LandCorp

Ashburton North Strategic Industrial Area (ANSIA)

Engineering Gap Analysis Report

238154-REP-001

B | 02 February 2015

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 238154

Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
Level 7 Wellington Central
836 Wellington Street
West Perth 6005
Australia
www.arup.com

Document Verification

ARUP

Job title	Ashburton North Strategic Industrial Area (ANSIA)	**Job number** 238154	
Document title	Engineering Gap Analysis Report	**File reference** 238154-001	
Document ref	238154-REP-001		

Revision	**Date**	**Filename**	238154-REP-001_A.docx		
A	14 Jan 2015	**Description**	Issued for Client Review		
			Prepared by	Checked by	Approved by
		Name	Stuart Manning	Sergio Soares	Damon Sunderland
		Signature			
B	02 Feb 2015	**Filename**	238154-REP-001_B.docx		
		Description	Revised to incorporate client comments		
			Prepared by	Checked by	Approved by
		Name	Stuart Manning	Sergio Soares	Damon Sunderland
		Signature			
		Filename			
		Description			
			Prepared by	**Checked by**	**Approved by**
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	**Checked by**	**Approved by**
		Name			
		Signature			

Press Control+Shift+D to insert or **Issue Document Verification with Document** ☑

Contents

Abbreviations, Acronyms and Terms Used

AHD	Australian Height Datum
ANSIA	Ashburton North Strategic Industrial Area
ARI	Average Recurrence Interval
ASS	Acid Sulfate Soils
BHPBP	BHP Billiton Petroleum
CUCA	Common User Coastal Area
DoW	Department of Water
DPA	Dampier Port Authority
DSD	Department of State Development
DWMS	District Water Management Plan
EPA	Environmental Protection Authority of Western Australia
FID	Final Investment Decision
FP	Foundation Proponent
FIA	Future Industry Area
GIA	General Industry Area
GIS	Geographic Information Systems
LNG	Liquefied Natural Gas
LOS	Level of Service
LWMS	Local Water Management Strategy
MOF	Materials Offloading Facility
MRWA	Main Roads Western Australia
MUAIC	Multi-user Access and Infrastructure Corridor
NWCH	North West Coastal Highway
OPIUP	Onslow Power Infrastructure Upgrade Project
OWIUP	Onslow Water Infrastructure Upgrade Project
PASS	Potential Acid Sulfate Soils

Proponents	The developers of the initial facilities, i.e. Chevron (Wheatstone), BHP Billiton (Macedon). Also used to refer to future developers.
The Shire	The Council for the Shire of Ashburton
TWA	Transient Workers Accommodation
UWMP	Urban Water Management Plan
WAPC	Western Australian Planning Commission
WWTP	Wastewater Treatment Plant

Executive Summary

Covering an area of over 8000ha, the Ashburton North Strategic Industrial Area (ANSIA) will accommodate the needs of proposed Liquefied Natural Gas (LNG) processing and downstream facilities as well as other heavy and light industries. The ANSIA is intended to be an internationally competitive industrial estate that offers a layout designed to facilitate and encourage industry synergies, functional transport links and viable port access.

Since October 2009, when the State Government announced its support for the establishment of the ANSIA, various stages have been achieved, via various Structure and Development Plans. Construction activities for Stage 1A are partially complete and include an LNG processing plant and the accommodation camp.

Currently, the Department of State Development and the Western Australian Land Authority (LandCorp) have resolved to implement an Improvement Plan, guiding an Improvement Scheme and Guide Plan, over the area to ensure efficient and optimum planning for the future of the estate.

As part of this Improvement Scheme and its associated Guide Plan, Arup Pty Ltd (Arup) has been engaged by LandCorp to assist in the completion of further engineering studies to support rezoning of the remaining ANSIA areas, namely Stage 1D and Stage 2 and potential areas of expansion.

The various Structure and Development Plans and the numerous supporting technical studies, have undergone an iterative process of identifying issues and opportunities, evaluating options, and implementing solutions to overcome engineering challenges. This report presents a holistic evaluation of the engineering information. By learning from preceding analysis, a platform for future engineering direction is established based on the key observations, lessons learnt, and proposed engineering solutions.

This report identifies gaps which occur within the set of previous engineering reports, and makes suggestions for possible steps or methods to remedy the gaps appropriate to areas of future ANSIA development.

To support the adoption of an Improvement Scheme and Guide Plan over the ANSIA, further strategic engineering advice is recommended, utilising this gap analysis report as a basis. Numerous linkages between the engineering fields exist, which enables the opportunity for efficient sequencing of future studies.

Initial focus should be targeted on investigations with the longest expected duration and which lead in to other activities. Consequently the following are recommended:

- Investigation to remove uncertainty regarding short-term and long-term water supply, for current and future stages of ANSIA;
- Infilling of gaps in the landform classification mapping as this relates to several other engineering fields;
- Clarify the validity of flood modelling results within the gap between the original hydrological sub-catchments and the Improvement Scheme boundary.

Identification of future viable development areas should be undertaken through collaboration of the following engineering aspects:

- Supplementary landform mapping, as highlighted above;
- Engineering advice, primarily the combined earthworks, stormwater management and geotechnical/ASS benefits of utilising ground at naturally higher elevation;
- Integration with Town Planning, Environmental, Social and Economic considerations, including possible sharing of spatial data utilising Geographic Information Systems (GIS).

Determining the opportunities and barriers for synergy is a key initiative linking water, wastewater and power. This understanding should be gained to inform co-location of industry types and appropriate clustering of potential future proponents, within the identified viable areas.

Once indicative areas of different types of industry are available, the matching of water demand estimates with water recycling/synergy opportunities should be fed into the water supply investigation. This will enable more meaningful evaluation of the supply options, considering the ‘business as usual’ and ‘total water cycle efficiency’ scenarios. Similarly, for power supply and telecoms investigation and enquiries, the initial areas of each type of industry would provide a useful basis for demand considerations.

Traffic investigations will also benefit from confirmation of previously reported information, such as land use assumptions, projected staffing levels etc., and new information for the proposed expansions areas in order to adequately quantify traffic impacts. It is notable that any requirements of future proponents for close transport connectivity, for example to the port or Onslow Road, will need to be considered alongside opportunities for synergy and co-location of shared-services industry.

Areas of development set at the appropriate design level, will be a major input into initial earthworks and flooding investigation. Concept design planning of the roads and drainage infrastructure would then utilise these investigations. Based on these plans, site investigations such as geotechnical and ASS would be targeted to specific areas.

For the planning of engineering investigations, due consideration should be given to the cumulative impacts of the future ANSIA as a whole. Any potential benefit arising from synergies and early implementation of the servicing infrastructure should be assessed, to potentially reduce costs for individual developments, and increase attractiveness for proponents.

1 Introduction

The State Government of Western Australia is developing a Strategic Industrial Area at Ashburton North, located approximately 11 km southwest of Onslow. This development is described as the Ashburton North Strategic Industrial Area (ANSIA) and will accommodate the needs of proposed Liquefied Natural Gas (LNG) processing and downstream facilities as well as other heavy and light industries.

Since October 2009, when the State Government announced its support for the establishment of the ANSIA, various major milestones have been achieved. These are described in detail in Sections 2 and 3 of this report. Currently, the Department of State Development and the Western Australian Land Authority (LandCorp) have resolved to implement an Improvement Plan, guiding an Improvement Scheme and Guide Plan, over the area to ensure efficient and optimum planning for the future of the estate.

As part of this Improvement Scheme and its associated Guide Plan, Arup Pty Ltd (Arup) has been engaged by LandCorp to assist in the completion of further engineering studies to support rezoning of the remaining ANSIA areas and potential areas of expansion.

1.1 Purpose of this report

This Engineering Gap Analysis Report provides the initial basis for strategic engineering advice for the proposed ANSIA Improvement Scheme and Guide Plan. It provides a summary of the many engineering related reports and key findings since 2009 and provides an appreciation of the major engineering related gaps (recommended for address) for future development.

This report may be utilised by LandCorp, planning consultants, future ANSIA proponents and engineers. The summary and presentation all previous engineering information aims to promote an ease of understanding for LandCorp and future proponents.

1.2 Structure of this report

Section 2 of this report introduces the site and provides context for future stages of the ANSIA. These next stages of development planning are described and provide an understanding of the intended future direction of the ANSIA.

Section 3 describes the planning and implementation documents which precede this report. A detailed summary is provided of the engineering discussion within these documents, with key findings extracted for Section 4 of this report.

Section 4 presents a holistic evaluation of the engineering information within numerous technical studies as well as the structure and development plans. The section is divided into the various engineering fields to assist with ease of reference for future studies. Relevant studies are identified. Key findings extracted from the studies and plans are included in this section, which aim to identify any engineering gaps. Engineering gap analysis is provided in the final section of each field.

Section 5 provides conclusions from this study. These are intended to guide future strategic engineering advice. Discussion of the most efficient flow of information is included. In particular, this section considers how the engineering fields interrelate with one another and with spatial advice from the project consultant team.

An Index of technical engineering reports containing design information relating to various stages of the ANSIA is provided within Appendix A1. This index will assist with future searching for more detailed information.

2 Site Context

2.1 Introduction and Vision

The ANSIA is located 11km south west of Onslow and 2km from the Ashburton River mouth. Figure 1 shows the position of the site in relation to Onslow Town Site on the north west coast of Western Australia.

The vision which has shaped the legacy of the ANSIA, as follows, indicates key considerations for this report and future studies. This has fed into the objectives for the Improvement Plan and future development at the site, as discussed in Section 2.4.

The objective of the ANSIA is to create a functional and sustainable Strategic Industrial Area through efficient use of the land and infrastructure while incorporating flexibility to respond to changes in industry requirements. The ANSIA will be an internationally competitive industrial estate that offers a layout designed to facilitate and encourage industry synergies, functional transport links and viable port access. (LandCorp, 2014)

The ANSIA currently comprises an area of more than 8,000ha, however the Improvement Plan includes additional land in order to provide a statutory land use buffer of 1km or 3km depending on the type of development within the ANSIA (URBIS, 2015).

The images throughout Section 4 of this report include a solid red line encompassing the core areas of the ANSIA up to Stage 2 of the development, with the dashed red line showing the additional buffer area. Section 2.3 provides further discussion of staging at the site. White lines indicate main areas within the ANSIA, however these may be expected to alter as the site develops. The Onslow water and power upgrade projects near the Onslow Road intersection are also indicated by white lines; the buffer to these projects is not shown.

2.2 Site Features

Establishing the current planning and development framework for the ANSIA commenced in the late 2000's, with substantial input from State and local government, and key stakeholders (URBIS, 2014a). The State Government announced its support for the establishment of the ANSIA in 2009.

The main pre-existing physical features surrounding the ANSIA site, which have contributed to the shaping of the ANSIA precinct, can be seen in Figure 1. These features are listed below:

- Old Onslow Town site - heritage and historical value, with associated curtilage,
- Hooley Creek - community access (including road access) to be retained,
- Onslow Salt - sensitivity requiring chemical management,
- Ashburton River - breakout flows contribute to flooding inundation. Tourism locations along the river such as campsites offer opportunity for social infrastructure provision,
- Onslow Airport - transport hub used by proponent employees and for transporting goods. The eastern runway has been upgraded in length and sealed, allowing for aeroplanes such as Fokker 100 passenger jets, in association with the Chevron commuter services serving the Wheatstone LNG plant (URBIS, 2014a).

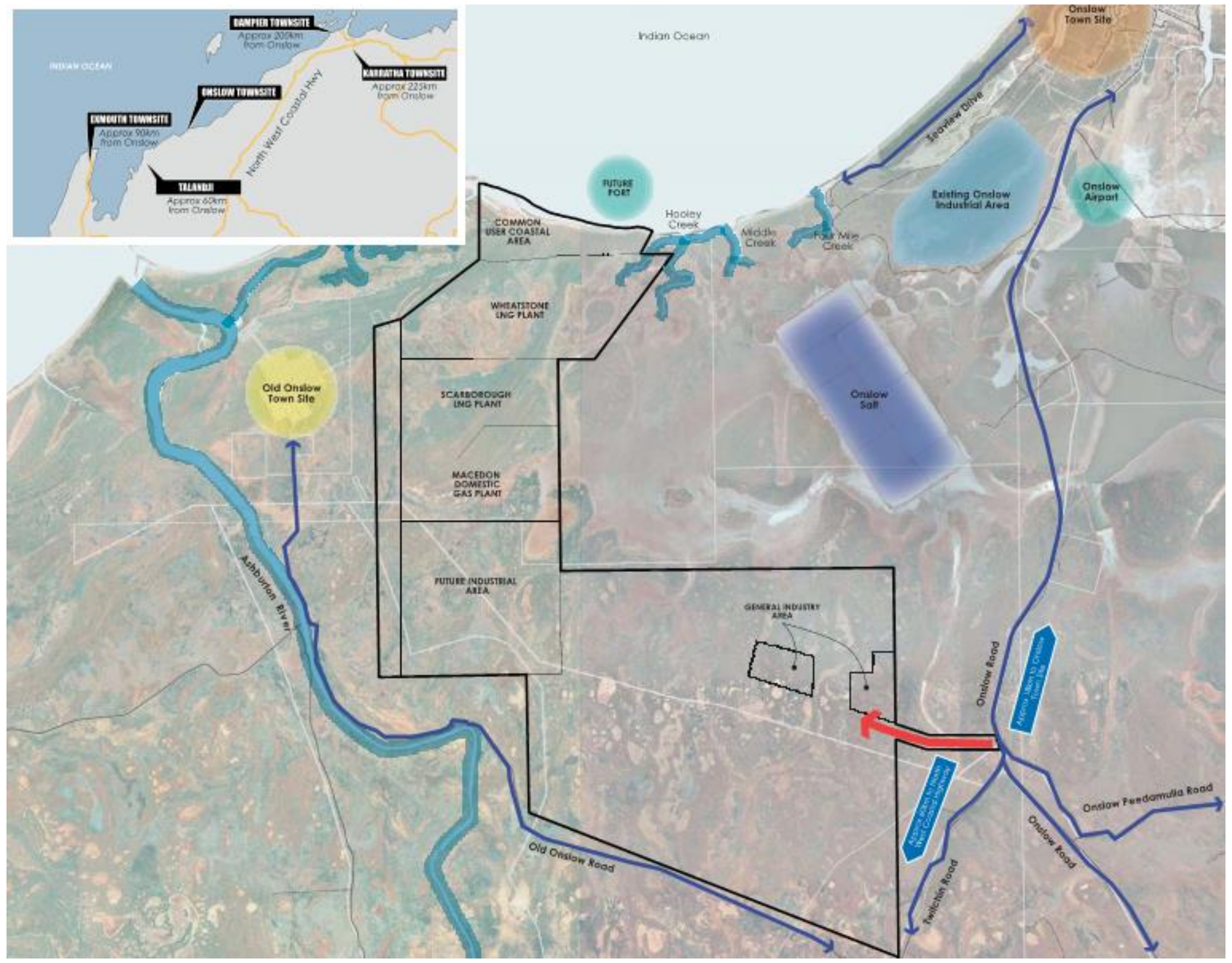

Figure 1 – Site context plan (Taylor Burrell Barnett, 2011)

2.3 Site Staging

The staged development approach to the ANSIA site is illustrated by Figure 2 and comprises:

- **Stage 1A** – consisting of the port, Common User Coastal Area (CUCA), the Wheatstone LNG and domestic gas (DOMGAS) plant, the Multi-user Access and Infrastructure Corridor (MUAIC) and the Wheatstone Transient Workers Accommodation (TWA). Construction of the Wheatstone LNG plant is ongoing while the TWA has been completed.
- **Stage 1B** - consisting of the Macedon LNG plant, the second LNG site (formerly Scarborough LNG site, currently pending project Financial Investment Decision[2]), second TWA site, and a Future Industrial Area (FIA),
- **Stage 1C** - the eastern and western General Industrial Areas (GIAs),
- **Stage 1D** - an additional area to the west of the Stage 1B area,
- **Stage 2** – strategic industrial expansion for the longer term (southern region), and
- **Potential expansion area** – located to the east of Stage 2 for investigation.

The key considerations for this report and future studies focus primarily on the future development, i.e. Stages 1D and 2 and the potential expansion area.

2.4 Improvement Plan, Improvement Scheme and Guide Plan

To assist with the future planning of the ANSIA estate, the Department of State Development and LandCorp have resolved to implement an Improvement Plan over the area. This will ensure that efficient and optimum planning will allow the ANSIA to reach its potential as an internationally competitive Strategic Industrial Area (LandCorp, 2014).

The Improvement Plan (URBIS, 2015) will establish a framework for land use co-ordination and infrastructure delivery, including appropriate land use buffers. The Improvement Plan will highlight the provisions required within an Improvement Scheme and Guide Plan, providing sufficient guidance for these to be developed. As stated by Urbis, the Improvement Scheme will be informed by the following objectives:

- *To create a strategic industrial estate comprising major hydrocarbon processing industries and synergistic services and/or facilities with viable port access.*
- *Ensure the safe and efficient use of land for the long-term industrial development of a strategic industrial area of regional, state and national significance.*
- *To provide an internationally competitive industrial estate that offers a layout designed to facilitate and encourage industry synergies, functional transport links and where possible, the sharing of infrastructure networks and corridors.*
- *To minimise and mitigate adverse impacts on the surrounding land, the terrestrial and marine environment, and the Onslow community.*
- *To ensure the appropriate separation and layout of land uses through appropriate internal and external buffers to prevent incompatible or conflicting land uses* (URBIS, 2015).

As part of the Improvement Scheme and Guide Plan, further engineering studies are to be completed to support rezoning of the remaining areas. The size of the site and consequently large number of completed studies leads to a complex set of information and conclusions which have developed in different ways. Gaining a thorough understanding of the provisions of existing documentation which may impact the project will inform an appropriate approach to future development.

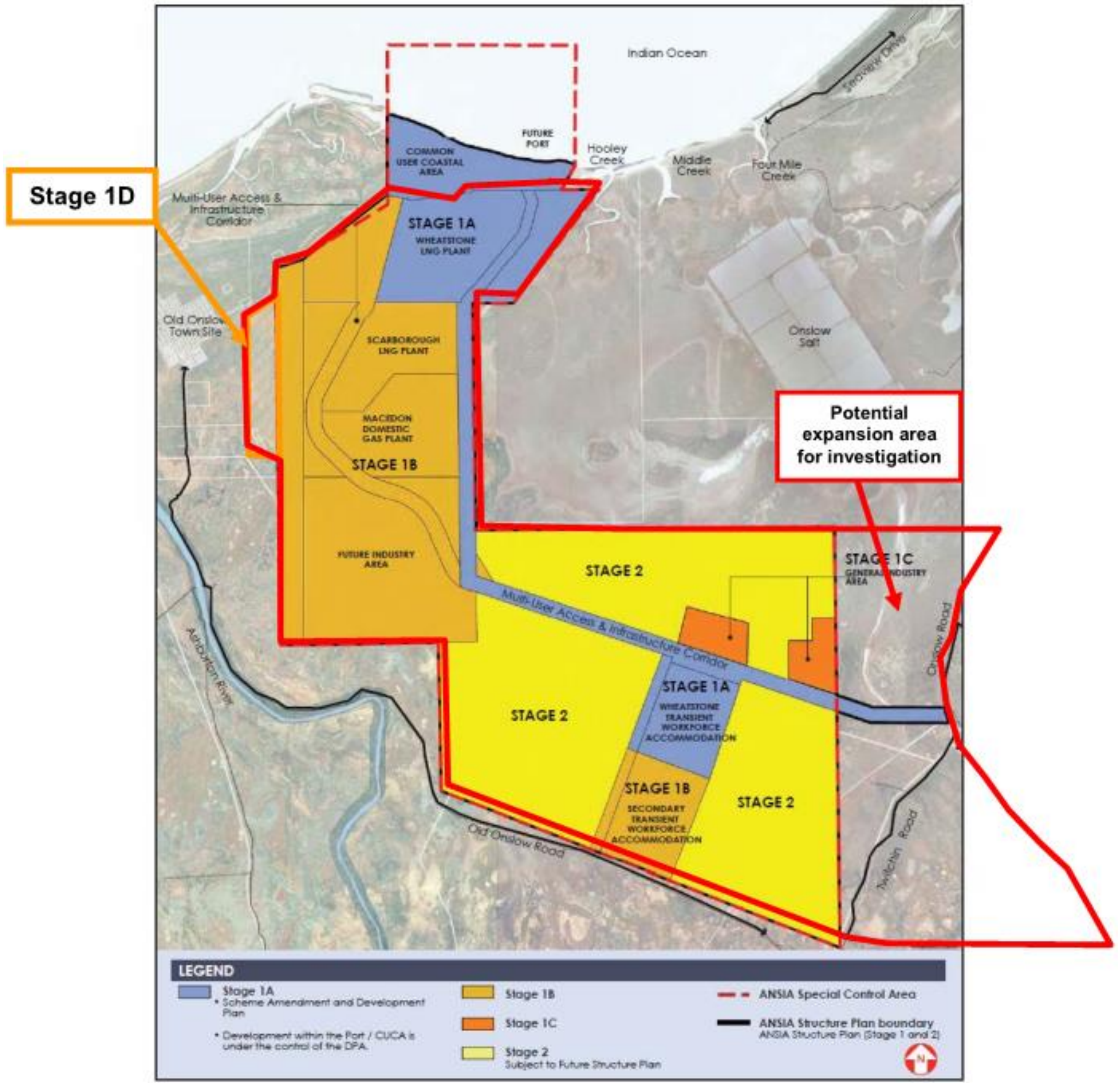

Figure 2 ANSIA Structure Plan showing indicative expansion areas (LandCorp, 2014)

[2]ExxonMobil is assessing development concepts for Scarborough and has commenced the environmental referral process for a Floating Liquefied Natural Gas (FLNG) development option for the gas field. FLNG is considered the best option for developing Scarborough at this stage although further engineering and design work must be undertaken before a final concept select decision is made (ExxonMobil website, 13th Jan 2015)

3 ANSIA Planning and Development Plans

The vision and implementation approach for the ANSIA has been defined through numerous planning documents and structure plans. These provide direction to the engineering schemes which continue to develop the site.

The structure and development plans are summarised below with indication of how each relates to the ANSIA stages:

- ANSIA Structure Plan - Stage 1
- Wheatstone Development Plan – Stage 1A
- ANSIA Stage 1B and 1C Development Plan – Stage 1B and 1C
- ANSIA GIA Eastern Portion Outline Development Plan – Stage 1C

The structure and development plans go through an iterative process of identifying issues and opportunities, evaluating options, and implementing solutions to overcome engineering challenges. This report seeks to capture such progress, enabling future plans and studies to achieve an advanced approach. Learning from the solutions devised within the previous and latest plans is anticipated to be beneficial for efficient problem solving on future projects.

3.1 Shire of Ashburton Local Planning Scheme 7

At the outset of the ANSIA, to facilitate the establishment of the ANSIA precinct, the Shire of Ashburton Local Planning Scheme 7 was amended to facilitate rezoning of the land from “Rural” to “Strategic Industrial”, “Industrial” and “Special Use” zones. The role of this planning scheme is to outline the land use permissibility and the requirements for establishing a planning framework for the ANSIA (URBIS, 2014a). Reference is made to the ANSIA Structure Plan for considering suitable and consistent land use planning.

A key objective for the engineering proposals is to optimise the effectiveness of zones as strategic industrial area by utilising major infrastructure, creating symbiosis with other industries or inclusion of resource processing industry. In doing this the development must minimise or offset impacts on local infrastructure, economic or community development (URBIS, 2014a).

Particular matters to be addressed by development plans stated within Local Planning Scheme 7, of relevance to this report, are given as follows:

(i) landform, topography, landscape, vegetation and soils of the area,

(ii) location, existing roads, land uses and surrounding land uses and features,

(iii) existing and proposed services and infrastructure including reticulated or other potable water supply, sewerage, energy, communications, drainage and catchment considerations,

(iv) existing places and features of heritage and/or cultural significance, including natural

landscapes, flora and fauna in addition to built structures and other modified environments,

(v) road layout and traffic assessment, communal and incidental parking areas, pedestrian/cycle

network/underpasses, including impacts on the surrounding movement networks,

(vi) public open space and recreation provision, environmental protection areas, and

relationships to natural features,

(vii) assessment of the impact of the proposal on the natural environment, including

management of potential effluent, emissions and other forms of pollution,

(vii) comprehensive drainage systems for stormwater runoff and natural drainage lines,

(viii) indicate the design of the proposal including lot layout, major buildings roads and

landscaping proposals,

3.1.1 Appendix 11 – Policy Statement

Appendix 11 of the Shire of Ashburton Local Planning Scheme 7 provides a policy statement outlining State and local government intentions and requirements for structure planning of the ANSIA. The following list provides a summary of the primary intentions for the development (URBIS, 2014a):

- Create a strategic industrial area catering for LNG and domestic gas processing as well as related downstream activities.
- Promote regional development.
- Monetise small sub-economical gas fields in the Carnarvon Basin, and promote more diverse sources of gas, including opportunities to commercialise relatively small gas fields in the basin.
- Provide land and new port facilities to service other potential gas processing development at Onslow and in the western Pilbara.
- Proponent driven development that does not imply a commitment from either State or local government to assemble land or provide the necessary transport and other infrastructure.

The Policy Statement required that a structure plan be prepared and endorsed. This plan would set the context for specific projects, and be adopted by local government prior to any rezoning. Requirements for the structure plan include: addressing State Planning Policies, defining common user infrastructure corridors, road infrastructure, environmental, social and cultural matters, development staging, and assessment of cumulative impacts of the whole ANSIA (URBIS, 2014a).

3.2 Ashburton North Strategic Industrial Area Structure Plan

The ANSIA Structure Plan, finalised in August 2011, focused on Stage 1 of the ANSIA, whilst identifying the principles, vision and objectives to support preparation of a subsequent plan for the Stage 2 area (Taylor Burrell Barnett, 2011). The planning undertaken for Stages 1A, 1B and 1C provided a basis to be utilised for Stage 2.

In planning terms, the purpose of the Structure Plan was to facilitate the development of the ANSIA and demonstrate compliance with Appendix 11 of LPS7 (URBIS, 2014b). Two levels of structure planning were anticipated; the ANSIA Structure Plan at higher level, with Development Plans prepared for specific sites, in accordance with LPS7.

At the time, staging of the ANSIA was broadly divided into the following categories:

Stage 1 – which encompasses both known LNG facilities (comprising Wheatstone, Macedon and Scarborough), TWA and indicative future industries associated with the hydrocarbon processing function and also General Industry Areas to support the key industries in the ANSIA and MUAIC; and

Stage 2 – an additional area to be set aside for strategic industrial expansion into the longer term. The potential use of this area is presently not defined, and is unlikely to become apparent in the short to medium term; therefore, it will be subject to further detailed consideration at some time in the future. (Taylor Burrell Barnett, 2011)

Within the Structure Plan the implementation measures for various engineering topics are outlined. These have been summarised in Table 1 to indicate how each proposal has developed through the various stages of the ANSIA. The topics are discussed further in the technical insights within Section 4 of this report.

Table 1 - ANSIA Structure Plan; summary of engineering discussion at the time (August 2011).

Topic	Issues and Opportunities	Implementation
Landform and Topography	Elevated topography provides opportunity for development.	Considering 4.8m AHD level of 100yr combined flood event (see below), land above 4m AHD expected to be prioritised for development.
Stormwater and Flooding	Ashburton River affecting both Southwest and Hooley Creek catchments, due to overtopping of catchment divides.	Maintain existing channels and model post development flows; volumes, velocities considered to have limited risk of increasing significantly.
	Very dynamic nature of the system; well suited to adapting to changes presented by development.	Changes to surface water regimes in individual project areas should not impact on adjoining project or common use areas.
	Large volumes of water involved in large events; management challenges.	Identify preferential surface water pathways; developments are to permit as much as possible the existing natural regimes for 1yr ARI and 100yr ARI.
		Access Road Design and Flood Modelling and Impact Assessment by URS found existing infrastructure specifically Onslow Road not impacted.
	Storm surge, rising sea levels, increased cyclonic events; potentially significant constraint. For simultaneous 100yr storm surge and 1:100yr ARI event, storm surge found to govern flood level, estimated at 4.8m AHD.	Modelling of tidal inundation and storm surge by URS incorporated sea level rise requirements. Further modelling by ANSIA proponents for future LWMS will be required. Engineering solutions are expected to enable safe and workable development.
		DoW requires habitable developments are created 0.5m above the 1:100 ARI event.
Geological and Geotechnical	Groundwater does not generally represent a constraint to development	Low lying areas of limited separation anticipated to be built up using engineered fill if developed.
Acid sulfate Soils	Large areas of potential acid sulfate soils (PASS).	Within medium or high risk of PASS, further assessment consistent with Department of Environment and Conservation guidelines is required.
Traffic Management	Existing regional roads unsuitable for ANSIA development.	Transport studies recognise development will include improvements to Onslow Road and various intersections; upgrades not yet detailed.
	Maintain community access to Hooley Creek and CUCA. Due to proximity, existing access will be unavailable.	Location of alternate access to Hooley Creek subject to consultation. ANSIA Structure Plan to be updated subject to community submissions.
Road Works and Alignments	The issue of road safety for Onslow Road, Old Onslow Road and Twitchin Road is a matter of priority for the Shire.	Upgrade requirements to be addressed at Development Plan phase. Dual approval with MRWA and the Shire will be required to ensure compliance.
	Peak construction traffic predicted during development of initial infrastructure to support the ANSIA.	Advanced road and associated drainage infrastructure works required.
	WAPC and MRWA identified key issues as culvert cover and specification, widening of Onslow Road, substandard vertical geometry and cross fall, and pavement life.	There will be a requirement to improve large sections of Onslow Road to North West Coastal Highway for industry expansion. This will include widening, some realignment , and pavement rehabilitation.
Water supply	Provision of services	Allocated primary routes within MUAICs.
	Sustainable water cycle management.	DWMS prepared for ANSIA Stage 1, in accordance with the Better Water Management Guidelines. All future development plans and subdivisions to comply with DWMS. DoW has agreed to a water framework, which will support a separate DWMS for Stage 2 ANSIA Structure Plan.
	Desirable to establish an integrated water supply scheme for the ANSIA. Should this not be achieved, each proponent will be responsible for their own systems for both potable and industry purposes.	Outcome shall be negotiated with the lead State Agency, DSD. Opportunity to be addressed by proponents in their respective Development Plans.
		Most likely source of water from desalination pipeline into the ocean or through bores. Discharge of brine would need to be investigated, requiring outfall to the sea or arrangement with Onslow Salt for disposal.
	Groundwater quality and availability limit potential use of this resource.	Each proponent to manage potential groundwater impacts using LWMS.
Wastewater	Provision of services	Allocated primary routes within MUAICs
	Management of waste water from proponent operations to the satisfaction of the approving authorities.	Not intended that an integrated disposal scheme be established at ANSIA inception. Proponents to address in their individual Development Plans.
Power	Limited known services include gas pipelines. Existing domestic gas (BHPB and BP LPG) pipeline traverses the FIA and unallocated land in an east-west direction.	Risk assessment for development adjacent existing pipelines relating to constraints. Pipeline protection plan may be required.
		Proponent to provide services to its development initially. State, proponents and service providers exploring integrated servicing opportunities.
	Provision of services	Allocated primary routes within MUAICs
	Integrated power supply for the ANSIA desired rather than each proponent having independent generation and distribution systems.	Outcome shall be negotiated with the lead State Agency DSD, Horizon Power and proponents, and addressed in the individual Development Plans
		Primary power supply likely to be gas turbine driven generators. Emergency power and start up most likely from diesel engine units.
		For gas supply, the proponents will be responsible to secure and supply their own operations.
Telecommunications	Various existing services available in Onslow townsite, including communication towers for television, emergency services and other functions.	Telstra 36 bit core fibre line proposed within 20m allocated common utilities corridor on south side of MUAIC. Land for comms infrastructure to be determined through Stage 1B, 1C and Stage 2 planning. Proponents will provide infrastructure on their own lease/land as required.
	Provision of services	Allocated primary routes within MUAICs

3.3 Wheatstone Development Plan

The Wheatstone Development Plan, commenced in November 2011 and finalised in July 2012 by TBB for Chevron, provided a greater level of detail over the project specific area of the ANSIA. In particular, the plan progressed elements such as shared facilities (MUAIC corridor and CUCA), Wheatstone LNG and Domestic Gas facilities and transient workforce accommodation (URBIS, 2014a).

Requirements for Development Plans relating to infrastructure have been identified as the following (URBIS, 2014a):

- Water management plan.
- Detailed earthworks designs.
- Necessary minimum finished floor levels.
- Detailed drainage designs.
- Details of pollution prevention measures.
- Details of water and wastewater servicing arrangements (both interim and long term arrangements).

Within the summary of engineering topics provided in Table 2, progression of the Structure Plan implementation is visible alongside refinement of other issues identified within the Development Plan. Where a gap is apparent, this is discussed within the following technical sections.

Table 2 - Wheatstone Development Plan; summary of engineering discussion at the time (July 2012).

Topic	Issues and Opportunities	Implementation
Landform and Topography	Land at higher elevation utilised.	Higher elevation land indicated on Issues and Opportunities Plan as more viable area.
Stormwater and Flooding	Break-out flows of Ashburton River; low laying areas inundated.	Extensive investigations undertaken to determine engineered solutions that minimise environmental impact.
	Appropriate serviceability and safety criteria for extreme flooding; combination of rainfall-runoff, inundation by seawater and river flooding.	Rational use of engineered fill to raise vulnerable areas above flooding levels. Flood frequency criteria set depending on vulnerability of area.
		Hydrological modelling for ANSIA Structure Plan covered all aspects of the Wheatstone Project; DWMS, Surface Water Studies, and access road flood modelling.
	Maintain natural surface water parthways.	Surface water preferential pathways identified; viable development space accounts for this.
		Internal Access Roads within the TWA will allow water to freely flow to maintain a natural drainage path.
Geological and Geotechnical	Acid Sulfate Soils risk. High potential within intertidal flats, tidal creeks and mangrove swamps.	Implementation of appropriate avoidance and management measures during construction and operational earthworks; risks can be reduced to low level.
	Providing suitable subgrade support and groundwater separation.	Areas of low lying clay pans and supratidal flats likely to involve replacement with structural fill.
	Earthworks material requirements, particularly for filling above flood levels.	Onshore quarry locations yet to be determined (at time of report), and transported by road.
Road Works and Alignments	Upgrades to existing road and drainage infrastructure to serve heavy construction traffic	Improvements scheduled by MRWA will be undertaken concurrent with the commencement of construction.
Traffic Management	Capacity and maintenance of existing road network	Local road network; traffic volumes found to be acceptable, management and maintenance plan prepared.
Water Quality Management	Surface water quality management for frequent events	1yr ARI event captured and treated by swales and basins. Earthworks measures to reduce offsite silt migration.
Servicing general	Provision of coordinated services	Investigations in conjunction with DSD. However, due to project time constraints and given that Chevron is not a service provider, no viable option could be established. Approval granted for a standalone system for Wheatstone plant and TWA.
Water supply	Water cycle management	Development Plan is in accordance with Structure Plan DWMS. LWMS appended to Development Plan.
	Sources of water.	Until month 9 of construction, water will be trucked to the TWA area and jobsite from Beadon Creek. Estimated consumption of 1200m3 per day. Pumps supplied by diesel fuel using mobile fuel truck.
		In the longer term, a desalination plant will pipe water to the TWA area and jobsite. This will include a seawater intake, also used for compaction seawater when required. Trucks will also distribute fresh water from the desal plant to other construction areas. The Beadon Creek system will then be decommissioned.
		A separate Reverse Osmosis treatment system is proposed to produce fresh water to meet various quality levels for process feedwater, potable water for plant facilities, and utility/fire water.
Wastewater	Sanitary sewage and domestic discharges.	Plant and TWA treated using package aerobic units. Effluent water recycled, or discharged offshore through outfall line. Sludge will be trucked for off-site disposal. Construction phase facilities installed in modular fashion. Operational phase, larger STP serving entire TWA within Utility Area of TWA. Resultant decommissioning of modular units. Pumping of sewage from further distances (e.g. Wheatstone construction offices) to STP.
	Recycling of treated effluent.	Sanitary effluent and seawater desalination brine initially will be reused for construction activities. Project wide and approved recycled water quality plan will require compliance prior to recycling or disposal.
	Surplus effluent disposal.	Later in the construction phase, this will be discharged to the ocean via an approved outfall system.
	LNG Plant wastewater management.	Treated through different parts of the plant, depending on source and level of contamination. Final effluent stream will be pumped to an ocean outfall as above.
Power	Construction phase power supply.	Standalone systems, consisting of diesel generators, fuel storage, transformers, substations and distribution, at both the accommodation village and plant site.
	Operations phase power supply.	Independent power generation and distribution system designed to operate in Category 5 cyclone conditions. This is located within the Wheatstone Utility area. The main gas turbine generators will be linked to diesel engine driven generators for 'black start' capability.
Telecommunications	Provision of project specific needs.	Negotiations being conducted with Telstra, with cables likely to be placed within the MUAIC.
		Chevron intention to install fibre optic loop connection between LNG Plant and FIFO Operations Village in Onslow. This will improve availability and reliability of services.

3.4 ANSIA Stage 1B and 1C Development Plan

Stage 1B of the ANSIA includes the second LNG site, Macedon Domestic Gas plant, portions of land associated with future industrial area and second Transient Workforce Accommodation (TWA) precinct. Stage 1C comprises the General Industry Area (URBIS, 2014a).

At this stage, from planning the ANSIA and Onslow town site growth, the State had become increasingly aware of the benefits associated with shared services. The May 2012 Stage 1B and 1C Development Plan recognised that when large-scale heavy industry proponents generate their own power and water, constructing infrastructure for their own needs, numerous economic, environmental and social benefits are lost (TPG, 2012). As a consequence, the ANSIA Stage 1B and 1C Development Plan resulted, finalised in May 2012. The main engineering issues, opportunities and implementations from this Development Plan are summarised in Table 3. These topics along with others are discussed further in Section 4 of this report.

Table 3 - ANSIA Stage 1B & 1C Development Plan; summary of engineering discussion at the time (May 2012).

Topic	Issues and Opportunities	Implementation
Landform and Topography	Visual impact.	Difficult to assess due to unknown nature of future stages. Recommended assessment at this stage on proponent basis at Development Application stage.
Stormwater and Flooding	Most appropriate areas for development.	Stage 2 is located downstream of the Ashburton River major flow break outs; some areas in Extreme Hazard category in an undeveloped state. Minimum ground levels 0.5m above 1 in 100 annual exceedance probability. "Islands of development" in those areas susceptible to flooding.
		Major natural waterways around the development site to be reserved to discharge without inundating development sites; 5 waterways identified for 100yr AEP.
Geological and Geotechnical	Most suitable areas for development considering foundation design.	Best areas are higher-lying Dune Zones where in most cases it is unlikely piling will be required. Sand and rock in these areas also likely to form good quality fill.
Acid Sulfate Soils	Identifying ASS risk in gap areas.	Testing for ASS by a broad approach would not be suitable as lithologies vary within the same geologic unit. Recommend focussed testing based on design plans e.g. subsurface utility corridors.
Traffic Management	Traffic management.	Concluded regional road volumes would increase yet remain within acceptable operation levels. Traffic impacts in Onslow town site due to employees living in the town to be addressed by Onslow Development Plan. Wider impacts; NWCH upgrade contributions, for widening and culvert to bridge works.
	Truck parking/laydown.	Permanent facility within GIA yet to be located. Informal area within ANSIA access road reserve preferred on outgoing side as near to Onslow Road as possible (at eastern GIA).
Road Works and Alignments	Western MUAIC alignment, considering land use, engineering, plant risk zones, cost and stakeholder criteria.	Preferred alignment (Option E) selected on basis of connecting whole western part of site along its length, with low severance impact, and moderate earthworks requirement.
	Road design criteria.	Conservative design speed of 120kph selected. Actual western MUAIC speed limit of 80kph recommended.
	Onslow road upgrades.	Considerable progress by MRWA prior to this Development Plan, between NWCH and ANSIA intersection.
	Access spacing and lane lengths through ANSIA.	Various distances indicated based on speed of 110 and 80kph; more detailed planning of movement systems at Development Application stage.
	Access road visibility for safety.	Further assessment of vertical profile sight distances at Development Application stage.
Water Quality Management	Mitigation of water quality risks.	Swales and basins to detain 1yr 1hour ARI rainfall runoff.
		Monitoring of every discharge point to the broad environment.
	Measures to prevent erosion.	Low longitudinal drainage grades, rock protection at bends, planning for natural creek riparian zones, landscaping, maintenance of vegetated drainage and protection at culverts.
Servicing General	Synergies and efficient use of resources.	Dependent on future proponents realising these and their type and location, and independent feasibility studies, which may or may not be in line with the Development Plan. The development plan opts for an indicative design proposal to implement this opportunity as far as possible. Main industrial ecology initiative realisable is shared use of utility infrastructure.
		Desalination and power generation collocated to gas-to-liquid cluster to optimise exchange of waste heat and off-gases.
		Landcorp and DSD investigating possibility of creating a shared services integrated network that can be extended to public use.
	Suitable access roads and services corridors for exchange between ANSIA proponents.	Ingress and egress to each lot for safety, service corridor width for pipelines, conveyors and other exchanges, seawater inlet and wastewater routes to the coast; full understanding of requirements. Need for each petroleum development site to have unimpeded access to service corridor and emergency access.
Water Supply	Water cycle management.	UWMP over Eastern GIA has been prepared and submitted to the Shire.
		Large amounts of seawater for cooling towers referenced; consideration of most efficient large pipeline system. Sharing of construction stages by proponents to achieve synergy.
Wastewater	Suitability of south-western corner allocation for Stage 1B area.	Shape and access suited better to WWTP than industrial proponent. WWTP position primarily based on natural low topography to aid gravity drainage. Expectation that this area will be able to house water recycling plant as ANSIA develops.
	Mitigation of environmental impacts.	Monitoring, sampling and analysis of WWTP discharge point.

3.5 ANSIA GIA Eastern Portion Outline Development Plan

The General Industrial Area (GIA) is proposed to provide a wide range of industrial activities which complement the major industries operating within the ANSIA. Throughout the construction and operation phases, examples of supporting activities suited to the GIA include: transport and logistics, pipeline integrity services, vehicle repair, construction and maintenance (URBIS, 2014b). This Outline Development Plan, compiled by URBIS in June 2014, applies to the eastern GIA only. No equivalent Development Plan of this level has been prepared for the western GIA.

As per Tables 1 to 3 for the earlier plans, Table 4 summarises the engineering topics, which are discussed further within the technical sections below.

Table 4 - ANSIA GIA Eastern Portion ODP; summary of engineering discussion at the time (June 2014).

Topic	Issues and Opportunities	Implementation
Landform and Topography	Site located primarily on Dune ridges. Small area over clay pan.	Portion of claypan may require soil amendment in later stages.
Stormwater and Flooding	Freshwater flooding, tidal inundation and storm surge, periodic and widespread.	Avoidance and mitigation undertaken at Structure Plan stage to select and design the GIA.
	Drainage treatment and attenuation.	Disposal of runoff via water quality control facilities. Stormwater not expected to be contained on site; velocity, erosion and sediment control managed. However, treatment train includes swales and weirs obstructing low flows. Photos do not show vegetation in swales; predominantly sand. Each proponent to install and maintain pollution control measures including interceptors and bunded storage.
	Drainage management during tenure.	LandCorp during leasehold tenure, transferred in agreed form to Shire of Ashburton on freehold subdivision.
Earthworks	Topography (undulation) resorting in significant earthworks and fill requirement.	Generally within four stages; batters terminate at the boundaries of the property.
Traffic Management	Continuation of traffic criteria.	Traffic levels consistent with ANSIA Traffic Impacts and Road Network Review report (Nov 2011)
Roads Works and Alignments	Access to MUAIC (Macedon Access Road)	MRWA supported maximum two access points. Secondary access for emergency purposes only.
	Design criteria.	Safe and efficient movement between internal lots including triple road trains. No footpaths/shared paths will be constructed. Roads will be constructed and sealed in accordance with Shire of Ashburton requirements to freehold subdivision standard.
Servicing General	Subdivision unable to be serviced by reticulated infrastructure in the short term as the power and water infrastructure in Onslow is at capacity.	Leasehold subdivision proposed in the initial stage of development. On-site infrastructure required in short-medium term, by each proponent, until reticulated services become available. Power and water infrastructure to be located approximately 3km east of the subdivision (Lot 524), expected completion 2016.
	Shared services.	Utilities cluster required for the ANSIA under Structure Plan, nor ANSIA Industrial Ecology Strategy, does not apply to the eastern GIA.
Water supply	Water cycle management.	Further UWMP to be prepared and approved prior to commencement of subdivision or development. To be consistent with ANSIA LWMP.
	Water supply provision.	Chevron required under SDA to construct 2ML/day desalination plant to service growth of Onslow town. Located in Lot 524.
Wastewater	Effluent disposal.	On-site infrastructure required in short-medium term, by each proponent, until reticulated services become available.
Power	Power supply provision.	Chevron required under SDA to construct 9MW power plant to service growth of Onslow town. Located in Lot 524.
Telecommunications	Provision of project specific needs.	Likely to be able to be provided to the development in the initial stages.

4 Engineering Design Information and Gap Analysis

A large number of engineering studies and reports have supported the plan documents throughout the various ANSIA Stages. An index of these studies and reports is provided in Appendix A. The reports provide the technical understanding and recommendations which have shaped the site development. By learning from preceding analysis, this section seeks to establish a platform for future projects based on the key observations, lessons learnt, and proposed solutions. As the development plans contain identified issues and approaches to implementation, reference is made to the plan documents as well as the technical studies that reside under these plan documents.

Also of relevance to the Improvement Plan is the varied intelligence and data which has been produced by the studies. Much of this provides a useful dataset for future analysis. To enable the most suitable information to be determined, this report seeks to understand how studies have built on previous work particularly where conclusions have evolved. This report interprets and summarises the direction for development recommended by the technical studies and development plans.

Further to the understanding of the reports and recommendations, this section of the report endeavours to identify gaps which may occur in the previous reports and associated analysis. At the end of each technical section, suggestions for possible steps or methods are provided to remedy the gaps such that coverage of the various disciplines is suitably detailed and appropriate for the future developments in this area.

4.1 Landform and Topography

4.1.1 Relevant Studies

Landform and topography are linked to numerous engineering disciplines, particularly geotechnical, earthworks, road alignments and flood modelling. Consequently, an understanding of the landform and topography can constrain or provide opportunities in studies across other engineering fields.

The key topographic data source for many of the engineering studies is a Light Detection and Radar (LIDAR) survey completed by FUGRO Lidar (URS, 2010a). The precise date of this data acquisition is unknown but it is believed to have been acquired between 2008 and 2010.

The first specific study on the landforms of the ANSIA was conducted by URS in 2010 as a technical appendix to the Wheatstone Environmental Impact Statement (URS, 2010c). The following list indicates studies from various engineering fields which provide relevant landform and topographic data relating to this section:

- URS, May 2010, “Baseline Soil Quality and Landforms Assessment”.
- URS, Sep 2010, “ANSIA Surface Water Studies” Draft Report.
- URS, Dec 2010, “Wheatstone Project Access Road Design Flood Modelling and Impact Assessment”.
- Cossill & Webley, Aug 2013, “Ashburton North GIA (East) Outline Development Plan Engineering Report”.
- Arup, May 2014, “ANSIA Fill and Basic Raw Materials Study Fill Sourcing Study Assessment Report”.

4.1.2 Key Findings

The ANSIA is located in a generally flat lying near-coastal environment with tidal flats and supratidal flats. Lower areas (~2 m AHD) become inundated during storm events. Areas within the western portion of the ANSIA contain a longitudinal network of isolated ridges trending northeast (within and adjacent to the Macedon area) associated with residual sand plains. Within the eastern areas of the site, specifically the Transient Workers Accommodation area and the eastern most General Industry Area, features associated with longitudinal dunes rise to 20mAHD.

The ANSIA Structure Plan classified areas with a topographic elevation of +7m AHD as being the most viable development areas, whilst areas of elevation +4-6m AHD are described as viable. This is due to the expense of earthworks to raise ground levels to above the 1 in 100 year flood level. Earthworks are further described in Section 4.5.

Various references are made to the initial Baseline Soil Quality and Landform Assessment report (URS, 2010c). The main ANSIA landforms are summarised as per the following:

- Tidal creeks, Intertidal Flats and Mangrove Swamp
- Supratidal Salt Flats,
- Samphire Flats,
- Claypans and Clay Plains,
- Alluvial/Colluvial Plains,
- Fringing and Coastal Dunes,
- Longitudinal Dunes and Interdunal swales, and
- Mainland Remnant Dunes.

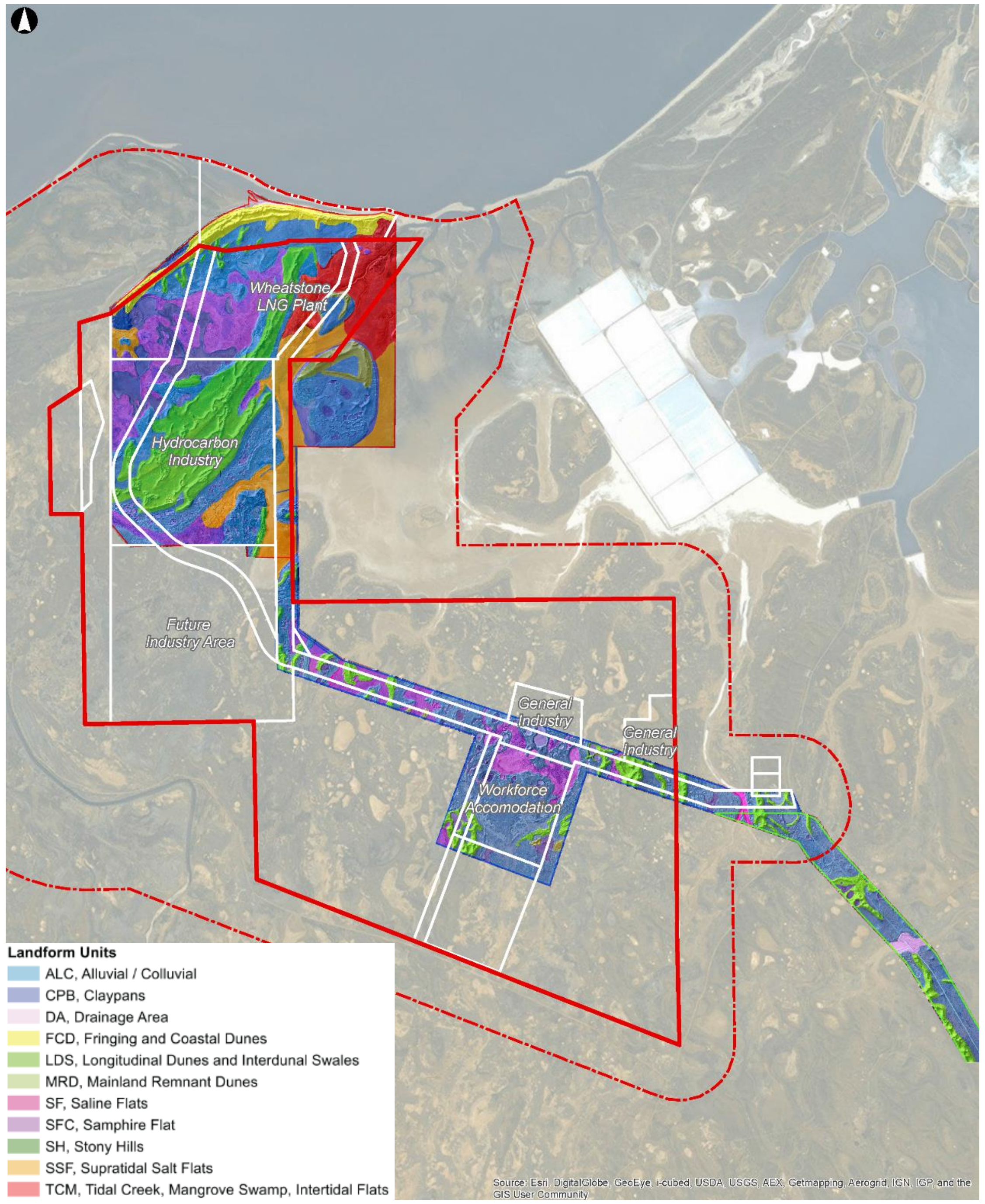

Figure 3 – Landform Units (URS, 2010c) in relation to future stages of the ANSIA.

The eastern portion of the GIA is primarily located on Dune ridges, which is advantageous from a geotechnical and hydrological perspective. However the site is also partially positioned over an existing clay pan. Clay pans are naturally occurring areas of impermeable ground, within which rainwater periodically collects and evaporates. For the GIA, it was found that the portion of development over the clay pan could be anticipated to require soil amendment as the development proceeded (URBIS, 2014b). There is a likely and manageable geotechnical/earthworks cost associated with development on clay pans and this provides an engineering consideration for future stages of the ANSIA.

As mentioned in the preceding section, the key topographic data source for many of the ANSIA engineering studies the FUGRO Lidar survey (URS, 2010a). This survey measured elevation data for the site, originally provided to a 1m spatial grid with a vertical tolerance of 0.3m. As can be seen from the extent of the data in Figure 4, the survey covers the entire Improvement Scheme boundary. It should be noted, for selection of appropriate resolution Lidar data for future studies, that the grid resolution was reduced to 40m for the original surface water modelling studies.

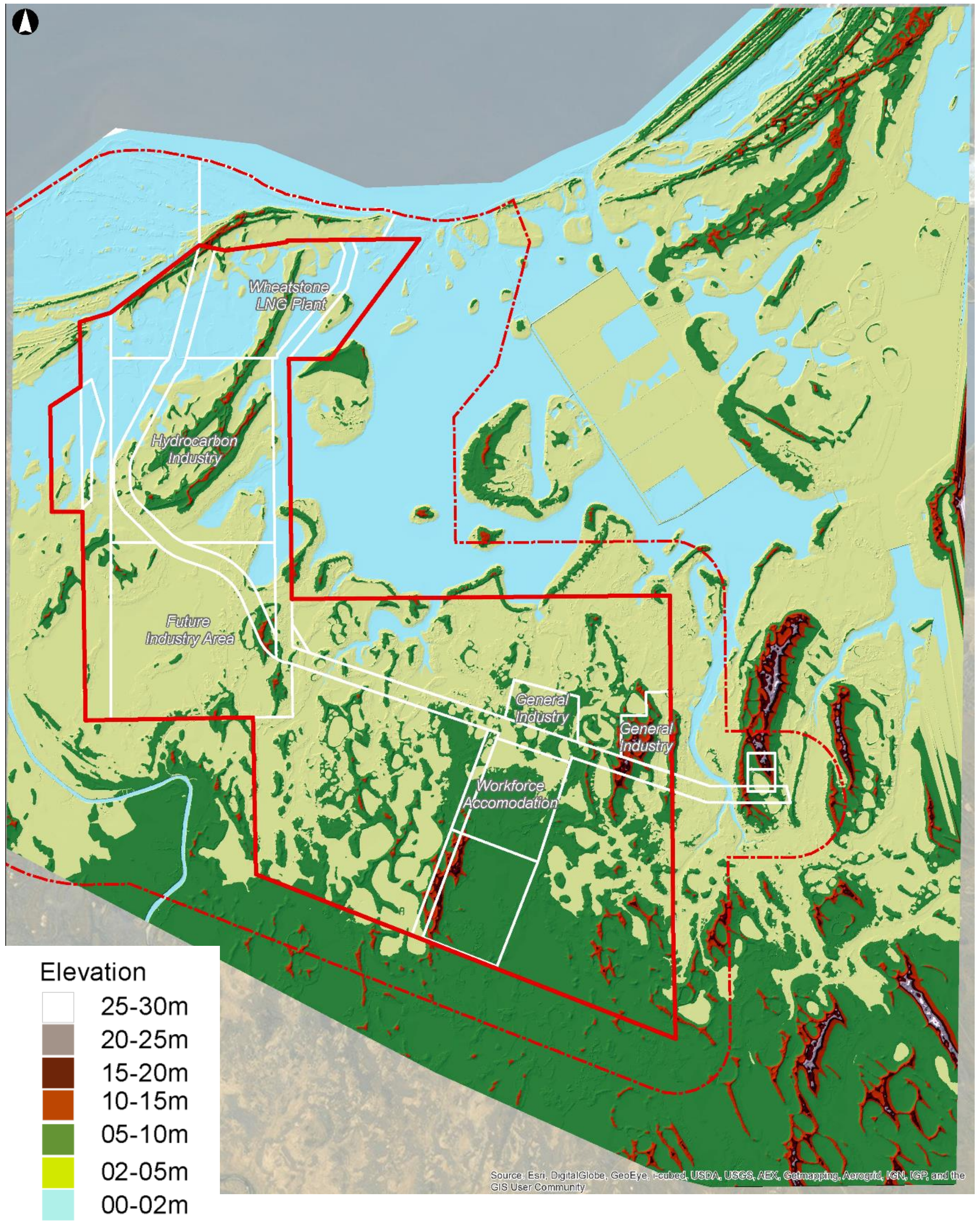

Figure 4 – GIS output showing Lidar elevations indicating low lying and natural high ground in relation to future areas of development at the ANSIA.

4.1.3 Gaps and Recommendations

The high quality LIDAR survey dataset provides a complete coverage of topography within the proposed Improvement Scheme boundary, depicted by the red boundary on Figure 4 and on subsequent figures in this report. Assuming that the data is shared with proponents, it is highly unlikely that additional topographic LIDAR datasets will need to be acquired.

The exact date that the LIDAR survey was flown is unknown, but is believed to have been acquired between 2008 and 2010. Based on this assumption, minimal changes to the landscape will have occurred since this period, and further LIDAR surveys are not considered as a “value for money” proposition at the moment.

This should however be re-evaluated in the future should the site topography change to such an extent that stormwater modelling could be affected. Potential topographic changes could result from either one or a combination of the following:

- A significant environmental event or events (e.g., storm/cyclone),
- Site development - sourcing (excavation) of significant quantities of borrow material, and
- Site development - raising ground levels and disrupting existing drainage.

As can be seen by the extent of the data collated in Figure 3, significant areas within Stage 1B, 1C, 1D and 2 and the eastern expansion area do not have an associated landform interpretation mapped. A small amount of further data, north of the TWA and partially covering the west GIA, is shown on Figure 4 of the ANSIA Structure Plan Environmental Assessment report (AECOM, 2010). For future expansion areas, particularly in the east, it would be useful to extend the limits of the mapped landform units to provide a better appreciation of landform types and any associated development risks.

4.2 Stormwater and Flooding

4.2.1 Relevant Studies

Prior to investigation being undertaken for the ANSIA, two significant storm surge studies are identified as providing background information for the Onslow District (Taylor Burrell Barnett, 2011):

- Halpern Glick and Maunsell, 2000, "Onslow Storm Surge Study", which sought to more accurately define the flood risk in Onslow; and
- MP Rogers & Associates, 2002, "Onslow Foreshore Investigations", which investigated coastal processes, flooding regimes and options for coastal protection.

The diagram below indicates the relationship between the ANSIA technical studies. The upper tier URS studies were undertaken at a similar stage for a wide area covering the entire site. The DWMS makes direct reference to the URS modelling for estimation of flood characteristics. In general, the lower tier studies use the model produced by URS; simulations were run with the scenarios and digital ground model updated to include design roads and development pads relevant to the topic being investigated. For the GIA Flood Study, a more detailed 2D (grid-based) hydraulic model was used covering the particular area of interest, with inflows derived from the URS model. The Eastern GIA UWMP uses the findings of the Flood Study and supplements this with modelling of the proposed drainage system.

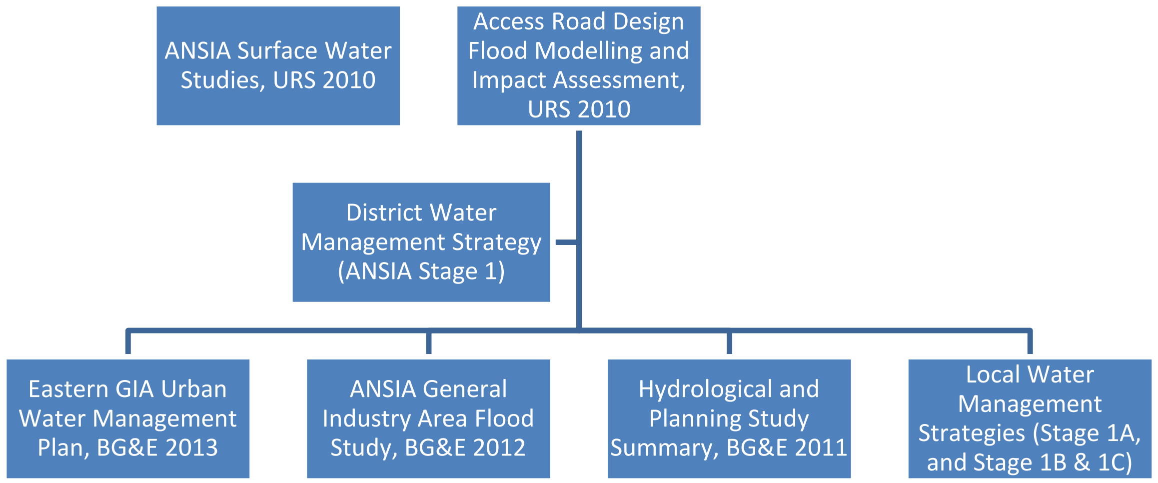

Figure 5 - Relationship between technical flood modelling studies and relevant reports

4.2.2 Key Findings

The Ashburton River Delta surface water hydrology is characterised by three main components (URS, 2010a). Extreme events resulting from tropical cyclones typically cause a near-shore storm surge which raises the sea level. High intensity, widespread rainfall following this causes runoff from the local catchments. Flows in the Ashburton River generated by the upper catchment result in breakout flows, which may influence a wide area due to the low separation between sub-catchment topography. The combined impact of these mechanisms forms the design flooding event to be mitigated by the engineering solutions.

The hydrological system has a dynamic nature, making it adaptable to changes presented by the development (Taylor Burrell Barnett, 2011). However, the large volumes of water involved in flooding events present stormwater management challenges. In response, the implementation approach within the Structure Plan proposed the following measures:

- Identify preferential surface water pathways, maintain existing major natural waterways; anticipated limited risk of post development flows and velocities increasing significantly.
- Permit as much as possible natural regimes for 1 year and 100 year ARI event. Impacts on surface water regimes in adjoining project or common use areas to be avoided.

The Wheatstone Development Plan achieved this through rational use of engineered fill to raise vulnerable areas above flooding levels (Taylor Burrell Barnett, 2012). The efficient approach involved focussing on the most viable development space at existing higher elevation. An impacts study during the early stages included modelling of two scenarios for raised development pads (URS, 2010a). To avoid large increases in flooding depth and velocity around the raised area, it was found that development islands between existing preferential channels were more appropriate than wide, obstructive blocks of raised ground. An example of how this approach has been successfully applied to development planning for the ANSIA is given in Figure 6.

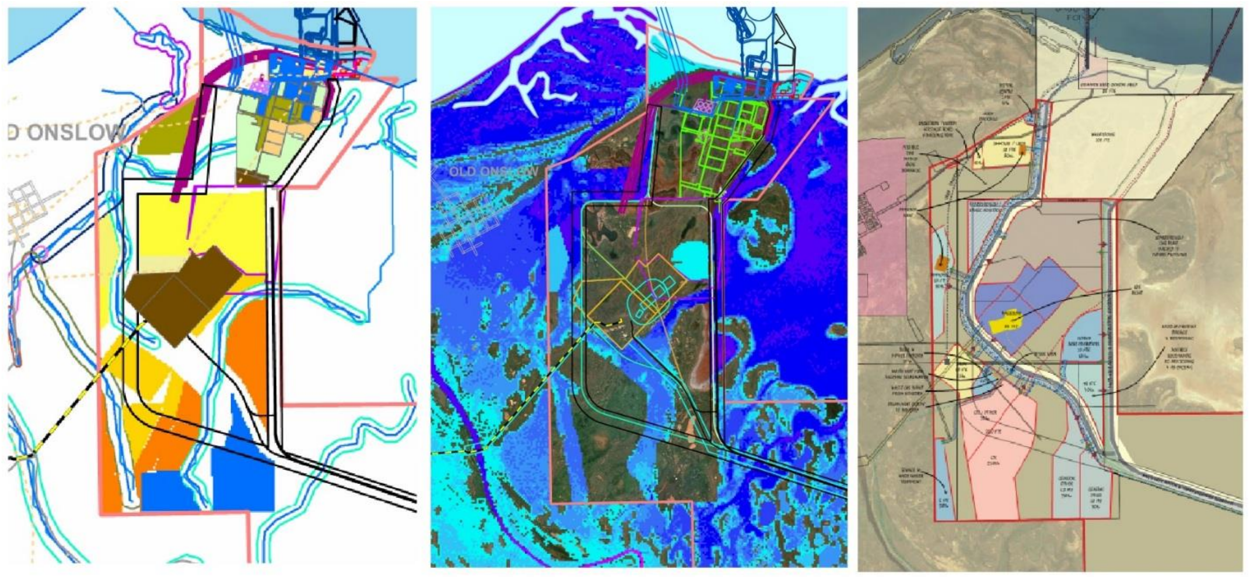

Figure 6 Series of report images showing how natural channels identified within the hydrological study (left and middle) (BG&E, 2011c) shaped part of the Stage 1B & 1C Development Plan (right) (TPG, 2012)

The levels of the development pads are determined from the adjacent modelled water levels and freeboard criteria above the design return period flood event. These criteria, according to the Basis of Design for Hydrological Planning supporting the LWMS produced for Stage 1B & 1C, are given in Table 5 below.

Table 5 - Basis of Design; flood level return period and freeboard (BG&E, 2011b)

Item	Minimum Design Level	Freeboard
Future Industrial Areas	100 Year	500
Support/General Industry Areas	100 Year	500
Accommodation/Camps	100 Year	500
Temporary Facilities (< 2 years)	20 Year	300
Storage Areas Hazardous Non-hazardous Vehicle/Car Parks	100 Year 20 Year	500 300
LNG precincts	100 year	500
Onslow Salt expansion	50 year	300

It is estimated that due to future changes in rainfall patterns the project area may experience longer dry spells dispersed by more intense rainfall events (URS, 2010a). An escalating number of severe category cyclone systems is also predicted. In combination with a predicted increase in the West Australian coast sea level up to 0.9m by 2100, the overall impact of future climate on the project is a significant consideration. The approach adopted for the most recent modelling study uses the following parameters for separate simulations, to assess the combined effects of the assumed future scenarios (BG&E, 2012a):

- 1 in 100 year riverine flood, including sea level rise expected in 50 years, and storm surge for 1 in 10 year event;
- 1 in 100 year storm surge model, including sea level rise expected in 50 years.

The original URS study covering the wider ANSIA area provides maximum flooding depth results for the 100 year ARI, pre-development, combined storm surge and riverine scenario. This is shown in Figure 7. It is apparent that flooding extents are influenced heavily by the topography, without being contained within the natural waterways for an event of this magnitude. The lighter colouring, corresponding to a reduced depth of flooding, gives a preliminary indication of areas likely to be more viable for development with minimal impact on the existing surface water regime. Being mindful of the pre-development characteristics is useful for understanding which areas permit natural surface water storage on the floodplain. Simulation of design scenarios including raised development pads may then be used to mitigate potential impacts such as displacement of flood water or impedance of natural preferential pathways.

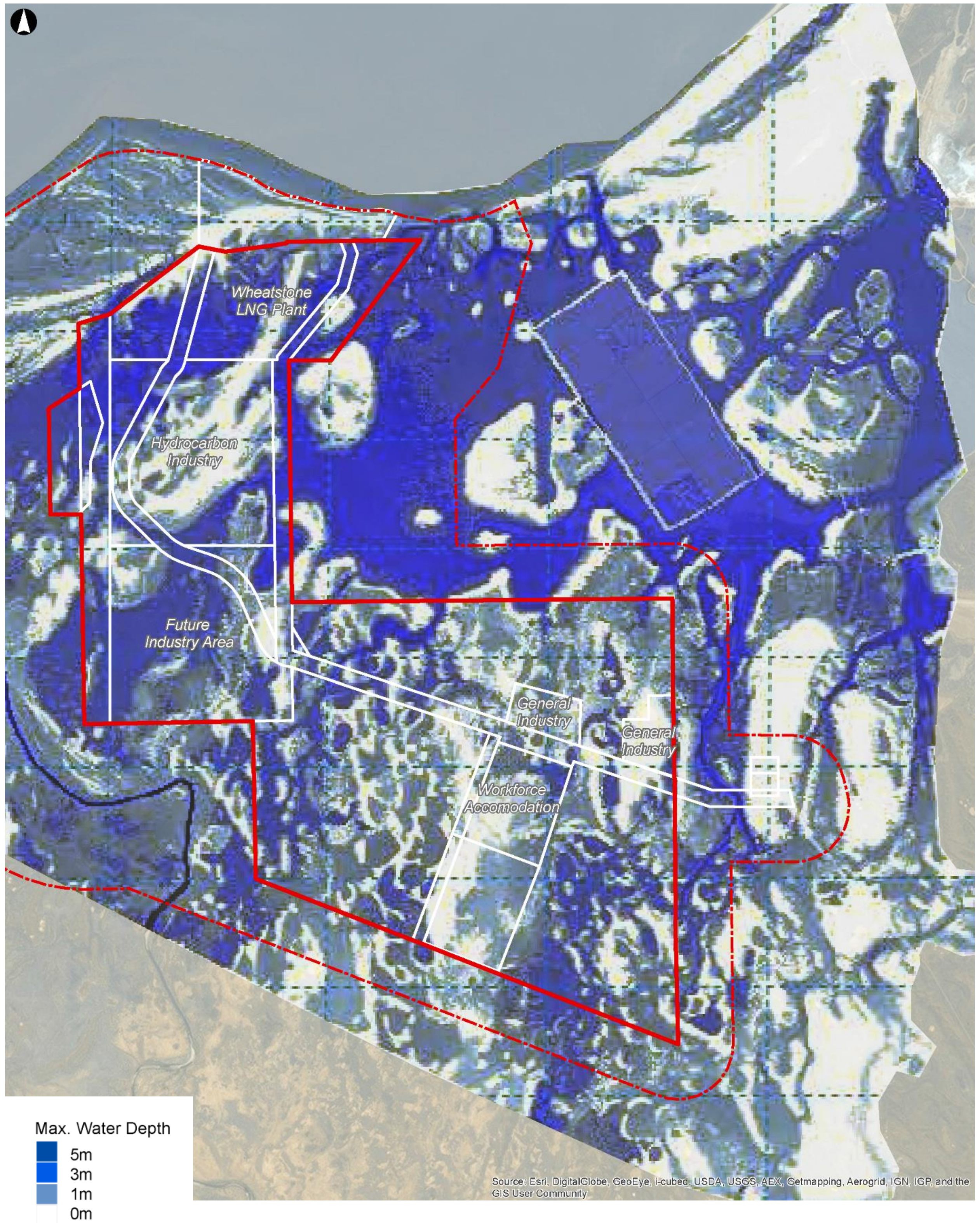

Figure 7 – GIS output showing Surface Water Studies pre-development scenario max. water depths (100year ARI) relative to future stages of the ANSIA (URS, 2010a)

4.2.3 Gaps and Recommendations

The URS modelling methodology and initial results, which form the basis for several more recent modelling activities, were endorsed by MRWA for the purpose of establishing Ashburton River breakout flows and for use in the design of the major access road drainage infrastructure (URS, 2010b). Within these endorsements, and accepting the limitations of the original method, continued use of the model is considered appropriate for Stage 1D and Stage 2. In a similar manner to the eastern GIA Flood Study (BG&E, 2012a), the URS model may provide inflow boundary conditions to more detailed hydraulic modelling over specific areas of development. In this case, the more detailed analysis used a finer grid resolution, and refined modelling of adjacent waterways, suitable to the size of the area under investigation. It is recommended that this approach be replicated for future areas of development. This will enable the stormwater management measures identified in Section 4.2.2 to be implemented.

The consideration of natural, existing surface water pathways will be particularly important for areas of Stage 2 in proximity to breakout flows from the Ashburton River. To satisfy DoW requirements, main water flow channels from the Ashburton River to Hooley Creek will need to be included within detailed hydrological modelling supporting Development Plans/Planning Applications (URBIS, 2014a).

The south east of the Stage 2 area and potential expansion area further east extend beyond the Hooley Creek sub-catchment defined within the original surface water modelling, as shown in Figure 8 (URS, 2010a). However the wider Ashburton River Sub-catchments cover the entire site including expansion areas. Since the catchment characteristics are fundamental to inflow hydrographs, it is recommended that the validity of modelling results which are outside the Hooley Creek sub-catchment is reviewed with a hydrological consultant with knowledge of the modelling methodology.

The impacts of future climate relative to the lifetime of the development including decommissioning should be assessed within any future studies. It has been identified that a LWMS accompanying future Development Plans will need to include storm surge modelling incorporating the revised sea level rise requirements of State Planning Policy 2.6 (URBIS, 2014a). The consultant undertaking this modelling should also evaluate the suitability of allowing for increase in rainfall intensity, in-line with current predictions and best practice.

The criteria for setting raised pad levels based on flooding return periods, as outlined in the Basis of Design for Hydrological Planning Study attached to the Stage 1B & 1C LWMS (BG&E, 2012b), is closely linked to earthworks requirements. These criteria for setting design levels should be reviewed for future stages, considering the vulnerability and resilience of different types of development and infrastructure. The objectives for this review would be appropriate and cost effective earthworks and structure planning, assessing the potential to position any infrastructure identified as less vulnerable or resilient in lower areas thereby maximising the availability of viable land at higher elevation.

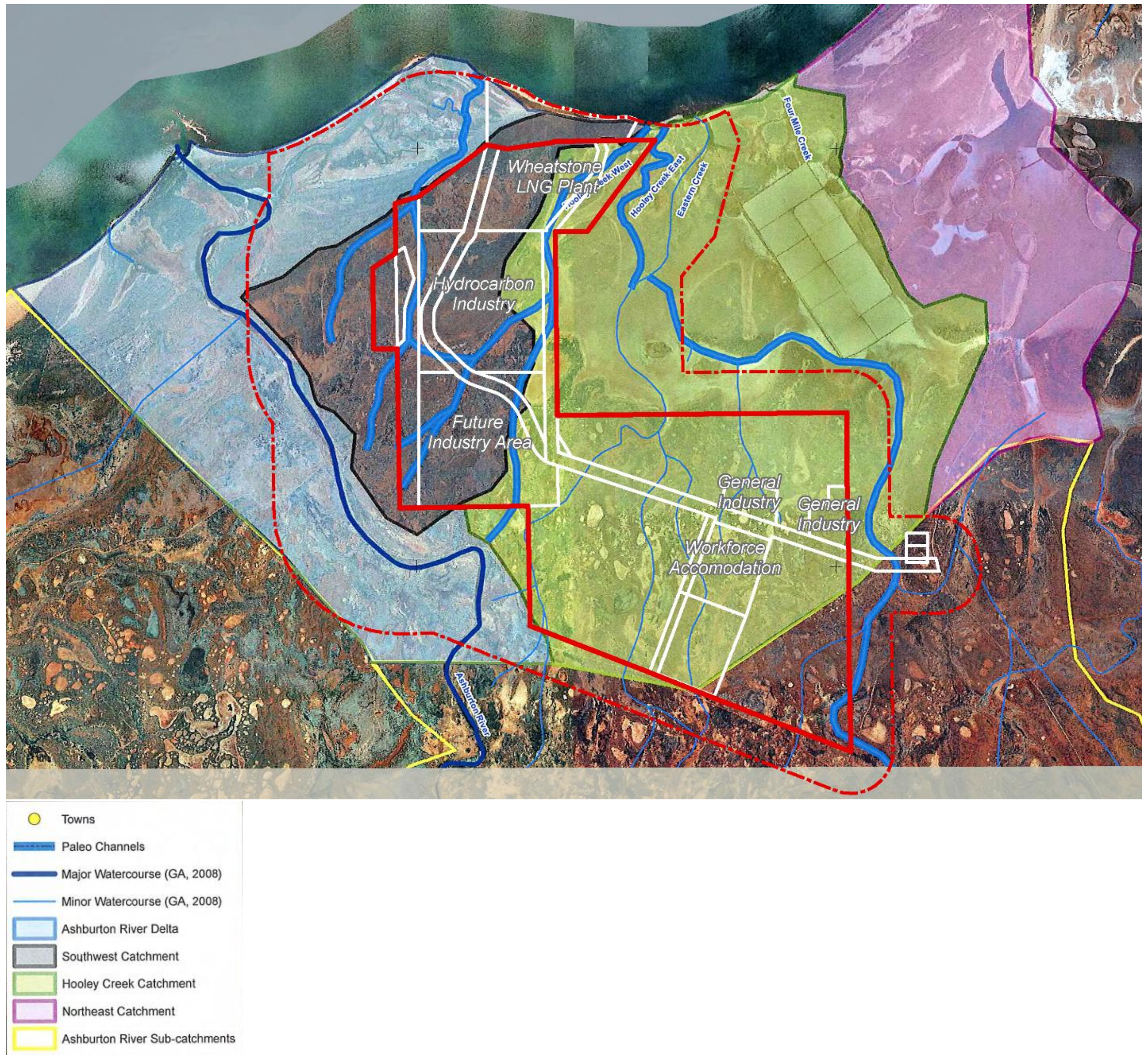

Figure 8 – GIS output showing surface water modelling sub-catchments in relation to future stages of the ANSIA (URS, 2010a)

4.3 Geological and Geotechnical

4.3.1 Relevant Studies

Prior to the establishment of the ANSIA, the main source of information for understanding the geology of the ANSIA site and potential geotechnical conditions was via geological mapping published by the Geological Survey of Western Australia. The 1:250,000 scale Onslow Sheet SF 50-5 and part of Sheet SF 49-8, (First Edition, 1981) cover the ANSIA site.

A number of site specific geotechnical investigations and studies have been undertaken within the ANSIA. These studies have largely focused on assessment of the ground conditions for proposed infrastructure. Table 6 below summarises the main geotechnical focussed studies. Within some of these reports, comments on piezometer installations and groundwater are noted.

Table 6 - Previous geotechnical studies undertaken relating to the ANSIA

Report	Area(s) of Investigation
Coffey (2010) - Final Interpretative Report – Onshore Geotechnical Investigation Ashbu rton North Site, Rev B, 23 Apr 2010.	Predominantly Wheatstone area (Stage 1A areas)
URS, Wheatstone Project - Final Environmental Impact Statement/Response to Submissions on the Environmental Review Management Programme – Appendix H Baseline Soil Quality and Landforms Assessment prepared for Chevron Australian Pty Ltd.	Wheatstone area (Stag e 1A areas)
Golder Associates (2011) Wheatstone Phase 3 Downstream Geotechnical Investigation, Final Onshore Factual Report, Ref No. 097642446-016-R-Rev2, 11 Feb 2011.	Wheatstone area and Transient Workers Accommodation 1 area (Stage 1A areas)
Golder Associates (2011), Wheatstone - Phase 3 – Downstream Geotechnical Investigation Final Evaluation Report – Onshore, 18 Feb2011.	Wheatstone area (Stage 1A areas)
Golder Associates (2011) Factual Report - Potential Acid Sulfate Soil Investigation - Wheatstone Phase 3, 25 Feb 2011.	Wheatstone area (Stage 1A areas)
Golder Associates (2011) Geotechnical Investigation, Quick Mud Creek Crossing, Plant Site Access Road, Macedon Gas Development Project, Geotechnical Services Package Onshore Works, Ref No. 117642115-007-R-Rev0 Sept 2011.	Specific location along the access road to the Macedon Gas Development (Stage 1B areas)
Galt Geotechnics (2011) Geotechnical Desk Study for ANSIA, Nov 2011.	Stage 1B areas
ENV Australia Pty Ltd (2012) Ashburton North Strategic Industrial Area – Preliminary Acid Sulfate soil report, Rep N0. 11/072, 18 Jan 2012.	Stage 1B areas
Galt Geotechnics (2013) Geotechnical Study Eastern General Industrial Area Ashburton North, Onslow, Reference J1301101 003 R Rev1, 13 Dec 2013	Eastern GIA (Stage 1C area)

4.3.2 Key Findings

4.3.2.1 Geology

As illustrated in Figure 9, the 1:250,000 Geology Sheet for Onslow depicts the ANSIA surface geology transitioning from coastal dunes (Qs), intertidal flats and mangrove swamps (Qw), and supra tidal flats in the northwest to Claypan dominant terrain (Czp) in the southeast. Alluvium (Cza) is present within nearby dominant drainage networks, specifically the Ashburton River to the south of the ANSIA. Soft and loose soils dominate the near-surface geologic profile across the ANSIA and rock material, albeit weak rock, is not expected to be widely encountered during site preparation of areas for future development.

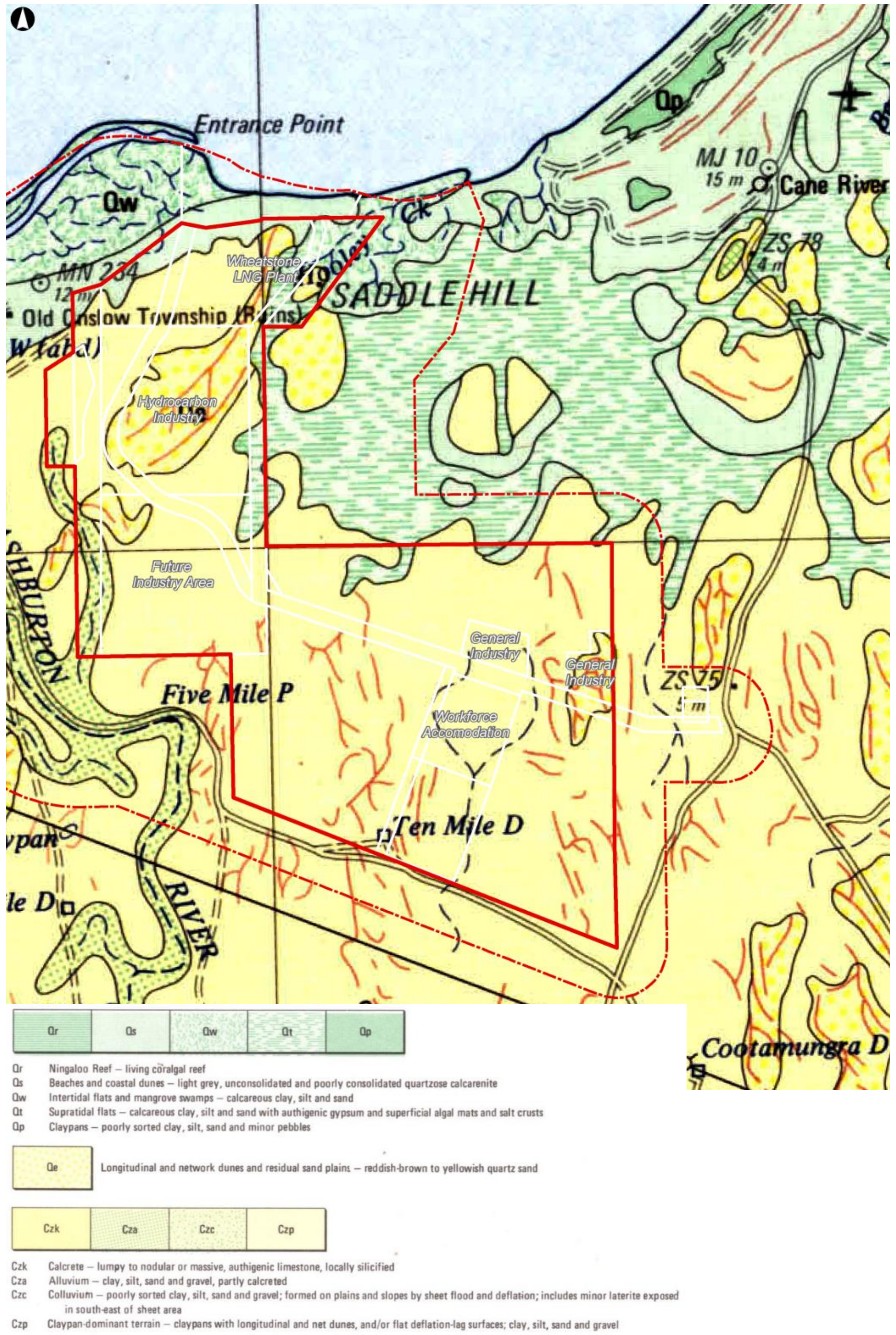

Figure 9 – GIS output showing geology of the region (Geological Survey of Western Australia, 1981) in relation to future stages of the ANSIA

4.3.2.2 Shallow Groundwater

Significant parts of the ANSIA are located within the intertidal zone and are accompanied by a complex coastal alluvial aquifer system. Shallow saline and hypersaline groundwater occurs as a result of tidal inundation, unconfined groundwater discharge and evaporation effects.

According to the DWMS (ENV, 2010) groundwater levels vary directly with topography with higher groundwater levels occurring beneath dunes and lower groundwater levels across the tidal flat. Groundwater levels are generally close to the ground surface in these low lying areas. ENV (DWMS, 2010) summarises a 2010 Wheatstone Groundwater Study by URS, which indicates groundwater levels ranging from +2m AHD in the south of the ANSIA to +0.25m AHD near the coast. The study also concluded that groundwater levels within the ANSIA are not influenced by tidal variation.

A design groundwater level of +1m AHD was also recommended for adoption by Golder (2011) at the Quick Mud Creek Crossing based on piezometer recordings.

Localised areas of shallow groundwater may perch on cemented strata during and after long or intense periods of rainfall.

4.3.2.3 Geotechnical

The various geotechnical investigations conducted across the ANSIA confirm the above described geological conditions. The geotechnical units listed below were first prescribed by Coffey (2010), then refined by Golder (2011b), and the resultant geotechnical/geological model has been utilised by others such as Galt (2011):

- Unit 1 – Aeolian sand and Calcareous Rocks (surface to ~4m below AHD)
- Unit 2 – Marine and Alluvial Deposits (surface to ~1m below AHD)
- Unit 3a – Ashburton Red Beds – soil (~4m to ~10m below AHD)
- Unit 3b – Ashburton Red Beds – weak rock (~10m to ~25m below AHD)
- Unit 4 – Carbonate Rocks (~25m to ~70m below AHD)
- Unit 5 – Glauconite Rocks (>~70m below AHD)

4.3.3 Gaps and Recommendations

Previous geotechnical investigations have focussed on the assessment of ground conditions for specific infrastructure, especially covering Stage 1A, 1B and 1C areas only, hence large areas of future potential development remain without site specific geotechnical data.

Whilst geotechnical investigations (including groundwater related installations) are not currently required, once engineering design plans for specific locations are produced, then site specific geotechnical investigations will be required. These investigations can be addressed based on a similar timing and magnitude as has been conducted at the Eastern GIA area.

Attention should be paid to the geology in the specific areas of proposed development and appropriate investigations should be tailored to suit the expected ground conditions and the proposed development. These investigations may also include an assessment of suitable borrow materials, which may potentially be sourced from areas outside of the ANSIA boundaries.

4.4 Acid Sulfate Soils

4.4.1 Relevant Studies

Prior to the establishment of the ANSIA, the main source of information for understanding the risk associated with Acid Sulfate Soils at ANSIA was through the WA Atlas ASS Risk Map published by the Department of Conservation (DEC), now covered by the Australian Soil Resource Information System (ASRIS).

Several previous Acid Sulfate Soil (ASS) investigations have been conducted at ANSIA either as stand-alone ASS factual or interpretive reports or comments/sections incorporated within multi-discipline and/or geotechnical reports. These studies have largely focused on assessment of the ground conditions for proposed infrastructure and borrow pit areas. The following list provides a summary of the main ASS related documentation for the ANSIA:

- Coffey, 23 April 2010, "Final Interpretative Report – Onshore Geotechnical Investigation Ashburton North Site" Rev B,
- URS, Feb 2011, "Wheatstone Project - Final Environmental Impact Statement/Response to Submissions on the Environmental Review Management Programme – Appendix H Baseline Soil Quality and Landforms Assessment prepared for Chevron Australian Pty Ltd".
- Golder Associates, 18 Feb 2011, "Wheatstone - Phase 3 – Downstream Geotechnical Investigation Final Evaluation Report – Onshore",
- Golder Associates, 25 Feb 2011, "Factual Report - Potential Acid Sulfate Soil Investigation - Wheatstone Phase 3".
- ENV Australia Pty Ltd, 18 Jan 2012, "ANSIA Preliminary Acid Sulphate Soil Report", Report No. 11/072.
- Galt Geotechnics, 5 Aug 2013, "Geotechnical Study, Eastern GIA, ANSIA", Report J1301101 001-R, Rev 0.

The first 4 reports all focus predominantly on Stage 1A and partially on Stage 1B and are directly associated with the Wheatstone LNG Development. The ENV authored report provides a preliminary assessment of ASS for ANSIA Stage 1B. It draws upon all the previous investigation reports and provides a summary of earlier reports. The final report in the list (authored by Galt under ANSIA Stage 1C) provides site specific ASS commentary relating to the eastern GIA only.

4.4.2 Key Findings

Risk mapping by the Department of Environment and Conservation (DEC) gives the ANSIA area a low to high risk of ASS being present with the higher risk areas located close to the coast in the low lying areas between 0 and 3 m AHD. This is apparent from Figure 10.

The ENV report (from 2012) identified that ASS is variably present across all geologic units at the ANSIA and identifies ASS risk categories based on the WA Atlas ASS risk map (from the DEC) to be closely associated with the following geological landforms identified across the site:

- High to moderate risk – supratidal flats;
- Moderate to low risk – low lying clay pans; and,
- No known risk - coastal dunes.

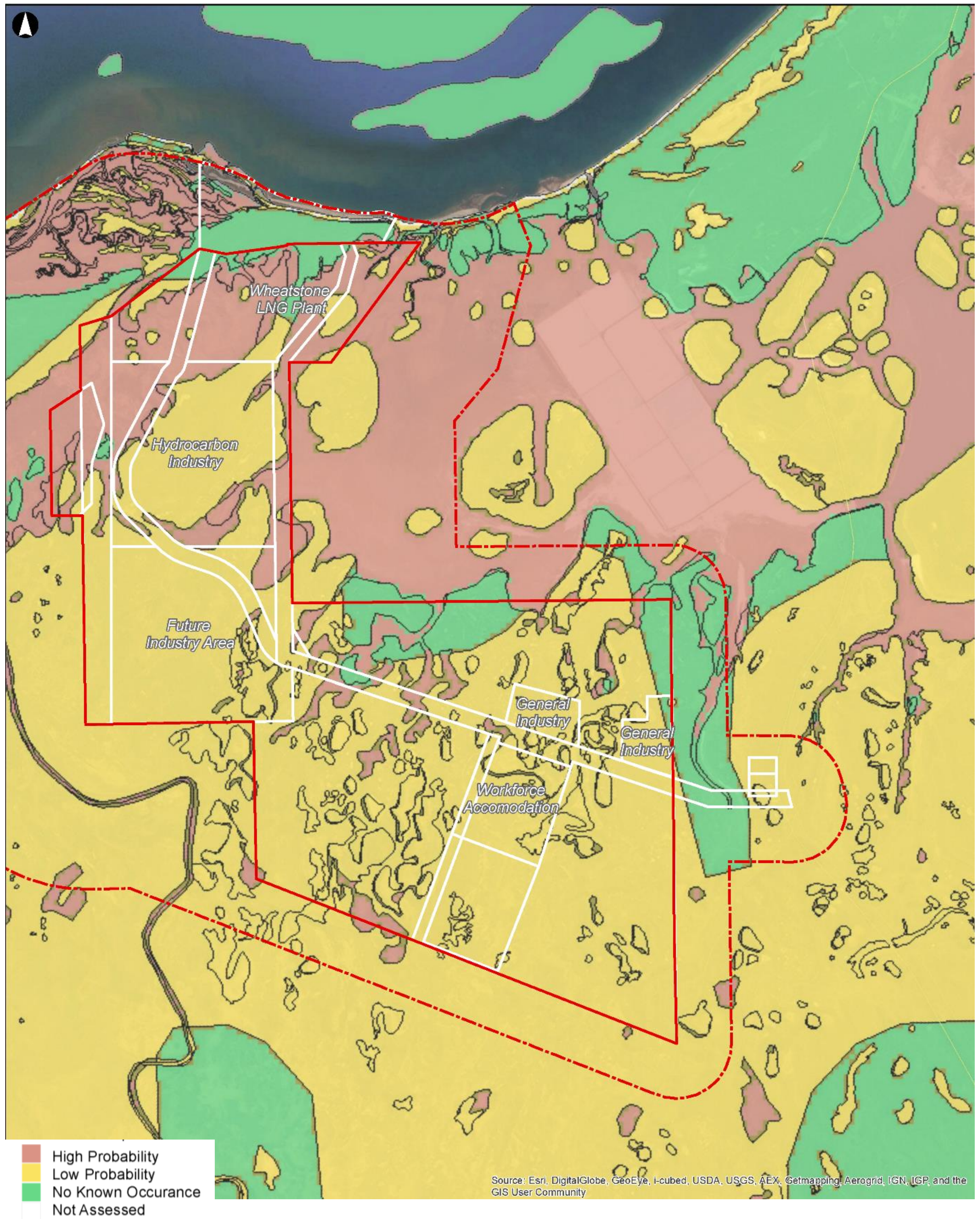

Figure 10 – GIS output showing Acid Sulfate Soil risk areas (Australian Soil Resource Information System, 2014) in relation to future areas of development at the ANSIA.

It is noted that the above risk classifications are broad and relate to materials within the upper 3m of the existing ground profile. It is recognised that ASS is present in varying levels within the ANSIA and that ASS is variably present across all the geological units. Where ground disturbance is required issues associated with ASS must be identified and strategies implemented as part of its management prior to ground disturbance commencing.

The specific ground investigations that have previously been conducted that assess the presence of ASS have been undertaken on most of the Stage 1A area and parts of the Stage 1B and 1C areas of the ANSIA.

4.4.3 Gaps and Recommendations

Stage 1A ANSIA areas have been well investigated from an ASS perspective, whilst Stage 1B and 1C have been partially investigated and Stages 1D and 2 have little to no ASS coverage.

Testing ‘gap areas’ across future ANSIA development areas for ASS/PASS by a broad or regional testing approach, is (similarly to geotechnical investigations) not currently required as the ground lithologies are too variable across geologic units.

Site specific ASS investigations however, will be required once engineering design plans for specific locations are identified, particularly below specific RLs and/or the groundwater table and where excavations (including borrow pit areas) and/or dewatering is planned. According to ENV (2012) claypans and supratidal areas should be the prime targets with marine sediments, fine grained organic sediments and grey to brown sands likely to have an associated ASS risk.

Development Plans/Planning Applications shall describe the Acid Sulfate risk present on the site consistent with the methods described in Identification and Investigation of Acid Sulfate Soils - Acid Sulfate Soils Guideline Series to the satisfaction of the DEC. (URBIS, 2014a)

Simultaneously with the progression of geotechnical investigations for identified areas of development, ASS sampling investigations and subsequent ASS (and dewatering) management plans are recommended to be conducted, in order to benefit from cost savings via a single mobilisation.

4.5 Earthworks

4.5.1 Relevant Studies

The following studies have been reviewed for insight into the earthworks engineering for future stages of the ANSIA:

- BG&E, May 2011, "ANSIA Access Road Corridor Study Part A Route Selection Report".
- Cossill & Webley, Aug 2013, "Ashburton North GIA (East) Outline Development Plan Engineering Report".
- Arup, May 2014, "ANSIA Fill and Basic Raw Materials Study Fill Sourcing Study Assessment Report".

4.5.2 Key Findings

The overriding strategy for minimising the earthworks requirements is to focus development on areas of the site at higher elevation, requiring less fill material to meet flooding resistance criteria. This is achieved through combined analysis of the existing landform and flooding extents, enabling a rational approach to defining raised pads suitable for lot allocation.

Figure 11 shows the elevation modelled from the Lidar survey data set. It is apparent that whilst much of Stage 1D is low lying, Stage 2 and the potential eastern expansion area south of the MUAIC are predominantly higher ground. The large elevated area north of the MUAIC in the eastern expansion area, which appears to be connected to the Longitudinal Dunes landform unit visible in Figure 3, is understood to act as an aesthetic visibility barrier between Onslow Road and completed Stage 1 industrial development. The importance of this aesthetic barrier from a social and/or environmental perspective, and the possibility of winning borrow materials, is a consideration that can be clarified or investigated further.

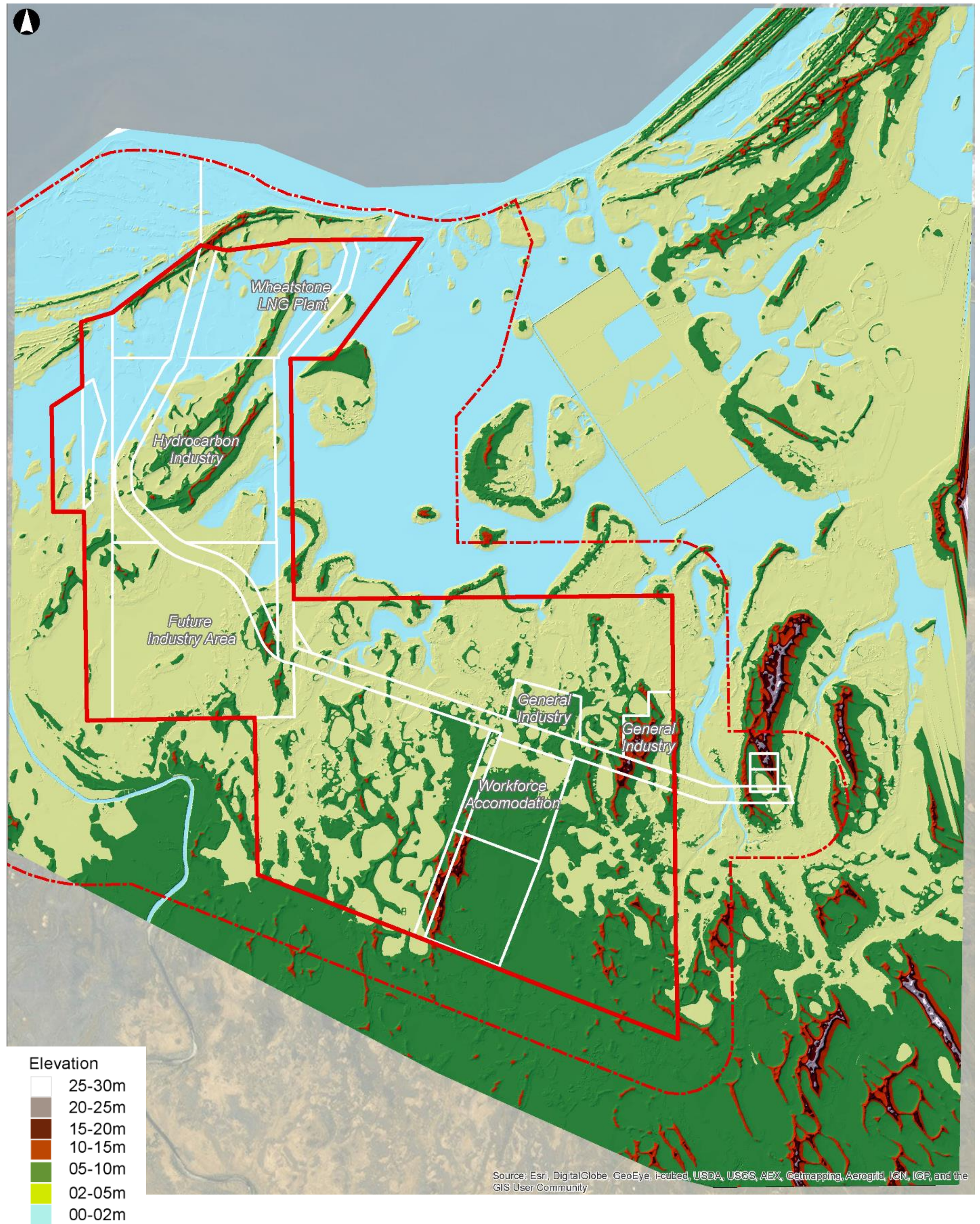

Figure 11 – GIS output of Lidar survey showing higher and low lying areas (m AHD) in relation to future stages of the ANSIA.

From previous cut and fill volumetric analysis it can be seen that within certain lots and finite areas, a high natural ground level enables a balance to be achieved. For example, the eastern GIA Engineering Report indicates that material is being cut, i.e. material is generated, from the majority of the site (Cossill & Webley, 2013). This is consistent with the analysis undertaken for the Fill Sourcing Study (Arup, 2014), which indicated a net cut (surplus of material) of 3M m^3 for the eastern GIA considered in isolation (highlighted within Figure 12). Other areas which produced a net cut were the second TWA and heavy industry site within Stage 1B.

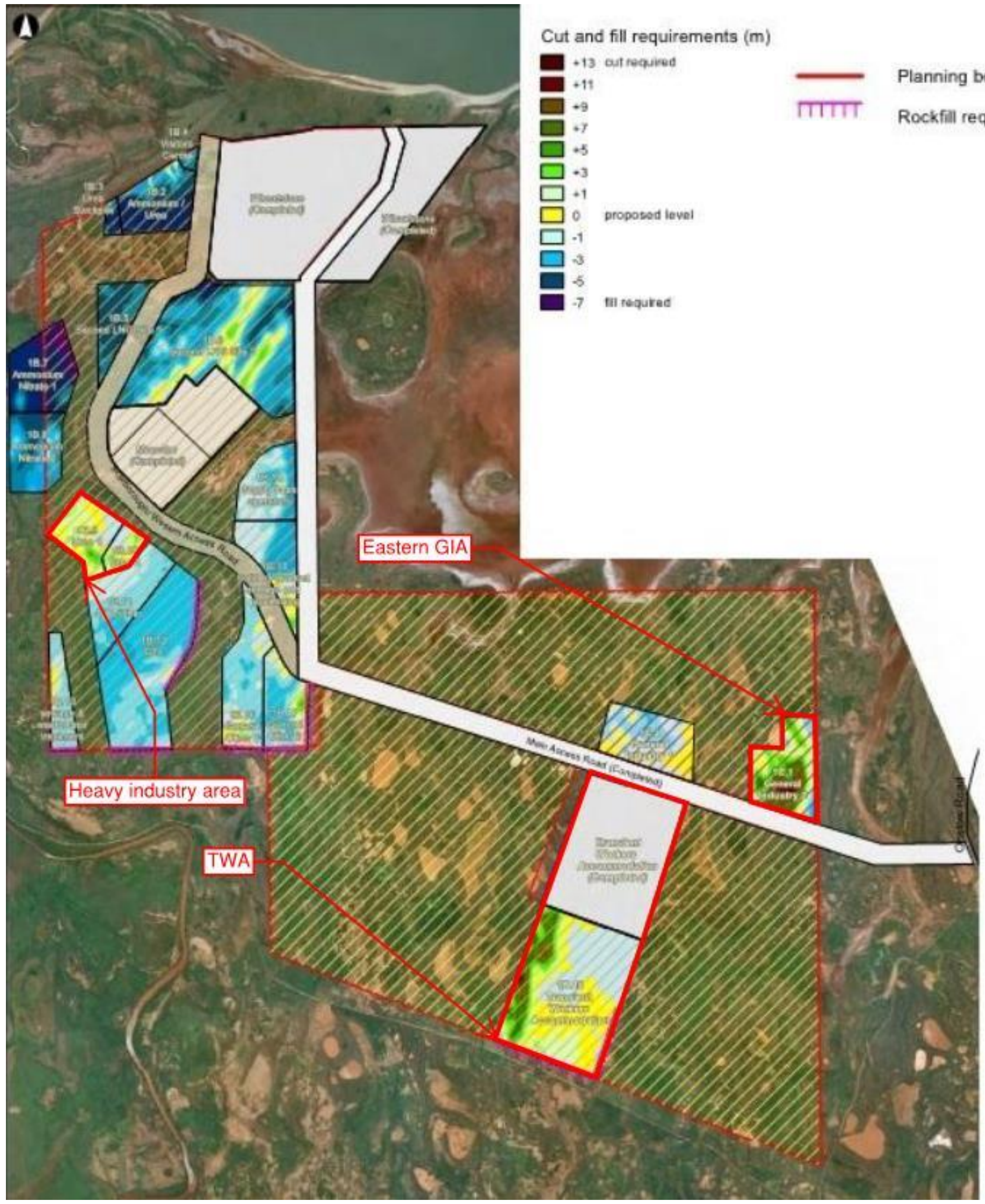

Figure 12 – Annotated extract of Fill Sourcing Study indicating cut-fill requirements from previous stages of the ANSIA , where green and brown indicates cut, blue indicates fill, and yellow is already balanced (Arup, 2014).

Due to the extensive requirement for fill in low lying areas of Stage 1A and 1B, a substantial overall fill requirement was identified for the ANSIA Stage 1 in its entirety. The Fill Sourcing Study investigated the suitability of importing fill from numerous sites in the region. A multi-criteria assessment was undertaken to understand the challenges likely to be encountered during the bulk earthworks from these potential source locations; refer to Table 7.

Table 7 - Extract from Fill Sourcing Study summarising potential sources of material in the region (Arup, 2014)

Source	Volume availability	Distance from ANSIA	Planning constraints
Within the ANSIA	<5M m^3	<20 km	Minor
Peedamulla Road – E 08/2586	>5M m^3	<20 km	Some
Yarri Mining – M 08/471	~5M m^3	<20 km	Some
FMG - Minderoo	~5M m^3	<20 km	Some
Onslow Resources – M 08/479	>5M m^3	>20 km	Additional
Yarri Mining – M 08/473	~3M m^3	<20 km	Some
Yarri Mining – M 08/478	<5M m^3	<20 km	Some
Onslow Dunes	<5M m^3	~20 km	Additional
Rio Tinto Operations at Mesa A	~5M m^3	>100 km	Minor
Mount Minnie WA Limestone – M 08/475 (existing operation)	~5M m^3	>50 km	Minor
NTC Quarries - Onslow	< 1M m^3	~20 km	Minor

Risks associated with sourcing substantial volumes of fill included:

- Costs affecting the feasibility of the activity and deterring development,
- Sourcing cost escalation without a competitive pricing environment,
- High demand for water, and
- Unexpected additional fill requirement due to settlement of pads (Arup, 2014).

Many of these can be readily mitigated with suitable measures by identifying risks at an early stage.

A specific type of material needed for erosion and scouring protection is rock armour. The reports found that, where possible there are benefits to using geotextiles. The need for rock armour is typically governed by high water flood events, particularly along the edges of developments facing the Ashburton River and other natural channels.

4.5.3 Gaps and Recommendations

It is strongly recommended that development is focussed on areas at higher elevation to reduce the earthworks requirements of raising pads above flooding levels. Where pads are set by flooding analysis, it is important to recognise that the flood level will vary spatially. Depending on the findings of flood modelling, it may therefore be inappropriate to prescribe a single flood water level and associated design pad level over wide areas of varying topography.

Due to the nature of earthworks modelling, which is reliant on proposed pad levels for volume estimation, further cut-fill analysis will need to be undertaken as development areas are identified. Since full coverage Lidar data is available, there are considered to be no major barriers to undertaking such work, when and if the requirement arises.

Should fill need to be imported from off-site, for example if there are insufficient areas of high ground to achieve a cut to fill balance, further investigation of fill sources will be required. The Fill Sourcing Study made recommendations for focussed investigation, which provide a strong starting point. Comparing the estimated fill requirement for Stage 1, between 21-30 M m^3, with the few off-site sources of greater than 5 M m^3 availability (Table 7), it is apparent that additional sources may need to be identified if the fill requirements for Stage 2 or the eastern expansion area are substantial.

Due to what are often long lead times associated with sourcing of fill materials, discussions with suppliers to more accurately determine limitations or opportunities from nominated source locations could be of benefit in the near future.

4.6 Traffic Management

4.6.1 Relevant Studies

The following key transport studies were reviewed:

- Arup, Nov 2010, "ANSIA Structure Plan Transport and Access Report".
- Riley, Nov 2011, "ANSIA Traffic Impacts and Road Network Review".
- Riley, Aug 2011, "Truck Laydown Area Review" Tehnical Note.
- Riley, Jan 2013, "Ashburton North Eastern GIA Subdivision Traffic Review" Technical Note.

4.6.2 Key Findings

Current studies indicate the existing surrounding road network is "operating appropriately" (TPG, 2012).

Development area land uses, along with respective employee and trip generation forecasts, are shown in Table 8 (Riley, 2011). These development areas do not include Stage 1D and the potential expansion area to the east of Stage 1C.

The ultimate development of these areas (excluding Stage 1D and the potential expansion areas) is expected to generate over 10,000 vehicle movement per day. However, given the high level of internal trips, this is likely to result in approximately 5,500vpd on the ANSIA access road (Riley, 2011).

Figure 13 shows the anticipated traffic generation for the ANSIA site at full development. The forecast traffic volumes indicated in Figure 13 (Riley, 2011) reflect a design range up to 2026 and assumes the construction of Wheatstone, Macedon and Scarborough projects has been completed. Analysis has been conducted on the assumption of a workforce of approximately 2,800 employees (Riley, 2011).

Construction traffic has been quantified for the Wheatstone and Macedon developments. However, quantification of construction traffic for other development have yet to be defined. The structure plan indicates that a traffic impact assessment and traffic management plan should be prepared by each proponent for the approval of MRWA and the Shire of Ashburton (Taylor Burrell Barnett, 2011).

Table 8 - ANSIA traffic generation - Ultimate development

Site	Area	Employees[1]	Work trips	Commercial trips	Trips per day
Wheatstone[1]		300	600	400	1000
Scarborough[1]		300	600	400	1000
Macedon[1]		80	160	107	267
DPA		20	40	27	67
Waste water treatment plant		5	10	7	17
Ammonium nitrate plant		70	140	93	233
Ammonia plant		50	100	67	167
Visitor centre		3	6	4	10
Urea or ammonia plant		60	120	80	200
Supply base operator		20	40	27	67
By-product and solid waste area		15	30	20	50
General other #1		60	120	80	200
General other #2		60	120	80	200
Urea plant		60	120	80	200
Water and power factory		5	10	7	17
Gas to liquid plant(s)		350	700	467	1,167
General Industrial Area East	100ha		1,800	1,200	3,000
General Industrial Area West	88ha		1,584	1,056	2,640
TOTAL			**6,300**	**4,200**	**10,500**

[1]Source – "Ashburton North Strategic Industrial Area Stage 1B Statutory Planning Services – Industrial Ecology Component – Craft Report November 2011"

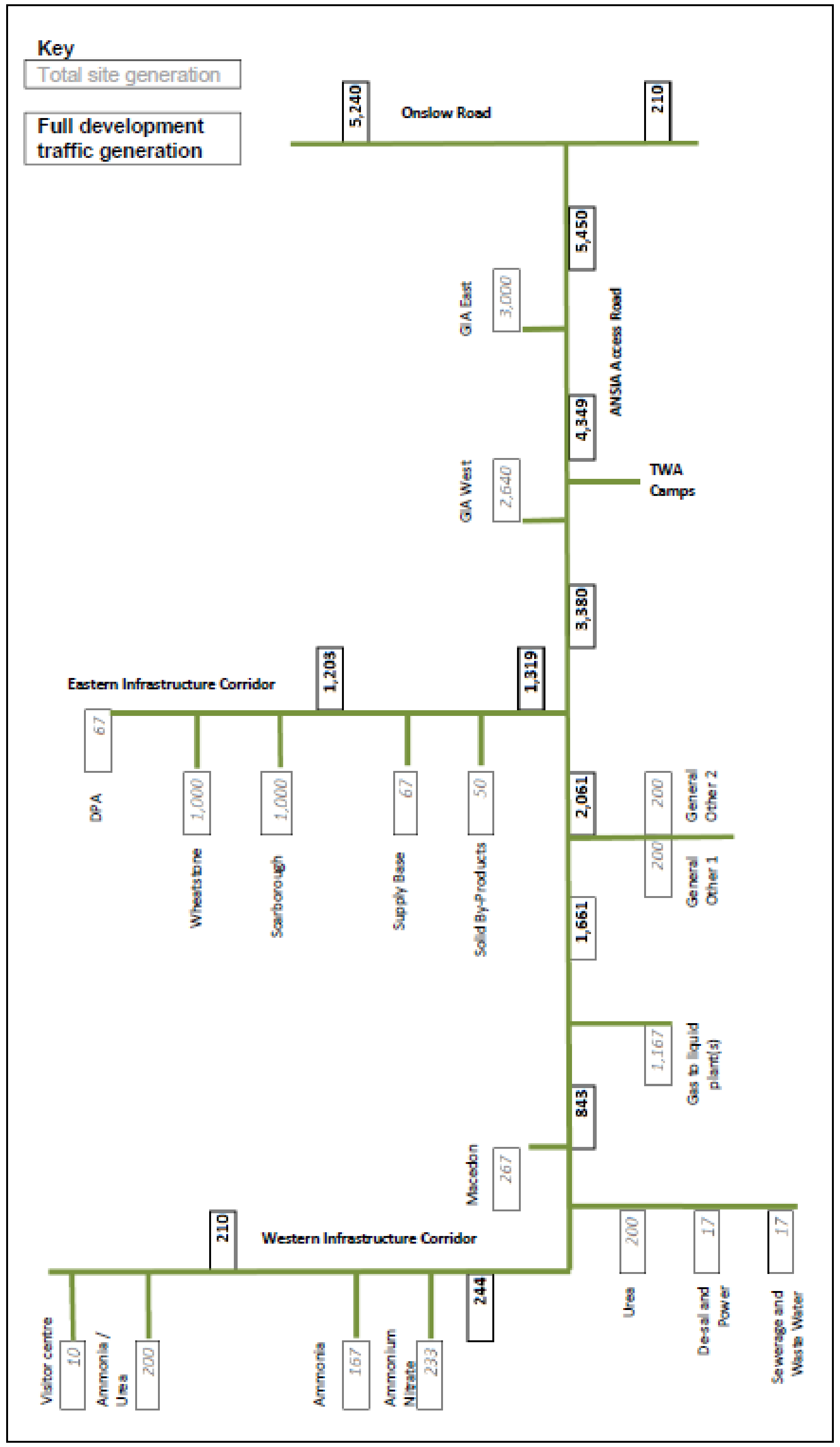

Figure 13 - Anticipated full development traffic volumes (Riley, 2011)

More detailed traffic analysis has been conducted on the eastern GIA subdivision. Traffic volumes are expected to be within the projections set out as part of the ANSIA traffic forecasts at full development, with an adequate level of service for access to the eastern GIA (Cossill & Webley, 2013).

Truck laydown areas were also considered as part of the stage 1B and 1C development plan. The study recommended the preferred location to be as near as possible to Onslow Road in order to service both ANSIA and the Onslow town site. It also indicated that an interim informal facility could be established along the ANSIA access road to cater for construction vehicles (TPG, 2012).

A review of current aerial imagery has indicated the configuration of the main intersection along the ANSIA access road (leading to the Macedon and Wheatstone LNG plants) has been upgraded recently. It currently reflects a revised T-intersection located approximately 1km to the north of the existing intersection. This revised intersection configuration is different to what was originally proposed as part of the ANSIA Development Plan.

4.6.3 Gaps and Recommendations

Current transport studies do not include all proposed future stages of the ANSIA, specifically Stage 1D and the potential expansion area. It is recommended that once the size of the proposed expansion areas and land uses are defined, analysis should be undertaken to ascertain trip generation, access arrangements and investigate impacts on the surrounding road network.

As part of future Development Plans or future consideration of Planning Approval, comprehensive traffic impact assessment is expected to be required (URBIS, 2014a), addressing the impacts on regional and local roads. Particular considerations for this are identified as being:

- Traffic volumes on Onslow Road, Old Onslow Road and Twitchin Road.
- Vehicle size (e.g. large haulage/freight).
- Timing of peak traffic and duration of traffic during both the construction and operational phase (URBIS, 2014a).

As current traffic generation has been based on floor area and operating staff projections, existing assumptions on the development and anticipated workforce size for the proposed development areas should be re-confirmed; taking into consideration any new or significantly altered developments (such as the Scarborough floating LNG development option).

Background traffic generation on the existing road network should be re-confirmed given the availability of new traffic counts (e.g. MRWA loop counter on the ANSIA access road etc.).

It is recommended to investigate the profile of heavy vehicles forecasted to be utilised after full development, including how this may impact the projected passenger car unit (PCU) traffic volumes.

Following the revised intersection treatment along the ANSIA access road (to the Macedon and Wheatstone LNG plant areas); it is recommended that as part of any traffic impact assessment, a review of the operation of this revised intersection should be considered.

4.7 Road Works and Alignments

4.7.1 Relevant Studies

Due to the substantial size and consequentially the potential earthworks and flooding backwater impacts of the MUAIC main roads, the most suitable corridor and vertical alignment were selected by technical studies, namely those below:

- BG&E, May 2011, "ANSIA Access Road Corridor Study Part A Route Selection Report".
- URS, Dec 2010, "Wheatstone Project Access Road Design Flood Modelling and Impact Assessment".

Internal access roads are not subject to this level of technical reporting. The main requirements and engineering rationale are described by the eastern GIA Outline Development Plan and supporting report:

- Cossill & Webley, Aug 2013, "Ashburton North GIA (East) Outline Development Plan Engineering Report".

4.7.2 Key Findings

The design criteria for the road network are related to the anticipated future use of the lots that this network serves. For the eastern GIA, the following criteria were implemented (Cossill & Webley, 2013):

- Size and turning movements of triple road trains.
- Operating speeds of 60km/hr for internal roads.
- No clearly defined footpaths within road cross-section.
- Standards: Department of Planning and Infrastructure, requirements of Shire of Ashburton.
- Standard verge alignments for utility services and drainage.
- Second access to MUAIC for emergency purposes only, sealed road of simplified cross section.

A key requirement of the road design is to complement the stormwater management measures for maintaining natural major waterways. This requires considered vertical alignment and drainage design to minimise backwater effects, through implementation of suitable conveyance through road embankments or floodways wherever these would otherwise disrupt a waterway.

During the early stages of the ANSIA, the existing Onslow Road, which traverses a number of floodways, was found to be unsuitable in terms of pavement construction and vertical geometry (e.g. drainage structure clearances, sight distances etc.) for the development access (Taylor Burrell Barnett, 2011). At the time of the Stage 1B & 1C Development Plan, there had been considerable progress by MRWA in implementing the necessary upgrades, between the North West Coastal Highway and the ANSIA (TPG, 2012). The timing of these works was advanced to be suitable for construction trafficking during the early ANSIA stages. The route of Onslow Road along the eastern boundary of the Improvement Scheme is shown in Figure 14.

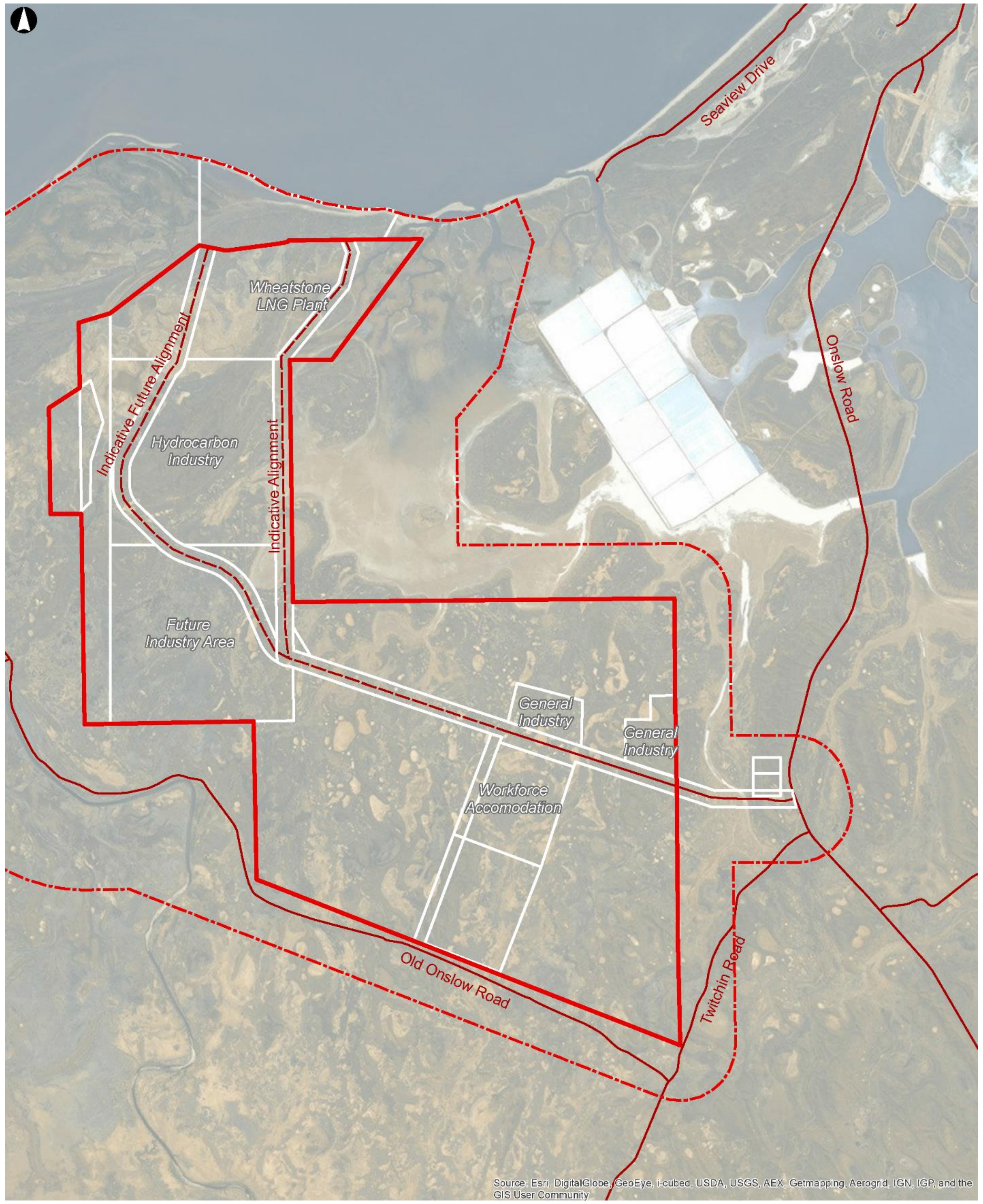

Figure 14 – GIS output showing existing road network in relation to future areas of development at the ANSIA (URBIS, 2014a).

4.7.3 Gaps and Recommendations

For future stages of the ANSIA, it has been identified that the road design criteria will be in accordance with Shire of Ashburton requirements, to freehold subdivision standard (URBIS, 2014b). In particular, the design will provide safe and efficient movement between internal lots. To achieve this criteria it is anticipated that the road reserve cross-section (an example is shown in Figure 15), specifically provision of footpaths, will need to be reviewed considering the needs of all road users including pedestrians. This will be dependent on the understanding of proposed lots and landuse.

Also related to the cross-sectional geometry are the requirements of shared utilities. Should specific utilities requirements arise in order to service multiple industries in a coordinated manner, the standard verge alignments previously assumed may no longer be appropriate. The allowance for shared utilities within the road reserve should be understood at an early stage.

The road network will need to effectively integrate alignment design with natural drainage pathways. This will require analysis of the landform and preferential stormwater routes, to be incorporated into the design workflow. Again, identifying and analysing proposed key routes at an early stage in the design is recommended, based upon the specific needs of the developments that the roadway will be serving.

In order to ensure a uniform level of service and amenity across the area, it may also be prudent to implement a standardised road pavement specification document for the design and construction of roadways within the site. This document could be developed in concert with the Shire of Ashburton and the Main Roads WA, and provide a guideline in order to inform the sustainable provision of a road network across the entire ANSIA.

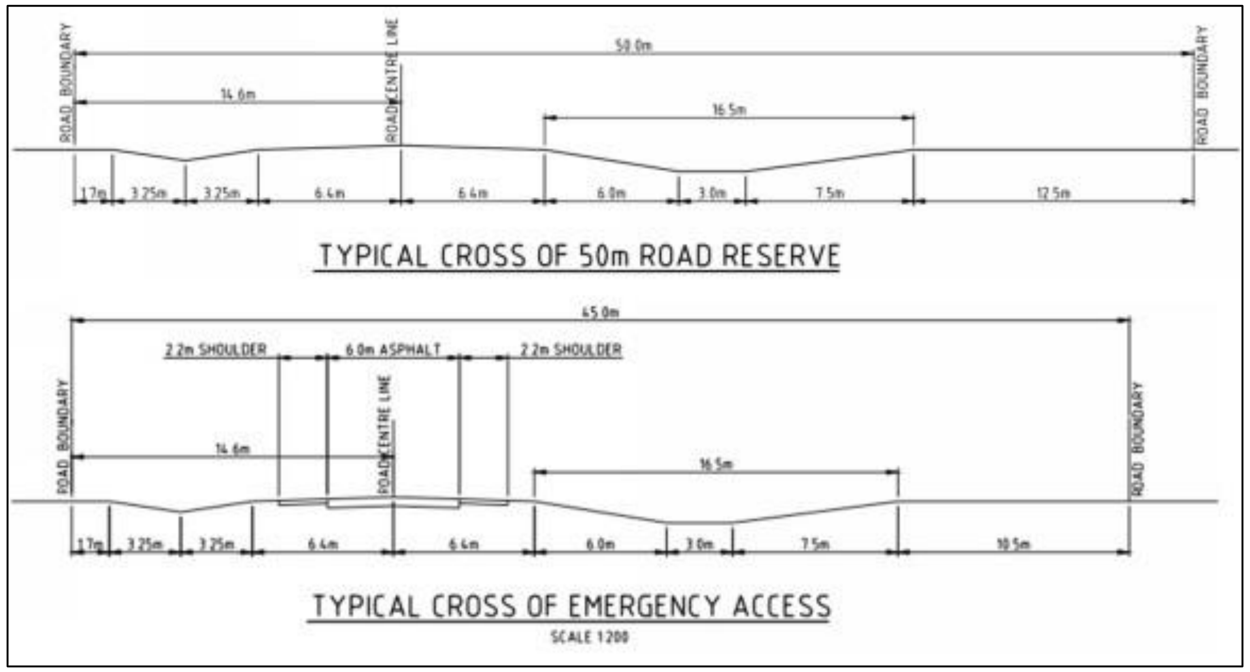

Figure 15 - Indication of typical internal road geometry compiled from eastern GIA Engineering Report (Cossill & Webley, 2013)

4.8 Water Quality Management

4.8.1 Relevant Studies

Strategy reports at different levels of implementation have been reviewed, providing an overview of how successfully the objectives for managing surface water quality have translated into design of engineering measures.

- ENV, Aug 2010, "ANSIA District Water Management Strategy".
- ENV, Jun 2011, "ANSIA Stage 1A Local Water Management Strategy".
- BG&E, Jan 2012, "ANSIA Local Water Management Strategy" [Stage 1B & 1C].
- Cossill & Webley, Aug 2013, "Ashburton North GIA [eastern] Outline Development Plan Engineering Report".
- BG&E, Nov 2013, "Ashburton North Eastern GIA Urban Water Management Plan".

The DWMS sets the broad objectives and requirements for future strategies covering specific project areas in more detail. This document also provides the context and recommendations of the appropriate approach. Following on from this, the LWMS documents support the Development Plans and describe how the objectives will be implemented. The strategies outline design requirements which are progressed by future development typically through an Urban Water Management Plan, such as the Eastern GIA UWMP. The GIA Engineering Report presents solutions for the GIA drainage system including proposed measures to control surface water quality.

4.8.2 Key Findings

Due to the proximity of Onslow Salt it was deemed appropriate to limit chemical transport along the eastern MUAIC at the early stages of the ANSIA (Taylor Burrell Barnett, 2011). This indicates the sensitivity of this adjacent stakeholder to changes in surface water characteristics, as well as potential influence on development in proximity such as the northern areas of Stage 2. In response, the DWMS requires the proposed drainage system to manage chemical spills without discharge to the broader environment (ENV, 2010). Within the hydrological catchment, all developments must be cognisant of the potential effects on Onslow Salt to ensure there are no adverse impacts (URBIS, 2014a).

The management of surface water quality was established by the DWMS to utilise Best Management Practices (BMP), including both structural and non-structural measures (Figure 16). Both types of these BMP were refined by the Stage 1A LWMS (ENV, 2011). Within the Stage 1B and 1C LWMS and the eastern GIA Engineering Report, the focus is placed on the first structural BMP shown in Figure 16.

The Stage 1B & 1C LWMS provided discussion of the natural characteristics of surface water; primarily ranging between high salinity and high turbidity depending on the relative influence of tidal variation or periodic flow from the upstream catchment. This LWMS considered that in general the receiving water environment was not sensitive to changes in surface water runoff (BG&E, 2012b). Nonetheless, managing chemical spills is evidently an important criteria.

The approach indicated by the Stage 1B & 1C LWMS included pollution control measures (hydrocarbon interceptors, bunded storage etc.) installed by the proponent developing each lot. The LWMS also implemented detention basins or swales within or close to the lots. In combination with proponent pollution control, the drainage system therefore forms a runoff management train.

> Structural BMPs should include:
>
> - Stormwater sedimentation basins and swales to minimise sediment and pollutant movement. Basins should be designed to manage chemical spills without discharge to the broader environment;
> - Separation of stormwater from clean sources (such as roofs) from 'dirty' sources such as process and maintenance areas into separate basins; and
> - Revegetation of cleared areas following construction, except where there will be buildings, paving or detention basins, where possible.
>
> Non-structural BMPs should include:
>
> - Environmental Management Plans that present details of stormwater management during both the construction and operational stages; and
> - Inclusion of stormwater and spill management and environmental awareness training for staff.

Figure 16 – Extract of Best Management Practices recommended by DWMS (ENV, 2010)

Minimising erosion caused by high velocity flow within the drainage system is an important approach to preventing sediment impacts on the downstream environment. The Stage 1A LWMS highlights this as a key issue (ENV, 2011). The Stage 1B & 1C LWMS suggests the following design parameters, which are also given as criteria within the Eastern GIA UWMP:

- Drainage infrastructure to have appropriate side slopes and a longitudinal grade of 1:1000 to reduce velocity;
- Rock protection in bends to reduce scour;
- Adequate planning practice with buffer zones to protect riparian zones (Figure 17) of natural creek as well as wide reserves;
- Landscaping with native plants;
- Maintenance of vegetated swales and verges;
- Protection around culverts.

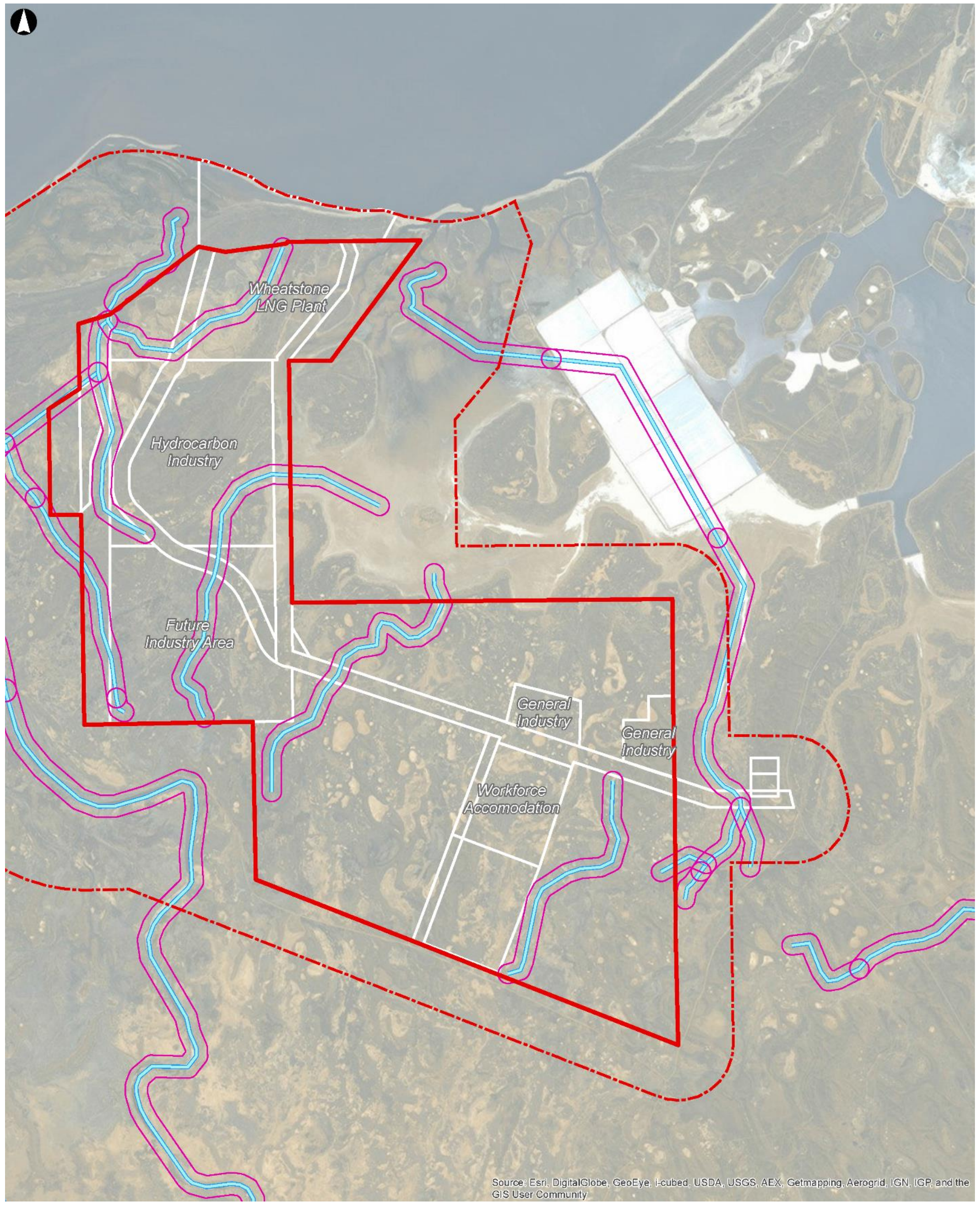

Figure 17 – GIS output showing watercourses and riparian zones (BG&E, 2012b) in relation to future stages of the ANSIA.

4.8.3 Gaps and Recommendations

Comparing the subtly differing approaches within the two LWMSs, the surface water management train comprising both proponent pollution controls, such as hydrocarbon interceptors, and drainage retention structural BMP, provides a robust water quality strategy.

The BMP relating to native vegetation of cleared slopes, swales and basins achieves the dual benefit of treating surface water runoff and controlling erosion. As the water quality strategy progressed from DWMS through to implementation within the eastern GIA UWMP, focus was adapted to native vegetation of swales in particular. It is recommended that the value of water quality and environmental BMP for various aspects of the development, as outlined in Section 4.8.2, are considered within future implementation strategies.

Improper maintenance of drainage systems can lead to the water quality management measures not functioning effectively. Maintenance is included within the LWMS erosion criteria, and inspection and initial responsibility are addressed within the Eastern GIA UWMP. Tangible maintenance aspects such as frequency, practices, and where this responsibility lies should continue to be implemented throughout future design for the benefit of long-term system performance.

4.9 Water Supply

4.9.1 Relevant Studies

Various studies and reports provide an insight into the progression of water supply options for the ANSIA. Since new investigation and data (e.g. on-site bores, Department of Water enquiries etc.) contribute significantly to the proposed approach at each stage, the chronology of the findings is particularly important. This is illustrated in Figure 18.

Figure 18 - Chronology of reports contributing to water supply findings

4.9.2 Key Findings

The ANSIA is situated in a challenging environment for fresh water supply. Described as a climate of extremes, the Pilbara coast experiences severe droughts and major floods at close intervals (BG&E, 2012b). Short lived river flows, intermittent large volumes, erratic rainfall and high evaporation are significant general disadvantages with the option of surface water supply. However the potential benefit of this option for flood protection has been highlighted by several of the reports.

The Wheatstone Development Plan describes use of trucked water from Beadon Creek (within eastern Onslow) seawater intake for the initial construction stages; later decommissioned following construction of a desalination plant (Taylor Burrell Barnett, 2012). Desalination may be utilised to treat either seawater or saline groundwater. This option has been chosen for much of the ANSIA development thus far. Reference is made in the reports to a proposed seawater intake supplying desalination plant at Wheatstone (Taylor Burrell Barnett, 2012), and to the Macedon system which includes Reverse Osmosis desalination plant supplied from the existing BHPB bore near Onslow Road (GHD, 2012).

At the time of the Stage 1B&1C LWMS, there was considerable uncertainty regarding long-term water servicing for the ANSIA (TPG, 2012). Discussions with the Water Corporation during the GIA Interim Servicing Options Study indicated that the system at Onslow is essentially at full capacity until 2016 (GHD, 2012). The Eastern GIA UWMP lacks a definite, development-wide supply solution for the interim, indicating this would be for proponents to address. In the long-term, the UWMP refers to connection to the OWIUP. However, more recent discussion indicates that a servicing request for the GIA would be classed as an unplanned project; whether there is any spare capacity will not be known until 2016 when capacity is taken up by Onslow (Water Corporation, 2014b).

The OWIUP implements the agreement between Chevron and the Department of State Development to increase the potable water supply to Onslow by 2ML/day (Water Corporation, 2014a). The Desalination Plant proposed to be constructed by Chevron will be handed over to Water Corporation, to supply the future population growth of Onslow township generated by Chevron activities (Water Corporation, 2014b). The source for this supply is proposed to be deep groundwater bores utilising rights to the existing bore licensed to BHPB. The OWIUP report includes thorough consideration of alternative sources of water for the Onslow supply requirements. This provides a useful background understanding of water supply constraints and opportunities for the future Stages of the ANSIA. The main alternative options, associated advantages and disadvantages identified by the OWIUP report, are summarised below (Water Corporation, 2014a):

Seawater Desalination

- ✓ Well-established process.
- ✓ Reliable quantity, seawater quality data available from other developments in the region.
- × Shallow nearshore environment; poor water quality, likely fouling of intake and outfall.
- × Significant issues with stabilisation of structures during cyclonic conditions.
- × Environmental impacts during construction and from discharge to the marine environment.

Lower Robe River, Cane River, and Ashburton River Aquifers

- ✓ Fresh to brackish water sources; potentially improved quality over seawater.
- × Schedule impacts from investigation, testing and proving water availability.
- × Generally there is uncertainty about the yield of these sources; licensing difficulty or a large number of bores required, depending on the aquifer.

Beadon Creek (alternative to nearshore seawater)

- ✓ Reduction in marine works.
- × Environmental issues; entrainment of fauna in intake, mangrove stands.
- × Land access.

The source utilised for the OWIUP is the Birdrong Aquifer, a deep artesian sandstone aquifer. Beneath the OWIUP Lot 556, near Onslow Road within Stage 2 of the ANSIA, the aquifer is approximately 370m below ground and 12m thick. Readily available water quality data identified the source had reduced salinity compared to seawater, requiring simplified treatment to produce potable water, also producing decreased residual solids after treatment (Water Corporation, 2014a).

Whereas the GIA Interim Options study assessed the Birdrong Aquifer as being fully allocated (GHD, 2012), the Stage 1B&1C LWMS indicates that allocation limits may be amended based upon updated hydrogeological reports provided to support new license applications. At the time of this LWMS, the allocation limit of the Birdrong Sandstone in the Carnarvon Artesian Basin was stated as 30 GL/year (TPG, 2012), with 2 GL/year applicable for new license application in 2007. To put the figures into context, the high end water demand estimate for the first stage of the GIA was 95 ML/year (GHD, 2012). Analysis within Appendix D of the OWIUP report gives further insight into the water availability. Pumping at the rates required for the OWIUP demand caused a predicted drawdown of the pressure head between 83-107m for an 80year abstraction. However, the aquifer was predicted to remain fully saturated, with the pressure head remaining artesian i.e. above ground level. Apart from the existing BHPB bore, there are no other known users of the Birdrong Aquifer, which has an assumed offshore extent of 120km (Water Corporation, 2014a). The substantial size of this resource is indicated by the model mesh representing the aquifer shown in Figure 19.

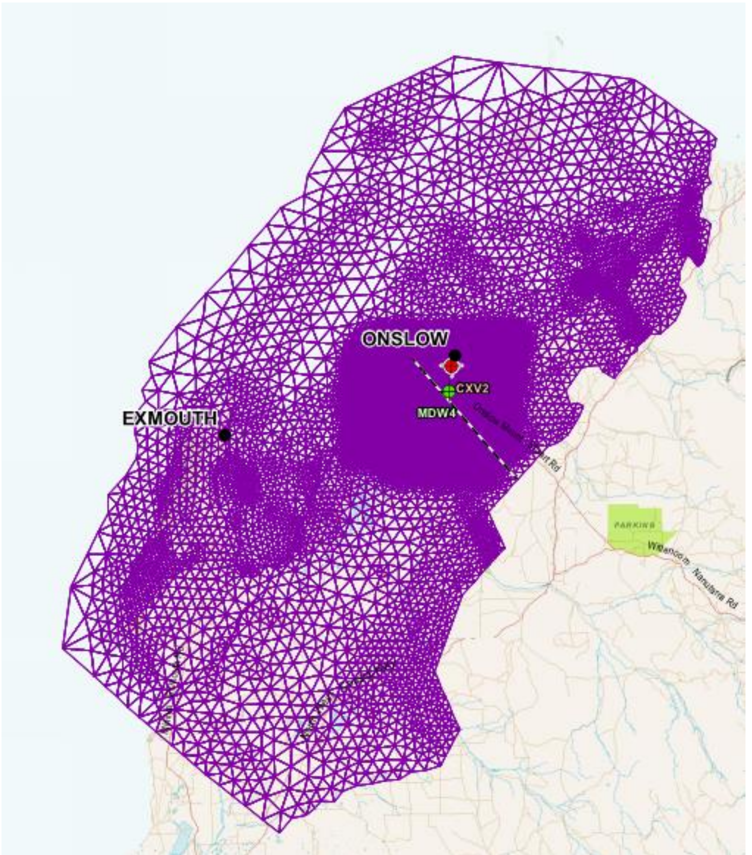

Figure 19 – Extents of model mesh representing the Birdrong Aquifer, used for the OWIUP study (Water Corporation, 2014a)

4.9.3 Gaps and Recommendations

On behalf of LandCorp, BG&E have undertaken preliminary consultation with the Department of Water regarding water management strategies to support future development. This has indicated that a LWMS would be suitable for Stage 2, rather than a separate DWMS.

The DWMS requirement for water balance to be assessed within the LWMS could be emphasised to include industrial and construction demands which do not require the same standard of water treatment. For example, saline groundwater may be suitable for certain uses, which would not compete for potable or fresh water use (ENV, 2010). Another suggestion was the seawater intake being used for compaction water (Taylor Burrell Barnett, 2012), which would be dependent on the fill material source and is expected to be more suitable for sand fills with low clay content (Arup, 2014). This approach should be considered by future LWMS, to match more readily available water of lower quality to significant demands for non-potable, saline or recycled water.

The potential of the Birdrong Aquifer providing a sustainable water resource for the entire ANSIA is not clear. However, there are considerable positive indications from the recent OWIUP study, which suggest further investigation of this resource is worthwhile. Appendix D of the OWIUP report references several studies by Golder relating to the Birdrong Aquifer, which should be reviewed to inform any future analysis. As a basis for further study, it may be beneficial to develop an understanding of the anticipated users of future lots and estimated water demands, so that supply scenarios could be targeted to particular stages if desired. Early

Due to the timescale of investigating, testing and proving a deep groundwater supply, a short-term solution may be required. It is notable that Beadon Creek was licensed for short-term use for the construction of Wheatstone (Taylor Burrell Barnett, 2012), however this source was not pursued by the OWIUP study (Water Corporation, 2014a). Should short-term water supply be found to be a significant challenge, this potential source could be further investigated.

4.10 Wastewater

4.10.1 Relevant Studies

Similarly to water supply, various reports discussing water cycle management provide insight into wastewater constraints and solutions. The ANSIA Industrial Ecology Strategy report in particular, discusses synergies between the water cycle and industrial activities at the ANSIA. The reports which have been reviewed for this section are listed below:

- Serling, Aug 2010, "North Ashburton Strategic Industrial Area Structure Plan Service Infrastructure Report".
- ENV, Aug 2010, "ANSIA District Water Management Strategy".
- ENV, Jun 2011, "ANSIA Stage 1A Local Water Management Strategy".
- BG&E, Jan 2012, "ANSIA Local Water Management Strategy" [Stage 1B&1C].
- Climate Change Response (CCR), Jan 2012, "ANSIA Industrial Ecology Strategy Concept Plan".
- Cossill and Webley, Aug 2013, "Ashburton North GIA Outline Development Plan Engineering Report".
- BG&E, Nov 2013, "Ashburton North Eastern GIA Urban Water Management Plan".
- Water Corporation, Aug 2014, "Onslow Water Infrastructure Upgrade Project (OWIUP) Supporting Documentation" Including appendices.

4.10.2 Key Findings

The common approach to wastewater treatment within various reports is as follows:

- Short term; each large industry proponent develop their own wastewater facilities as required, for example package aerobic treatment units, which are flexible for expansion.
- Longer term; larger, centralised plant for multiple proponents.

Several references are made in the reports to main WWTP locations. For Wheatstone it was envisaged that at a later stage, a larger plant would be commissioned to service the entire transient workers accommodation (Taylor Burrell Barnett, 2012). The Stage 1B&1C LWMS refers to an identified location for a WWTP in the ANSIA area (TPG, 2012), in the south west corner of Stage 1B at lower elevation to benefit gravity drainage. For development of the ANSIA Stage 1, the industrial ecology report considered that a common WWTP would be in service at the interim stage, coinciding with development of the second LNG plant and an export ammonia plant (CCR, 2012).

For Stage 1B&1C, the location of the utilities cluster containing the WWTP was influenced by co-location to utilise waste-heat from power generation and gas-to-liquid plant. The shape and ease of access of the available lot would have been less suitable for conventional or higher risk industrial development, reinforcing the logical allocation for the utilities cluster (CCR, 2012).

The DWMS recognises that the high cost of desalination provides a strong incentive for reuse of wastewater, with co-operative use of water recycling infrastructure recommended for the longer term (ENV, 2010). Shared use of utility infrastructure, mainly water (e.g. water supply and recovery) and energy, was identified as the main industrial ecology initiative realisable in the ANSIA (CCR, 2012).

To achieve economies and efficiencies of scale, utility synergies where larger facilities are developed and shared by a number of industries was recommended (CCR, 2012). The anticipated savings are realised both within the utility plants themselves and from reduced costs of common service pipelines, rather than each individual proponent having its own smaller plant and service lines.

A useful, previous example was identified as the Kwinana Water Reclamation Plant (KWRP). A plant similar to this would allow significant amounts of sewerage and industrial wastewater to be recycled and reused within industrial sites at the ANSIA (CCR, 2012). As well as significantly reducing the need for desalinated potable water, this would also minimise the need for disposing of industrial wastewater outside of the site.

Two main options for disposal of residual wastewater are discussed within the reports. The Stage 1B&1C LWMS identifies that water not suitable for reuse will be discharged via pipeline to the ocean (BG&E, 2012b). Given the shallow nearshore environment, this would need to be of suitable length and depth to enable sufficient mixing. The potential for discharging treated wastewater effluent to surrounding watercourses is heavily dependent on the characteristics of the wastewater, as well as the sensitivity of receiving environment. For the residual saline stream from the OWIUP desalination plant, study found that the chemical composition of effluent in the worst case compares favourably to the receiving surface water environment (Water Corporation, 2014a).

4.10.3 Gaps and Recommendations

The allocated location of the common WWTP at the south west corner of Stage 1B is a considerable distance from eastern Stage 2. Although the sewer line from the TWA may provide some opportunity for future stages to connect to this WWTP, the distance and capacity within the allocated lot may mean a further WWTP lot is required within Stage 2. This will need to be considered within future water management strategies or servicing studies.

For future water strategies, it is recommended that a total water cycle management approach is more thoroughly applied. This should seek to realise the opportunities for economies of scale within wastewater treatment and reuse. It has been identified that the LWMS accompanying Development Plans will need to provide site specific details to ensure total water cycle management, and demonstrate the means to implement this (URBIS, 2014b).

The scale of the future stages of the ANSIA may introduce opportunities for utilising wastewater as a resource beyond what was previously anticipated. This may extend beyond water recycling to the solids production stream of municipal wastewater treatment. In many parts of the world wastewater and industrial sludge is utilised as a resource, for example within anaerobic digestion energy generation or fertiliser production. This is one example of holistic wastewater planning from which economical resource production may be achievable by future industry, particularly at the scale of the ANSIA. Wastewater resource opportunities should be viewed in combination with other processing streams, such as solid waste disposal or fill treatment, to identify mutual benefits and coherent solutions.

4.11 Power

4.11.1 Relevant Studies

The following studies have been reviewed for insight into power provision for the future ANSIA stages:

- Serling, Aug 2010, "North Ashburton Strategic Industrial Area Structure Plan Service Infrastructure Report".
- Climate Change Response (CCR), Jan 2012, "ANSIA Industrial Ecology Strategy Concept Plan".
- GHD, Oct 2012, "Ashburton North GIA Interim Servicing Options Study".
- Cossill and Webley, Aug 2013, "Ashburton North GIA Outline Development Plan Engineering Report".
- Horizon Power, Aug 2014, "Onslow Power Infrastructure Upgrade Project (OPIUP)" Supporting Documentation for Environmental Referral.

4.11.2 Key Findings

Apart from the interim options for the first stage of the GIA, which found diesel engines to be suitable (GHD, 2012), the studies indicate the primary power supply to the ANSIA to be dual fuel gas and diesel generation. At the early stage, natural gas was considered the main source of power generation, with diesel used for start-up, as well as generation in the short-term prior to the gas plant being commissioned (Serling Consulting, 2010). The OPIUP, which implements the Ashburton North State Development Agreement to develop a 9 MW output power station to support Onslow, proposes five gas fuelled and four diesel reciprocating generating sets (Horizon Power, 2014). The OPIUP generation facility is sited adjacent the existing BHPB groundwater bore near the Onslow Road intersection, within the ANSIA eastern expansion area under investigation.

The OPIUP report considered photovoltaic (PV) power providing part of the generation. With 10% area load PV contribution (approximately 900 kW), the report found that the system did not offer a robust economic solution. At 20%, intermediate energy storage such as battery tanks required would greatly increase the capital cost, and introduce operational uncertainty with the technology (Horizon Power, 2014).

During the interim options study for the first stage of the GIA, it was found that the ability for the power generation facility to expand as the development becomes increasingly built out was important (GHD, 2012). The distribution system however was proposed to be installed with full capacity up front, to achieve cost savings. Road reserve allocations were facilitated to accommodate the underground power network, in anticipation of the main generation plant being installed. Prior to underground power being available within the development, solar street lighting was proposed for this stage of the GIA, subject to discussions with the Shire of Ashburton (GHD, 2012).

Utilities synergy was identified as a significant opportunity to achieve cost efficiencies from power generation for the ANSIA development (CCR, 2012). For example, co-locating desalination and power plants allows, physically and economically, the option to use low grade heat from the power plant and nearby industry for thermal desalination. An example of successful synergy was given as Kwinana Industrial Area, where fuel gas made from waste gases at the refinery supplements the gas turbine, which in turn provides power and steam to the refinery. As a result, a significant reduction in waste gases flared and efficient use of the waste heat is achieved (CCR, 2012). The location of facilities within Stage 1B of the ANSIA is an important enabler for such synergy; the transfer in this case being waste gases, heat and steam between the gas-to-liquid plants and power generation gas turbines.

4.11.3 Gaps and Recommendations

Until the ANSIA Stage 2 and future expansion proponents and lot sizes are known, energy demands and therefore power generation requirements cannot be accurately quantified. However, as more information on anticipated lots and land use becomes available, power criteria can be estimated as a basis for considering generation options in more detail. Within future studies, consideration should be given to potential financial gains from advancing the main power generation infrastructure, in which case temporary power provision may not be a requirement for prospective future proponents. In this case, the envelope of power demand growth would need to be investigated, and a generation solution which is flexible to future expansion may be required.

The vision, opportunities and economic benefit of utilities synergy were discussed within the ANSIA Structure Plan. As such it is not a new idea, however limited implementation is tangible within the more recent reports. Future stage Development Plans will need to address a collaborative approach to the provision of infrastructure with reference to opportunities for a co-ordinated approach to servicing, to the satisfaction of the Shire of Ashburton (URBIS, 2014b). By gaining an understanding of the barriers to synergy, for example those leading to OPIUP finding no practical use for waste heat (Horizon Power, 2014) despite the proximity to OWIUP desalination, future studies may more effectively identify measures to deliver the cost efficiencies.

4.12 Telecommunications

4.12.1 Relevant Studies

The provision of telecommunications has been addressed to a limited extent within previous studies, with information on this subject also provided by various Development Plans.

The following technical reports have contributed to this section:

- Serling, Aug 2010, "North Ashburton Strategic Industrial Area Structure Plan Service Infrastructure Report".
- Cossill and Webley, Aug 2013, "Ashburton North GIA Outline Development Plan

4.12.2 Key Findings

As an indication of the availability of telecommunications in the area, the reports reference services in Onslow including: Telstra telephone landlines, ADSL, wireless mobile phone, 3G data coverage, and satellite internet access (Cossill & Webley, 2013). There are a number of communications towers in the town for television and emergency services amongst other functions (Serling Consulting, 2010).

The ANSIA Structure Plan [Stage 1] proposed telecoms within the 20m common utilities corridor on the south side of the MUAIC to include Telstra 36 bit core fibre line. Further telecoms infrastructure was proposed to be provided by proponents on their own land as required (Taylor Burrell Barnett, 2011). During investigation for the eastern GIA, it was understood that Chevron had previously negotiated a high speed telecoms network to the TWA and Wheatstone plant site, and that further negotiations with Telstra for the GIA would be required (Cossill & Webley, 2013). Primary routes for this network were deemed likely to be placed within the MUAIC (Taylor Burrell Barnett, 2012).

4.12.3 Gaps and Recommendations

Overall, the provision of telecoms has not been found to be problematic for the development thus far. However, given the substantial area intended for future industry and associated technical systems within the ANSIA, it is recommended that the telecoms infrastructure requirements for the fully developed scenario are investigated and analysed. This could potentially be included within future servicing reports.

With regard to infrastructure already installed at the ANSIA, the suitability of reusing the ducts or cabling is not clear from the previous reports. Determining the most efficient means of meeting the telecommunications requirements considering the infrastructure already in-place should be an objective of future servicing reports. This is likely to require enquiries to Telstra, as well as possible on-site investigations, to identify where upgrades may be required.

5 Conclusions

To support the adoption of an Improvement Scheme and Guide Plan over the ANSIA, further strategic engineering advice is recommended, utilising this gap analysis report as a basis. Numerous linkages between the engineering fields exist, which enables the opportunity for efficient sequencing of future studies.

Initial focus should be targeted on investigations with the longest expected duration and which lead in to other activities. Consequently the following are recommended:

- Investigation to remove uncertainty regarding short-term and long-term water supply, for current and future stages of ANSIA;
- Infilling of gaps in the landform classification mapping as this relates to several other engineering fields;
- Clarify the validity of flood modelling results within the gap between the original hydrological sub-catchments and the Improvement Scheme boundary.

Identification of future viable development areas should be undertaken through collaboration of the following engineering aspects:

- Supplementary landform mapping, as highlighted above;
- Engineering advice, primarily the combined earthworks, stormwater management and geotechnical/ASS benefits of utilising ground at naturally higher elevation;
- Integration with Town Planning, Environmental, Social and Economic considerations, including possible sharing of spatial data utilising Geographic Information Systems (GIS).

Determining the opportunities and barriers for synergy is a key initiative linking water, wastewater and power. This understanding should be gained to inform co-location of industry types and appropriate clustering of potential future proponents, within the identified viable areas.

Once indicative areas of different types of industry are available, the matching of water demand estimates with water recycling/synergy opportunities should be fed into the water supply investigation. This will enable more meaningful evaluation of the supply options, considering the ‘business as usual’ and ‘total water cycle efficiency’ scenarios. Similarly, for power supply and telecoms investigation and enquiries, the initial areas of each type of industry would provide a useful basis for demand considerations.

Traffic investigations will also benefit from confirmation of previously reported information, such as land use assumptions, projected staffing levels etc., and new information for the proposed expansions areas in order to adequately quantify traffic impacts. It is notable that any requirements of future proponents for close transport connectivity, for example to the port or Onslow Road, will need to be considered alongside opportunities for synergy and co-location of shared-services industry.

Areas of development set at the appropriate design level, will be a major input into initial earthworks and flooding investigation. Concept design planning of the roads and drainage infrastructure would then utilise these investigations. Based on these plans, site investigations such as geotechnical and ASS would be targeted to specific areas.

For the planning of engineering investigations, due consideration should be given to the cumulative impacts of the future ANSIA as a whole. Any potential benefit arising from synergies and early implementation of the servicing infrastructure should be assessed, to potentially reduce costs for individual developments, and increase attractiveness for proponents.

6 References

References

AECOM. (2010). *ANSIA Structure Plan Environmental Assessment.*
Arup. (2010). *ANSIA Concept Design Planning Study.*
Arup. (2014). *ANSIA Fill and Basic Raw Materials Study.*
Australian Soil Resource Information System. (2014). *Acid Sulfate Soils Online Mapping Data.* http://www.asris.csiro.au/index_ie.html.
BG&E. (2011a). *ANSIA Access Road Corridor Study Part A: Route Selection Report.*
BG&E. (2011b). *ANSIA Basis of Design for Hydrological Planning Study.*
BG&E. (2011c). *Hydrological and Planning Study Summary.*
BG&E. (2012a). *ANSIA GIA [eastern] Flood Study.*
BG&E. (2012b). *ANSIA Local Water Management Strategy.*
BG&E. (2013). *Ashburton North Eastern GIA Urban Water Management Plan.*
CCR. (2012). *ANSIA Industrial Ecology Strategy Concept Plan.*
Coffey. (2010). *Final Interpretative Report Onshore Geotechnical Investigation Ashburton North Site.*
Cossill & Webley. (2013). *Ashburton North GIA (East) Outline Development Plan Engineering Report.*
ENV. (2010). *ANSIA District Water Management Strategy.*
ENV. (2011). *ANSIA Stage 1A Local Water Management Strategy.*
ENV. (2012). *ANSIA Preliminary Acid Sulfate Report.*
ExxonMobil website. (13th Jan 2015). *What we do Western Australia Scarborough.* http://www.exxonmobil.com.au/Australia-English/PA/about_what_wa_scarborough.aspx.
Galt Geotechnics. (2011). *Geotechnical Desk Study for ANSIA [Stage 1B].*
Galt Geotechnics. (2013). *Geotechnical Study for Eastern GIA ANSIA.*
Geological Survey of Western Australia. (1981). *Onslow; Australia 1:250,000 Geological Series.*
GHD. (2012). *Ashburton North GIA Interim Servicing Options Study.*
Golder. (2011a). *Geotechnical Investigation, Quick Mud Creek Crossing, Plant Site Access Road, Macedon Gas Development Project, Geotechnical Services Package 3, Onshore Works.*
Golder. (2011b). *Wheatstone Phase 3 Downstream Geotechnical Investigation Final Evaluation Report.*
Horizon Power. (2014). *Onslow Power Infrastructure Upgrade Project Supporting Documentation.*
LandCorp. (2014). *Request for Proposal; Engineering Consultant; ANSIA.*
Riley. (2011). *ANSIA Traffic Impacts and Road Network Review.*
Serling Consulting. (2010). *North Ashburton Strategic Industrial Area Service Infrastructure Report.*
Taylor Burrell Barnett. (2011). *ANSIA Structure Plan.*
Taylor Burrell Barnett. (2012). *Wheatstone Development Plan.*
TPG. (2012). *ANSIA Stage 1B & 1C Development Plan Report.*
URBIS. (2014a). *ANSIA Background Review.*
URBIS. (2014b). *ANSIA GIA Eastern Portion Outline Development Plan.*
URBIS. (2015). *ANSIA Improvement Plan No. 41.*
URS. (2010a). *Draft Report ANSIA Surface Water Studies.*
URS. (2010b). *Wheatstone Project - Access Road Design. Flood Modelling and Impact Assessment.*
URS. (2010c). *Baseline Soil Quality and Landforms Assessment.*
Water Corporation. (2014a). *Onslow Water Infrastructure Upgrade Project (OWIUP) Environmental Referral Supporting Document.*
Water Corporation. (2014b). *Letter from Water Corporation to LandCorp regarding Ashburton North General Industry Area Feasibility Study for Potable Water Supply.*

7 Appendices

Appendix A

Index of Technical Reports
Relating to ANSIA Projects

ARUP

Index of technical reports containing design information related to ANSIA projects. All report titles are written as they appear on the title page of the report.

Report Date	Consultant	Report Title	Subject	Produced for (project name), as stated in report	Appendix of (report name)
Apr-10	Coffey	Final Interpretative Report Onshore Geotechnical Investigation Ashburton North Site	GTH, ASS	Wheatstone	Standalone
May-10	URS	Baseline Soil Quality and Landforms Assessment	GTH, ASS	Wheatstone	Wheatstone Draft Environmental Impact Statement (Technical Appendix)
May-10	URS	Wheatstone Project Surface Water Studies	STM, WAT	Wheatstone	Wheatstone Draft Environmantal Impact Statement (Technical Appendix)
Feb-11	Golder	Wheatstone Phase 3 Downstream Geotechnical Investigation, Final Onshore Factual Report	GTH, ASS	Wheatstone	Standalone
Feb-11	Golder	Wheatstone Phase 3 Downstream Geotechnical Investigation Final Evaluation Report	GTH, ASS	Wheatstone	Standalone
Feb-11	Golder	Factual Report Potential Acid Sulfate Investigation Wheatstone Phase 3	ASS	Wheatstone	Standalone
Sep-11	Golder	Geotechnical Investigation, Quick Mud Creek Crossing, Plant Site Access Road, Macedon Gas Development Project, Geotechnical Services Package 3, Onshore Works	GTH	Macedon and Access Road	Standalone
Sep-10	Arup	ANSIA Concept Design Planning Study	All disciplines	ANSIA	Standalone
Jul-11	TBB	ANSIA Social Impact Statement	-	ANSIA Stage 1	ANSIA Structure Plan
Nov-10	AECOM	ANSIA Environmental Assessment	-	ANSIA	ANSIA Structure Plan
Nov-10	SKM	Chevron Wheatstone Project, Cumulative Air Quality Modelling for Stage 1 of the ANSIA	-	ANSIA Stage 1	ANSIA Structure Plan
Nov-10	SVT	Cumulative Noise Impact Assessment for the Ashburton North Industrial Area	-	ANSIA	ANSIA Structure Plan
Aug-10	ENV	ANSIA District Water Management Strategy	WAT, STM, ASS	ANSIA	ANSIA Structure Plan
Sep-10	URS	Draft Report, ANSIA Surface Water Studies [AKA Cumulative Impacts Study]	STM	ANSIA Stage 1	ANSIA Structure Plan
Dec-10	URS	Wheatstone Project Access Road Design Flood Modelling and Impact Assessment	STM, RDW	Wheatstone	ANSIA Structure Plan, ANSIA Stage 1A LWMS
Nov-10	Arup	ANSIA Draft Structure Plan Transport and Access Report	TRF	ANSIA Stages 1A and 1B	ANSIA Structure Plan
Sep-09	Transcore	Draft Chevron Wheatstone Project Transport Assessment	TRF	Wheatstone	ANSIA Structure Plan
Aug-10	Serling	North Ashburton Strategic Industrial Area Structure Plan Service Infrastructure Report	WAT, PWR, TEL	ANSIA	ANSIA Structure Plan
Mar-12	Chevron	Wheatstone Project Social Impact Statement	-	Wheatstone	Wheatstone Development Plan [AKA ANSIA Stage 1A]
Jun-12	Chevron	Wheatstone Project Construction Workforce Management Plan	-	Wheatstone	Wheatstone Development Plan [AKA ANSIA Stage 1A]
Feb-12	i3	Construction Traffic Management Plan	TRF	Wheatstone	Wheatstone Development Plan [AKA ANSIA Stage 1A]
Jan-12	Chevron	Wheatstone Project Mosquito Management Plan	-	Wheatstone	Wheatstone Development Plan [AKA ANSIA Stage 1A]
Jun-11	ENV	ANSIA Stage 1A Local Water Management Strategy	WAT, STM	ANSIA Stage 1A	Wheatstone Development Plan [AKA ANSIA Stage 1A]
Jan-12	Chevron	Wheatstone Project LNG Plant Bechtel Fire Prevention and Control Plan	-	Wheatstone	Wheatstone Development Plan [AKA ANSIA Stage 1A]
Jan-12	ENV	ANSIA Biological Desktop Review	-	ANSIA	ANSIA Stage 1B & 1C Development Plan
Jan-12	ENV	ANSIA Flora and Vegetation Assessment	-	ANSIA	ANSIA Stage 1B & 1C Development Plan
Jan-12	ENV	ANSIA Fauna Assessment	-	ANSIA	ANSIA Stage 1B & 1C Development Plan
Jan-12	ENV	ANSIA Preliminary Acid Sulfate Soil Report	ASS	ANSIA Stage 1B	ANSIA Stage 1B & 1C Development Plan
Jan-12	CCR	ANSIA Industrial Ecology Strategy Concept Plan	WAT, PWR	ANSIA Wheatstone, Macedon and Scarborough	ANSIA Stage 1B & 1C Development Plan
Nov-11	Galt	Geotechnical Desk Study for ANSIA	GTH	ANSIA Stage 1B	ANSIA Stage 1B & 1C Development Plan
Jun-11	BG&E	Hydrological and Planning Study Summary	STM	ANSIA	ANSIA Stage 1B & 1C Development Plan
Jan-12	BG&E	ANSIA Local Water Management Strategy	WAT, STM	ANSIA Stage 1B & 1C	ANSIA Stage 1B & 1C Development Plan
Jan-11	BG&E	ANSIA Basis of Design for Hydrological Planning Study	STM	ANSIA	ANSIA Local Water Management Strategy
Dec-11	TPG	ANSIA Stage 1B and 1C European Heritage Technical Study Report	-	ANSIA Stage 1B & 1C	ANSIA Stage 1B & 1C Development Plan
Nov-11	Riley	ANSIA Traffic Impacts and Road Network Review	TRF	ANSIA	ANSIA Stage 1B & 1C Development Plan
May-11	BG&E	ANSIA Access Road Corridor Study Part A Route Selection Report	RDW	ANSIA MUAIC eastern and western	ANSIA Stage 1B & 1C Development Plan
Aug-11	Riley	Technical Note, ANSIA Truck Laydown Area Review	TRF	ANSIA	ANSIA Stage 1B & 1C Development Plan
May-12	Landcorp	Landcorp Social Impact Statement for the Shire of Ashburton Local Planning Policy 20	-	ANSIA	ANSIA Stage 1B & 1C Development Plan
Jan-13	Riley	Technical Note, Ashburton North Eastern GIA Subdivision Traffic Review	TRF	ANSIA eastern GIA	ANSIA General Industrial Area Eastern Portion Outline Development Plan
Aug-13	C&W	Ashburton North GIA (East) Outline Development Plan Engineering Report	STM, EWK, RDW, WAT	ANSIA eastern GIA	ANSIA General Industrial Area Eastern Portion Outline Development Plan
Aug-13	Galt	Geotechnical Study Eastern GIA ANSIA	GTH, ASS	ANSIA eastern GIA	Ashburton North GIA (East) Outline Development Plan Engineering Report
Dec-12	BG&E	ANSIA GIA Flood Study	STM	ANSIA GIA Area 5 [eastern]	ANSIA General Industrial Area Eastern Portion Outline Development Plan
Oct-12	GHD	Ashburton North GIA Interim Servicing Options Study	WAT, PWR	ANSIA eastern GIA	Standalone
Nov-13	BG&E	Ashburton North Eastern GIA Urban Water Management Plan	STM, WAT	ANSIA eastern GIA	Standalone
May-14	Arup	ANSIA Fill and Basic Raw Materials Study Fill Sourcing Study Assessment Report	EWK	ANSIA	Standalone
Aug-14	WaterCorp	OPIUP Supporting Documentation for the Environmental Referral for the Department of the Environment	PWR	OPIUP	Standalone
Mar-14	Horizon	OWIUP Environmental Referral Supporting Document	WAT	OWIUP	OWIUP Referral under S38 of the Environmental Protection Act
Oct-14	Urbis	Draft Report, ANSIA Background Review [context for Improvement Plan]	-	ANSIA Improvement Plan	Standalone
Jan-15	Arup	ANSIA Engineering Gap Analysis Report	All disciplines	ANSIA Improvement Plan	Standalone

Note 1: Disciplines: STM = stormwater and flooding, GTH = geological and geotechnical, ASS = acid sulfate soils, EWK = earthworks, TRF = Traffic managment, RDW = road works and alignments, WAT = water quality management, water supply, and wastewater, PWR = power, TEL = telecommunications