APPENDIX L

Draft Erosion and Sediment Control Plan

PowerWater

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1 Introduction

1.1 Background

Power and Water Corporation (PWC), propose to construct a duplicate Effluent Rising Main (ERM) at East Point, extending from the Ludmilla Wastewater Treatment Plant (WWTP) to a terminal manhole at the landward end of the East Point Outfall (EPO) (referred to as the 'Proposed Development').

A draft Public Environmental Report (PER) and Supplementary to the PER were prepared to address key risk outlined by the Department of Natural Resources, Environment, The Arts and Sport (NRETAS) in the *Guidelines for Preparation of a Public Environmental Report, Duplication of the East Point Effluent Rising Main and Extension of the East Point Outfall*, *Darwin, NT* (the Guidelines).

Soil erosion and sedimentation was identified as a potential risk to the environment (PWC, 2011a). To minimise the risks to the environment, PWC will require the contractor to develop a site specific Erosion and Sediment Control Plan (ESCP). The ESCP developed by the contractor will align with the *Erosion and Sediment Control Guidelines, Built Environment* (NRETAS, 2012a) and the *New South Wales (NSW) "Construction Blue Book"*. The overall objective of the ESCP will be to:

- Control soil erosion and sediment generation from areas disturbed by construction activities
- Control soil erosion as a result of high rainfall and subsequent pump out of trenches and excavations
- Mobilised sediment and sediment accumulating in the receiving environment
- Prevent erosion and sedimentation both during and post construction
- Provide a timeline for programmed works to ensure erosion and sediment control measures are completed / implemented on time.

1.2 Purpose of this Draft ESCP

This draft ESCP outlines minimum strategies and measures likely to be implemented to minimise soil erosion and sedimentation during construction. However, as the construction methodology is unknown at this stage it will be a contractual requirement that the ESCP be tailored to their construction methodology. The contractor will be required to consultation with Darwin City Council and NRETAS during the development of the ESCP. The ESCP will be developed by a suitable qualified person and must be approved by PWC prior to the start of the works.

1.3 Supporting Documentation

- *Draft Public Environmental Report for the Proposed Duplication of the East Point Effluent Rising Main*, Power and Water Corporation, November 2011.
- *Erosion & Sediment Control Plan Content*, *Fact Sheet,* Vegetation and Land Management, Natural Resource Management Division, Northern Territory Government
- *Erosion and Sediment Control Guidelines, Built Environment*, Department of Natural Resources, Environment, The Arts and Sport
- New South Wales construction "Blue Book".
- *Best Practice Erosion and Sediment Control Series* published by the International Erosion Control Association (IECA).

1 Introduction

1.4 Legislation

The two main Northern Territory (NT) acts which relate to erosion and sediment control are (NRETAS, 2012a):

- *Soil* Conservation *and Land Utilization Act,* which assists in protecting sensitive areas and in reducing the impact of sediment on land downstream
- *Water Act*, which provides for the investigation, use, control, protection, management and administration of water resources within the Northern Territory

2 Project Description

2.1 Project Overview

The Proposed Development involves constructing a duplicate ERM from the Ludmilla WWTP to East Point, where it will be connected to an existing terminal manhole. The ERM is a pressurised pipe that will transport effluent, for final disposal through the EPO. The proposed works will be conducted between July and November 2012. As the works are scheduled to occur beyond the 30th of October a detailed ESCP is required.

The ERM will be approximately 3.2 km in length with a 10 m wide construction corridor. The proposed development will require the clearing of approximately three hectares of terrestrial vegetation and potentially disturbing another thee hectares (PWC, 2012a). It will consist of buried high tensile steel or reinforced concrete pipeline (PWC, 2011a). The alignment for the ERM has been selected to minimise the potential for clearing of vegetation. It traverses an area of mostly cleared land, roadsides and grassed reserves. Construction of the rising main will typically involve a number of sequential activities outlined below:

- Establishment of temporary facilities;
- Use of access tracks;
- Clearing and grading;
- Trenching for the pipeline;
- Laying of the pipe and backfilling the trench;
- Testing of pipeline for potential leaks; and
- Clean-up and rehabilitation of the site.

Each of these activities is described in detail below.

2.1.1 Temporary Facilities

A range of temporary facilities will be required throughout the construction of the ERM. Including the following:

- Construction site compound including site office, ablution block, common room
- Lay down
- Temporary fencing
- Equipment stock pile (e.g. pipes).

The location of the temporary facilities will be based upon logistical requirements and the objectives for the rising main route selection. Worker accommodation will not be required during the construction activities, due to the sites proximity to Darwin. However, it is likely a caretaker facility will be established on site for security. The locations of the temporary site facilities will be determined by the contractor.

2.1.2 Access

During construction, access tracks will be established to access areas such as the pipeline corridor and work areas. Existing roads, tracks and disturbed areas will be utilised as far as practicable to minimise disturbance to the surrounding areas. The selection of access track routes will be based on the ERM route selection. Gates will be installed where fence lines are required to be breached. The locations of access points and tracks will be determined by the contractor. However, to reduce rehabilitation and stabilisation costs it is likely these will be kept to a minimum. Any works outside of the proposed developments 10 m wide corridor will require permission from the Darwin City Council (DCC), whom own

2 Project Description

the adjacent land. In order to prevent any delays gaining appropriate approvals from the DCC it is envisioned the majority of the works will be restricted to within the construction corridor.

2.1.3 Clearing and Grading

The pipeline corridor will be cleared of existing vegetation where required. Cleared vegetation will be stockpiled onsite for re-use during the site rehabilitation and revegetation. Vegetation cleared for vehicle and plant access will be chain sawed at ground level to enable root stock to stabilise the area and reduce erosion. Vegetation will be retained where possible, in particular large trees will be preserved wherever practicable. Retained vegetation will be fenced off as “No-Go” areas throughout the works. The works area will be levelled to the required gradient using graders, backhoes and bulldozers. Topsoil will be stockpiled separately for reuse during rehabilitation.

2.1.4 Trenching

The trench will be prepared using excavators, trenching machines, rock saws or with drilling where required due to hard rock. Due to safety reason open trenching will be kept to a minimum at all times. Trenching will be conducted in accordance with NT WorkSafe guidelines and other relevant NT and Commonwealth regulations.

The top of the ERM will be buried to an average depth of 750 mm and 1,200 mm at the intersection with Colivas Road. The method used for crossing this road will be dependent on environmental factors and geotechnical constraints, but will most likely consist of open trenching. The road will then be reinstated. The works will also intersect a pedestrian crossing which is part of the Mangrove Board walk, which will also be repaired.

2.1.5 Laying of the Pipe and Backfilling

In order to protect the pipe graded material e.g. sand will be placed in the bottom of the trench. The pipe will then be lifted off the skids and lowered into the trench using side-boom tractors, cranes or excavators. The pipeline will then be covered with more graded material and back filled using both excavated and imported material.

2.1.6 Testing

The pipeline will be hydrostatically tested for potential leaks by being filled with water and pressurised to a pressure greater than its maximum operating pressure.

2.1.7 Clean up and Rehabilitation

Clean up and rehabilitation measures will be applied to the ERM corridor and access tracks in consultation with the relevant land holder/owner. Generally, clean up and rehabilitation will involve removal of foreign material (construction material and waste), surface contouring, re-spreading topsoil, and re-spreading vegetation. In certain areas, a low 'formed camber' of material may be allowed to remain over the trench line to allow for possible subsidence.

Following the completion of the works the trench will be back filled and compacted. Stockpiled topsoil will be spread across the site to facilitate the rehabilitation of the site. Cleared vegetation will also be spread across the site to reduce the erosion risk at the site. Depending of the finished surface, earth bunds will be installed to break up the slope length and to slow the velocity of water down. All tracks and access

2 Project Description

site will be restricted. The location and frequency of temporary and permanent controls will be addressed in the contractors site specific ESCP.

2.2 Proposed Alignment

The location of the existing and proposed duplicated effluent rising main is illustrated in **Figure 2-1**, with further detail of the proposed alignment for the duplicated effluent rising main provided as **Appendix A** (drawing number B09-1687 to B09-1694).

2.3 Timing

A preliminary construction program for the Proposed Development is presented in **Figure 2-2**. The construction program shows the following three phases:

- Phase 1 – February 2012, concept and developed of detailed designs;
- Phase 2 – July 2012, completion of tender documents, including procurement and tender assessment
- Phase 3 – October 2012, completion of construction.

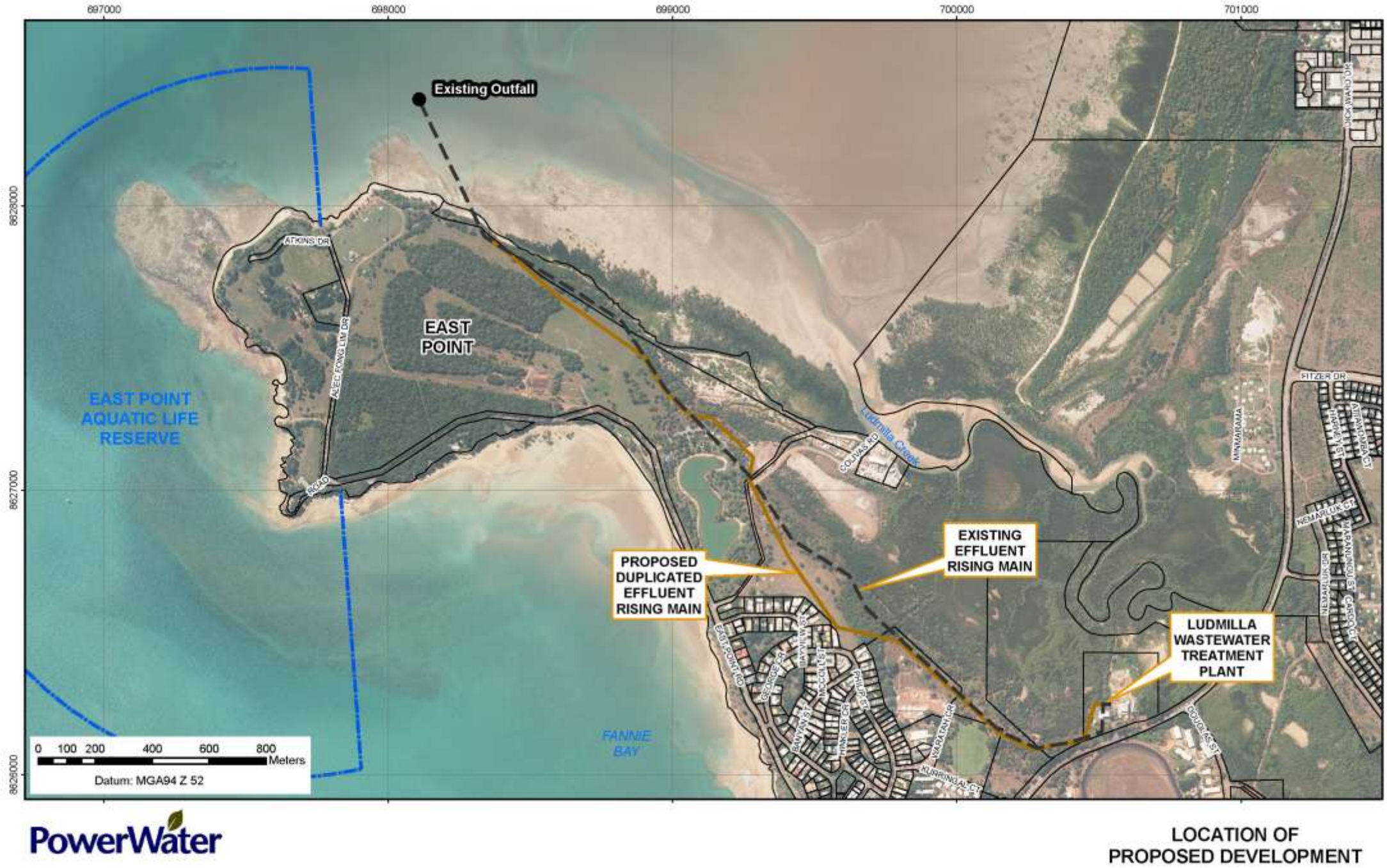

Figure 2-1 Proposed Alignment for the Duplicated Effluent Rising Main

2 Project Description

Figure 2-2 Preliminary Construction Program - Proposed Duplicated East Point Effluent Rising Main

3 Site Description

3.1 Locality

East Point is located approximately 6 km north of the Darwin Central Business District (CBD). Much of East Point has been designated public open space, and is now the East Point Recreation Reserve. The Ludmilla WWTP, which is the origin of the effluent rising main, is located on Dick Ward Drive at the south east boundary of East Point, with the suburb of Ludmilla on the opposite side of Dick Ward Drive. The entire Proposed Development is located within the DCC local government area. The regional setting is shown at **Figure 3-1**, and the location of the Proposed Development is shown at **Figure 2-1**.

Figure 3-1 Darwin Regional Setting

3 Site Description

3.2 Tenure

The site of the Proposed Development is on allotments owned by the Northern Territory Government (NTG) or DCC. An easement for the Proposed Development will extend from the Ludmilla WWTP to the terminal manhole. The property descriptions for these allotments are listed in **Table 3-1**.

Table 3-1 Real Property Description Details for Proposed Development Corridor

Parcel Type	Parcel Number	Survey ID	Suburb	Zone	Tenure
Lot	7302	S2001/155	Ludmilla	Utilities	Freehold
Lot	5794	S90/248C	Ludmilla	Multi Zone	Vacant
Lot	5775	S90/248D	East Point	Multi Zone	Freehold
Lot	3729	C000111	Fannie Bay	Public Open Space	Freehold
Lot	5693	S89/194A	Fannie Bay	Community Purpose	Crown Lease Term
Lot	5983	S90/248F	Town of Darwin	Public Open Space	N/A

Note: Property information obtained from *NT Atlas and Spatial Data Directory*, at http://www.ntlis.nt.gov.au/atlas

3.3 Soils

The surface soils of the East Point area, as defined on Northern Territory Geological Survey map EXTRACT GEOLOGY OF THE OUTER DARWIN AREA, consist of costal alluvium (mud, silt and clay) and laterite gravels (pisolithic and nodular duracrust / fericrete). The underlying rock unit in the area is claystone/sandstone of the Darwin Formation. Soil and rock types vary in composition and strength along the project corridor, with four distinct subsurface materials identified. The general stratigraphic sequence is as follows (Cardno Ullman & Nolan, 2010):

- A surface layer of alluvium comprising loose to dense, gravels, silts and sands with thickness ranging from 0.2 to 0.5 m. Loose, clayey sand and soft clay, deposited in a shallow marine or mangrove type environment, was encountered in some locations at the Ludmilla WWTP end of the Proposed Development alignment.
- The underlying material was predominately a layer of laterite comprising medium dense to very dense, silty or clayey, sandy gravel. The thickness of the laterite varied from approximately 0.2 to 0.9 m.
- Underlying unit of residual soil / extremely weathered rock, varying in composition from soft–hard clay to loose–very dense sand and gravel.
- Underlying very low to moderate strength, highly weathered porcellanite rock. The depth of the porcellanite layer was generally indicated borehole refusal.

Fill materials comprising loose to very dense, silty or clayey sandy gravel to depths ranging from 0.75 to 2.0 m have been identified at some locations along the Proposed Development alignment (Cardno Ullman & Nolan, 2010).

Soils within the project area include deep loamy massive earths, gravelly yellow massive earths, shallow very gravelly yellow massive earths and intertidal area characterised by loose silty and pebbly sand over soft mangrove clay (Douglas Partners, 1998).

Land Units (LU) associated with the project area are summarised in **Table 3-2**, which also include the capability constraints in terms of for each of the land units. **Figure 3-2** shows the Land Units in relation to the Proposed Development Corridor.

3 Site Description

Table 3-2 Land Unit Properties

LU Code	Land Unit (LU) description	Erosion Risk
3b	Flat to gently undulating upland surface; slopes 0.5 – 2%; deep Loamy Massive Earths; Eucalypt Woodland and minor open woodland	Low
3c	Flat to gently undulating upland surface; slope 1 – 3%; shallow very gravelly yellow massive earths; Eucalypt woodland	Low
3d	Flat to gently undulating upland surface; slope 1 – 3%; shallow gravelly lithosols; Eucalypt open woodland	Low
4c	Gentle lower slopes' slope 0.5 – 1%; slow drainage; yellow massive earths; Eucalypt open forest with minor woodland	Low
9a	Estuarine fringes; slopes negligible with tidal inundation, with Saline muds and clays. Usually bare small areas of samphire and salt tolerant grasses.	Low

Source: After DCC 2009a and DCC 2009b

No areas of significant erosion or sedimentation have been observed at the site. Erosion risk is considered low along the proposed realignment of the ERM due to the relatively level terrain.

3.4 Topography

The Proposed Development will be located on a narrow peninsula known as East Point, which extends north-westerly from the mainland north of Darwin and into Beagle Bay. The peninsula is bordered on the west and southwest by Fannie Bay and on the northeast by Ludmilla Creek. The topography of East Point is relatively flat to gently undulating except along the coastline, where the ground surface drops off as steep, rocky headlands (see **Figure 3-3**).

3.5 Climate

Darwin is located 12° south of the equator in the seasonally dry monsoon tropics. Rainfall seasonality and intense tropical storm activity are the most distinguishing features of the local and regional climatic pattern. The wet season, brought on by the northwest monsoon weather pattern, runs between September and May. The dry season, brought on by the south east trade weather pattern across the Australian continent, runs between June and August (PWC, 2011a).

Localised thunderstorms occur during transitional periods at the start and of the wet between September to November and March to May. Monsoonal rain resulting from the monsoon trough (intertropical convergence zone) falls across the Top End region between December and March. Large low pressure systems associated with the monsoon trough can produce severe tropical cyclones that lead to significant damage to above ground structures (PWC, 2011a).

Rainfall

Over 80% of the average annual rainfall occurs as general monsoon rain during the period from December to February. The mean annual rainfall is approximately 1,722.6 mm, with January statistically being the wettest month and July the driest. Relatively short duration, high intensity events, associated with afternoon and evening showers and thunderstorms dominate the rainfall pattern (BoM, 2011).

During the proposed construction period (July to November, 2012) the mean rainfall varies between 1.2 mm (July) and 140 mm (Nov) (BoM, 2011).

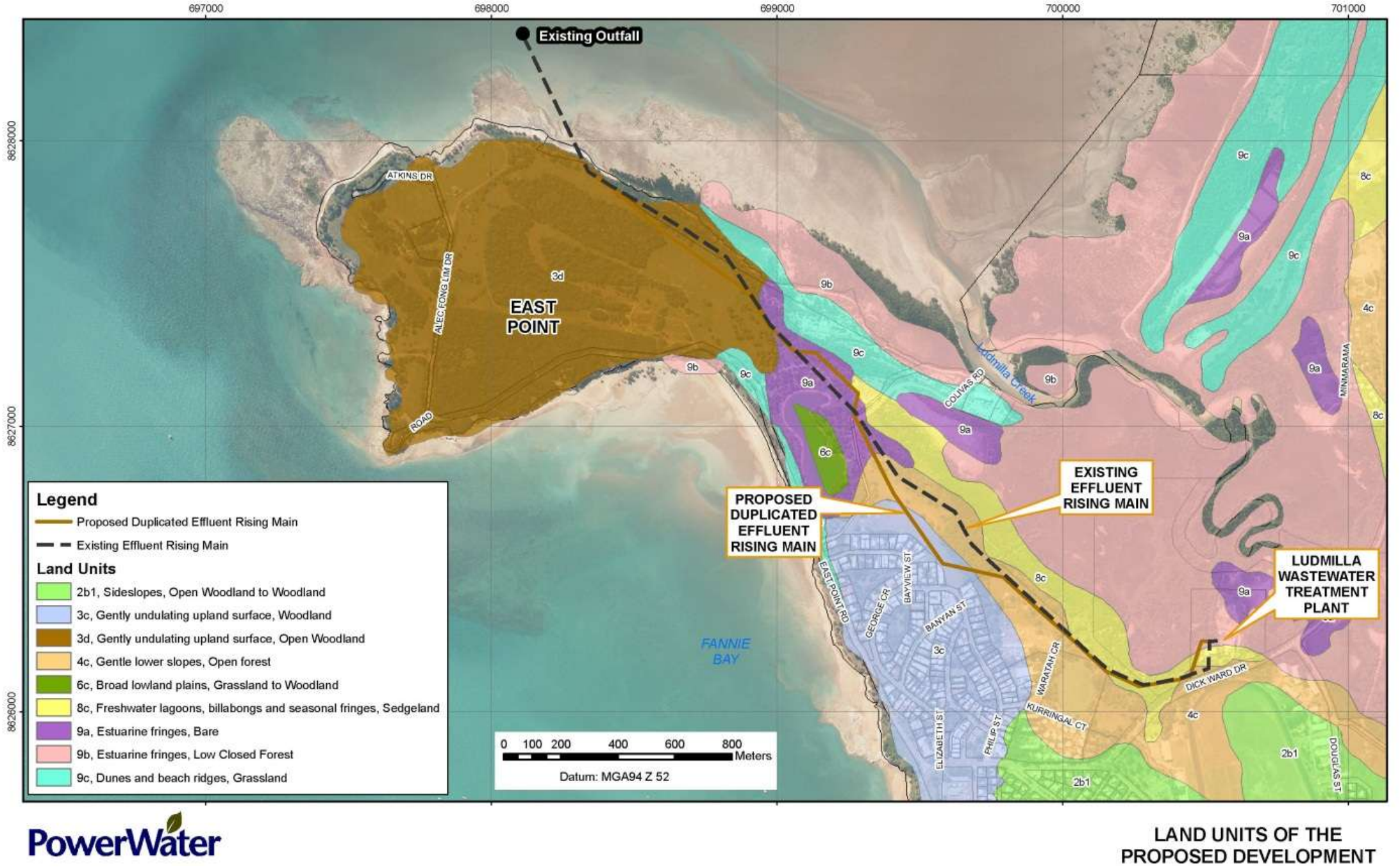

Figure 3-2 Land units at East Point

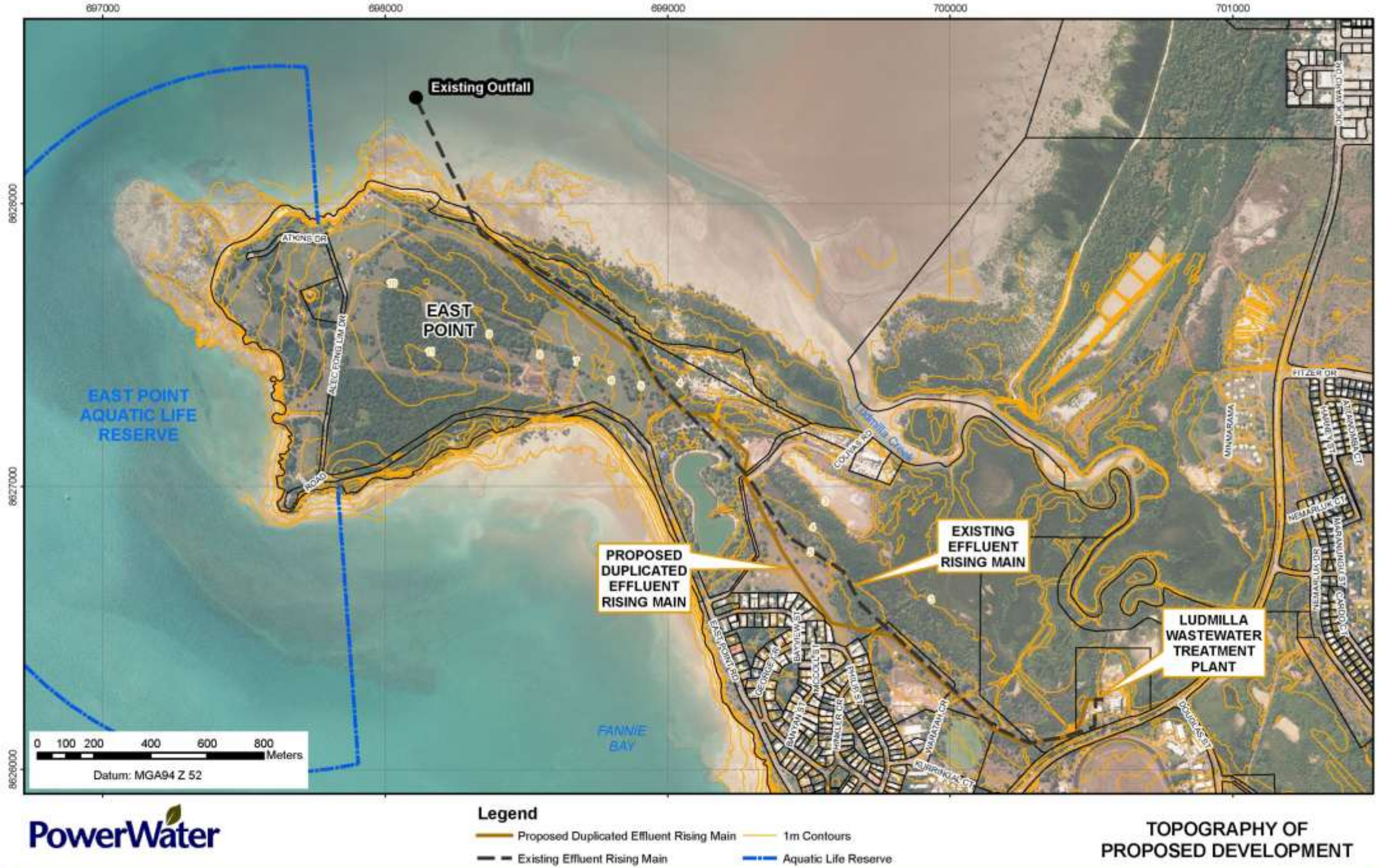

Figure 3-3 Contour Map of East Point and Ludmilla Area

3.6 Geology and Hydrogeology

According to the Northern Territory Geological Survey (NTGS) 1:100,000 Darwin geologic sheet, the Darwin member of the Bathurst Island Formation underlies the site. These horizontally bedded strata consist predominantly of claystone, sandy claystone, glauconitic sandstone and a basal unit of conglomerate. A duricrust has developed in the upper few metres of the strata, which is known locally as porcellanite. These strata are overlain by a veneer of unconsolidated sand, clayey sand, soil and, in some places, artificial fill. Boreholes advanced by Cardno Ullman & Nolan (2010) along the realignment indicate that the unconsolidated sediments are in most cases less than 1 m in thickness.

Groundwater[1] was encountered in 10 boreholes advanced by Cardno Ullman & Nolan (2010) at depths ranging from 0.4 to 2.5 m below ground level (bgl). Groundwater levels, flow direction and vertical gradient are likely to be highly variable across the site and are expected to fluctuate both seasonally and with the tides.

3.7 Nature of Existing Vegetation

The biological environment at East Point is described in the draft PER (PWC, 2011a) and Supplementary to the draft PER (PWC, 2012a), which describe the vegetation along the Proposed Development corridor as '*dominated by urban parkland and road clearings. Regrowth vegetation along the Proposed Development corridor is made up of Mixed Species Open Woodlands and small patches and understorey of Coastal Monsoon Vine Forest.'*

The following five terrestrial vegetation communities were identified (PWC, 2011a; PWC, 2012a):

- Coastal Monsoon Vine Forest;
- Low to Mid – Mixed Species Closed to Open Forest;
- Low to Mid – Mixed Species Open Woodland;
- Mangrove (Mangal) Forest; and
- Urban (Parkland, Development Sites).

Only the Mangrove communities are recognised as sensitive, or significant vegetation, under the *Northern Territory Land Clearing Guidelines* (NRETAS, 2010a). However, they are not listed as threatened under the *EPBC Act 1999* (PWC, 2012a).

The existing ERM corridor, proposed route of the duplicate ERM corridor, recorded vegetation communities, location of flora and fauna assessment and check sites (discussed below) are illustrated in **Figure 3-4**.

[1] Field work was carried out by Cardno, Ullman and Nolan between the 4th – 8th of October 2010, when an annual rainfall of 2257.2 mm was recorded for 2010, some 523.2 mm above the mean rainfall between 1941 to 2012 (BoM

3 Site Description

Area of Disturbance

Disturbance along the Proposed Development corridor can be described as (PWC, 2012a):

- A 10 m wide corridor that result in clearing of approximately 3 ha of terrestrial vegetation, of which 2.54 ha (85%) is classified as Community 5 disturbed and urban areas with regrowth
- The clearing of undisturbed land is less than 0.5 ha; this includes the clearing and potential disturbance of a small area (0.05 – 0.13 ha) of Mangrove Forest
- Additional area of potential disturbance to vegetation and soil resulting from the clearing and construction activities (measured at 5 m either side of the 10 m corridor) have also been calculated to clearly depict the maximum and minimum areas of disturbance.

Table 3-3 provides the details of the disturbance of the vegetation communities as calculated using Geographical Information System (GIS). The table illustrates that the majority of the Proposed Development corridor will pass through disturbed urban parkland and development areas with regrowth (Community 5).

Table 3-3 Areas of Clearing and Disturbance of Each Vegetation Community (1 to 5)

Vegetation Community	Map unit	Cleared (ha)	Potentially disturbed (ha)	Total (ha)
Community 1: Coastal Monsoon Vine Forest	12	0.034	0.081	0.115
Community 2: Low to Mid, Mixed Species Closed Forests	6	0.363	0.379	0.742
Community 3: Low to Mid High, Mixed Species Open Woodland to Woodland	13	0.652	0.686	1.338
Community 4: Mangrove Forest	4	0.056	0.078	0.134
Community 5: Disturbed Areas with Regrowth	16	1.893	1.8	3.696
Total Terrestrial Vegetation	-	*2.94*	*2.95*	*5.89*
Total Vegetation Marine Component	-	*0.056*	*0.078*	*0.134*
Total Area	**-**	**2.99**	**3.03**	**6.02**

Note: The column 'Potential disturbance' includes estimates of the additional area of potential disturbance to vegetation and soil resulting from the clearing and construction activities (measured at 5 m either side of the 10 m corridor). This has been included to clearly depict the maximum and minimum areas of disturbance.

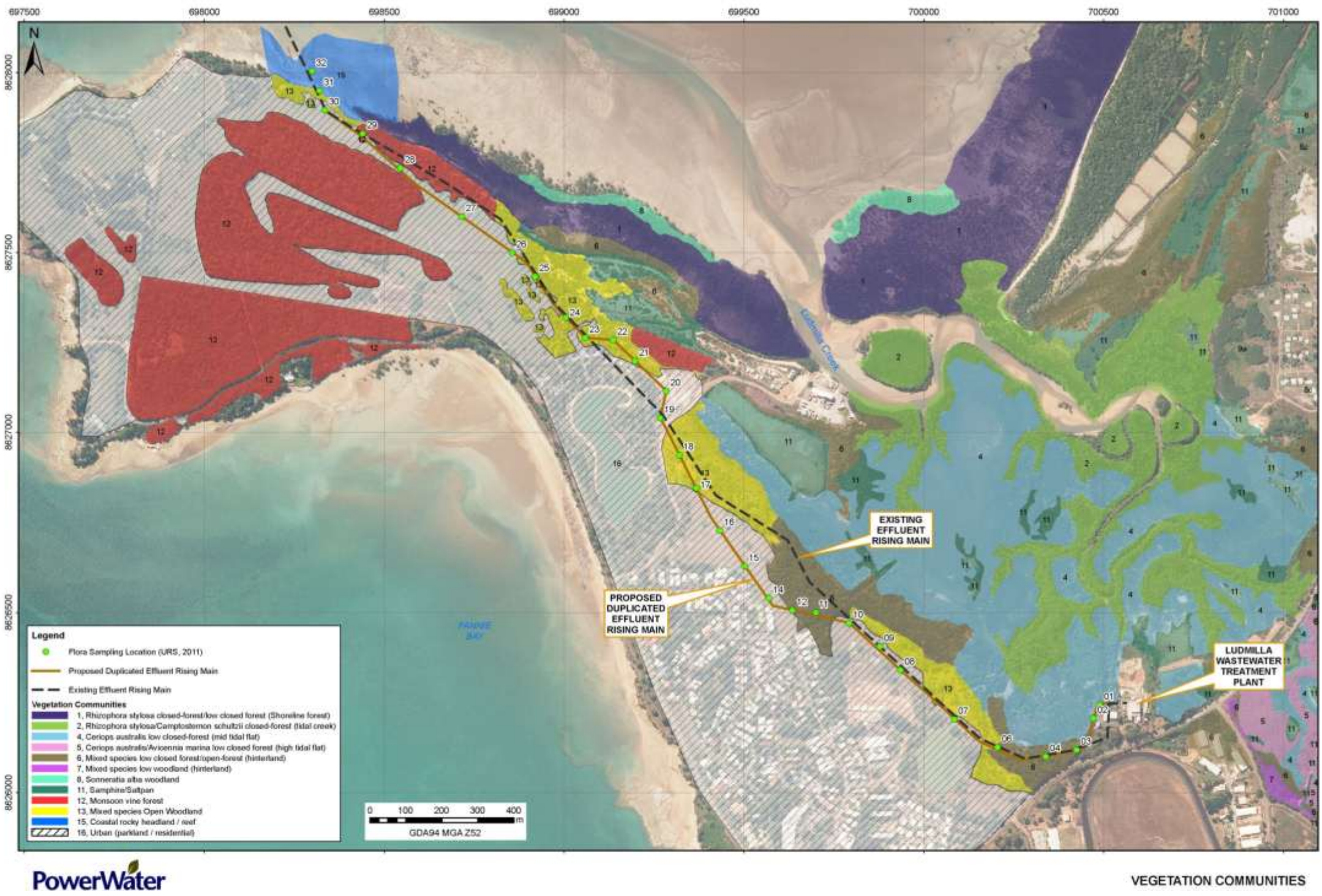

Figure 3-4 Location of Flora and Fauna Assessment and Checks Sites along the Proposed ERM Corridor

4 Erosion and Sediment Control Measures

A detailed ESCP will be developed by the contractor following the award of the contract. The ESCP will incorporate NRETAS '*Erosion and Sediment Control Plan Content'* (see **Appendix B**) and '*Best Practice Erosion and Sediment Control'* series, published by the International Erosion Control Association (IECA), http://www.austieca.com.au (2012a), which states the following:

- *Clearing of vegetation to be restricted to nominated areas*
- *All erosion and sediment control measures to be installed prior to any site disturbance*
- *All NO-GO zones must be flagged or fenced to restrict access and inspected by NRETAS prior to any site disturbance*
- *Top soil stripped from construction areas to be stockpiled at nominated site*
- *Limit and fill batter gradients to 1(V):4(H) maximum*
- *All temporary earth structures to be machine compacted and maintained*
- *Construct all sediment fences on contour where possible. Where sediment fences are not to be constructed on contour incorporate return panels at regular intervals not exceeding 20m.*
- *On completion of stormwater inlet pits protection measures to be immediately installed.*
- *All sediment control structures to be inspected after each rain fall event for damage and effectiveness.*
- *Trapped sediment to be removed to a nominated site.*
- *Divert all stormwater runoff away from disturbed soil into intact native vegetation or stormwater drainage system.*
- *Complete all final erosion prevention and sediment control measures prior to final subdivision handover*
- *Establish and maintain a street sweeping program for the duration of the works.*
- *Any changes to the erosion and sediment control plan shall be submitted to NRETAS for approval prior to works commencing*
- *All erosion and sediment control measures to be undertaken to the satisfaction of NRETAS.*

Standard specifications (i.e. diagrams of the proposed control structures) and technical notes will also be included e.g. the installation of sediment fences (see **Appendix D**).

To ensure the contractors compliance with their ESCP the following will occur:

- A site environmental checklist to assist in the planning of erosion and sediment controls (see **Appendix C)**
- Inspections/audits
  - Regular site inspections and audits of control measures will be undertaken by both PWC and the contractor for example weekly, monthly. Additional inspections will be required at construction milestones and after rain events.
  - PWC will audit against the contractors ESCP and inspection program to ensure compliance with the ESCP and to ensure controls are effective.
  - Prior to the completion of the project, an inspection will be conducted to ensure stability of all excavated areas. Additional controls will be recommended where required.
  - PWC will conduct regular inspection during the defects liability period.

5 References

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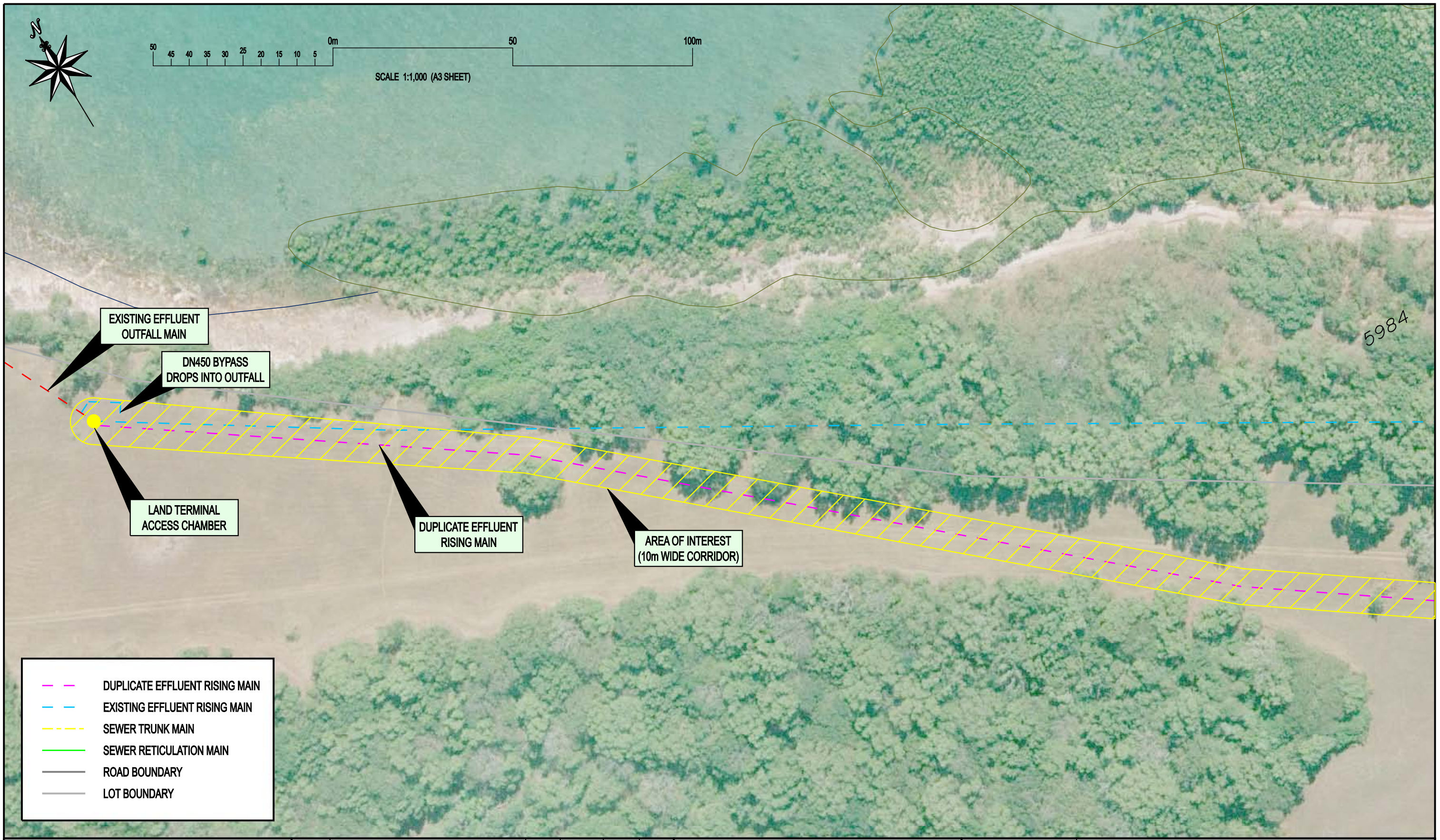
Appendix A Proposed Development Corridor



DRAWING SERVICES
telephone: (08) 89857141
Power and Water Corporation
NORTHERN TERRITORY

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AMENDMENTS

PowerWater
NORTHERN TERRITORY

DES	K.MORAN
DRN	R.INNES
CKD	...
APPD	...
SCALE	1:1,000
ISSUED	FEB'09
ALL DIM. IN mm	
DRAFTING STANDARD TO A.S.1100	

DARWIN SEWERAGE SYSTEM
EAST POINT SEWER MAIN DUPLICATION
PROPOSED ALIGNMENT SHEET 1 OF 8

A3

DRAWING NUMBER B09-1687

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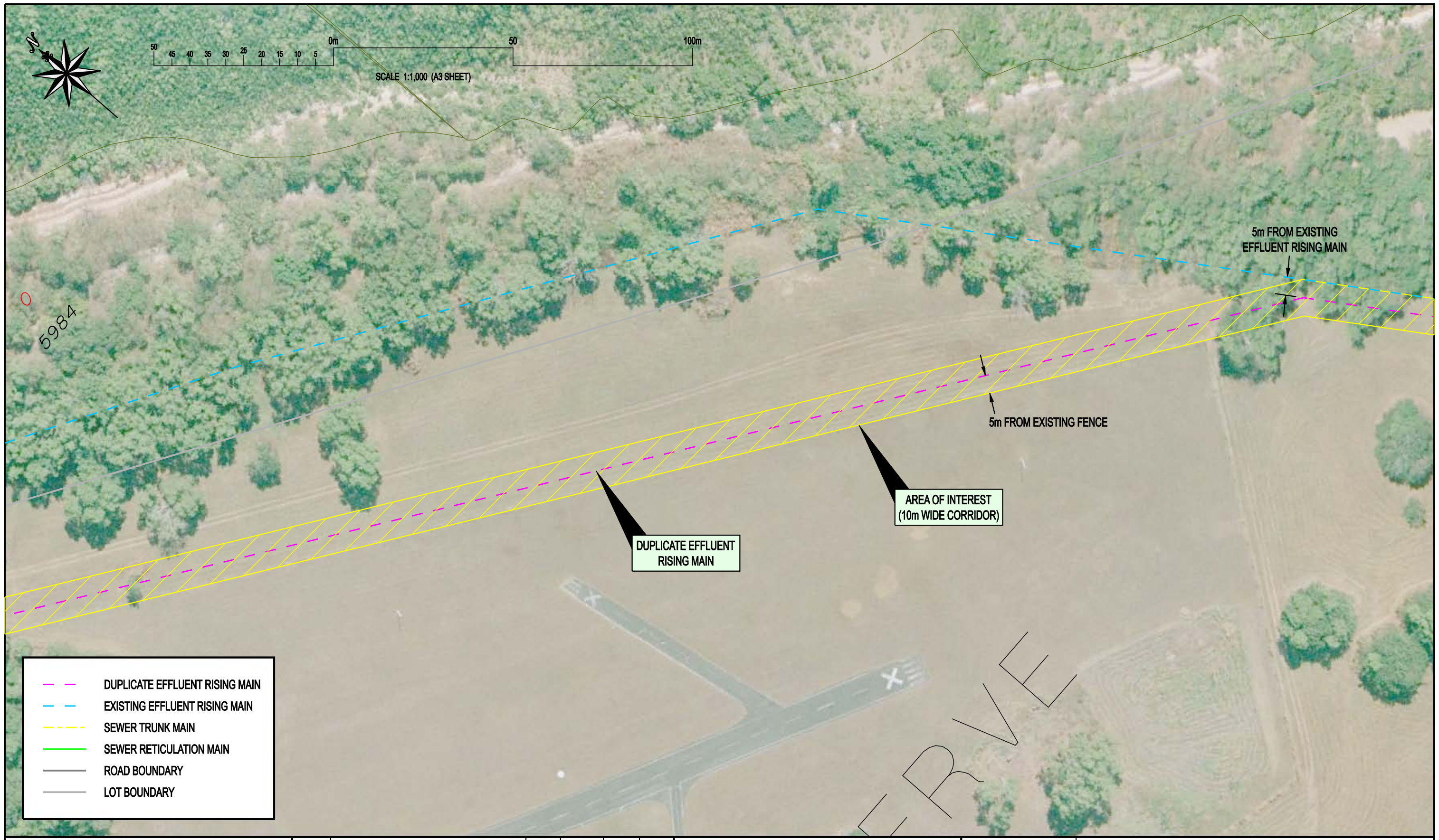

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Power and Water Corporation
NORTHERN TERRITORY

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AMENDMENTS

PowerWater
NORTHERN TERRITORY

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CKD	...
APPD	...
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ISSUED	FEB'09
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DARWIN SEWERAGE SYSTEM
EAST POINT SEWER MAIN DUPLICATION
SHEET 2 OF 8

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DARWIN SEWERAGE SYSTEM
EAST POINT SEWER MAIN DUPLICATION
SHEET 3 OF 8

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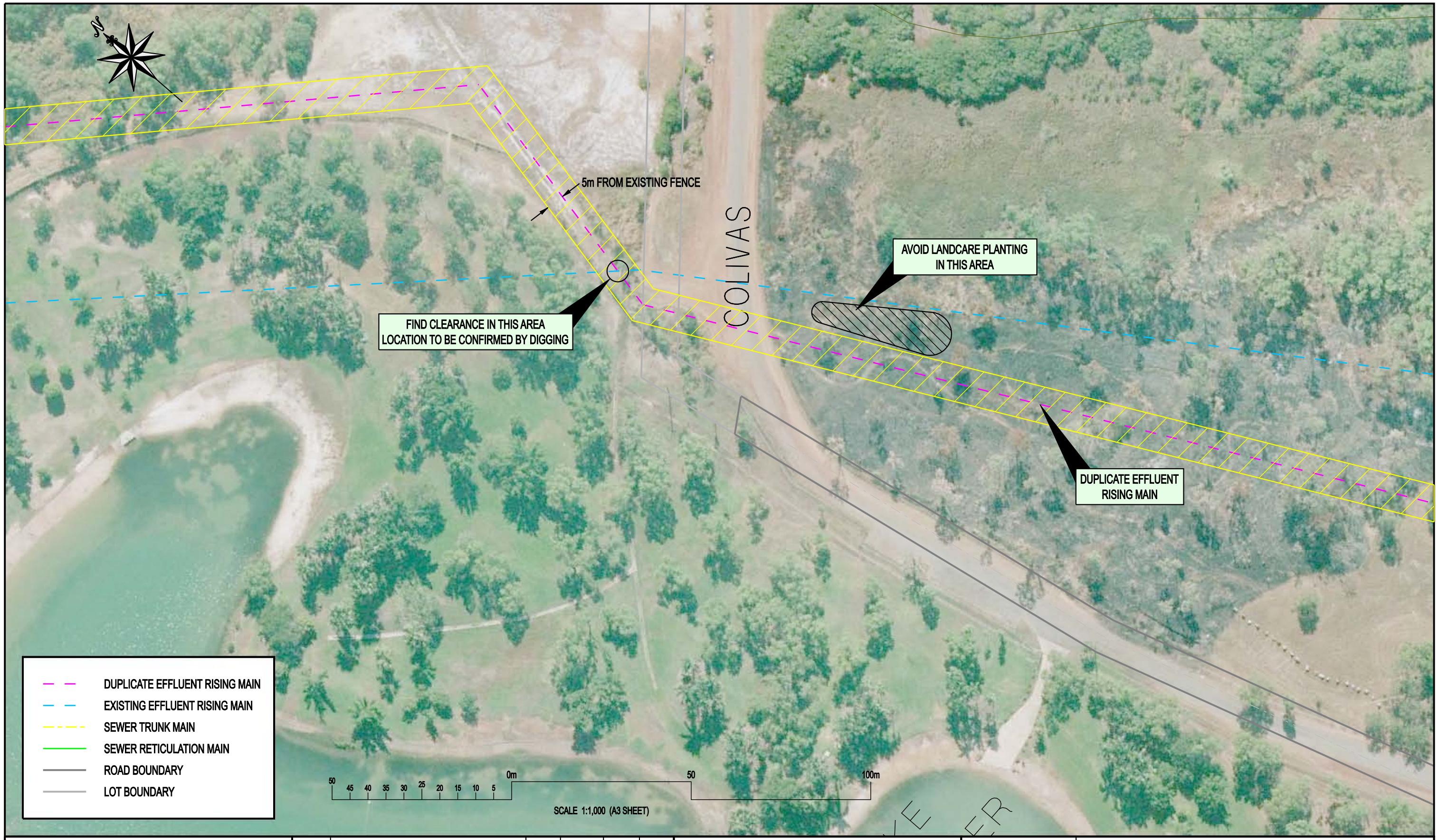

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NORTHERN TERRITORY

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AMENDMENTS

PowerWater
NORTHERN TERRITORY

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APPD	...
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ISSUED	FEB'09
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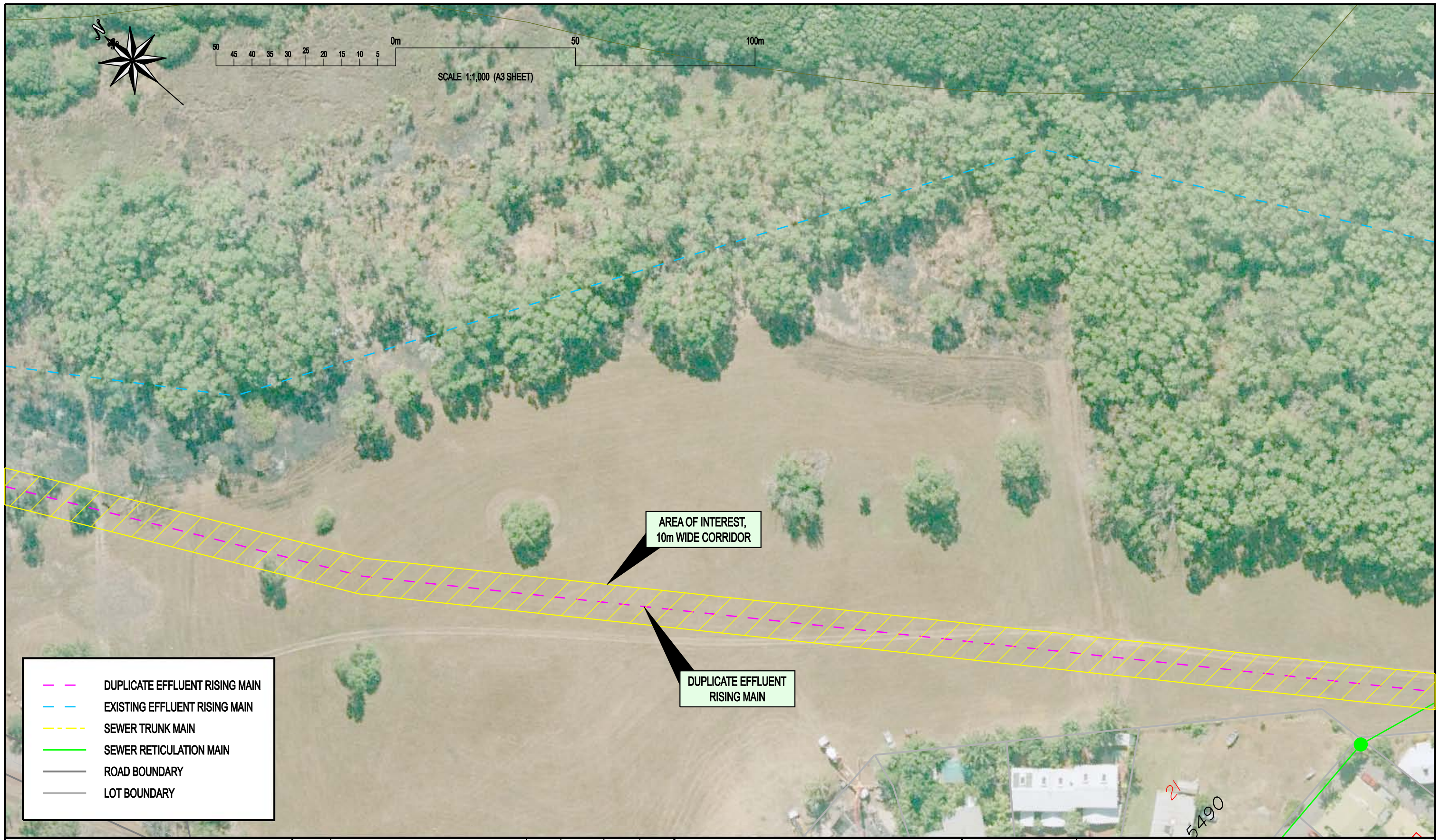
DARWIN SEWERAGE SYSTEM
EAST POINT SEWER MAIN DUPLICATION
SHEET 4 OF 8

A3

DRAWING NUMBER B09-1690

CAD PRODUCT - DO NOT AMEND MANUALLY

C AMDT



DRAWING SERVICES
telephone: (08) 89857141
Power and Water Corporation
NORTHERN TERRITORY

NO	DESCRIPTION	DRN	DATE	CKD	APPD
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AMENDMENTS

PowerWater
NORTHERN TERRITORY

DES	K.MORAN
DRN	R.INNES
CKD	...
APPD	...
SCALE	1:1,000
ISSUED	FEB'09
ALL DIM. IN mm	

DRAFTING STANDARD TO A.S.1100

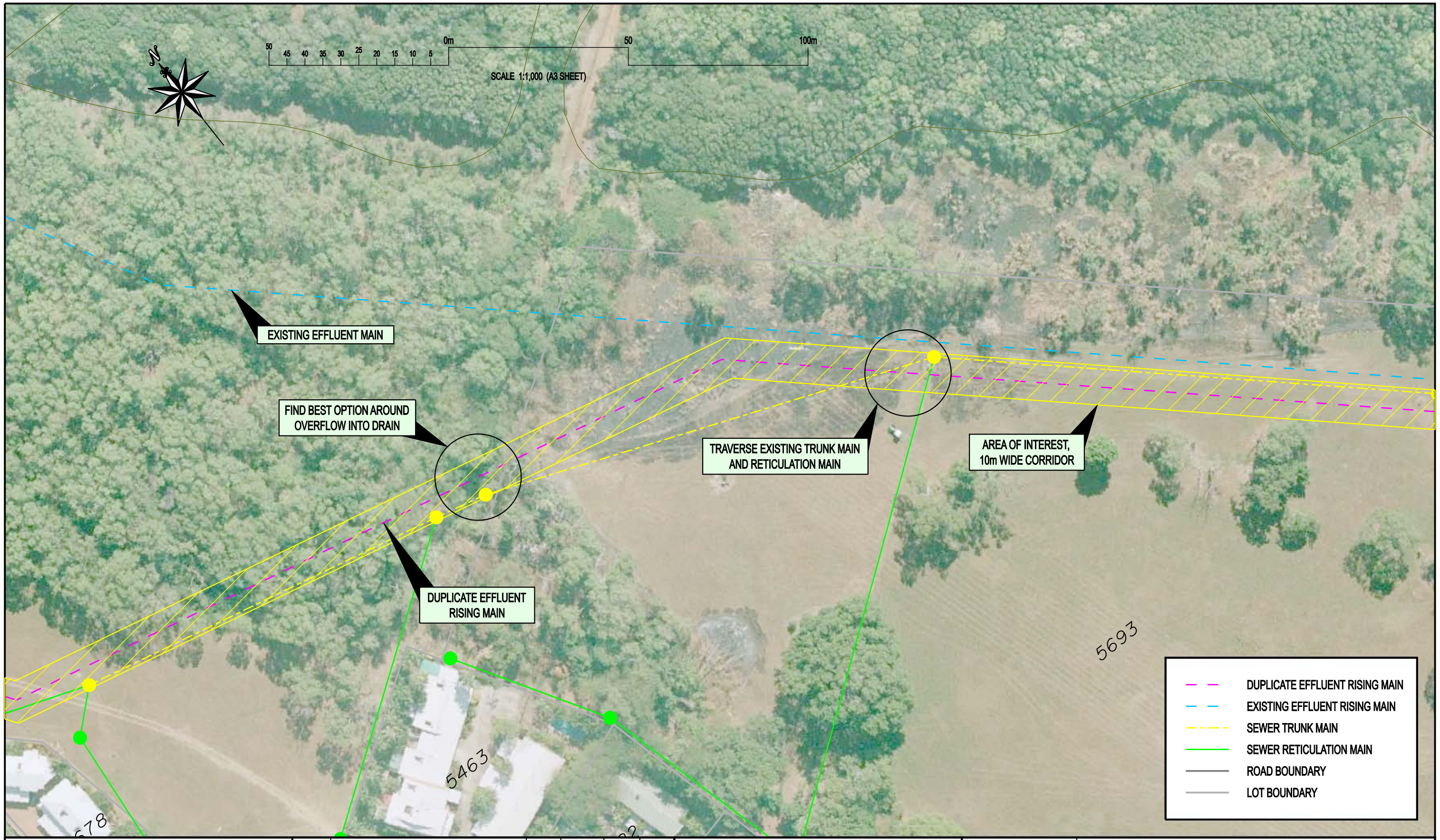
DARWIN SEWERAGE SYSTEM
EAST POINT SEWER MAIN DUPLICATION
SHEET 5 OF 8

A3

DRAWING NUMBER B09-1691

C AMDT

CAD PRODUCT - DO NOT AMEND MANUALLY



DRAWING SERVICES
telephone: (08) 89857141
Power and Water Corporation
NORTHERN TERRITORY

NO	DESCRIPTION	DRN	DATE	CKD	APPD
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AMENDMENTS

PowerWater
NORTHERN TERRITORY

DES	K.MORAN
DRN	R.INNES
CKD	...
APPD	...
SCALE	1:1,000
ISSUED	FEB'09
ALL DIM. IN mm	
DRAFTING STANDARD TO A.S.1100	

DARWIN SEWERAGE SYSTEM
EAST POINT SEWER MAIN DUPLICATION
SHEET 6 OF 8

A3

DRAWING NUMBER B09-1692

CAD PRODUCT - DO NOT AMEND MANUALLY

C AMDT

DRAWING SERVICES
telephone: (08) 89857141
Power and Water Corporation
NORTHERN TERRITORY

NO	DESCRIPTION	DRN	DATE	CKD	APPD
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AMENDMENTS

PowerWater
NORTHERN TERRITORY

DES	K.MORAN
DRN	R.INNES
CKD	...
APPD	...
SCALE	1:1,000
ISSUED	FEB'09
ALL DIM. IN mm	

DARWIN SEWERAGE SYSTEM
EAST POINT SEWER MAIN DUPLICATION
SHEET 7 OF 8

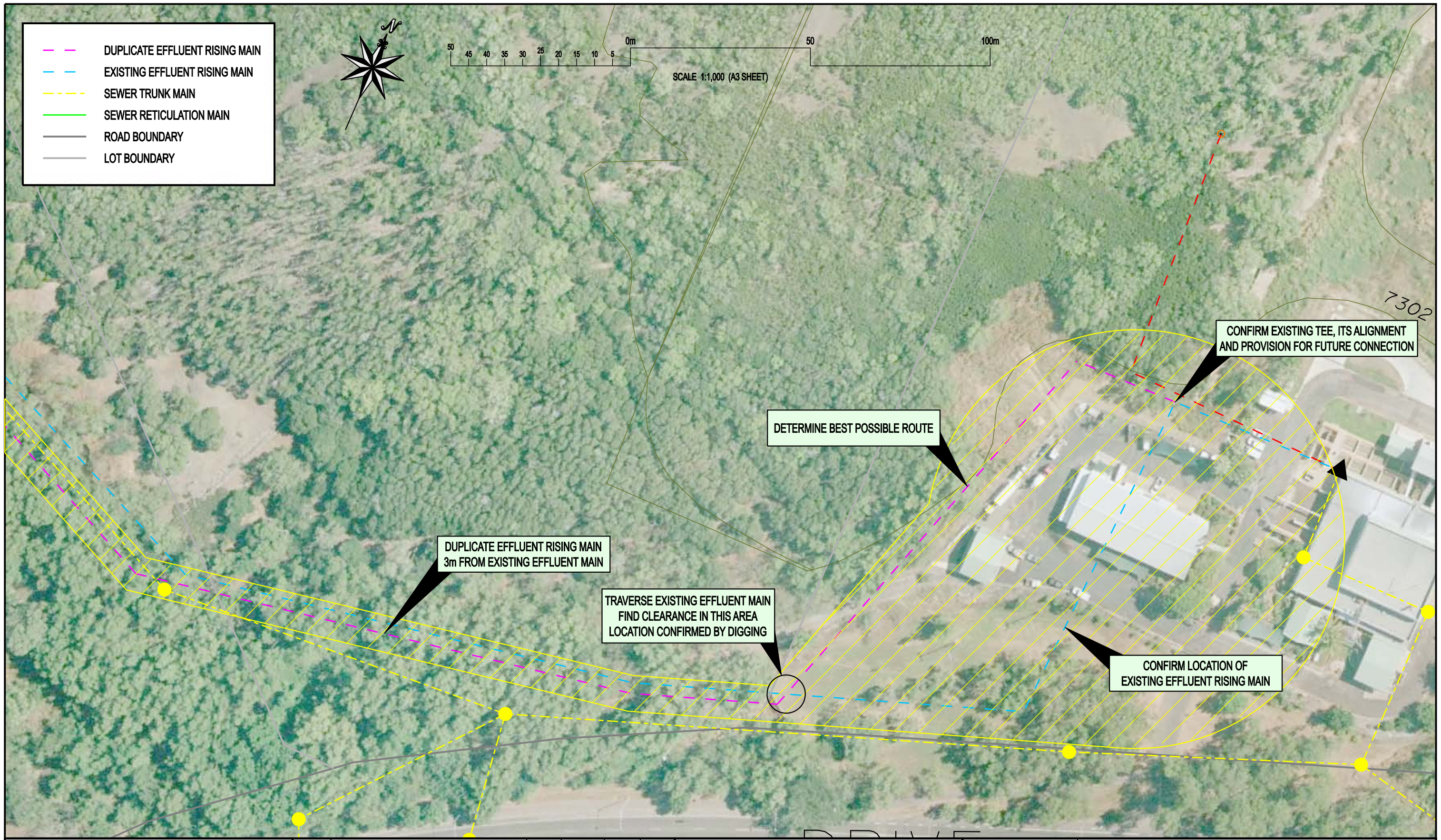
A3

DRAWING NUMBER B09-1693

C AMDT

DRAFTING STANDARD TO A.S.1100

CAD PRODUCT - DO NOT AMEND MANUALLY



DRAWING SERVICES
telephone: (08) 89857141
Power and Water Corporation
NORTHERN TERRITORY

NO	DESCRIPTION	DRN	DATE	CKD	APPD
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AMENDMENTS

PowerWater
NORTHERN TERRITORY

DES	K.MORAN
DRN	R.INNES
CKD	...
APPD	...
SCALE	1:1,000
ISSUED	FEB'09
ALL DIM. IN mm	
DRAFTING STANDARD TO A.S.1100	

DARWIN SEWERAGE SYSTEM
EAST POINT SEWER MAIN DUPLICATION
SHEET 8 OF 8

A3

DRAWING NUMBER B09-1694

C AMDT

CAD PRODUCT - DO NOT AMEND MANUALLY

Appendix B Erosion and Sediment Control Guidelines, Built Environment

Northern Territory Government

DEPARTMENT OF
NATURAL RESOURCES, ENVIRONMENT AND THE ARTS

Erosion and Sediment Control Guidelines

Built Environment

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Introduction

There are two main ways in which erosion occurs. One is a natural process in which the landscape is impacted upon by weather events and the landscape is gradually changed over time. The other is an accelerated anthropological process which occurs when land is cleared, modified and exposed to rain, wind or waves. If no precautions have been taken this process will cause excessive removal of soil particles from one area to another and this can have serious environmental, economic and social consequences.

Erosion and Sediment Control Guidelines for the **Built Environment**, **Service Corridors, Transport Corridors**, **Broadacre Agricultural Farming** and the **Rehabilitation of Old Infrastructure** and the associated **Technical Notes** will provide a valuable resource in helping to plan, control and limit the impact of erosion and sedimentation. These guidelines each focus on the particular erosion and sediment issues which may arise with developments within these areas and provide information for the preparation and implementation of Erosion and Sediment Control Plans for the various site types.

These guidelines can assist land developers, owners and managers to fulfil their duty of care and avoid potential penalties under current legislation. By following the principles outlined in the guidelines when planning for development, the protection and maintenance of environmental, cultural and recreational land and water resources can be achieved.

Erosion and sediment controls should be incorporated early in any large or small scale land development process and be included in budget estimates. In selecting and constructing erosion and sediment control systems, an appreciation of the differences between the two is important.

- Erosion control measures assist in protecting or strengthening the soil's surface or subsurface from being eroded and diverts runoff in a non-erosive way.
- Sediment control measures capture and remove eroded soil particles from runoff prior to the water leaving the site.

Installation of erosion control measures should be undertaken in the first instance as erosion control measures are cheaper and easier to implement than sediment control systems. However, when erosion controls are used in conjunction with sediment controls, the size of the sediment control structures and associated maintenance may be reduced, decreasing the overall treatment costs.

Erosion and Sediment Control Plans (ESCP)

The key to successful erosion and sediment control is planning. Generally control measures are not enough if just considered on their own. There must be a combination of structural controls, good site management and construction practices to achieve effective controls. ESCPs can assist in bringing together all of these aspects.

An ESCP is a plan that shows how to minimise soil erosion on, and sediment from, any type of development site. These plans should communicate how erosion and sedimentation can be controlled on and off site. The erosion and sediment control measures as outlined in the plan must be installed before any disturbance of the site occurs.

As a general rule an ESCP should be prepared when:

- The area(s) to be cleared on a site contain highly erosive soils
- The area(s) to be cleared on a site have slopes with more than a 2 per cent gradient
- The proposed development involves major earthworks or major changes to natural drainage.
- The area(s) to be cleared are located in the tropical regions of the Northern Territory and will have exposed soils between 30 September and 1 May
- The area(s) to be cleared will have exposed soils at any time of the year within the arid and semi-arid regions of the Northern Territory

It is best practice to develop an erosion and sediment control plan for any earthworks to be undertaken whether they are subject to statutory requirements or not. Developing a plan helps to identify the overall requirements for drainage and revegetation, assists in determining what level of protection methods may be required and reduces costs for repairs and/or rehabilitation.

Where developers have been given a condition of approval, a component of an environmental management plan or a reason for deferment which requires an erosion and sediment control plan, it is their responsibility to source the appropriate information and to develop the plan. Developing, gaining approval and implementing an erosion and sediment control plan is generally a condition of a development permit for subdivisions, large scale clearing activities and other developments where substantial earthworks are to be undertaken.

Erosion and sediment control plans are normally submitted to the Department of Natural Resources, Environment and The Arts (NRETA) for approval prior to works commencing on site. Officers will assess the plan and liaise with the developer regarding the content of the plan. Once the plan is determined to be satisfactory, an approval letter will be provided to the Development Consent Authority and copied to the developer. This process will generally be undertaken within a two week period from the date the final plan has been submitted to NRETA.

The implementation and maintenance of the erosion and sediment control structures also resides with the developer and NRETA will ensure that the plan is adhered to. An endorsed and operational erosion and sediment control plan may not require any further reporting by the developer but rather a maintenance schedule of activities which are often closely linked to final sign-offs and prevailing weather conditions.

Contact details for submission of ESCPs are provided at the back of these guidelines.

Legislation

While the Northern Territory Government is ultimately responsible for the safe keeping of the resources, the landowner has the primary responsibility for the prevention and control of land degradation, and care of resources. The two main Acts which relate to erosion and sediment control are:

Soil Conservation and Land Utilization Act and Water Act

The *Soil Conservation and Land Utilization Act*, which assists in protecting sensitive areas and in reducing the impact of sediment on land downstream, and the *Water Act* which provides for the investigation, use, control, protection, management and administration of water resources within the Northern Territory. Both of these Acts are administered by the Natural Resource Management Division of NRETA. Copies of the Acts can be viewed on the Northern Territory Government website www.nt.gov.au

For further information on issues relating to either of these two Acts please contact:

Natural Resources Management Division – Darwin

Address PO Box 30
Palmerston NT 0831
Telephone (08) 8999 4552
Facsimile (08) 8999 4445

Natural Resources Management Division – Alice Springs

Address PO Box 1120
Alice Springs NT 0871
Telephone (08) 8951 9208
Facsimile (08) 8951 9268

Related Legislation

There are a number of other legislative Acts which may be relevant to erosion and sediment controls, pending the type of development or the location of the proposed site. All of these can be viewed on the Northern Territory Government website www.nt.gov.au and include the following:

Pastoral Land Act

The Northern Territory's pastoral land administration system is designed to promote sustainable land use and sound land management practices. A fundamental objective of the *Pastoral Land Act* is to ensure that pastoral leases achieve sustainable use of natural resources and remain economically viable. The Act is administered by the Rangelands Management Branch of NRETA. For further information on issues relating to this Act please contact:

Rangelands Management Branch – Darwin

Address PO Box 30
Palmerston NT 0831
Telephone (08) 8999 4455
Facsimile (08) 8999 4403
Email rangelands.nreta@nt.gov.au

Rangelands Management Branch – Alice Springs

Address PO Box 1120
Alice Springs NT 0871
Telephone (08) 8951 9220
Facsimile (08) 8951 9268
Email rangelands.nreta@nt.gov.au

Planning Act

The *Planning Act* provides for the planning and control of the use and development of land contained within designated planning areas (which may or may not be subject to a planning instrument) and to all other freehold land. The Act is administered by Development Assessment Services in the Department of Planning and Infrastructure. For further information on issues relating to this Act please contact:

Development Assessment Services – Darwin

Address GPO Box 1680
Darwin NT 0801
Telephone (08) 8999 6630
Facsimile (08) 8999 7189

Development Assessment Services – Alice Springs

Address PO Box 2130
Alice Springs NT 0871
Telephone (08) 8951 9242
Facsimile (08) 8951 9222

Mining Management Act

The *Mining Management Act* contains general provisions for the management of potential environmental effects emanating from mine sites including water and ground water management. The Act is administered by the Minerals and Energy Group of the Department of Primary Industry, Fisheries and Mines. For further information on issues relating to this Act please contact:

Minerals and Energy Group – Darwin

Address GPO Box 3000
Darwin NT 0801
Telephone (08) 8999 6443
Facsimile (08) 8999 6824
Email geoscience.info@nt.gov.au

Minerals and Energy Group – Alice Springs

Address PO Box 8760
Alice Springs NT 0871
Telephone (08) 8951 8177
Facsimile (08) 8951 8188
Email minerals@nt.gov.au

Energy Pipelines Act

The *Energy Pipelines Act* provides for the regulation of the construction, operation and maintenance of pipelines used for the carriage of energy producing hydro-carbons. The Act is administered by the Minerals and Energy Group of the Department of Primary Industry, Fisheries and Mines. For further information on issues relating to this Act please contact:

Minerals and Energy Group – Darwin

Address GPO Box 3000
Darwin NT 0801
Telephone (08) 8999 6443
Facsimile (08) 8999 6824
Email geoscience.info@nt.gov.au

Minerals and Energy Group – Alice Springs

Address PO Box 8760
Alice Springs NT 0871
Telephone (08) 8951 8177
Facsimile (08) 8951 8188
Email minerals@nt.gov.au

Heritage Conservation Act

The *Heritage Conservation Act* provides for the recording, declaration, conservation and protection of heritage and archaeological places and objects. The Act is administered by the Heritage Conservation Services of NRETA. For further information on issues relating to this Act please contact:

Heritage Conservation Services - Darwin

Address PO Box 496
Palmerston NT 0831
Telephone (08) 8924 4143
Facsimile (08) 8924 4053
Email heritage.nreta@nt.gov.au

Heritage Conservation Services – Alice Springs

Address GPO Box 1120
Alice Springs NT 0871
Telephone (08) 8951 9247
Facsimile (08) 8951 9222
Email

Waste Management and Pollution Control Act

The *Waste Management and Pollution Control Act* assists in ensuring clean air, water and land resources for the benefits of all Territorians, industry, businesses and individuals who create waste and potentially pollute. The Act is administered by the Environmental Operations Branch at the Environment, Heritage and The Arts Division. For further information on issues relating to this Act please contact:

Environment, Heritage and The Arts Division – Darwin

Address PO Box 496
Palmerston NT 0831
Telephone (08) 8924 4138
Facsimile (08) 8924 4053

Environment, Heritage and The Arts Division – Alice Springs

Address PO Box 1120
Alice Springs NT 0871
Telephone (08) 8951 9201
Facsimile (08) 8951 9268

Environmental Assessment Act

The *Environmental Assessment Act* provides for the assessment of the potential environmental effects of development proposals prior to the determination of project consent through the preparation and review of an environmental report. The Act is administered by the Environment, Heritage and The Arts Division. For further information on issues relating to this Act please contact:

Environment, Heritage and The Arts Division - Darwin

Address PO Box 496
Palmerston NT 0831
Telephone (08) 8924 4138
Facsimile (08) 8924 4053

Environment, Heritage and The Arts Division – Alice Springs

Address GPO Box 1120
Alice Springs NT 0871
Telephone (08) 8951 9201
Facsimile (08) 8951 9222

The 5 erosion factors

There are five basic factors which determine the potential occurrence and severity of erosion. These factors are:

- Rain or wind
- Soil erosion risk
- Runoff velocity
- Vegetation
- Erosion control techniques

These factors are all linked closely. Intense rainfall on a disturbed slope with no vegetation, highly erosive soil and no control measures will cause severe erosion, whereas a slope under the same conditions but vegetated and with appropriate erosion control measures in place will not erode at a faster pace than what could be expected to happen naturally.

The key to ensuring that the erosion factors are balanced lies in a thorough assessment of the area prior to development based on which an estimation of the annual rate of erosion can be made. An elaborate equation known as the Revised Universal Soil Loss Equation (RUSLE) has been developed in NSW to measure the susceptibility of a site to erode. It is a complex equation requiring extensive data, some of which is not readily available for the Northern Territory and which may not be applicable to the Northern Territory, consequently it has not been used widely here. While there is no need to use this equation, as a very good estimate can be made based on a thorough assessment of a site, some may wish to regardless. Details of the RUSLE can be obtained through the website of the NSW Department of Natural Resources in the free publication *Soiloss: A Program to Assist in the Selection of Management Practices to Reduce Erosion*.

Rain or wind

The wet season in the tropical areas of the Northern Territory with intense rainfalls and the intense, but less frequent, rainfalls in the arid and semi-arid regions provide high amounts of energy for erosion. Soil particles are more likely to be broken up and carried away by heavy storms due to heavier raindrops. However, in the lower rainfall regions of the Northern Territory, wind is the prevalent cause of erosion during dry periods.

In assessing a site and its requirements in terms of the control measures that may be required it is necessary to take into account the intensity and quantities of rain which can be expected in that particular area. Rainfall data can be obtained from the website of the Bureau of Meteorology (www.bom.gov.au).

In the arid and semi-arid regions of the Northern Territory erosion caused by wind is a significant factor. While erosion by wind can occur all year around, it is the combination of soil characteristics (particle size, clay content, etc), topographic features, rainfall, vegetation and of course the wind which determines the likelihood of it occurring. As a general rule, the risk of wind erosion is greater on areas with sandy soils, flat open country, during dry times when soil moisture is lowest, when vegetation cover is lost and winds above 28km/h are present.

In the Alice Springs area September is the time when wind erosion is most likely to occur, because the vegetation has been eaten, died or blown away leaving the very dry soils exposed to the wind.

Soil erosion risk

Soil is a valuable resource which takes thousands of years to form. It is created from the breakdown of sediments and rocks and involves a range of biological, chemical and physical processes.

The susceptibility of soil to erode is determined by its ability to resist detachment and transport as a consequence of rainfall, wind and runoff, and by its ability for water to infiltrate into the soil. Some hard setting soils and soils with an impenetrable surface, suffer from reduced infiltration and increased velocity of run-off which results in erosion risk down slope. Aspects such as protective ground or surface cover, land slope, drainage, soil texture, aggregate size and aggregate density are important factors for the soil to resist erosion.

There are five basic components to any soil:

- Mineral particles (clay, silt and sand)
- Organic matter
- Water
- Air
- Living organisms

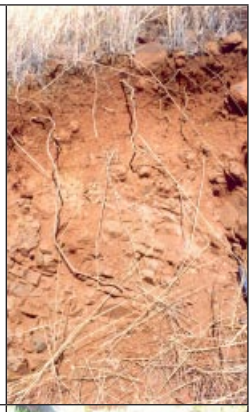
Soils contain varying levels of these components which all contribute to the unique appearance, fertility levels and chemical composition of the soils.

Some soils are naturally more inclined to erode than others and it is therefore important to assess the soil which will be exposed during development to determine the erosion risk of the soil.

Following, is a quick guide to identifying basic soil types.

SOILS OF THE NORTHERN TERRITORY				
TYPE	**CHARACTERISTICS**	**MANAGEMENT ISSUES**	**LANDSCAPES**	**PROFILE**
SILTSTONE SOILS	Pale brown Prominent on undulating to steeper slopes Very shallow (<50cm)	High erosion risk due to slope and silt content Prone to forming 'bulldust' when disturbed Weathered siltstone underlying these soils can be used as a stable medium for the base of table drains	Common in the Darwin region such as the Mitchell Creek Catchment, Channel Island Road, Finniss Range, Marrakai, Adelaide River and Mt. Bundey vicinities. Outcrops across the Daly Basin.	
LATERITIC SOILS	Widespread across gentle landscapes Often deeper then those soils formed on siltstone Brown or red in colour	Generally the better soils in the Top End for gardening and horticulture. Retain top soil where possible. Coffee rock underlying these soils like weathered siltstone can be used as a stable medium for the base of table drains Erodible if disturbed due to their sandy nature	Laterite forms large almost continuous sheets across the Top End in the Wadeye region, Tiwi islands, Dundee Beach and the Howard Springs and Humpty Doo rural areas. They are also common across the coastal plains of Arhnem Land, Sturt Plateau and south into the Victoria River District, Roper and Southern Gulf regions.	
GRANITIC SOILS	Underlain by weathered granite including quartz, coarse granitic sand or pale kaolonite Generally shallow Coarse sandy textured (gritty)	Very high erosion risk due to the presence of coarse sand, especially where sand has been deposited from hill slope or creek wash. Avoid disturbance.	Widespread in the Pine Creek region. Extend north in patches to areas north and south of the Finniss River and the upland plains adjacent to the Mary River floodplains. Pockets in the southern Victoria River District and Tanami and Arnhem region.	
POORLY DRAINED SOILS	Seasonally waterlogged soils Located on flat landscapes and drainage depressions more prominent in the Top End Grey, pale or dark in colour, as opposed to dark brown red Often in association with tall termite mounds Soil mottling common at depth	Saturated and/or inundated in most wet seasons Soils can be unstable High erosion risk due the movement of water over the soil during wet periods Not suitable for housing and associated infrastructure (ie. bores and septics) Often not identified as being wet because they dry later in the year Avoid disturbance	Widespread across the Top End in drainage depressions and some flat landscapes in the Top End. Extend south to the Sturt Plateau, Roper, Southern Gulf and Northern Victoria River District.	

VERY POORLY DRAINED SOILS	Swamps, wetlands, mangroves, stream channels and floodplains Annual seasonal inundation for several months in most years	Saturated and/or possibly inundated during wet seasons extending well into the dry season High erosion risk due the movement of water over the soil during wetter months Unstable soils Not suitable for housing and associated infrastructure (ie. bores, septics) Protection supported by legislation Important areas for groundwater recharge, bird habitat and general landscape health Do not disturb	Includes coastal floodplain systems, wetlands and swamps of the Top End including marine environments such as mangroves. Well known areas in the Darwin region include Knuckey's and McMinn's lagoons and the coastal floodplains of the Mary and Adelaide Rivers.	
SANDY SOILS	Soils formed from the weathering of sandstone or deposition of sand. Vary from very shallow sands on sandstone, to deep sands washed from adjacent hills to deep wind blown sands in the arid zone. Differ to granitic soils in that they are made up of finer sand particles Loosely composed	Low cohesion therefore easily disturbed and eroded Unstable	Widespread across the arid zone, Sturt Plateau and levees of rivers in the Top End. Also common at the base of sandstone scarps such as the Arnhem escarpment and Pinkerton, Davenport, MacDonnell and Wingate Ranges	
CRACKING CLAYS	Cracking clay soils often formed from basalt, limestone or alluvial action Usually black or dark brown Favorable pastoral land High nutrient levels compared to other soils in the Northern Territory	Generally occur on flat landscapes so therefore have a lower erosion risk then those soils on steeper slopes Heavily grazed exposed areas with some slope can be a high erosion hazard during intense storm activity	Form extensive areas across the Barkly Tableland, Victoria River District, Lower Keep River, Sturt plateau and coastal floodplains of major river system in the Top End. Can be saline at depth in lower rainfall areas such as the Barkly Tableland and Alice Springs regions	
CALCAREOUS SOILS	Soils formed on limestone Attractive for horticulture and agriculture	In some areas such as Hardman basin in the upper Ord catchment these soils are very highly erodible A highly erodible soil combined with heavy grazing pressure in the past has resulted in some areas in the Upper Ord River catchment to only very lightly stocked or even de-stocked completely The chemical composition of these soils needs to be measured to determine soil erodibility	Restricted to small areas in the Mataranka, Katherine, Tindall and Daly Districts. Also occur in the Victoria River and Ord River Catchments	

VOLCANIC SOILS	Formed on basalt and dolerite Generally structured Higher clay content then soils formed from sandstone, limestone and laterite Dark brown or red Contain significant amounts of rock Shallow	Low to moderate erosion risk Higher fertility then soils formed from sandstone, limestone and laterite Associated with significant slopes	Restricted to the Victoria River District and small areas in the Roper, Barkly and Alligator Rivers Region.	
ACID SULFATE SOILS	Form naturally in mangrove, salt marshes and coastal floodplains Inundated from tides or annual flooding Harmless if undisturbed	If drained or dried sulfuric acid is formed and heavy metals released. Acid runoff kills fish and other marine life Only disturb where absolutely necessary If disturbance is necessary an investigation must be undertaken by a trained professional to determine if they are present and at what levels Any disturbance must be accompanied by appropriate investigations and an acid sulfate soil management plan	Restricted to mangrove and estuarine environments including former marine landscapes such as the coastal floodplains of major river systems.	
SODIC SOILS	Restricted to older alluvial plains Very pale bull dust soils	Very high erosion risk due to the particle size and presence of sodium Once sodic subsoil is exposed soil particles repel each other causing a catastrophic erosion affect Very expensive and difficult to rehabilitate Avoid any disturbance especially at depth	Common across the Tortilla Flats and floodplains immediately south of the Adelaide River Township and the Mt Bundey areas. Also known to occur on clay plains in the semi arid and arid zone.	

Essentially, unconsolidated or mechanically disturbed soils are at high erosion risk, therefore cut and fill operations should be minimised and care should be taken to ensure fill is appropriately compacted and stabilised.

Further information on soils can be obtained from NRETA's website at http://www.nt.gov.au/nreta/natres/soil/ or from the list of reading resources at the back of this guideline.

Runoff velocity

The slope of the land is an important factor in determining the capability of the land to adequately sustain any proposed development. The runoff velocity or speed with which runoff occurs is associated with the length and steepness of a site. It is important to gain a sound understanding of the surrounding topography to determine how much water will run onto the site and also where water will drain to after leaving the site. This enables adequate planning for drainage requirements during construction as well as at the completion. By assessing this prior to the commencement of works the potential changes to runoff can be adequately addressed and structures and drainage can be planned accordingly. For this reason topographic maps with elevation contours are invaluable for the initial planning of the development. Contour lines can be used to determine the location of steep terrain, creeks and drainage lines.

An estimation of the runoff for a site should be determined before appropriate control measures are selected for a site as the correct size and style of a control measure can avoid unnecessary maintenance, reduce sediment offsite, and subsequently save money in the long run. The Bureau of Meteorology (www.bom.gov.au) will be able to supply the maximum rainfall figures for your area of interest which will, along with soil type and topographic details, assist in preparing an erosion and sediment control plan.

Vegetation

Vegetation or mulch protects the soil surface from the impact of raindrops or wind. It also reduces runoff velocity, disperses water flow, and promotes infiltration and deposition of sediment. With little or no vegetation or ground cover the risk of erosion increases. In planning development of a site it is preferable that as much of the existing vegetation as possible is retained to reduce the impact of erosion.

Erosion control techniques

If the rainfall, soil, runoff velocity and vegetation factors are not ideal to protect an area from soil erosion, there are various techniques which can be used to improve potential detrimental impact on a site. The suitability of various erosion and sediment control structures vary dependent on the site, the location within the catchment and regional rainfall levels. Various measures are mentioned below and technical details of erosion and sediment control measures and techniques are outlined in the Technical Notes.

Types of erosion

There are a number of types of erosion which all require slightly different methods of control, treatment or management. Below are brief descriptions and causes of each type followed by relevant erosion control measures which can potentially be applied to stop or slow down the problem. The effectiveness of these methods will depend on the situation and will need to be assessed individually as outlined above.

Coastal erosion

Erosion of the coastline can be caused by a number of human activities including construction of buildings, removal of vegetation and heavy usage. The general outcome is a reduction in dunes, loss of beach or mass movement of cliff face.

There are a number of ways to prevent further coastal erosion including:

- Rehabilitation and revegetation of degraded sites
- The planting of native grasses and plants
- Engineered structures

Rill erosion

If runoff is travelling over uneven soil at a quick pace shallow channels may form. These are known as rills and are usually no more than 30cm deep. They can, however, be quite long and widespread over an area. Water flows quickly in a rill because it is concentrated, leading to increased detachment and transportation of soil particles. The faster water travels, the greater it's scouring and cutting force. This can in some cases lead to the formation of gullies.

As with sheet erosion, degree of slope and vegetation play an important role in determining the severity of rill erosion. On long slopes, water can accumulate quickly in channels and form rills. This is particularly the case where vegetation is scarce. Vegetation and ground cover spreads the flow over a wider area, reducing its velocity. At lower velocities, the runoff cannot carry as much loose soil, and the excess is deposited as sediment.

The main way to prevent further rill erosion includes:

- Rehabilitation and revegetation of degraded sites
- The planting of native grasses and plants

Gully erosion

Gullies are formed when rills become deeper channels and they flow intermittently, during and shortly after rainfall. Gully formation begins with scouring of the topsoil within a channel. The gully head then usually moves upslope due to incision by concentrated runoff, or slumping by subsoil dispersion. This causes the channel to become longer and wider. A waterfall may form at the gully head, which can lead to undercutting and further slumping of material into the gully floor, also contributing to the advancement of the gully head.

Factors affecting the rate of gully erosion include the slope of the channel (the steeper the slope, the higher the erosive power of the flow), the size and shape of the gully and the direction of the channel. Other factors are the size and nature of the catchment, soil type and vegetation.

Gullies cannot be stabilised through cultivation, due to their depth and size. Treatment of gully erosion requires careful planning and attention to detail as inadequate treatment often makes the problem worse. The first requirement is to remove the cause of the problem. This may involve the removal or exclusion of stock, relocation of tracks, revegetation of cleared areas, and/or drainage redesign.

Filling should only be attempted after the water flow that caused the gully has been controlled or diverted above the gully head. Otherwise fill placed in the gully is likely to be undermined and washed away. The common practice of filling gullies with rubbish, logs, rocks, car bodies and other foreign material does very little to solve the problem. In most cases, it makes the gully worse.

There are a number of ways to prevent further gully erosion including:

- Rehabilitation and stabilisation
- Diversion banks
- Level sills / spreaders
- Drop structures

Sheet erosion

Sheet erosion occurs when loose or detached soil is transported in a uniform layer, with no channelled flow. Small particles are carried in suspension, while larger, heavier particles are “bounced” along (saltation). Long, steep slopes also increase the effects of sheet erosion due to the higher velocity of runoff.

There are a number of ways to prevent further sheet erosion including:

- Rehabilitation and revegetation of degraded sites
- The planting of native grasses and plants
- Installing temporary sediment fences

Stream bank and bed erosion

Rivers are naturally dynamic systems that transport and deposit sediment throughout their course. Generally the outer edges of bends in the system (where the water flows faster) are undercut and eroded, with the resultant sediment being deposited on the inside edges.

This process produces and extends meanders. Any change in the amount and frequency of flow will have an effect on these processes. If channel flow increases, the water is able to carry more and larger particles. This can lead to bank erosion, and in severe cases whole sections of riverbank can fall into the river and be transported downstream as sediment. Soil carried in suspension may travel hundreds of kilometres before being deposited.

Anything that increases runoff within a catchment can result in increased channel flow. Obviously, an increase in runoff allows more water to enter the river/stream system. This situation is worsened if the vegetative cover along the banks of waterways is reduced or destroyed.

There are a number of ways to prevent further stream bank erosion including:

- Rehabilitation and revegetation of degraded sites
- The planting of native grasses and plants

Tunnel erosion

This is a minor form of erosion in the Northern Territory, and occurs mostly in sodium rich clay subsoils. When water penetrates the subsoil, this soil becomes non-cohesive and is easily dispersed.

Water may enter the subsoil through old stump holes, burrows or other depressions. In severe cases, enough subsoil may be washed away to form a tunnel. If the overlying topsoil collapses, a gully is formed.

There are few ways to prevent further tunnel erosion and mostly it is a matter of stabilising the area once the tunnel(s) has been discovered.

Water erosion

Raindrops falling on bare soil break individual soil particles loose, allowing them to be picked up and carried away by runoff. These particles block air and water pathways into the soil, decreasing infiltration and increasing runoff.

The size and velocity of raindrops determine their ability to dislodge the soil therefore the higher the intensity of the storm, the greater the erosive capacity of the raindrops. Vegetative cover and surface litter absorb energy from raindrops, reducing the amount of soil splash.

There are a number of ways to prevent further water erosion including:

- Rehabilitation and revegetation of degraded sites
- The planting of native grasses and plants
- Mulching

Mass movement

Mass movement is the process where a mass of land slides down slope. The activating force is gravity, but movement usually occurs when the weight of the soil has been increased. This is often caused by excessive groundwater entering the area, usually through the removal of vegetative cover. The removal of support at the toe of a slope is also a major cause of mass movement. This is not a major form of erosion in the Northern Territory. It may occur at road cuttings where excavation has been too steep, on riverbanks or on construction sites.

The main way to prevent further mass movement erosion includes:

- Rehabilitation and revegetation of degraded sites
- The planting of native grasses and plants

Wind erosion

Wind erosion occurs on relatively dry soils, so it is more of a problem during dry seasons and drought. Air turbulence created by vehicles driving along unsealed roads and tracks acts on the road surface in the same way as natural wind, and can lead to the loss of significant amounts of fine-grained material from the road surface.

Wind transports soil in three ways - saltation, suspension and surface creep. Saltation occurs through direct pressure of the wind on the soil, where particles are detached by the wind and bounced along the surface. Airborne particles hitting the ground may dislodge other particles, which in turn are carried forward.

Some of the detached particles will be small and light, and so will be carried in suspension and blown away as dust. Larger particles that are too heavy to be bounced or suspended are rolled along the ground, either directly by the wind or by the impact of other particles. This is known as surface creep.

The susceptibility of an area to wind erosion depends primarily on climate, soil texture and vegetation cover. Unlike erosion by water, wind erosion is not as heavily influenced by terrain or slope.

There are a number of ways to prevent further wind erosion including:

- Rehabilitation and revegetation of degraded sites
- The planting of native grasses and plants
- Applying chemical surface stabilisers
- Wind breaks

The Built Environment

There are many types of different developments associated with the built environment, however this section deals primarily with urban and rural subdivisions and industrial and commercial development.

In many cases when undertaking urban and rural subdivisions, consideration of similar issues are required. Urban subdivisions require the provision of comprehensive services such as reticulated water, sewerage, power, communication lines, roads, footpaths and drainage, (both piped and open). Compared to a rural subdivision, the works required for urban subdivisions are considerably higher in costs, more complex and are usually a significant modification of the landscape.

Rural subdivisions on the other hand require the construction of firebreaks, fence lines, accesses, roads, and drainage, usually over a much larger area than urban subdivision. As works required for rural subdivisions are often of lower density the degree of disturbance required is reduced compared to a subdivision of urban land. Vegetation clearing in rural subdivision development is largely restricted to roads, firebreaks and fence lines.

In either urban or rural subdivision, issues such as significant and sensitive native vegetation, natural features such as drainage lines, creeks, rivers, and escarpments and coastal fringes, all need to be thoroughly considered in the initial planning stages to ensure that the proposed works will not have a detrimental impact on the surrounding environments.

Commercial land development requires the construction of services such as sewerage, power, reticulated water, communication lines, roads, drainage (piped and open) but are also often subject to substantial cut and fill earthworks and on completion are often completely sealed. Due to the large areas of hardstand and subsequent reduced infiltration on these sites, it is essential that drainage design and protection measures are given extensive planning and consideration at the beginning of the process.

Industrial land requires the installation of similar services to urban and commercial subdivisions and development, thereby requiring high levels of disturbance through earthworks and compaction. Industrial subdivisions may not necessarily be sealed on the completion of works and can be subject to heavy traffic. Typical issues associated with these developments include reduced infiltration and increased runoff. Drainage design and protection measures are high priority areas for the management of erosion and sediment control and ultimately drainage plans may need to accommodate various waste or pollutants on site.

For both industrial and commercial development the major issues are drainage and pollutants.

Design

The first step to managing the potential for erosion and sediment at a given location is to undertake a risk assessment of the site. A risk assessment involves looking at the site and identifying those issues which may arise and which will require planning and management prior to the commencement of development at the site. The issues to be assessed should include:

- Identifying areas which will be disturbed
- Identifying areas of vegetation to be retained (including ‘No-Go’ areas)
- Location of existing infrastructure
- Location of site entry and exit points
- Location of existing drainage lines
- Assessing areas of existing erosion, if any
- Ascertaining soil types on the site and in particular erosion prone soils

Site layout

Once these key issues are identified the next step is to determine site layout. Identify where particular works will be undertaken giving consideration to the location of the above key issues. Include things such as:

- Areas of future disturbance
- Location and number of stockpiles
- Site entry and exit points. It is good practice to have one entry and exit so as to minimise the area of disturbance and reduce the amount of controls required
- Location and design of drains. The type of drain will determine the amount of soil disturbance required
- Location of driveways
- Location of roads
- Location of access tracks throughout the site
- Location of the works compound and site office. If possible, select an area close to site entry and one which is already disturbed
- Location of parkland (if any) so native vegetation can be retained in this area

Once these issues are identified, consideration should now be given to how these risks will be managed. In considering how the site will be protected and what controls will be utilised to minimise the risk of erosion and subsequent sedimentation, the topography, drainage, soil erodibility and vegetation will need to be factored in.

Topography

Topography refers to the characteristics of land in terms of elevation, slope and orientation. This information can be recorded on a map by a variety of techniques including contour lines. Topographic information is required for an Erosion and Sediment Control Plan (ESCP) to ensure that the proposed development is located and constructed in appropriate locations to minimise the impact on the surrounding environment and to enable control structures to be located in the most effective location. The topography or slope of the land will determine how water and sediment will behave on a site and where it will concentrate and move off-site. It can also help determine where problem areas may be and prevent subsequent costly solutions such as the undermining and damage of expensive infrastructure. Other features of the landscape such as vegetation and man made features should also be added to the plan along with contour lines to ensure that the ESCP reflects all the natural and man-made features of the site.

Drainage

With any change in land use such as a subdivision or industrial development it is important to understand the impact drainage may have on the surrounding environment. When planning the development it is essential to have an understanding of the existing natural drainage not only on the site but also of the surrounding catchment.

Run-on from upslope of the work area will have to be diverted around or managed through the site. A good understanding of the natural drainage system will assist in dealing with and discharging these flows so that they are not detrimental to the site or adjacent land and waterways.

When considering drainage there are several aspects to take into account:

- Identify any natural waterways (eg. drainage lines, creeks and rivers).
- Ensure that receiving waters and habitats are protected from the impacts of stormwater and runoff (eg. using buffer zones, filter strips).
- Ensure that when draining towards a natural waterway the drain is terminated a minimum of 25 metres away from the waterway and any associated native vegetation buffer so that it can sheet flow through established native vegetation.
- Ensure that the drainage design minimises stormwater runoff by avoiding channelling and concentration of flow and makes use of the existing topography, natural drainage lines and vegetation to treat, detain, retain and allow for infiltration of stormwater.
- Where drain construction is required it is recommended that trapezoidal or parabolic drains are constructed not "V" drains or open unlined drains.
- All drains are stabilised, and preferably vegetated.

In small subdivisions it may not be necessary to provide extra drainage but it is recommended to investigate any existing drainage systems (or sheet flows) for signs of erosion that may require rectification works and to conduct an assessment on the efficiency of existing drainage systems.

Soil erosion risk

While some types of soils are more susceptible to erosion than others, all areas cleared of vegetation are at some risk of either water or wind erosion. It is therefore desirable that any area of soil exposed by clearing should be minimised at any one time. If extensive clearing is unavoidable, land which is not to be used immediately should be stabilised with a grass cover prior to the first wet season rains in the tropical regions and as soon as possible in the arid and semi-arid regions where rain is more unpredictable. In the tropical regions, this should be done well in advance so that sufficient time is allowed for the grass to establish before the onset of the wet season.

Vegetation

Vegetation clearing should be kept to a minimum to retain or preserve as much native vegetation as is possible. Retained vegetation is very effective in reducing runoff and filtering sediments and can be utilised throughout the construction phase. Retained native vegetation can also help reduce costs and labour in managing runoff and sediment.

Low areas including areas subject to seasonal water logging should be avoided as they require considerable fill to create positive drainage.

The installation of services (power, water, sewerage, roads etc) will in many cases require the removal of native vegetation. In these instances the areas not to be cleared should be clearly identified as NO-GO areas and flagged to ensure that plant operators are aware of these locations and that the impact on adjoining vegetation is minimised.

Cleared vegetation can be mulched and stored onsite and then used in the construction of controls such as mulch banks during the course of construction.

For further details on mulch banks refer to Technical Note No. 4: Filter Strips.

Site management

Timing and duration of development

When planning new development it is highly recommended that a timeline is developed which takes into consideration all of the activities that will be undertaken. This helps to ensure that the proposed commencement and completion dates are achievable and that the site is rehabilitated or at least stabilised in the interim prior to October in the tropics and as soon as possible in the arid and semi-arid regions where rain is more unpredictable. If the development is of a magnitude that will not be completed prior to this time, consideration should be given to staging the proposed works. Staging can reduce the cleared, disturbed or modified area to a more manageable size. It is important to remember that the larger the disturbed area, the more management and maintenance will be required to ensure erosion and subsequent sedimentation is minimised. It is also important to remember that the tropical wet season can often cause extended delays and pauses during construction.

Erosion and sediment controls

Due to the nature of subdivisions, there are generally large areas of exposed soil. While these can be reduced by retaining vegetation on individual lots until they are sold, by staging the subdivision works, and by breaking up the internal catchment into more manageable parcels, there will be a number of areas where the risk of erosion is higher than in other areas of the development site and priority can be given to management of these areas.

In urban subdivisions these areas include:

- Along verges and footpaths
- In open stormwater drains and along the edges of inverts
- Around headwalls of culverts where the area is subject to rilling and eventually gully erosion
- On large bare areas which are particularly prone to wind erosion and sheet erosion

Rural subdivisions have a tendency of higher erosion risk in the following areas:

- On boundary lines located along a slope
- In the area around headwalls of culverts
- In table drains
- Around power poles (liaise with local power authority to determine locations)
- Around windrows which have not been removed (windrows should not be created as they channel water and increase erosion risks)
- In open stormwater drains
- Around permanent structures

For industrial and commercial development sites, high erosion risks to be aware of include:

- In open drains if batter ratios are insufficient
- Sites left undeveloped for extended periods of time. Ideally all cleared sites should be grassed to stabilise the site until development is commenced

Generally the development should be mindful of steep slopes, long low slopes and areas which require substantial modification. The following points should also be considered where relevant:

- Concentrated flows should be diverted to points where they can pass through or around the site with minimal impact on the development.
- Water from the upper catchment above the construction site should be directed away from the work area during construction.
- Any offsite devices such as gross pollutant traps and sediment control basins, are only effective in trapping coarse sediments. For that reason, onsite controls and practices such as sediment fences and diversion of clean water around the site are important and ultimately less costly than offsite controls.
- It is recommended that only one construction exit/entry pad is established and used for the site.
- Grassing of exposed / bare areas on the development site to assist trapping of soil before it reaches the roadway and stormwater system.

Supplies and stockpiles

There are a few basic methods which can significantly reduce erosion of stockpiles and supplies and stop sediment entering waterways.

- Try to locate all stockpiles in a central area, on an open flat area and away from drainage lines and creeks. Building materials at risk of erosion should not be placed on nature strips, footpaths, roads, kerbs, on or near site access points, or on public reserves.
- It is good practice for all stockpiles, no matter where they are located, to have controls such as sediment fencing installed a few metres from the base. This will minimise the risk of sediment leaving the stockpile area in un-seasonal rain events.
- All stockpiles and building materials should be protected from run off by placing diversion banks upslope.
- Accidental spills of soil or other materials onto the road or gutter should be removed before they enter the stormwater system.
- All site debris and unused construction materials should be removed from the site or protected from erosion before the site is vacated.

Construction of Control Measures

Below are a number of control measures which are commonly used to control erosion and sediment for this type of development. Depending on the individual situation and the nature of the issue which requires control it may only be one or a combination of measures which would suit a specific location. Please refer to the relevant *Technical Note* for more information on the limitations, advantages and construction requirements of each of the measures.

Commonly used structures and techniques for erosion and sediment control

Temporary measures

- Catch drain (only suitable for use in the tropical regions)
- Coir logs
- Construction site exit pad
- Diversion bank
- Filter strips
- Geo binders
- Geotextile (temporary stabilisation of drain batters, installed under any temporary rock placements)
- Grassing
- Inlet pit protection devices
- Jute matting/mesh
- Mulch banks
- Ponding
- Retained native vegetation
- Check dams
- Sediment basin
- Sediment fence
- Water spraying

Permanent measures

- Cellular Confinement System (product consisting of expandable, polyethylene panels)
- Drop structures
- Gabions
- Geotextile (installed under any permanent rock placements)
- Grassing (open drains, verges and large disturbed areas)
- Ground covers and mulch
- Flumes, chutes and batter drains
- Mulch (composted organic mulch, gravel, hydromulch)
- Outlet dissipaters (impact, rock rip rap, reno mattress)
- Recycled tyre derived products (product used for drop structures, erosion control systems)
- Rock lined drain batters
- Sediment basin
- Stone/rock pitching

Maintenance

Erosion and sediment control structures are only effective if they are maintained regularly. The importance of maintenance of structures cannot be stressed enough. As a general rule the maintenance of any structures can be reduced if general good practices are put in place including:

- Building the structure properly with the right material.
- Keeping the site neat and tidy at all times.
- Assessment and identification of risks are undertaken and measures are prepared and put in place to deal with potential emergencies.

Monitoring

Monitoring should be carried out on a regular basis. It is good practice to monitor erosion and sediment controls regularly throughout the duration of the development, even in periods of dry weather. A standard monitoring schedule should include timing such as:

- Following each rain event after the ground has dried out (in the arid and semi-arid regions).
- Following each storm event (in the tropical region).
- At weekly intervals.

While undertaking the monitoring, note the location of the control and the type of maintenance required eg cleaning, installation repairs or replacement. This information can then be added to the maintenance schedule.

Maintenance schedule

For the regular maintenance requirements of specific erosion and sediment control measures please check the relevant Technical Note where this is detailed.

However, in some cases immediate action is required. This includes:

- Any damage to erosion and sediment structures which should always be repaired immediately.
- Any eroded areas which should be repaired as soon as they become apparent.
- Accidental spills of soil or other material on roads, in gutters or drains should be removed at least by the end of each work day or before rainfall. Such materials should be removed by sweeping and not washed down into the gutter or drains.

Rehabilitation

Prior to any works commencing consideration should be given to the rehabilitation of all disturbed areas. The type and extent of rehabilitation will vary depending on the extent of disturbance, location, soil type and slope.

The rehabilitation of an area is not required just for aesthetic reasons, it is important for maintaining ongoing soil stability, soil health and dust suppression.

Rehabilitation may be in the form of diversion banks, earth shaping, ripping on contour to slow runoff and allow for natural regeneration from the seed bank located in the soil or a combination of earthworks to reduce the velocity of runoff and revegetation to provide short and long term soil protection.

A thorough inspection of the site should be undertaken to identify areas of active erosion and the level of works required.

Rehabilitation of disturbed areas during and post construction should be undertaken prior to the wet season in the tropics and as soon as possible in the arid and semi-arid regions of the Northern Territory (i.e. progressive revegetation).

Revegetation

Primary revegetation consists of establishing fast growing grass species (not necessarily native species) to provide protection for disturbed soils. Primary rehabilitation requires constant maintenance to ensure a high level of ground cover is retained and not invaded by weed species.

Secondary revegetation consists of establishing native species which will provide longer term protection for the disturbed site. The establishment of native species will also require maintenance, especially in the establishment phase to ensure the area is not invaded by weed species but once established, native species will not require the same level of maintenance as many exotic species.

Where water is available revegetation of disturbed areas during and post construction should be undertaken prior to the wet season in the tropics and as soon as possible in the arid and semi-arid regions of the Northern Territory.

For further information on revegetation processes and choosing vegetation refer to Technical Note No. 13: Native Plant & Grasses of the Arid and Semi-Arid Regions or Technical Note No. 14: Native Plant & Grasses of the Tropical Region.

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Erosion and sediment

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Glossary

Annuals	A plant that completes its life cycle (germination, growth, flowering and fruiting, then death) in a single growing season and so has a lifespan of 1 year.
Arid Zone	Often referred to as the Alice Springs Region or Central Australia. Characterised by hummock grasslands and mulga shrublands. Landscape is generally desert with sand dunes (south east and south west) and steep range country (central Alice Springs area). Rainfall is highly variable (175mm-300mm) and occurs all year round. Soils are generally Rudosols (Simpson Desert Area) and Tenosols (Western Desert Area).
Batter	A sloping section of exposed soil, usually created through earthmoving and construction operations.
Berm	A constructed ledge formed at one or more levels between the top and bottom of a batter. Its purpose is to intercept runoff and reduce slope instability.
Biodiversity	Short for biological diversity. A measure of variation (the number of different varieties) amongst living things. The word is most commonly used to describe 'species diversity', the number and relative abundance of different species within a particular area.
Borrow pit	A pit from which earth has been excavated for construction operations. Also known as a gravel pit.
Buffer zone	An area of land or water, usually around or beside a sensitive wildlife habitat (such as a wetland), that contains undisturbed vegetation and is designed to minimise sharp changes in habitat, inhibit soil erosion or prevent disturbance from surrounding land uses. Also known as **buffer**, **buffer strip** or **filter strip**.
Catch drain	A diversion drain adjacent to a batter or embankment for the purpose of intercepting runoff flowing onto or away from it. This type of drain should never be used in arid regions as they are a major source of erosion in these locations.
Catchment	The area of land that is drained by a river and its tributaries. The boundary of a catchment is defined by the drainage divide, and the area within the divide is the drainage area. Also known as **drainage basin**, **basin**, **water catchment**, **watershed** and **river basin**.
Check dam	A small dam constructed in a gully to decrease the flow velocity, minimize channel scour, and promote deposition of sediment.
Chemical surface stabiliser	A number of differing products with a relative short lifespan (including bitumen and resin based products) which are used for dust control or the control of erosion caused by raindrop impact. They are also used for tacking organic mulches.
Chute	A semi-circle shaped channel, through, tube, shaft, etc., for conveying water to a lower level.
Coir logs	A sausage shaped product consisting of coir fibre in a tubular net. Used in providing erosion control along streambanks, linear constructions and in the establishment of vegetation. Increasingly used as a sediment control in lieu of sediment fences.
Construction exit	A dry or wet system designed to remove soil, mud, clods, dust and debris from tyres of vehicles as they leave a construction site.
Contour	A line drawn on a map that connects points of the same elevation. Also known as a **contour line**.
Cross bank	See **Diversion bank**.
Crossfall drainage	Drainage which occurs when the surface of a road or other access track has sufficient cross slope to cause water to flow across and off the surface, rather than along it.
Crowning	Where the road surface is convex in shape with a slight building up of the middle section causing water to flow away from the road centre to both edges.

Culvert	A drain or pipe that carries surface water under a built structure such as a road or railway.
Cut	Portion of land surface from which material has been removed by excavation during earthmoving operations.
Cut-off wall	A water tight barrier used to prevent water seeping under or past an erosion control structure; usually a masonry wall, collar or core of impervious material, intended to reduce percolation of water along otherwise smooth surfaces.
Dispersible soil	A soil which readily disperses into its constituent particles (clay, silt, sand) in water. Usually associated with high levels of exchangeable sodium in the clay fraction, and low levels of soluble salts in the soil. Highly dispersible soils are normally at high risk of eroding. They are typically slushy when wet and very hard setting when dry. Sub-surface tunnels and pipes can form.
Diversion bank	A compacted ridge of soil or other material used to intercept and divert the flow of water to a stable area.
Drainage lines	A depression down which water naturally concentrates and flows, conveying water only during or immediately after periods of heavy rainfall. Drainage lines may or may not be incised.
Drop structure	A structure that disrupts the continuous surface flow pattern in a drain by producing a pooling of water behind the structure and a rapid drop in the surface gradient for water flowing over the structure. The structure is used to reduce the velocity of water flow.
Embankment	An artificial elevation of earth, longer than it is wide, typically constructed for the purpose of controlling the flow of, or storing water as in a bank or dam.
End wall	A cut-off wall at the outlet of a hydraulic structure. Its primary purpose is to prevent undercutting flows leaving the structure.
Energy dissipater	A device located in the base of a channel of running water where it dissipates the energy of the flow. The dissipater reduces the velocity and depth by spreading the water flow over a larger area and thus mitigates erosion in the channel bed. Energy dissipaters can be constructed in several forms and from different materials including rocks, gabions, logs, steel baffles and concrete blocks.
Erosion	A group of natural geological processes by which soil and rock material are loosened (weathering) or dissolved (solution) and then moved (transportation) from their original location. The processes involve transporting agents such as running water, moving ice, or blowing wind, which are active within rivers, coasts and oceans, glaciers and periglacial areas, as well as deserts and semi-arid areas. 10 million tonnes of sediment is eroded from the world's continents each year with the vast majority (nearly 95%) eroded by rivers. Much smaller quantities are eroded by wind and ice. Rates of erosion vary a great deal from place to place, reflecting variations in key controlling factors such as climate (particularly temperature and rainfall), vegetation cover, changes in land use, geology and soil type, and topography (particularly the steepness and uniformity of a slope). Human activities can significantly alter the pace and pattern of erosion. The United Nations Environment Programme estimates that, as a result of human activities world-wide, some 10930 million square kilometres of land have been seriously damaged by water erosion, 9.2 million square kilometres by sheet and slope erosion, and 1.73 million square kilometres by the development of rills and gullies. The main causes are clearance of natural vegetation and forest (43 per cent), overgrazing (29 per cent), poor farming practices such as cultivation of steep slopes (24 per cent), and over-exploitation of natural vegetation (4 per cent).
Fill	Soil that is added to change the height of the land, for example to fill in a hole or to build an embankment.

Filter strip	See **buffer zone**.
Floodway	The river channel and parts of the adjacent floodplain that are required to carry flood water and must therefore not be built on or restricted.
Flume	A natural or man-made structure that conveys water down steep grades.
Gabion	A woven wire basket filled with rock used in erosion control structures such as retaining walls.
Geotextile	Product used as a soil reinforcement to control erosion and as a filter medium. It can be made of jute mesh, felt and plastic / synthetic fibres manufactured in a woven or loose non-woven manner to form a blanket-like product.
Grade	The slope of the surface of the Earth. The grade/gradient may be expressed as a ratio or percentage.
Gross pollutant trap	Devices used to trap large items / litter at drain outlets.
Infiltration	The movement of water from the ground surface into a soil or into a porous rock or sediment.
Invert	A concrete strip in the base of a drain to aid flow in areas of low gradient.
Level sill / spreader	A shallow level excavation at the outlet of a drain to allow sediment to settle and disperse outflow and convert any potentially erosive concentrated flow to non-erosive sheet flow.
Mitre drain	A drain used to conduct runoff water from the shoulders of the road to a disposal area away from the road alignment.
Mulch	A protective covering for soil; any natural or artificial substance that is spread or allowed to remain on the soil surface in order to conserve soil moisture, shield soil particles from erosion, and control the growth of weeds.
Outfall / outlet	The point at which water discharges from a river, creek or other flow lines or natural or artificial water bodies.
Outlet dissipater	See **Energy dissipater**.
Ped	A small unit (aggregate) of soil that is composed of individual particles of sand, silt, clay, and other soil material that stick together into a specific structure (such as a crumb or granule), and is formed by natural processes.
Perennials	Plants that live for three or more growing seasons.
Perimeter bank	A temporary control measure. The bank is made of earth and is located around the perimeter of a disturbed area such as a construction site.
Rehabilitation	The process of returning a disturbed site, habitat, or ecosystem to its original condition.
Reno mattress	A mattress of woven wire filled with rock and used to stabilise and control erosion on slopes and batters.
Return period	The average period of time, usually measured in years, between two successive floods of a given size (discharge) at a particular location within a river system, as calculated by flood frequency analysis. Also referred to as **recurrence interval (RI)**.
Revegetation	Re-establishing and developing plant cover, by either natural or artificial means, such as reseeding.
Riparian vegetation	Plants that are adapted to grow in the moist conditions found along the banks of streams, lakes and waterbodies.
Ripping	The tillage of soil by a mechanical implement for the purpose of loosening it and / or improving water movement and allowing root penetration.

Rip rap	A layer of medium to large rocks or logs that is used to stabilise banks along watercourses, rivers and down slope of floodways and spillways.
Runoff	That part of precipitation or irrigation water which flows across the land to streams or other waterbodies.
Scalds	Bare areas of land produced by the removal of sandy topsoil by wind and water and which subsequently exposes clay subsoil which is not very permeable to water.
Scouring	A term commonly used to describe localised erosion of a bank or channel which typically occurs due to excessive slope, turbulence or flow velocity.
Sediment	Grains of solid (usually mineral) material that have been deposited by some erosive process.
Sediment basin	A tank or man-made basin, used in water treatment, in which solids settle to the bottom and are removed as sludge.
Sediment fence	A temporary structure using fabric which filters runoff and traps sediment.
Sediment trap	A structure designed to collect soil material transported in run-off and also to reduce water flow velocity and therefore scouring and erosion. Sediment traps mitigate siltation of natural drainage features.
Sedimentation	The deposition of sediment from a state of suspension in water or air. Also known as **siltation**.
Semi-Arid Zone	Often referred to as the Barkly – Tennant Creek Region. Characterised by grasslands, low open woodlands and spinifex in the western desert area. The landscape is generally desert (west) and tablelands country (east). Rainfall is predominantly in summer and is approx. 250mm – 650mm. Soils are generally Kandosols (Davenport Range), Rudosols and Tenosols (Tennant Creek Area and Western Desert) and Vertosols (Barkly Tableland).
Sheeting	The removal of a uniform layer of soil from the land surface by raindrop splash and / or runoff. No perceptible channels are formed.
Site drainage	The natural interception and removal of excess surface water from land.
Slope	The angle at which something is inclined, which is normally expressed as fall (drop in height) (metres) per unit distance (kilometres), or metres per kilometre. Also known as **gradient**.
Soil horizon	A relatively uniform layer within a soil profile that has distinct characteristics.
Soil pH	A numerical measure of hydrogen ion activity in soil with the neutral point being 7.0. All pH values below 7.0 are acid, and all above 7.0 are alkaline. The pH levels in soils affects availability of plant nutrients (in general, optimal pH is between 5.5-7.5).
Soil profile	The vertical arrangement of layers or horizons in a soil. The **A horizon** is the top layer and is where humus is abundant and chemical weathering is active. The upper part of the A horizon contains most of the organic matter and is strongly leached. The concentration of humus tends to make the dark coloured near the surface. The lower part of the A horizon has much less organic matter and has suffered maximum leaching, particularly of calcium (Ca) and iron (Fe). The A horizon may be at the surface, or may underlay a **O horizon** composed of accumulated organic matter. The **B horizon** is largely a zone of deposition, where clay particles are trapped and solutes are absorbed. It is thus enriched in clay and/or iron and aluminium hydroxides. The **C horizon** is the sub-soil and consists of weathered bedrock grading into unweathered bedrock (the **D horizon**). The nature of any particular soil will depend on its parent material, the topography, the climate, the plant life available and time.
Soil salinity	A soil that has become damaged by large quantities of salts.
Soil structure	The arrangement of soil particles into larger particles or clumps.

Soil texture	The relative proportion of the various size groups of individual particles (sand, silt and clay) in a soil.
Stabilisation	The provision of adequate measures, vegetative, structural and/or mechanical, to prevent or control erosion.
Stone / rock pitching	Stone or rock set in concrete to dissipate energy and prevent erosion.
Surface runoff	See **Runoff**.
Swale	A grass covered, broad and shallow depression designed to detain, treat and/or infiltrate stormwater.
Table drain	The side drain of a road adjacent to the shoulders and comprising part of the road formation.
Toe (of slope)	The base or bottom of a slope at the point where the ground surface abruptly changes to a significantly flatter grade.
Topsoil	Topsoil is the uppermost layer of soil, usually the top 7-20cm (the A horizon – see **soil profile**). It has the highest concentration of organic matter and microorganisms and plants generally concentrate their roots in, and obtain most of their nutrients from this layer. Topsoil is the most important part of the soil with respect to growth of crops and pastures and its loss or degradation represents the most serious aspect of soil erosion. Its retention is particularly important in the revegetation of exposed batters or earthworks.
Tropical Zone	Often referred to as the Top End and / or the Gulf Region. Characterised by savannah woodlands inland and extensive areas of mangroves on the coastal areas. Includes escarpment and floodplain country. Rainfall is fairly predictable (Wet/Dry Season) approx 650mm - 1500mm. Soils are generally a combination of Tenosols (largest proportion), Kandosols and Rudosols.
Watercourse	A permanent or semi-permanent navigable waterway such as a river, stream or creek.
Water ponding	Water ponding is a technique used for reclaiming scalded and unproductive country. U-Shaped earth banks are constructed to pond water, improving soil conditions and enabling vegetation to establish.
Windrow	A long continual heap of soil that is usually left to one side of a graded track or the accumulation of slash, wooden branches and debris pushed into lines during a clearing operation.

References include:

Oxford Dictionary of Environment and Conservation 2007

The Macquarie Dictionary 1988

U.S. Environmental Protection Authority <http://www.epa.gov/nps/MMGI/Chapter3/ch3-3.html>

Washington State University <http://soils.tfrec.wsu.edu/mg/chemical.htm>

Rensselaer Polytechnic Institute <http://www.rpi.edu/dept/geo/pe1/chapter7.html>

Northern Rivers Private Forestry Development Committee <http://www.privateforestry.org.au/glos_a-g.htm>

Hancock County Government <http://www.hancockcoingov.org/surveyor/drainage_glossary_of_terms.asp>

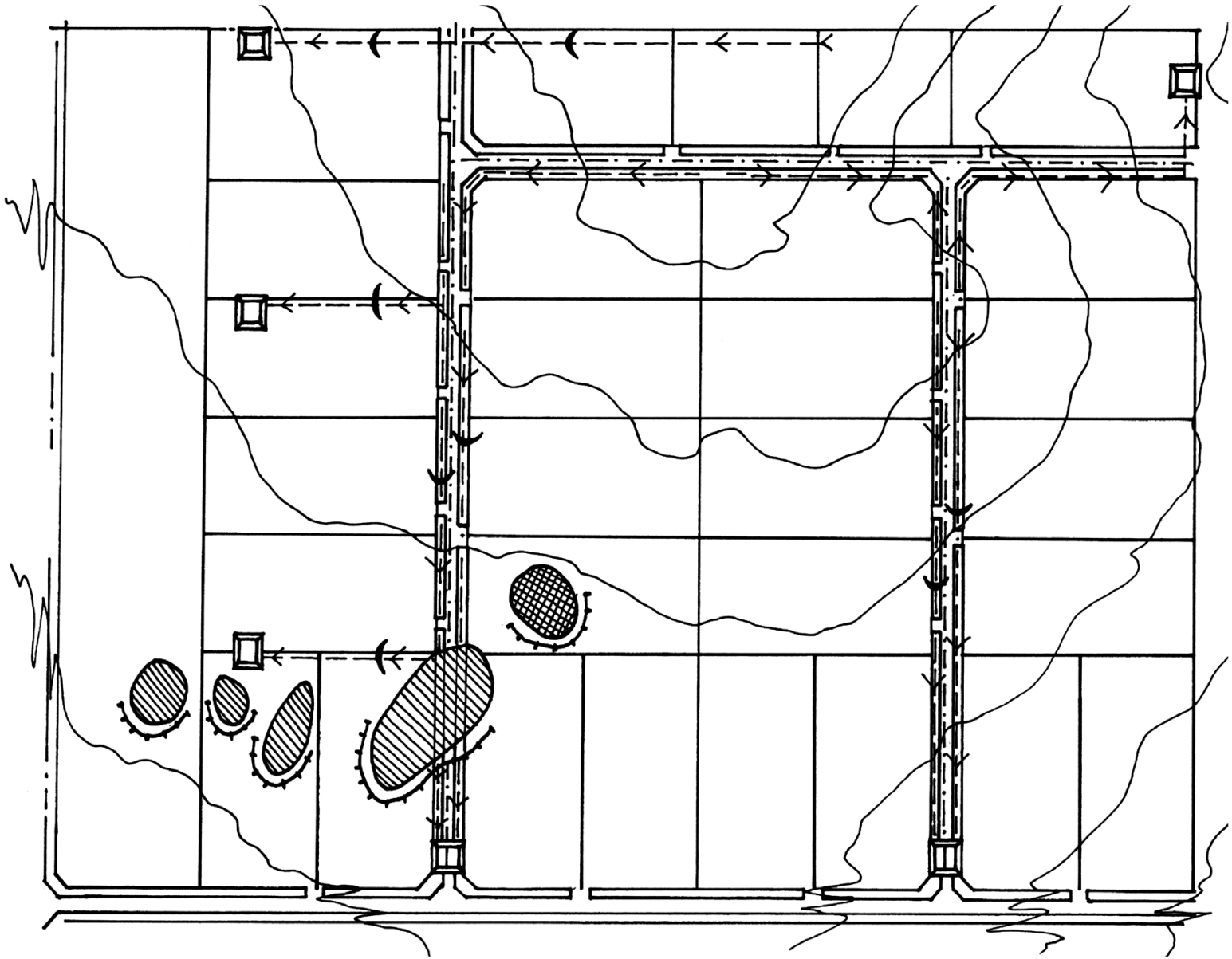
Contact details

INFORMATION	AGENCY	PHONE NO.
Land Management including erosion and sediment controls	Senior Natural Resource Scientist Department of Natural Resources, Environment and the Arts	
	3rd floor, Goyder Centre, 25 Chung Wah Terrace, Palmerston PO Box 30, Palmerston NT 0831	**(08) 8999 4678**
	Randazzo Building, 16 Katherine Terrace, Katherine PMB 123, Katherine NT 0852	**(08) 8973 8111**
	1st floor, Alice Plaza, Todd Mall, Alice Springs PO Box 1120, Alice Springs NT 0871	**(08) 8951 9208**
Land and water resources including land unit mapping, vegetation mapping and land capability advice	Senior Land Resource Officer Department of Natural Resources, Environment and the Arts	
	4th floor, Goyder Centre, 25 Chung Wah Terrace, Palmerston	**(08) 8999 4443**
	1st floor, Alice Plaza, Todd Mall, Alice Springs	**(08) 8951 9212**
Cadastral mapping and aerial photos	Land Information Centre Department of Planning and Infrastructure	
	3rd floor, NAB Building, 71 Smith Street, Darwin	**(08) 8995 5300**
	1st floor, Alice Plaza, Todd Mall, Alice Springs	**(08) 8951 5316**
Environmental assessment, archaeological and heritage places	Environment and Heritage Department of Natural Resources, Environment and the Arts	
	2nd floor, Darwin Plaza, Smith Street Mall, Darwin	**(08) 8924 4143**
	1st floor, Alice Plaza, Todd Mall, Alice Springs	**(08) 8951 9201**
Rainfall data	Northern Territory Climate Services Centre Bureau of Meteorology	
	13 Scaturchio Street, Casuarina PO Box 40050, Casuarina NT 0811	**(08) 8920 3819**

INFORMATION	AGENCY	PHONE NO.
Native vegetation clearing	Native Vegetation Assessment Officer Department of Natural Resources, Environment and the Arts	
	3rd floor, Goyder Centre, 25 Chung Wah Terrace, Palmerston	**(08) 8999 3631**
	Randazzo Building, 16 Katherine Terrace, Katherine	**(08) 8973 8111**
	1st floor, Alice Plaza, Todd Mall, Alice Springs	**(08) 8951 9208**
Water Management ground and surface water information and water allocation planning	Water Resource Planner Department of Natural Resources, Environment and the Arts	
	3rd floor, Goyder Centre, 25 Chung Wah Terrace, Palmerston	**(08) 8999 4640**
	Randazzo Building, 16 Katherine Terrace, Katherine	**(08) 8973 8115**
	1st floor, Alice Plaza, Todd Mall, Alice Springs	**(08) 8951 9254**
Planning and development assessment services	Department of Planning and Infrastructure	
	Ground floor, Cavenagh House, 38 Cavenagh Street, Darwin	**(08) 8999 7867**
Weed management	Department of Natural Resources, Environment and the Arts	
	3rd floor, Goyder Centre, 25 Chung Wah Terrace, Palmerston	**(08) 8999 4567**
	Randazzo Building, 16 Katherine Terrace, Katherine	**(08) 8973 8101**
	99 Patterson Street, Tennant Creek	**(08) 8962 4495**
	Arid Zone Research Institute, Alice Springs	**(08) 8951 8195**
Biodiversity conservation and Herbarium	Department of Natural Resources, Environment and the Arts	
	2nd floor, Goyder Centre, 25 Chung Wah Terrace, Palmerston	**(08) 8999 4582**
	Tom Hare Building, Arid Zone Research Institute, Stuart Highway, Alice Springs	**(08) 8951 8211**

ESCP Checklist

Site	Has a plan showing the development site with clearly marked boundaries and showing external catchment area been prepared?	☐
	Is the map/plan to scale and is north clearly marked with an arrow?	☐
	Has erosion risk been identified?	☐
	Has a commencement date of development been included?	☐
	Has an expected date of completion been included?	☐
	Have all major soil types on the site been identified?	☐
	Have any potential acid sulphate soils been located? (if so, has a treatment / management plan been prepared?)	☐
	Does the plan show the existing and finished topography with clearly marked contour lines?	☐
	Does the plan clearly show the general locations of existing vegetation?	☐
	Does the plan clearly indicate where protected areas, trees, buffer zones and vegetation to be retained are located?	☐
Design	Have all areas that will be disturbed during the development been clearly marked on the plan?	☐
	Have all proposed drainage works been clearly marked on the plan?	☐
Construction	Have temporary and permanent control measures been identified on the plan?	☐
Maintenance	Has a schedule been prepared for the monitoring and maintenance of erosion and sediment control structures?	☐
Rehabilitation	Has a species list been provided for revegetation areas?	☐



				Consultant Name	Developer Name Project Location		EROSION AND SEDIMENT CONTROL PLAN
01	01/01	REVISION DETAILS	BY				
REV	DATE						

Project No.
Scale
Drawing No. Rev

Rural Erosion Control Notes

1. Proposed commencement April 2008. Proposed completion December 2008.

2. All clearing shall be restricted to road reserves, firebreaks and 3m each side of top of new drain batters and silt traps. Erosion and sediment control shall be implemented in accordance with these Erosion Control Notes.

3. The contractor shall be responsible for the control of all traffic into and out of the site, including the movement of construction traffic within the site and shall maintain dust suppression measures to the satisfaction of the superintendent. Access to the site shall be limited to a maximum of two locations.

4. All disturbed and unsealed areas shall be dampened and rolled to seal the surface to minimise dust.

5. Install all erosion and sediment control devices and silt traps prior to the commencement of construction activities.

6. Top soil stripped from construction areas to be stockpiled at a nominated site.

7. Limit cut and fill batter gradients to 1(V):4(H) maximum.

8. Construct all sediment control fences along contour where possible. Where sediment control fences are not constructed along contour incorporate return panels at regular intervals not exceeding 20m.

9. Inspect all silt traps weekly and after storms for structural damage or clogging.

   Remove all silt to maintain silt trap storage capacity. Repair any damage and make good to the satisfaction of the superintendent.

10. Divert all stormwater runoff away from disturbed soil into intact native vegetation or stormwater drainage system.

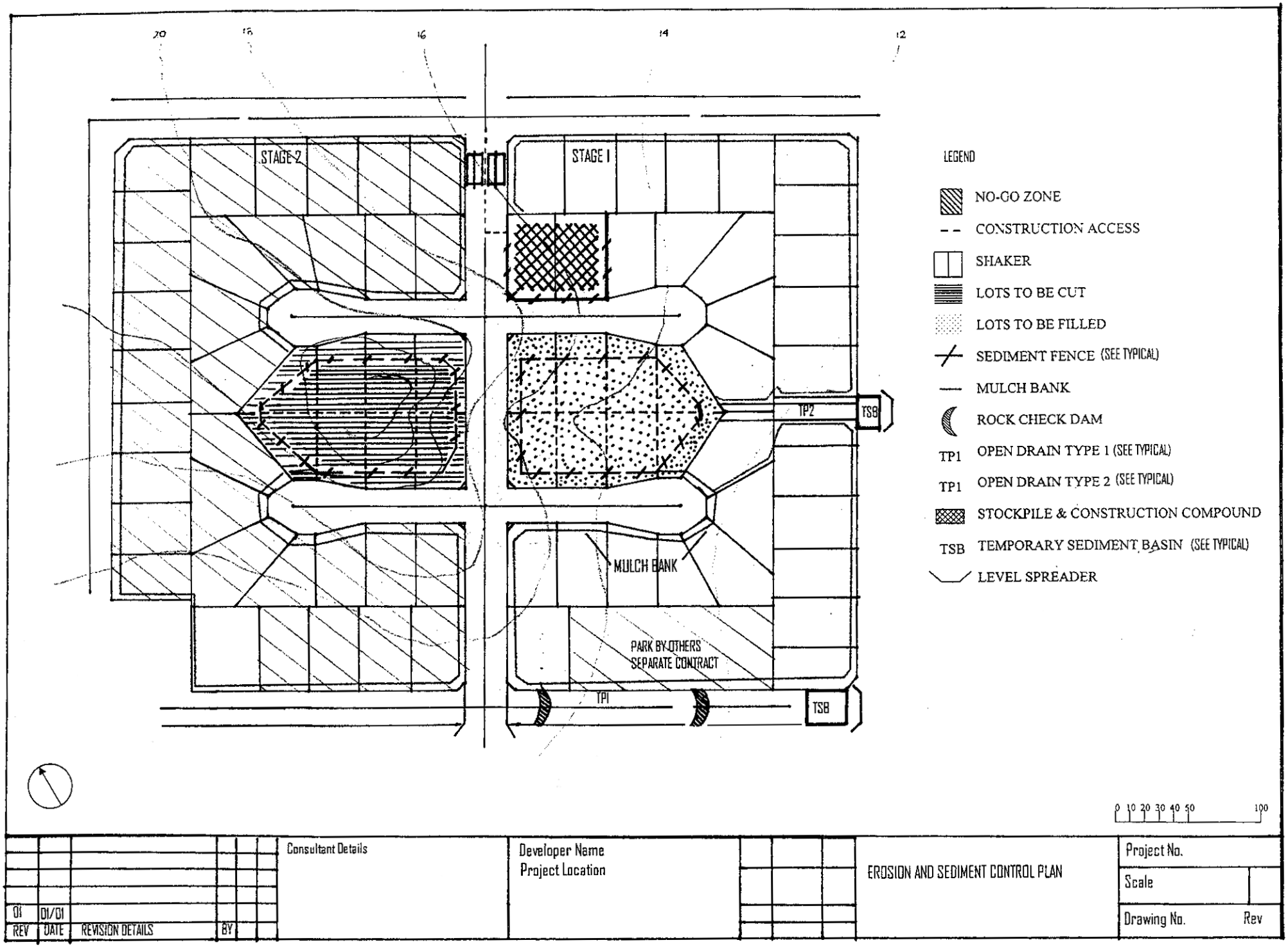
11. Construct and maintain a berm 200mm in height or greater at the top of fill batters where catchment contribution is greater than 5m.

12. Complete all final erosion prevention measures prior to the final subdivision handover inspection. Maintain all control devices until the end of the defects liability period.

13. Any changes to the erosion and sediment control plan shall be submitted and approved by Natural Resource Management Division, NRETA prior to commencement.

14. Additional erosion controls may be required during construction as determined by the superintendent in consultation with the Natural Resource Management Division, NRETA.

15. All erosion and sediment control measures to be undertaken to the satisfaction of NRETA.


STAGE 2
STAGE 1
TP2
TSB
MULCH BANK
PARK BY OTHERS
SEPARATE CONTRACT
TP1
TSB
LEGEND
NO-GO ZONE
CONSTRUCTION ACCESS
SHAKER
LOTS TO BE CUT
LOTS TO BE FILLED
SEDIMENT FENCE (SEE TYPICAL)
MULCH BANK
ROCK CHECK DAM
TP1 OPEN DRAIN TYPE 1 (SEE TYPICAL)
TP1 OPEN DRAIN TYPE 2 (SEE TYPICAL)
STOCKPILE & CONSTRUCTION COMPOUND
TSB TEMPORARY SEDIMENT BASIN (SEE TYPICAL)
LEVEL SPREADER
0 10 20 30 40 50 100
Consultant Details
Developer Name
Project Location
EROSION AND SEDIMENT CONTROL PLAN
Project No.
Scale
Drawing No.
Rev
01 01/01
REV DATE REVISION DETAILS BY

Urban Construction Notes

1. Clearing of vegetation to be restricted to nominated areas
2. All erosion and sediment control measures to be installed prior to any site disturbance.
3. All NO-GO zones must be flagged or fenced to restrict access and inspected by NRETA prior to any site disturbance.
4. Top soil stripped from construction areas to be stockpiled at nominated site.
5. Limit and fill batter gradients to 1(V):4(H) maximum.
6. All temporary earth structures to be machine compacted and maintained.
7. Construct all sediment fences on contour where possible. Where sediment fences are not to be constructed on contour incorporate return panels at regular intervals not exceeding 20m.
8. On completion of stormwater inlet pits protection measures to be immediately installed.
9. All sediment control structures to be inspected after each rain fall event for damage and effectiveness. Trapped sediment to be removed to a nominated site.
10. Divert all stormwater runoff away from disturbed soil into intact native vegetation or stormwater drainage system.
11. Complete all final erosion prevention and sediment control measures prior to final subdivision handover.
12. Establish and maintain a street sweeping program for the duration of the works.
13. Proposed commencement May 2007. Proposed completion November 2007.
14. Any changes to the erosion and sediment control plan shall be submitted to NRETA for approval prior to works commencing.
15. All erosion and sediment control measures to be undertaken to the satisfaction of NRETA.

Appendix C ESCP Checklist

Source: IECA, 2012, *Site Inspection Checklist – Building Sites*, accessed on 9-2-2012 at [http://www.austieca.com.au/BestPracticeESCDocumentInfo.aspx]

Appendix C ESCP Checklist

Part A: Data collection and review

Item	Consideration	Assessment
1	*Erosion Risk Mapping* or *Erosion Hazard Assessment* completed on the site.	.....
2	Critical on-site and off-site environmental values identified.	.....
3	Potential impacts of the development on environmental values identified.	.....
4	Potential site constraints with respect to soils, topography, water supply and vegetation have been identified.	.....
5	Appropriate soil testing and soil mapping has been completed.	.....
6	Site contour map prepared and provided with application.	.....
7	All on-site and receiving water identified, including creeks, ponds, lakes, wetlands and waterways.	.....
8	Fish passage requirements of affected waterways identified.	.....
9	Vegetation mapping completed on the site.	.....
10	Vegetation subject to statutory protection identified.	.....

Part B: Site layout

Item	Consideration	Assessment
11	Site layout and construction footprint has been appropriately integrated into the site's topography, soil types, protected vegetation, environmental values and constraints.	.....
12	Site layout does not interfere with the construction and operation of the major sediment traps.	.....
13	Site layout provides sufficient useable land for stockpiling construction materials (e.g. topsoil, spoil, mulch).	.....

Appendix C ESCP Checklist

Part C: Environmental considerations

Item	Consideration	Assessment
14	Areas of potential acid sulfate soils identified.	.....
15	Areas of highly dispersive soils identified.	.....
16	Active coastal erosion zone and/or coastal protection zone identified.	.....
17	Areas likely to be subject to wave action (e.g. trafficable waterways, lake shores, coastal zones) identified.	.....
18	Protected waterway buffer zones identified.	.....
19	Potential drainage problem areas identified.	.....
20	Existing watercourse and gully erosion identified.	.....
21	Potential flood-prone land identified.	.....
22	Areas subject to potential mass movement (e.g. landslipe) identified.	.....
23	Critical environmental habitats (e.g. habitats of threatened species) identified.	.....

Part D: Consideration of ESC issues

Item	Consideration	Assessment
24	Appropriate procedures have been established to ensure all erosion and sediment control and associated environmental requirements are suitably costed and funded.	.....
25	Location and size of major sediment traps (e.g. *Sediment Basins*) has been identified and sufficient useable land made available for their construction and operation.	.....
26	Location and operation of major construction site sediment traps takes account of expected changes in site topography and overland flow paths (e.g. sediment traps are able to capture and treat all necessary sediment-laden runoff throughout the full construction phase.	.....
27	Site layout does not interfere with the construction and operation of the major sediment traps.	.....
28	Site layout allows “clean” up-slope stormwater to be temporarily diverted around construction activities.	.....

Appendix D Sediment Fence Drawing (IECA)