talis
delivering solutions

Assets | Engineering | Environment | Noise | Spatial | Waste

Surface Water Management Plan

Pilbara Regional Waste Management Facility

shire of Ashburton
reef to range

Prepared for Shire of Ashburton

October 2018

Project Number: TW18004

DOCUMENT CONTROL

Version	Description	Date	Author	Reviewer
0a	Internal Review	28/06/18	LW+CP	LM
1a	Draft Released to Pells Sullivan Meynink for Review	18/07/18	CP	LM
1b	Released to Client for Review	04/09/18	CP	LM
1c	Final Report	15/10/18	CP	LM

Approval for Release

Name	Position	File Reference
Ronan Cullen	Director and Waste Management Section Leader	TW18004 - Surface Water Management Plan.1c

Signature

Table of Contents

Tables

Diagrams

Figures

Appendices

1 Introduction

Talis Consultants Pty Ltd (Talis) was commissioned by the Shire of Ashburton (the Shire) to prepare the approval documentation for the Pilbara Regional Waste Management Facility (the Site). As part of the supporting documentation, a Surface Water Management Plan (SWMP) has been developed, summarising the assessments and strategy for managing surface water during the development, operation and closure of the Site.

1.1 Background

The Shire of Ashburton is progressing with the development of a new regional waste management facility located at Lot 150 Onslow Road, Talandji, Western Australia. With the rapid increase in industrial development and its associated growth within the Shire and Pilbara Region, there will be a significant increase in the volume of waste generated. Therefore, the Shire identified the need for the establishment of a new facility that can meet the waste management needs of Onslow and the wider Pilbara region.

The project, referred to as the Pilbara Regional Waste Management Facility (PRWMF), will provide a range of waste management services including sustainable initiatives such as reuse, recycling and recovery as well as treatment and disposal. The proposed Class IV facility and its associated infrastructure will be designed and constructed to Environmental Protection Authority (EPA) Victoria's Best Practice Environmental Management Guidelines for the Siting, Design, Operation and Rehabilitation of Landfills (August 2015) (Best Practice Landfill Standards). It will consist of a double composite lined landfill cells with leachate collection that will accept municipal solid waste and commercial waste, as well as contaminated soil and sludge (including encapsulated wastes).

1.2 Scope of Works

The SWMP contains the following scope of works:

- Site description;
- Local climate data;
- Surface Water Management Strategy;
  - Surface water management requirements;
  - Surface water generation modelling;
  - Surface water infrastructure requirements;
  - Operational management and monitoring strategy; and
- Local flood risk assessment.

2 Site Description

2.1 Site Information

The Site is located approximately 36km south of Onslow within Lot 150 Onslow Road, Talandji, which occupies an area of 434 hectares (ha). The proposed Site footprint occupies a total of approximately 70ha and is accessible from Onslow Road, which is a main road and primary distributor. The Site is located behind an approximately 3km long sand ridge and, therefore, most of the PRWMF will not be visible from Onslow Road.

2.2 Environmental Attributes

The following sections outline the key existing environmental attributes of the Site, including topography, geology and surface water, which affect the development of the surface water management system.

2.2.1 Topography

The Site is relatively flat, with a gentle slope across the sand plain towards the north-west and the Indian Ocean. The Site topography ranges from 17 to 13 metres (m) Australian Height Datum (AHD) on the lower sand plain to 40mAHD along the crest of the sand ridge. A number of surface depressions of various sizes are distributed across the sand ridge. The topography of the Site is provided in Figure 2.

2.2.2 Geology

In 2017, Talis was commissioned by the Shire to undertake a geotechnical investigation of the Site. As part of the works, a total of 112 trial pits (TP01-TP112) were excavated across the Site to assess the shallow subsurface, and to allow the collection of bulk soil samples for laboratory testing. The trial excavations described the underlying soil horizon to primarily be a SAND, with its structure described as fine to medium grained, rounded to sub rounded, dry and loose with occasional roots. It was also described as a SILTY SAND/SANDY SILT of low plasticity. This horizon is colloquially known as 'Pindan'. This horizon was encountered to a maximum depth of between 0.5m and 5m below ground level.

The conditions were recorded to be generally homogenous across the Site. Therefore, the following generalised profile has been determined for the Site:

- SAND – loose, fine to medium grained (Pindan) generally corresponding to the sand dune ridge;
- Sandy clayey SILT/Silty clayey SAND – loose to dense, fine to medium grained, rounded to sub-rounded, red brown and dry (Pindan); underlain by
- Cemented GRAVEL/SILCRETE – cemented gravels in silty sand/sandy silt matrix – hard, red brown and white, becoming brown with depth, and dry; underlain by
- SANDSTONE interfingered with cemented gravel – medium grained, occasional clasts, siliceous veins and vugs, dry, red to yellow.

2.2.3 Surface Water

There are no surface water bodies located within the Site. The nearest surface water body identified in NationalMap is a salt lake located approximately 2.5km west from the boundary of the Site. The Site is located in between two major ephemeral watercourses. The Ashburton River is located approximately 20km south-west of the Site and the Cane River is located approximately 21km to the north-east. The Site is located within the Ashburton River Catchment Area (Figure 4). These major rivers discharge over the coastal flats towards the Indian Ocean. According to the Department of Water's 'Pilbara Regional Water Plan 2010-2030 Supporting Detail' (May 2010), these rivers are highly seasonal and variable and flow following rainfall and cyclonic activities. The hydrology and hydrographic catchments surrounding the Site are shown in Figure 3 and 4 respectively.

3 Local Climate Data

The local and regional climate data sources utilised in designing the surface water management systems at the Site, include the following:

- Pan evaporation;
- Intensity Frequency Duration
  - Design rainfall depth;
  - Design rainfall intensity;
- Areal-reduction factors;
- Storm losses; and
- Areal temporal patterns.

Historic weather data was sourced from the Bureau of Meteorology (BOM) website utilising the Onslow Airport weather station data (Station ID: 005017): http://www.bom.gov.au/climate/data/. The station is approximately 4 kilometres (km) from the coast and approximately 30km from the Site.

3.1 Temperature

The climate of the Onslow area is considered to be a grassland climate and arid with a hot, humid summer zone. Table 3-1 shows the mean minimum and maximum temperature at the Onslow Airport from 1940 to 2017.

Table 3-1: Average Maximum and Minimum Temperatures (°C) at Onslow Airport (1940-2017)

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Minimum	24.4	25.0	24.2	21.4	17.4	14.3	13.0	13.6	15.4	17.9	20.1	22.4	19.1
Maximum	36.4	36.3	36.1	33.9	29.3	26.0	25.4	27.3	30.1	32.9	34.4	35.9	32.0

As shown above, the lowest minimum mean temperature for Onslow is 13.0°C during the winter months and highest maximum mean temperature is 36.4°C during the summer months.

3.2 Rainfall

Being an arid zone, the wet season for the Pilbara region occurs from December to April each year. Table 3-2 and Diagram 3-1 presents the summary of rainfall records collected from the Onslow Airport from 1940 to 2017.

Table 3-2: Rainfall Overview at Onslow Airport (1940-2017)

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	38.6	61.0	72.0	11.4	48.6	45.5	20.3	8.6	1.4	0.8	2.8	3.4	314.4
90th Percentile	112.4	179.2	248.6	28.9	111.8	111.6	51.3	30.0	2.2	1.6	4.7	6.7	540.5
Highest	275.6	358.6	374.9	163.4	236.7	230.8	115.4	81.8	24.7	15.0	60.2	54.0	1,085.1

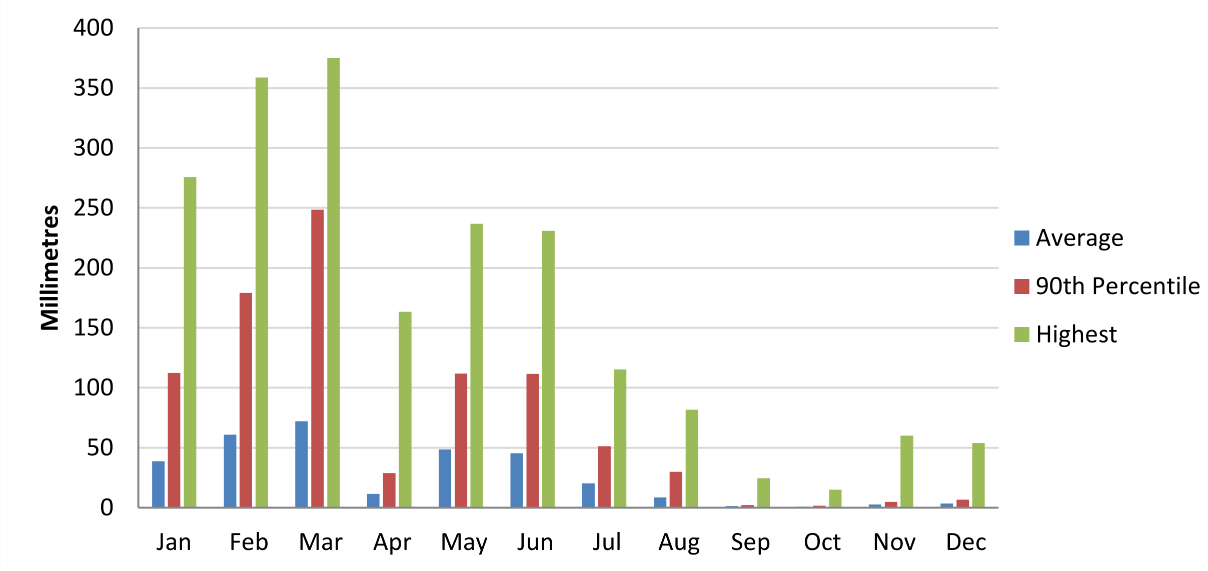


Diagram 3-1: Onslow Airport Rainfall from 1940 -2017

The mean annual rainfall for Onslow is reported as 314.4 millimetres (mm). Regionally, the Ashburton River Catchment Area's mean annual rainfall varies from 230mm to 400mm. Mean annual rainfall trends downwards heading east from the coast and south from the Hamersley Range (approximately 150km east of the Site). Larger rainfall events are typically associated with tropical cyclones and large low pressure systems that most frequently affect the region between January and March.

3.2.1 Short Duration Design Rainfall

Rainfall Intensity Frequency Duration (IFD) data for Onslow was obtained using the BOM Computerised Design IFD Rainfall System (CDIRS) and the Australian Rainfall and Runoff 2016 database (ARR2016). CDIRS produces a complete set of IFD curves and associated weather data based on user-defined coordinates.

Table 3-1 summarises the Annual Exceedance Probability (AEP) of storms with 1 to 72 hour (hr) durations. Rare historic weather events with recurrence intervals of up to 1000 years have also been included for 24, 48 and 72hr durations. AEPs are required to estimate design flood discharges for a range of events can be found in Diagram 3-2.

Table 3-1: Summary of Annual Exceedance Probabilities for Onslow Airport (ARR2016)

Storm Duration	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200	1 in 500	1 in 1000
	10%	5%	2%	1%	0.5%	0.2%	0.1%
	Rainfall Depth (mm)						
1 hour	53.5	63.6	77.4	88.3	-	-	-
2 hour	70	83.8	103	118	-	-	-
3 hour	82.3	99.2	123	142	-	-	-
6 hour	110	134	169	197	-	-	-
12 hour	146	182	231	272	-	-	-
24 hour	188	235	301	355	426	515	589

Storm Duration	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200	1 in 500	1 in 1000
	10%	5%	2%	1%	0.5%	0.2%	0.1%
	Rainfall Depth (mm)						
48 hour	222	278	355	419	493	592	675
72 hour	234	291	370	436	509	609	692

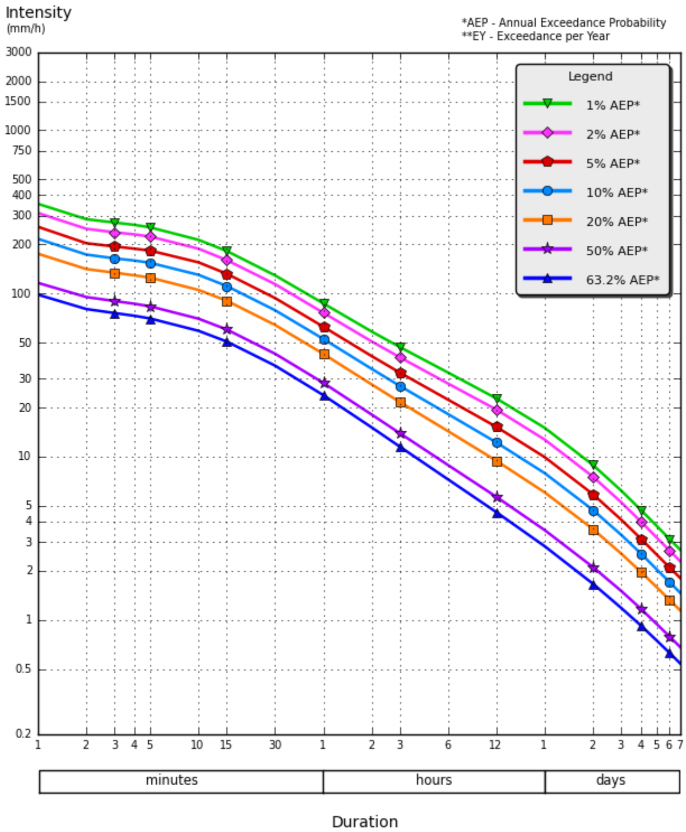


Diagram 3-2: Summary of IFD Design Curves

According to Best Practice Landfill Standards, the storage ponds and other components of the management system should be designed to contain and control surface water runoff from a 1-in-20 year storm event, at a minimum, for putrescible landfills. However, storm events up to 1-in-100 year recurrence intervals should also be considered to ensure that they do not result in any catastrophic failures such as flooding of the landfill or failure of dams or leachate storage ponds. Therefore, 1-in-100 year, 72hr storm events have been considered for the design of the surface water management infrastructure at the Site.

3.3 Pan Evaporation

The Onslow Airport weather station does not record mean daily evaporation. Therefore, monthly evaporation rates were interpolated from BOM's 1975-2005 Average Pan Evaporation Map (http://www.bom.gov.au/jsp/ncc/climate_averages/evaporation/index.jsp?#maps).

The approximate average daily pan evaporation rates were calculated from the monthly rates. The pan evaporation data for the Onslow has been provided in Table 3-3.

Table 3-3: Pan Evaporation Data for the Onslow Area in Millimetres (mm)

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Monthly	350	300	300	300	175	125	125	175	250	300	350	400	**3,150**
Daily Average	11.3	10.7	9.7	10.0	5.6	4.2	4.0	5.6	8.3	9.7	11.7	12.9	**8.6**

The daily average pan evaporation ranges from 4.2mm to 12.9mm and monthly from 125mm to 400mm. The total annual pan evaporation for Onslow is reported as 3,150mm.

3.4 Regional Flood Trends

The Site is located on the Onslow Coastal Plain between two major river systems namely the Ashburton River and the Cane River. Due to the nature of the regional topography and the proximity to flowing water systems, the area around the Site could be subject to flooding either by direct rainfall or by regional overland flow. During the site selection works, a regional flood study was undertaken by Pells Sullivan Meynink (PSM) in August 2017.

The regional flood study included regional and local hydrologic and hydraulic analysis which covered:

- Rainfall runoff modelling of the Ashburton River catchment;
- Flood frequency analysis of the Ashburton and Cane river stream flow gauges;
- Regional methods of peak flow estimation;
- Hydraulic modelling of the Onslow Coastal Plain in the region downstream of the Ashburton and Cane River stream flow gauges;
- High spatial resolution hydraulic modelling of the area around the Site, supported by a topographic survey; and
- Sensitivity testing of selected model parameters.

The assessment concluded that regionally direct rainfall and local runoff is responsible for the largest flows impacting the Site. It was also established that flows from the Ashburton River were capable of reaching the Site but not from the Cane River. The south-western half of the Site was affected by significant upstream flows. However, a lack of defined surface channels resulted in shallow, low velocity (typically less than 0.5m/s) flow even during significant weather events.

Based on the conclusions from the flood study, it was recommended that surface water management infrastructure include drainage and flood protection designs.

As a result of the study, along with some other key engineering design considerations, the development footprint for the landfill at the Site was re-located adjacent to the pindan sand ridge line, which experienced minimal to no risk of flooding.

4 Surface Water Management Strategy

The surface water management strategy for the Site will closely align with Best Practice Landfill Standards, with the surface water management infrastructure designed to manage and control rainfall runoff from 1-in-100 year 72hr storm events. The infrastructure for the surface water management system will include attenuation/infiltration ponds, a levee embankment and perimeter drains around the Site.

The following sections detail the key infrastructure components and their design to ensure that surface water is appropriately collected, stored and/or diverted based on the regional weather records.

4.1 Key Infrastructure

4.1.1 Perimeter Drains

Perimeter drains in the form of trapezoidal open channel swales will be utilised to effectively transport runoff within the Site to collection points for attenuation, infiltration or diversion off-site. The swale system is critical to minimise the generation of leachate, increase control over erosion, and mitigate the risk of localised flooding. The ultimate design of the system incorporated the restoration profile of the landfill after its closure to ensure that the system can appropriately manage surface water during the closure and aftercare period of the landfill.

4.2 Surface Water Modelling

To determine the appropriate design for the proposed surface water management infrastructure, modelling was undertaken utilising a Microsoft Excel surface water pond and swale sizing algorithm initially and further defined through Runoff Routing software (RORB). RORB is a general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other inputs for urban and rural applications. RORB subtracts rainfall losses due to ground seepage to determine the route of excess surface water through the model.

4.2.1 Catchment Areas

To assist modelling, the Site was split into sub-catchment areas, with the Site divided into four sub-catchments based on topographical data, the design of the landfill and other supporting infrastructure. The catchment area are illustrated in Diagram 4-1 and are labelled as the following:

- 1: Northern Catchment;
- 2: North-eastern Catchment;
- 3: Southern Catchment; and
- 4: Landfill Catchment.

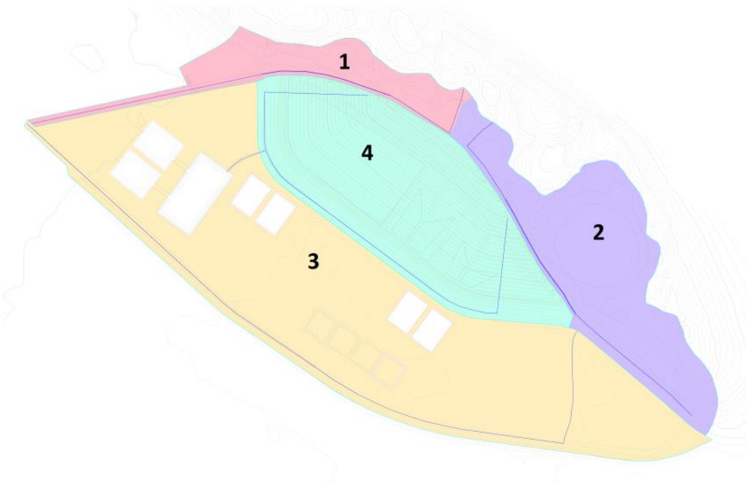


Diagram 4-1: Catchment Overview

The Southern Catchment area excluded the leachate and surface water ponds to reflect post-development of infrastructure. These areas are depicted in white in Diagram 4-1, and account for a minor reduction in potential runoff from the catchment area. The Landfill Catchment assumes the full restored landfill profile after operations are complete. Only the surface water from the Landfill Catchment will contribute to the surface water attenuation and infiltration pond system. The surface water from the three remaining catchments will be diverted directly from the Site through the use of the perimeter drains.

Table 4-1: Summary of Catchment Areas

Catchment	Catchment Area (ha)
1: Northern	5.937
2: North-eastern	13.262
3: Southern	35.920
4: Landfill	19.020
Total	**74.139**

The catchment areas identified in Table 4-1 are utilised to calculate the capacity of the surface water ponds and the swale system across the Site.

4.2.1.1 Runoff Coefficient

The site geology (as discussed in Section 2.2.2) consists of Pindan sand soil horizons.

While a runoff coefficient value of 0.1 would be acceptable for vegetated sands of a similar grading, Pindan sand is highly variable and can display self-cementation properties which can result in an increased runoff despite a vegetated and irregular terrain. Therefore, for the purpose of the calculations the runoff coefficient for the each of the catchments is assumed to be 0.40.

4.2.1.2 Kerby's Roughness Factor

With regards to Kerby's roughness factor, the description of the area is considered to be smooth bare soil, therefore for the modelling works a roughness factor of 0.10, has been utilised. This is a conservative value that simulates a worst-case scenario. It essentially means that as the surface water travels across the catchment area to the swale its velocity is not slowed down by the roughness of the surface.

4.2.2 Swale System

The Microsoft Excel spreadsheet algorithm uses the Kerby-Kirpich Method to determine the flow rate of the surface water through the swale system during a specified rainfall event. In order to use this method, the movement of the surface water through the swale system has been conceptualised with the key components of the swale system outlined in the following sub-sections.

4.2.2.1 Kerby-Kirpich Method

The swale system was designed using a Microsoft Excel algorithm modelled after the Kerby-Kirpich method to estimate the watershed time of concentration (t_c) for a rainfall event. The method requires adding the overland flow time (Kerby, t_{ov}) to the channel flow time (Kirpich, t_{ch}) in order to obtain the time of concentration. The following equations were utilised to determine the time of concentration:

$$t_c = t_{ov} + t_{ch} \qquad \text{Eq. 1}$$

$$t_{ov} = 1.44 \times (L \times N)^{0.467} \times S^{-0.235} \qquad \text{Eq. 2}$$

where L = Length of overland flow
N = Kerby's roughness coefficient, 0.10
S = Slope gradient of the overland flow

$$t_{ch} = 0.0195 \times L^{0.770} \times S^{-0.385} \qquad \text{Eq. 3}$$

where L = Length of swale flow
S = Slope gradient of the swale flow

Once the time of concentration has been determined, then the theoretical peak flow rate through each swale can be calculated and compared to the maximum allowable flow rate through the swale as determined by the design geometry of the swale. If the maximum allowable flow rate is greater than the theoretical peak flow rate, then the design of swale has passed. The following equations were utilised to perform this design check:

$$Q_t = C \times I \times A \qquad \text{Eq. 4}$$

where Q_t = Theoretical peak flow rate, m^3/hr
C = Runoff coefficient, 0.40
I = Rainfall intensity at time of concentration, m/hr
A = Catchment surface area, m^2

$$V = 1/n \times R_h^{2/3} \times S_s^{1/2} \quad \text{Eq. 5}$$

where
V = Velocity of surface water through the swale
n = Manning's coefficient
R_h = Hydraulic radius
S_s = Slope of swale

$$Q_a = V \times A_s \quad \text{Eq. 6}$$

where
Q_a = Maximum allowable flow rate, m^3/hr
V = Velocity of surface water through the swale, m/hr
A_s = Cross-sectional area of the swale, m^2

4.2.2.2 Surface Water Movements

A series of catch drains/swales for clean and potentially 'dirty' water systems will be constructed around the facility to enable the effective management of surface water. The surface water movement/interaction between the swales and Site infrastructure/roads is discussed as follows.

A swale will be constructed around the south-eastern boundary of the landfill development footprint. The swale will direct potentially 'dirty' water into the surface water attenuation pond and infiltration/evaporation pond system. A Site access road will cross over the discharge channel to the surface water ponds and will therefore require a culvert to be constructed.

The North-eastern Catchment swale will direct clean flow south eastwards towards the Southern Catchment swale. To enable discharge into the Southern Catchment swale, a culvert will be required under the main Site access road and the southern bushfire control access road.

The Southern Catchment swale will be constructed along the entire interior perimeter of the levee embankment, and discharge into the sand plain north-west of the Site. Any overflow from the Infiltration/Evaporation Pond #2 will also connect into the swale to direct water offsite. The southern bushfire control access road will cross the offsite discharge swale and will require the installation of a culvert.

The Northern Catchment swale directs surface water flow north-westerly around the perimeter of the landfill development footprint then westerly towards the junction with the Southern Catchment swale. At this point, the surface water will be allowed to flow offsite into the regional sand plain. In addition, the overflow from Infiltration/Evaporation Pond #1 will connect to the swale. Therefore, scour protection measures will be required at these two junction points. The Site access road will also cross over the swale.

4.2.2.3 Manning's Coefficient

Manning's coefficient describes the roughness of the swale surface, which is determined by the material used to construct the swale. The following Manning's coefficients (n) would be considered for the swale system:

- Unlined earth channel: 0.022;
- Bottom and sides lined with riprap: 0.035; and
- Bottom and sides lined with HDPE plastic: 0.009.

4.2.2.4 Swale System Design Summary

A summary of the swale system's design considerations is provided in Table 4-2.

Table 4-2: Key Design Considerations for Swale System

Location	Swale Section		Manning's Coefficient	Average Gradient	Other Key Considerations
Northern Catchment	A	Unlined	0.022	0.009	• Two junction points • Two intersection points with a Site access road
	B-Inclined	Lined-Riprap	0.035	0.053	
	C	Unlined	0.022	0.002	
North-eastern Catchment	A	Unlined	0.022	0.017	• One junction point • One intersection point with a Site access road
	B-Inclined	Lined-Riprap	0.035	0.039	
	C	Unlined	0.022	0.002	
Southern Catchment	A	Unlined	0.022	0.001	• Three junction points • A significant bend in the beginning section of swale • One intersection point with a Site access road
Landfill Catchment	A	Lined-HDPE	0.009	0.002	• One junction point • One intersection point with a Site access road

Note: If a section of the swale has a slope gradient greater than 0.020, then it is classified as 'inclined'.

These will be key inputs into the Microsoft Excel algorithm as well as the RORB modelling software.

4.2.3 RORB

4.2.3.1 Data Files

In order to use RORB effectively, region specific modelling files that summarise the weather data for Onslow was obtained from the Australian Rainfall & Runoff (ARR) Data Hub. The following files were downloaded and inputted into RORB:

- Areal Reduction Factors (ARFs) and losses;
- Temporal Patterns; and
- BOM IFD data.

For consistency, the coordinates used to obtain these files were the same coordinates for the Onslow Airport weather station (Station ID: 005017).

4.2.3.2 Initial and Continuing Losses

Instead of using runoff coefficients and Kerby's roughness factor, the RORB program uses Initial Loss (IL) and Continuing Loss (CL) to represent the infiltration and excess of surface water during a rainfall event. IL denotes the infiltration of rainfall during the initial stages of a rainfall event before runoff begins. CL denotes the continued average infiltration of rainfall per hour during the remaining rainfall event.

For arid regions, IL range from 10mm to 60mm and CL range from 1mm/hr to 5.5mm/hr. However, the PSM flood study utilised IL values ranging from 30 to 60 mm, with a fixed CL of 6 mm/hr. For consistency, the RORB modelling performed to dictate the design of the swale and surface water pond systems utilised the same values for IL. In order to assess the sensitivity to continuing loss, a CL of 3mm/hr was also modelled.

4.2.3.3 Surface Water Pond Capacity

For further analysis of the surface water pond system requirements, RORB was implemented using the software's built-in storage-discharge relationship for a storage pond utilising the following equation:

$$S = kQ^m \qquad \text{Eq. 7}$$

where S = Storage volume, m^3
k = dimensionless empirical coefficient based on the catchment area
Q = Discharge into the storage system, m^3/s
m = unit-less cross-sectional shape factor, 0.80

The value of k can be user defined or calculated by the RORB program. For the purposes of this report, the value of k calculated by the RORB program will be adopted. The results from RORB will be used to ensure that the surface waste pond system meets the minimum requirements for managing rainfall from a 1-in-100 year, 72hr duration storm events under various IL and CL conditions.

4.3 Surface Water Infrastructure Design

The following sections describe the modelling results and the finalised design characteristics of the key infrastructure proposed for the Site's surface water management strategy.

4.3.1 Perimeter Drains

The perimeter drains will be trapezoidal open channel swales and constructed along the lowest boundary of each catchment. Diagram 4-2 provides an illustration of the cross-sectional area of the swale.

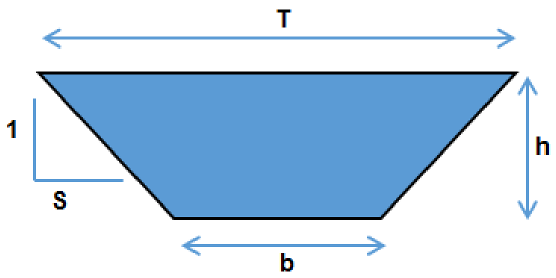


Diagram 4-2: Swale Geometry

Based on the geometry depicted in Diagram 4-2, Table 4-3 provides the corresponding values for each of the different swale designs.

Table 4-3: Key Design Characteristics of the Swale System

Location	Design No.	[1:S] Side Slope (V:H)	[b] Bottom Width (m)	[T] Top Width (m)	[h] Height (m)
Northern Catchment	1	1:6	2	14	1
	2	1:6	4	16	1
North-eastern Catchment	1	1:6	2	14	1
	2	1:3	2	8	1
Southern Catchment	1	1:6	4	16	1
Landfill Catchment	1	1:6	3	15	1

Note: The swales that are part of the surface water pond system have the same design as the Landfill Catchment swale.

The height of the water was modelled to only reach to an approximate height of 0.5m as a conservative measure to allow for an approximate 0.5m freeboard.

These swale designs will be required to accommodate flow rates generated in 1-in-100 year, 72hr duration storm events. The Microsoft Excel algorithm using the Kerby-Kirpich Method and the RORB program were used to determine whether these are acceptable swale designs.

4.3.1.1 Initial Modelling

Table 4-4 outlines the checks performed using the Microsoft Excel algorithm and the Kerby-Kirpich Method. The calculations have been provided in Appendix C.

Table 4-4: Modelling Results of the Swale System

Location	Swale Design	Swale Section	Q_t (m^3/hr) [Eq. 4]	V (m/s) [Eq. 5]	Q_a (m^3/hr) [Eq. 6]	Check $Q_t < Q_a$
Northern Catchment	1	A	2,814	1.95	17,552	Pass
	1	B		3.01	27,119	Pass
	2	C		0.93	11,751	Pass

Location	Swale Design	Swale Section	Q_t (m³/hr) [Eq. 4]	V (m/s) [Eq. 5]	Q_a (m³/hr) [Eq. 6]	Check $Q_t < Q_a$
North-eastern Catchment	1	A	7,180	2.74	24,650	Pass
	1	B		2.59	23,321	Pass
	2	C		0.99	7,318	Pass
Southern Catchment	1	A	11,681	0.87	12,577	Pass
Landfill Catchment	1	A	8,391	2.17	23,441	Pass

Note: Q_t is the theoretical peak flow rate that the swale would need to manage.
V is the maximum velocity of the water through the swale.
Q_a is the maximum allowable flow rate that the swale can manage while maintaining an approximate 0.5m freeboard.
The swales for the surface water pond system were not directly modelled as the flow characteristics are assumed to be similar to the flow characteristics for the Landfill Catchment.

All of the swale designs are acceptable for managing the surface water as it passes through the various sections of the swale system.

4.3.1.2 RORB Modelling

For the RORB model, the key characteristics of each catchment including the breakdown of the swale design were recorded in the RORB program. However, the resulting peak flow rates were vastly lower than the ones calculated using the Microsoft Excel algorithm. Therefore, the peak flow rates calculated in the initial modelling were the adopted flow rates used in the final design of the swale system as provided in Table 4-3.

4.3.2 Surface Water Ponds

4.3.2.1 Initial Modelling

The surface water pond sizing was initially conducted using a simple Microsoft Excel algorithm. According to the IFD data from BOM, the total rainfall during a 1-in-100 storm with a 72hr duration is 436mm. Based on the surface area of the Landfill Catchment and an assumed runoff coefficient of 0.40, the minimum total capacity required is approximately 33,500m^3. The rainfall that falls directly into the swales is considered negligible.

4.3.2.2 RORB Modelling

The catchment features and swale system were inputted into the RORB model for the Landfill Catchment. The model was then run under various IL and CL conditions, and considered both 3.0mm/hr and 6.0mm/hr for CL, as well as IL values between 30mm and 60mm, in line with the PSM flood study. A summary of the results of the RORB analysis can be found in Table 4-5 and the detailed calculations are provided in Appendix B.

Table 4-5: RORB Modelling Results for Pond Storage Requirements

Model Iteration	IL (mm)	CL (mm/hr)	Inflow (m^3)
1	60	6.0	22,700
2	60	3.0	39,100
3	50	6.0	24,300
4	50	3.0	40,800
5	40	6.0	25,800
6	40	3.0	42,400
7	30	6.0	25,900
8	30	3.0	42,500

In all four iterations with a CL of 6.0mm, the inflow volumes did not exceed 30,000m^3, whereas for iterations with a CL of 3.0mm, the inflow volumes were up to 42,500m^3. The results utilising a CL of 3.0mm are higher than what is calculated in the Microsoft Excel modelling. Therefore, to allow for conservativism and redundancy in the surface water management system, the highest inflow volume of 42,500m^3 was adopted for the design of the surface water ponds.

4.3.2.3 Surface Water Pond Design Characteristics

Table 4-6 contains the dimensions of the surface water pond system that will accommodate the operational requirements determined in the initial modelling.

Table 4-6: Design Characteristics of Surface Water Pond System

Type of Pond	Length (m)	Width (m)	Depth (m)	Internal Pond Side Slope (V:H)	Surface Area (m^2)	Operational Volume (m^3)
Attenuation Pond	163.6	88.6	3.42	1:3	14,495	34,620
Infiltration/ Evaporation Pond # 1	91.0	71.0	1.76	1:3	6,461	5,611
Infiltration/ Evaporation Pond # 2	91.0	71.0	1.76	1:3	6,461	5,611

*Notes: * The Operational Volume is calculated from the 0.5m freeboard level to the bottom level of each pond.*

The total operational volume of the surface water pond system is approximately 45,842m^3. To ensure that no superficial surface water flows into the surface water pond system, each pond will be raised 0.5m above existing ground with 1:6 (V:H) external side slopes.

4.3.3 Other Associated Infrastructure

4.3.3.1 Rock Armouring

To mitigate scouring and maintain the integrity of the swale system, rock armouring will be installed in strategic points across the system, specifically at steeper sections (slope gradient >0.020), junction and intersection points. The methodology for determining the minimum stone diameter used in the rock armouring and thickness of the armouring itself is outlined in Austroads Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodways. The maximum velocity in each swale section has already been calculated using the Microsoft Excel algorithm. Table 4-7 outlines the proposed rock armouring details for the swale system, and the calculations are provided in Appendix D.

Table 4-7: Rock Armouring Details for Swale System

Location	Maximum Velocity (m/s)	Bed Velocity (m/s)	Stone Diameter (mm)	Minimum Thickness (mm)
Northern Catchment	3.01	2.107	150	225
North-eastern Catchment	2.77	1.939	150	225
Southern Catchment	0.87	0.609	75	112.5
Landfill Catchment	2.17	1.519	75	112.5

Notes: The Maximum Velocity is the maximum velocity of the surface water through any part of the swale for the specified catchment.
The Bed Velocity is 0.70 times the Velocity through the swale.
The Minimum Thickness of the rock armouring is 1.5 times the largest stone diameter.
Any rock armouring that is required for swales within the surface water pond system will have the same details as the rock armouring for the Landfill Catchment.

It is proposed that rock armouring for the Northern, North-eastern and Southern Catchment, swales, will have a minimum thickness of 225mm with a minimum stone diameter of 150mm. Rock armouring will need to be installed on junction points and on either end of the culverts.

For the Landfill Catchment swale, the rock armouring at the junction point with the inlet into the surface water pond system must have a minimum thickness of 112.5mm with a minimum stone diameter of 75mm.

The locations of proposed rock armouring and details are shown on Drawings G-100, G-101, G102 and G-103, which are provided in Appendix A.

4.3.3.2 Culvert System

There are five intersection points where a site access road crosses over the swale system. In order to manage these intersection points, a culvert system is required to safely divert the surface water under the access roads. A Factor of Safety of at least 1.5 at the inlet was selected to account for partial blockages and silt build-ups, prior to maintenance/clearing.

The methodology presented in Section 3 of the Austroads Part 5B: Drainage – Open Channels, Culverts and Floodways Design Manual, in conjunction with the box culvert nomographs contained in Appendix B, was applied. The detailed calculations have been provided in Appendix D of this Report.

Where the system constricts from a trapezoidal channel to a rectangular culvert and then back to a trapezoidal channel, the Froude number for the upstream and downstream conditions was calculated to determine if a hydraulic jump was likely to occur. A hydraulic jump arises when supercritical flow (Froude number is greater than 1) representing fast, high energy flow transitions to subcritical flow

(Froude number less than 1). This event can cause significant erosion and scouring issues over time. The maximum Froude number calculated using the Microsoft Excel algorithm was 0.27.

It was determined that the culvert required for Intersection Points #1, #3 and #4 is a set of 4 box culverts that have an operational height of 0.9m and an operational width of 4.8m. For Intersection Point #2, a set of 8 box culverts with an operational height of 0.9m and an operational width of 9.6m will be required. Intersection Point #5 will require a set of 3 box culverts installed with an operational height of 0.9m and an operational width of 3.6m.

4.3.4 Summary

4.3.4.1 Swale System

In order to determine the design of the swale system, several considerations need to be made. Each swale is to be placed at the topographical low point of each catchment area. For sections of the swale that have a slope gradient greater than 0.020, the bottom and sides of the swale will be lined with riprap, or rock armouring, in order to slow the velocity of the water moving through the swale. This will assist to mitigate scouring or erosion issues and maintain the integrity of the swale system. Where a steeper section of swale is followed by a relatively flat slope gradient (less than 0.020), then an additional 25m of the swale will be lined with riprap to mitigate scouring. If the swale has a significant bend, then riprap will be placed along the length of that bend. As per Best Practice Landfill Standards, the swale along the landfill catchment will be lined with a geomembrane liner. All other sections of the swale system will be an unlined earth channel.

At junction points where the surface water from two swales is combined, scour protection measures in the form of rock armouring will be required. At the intersection points between the swale system and a Site access road, a box culvert system will be required to direct the water under the road.

The details for the swale system are illustrated in Drawings G-101, G-102 and G-103, which are provided in Appendix A.

4.3.4.2 Surface Water Ponds

The perimeter drains along the landfill footprint will divert surface water into the surface water pond system, which will consist of a lined attenuation pond and eventually two unlined infiltration/evaporation ponds. The attenuation pond is designed to minimise the release of sediment eroded from the landfill catchment to the downstream environment. The pond will be relatively deep to encourage sedimentation before it feeds the excess surface water into one of two infiltration/evaporation ponds. Only one infiltration/evaporation pond will be built during the early stages of the Site operations followed by the construction of a second pond as the Site activities and development footprint increases. The infiltration ponds will have shallow depths and large surface areas to assist the rate of evaporation.

Cargo netting/roped egress points will be installed on the interior face of each lined pond which will also be enclosed by a 1.8m high chain-link fence as a health and safety measure.

The infiltration ponds will also be constructed with overflows to enable controlled discharge of water from storm events above the 1-in-100 year, 72hr storm durations.

The layout of the surface water pond system is demonstrated in Drawing G-100, which has been provided in Appendix A.

4.4 Operational Management and Monitoring Strategy

To ensure environmental impacts are mitigated and the facility meets licence requirements, appropriate operational management, especially for surface water, must be undertaken. Regular site maintenance and repairs of drains and other associated surface water management infrastructure will be undertaken. Site staff will particularly inspect the system for evidence of contamination, excessive sedimentation and structural integrity of the system on a regular basis. Any ponding within the surface depressions along the sand ridge northeast of the landfill development footprint will be managed via a mobile pump when necessary. Further details of the operational management strategy are provided in the Site's Operational and Environmental Management Plan (OEMP).

5 Local Flood Risk Assessment

The PSM flood study concluded that the Site could be potentially affected by flooding in the surrounding areas. To protect the Site from such events, it is proposed that a levee embankment will be constructed along the southern boundary of the Site. Where the outside edge of the levee embankment is likely to be effected by flooding, rock armouring will be installed to protect the embankment from erosion and scouring caused by the regional flooding events.

5.1 Levee Embankment Design

The levee embankment will be constructed along the southern boundary of Site's operational area to protect the Site from regional flooding events. The levee will be constructed from compacted soil excavated from the Site, and be compacted to a minimum of 95% Maximum Modified Dry Density (MMDD). The embankment will be keyed into the existing ground profile along the centreline and outer toe of the bund. Table 5-1 provides a summary of the key design characteristics of the proposed levee embankment.

Table 5-1: Key Design Characteristics of the Levee Embankment

Outer External Side Slope (V:H)	Maximum Bottom Width (m)	Maximum Top Width (m)	Length (m)	Height (m)	Volume of Soil Required (m^3)
1:6	20	2	1600	2	~34,300

Rock armouring will be utilised on the outside edge of the levee embankment for scour prevention and erosion resistance from regional flooding events.

According to the PSM flood study, the Site experiences low velocity (typically less than 0.50m/s) flow at less than one metre depths even during significant weather events, due to a lack of defined surface channels. The methodology for determining the minimum stone diameter used in the rock armouring and thickness of the armouring itself is outlined in Austroads Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodways, specifically Figure 2.22. Using the PSM flow velocity, Table 5-2 provides a summary of the minimum rock armouring requirements for the levee embankment system.

Table 5-2: Minimum Rock Armouring Details for Levee Embankment

Bed Velocity (m/s)	D_{50} Stone Diameter (mm)	Minimum Thickness (mm)
0.50	50	75

The minimum thickness of the rock armouring for the levee embankment system is 75mm, using a minimum stone size of 50mm in diameter. Calculations are presented in Appendix D.

In order to protect the integrity of the development area and allow for regional flood events above the modelled scenario, a Factor of Safety of 3.5 has been applied to the flow velocity. It is therefore proposed that rock armouring to the levee embankment will consist of a separation geotextile, 150mm granular filter layer and 225mm minimum thickness of well graded riprap (125mm maximum stone diameter), placed to a height of up to 1.5m. Typical levee embankment construction details are shown on Drawing G-103.

5.2 Design Review

PSM has undertaken a review of the surface water management design, and updated the regional flood study model. With regards to the levee embankment, the proposed design was assessed against a number of flood events, including 1 in 50 year, 1 in 100 year and 1 in 500 year for durations of 24 hours.

The surface water review and flood modelling by PSM is included in Appendix E.

A summary of the PSM modelling and review is presented as follows:

The levee embankment does not overtop at any point for any of the flood events, with the freeboard to the top of the flood protection bund [levee embankment] in excess of 0.5m for all modelled events. "*Additionally, the velocity adjacent to the flood protection bund* [levee embankment] *is below 2m/s (i.e. the typical erosional threshold presented in the Austroads Guide to Road Design), with velocities typically less than 0.3m/s at the southern toe of the flood protection bund* [levee embankment]."

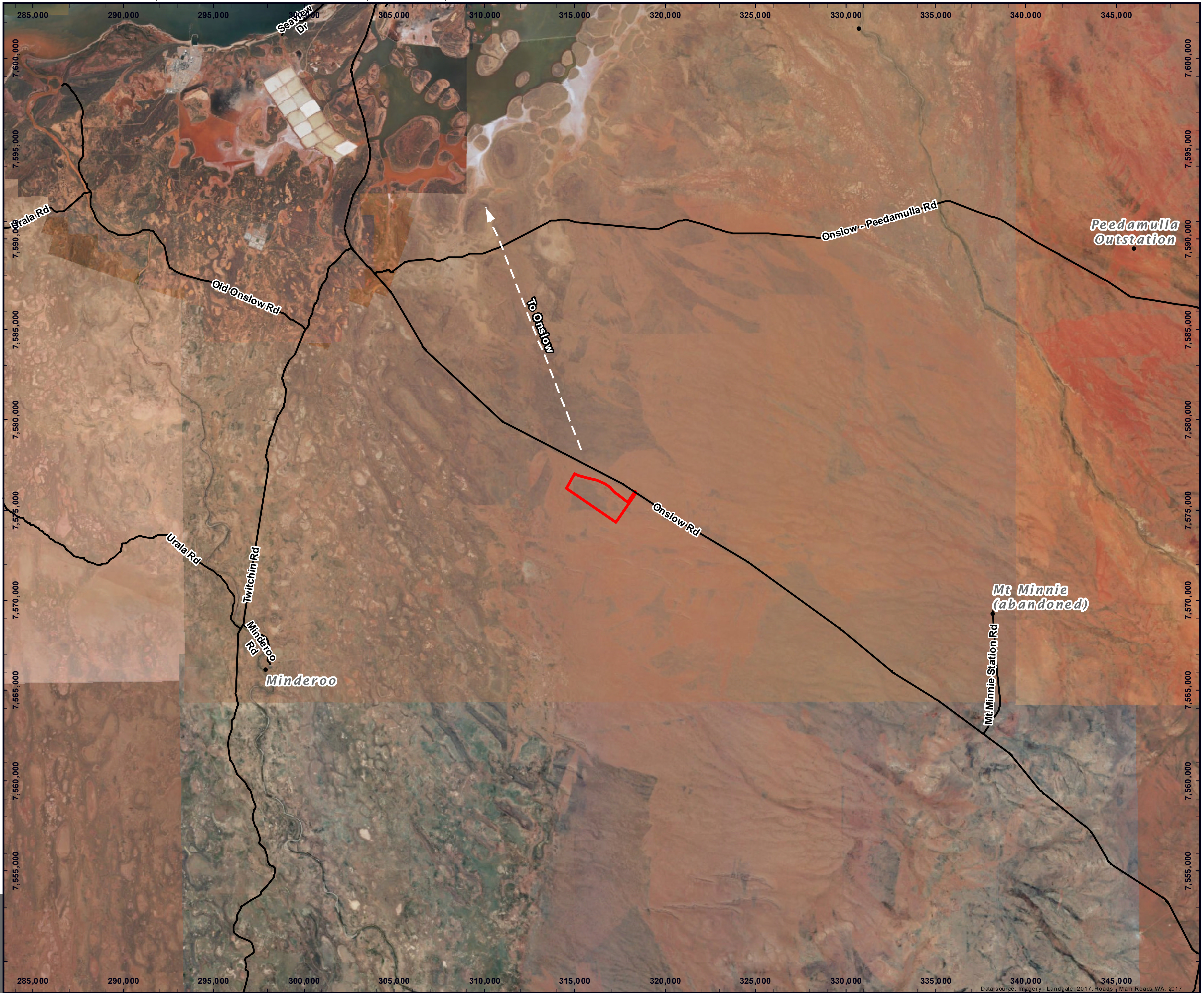
Further, the PSM report states:

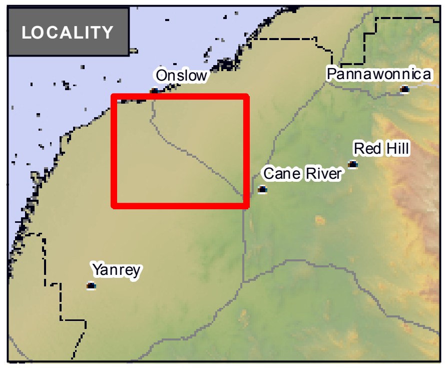
> "*Whilst optimisation of the flood protection bund* [levee embankment] *could be possible the current design is still recommended:*
>
> - *The additional freeboard allows some flexibility if a more extreme design event were required by the regulator, and*
> - *Whilst the velocity of the flood flow is typically less than 0.3 m/s the rip-rap protection provided, will help protect against scour and erosion in small scale localised velocity hotspots (which have not been picked the hydraulic modelling with a 10m grid size) and improve the assets longevity. Provision of rip-rap protection along the entire flood protection would be useful and is recommended for the segment to the east of 317,000 mE.*"

Rock armouring will, therefore, be placed on the outside edge of the levee embankment at a minimum from 317,000 mE, (eastwards to the site access road), for scour prevention and erosion resistance from regional flooding events.

Figures

P: PO Box 454, Leederville WA 6903 | A: Level 1 660 Newcastle St, Leederville WA 6007 | T: 1300 251 070 | W: www.talisconsultants.com.au





LOCALITY PLAN

Surface Water Management Plan
Pilbara Regional Waste Management Facility
Lot 150 Onslow Road
Talandji, WA 6710

0 1 2 3 4 8 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3:1:200,000

Prepared: F Walker	Date: 13/09/2018
Checked: E. Porter	Project No: TW18004
Reviewed: N King	Revision: A

talis delivering solutions

Figure 01

Data source: Imagery - Landgate, 2017. Roads - Main Roads WA, 2017

P: PO Box 454, Leederville WA 6903 | A: Level 1 660 Newcastle St, Leederville WA 6007 | T: 1300 251 070 | W: www.talisconsultants.com.au

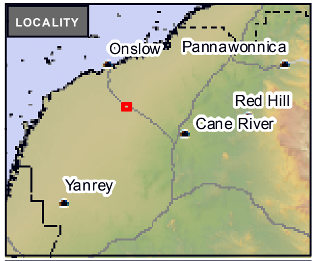
Data source: Imagery - Landgate, 2018; Topography - Denada Surveys, 2017

LEGEND

Site Boundary

Elevation (mAHD)

LOCALITY



TOPOGRAPHY

Surface Water Management Plan
Pilbara Regional Waste Management Facility
Lot 150 Onslow Road
Talandji, WA 6710

0 125 250 375 500 metres

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A4:1:20,000

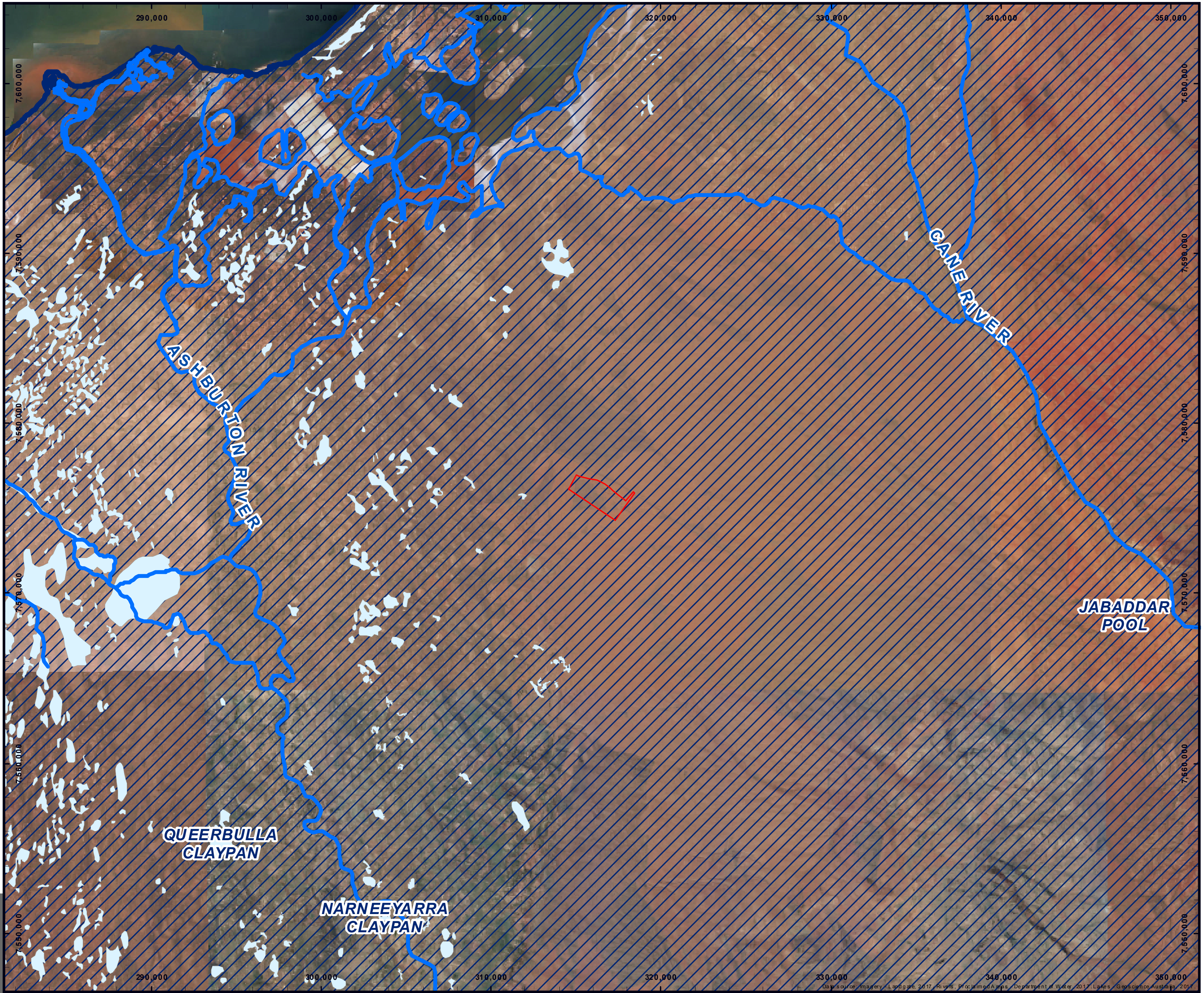
Prepared: F Walker	Date: 13/09/2018
Checked: C. Panizza	Project No: TW18004
Reviewed: N King	Revision: A

talis
delivering solutions

Figure 02

Document Path: \\SERVER\Talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow Approval Documentation\GIS\Maps\SWMP\TW18004_02_Topography_RevA.mxd

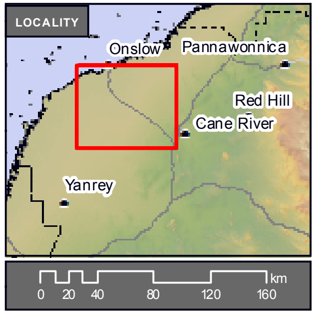
P: PO Box 454, Leederville WA 6903 | A: Level 1 660 Newcastle St, Leederville WA 6007 | T: 1300 251 070 | W: www.talisconsultants.com.au



Data source: Imagery - Landgate, 2017. Rivers, Proclaimed Areas - Department of Water, 2017. Lakes - Geoscience Australia, 2017.

LEGEND

- Site Boundary
- Rivers
- Lakes
- Surface Water Resource Proclaimed Area (RIWI Act)



HYDROLOGY

Surface Water Management Plan
Pilbara Regional Waste Management Facility
Lot 150 Onslow Road
Talandji, WA 6710

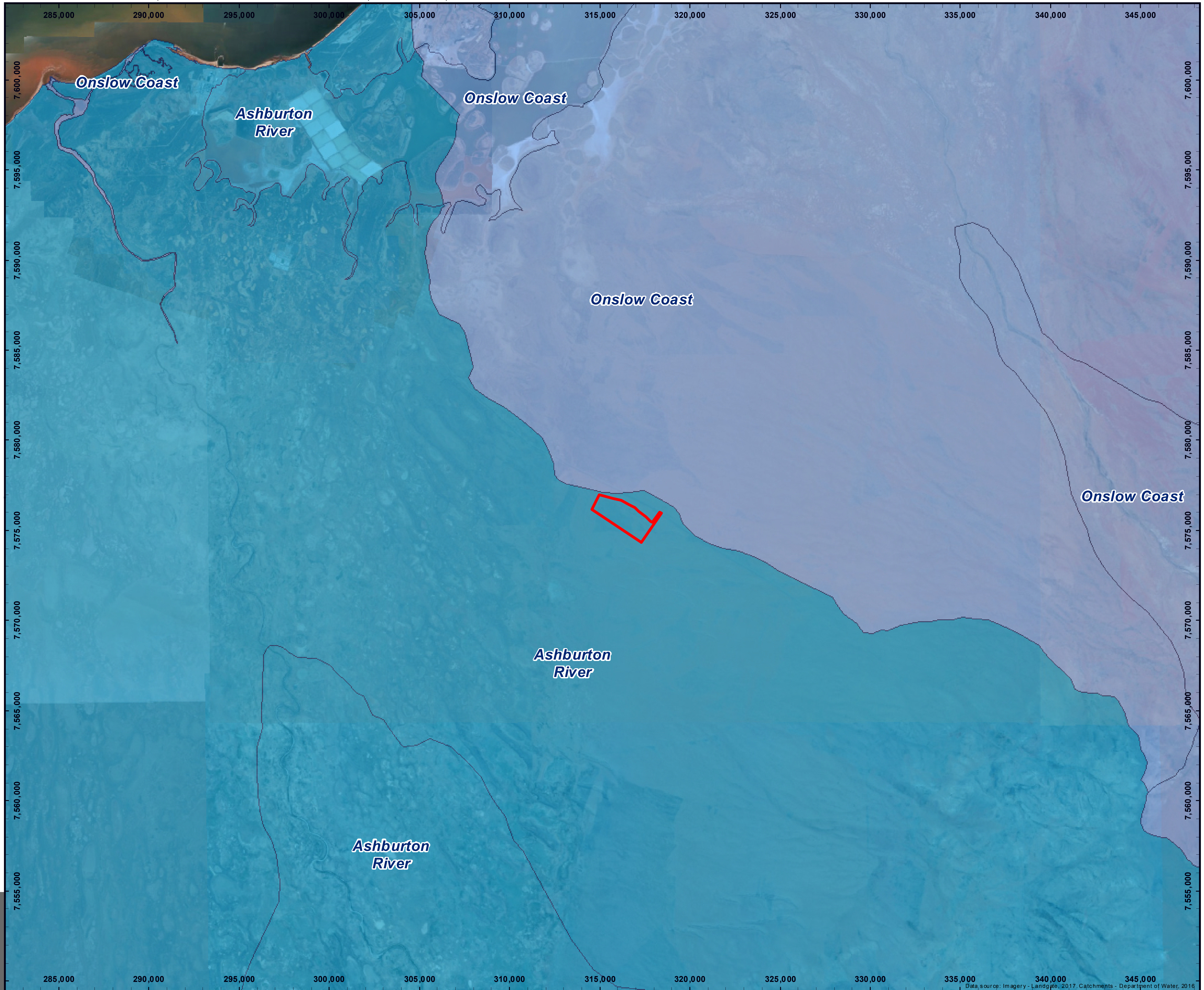
0 1 2 3 4 8 Km
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A4: 1:300,000

Prepared: F Walker	Date: 13/09/2018
Checked: C. Panizza	Project No: TW18004
Reviewed: N King	Revision: A

talis
delivering solutions

Figure 03

P: PO Box 454, Leederville WA 6903 | A: Level 1 660 Newcastle St, Leederville WA 6007 | T: 1300 251 070 | W: www.talisconsultants.com.au



LEGEND

Site Boundary

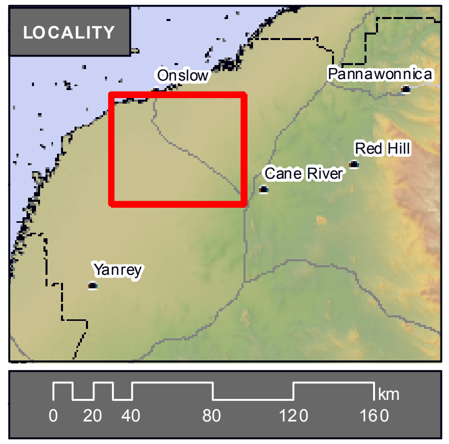
Hydrographic Subcatchments

Basin Name

Ashburton River

Onslow Coast

LOCALITY



CATCHMENT AREAS

Surface Water Management Plan
Pilbara Regional Waste Management Facility
Lot 150 Onslow Road
Talandji, WA 6710

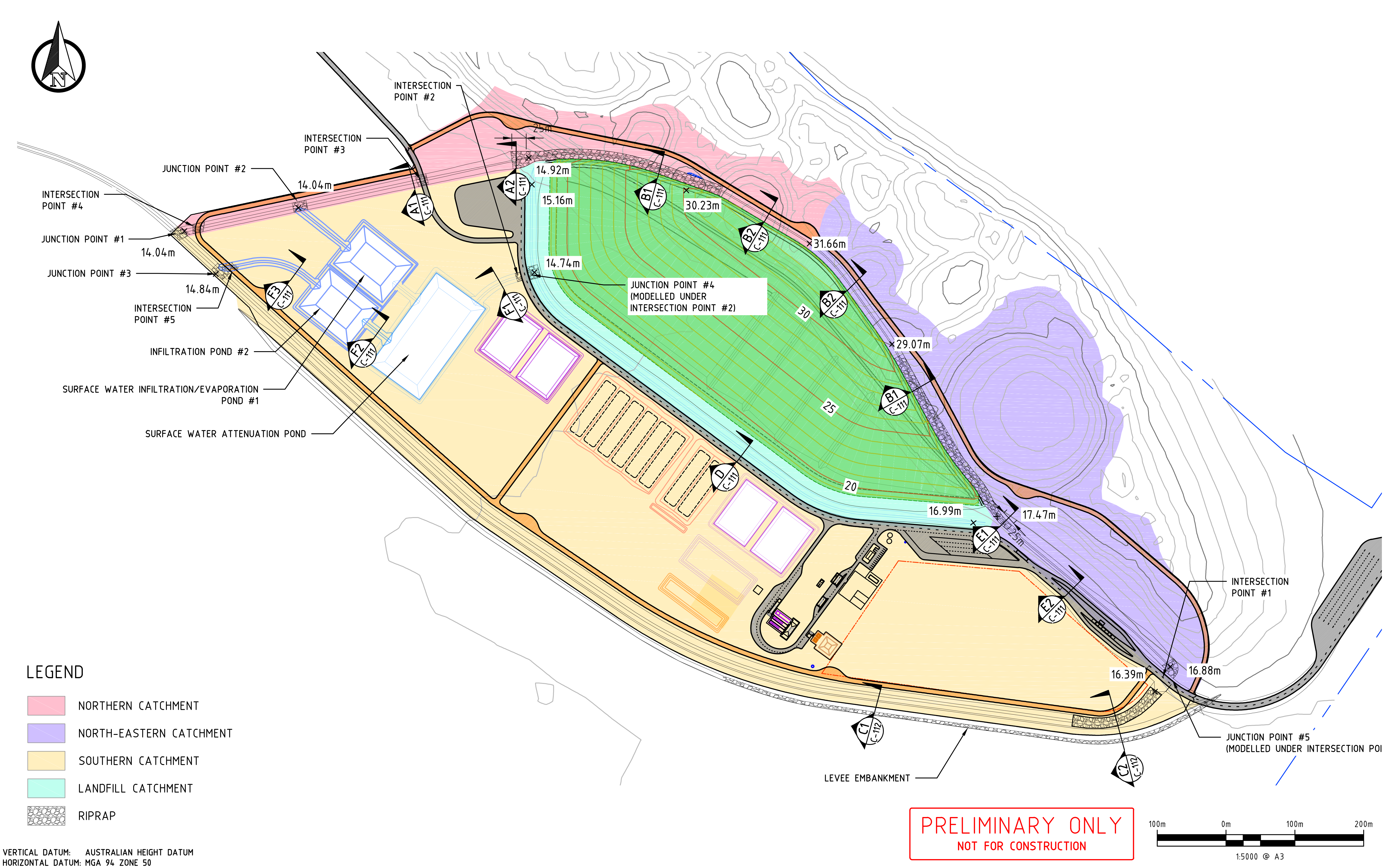
0 1 2 3 4 8 Km
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator, Datum: GDA 1994
Scale @ A3:1:200,000

Prepared:	F Walker	Date:	13/09/2018
Checked:	E. Porter	Project No:	TW18004
Reviewed:	N King	Revision:	A

talis delivering solutions

Figure 04

Appendix A: Drawings



talis
delivering solutions

ASSET MANAGEMENT
CIVIL ENGINEERING
ENVIRONMENTAL SERVICES
SPATIAL INTELLIGENCE
WASTE MANAGEMENT

Level 1 660 Newcastle Street,
Leederville WA 6007
PO Box 454, Leederville WA 6903
www.talisconsultants.com.au
T: 1300 251 070

Client: SHIRE OF ASHBURTON

NOTES

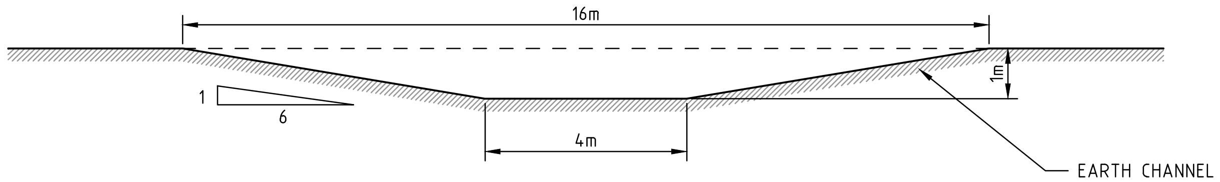
1. This drawing is the property of Talis Consultants Pty Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent.
2. DO NOT SCALE, use figured dimensions only, if in doubt please contact Talis Consultants.

No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	20.07.18	MH	CP	DRAFT ISSUED FOR REVIEW	DF

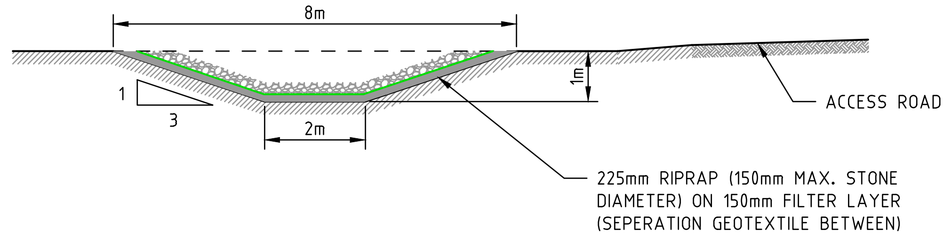
Project: PILBARA REGIONAL WASTE MANAGEMENT FACILITY

Title: SURFACE WATER MANAGEMENT SYSTEM

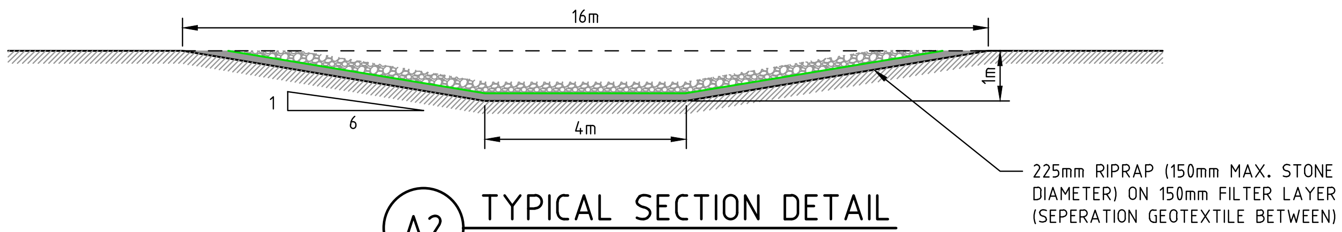
Drawn by:	MH	Job No:	TW17053
Checked by:	CP	File No:	TW17053-C110
Approved by:		Drg. No:	C-110
Scale:	1:5,000 @ A3	Rev:	A
Date:	20.07.18		



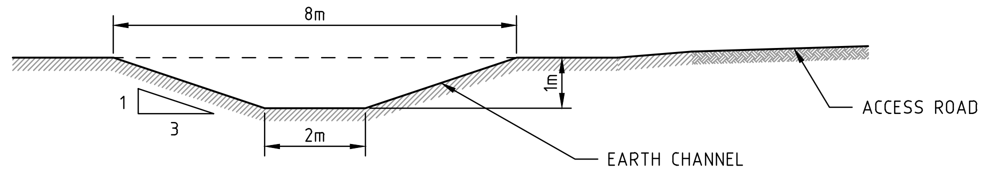
A1 TYPICAL SECTION DETAIL
SCALE: NTS



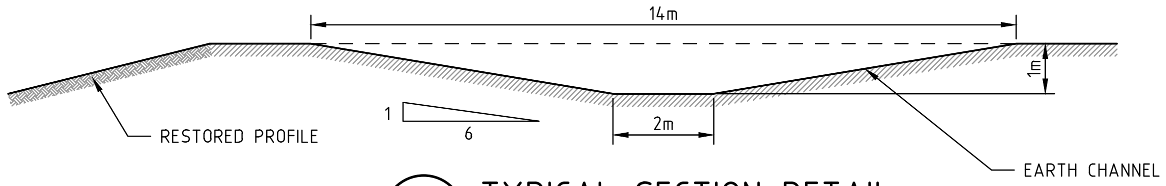
E1 TYPICAL SECTION DETAIL
SCALE: NTS



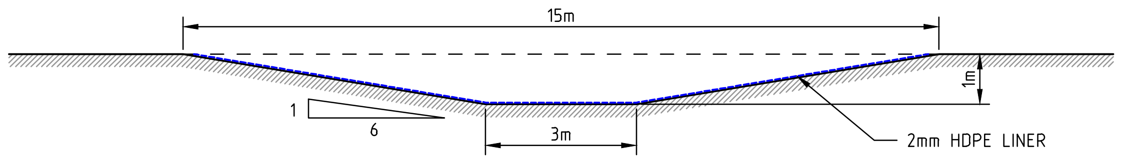
A2 TYPICAL SECTION DETAIL
SCALE: NTS



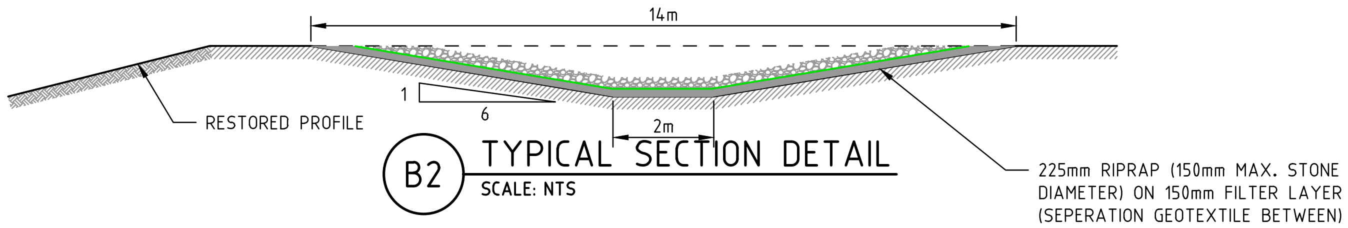
E2 TYPICAL SECTION DETAIL
SCALE: NTS



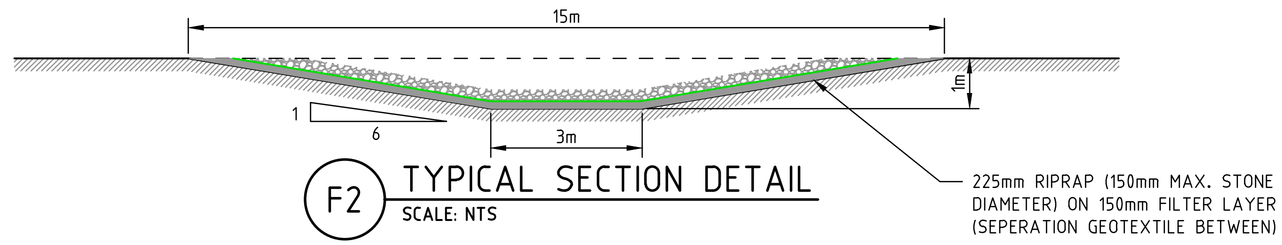
B1 TYPICAL SECTION DETAIL
SCALE: NTS



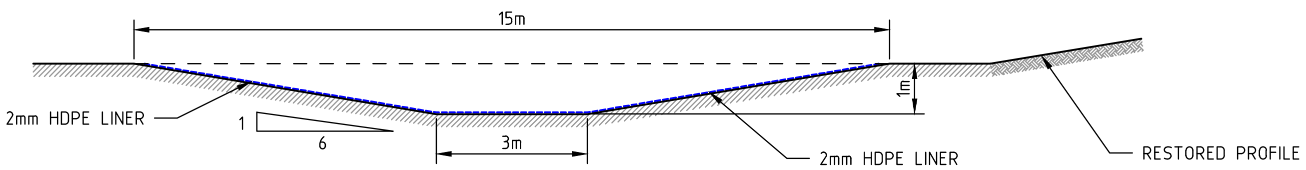
F1 TYPICAL SECTION DETAIL
SCALE: NTS



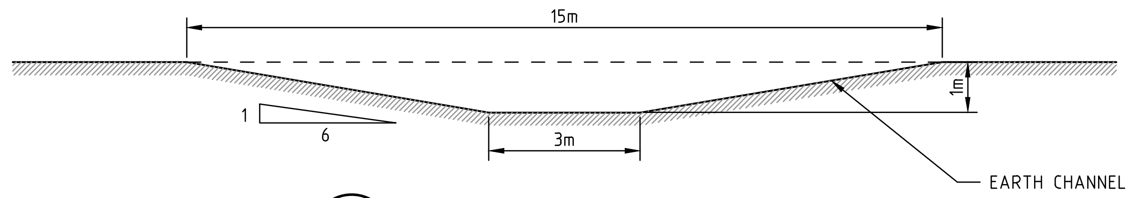
B2 TYPICAL SECTION DETAIL
SCALE: NTS



F2 TYPICAL SECTION DETAIL
SCALE: NTS



D TYPICAL SECTION DETAIL
SCALE: NTS



F3 TYPICAL SECTION DETAIL
SCALE: NTS

PRELIMINARY ONLY
NOT FOR CONSTRUCTION

talis
delivering solutions
www.talisconsultants.com.au T: 1300 251 070

ASSET MANAGEMENT
CIVIL ENGINEERING
ENVIRONMENTAL SERVICES
SPATIAL INTELLIGENCE
WASTE MANAGEMENT

Level 1 660 Newcastle Street, Leederville WA 6007
PO Box 454, Leederville WA 6903

Client: SHIRE OF ASHBURTON

NOTES
1. This drawing is the property of Talis Consultants Pty Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent.
2. All levels refer to Australian Height Datum.
3. DO NOT SCALE, use figured dimensions only, if in doubt please contact Talis Consultants.

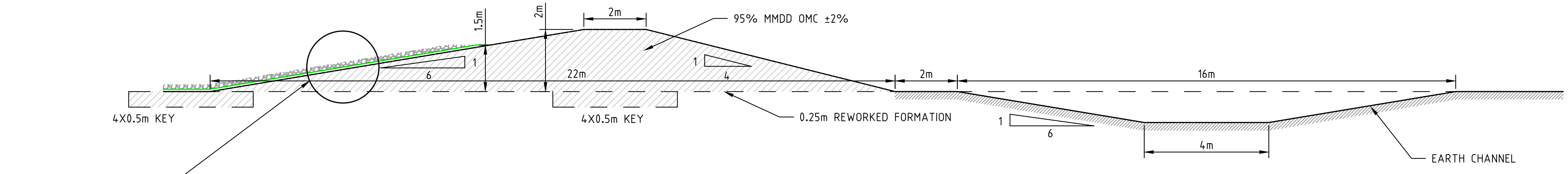
No.	Date	Drawn / Chk.	Amendment / Issue	App.
A	20.07.18	MH / CP	DRAFT ISSUED FOR REVIEW	

Project: PILBARA REGIONAL WASTE MANAGEMENT FACILITY

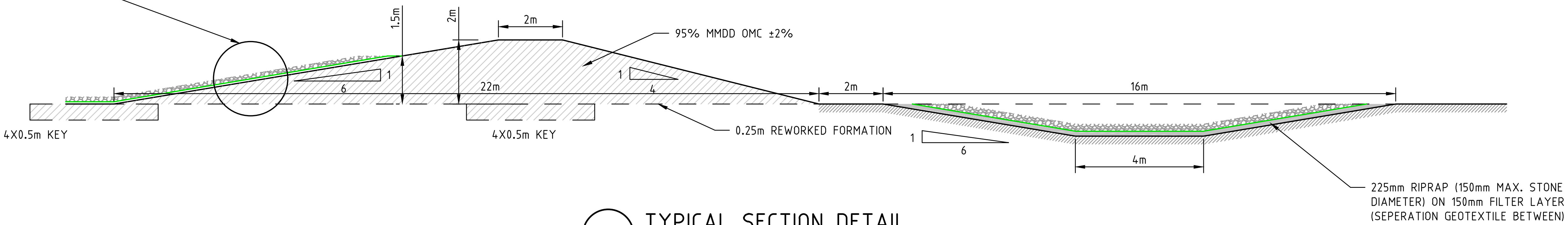
Title: SWALE SECTION DETAILS

Drawn by:	MH	Job No:	TW17053
Checked by:	LM	File No:	TW17053-C-111
Approved by:		Drg. No:	Rev:
Scale: NTS		C-111	A
Date:	20.07.2018		

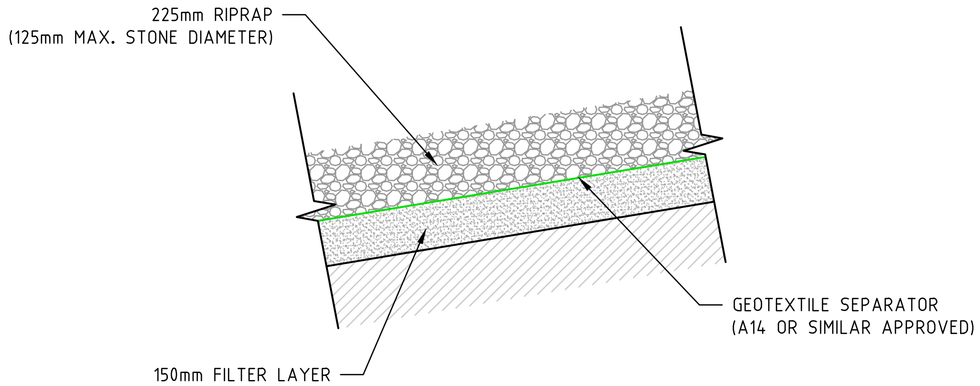
FILENAME: Y:\SECTIONS\WASTE\PROJECTS\TW2017\TW17053 - ONSLOW PROJECT MANAGEMENT\DRAWINGS\PROD DRGS\SWMP 2.DWG



C1 TYPICAL SECTION DETAIL
SCALE: NTS



C2 TYPICAL SECTION DETAIL
SCALE: NTS



C DETAIL-C
SCALE: NTS

PRELIMINARY ONLY
NOT FOR CONSTRUCTION

talis
delivering solutions
www.talisconsultants.com.au T: 1300 251 070

ASSET MANAGEMENT
CIVIL ENGINEERING
ENVIRONMENTAL SERVICES
SPATIAL INTELLIGENCE
WASTE MANAGEMENT

Level 1 660 Newcastle Street,
Leederville WA 6007
PO Box 454, Leederville WA 6903

Client: SHIRE OF ASHBURTON

NOTES
1. This drawing is the property of Talis Consultants Pty Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent.
2. All levels refer to Australian Height Datum.
3. DO NOT SCALE, use figured dimensions only, if in doubt please contact Talis Consultants.

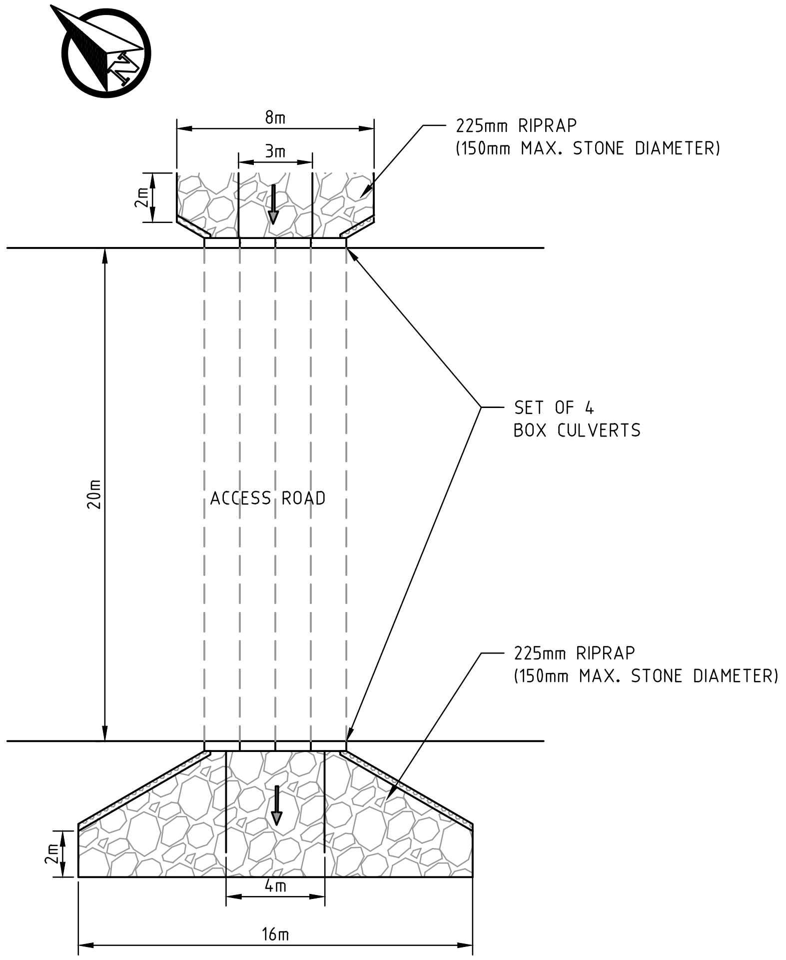
No.	Date	Drwn. Chk.	Amendment / Issue	App.
A	07.05.18	MH CP	ISSUED FOR CLIENT COMMENT	DF

Project: PILBARA REGIONAL WASTE MANAGEMENT FACILITY

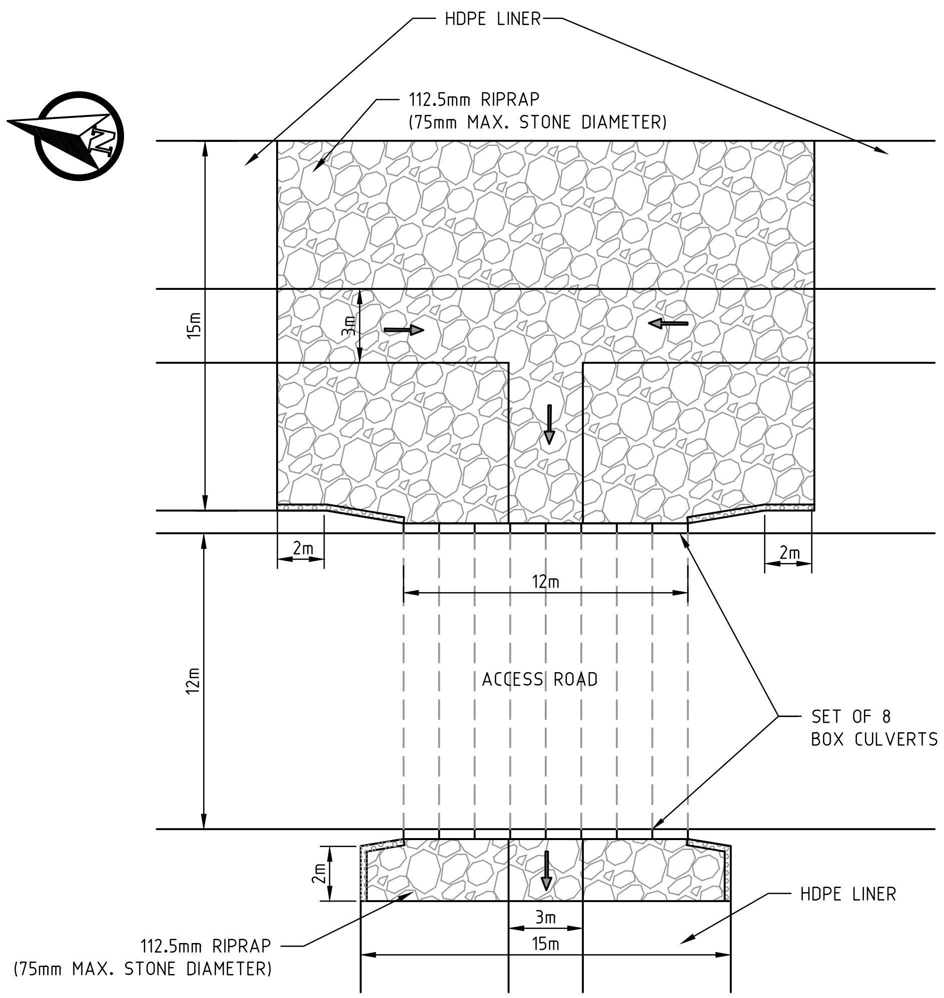
Title: LEVEE EMBANKMENT AND SWALE SECTION DETAILS

Drawn by:	MH	Job No:	TW17053
Checked by:	CP	File No:	TW17053-C-112
Approved by:		Drg. No: C-112	Rev: A
Scale: NTS			
Date:	20.07.18		

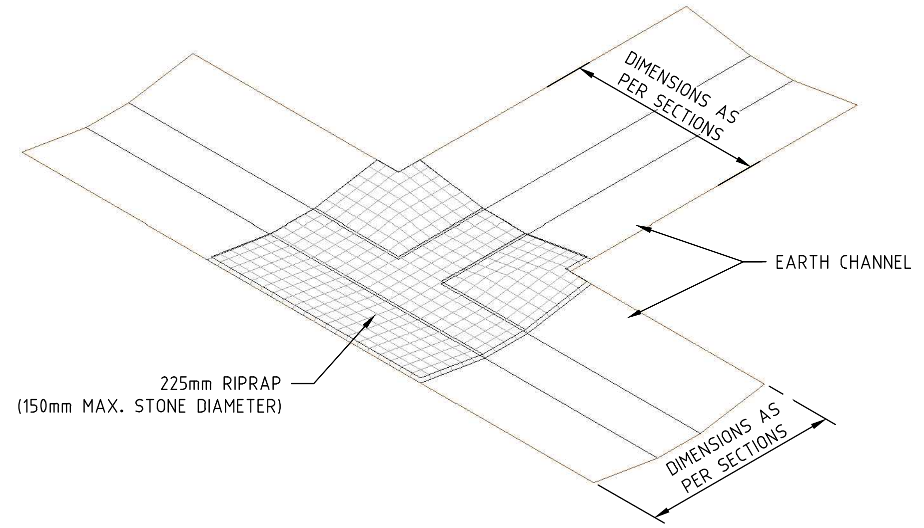
Printed by Armand Bester on 28.09.2018 08:17 AM



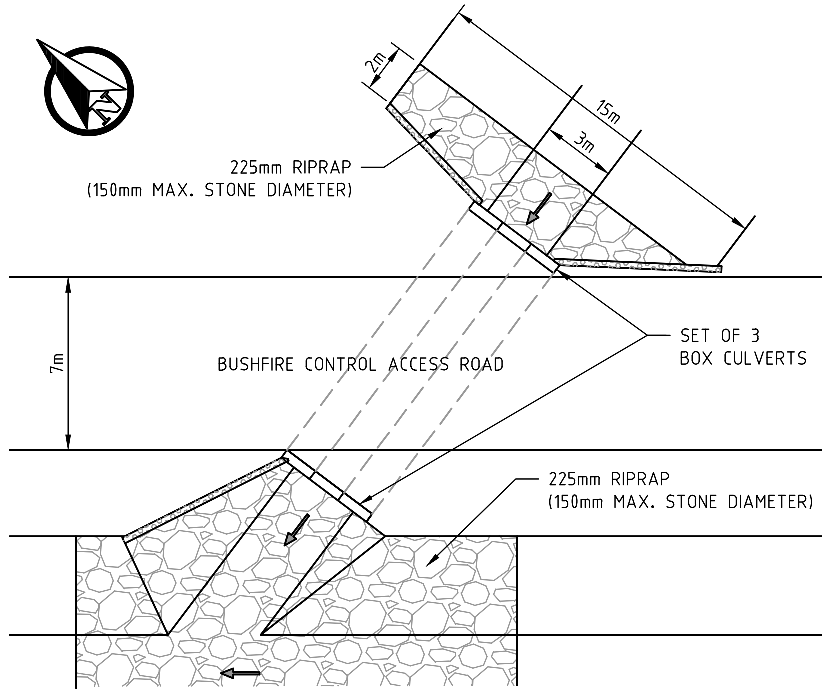
1 INTERSECTION #1 DETAIL
SCALE: NTS



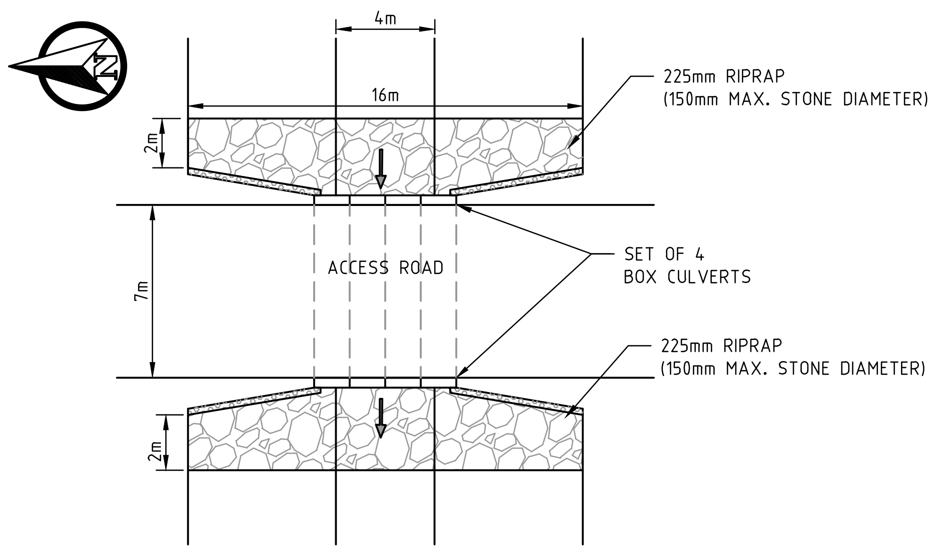
2 INTERSECTION #2 DETAIL
SCALE: NTS



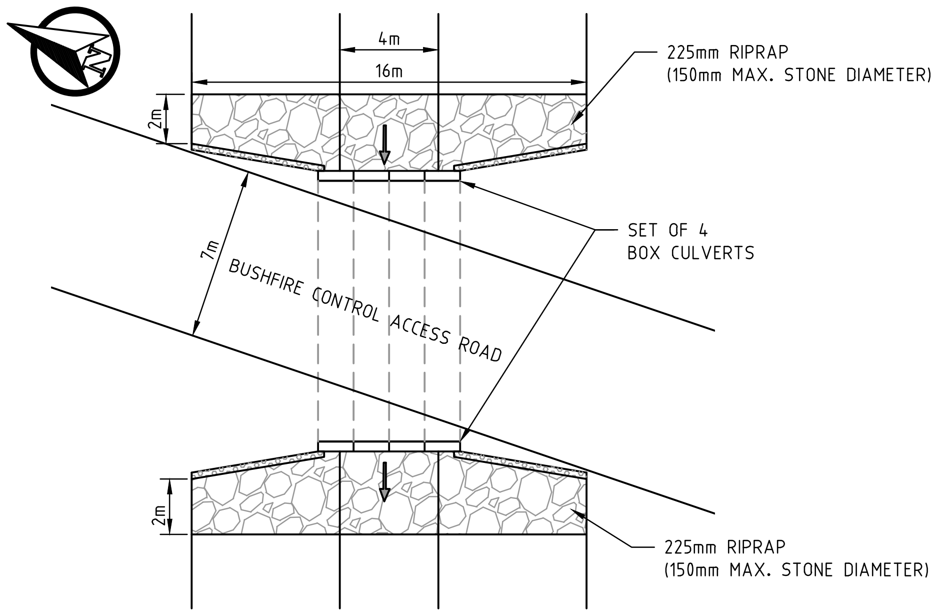
1 TYPICAL JUNCTION DETAIL
SCALE: NTS



5 INTERSECTION #5 DETAIL
SCALE: NTS



3 INTERSECTION #3 DETAIL
SCALE: NTS



4 INTERSECTION #4 DETAIL
SCALE: NTS

VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 94 ZONE 50

DRAWING NOTES

1. ALL THE DIMENSIONS ARE IN METER UNLESS OTHERWISE NOTED.

PRELIMINARY ONLY
NOT FOR CONSTRUCTION

FILENAME: Y:\SECTIONS\WASTE\PROJECTS\TW2017\TW17053 - ONSLOW PROJECT MANAGEMENT\DRAWINGS\PROD DRGS\SWMP 3.DWG

talis
delivering solutions
www.talisconsultants.com.au T: 1300 251 070

ASSET MANAGEMENT
CIVIL ENGINEERING
ENVIRONMENTAL SERVICES
SPATIAL INTELLIGENCE
WASTE MANAGEMENT

Level 1 660 Newcastle Street,
Leederville WA 6007
PO Box 454, Leederville WA 6903

Client: SHIRE OF ASHBURTON

NOTES
1. This drawing is the property of Talis Consultants Pty Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent.
2. DO NOT SCALE, use figured dimensions only, if in doubt please contact Talis Consultants.

No.	Date	Drwn. Chk.	Amendment / Issue	App.
A	20.07.18	MH CP	DRAFT ISSUED FOR REVIEW	

Project: PILBARA REGIONAL WASTE MANAGEMENT FACILITY

Title: JUNCTION & INTERSECTION DETAILS

Drawn by: MH	Job No: TW17053		
Checked by: CP	File No: TW17053-C-113		
Approved by:	Drg. No: C-113	Rev: A	
Scale: 1:NTS @ A3			
Date: 20.07.18			

Appendix B: RORB Modelling Results

```
RORBWin Output File
*******************

Program version 6.32 (last updated 3rd September 2017)
Copyright Monash University and Hydrology and Risk Consulting

Date run: 28 Aug 2018 12:59

Vector file       : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow
Approval Documentation\Data\Surface Water\RORBWin\New Catchments\Area 4
Simulation\Area4-New2_Storage.catg
Storm file        : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow
Approval Documentation\Data\Surface Water\RORBWin\New Catchments\Area 4
Simulation\Area4-New2_Storage_dr16ari7.stm
Output information: Flows & all input data


Data checks:
************
Next data to be read & checked:

Catchment name & reach type flag
Control vector & storage data
Code no.   7    16.0
Sub-area areas
Impervious flag
Initial storm data
Rainfall burst times
Pluviograph 1
Sub-area rainfalls

Data check completed



Data:
****

Area4


Time data, in increments from initial time
Area4: 72 hour 1% Design Storm
Time increment (hours)=  3.00

                  Start   Finish
Rainfall times:     0       24


End of hyeto/hydrographs:   24
Duration of calculations:   70



Pluviograph data (time in incs, rainfall in mm, in
                  increment following time shown)

        1:Temporal pattern (% of depth
  Time     1
    0     8.9
    1     9.9
    2     4.5
    3     9.8
    4     3.5
    5     4.8
    6     6.6
    7     4.8
    8    18.3
    9    10.9
   10     2.7
   11     0.6
   12     0.7
   13     0.0
   14     0.0
   15     0.0
   16     0.4
```

17	5.2
18	0.7
19	0.0
20	0.0
21	0.1
22	2.3
23	5.3

Total 100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	3	Store hydrograph from step 2; reset hydrograph to zero
4	1	Add sub-area 'B' inflow & route thru normal storage 3
5	5	Route hydrograph thru normal storage 4
6	4	Add h-graph ex step 3 to h-graph ex step 5
7	16.0	Route thru existing storage, Pond
8	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	1.61E-01	6.25E-01
B	2.90E-02	3.20E-01

Total 1.900E-01

For whole catchment ; Av. Dist., km* = 0.58
For interstation area 1; Av. Dist., km* = 0.58; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	0.1	0.190	Natural	
2	0.5	0.242	Lined	0.167
3	0.1	0.182	Natural	
4	0.2	0.018	Lined	6.772

* or other function of reach properties related to travel time

Special storage data

Storage: Pond
Initial water level at cease to flow elevation
Storage-discharge reln.: Storage = 3600*0.829E+02*(disch)** 0.74 cub. m.
Elevation (m) - Storage (m³) table

0.50	5.017E+03
1.00	1.044E+04
1.50	1.601E+04
2.00	2.181E+04
2.50	2.784E+04
3.00	3.410E+04

Input of parameters:
****

Area4
DESIGN Run

Area4: 72 hour 1% Design Storm
Time increment = 3.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catchment	Sub-Area A	B
0	38.9	39	39
1	43.3	43	43
2	19.4	19	19
3	42.6	43	43
4	15.0	15	15
5	20.7	21	21
6	28.9	29	29
7	20.7	21	21
8	79.7	80	80
9	47.7	48	48
10	11.9	12	12
11	2.5	3	3
12	3.1	3	3
13	0.0	0	0
14	0.0	0	0
15	0.0	0	0
16	1.9	2	2
17	22.6	23	23
18	3.1	3	3
19	0.0	0	0
20	0.0	0	0
21	0.6	1	1
22	10.0	10	10
23	23.2	23	23
Tot.	436.0	436	436
Pluvi. ref. no.		1	1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catchment	Sub-Area A	B
0	0.0	0	0
1	34.3	34	34
2	10.4	10	10
3	33.6	34	34
4	6.0	6	6
5	11.7	12	12
6	19.9	20	20
7	11.7	12	12
8	70.7	71	71
9	38.7	39	39
10	2.9	3	3
11	0.0	0	0
12	0.0	0	0
13	0.0	0	0
14	0.0	0	0
15	0.0	0	0
16	0.0	0	0
17	13.6	14	14
18	0.0	0	0
19	0.0	0	0
20	0.0	0	0
21	0.0	0	0
22	1.0	1	1
23	14.2	14	14
Tot.	268.8	269	269

Routing results:
****
Area4
Area4: 72 hour 1% Design Storm
DESIGN run no. 1

Parameters: kc = 0.90 m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	30.00	3.00

Results of routing through special storage Pond
with ks = 0.8289E+02 & ms = 0.74
Peak elevation exceeds max. of elev.-stor. table, 3.00
Peak outflow = 0.07 m³/s
Peak storage = 4.25E+04 m³

*** Special storage : Pond

	Hydrograph Outflow	Hydrograph Inflow
Peak discharge,m³/s	0.072	1.040
Time to peak,h	33.0	27.0
Volume,m³	3.25E+04	5.18E+04
Time to centroid,h	100.	26.
Lag (c.m. to c.m.),h	76.3	2.5
Lag to peak,h	9.59	3.59

Hydrograph summary
****

Site	Description
01	Special storage : Pond - Outflow
02	Special storage : Pond - Inflow

Inc	Time	Hyd0001	Hyd0002
1	3.00	0.0000	0.0000
2	6.00	0.0000	0.0000
3	9.00	0.0015	0.4604
4	12.00	0.0061	0.3651
5	15.00	0.0114	0.3876
6	18.00	0.0170	0.3402
7	21.00	0.0200	0.0411
8	24.00	0.0237	0.4139
9	27.00	0.0290	0.2005
10	30.00	0.0410	1.0403
11	33.00	0.0621	0.9304
12	36.00	0.0719	0.0151
13	39.00	0.0708	0.0350
14	42.00	0.0695	0.0000
15	45.00	0.0678	0.0000
16	48.00	0.0662	0.0000
17	51.00	0.0646	0.0000
18	54.00	0.0631	0.0000
19	57.00	0.0636	0.1730
20	60.00	0.0653	0.0979
21	63.00	0.0649	0.0000
22	66.00	0.0634	0.0000
23	69.00	0.0619	0.0000
24	72.00	0.0606	0.0103
25	75.00	0.0616	0.1934
26	78.00	0.0635	0.0943
27	81.00	0.0631	0.0000
28	84.00	0.0616	0.0000
29	87.00	0.0602	0.0000
30	90.00	0.0588	0.0000
31	93.00	0.0574	0.0000
32	96.00	0.0561	0.0000
33	99.00	0.0548	0.0000
34	102.00	0.0536	0.0000
35	105.00	0.0524	0.0000

36	108.00	0.0512	0.0000
37	111.00	0.0501	0.0000
38	114.00	0.0490	0.0000
39	117.00	0.0479	0.0000
40	120.00	0.0468	0.0000
41	123.00	0.0458	0.0000
42	126.00	0.0448	0.0000
43	129.00	0.0439	0.0000
44	132.00	0.0429	0.0000
45	135.00	0.0420	0.0000
46	138.00	0.0411	0.0000
47	141.00	0.0403	0.0000
48	144.00	0.0394	0.0000
49	147.00	0.0386	0.0000
50	150.00	0.0378	0.0000
51	153.00	0.0370	0.0000
52	156.00	0.0363	0.0000
53	159.00	0.0355	0.0000
54	162.00	0.0348	0.0000
55	165.00	0.0341	0.0000
56	168.00	0.0334	0.0000
57	171.00	0.0327	0.0000
58	174.00	0.0321	0.0000
59	177.00	0.0315	0.0000
60	180.00	0.0308	0.0000
61	183.00	0.0302	0.0000
62	186.00	0.0296	0.0000
63	189.00	0.0291	0.0000
64	192.00	0.0285	0.0000
65	195.00	0.0280	0.0000
66	198.00	0.0274	0.0000
67	201.00	0.0269	0.0000
68	204.00	0.0264	0.0000
69	207.00	0.0259	0.0000
70	210.00	0.0254	0.0000
71	213.00	0.0250	0.0000

```
RORBWin Output File
*******************

Program version 6.32 (last updated 3rd September 2017)
Copyright Monash University and Hydrology and Risk Consulting

Date run: 27 Jun 2018 13:05

Vector file       : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow
Approval Documentation\Data\Storm Water\RORBWin\New Catchments\Area 4
Simulation\Area4.catg
Storm file        : \\SERVER\Talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow
Approval Documentation\Data\Storm Water\RORBWin\New Catchments\Area 4
Simulation\Area4_dr16ari7.stm
Output information: Flows & all input data


Data checks:
************
Next data to be read & checked:

Catchment name & reach type flag
Control vector & storage data
Code no.  21    16.0
Sub-area areas
Impervious flag
Initial storm data
Rainfall burst times
Pluviograph 1
Sub-area rainfalls

Data check completed



Data:
****

Area4


Time data, in increments from initial time
Area4: 72 hour 1% Design Storm
Time increment (hours)=  3.00

                  Start   Finish
Rainfall times:     0       24


End of hyeto/hydrographs:   24
Duration of calculations:   70



Pluviograph data (time in incs, rainfall in mm, in
                  increment following time shown)

        1:Temporal pattern (% of depth
  Time     1
    0     8.9
    1     9.9
    2     4.5
    3     9.8
    4     3.5
    5     4.8
    6     6.6
    7     4.8
    8    18.3
    9    10.9
   10     2.7
   11     0.6
   12     0.7
   13     0.0
   14     0.0
   15     0.0
   16     0.4
```

17	5.2
18	0.7
19	0.0
20	0.0
21	0.1
22	2.3
23	5.3
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	3	Store hydrograph from step 2; reset hydrograph to zero
4	1	Add sub-area 'B' inflow & route thru normal storage 3
5	4	Add h-graph ex step 3 to h-graph ex step 4
6	5	Route hydrograph thru normal storage 4
7	3	Store hydrograph from step 6; reset hydrograph to zero
8	1	Add sub-area 'C' inflow & route thru normal storage 5
9	4	Add h-graph ex step 7 to h-graph ex step 8
10	5	Route hydrograph thru normal storage 6
11	3	Store hydrograph from step 10; reset hydrograph to zero
12	1	Add sub-area 'D' inflow & route thru normal storage 7
13	4	Add h-graph ex step 11 to h-graph ex step 12
14	5	Route hydrograph thru normal storage 8
15	3	Store hydrograph from step 14; reset hydrograph to zero
16	1	Add sub-area 'E' inflow & route thru normal storage 9
17	4	Add h-graph ex step 15 to h-graph ex step 16
18	3	Store hydrograph from step 17; reset hydrograph to zero
19	1	Add sub-area 'F' inflow & route thru normal storage 10
20	4	Add h-graph ex step 18 to h-graph ex step 19
21	16.0	Route thru existing storage, Pond
22	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	2.80E-02	6.98E-01
B	2.80E-02	5.36E-01
C	2.80E-02	3.74E-01
D	2.80E-02	2.12E-01
E	2.80E-02	1.00E-01
F	2.80E-02	5.00E-02

Total 1.680E-01

For whole catchment ; Av. Dist., km* = 0.33
For interstation area 1; Av. Dist., km* = 0.33; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	0.1	0.152	Natural	
2	0.2	0.265	Unlined	0.149
3	0.1	0.152	Natural	
4	0.2	0.265	Unlined	0.149
5	0.1	0.152	Natural	
6	0.2	0.265	Unlined	0.149
7	0.1	0.152	Natural	
8	0.2	0.265	Unlined	0.149
9	0.1	0.163	Unlined	0.149
10	0.1	0.152	Natural	

* or other function of reach properties related to travel time

Special storage data

Storage: Pond
Initial water level at cease to flow elevation
Storage-discharge reln.: Storage = 3600*0.829E+02*(disch)** 0.74 cub. m.
Elevation (m) - Storage (m³) table

0.50	5.017E+03
1.00	1.044E+04
1.50	1.601E+04
2.00	2.181E+04
2.50	2.784E+04
3.00	3.410E+04

Input of parameters:
****

Area4
DESIGN Run
Area4: 72 hour 1% Design Storm
Time increment = 3.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F
0	38.9	39	39	39	39	39	39
1	43.3	43	43	43	43	43	43
2	19.4	19	19	19	19	19	19
3	42.6	43	43	43	43	43	43
4	15.0	15	15	15	15	15	15
5	20.7	21	21	21	21	21	21
6	28.9	29	29	29	29	29	29
7	20.7	21	21	21	21	21	21
8	79.7	80	80	80	80	80	80
9	47.7	48	48	48	48	48	48
10	11.9	12	12	12	12	12	12
11	2.5	3	3	3	3	3	3
12	3.1	3	3	3	3	3	3
13	0.0	0	0	0	0	0	0
14	0.0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0
16	1.9	2	2	2	2	2	2
17	22.6	23	23	23	23	23	23
18	3.1	3	3	3	3	3	3
19	0.0	0	0	0	0	0	0
20	0.0	0	0	0	0	0	0
21	0.6	1	1	1	1	1	1
22	10.0	10	10	10	10	10	10
23	23.2	23	23	23	23	23	23
Tot.	436.0	436	436	436	436	436	436
Pluvi. ref. no.		1	1	1	1	1	1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F
0	0.0	0	0	0	0	0	0
1	25.3	25	25	25	25	25	25
2	1.4	1	1	1	1	1	1
3	24.6	25	25	25	25	25	25

4	0.0	0	0	0	0	0	0
5	2.7	3	3	3	3	3	3
6	10.9	11	11	11	11	11	11
7	2.7	3	3	3	3	3	3
8	61.7	62	62	62	62	62	62
9	29.7	30	30	30	30	30	30
10	0.0	0	0	0	0	0	0
11	0.0	0	0	0	0	0	0
12	0.0	0	0	0	0	0	0
13	0.0	0	0	0	0	0	0
14	0.0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0
16	0.0	0	0	0	0	0	0
17	4.6	5	5	5	5	5	5
18	0.0	0	0	0	0	0	0
19	0.0	0	0	0	0	0	0
20	0.0	0	0	0	0	0	0
21	0.0	0	0	0	0	0	0
22	0.0	0	0	0	0	0	0
23	5.2	5	5	5	5	5	5
Tot.	168.8	169	169	169	169	169	169

Routing results:
****

Area4
Area4: 72 hour 1% Design Storm
DESIGN run no. 1

Parameters: kc =   0.90   m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	30.00	6.00

Results of routing through special storage Pond
with ks = 0.8289E+02 & ms = 0.74
Peak elevation=   2.34 m
Peak outflow =   0.04 m^3/s
Peak storage =   2.59E+04 m^3

*** Special storage :   Pond

	Hydrograph Outflow	Inflow
Peak discharge, m^3/s	0.0369	0.7422
Time to peak,h	36.0	30.0
Volume, m^3	1.67E+04	2.93E+04
Time to centroid,h	102.	25.
Lag (c.m. to c.m.),h	79.8	2.6
Lag to peak,h	13.9	7.9

Hydrograph summary
****

Site	Description
01	Special storage : Pond - Outflow
02	Special storage : Pond - Inflow

Inc	Time	Hyd0001	Hyd0002
1	3.00	0.0000	0.0000
2	6.00	0.0000	0.0000
3	9.00	0.0007	0.2458
4	12.00	0.0027	0.1986
5	15.00	0.0049	0.2025
6	18.00	0.0073	0.1861
7	21.00	0.0087	0.0246
8	24.00	0.0096	0.1171
9	27.00	0.0111	0.1051
10	30.00	0.0169	0.6486
11	33.00	0.0292	0.7422

12	36.00	0.0368	0.0792
13	39.00	0.0369	0.0000
14	42.00	0.0361	0.0000
15	45.00	0.0354	0.0000
16	48.00	0.0347	0.0000
17	51.00	0.0340	0.0000
18	54.00	0.0333	0.0000
19	57.00	0.0330	0.0363
20	60.00	0.0330	0.0360
21	63.00	0.0328	0.0052
22	66.00	0.0322	0.0000
23	69.00	0.0316	0.0000
24	72.00	0.0309	0.0000
25	75.00	0.0307	0.0417
26	78.00	0.0309	0.0407
27	81.00	0.0308	0.0054
28	84.00	0.0302	0.0000
29	87.00	0.0297	0.0000
30	90.00	0.0291	0.0000
31	93.00	0.0285	0.0000
32	96.00	0.0280	0.0000
33	99.00	0.0274	0.0000
34	102.00	0.0269	0.0000
35	105.00	0.0264	0.0000
36	108.00	0.0259	0.0000
37	111.00	0.0254	0.0000
38	114.00	0.0250	0.0000
39	117.00	0.0245	0.0000
40	120.00	0.0240	0.0000
41	123.00	0.0236	0.0000
42	126.00	0.0232	0.0000
43	129.00	0.0228	0.0000
44	132.00	0.0223	0.0000
45	135.00	0.0219	0.0000
46	138.00	0.0215	0.0000
47	141.00	0.0212	0.0000
48	144.00	0.0208	0.0000
49	147.00	0.0204	0.0000
50	150.00	0.0201	0.0000
51	153.00	0.0197	0.0000
52	156.00	0.0194	0.0000
53	159.00	0.0190	0.0000
54	162.00	0.0187	0.0000
55	165.00	0.0184	0.0000
56	168.00	0.0181	0.0000
57	171.00	0.0178	0.0000
58	174.00	0.0175	0.0000
59	177.00	0.0172	0.0000
60	180.00	0.0169	0.0000
61	183.00	0.0166	0.0000
62	186.00	0.0163	0.0000
63	189.00	0.0160	0.0000
64	192.00	0.0158	0.0000
65	195.00	0.0155	0.0000
66	198.00	0.0153	0.0000
67	201.00	0.0150	0.0000
68	204.00	0.0148	0.0000
69	207.00	0.0145	0.0000
70	210.00	0.0143	0.0000
71	213.00	0.0141	0.0000

RORBWin Output File
****

Program version 6.32 (last updated 3rd September 2017)
Copyright Monash University and Hydrology and Risk Consulting

Date run: 28 Aug 2018 12:58

Vector file   : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow Approval Documentation\Data\Surface Water\RORBWin\New Catchments\Area 4 Simulation\Area4-New2_Storage.catg
Storm file   : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow Approval Documentation\Data\Surface Water\RORBWin\New Catchments\Area 4 Simulation\Area4-New2_Storage_dr16ari7.stm
Output information: Flows & all input data

Data checks:
****
Next data to be read & checked:

Catchment name & reach type flag
Control vector & storage data
Code no.   7   16.0
Sub-area areas
Impervious flag
Initial storm data
Rainfall burst times
Pluviograph 1
Sub-area rainfalls

Data check completed

Data:
****

Area4

Time data, in increments from initial time
Area4: 72 hour 1% Design Storm
Time increment (hours)= 3.00

	Start	Finish
Rainfall times:	0	24

End of hyeto/hydrographs: 24
Duration of calculations: 70

Pluviograph data (time in incs, rainfall in mm, in
                  increment following time shown)

1:Temporal pattern (% of depth

Time	1
0	8.9
1	9.9
2	4.5
3	9.8
4	3.5
5	4.8
6	6.6
7	4.8
8	18.3
9	10.9
10	2.7
11	0.6
12	0.7
13	0.0
14	0.0
15	0.0
16	0.4

17	5.2
18	0.7
19	0.0
20	0.0
21	0.1
22	2.3
23	5.3
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	3	Store hydrograph from step 2; reset hydrograph to zero
4	1	Add sub-area 'B' inflow & route thru normal storage 3
5	5	Route hydrograph thru normal storage 4
6	4	Add h-graph ex step 3 to h-graph ex step 5
7	16.0	Route thru existing storage, Pond
8	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	1.61E-01	6.25E-01
B	2.90E-02	3.20E-01

Total 1.900E-01

For whole catchment ; Av. Dist., km* = 0.58
For interstation area 1; Av. Dist., km* = 0.58; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	0.1	0.190	Natural	
2	0.5	0.242	Lined	0.167
3	0.1	0.182	Natural	
4	0.2	0.018	Lined	6.772

* or other function of reach properties related to travel time

Special storage data

Storage: Pond
Initial water level at cease to flow elevation
Storage-discharge reln.: Storage = 3600*0.829E+02*(disch)** 0.74 cub. m.
Elevation (m) - Storage (m³) table

Elevation (m)	Storage (m³)
0.50	5.017E+03
1.00	1.044E+04
1.50	1.601E+04
2.00	2.181E+04
2.50	2.784E+04
3.00	3.410E+04

Input of parameters:
****

Area4
DESIGN Run

Area4: 72 hour 1% Design Storm
Time increment = 3.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	Sub-Area B
0	38.9	39	39
1	43.3	43	43
2	19.4	19	19
3	42.6	43	43
4	15.0	15	15
5	20.7	21	21
6	28.9	29	29
7	20.7	21	21
8	79.7	80	80
9	47.7	48	48
10	11.9	12	12
11	2.5	3	3
12	3.1	3	3
13	0.0	0	0
14	0.0	0	0
15	0.0	0	0
16	1.9	2	2
17	22.6	23	23
18	3.1	3	3
19	0.0	0	0
20	0.0	0	0
21	0.6	1	1
22	10.0	10	10
23	23.2	23	23
Tot.	436.0	436	436
Pluvi. ref. no.		1	1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	Sub-Area B
0	0.0	0	0
1	33.2	33	33
2	10.4	10	10
3	33.6	34	34
4	6.0	6	6
5	11.7	12	12
6	19.9	20	20
7	11.7	12	12
8	70.7	71	71
9	38.7	39	39
10	2.9	3	3
11	0.0	0	0
12	0.0	0	0
13	0.0	0	0
14	0.0	0	0
15	0.0	0	0
16	0.0	0	0
17	13.6	14	14
18	0.0	0	0
19	0.0	0	0
20	0.0	0	0
21	0.0	0	0
22	1.0	1	1
23	14.2	14	14
Tot.	267.7	268	268

Routing results:
****
Area4
Area4: 72 hour 1% Design Storm
DESIGN run no. 1

Parameters: kc = 0.90 m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	40.00	3.00

Results of routing through special storage Pond
with ks = 0.8289E+02 & ms = 0.74
Peak elevation exceeds max. of elev.-stor. table, 3.00
Peak outflow = 0.07 m³/s
Peak storage = 4.24E+04 m³

*** Special storage : Pond

	Hydrograph Outflow	Inflow
Peak discharge,m³/s	0.072	1.040
Time to peak,h	33.0	27.0
Volume,m³	3.24E+04	5.16E+04
Time to centroid,h	100.	26.
Lag (c.m. to c.m.),h	76.3	2.5
Lag to peak,h	9.52	3.52

Hydrograph summary
****

Site	Description
01	Special storage : Pond - Outflow
02	Special storage : Pond - Inflow

Inc	Time	Hyd0001	Hyd0002
1	3.00	0.0000	0.0000
2	6.00	0.0000	0.0000
3	9.00	0.0015	0.4453
4	12.00	0.0059	0.3590
5	15.00	0.0111	0.3916
6	18.00	0.0167	0.3375
7	21.00	0.0197	0.0427
8	24.00	0.0234	0.4131
9	27.00	0.0287	0.2010
10	30.00	0.0407	1.0402
11	33.00	0.0617	0.9304
12	36.00	0.0715	0.0152
13	39.00	0.0704	0.0349
14	42.00	0.0691	0.0000
15	45.00	0.0674	0.0000
16	48.00	0.0658	0.0000
17	51.00	0.0643	0.0000
18	54.00	0.0628	0.0000
19	57.00	0.0633	0.1730
20	60.00	0.0650	0.0979
21	63.00	0.0646	0.0000
22	66.00	0.0631	0.0000
23	69.00	0.0616	0.0000
24	72.00	0.0603	0.0103
25	75.00	0.0613	0.1934
26	78.00	0.0632	0.0943
27	81.00	0.0628	0.0000
28	84.00	0.0614	0.0000
29	87.00	0.0599	0.0000
30	90.00	0.0585	0.0000
31	93.00	0.0572	0.0000
32	96.00	0.0559	0.0000
33	99.00	0.0546	0.0000
34	102.00	0.0534	0.0000
35	105.00	0.0522	0.0000

36	108.00	0.0510	0.0000
37	111.00	0.0499	0.0000
38	114.00	0.0488	0.0000
39	117.00	0.0477	0.0000
40	120.00	0.0467	0.0000
41	123.00	0.0456	0.0000
42	126.00	0.0447	0.0000
43	129.00	0.0437	0.0000
44	132.00	0.0428	0.0000
45	135.00	0.0418	0.0000
46	138.00	0.0410	0.0000
47	141.00	0.0401	0.0000
48	144.00	0.0393	0.0000
49	147.00	0.0384	0.0000
50	150.00	0.0377	0.0000
51	153.00	0.0369	0.0000
52	156.00	0.0361	0.0000
53	159.00	0.0354	0.0000
54	162.00	0.0347	0.0000
55	165.00	0.0340	0.0000
56	168.00	0.0333	0.0000
57	171.00	0.0326	0.0000
58	174.00	0.0320	0.0000
59	177.00	0.0313	0.0000
60	180.00	0.0307	0.0000
61	183.00	0.0301	0.0000
62	186.00	0.0295	0.0000
63	189.00	0.0290	0.0000
64	192.00	0.0284	0.0000
65	195.00	0.0279	0.0000
66	198.00	0.0273	0.0000
67	201.00	0.0268	0.0000
68	204.00	0.0263	0.0000
69	207.00	0.0258	0.0000
70	210.00	0.0253	0.0000
71	213.00	0.0249	0.0000

RORBWin Output File
****

Program version 6.32 (last updated 3rd September 2017)

Date run: 27 Jun 2018 13:04

```
 Vector file       : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow
Approval Documentation\Data\Storm Water\RORBWin\New Catchments\Area 4
Simulation\Area4.catg
 Storm file        : \\SERVER\Talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow
Approval Documentation\Data\Storm Water\RORBWin\New Catchments\Area 4
Simulation\Area4_dr16ari7.stm
 Output information: Flows & all input data
```

Data checks:
****
Next data to be read & checked:

```
Catchment name & reach type flag
Control vector & storage data
Code no.  21    16.0
Sub-area areas
Impervious flag
Initial storm data
Rainfall burst times
Pluviograph 1
Sub-area rainfalls
```

Data check completed

Data:
****

Area4

```
Time data, in increments from initial time
Area4: 72 hour 1% Design Storm
Time increment (hours)=  3.00

                  Start   Finish
Rainfall times:     0       24


End of hyeto/hydrographs:   24
Duration of calculations:   70



Pluviograph data (time in incs, rainfall in mm, in
                  increment following time shown)

        1:Temporal pattern (% of depth
  Time     1
    0     8.9
    1     9.9
    2     4.5
    3     9.8
    4     3.5
    5     4.8
    6     6.6
    7     4.8
    8    18.3
    9    10.9
   10     2.7
   11     0.6
   12     0.7
   13     0.0
   14     0.0
   15     0.0
   16     0.4
```

17	5.2
18	0.7
19	0.0
20	0.0
21	0.1
22	2.3
23	5.3

Total 100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	3	Store hydrograph from step 2; reset hydrograph to zero
4	1	Add sub-area 'B' inflow & route thru normal storage 3
5	4	Add h-graph ex step 3 to h-graph ex step 4
6	5	Route hydrograph thru normal storage 4
7	3	Store hydrograph from step 6; reset hydrograph to zero
8	1	Add sub-area 'C' inflow & route thru normal storage 5
9	4	Add h-graph ex step 7 to h-graph ex step 8
10	5	Route hydrograph thru normal storage 6
11	3	Store hydrograph from step 10; reset hydrograph to zero
12	1	Add sub-area 'D' inflow & route thru normal storage 7
13	4	Add h-graph ex step 11 to h-graph ex step 12
14	5	Route hydrograph thru normal storage 8
15	3	Store hydrograph from step 14; reset hydrograph to zero
16	1	Add sub-area 'E' inflow & route thru normal storage 9
17	4	Add h-graph ex step 15 to h-graph ex step 16
18	3	Store hydrograph from step 17; reset hydrograph to zero
19	1	Add sub-area 'F' inflow & route thru normal storage 10
20	4	Add h-graph ex step 18 to h-graph ex step 19
21	16.0	Route thru existing storage, Pond
22	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	2.80E-02	6.98E-01
B	2.80E-02	5.36E-01
C	2.80E-02	3.74E-01
D	2.80E-02	2.12E-01
E	2.80E-02	1.00E-01
F	2.80E-02	5.00E-02

Total 1.680E-01

For whole catchment ; Av. Dist., km* = 0.33
For interstation area 1; Av. Dist., km* = 0.33; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	0.1	0.152	Natural	
2	0.2	0.265	Unlined	0.149
3	0.1	0.152	Natural	
4	0.2	0.265	Unlined	0.149
5	0.1	0.152	Natural	
6	0.2	0.265	Unlined	0.149
7	0.1	0.152	Natural	
8	0.2	0.265	Unlined	0.149
9	0.1	0.163	Unlined	0.149
10	0.1	0.152	Natural	

* or other function of reach properties related to travel time

Special storage data

Storage: Pond
Initial water level at cease to flow elevation
Storage-discharge reln.: Storage = 3600*0.829E+02*(disch)** 0.74 cub. m.
Elevation (m) - Storage (m³) table

0.50	5.017E+03
1.00	1.044E+04
1.50	1.601E+04
2.00	2.181E+04
2.50	2.784E+04
3.00	3.410E+04

Input of parameters:
****

Area4
DESIGN Run
Area4: 72 hour 1% Design Storm
Time increment = 3.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F
0	38.9	39	39	39	39	39	39
1	43.3	43	43	43	43	43	43
2	19.4	19	19	19	19	19	19
3	42.6	43	43	43	43	43	43
4	15.0	15	15	15	15	15	15
5	20.7	21	21	21	21	21	21
6	28.9	29	29	29	29	29	29
7	20.7	21	21	21	21	21	21
8	79.7	80	80	80	80	80	80
9	47.7	48	48	48	48	48	48
10	11.9	12	12	12	12	12	12
11	2.5	3	3	3	3	3	3
12	3.1	3	3	3	3	3	3
13	0.0	0	0	0	0	0	0
14	0.0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0
16	1.9	2	2	2	2	2	2
17	22.6	23	23	23	23	23	23
18	3.1	3	3	3	3	3	3
19	0.0	0	0	0	0	0	0
20	0.0	0	0	0	0	0	0
21	0.6	1	1	1	1	1	1
22	10.0	10	10	10	10	10	10
23	23.2	23	23	23	23	23	23
Tot.	436.0	436	436	436	436	436	436
Pluvi. ref. no.		1	1	1	1	1	1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F
0	0.0	0	0	0	0	0	0
1	24.2	24	24	24	24	24	24
2	1.4	1	1	1	1	1	1
3	24.6	25	25	25	25	25	25

4	0.0	0	0	0	0	0	0
5	2.7	3	3	3	3	3	3
6	10.9	11	11	11	11	11	11
7	2.7	3	3	3	3	3	3
8	61.7	62	62	62	62	62	62
9	29.7	30	30	30	30	30	30
10	0.0	0	0	0	0	0	0
11	0.0	0	0	0	0	0	0
12	0.0	0	0	0	0	0	0
13	0.0	0	0	0	0	0	0
14	0.0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0
16	0.0	0	0	0	0	0	0
17	4.6	5	5	5	5	5	5
18	0.0	0	0	0	0	0	0
19	0.0	0	0	0	0	0	0
20	0.0	0	0	0	0	0	0
21	0.0	0	0	0	0	0	0
22	0.0	0	0	0	0	0	0
23	5.2	5	5	5	5	5	5
Tot.	167.7	168	168	168	168	168	168

Routing results:
****
Area4
Area4: 72 hour 1% Design Storm
DESIGN run no. 1

Parameters: kc = 0.90 m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	40.00	6.00

Results of routing through special storage Pond
with ks = 0.8289E+02 & ms = 0.74
Peak elevation= 2.33 m
Peak outflow = 0.04 m³/s
Peak storage = 2.58E+04 m³

*** Special storage : Pond

	Hydrograph Outflow	Inflow
Peak discharge,m³/s	0.0366	0.7422
Time to peak,h	36.0	30.0
Volume,m³	1.65E+04	2.91E+04
Time to centroid,h	102.	25.
Lag (c.m. to c.m.),h	79.8	2.6
Lag to peak,h	13.8	7.8

Hydrograph summary
****

Site	Description
01	Special storage : Pond - Outflow
02	Special storage : Pond - Inflow

Inc	Time	Hyd0001	Hyd0002
1	3.00	0.0000	0.0000
2	6.00	0.0000	0.0000
3	9.00	0.0006	0.2346
4	12.00	0.0025	0.1913
5	15.00	0.0047	0.2050
6	18.00	0.0071	0.1854
7	21.00	0.0085	0.0238
8	24.00	0.0093	0.1173
9	27.00	0.0108	0.1051
10	30.00	0.0167	0.6486
11	33.00	0.0289	0.7422

12	36.00	0.0365	0.0791
13	39.00	0.0366	0.0000
14	42.00	0.0358	0.0000
15	45.00	0.0351	0.0000
16	48.00	0.0344	0.0000
17	51.00	0.0337	0.0000
18	54.00	0.0330	0.0000
19	57.00	0.0327	0.0363
20	60.00	0.0328	0.0360
21	63.00	0.0325	0.0052
22	66.00	0.0319	0.0000
23	69.00	0.0313	0.0000
24	72.00	0.0307	0.0000
25	75.00	0.0305	0.0417
26	78.00	0.0307	0.0407
27	81.00	0.0306	0.0054
28	84.00	0.0300	0.0000
29	87.00	0.0294	0.0000
30	90.00	0.0289	0.0000
31	93.00	0.0283	0.0000
32	96.00	0.0278	0.0000
33	99.00	0.0273	0.0000
34	102.00	0.0267	0.0000
35	105.00	0.0262	0.0000
36	108.00	0.0257	0.0000
37	111.00	0.0253	0.0000
38	114.00	0.0248	0.0000
39	117.00	0.0243	0.0000
40	120.00	0.0239	0.0000
41	123.00	0.0234	0.0000
42	126.00	0.0230	0.0000
43	129.00	0.0226	0.0000
44	132.00	0.0222	0.0000
45	135.00	0.0218	0.0000
46	138.00	0.0214	0.0000
47	141.00	0.0210	0.0000
48	144.00	0.0207	0.0000
49	147.00	0.0203	0.0000
50	150.00	0.0199	0.0000
51	153.00	0.0196	0.0000
52	156.00	0.0192	0.0000
53	159.00	0.0189	0.0000
54	162.00	0.0186	0.0000
55	165.00	0.0183	0.0000
56	168.00	0.0180	0.0000
57	171.00	0.0176	0.0000
58	174.00	0.0173	0.0000
59	177.00	0.0171	0.0000
60	180.00	0.0168	0.0000
61	183.00	0.0165	0.0000
62	186.00	0.0162	0.0000
63	189.00	0.0159	0.0000
64	192.00	0.0157	0.0000
65	195.00	0.0154	0.0000
66	198.00	0.0152	0.0000
67	201.00	0.0149	0.0000
68	204.00	0.0147	0.0000
69	207.00	0.0144	0.0000
70	210.00	0.0142	0.0000
71	213.00	0.0140	0.0000

RORBWin Output File
****

Program version 6.32 (last updated 3rd September 2017)

Date run: 28 Aug 2018 12:57

Vector file   : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow Approval Documentation\Data\Surface Water\RORBWin\New Catchments\Area 4 Simulation\Area4-New2_Storage.catg
Storm file   : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow Approval Documentation\Data\Surface Water\RORBWin\New Catchments\Area 4 Simulation\Area4-New2_Storage_dr16ari7.stm
Output information: Flows & all input data

Data checks:
****
Next data to be read & checked:

Catchment name & reach type flag
Control vector & storage data
Code no.   7   16.0
Sub-area areas
Impervious flag
Initial storm data
Rainfall burst times
Pluviograph 1
Sub-area rainfalls

Data check completed

Data:
****

Area4

Time data, in increments from initial time
Area4: 72 hour 1% Design Storm
Time increment (hours)= 3.00

	Start	Finish
Rainfall times:	0	24

End of hyeto/hydrographs: 24
Duration of calculations: 70

Pluviograph data (time in incs, rainfall in mm, in
increment following time shown)

1:Temporal pattern (% of depth

Time	1
0	8.9
1	9.9
2	4.5
3	9.8
4	3.5
5	4.8
6	6.6
7	4.8
8	18.3
9	10.9
10	2.7
11	0.6
12	0.7
13	0.0
14	0.0
15	0.0
16	0.4

17	5.2
18	0.7
19	0.0
20	0.0
21	0.1
22	2.3
23	5.3
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	3	Store hydrograph from step 2; reset hydrograph to zero
4	1	Add sub-area 'B' inflow & route thru normal storage 3
5	5	Route hydrograph thru normal storage 4
6	4	Add h-graph ex step 3 to h-graph ex step 5
7	16.0	Route thru existing storage, Pond
8	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	1.61E-01	6.25E-01
B	2.90E-02	3.20E-01

Total 1.900E-01

For whole catchment ; Av. Dist., km* = 0.58
For interstation area 1; Av. Dist., km* = 0.58; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	0.1	0.190	Natural	
2	0.5	0.242	Lined	0.167
3	0.1	0.182	Natural	
4	0.2	0.018	Lined	6.772

* or other function of reach properties related to travel time

Special storage data

Storage: Pond
Initial water level at cease to flow elevation
Storage-discharge reln.: Storage = 3600*0.829E+02*(disch)** 0.74 cub. m.
Elevation (m) - Storage (m³) table

0.50	5.017E+03
1.00	1.044E+04
1.50	1.601E+04
2.00	2.181E+04
2.50	2.784E+04
3.00	3.410E+04

Input of parameters:
****

Area4
DESIGN Run

Area4: 72 hour 1% Design Storm
Time increment = 3.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B
0	38.9	39	39
1	43.3	43	43
2	19.4	19	19
3	42.6	43	43
4	15.0	15	15
5	20.7	21	21
6	28.9	29	29
7	20.7	21	21
8	79.7	80	80
9	47.7	48	48
10	11.9	12	12
11	2.5	3	3
12	3.1	3	3
13	0.0	0	0
14	0.0	0	0
15	0.0	0	0
16	1.9	2	2
17	22.6	23	23
18	3.1	3	3
19	0.0	0	0
20	0.0	0	0
21	0.6	1	1
22	10.0	10	10
23	23.2	23	23
Tot.	436.0	436	436
Pluvi. ref. no.		1	1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B
0	0.0	0	0
1	23.2	23	23
2	10.4	10	10
3	33.6	34	34
4	6.0	6	6
5	11.7	12	12
6	19.9	20	20
7	11.7	12	12
8	70.7	71	71
9	38.7	39	39
10	2.9	3	3
11	0.0	0	0
12	0.0	0	0
13	0.0	0	0
14	0.0	0	0
15	0.0	0	0
16	0.0	0	0
17	13.6	14	14
18	0.0	0	0
19	0.0	0	0
20	0.0	0	0
21	0.0	0	0
22	1.0	1	1
23	14.2	14	14
Tot.	257.7	258	258

Routing results:
****
Area4
Area4: 72 hour 1% Design Storm
DESIGN run no. 1

Parameters: kc = 0.90 m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	50.00	3.00

Results of routing through special storage Pond
with ks = 0.8289E+02 & ms = 0.74
Peak elevation exceeds max. of elev.-stor. table, 3.00
Peak outflow = 0.07 m³/s
Peak storage = 4.08E+04 m³

*** Special storage : Pond

	Hydrograph Outflow	Inflow
Peak discharge,m³/s	0.068	1.039
Time to peak,h	33.0	27.0
Volume,m³	3.09E+04	4.97E+04
Time to centroid,h	100.	27.
Lag (c.m. to c.m.),h	76.3	2.5
Lag to peak,h	8.78	2.78

Hydrograph summary
****

Site	Description
01	Special storage : Pond - Outflow
02	Special storage : Pond - Inflow

Inc	Time	Hyd0001	Hyd0002
1	3.00	0.0000	0.0000
2	6.00	0.0000	0.0000
3	9.00	0.0009	0.3053
4	12.00	0.0039	0.2996
5	15.00	0.0085	0.4304
6	18.00	0.0140	0.3121
7	21.00	0.0167	0.0576
8	24.00	0.0204	0.4056
9	27.00	0.0256	0.2048
10	30.00	0.0374	1.0388
11	33.00	0.0581	0.9306
12	36.00	0.0679	0.0161
13	39.00	0.0668	0.0336
14	42.00	0.0656	0.0000
15	45.00	0.0641	0.0000
16	48.00	0.0626	0.0000
17	51.00	0.0611	0.0000
18	54.00	0.0597	0.0000
19	57.00	0.0603	0.1730
20	60.00	0.0621	0.0979
21	63.00	0.0618	0.0000
22	66.00	0.0603	0.0000
23	69.00	0.0589	0.0000
24	72.00	0.0577	0.0103
25	75.00	0.0587	0.1934
26	78.00	0.0607	0.0943
27	81.00	0.0604	0.0000
28	84.00	0.0590	0.0000
29	87.00	0.0576	0.0000
30	90.00	0.0563	0.0000
31	93.00	0.0550	0.0000
32	96.00	0.0538	0.0000
33	99.00	0.0526	0.0000
34	102.00	0.0514	0.0000
35	105.00	0.0502	0.0000

36	108.00	0.0491	0.0000
37	111.00	0.0480	0.0000
38	114.00	0.0470	0.0000
39	117.00	0.0460	0.0000
40	120.00	0.0450	0.0000
41	123.00	0.0440	0.0000
42	126.00	0.0431	0.0000
43	129.00	0.0421	0.0000
44	132.00	0.0412	0.0000
45	135.00	0.0404	0.0000
46	138.00	0.0395	0.0000
47	141.00	0.0387	0.0000
48	144.00	0.0379	0.0000
49	147.00	0.0371	0.0000
50	150.00	0.0364	0.0000
51	153.00	0.0356	0.0000
52	156.00	0.0349	0.0000
53	159.00	0.0342	0.0000
54	162.00	0.0335	0.0000
55	165.00	0.0328	0.0000
56	168.00	0.0322	0.0000
57	171.00	0.0315	0.0000
58	174.00	0.0309	0.0000
59	177.00	0.0303	0.0000
60	180.00	0.0297	0.0000
61	183.00	0.0292	0.0000
62	186.00	0.0286	0.0000
63	189.00	0.0280	0.0000
64	192.00	0.0275	0.0000
65	195.00	0.0270	0.0000
66	198.00	0.0265	0.0000
67	201.00	0.0260	0.0000
68	204.00	0.0255	0.0000
69	207.00	0.0250	0.0000
70	210.00	0.0246	0.0000
71	213.00	0.0241	0.0000

RORBWin Output File
****

Program version 6.32 (last updated 3rd September 2017)
Copyright Monash University and Hydrology and Risk Consulting

Date run: 27 Jun 2018 13:02

Vector file   : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow Approval Documentation\Data\Storm Water\RORBWin\New Catchments\Area 4 Simulation\Area4.catg
Storm file   : \\SERVER\Talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow Approval Documentation\Data\Storm Water\RORBWin\New Catchments\Area 4 Simulation\Area4_dr16ari7.stm
Output information: Flows & all input data

Data checks:
****
Next data to be read & checked:

Catchment name & reach type flag
Control vector & storage data
Code no. 21   16.0
Sub-area areas
Impervious flag
Initial storm data
Rainfall burst times
Pluviograph 1
Sub-area rainfalls

Data check completed

Data:
****

Area4

Time data, in increments from initial time
Area4: 72 hour 1% Design Storm
Time increment (hours)= 3.00

	Start	Finish
Rainfall times:	0	24

End of hyeto/hydrographs: 24
Duration of calculations: 70

Pluviograph data (time in incs, rainfall in mm, in
increment following time shown)

1:Temporal pattern (% of depth

Time	1
0	8.9
1	9.9
2	4.5
3	9.8
4	3.5
5	4.8
6	6.6
7	4.8
8	18.3
9	10.9
10	2.7
11	0.6
12	0.7
13	0.0
14	0.0
15	0.0
16	0.4

17	5.2
18	0.7
19	0.0
20	0.0
21	0.1
22	2.3
23	5.3
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	3	Store hydrograph from step 2; reset hydrograph to zero
4	1	Add sub-area 'B' inflow & route thru normal storage 3
5	4	Add h-graph ex step 3 to h-graph ex step 4
6	5	Route hydrograph thru normal storage 4
7	3	Store hydrograph from step 6; reset hydrograph to zero
8	1	Add sub-area 'C' inflow & route thru normal storage 5
9	4	Add h-graph ex step 7 to h-graph ex step 8
10	5	Route hydrograph thru normal storage 6
11	3	Store hydrograph from step 10; reset hydrograph to zero
12	1	Add sub-area 'D' inflow & route thru normal storage 7
13	4	Add h-graph ex step 11 to h-graph ex step 12
14	5	Route hydrograph thru normal storage 8
15	3	Store hydrograph from step 14; reset hydrograph to zero
16	1	Add sub-area 'E' inflow & route thru normal storage 9
17	4	Add h-graph ex step 15 to h-graph ex step 16
18	3	Store hydrograph from step 17; reset hydrograph to zero
19	1	Add sub-area 'F' inflow & route thru normal storage 10
20	4	Add h-graph ex step 18 to h-graph ex step 19
21	16.0	Route thru existing storage, Pond
22	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	2.80E-02	6.98E-01
B	2.80E-02	5.36E-01
C	2.80E-02	3.74E-01
D	2.80E-02	2.12E-01
E	2.80E-02	1.00E-01
F	2.80E-02	5.00E-02

Total 1.680E-01

For whole catchment ; Av. Dist., km* = 0.33
For interstation area 1; Av. Dist., km* = 0.33; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	0.1	0.152	Natural	
2	0.2	0.265	Unlined	0.149
3	0.1	0.152	Natural	
4	0.2	0.265	Unlined	0.149
5	0.1	0.152	Natural	
6	0.2	0.265	Unlined	0.149
7	0.1	0.152	Natural	
8	0.2	0.265	Unlined	0.149
9	0.1	0.163	Unlined	0.149
10	0.1	0.152	Natural	

* or other function of reach properties related to travel time

Special storage data

Storage: Pond
Initial water level at cease to flow elevation
Storage-discharge reln.: Storage = 3600*0.829E+02*(disch)** 0.74 cub. m.
Elevation (m) - Storage (m³) table

Elevation (m)	Storage (m³)
0.50	5.017E+03
1.00	1.044E+04
1.50	1.601E+04
2.00	2.181E+04
2.50	2.784E+04
3.00	3.410E+04

Input of parameters:
****

Area4
DESIGN Run
Area4: 72 hour 1% Design Storm
Time increment = 3.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F
0	38.9	39	39	39	39	39	39
1	43.3	43	43	43	43	43	43
2	19.4	19	19	19	19	19	19
3	42.6	43	43	43	43	43	43
4	15.0	15	15	15	15	15	15
5	20.7	21	21	21	21	21	21
6	28.9	29	29	29	29	29	29
7	20.7	21	21	21	21	21	21
8	79.7	80	80	80	80	80	80
9	47.7	48	48	48	48	48	48
10	11.9	12	12	12	12	12	12
11	2.5	3	3	3	3	3	3
12	3.1	3	3	3	3	3	3
13	0.0	0	0	0	0	0	0
14	0.0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0
16	1.9	2	2	2	2	2	2
17	22.6	23	23	23	23	23	23
18	3.1	3	3	3	3	3	3
19	0.0	0	0	0	0	0	0
20	0.0	0	0	0	0	0	0
21	0.6	1	1	1	1	1	1
22	10.0	10	10	10	10	10	10
23	23.2	23	23	23	23	23	23
Tot.	436.0	436	436	436	436	436	436
Pluvi. ref. no.		1	1	1	1	1	1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F
0	0.0	0	0	0	0	0	0
1	14.2	14	14	14	14	14	14
2	1.4	1	1	1	1	1	1
3	24.6	25	25	25	25	25	25

4	0.0	0	0	0	0	0	0
5	2.7	3	3	3	3	3	3
6	10.9	11	11	11	11	11	11
7	2.7	3	3	3	3	3	3
8	61.7	62	62	62	62	62	62
9	29.7	30	30	30	30	30	30
10	0.0	0	0	0	0	0	0
11	0.0	0	0	0	0	0	0
12	0.0	0	0	0	0	0	0
13	0.0	0	0	0	0	0	0
14	0.0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0
16	0.0	0	0	0	0	0	0
17	4.6	5	5	5	5	5	5
18	0.0	0	0	0	0	0	0
19	0.0	0	0	0	0	0	0
20	0.0	0	0	0	0	0	0
21	0.0	0	0	0	0	0	0
22	0.0	0	0	0	0	0	0
23	5.2	5	5	5	5	5	5
Tot.	157.7	158	158	158	158	158	158

Routing results:
****
Area4
Area4: 72 hour 1% Design Storm
DESIGN run no. 1

Parameters: kc =   0.90   m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	50.00	6.00

Results of routing through special storage Pond
with ks = 0.8289E+02 & ms = 0.74
Peak elevation=   2.20 m
Peak outflow =   0.03 m³/s
Peak storage =   2.43E+04 m³

*** Special storage :   Pond

	Hydrograph Outflow	Inflow
Peak discharge,m³/s	0.0337	0.7423
Time to peak,h	36.0	30.0
Volume,m³	1.53E+04	2.74E+04
Time to centroid,h	103.	26.
Lag (c.m. to c.m.),h	79.7	2.6
Lag to peak,h	12.7	6.7

Hydrograph summary
****

Site	Description
01	Special storage : Pond - Outflow
02	Special storage : Pond - Inflow

Inc	Time	Hyd0001	Hyd0002
1	3.00	0.0000	0.0000
2	6.00	0.0000	0.0000
3	9.00	0.0003	0.1316
4	12.00	0.0012	0.1211
5	15.00	0.0029	0.2277
6	18.00	0.0052	0.1797
7	21.00	0.0064	0.0157
8	24.00	0.0072	0.1192
9	27.00	0.0086	0.1046
10	30.00	0.0142	0.6487
11	33.00	0.0261	0.7423

12	36.00	0.0335	0.0790
13	39.00	0.0337	0.0000
14	42.00	0.0330	0.0000
15	45.00	0.0323	0.0000
16	48.00	0.0317	0.0000
17	51.00	0.0311	0.0000
18	54.00	0.0305	0.0000
19	57.00	0.0302	0.0363
20	60.00	0.0303	0.0360
21	63.00	0.0301	0.0052
22	66.00	0.0296	0.0000
23	69.00	0.0290	0.0000
24	72.00	0.0285	0.0000
25	75.00	0.0283	0.0417
26	78.00	0.0286	0.0407
27	81.00	0.0285	0.0054
28	84.00	0.0280	0.0000
29	87.00	0.0275	0.0000
30	90.00	0.0269	0.0000
31	93.00	0.0264	0.0000
32	96.00	0.0259	0.0000
33	99.00	0.0254	0.0000
34	102.00	0.0250	0.0000
35	105.00	0.0245	0.0000
36	108.00	0.0241	0.0000
37	111.00	0.0236	0.0000
38	114.00	0.0232	0.0000
39	117.00	0.0228	0.0000
40	120.00	0.0224	0.0000
41	123.00	0.0220	0.0000
42	126.00	0.0216	0.0000
43	129.00	0.0212	0.0000
44	132.00	0.0208	0.0000
45	135.00	0.0204	0.0000
46	138.00	0.0201	0.0000
47	141.00	0.0197	0.0000
48	144.00	0.0194	0.0000
49	147.00	0.0190	0.0000
50	150.00	0.0187	0.0000
51	153.00	0.0184	0.0000
52	156.00	0.0181	0.0000
53	159.00	0.0178	0.0000
54	162.00	0.0175	0.0000
55	165.00	0.0172	0.0000
56	168.00	0.0169	0.0000
57	171.00	0.0166	0.0000
58	174.00	0.0163	0.0000
59	177.00	0.0160	0.0000
60	180.00	0.0158	0.0000
61	183.00	0.0155	0.0000
62	186.00	0.0153	0.0000
63	189.00	0.0150	0.0000
64	192.00	0.0148	0.0000
65	195.00	0.0145	0.0000
66	198.00	0.0143	0.0000
67	201.00	0.0141	0.0000
68	204.00	0.0138	0.0000
69	207.00	0.0136	0.0000
70	210.00	0.0134	0.0000
71	213.00	0.0132	0.0000

RORBWin Output File
****

Program version 6.32 (last updated 3rd September 2017)
Copyright Monash University and Hydrology and Risk Consulting

Date run: 28 Aug 2018 12:46

Vector file : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow Approval Documentation\Data\Surface Water\RORBWin\New Catchments\Area 4 Simulation\Area4-New2_Storage.catg
Storm file : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow Approval Documentation\Data\Surface Water\RORBWin\New Catchments\Area 4 Simulation\Area4-New2_Storage_dr16ari7.stm
Output information: Flows & all input data

Data checks:
****
Next data to be read & checked:

Catchment name & reach type flag
Control vector & storage data
Code no. 7 16.0
Sub-area areas
Impervious flag
Initial storm data
Rainfall burst times
Pluviograph 1
Sub-area rainfalls

Data check completed

Data:
****

Area4

Time data, in increments from initial time
Area4: 72 hour 1% Design Storm
Time increment (hours)= 3.00

	Start	Finish
Rainfall times:	0	24

End of hyeto/hydrographs: 24
Duration of calculations: 70

Pluviograph data (time in incs, rainfall in mm, in increment following time shown)

1:Temporal pattern (% of depth

Time	1
0	8.9
1	9.9
2	4.5
3	9.8
4	3.5
5	4.8
6	6.6
7	4.8
8	18.3
9	10.9
10	2.7
11	0.6
12	0.7
13	0.0
14	0.0
15	0.0
16	0.4

17	5.2
18	0.7
19	0.0
20	0.0
21	0.1
22	2.3
23	5.3
Total	100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	3	Store hydrograph from step 2; reset hydrograph to zero
4	1	Add sub-area 'B' inflow & route thru normal storage 3
5	5	Route hydrograph thru normal storage 4
6	4	Add h-graph ex step 3 to h-graph ex step 5
7	16.0	Route thru existing storage, Pond
8	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	1.61E-01	6.25E-01
B	2.90E-02	3.20E-01

Total 1.900E-01

For whole catchment ; Av. Dist., km* = 0.58
For interstation area 1; Av. Dist., km* = 0.58; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	0.1	0.190	Natural	
2	0.5	0.242	Lined	0.167
3	0.1	0.182	Natural	
4	0.2	0.018	Lined	6.772

* or other function of reach properties related to travel time

Special storage data

Storage: Pond
Initial water level at cease to flow elevation
Storage-discharge reln.: Storage = 3600*0.829E+02*(disch)** 0.74 cub. m.
Elevation (m) - Storage (m³) table

0.50	5.017E+03
1.00	1.044E+04
1.50	1.601E+04
2.00	2.181E+04
2.50	2.784E+04
3.00	3.410E+04

Input of parameters:
****

Area4
DESIGN Run

Area4: 72 hour 1% Design Storm
Time increment = 3.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catchment	Sub-Area A	Sub-Area B
0	38.9	39	39
1	43.3	43	43
2	19.4	19	19
3	42.6	43	43
4	15.0	15	15
5	20.7	21	21
6	28.9	29	29
7	20.7	21	21
8	79.7	80	80
9	47.7	48	48
10	11.9	12	12
11	2.5	3	3
12	3.1	3	3
13	0.0	0	0
14	0.0	0	0
15	0.0	0	0
16	1.9	2	2
17	22.6	23	23
18	3.1	3	3
19	0.0	0	0
20	0.0	0	0
21	0.6	1	1
22	10.0	10	10
23	23.2	23	23
Tot.	436.0	436	436
Pluvi. ref. no.		1	1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catchment	Sub-Area A	Sub-Area B
0	0.0	0	0
1	13.2	13	13
2	10.4	10	10
3	33.6	34	34
4	6.0	6	6
5	11.7	12	12
6	19.9	20	20
7	11.7	12	12
8	70.7	71	71
9	38.7	39	39
10	2.9	3	3
11	0.0	0	0
12	0.0	0	0
13	0.0	0	0
14	0.0	0	0
15	0.0	0	0
16	0.0	0	0
17	13.6	14	14
18	0.0	0	0
19	0.0	0	0
20	0.0	0	0
21	0.0	0	0
22	1.0	1	1
23	14.2	14	14
Tot.	247.7	248	248

Routing results:
****
Area4
Area4: 72 hour 1% Design Storm
DESIGN run no. 1

Parameters: kc = 0.90 m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	60.00	3.00

Results of routing through special storage Pond
with ks = 0.8289E+02 & ms = 0.74
Peak elevation exceeds max. of elev.-stor. table, 3.00
Peak outflow = 0.06 m³/s
Peak storage = 3.91E+04 m³

*** Special storage : Pond

	Hydrograph Outflow	Inflow
Peak discharge,m³/s	0.064	1.037
Time to peak,h	33.0	27.0
Volume,m³	2.95E+04	4.78E+04
Time to centroid,h	101.	28.
Lag (c.m. to c.m.),h	76.2	2.6
Lag to peak,h	7.99	1.99

Hydrograph summary
****

Site	Description
01	Special storage : Pond - Outflow
02	Special storage : Pond - Inflow

Inc	Time	Hyd0001	Hyd0002
1	3.00	0.0000	0.0000
2	6.00	0.0000	0.0000
3	9.00	0.0004	0.1682
4	12.00	0.0021	0.2355
5	15.00	0.0061	0.4714
6	18.00	0.0113	0.2850
7	21.00	0.0139	0.0735
8	24.00	0.0176	0.3974
9	27.00	0.0226	0.2091
10	30.00	0.0341	1.0372
11	33.00	0.0545	0.9307
12	36.00	0.0642	0.0171
13	39.00	0.0633	0.0320
14	42.00	0.0621	0.0000
15	45.00	0.0607	0.0000
16	48.00	0.0593	0.0000
17	51.00	0.0579	0.0000
18	54.00	0.0566	0.0000
19	57.00	0.0573	0.1730
20	60.00	0.0591	0.0979
21	63.00	0.0589	0.0000
22	66.00	0.0575	0.0000
23	69.00	0.0562	0.0000
24	72.00	0.0550	0.0103
25	75.00	0.0561	0.1934
26	78.00	0.0581	0.0943
27	81.00	0.0579	0.0000
28	84.00	0.0565	0.0000
29	87.00	0.0552	0.0000
30	90.00	0.0540	0.0000
31	93.00	0.0528	0.0000
32	96.00	0.0516	0.0000
33	99.00	0.0504	0.0000
34	102.00	0.0493	0.0000
35	105.00	0.0482	0.0000

36	108.00	0.0472	0.0000
37	111.00	0.0461	0.0000
38	114.00	0.0451	0.0000
39	117.00	0.0442	0.0000
40	120.00	0.0432	0.0000
41	123.00	0.0423	0.0000
42	126.00	0.0414	0.0000
43	129.00	0.0405	0.0000
44	132.00	0.0397	0.0000
45	135.00	0.0389	0.0000
46	138.00	0.0380	0.0000
47	141.00	0.0373	0.0000
48	144.00	0.0365	0.0000
49	147.00	0.0357	0.0000
50	150.00	0.0350	0.0000
51	153.00	0.0343	0.0000
52	156.00	0.0336	0.0000
53	159.00	0.0330	0.0000
54	162.00	0.0323	0.0000
55	165.00	0.0317	0.0000
56	168.00	0.0310	0.0000
57	171.00	0.0304	0.0000
58	174.00	0.0298	0.0000
59	177.00	0.0293	0.0000
60	180.00	0.0287	0.0000
61	183.00	0.0281	0.0000
62	186.00	0.0276	0.0000
63	189.00	0.0271	0.0000
64	192.00	0.0266	0.0000
65	195.00	0.0261	0.0000
66	198.00	0.0256	0.0000
67	201.00	0.0251	0.0000
68	204.00	0.0246	0.0000
69	207.00	0.0242	0.0000
70	210.00	0.0237	0.0000
71	213.00	0.0233	0.0000

```
RORBWin Output File
*******************

Program version 6.32 (last updated 3rd September 2017)
Copyright Monash University and Hydrology and Risk Consulting

Date run: 27 Jun 2018 12:36

Vector file       : \\server\talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow
Approval Documentation\Data\Storm Water\RORBWin\New Catchments\Area 4
Simulation\Area4.catg
Storm file        : \\SERVER\Talis\SECTIONS\Waste\PROJECTS\TW2018\TW18004 - Onslow
Approval Documentation\Data\Storm Water\RORBWin\New Catchments\Area 4
Simulation\Area4_dr16ari7.stm
Output information: Flows & all input data


Data checks:
************
Next data to be read & checked:

Catchment name & reach type flag
Control vector & storage data
Code no.  21    16.0
Sub-area areas
Impervious flag
Initial storm data
Rainfall burst times
Pluviograph 1
Sub-area rainfalls

Data check completed



Data:
****

Area4


Time data, in increments from initial time
Area4: 72 hour 1% Design Storm
Time increment (hours)=  3.00

                  Start   Finish
Rainfall times:     0       24


End of hyeto/hydrographs:   24
Duration of calculations:   70



Pluviograph data (time in incs, rainfall in mm, in
                  increment following time shown)

        1:Temporal pattern (% of depth
  Time     1
    0     8.9
    1     9.9
    2     4.5
    3     9.8
    4     3.5
    5     4.8
    6     6.6
    7     4.8
    8    18.3
    9    10.9
   10     2.7
   11     0.6
   12     0.7
   13     0.0
   14     0.0
   15     0.0
   16     0.4
```

17	5.2
18	0.7
19	0.0
20	0.0
21	0.1
22	2.3
23	5.3

Total 100.0

DESIGN run control vector

Step	Code	Description
1	1	Add sub-area 'A' inflow & route thru normal storage 1
2	5	Route hydrograph thru normal storage 2
3	3	Store hydrograph from step 2; reset hydrograph to zero
4	1	Add sub-area 'B' inflow & route thru normal storage 3
5	4	Add h-graph ex step 3 to h-graph ex step 4
6	5	Route hydrograph thru normal storage 4
7	3	Store hydrograph from step 6; reset hydrograph to zero
8	1	Add sub-area 'C' inflow & route thru normal storage 5
9	4	Add h-graph ex step 7 to h-graph ex step 8
10	5	Route hydrograph thru normal storage 6
11	3	Store hydrograph from step 10; reset hydrograph to zero
12	1	Add sub-area 'D' inflow & route thru normal storage 7
13	4	Add h-graph ex step 11 to h-graph ex step 12
14	5	Route hydrograph thru normal storage 8
15	3	Store hydrograph from step 14; reset hydrograph to zero
16	1	Add sub-area 'E' inflow & route thru normal storage 9
17	4	Add h-graph ex step 15 to h-graph ex step 16
18	3	Store hydrograph from step 17; reset hydrograph to zero
19	1	Add sub-area 'F' inflow & route thru normal storage 10
20	4	Add h-graph ex step 18 to h-graph ex step 19
21	16.0	Route thru existing storage, Pond
22	0	**********End of control vector**********

Sub-area data

Sub-area	Area km²	Dist. km*
A	2.80E-02	6.98E-01
B	2.80E-02	5.36E-01
C	2.80E-02	3.74E-01
D	2.80E-02	2.12E-01
E	2.80E-02	1.00E-01
F	2.80E-02	5.00E-02

Total 1.680E-01

For whole catchment ; Av. Dist., km* = 0.33
For interstation area 1; Av. Dist., km* = 0.33; ISA Factor = 1.000

* or other function of reach properties related to travel time

Normal storage data

Storage no.	Length km*	Rel. delay time	Type	Slope percent
1	0.1	0.152	Natural	
2	0.2	0.265	Unlined	0.149
3	0.1	0.152	Natural	
4	0.2	0.265	Unlined	0.149
5	0.1	0.152	Natural	
6	0.2	0.265	Unlined	0.149
7	0.1	0.152	Natural	
8	0.2	0.265	Unlined	0.149
9	0.1	0.163	Unlined	0.149
10	0.1	0.152	Natural	

* or other function of reach properties related to travel time

Special storage data

Storage: Pond
Initial water level at cease to flow elevation
Storage-discharge reln.: Storage = 3600*0.829E+02*(disch)** 0.74 cub. m.
Elevation (m) - Storage (m³) table

0.50	5.017E+03
1.00	1.044E+04
1.50	1.601E+04
2.00	2.181E+04
2.50	2.784E+04
3.00	3.410E+04

Input of parameters:
****

Area4
DESIGN Run
Area4: 72 hour 1% Design Storm
Time increment = 3.00 hours

Constant loss model selected

Rainfall, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F
0	38.9	39	39	39	39	39	39
1	43.3	43	43	43	43	43	43
2	19.4	19	19	19	19	19	19
3	42.6	43	43	43	43	43	43
4	15.0	15	15	15	15	15	15
5	20.7	21	21	21	21	21	21
6	28.9	29	29	29	29	29	29
7	20.7	21	21	21	21	21	21
8	79.7	80	80	80	80	80	80
9	47.7	48	48	48	48	48	48
10	11.9	12	12	12	12	12	12
11	2.5	3	3	3	3	3	3
12	3.1	3	3	3	3	3	3
13	0.0	0	0	0	0	0	0
14	0.0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0
16	1.9	2	2	2	2	2	2
17	22.6	23	23	23	23	23	23
18	3.1	3	3	3	3	3	3
19	0.0	0	0	0	0	0	0
20	0.0	0	0	0	0	0	0
21	0.6	1	1	1	1	1	1
22	10.0	10	10	10	10	10	10
23	23.2	23	23	23	23	23	23
Tot.	436.0	436	436	436	436	436	436
Pluvi. ref. no.		1	1	1	1	1	1

Rainfall-excess, mm, in time inc. following time shown

Time Incs	Catch ment	Sub-Area A	B	C	D	E	F
0	0.0	0	0	0	0	0	0
1	4.2	4	4	4	4	4	4
2	1.4	1	1	1	1	1	1
3	24.6	25	25	25	25	25	25

4	0.0	0	0	0	0	0	0
5	2.7	3	3	3	3	3	3
6	10.9	11	11	11	11	11	11
7	2.7	3	3	3	3	3	3
8	61.7	62	62	62	62	62	62
9	29.7	30	30	30	30	30	30
10	0.0	0	0	0	0	0	0
11	0.0	0	0	0	0	0	0
12	0.0	0	0	0	0	0	0
13	0.0	0	0	0	0	0	0
14	0.0	0	0	0	0	0	0
15	0.0	0	0	0	0	0	0
16	0.0	0	0	0	0	0	0
17	4.6	5	5	5	5	5	5
18	0.0	0	0	0	0	0	0
19	0.0	0	0	0	0	0	0
20	0.0	0	0	0	0	0	0
21	0.0	0	0	0	0	0	0
22	0.0	0	0	0	0	0	0
23	5.2	5	5	5	5	5	5
Tot.	147.7	148	148	148	148	148	148

Routing results:
****
Area4
Area4: 72 hour 1% Design Storm
DESIGN run no. 1

Parameters: kc =   0.90   m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	60.00	6.00

Results of routing through special storage Pond
with ks = 0.8289E+02 & ms = 0.74
Peak elevation=   2.08 m
Peak outflow =   0.03 m³/s
Peak storage =   2.27E+04 m³

*** Special storage :   Pond

	Hydrograph Outflow	Inflow
Peak discharge,m³/s	0.0308	0.7423
Time to peak,h	36.0	30.0
Volume,m³	1.41E+04	2.56E+04
Time to centroid,h	104.	27.
Lag (c.m. to c.m.),h	79.4	2.7
Lag to peak,h	11.4	5.4

Hydrograph summary
****

Site	Description
01	Special storage : Pond - Outflow
02	Special storage : Pond - Inflow

Inc	Time	Hyd0001	Hyd0002
1	3.00	0.0000	0.0000
2	6.00	0.0000	0.0000
3	9.00	0.0000	0.0333
4	12.00	0.0002	0.0463
5	15.00	0.0013	0.2494
6	18.00	0.0034	0.1744
7	21.00	0.0044	0.0075
8	24.00	0.0051	0.1219
9	27.00	0.0065	0.1035
10	30.00	0.0118	0.6490
11	33.00	0.0233	0.7423

12	36.00	0.0306	0.0788
13	39.00	0.0308	0.0000
14	42.00	0.0302	0.0000
15	45.00	0.0296	0.0000
16	48.00	0.0290	0.0000
17	51.00	0.0285	0.0000
18	54.00	0.0279	0.0000
19	57.00	0.0277	0.0363
20	60.00	0.0279	0.0360
21	63.00	0.0278	0.0052
22	66.00	0.0273	0.0000
23	69.00	0.0268	0.0000
24	72.00	0.0263	0.0000
25	75.00	0.0262	0.0417
26	78.00	0.0265	0.0407
27	81.00	0.0264	0.0054
28	84.00	0.0260	0.0000
29	87.00	0.0255	0.0000
30	90.00	0.0250	0.0000
31	93.00	0.0245	0.0000
32	96.00	0.0241	0.0000
33	99.00	0.0236	0.0000
34	102.00	0.0232	0.0000
35	105.00	0.0228	0.0000
36	108.00	0.0224	0.0000
37	111.00	0.0220	0.0000
38	114.00	0.0216	0.0000
39	117.00	0.0212	0.0000
40	120.00	0.0208	0.0000
41	123.00	0.0204	0.0000
42	126.00	0.0201	0.0000
43	129.00	0.0197	0.0000
44	132.00	0.0194	0.0000
45	135.00	0.0191	0.0000
46	138.00	0.0187	0.0000
47	141.00	0.0184	0.0000
48	144.00	0.0181	0.0000
49	147.00	0.0178	0.0000
50	150.00	0.0175	0.0000
51	153.00	0.0172	0.0000
52	156.00	0.0169	0.0000
53	159.00	0.0166	0.0000
54	162.00	0.0163	0.0000
55	165.00	0.0161	0.0000
56	168.00	0.0158	0.0000
57	171.00	0.0155	0.0000
58	174.00	0.0153	0.0000
59	177.00	0.0150	0.0000
60	180.00	0.0148	0.0000
61	183.00	0.0146	0.0000
62	186.00	0.0143	0.0000
63	189.00	0.0141	0.0000
64	192.00	0.0139	0.0000
65	195.00	0.0136	0.0000
66	198.00	0.0134	0.0000
67	201.00	0.0132	0.0000
68	204.00	0.0130	0.0000
69	207.00	0.0128	0.0000
70	210.00	0.0126	0.0000
71	213.00	0.0124	0.0000

Appendix C: Surface Water Drainage and Pond System Design Calculations

Note:	(yellow)	*Fill in yellow fields*
	(orange)	*= Final values*

Intensity-Frequency-Duration Data

Location	Onslow Road Landfill, Onslow	
Co-ordinates	South	-21.6540
https://www.google.com.au/maps	East	115.1350

Annual Exceedance Probability
http://www.bom.gov.au/water/designRainfalls/revised-ifd/?ye

		Rainfall (mm)										
Duration		63%	50%	20%	10%	5%	2%	1%	0.5%	0.2%	0.1%	0.05%
	0.5	1:1	1:2	1:5	1:10	1:20	1:50	1:100	1:200	1:500	1:1000	1:2000
1 min	0.017	1.67	1.98	2.97	3.67	4.36	5.29	6.02				
2 min	0.033	2.74	3.25	4.82	5.89	6.93	8.44	9.67				
3 min	0.050	3.88	4.6	6.85	8.4	9.92	12.1	13.8				
4 min	0.067	4.97	5.89	8.81	10.8	12.8	15.6	17.8				
5 min	0.083	5.99	7.1	10.6	13.1	15.5	18.9	21.6				
10 min	0.167	10.1	11.9	17.9	22.1	26.3	31.9	36.2				
15 min	0.25	13	15.3	23	28.4	33.7	40.9	46.4				
30 min	0.5	18.4	21.8	32.7	40.2	47.7	57.9	65.7				
1 hour	1	24.3	28.8	43.4	53.5	63.6	77.4	88.3				
2 hour	2	30.7	36.8	56.3	70	83.8	103	118				
3 hour	3	35	42.2	65.6	82.3	99.2	123	142				
6 hour	6	43.7	53.5	85.9	110	134	169	197				
12 hour	12	54.6	67.8	113	146	182	231	272				
24 hour	24	67	84.2	143	188	235	301	355	426	515	589	670
48 hour	48	78.8	99.5	170	222	278	355	419	493	592	675	764
72 hour	72	84.2	106	180	234	291	370	436	509	609	692	782
96 hour	96	86.9	110	185	239	295	374	440	515	616	699	788
120 hour	120	88.5	112	187	241	296	375	441	520	622	705	795
144 hour	144	89.3	113	188	242	297	375	441	526	629	713	804
168 hour	168	89.9	113	189	243	298	376	442	533	637	723	816

	Intensity (mm/hr)										
Duration	63%	50%	20%	10%	5%	2%	1%	0.5%	0.2%	0.1%	0.05%
	1:1	1:2	1:5	1:10	1:20	1:50	1:100	1:200	1:500	1:1000	1:2000
1 min	100	119	178	219	260	316	360				
2 min	82.4	97.2	144	176	207	254	294				
3 min	77.8	92	137	168	198	243	279				
4 min	74.8	88.4	132	162	192	235	270				
5 min	72	85.2	127	157	186	227	260				
10 min	60.4	71.5	107	132	157	191	217				
15 min	51.9	61.3	91.8	113	135	163	185				
30 min	36.9	43.7	65.2	80.3	95.4	116	131				
1 hour	24.4	29	43.5	53.6	63.7	77.8	88.9				
2 hour	15.6	18.6	28.4	35.3	42.3	52.1	60				
3 hour	11.9	14.3	22.2	27.8	33.5	41.6	48.2				
6 hour	7.5	9.16	14.7	18.7	23	28.8	33.5				
12 hour	4.71	5.83	9.68	12.6	15.6	19.8	23.2				
24 hour	2.89	3.62	6.15	8.06	10.1	12.9	15.2	17.7	21.4	24.5	27.9
48 hour	1.69	2.13	3.62	4.74	5.92	7.57	8.96	10.3	12.3	14.1	15.9
72 hour	1.19	1.51	2.55	3.31	4.11	5.25	6.23	7.06	8.46	9.61	10.9
96 hour	0.923	1.16	1.95	2.53	3.11	3.97	4.73	5.37	6.41	7.28	8.21
120 hour	0.751	0.944	1.58	2.03	2.5	3.18	3.79	4.34	5.18	5.88	6.62
144 hour	0.632	0.795	1.33	1.7	2.09	2.65	3.16	3.65	4.37	4.95	5.59
168 hour	0.547	0.687	1.14	1.47	1.8	2.28	2.72	3.17	3.79	4.31	4.86

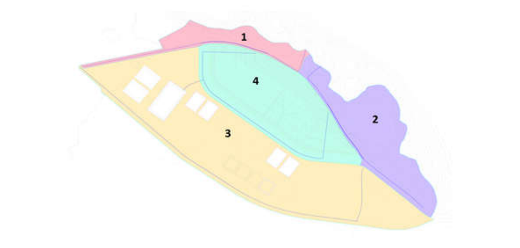
AR&R87 IFDs
http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtm
(Coefficients Tab)
OBSOLETE

ARI in years	Coefficient A	Coefficient B	Coefficient C	Coefficient D	Coefficient E	Coefficient F	Coefficient G
1	3.11E+00	-6.66E-01	-7.89E-02	9.57E-03	4.33E-03	-4.95E-04	-8.02E-05
2	3.42E+00	-6.57E-01	-7.59E-02	1.04E-02	3.90E-03	-6.02E-04	-4.97E-05
5	3.83E+00	-6.25E-01	-6.73E-02	1.02E-02	3.05E-03	-6.28E-04	-1.98E-05
10	4.03E+00	-6.08E-01	-6.29E-02	1.02E-02	2.66E-03	-6.36E-04	-8.81E-06
20	4.23E+00	-5.95E-01	-5.88E-02	1.04E-02	2.20E-03	-6.75E-04	1.16E-05
50	4.47E+00	-5.80E-01	-5.48E-02	1.02E-02	1.83E-03	-6.79E-04	2.27E-05
100	4.62E+00	-5.69E-01	-5.18E-02	1.02E-02	1.53E-03	-6.90E-04	3.32E-05

1. Pond Design Inputs

			Unit	Description
Area 1		59370	m^2	**1 - North Catchment**
Runoff Coefficient 1 =	Sandy Soil, Flat, 5 - 10%	0.4		
Area 2		132620	m^2	**2 - North-West Catchment**
Runoff Coefficient 2 =	Sandy Soil, Flat, 5 - 10%	0.4		
Area 3		359200	m^2	**3 - South-West Catchment**
Runoff Coefficient 3 =	Sandy Soil, Flat, 5 - 10%	0.4		
Area 4		190200	m^2	**4 - Landfill Catchment**
Runoff Coefficient 4 =	Sandy Soil, Flat, 5 - 10%	0.4		
Composite Runoff Coefficient, C		**0.40**		

Catchment Locations



**Source for Design Input data from AutoCAD Drawing

2. Swale Design Inputs

Equations (reference below)
http://onlinemanuals.txdot.gov/txdotmanuals/hyd/

2.1 Swale #1: Area 1 (Northern)

		Value	Unit	
Overland Flow (over waste mass)				
Flow Length		100.00	m	
ΔRL		7.46	mAHD	
Slope		0.075	m/m	**Slope = ΔRL/ΔFlow Length**
Kerby's Roughness Facto	Smooth bare soil	0.10		
Time of concentration, **Tc-o**		7.77	min	**Tc-o = K*((L*N)^0.467)*(S^-0.235)**
Channel Flow (through swale) A				K=constant; =1.44 for SI
Flow Length		150.00	m	L=flow length (m)
ΔRL		1.32	mAHD	N=Kerby's roughness
Slope		0.009	m/m	
Time of concentration, **Tc-ch**		5.71	min	**Tc-ch = K*(L^0.770)*(S^-0.385)**
Manning's, **n =**	Earth channel - clean	0.022		K=constant; =0.0195 for SI
Channel Flow (through swale) B - Steep				L=flow length (m)
Flow Length		290.00	m	S=slope (m/m)
ΔRL		15.42	mAHD	
Slope		0.053	m/m	
Time of concentration, **Tc-ch**		4.75	min	**Tc-ch = K*(L^0.770)*(S^-0.385)**
Manning's, **n =**	Earth channel - stony, cobbles	0.035		K=constant; =0.0195 for SI
Channel Flow (through swale) C				L=flow length (m)
Flow Length		510.00	m	S=slope (m/m)
ΔRL		0.88	mAHD	
Slope		0.002	m/m	
Time of concentration, **Tc-ch**		27.46	min	**Tc-ch = K*(L^0.770)*(S^-0.385)**
Manning's, **n =**	Earth channel - clean	0.022		K=constant; =0.0195 for SI
Total Flow Time, Tc (min)		**45.69**	min	L=flow length (m)
				S=slope (m/m)

2.2 Swale #2: Area 2 (Eastern)

		Value	Unit	
Overland Flow (over waste mass)				
Flow Length		75.00	m	
ΔRL		8.59	mAHD	
Slope		0.115		**Slope = ΔRL/ΔFlow Length**
Kerby's Roughness Facto	Smooth bare soil	0.10		
Overland Flow, **Tc-o**		6.14	min	**Tc-o = K*((L*N)^0.467)*(S^-0.235)**
Channel Flow (through swale) A				K=constant; =1.44 for SI
Flow Length		140.00	m	L=flow length (m)
ΔRL		2.43	mAHD	N=Kerby's roughness
Slope		0.017		
Concentrated Flow, **Tc-c**		4.17	min	**Tc-ch = K*(L^0.770)*(S^-0.385)**
Manning's, **n =**	Earth channel - clean	0.022		K=constant; =0.0195 for SI
Channel Flow (through swale) B - Steep				L=flow length (m)
Flow Length		295.00	m	S=slope (m/m)
ΔRL		11.60	mAHD	
Slope		0.039		
Concentrated Flow, **Tc-c**		5.41	min	**Tc-ch = K*(L^0.770)*(S^-0.385)**
Manning's, **n =**	Earth channel - stony, cobbles	0.035		K=constant; =0.0195 for SI
Channel Flow (through swale) B - Steep				L=flow length (m)
Flow Length		335.00	m	S=slope (m/m)
ΔRL		0.59	mAHD	
Slope		0.002		
Concentrated Flow, **Tc-c**		19.71	min	**Tc-ch = K*(L^0.770)*(S^-0.385)**
Manning's, **n =**	Earth channel - clean	0.022		K=constant; =0.0195 for SI
Total Flow Time, Tc (min)		**35.43**	min	L=flow length (m)
				S=slope (m/m)

2.3 Swale #3: Area 3 (Southern)

		Value	Unit	
Overland Flow (over waste mass)				
Flow Length		250.00	m	
ΔRL		1.18	mAHD	
Slope		0.005		**Slope = ΔRL/ΔFlow Length**
Kerby's Roughness Facto	Smooth bare soil	0.10		
Overland Flow, **Tc-o**		22.79	min	**Tc-o = K*((L*N)^0.467)*(S^-0.235)**
Channel Flow (through swale)				K=constant; =1.44 for SI
Flow Length		1390.00	m	L=flow length (m)
ΔRL		1.88	mAHD	N=Kerby's roughness
Slope		0.001		
Concentrated Flow, **Tc-c**		65.26	min	**Tc-ch = K*(L^0.770)*(S^-0.385)**
Manning's, **n =**	Earth channel - clean	0.022		K=constant; =0.0195 for SI
Total Flow Time, Tc (min)		**88.1**	min	L=flow length (m)
				S=slope (m/m)

2.4 Swale #4: Area 4 (Landfill)

		Value	Unit	
Overland Flow (over waste mass)				
Flow Length		210.00	m	
ΔRL		14.56	mAHD	
Slope		0.069		**Slope = ΔRL/ΔFlow Length**
Kerby's Roughness Facto	Poor grass/rough bare soil	0.20		
Overland Flow, **Tc-o**		15.45	min	**Tc-o = K*((L*N)^0.467)*(S^-0.235)**
Channel Flow (through swale)				K=constant; =1.44 for SI
Flow Length		730.00	m	L=flow length (m)
ΔRL		1.22	mAHD	N=Kerby's roughness
Slope		0.002		
Concentrated Flow, **Tc-c**		36.64	min	**Tc-ch = K*(L^0.770)*(S^-0.385)**
Manning's, **n =**	Plastic	0.009		K=constant; =0.0195 for SI
Total Flow Time, Tc (min)		**52.1**	min	L=flow length (m)
				S=slope (m/m)

Scenario 1 = 1:100 Year 72 hour Storm

Rainfall Data	
Design Period	1:100
Storm Duration (hrs):	72 hour
Total Rainfall (mm)	436.0

Volume per Catchment

1 - North Catchment		2 - North-West Catchment		3 - South-West Catchment		4 - Landfill Catchment	
Catchment Area (m²):	59370	Catchment Area (m²):	132620	Catchment Area (m²):	359200	Catchment Area (m²):	190200
Runoff Coefficient, **C**:	0.400	Runoff Coefficient, **C**:	0.400	Runoff Coefficient, **C**:	0.400	Runoff Coefficient, **C**:	0.400
Rainfall (mm)	436.0	Rainfall (mm)	436.0	Rainfall (mm)	436.0	Rainfall (mm)	436.0
Storage Requirement (m³)	**10,354**	**Storage Requirement (m³)**	**23,129**	**Storage Requirement (m³)**	**62,644**	**Storage Requirement (m³)**	**33,171**
						Total Storage Required (m^3)	**33,171**
						Design Volume (m^3)	45,842
						Difference (m^3)	12,671

Design Operational Volumes
Main attenuation pond = 34,620m3
Evaporation pond #1 = 5,611m3
Evaporation pond #2 = 5,611m3
Total = 45,842m3

Scenario 2 = 1:100 Year 24 hour Storm

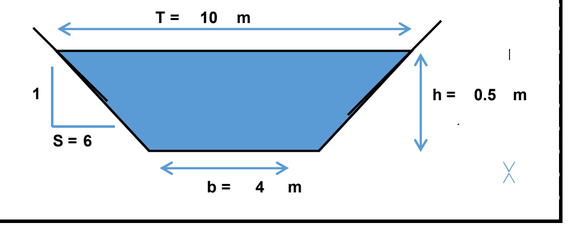
Rainfall	
Design Period	1:100
Storm Duration (hrs):	24 hour
Rainfall (mm)	355.0

Volume per Catchment

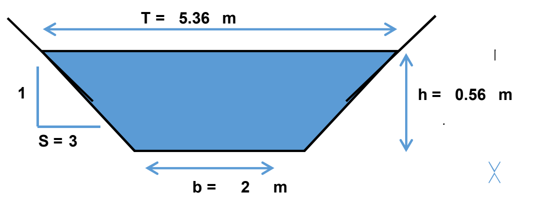
1 - North Catchment		2 - North-West Catchment		3 - South-West Catchment		4 - Landfill Catchment	
Catchment Area (m²):	59370	Catchment Area (m²):	132620	Catchment Area (m²):	359200	Catchment Area (m²):	190200
Runoff Coefficient, **C**:	0.400	Runoff Coefficient, **C**:	0.400	Runoff Coefficient, **C**:	0.400	Runoff Coefficient, **C**:	0.400
Rainfall (mm)	355.0	Rainfall (mm)	355.0	Rainfall (mm)	355.0	Rainfall (mm)	355.0
Storage Requirement (m³)	**8,431**	**Storage Requirement (m³)**	**18,832**	**Storage Requirement (m³)**	**51,006**	**Storage Requirement (m³)**	**27,008**
						Total Storage Required (m^3)	**27,008**
						Design Volume (m^3)	45,842
						Difference (m^3)	18,834

talis
delivering solutions

2.1 Swale #1: Area 1 (Northern)		Comments	Equations (references below)			
			http://onlinemanuals.txdot.gov/txdotmanuals/hyd/rational_method.htm			(1)
			http://www.bom.gov.au/water/designRainfalls/ifd/howtoIFDTool.shtml			(2)
Rainfall Data			http://www.ce.utexas.edu/prof/maidment/CE365KSpr14/Visual/OpenChannels.pdf			(3)
Design Period (yrs):	100		http://www.efm.leeds.ac.uk/CIVE/CIVE2400/OpenChannelHydraulics2.pdf			(4)
Total Concentration Time, **Tc** (min)	45.69					
1	26.7		**ln(I) = A+B(ln(Tc))+C(ln(Tc))^2+D(ln(Tc))^3+E(ln(Tc))^4+F(ln(Tc))^5+G(ln(Tc))^6**			(2)
2	36.3		I = intensity (mm/hr)			
5	54.1		Tc = total time concentration (hr)			
10	65.9		A through G = ARI coefficients (from table at top of spreadsheet)			
20	80.8					
50	101.7					
100	118.5		2813.55411			
Intensity for Tc (mm/h)	118.5					
Peak Flow Rate (m^3/h)	**2813.55**		**Q = ((C*I*(A/10000))/360)*3600 for m3/hr**			(1)
			C=runoff coefficient			
Swale Geometry			I=rainfall intensity (mm/hr)			
Depth of Flow, **h** (m)	0.5		A=area(m2)			
Bottom width, **b** (m)	4					
Side slope, **S** (m)	6					
Top width, **T** (m)	10		**T = b + (2*S*h)**			(3) pg2
Swale Area, **As** (m^2)	3.5		**As = (b+S*h)*h**			(3)
Wetted Perimeter, **Pw** (m)	10.08		**Pw = b + 2*h*sqrt(1+S^2)**			(3)
Hydraulic Radius, **Rh** (m)	0.347		**Rh = As/Pw**			(3)
Hydraulic Depth, **Dh** (m)	0.350		**Dh = As/T**			(3)
Slope A						
Flow Length (m)	150.00					
Total Fall (m)	1.32					
Slope of Swale, **Ss**	0.009		**Slope = ΔRL/ΔFlow Length**			
Slope B - Steep						
Flow Length (m)	290.00					
Total Fall (m)	15.42					
Slope of Swale, **Ss**	0.05		**Slope = ΔRL/ΔFlow Length**			
Slope C						
Flow Length (m)	510.00					
Total Fall (m)	0.88					
Slope of Swale, **Ss**	0.0017		**Slope = ΔRL/ΔFlow Length**			
Channel Flow						
A: Manning's coefficient, **n**	0.022					
A: Maximum Velocity, **V** (m/s)	2.11		**V = (1/n)*(Rh^(2/3))*(Ss^1/2)**	7.37		(3)
B - Steep: Manning's coefficient, **n**	0.035					
B - Steep: Maximum Velocity, **V** (m/s)	3.25		**V = (1/n)*(Rh^(2/3))*(Ss^1/2)**	11.39		(3)
C: Manning's coefficient, **n**	0.022					
C: Maximum Velocity, **V** (m/s)	0.93		**V = (1/n)*(Rh^(2/3))*(Ss^1/2)**	3.26		(3)
Maximum Flow, **Q** (m^3/s)	3.26		**Q = V*As**	22.02	17.62	(3)
Maximum Flow, Q (m^3/h)	**11751**	**Pass**				
Froude Number, Fr	**1.14**	Supercritical	**Fr = V/sqrt(g*Dh)**, where g = gravitational force; = 9.81 m/s2			(3)
Reynolds Number, Re (channel)	**409,111**	Turbulent	**Re = V*(As/Pw)*(1/v) = V*Rh*(1/v)**, where v is kinematic viscosity (m2/s); = 1.787*10^-6 @ 0°C			(4) pg15

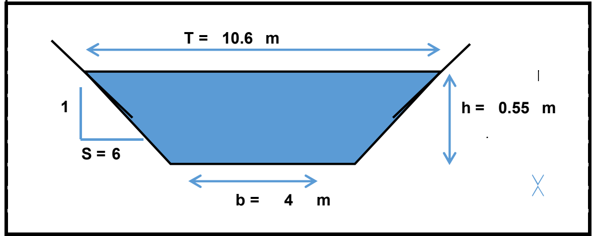


2.2 Swale #2: Area 2 (Eastern)		Comments	Equations (references below)	
			http://onlinemanuals.txdot.gov/txdotmanuals/hyd/rational_method.htm	(1)
			http://www.bom.gov.au/water/designRainfalls/ifd/howtoIFDTool.shtml	(2)
Rainfall Data			http://www.ce.utexas.edu/prof/maidment/CE365KSpr14/Visual/OpenChannels.pdf	(3)
Design Period (yrs):	100		http://www.efm.leeds.ac.uk/CIVE/CIVE2400/OpenChannelHydraulics2.pdf	(4)
Total Concentration Time, **Tc** (min)	35.43			
Intensity for Tc (mm/h)	135.3			
Peak Flow Rate (m^3/h)	**7,180**		**Q = ((C*I*(A/10000))/360)*3600 for m3/hr** C=runoff coefficient I=rainfall intensity (mm/hr) A=area(m2)	(1)
Swale Geometry				
Depth of Flow, **h** (m)	0.56			
Bottom width, **b** (m)	2			
Side slope, **S** (m)	3			
Top width, **T** (m)	5.36		**T = b + (2*S*h)**	(3) pg2
Swale Area, **As** (m^2)	2.0608		**As = (b+S*h)*h**	(3)
Wetted Perimeter, **Pw** (m)	5.54		**Pw = b + 2*h*sqrt(1+S^2)**	(3)
Hydraulic Radius, **Rh** (m)	0.372		**Rh = As/Pw**	(3)
Hydraulic Depth, **Dh** (m)	0.384		**Dh = As/T**	(3)
Slope A				
Flow Length (m)	140.00			
Total Fall (m)	2.43			
Slope of Swale, **Ss**	0.017		**Slope = ΔRL/ΔFlow Length**	
Slope B - Steep				
Flow Length (m)	295.00			
Total Fall (m)	11.60			
Slope of Swale, **Ss**	0.039		**Slope = ΔRL/ΔFlow Length**	
Slope C				
Flow Length (m)	335.00			
Total Fall (m)	0.59			
Slope of Swale, **Ss**	0.002		**Slope = ΔRL/ΔFlow Length**	
Flow				
A: Manning's coefficient, **n**	0.022			
A: Maximum Velocity, **V** (m/s)	3.10		**V = (1/n)*(Rh^(2/3))*(Ss^1/2)**	(3)
B - Steep: Manning's coefficient, **n**	0.035			
B - Steep: Maximum Velocity, **V** (m/s)	2.93		**V = (1/n)*(Rh^(2/3))*(Ss^1/2)**	(3)
C: Manning's coefficient, **n**	0.022			
C: Maximum Velocity, **V** (m/s)	0.99		**V = (1/n)*(Rh^(2/3))*(Ss^1/2)**	(3)
Maximum Flow, **Q** (m^3/s)	2.03		**Q = V*As**	(3)
Maximum Flow, Q (m^3/h)	**7,318**	**Pass**		
Froude Number, Fr	**1.51**	Supercritical	**Fr = V/sqrt(g*Dh)**, where g = gravitational force; = 9.81 m/s2	(3)
Reynolds Number, Re (channel)	**609,687**	Turbulent	**Re = V*(As/Pw)*(1/v) = V*Rh*(1/v)**, where v is kinematic viscosity (m2/s); = 1.787*10^-6 @ 0°C	(4) pg15



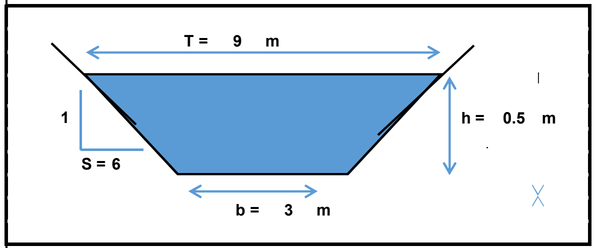
talis
delivering solutions

2.3 Swale #3: Area 3 (Southern)		Comments	Equations (references below)	
			http://onlinemanuals.txdot.gov/txdotmanuals/hyd/rational_method.htm	(1)
			http://www.bom.gov.au/water/designRainfalls/ifd/howtoIFDTool.shtml	(2)
Rainfall Data			http://www.ce.utexas.edu/prof/maidment/CE365KSpr14/Visual/OpenChannels.pdf	(3)
Design Period (yrs):	100		http://www.efm.leeds.ac.uk/CIVE/CIVE2400/OpenChannelHydraulics2.pdf	(4)
Total Concentration Time, **Tc** (min)	88.06			
Intensity for Tc (mm/h)	81.3			
Peak Flow Rate (m^3/h)	**11,681**		**Q = ((C*I*(A/10000))/360)*3600 for m3/hr**	(1)
			C=runoff coefficient	
Swale Geometry			I=rainfall intensity (mm/hr)	
Depth of Flow, **h** (m)	0.55		A=area(m2)	
Bottom width, **b** (m)	4			
Side slope, **S** (m)	6			
Top width, **T** (m)	10.6		**T = b + (2*S*h)**	(3) pg2
Swale Area, **As** (m^2)	4.015		**As = (b+S*h)*h**	(3)
Wetted Perimeter, **Pw** (m)	10.69		**Pw = b + 2*h*sqrt(1+S^2)**	(3)
Hydraulic Radius, **Rh** (m)	0.376		**Rh = As/Pw**	(3)
Hydraulic Depth, **Dh** (m)	0.379		**Dh = As/T**	(3)
Slope				
Flow Length (m)	1390.00			
Total Fall (m)	1.88			
Slope of Swale, **Ss**	0.001		**Slope = ΔRL/ΔFlow Length**	
Flow				
Manning's coefficient, **n**	0.022			
Maximum Velocity, **V** (m/s)	0.87		**V = (1/n)*(Rh^(2/3))*(Ss^1/2)**	(3)
Maximum Flow, **Q** (m^3/s)	3.49		**Q = V*As**	(3)
Maximum Flow, Q (m^3/h)	**12,577**	**Pass**		
Froude Number, Fr	**0.45**	**Subcritical**	**Fr = V/sqrt(g*Dh)**, where g = gravitational force; = 9.81 m/s2	(3)
Reynolds Number, Re (channel)	**182,866**	**Turbulent**	**Re = V*(As/Pw)*(1/v) = V*Rh*(1/v)**, where v is kinematic viscosity (m2/s); = 1.787*10^-6 @ 0°C	(4) pg15



talis
delivering solutions

2.4 Swale #4: Area 4 (Landfill)		Comments	Equations (references below)	
			http://onlinemanuals.txdot.gov/txdotmanuals/hyd/rational_method.htm	(1)
			http://www.bom.gov.au/water/designRainfalls/ifd/howtoIFDTool.shtml	(2)
Rainfall Data			http://www.ce.utexas.edu/prof/maidment/CE365KSpr14/Visual/OpenChannels.pdf	(3)
Design Period (yrs):	100		http://www.efm.leeds.ac.uk/CIVE/CIVE2400/OpenChannelHydraulics2.pdf	(4)
Total Concentration Time, **Tc** (min)	52.08			
Intensity for Tc (mm/h)	110.3			
Peak Flow Rate (m^3/h)	**8,391**		**Q = ((C*I*(A/10000))/360)*3600 for m3/hr**	(1)
			C=runoff coefficient	
Swale Geometry			I=rainfall intensity (mm/hr)	
Depth of Flow, **h** (m)	0.5		A=area(m2)	
Bottom width, **b** (m)	3			
Side slope, **S** (m)	6			
Top width, **T** (m)	9		**T = b + (2*S*h)**	(3) pg2
Swale Area, **As** (m^2)	3		**As = (b+S*h)*h**	(3)
Wetted Perimeter, **Pw** (m)	9.08		**Pw = b + 2*h*sqrt(1+S^2)**	(3)
Hydraulic Radius, **Rh** (m)	0.330		**Rh = As/Pw**	(3)
Hydraulic Depth, **Dh** (m)	0.333		**Dh = As/T**	(3)
Slope				
Flow Length (m)	730.00			
Total Fall (m)	1.22			
Slope of Swale, **Ss**	0.002		**Slope = ΔRL/ΔFlow Length**	
Flow				
Manning's coefficient, **n**	0.009			
Maximum Velocity, **V** (m/s)	2.17		**V = (1/n)*(Rh^(2/3))*(Ss^1/2)**	(3)
Maximum Flow, **Q** (m^3/s)	6.51		**Q = V*As**	(3)
Maximum Flow, Q (m^3/h)	**23,441**	**Pass**		
Froude Number, Fr	**1.20**	Supercritical	**Fr = V/sqrt(g*Dh)**, where g = gravitational force; = 9.81 m/s2	(3)
Reynolds Number, Re (channel)	**401,166**	Turbulent	**Re = V*(As/Pw)*(1/v) = V*Rh*(1/v)**, where v is kinematic viscosity (m2/s); = 1.787*10^-6 @ 0°C	(4) pg15



Appendix D: Culvert and Rock Armouring Design Calculations

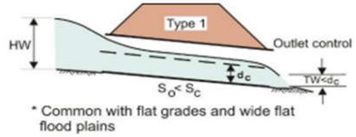
Pilbara Regional Waste Management Facility
Shire of Ashburton

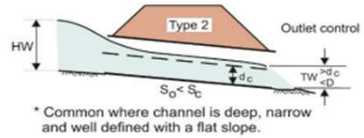
Culvert Design Calculations

Parameter	Intersection Point #1		Intersection Point #2		Intersection Point #3		Comments
	Value	Units	Value	Units	Value	Units	
Maximum Inlet Flow Rate, Qi =	2.03	m3/s	6.51	m3/s	3.26	m3/s	
Maximum Outlet Flow Rate, Qo =	3.5	m3/s	6.51	m3/s	3.26	m3/s	
Rainfall Event, ARI =	100	years	100	years	100	years	
Tail Water, TW =	0.5	m	0.5	m	0.5	m	Height of the water designed for the swales
Box culvert width, B =	4.8	m	9.6	m	4.8	m	
Box culvert Height, D =	0.9	m	0.9	m	0.9	m	
Box Culvert crossectional area, A =	4.32	m2	8.64	m2	4.32	m2	
Length, L =	20	m	12	m	5	m	
Slope, So =	0.0117		0.0022		0.0000		
Ratio Qi/B =	0.42		0.68		0.68		
Allowable Head water, AHW =	0.8	m	0.8	m	0.8	m	
HW/D =	0.44	m	0.6	m	0.6	m	Appendix B, Figure B1, pg 146 Austroads
Hwi =	0.40	m	0.54	m	0.54	m	
Check Hwi < AHW	PASS		PASS		PASS		
Factor of Safety	2.0		1.5		1.5		
Entry loss coefficient, ke =	0.5		0.5		0.5		Table 3.2, pg 84 Austroads 0.5 = reinforced concrete box, square on 3 edges
Head, H =	0	m	0	m	0	m	Appendix B, Figure B5, pg 150 Austroads
Critical depth, dc =	0.26	m	0.36	m	0.36	m	
(dc + D)/2 =	0.58	m	0.63	m	0.63	m	
ho =	0.58	m	0.63	m	0.63	m	if TW > D: if yes, ho = TW if if no, ho = the larger of TW and (dc + D)/2
L*So =	0.23	m	0.026	m	0	m	
Headwater under outlet control conditions, Hwo =	0.35	m	0.60	m	0.63	m	
Check Hwo < AHW	PASS		PASS		PASS		
Factor of Safety	2.3		1.3		1.3		
Outlet Velocity	0.81	m/s	0.75	m/s	0.75	m/s	Qo/A
Inlet Froude, Fri =	0.16		0.25		0.25		Qo*sqrt(B/(g(A^3)))
Outlet Froude, Fro =	0.27		0.25		0.25		

LEGEND	
	= Input
	= PASS
	= FAIL
	= Factor of Safety

Free water surface
HW < 1.2D





*Source: Austroads Guide to Road Design - Part 5B: Drainage - Open Channels, Culverts and Floodways
**Table is a modification of the worksheet provided on page 86 of the Austroads Design Guide

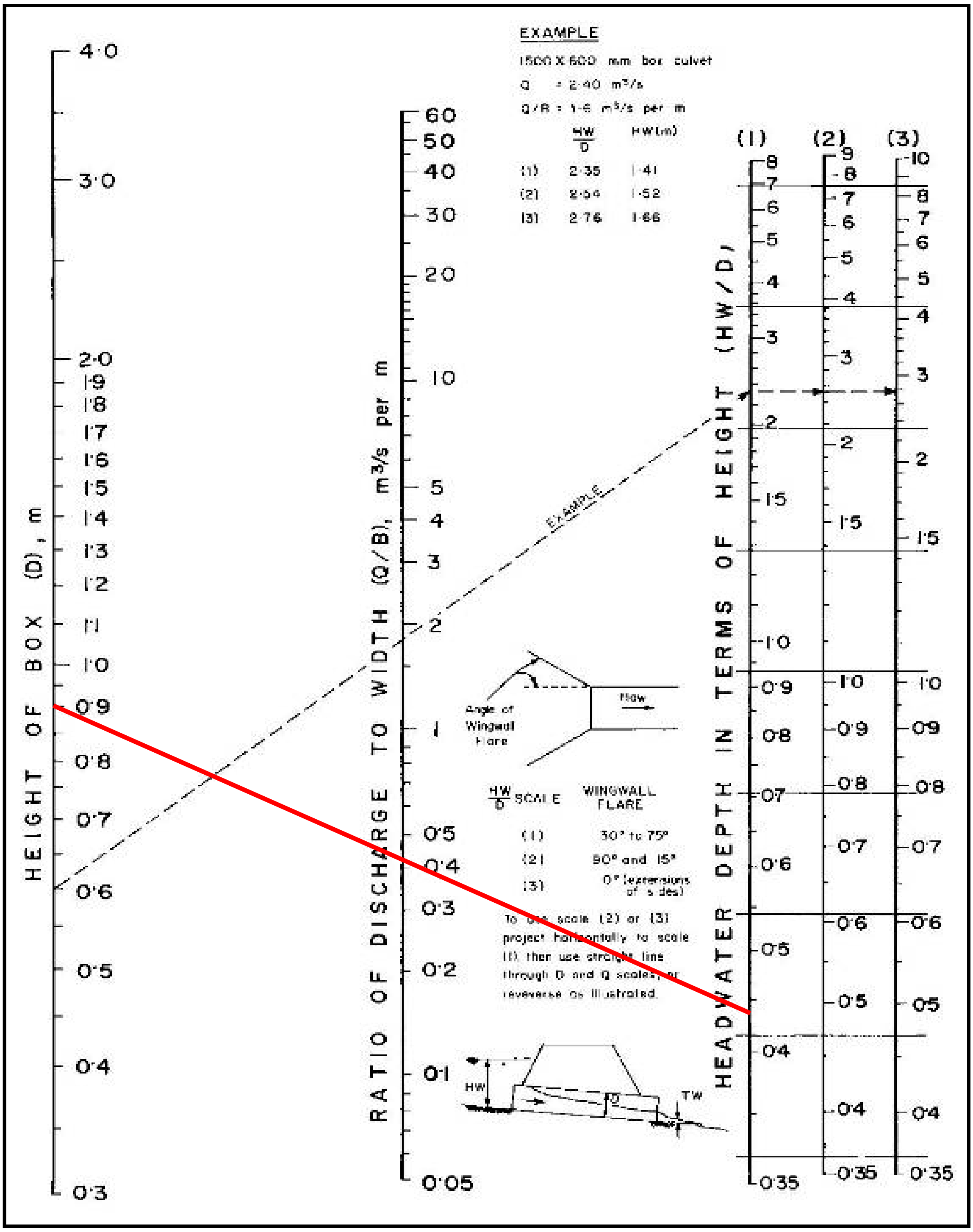
talis
delivering solutions

Intersection Point #1 Culvert

B.2 Inlet Control

D = 0.9m

Q/B = 0.42



HW/D = 0.44

*Assuming a wingwall flare between 30 and 70 degrees

Source: DTMR (2010).

Figure B 1: Headwater depth for box culvert with inlet control

Intersection Point #1 Culvert

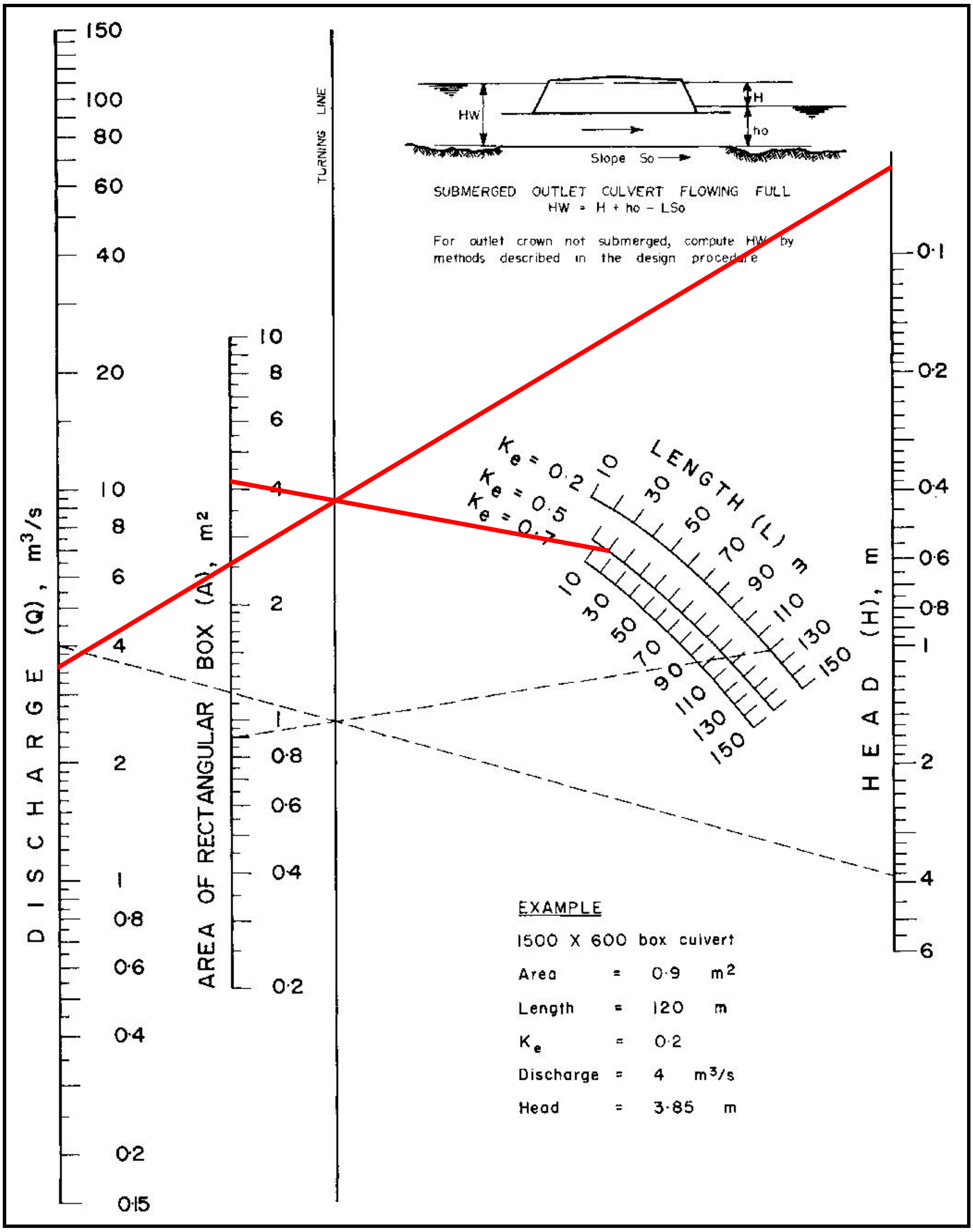
B.3 Outlet Control

Q = 3.50m3/s

A = 4.32m2

ke = 0.5

L = 20m



H < 0.1m Therefore, H is considered negligible

Source: DTMR (2010).

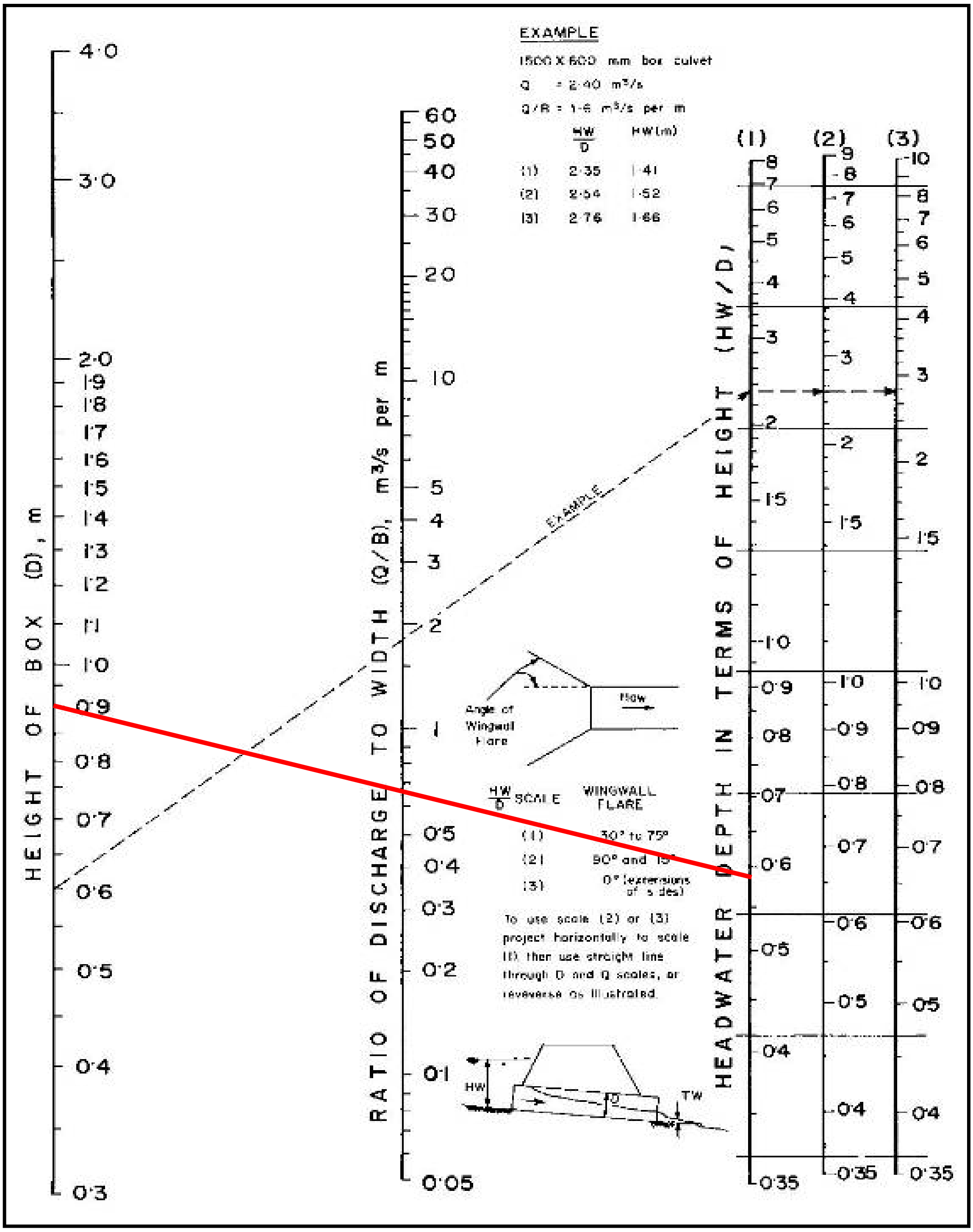
Figure B 5: Head for concrete box culverts flowing full with outlet control (n=0.012)

Intersection Point #2 Culvert

B.2 Inlet Control

D = 0.9m

Q/B = 0.68



HW/D = 0.59

*Assuming a wingwall flare between 30 and 70 degrees

Source: DTMR (2010).

Figure B 1: Headwater depth for box culvert with inlet control

Intersection Point #2 Culvert

B.3 Outlet Control

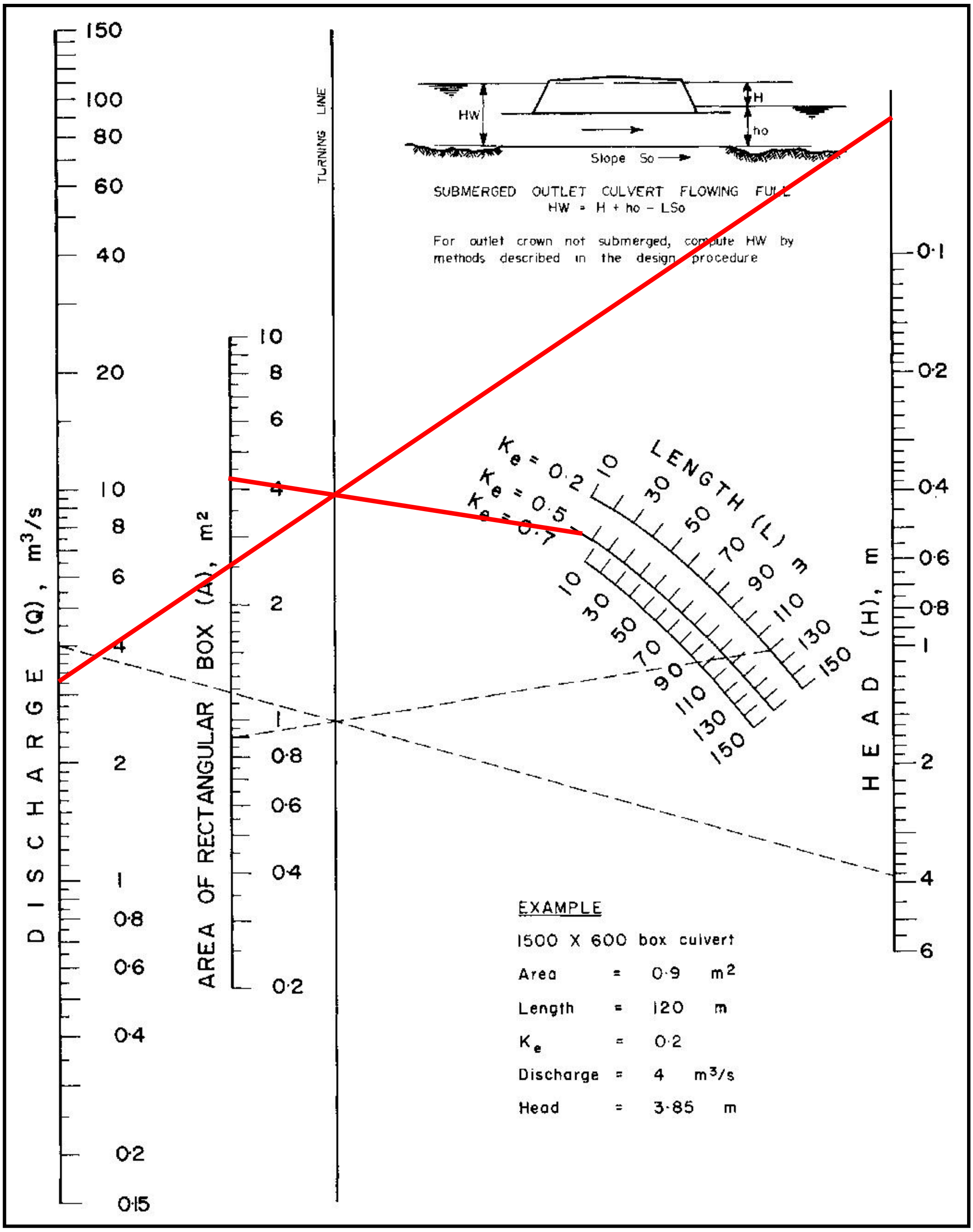
H < 0.1m
Therefore, H is considered negligible

Q = 3.26m3/s

A = 4.32m2

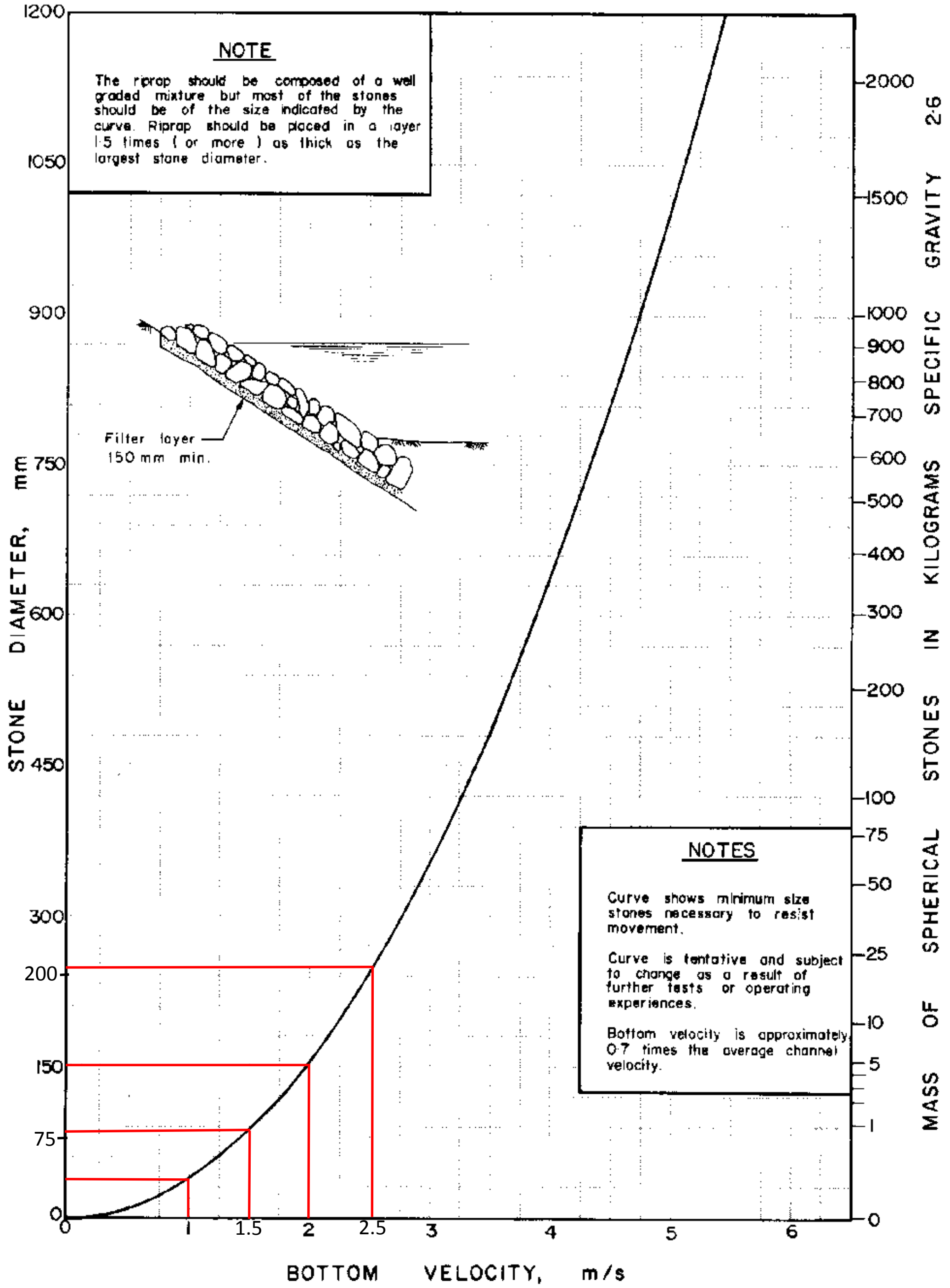
ke = 0.5

L = 5m



Source: DTMR (2010).

Figure B 5: Head for concrete box culverts flowing full with outlet control (n=0.012)



Source: DTMR (2010).

Figure 2.22: Relationship between bed velocity and rock diameter