will also be required for the sediment basin design.

1 Conceptual Site Based Stormwater Management Plan (SBSMP)

1.1 Background

This report aims to identify stormwater management options that can be implemented to manage the stormwater (quantity and quality) on the site during both the construction and operational phases, in order to maintain the environmental values of the receiving waters.

This conceptual Site Based Stormwater Management Plan (SBSMP) will provide guidelines for the planning and design of the management systems and strategies. Section 2 of this report outlines the specific measures to be implemented during the construction phase, whilst this section outlines measures for the operation of the facility with respect to stormwater management.

The key objectives for the conceptual SBSMP are :

- To provide a design basis for the management of stormwater on the site with respect to water quantity and water quality , and
- To ensure stormwater does not adversely impact upon the aesthetic or environmental values of receiving waters.

During normal operation of the plant is not anticipated that processing reagents, mineral concentrates, hydrocarbons etc. will enter the site stormwater system, as these potential pollutants will be contained within controlled bunded areas and collected in sumps. The discharge quality shall be assessed and if of suitable quality it will be released into the internal stormwater system, which could include discharging into stormwater ponds or tanks for re-use. Any potentially pollutant discharge will be diverted to wastewater treatments plants for processing.

The stormwater management systems outlined in this plan are mainly addressing the treatment of sediment, gross pollutants, nutrients and incidental hydrocarbons within the stormwater runoff from the balance of the site (e.g. roads / roofs / paved and unpaved areas), that may decrease the environmental values of downstream receiving waters. This SBSMP will identify and present a conceptual design of stormwater management measures to minimise this impact.

Due to the minor changes associated with the ongoing development of the design of the proposed project, generic design intents will be specified for this Environmental Impact Statement (EIS). Hence the design of the stormwater minor and major conveyance systems, minor diversion systems and other stormwater management features (such as Stormwater Quality Improvement Devices (SQUIDs), bioretention basins etc) are expected to be undertaken during the detailed design phases of the project once site layouts and design constraints are finalised. Additionally, operational management, monitoring and maintenance plans should be developed with clear responsibilities assigned to relevant site personnel following completion of detailed design.

1.2 Site Description

There are two (2) general facility areas associated with the proposed project, the main facility located on the southern peninsula and additional facilities located on the northern peninsula. The southern and northern peninsulas will be connected by a road running north-south, running parallel with the existing rail corridor.

Details of the catchment sub-division adopted for the development of this conceptual SBSMP are shown in Appendix A. The catchments have been based on the conceptual earthworks plans developed by TNG for the site, specifically for the main facility on the southern peninsula which has a final platform level of RL 8.70m AHD for the main hub (catchments S2 and S3) and a final platform level ranging from RL 13.5m AHD to RL 10.5m AHD for the material delivery (rail) area (catchment S1). The platform levels for the balance of the southern peninsula (catchment S4) and the northern peninsula (catchments N1 and N2) have not been determined by TNG, however it is expected that these areas will require minimal cut and fill earthwork operations to create level platforms with the required freeboard to the relevant storm surges events. The road corridor (catchments R1, R2 and R3) are expected to require minimal earthwork operations.

The proposed land uses on the project site, as detailed on the catchment plans in Appendix A, include the following:

- Road pavements (asphalt sealed or unsealed gravel) – considered 100% impervious
- Buildings and hardstand areas (asphalt or concrete paved) – considered 100% impervious, and
- Grassed areas – considered 100% pervious.

It is noted that no land use details for catchment S4 on the southern peninsula have been established at this stage, so for the purpose of this report we have adopted a similar land use to the S1 catchment.

Table 1-1 provides details of the project site catchments and the respective developed land uses.

Table 1-1 Project Site Catchment Details

Catchment	Road Area (Ha)	Buildings / Hardstand (Ha)	Grassed Area (Ha)	Total Catchment Area (Ha)
S1	0.15	18.29	8.86	27.3
S2	1.61	6.99	24.30	32.9
S3	8.04	12.31	30.05	50.4
S4	3.79	5.93	16.28	26.0
N1	9.58	9.59	21.83	41.0
N2	5.90	11.07	20.63	37.6
R1	2.03	0.17	8.20	10.4
R2	3.03	0	8.97	12.0
R3	3.60	0	10.00	13.6

There are two (2) locations where upstream catchment flows potentially can enter through the site. The locations, as shown on the catchment plans in Appendix A, are;

- Upstream of catchments S1 and S3, there is a small catchment on the Channel Island Road reserve that will need to be diverted to the west of the site by means of a diversion channel, and
- The catchment upstream of R2 will need to be conveyed directly across the site's road reserve. The culvert system under the road reserve will need to be sized to ensure conveyance of the site and upstream catchment flow, whilst providing the required flood immunity for the crossing.

The Hydrogeological Study TNG Darwin Processing Facility (Draft EIS Darwin Processing Facility Appendix M Technical Report for Hydrogeology) (Golder, 2019) undertook groundwater monitoring at twelve (12) locations on the southern and northern peninsula of the project site. The study determined that the May 2019 groundwater measurements ranged from 1.5 to 4.6 m below ground level (bgl) (between RL 4.5m AHD and RL 8.3m AHD in the northern peninsula and between RL 5.0m AHD and RL 8.6m AHD in the southern peninsula) and that the September 2019 groundwater measurements ranged from 3.2 to 7.2 m bgl (between RL 3.0m AHD and RL 5.5m AHD in the northern peninsula and between RL 1.9m AHD and RL 6.3m AHD in the southern peninsula). The study noted that the seasonal maximum could rise to less than one (1) metre below the ground level in some wells. For the purpose of this report the maximum seasonal groundwater level has been adopted as a nominal one (1) metre below the natural ground level.

1.3 Stormwater System Design

As noted earlier the main process plant infrastructure and chemical storage areas will predominantly be within the plant buildings and bunding / containments systems will be in place that will divert any potentially pollutant discharge, that may contain processing reagents, mineral concentrates, hydrocarbons etc., to collection sumps. The discharge quality shall be assessed and if of suitable quality it will be released into the internal stormwater system, which could include discharging into stormwater ponds or tanks for re-use. Any potentially pollutant discharge will be diverted to wastewater treatments plants for processing.

The internal stormwater system design approach for the balance of the project site will comply with the requirements of the *Development and Subdivision Standards* of the Litchfield Council (2017) and the relevant stormwater standards, guidelines and codes referenced by the document, which includes Queensland Urban Drainage Manual (IPWEA 2016) and ARR (2019).

The design philosophy for the internal stormwater system, that mainly addresses the treatment of sediment, gross pollutants, nutrients and incidental hydrocarbons, will be as follows:

- The drainage system will need to cater for the major and minor storm events, through the appropriate development of the major and minor drainage systems. These systems must be designed to control and convey the storm flows through and within the site.
- For the project site the appropriate design events would be 20 Year ARI for the minor storm and 100 Year ARI for the major storm.
- The minor system within the main process areas, typified by buildings and hardstands, will generally comprise of a underground piped system discharging to the road network / perimeter channel system.

- The minor system within the main site areas and roads will be limited generally to an open channel / drain system that conveys stormwater discharge to the outlet. The open channels, which would typically be aligned along the sides of the internal roads, would need to have a minimum longitudinal slope in the order of 1 in 500 (0.2%).
- The minor system shall be designed to ensure that at least a minimum of three (3) metres of the roadway are flood free during the minor flood event (20 Year ARI) to ensure continued safe access throughout the plant. During the major flood event the flow may spread to the road boundary but the maximum depth of flow in the roadway should not exceed 150 mm above the crown of the road, nor should the depth of flow (m) x the flow velocity (m/s) exceed 0.32 (LC 2017).
- A minimum freeboard to all building floor levels of 300mm should be achieved for the major flood event (100 year ARI).
- To achieve the requirements for the major flood event, it may be necessary to increase the capacity of the minor drainage system at some locations within the site, i.e. the minor drainage channel system may require a capacity greater than the 20 Year ARI flow.

1.4 Hydrology

For the SBSMP the pre-developed and developed flows from the site have been determined using the Rational Method which is in accordance with the *Development and Subdivision Standards* of the Litchfield Council (2017), which permits the use of this method to determine peak flows provided the catchment is not greater than 500 hectares (Ha).

1.4.1 Pre-Development Flows

The peak pre-development flows at the site where determined based on the following parameters:

- The runoff coefficients were selected based on guidance from ARR2019, assuming a land description of light cover bushland and a medium to low soil permeability. The adopted coefficient was 0.74 for the 20 Year ARI and 0.77 for the 100 Year ARI events (based on the application of QUDM coefficient factors to the 10 Year ARI coefficient of 0.70)
- The time of concertation was determined, as recommended by ARR2019, by use of the Bransby Williams equation.

A copy of the rational method calculations for the pre-developed case are contained in Appendix B and summarised in Table 1-2 below.

Table 1-2 Pre-Development Flows

Catchment	Catchment Area (Ha)	20 Year ARI Peak Flow (m3/s)	100 Year ARI Peak Flow (m3/s)
S1	27.3	7.8	10.4
S2	32.9	14.1	18.9
S3	50.4	13.9	18.6
S4	26.0	8.8	11.8
N1	41.0	13.9	18.5
N2	37.6	12.4	16.6
R1	10.4	3.5	4.7
R2	12.0	3.4	4.5
R3	13.6	3.7	4.9

1.4.2 Post Development Flows

The peak post-development flows at the site were determined based on the following parameters:

- The runoff coefficients were selected based on guidance from the *Development and Subdivision Standards* of the Litchfield Council (2017). As per the standards the impervious coefficients adopted were 0.95 for the 20 Year ARI event and 1.0 for the 100 Year ARI event. For the pervious areas , the higher conservative coefficients from the Queensland Urban Drainage Manual (IPWEA 2016) were adopted as 0.74 for the 20 Year ARI event and 0.84 for the 100 Year ARI event.
- The time of concertation was determined based on sheet flow from the pervious areas up to a maximum of 200 metres using Friend's equation and assuming a Norton's roughness of 0.035 and a travel time in the open channel drainage system assuming a channel velocity in the order of 1.0 to 1.2 m/s. Alternatively for the building and hardstand areas a standard inlet time of 5 minutes was adopted. As per the *Development and Subdivision Standards* of the Litchfield Council (2017), for urban areas a typical maximum time of concentration of 20 minutes is adopted, therefore conservatively a 20 minute maximum time of concentration has been adopted for all sub-catchments on the site.

A partial area calculation check was undertaken to ensure that peak flows would not occur as a result of runoff from the fully pervious sections (process areas) of the catchment only.

A copy of the rational method calculations for the post-developed case are contained in Appendix B and summarised in Table 1-3 below. It should be noted that the post-development flows are conservative as they take no account of any attenuation measures that may be implemented on the site , e.g. adoption of stormwater storage tanks or basins as part of stormwater harvesting activities that could have the potential to attenuate peak flows discharging from the site.

Table 1-3 Post-Development Flows

Catchment	Catchment Area (Ha)	20 Year ARI Peak Flow (m3/s)	100 Year ARI Peak Flow (m3/s)
S1	27.3	10.7	14.9
S2	32.9	13.6	19.5
S3	50.4	18.4	26.2
S4	26.0	11.1	15.8
N1	41.0	15.3	21.5
N2	37.6	13.9	19.7
R1	10.4	3.6	5.2
R2	12.0	4.2	6.1
R3	13.6	4.8	6.9

1.4.3 Comparison of Pre and Post Development Flows

As expected, as result of the development of the project with the increase in impervious areas and development of a formalised stormwater systems, the post development peak flows from the site will be greater than the pre-development peak flows. Table 1-4 provides a summary of the increase per catchment for the 100 Year ARI flood event.

Table 1-4 Comparison of Pre-Development and Post Development Peak Flows

Catchment	100 Year ARI Pre-Development Peak Flow (m^3/s)	100 Year ARI Post Development Peak Flow (m^3/s)	100 Year ARI Peak Flow Increase (m^3/s)
S1	10.4	14.9	4.5
S2	18.9	19.5	0.6
S3	18.6	26.2	7.6
S4	11.8	15.8	4.0
N1	18.5	21.5	3.0
N2	16.6	19.7	3.1
R1	4.7	5.2	0.5
R2	4.5	6.1	1.6
R3	4.9	6.9	2.0

Although there are increases in the peak flows from the project site as a result of the development, it is considered that there will be no perceived impacts on the downstream receiving waterways resulting from the stormwater quantity changes given the location of the site adjacent to the East Arm, i.e. there is no downstream properties or infrastructure that would be impacted by the increase in peak flows.

As a result, we consider there to be no requirement to attenuate the peak flows from the project site to ensure that the post development flows discharging from the site are less than the pre-development flows (i.e. there is no requirement to incorporate detention basins or other on site detention devices) due to the legal point of discharge being East Arm.

It is noted however that other stormwater management strategies proposed (discussed further in section 1.5), such as the adoption of stormwater harvesting will have the effect of reducing the post development peak flows and volumes. The peak flow increases presented in Table 1-4 are therefore considered conservative.

As part of the detailed design of the stormwater system particular attention needs to be paid to limiting the flow velocities at all outlets for the post development flows in order to minimise scour risk to the receiving environment. It should be noted that generally it is expected that the velocities in the channels in the development will not be high due to the adoption of minimal longitudinal slopes to suit the developed site topography. However, the following strategies can be adopted to further minimise the velocities to the site;

- At the approach to the outlet ensure that channel slope to a minimised,
- At the approach to the outlet widen the channel profile including increasing the base width and / or flatten the channel side slopes, and
- At the approach to the outlet increase the channel roughness (e.g. introduce vegetation, rock line the base and batters and if required introduce rock elements for energy dissipation).

1.5 Stormwater Quality

With respect to the water quality outcomes for the development, the project will adopt a holistic water sensitive urban design (WSUD) approach that aims to minimize the impacts of the development on the natural water cycle and downstream environmental systems.

The water quality targets for the development shall be set based on a number of guidelines including the following:

- *A Stormwater Strategy for the Darwin Harbour Region* (NT EPA)
- *Darwin Harbour Water Quality Protection Plan* (DENR)
- *Guidelines for Fresh and Marine Water Quality* (ANZECC)
- *Australian Guideline for Urban Stormwater Management* (ANZECC, 2000)

Following these guidelines, the stormwater quality objectives after development of a site should be as a minimum:

- 80% reduction of the typical urban annual load for Total Suspended Solids (TSS).
- 45% reduction of the typical urban annual load for Total Phosphorus (TP).
- 45% reduction of the typical urban annual load for Total Nitrogen (TN).

The stormwater quality objectives for the site will be achieved through the implementation of the following "structural" measures on the site;

- The maximisation of pervious (grassed) areas on the site, which will minimise stormwater runoff and also provide an opportunity for infiltration of rainfall into the groundwater. Additionally, the establishment and maintenance of 100% of grass cover will assist in minimising the amount of sediment load potentially produced by the development.
- In the process plant areas, typified by buildings and paved hardstands, Stormwater Quality Improvement Devices (SQUIDs) should be installed to capture the high frequency flood events (typically the three-month ARI flood event). These devices are typically underground tanks/structures that feature two compartments, the first compartments captures sediment and the second compartment has a coalescer unit to capture oil / hydrocarbons and other light liquids.
- On all pits and grates within the project site install litter baskets to collect gross pollutants.
- On all paved areas and road pavement area install bioretention pods where practical.
- At the outlet to each catchment provide a regional bioretention basin (refer section 1.5.1 for further details of the basins).
- From the SQUIDs and bioretention basins installed on the site there will be an opportunity to harvest the treated stormwater for reuse on the site for use as process water and for irrigation of the site. All of the treated water from the devices can be pumped to stormwater storage tanks or water storage ponds. In the process areas the storage will be more appropriately achieved via underground storage tanks installed under hardstand areas. Due to the potential high groundwater levels the tanks will need to consider uplift in their design. The treated discharge from the bioretention basins could be collected and pumped to regional water storage ponds. These ponds would be lined with an impermeable liner to prevent loss to the groundwater. Again, due to the high groundwater levels it is recommended that the base of the ponds not be any deeper than one (1) metre below the natural ground level. Due to this restriction the ponds may need to be generally an embankment type construction to achieve the desired storage volume

It is noted that with respect for the potential harvesting of stormwater on the site, as a significant portion of the annual stormwater runoff volume from urbanised catchments occurs from the frequent, smaller flood events and from a proportion of the less frequent, larger events, treating the nominal three-month ARI flow will potentially capture in the order of ninety (90) percent of the mean annual runoff volume from the site (ANZECC 2000). Therefore, the possibility for stormwater harvesting on the site is potentially only limited by the ability to provide storage on the site.

Other non- structural operational WSUD measure to be adopted would include

- Access to the facility shall be limited to authorised vehicles through a controlled access point.
- Transport loads shall be covered to prevent entry of pollutants to the stormwater system.
- Any spillage of wastes, contaminants or other materials shall be cleaned up as quickly as practicable using procedures that prevent contaminants or material being transferred to the stormwater drainage system. It is noted that the adoption of SQUIDs and the bioretention basins provide the opportunity to trap / contain any accidental spills on the site, including along the access road reserve between the southern and northern peninsula sites.
- The stormwater system for the site shall be inspected regularly to identify any failures and, if necessary, repairs shall be undertaken; and
- Trapped sediment shall be removed from SQUIDs and bioretention sediment forebays and relocated to a stabilised stockpile, either onsite or offsite, or taken to an appropriate land fill area.

As part of the detailed design process, detailed water quality modelling should be undertaken to design all of the individual elements of the proposed water quality treatment train for the site and to demonstrate that the water quality objectives can be met. Additionally, water balance modelling should be undertaken to determine the optimised stormwater harvesting approach for the site.

It is noted that whilst this conceptual SBSMP has nominated potential treatment devices and indicative sizing of these devices, alternative treatments could be adopted in the final design provided that the devices achieve the required water quality objectives. For instance, in lieu of the regional bioretention basin system, treatment could be achieved with a treatment train of either smaller basins throughout the catchment. Additionally, propriety tank type SQUIDs could be used in lieu of the installation of bioretention basins. The presentation of the devices in this conceptual plan provide one possible stormwater treatment approach that could be implemented on the site, but a range of options would be available for the development of the site.

1.5.1 Bioretention Basin

A typical arrangement and details for a bioretention basin to be implemented on the site is provide in Appendix C.

Bioretention systems use ponding above a treatment surface to maximise the volume of runoff flowing through the filtration media. The treatment system operates by firstly filtering surface flows through surface vegetation and then percolating runoff through prescribed filtration media. This media provides treatment through fine filtration, extended detention and biological uptake of nutrients.

An underdrain system will collect the flow that has passed through the filter media and discharge to a sump structure. From the sump the treated stormwater flow can be pumped to stormwater storage ponds.

As per guidelines the individual cell areas should be limited to a maximum of 800 m^2.

The basin will be designed to accept a design flow (typically equivalent to the three-month ARI flow). The flows above the design event through overflow pits or via the outlet weir. The design flow is diverted from the main channel via a diversion weir and culverts. Higher flows (i.e. the flows that exceed the treatment flow) will bypass the basin by overtopping the diversion weir and continuing along the main channel to the outlet.

The basin would feature a trash rack, located at the outlet to the bypass culverts, to capture gross pollutants prior to entering the bioretention basin system.

To ensure that the deposition of coarse sediment on the filter media surface does not affect its function, bioretention systems should be designed with pre-treatment to limit the amount of coarse sediment reaching the filter media. WaterByDesign's *Bioretention Technical Design Guideline* recommends a sediment forebay if the contributing catchment is greater than 2 ha. The guideline also suggests consideration of the use of a sediment pond if catchments exceed 5 ha.

In this situation the contributing catchment is well in excess of 5 ha however it is proposed that a sediment forebay, with limited permanent ponding of water, be adopted for the following reasons:

- Runoff from a large proportion of the catchment will pass through treatment measures prior to discharge to the bioretention basin removing coarse sediment (i.e. SQUIDs, bioretention pods), and

- The potential groundwater levels on the site would make the operation of a sediment pond difficult.

Preliminary design indicates that a sediment forebays of a minimum surface area of approximately ten (10) percent of the bioretention treatment area will be required with an extended detention depth of 0.2 m to 0.3 m required. The conceptual design on the drawings in Appendix C show a forebay five (5) wide running the length of the basin. The forebay would have access ramps to permit regular removal of sediment, as regular maintenance will be an important operational issue for the basins to ensure that they operate effectively.

As shown on the typical basin sections in Appendix C, due the potential for the groundwater to reach the underside of the basin, the base of the basins will need to be lined with an impermeable liner. The selected liner, as shown on the typical section, is a multi-component geo-synthetic clay liner (GCL) (Bentofix NSP X- type or similar) which features a uniform core of high-swelling powder sodium bentonite clay between two layers of a needle punched geotextile layers. Additionally, a polyethylene (PE) coating is extruded directly onto one side of the geotextile. The PE coated face should be placed face down and would protect the bentonite clay layer in the GCL from any potential aggressive groundwater impacts on the GCL.

The liner proposed has been assessed and we confirm that the liner;

- would contain the basin treatment flows and would prevent release of the stormwater into the groundwater,
- if correctly installed, would achieve a permeability of 1 x 10^{-9} m/s or less,
- the liner would be resistant to chemical and physical erosion, and
- if correctly installed will withstand construction loads and the weight of the operating basin.

With the maximum seasonal groundwater level shown on the section in Appendix C (the basin shown would apply to the S3 site) the weight of the basin filter material would resist any uplift pressures from the groundwater. Additionally, if the extreme Year 2100 – 1 in 1,000 AEP storm tide event occurred, inundation of the basin would not occur, and the weight of the basin filter material would again be sufficient to resist any uplift pressures.

It can be seen also from the sections that provided the basins are not constructed during the "wet" season, the groundwater levels should be low enough at the basin site to enable construction of the basin to occur without the need for groundwater dewatering.

As per ARR (2019) a typical basin filter area requirement to ensure the water quality objectives are met is between 1% and 2% of the catchment it serves. The conceptual design has adopted a 1% rate as we have specified upstream treatment devices as part of an overall treatment train for the site (i.e. SQUIDs, bioretention pods). As noted earlier as part of the detailed design process, a detailed water quality model will need to be developed for the site to determine the optimum basin filter area , depth etc. , however we consider that the adopted 1% rate is a reasonable assumption for the development of this conceptual design. Table 1-5 below provides details of the conceptual bioretention size required for each catchment. Appendix C details the proposed locations of each bioretention basin.

Table 1-5 Indicative Bioretention Basin Sizing

Catchment name	Catchment area (ha)	1% Catchment Area (m^2)	Cell Numbers	Cell Length (m)	Cell Width (m)	Bioretnation Area (m^2)
N1	41.0	4,100	6	34	20	4,100
N2	37.6	3,760	6	31	20	3,760
S1	27.3	2,730	4	34	20	2,730
S2	32.9	3,290	6	33	20	3,290
S3	50.4	5,400	8	32	20	5,040
S4	26.0	2,600	4	33	20	2,600
R1	10.4	1,040	2	26	20	1,040
R2	12.0	1,200	2	30	20	1,200
R3	13.6	1,360	2	34	20	1,360

1.6 Conceptual Site Based Stormwater Management Plan Summary

The key aspects of the conceptual stormwater management for the site are as follows:

- Much of the proposed project site is located on unconstrained areas requiring no diversion of stormwater runoff from upstream catchments, however there is a small catchment upstream of catchments S1 and S3 on the Channel Island Road reserve that will require diversion around the site. Additionally, the catchment upstream of R2 will need to be conveyed through the site's road reserve into the East Arm.
- The groundwater on the site has the potential to significantly impact / influence the design of the stormwater systems on the site and for the purpose of this report the maximum seasonal groundwater level has been adopted as being a nominal one (1) metre below the natural ground level.
- The site drainage system will need to cater for the major and minor storm events. For the project site the appropriate design events would be the 20 Year ARI for the minor storm event and the 100 Year ARI for the major storm event. It is expected that generally the stormwater will be conveyed from the site via open channels.
- The development of the site will result in an increase in the peak flows discharging from the site, however as the legal point of discharge is the East Arm we do not consider that there is a requirement to ensure that the post development flows from the site are less than the predevelopment flows.
- As part of the detailed design of the stormwater system, particular attention needs to be paid to limiting the flow velocities at all outlets for the post development flows in order to minimise scour risk to the receiving environment.

- A number of structural measures to achieve the stormwater quality objectives for the site have been specified including maximisation of the pervious (grassed) areas on the site, the adoption of Stormwater Quality Improvement Devices (SQUIDs), the installation of litter baskets on all pits, the adoption of bioretention pods in hardstand and road reserves and the adoption of regional bioretention basins incorporating sediment forebays at the outlets to all site catchments. The presentation of the devices in this conceptual plan provide one possible stormwater treatment approach that could be implemented on the site, but a range of options would be available for the development of the site.
- The opportunity to harvest stormwater flows at a number of the stormwater quality devices (e.g. SQUIDs and bioretention basins) for re-use on the site has been identified. The harvested stormwater can be stored either in an underground tank system or in regional water storage ponds.
- Generic design intents have been used for this Environmental Impact Statement and hence final design of the minor and major stormwater systems, minor diversion systems and stormwater quality management features (e.g. SQUIDs, bioretention basins etc) will need to be undertaken during the detailed design phases of the project. As a minimum this would involve detailed engineering hydraulic design / modelling to ensure that the major and minor drainage systems achieve the required performance standards and water quality modelling to ensure that the treatments recommend achieve the desired water quality objectives for the site . Additionally, water balance modelling should be undertaken to determine the optimised stormwater harvesting design for the site.
- Operational management, monitoring and maintenance plans should be developed with clear responsibilities assigned to relevant site personnel to ensure successful operation of all stormwater systems.

2 Conceptual Construction Erosion and Sediment Control Plan

2.1 Background

Appropriate erosion and sediment control measures should be in place during the construction phase in addition to during the operations phase for the project. The operational controls are discussed in Section 1.5 and this section details the construction requirements.

As detailed in Section 1.2, the site has been divided into the sub-catchments. All external upstream areas of clean runoff will be diverted around or through the site (particularly the catchment upstream of S1 and S3, and the catchment upstream of R2).

The majority of the project site is currently highly disturbed (*The soil and weathering profile have been historically modified by quarrying activities […]. Following the historical quarrying, a sandy layer is filled on top of the weathered bedrock in many areas* (Golder, 2019)) and would be expected to be contributing a significant sediment load into the receiving waters of the East Arm.

Management of erosion and sedimentation is based on the following principles:

- Diversion of clean water around disturbed areas
- Minimise the extent and duration of soil disturbance
- Control the location and velocity of drainage flow
- Minimise soil erosion initiated by wind, rain or concentrated flow
- Minimise sediment flow from site
- Promptly revegetate/stabilise all exposed and/or unstable soil surfaces
- Install, operate and maintain appropriate erosion and sediment control (ESC) measures.

The extent and type of ESC measure depends on the likelihood and intensity of expected rainfall and sheet flow.

Erosion control measures are required to minimise movement and loss of sediments at the source, while sediment controls are measures that trap and retain sediments, removing sediment from the stormwater flow.

2.2 Purpose and Outcomes

In accordance with Chapter 5.2 of Best Practice Erosion and Sediment Control (IECA 2008) the purpose of the Conceptual Erosion and Sediment Control Plan is to:

- Ensure appropriate soil data is collected and site constraints are identified.
- Ensure consideration of erosion and sediment control requirements, site constraints and key environmental issues are introduced at the planning and site layout phase.
- Allow regulatory authorities to voice their key concerns before a development proposal progresses too far through the planning and site layout phase.

- Demonstrate to the regulatory authority that there is a feasible means of constructing the project while still protecting key environmental values.

Outcomes:

- Identify the likely need for the construction of Sediment Basins on the site.
- Identify that adequate space has been made available for the construction and operation of major sediment traps and essential flow diversion systems.
- Demonstrate to the regulatory authority that there is a feasible means of constructing the project while still protecting key environmental values.
- Identify problem soil areas including, dispersive soils, acid sulfate soils, areas of potential mass movement.
- Identify protected environmental features such as protected vegetation.

2.3 Conceptual Erosion and Sediment Control Measures

Erosion and sediment control measures may include, but are not limited to the following:

- Sediment fences;
- Limited excavation and earth movement during windy conditions;
- Runoff from exposed areas directed to sediment ponds;
- Keeping the area of exposed soil to a minimum as necessary for construction and operational purposes;
- Stockpiles management
- Early stage rehabilitation with grasses and mulches; and
- Keeping exposed soil moist to reduce wind drift.

2.4 RUSLE Erosion Risk Assessment

The revised universal soil loss equation has been used as the risk assessment tool to predict the potential long-term average annual mass of soil loss over the site for the baseline and construction phases.

A = R * K * LS * C * P

A = annual estimated average soil loss due to erosion (t/ha/yr)

R = rainfall erosivity factor (13,738 for this site based on rainfall intensity discussed in Section 2.4.1)

K = soil erodibility factor varied across the site and in some cases between baseline and construction discussed in Section 2.4.2

LS = combined slope length and gradient factor varied across the site as discussed in Section 2.4.3

C = cover factor varied across the site and between baseline and construction as discussed in Section 2.4.4

P = land management/practice factor varied across the site and between baseline and construction as discussed in Section 2.4.5.

2.4.1 Rainfall Erosivity Factor

The rainfall erosivity factor (R) is a measure of the ability of rainfall to cause erosion. BPESC (IECA, 2008) provides tables of R values for various locations in Australia, with Darwin's annual R-Factor = 4,245 (Table E2). An R-Factor of 13,738 is the current recommendation from the Darwin Harbour Advisory Committee (NT Department of Environment, Parks and Water Security 2020, personal communication 12 November). The more conservative R-Factor of 13,738 has been used in the CESCP. Monthly R-Factor and erosion risk rating has been assessed based on the annual R-Factor (13,738) and Table 4.4.1 of BPESC (IECA 2008), as shown in Table 2-1.

Table 2-1 Monthly R-Factor and Erosion Risk Rating

Month	R-Factor	Erosion Risk Rating
January	4,208	Extreme
February	3,025	Extreme
March	2,145	Extreme
April	798	High
May	83	Low
June	14	Very Low
July	0	Very Low
August	0	Very Low
September	55	Very Low
October	344	High
November	894	High
December	2,173	Extreme

2.4.2 Soil Erodibility Factor

The soil erodibility factor K, is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Soil texture is the principle component affecting K, but soil structure, organic matter and profile permeability also contribute (IECA, 2008).

The borehole logs in the Preliminary Site Investigation and Shallow Soil Baseline Assessment TNG Darwin Processing Facility (Draft EIS Darwin Processing Facility Appendix H Technical Report for Soils) (Golder, 2019) showed that most of the soils in the catchments to 1.5m below ground level are sand, sandy gravel or gravelly sand.

Based on the proposed design levels to a pad of RL 8.7m in most of catchments S1, S2 and S3 from the drawing Earth movements, limitation of build figure dated 10 January 2020 reference 1009679299 there are cut and fill requirements and the associated soils relevant to those varying levels have been used in the RUSLE construction calculations. There are no boreholes in the cut areas of the site (Golder, 2019). The assumption is that these areas will cut into silt based on the boreholes in the fill areas. Given the reasonably flat topography and nature of the potential construction in the remainder of the catchments, subsoils to 1.5m only are assumed to be disturbed.

Based on tables E3 and E4 in BPESC the K-factor for each catchment has been selected (IECA, 2008) and is included in Section 2.4.6.

Soil analysis at the nearby Ichthys site indicates that soils in the area are generally Emersion class 5 and 6, non-dispersive (URS, 2009). Thus, no adjustment to the K-Factor is required.

2.4.3 Slope Length Factor

Slope Length (LS) Factor is a numerical representation of length-slope combination (Landcom, 2004). LS-Factor for undisturbed land was determined by analysing the DEM gradients and slopes lengths. *A slope length of 80m should be adopted within the RUSLE analysis unless permanent drainage or landscape features reduce this length* (IECA, 2018). At this conceptual stage, a slope length for overland flows of 80m has been used and LS-factors were determined for each catchment using Table E3 in BPESC (IECA, 2008).

Given the low gradients of the construction areas, the LS-Factor for disturbed areas is assumed to be that of the current topography.

2.4.4 Cover Factor

Cover Factor (C-Factor) measures the combined effect of all the interrelated cover and management variables. C-Factor for undisturbed land is derived from satellite imagery (Viscarra Rossel, R., *et al*, 2016). Disturbed areas assume the default C-Factor for construction sites of 1.

2.4.5 Land Management Factor

Land Management Factor (P-Factor) measures the combined effect of all support practices and management variables, along with structural methods for controlling erosion. P-Factor for undisturbed land was determined by averaging values derived from satellite imagery (Viscarra Rossel, R., *et al*, 2016). Disturbed areas assume the default P-Factor for construction sites of 1.3 (IECA 2008).

2.4.6 Results

Based on the discussions above, the predicted potential average annual mass of soil loss for baseline and construction phase has been determined as shown in Table 2-2. Erosion risk is based on soil loss according to the criteria in BPESC Table 4.4.3 (IECA, 2008).

Table 2-2 Annual RUSLE calculations and erosion risk rating

Name	LS-Factor	Baseline K-factor	Baseline A (t/ha/yr)	Construction K-factor	Construction A (t/ha/yr)	Erosion Risk
N1	0.41	0.02	2.53	0.03	219.67	low
N2	0.41	0.03	5.07	0.03	219.67	low
S1	0.41	0.03	5.07	0.07	483.28	moderate
S2	0.65	0.03	5.36	0.07	766.17	high
S3	0.65	0.03	8.04	0.07	766.17	high
S4	0.41	0.03	3.38	0.04	322.18	moderate
R1	0.78	0.03	9.64	0.03	417.91	moderate
R2	0.65	0.03	5.36	0.03	348.26	moderate
R3	0.30	0.03	2.47	0.03	160.73	low

Sediment Control standards are based on erosion rate and catchment area, according to BPESC Table B-1 (IECA, 2018). The sediment control standard and control techniques are shown in Table 2-3. Further explanation and details of the control techniques is outlined in BPESC (IECA, 2008 & IECA, 2018).

Table 2-3 Sediment control standard based on local erosion factors

Type	Threshold area	Concentrated flow techniques	Sheet flow techniques
Type 1	Disturbance > 2,500 m^2	Sediment basin in accordance with IECA 2018	Buffer zone capable of infiltrating 100% of stormwater runoff Infiltration basin or sand filter bed capable of infiltrating 100% of stormwater runoff
Type 2	Disturbance area 1,000 – 2,500 m^2	Sediment basin smaller than the design standard Filter Tube Dam Rock Filter Dam Sediment Trench Sediment Weir	Buffer zone capable of infiltrating majority of stormwater from design storms Compost and mulch berms
Type 3	Disturbance area 250 – 1,000 m^2	Coarse Sediment Trap Modular Sediment Trap U-Shaped Sediment Trap	Buffer zone Filter fence Straw bale barrier (short-term only)

Type	Threshold area	Concentrated flow techniques	Sheet flow techniques
			Sediment fence

The distinct wet/dry season of Darwin means that sediment control standard for short duration works (less than 6 months) varies by month. Applying the monthly R-Factor to the site-specific K, LS, C and P-Factors provides monthly average soil loss, with the required sediment control standard based on criteria from BPESC Table B-1 (IECA, 2018).

Table 2-4: Monthly RUSLE calculations, erosion risk rating and sediment control standard

Month	R-Factor (monthly)	Erosion risk rating	N1 and N2		S1		S2 and S3		S4		R1		R2		R3	
			Average soils loss - A (t/ha/month)	Sediment control standard	Average soils loss A (t/ha/month)	Sediment control standard	Average soils loss - A (t/ha/month)	Sediment control standard	Average soils loss - A (t/ha/month)	Sediment control standard	Average soils loss - A (t/ha/month)	Sediment control standard	Average soils loss - A (t/ha/month)	Sediment control standard	Average soils loss - A (t/ha/month)	Sediment control standard
January	4,208	Extreme	67.3	1	148.0	1	234.7	1	98.7	1	128.0	1	106.7	1	49.2	1
February	3,025	Extreme	48.4	1	106.4	1	168.7	1	70.9	1	92.0	1	76.7	1	35.4	1
March	2,145	Extreme	34.3	1	75.5	1	119.6	1	50.3	1	65.3	1	54.4	1	25.1	1
April	798	High	12.8	1	28.1	1	44.5	1	18.7	1	24.3	1	20.2	1	9.3	1
May	83	Low	1.3	3	2.9	3	4.6	3	1.9	3	2.5	3	2.1	3	1.0	3
June	14	Very Low	0.2	3	0.5	3	0.8	3	0.3	3	0.4	3	0.4	3	0.2	3
July	0	Very Low	0.0	3	0.0	3	0.0	3	0.0	3	0.0	3	0.0	3	0.0	3
August	0	Very Low	0.0	3	0.0	3	0.0	3	0.0	3	0.0	3	0.0	3	0.0	3
September	55	Very Low	0.9	3	1.9	3	3.1	3	1.3	3	1.7	3	1.4	3	0.6	3
October	344	High	5.5	3	12.1	1	19.2	1	8.1	1	10.5	1	8.7	1	4.0	3
November	894	High	14.3	1	31.4	1	49.9	1	21.0	1	27.2	1	22.7	1	10.5	1
December	2,173	Extreme	34.7	1	76.4	1	121.2	1	51.0	1	66.1	1	55.1	1	25.4	1

2.5 Indicative Sediment Basin Sizing

All catchments require Type 1 controls of a Sediment Basin (unless work is conducted solely between May and September inclusive (to October for catchments N1, N2 and R3) as shown in Table 2-4). The indicative sizing of the basins is calculated assuming a Type D sediment basin, discharging to a sensitive environment. This ensures that enough space is available for all options of sediment control (Type A, C or D) according to the procedures of BPESC (IECA, 2018).

Settlement volume is given by the following equation (BPESC Equation B35).

$$V_s = 10 \times R_{(Y\%,5\text{-day})} \times C_v \times A$$

Where: V_s = volume of settling zone [m^3]

$R_{(Y\%,\ 5\text{-day})}$ =Y%, 5-day rainfall depth [mm]

C_v = Volumetric runoff coefficient

A = effective catchment area connected to the basin [ha]

The design rainfall for basin capacity is the 85th percentile 5-day for Darwin is 46.2 mm (Table B-28 and B-30, IECA 2018). Conservatively (as most soils were sandy gravel or gravelly sand with trace clay (Golder, 2019)) assuming Soil Hydrologic Group D (Clay), Volumetric runoff coefficient (Cv) is 0.69 (IECA 2018, Table B31). Sediment storage (Vss) is 50% of settling volume (IECA 2016, Table B32). Minimum settling depth is 0.6 m, however a depth of 2 m has been used to determine the indicative dimensions, where a width to length ratio of 1:3 is achieved. Results for each catchment are shown in Table 2-5.

Table 2-5 Indicative Sediment Basin Sizing

Catchment name	Catchment area (ha)	Settlement volume (m^3)	Sediment storage (m3)	Total volume (m3)	Settling Depth (m)	Storage Depth (m)	Width (m)	Length (m)
N1	41	13,070	6,535	19,605	2	1	47	141
N2	37.6	11,986	5,993	17,979	2	1	45	135
S1	27.3	8,703	4,351	13,054	2	1	39	117
S2	32.9	10,488	5,244	15,732	2	1	42	126
S3	50.4	16,067	8,033	24,100	2	1	52	156
S4	26	8,288	4,144	12,432	2	1	38	114
R1	10.4	3,315	1,658	4,973	2	1	24	72
R2	12.0	3,825	1,913	5,738	2	1	26	78
R3	13.6	4,335	2,168	6,503	2	1	27	81

The settling depth of 2m (and sediment storage depth of 1m) has been used given the high groundwater table in the area. The proposed locations of the sediment basins have enough fall to fit these structures.

Sediment basins should be designed with an emergency spillway sized in accordance with the criteria specified in Table B35 of BPESC Appendix B (IECA 2018).

While the indicative sizing of the basins has been calculated assuming a Type D sediment basin to ensure enough space is available, detailed design needs to assess Type A basins (automatic chemical flocculation). Type A basins are typically sized for a 1 year ARI, 24 hour design event for the construction phase (IECA 2018). The size of Type A basins is dependent on the settlement rate of in situ soils. Assessment of the settlement rate through jar tests is required prior to the design being undertaken to ensure proposed sizing is appropriate. All basins must be sized and designed based on Appendix B of BPESC (IECA 2018).

2.6 Indicative Sediment Basin Location

The drawings in Appendix D show the proposed indicative locations for the sediment basins to scale (based on length and width in Table 2-5) compared with the proposed design footprint (where provided). This shows that sufficient land is available for the construction and operation of these basins.

A typical construction sedimentation basin longitudinal section showing the proposed settlement zone depth, storage zone depth, natural surface profile and groundwater levels are provided on the drawings in Appendix D. As detailed on the drawings, the maximum seasonal groundwater level (adopted as nominally one (1) metre below the natural surface profile) will potentially be above the basin base, therefore an impermeable liner will need to be installed on the base and sides of the basin. The liner will be the multi-component geo-synthetic clay liner (GCL) as detailed in section 1.5.1 of this report.

In order to ensure that the liner can accommodate equipment used to remove sediment from the basin, a 300mm gravel protection layer is proposed over the liner. The gravel protection layer will also act as a “marker” to ensure the equipment removing sediment does not impact the liner.

It can be seen also from the sections that provided the basins are not constructed during the “wet” season, the groundwater levels should be low enough at the basin site to enable construction of the basin to occur without the need for groundwater dewatering.

These longitudinal sections are conceptual, and the construction erosion and sediment control plan may be able to be less conservative following additional soil sampling/analysis and groundwater monitoring. However, the proposed sediment basin dimensions, locations and liner will operate appropriately, if required.

2.7 Indicative Sediment Basin Discharge Criteria

In the absence of site-specific discharge criteria, based on Table B40 in BPESC 90 percentile total suspended solids concentration not exceeding 50 mg/L and pH in the range of 6.5 to 8.5 should be adopted (IECA, 2018).

2.8 Maintenance

Drainage and ESC measures require ongoing maintenance, and the following should apply:

- Mitigation measures requiring minimal regular maintenance or simple maintenance procedures would be preferred.
- Appropriate access should be provided if maintenance is required on any structure.

A checklist should be developed that records maintenance problems likely to occur for each of the ESC measures adopted on site, and identifies the person responsible for implementing, maintaining, inspecting, repairing and modify controls.

A monitoring checklist should be kept of all ESC measures, with entries made following inspection and maintenance activities detailing the following:

- Removal of ESC measures.
- Condition of ESC structures and stabilised surfaces.
- Repair of any damage to ESC structures.
- Rainfall, including duration and times.

Corrective actions should be investigated and implemented within 24 hours where practicable where findings of the ESC monitoring indicate a non-conformance. More details are provided in chapters 6 and 7 of BPESC (IECA 2008).

2.9 Acid Sulfate Soil

"Actual acid sulfate soil (AASS) was detected at multiple locations in both the northern and southern peninsulas. There is a high potential for acid sulfate soils to be encountered more broadly across the site" (Golder, 2019). As recommended by Golder "Additional investigation of ASS at the specific locations that will be disturbed by the proposed construction works to inform the ASS management measures that will be required (Golder, 2019)."

The measures in the Draft EIS Darwin Processing Facility Appendix I: Acid Sulfate Soils Management Plan will be implemented to manage the impacts of ASS. ASS management measures may include but would not be limited to (Animal Plant Mineral Pty Ltd):

- avoiding disturbance of ASS, where practical
- minimising disturbance to prevent environmental impacts caused by the oxidation of ASS
- liming ASS on a dedicated treatment pad
- retaining all stormwater or ASS leachate from stockpiles or other exposed areas in a retention pond and treating the wastewater (if required)
- monitoring of wastewater conducted prior to discharging indicates parameters comply with the performance indicators.

2.10 Conceptual Erosion and Sediment Control Summary

The key aspects of the erosion and sediment control are as follows:

- Most of the site has a low to moderate erosion risk due to the low gradients of the existing site. Catchments S2 and S3 have a high erosion risk due to the cut potentially in silt.
- Soil testing nearby has classified soils as non-dispersive.

- AASS will be managed under the Acid Sulfate Soils Management Plan including but not limited to the measures in Section 2.9.
- Generally, Type 1 sediment control (e.g. sediment basin) is required for construction activities.
- Type 3 sediment control (e.g. sediment fencing) is required in cases where defined work can be completed between May and September inclusive (or May to October inclusive for catchments N1, N2 and R3).
- Enough space is available for construction of sediment basins in all areas, assuming conservative design parameters. This is a conceptual design to demonstrate it is practical and will be refined in detailed design.
- Type D basins have been assumed only to ensure enough space is available. Detailed design needs to assess Type A Basins (automatic chemical flocculation). Type D basins should only be selected where it is demonstrated that Type A Basins are not reasonable nor practical.
- Given the maximum seasonal groundwater level has been conservatively adopted as one (1) metre below the natural surface level an impermeable liner has been proposed for the base and side of the basins. These are conceptual options to demonstrate feasibility and may not represent the final detailed design approach.
- Detailed design and specification of erosion and sediment control techniques will be required in the Construction Erosion and Sediment Control Plan.

Additional sampling is recommended to inform the Construction Erosion and Sediment Control Plan. Existing data from the area indicates soils are non-dispersive (specifically results showed Emerson Class 5 or 6 (URS, 2009)). Additional site-specific Emerson Class sampling is required. In addition, further sampling will be undertaken following consideration of Section 3.5 of the BPESC.

This sampling can be undertaken as part of detailed geotechnical investigations of the site. . In addition to the above, jar testing is recommended to be undertaken based on Section B3(V) of BPESC Appendix B for the sediment basin design (IECA, 2018).

3 Conclusions and Recommendations

3.1 Site Based Stormwater Management

A high-level assessment of potential stormwater management options has been undertaken to mitigate potential adverse waterway impacts relating to the on-going operation of the proposed facility. The addition of reagents, mineral concentrates, sediments, litter, nutrients, hydrocarbons and other pollutants to stormwater runoff may decrease environmental values of downstream receiving environments, if primary containment structures fail. These impacts can be minimised by implementation of stormwater management measures specified in this conceptual SBSMP (e.g. SQUIDs, bioretention pods and basins etc.).

Much of the proposed project site is located on unconstrained areas requiring no diversion of stormwater runoff from upstream catchments, however there is a small catchment upstream of the central hub on the southern peninsula that will require diversion around the site. Additionally, the catchment upstream of a section of the road reserve between the southern and northern peninsulas will need to be conveyed through the site's road reserve into the East Arm.

Generally, stormwater flow from the site will be conveyed in an open channel system. The system will need to cater for the minor storm event of 20 year ARI and major storm event of 100 Year ARI.

3.1.1 Recommendations

Generic design intents have been used for this Environmental Impact Statement and hence final design of the minor and major stormwater systems, minor diversion systems and stormwater quality management features (e.g. SQUIDs, bioretention basins etc) will need to be undertaken during the detailed design phases of the project. As a minimum this would involve detailed engineering hydraulic design / modelling to ensure that the major and minor drainage systems achieve the required performance standards and water quality modelling to ensure that the treatments recommended achieve the desired water quality objectives for the site. Additionally, water balance modelling should be undertaken to determine the optimised stormwater harvesting design for the site.

The presentation of the devices in this conceptual plan provide one possible stormwater treatment approach that could be implemented on the site, but a range of options would be available for the development of the site.

Operational management, monitoring and maintenance plans should be developed with clear responsibilities assigned to relevant site personnel to ensure successful operation of all stormwater systems.

3.2 Erosion and Sediment Control

The conceptual erosion and sediment control plan has identified measures to be implemented during the construction of the facility.

Most of the site has a low to moderate erosion risk due to the low gradients of the existing site, with soil testing nearby classifying soils as non-dispersive. However, catchments S2 and S3 potentially have a high erosion risk. Generally, Type 1 sediment control (e.g. sediment basins) are required for construction activities. However, due to the seasonality of rainfall at the project location, only Type 3 sediment controls (e.g. sediment fencing) are required in cases where defined works can be completed between May and September, inclusive (or May to October inclusive for N1, N2 and R3).

Groundwater levels on site have been considered during the design of the sediment basins with an impermeable liner included. These are conceptual options to demonstrate feasibility and may not represent the final detailed design approach.

Enough space is available for construction of sediment basins, assuming conservative design parameters. This is a conceptual design to demonstrate it is practical. Detailed design and specification of erosion and sediment control techniques will be required in the Construction Erosion and Sediment Control Plan.

3.2.1 Recommendations

Additional sampling is recommended to inform the Construction Erosion and Sediment Control Plan. Existing data from the area indicates soils are non-dispersive (specifically results showed Emerson Class 5 or 6 (URS, 2009)). Additional site-specific Emerson Class sampling is required. Following consideration of Section 3.5 of the BPESC, further soil sampling will be undertaken. Jar testing will also be required for the sediment basin design.

4 Reference List

Alongi, D. (2012). Carbon sequestration in mangrove forests. *Carbon Management*, *3*(3), 313-322.

Animal Plant Mineral Pty Ltd. (2019). Acid Sulfate Soils Management Plan Darwin Processing Facility

Aquatic Health Unit (2012). Darwin Harbour Region 2012 Report Card. Report No 18/2012D. Aquatic Health Unit, Department of Land Resource Management, Northern Territory Government.

Australia and New Zealand Environment and Conservation Council (ANZECC) (2000) and Agricultural and Resource Management Council of Australia and New Zealand, *Australia Guidelines for Urban Stormwater Management,*

Australian Government Department of the Environment (DotE). (2015). *Environment Protection and Biodiversity Conservation (EPBC) Act 2015-7604 Referral*.

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) *Australian Rainfall and Runoff: A Guide to Flood Estimation,* Commonwealth of Australia (Geoscience Australia), 2019.

Cardno. (2013b). *Quarterly Mangrove Community Health Monitoring Program Baseline Phase Report*. Ichthys Nearshore Environmental Monitoring Program. Report No. L384-AW-REP-10001.

Cardno. (2013b). *Quarterly Mangrove Community Health Monitoring Report - Dredging Report 1*. Ichthys Nearshore Environmental Monitoring Program. Report No. L384-AW-REP-10007.

Cardno. (2013c). *Quarterly Mangrove Community Health Monitoring Report - Dredging Report 2*. Ichthys Nearshore Environmental Monitoring Program. Report No. L384-AW-REP-10031.

Cardno. (2013d). *Quarterly Mangrove Community Health Monitoring Report - Dredging Report 3*. Ichthys Nearshore Environmental Monitoring Program. Report No. L384-AW-REP-10032.

Cardno. (2013e). *Quarterly Mangrove Community Health Monitoring Report - Dredging Report 4*. Ichthys Nearshore Environmental Monitoring Program. Report No. L384-AW-REP-10033.

Cardno. (2014a). *Quarterly Mangrove Community Health Monitoring Report - Dredging Report 5*. Ichthys Nearshore Environmental Monitoring Program. Report No. L384-AW-REP-10034.

Cardno. (2014b). *Quarterly Mangrove Community Health Monitoring Report - Dredging Report 6*. Ichthys Nearshore Environmental Monitoring Program. Report No. L384-AW-REP-10035.

Cardno. (2014c). *Quarterly Mangrove Community Health Monitoring Report - Dredging Report 7*. Ichthys Nearshore Environmental Monitoring Program. Report No. L384-AW-REP-10036.

Cardno. (2014). *Elizabeth and Blackmore River Catchments – Flood Study*, Northern Territory Government

Coombes, P., and Roso, S. (Editors), 2019 Runoff in Urban Areas, Book 9 in Australian Rainfall and Runoff - A Guide to Flood Estimation, Commonwealth of Australia, © Commonwealth of Australia (Geoscience Australia), 2019

CSIRO and Bureau of Meteorology, 2015, *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report,* CSIRO and Bureau of Meteorology, Australia

Drewry, J., Dostine, P.L., Fortune, J., Majid, M., Schult, J., Lamche, G. 2010. Darwin Harbour Region Report Cards 2010. Department of Natural Resources, Environment, The Arts and Sport. Report No 25/2010D. Palmerston, NT, Australia.

Drewry, J., Fortune, J., & Browne, D. (2010). *Water quality of the Elizabeth River estuary, Darwin Harbour, before and during the 2006-2007 wet season*. Darwin: Northern Territory Government Department of Natural Resources, Environment, The Arts and Sport.

Drewry, J., Fortune, J., Majid, M., Schult, J., Lamche, G., Townsend & S., Cussack, S. (2011). Darwin Harbour Region 2011 Report Card Water Quality Supplement. Report No. 17/2011D. Aquatic Health Unit, Department of Natural Resources, Environment, The Arts and Sport. Palmerston, NT.

Drewry, J., Newham, L., & Croke, B. (2009). Suspended sediment, nitrogen and phosphorus concentrations and exports during storm-events to the Tuross estuary, Australia. Journal Of Environmental Management, 90(2), 879-887. doi: 10.1016/j.jenvman.2008.02.004

Eddy, F. (2005). Ammonia in estuaries and effects on fish. *Journal Of Fish Biology*, *67*(6), 1495-1513.

Fortune, J (2015). Supplement to the 2014 Darwin Harbour Region Report Card. Report No. 01/2015D. Aquatic Health Unit, Department of Land Resource Management. Palmerston, NT.

Fortune, J and Drewry, J (2009). Darwin Harbour Region 2009 Report Cards. Aquatic Health Unit, Department of Natural Resources, Environment, The Arts and Sport. Palmerston, NT.

Fortune, J and Patterson, R (2016). Darwin Harbour Region 2015 Report Card Water Quality Supplement. Report No. 4/2016D. Aquatic Health Unit, Department of Land Resource Management. Palmerston, NT.

Fortune, J. (2010). Water Quality Objectives for the Darwin Harbour region –background document. Department of Natural Resources, Environment, The Arts and Sport. Palmerston NT.\

Fortune, J. (2016). Darwin Harbour Region 2016 Report Card Water Quality Supplement. Report No. 22/2016D. Aquatic Health Unit, Department of Environment and Natural Resources. Palmerston, NT.

Golder (2019) Preliminary Site Investigation and Shallow Soil Baseline Assessment TNG Darwin Processing Facility (19115223-001-R-Rev3) – Draft EIS Darwin Processing Facility Appendix H: Technical Report for Soils

Golder (2019) Hydrogeological Study TNG Darwin Processing Facility (19115223-002-R-Rev2) – Draft EIS Darwin Processing Facility Appendix M: Technical Report for Hydrogeology

Greencap Pty Ltd. (2018) *EPA7 Annual Report 2018 – Environmental Impact Monitoring Program*. Report No. L384-AW-REP-10885.

IECA (2008), Best Practice Erosion and Sediment Control

IECA (2018,) Best Practice Erosion and Sediment Control Appendix B

Institute of Public Works Engineering Australasia (IPWEA) (2016) *Queensland Urban Drainage Manual*

Jaensch, R. (2019). Australian Wetlands Database - Directory Wetland Information Sheet. Retrieved from https://www.environment.gov.au/cgi-bin/wetlands/report.pl

Landcom (2004), Managing Urban Stormwater: Soils and Construction (Blue Book). New South Wales Government

Lee, G.P. (2003), Mangroves in the Northern Territory, Department of Infrastructure, Planning and Environment, Darwin.

Li, L., Wang, X., Williams, D., Sidhu, H., & Song, D. (2012). Numerical study of the effects of mangrove areas and tidal flats on tides: A case study of Darwin Harbour, Australia. *Journal Of Geophysical Research: Oceans*, *117*(C6).

Litchfield Council (20 July 2017), *Development and Subdivision Standards*

Mauraud, N. (2013): Darwin Harbour Water Quality: Supplement to the 2013 Darwin Harbour Region Report Card. Report No 12/2013D. Aquatic Health Unit, Department of Land Resource Management, Northern Territory Government.

Metcalfe, K. (2007). Thesis: The Biological Diversity, Recovery from Disturbance and Rehabilitation of Mangroves in Darwin Harbour, Northern Territory. *Faculty Of Education, Health & Science Charles Darwin University*.

Montgomery, J., Bryan, K., Horstman, E., & Mullarney, J. (2018). Attenuation of Tides and Surges by Mangroves: Contrasting Case Studies from New Zealand. *Water*, *10*(9), 1119.

Montgomery, J., Bryan, K., Mullarney, J., & Horstman, E. (2019). Attenuation of Storm Surges by Coastal Mangroves. *Geophysical Research Letters*, *46*(5), 2680-2689.

Moritz-Zimmermann, A., Comley, B. and Lewis, D. (2002). Darwin Harbour Mangrove Monitoring Methodology Technical Manual. Land Monitoring Series No.3, Report No. 25/2002. Department of Infrastructure Planning and Environment, Darwin, Northern Territory.

Northern territory Government Department of Lands and Housing (DLH). (1990). *Darwin Regional Land Use Structure Plan 1990.* Darwin: Northern territory Government.

Northern Territory Government Department of Lands, Planning and the Environment (DLPE). (2015). *Darwin Regional Land Use Plan 2015.* Darwin: Northern territory Government.

Northern territory Government Department of Natural Resources, Environment, The Arts and Sport (DNRETAS). (2010). *Water Quality Objectives for the Darwin Harbour Region - Background Document*. Darwin: Northern territory Government.

Polidoro, B., Carpenter, K., Collins, L., Duke, N., Ellison, A., & Ellison, J. et al. (2010). The Loss of Species: Mangrove Extinction Risk and Geographic Areas of Global Concern. *Plos ONE*, *5*(4), e10095.

Prosser, J. I. & Embley, T. (2002). Cultivation-based and molecular approaches to characterisation of terrestrial and aquatic nitrifiers. *Antonie van Leeuwenhoek* 81, 165–179.

Smit, N., Penny, S.S. and Griffiths, A.D. 2012. *Assessment of marine biodiversity and habitat mapping in the Weddell region, Darwin Harbour*. Report to the Department of Lands, Planning and Environment. Department of Land Resource Management, Palmerston.

Systems Engineering Australia, 2006, *Darwin Storm Tide Mapping Study 2006,* Northern Territory Government

Systems Engineering Australia, 2010, *High Resolution Storm Tide and Climate Change Impacts* Study 2010, Northern Territory Government

University of Western Australia*, Extreme Sea Levels in Australia* (http://sealevelx.ems.uwa.edu.au)

URS Australia Pty Ltd (2009b). Ichthys Gas Field Development Project: onshore topography, geology, geomorphology and soils study. Report prepared for INPEX Browse, Ltd., Perth, Western Australia.

Viscarra Rossel, Raphael; Teng, Hongfen; Zhou, Shi; Behrens, Thorsten; Chappell, Adrian; Bui, Elisabeth (2016): Maps of Australian soil loss by water erosion derived using the RUSLE. v1. CSIRO. Data Collection. https://doi.org/10.4225/08/582cef2dd5966Wilson, D., Padovan, A., & Townsend, S. (2004). *The Water Quality of Spring and Neap Tidal Cycles in the Middle Arm of Darwin Harbour during the Dry Season*. Darwin: Northern Territory Department of Infrastructure, Planning and the Environment.

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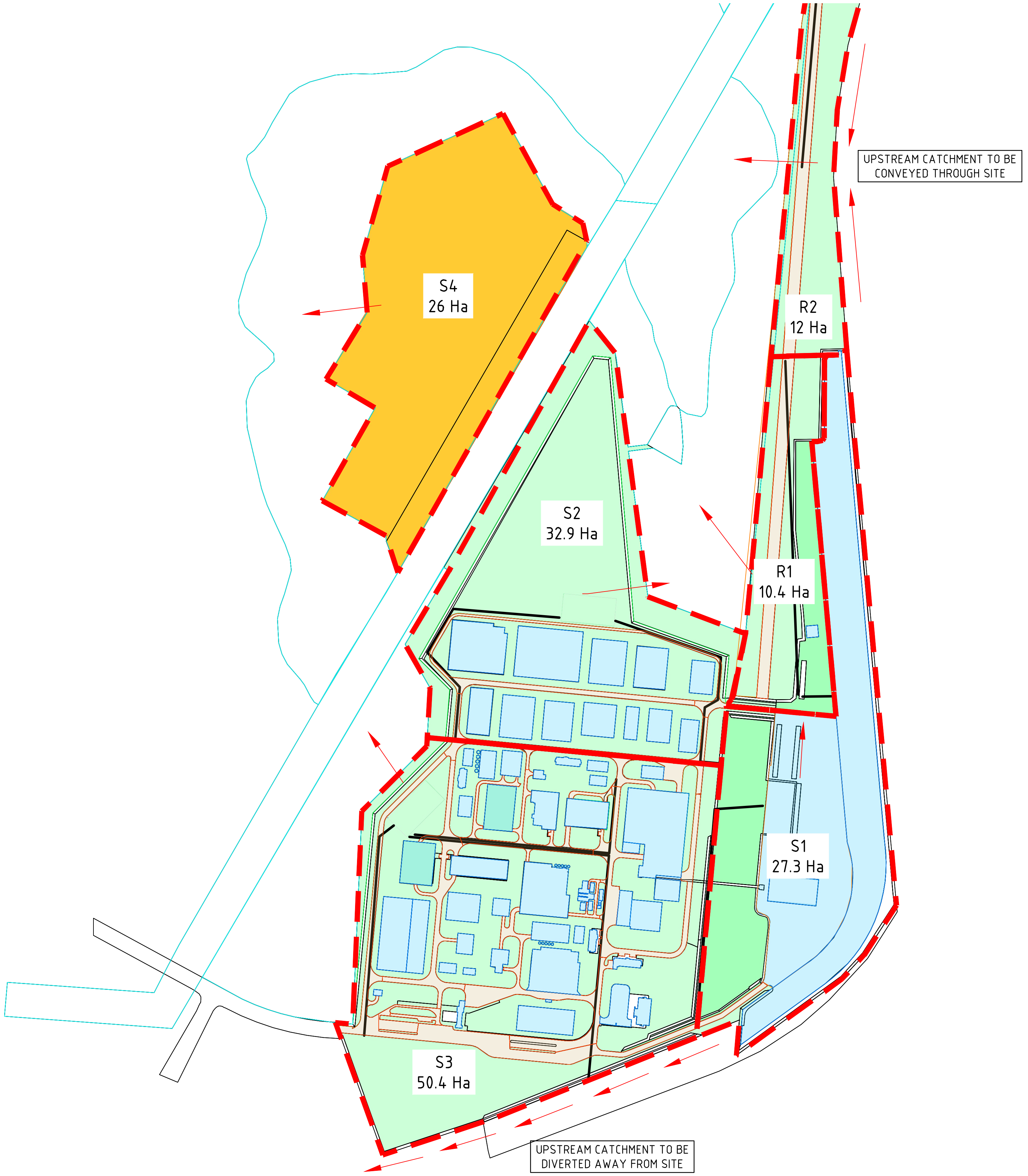
Appendix A
Catchment Plans



LEGEND

- CATCHMENT BOUNDARY
- CATCHMENT DISCHARGE POINT
- S3 48.9 Ha — CATCHMENT LABEL AND AREA
- ROADS (IMPERVIOUS)
- BUILDINGS/HARDSTAND (IMPERVIOUS)
- GRASS (PERVIOUS)
- SURFACE TO BE DETERMINED

Advisian
Worley Group

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	09.12.2020	ISSUED FOR INFORMATION	JE
A	02.11.2020	ISSUED FOR INFORMATION	JE

100 0 100 200 300 400 500
SCALE OF METRES 1:5000

TNG LIMITED
DARWIN PROCESSING FACILITY
CATCHMENT PLAN - SHEET 1
SKT- 0004

LOCATION: G:\301001\02135 PROJ - TNG DARWIN HYDROLOGY\5_ENGINEERING\SWMP\TNG CATCHMENT PLAN.DWG
USER NAME: jennifer.emmett CTB FILE: Worley-Full.ctb Plotter-None
PLOT DATE & TIME: 15/12/2020 12:25:53 PM SAVE DATE & TIME: 14/12/2020 10:15:33 AM

Advisian
Worley Group

OneWay to zero harm

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	09.12.2020	ISSUED FOR INFORMATION	JE
A	02.11.2020	ISSUED FOR INFORMATION	JE

100 0 100 200 300 400 500
SCALE OF METRES 1:5000

TNG LIMITED
DARWIN PROCESSING FACILITY
CATCHMENT PLAN - SHEET 2

SKT- 0005

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SAVE DATE & TIME: 14/12/2020 10:15:33 AM CTB FILE: Worley-Full.ctb Plotter:None

Appendix B
Rational Method Calculations

Advisian

Calculation Sheet

TNG LIMITED

Customer	TMG Limited		301001-02135
Project Title	Darwin Processing Facility		
Calculation Title	Stormwater Drainage Calculations		
Project File Location	\\aubriwpdfs02v\Brisbane\Projects\301001\02135 PROJ - TNG Darwin Hydrology\5_Engineering\SWMP\Calcs\[Rational Calc Rev B.xlsm]Calculation Cover Sheet		of 9

Revision	Date	By	Checked	Revision	Date	By	Checked	Date	By
A	04-Nov-20	S.Smith	S.Joughin	B	15-Dec-20	S.Smith	S.Joughin	00-Jan-00	0-01-00

DEVELOPED CASE

CATCHMENT FLOW CALCULATIONS

CATCHMENT DETAILS / RUNOFF CO-EFFICIENTS - QUDM

CATCHMENT ID		CONTRIBUTING CATCHMENTS	CATCHMENT AREA (ha)	CATCHMENT TYPE	FRAC IMP (%)	RUNOFF CO-EFFICIENT C_1	C_5	C_{10}	C_{20}	C_{100}	EQ IMP AREA (ha) Q_1	Q_5	Q_{10}	$Q2_0$	Q_{100}
N1															
		Hardstand	9.59	Urban	100	0.72	0.86	0.90	0.95	1.00	6.90	8.20	8.63	9.06	9.59
		Road	9.58	Urban	100	0.72	0.86	0.90	0.95	1.00	6.90	8.19	8.62	9.05	9.58
		Grass	21.83	Urban	0	0.56	0.67	0.70	0.74	0.84	12.22	14.52	15.28	16.05	18.34
		TBC	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		Basin	0.00	Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		TOTAL	**41.00**								26.03	30.91	32.53	34.16	37.51
N2															
		Hardstand	11.07	Urban	100	0.72	0.86	0.90	0.95	1.00	7.97	9.46	9.96	10.46	11.07
		Road	5.90	Urban	100	0.72	0.86	0.90	0.95	1.00	4.25	5.04	5.31	5.58	5.90
		Grass	20.63	Urban	0	0.56	0.67	0.70	0.74	0.84	11.55	13.72	14.44	15.16	17.33
		TBC	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		Basin	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		TOTAL	37.60								23.77	28.23	29.71	31.20	34.30
R1															
		Hardstand	0.17	Urban	100	0.72	0.86	0.90	0.95	1.00	0.12	0.15	0.15	0.16	0.17
		Road	2.03	Urban	100	0.72	0.86	0.90	0.95	1.00	1.46	1.74	1.83	1.92	2.03
		Grass	8.20	Urban	0	0.56	0.67	0.70	0.74	0.84	4.59	5.45	5.74	6.03	6.89
		TBC	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		Basin	0.00	Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		TOTAL	10.40								6.18	7.33	7.72	8.11	9.09
R2															
		Hardstand	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		Road	3.03	Urban	100	0.72	0.86	0.90	0.95	1.00	2.18	2.59	2.73	2.86	3.03
		Grass	8.97	Urban	0	0.56	0.67	0.70	0.74	0.84	5.02	5.97	6.28	6.59	7.53
		TBC		Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		Basin	0.00	Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		TOTAL	12.00								7.20	8.56	9.01	9.46	10.56
R3															
		Hardstand	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		Road	3.60	Urban	100	0.72	0.86	0.90	0.95	1.00	2.59	3.08	3.24	3.40	3.60
		Grass	10.00	Urban	0	0.56	0.67	0.70	0.74	0.84	5.60	6.65	7.00	7.35	8.40
		TBC	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		Basin	0.00	Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		TOTAL	13.60								8.19	9.73	10.24	10.75	12.00
S1			18.29												
		Hardstand	18.29	Urban	100	0.72	0.86	0.90	0.95	1.00	13.17	15.64	16.46	17.28	18.29
		Road	0.15	Urban	100	0.72	0.86	0.90	0.95	1.00	0.11	0.13	0.14	0.14	0.15
		Grass	8.86	Urban	0	0.56	0.67	0.70	0.74	0.84	4.96	5.89	6.20	6.51	7.44
		TBC	0.00	Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		Basin	0.00	Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		TOTAL	27.30								18.24	21.66	22.80	23.94	25.88
S2															
	0.21	Hardstand	6.99	Urban	100	0.72	0.86	0.90	0.95	1.00	5.03	5.98	6.29	6.61	6.99
	0.05	Road	1.61	Urban	100	0.72	0.86	0.90	0.95	1.00	1.16	1.38	1.45	1.52	1.61
	0.74	Grass	24.30	Urban	0	0.56	0.67	0.70	0.74	0.84	13.61	16.16	17.01	17.86	20.41
		TBC	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		Basin	0.00	Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		TOTAL	32.90								19.80	23.51	24.75	25.99	29.01
S3															
	0.24	Hardstand	12.31	Urban	100	0.72	0.86	0.90	0.95	1.00	8.86	10.53	11.08	11.63	12.31
	0.16	Road	8.04	Urban	100	0.72	0.86	0.90	0.95	1.00	5.79	6.87	7.24	7.60	8.04
	0.6	Grass	30.05	Urban	0	0.56	0.67	0.70	0.74	0.84	16.83	19.98	21.04	22.09	25.24
		TBC	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		Basin	0.00	Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		TOTAL	50.40								31.48	37.38	39.35	41.32	45.59
S4															
		Hardstand	5.93	Urban	100	0.72	0.86	0.90	0.95	1.00	4.27	5.07	5.33	5.60	5.93
		Road	3.79	Urban	100	0.72	0.86	0.90	0.95	1.00	2.73	3.24	3.41	3.58	3.79
		Grass	16.28	Urban	0	0.56	0.67	0.70	0.74	0.84	9.12	10.83	11.40	11.97	13.68
		TBC	0.00	Urban	100	0.72	0.86	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00
		Basin	0.00	Urban	100	0.56	0.67	0.70	0.74	0.84	0.00	0.00	0.00	0.00	0.00
		TOTAL	26.00								16.11	19.13	20.14	21.15	23.39

STD INLET TIME / OVERLAND SHEET FLOW TIME - HORTONS EQUATION / DRAIN FLOW TIME / FLOW CALCULATION

CATCHMENT ID	STD INLET TIME (min)	SURFACE CONDITION	HORTON'S ROUGHNESS n	MAX FLOW LENGTH L_{MAX} (guide)	LENGTH L_O (m)	AVERAGE SLOPE S_O (%)	VELOCITY v_O (m/s)	SHEET FLOW TIME t_O (min)	LENGTH L_D (m)	VELOCITY v_D (m/s)	AVERAGE SLOPE (%)	DRAINFLOW TIME td (mins)	TOTAL TIME t_c (mins)	ADOPTED TIME t_c (mins)	RAINFALL INTENSITY I (Q_b) (mm/hr) I_1	I_5	I_{10}	I_{20}	I_{100}	DESIGN FLOW Q (m^3/s) $Q_{0.25}$	Q_1	Q_5	Q_{10}	Q_{20}	Q_{100}
N1	5	Poorly Grassed Surface	0.035	200	0	0.5	0.0	0.0	950	0.99	0.3	16.1	21.1	20.0	85	129	142	161	206	3.06	6.11	11.04	12.80	15.25	21.51
N2	5	Hardstand	0.021	100	0	3.0	0.0	0.0	1000	0.99	0.3	16.9	21.9	20.0	85	129	142	161	206	2.79	5.58	10.08	11.70	13.93	19.67
R1		Poorly Grassed Surface	0.035	100	75	2.2	0.1	13.5	450	0.99	0.3	7.6	21.1	20.0	85	129	142	161	206	0.72	1.45	2.62	3.04	3.62	5.21
R2		Poorly Grassed Surface	0.035	200	100	0.5	0.1	20.0	470	0.99	2.0	8.0	27.9	20.0	85	129	142	161	206	0.85	1.69	3.06	3.54	4.22	6.06
R3		Poorly Grassed Surface	0.021	100	100	3.0	0.2	8.4	900	0.99	0.6	15.2	23.6	20.0	85	129	142	161	206	0.96	1.92	3.47	4.03	4.80	6.88
S1	0	Hardstand	0.021	50	50	1.8	0.1	7.4	850	0.99	0.3	14.4	21.7	20.0	85	129	142	161	206	2.14	4.28	7.73	8.97	10.69	14.85
S2	5	Poorly Grassed Surface	0.035	200	0	3.0	0.0	0.0	550	0.99	0.3	9.3	14.3	14.3	98	150	166	188	242	2.71	5.42	9.82	11.40	13.59	19.54
S3	5	Poorly Grassed Surface	0.035	200	0	0.9	0.0	0.0	900	0.99	0.3	15.2	20.2	20.0	85	129	142	161	206	3.70	7.39	13.35	15.49	18.44	26.15
		Poorly Grassed Surface	0.035	200	200	0.9	0.1	22.4	450	1.46	0.3	5.1	27.5												
S4	5	Poorly Grassed Surface	0.035	200	0	0.3	0.0	0.0	550	0.99	0.3	9.3	14.3	14.3	98	150	166	188	242	2.20	4.41	7.99	9.28	11.06	15.75

EXISTING CASE

CATCHMENT DETAILS / RUNOFF CO-EFFICIENTS- AR&R 1997

CATCHMENT ID	CONTRIBUTING CATCHMENTS	CATCHMENT AREA (ha)	CATCHMENT TYPE	FRAC IMP (%)	RUNOFF CO-EFFICIENT C_1	C_5	C_{10}	C_{20}	C_{100}	EQ IMP AREA Q_1 (ha)	Q_5 (ha)	Q_{10} (ha)	Q_{20} (ha)	Q_{100} (ha)
N1	Poorly grassed/bare earth	41.00	Rural	0	0.56	0.67	0.70	0.74	0.77	22.96	27.27	28.70	30.34	31.57
N2	Poorly grassed/bare earth	37.60	Rural	0	0.56	0.67	0.70	0.74	0.77	21.06	25.00	26.32	27.82	28.95
R1	Poorly grassed/bare earth	10.40	Rural	0	0.56	0.67	0.70	0.74	0.77	5.82	6.92	7.28	7.70	8.01
R2	Poorly grassed/bare earth	12.00	Rural	0	0.56	0.67	0.70	0.74	0.77	6.72	7.98	8.40	8.88	9.24
R3	Poorly grassed/bare earth	13.60	Rural	0	0.56	0.67	0.70	0.74	0.77	7.62	9.04	9.52	10.06	10.47
S1	Poorly grassed/bare earth	27.30	Rural	0	0.56	0.67	0.70	0.74	0.77	15.29	18.15	19.11	20.20	21.02
S2	Poorly grassed/bare earth	32.90	Rural	0	0.56	0.67	0.70	0.74	0.77	18.42	21.88	23.03	24.35	25.33
S3	Poorly grassed/bare earth	50.40	Rural	0	0.56	0.67	0.70	0.74	0.77	28.22	33.52	35.28	37.30	38.81
S4	Poorly grassed/bare earth	26.00	Rural	0	0.56	0.67	0.70	0.74	0.77	14.56	17.29	18.20	19.24	20.02

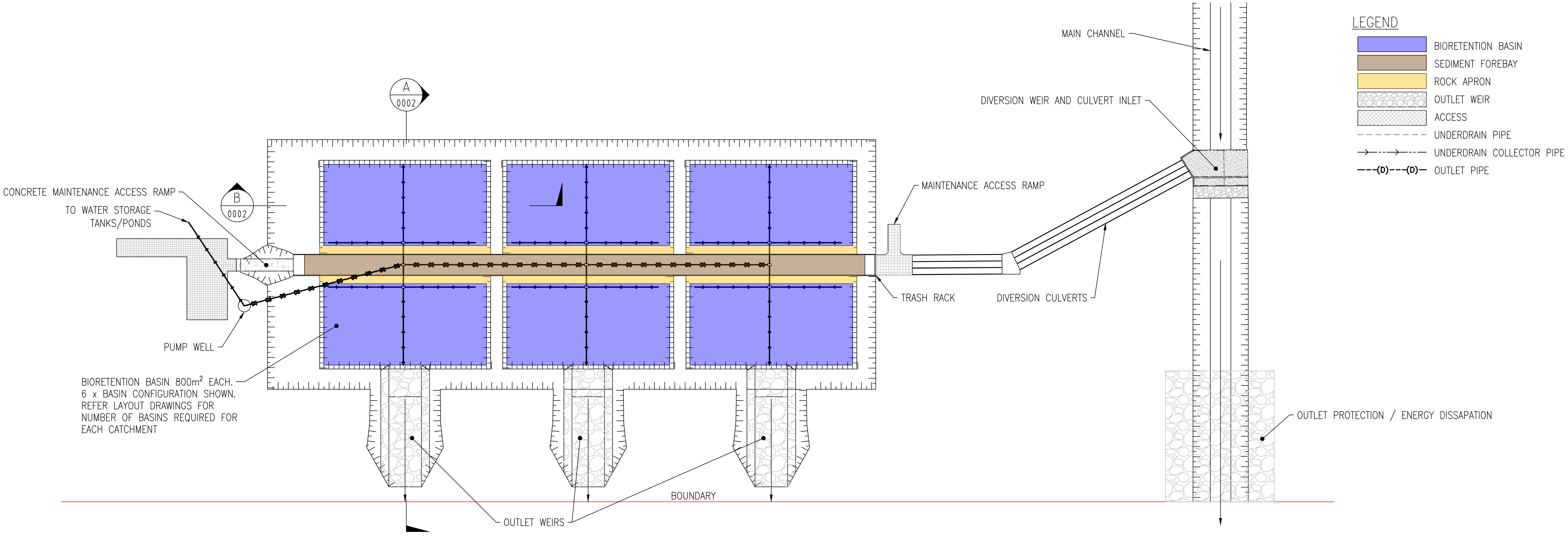
STD INLET TIME / OVERLAND SHEET FLOW TIME - BRANSBY WILLIAMS EQUATION

CATCHMENT ID	STD INLET TIME		Mainstream length L (km)	Eq area slope Se (m/km)	time (min)
N1	0	Poorly grassed/bare earth	0.46	7.80	19.15
N2	0	Poorly grassed/bare earth	0.46	6.50	20.03
R1	0	Poorly grassed/bare earth	0.38	5.50	19.46
R2	0	Poorly grassed/bare earth	0.64	12.20	27.54
R3	0	Poorly grassed/bare earth	1.05	6.30	50.93
S1	0	Poorly grassed/bare earth	0.70	14.00	27.00
S2	0	Poorly grassed/bare earth	0.26	6.90	11.34
S3	0	Poorly grassed/bare earth	0.75	9.60	29.34
S4	0	Poorly grassed/bare earth	0.52	19.60	18.84

FLOW CALCULATION

CATCHMENT ID	TIME OF CONC t_c (mins)	RAINFALL INTENSITY I (Q_5) (mm/hr) I_1	I_5	I_{10}	I_{20}	I_{100}	DESIGN FLOW Q (m^3/s) $Q_{0.25}$	Q_1	Q_5	Q_{10}	Q_{20}	Q_{100}
N1	19.15	86	132	145	165	211	2.76	5.52	9.97	11.56	13.87	18.54
N2	20.03	85	129	142	161	206	2.47	4.94	8.93	10.36	12.42	16.61
R1	19.46	86	132	145	165	211	0.70	1.40	2.53	2.93	3.52	4.70
R2	27.54	72	109	120	137	175	0.67	1.34	2.42	2.81	3.37	4.50
R3	30.00	69	106	116	132	169	0.74	1.47	2.65	3.07	3.68	4.92
S1	27.00	73	111	123	139	179	1.56	3.11	5.62	6.51	7.80	10.42
S2	11.34	108	166	183	208	269	2.77	5.55	10.09	11.72	14.09	18.91
S3	29.34	71	107	118	134	172	2.77	5.54	10.00	11.59	13.89	18.56
S4	18.84	86	132	145	165	211	1.75	3.50	6.32	7.33	8.79	11.76

Appendix C
Bioretention Basin Plans and Details



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to zero harm

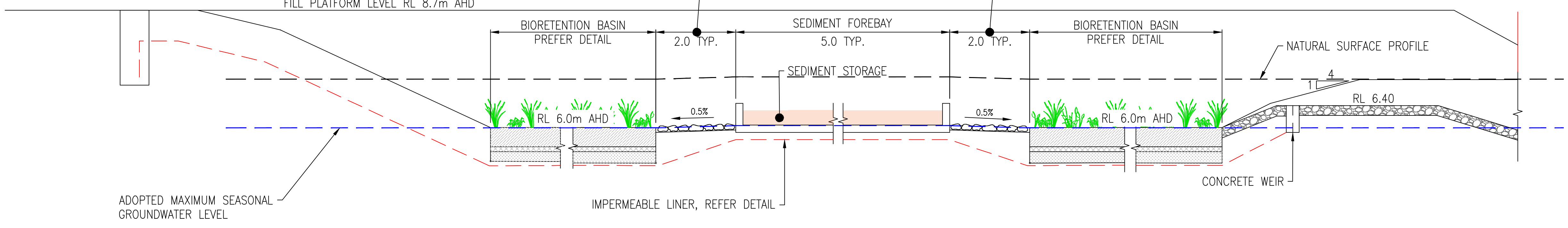
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
A	02.11.2020	ISSUED FOR INFORMATION	JE

10 0 10 20 30 40 50
SCALE OF METRES 1:500

TNG LIMITED
DARWIN PROCESSING FACILITY
BIORETENTION BASIN - TYPICAL LAYOUT

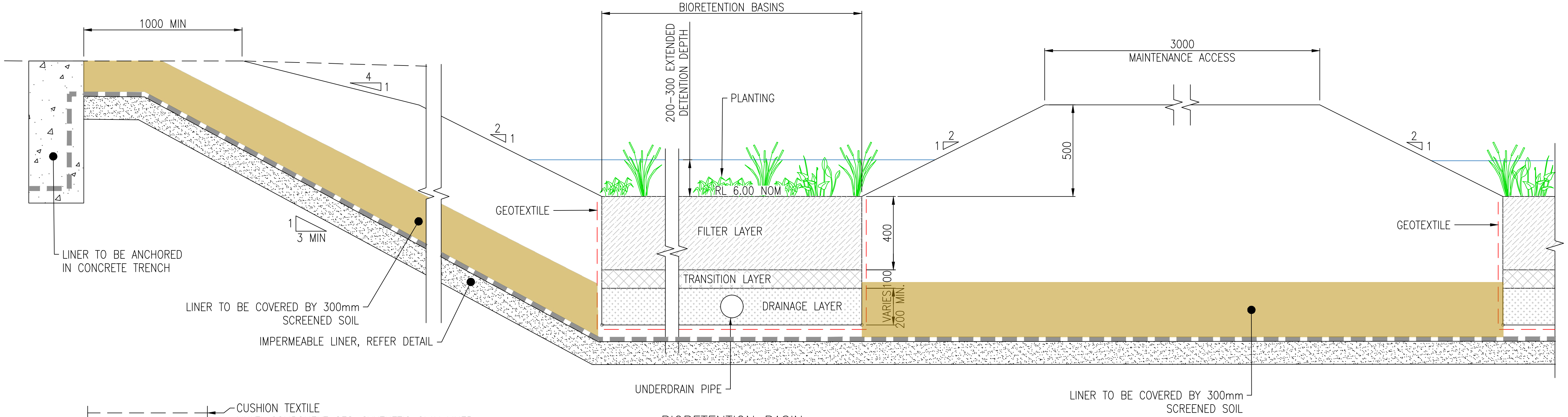
SKT- 0001

PLOT DATE & TIME: 3/11/2020 10:30:11 AM USER NAME: jennifer.emmett LOCATION: \\AUBRIWPDFS02V\BRISBANE\PROJECTS\301001\02135 PROJ - TNG DARWIN HYDROLOGY\5_ENGINEERING\SWMP\BIORETENTION SKETCH - LAYOUT.DWG
SAVE DATE & TIME: 3/11/2020 9:20:52 AM CTB FILE: Worley-Full.ctb Plotter:None



SECTION A
SCALE: N.T.S 0001

NOTE: BASIN SECTION SHOWN IS FOR BIORETENTION BASIN S3.
SIMILAR DETAILS/APPROACH FOR OTHER BASINS



BIORETENTION BASIN

SECTION B
SCALE: N.T.S 0001

IMPERMEABLE LINER DETAIL
NTS

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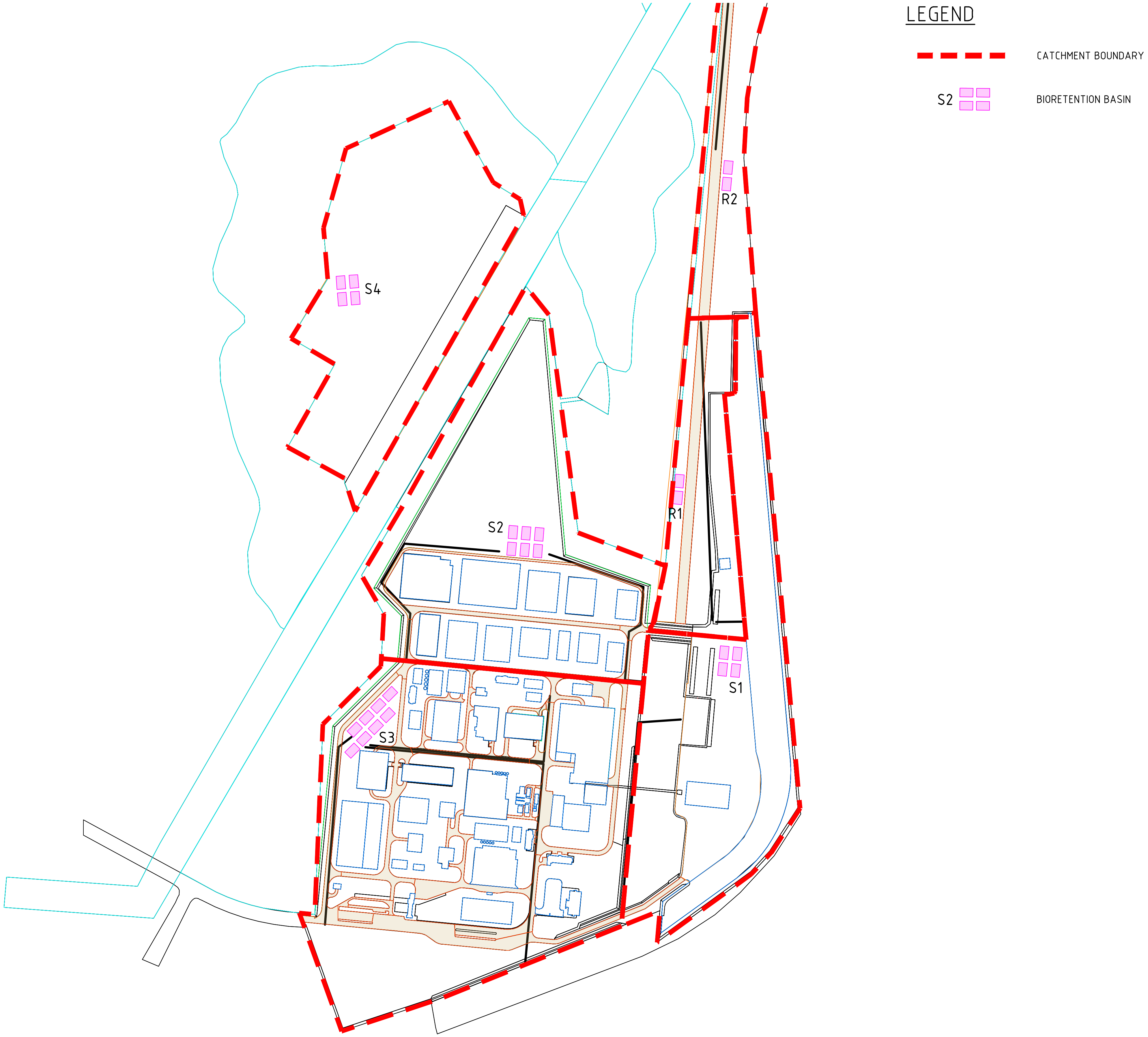
A	02.11.2020	ISSUED FOR INFORMATION	JE

TNG LIMITED
DARWIN PROCESSING FACILITY
BIORETENTION BASIN - TYPICAL SECTIONS

SKT- 0002

USER NAME: jennifer.emmett
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 4/11/2020 11:34:19 AM
SAVE DATE & TIME: 3/11/2020 6:31:33 PM



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ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	09.12.2020	ISSUED FOR INFORMATION	JE
A	02.11.2020	ISSUED FOR INFORMATION	JE

100 0 100 200 300 400 500
SCALE OF METRES 1:5000

TNG LIMITED
DARWIN PROCESSING FACILITY
CATCHMENT PLAN - BIORETENTION BASINS - SHEET 1
SKT- 0006

PLOT DATE & TIME: 15/12/2020 12:27:22 PM USER NAME: jennifer.emmett LOCATION: G:\301001\02135 PROJ - TNG DARWIN HYDROLOGY\5_ENGINEERING\SWMP\TNG CATCHMENT PLAN.DWG
SAVE DATE & TIME: 14/12/2020 10:15:33 AM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

CATCHMENT BOUNDARY

S2 BIORETENTION BASIN

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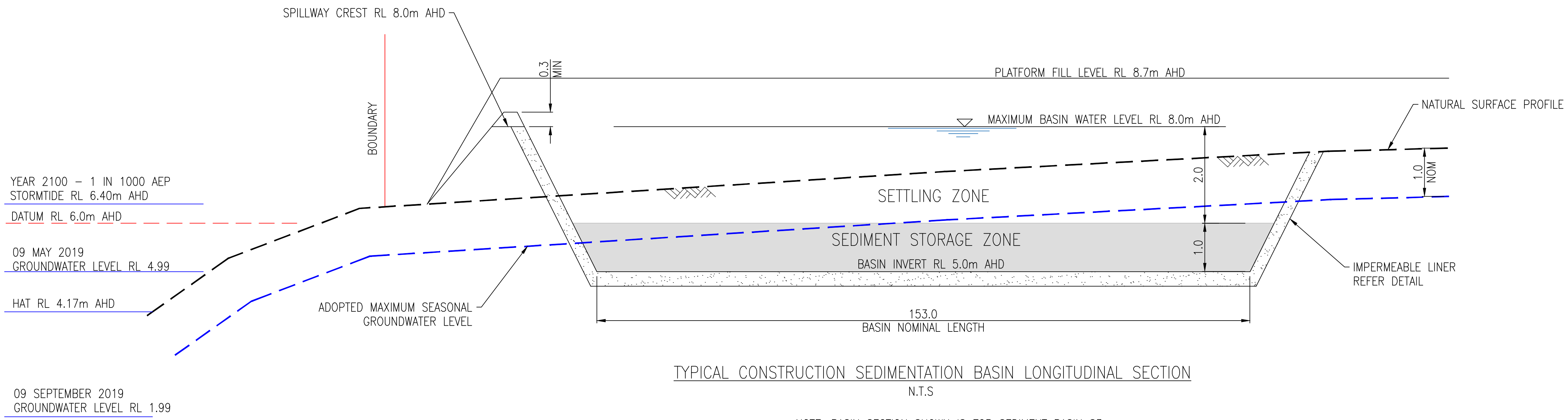
ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	09.12.2020	ISSUED FOR INFORMATION	JE
A	02.11.2020	ISSUED FOR INFORMATION	JE

100 0 100 200 300 400 500
SCALE OF METRES 1:5000

TNG LIMITED
DARWIN PROCESSING FACILITY
CATCHMENT PLAN - BIORETENTION BASINS - SHEET 2
SKT- 0007

PLOT DATE & TIME: 15/12/2020 12:28:23 PM USER NAME: jennifer.emmett LOCATION: G:\301001\02135 PROJ - TNG DARWIN HYDROLOGY\5_ENGINEERING\SWMP\TNG CATCHMENT PLAN.DWG
SAVE DATE & TIME: 14/12/2020 10:15:33 AM CTB FILE: Worley-Full.ctb Plotter:None

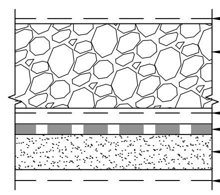
Appendix D
Sedimentation Basin Plans and Details



TYPICAL CONSTRUCTION SEDIMENTATION BASIN LONGITUDINAL SECTION

N.T.S

NOTE: BASIN SECTION SHOWN IS FOR SEDIMENT BASIN S3.
SIMILAR DETAILS/APPROACH FOR OTHER BASINS



IMPERMEABLE LINER DETAIL

NTS

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ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
A	02.11.2020	ISSUED FOR INFORMATION	JE

TNG LIMITED
DARWIN PROCESSING FACILITY
SEDIMENT BASIN - TYPICAL SECTION

SKT- 0003

LOCATION: \\AUBRIWPDFS02V\BRISBANE\PROJECTS\301001\02135 PROJ - TNG DARWIN HYDROLOGY\5_ENGINEERING\SWMP\SEDIMENT BASIN SKETCH.DWG
USER NAME: jennifer.emmett
CTB FILE: Worley-Full.ctb Plotter:None
PLOT DATE & TIME: 3/11/2020 4:43:12 PM
SAVE DATE & TIME: 3/11/2020 3:05:02 PM

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ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	09.12.2020	ISSUED FOR INFORMATION	JE
A	02.11.2020	ISSUED FOR INFORMATION	JE

100 0 100 200 300 400 500
SCALE OF METRES 1:5000

TNG LIMITED
DARWIN PROCESSING FACILITY
CATCHMENT PLAN - SEDIMENT BASINS - SHEET 1
SKT- 0008

PLOT DATE & TIME: 14/12/2020 9:54:45 AM USER NAME: jennifer.emmett LOCATION: G:\301001\02135 PROJ - TNG DARWIN HYDROLOGY\5_ENGINEERING\SWMP\TNG CATCHMENT PLAN.DWG
SAVE DATE & TIME: 9/12/2020 1:47:40 PM CTB FILE: Worley-Full.ctb Plotter:None

LEGEND

CATCHMENT BOUNDARY

S2 SEDIMENT BASIN

ISSUE	DATE	ISSUE DESCRIPTION	DRAWN
B	09.12.2020	ISSUED FOR INFORMATION	JE
A	02.11.2020	ISSUED FOR INFORMATION	JE

100 0 100 200 300 400 500

SCALE OF METRES 1:5000

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TNG LIMITED
DARWIN PROCESSING FACILITY
CATCHMENT PLAN - SEDIMENT BASINS - SHEET 2

SKT- 0009

PLOT DATE & TIME: 14/12/2020 9:56:14 AM USER NAME: jennifer.emmett LOCATION: G:\301001\02135 PROJ - TNG DARWIN HYDROLOGY\5_ENGINEERING\SWMP\TNG CATCHMENT PLAN.DWG
SAVE DATE & TIME: 9/12/2020 1:47:40 PM CTB FILE: Worley-Full.ctb Plotter:None