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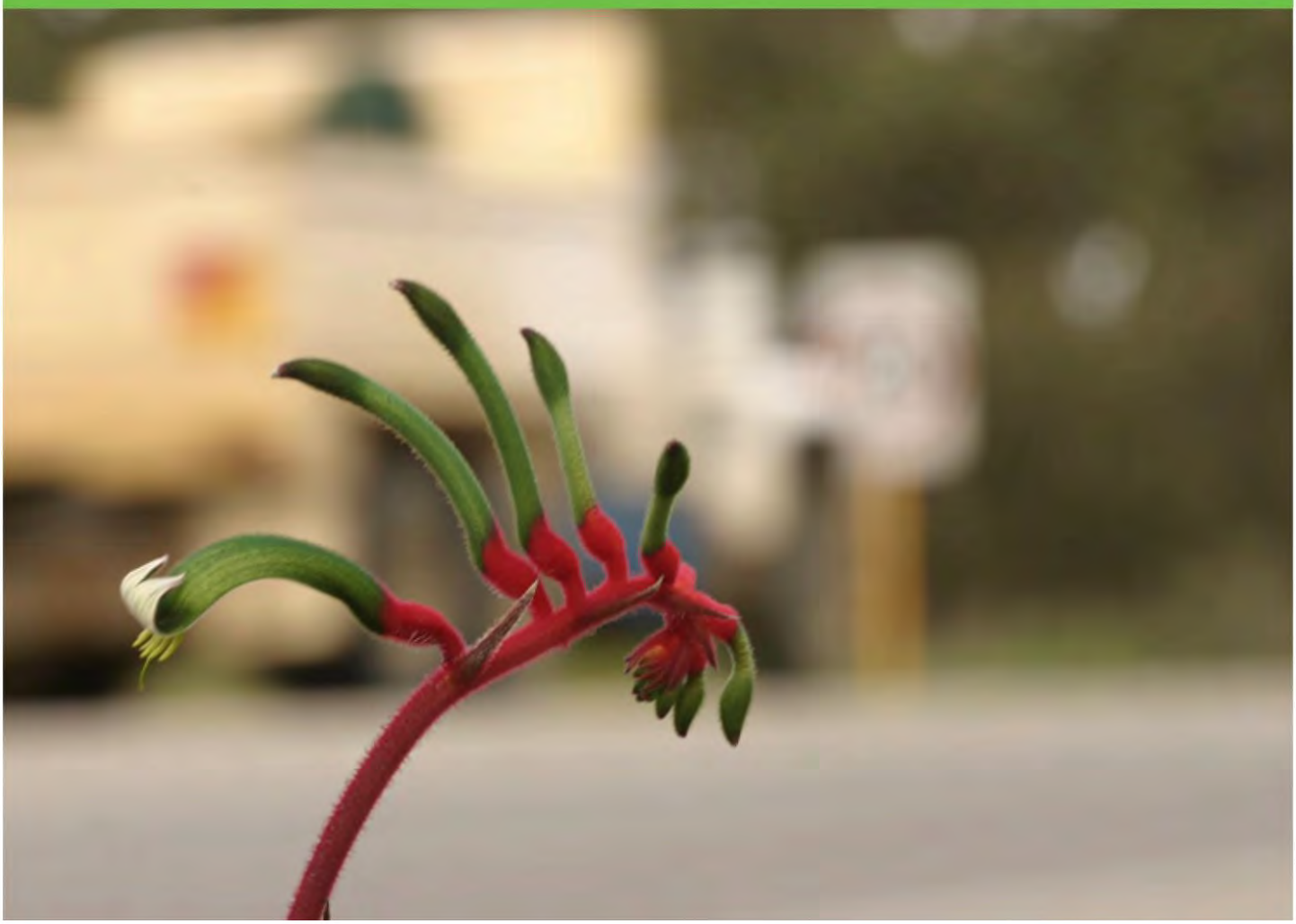
NorthLinkWA
Perth-Darwin National Highway

Condition Environmental Management Plan

Flora and Vegetation – Inland Waters

Perth–Darwin National Highway (Swan Valley Section)

JANUARY 2020



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Document *Control*

Revision	Date	Description	Prepared	Reviewed	Approved
A	07/07/2016	Draft (Coffey v1)	T. Vu	E. Waterhouse	B. Napier
B	31/08/2016	Draft (Coffey v2)	T. Vu	B. Napier	E. Waterhouse
0	08/12/2016	Final for submission to OEPA (Coffey v3)	T. Vu	D. Morley	D. Morley
1	17/02/2017	Addressed OEPA comments (Coffey v4)	T. Vu	D. Morley	D. Morley
2	10/03/2017	Addressed OEPA comments (Coffey v5)	T. Vu	D. Morley	D. Morley
3	14/03/2017	Addressed OEPA comments (Coffey v6)	D. Morley		D. Morley
4	03/11/2017	Revised draft (Coffey v7)	R. Bunbury	C. Baldock	D. Morley
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7	11/04/2018	Addressed DWER comments (Coffey v10)	D. Morley		D. Morley
8	14/01/2019	Amended following annual review (ELA v11)	D. Morley R. Bunbury	J. Longstaff	J. Longstaff
9	18/10/2019	Amended following section 46 inquiry (ELA v12)	D. White	N. McAlinden	J. Longstaff
10	29/01/2020	Amended following section 46 inquiry and subsequent amendments to Statement 1036, as well as addressing DWER comments received 29 November 2019 (ELA v13).	N. Thompson	N. McAlinden	J. Longstaff

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1 INTRODUCTION

This Flora and Vegetation – Inland Waters Condition Environmental Management Plan (Condition EMP) (this plan) is submitted in accordance with Ministerial Statement No. 1036 condition 8-1 and Ministerial Condition No. 1116 condition 14-1 for the Perth–Darwin National Highway (Swan Valley Section) by Main Roads Western Australia (MRWA). It is a revision of the previous version approved by the Department of Water and Environmental Regulation (DWER) on 4 May 2018 (reference NLWA-03-EN-RP-0055 / Rev 7).

Table 1 details the environmental criteria to measure achievement of the conditioned environmental outcome that must be met through implementation of this Condition EMP.

Table 1 Flora and Vegetation – Inland Waters Condition EMP summary

Item	Detail	
Title of proposal	Perth–Darwin National Highway (Swan Valley Section)	
Proponent	Commissioner for Main Roads Western Australia	
Ministerial Statement Nos.	1036 and 1116 (note that condition 14 of MS 1036 has been deleted and is replaced with condition 14 of MS 1116)	
Purpose of this Condition EMP	The Flora and Vegetation – Inland Waters Condition Environmental Management Plan is submitted to fulfil the requirements of condition 8-1 of Ministerial Statement 1036 and condition 14-1 of Ministerial Statement 1116.	
EPA's environmental objective for the key environmental factor flora and vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.	
EPA's environmental objective for the key environmental factor inland waters	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.	
Environmental criteria	**Trigger criteria**	**Threshold criteria**
Condition environmental outcome14-1(1): To ensure that construction and operation of the proposal, including from dewatering and groundwater abstraction, does not result in indirect impacts to *Communities of Tumulus Springs* (*Organic Mound Springs, Swan Coastal Plain*) and Conservation Category Wetlands as shown in Figures 5 of Ministerial Statement 1036 and Figure 6 attached to this Statement [Ministerial Statement 1116]; through implementation of the Flora and Vegetation – Inland Waters – Condition Environmental Management Plan approved by the CEO.		
Environmental criteria 1 – Groundwater, surface water and basin sediment quality	Groundwater quality trigger criteria listed in Appendix A. Surface water quality trigger criteria listed in Appendix B. Basin sediment quality trigger criteria listed in Table 8.	Groundwater quality threshold criteria listed in Appendix A. Surface water quality threshold criteria listed in Appendix B. Basin sediment quality threshold criteria listed in Table 8.
Environmental criteria	**Trigger criteria**	**Threshold criteria**
Environmental criteria 2 – Groundwater level	Groundwater level trigger criteria listed in Appendix A.	Groundwater level threshold criteria listed in Appendix A.

Environmental criteria 3 – Wetland flora and vegetation	Observed plant stress rating 2 (Appendix C).	Observed plant stress rating 3 (Appendix C).
Condition environmental outcome 14-1(2): To ensure that construction of the proposal maintains predevelopment surface water flows to *Darwinia foetida*, *Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)* and Conservation Category Wetlands as shown in Figures 3 and 5 of Ministerial Statement 1036 and Figure 6 attached to this Statement [Ministerial Statement 1116]; through implementation of the Flora and Vegetation – Inland Waters – Condition Environmental Management Plan approved by the CEO.		
Environmental criteria 4 – Surface water flows to *Darwinia foetida*	Clearing or construction of laydown areas or stockpiles within 40 m of the known population of *Darwinia foetida*.	Clearing or construction of laydown areas or stockpiles within 10 m of the known population of *Darwinia foetida*.
Environmental criteria 5 – Surface water flows to Communities of Tumulus Springs and CCWs	Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 6 m.	Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 10 m.

2 CONTEXT AND SCOPE

2.1 Description of the Proposal

Main Roads Western Australia (MRWA) proposes to construct a new 38 km section of the Perth–Darwin National Highway (PDNH) (Figure 1) between Malaga and Muchea in Western Australia (the proposal). The proposal is a dual carriageway highway and will connect the intersection of Tonkin Highway and Reid Highway in the south with Great Northern Highway and Brand Highway in the north.

2.2 Key Environmental Factors

This plan addresses the Inland Waters environmental factor of the Water theme and the Flora and Vegetation environmental factor of the Land theme (EPA, 2013).

Darwinia foetida, *Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)* Threatened Ecological Community (TEC) and Conservation Category Wetlands (CCWs) are at risk of direct and indirect impacts as a result of proposal activities.

Claypans of the Swan Coastal Plain TEC is no longer considered at risk of direct or indirect impacts as a result of proposal activities. Emerge Associates conducted further vegetation surveys at the site mapped as Claypans of the Swan Coastal Plain TEC in the original Ministerial Statement No. 1036 and found that the vegetation was not representative of the TEC (Emerge Associates, 2017). This conclusion was supported by the Department of Parks and Wildlife (DPAW [V. English, pers. com., 2016]).

The relevance of the environmental factors and values to the proposal is presented in Table 2.

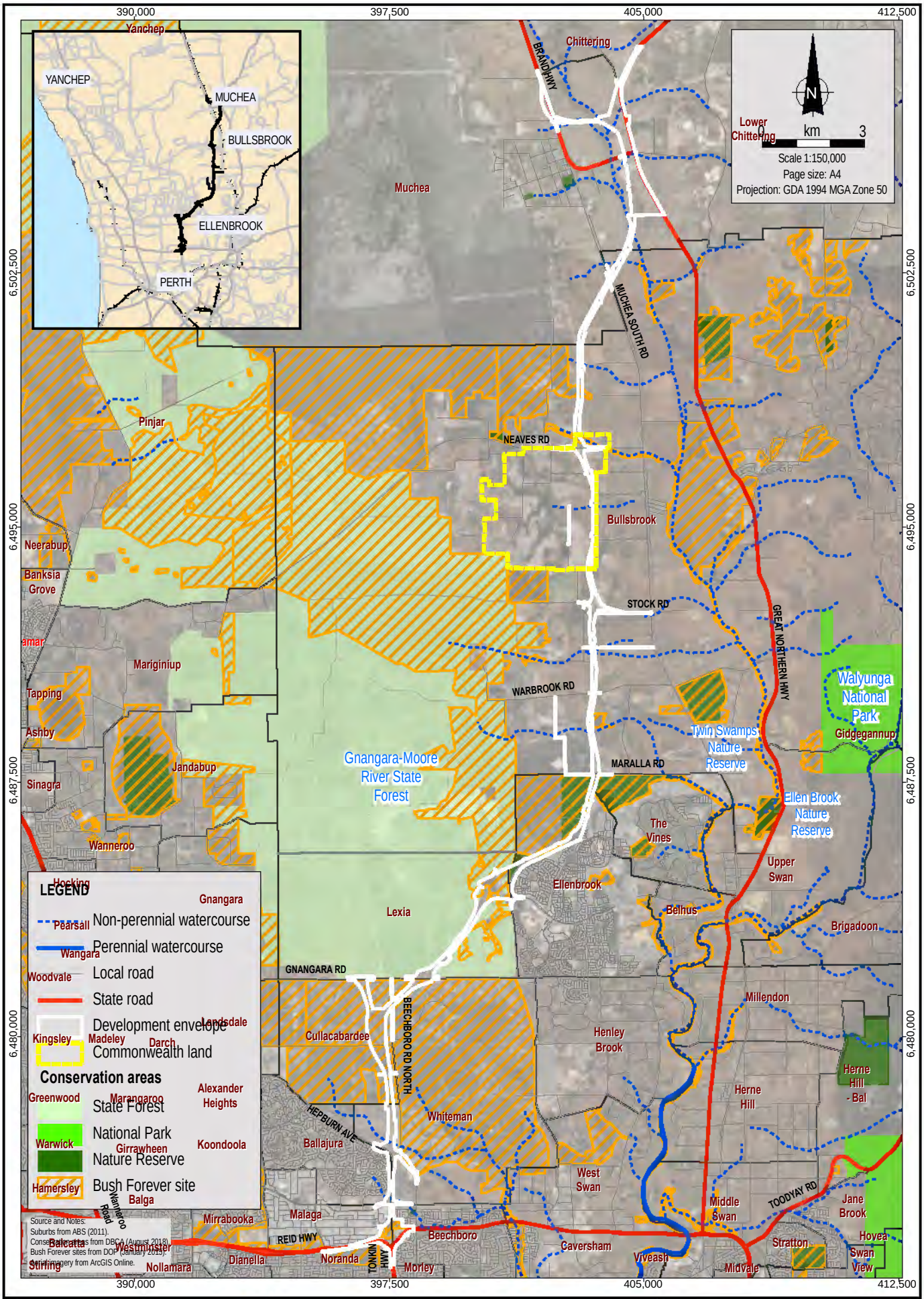
Table 2 Key environmental factors

Environmental aspect of the proposal	Affected environmental value	Impact	Activity/Threatening process
Water abstraction for construction water requirements.	• Groundwater levels adjacent to: – Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain). – CCWs.	Localised lowering of the groundwater table causing indirect impacts such as degradation and potential loss of flora and vegetation.	Changed groundwater levels from abstraction to supply water for construction purposes.

Environmental aspect of the proposal	Affected environmental value	Impact	Activity/Threatening process
Dewatering during bridge footing construction or deep excavations.	• During the wet season, groundwater levels adjacent to: – CCWs. • Surface water quality of: – CCWs. No values are affected during the dry season as dewatering is not required during this period.	Localised lowering of the groundwater table causing indirect impacts such as degradation and potential loss of flora and vegetation. CCWs are located within the radius of influence of dewatering at one of the nine dewatering locations (Figure 3).	Dewatering may be required to construct bridge abutments and foundations. Pumping and recharge of groundwater from dewatering and construction water abstraction activities has the potential to re-distribute existing contamination.
Altered surface water flow (piping (culverts) and bridging surface water features, diversion of overland surface water flows, road pavement and hardstand areas).	• Surface water flows to: – Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain). – CCWs.	Concentrated flows and increased volume of stormwater runoff to CCWs can cause scouring, bank erosion, instability. CCWs located west of the development envelope and Communities of Tumulus Springs are located upstream of the development envelope. The only potential for surface water flow impact is from backwater or ponding of water upstream of the development envelope. These impacts could indirectly impact flora and vegetation.	Diversion of surface water flows through installation of stormwater drainage systems, stormwater runoff infiltration and retention basins, culverts and bridges. Low permeability of the road surface causing increased volume of stormwater runoff.
Construction of infiltration basins	• Groundwater quality and levels adjacent to: – Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain). – CCWs.	Localised and temporary changes to groundwater levels and the potential contamination of groundwater through stormwater runoff from the road could cause indirect impacts such as degradation and potential loss of flora and vegetation.	Diversion, collection and retention of stormwater in infiltration basins. Poor effectiveness and condition of stormwater infiltration and retention basins.

Environmental aspect of the proposal	Affected environmental value	Impact	Activity/Threatening process
Hydrocarbon or hazardous material spills from plant, vehicles and equipment and road users during operation.	• Water quality of: – Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain). – CCWs.	Contamination of groundwater and surface water.	Contaminated runoff from the road or spills introducing contaminants to surface water bodies.
Unauthorised clearing, maintenance works or construction of laydown areas or stockpiles.	• *Darwinia foetida.*	Vegetation stress from lack of surface water flows to the receptors.	Altered surface water flow from unauthorised construction works and presence of laydown areas or stockpiles.

The project design includes retention and infiltration basins, spill management, local government area drainage systems, culverts and separation/buffer distances to water production wellheads as part of the drainage strategy (BG&E, 2015). Stormwater retention and infiltration basins will capture and control runoff from the road along the alignment. Their proposed locations and sizing are detailed in the drainage strategy. The final location of retention and infiltration basins will be confirmed in detailed design and reported in the pre-construction Infrastructure Plan required by condition 6 of Ministerial Statement No. 1036.



NorthLinkWA	coffey	Date: 21.08.2018 MXD: 4483AA_63_GIS001_4 File Name: 4483AA_63_F001_GIS	Perth–Darwin National Highway Flora and Vegetation - Inland Waters Environmental Quality Hydrological Processes - Condition EMP	Proposal overview	Figure No: 1

2.3 Requirements of the Conditions

This plan is submitted in accordance with Ministerial Statement No. 1036 condition 8-1, and Ministerial Statement 1116 conditions 14-1 to 14-6 for the proposal.

As required under condition 5-1 of Ministerial Statement 1036, this plan will be made publicly available for the life of the proposal.

Condition requirements and in-plan section references are provided in Table 3.

Note that the former of Office of the Environmental Protection Authority (OEPA) was replaced by the DWER EPA Services Division on 1 July 2017. References to OEPA in this plan have been changed to DWER except for direct quotations of the condition text from Ministerial Statement No. 1036.

Table 3 Condition requirements and in-plan section references

Condition No.	Condition	Section in this plan
Ministerial Statement No. 1036		
8-1	Prior to the commencement of ground disturbing activities, or as otherwise agreed in writing by the CEO, the proponent shall prepare and submit Condition Environmental Management Plan(s) to satisfaction of the CEO to demonstrate that the environmental outcomes in condition 14-1 of Ministerial Statement 1116 will be met.	This plan
8-2	The Condition Environmental Management Plan(s) shall: 1. Specify trigger criteria that will trigger the implementation of trigger level actions if exceeded. 2. Specify threshold criteria that: a) Provides a limit beyond which the environmental outcomes identified in condition 14-1 of Ministerial Statement 1116 are not achieved. b) Will trigger the implementation of threshold contingency actions if exceeded.	Section 3 and Appendices A and B
	3. Specify monitoring to determine if trigger criteria and threshold criteria are exceeded.	Section 4
	4. Specify trigger level actions to be implemented in the event that trigger criteria have been exceeded. 5. Specify threshold contingency actions to be implemented in the event that threshold criteria are exceeded.	Section 5
	6. Provide the format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that condition 14-1 of Ministerial Statement 1116 have been met over the reporting period in the Compliance Assessment Report required by condition 4. 7. Provide for reporting of exceedances of the trigger and threshold criteria.	Section 7

Condition No.	Condition	Section in this plan
8-3	After receiving notice in writing from the CEO that the Condition Environmental Management Plan(s) satisfies the requirements of condition 8-2 for condition 14-1 of Ministerial Statement 1116, the proponent shall prior to the commencement of ground disturbing activities: 1. Implement the provisions of the approved Condition Environmental Management Plan(s). 2. Continue to implement the approved Condition Environmental Management Plans until the CEO has confirmed by notice in writing that the proponent has met the relevant objectives specified in the approved Condition Environmental Management Plan and no longer needs to implement that particular Condition Environmental Management Plan.	Section 2.4 Refer to the Compliance Assessment Plan for details relating to annual compliance assessment reporting of implementation of the Condition Environmental Management Plans.
8-4	In the event that monitoring indicates exceedance of trigger criteria and/or threshold criteria specified in the Condition Environmental Management Plan(s), the proponent shall: 1. Report the exceedance in writing within 7 days of the exceedance being identified. 2. Immediately implement the trigger level actions and/or threshold contingency actions specified in the Condition Environmental Management Plan(s) and continue implementation of those actions until the trigger criteria are being met, or until the CEO has confirmed by notice in writing that it has been demonstrated that the environmental outcomes in condition 14-1 of Ministerial Statement 1116 are being met and implementation of the trigger level actions and/or threshold contingency actions are no longer required. 3. Investigate to determine the cause of the trigger criteria and/or threshold criteria being exceeded. 4. Identify additional measures required to prevent the trigger and/or threshold criteria being exceeded in the future. 5. Investigate to determine potential environmental harm or alteration of the environment that occurred due to threshold criteria being exceeded. 6. Provide a report to the CEO within 60 days of the exceedance being reported. The report shall include: a) Details of trigger level actions or threshold contingency actions implemented. b) The effectiveness of the trigger level actions or threshold contingency actions implemented, monitored and measured against trigger criteria and threshold criteria. c) The findings of the investigations required by conditions 8-4(3) and 8-4(5). d) Additional measures to prevent the trigger or threshold criteria being exceeded in the future.	Sections 5 and 7.3

Condition No.	Condition	Section in this plan
	e) Measures to prevent, control or abate the environmental harm which may have occurred.	
8-5	The proponent: 1. May review and revise the Condition Environmental Management Plan(s). 2. Shall review and revise the Condition Environmental Management Plan(s) as and when directed by the CEO.	Section 8.2
8-6	The proponent shall implement the latest revision of the Condition Environmental Management Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 8-2.	Section 8.2
Ministerial Statement 1116		
14-1	The proponent shall manage the construction of the proposal to meet the following environmental outcomes: 1. To ensure that construction and operation of the proposal, including from dewatering and groundwater abstraction, does not result in indirect impacts to the *Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain*) and Conservation Category Wetlands as shown in Figures 5 of Ministerial Statement 1036 and Figure 6 attached to this Statement [Ministerial Statement 1116]; and 2. To ensure that construction of the proposal maintains predevelopment surface water flows to the *Darwinia foetida, Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain*) and Conservation Category Wetlands as shown in Figures 3 and 5 of Ministerial Statement 1036 and Figure 6 attached to this Statement [Ministerial Statement 1116], through implementation of the Flora and Vegetation – Inland Waters – Condition Environmental Management Plan approved by the CEO.	Section 1
14-2	The proponent shall prepare the Flora and Vegetation – Inland Waters – Condition Environmental Management Plan required by condition 8-1 of Ministerial Statement 1036 on advice of the Department of Water and Environmental Regulation and the Department of Biodiversity, Conservation and Attractions.	Section 9
14-3	The proponent shall determine the trigger and threshold criteria required by condition 8-2 (1) and 8-2(2) of Ministerial Statement 1036 based on the results of baseline surveys.	Section 3
14-4	The proponent shall undertake monitoring as required by condition 8-2(3) of Ministerial Statement 1036 for a period of 3 years, or as otherwise agreed in writing by the CEO, post construction in order to demonstrate that the outcomes in conditions 14-1(1) and 14-1(2) have been met.	Section 4.2
14-5	In the event that monitoring required by condition 14-4 indicates that the outcomes in conditions 14-1(1) and 14-1(2) have not been met the proponent shall undertake the requirements of condition 8-4 of Ministerial Statement 1036.	Sections 5 and 7.3
14-6	The proponent shall not construct laydowns areas or stock piles within 50 m of *Communities of Tumulus Springs* (*Organic Mound Springs, Swan Coastal Plain*) and Conservation Category Wetlands as shown in Figure 5 of Ministerial	Section 6

Condition No.	Condition	Section in this plan
	Statement 1036 and Figure 6 attached to this Statement [Ministerial Statement 1116].	

2.4 Management Approach

Implementation of a proposal-specific management approach will ensure the condition environmental outcome for the proposal is met. The management approach to meet the condition environmental outcome stated in Table 1 was developed using results of baseline surveys. For the groundwater and surface water baseline survey eleven sampling events comprise the baseline at the time of preparation of this plan.

Review of the baseline survey results identified key assumptions and uncertainties associated with the management approach. It also provided rationale to support trigger criteria, threshold criteria, trigger level actions and threshold contingency actions developed to ensure the condition environmental outcome is met.

The management approach for potential impacts from the proposal on the identified environmental values is a monitoring and management program that identifies, monitors and manages indicators (environmental criteria) for flora and vegetation, inland waters environmental quality and hydrological processes in relation to *Darwinia foetida,* Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) and CCWs. This program defines trigger and threshold criteria to determine whether the environmental outcome is being met or, if the criteria are exceeded, additional actions need to be taken.

In accordance with condition 8-3 of Ministerial Statement 1036, this plan will continue to be implemented until the CEO of the DWER has advised that the environmental outcome has been met and the plan is no longer required to be implemented.

In accordance with condition 14-4 of Ministerial Statement 1116, the monitoring required by condition 8-2(3) of Ministerial Statement 1036 will be undertaken for a period of three years post-construction, or as otherwise agreed in writing by the CEO of the DWER.

2.5 Key Assumptions and Uncertainties

The following assumptions have been made:

- The majority of the proposal footprint is a highly altered environment, with a variety of land uses including residential properties, farming properties, plantations and recreational areas.
- Groundwater levels within the proposal footprint experience a seasonal high following the winter rains (around September/October) and are at a seasonal low around April/May. The extent of seasonal variation depends on the hydraulic conductivity of the geological unit, but generally a seasonal fluctuation of about 2 to 3 m is expected in areas of clay and about 1 to 1.5 m in Bassendean Sands (Coffey, 2017).
- Calculation of groundwater levels in mAHD has been undertaken to assess groundwater interception levels in relation to proposed infrastructure levels along the alignment. Levels range from approximately 27 mAHD at the southernmost section of the alignment to 55 mAHD in the northern portion of the alignment near Muchea within the intersection area of the series of mapped Communities of Tumulus Springs (Organic Mound Springs) TEC buffer zones (Coffey, 2017).
- Dewatering, abstraction and/or ground disturbance activities in a known or suspected ASS risk area will be managed through site-specific ASS management plans (ASSMPs) in line with DER ASS

management guidelines (Treatment and management of soil and water in ASS landscapes (DER, 2015)). As such, monitoring and management requirements for ASS and dewatering are not presented in this plan.

- Dewatering and abstraction licence provisions are separate to this plan. Dewatering and abstraction activities will be avoided where possible by conducting construction activities in the appropriate season. If dewatering or abstraction activities are required, management conditions for dewatering and abstraction will be included in the relevant licence issued by the Department of Water under the *Rights in Water and Irrigation Act 1914*. Where required, a hydrogeological assessment and an operating strategy will be developed to support the licence application informing the dewatering management strategy. Monitoring requirements as part of the licence will confirm predictions made by the hydrogeological assessment to minimise risks to key environmental factors.
- In the event dewatering or abstraction activities are required, groundwater monitoring sites within the zone of influence will adopt reporting levels as specified within the approved operating strategy. In such a case the environmental criteria (i.e. trigger and threshold criteria) for the monitoring sites within the specified zone of influence affected by dewatering activities and/or groundwater abstraction may be revised to be relevant to the anticipated drawdown extent during the dewatering or abstraction period.
- The Gnangara Mound supports wetlands including Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plains) and some CCWs. Wetlands supported by the Gnangara Mound receive water from groundwater discharge from the regional unconfined aquifer (DEC, 2012). Groundwater levels close to these wetlands is considered an appropriate parameter to monitor potential altered hydrology/surface water levels as a result of the proposal. The surface water level at Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plains) will also be monitored to identify potential changes to predevelopment surface water flows as a result of the proposal.
- Review of Interim Recovery Plan No. 198 (CALM, 2006) refers to monitoring groundwater levels to ascertain the quality of Communities of Tumulus Springs given changes in the level of the water table are very likely to influence the hydrology of these wetlands as they are likely to be almost entirely dependent on groundwater for water supply.
- Surface water levels alone are not an appropriate parameter for monitoring potential impacts on wetlands as there is no typical wetland water pattern for Western Australian wetlands (DEC, 2012). Surface water levels often fluctuate naturally from season to season, year to year, and over the long term and differentiating the cause of any observed changes is difficult. Surface water levels will not be used as an indicator of change to surface water flow.
- Most CCWs adjacent to the alignment (with the exception of CCW 8773) are groundwater dependent and receive no dedicated surface water flows. Only CCW 8773 in the vicinity of Neaves Road may be impacted by alterations to surface water flows from the construction and operation of the proposal.
- The Communities of Tumulus Springs are entirely groundwater fed. Those in proximity to the alignment are upstream of the alignment. Only backwater from the road acting as a dam could affect surface water flows to the Communities of Tumulus Springs.
- Significant changes to the hydrology of seasonal wetlands (such as increased surface water run-off) will alter the vegetation suite present. Most Western Australian wetlands, including CCWs, are seasonally wet and dry at different times (DEC, 2012).
- Changes to surface water flows to the known population of *Darwinia foetida* will only eventuate if road pavement areas or unpaved road shoulders of Great Northern Highway's (GNH) roadside rest area are

altered (local catchment). The proposal has no planned activities for GNH's roadside rest area. If there are no works in the local catchment or to the roadside drain, there will be no impacts to surface water flows to the known population of *Darwinia foetida* as a result of the proposal. Monitoring of disturbance within the local catchment of *Darwinia foetida* is an appropriate parameter to identify potential changes to predevelopment surface water flows as a result of the proposal.

- Seasonal wetlands are known to appear devoid of life when naturally dry during summer months and when wet flora and vegetation flourishes (TSSC, 2012). Annual spring survey monitoring will be conducted in line with baseline survey timing to avoid inadvertently exceeding the wetland flora and vegetation trigger level.
- Of the 18 surface water monitoring sites in the baseline survey, 10 were dry throughout all seasons and three were unable to be accessed. The three sites unable to be accessed – SWL13, SWL14 and SWL20 – are not suitable for ongoing monitoring and are not included in this plan.
- Throughout the duration of the baseline monitoring survey and ongoing surface locations SWL6, SWL7, SWL8, SWL9, SWL10, SWL11, SWL12 have been dry or the volume of water present was not sufficient in quantity to allow collection of samples. SWL6, SWL7, SWL8, SWL9, SWL10, SWL11 and SWL12 will continue to be monitored as set out in this plan, although it is likely that these sites will continue to be dry or contain insufficient surface water to enable sampling during future monitoring events.
- The half-life of glyphosate in soils ranges from 2 to 197 days. However, it binds tightly to soil and is expected to be relatively immobile with low potential to contaminate groundwater. The use of glyphosate directly within surface water bodies is not proposed.
- The project design includes the installation of culverts as part of the drainage strategy. Culverts are designed and intended to maintain surface water flows.

Uncertainties are as follows:

- Final design and construction programs of the proposal were not known at time of preparing this plan. Following final design, this plan may need to be revised to manage and target specific construction activities and locations within the proposal footprint.

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3 TRIGGER AND THRESHOLD CRITERIA

This section sets out the trigger and threshold criteria adopted to meet the condition environmental outcomes. A discussion on how the trigger and threshold criteria have been set follows.

3.1 Trigger and Threshold Criteria

Trigger criteria are set to ensure trigger level actions can be implemented well in advance of the environmental outcome being compromised.

Threshold criteria are framed to measure achievement of the environmental outcome. Failure to meet threshold criteria signals the environmental outcome is not being met.

Trigger and threshold criteria to meet the condition environmental outcomes are set out in Table 4.

Table 4 Trigger and threshold criteria

	Trigger criteria	Threshold criteria
Environmental criteria 1 – Groundwater, surface water and basin sediment quality	Groundwater quality trigger criteria listed in Appendix A. Surface water quality trigger criteria listed in Appendix B. Basin sediment quality trigger criteria listed in Table 8.	Groundwater quality threshold criteria listed in Appendix A. Surface water quality threshold criteria listed in Appendix B. Basin sediment quality threshold criteria listed in Table 8.
Environmental criteria 2 – Groundwater level	Groundwater level trigger criteria listed in Appendix A.	Groundwater level threshold criteria listed in Appendix A.
Environmental criteria 3 – Wetland flora and vegetation	Observed plant stress rating 2 (Appendix C).	Observed plant stress rating 3 (Appendix C).
Environmental criteria 4 – Surface water flows to *Darwinia foetida*	Clearing or construction of laydown areas or stockpiles within 40 m of the known population of *Darwinia foetida*.	Clearing or construction of laydown areas or stockpiles within 10 m of the known population of *Darwinia foetida*.
Environmental criteria 5 – Surface water flows to Communities of Tumulus Springs and CCWs	Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 6 m.	Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 10 m.

Note: the trigger and threshold criteria for environmental criteria 1 and 2 are too numerous to detail in the body of this document and are instead listed in appendices to this Condition EMP. The trigger and threshold criteria in the appendices are summarised as high-level groundwater and surface water quality criteria in Table 4 for the purpose of overall compliance reporting.

Refer to Section 5 for trigger level actions and threshold contingency actions that must be implemented if the trigger criteria or threshold criteria are exceeded.

3.2 Rationale for Selection of Environmental Criteria

In accordance with condition 14-3 of Ministerial Statement 1116, trigger and threshold criteria are required to be established with reference to baseline survey data. Environmental criteria 1 and 2 have been set using groundwater and surface water baseline survey data that has included 16 sampling events undertaken by Coffey and four sampling events undertaken by Great Northern Connect (GNC), the construction contractor engaged by MRWA to construct the southern section of the PDNH and conduct ongoing groundwater and surface water monitoring for that section in accordance with this plan.

It is intended that trigger criteria provide an advance warning that threshold criteria may be exceeded, which requires trigger criteria to be set below the corresponding threshold criteria.

The following sections provide more detail and background on this approach for the environmental criteria for each target area.

3.2.1 Environmental Criteria 1 – Groundwater, Surface Water and Basin Sediment Quality

The selection of environmental criteria for groundwater, surface water and basin sediment quality was based on results of the groundwater and surface water baseline survey and Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000).

This section details the approach and background in establishing trigger and threshold criteria associated with environmental criteria 1.

3.2.1.1 Baseline Surveys and Ongoing Monitoring Assessments

A monthly baseline groundwater and surface water survey commenced in December 2015 and concluded in April 2017. Groundwater and surface water monitoring during road construction has continued using the same sampling methodology applied during the baseline survey. A review of the results collected by GNC has been undertaken and the data is considered suitable to supplement the baseline survey dataset. As such results from 16 baseline survey and four construction monitoring events have informed the preparation of this plan.

The objectives of the baseline survey were to:

- Determine groundwater and surface water baseline values of the Communities of Tumulus Springs and CCWs for monitoring future project environmental performance.
- Inform the selection of trigger and threshold criteria for environmental criteria 1 and 2.

The compiled dataset has demonstrated some analytes (e.g., aluminium, cadmium, zinc) are commonly elevated within groundwater resources along the proposal alignment (Coffey, 2017). Recorded concentrations for some analytes at some sites exceed the guideline values in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality by many multiples.

Basins can only be surveyed once constructed and in operation, therefore a baseline for basin sediment cannot be established at this time.

3.2.1.2 Water Quality Analytes

Groundwater and surface water quality is determined by a range of parameters relating to physical, chemical and other properties of water.

The analytes used to measure groundwater and surface water quality are based on the:

- Analytes listed in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality for slightly to moderately disturbed fresh water aquatic ecosystems (ANZECC and ARMCANZ, 2000).

- Contaminants that have the potential to be introduced to groundwater and/or surface water from proposal activities (e.g., earthworks resulting in erosion) or incidents (e.g., accidental chemical/hydrocarbon spills).
- Disturbance of ASS resulting in mobilisation of high levels of potential pollutants such as metals and nutrients.

Baseline survey monitoring for total recoverable hydrocarbons, benzene, toluene, ethylbenzene and xylenes (BTEX) and organochlorine and organophosphorus pesticides (OCP/OPP) occurred for baseline survey events 3, 6 and 12. There were no detections at the survey sites above the limit of reporting (LOR) for all TRH/BTEX (with the exception of MW55, now removed) and OCP/OPP analytes. Given that proposal activities include the use of hydrocarbons these analytes have been included in the monitoring provisions. Following the non-detection of OCP/OPP, these analytes will not be monitored, given that proposal activities do not include their use.

Based on review of 20 months of data, the water suite proposed for ongoing laboratory analysis has been modified. The analytes used to determine water quality in this plan are listed in Table 5.

Table 5 Water quality analytes to be monitored under this plan

Group	New indicators/analytes
Metals	• Aluminium (Al) • Arsenic (As) • Cadmium (Cd) • Chromium (Cr) • Copper (Cu) • Iron (Fe) • Lead (Pb) • Manganese (Mn) • Mercury (Hg) • Nickel (Ni) • Selenium (Se) • Zinc (Zn)
Total recoverable hydrocarbons (TRH)/benzene, toluene, ethylbenzene and xylenes (BTEX)	• TRH C6-C10 • TRH >C10-C40
Polycyclic aromatic hydrocarbons (PAH)	• Total PAHs

Group	New indicators/analytes
Nutrients and physical parameters	• Acidity (as $CaCO_3$) • Nitrogen (total) • pH • Phosphate (total) (P) • Phosphorus (reactive as P) • TDS • Turbidity (surface water only)
Herbicide	• Glyphosate (during landscaping works only)

3.2.1.3 Basin Sediment Analytes

Basin sediment quality is determined by a range of parameters relating to chemical contamination from proposal activities.

The analytes chosen to measure basin sediment quality are based on:

- Analytes listed in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality for interim sediment quality guidelines (ANZECC and ARMCANZ, 2000).
- Contaminants that have the potential to be introduced to groundwater and/or surface water from proposal activities (e.g., earthworks resulting in erosion and/or the disturbance of ASS) or incidents (e.g., accidental chemical/hydrocarbon spills).
- Disturbance of naturally occurring high levels of potential pollutants such as metals and nutrients.

In addition to basin sediment sampling, the effectiveness and condition of stormwater infiltration and retention basins will be measured through comparison of water quality data recorded upstream and downstream of the basin, opportunistic sampling of surface water retained in the basin. The choice of trigger levels and threshold criteria are based on the trigger value relevant to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality for interim sediment quality guidelines (ANZECC and ARMCANZ, 2000).

The analytes used to determine basin sediment quality in this plan (i.e. those with threshold and trigger criteria set) are listed in Table 6.

Table 6 Sediment analytes to be monitored under this plan

Group	Indicator/analyte	
Metals	• Arsenic (As) • Cadmium (Cd) • Chromium (Cr) • Copper (Cu)	• Lead (Pb) • Mercury (Hg) • Nickel (Ni) • Zinc (Zn)
Organics	• Total PAHs	• TRH C6-C10 • TRH >C10-C40

3.2.1.4 Method for Setting Water Quality Analyte Threshold Criteria

Threshold criteria for each analyte are set separately. Groundwater and surface water threshold criteria are also set separately.

In some instances, baseline levels of an analyte recorded at one or more survey sites exceed the guideline value. Where the maximum baseline value equals or exceeds the guideline value, a site-specific threshold criterion is set at one standard deviation of the baseline dataset above the maximum value for the site. The standard deviation and maximum of the baseline dataset are calculated after discarding outliers from the dataset. The maximum value of the dataset is representative of baseline characteristics within the system. Adding one standard deviation (representing the dispersion of the data set from the mean) to the baseline maximum, and also taking into account the low range between minimum and maximum values at most locations, will allow for assessment of deviation from threshold levels whilst at the same time reducing the risk of triggering a Type II error; i.e., the risk of claiming a pollution event is acceptable.

A modified method for determining threshold criteria applies for pH, which requires a range to be set. The baseline survey has shown pH to be already generally in the acidic range and often outside the guideline range of 6.5 to 8.5 (Coffey, 2017). A site-specific lower threshold criterion for pH is set at the lower trigger criterion minus 1. The upper threshold criterion is set at the upper trigger criterion plus 1. This method is consistent with DER guidance for managing acid sulfate soils (DER, 2015), which recommends adopting a deviation of 1 from "baseline values" as a threshold for increased management. Baseline values are taken in this context to be equivalent to the baseline range, which are represented by the baseline maximum (or minimum) plus (or minus) one standard deviation, i.e. the trigger values as established in Section 3.2.1.5.

Standard deviations, maxima and minima are all calculated after discarding outliers from the dataset. Outliers are excluded in accordance with the statistical method suggested in the Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC and ARMCANZ, 2000b), where results more than four standard deviations from the mean may be considered outliers.

A modified method for determining threshold criteria was applied to hardness-related metals. To account for local water hardness, the threshold criteria for hardness-related metals are modified according to ANZECC and ARMCANZ (2000) using $T_{HM} = T \times (H / 30) \times k$, where:

- T_{HM} is the hardness-modified threshold criterion.
- T is the unmodified threshold criterion.
- H is the average measured hardness for the relevant site.
- k is 0.85 for copper, nickel and zinc; 0.89 for cadmium; and 1.27 for lead.

In accordance with ANZECC and ARMCANZ (2000), the hardness-dependant formula was used at sites where the mean of the measured hardness (as $CaCO_3$) was outside the mid-range of each hardness category. The hardness-dependant formula was not used at sites measuring hardness of less than 25 mg/L. A hardness-modified threshold value was not calculated for chromium given the absence of an ANZECC and ARMCANZ (2000) guideline value for insertion in the algorithm.

3.2.1.5 Method for Setting Water Quality Analyte Trigger Criteria

Trigger criteria for each analyte are set separately. Groundwater and surface water threshold criteria are also set separately.

With reference to the baseline survey, most trigger criteria are greater than the relevant limits of reporting (LOR). Where trigger criteria have been set below the LOR, future laboratory analyses must be amended to ensure the LOR is lowered for future monitoring rounds.

In some instances, baseline levels of an analyte recorded at one or more survey sites exceeds the guideline value. Where two or more of the baseline dataset equals or exceeds the guideline value, a site-specific trigger criterion is set. Previously, using methods presented within ANZECC and ARMCANZ (2000), a site-specific trigger was calculated using the 75th percentile of the baseline value as a trigger. However, additional data has provided confidence in the data set and it is considered the site-specific trigger level can be set at the 80th percentile of the data set in accordance ANZECC and ARMCANZ (2000) methodology.

It is noted that ANZECC and ARMCANZ (2000) recommends the application of the median as trigger criteria in the absence of 24 months of data. However, this is not considered a suitable trigger mechanism for this project. The application of the mean as the trigger level will result in 50% of the data requiring trigger level actions to be implemented and the risk of triggering a false project-attributable pollution event (Type I error).

This method recognises that baseline levels already exceed the guideline values, defining the top quartile of baseline survey results for a particular analyte and site as exceeding the trigger criterion in order to provide sufficient warning of the threshold criterion being approached.

A modified method for determining trigger criteria applies for pH, which requires lower and upper limits to be set. Trigger criteria are set individually for each site. The lower trigger criterion is set at the minimum baseline value minus one standard deviation. Due to the generally low pH values already recorded in the baseline survey (Coffey, 2016), the upper trigger criterion is set at the maximum baseline value plus one standard deviation.

Minimum and maximum baseline values and standard deviations are calculated on a site-by-site basis. All standard deviations are currently less than 1, resulting in lower trigger criteria that are always greater than corresponding lower threshold criteria. However, if further baseline data is collected and standard deviations increase to values greater than 1, then the method for setting lower trigger criteria and lower threshold criteria will require review.

3.2.1.6 Summary of Framework for Setting Water Quality Analyte Environmental Criteria

A summary of the framework for setting groundwater and surface water threshold and trigger criteria is provided in Table 7. This framework is applied per analyte per site.

Table 7 Framework for setting groundwater and surface water environmental criteria

Scenario	Threshold criteria	Trigger criteria
Parameters other than pH		
All baseline values are less than the guideline value	Set at 115% of trigger criteria.	Set at guideline value.
Two or more baseline values is equal to or exceeds the guideline value	Set at one standard deviation above maximum baseline value.	Set at 80th percentile of baseline dataset.
pH		
Upper limit	Set at upper trigger criterion plus 1.	Set at maximum baseline value plus one standard deviation.
Lower limit	Set at lower trigger criterion minus 1.	Set at minimum baseline value minus one standard deviation.

Note: Outliers are excluded from baseline. Guideline values are as set out in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality for slightly to moderately disturbed fresh water aquatic ecosystems for surface water pH (ANZECC and ARMCANZ, 2000) and DER guidance for managing acid sulfate soils (DER, 2015) pH guideline values for groundwater.

3.2.1.7 Environmental Criteria for Basin Sediment Quality

Basin sediment quality threshold criteria have been derived from the Interim sediment quality guideline – High (ANZECC and ARMCANZ, 2000).

Basin sediment quality trigger criteria have been derived from the ANZECC and ARMCANZ Interim sediment quality guideline – Low (trigger value) (ANZECC and ARMCANZ, 2000), which will allow time to implement trigger level actions to prevent exceedance of the threshold criterion.

Table 8 details the basin sediment quality environmental criteria. For threshold and trigger criteria in Table 8, a criterion is exceeded when the recorded level is greater than the criterion.

Table 8 Environmental criteria for basin sediment quality

Indicator/analyte	Unit	Trigger criteria	Threshold criteria
Metals			
Arsenic (As)	mg/kg dry wt	20	70
Cadmium (Cd)	mg/kg dry wt	1.5	10
Chromium (Cr)	mg/kg dry wt	80	370
Copper (Cu)	mg/kg dry wt	65	270
Lead (Pb)	mg/kg dry wt	50	220
Mercury (Hg)	mg/kg dry wt	0.15	1
Nickel (Ni)	mg/kg dry wt	21	52
Zinc (Zn)	mg/kg dry wt	200	410
Total PAHs	µg/kg dry wt	4,000	45,000
TRH C6-C10	µg/kg dry wt	LOR	LOR
TRH >C10-C40	µg/kg dry wt	LOR	LOR

3.2.2 Environmental Criteria 2 – Groundwater Level

The selection of environmental criteria for groundwater levels was based on results of the groundwater and surface water baseline survey.

This section details the approach and background in establishing trigger and threshold criteria associated with environmental criteria 2.

3.2.2.1 Baseline Survey

The monthly baseline groundwater and surface water survey as detailed in Section 3.2.1.1 included standing water levels at each groundwater monitoring well.

Groundwater standing water level baseline survey data is used to establish environmental criteria 2.

3.2.2.2 Groundwater Level

Rapidly reduced groundwater levels may be an indicator of groundwater drawdown effects from abstraction and dewatering for the proposal.

The trigger criteria and threshold criteria for groundwater levels are set at the seasonal minimum on a site-by-site basis.

3.2.2.3 Method for Setting the Groundwater Level Threshold Criteria

Threshold criteria for groundwater levels are set separately for each site.

Groundwater threshold criteria are set for each monitoring site at the minimum piezometric head as identified within baseline survey data minus one standard deviation for each monitoring site. The groundwater level threshold criteria will ensure that drawdown created by dewatering and/or abstraction activities does not exceeded the reasonable range of natural variation in the water table. Communities of Tumulus Springs and CCWs will not be indirectly impacted if groundwater levels are within baseline survey levels.

This method of setting site-specific threshold criteria is consistent with condition 14-1(1) of Ministerial Statement 1116, which requires the proposal not to result in indirect impacts to Communities of Tumulus Springs and CCWs.

3.2.2.4 Method for Setting the Groundwater Level Trigger Criteria

Trigger criteria for groundwater levels are set separately for each monitoring site.

To provide adequate early warning of threshold criteria being approached, groundwater level trigger criteria are set to correspond to the minimum piezometric head as identified within baseline survey data.

3.2.2.5 Summary of Framework for Setting Groundwater Level Environmental Criteria

A summary of the framework for setting groundwater level threshold and trigger criteria is provided in Table 9.

Table 9 Framework for setting groundwater level environmental criteria

Indicator	Threshold criteria	Trigger criteria
Groundwater level	Set at the minimum baseline groundwater level minus one standard deviation recorded at each groundwater monitoring site.	Set at the minimum baseline groundwater level at each groundwater monitoring site.

3.2.3 Environmental Criteria 3 – Wetland Flora and Vegetation

The selection of environmental criteria for wetland flora and vegetation was based on results of a baseline wetland flora and vegetation assessment to inform vegetation stress criteria.

This section details the approach and background in establishing trigger and threshold criteria associated with environmental criteria 3.

3.2.3.1 Baseline Wetland Flora and Vegetation Assessment

A Level 2 spring flora and vegetation survey was conducted in September 2014 as part of the PDNH Wetland Assessment (Coffey, 2015). The objectives of the wetland flora and vegetation assessment were to:

- Determine wetland flora and vegetation baseline values of Communities of Tumulus Springs and CCWs.
- Inform the pre-construction monitoring method to determine trigger and threshold criteria for environmental criteria 3.

3.2.3.2 Level of Plant Stress

The level of plant stress on wetland flora and vegetation has been used as an indicator of altered surface water flows to *Darwinia foetida* habitat, Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plains) and CCWs.

The choice of trigger levels and threshold criteria for wetland flora and vegetation monitoring are based on detecting signs of plant stress in these environmental values that are outside the range of baseline observations. It will be assessed by observation of evidence of wilting of foliage and the extent of wilting, and/or leaf colour. The assessment of plant stress caused by changes in surface water flows will consider other factors prevailing at the time. A scale comprising five increments will be used to indicate the level of stress a plant is potentially under (Appendix C).

3.2.3.3 Wetland Flora and Vegetation Threshold Criterion

The wetland flora and vegetation threshold criterion has been set at a plant stress level of 3, where plants exhibit signs of stress.

Given plant stress can be caused by a range of anthropogenic and natural factors including drought or kangaroo grazing, various monitoring parameters will also be reviewed to help validate plant stress originating from changes to surface water flow. Details on the plant stress rating method and parameters to be monitored are provided in Appendix C.

3.2.3.4 Wetland Flora and Vegetation Trigger Criterion

To provide adequate early warning of threshold criteria being approached, the wetland flora and vegetation condition trigger criterion is set at a plant stress level of 2, where plants exhibit symptoms of stress.

3.2.4 Environmental Criteria 4 – Surface Water Flows to *Darwinia foetida*

The selection of environmental criteria for surface water flows to *Darwinia foetida* was based on the high-level local surface water flow assessment.

This section details the approach and background in establishing trigger and threshold criteria associated with environmental criteria 4.

3.2.4.1 High-level Local Surface Water Flow Assessment

A high-level local surface water flow assessment using LiDAR contours from the drainage strategy (BG&E, 2015) was undertaken focusing on the known population of *Darwinia foetida*.

The following section provides a summary of the LiDAR contour assessments for *Darwinia foetida* to identify the local catchment area for the known population of *Darwinia foetida*, relevant proposal activities with the potential to impact surface water flows and the environmental criteria based on the assessment.

3.2.4.2 Method for Setting Environmental Criteria for Surface Water Flows to *Darwinia foetida*

The assessment of LiDAR contours surrounding the known population of *Darwinia foetida* identified an increase in elevation to occur east of the population due to the presence of Great Northern Highway. It is expected that surface water flow to the known population of *Darwinia foetida* would be from runoff from Great Northern Highway located approximately 10 m east of the population (see Figure 2A). Approximately 10 m west of the known population of *Darwinia foetida*, elevation contours decrease due to the presence of Great Northern Highway's drain. It is expected that surface water flow from the known population of *Darwinia foetida* would be directed into Great Northern Highway's drain.

Based on the elevation contours, surface water flow is expected to run from the Great Northern Highway, past the known population of *Darwinia foetida* and into the Great Northern Highway's drain. The local surface water flow for the known population of *Darwinia foetida* is therefore located within a 10 m buffer, which validates the prohibition of clearing or construction of any laydown areas or stockpiles within the 10 m buffer of *Darwinia foetida* as required by condition 9-9(2) of Ministerial Statement 1036 (refer to Section 6).

Following the late discovery of the population during the environmental assessment phase, the area within 10 m of the population's location has been excluded from construction activities.

Currently all surface flows received by the *Darwinia foetida* population are from the existing Great Northern Highway and the adjacent roadside rest area. As there are no changes to the extent of sealed road and embankment within the upstream catchment or within 10 m of any individual, surface water flows to the population will not be impacted.

Potential impacts to the *Darwinia foetida* will only eventuate if unauthorised project activities occur within the upstream surface water catchment of the *Darwinia foetida* population. To maintain predevelopment flow to the *Darwinia foetida*, condition 9-9(2) of Ministerial Statement 1036 will be implemented.

Based on the high-level LiDAR assessment and aspects of the proposal that have the potential to impact surface water flow to the known population of *Darwinia foetida*, the environmental criteria for surface water flows to *Darwinia foetida* are as follows:

- **Threshold criterion:** Clearing or construction of laydown areas or stockpiles within 10 m of the known population of *Darwinia foetida*.

  The defined 10 m buffer is based on the assessed local surface water catchment area.

- **Trigger criterion:** Clearing or construction of laydown areas or stockpiles within 40 m of the known population of *Darwinia foetida*.

The defined 40 m trigger buffer ensures any activities conducted within 40 m of the known population of *Darwinia foetida* are aware of the population and can manage their activity to ensure there is no impact on the population.

3.2.5 Environmental Criteria 5 – Surface Water Flows to the Communities of Tumulus Springs and CCWs

The selection of environmental criteria for surface water flows to Communities of Tumulus Springs and CCWs was based on the high-level local surface water flow assessment.

This section details the approach and background in establishing trigger and threshold criteria associated with environmental criteria 5.

3.2.5.1 High-level Local Surface Water Flow Assessment

A high-level local surface water flow assessment using LiDAR contours from the drainage strategy (BG&E, 2015) was undertaken focusing on the Communities of Tumulus Springs and CCWs.

The drainage design includes the installation of culverts along the alignment with the aim to maintain the existing hydrological regime across the development envelope. The culvert locations relative to the Communities of Tumulus Springs and CCWs were also reviewed.

The following sections provide summaries of the LiDAR contour assessments for each receptor to identify potential impacts by changes to surface water flows, determine what aspects are not reliant on surface water flows and relevant environmental criteria based on the assessment.

3.2.5.2 Method for Setting Environmental Criteria for Surface Water Flows to the Communities of Tumulus Springs

The Communities of the Tumulus Springs are a groundwater dependent ecosystem. They do not receive surface water from any source, but are an upwelling of groundwater. There is no known occurrence of this TEC within the development envelope. The closest occurrence is approximately 100 m upstream from the development envelope (refer to Figure 6 of Ministerial Statement 1116).

The Communities of Tumulus Springs are upstream/uphill of the development envelope. Figure 2 shows elevation contours decreasing from west to east (see Figure 2B). It is expected that surface water flow generated from the groundwater upwelling at the Communities of Tumulus Springs would travel down-gradient to the east towards the development envelope located approximately 100 m from the Communities of Tumulus Springs. A major flow path (determined based on LiDAR assessment) that runs along the waterway through the closest occurrence of Communities of the Tumulus Springs (as shown in Figure 2B) confirms the surface water flow direction; i.e., surface water flows down-gradient to the east towards the development envelope.

To maintain predevelopment flow from the Communities of Tumulus Springs, PDNH culvert 44 will be installed and maintained (Figure 3). These measures will ensure the Communities of Tumulus Springs will remain groundwater fed and does not include the presence of backwater or ponding of water upstream of culvert 44, which has the potential to occur if drainage infrastructure is not in place (i.e., during construction).

Based on the high-level LiDAR assessment and aspects of the proposal that have the potential to introduce surface water flow to the Communities of Tumulus Springs before drainage infrastructure is in place, the environmental criteria for surface water flows to the Communities of Tumulus Springs are:

- **Threshold criterion:** Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 6 m.

- **Trigger criterion:** Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 10 m.

3.2.5.3 Method for Setting Environmental Criteria for Surface Water Flows to CCWs

The assessment of LiDAR contours surrounding CCWs adjacent to the development envelope show CCW 8773 at Neaves Road is located within a defined surface water flow channel. The assessment did not identify defined surface water flow channels for any other CCWs adjacent to the development envelope.

Review of the drainage design identified major flow paths that run across the development envelope into adjacent CCWs located either downstream or upstream from the development envelope. These CCWS are considered to have the potential to be fed by surface water flows. Table 10 provides details on the major flow path location and direction across the development envelope, corresponding culverts and the CCW located within the major flow path. Figure 2 shows the locations of the culverts and CCWs.

Table 10 Major flow paths and relevant culverts and CCWs

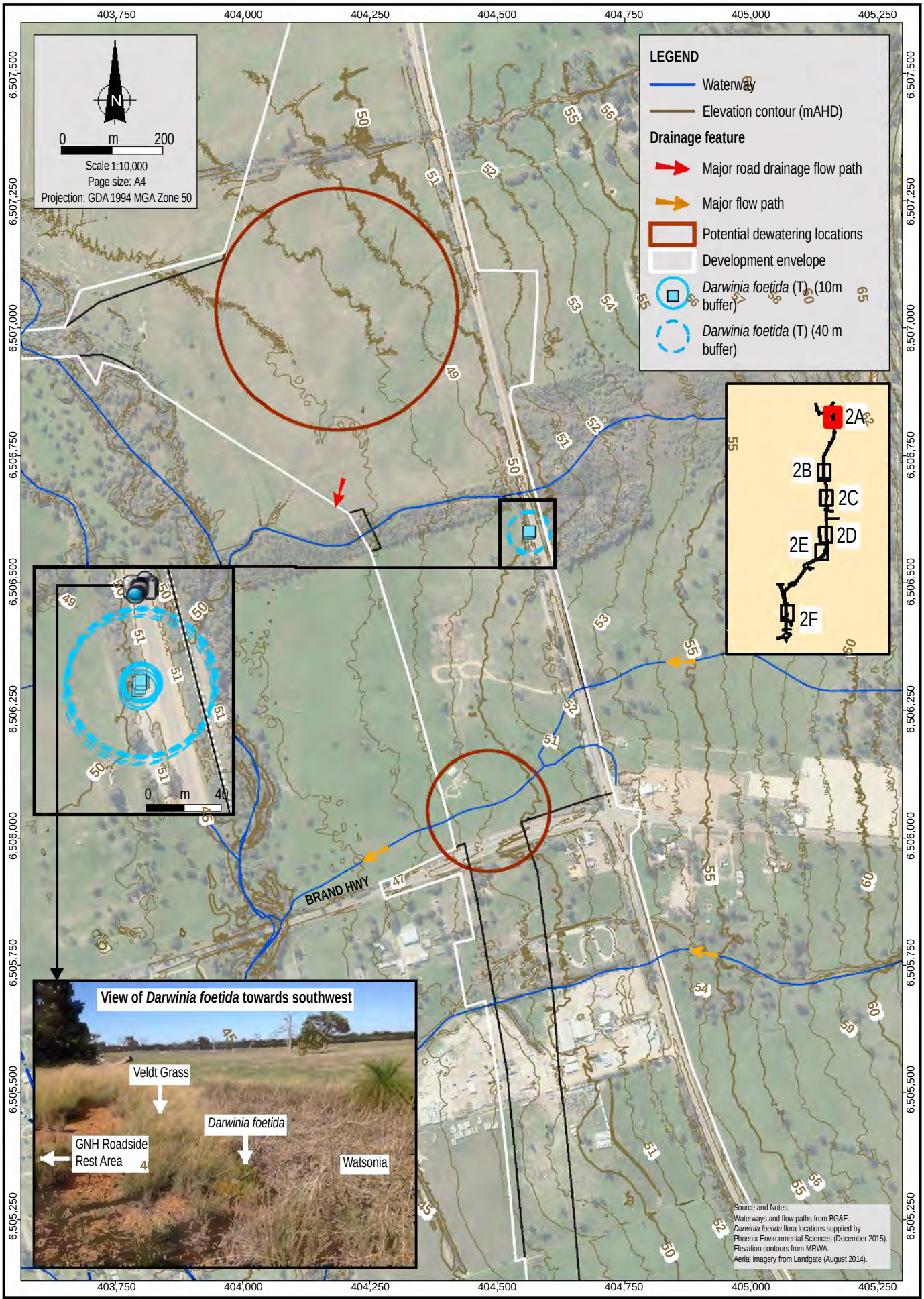
Major flow path location	Major flow path direction	Culvert	CCW	Figure reference
North of Hepburn Avenue	East to west	3	8416 (downstream)	Figure 2F
Between Hepburn Avenue and Gnangara Road	Northwest to southeast	4, 5, 6, 7	8404 (downstream)	Figure 2F
North of Maralla Road	East to west	14	8798 (upstream)	Figure 2D
South of Warbrook Road	East to west	16, 17	8926 (downstream)	Figure 2D
North of Robinson Road	East to west	32, 33	8914 (downstream)	Figure 2C
North of Neaves Road	East to west	40, 41	8773 (downstream)	Figure 2B

The culverts located next to the CCWs located within major flow paths are expected to maintain the surface water flow to or from the CCWs adjacent to the development envelope. The culverts will ensure surface water flows to CCWs are maintained where the development envelope intersects major event flow paths to CCWs.

The remaining CCWs adjacent to the development envelope are considered groundwater dependent based on the locations within the Gnangara Mound and absence of major flow paths and surface water flow channels crossing the CCWs (Figure 2E). These CCWs are not considered to have the potential to be fed by surface water flows (see Figure 2E). As noted in Section 2.5, the Gnangara Mound supports some CCWs that receive water from groundwater discharge (DEC, 2012). Infiltration basins next to CCWs within the Gnangara Mound aim to maintain the local water balance and allow surface water to infiltrate into the soil profile to replenish local groundwater. Rationale and method to determine environmental criteria relevant to groundwater levels and CCWs are provided in Section 3.2.2.

Based on the high-level LiDAR assessment, review of the drainage design and aspects of the proposal that have the potential to impact surface water flow to CCWs before drainage infrastructure is in place, the environmental criteria for surface water flows to CCWs are:

- **Threshold criterion:** Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 6 m.
- **Trigger criterion:** Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 10 m.



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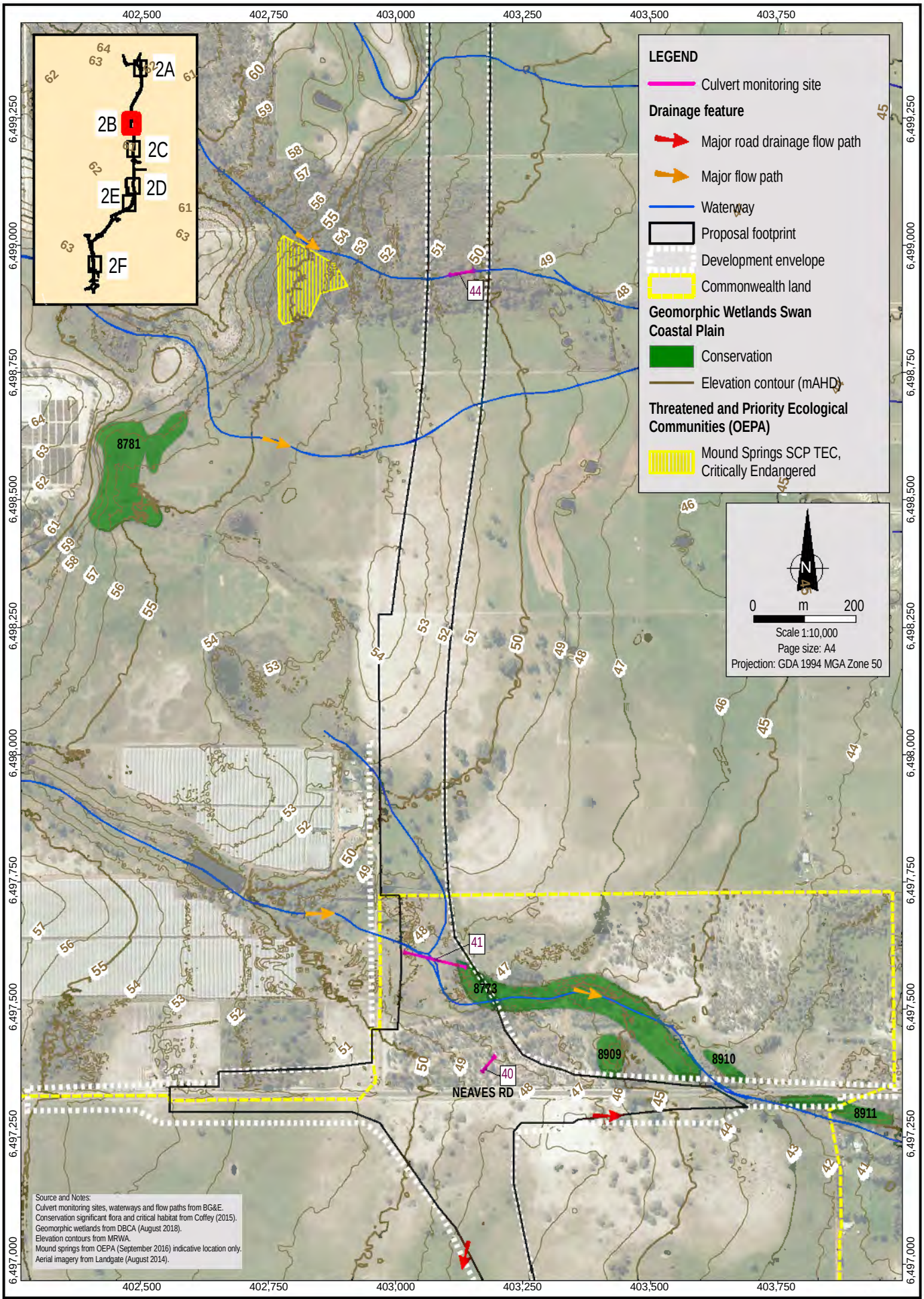

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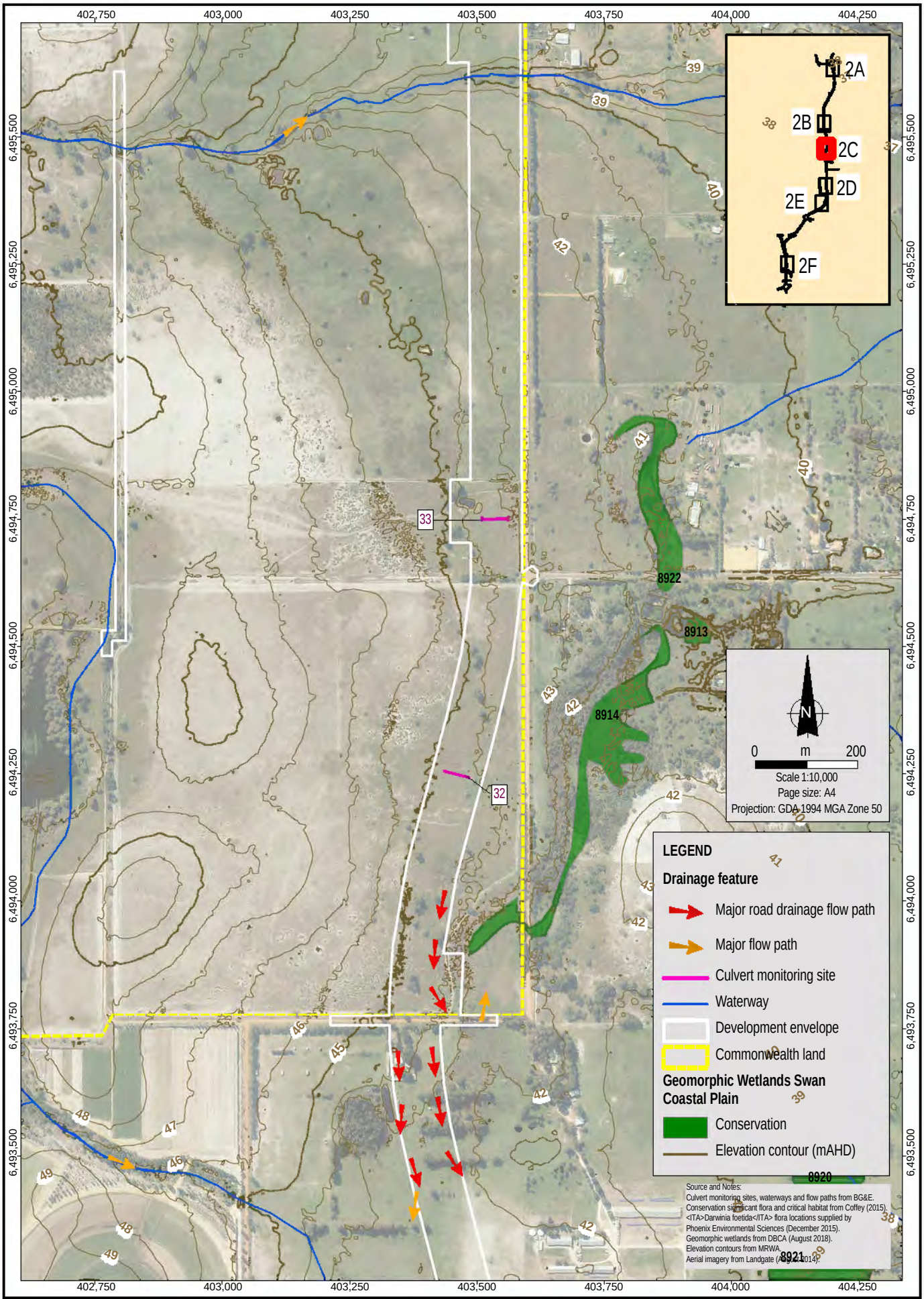

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Date: 21.08.2018
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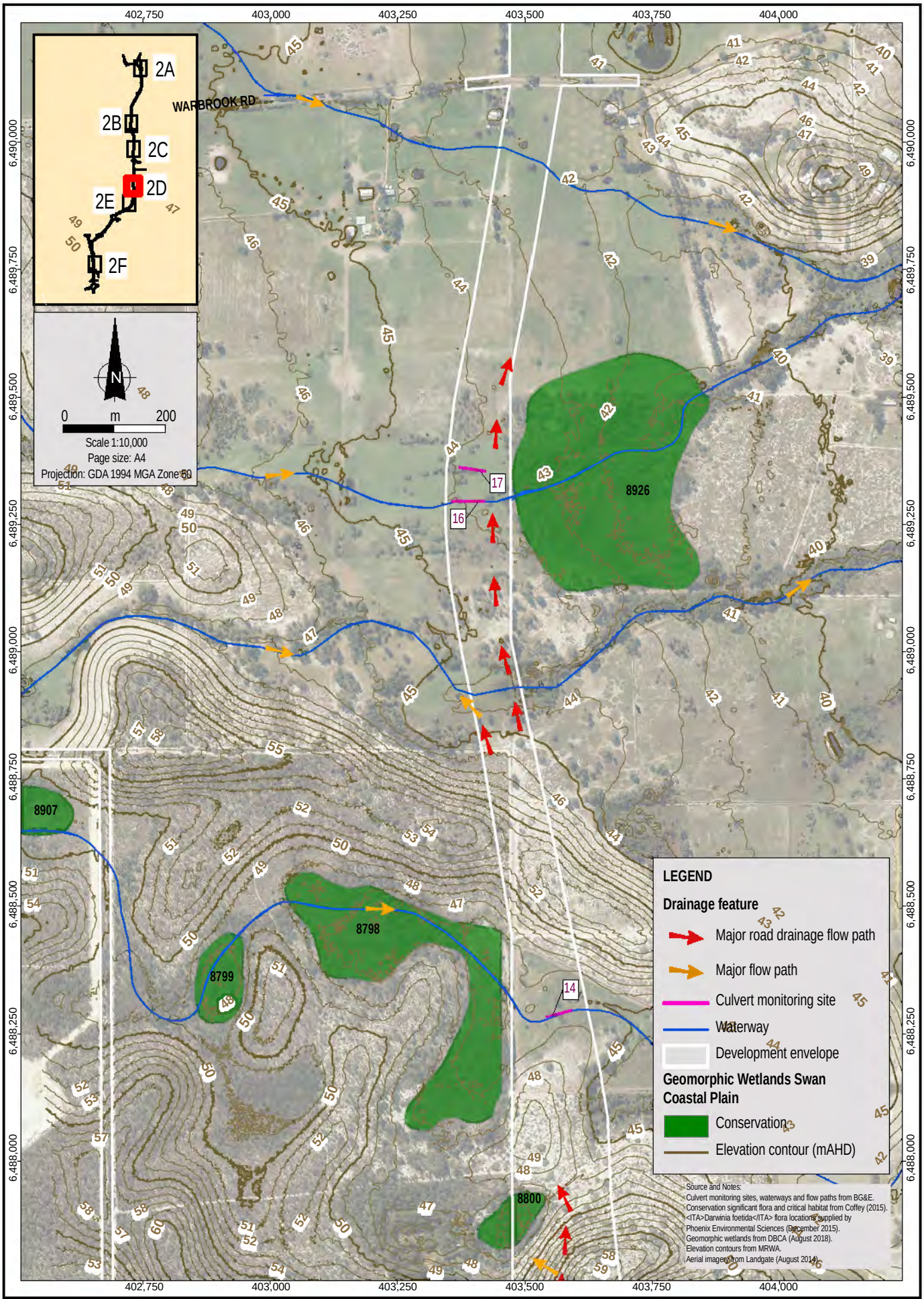
Perth-Darwin National Highway

Baseline Survey Plan - Flora and Vegetation - Inland Waters Environmental Quality - Hydrological Processes

Surface water flow assessment

Figure No: 2C



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Perth-Darwin National Highway

Baseline Survey Plan - Flora and Vegetation - Inland Waters Environmental Quality - Hydrological Processes

Surface water flow assessment

Figure No: **2D**

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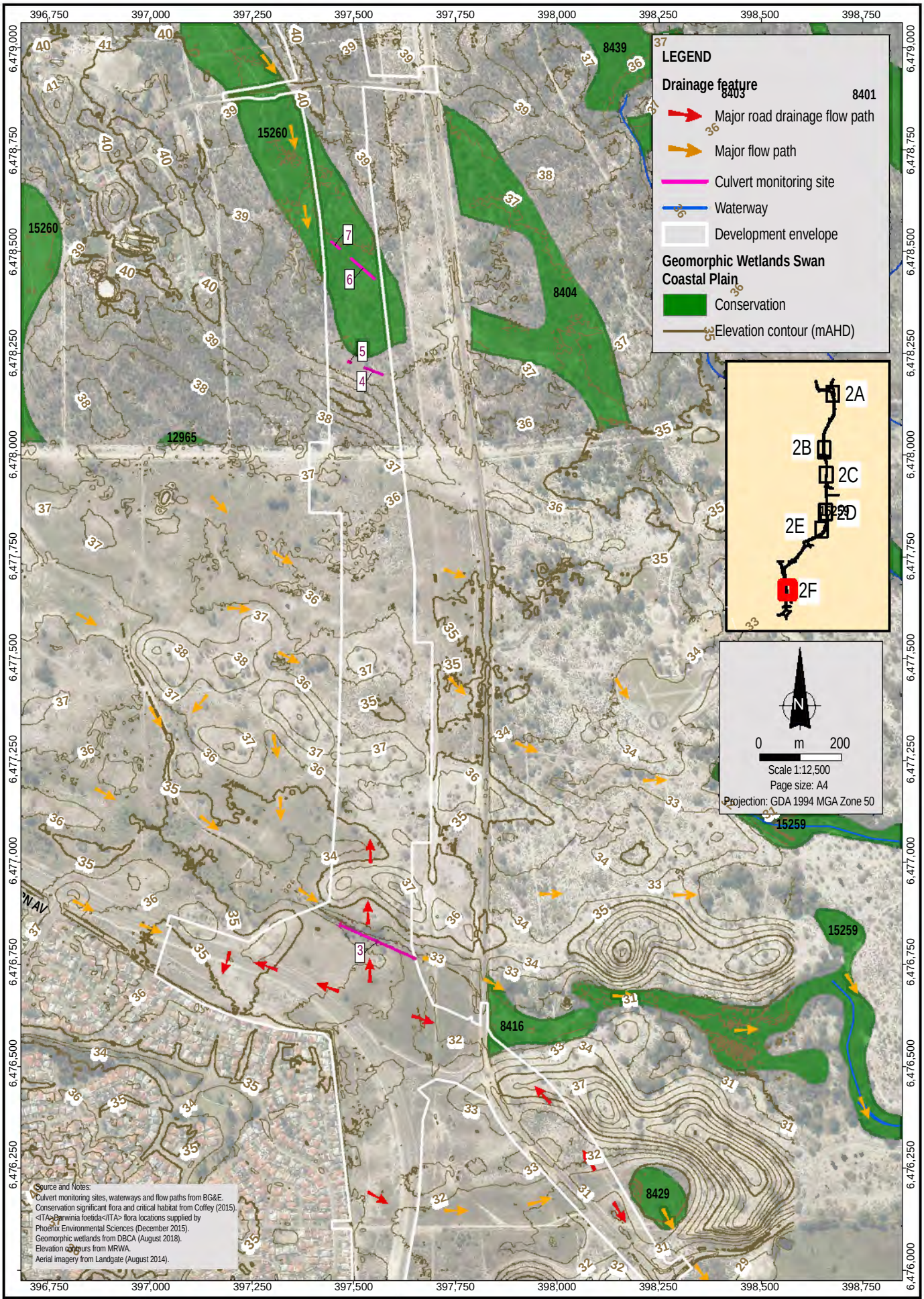
MXD: 4483AA_63_GIS007_10
File Name: 4483AA_63_F002E_GIS

Perth-Darwin National Highway

Baseline Survey Plan - Flora and Vegetation - Inland Waters Environmental Quality - Hydrological Processes

Surface water flow assessment

Figure No: 2E



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File Name: 4483AA_63_F002F_GIS

Perth-Darwin National Highway

Baseline Survey Plan - Flora and Vegetation - Inland Waters Environmental Quality - Hydrological Processes

Surface water flow assessment

Figure No: 2F

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4 MONITORING

This section sets out monitoring provisions for determining whether trigger and threshold criteria are exceeded, and ultimately whether the condition environmental outcomes are being achieved. A discussion on how the monitoring provisions have been developed follows.

4.1 Monitoring Provisions Summary

Monitoring will be undertaken along the extent of the proposal to determine whether the trigger and threshold criteria are being met.

Monitoring will occur during construction and post-construction. In accordance with condition 8-3 of Ministerial Statement 1036, monitoring will continue to be implemented until the CEO of the DWER has advised that the environmental outcome has been met and the plan is no longer required to be implemented. In accordance with condition 14-4 of Ministerial Statement 1116, the monitoring required by condition 8-2(3) of Ministerial Statement 1036 will be undertaken for a period of three years post-construction, or as otherwise agreed in writing by the CEO of the DWER.

The monitoring provisions in this plan are set out in Table 11. The monitoring sites listed in Table 11 are shown on Figure 3. One groundwater monitoring well (MW11, now MW11A) has been relocated as the road alignment will cover its original location. A number of similar well relocations are proposed but not yet in effect; the replacement well locations are set out and denoted in Appendix D.

Table 11 Monitoring provisions

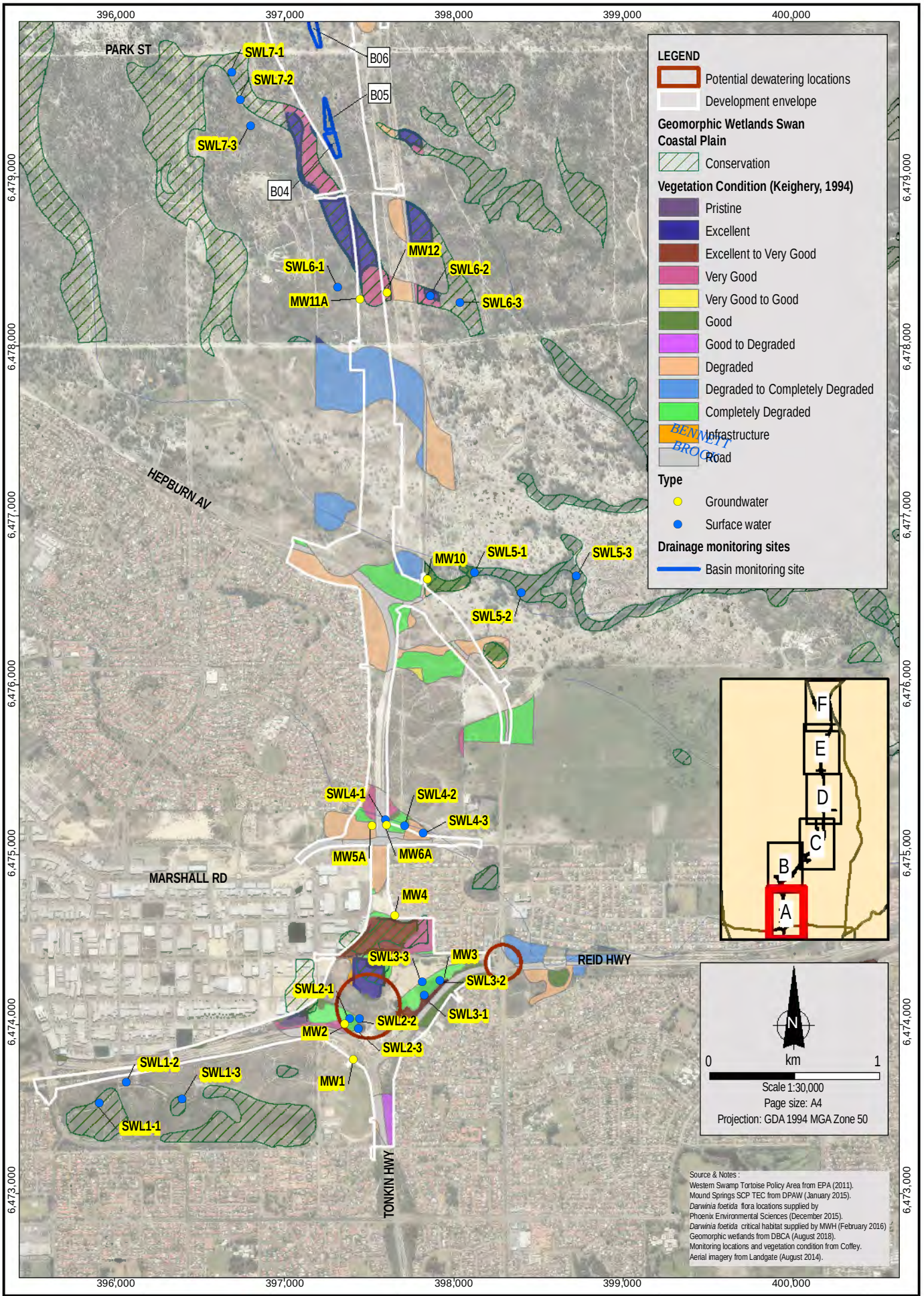
Environmental value	Method summary	Monitoring sites[1]	Parameters to be analysed	Frequency (during construction)	Frequency (post-construction)
Groundwater and surface water quality relevant to Communities of Tumulus Springs and CCWs.	**Groundwater quality:** • Measure physicochemical water quality, using a calibrated water quality meter. • Collect groundwater samples using a passive sampling device or other industry accepted method deemed suitable for groundwater monitoring purposes. **Surface water quality:** • Measure physicochemical water quality at the surface water locations and collect samples, if surface water is present. Note observations if no surface water is present at the time of survey. • To ensure a representative and comparable baseline dataset, three surface water samples are to be collected from each wetland sampling location. All sampling is to be undertaken in accordance with relevant guidelines and standard operating procedures.	**Sampling group Communities of Tumulus Springs** SWL17 MW40, MW41, MW42 **Sampling group CCWs** SWL1, SWL2, SWL3, SWL4, SWL5, SWL6, SWL7, SWL8, SWL9, SWL10, SWL11, SWL12, SWL15, SWL16, SWL17 MW1, MW2, MW4, MW5A, MW6A, MW10, MW11A, MW12, MW26, MW27, MW28, MW29, MW30, MW31, MW32, MW36, MW37, MW38, MW39, MW40, MW41, MW42	• Metals • Nutrients and physical parameters	Fortnightly in active dewatering zones. Monthly in construction zones. Quarterly in all other areas (March, June, September and December).	Biannually (March and September).
			• Total PAHs • TRH C6-C10 • TRH >C10-C40	Monthly in construction zones. Quarterly in all other areas (March, June, September and December).	
			• Herbicide (glyphosate)	Quarterly – only during landscaping works.	

Environmental value	Method summary	Monitoring sites[1]	Parameters to be analysed	Frequency (during construction)	Frequency (post-construction)
Basin sediment quality relevant CCWs.	Collect basin sediment samples using a passive sampling device or other industry accepted method deemed suitable for sediment monitoring purposes. All sampling is to be undertaken in accordance with relevant guidelines and standard operating procedures.	**Basin monitoring sites** B04, B05, B06, B20, B21, B22	• Metals • Total PAHs	Once after installation	Annually
Surface water level relevant to Communities of Tumulus Springs and CCWs.	Measure surface water level.	**CCWs** SWL1 **Communities of Tumulus Springs** SWL17	• Surface water level	Fortnightly in active dewatering zones. Monthly in construction zones. Quarterly in all other areas.	Biannually.

Environmental value	Method summary	Monitoring sites[1]	Parameters to be analysed	Frequency (during construction)	Frequency (post-construction)
Groundwater level relevant to Communities of Tumulus Springs and CCWs.	Gauge groundwater monitoring wells.	**Sampling group Communities of Tumulus Springs** MW40, MW41, MW42 **Sampling group CCWs** MW1, MW2, MW4, MW5A, MW6A, MW10, MW11A, MW12, MW26, MW27, MW28, MW29, MW30, MW31, MW32, MW36, MW37, MW38, MW39, MW40, MW41, MW42	• Groundwater level	Fortnightly in active dewatering zones. Monthly in construction zones. Quarterly in all other areas.	Biannually.
Wetland flora and vegetation relevant to Communities of Tumulus Springs and CCWs.	Undertake wetland flora and vegetation stress monitoring using two transects perpendicular and parallel to the wetland with a 5 x 5 m quadrat placed in the corner of the joining transect lines. Refer to Appendix C.	**Wetland (CCW) flora and vegetation transect sites** GHD12, SVB020, GHD21, SVB040, SVB044, SVB048, SVB052, SVB056 **Communities of Tumulus Springs flora and vegetation transect site** SVB098	Within the 5 x 5 m plot: • Level of plant stress (0-4 scale) (refer to Appendix C). Other parameters that may inform the level of plant stress are provided in Appendix C.	Annually in spring in construction zones.	Annual spring surveys.

Environmental value	Method summary	Monitoring sites[1]	Parameters to be analysed	Frequency (during construction)	Frequency (post-construction)
Surface water flows to *Darwinia foetida*	Visual observation for evidence of unauthorised works. Photographic record.	40 m and 10 m monitoring buffers established around the known population of *Darwinia foetida* (FV37B).	• Construction works. • Presence of laydown areas. • Presence of stockpiles.	Weekly during construction.	Biannually.
Surface water flows to Communities of Tumulus Springs and CCWs	Visual inspection and measurement of backwater or ponding of water.	**PDNH culvert monitoring sites** 3, 4, 5, 6, 7, 14, 16, 17, 32, 33, 40, 41, 44 (edge of development envelope if culvert not installed at time of monitoring).	• Backwater or ponding of water.	Immediately after significant rainfall events (over 15 mm rainfall), and then daily for three days while standing water is present.	Once annually in August, immediately after a significant rainfall event (over 15 mm rainfall), and then daily for three days while standing water is present.

Notes:
1. Refer to Appendix D for monitoring site coordinates. The locations of monitoring sites are shown on Figure 3.



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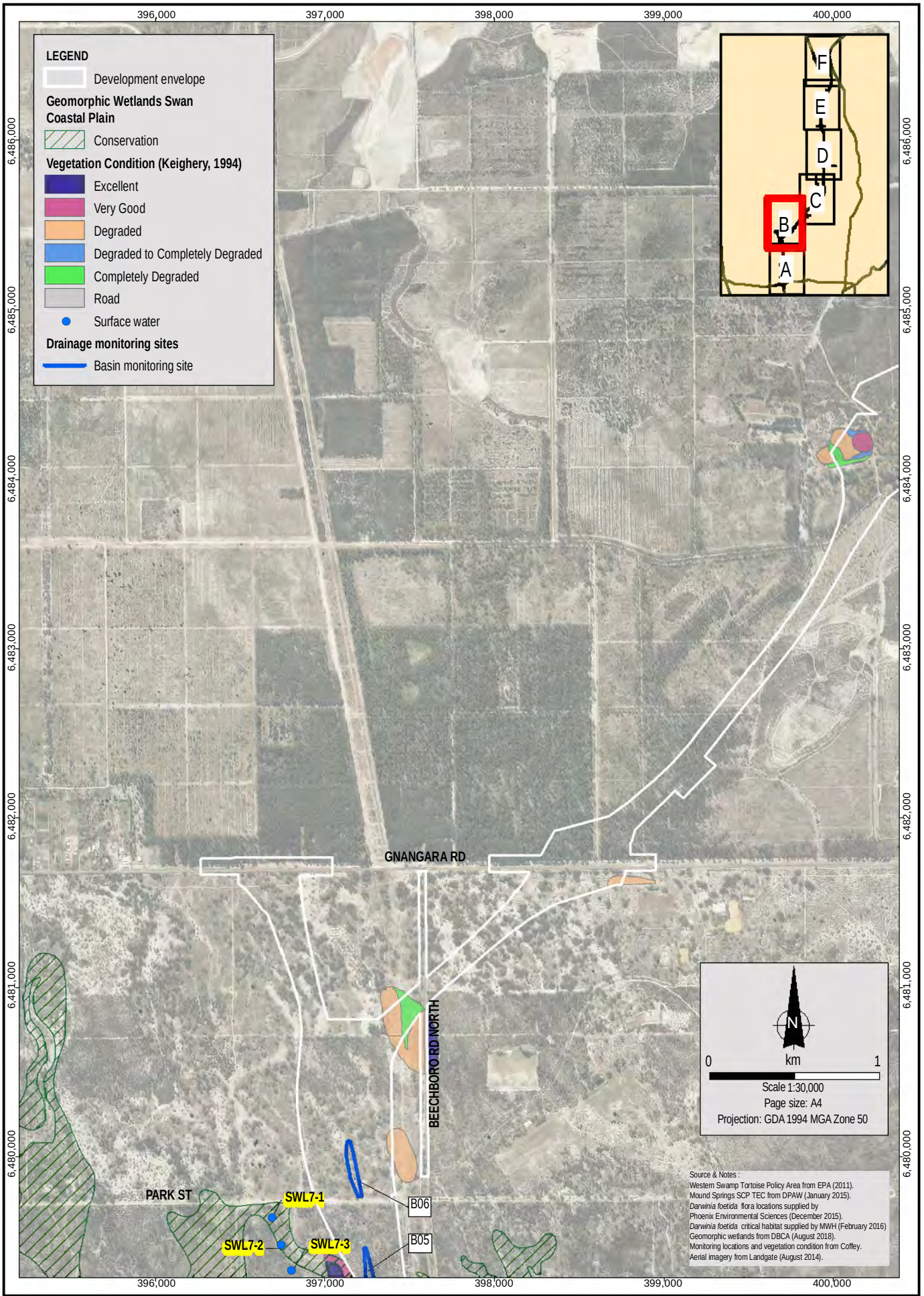
File Name: 4483AA_63_F003A_GIS

Perth-Darwin National Highway
Flora and Vegetation - Inland Waters Environmental Quality Hydrological Processes - Condition EMP

Monitoring site locations
Map 1 of 6

Figure No:
3A



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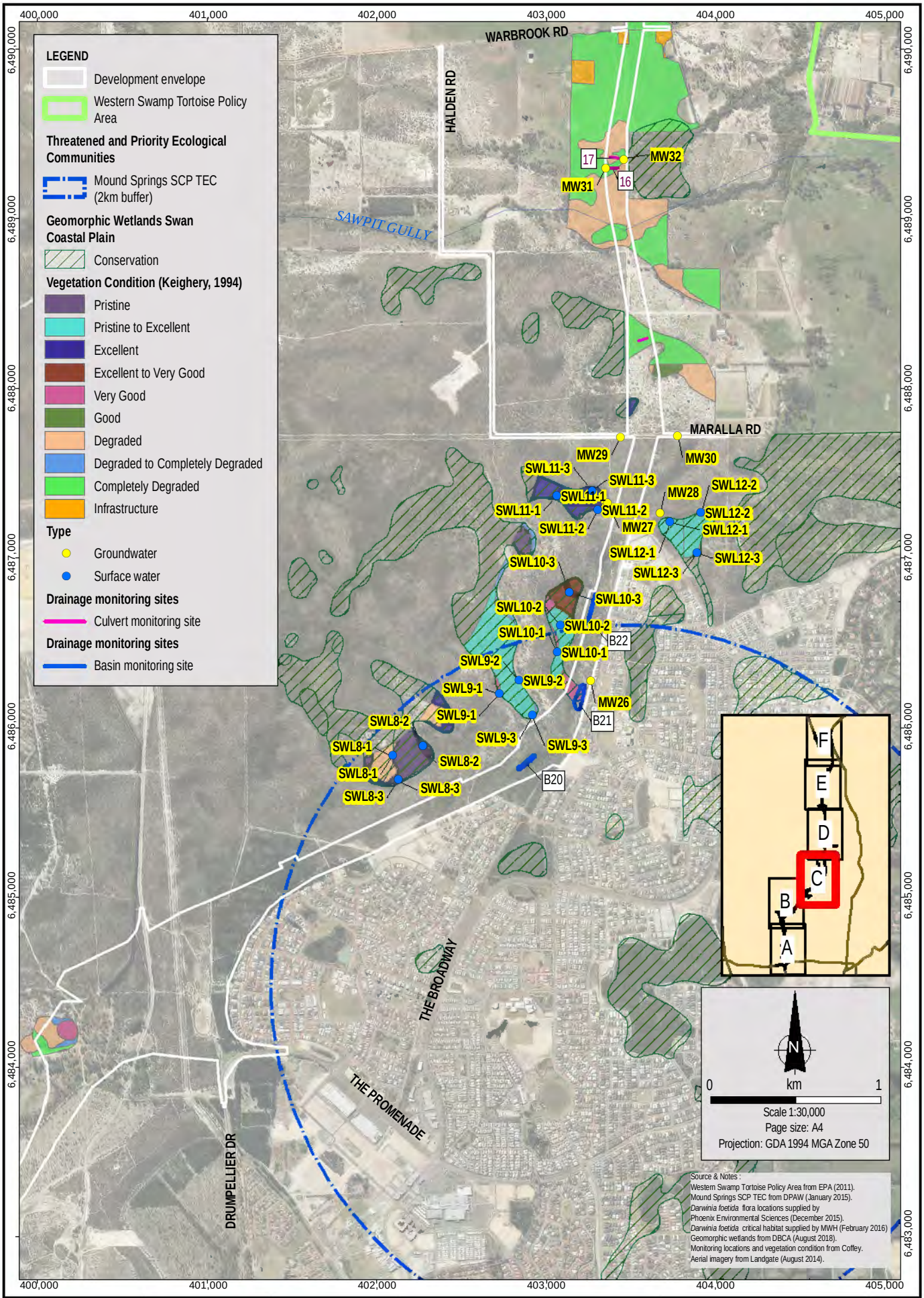
Flora and Vegetation -
Inland Waters Environmental Quality
Hydrological Processes - Condition EMP

Monitoring site locations
Map 2 of 6

Figure No:
3B



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File Name: 4483AA_63_F003C_GIS

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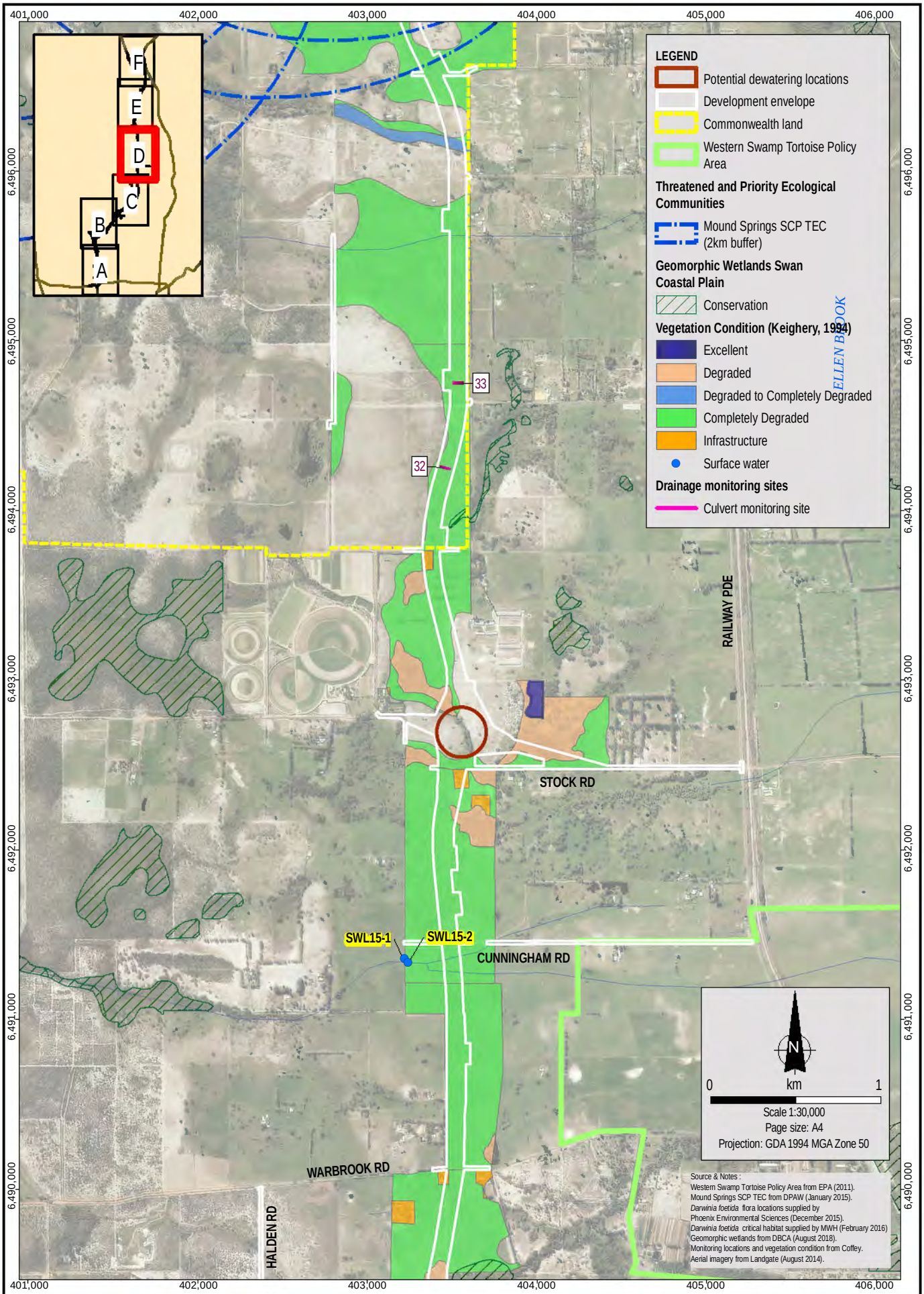
Flora and Vegetation -
Inland Waters Environmental Quality
Hydrological Processes - Condition EMP

Monitoring site locations
Map 3 of 6

Figure No:
3C



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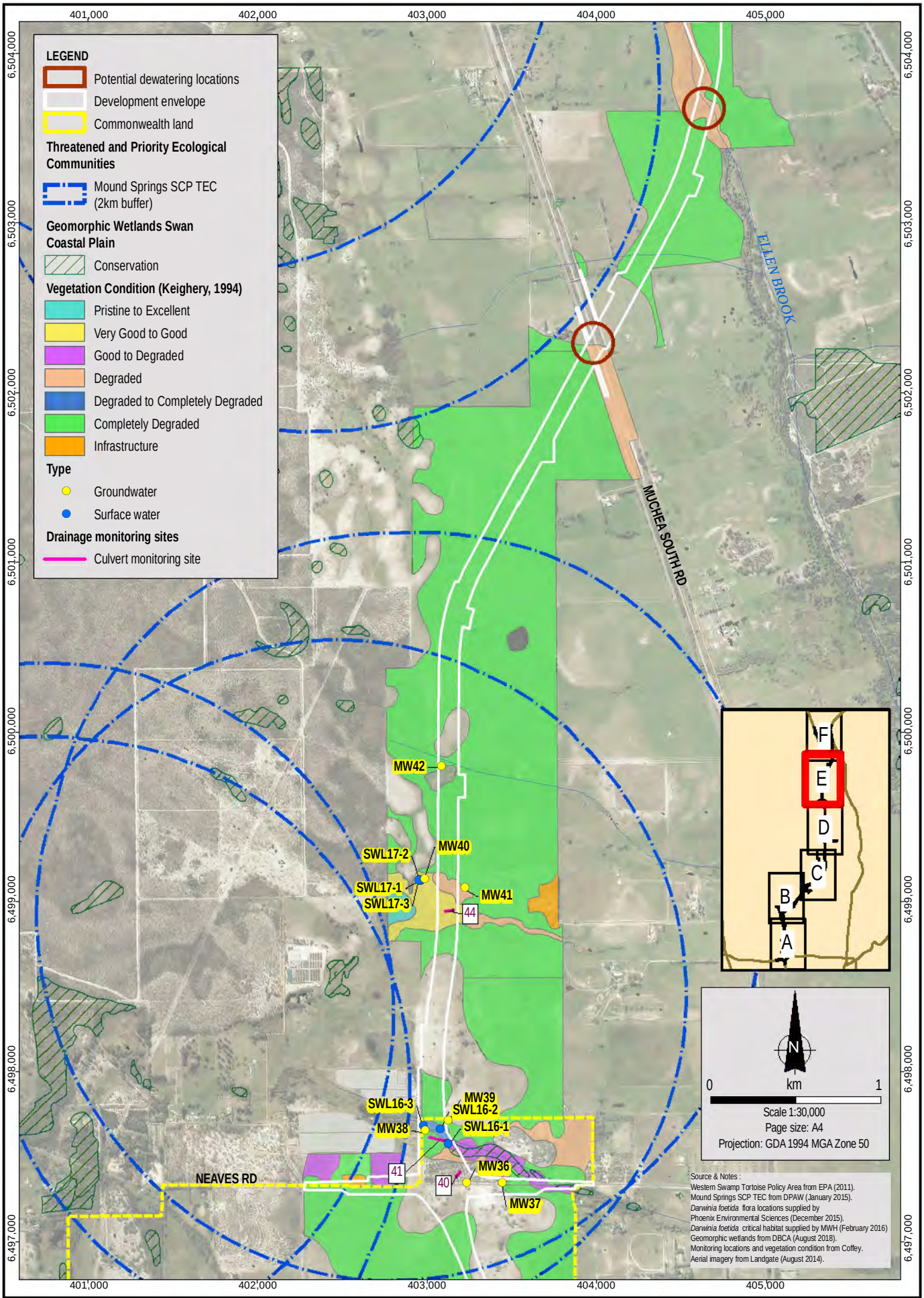
File Name: 4483AA_63_F003D_GIS

Perth-Darwin National Highway
Flora and Vegetation -
Inland Waters Environmental Quality
Hydrological Processes - Condition EMP

Monitoring site locations
Map 4 of 6

Figure No:
3D



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Date: 03.01.2019
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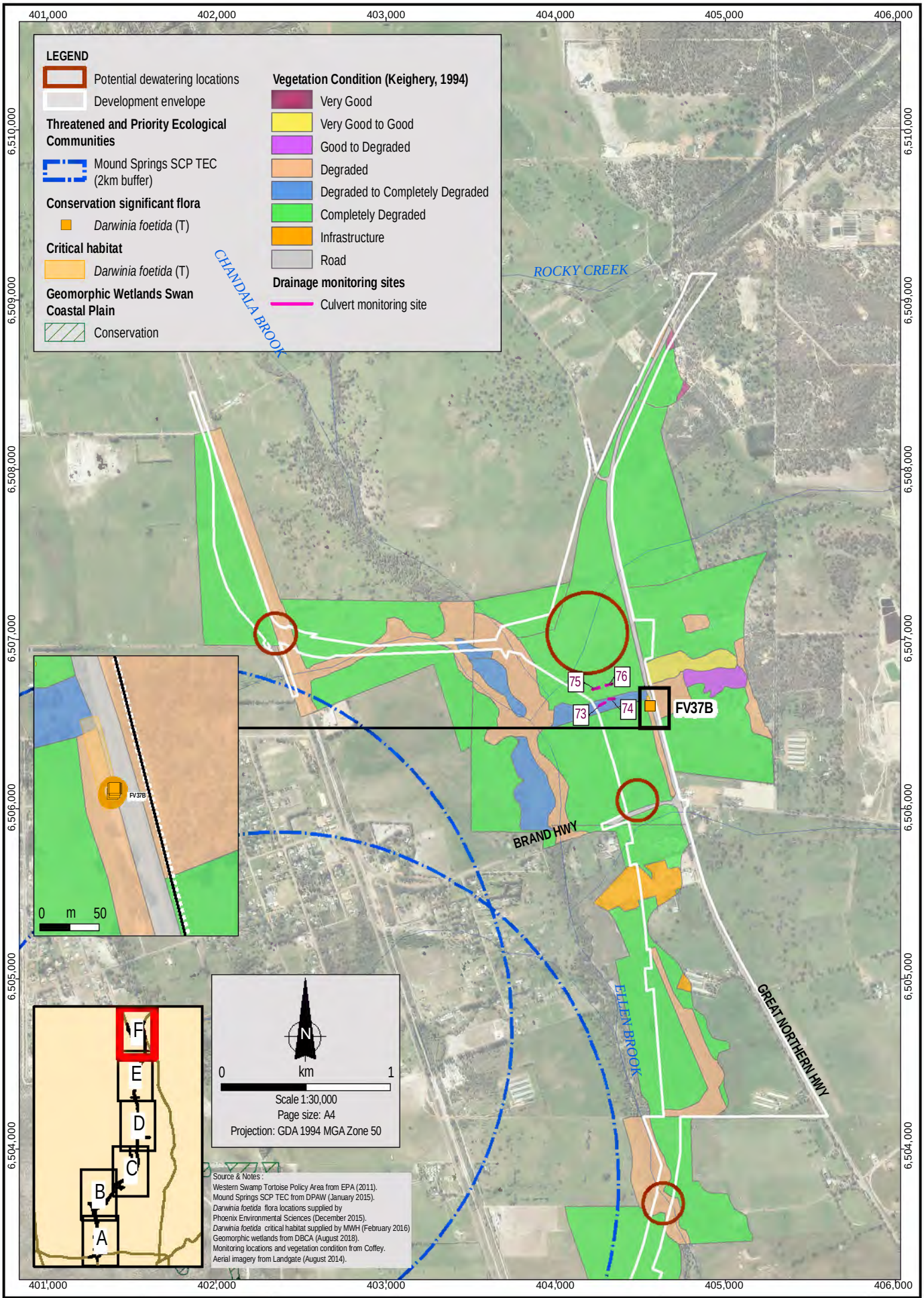
Perth-Darwin National Highway
Flora and Vegetation - Inland Waters Environmental Quality Hydrological Processes - Condition EMP

Monitoring site locations
Map 5 of 6

Figure No:
3E



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Perth-Darwin National Highway

Flora and Vegetation - Inland Waters Environmental Quality Hydrological Processes - Condition EMP

Monitoring site locations Map 6 of 6

Figure No: **3F**

4.2 Monitoring Method

The monitoring method to be used is summarised in Table 11.

At most surface water locations, three samples will be taken to ensure a representative and comparable monitoring dataset is collected for the surface water monitoring site. Due to difficulties accessing more than two sample locations at SWL15 only two samples will be undertaken at this site. Figure 3 shows the three sample locations for each surface water monitoring site and SWL15's two sample locations.

Monitoring will be completed in accordance with regulatory guidelines and standards, where applicable, including:

- Groundwater and surface water quality and level monitoring will be undertaken in accordance with the following regulatory guidelines and standards:
  - National Environment Protection Council 1999 (amended 2013) National Environment Protection (Assessment of Site Contamination) Measure (NEPM), Schedule B2: Guideline on Data Collection, Sample Design and Reporting.
  - Department of Water Field Sampling Guidelines: A guideline for Field Sampling for Surface Water Quality Monitoring Programs (DOW, 2009).
  - Department of Environment and Regulation Treatment and Management of Soil and Water in Acid Sulfate Soil Landscapes (DER, 2015).
  - Department of Environment and Regulation Contaminated Sites Guidelines: Assessment and Management of Contaminated Sites (DER, 2014).
  - Australian Standard AS 5667.4:1998 Water Quality-Sampling – Guidance on Sampling from Lakes, Natural and Man-made.
  - Australian Standard AS 5667.6:1998 Water Quality Sampling – Guidance on Sampling of Rivers and Streams.
  - Australian Standard AS 5667.11:1998 Water Quality-Sampling – Guidance on Sampling of Groundwaters.
- Basin sediment quality monitoring will be undertaken in accordance with the following guideline:
  - National Environment Protection Council 1999 (amended 2013) National Environment Protection (Assessment of Site Contamination) Measure (NEPM), Schedule B2: Guideline on Data Collection, Sample Design and Reporting.
  - Department of Environment and Regulation (DER, 2014) Contaminated Sites Guidelines: Assessment and Management of Contaminated Sites.
- Wetland flora and vegetation monitoring will be undertaken in accordance with the following regulatory guidelines and standards:
  - Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004).
  - Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA and DPAW, 2015).
  - Standard Operating Procedure Establishing Vegetation Transects SOP No. 6.2 (DEC, 2009).

Laboratories accredited by the National Association of Testing Authorities (NATA) will be used for the analyses.

The sites used as part of the baseline groundwater and surface water survey will be used as monitoring sites for this plan throughout the life of the project, wherever possible.

Environmental impacts may occur in ASS areas where dewatering is proposed (see Figure 3). Dewatering or groundwater disturbance in an ASS location (including dewatering discharge) will be managed through a site-specific ASSMP in accordance with the guideline Treatment and management of soil and water in acid sulfate soil landscapes (DER, 2015). If works occur in areas requiring an ASSMP, then the relevant ASS management guidelines, including trigger levels and thresholds, will be followed.

Results of the Level 2 spring flora and vegetation survey were used to inform the monitoring method adapted from the DPAW SOP No. 6.2 Establishing Vegetation Transects. As part of the monitoring method, a 2016 pre-construction survey was conducted to provide further baseline data for comparison with data collected from monitoring during construction and operation.

In accordance with condition 14-4 of Ministerial Statement 1116, monitoring will be undertaken for three years, or as otherwise agreed in writing by the CEO, post construction in order to demonstrate that the condition environmental outcomes were met.

In the event condition environmental outcomes are not met, trigger level actions and/or threshold contingency actions will be implemented (refer to Section 5).

4.3 Rationale for Monitoring Provisions

4.3.1 Methods

The methods outlined in Table 11 and Section 4.2 are based on best practice and adherence to relevant guidelines and standard operating procedures.

The groundwater and surface water monitoring methods have been kept as consistent as practicable with the monitoring method used for the groundwater and surface water baseline survey, which is set out in the Flora and Vegetation – Inland Waters Environmental Quality – Hydrological Processes – Baseline Survey Plan (Coffey, 2017).

The wetland flora and vegetation monitoring method is adapted from Standard Operating Procedure Establishing Vegetation Transects SOP No. 6.2 (DEC, 2009) which is relevant for a monitoring program. Further details are provided in Appendix C. The baseline data collected from the Level 2 spring flora and vegetation survey was conducted in September 2014 as part of the PDNH Wetland Assessment (Coffey, 2015) will inform potential changes to wetland flora and vegetation identified during monitoring.

The effectiveness and condition of stormwater infiltration and retention basins will be monitored through comparison of water quality measured upstream and downstream of the basin and opportunistic sampling of surface water retained in the basin.

4.3.2 Monitoring Site Locations

The location of all monitoring sites is based on the known groundwater and surface water flow directions, location of infiltration and retention basins and culverts and risks to environmental values of the *Darwinia foetida*, Communities of Tumulus Springs and CCWs.

Rationale for surface water flow monitoring site locations are provided in Section 3.2.4 and 3.2.5.

Wetland flora and vegetation monitoring sites have not been located in parts of the development envelope located on land that is 'Degraded to Completely Degraded' due to existing clearing or farming activities, with the exception of the location of *Darwinia foetida*.

The groundwater and surface water monitoring site locations include proxies for ecological sites relevant to the receptors, such as groundwater level and flora and vegetation monitoring data to identify indirect impacts from absence of surface water levels.

The monitoring network will enable identification of local and regional changes in water quality and changes to surface water flow in the vicinity of identified sensitive receptors.

4.3.3 Acid Sulfate Soils

Environmental impacts may occur in ASS areas where dewatering or ground disturbance is proposed (Figure 3). Dewatering or groundwater disturbance in an ASS location (including dewatering discharge) will be managed through a site-specific ASSMP in accordance with the guideline Treatment and management of soil and water in acid sulfate soil landscapes (DER, 2015).

A sufficient level of ASS assessment pre-disturbance will be undertaken in accordance with DER guidelines, where groundwater disturbance activities are proposed in order to characterise ASS risk. As stated in Section 2.5, monitoring and management of ASS is not covered in this plan.

5 TRIGGER LEVEL ACTIONS AND THRESHOLD CONTINGENCY ACTIONS

This section details the trigger level actions and threshold contingency actions that will be implemented in the event that trigger criteria or threshold criteria are exceeded.

5.1 Trigger Level Actions

Trigger level actions have been developed and will be implemented immediately if the trigger criteria are exceeded.

Trigger level actions aim to prevent an exceedance of threshold criteria so that the threshold criteria are safeguarded. Trigger level actions will investigate the cause of exceedances and introduce measures to reduce the impact, including increasing the frequency of monitoring during high-risk activities or to determine if a trend is establishing. Trigger level actions will continue to be implemented until trigger criteria are met or the CEO of the DWER confirms in writing that the environmental outcome is being met and that trigger level actions are no longer required to be implemented.

Trigger criteria will be considered to be exceeded if it is determined following investigation that the exceedance is project-attributable.

Table 12 sets out the trigger level actions to be implemented if trigger criteria are exceeded.

Table 12 Trigger level actions

Parameter	Trigger	Trigger level actions
Groundwater and surface water quality	Exceedance of water quality trigger levels	1. Confirm validity of result (i.e., review sampling procedures, review dataset). 2. Review results from nearby monitoring locations, where available. 3. Investigate if cause of the change is due to the construction or operation of the proposal using appropriate trend/statistical analyses, where appropriate. If results are assessed to be likely due to the construction or operation of the proposal, the exceedance is considered to be project-attributable and the trigger criteria are considered to have been exceeded. **For project-attributable exceedances of trigger criteria:** 4. Resample affected monitoring location as soon as practicable and review the result no later than one week following resampling. 5. If both rounds of monitoring show trigger levels have been exceeded, increase frequency of monitoring in order to further assess changes. If TRH >C10-C40 or total PAH trigger levels are exceeded, request speciation of the sample as per respective analytes shown in Appendix E to determine which constituents are present. 6. Notify the CEO within 7 days of becoming aware of the exceedance. 7. Identify and implement relevant alternative activities which do not contribute to the exceedance. 8. Identify additional measures required to prevent the trigger level being exceeded in the future (refer to Section 8.1 for potential adaptive management actions).

Parameter	Trigger	Trigger level actions
		9. Provide a report to the CEO within 60 days from the date of awareness of the exceedance. **For all exceedances of trigger criteria:** 10. Document the trigger exceedance for later inclusion in the annual Compliance Assessment Report (see Section 7.2).
Groundwater levels	Exceedance of water level trigger levels	1. Confirm validity of result (i.e., review gauging procedures, review dataset). 2. Review results from nearby monitoring locations, where available. 3. Investigate if cause of the change is due to the construction or operation of the proposal using appropriate trend/statistical analyses, where appropriate. If results are assessed to be likely due to the construction or operation of the proposal, the exceedance is considered to be project-attributable and the trigger criteria are considered to have been exceeded. **For project-attributable exceedances of trigger criteria:** 4. Undertake additional gauging round as soon as practicable following implementation of contingency actions and review the result. 5. If both rounds of monitoring show trigger levels have been exceeded increase frequency of monitoring in order to further assess changes. 6. Notify the CEO within 7 days of becoming aware of the exceedance. 7. Identify additional measures required to prevent the trigger level being exceeded and implement as required (refer to Section 8.1 for potential adaptive management actions). 8. Provide a report to the CEO within 60 days from the date of awareness of the exceedance. **For all exceedances of trigger criteria:** 9. Document the trigger exceedance for later inclusion in the annual Compliance Assessment Report (see Section 7.2).
Infiltration and retention basins	Exceedance of basin sediment quality trigger levels	1. Confirm validity of result (i.e., review sampling procedures). 2. Review results from locations within similar settings along the road. If total PAH trigger levels are exceeded, request speciation of the sample as per respective analytes shown in Appendix E to determine which constituents are present, noting constituents of total PAHs and total TRH do not vary between groundwater, surface water or sediment. 3. Investigate if infiltration and retention basin is working effectively, and if not, organise maintenance or replacement of infiltration and retention basins. 4. Notify the CEO of project-attributable exceedances within 7 days of becoming aware of the exceedance. 5. Continue monitoring post maintenance or replacement. 6. Identify additional measures required to prevent the trigger level being exceeded in the future (refer to Section 8.1 for potential adaptive management actions). 7. Provide a report to the CEO within 60 days from the date of awareness of the exceedance.

Parameter	Trigger	Trigger level actions
Wetland flora and vegetation	Exceedance of wetland flora and vegetation condition trigger levels	1. Confirm validity of result (i.e., review monitoring method). 2. Review results from similar monitoring locations. 3. Investigate if cause of the change is due to the construction or operation of the proposal. If results are assessed to be likely due to the construction or operation of the proposal, the exceedance is considered to be project-attributable and the trigger criteria are considered to have been exceeded. **For project-attributable exceedances of trigger criteria:** 4. Conduct detailed survey of the monitoring location as soon as practicable and review the result no later than one week following the detailed survey. 5. If both monitoring and detailed survey results show trigger levels have been exceeded, undertake ASS sampling to further assess changes. 6. Notify the CEO within 7 days of becoming aware of the exceedance. 7. Identify relevant alternative activities which do not contribute to the exceedance. 8. Identify additional measures required to prevent the trigger level being exceeded in the future (refer to Section 8.1 for potential adaptive management actions). 9. Provide a report to the CEO within 60 days from the date of awareness of the exceedance. **For all exceedances of trigger criteria:** 10. Document the trigger exceedance for later inclusion in the annual Compliance Assessment Report (see Section 7.2).
Surface water flows	Exceedance of surface water flows trigger levels	1. Confirm validity of result (i.e., review monitoring method). 2. Investigate if cause of the change is due to the construction or operation of the proposal. If results are assessed to be likely due to the construction or operation of the proposal, the exceedance is considered to be project-attributable and the trigger criteria are considered to have been exceeded. **For project-attributable exceedances of trigger criteria:** 3. Notify the CEO within 7 days of becoming aware of the exceedance. 4. Identify relevant alternative activities which do not contribute to the exceedance. 5. Identify additional measures required to prevent the trigger level being exceeded in the future (refer to Section 8.1 for potential adaptive management actions). 6. Provide a report to the CEO within 60 days from the date of awareness of the exceedance. **For all exceedances of trigger criteria:** 7. Document the trigger exceedance for later inclusion in the annual Compliance Assessment Report (see Section 7.2).

5.2 Threshold Contingency Actions

Threshold contingency actions have been developed and will be implemented immediately if threshold criteria are exceeded.

An exceedance of the threshold criteria indicates the environmental outcome is not being met. The aim of threshold contingency actions is to prevent further damage to the environment, ascertain the extent of impact and remediate or rectify damage, where required. Initial investigations will determine probable causes and halt activities that may be contributing.

Threshold contingency actions will be implemented to mitigate and manage the impact to below threshold and trigger criteria to achieve the environmental outcome. Threshold level actions will continue to be implemented until trigger criteria are met or the CEO of the DWER confirms in writing that the environmental outcome is being met and that threshold level actions are no longer required to be implemented.

Table 13 sets out the threshold contingency actions to be implemented if the threshold criteria are exceeded.

Table 13 Threshold contingency actions

Parameter	Trigger	Threshold contingency actions
Groundwater and surface water quality	Exceedance of water quality threshold levels	1. Confirm validity of result (i.e. review sampling procedures). 2. Notify the CEO within 7 days of becoming aware of the exceedance. 3. Review results from nearby (upstream and downstream) monitoring locations. 4. If results are assessed as likely to be due to construction or operation of the proposal, resample affected monitoring location as soon as possible (within one day) to verify the result. 5. Where construction or operation of the proposal are found to contribute to the exceedance, halt relevant activities. Remediate, where necessary. 6. Continue monitoring including effectiveness of remediation to determine potential environmental harm or alteration of the environment. 7. Identify additional measures required to prevent the threshold level being exceeded in the future (refer to Section 4.1 for potential adaptive management actions). 8. Regardless of whether or not the threshold exceedance is project-attributable, provide a report to the CEO within 60 days from the date of awareness of the exceedance.
Groundwater levels	Exceedance of water level threshold levels	1. Confirm validity of result (i.e. review sampling procedures). 2. Notify the CEO within 7 days of becoming aware of the exceedance. 3. Review results from nearby (upstream and downstream) monitoring locations. 4. Investigate if cause of the change is due to construction or operation of the proposal using appropriate trend/statistical analyses, where appropriate. 5. If results are assessed as likely to be due to construction or operation of the proposal, resample affected monitoring location as soon as possible (within one day) to verify the result. 6. Where construction or operation of the proposal are found to contribute to the exceedance, halt relevant activities. Remediate, where necessary. 7. Continue monitoring including effectiveness of remediation to determine potential environmental harm or alteration of the environment. 8. Identify additional measures required to prevent the threshold level being exceeded in the future (refer to Section 4.1 for potential adaptive management actions).

Parameter	Trigger	Threshold contingency actions
		9. Regardless of whether or not the threshold exceedance is project-attributable, provide a report to the CEO within 60 days from the date of awareness of the exceedance.
Infiltration and retention basins	Exceedance of basin sediment quality threshold levels	1. Confirm validity of result (i.e., review monitoring method). 2. Notify the CEO within 7 days of becoming aware of the exceedance. 3. Review results from locations within similar settings along the road. 4. Investigate if infiltration and retention basin is working effectively, and if not, organise maintenance or replacement of infiltration and retention basins. 5. Continue monitoring post maintenance or replacement. 6. Identify additional measures required to prevent the threshold level being exceeded in the future (refer to Section 4.1 for potential adaptive management actions). 7. Provide a report to the CEO within 60 days from the date of awareness of the exceedance.
Wetland flora and vegetation	Exceedance of wetland flora and vegetation condition threshold levels	1. Confirm validity of result (i.e., review monitoring method). 2. Notify the CEO within 7 days of becoming aware of the exceedance. 3. Review results from similar monitoring locations. 4. Investigate if cause of the change is due to construction activities. 5. If results are assessed as likely to be due to construction activities, conduct comprehensive survey of the monitoring location as soon as practicable and review the result no later than one week following the comprehensive survey. 6. Where construction activities are found to contribute to the exceedance, halt relevant activities. 7. Continue monitoring and evaluation against groundwater and surface water quality to determine potential environmental harm or alteration of the environment. 8. Identify additional measures required to prevent the threshold level being exceeded in the future (refer to Section 4.1 for potential adaptive management actions). 9. Provide a report to the CEO within 60 days from the date of awareness of the exceedance.
Surface water flows	Exceedance of surface water flows threshold levels	1. Confirm validity of result (i.e., review monitoring method). 2. Notify the CEO within 7 days of becoming aware of the exceedance. 3. Investigate if cause of the change is due to construction activities. 4. Identify additional measures required to prevent the threshold level being exceeded in the future (refer to Section 4.1 for potential adaptive management actions). 5. Provide a report to the CEO within 60 days from the date of awareness of the exceedance.

6 OTHER CONDITIONED REQUIREMENTS

This section contains requirements of the conditions that are not provided for elsewhere in this plan.

Condition 14-6 of Ministerial Statement No. 1116 contains requirements that will be implemented as part of this outcome-based Condition EMP. These requirements are listed in Table 14. While the construction and operation of the proposal is required to meet the environmental outcome in condition 14-1(2) of Ministerial Statement 1116, the requirements listed in Table 14 will be implemented during construction only as they are relevant only to construction activities.

Table 14 Other conditioned requirements

Condition No.	Requirement
14-6	Laydown areas or stock piles will not be constructed within 50 m of *Communities of Tumulus Springs* (*Organic Mound Springs, Swan Coastal Plain*) and Conservation Category Wetlands as shown in Figures 5 of Ministerial Statement 1036 and Figure 6 attached to this Statement [Ministerial Statement 1116].

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7 REPORTING

7.1 Monitoring Report

A monitoring report will be prepared after each monitoring event to summarise the results of monitoring. These results will be provided in the annual compliance assessment report (CAR).

7.2 Annual Compliance Assessment Report

The first CAR will be submitted to the CEO, 15 months from the date of issue of Ministerial Statement No. 1036, then annually from the date of submission of the first CAR, or otherwise agreed in writing by the CEO.

The annual CAR will include:

- Climate and rainfall information.
- Demonstration of management implemented.
- Documentation of monitoring undertaken.
- Comparison of monitoring results against baseline and evaluation against the trigger and threshold criteria.
- A listing of all exceedances of trigger criteria (whether project-attributable or not) and exceedances of threshold criteria.
- Any management or contingency actions undertaken where trigger criteria and/or trigger and threshold criteria are exceeded in the reporting period and an analysis of trends.

Table 15 sets out the reporting template for this plan against the condition environmental outcome and environmental criteria to be included in the CAR.

Table 15 Condition Environmental Management Plan reporting table

Flora and Vegetation – Inland Waters Condition Environmental Management Plan Ministerial Statement No. 1116, condition 14			
Condition environmental outcome	**Environmental criteria**	**Status justification**	**Status**
Construction and operation of the proposal, including from dewatering and groundwater abstraction, does not result in indirect impacts to the Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) and	**Trigger criterion 1** Groundwater quality trigger criteria listed in Appendix A. Surface water quality trigger criteria listed in Appendix B. Basin sediment quality trigger criteria listed in Table 8.	[*Comment as required*]	Achieved Not achieved
	Threshold criterion 1 Groundwater quality threshold criteria listed in Appendix A. Surface water quality threshold criteria listed in Appendix B. Basin sediment quality threshold criteria listed in Table 8.	[*Comment as required*]	Achieved Not achieved

Flora and Vegetation – Inland Waters Condition Environmental Management Plan Ministerial Statement No. 1116, condition 14			
Condition environmental outcome	**Environmental criteria**	**Status justification**	**Status**
Conservation Category Wetlands as shown in figures 5 of Ministerial Statement 1036 and Figure 6 of Ministerial Statement 1116.	**Trigger criterion 2** Groundwater level trigger criteria listed in Appendix A.	[*Comment as required*]	Achieved Not achieved
	Threshold criterion 2 Groundwater level threshold criteria listed in Appendix A.	[*Comment as required*]	Achieved Not achieved
	Trigger criterion 3 Observed plant stress rating 2 (Appendix C).	[*Comment as required*]	Achieved Not achieved
	Threshold criterion 3 Observed plant stress rating 3 (Appendix C).	[*Comment as required*]	Achieved Not achieved
Construction of the proposal maintains predevelopment surface water flows to the Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) and Conservation Category Wetlands as shown in Figures 3 and 5 of Ministerial Statement 1036, and Figure 6 of Ministerial Statement 1116.	**Trigger criterion 4** Clearing or construction of laydown areas or stockpiles within 40 m of the known population of *Darwinia foetida*.	[*Comment as required*]	Achieved Not achieved
	Threshold criterion 4 Clearing or construction of laydown areas or stockpiles within 10 m of the known population of *Darwinia foetida*.	[*Comment as required*]	Achieved Not achieved
	Trigger criterion 5 Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 6 m.	[*Comment as required*]	Achieved Not achieved
	Threshold criterion 5 Presence of backwater or ponding of water from the edge of the development envelope over a period of two consecutive days from the date ponding was identified at distances further than 10 m.	[*Comment as required*]	Achieved Not achieved

Notes:
1. The status of achievement of the condition environmental outcomes and conditioned management actions is indicated as follows:
Yes – condition environment outcome or conditioned management action achieved.
No – condition environmental outcome or conditioned management action not achieved.

7.3 Reporting on Exceedance of the Trigger and/or Threshold Criteria

Table 16 lists exceedance of environmental criteria reporting requirements as specified in Ministerial Statement No. 1036.

Note that the 7-day reporting period for trigger criteria exceedances applies only where the exceedance is **project-attributable**. The 7-day reporting period for threshold criteria exceedances applies for all exceedances of threshold criteria.

Table 16 Reporting requirements

Condition	Reporting requirement	Reporting timeframe
4-5	Advise the CEO of any potential non-compliance within seven (7) days of that non-compliance being known.	Within 7 days of known non-compliance.
4-6(3)	[The Compliance Assessment Report shall identify all potential non-compliances and describe corrective and preventative actions taken.	As required for the CAR (see Section 7.2).
8-4(1)	In the event that monitoring indicates exceedance of trigger criteria and/or threshold criteria specified in the Condition EMPs, the proponent shall: 1. Report the exceedance in writing within 7 days of the exceedance being identified.	For exceedances of the threshold criteria and project-attributable exceedances of the trigger criteria – written notification to the CEO within 7 days becoming aware of the exceedance.
8-4(6)	Provide a report to the CEO within 60 days of the exceedance being reported. The report shall include: a) Details of trigger level actions or threshold contingency actions implemented. b) The effectiveness of the trigger level actions or threshold contingency actions implemented, monitored and measured against trigger criteria and threshold criteria. c) The findings of the investigations required by conditions 8-4(3) and 8-4(5). d) Additional measures to prevent the trigger or threshold criteria being exceeded in the future. e) Measures to prevent, control or abate the environmental harm which may have occurred.	Investigation report submitted to the CEO within 60 days of becoming aware of the exceedance.

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8 ADAPTIVE MANAGEMENT AND REVIEW

8.1 Adaptive Management

Adaptive management will be implemented to learn from the implementation of management measures, monitoring and evaluation against the environmental criteria, to more effectively meet the condition environmental outcome.

Potential adaptive management actions may include, but are not limited to:

1. Exceedance of trigger or threshold criteria for groundwater or surface water quality or level:
   - Determine/investigate cause/source.
   - Improve and implement additional trigger level actions or threshold contingency actions as necessary.
   - Monitor the success of remedial actions.
2. Identification of contaminated basin:
   - Determine/investigate cause/source.
   - Remove contaminated sediment and clean basin.
   - Monitor basins within the vicinity of the contaminated basin.
   - Monitor sediment at surface water site locations within the vicinity of the contaminated basin.
   - Improve and implement additional trigger level actions or threshold contingency actions as necessary.
   - Monitor the success of remedial actions.
3. Identification of LOR equivalent trigger criteria value exceedance:
   - Determine/investigate cause/source.
   - Conduct different laboratory analysis with lower LOR value below trigger level value.
   - Revise trigger level value as necessary.
   - Improve and implement additional trigger level actions or threshold contingency actions as necessary.
   - Monitor the success of remedial actions.
4. Identification of disturbance within the local catchment for *Darwinia foetida* or presence of laydown areas or stockpiles within 50 m of Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) and CCWs:
   - Determine/investigate cause/source.
   - Restrict access.
   - Improve training and education for construction personnel.
   - Improve and implement increased management actions as necessary.
   - Monitor the success of remedial actions.

5. Identification of herbicide (glyphosate) concentrations in groundwater or surface water quality samples:
   - Determine/investigate cause/source.
   - Investigate other herbicides or compounds used.
   - Improve training and education for construction personnel on herbicide application and disposal.
   - Improve and implement additional trigger level actions or threshold contingency actions as necessary.
   - Monitor the success of remedial actions.

8.2 Review

This plan has been reviewed in accordance with the provisions set out in Section 8.2 of the previously approved version of this document, specifically:

- **Upon completion of the baseline survey.** To review and refine trigger and threshold criteria.
- **Annually.** To review and refine trigger and threshold criteria and other provisions following construction works.

This plan will be reviewed in accordance with condition 8-5 of Ministerial Statement No. 1036. Timing of reviews for this plan include:

- **As required.** To determine if management, trigger and threshold criteria and trigger level and threshold contingency actions require review and revision.
- **When directed by the CEO.** In accordance with condition 8-5(2).
- **Following construction.** To evaluate applicability of monitoring provisions for operations.
- **In the event a project-attributable exceedance of a threshold criterion is recorded.** To review and revise the plan, if required by the findings of the investigation report.
- **Once groundwater abstraction volumes are known.** To review and revise the plan, if required.

In relation to reviews in line with annual monitoring reporting, the potential reasons or triggers for revising management, trigger and threshold criteria, and trigger level or threshold contingency actions include:

- Changes to road design, construction and operation.
- Results of trend analysis in monitoring results.
- New or revised information becoming available on groundwater and surface water behaviour.
- Changes to state or federal legislation.
- Changes to the regulatory framework.

The implementation of this plan will be audited.

The latest version of this plan shall be implemented once the CEO has confirmed in writing that it satisfies the requirements of condition 8-2 of Ministerial Statement 1036.

9 STAKEHOLDER CONSULTATION

MRWA consulted with stakeholders while developing this plan. This section provides a summary of consultation that occurred. The comments raised during consultation with stakeholders were considered in preparing this plan.

The former Department of Water (DOW; now known as the Department of Water and Environmental Regulation) and former Department of Parks and Wildlife (DPAW; now known as the Department of Biodiversity, Conservation and Attractions) were consulted in accordance with condition 14-2 of Ministerial Statement 1036. It should be noted that condition 14-2 has since been deleted and replaced with condition 14-2 of Ministerial Statement 1116 which refers to both departments under their current names.

Table 17 presents a summary of consultation and MRWA's response.

Table 17 Stakeholders consulted, comments and responses

Date	Organisation	Summary of consultation	MRWA response to comment/concern
17 October 2016	DOW	Workshop to discuss this plan and other Condition Environmental Management Plans, which have overlapping themes with this plan.	MRWA has taken into account DOW's comments and revised the plan where appropriate.
25 October 2016	DPAW	Workshop to discuss this plan and other Condition Environmental Management Plans, which have overlapping themes with this plan.	MRWA has taken into account DPAW's comments and revised the plan where appropriate.

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10 REFERENCES

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APPENDIX A

Groundwater Quality and Levels Environmental Criteria

Table A1
Northlink Flora and Vegetation - Inland Waters Environmental Quality-Hydrogeological Processes
Groundwater Trigger and Threshold Criteria
ENAUPERT04483AA

Analyte		Metals Dissolved																					
		Aluminium (Filtered)		Arsenic (Filtered)		Cadmium (Filtered)*		Chromium (Filtered)		Copper (Filtered)		Iron (Filtered)		Lead (Filtered)		Manganese (Filtered)		Mercury (Filtered)		Nickel (Filtered)		Selenium (Filtered)		Zinc (Filtered)	
	Units	Units		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
	LOR	0.05		0.001		0.00005		0.001		0.001		0.05		0.001		0.005		0.0001		0.001		0.001		0.001	
Sample ID	ANZECC FW 95%	0.055		0.024		0.0002		NE		0.0014		NE		0.0034		1.9		0.0006		0.011		0.011		0.008	
	DER 2015	1		NE		NE		NE		NE		1		NE		NE		NE		NE		NE		NE	
Trigger / Threshold		Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh
MW1		0.13	0.34	0.024	0.028	0.0002	0.00071	0.005	0.007	0.002	0.005	1	1.15	0.0034	0.017	1.9	2.185	0.0006	0.0007	0.011	0.037	0.011	0.013	0.010	0.027
MW2		0.16	0.33	0.024	0.028	0.0002	0.00035	0.002	0.003	0.001	0.003	1	1.15	0.0034	0.009	1.9	2.185	0.0006	0.0007	0.011	0.019	0.011	0.013	0.007	0.014
MW4		0.11	0.15	0.024	0.028	0.0002	0.00027	0.001	0.001	0.001	0.002	1	1.15	0.0034	0.007	1.9	2.185	0.0006	0.0007	0.011	0.014	0.011	0.013	0.008	0.010
MW5A		1.24	2.44	0.024	0.028	0.0002	0.00023	0.003	0.004	0.005	0.008	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.009	0.013
MW6A		0.77	2.10	0.024	0.028	0.0002	0.00023	0.001	0.001	0.004	0.011	1	1.15	0.0034	0.005	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.019
MW10		0.38	0.62	0.024	0.028	0.0002	0.00038	0.002	0.003	0.002	0.004	3.50	9.03	0.0034	0.009	1.9	2.185	0.0006	0.0007	0.011	0.020	0.011	0.013	0.009	0.018
MW11A		5.28	8.48	0.024	0.028	0.0002	0.00023	0.002	0.003	0.001	0.002	5.68	11.38	0.006	0.010	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.006	0.013
MW12		3.52	6.63	0.024	0.028	0.0002	0.00023	0.001	0.001	0.001	0.002	1.74	5.74	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.009
MW26		1.84	2.95	0.024	0.028	0.0002	0.00023	0.001	0.001	0.002	0.003	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.006	0.014
MW27		1.02	1.34	0.024	0.028	0.0002	0.00023	0.002	0.004	0.001	0.002	1.36	2.95	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.007	0.011
MW28		0.80	1.71	0.024	0.028	0.0002	0.00023	0.001	0.001	0.001	0.002	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.009
MW29		1.52	2.38	0.024	0.028	0.0002	0.00023	0.002	0.004	0.002	0.003	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.012
MW30 / MW30A		0.56	1.03	0.024	0.028	0.0002	0.00023	0.001	0.001	0.003	0.006	1	1.15	0.0034	0.005	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.051
MW31		2.20	4.02	0.024	0.028	0.0002	0.00023	0.002	0.004	0.003	0.004	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.004	0.010
MW32 / MW32A		0.65	1.48	0.024	0.028	0.0002	0.00023	0.001	0.001	0.001	0.002	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.006	0.228
MW36 / MW36A		0.10	0.12	0.024	0.028	0.0002	0.00023	0.001	0.001	0.001	0.002	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.009
MW37 / MW37A		0.24	0.33	0.024	0.028	0.0002	0.00023	0.001	0.001	0.001	0.002	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.009
MW38		0.55	4.54	0.024	0.028	0.0002	0.00050	0.004	0.008	0.001	0.003	1.06	6.07	0.0034	0.012	1.9	2.185	0.0006	0.0007	0.011	0.026	0.011	0.013	0.030	0.102
MW39		0.24	0.35	0.024	0.028	0.0002	0.00030	0.001	0.001	0.001	0.002	0.76	1.42	0.0034	0.007	1.9	2.185	0.0006	0.0007	0.011	0.016	0.011	0.013	0.006	0.017
MW40		1.40	1.78	0.024	0.028	0.0002	0.00023	0.001	0.001	0.001	0.002	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.016
MW41		1.94	2.42	0.024	0.028	0.0002	0.00032	0.002	0.004	0.005	0.011	0.76	1.33	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.014	0.424
MW42 / MW42A		0.39	0.65	0.024	0.028	0.0002	0.00023	0.001	0.001	0.001	0.002	1	1.15	0.0034	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.007	0.012
MW55A		0.25	0.36	0.024	0.028	0.0002	0.00023	0.002	0.003	0.002	0.004	1	1.15	0.0034	0.016	1.9	2.185	0.0006	0.0007	0.011	0.034	0.011	0.013	0.010	0.025

Notes:

NE = Not Established
mg/L = Milligrams per litre
µg/L = Micrograms per litre
LOR = Limit of reporting
mBTOC = metres below top of casing
mAHD = metres Australian Height Datum
Thresh = threshold
MW = Monitoring well

Legend:

- Site Specific Trigger level, 80 percentile of the data set
- Site Specific Threshold, Baseline Max + one standard deviation
- Trigger Level is ANZECC 95% moderately disturbed freshwater guideline value
- Threshold Level is 115% of the trigger level or LOR (where no guideline value is available)
- Threshold criteria is calculated using hardness modification in accordance with ANZECC & ARMCANZ (2000) guidance
- Lower trigger level is set at the baseline minimum minus one standard deviation
- Lower threshold trigger level is lower trigger level minus 1 pH
- Upper trigger level is set at the baseline maximum plus standard deviation
- Upper threshold level is lower trigger level plus 1 pH
- No guideline available, all samples below LOR, trigger level is equal to the LOR
- Trigger level is set at the minimum piezometric head from the dataset
- Threshold level is set at the minimum piezometric head from the dataset plus one standard deviation

* Trigger value is below LOR therefore LOR must be lowered for future monitoring rounds

Investigation Levels:

1. ANZECC & ARMCANZ (2000) Fresh water 95% level protection - Slightly to moderately disturbed ecosystems
2. DER (2015) Treatment and management of soil and water in acid Sulfate soil landscapes

In the instance of two or more relevant criteria the FWG 95% is used in the first instance then the next most conservative value
_ = pH data sourced from the latest 12 months of data due to change in pH

Table A1
Northlink Flora and Vegetation - Inland Waters Environmental Quality-Hydrogeological Processes
Groundwater Trigger and Threshold Criteria
ENAUPERT04483AA

Analyte		Other Parameters																		Standing Water Level			
		pH (Lab)				TDS		Acidity (as CaCO3)		Nitrogen (Total)		Phosphate total (P)		Phosphorus reactive (as P)		Total PAHs		TRH C6 - C10		TRH >C10 - C40		Depth to Water		Water level	
Sample ID	Units	pH_Units				mg/L		mg/L		mg/L		mg/L		mg/L		µg/L		µg/L		µg/L		mBTOC		mAHD	
	LOR	0.01				10		10		0.2		0.05		0.05*		5		100		100		0.001			
	ANZECC FW 95%	NE				NE		NE		1.5		0.06		0.03		NE		NE		NE		NE		NE	
	DER 2015	Lower - 6.5		Upper - 8.5		NE		>40		NE		NE		NE		NE		NE		NE		NE		NE	
Trigger / Threshold		Lower Trigger	Lower Thresh	Upper Trigger	Upper Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh
MW1		<6.09	<5.09	>8.51	>9.51	414	667	>40	>46	15.2	33.0	0.16	0.23	0.11	0.15	5	5.75	20	23	100	115	4.491	4.993	28.670	29.172
MW2		<5.25	<4.25	>8.25	>8.25	372	577	>31	>72	1.9	5.1	0.11	0.30	0.03	0.035	5	5.75	20	23	100	115	3.550	4.037	28.920	29.407
MW4		<5.35	<4.35	>7.75	>8.75	164	250	>38	>54	4.9	10.8	0.30	0.50	0.13	0.18	5	5.75	20	23	100	115	3.920	4.226	29.090	29.396
MW5A		<3.51	<2.51	>7.19	>8.19	300	437	>49	>104	2.4	5.9	0.11	0.21	0.03	0.035	5	5.75	20	23	100	115	2.608	2.981	29.930	30.303
MW6A		<4.20	<3.20	>8.00	>9.00	610	1500	>75	>140	3.9	51.3	0.13	0.17	0.03	0.035	5	5.75	20	23	100	115	3.568	3.969	29.850	30.251
MW10		<5.45	<4.45	>8.35	>9.35	230	313	>46	>99	5.9	24.5	0.14	0.18	0.03	0.035	5	5.75	20	23	100	115	3.210	3.605	30.652	31.047
MW11A		<3.35	<2.35	>5.05	>6.05	480	671	>69	>128	2.0	3.8	0.06	0.06	0.03	0.035	5	5.75	20	23	100	115	5.110	5.461	33.870	34.221
MW12		<3.73	<2.73	>4.77	>5.77	182	243	>48	>99	0.7	1.4	0.06	0.07	0.03	0.035	5	5.75	20	23	100	115	5.410	5.744	33.766	34.100
MW26		<3.30	<2.30	>5.60	>6.60	432	651	>82	>148	2.2	4.1	0.19	0.30	0.03	0.035	5	5.75	20	23	100	115	5.845	6.212	43.118	43.485
MW27		<3.09	<2.09	>5.01	>6.01	270	613	>64	>118	1.6	4.8	0.16	1.02	0.04	0.07	5	5.75	20	23	100	115	5.656	6.193	45.461	45.998
MW28		<3.77	<2.77	>5.13	>6.13	308	379	>58	>104	5.0	9.2	0.17	0.27	0.14	0.28	5	5.75	20	23	100	115	4.007	4.434	41.916	42.343
MW29		<3.56	<2.56	>5.82	>6.82	322	485	>65	>101	2.2	4.6	0.16	0.37	0.15	0.23	5	5.75	20	23	100	115	5.195	5.490	45.220	45.515
MW30 / MW30A		<5.04	<4.04	>8.06	>9.06	180	277	>40	>46	3.5	6.8	0.08	0.23	0.04	0.08	5	5.75	20	23	100	115	7.414	7.671	42.279	42.536
MW31		<3.70	<2.70	>6.30	>7.30	500	775	>69	>123	6.1	11.9	1.94	3.48	2.10	3.17	5	5.75	20	23	100	115	2.357	2.754	43.479	44.957
MW32 / MW32A		<5.17	<4.17	>6.73	>7.73	520	809	>37	>59	3.0	5.4	0.89	1.51	0.70	1.51	5	5.75	20	23	100	115	2.466	2.838	43.004	43.376
MW36 / MW36A		<5.95	<4.95	>7.45	>8.45	120	162	>40	>46	4.4	6.6	0.15	0.24	0.12	0.16	5	5.75	20	23	100	115	3.232	3.714	47.500	47.982
MW37 / MW37A		<3.98	<2.98	>7.42	>8.42	120	201	>34	>56	2.4	4.7	0.57	0.93	0.30	0.53	5	5.75	20	23	100	115	2.375	2.736	45.116	45.477
MW38		<4.98	<3.98	>7.62	>8.62	1170	4854	>79	>164	3.9	10.2	1.07	1.91	0.77	1.28	5	5.75	20	23	100	115	1.665	1.981	48.105	48.421
MW39		<6.07	<5.07	>8.07	>9.07	358	916	>40	>46	2.7	5.9	1.10	1.98	1.10	1.94	5	5.75	20	23	100	115	2.442	2.995	48.140	48.653
MW40		<3.64	<2.64	>4.84	>5.84	300	383	>58	>133	1.5	1.7	0.11	0.16	0.42	0.78	5	5.75	20	23	100	115	1.570	1.866	52.060	52.356
MW41		<2.89	<1.89	>4.01	>5.01	806	1289	>140	>185	5.7	10.5	0.95	1.24	0.82	1.17	5	5.75	20	23	100	115	1.990	2.335	49.710	50.055
MW42 / MW42A		<4.02	<3.02	>4.48	>5.48	200	253	>39	>52	1.5	1.7	0.12	0.16	0.03	0.035	5	5.75	20	23	100	115	1.930	2.384	55.308	55.762
MW55A		<6.09	<5.09	>8.51	>9.51	636	830	>57	>103	4.1	15.5	0.09	0.11	0.03	0.035	5	5.75	20	23	270	758	4.632	4.969	24.093	24.430

Notes:

NE = Not Established
mg/L = Milligrams per litre
µg/L = Micrograms per litre
LOR = Limit of reporting
mBTOC = metres below top of casing
mAHD = metres Australian Height Datum
Thresh = threshold
MW = Monitoring well

Legend:

- Site Specific Trigger level, 80 percentile of the data set
- Site Specific Threshold, Baseline Max + one standard deviation
- Trigger Level is ANZECC 95% moderately disturbed freshwater guideline value
- Threshold Levels is 115% of the trigger level
- Threshold criteria is calculated using hardness modification in accordance with ANZECC & ARMCANZ (2000) guidance
- Lower trigger level is set at the baseline minimum minus one standard deviation
- Lower threshold trigger level is lower trigger level minus 1 pH
- Upper trigger level is set at the baseline minimum minus one standard deviation
- Threshold trigger level is lower trigger level minus 1 pH
- No guideline present, all samples below LOR, so trigger level or threshold is equal to the LOR
- Trigger level is set at the minimum piezometric head from the dataset
- Threshold level is set at the minimum piezometric head from the dataset plus one standard deviation

* Trigger value is below LOR therefore LOR must be lowered for future monitoring rounds

Investigation Levels:

1. ANZECC & ARMCANZ (2000) Fresh water 95% level protection - Slightly to moderately disturbed ecosystems
2. DER (2015) Treatment and management of soil and water in acid Sulfate soil landscapes

In the instance of two or more relevant criteria the FWG 95% is used in the first instance then the next most conservative value
_ = pH data sourced from the latest 12 months of data due to change in pH

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APPENDIX B

Surface Water Quality Environmental Criteria

Table B1
Surface Water Trigger and Threshold Criteria
NorthLink
ENAUPERT04483AA

Analyte		Metals Dissolved																					
		Aluminium (Filtered)		Arsenic (Filtered)		Cadmium (Filtered)*		Chromium (Filtered)		Copper (Filtered)		Iron (Filtered)		Lead (Filtered)		Manganese (Filtered)		Mercury (Filtered)		Nickel (Filtered)		Selenium (Filtered)		Zinc (Filtered)	
Sample ID	Units	mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
	LOR	0.05*		0.001		0.00005		0.001		0.001		0.05		0.001		0.005		0.0001		0.001		0.001		0.001	
	ANZECC FW 95%	0.055		0.024		0.0002		NE		0.0014		NE		0.0034		1.9		0.0006		0.011		0.011		0.008	
	ANZECC Lowland	NE		NE		NE		NE		NE		NE		NE		NE		NE		NE		NE		NE	
	DER 2015	1.00		NE		NE		NE		NE		1		NE		NE		NE		NE		NE		NE	
Trigger / Threshold		Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh
SWL1-1		0.07	0.13	0.024	0.028	0.0002	0.00023	0.003	0.0044	0.001	0.002	1.00	1.15	0.003	0.005	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.020	0.054
SWL1-2		0.06	0.07	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.001	0.003	1.00	1.15	0.003	0.005	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.037	0.058
SWL1-3		0.04	0.07	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.002	0.004	1.00	1.15	0.003	0.005	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.049	0.081
SWL2-1		0.19	0.31	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.001	0.002	1.00	1.15	0.003	0.005	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.009
SWL2-2		0.17	0.24	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.002	0.003	1.00	1.15	0.003	0.006	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.009	0.015
SWL2-3		0.21	0.44	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.002	0.003	1.00	1.15	0.003	0.006	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.009
SWL3-1		0.30	0.44	0.024	0.028	0.0002	0.00035	0.001	0.0016	0.001	0.002	1.00	1.15	0.003	0.008	1.9	2.185	0.0006	0.0007	0.011	0.018	0.011	0.013	0.008	0.013
SWL3-2		0.28	0.40	0.024	0.028	0.0002	0.00035	0.001	0.0016	0.001	0.002	1.00	1.15	0.003	0.008	1.9	2.185	0.0006	0.0007	0.011	0.018	0.011	0.013	0.008	0.013
SWL3-3		0.30	0.41	0.024	0.028	0.0002	0.00037	0.001	0.0017	0.001	0.002	1.00	1.15	0.003	0.009	1.9	2.185	0.0006	0.0007	0.011	0.019	0.011	0.013	0.008	0.014
SWL4-1		0.26	0.75	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.002	0.005	1.00	1.15	0.003	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.022	0.033
SWL4-2		0.15	0.28	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.002	0.003	1.00	1.15	0.003	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.025	0.059
SWL4-3		0.17	0.48	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.002	0.005	1.00	1.15	0.003	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.025	0.359
SWL5-1		0.66	0.81	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.002	0.005	1.00	1.15	0.003	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.008	0.009
SWL15-1		0.74	1.17	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.004	0.007	1.00	1.15	0.003	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.013	0.022
SWL15-2		0.77	1.14	0.024	0.028	0.0002	0.00023	0.001	0.0012	0.003	0.004	1.00	1.15	0.003	0.004	1.9	2.185	0.0006	0.0007	0.011	0.013	0.011	0.013	0.016	0.026
SWL16-1		0.28	0.47	0.024	0.028	0.0002	0.00032	0.001	0.0015	0.001	0.002	0.95	1.93	0.003	0.008	1.9	2.185	0.0006	0.0007	0.011	0.017	0.011	0.013	0.008	0.014
SWL16-2		0.32	0.54	0.024	0.028	0.0002	0.00027	0.001	0.0012	0.001	0.002	1.00	1.15	0.003	0.006	1.9	2.185	0.0006	0.0007	0.011	0.014	0.011	0.013	0.009	0.016
SWL16-3		0.33	0.54	0.024	0.028	0.0002	0.00031	0.001	0.0014	0.002	0.003	1.00	1.15	0.003	0.008	1.9	2.185	0.0006	0.0007	0.011	0.016	0.011	0.013	0.009	0.200
SWL17-1		0.72	1.13	0.024	0.028	0.0002	0.00043	0.001	0.0020	0.001	0.003	1.00	1.15	0.003	0.011	1.9	2.185	0.0006	0.0007	0.011	0.023	0.011	0.013	0.008	0.017
SWL17-2		0.84	1.17	0.024	0.028	0.0002	0.00042	0.001	0.0019	0.002	0.003	1.00	1.15	0.003	0.010	1.9	2.185	0.0006	0.0007	0.011	0.022	0.011	0.013	0.008	0.016
SWL17-3		0.77	1.18	0.024	0.028	0.0002	0.00040	0.001	0.0019	0.001	0.003	1.00	1.15	0.003	0.010	1.9	2.185	0.0006	0.0007	0.011	0.021	0.011	0.013	0.008	0.015

Notes:

NE = Not established
mg/L = Milligrams per litre
LOR = Limit of reporting
SWL = Surface Water location
NTU = Nephelometric Turbidity Units
µg/L = Micrograms per litre
Thresh = Threshold

Legend:

- Site Specific Trigger level, 80 percentile of the data set
- Site Specific Threshold, Baseline Max + one standard deviation
- Trigger Level is ANZECC 95% moderately disturbed freshwater guideline value
- Threshold Levels is 115% of the trigger level
- Trigger Level is ANZECC lowland guideline value
- Threshold criteria is calculated using hardness modification in accordance with ANZECC & ARMCANZ (2000) guidance
- Lower trigger level is set at the baseline minimum minus one standard deviation
- Lower threshold trigger level is lower trigger level minus 1 pH
- Upper trigger level is set at the baseline minimum minus one standard deviation
- Threshold trigger level is lower trigger level minus 1 pH
- No guideline present, all samples below LOR, so trigger level or threshold is equal to the LOR

* Trigger value is below LOR therefore LOR must be lowered for future monitoring rounds

Investigation Levels:

1. ANZECC & ARMCANZ (2000) Fresh water 95% level protection - Slightly to moderately disturbed ecosystems
2. ANZECC & ARMCANZ (2000) Lowland river - South -west Australia
2. DER (2015) Treatment and management of soil and water in acid Sulfate soil landscapes

In the instance of two or more relevant criteria the FWG 95% is used in the first instance then the next most conservative value

Table B1
Surface Water Trigger and Threshold Criteria
NorthLink
ENAUPERT04483AA

Analyte		Other Parameters																					
		pH (Lab)				TDS		Turbidity		Acidity (as CaCO3)		Nitrogen (Total)		Phosphate total (P)		Reactive Phosphorus as P		Total PAHs		TRH C6 - C10		TRH >C10 - C40	
Sample ID	Units	pH_Units				mg/L		NTU		mg/L		mg/L		mg/L		mg/L		µg/L		µg/L		µg/L	
	LOR	0.01				10		1		10		0.2		0.05		0.05*		5		20		100	
	ANZECC FW 95%	Lower-6.5		Upper-8.0		NE		10 to 100		NE		1.5		0.06		0.03		NE		NE		NE	
	ANZECC Lowland	Lower 6.5		Upper 8.0		NE		10 to 20		NE		1.2		0.065		0.04		NE		NE		NE	
	DER 2015	Lower-6		Upper-8.5		NE		NE		>40		NE		NE		NE		NE		NE		NE	
Trigger / Threshold		Lower Trigger	Lower Thresh	Upper Trigger	Upper Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh	Trigger	Thresh
SWL1-1		<6.45	<5.45	>7.65	>8.65	256	419	100	115	>40	>46	1.2	1.4	0.05	0.06	0.03	0.035	5	6	20	23	100	115
SWL1-2		<6.63	<5.63	>7.37	>8.37	222	291	100	115	>40	>46	1.2	1.4	0.06	0.06	0.03	0.035	5	6	20	23	100	115
SWL1-3		<6.67	<5.67	>7.23	>8.23	228	297	100	115	>40	>46	1.2	1.4	0.12	0.16	0.03	0.035	5	6	20	23	100	115
SWL2-1		<6.51	<5.51	>8.09	>9.09	240	286	100	115	>40	>46	1.2	1.4	0.34	0.66	0.03	0.035	5	6	20	23	100	115
SWL2-2		<6.54	<5.54	>7.96	>8.96	240	288	100	115	>40	>46	1.2	1.4	0.78	1.24	0.03	0.035	5	6	20	23	100	115
SWL2-3		<6.49	<5.49	>8.01	>9.01	240	292	100	115	>40	>46	1.2	1.4	0.01	0.01	0.03	0.035	5	6	20	23	100	115
SWL3-1		<6.49	<5.49	>8.31	>9.31	244	290	100	115	>40	>46	1.2	1.4	0.06	0.07	0.03	0.035	5	6	20	23	100	115
SWL3-2		<6.50	<5.50	>8.41	>9.41	250	301	100	115	>40	>46	1.2	1.4	0.07	0.08	0.03	0.035	5	6	20	23	100	115
SWL3-3		<6.97	<5.97	>8.13	>9.13	254	346	100	115	>40	>46	1.2	1.4	0.06	0.07	0.03	0.035	5	6	20	23	100	115
SWL4-1		<5.91	<4.91	>7.09	>8.09	400	553	100	115	>40	>46	1.3	3.6	0.14	0.56	0.03	0.035	5	6	20	23	100	115
SWL4-2		<5.96	<4.96	>7.08	>8.05	360	549	100	115	>40	>46	1.2	1.4	0.27	0.71	0.03	0.035	5	6	20	23	100	115
SWL4-3		<6.08	<5.08	>7.42	>8.42	402	586	100	115	>40	>46	1.2	1.4	0.12	0.16	0.03	0.035	5	6	20	23	100	115
SWL5-1		<4.35	<3.35	>6.75	>7.75	234	394	100	115	>40	>46	1.9	3.3	0.20	0.21	0.03	0.035	5	6	20	23	100	115
SWL15-1		<3.42	<2.42	>6.58	>7.58	360	459	100	115	>32	>52	2.1	7.3	0.52	1.03	0.45	0.93	5	6	20	23	100	115
SWL15-2		<3.37	<2.37	>7.13	>8.13	368	607	100	115	>40	>46	1.9	4.8	0.62	1.61	0.36	0.88	5	6	20	23	100	115
SWL16-1		<6.00	<5.0	>8.11	>9.11	666	932	100	115	>40	>46	3.0	3.9	1.52	2.65	1.44	1.95	5	6	20	23	100	115
SWL16-2		<6.42	<5.42	>7.88	>8.88	382	591	100	115	>40	>46	2.3	3.7	1.00	1.77	0.88	1.19	5	6	20	23	100	115
SWL16-3		<6.44	<5.44	>7.76	>8.76	392	932	100	115	>40	>46	3.0	4.0	1.20	2.36	0.80	1.60	5	6	20	23	100	115
SWL17-1		<3.48	<2.48	>4.12	>5.12	480	687	100	115	>58	>87	2.2	3.6	0.25	0.38	0.16	0.43	5	6	20	23	100	115
SWL17-2		<3.45	<2.45	>4.15	>5.15	518	749	100	115	>65	>97	2.3	4.9	0.21	0.44	0.09	0.13	5	6	20	23	100	115
SWL17-3		<3.31	<2.31	>4.19	>5.19	500	819	100	115	>65	>96	2.3	4.3	0.24	0.55	0.09	0.13	5	6	20	23	100	115

Notes:

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mg/L = Milligrams per litre
LOR = Limit of reporting
SWL = Surface Water location
NTU = Nephelometric Turbidity Units
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Legend:

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- Lower trigger level is set at the baseline minimum minus one standard deviation
- Lower threshold trigger level is lower trigger level minus 1 pH
- Upper trigger level is set at the baseline minimum minus one standard deviation
- Threshold trigger level is lower trigger level minus 1 pH
- No guideline present, all samples below LOR, so trigger level or threshold is equal to the LOR

* Trigger value is below LOR therefore LOR must be lowered for future monitoring rounds

Investigation Levels:

1. ANZECC & ARMCANZ (2000) Fresh water 95% level protection - Slightly to moderately disturbed ecosystems
2. ANZECC & ARMCANZ (2000) Lowland river - South -west Australia
2. DER (2015) Treatment and management of soil and water in acid Sulfate soil landscapes

In the instance of two or more relevant criteria the FWG 95% is used in the first instance then the next most conservative value

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APPENDIX C

Wetland Flora and Vegetation Monitoring Method

WETLAND FLORA AND VEGETATION MONITORING METHOD

The following monitoring method has considered the following standard and guidelines in the preparation of this documents:

- Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004).
- Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA and DPAW, 2015).
- Standard Operating Procedure Establishing Vegetation Transects SOP No. 6.2 (DEC, 2009).

Transect Monitoring Method

Transect monitoring sites will be located in remnant vegetation along the development envelope and close to Conservation Category Wetlands (CCW). A line-intercept method will be used to monitor the vegetation surrounding CCWs to monitor vegetation stress from any changes to surface water flows as a result of the proposal. A quadrat will be established at each site to supplement species diversity data. Transects will not be placed within Completed Degraded areas. All monitoring will be undertaken by an experienced botanist. Transect monitoring method will be conducted as follows:

- The location will be recorded by GPS. A permanent marker will be used to mark the transect start point.
- The transect will run 15 m perpendicular to the wetland and up to 40 m parallel to the wetland. There will be a 5 x 5 m quadrat placed in the corner of the joining transect lines (Figure A1). The following parameters will be recorded:
  - Within the 5 x 5 m plot:
    - Vegetation cover (%).
    - Species diversity (richness and abundance).
    - Annuals and perennials.
    - Vegetation condition (Keighery, 1994).
    - Vegetation structure.
    - Introduced annuals and perennials.
    - Level of plant stress (0-4 scale) (refer to Table 1).
  - Along the parallel and perpendicular transects:
    - Species diversity (richness and abundance).
    - Vegetation density (%).
    - Perennial vegetation (only), including weeds.
    - Presence or absence of backwater or ponding of water.
    - Presence or absence of erosion and/or scouring.

- A photo will be taken at the start and end point of each transect and a quadrat photo will be taken from the corner of the quadrat where the perpendicular and parallel transects intersect.

Phreatophytic species (flora species that rely wholly or partially on the groundwater) will be used as the "key species" for the purposes of monitoring potential impacts to the health and structure of the wetland vegetation due to changes in groundwater levels. Analysis of the data collected after the pre-construction survey will assist in the determination of the key species that define the wetland community.

The results of the line-intercept and species diversity data will be analysed over time to determine if the vegetation has altered significantly as a result of the project. The results of the monitoring will be graphically represented to show variation from subsequent monitoring events. If any indirect impacts are occurring they would be expected to be observed as a change over time in one or more of the parameters. Each monitoring site will be tested independently from the remaining sites as the prevailing environment (i.e. vegetation structure, condition, environmental receptor) at each location will be different.

The vegetation health may change due to factors other than as a result of construction and operation of the proposal. Results of monitoring groundwater and surface water quality as part of environmental criteria 1 will be reviewed to assist in identifying any potential change in vegetation health as part of environmental criteria 3.

Plant Stress Indicator

Plant stress can be caused by a range of anthropogenic and natural factors including drought. The assessment of plant stress caused by changes in surface water flows will consider other factors prevailing at the time. It will be assessed by observation of evidence of wilting of foliage and the extent of wilting. Kjelgren et al. (2009) note that visible indicators of water stress are wilting and leaf curling. Jones (2007) notes that wilting (as an indicator of stem, leave or fruit shrinkage and reduction in growth rate) is a suitable visible expression of plant water deficit/stress. Else et al. (2001) as cited in Shaw (2015) note that some species exhibit wilted leaves in response to waterlogging. Wilting can therefore be an appropriate early visual indicator of plant stress whether caused by water deficit or waterlogging.

Experience gained from monitoring already conducted shows that not all species typically encountered for this project necessarily exhibit signs of wilting or leaf curling. In these cases, leaf colour is a more appropriate indicator of foliage health, from which stress can be inferred as a proportion of affected foliage (H. Taylor, pers. com., 2018).

A scale comprising five increments will be used to indicate the level of stress a plant is potentially under. Table 1 lists the indicators to be used in assessing plant stress. The most suitable score will be assigned based on the criteria available and their applicability to the vegetation being assessed, e.g. for species where leaf colour is the appropriate indicator, the percentage of plants or foliage cover affected will be used to determine the plant stress score.

Table 1 Level of plant stress

Rating	Plant stress criteria
0	No evidence of wilting of foliage. Foliage intact and healthy. Plants not stressed.
1	Plant leaves show signs of wilting at periphery. Less than 10% of plants or foliage cover affected. Plants potentially stressed.
2	Plant leaves wilting with noticeable curling of leaf periphery. 10% to 20% of plants or foliage cover affected. Plants exhibiting symptoms of stress.
3	Plant leaves wilting with noticeable curling of leaf. 20% to 30% of plants or foliage cover affected. Plants exhibiting signs of stress.
4	Plant leaves wilting with noticeable curling of leaf (approaching closure). More than 30% of plants or foliage cover affected. Plants clearly stressed.

The general plant community (not individual species) will be used to set the plant stress level for each monitoring site, taking into account the variation in individual species and their tolerance to changes in surface water regimes.

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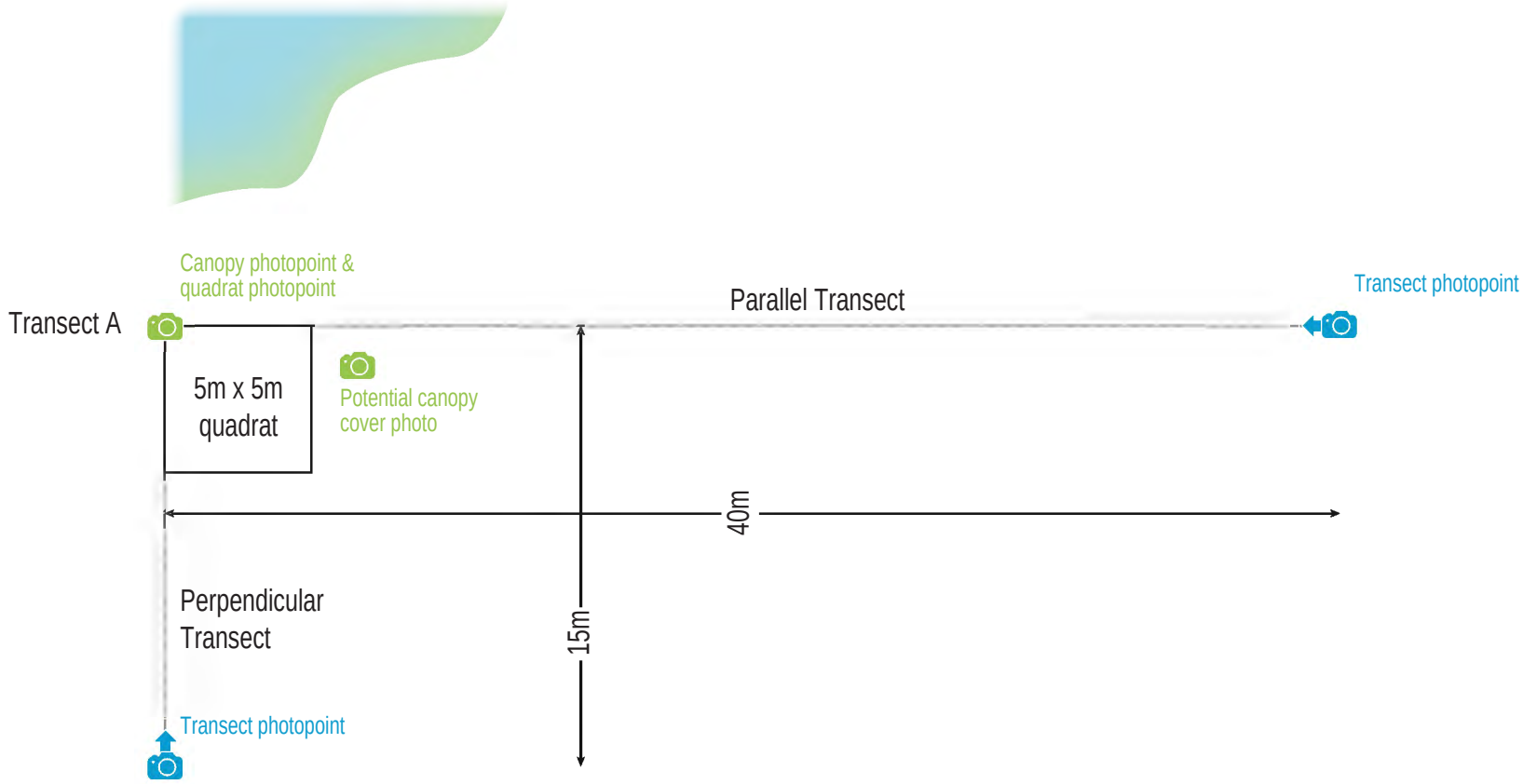

Note:
Drawing is not to scale and is for illustrative purposes only.

NorthLinkWA

coffey
A TETRA TECH COMPANY

Date: 07.11.2016

File Name: 4483AA_63_FA01_GRA

Perth–Darwin National Highway

Flora and Vegetation – Inland Waters Environmental Quality Hydrological Processes – Condition EMP

Typical wetland transect line

Figure No: A1

AI Reference: 4483AA_63_GRA001_v1.ai_3

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APPENDIX D

Monitoring Locations

Table D1 **Approximate location of groundwater, surface water, basin and flora and vegetation monitoring sites (survey locations reported in GDA94 unless otherwise stated)**

Monitoring location	Easting	Northing
Surface water		
SWL1	396,794	6,473,484
SWL2	397,250	6,474,043
SWL3	397,840	6,474,198
SWL4	398,223	6,476,207
SWL5	397,869	6,476,648
SWL6	397,350	6,478,642
SWL7	397,119	6,479,313
SWL8	402,258	6,485,793
SWL9	402,863	6,486,129
SWL10	403,075	6,486,308
SWL11	403,280	6,487,337
SWL12	403,699	6,487,200
SWL15	403,525	6,493,945
SWL16	403,300	6,497,522
SWL17	403,016	6,499,812
Groundwater		
MW1	397,404	6,473,780
MW2	397,353	6,473,993
MW4	397,648	6,474,628
MW5A (PCG94)	59470.656	274262.592
MW6A (PCG94)	59558.236	274263.730
MW10	397,844	6,476,609
MW11A (PCG94)	59427.123	277382.777
MW12	397,607	6,478,318
MW26	403,202	6,486,100
MW27	403,396	6,487,245
MW28	403,508	6,487,227
MW29	403,529	6,487,742
MW30	403,653	6,487,735
MW30A (proposed)	403,924.37	6,487,715
MW31	403,348	6,489,247
MW32	403,471	6,489,244

Monitoring location	Easting	Northing
MW32A (proposed)	403,362	6,489,498
MW36	403,409	6,497,286
MW36A (proposed)	403,309	6,497,301
MW37	403,642	6,497,313
MW37A (proposed)	403,562	6,497,305.75
MW38	402,979	6,497,722
MW38A (possible relocation)	–	–
MW39	403,130	6,497,629
MW40	403,061	6,499,002
MW41	403,180	6,498,985
MW42	403,052	6,499,347
MW42A (proposed)	403,068	6,499,890
Basins		
B04	397,289	6,479,195
B05	397,254	6,479,346
B06	397,163	6,479,928
B20	402,881	6,485,798
B21	403,191	6,486,176
B22	403,263	6,486,703
Flora and vegetation		
GHD12	397,889	6,476,585
SVB020	397,321	6,478,441
GHD21	396,717	6,479,336
SVB040	402,133	6,485,710
SVB044	402,881	6,486,159
SVB048	403,044	6,486,779
SVB052	403,306	6,487,373
SVB056	403,727	6,487,192
SVB098	403,006	6,498,934
FV37B	404,564	6,506,500
360Q02	397,531	6,478,354
Culverts		
3	397,557	6,476,807
4	397,548	6,478,207

Monitoring location	Easting	Northing
5	397,490	6,478,228
6	397,522	6,478,457
7	397,455	6,478,515
14	403,570	6,488,291
16	403,389	6,489,295
17	403,396	6,489,358
32	403,460	6,494,250
33	403,530	6,494,751
40	403,179	6,497,388
41	403,072	6,497,600
44	403,125	6,498,945

Note: eastings and northings are in GDA94 MGA Zone 50.

APPENDIX E

Individual Parameters to be Analysed

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Table E1 Total PAH and total TRH individual constituents

Group	Individual constituents
Total TRH	• Benzene • Ethylbenzene • Toluene • Xylene total • TRH C6-C10 • TRH >C10-C16 • TRH >C16-C34 • TRH >C34-C40
Total PAH	• Acenaphthene • Acenaphthylene • Anthracene • Benzo(a)anthracene • Benzo(a)pyrene • Benzo(g,h,i)perylene • Benzo(k)fluoranthene • Chrysene • Benzo[b+j]fluoranthene • Dibenz(a,h)anthracene • Fluoranthene • Fluorene • Indeno(1,2,3-c,d)pyrene • Naphthalene • Phenanthrene • Pyrene

Note: Results of individual constituent analysis should be compared to DWER/NEPM guideline values, where available, to assess concentrations and potential risk.

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