THE SCIENTIFIC INQUIRY INTO HYDRAULIC FRACTURING IN THE NORTHERN TERRITORY

PANGAEA

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Tim Radburn
Executive Director
Pangaea Resources Pty Ltd

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INTRODUCTION

Pangaea welcomes the opportunity to make a submission to *The Scientific Inquiry into Hydraulic Fracturing in the Northern Territory.*

Pangaea is a member of APPEA and the NT Onshore Operators Forum, which consists of 15 petroleum exploration companies in various stages of the upstream exploration phase. The majority of these companies are exploring for shale resources in the Northern Territory (NT).

Pangaea holds exploration permits across a series of stacked sedimentary basins which include the Greater McArthur and Roper basins, which encompasses the Beetaloo Sub-basin. The Northern Territory Geological Survey has recognised these basins as having vast potential for shale resources.

About Pangaea

Established in 1997, Pangaea is an independent Australian exploration and production company with a diverse portfolio of oil and natural gas operations across onshore Australia.

Pangaea employs a collaborative approach in all our activities. We believe our stakeholders, including our employees, partners, local communities, service providers, government and regulatory bodies, all have the shared objective of safely developing Australia's energy resources.

Our team and subcontractors give priority to safety and we are proactive in quality, health, safety and environmental awareness and protection. We strive to exceed compliance standards in state and federal regulations.

Pangaea has a very responsible, culturally sensitive and direct engagement approach with regards to Native Title negotiations and has been very successful in building relationship and trust which is the key to operating in Australia.

Our exploration approach usually commences with airborne magnetic and gravity surveys to identify favourable areas with petroleum potential and to focus seismic surveys. This is followed by well-designed, culturally and environmentally-conscious seismic surveys and, if warranted, drilling programs. These are all undertaken in consultation with local stakeholders.

Ultimately, we seek to produce energy resources through proven, safe exploration and engineering operations whilst continuously incorporating state-of-the-art methodologies in order to achieve a high standard of operating excellence.

Pangaea's interests in the Northern Territory

Pangaea holds exploration permits (EP) 167, 168 and 169 located 450 km south of Darwin, adjacent to the towns of Elliot and Katherine in the Northern Territory, and EP 198 and EP 305 located in the north-eastern Western Greater McArthur Basin approximately 600 km south of Darwin near the town of Yarralin.

The eastern portions of EP 167 and EP 168 are traversed by the Stuart Highway, the Darwin-Tarcoola Rail Track and the Amadeus Gas Pipeline. These three blocks are within the Beetaloo Sub-basin which contain thick sequences of organic rich source rocks (shale) capable of generating significant quantities of oil and natural gas.

Pangaea has undertaken major exploration work programs in its tenements and has significantly exceeded its required expenditure commitments. Pangaea's technical focus in the last several years has centred on the unconventional potential of the Beetaloo Sub-basin. The accumulated knowledge acquired through our work programs which have included, 7 wells, 1,800 line km 2d seismic, 29,000 line km airborne gravity, 3,539 metres of core, two (2) DFIT's and two (2) vertical well stimulations has systematically and scientifically allowed us to define areas for development and production, and provide focus for additional appraisal and exploration.

In 2016, Pangaea lodged a Petroleum Discovery Notice with the Northern Territory Government in regard to its exploration permits EP167 and EP168, this Notice was accepted by the Northern Territory Government in March 2016. In June 2016, Pangaea undertook early relinquishment of the northern portion of one of its tenements, EP167, after finding the area not commercially prospective following its extensive exploration program.

'THE NT WAY'

Pangaea has a long-term focus towards community integration through working with traditional owners, local content and the government. Examples of the way that Pangaea uses local content include: employing pastoralists in seismic preparation; traditional owners in civil access and construction works; environmental baseline assessment by a leading local NT environmental consultancy; water bore drilling by a local NT driller; locally employed civil earthworks contractors; local waste disposal companies local camp and accommodation companies; local civil infrastructure engineers; local indigenous training organisations; and multiple local Landmen for pastoralist liaison, operations supervision and management.

"I can't help thinking that if the gas industry as a whole and the Northern Territory government had been as communicative, open, and as effective in dealing with the general public as Pangaea has been with the Sturt Plateau producers and traditional owners that we might all be in a much better informed position today"

Tom Stockwell, President NTCA, 17/3/2016 address to Northern Territory Cattlemen's Association 32nd Annual Conference

"I am here with Pangaea today as partners to a project that has delivered exceptional outcomes. These outcomes, I have overseen over so many years are aspired to be met by many companies, yet very few deliver.

In fact when I first met with Tim and we discussed the project – I had quietly thought he may be a little too ambitious – but he and the men standing here today have proven me wrong. And I have to stay that it is not too often that this happens and … today is a great day."

Leanne Liddle, Northern Land Council, re: Indigenous Employment Training Pilot Program, September 2015, Graduation Day

As a company that values integrity and responsibility to community, Pangaea continue to prioritise the social licence to operate amongst Traditional Owners, Pastoralists, other stakeholders and the Northern Territory Government at its strategic Board level in order to ensure it operates 'The Northern Territory Way' across its Exploration Permits.

PUBLIC BENEFIT

Territory-wide

The Northern Territory's onshore unconventional gas industry can help underpin initiatives across the top end for new business, unlocking the full potential of the Federal Government's $5 billion Northern Australia Infrastructure Fund.

The industry has the potential to overcome 'peaks and troughs' in the Northern Territory economy by providing long term economic benefits, the potential for an affordable supply of energy for manufacturing and establishment of new industries based on by-products.

The opportunities for infrastructure which will benefit remote regions of the Northern Territory includes not just roads, but bridges and other transport facilities as well. Pangaea notes the negligible impacts that the oil and gas industry creates on the agriculture and horticulture industries in the Northern Territory.

The industry has the potential to both overcome fuel supply issues in the Northern Territory and the opportunity for processing to be undertaken here instead of overseas.

Further, with the imminent construction of the Northern Gas Pipeline, the Northern Territory could become a key component of the national energy security system of Australia.

Public Benefit

Pangaea's focus on the Beetaloo Sub-basin underpins multiple economic benefits, in synergy with pastoralists and government development strategies.

In 2015 Pangaea initiated discussions for the sealing of Western Creek Road. The initiative was widely supported by pastoralists and government agencies who appreciated the public benefit that would come from having access to an all-weather cattle station access road year-round. Pangaea contracted a local engineering firm to design, submit and project manage the works before it was postponed due to the moratorium on hydraulic fracture stimulation.

The benefits to pastoralists of the improved access from the sealing of Western Creek Road cannot be underestimated. The ability for pastoralists to move cattle year-round would be greatly beneficial not only to the pastoralists, but for wider public benefit.

The further development of Pangaea's tenements would include working closely with stakeholders and government agencies to map a path to wider public benefit initiatives such as increased access to station water through the construction of both bores, dams and research into potential alternative water sources.

RESPONSE TO THE BACKGROUND AND ISSUES PAPER (20 FEBRUARY 2017)

The following tables attempt to respond to the potential risks of the hydraulic fracturing of onshore unconventional shale reservoirs and its associated activities in the Northern Territory[1] may have on the theme areas identified in the Background and Issues Paper. Pangaea operates in accordance with all Northern Territory current regulations and international oil & gas field best practice (refer Table 7.9 'Regulatory Framework').

Pangaea's 2016 NT Appraisal Campaign EP 167 & EP 168 Environmental Management Plan (EMP) (submitted to the Northern Territory Government) is attached as Appendix A – the work was postponed due to the impending moratorium on hydraulic fracturing and stimulation. Also attached as Appendices B – G are the EMP Summaries (EMPS) for Pangaea's exploration works from 2014 - 2015. Responses below have been drawn in the first instance from Pangaea EMP's which have been thoroughly reviewed and approved by the Northern Territory Department of Mines and Energy and the Northern Territory Environmental Protection Agency under all applicable laws and regulations including the NT Petroleum (Environment) Regulations[2] and Schedule of Onshore Petroleum Exploration and Production Requirements (2016)[3] before operations commence. Please note that these EMPs were written under the previous Schedule of Onshore Petroleum Exploration and Production Requirements (2012) rather than the current 2016 version.

Site Induction & Training

Pangaea ensures that all relevant personnel undertake an *environmental induction* before working on-site to minimise all potential environmental impacts. A particular focus is on the use of spill kits to contain any chemical, fuel or oil spills, cultural heritage protection and prevention of soil erosion. The session is compulsory for all personnel and service providers and covers:

- Purpose & objectives of the EMP;
- Requirements of due diligence and duty of care;
- Conditions of environmental licences, permits and approvals;
- Environmental emergency response;
- Management and reporting process for environmental incidents;
- Lessons learnt from environmental incidents;
- Environmental controls that are identified in the EMP;
- Weed management and clean down provisions;
- Fire control and prevention;
- Land access;
- Site-specific issues including, but not limited to those detailed in the EMP;
- Environmentally sensitive areas; and
- Cultural Awareness Training.

Records of attendance at the environmental induction are maintained by the Pangaea Representative on site.

[1] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory *Background and Issues Paper* (20 February 2017) 3 <https://frackinginquiry.nt.gov.au/news>.

[2] Petroleum (Environment) Regulations 2016 (NT).

[3] Northern Territory Government *Schedule of Onshore Petroleum Exploration and Production Requirements 2016* (2016) <https://nt.gov.au/industry/mining-and-petroleum/about-mineral-and-energy-resources-in-the-nt/laws-and-regulations>.

RISK THEMES

Water

In 2015, Pangaea contracted a local Northern Territory environmental consultancy to produce regionally extensive environmental baseline studies within Pangaea's exploration permits in the Beetaloo Sub-basin covering approx. 16 million acres. The studies are attached as Appendix H Surface and Groundwater Characterisation Report[4] and Appendix I Flora and Fauna Characterisation Report[5]. Both studies found no major risk areas, no conservation reserves, low to moderate fire frequency, no endangered species and weeds manageable through proper procedures. The recommendations from these studies were for a surface water monitoring program and water extraction impact plan to be considered.

Throughout its exploration activities, Pangaea has undertaken regional baseline water studies (attached as Appendix J) through the analysis of water samples from identified water bores at various times throughout the drilling campaigns. This analysis provides an understanding of the baseline aquifer characteristics that Pangaea intends to continue to build on and shares with the NT Government.

Pangaea, through the engagement of EcOz Environmental Consultants, assesses and monitors regionally extensive registered bores. The data (and associated analysis) forms the basis of a baseline assessment of groundwater conditions, including (but not limited to) details on standing water levels, and groundwater quality in the region (refer Appendix J).

Sampling has been ongoing for three years (prior to the initiation of the Northern Territory Moratorium on Hydraulic Stimulation) and will continue to be tested when operations re-commence, at a minimum on the full spectrum of testing, on a bi-annual basis. EcOz Environmental Consultants, as part of monthly environmental audits, will continue to monitor electronic downhole water loggers (11), as well as other groundwater, soil, air, flora and fauna conditions. Pangaea supports current regulations required for groundwater water monitoring and testing.

Testing is in accordance with a consistent methodology employing best practice techniques and equipment, and appropriate quality assurance and quality control which ensures that the risk of contamination is minimised in the collection of samples for testing. The development of the methodology was tailored to site specific and operational conditions and draws upon:

- Groundwater Sampling and Analysis - A Field Guide[6]; and
- AS/NZS 5667:1998 Water Quality - Guidance on Sampling of Groundwater[7].

Prior to Pangaea commencing its NT exploration campaign in 2012 Pangaea spent a considerable amount of time attempting to collate available government hydrology data for the region. Ultimately, very little was known about groundwater conditions in the region as they had not previously been documented in detail. Parameters that are measured in the field include pH, specific conductivity, electrical conductivity (EC), temperature, dissolved oxygen (DO) and redox potential (Eh). Field parameters are measured in a flow cell to avoid contact and contamination between the groundwater and the atmosphere. Field parameters are measured using a multi-parameter meter

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[4] EcOz Environmental Consultants *Surface and Groundwater Characterisation Report* (2015).

[5] EcOz Environmental Consultants *Flora and Fauna Characterisation Report* (2015).

[6] Geoscience Australia *Groundwater sampling and analysis – a field guide* (2009) <http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_68901>.

[7] SAI Global *Water quality – sampling – guidance on sampling of groundwaters* AS/NZS 5667.11:1998 (R2016) <https://infostore.saiglobal.com/store/details.aspx?ProductID=387183>.

calibrated against known standards before each use according to manufacturer's requirements. Calibration records are kept detailing the date, time and values of each calibration.

Laboratory sampling tests for all elements proposed to be used 'down-hole' during drilling plus major cations, major anions, alkalinity and hardness, a selection of dissolved metals, methane, nutrients, tannins, silica (reactive), TRH, TPH and BTEXN. Note that the cations/anions and dissolved metal suites will cover the major constituents of bentonite, KCl, NaCl, NaOH and lime (i.e. $CaO/Ca(OH)_2$).

Table 7.1 Water from Background and Issues Paper[8]

Value	Risk	Pangaea Response
Water Quality	**Groundwater** There may be a risk of groundwater contamination as a result of: 1. induced connectivity between hydraulically fractured shale formations and overlying or underlying aquifers; 2. surface spills of chemicals, flowback water or produced water into near-surface groundwater; 3. leaky wells as a result of poor design, construction, operation or abandonment practices or as a result of well degradation over the life of the well; 4. re-injection of flowback water, produced water or treatment brines into a groundwater aquifer; and/or 5. induced connectivity between different groundwater systems as a result of seismic activity caused by hydraulic fracturing or reinjection of water.	To protect against the risk of groundwater contamination, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Water Act (2011) – Part II, Division 2 (29) (page 24) • Waste Management and Pollution Control Act (2014) • Petroleum (Environment) Regulations (2016) • Dangerous Goods Act (2012) • An Explanatory Guide to Petroleum (Environment) regulations - 3.9.2.2 Baseline Water Monitoring; 3.10 Environmental risk assessment; 3.11.2 Environmental Performance Standards; 3.13 Reporting; • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) 306 'Casing' 325 'Protection of Aquifers', 326 'Production or Drill Stem Tests', 329 'Abandonment of a Well', 342 'Hydraulic Fracturing', 418 'Waste or Contamination of Petroleum or Water'

[8] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, above n 1, 16.

	<u>Surface Water</u> There may be a risk of impacts on surface water quality as a result of the following types of incidents: 6. on-site spills, including as a result of extreme weather events such as cyclones and floods; 7. spills that occur during transportation of chemicals to or from the site during the development and production phases; and/or 8. spills of flowback water, produced water or brines produced by water treatment.	• API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 52 Land drilling practices for protection of the environment (R2010) • API RP 53 Recommended practices for blowout prevention equipment systems for drilling wells • API RP 54 Recommended practice for occupational safety for oil and gas well drilling and servicing • API RP 59 Recommended practice for well control operations (R2006) • API RP 100-1 Hydraulic fracturing – well integrity and fracture containment, First edition (2015) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF1 Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines (2009) • API GD HF2 Water management associated with hydraulic fracturing (2010) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • API Standard 65 – Part 2 Isolating potential flow zones during well construction • ISO 14001:2004 Environmental management systems - Standard • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 <u>Subsurface Protection</u> The risk of induced connectivity between hydraulically fractured shale formations and any overlying/underlying freshwater aquifer systems is considered to be extremely low risk. Groundwater aquifers are isolated by several steel casing and cement layers. The well design and construction provides the mechanical integrity within the wellbore to

		protect the aquifers from any leakage during stimulation, flowback operations, and the life of the well. Pressure testing of the casing strings ensures the casing designs are suitable to endure the fracture stimulation process under all the operating conditions that the well is expected to experience. Cement bond logs confirm the integrity of the cement between the casing/wellbore which prevents migration. The shallow freshwater Cambrian Limestone Aquifer (CLA) systems that are utilised by the pastoralists and communities in the region are separated from the middle Velkerri Formation shale reservoirs in the Beetaloo Sub-basin by multiple thick shale, siltstone and volcanic aquitards. The vertical distance between the shale target and the aquifer systems is typically over 1000 m. In addition to the significant vertical distance between the Cambrian Limestone Aquifer systems and the middle Velkerri Formation shale reservoirs, lithological and geomechanical data collected from core and downhole wireline geophysical logs have identified multiple rock units which act as confining barriers to vertical fracture propagation from hydraulic fracture stimulations. These confining units are regionally extensive and occur directly above, within and directly below the middle Velkerri Formation shale reservoirs. ***What prevents oil, gas, and water moving uphole into fresh water aquifers and/or the surface - both during and after production of oil and gas?*** A properly constructed and, after production, properly abandoned well, combined with geologic factors that prevent fluid movements in naturally occurring conditions, prevent the movement of fluids uphole and / or to the earth's surface. A physical barrier to upward flow is created by cement pumped into the space between the rock formations and the steel casing used to build a well. During the construction phase of a well, each string of casing is cemented into place. A hole is drilled, steel casing is run nearly to bottom of the hole, and cement is pumped through the inside of the casing to fill the space between the outside of the casing and the rock behind it. This sheath of cement also adheres the rock to the casing to provide a physical barrier to upward flow of fluids. Industry practice is to pump enough cement to fill more than 100% of the calculated volume behind the casing.

		Before casing is run in the hole, a caliper tool is run in the wellbore to determine where washouts or small collapse of rocks have left more void space than just the drilled diameter of rock. The approach to pump more than 100% of the calculated volume between casing and rock formations insures that an overwhelming portion of the void space is filled. The pumping of additional volumes of cement under pressure also causes cement to be pushed into fractures present at the wellbore and, in some cases, to fill pore space within the rock itself leading to significant reductions in permeability from porous rock units also. Some voids continue to exist, but they are rarely connected, and small cracks can develop as the cement cures. The discontinuous voids cause the cracks to dissipate out and help in preventing large scale cracks - similar to the way expansion spaces work between squares of cement in a sidewalk or driveway. Cementation should be conducted with the understanding of: • the temperatures downhole; • presence of gasses – like CO2 – in the subsurface; • chemistry of the mud used in drilling; • chemistry of the rock being adhered to; • pore pressures and fracture gradients of the rocks; and • the presence and depths of permeable rocks containing oil, gas, or water. Each of these factors, comes into play when a cement job is being designed. The specific additives and type of cement become very important in getting a good cement job. It is not always a good practice to attempt to fill all the void space between the casing and the rock. In some cases, this can cause fracturing of the rock itself and create pathways that one is attempting to seal. The density and height of the cement may, in some cases, act to cause these types of fractures. ***So what attributes does an effective cement job have?*** First, it must be able to withstand pressures during the next stage of drilling. To test this attribute, a meter or two of new rock is drilled after casing from the previous hole section, is set and

		cemented. Then, the driller applies pressure to the fluids in the wellbore until the pressures exerted either reach a point safely above the expected breaking point of the rock (a Formation Integrity Test or FIT), or until the rock itself fails (a Leak Off Test, or LOT). If the cement fails first, the pressure plot vs time will look different than if the rock breaks. Second, a cement bond log may be run inside of casing. This is typically done in cases where a new type of cement and associated additive mix is run and one wants to verify that it has filled the space as expected. It may also be run to verify that the critical zones which are permeable and fluid-filled have been securely cemented to avoid cross-flow between those levels. Should a pathway exist, or develop, during the production phase of the well, anomalous pressures will begin to be measured within the well. A high quality operation will closely monitor pressures throughout the production stage of the well. In the event that a cement job either has not gone to plan, or is compromised during the production phase, the cement job may be remediated. The details of how this is done will be dependent upon where the cement does not meet standards. If for example, it is at the casing shoe before the next stage of casing is run and cemented, a squeeze is conducted by pushing additional cement down through the bottom of the existing casing and under pressure into the cracked cement above until it is stable. If the problem is shallower in the wellbore, the casing may need to be perforated and cement squeezed through the perforations into the space behind the casing. The best thing to do – and most cost and time effective – is to perform the cement job using best practices for the specific area and not cut any corners on quality of cement or the method used to emplace the cement. The overall architecture of a wellbore combined with excellent cementing practices should address insuring that uphole, non-producing zones containing oil and/or gas are particularly well cemented. Identifying such zones and designing the details around where casing is set and how it is cemented is a powerful, proactive way to prevent shallow zones from flowing uphole, or across to shallower formations. This is done as

		a measure to insure future drilling does not encounter dangerous situations of pressure build ups in these shallower zones as well as preventing environmental issues in the near-surface or surface. After production has concluded, several additional factors prevent fluid flow. First, cement, often in combination with steel bridge plugs are inserted into the inside of the wellbore at various levels. These cement and steel plugs provide long term barriers to fluid flow up the inside of the wellbore. They create segmented pressure cells should the casing ever corrode and/or be broken by acidic fluids coming from the local geologic setting or tectonic stresses over time. The internal plugs are each pressure tested for assurance during the abandonment stage and are re-cemented in the rare cases where they fail the pressure tests. After downhole and surface plugs are set, the well head equipment and casing will be removed to a specified depth below ground level or mud line. After which an abandonment marker plate will be installed as specified by government requirements. Another important aspect to this discussion is the pressure profile within the reservoir itself. During production, the formation pressures may be drawn down by upwards of 80% for permeable reservoirs initially filled with natural gas, and usually over 30% in gas-filled shale reservoirs requiring hydraulic fracturing to be able to flow gas to surface. If a pathway exists, fluids will flow from higher to lower zones of pressure. This means that fluids initially prefer to flow upward (vertically) if there is a pathway. Geological constraints are naturally present (or almost all oil and gas would have already found its way into the atmosphere through the geologic millennia). After the wellbore is plugged, the fluids left in the reservoir are no longer capable of flowing upward because the lowest pressures within a pathway are into - not out of - the reservoir. If the cement behind casing is continuous over even a tiny portion of the 30% of the bottom of the wellbore, the fact that fluids flow toward the lowest pressure in the path insures that fluids from the reservoir will not move upward. Cement plugs should also be set inside casing adjacent to zones bearing hydrocarbons or permeable water-bearing zones. The placement of cement insures that the cement external to the casing and the casing itself is not compromised by corrosive fluids or

		tectonic stresses over long periods of time. If fluids do gain a path into the casing, the presence of several layers of cement plugs should mitigate the risk of the fluids continuing to move into a place where environmental harm is possible. ***So then, some people ask, how does one explain the presence of methane in fresh water aquifers or hydrocarbons bubbling up to the ground?*** First, methane and oil, through hundreds of thousands to millions of years of geologic time - often in connection with the occurrence of large earthquakes - do naturally occur as seeps. Methane, in small amounts, has been observed in a significant percentage of water wells tested in the Beetaloo Sub-basin region in the Northern Territory. This methane was present well before any drilling for hydrocarbons occurred in these areas. Second, older oil and gas wells and deep borings to explore for minerals can be pathways to fluid flow if they were drilled deep enough to intersect with modern hydraulic fractures. This is much more likely in areas of the world like Pennsylvania, USA, where thousands of wells were drilled and abandoned long before regulations regarding drilling and abandonment of wells were established. If any deep, unplugged wells exist within the reach of the lateral extent (a maximum of about 2 km from a wellbore) of an area targeted for hydraulic fracturing, these wells should be properly cemented before any horizontal drilling and hydraulic fracturing occurs. With modern well architecture, construction, and abandonment, the possibility of leaks of fluids to freshwater aquifers or to the surface is extremely unlikely. Combined with the extremely small number of previously drilled wells in the Northern Territory, this possibility becomes almost impossible. Most induced seismicity associated with fracture stimulation is micro-seismicity and is not of a magnitude capable of deforming formations and creating migration pathways by breaching aquitards.

		<u>Surface Water Protection</u> To protect against the risk of impacts on surface and subsurface water quality, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act 2016 • Water Act (2011) • Waste Management and Pollution Control Act (2014) • Petroleum (Environment) Regulations (2016) • An Explanatory Guide to Petroleum (Environment) regulations - 3.10 Environmental risk assessment; 3.11.2 Environmental Performance Standards; 3.13 Reporting; • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) 325 'Protection of Aquifers', 329 'Abandonment of a Well', 418 'Waste or Contamination of Petroleum or Water' • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 52 Land drilling practices for protection of the environment (R2010) • API RP 53 Recommended practices for blowout prevention equipment systems for drilling wells • API RP 54 Recommended practice for occupational safety for oil and gas well drilling and servicing • API RP 59 Recommended practice for well control operations (R2006) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015)

		• API GD HF1 Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines (2009) • API GD HF2 Water management associated with hydraulic fracturing (2010) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 During stimulation and flowback operations; the flowback fluid passes through iron piping and wellhead equipment which is designed to meet the stresses and loads associated with the operations. All surface equipment associated with the pumping and flowback of stimulation fluid is pressure tested prior to commencing operations. Chemicals onsite are stored and handled in accordance with relevant standards and guidelines. Bulk fuel and chemicals are stored with appropriate secondary containment as required. Flowback stimulation fluid is stored in lined and fenced off temporary storage ponds which have been constructed to ensure the fluid is properly contained. The perimeter of storage ponds contains a ~1.5m bund (above ground level) to prevent seepage or release of any fluid. The ponds are constructed to withstand a 1-in-100 year rainfall occurrence and are monitored regularly and operated below maximum fill levels to prevent any overflow potential. Following flowback operations the fluid remains in the lined ponds to evaporate. Post-evaporation, pond liners are removed and disposed of to an appropriately licensed waste disposal facility. The ponds are all left to dry out, before being backfilled to return the areas to an appropriate slope (considering the landscape's 'pre-drilling' characteristics). If it appears that the water will not be fully evaporated by the time the wet season approaches the water is pumped out into an NTRS NT EPA Approved and

		licenced disposal vehicle before being taken to the nearest appropriately licenced NTRS EPA approved facility for disposal. The handling and storage of flowback fluids complies with the Schedule of Onshore Petroleum Exploration and Production Requirements 2016, in which formation water and other waste fluids produced from a well shall be disposed of in a manner which does not cause risk to public health or safety or cause the contamination of water or land not specifically designated for waste disposal. There are many variables that need to be considered when evaluating water treatment options for hydraulic fracturing flowback and produced water during the production phase. These can include the removal of Total Suspended Solids (TSS) (and disinfection), Total Dissolved Solids (TDS), oil and grease and Hardness. Hence, there is no single water treatment technology that removes all of these constituents, and multiple water treatment technology may be required depending upon the specific water chemistry[9] (refer attached Appendix K Improving the Water Efficiency of Unconventional Development). Based water chemistry flow back analysis Pangaea has completed over a number of years with leading US Water Chemistry experts we are confident that 100% of the flow back / produced water in ongoing completions will be able to be re-used. Based on expected flow back volumes, Pangaea anticipates large capacity flow back ponds where aeration could be used to combat organics and bacterial growth while allowing for gravimetric separation of suspended solids. There are friction reducers (and biocides and scale inhibitors) suitable for use in water of the constituency expected so options also include either using the water straight in a completion method or diluted to some degree with additional water.

[9] Schlumberger '*Improving the Water Efficiency of Unconventional Development*' 20.

		<u>Mitigation Measures & Strategies</u> • Pangaea's Corporate Quality, Health, Safety and Environmental Policy is adhered to (Appendix L). • The Ground and Surface Water Management Plan is adhered to. • The provisions and schedules embodied in the NT Waste Management and Pollution Control Act is adhered to. • As part of job-site induction prior to arrival on-site, awareness of surface and groundwater related issues are provided for relevant staff. • Fuels, lubricants and chemicals are stored and handled within containment areas (such as portable bunding, or self bunded) that are designed to prevent the release of spilt substances to the immediate neighbouring environment, in accordance with relevant legislation and standards. • Appropriate sedimentation and erosion control measures are put in place at each location. • All surface water runoff will be directed away from the sites to prevent contamination. • Spill kits appropriate to the size of the operation are available at site. • Personnel are advised of the location and use of the spill containment equipment in the site induction. • Refuelling is undertaken within the designated refuelling sites. Where refuelling is required outside the camp sites, the vehicle shall be on flat and stable ground and not within 25m of a watercourse or other riparian area. • The amount of hazardous material stored and used on site shall be kept to a minimum.

		• Hazardous materials shall be transported, stored and handled in accordance with the requirements of relevant legislation (e.g. Road and Rail Transport (Dangerous Goods) Act 1997, Australian Dangerous Goods Code) and Australian and Industry Standards. • Spills or leaks are immediately reported to the Pangaea Representative on site who will initiate appropriate 'clean up' actions in consultation with the Environmental Management Representative. • In the event of a spill the material will be contained to the smallest area practicable and Emergency Procedures are to be followed.
Water supply and distribution (quantity)	There may be a risk of adverse environmental impacts (including those listed in this table) as a result of reduced water supply due to the large amounts of water being extracted for use in hydraulic fracturing. There may be a risk of changes to the timing and/or quantity of surface water flows because of the discharge of produced water, which may be significant particularly in arid to semi-arid landscapes. There may be a risk to surface water and groundwater flow processes as the result of possible seismic activity caused by hydraulic fracturing or reinjection of water.	To protect against the risk of adverse environmental impacts from reduced water supply, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Water Act (2011) • Petroleum (Environment) Regulations (2016) • An Explanatory Guide to Petroleum (Environment) regulations - 3.10 Environmental risk assessment; 3.11.2 Environmental Performance Standards • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) 325 'Protection of Aquifers', 418 'Waste or Contamination of Petroleum or Water' • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF2 Water management associated with hydraulic fracturing (2010)

		• API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • API Standard 65 – Part 2 Isolating potential flow zones during well construction • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 As part of the Surface and Groundwater Characterisation Report (Appendix H), stock watering was identified as the major water use, supplied from approximately 475 registered bores in the drilling project area. Assuming 4-6 head of cattle per km[10] , an area of 32,300 km^2 (combined area of study region), gives approximately 130,000 to 194,000 head of cattle watered from groundwater resources of the Cambrian Limestone Aquifer (CLA). Assuming an average consumption of 50 litres/head/day, the stock usage is estimated between 2370 and 3540 ML/year across the project area. From Pangaea's development analogue scenario, it is assumed a seven year development program would drill approximately 42 wells per year. For a 1700 m well, 17 stages is assumed. Water use per stage is estimated at between 0.8 ML to 1.2 ML (it is assumed this water use will reduce by approximately 30% with recycling of flowback water) and 0.3 ML to drill each well. Hence, the water required is approximately 13.9 ML – 20.7 ML per well or 583.8 ML – 869.4 ML per year (for 42 wells). This works out to be approximately 16 – 25% of the water used for stock in the study region of the Report (EP 167 and EP 168). This number would decrease with the installation of water recycling and treatment facilities, and furthermore, stress on the primary aquifer could be reduced with the use of alternative deeper, brackish aquifer(s). As part of Pangaea's 2015 operations, a significant brackish aquifer in the Jamison Sandstone within the Beetaloo Sub-basin was identified. Pangaea's intention would be

[10] NT Department of Primary Industry and Fisheries *The 2010 pastoral industry survey – Barkly Region* (2010)

		to further evaluate this aquifer for its future water requirements along with surface engineered and constructed multi use / public benefit catchment dams able to supplement pastoral cattle uses.
Aquatic ecosystems and biodiversity	There may be a risk of adverse impacts on aquatic ecosystems and biodiversity, including groundwater dependent ecosystems. This may result from changes in the quality and/or quantity of surface and/or ground water available to them.	In the Surface and Groundwater characterisation and Flora and Fauna characterisation studies, risks to aquatic ecosystems and biodiversity regions within and surrounding the study area of EP167 and EP168 have been identified as low and manageable. To protect against the risk of adverse impacts on aquatic ecosystems and biodiversity, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Water Act (2011) • Waste Management and Pollution Control Act (2014) • Petroleum (Environment) Regulations (2016) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008

Amenity values	There may be adverse impacts on general amenity values such as national parks, rangelands and recreational fishing areas. This may result from changes in the quality and/or quantity of water available.	To protect against the risk of adverse impacts on general amenity values, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Heritage Conservation Act (2008) • Public and Environmental Health Act (2011) • Soil Conservation and Land Utilisation Act (2009) • Territory Parks and Wildlife Conservation Act (2011) • Water Act (2011) • Waste Management and Pollution Control Act (2014) • Petroleum (Environment) Regulations (2016) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008

Public health	There may be adverse impacts on human and livestock health due to changes to water quality, supply and distribution as a result of hydraulic fracturing and the associated activities.	To protect against the risk of adverse impacts on human health and livestock health, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Heritage Conservation Act (2008) • Public and Environmental Health Act (2011) • Soil Conservation and Land Utilisation Act (2009) • Territory Parks and Wildlife Conservation Act (2011) • Water Act (2011) • Waste Management and Pollution Control Act (2014) • Petroleum (Environment) Regulations (2016) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • Northern Territory Department of Health Fact Sheet 700, Requirements for Mining and Construction Projects • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008

		The impact of water use on public health, including human and livestock due to change in supply can be risked in comparison to the regional water use. The Surface and Groundwater Characterisation Report (Appendix H) has detailed the water usage of community, stock and domestic, and irrigated horticulture usage. Using Australian Bureau of Statistics population figures for 2011[11], the community water supplies are of the order of 400 – 500 ML/year[12]. This includes Mataranka, Jilkminngan, Daly Waters, Larrimah, and Newcastle Waters and Jingaloo. As detailed in the water supply and distribution section above, stock usage is in the order of 3500 ML/year. Irrigated horticulture forms the major use of groundwater across the project regional area with extraction focused in the north and north-east of the region within the Daly Roper Water Control District. As of September 2015, the NTG Department of Land Resource Management (DLRM) groundwater extraction license (GWEL) register[13] reports a total licensed extraction of 116 000 ML/year for the Daly Roper Water Control District. This is comprised of 44 000 ML/year for the Tindall, Jinduckin and minor aquifers around the Katherine and Mataranka regions and 72 000 ML/yr for the Oolloo Dolostone Aquifer to north-east of the Region. Note that the licensed allocation volume will be greater than the actual annual licensed groundwater extraction. This totals to approximately 120 000 ML/year. Using Pangaea's seven year development analog of 42 wells per year (as per the previous section above), shows the approximate required water for hydraulic fracture stimulation to be between 583.8 ML – 869.4 ML/year, or around 0.50 - 0.75% of regional licensed groundwater extraction. Based on this relatively small volume of water used for the development analog, any adverse impacts on human and livestock health due to changes to water quality, supply and distribution as a result of hydraulic

[11] Australian Bureau of Statistics Census 2011 <http://www.abs.gov.au/websitedbs/censushome.nsf/home/map>.
[12] EcOz Environmental Consultants, above n4, 37.
[13] Northern Territory Government *Approved water extraction licences* (29 November 2016) <https://nt.gov.au/environment/water/approved-water-extraction-licences>.

		fracturing and the associated activities is considered to be extremely small when compared to water usage of community, stock and domestic, and irrigated horticulture usage in the region.
Aboriginal people and their culture	Natural water bodies are central to traditional land use and many sites of significance to Aboriginal people relate to water. A reduction in either water quantity or quality may impair the traditional use and/or value of the sites.	Refer Table 7.5 Aboriginal people and their culture below.
Economic	Changes to water quality, supply and distribution may have an adverse impact on industries that may co-exist with the onshore unconventional gas industry, such as agriculture, pastoralism and tourism.	To protect against the risk of changes to water quality, supply and distribution, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Water Act (2011) • Petroleum (Environment) Regulations (2016) • An Explanatory Guide to Petroleum (Environment) regulations - 3.10 Environmental risk assessment; 3.11.2 Environmental Performance Standards • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) 325 'Protection of Aquifers', 418 'Waste or Contamination of Petroleum or Water' • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF2 Water management associated with hydraulic fracturing (2010)

		• API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • API Standard 65 – Part 2 Isolating potential flow zones during well construction • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 A comparison of water supply and distribution has been discussed in the above sections, specifically Public health.

Land

Table 7.2 Land from Background and Issues Paper[14]		
Value	**Risk**	**Pangaea Response**
Terrestrial ecosystems and biodiversity	There may be a risk that hydraulic fracturing and the associated activities will have an adverse impact on terrestrial ecosystems and biodiversity in the Northern Territory. Specifically, there may be:	
	• a risk of **vegetation loss** on a **local scale** as a result of areas being cleared for **roads**, **pipelines** and **drill pads** or as a result of **spills**;	To protect against the risk of vegetation loss on a local scale, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Petroleum (Environment) Regulations (2016) • Fire and Emergency Act (2004) • Bushfires Act (2009) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • Control of Roads Act (2008) • Maintenance of Pastoral Access Roads Policy 2014 • Road and Pavement Maintenance Policy 2014 • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016)

[14] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, above n 1, 17.

		• Northern Territory Weed Management Strategy • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 In addition to the above, through its hazard identification process Pangaea mitigates hazards & risks of vegetation loss from clearing for roads through consultations with local pastoralists and landowners on the planning, installation, or upgrading of new or existing roads, minimising soil erosion by the use of existing roads and tracks where applicable, deviating around creeks, river banks and naturally formed depressions and not accessing roads in wet conditions. Other measures include circumnavigating of large habitats and acacia woodlands and the proper rehabilitation of access roads and tracks that are not required by pastoralists and are not on existing fence lines or public roads. Any contaminated or unsuitable material (e.g. gravel) is removed from the roads and hardstand surfaces and disposed of at an approved location. Minor reshaping work will be undertaken to ensure surface level consistency with the surrounding areas. Any creek crossings will be removed and the pre-existing drainage line re-instated by revegetation and rehabilitation. Pangaea routinely consults with Traditional Owners, local pastoralists and landowners on the planning, installation or upgrading of new or existing surface infrastructure. Through its hazard identification process Pangaea mitigates hazards & risks of vegetation loss from clearing for drill pads through consultations with traditional owners, local pastoralists and landowners on the planning, installation, or upgrading

		of new or existing drill pads. All previous Pangaea well sites have been designed with due consideration of the surface and subsurface environments. The sites have been selected and constructed to avoid large scale levelling and clearance of vegetation. For rehabilitation operations, a plan is outlined for the overall rehabilitation strategy for well sites, including descriptions of key components of the rehabilitation strategy integral to the anticipated final landform. Rehabilitation approach - Where possible, topsoil inclusive of vegetative material (removed during site preparation) would be re-spread directly onto the well site. Where topsoil resources allow, topsoil would be spread to a nominal minimum depth range of 0.1 to 0.3 m on all areas to be rehabilitated. Top-soiled areas will also be contour-ripped (after topsoil spreading) to create a 'key' between the topsoil and the subsoil. Ripping would ideally be undertaken on the contour and the tynes lifted for approximately 2m every 200 m to reduce the potential for channelized erosion on slopes greater than 10 degrees. Ripping will be undertaken where practical, when soil is dry to achieve best results in fracturing the compacted soils. Rehabilitation shall be considered successful when the following conditions have been met: 1. The site can be managed for its designated land-use (e.g. consistent with surrounding undisturbed land), 2. Evidence that the agreed rehabilitation criteria have been met, 3. No greater management input is required for site than that of surrounding areas consistent with designated land use; and 4. Written agreement has been attained by the pastoralist and the administering authority. Pangaea also undertakes rehabilitation maintenance - In the context of this strategy, 'maintenance' constitutes any additional erosion & sediment control, re-application of seed to promote ground-cover or further management of weeds is required. However, this management frequency would vary depending on the extent of rehabilitation success and necessary method for mitigating failing rehabilitation.

		Through its hazard identification process Pangaea mitigates hazards & risks of vegetation loss from spills through daily site inspections and spot checks throughout the operation. Any and all spills or uncontrolled discharge of hydrocarbons will be recorded and reported immediately, or as soon as practicable, to the Environmental Management Representative. The Operations Coordinator will liaise with the Department to ensure the timely submission of environmental incident, close-out and external auditing reports. Each report is provided to the appropriate departmental contact in accordance with the appropriate reporting clause (specific to the incident) of the NT Schedule of Onshore Petroleum Exploration and Production Requirements 2016.
	• a risk of **loss and/or fragmentation** of **habitat for fauna** on a regional **scale** as a result of **road** and **pipeline** construction and operation;	To protect against the risk of loss and/or fragmentation of habitat for fauna on a regional scale, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Petroleum (Environment) Regulations (2016) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • Maintenance of Pastoral Access Roads Policy 2014 • Road and Pavement Maintenance Policy 2014 • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • Northern Territory Weed Management Strategy • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007)

		• API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • AS/NZS ISO 31000:2009 Risk Management • AS 1289 Testing of Soils for Engineering Purposes • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 Mitigation measures and strategies for risk and/or fragmentation of habitat for fauna on a regional scale as a result of: **<u>PIPELINE CONSTRUCTION</u>** **Preliminary Geotechnical design evaluation phase:** • Engineering into the construction of a gas header pipeline from an initial pilot well has commenced. The design and construction of the initial header needs to ensure that infrastructure developed during the initial pilot testing is consistent with the requirements for the full field development. • A geotechnical investigation is required to inform the options assessment process and concept design, and to understand environmental, safety, construction, and cost considerations. • All field works for major project construction works are undertaken in accordance with Pangaea policies, QHSE Management plans, landowner and traditional owner consultation. • Boreholes shall be completed using solid flight augers or rotary mud drilling (wash boring) in soils, and diamond coring in rock. For the top 1m of boreholes, disturbed soil samples shall be collected at a minimum of 0.5m intervals. Below 1m depth, disturbed and undisturbed samples in sand should be collected using Standard Penetrometer Tests (SPT). Undisturbed samples in clays would be collected using thin walled tubes (U75). The SPT's shall be conducted in accordance with *AS1289-6.3.1 Methods of testing soils for*

		engineering purposes – Method 6.3.1: Soil strength and consolidation tests – Determination of the standard penetration resistance of a soil – Standard penetration tests (SPT). To assist in the soil strength assessment of cohesive soils, pocket penetrometer tests and hand held shear vane tests shall be performed at the ends of the U75 tubes. • Any recovered rock will be photographed and boxed. The soil samples and any recovered core rock shall be placed in temporary storage at the consultant's premises to enable later inspection and testing. • Upon completion boreholes will be grouted and any remaining spoil shall be disposed to the satisfaction of the Pangaea site representative. • Test pits shall be excavated to a minimum depth of 2m. Disturbed samples of indicative materials shall be collected for laboratory testing, visual classification and logging purposes. A record of the machinery size and type shall be made for each test pit. Any observations from the field crew on dig ability will be noted. Test pits shall be backfilled with the excavated spoil, tamped in place, and track rolled. Any excess spoil should be mounded on the surface. The height of the remaining mound should allow for the unexpected settlement based on local site knowledge. • Dynamic Cone Penetrometer (DCP) tests shall be performed adjacent to each test pit location to assist in assessing the consistency / density of subsurface soils. Additional DCP tests should be performed at additional location at the discretion of the consultant where additional information on compaction requirements is required. • All works will be performed with the least amount of surface disturbance possible and in consultation with pastoral/traditional owners consultation. All test sites and access routes will be remediated upon the completion of the works in accordance with the Pangaea EMP. • Engineering and analysis from the geotechnical collection activity will include but is not limited to the following: o Field records o Field observations

		○ Subsurface conditions encountered ○ Laboratory test results ○ Interpretation of laboratory results ○ Commentary on relationship between results and the proposed infrastructure ○ Geological parameters required for design ○ Dig ability of onsite soils and rocks in regard to buried pipelines, and type of machinery that may be required ○ Risks to the operation / construction of the crossing HDD or thrust bore operations ○ Excavation and support of HDD or thrust bore launching and receiving pits ○ Suitability of site soils for founding structures ○ Bulking and compaction for earthworks ○ Erodibility of onsite soils and provision of mitigating options ○ Areas prone to surface water saturation groundwater observations. • The laboratory testing shall be performed by a NATA accredited laboratory in accordance with AS 1289 Testing of Soils for Engineering Purposes. **Pangaea General Pipeline Major Project Construction objectives:** <u>Concept Design Phase</u> During concept phase options are analysed based on the project requirements, and an assessment of the suitability of each solution is completed. Based on this initial assessment an option is selected as the preferred solution and a concept design is created. A hold point is identified at this point for review of the selected solution to ensure that the assumptions made during the analysis are valid and to ensure that the project requirements have not changed. Subject to Pangaea approval the project would then proceed to a front-end engineering design (FEED) phase. It is anticipated that the concept phase will be completed within 3 months of project initiation.

		• Project Management Deliverables for the Concept Phase
		  o Project Brief
		  o Project budget and schedule
		  o Options identification
		  o Analyse costs and benefits of each option
		  o Selection of preferred option for FEED study
		  o Draft FEED project execution plan
		  o Draft FEED contracting strategy
		  o Class 5 estimate based on AACEE classification
		• Design Deliverables for Concept Phase
		  o Preliminary Design basis
		  o Scope and award Geo-technical study along route and at surface facilities
		  o Process flow diagrams
		  o Limited design documentation consistent with Class 5 estimate classification
		• Approval Deliverables for Concept Phase
		  o Pipeline survey permit.
		  o Pipeline infrastructure description and design information for environmental impact assessment.
		• Land Access deliverables
		  o Draft agreements with Department of Transport for easement/licence
		  o Draft agreement with Australasia for easement/licence for rail crossing
		  o Draft Stakeholder agreements as required
		• Procurement Deliverables
		  o Tender for FEED Design services
		
		<u>FEED Phase</u>
		
		During the FEED phase the selected concept design is developed to the stage where the risks of proceeding with the project are clearly understood, the cost of the project

		is determined, and the preliminary design, specification, and tendering of major equipment packages is completed. Uncertainty is progressively reduced to the point that a predictable project outcome can be achieved in the execution and delivery phase. At the completion of the FEED phase Pangaea is fully appraised of the risks and the cost of the project and is in a position to decide whether to proceed with the project or not. It is anticipated that FEED would be completed 6 months after completion of the concept phase. *Pipeline* • FEED Design Deliverables o FEED Design basis o Complete Geo-technical study along pipeline route and surface facilities o Site survey works as required o Design documentation consistent with Class 3 estimate classification o Final process design calculations and drawings o Preliminary mechanical, electrical, instrument, civil, structural drawing packages o Final specifications for major equipment packages • FEED Approval Deliverables o Pipeline Licence or appropriate production license depending on regulatory requirements. o Detailed input into the environmental impact assessment and planning approval process as required. • Land Access Deliverables o Final agreements with Department of Transport for easement/licence o Final agreement with Australasia for easement/licence for rail crossing o Draft easement plans as required for titles office o Final stakeholder access agreements as required • Procurement Deliverables

		○ Develop tender procedures and process in accordance with Pangaea requirements. ○ Draft quality management plan for packages to be procured by Pangaea. ○ Tenders for; ▪ Coated line pipe and induction bends ▪ Main valves ▪ Pressure vessels ▪ Monolithic insulating joints (MIJ) ▪ Construction services ▪ Detail design services *Construction* • Preliminary construction methodology • Evaluation of construction capability and capacity in the Northern Territory and within the local region considering engineering design input gained from extensive Pangaea acquired LIDAR imagery which has been shared with the Northern Territory Government in order to enhance strategic government infrastructure planning and engineering design work. • Identify preferred contracting strategy and local training and employment strategy • Manage construction tender in conjunction with procurement • Organize site visits as required • Draft Pangaea Safety and Environmental Management Construction Requirements • Draft construction quality management plan. • Conditional award of construction agreement subject to Pangaea approval to proceed

		<u>Execution (Construction) Phase</u> The resources required for the construction phase and start up phases of the projects are not described in detail in this submission due to the wide range of possible outcomes resulting from work that will be completed in the concept and FEED phases. During the FEED stage of the project the project team will identify the optimal project delivery strategy and the resources required to deliver the strategy and outcomes required by Pangea. It is anticipated that the execution phase would be completed 12 to 18 months after the completion of the FEED phase and formal project investment decision. At a minimum, however the following management functions will be adhered to during the execution (construction) phase: • Contract manage commercial agreements. • Detailed Design packages • Final process design drawings • Final mechanical, electrical, instrument, civil, structural drawing packages • Manage technical queries and design issues arising from construction works. • Manage compliance to project approvals and licences. • Audit contractors on scheduled basis. • Manage compliance to easement agreements • Manage landholder communications • Contract manage construction contractor, superintend contract if required. • Work with contractor to manage shared risks, and ensure Pangaea risk issues do not impact the critical path. • Completed safety and environmental audits on contractor on scheduled basis • Measure progress of construction contractor • Feedback regular Construction progress reports to the Northern Territory Government.

	• a risk of adverse impacts on **terrestrial ecosystems**, including fauna and flora, as a result of changes to **water quality** and availability;	Refer above Table 7.1 Water, specifically the Water Quality section.
	• a risk of **weed** invasion as a result of increased **traffic**;	To protect against the risk of weed invasion as a result of increased traffic, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Petroleum (Environment) Regulations (2016) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • Maintenance of Pastoral Access Roads Policy 2014 • Road and Pavement Maintenance Policy 2014 • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • Northern Territory Weed Management Strategy • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008

		Pangaea has undertaken an extensive pastoral consultation approach to its weed mitigation strategy including discussions with 16 pastoral cattle stations in the region to ensure best practice in local biodiversity and weed control. The presence of weed species has a potential major impact on re-vegetation and regeneration outcomes. In addition to this, the presence of weed species within the surrounding land has the potential to significantly impact on the biodiversity value of the rehabilitated area & weed management will be a critical component of the rehabilitation activities. Weed control measures are undertaken in a manner that minimises soil disturbance. Any use of herbicides would be carried out in accordance with appropriate requirements to minimise the risk of impact on downstream water quality and with approval from the pastoralist to ensure no agricultural organic or export produce certifications are breached. Consultation with pastoralists is also undertaken prior to using herbicides if required. Records would be maintained of weed infestations, and control programs would be implemented according to accepted management practice for the weed species concerned. All weed management personnel would be trained in the use of herbicides. Herbicides listed under international conventions, such as the World Health Organisation and the Stockholm Convention, would only be used according to the requirements of those conventions. Compared to other grazing regions, the Sturt plateau is relatively weed free. There are limited infestations of bellyache bush (Jatrophagossypifolia), devil's claw (Martyniaannua), hyptis (Hyptissuaveolens) and Sida spp. The spread of weeds is likely to increase if the area becomes more populated and developed[15]. A total of 17 weed species have been recorded across Pangaea's tenements with the majority of recordings along roadsides or on crossing points of major rivers/creeks (i.e. trafficable areas). Most weeds requiring management attention are usually most

[15] Tropical Savannas CRC *Grazing management issues: Sturt Plateau* (2014) <http://www.savanna.org.au/vs/vs_plateau.html>.

		prevalent in riparian habitats, are spread by wet season floodwaters or are associated with water-holding black soil areas. Weed control works on pastoral land generally take into consideration weed risk (invasiveness, impacts on grazing land/land value and potential distribution) as well as feasibility of control (control costs, current distribution and persistence). Weed prevention and mitigation measures being taken by Pangaea are detailed in a Weed Management Plan (WMP) which provides a strategy for preventing the spread of weeds during operations. The WMP is prepared considering the *Northern Territory Weed Management Handbook*[16] which aligns with priorities identified in the *Katherine Regional Weed Management Plan 2015-2020*[17]. The objectives of the WMP are: • To ensure appraisal activities including rehabilitation meet stakeholder's expectations in the control and prevention of the establishment Class A, B & C weeds as listed in the NT Weeds Management Act. • To ensure no new weed infestations are established as a direct result of appraisal activities. • To ensure appropriate mitigation measures are in place to: • Avoid mapped weed infested areas, • Mitigate against activities that may spread weeds; and • Provide a mechanism to monitor rehabilitated areas to ensure appropriate weed management post appraisal. Machinery and vehicles used during operations are subject to the WMP which includes: job-site induction including an understanding of weeds in the area;

[16] Northern Territory Government *Northern Territory Weed Management Handbook* (2015) <https://nt.gov.au/environment/weeds/weed-management-handbook>.

[17] Northern Territory Government *Katherine Regional Weed Management Plan 2015-2020* (2015) <https://denr.nt.gov.au/land-resource-management/rangelands/publications/weed-management-publications>.

		certification by a registration of 'weed-free' status prior to arriving at, and upon departure from, site; visual checks; blow-down points and record keeping. <u>Mitigation Measures & Strategies</u> • Pangaea's Corporate Quality, Health, Safety and Environmental Policy is adhered to (Appendix L). • The Weed Management Plan is adhered to. • As part of job-site induction prior to arrival on-site, awareness of flora & fauna related issues will be provided for relevant staff. • Weed/pest inspections of machinery will be undertaken prior to arriving at site. And interstate vehicles are required to provide third party weed inspection certificates. • Machinery will be cleaned of mud and seed prior to arriving at each new site at a designated and bunded area. • Assess the potential impacts on threatened species, populations, ecological communities and their habitats at each site. • Waste material (domestic waste) is stored in suitable receptacles and disposed of accordingly at municipal managed locations. • Access tracks and seismic lines are located in areas that will result in minimal ground disturbance and do not impact on threatened flora or fauna, or endangered ecological communities. • Seismic line preparation through vegetated areas (off existing tracks and fence lines) is conducted with a regular straight blade or a stick rake. The source lines will not be wider than 5 meters, with the receiver lines not wider than 3 meters. • In areas where the seismic line follows existing tracks and fence lines, a grader may be used to sweep the tracks for more efficient access. • Avoid creation of windrows with mixed logs, branches and cleared grass. • Promote ground cover on bare sites by leaving topsoils in-situ and/or pulling back logs, sticks and pruned branches.

		• Where required, additional erosion controls will be installed in strategic locations to stop or slow water flow along access tracks and seismic lines. • Provide crew weed field ID guides and training sessions before entering the field. • Avoid areas of known environmental weeds, noxious weeds or problem plants as defined by the weeds unit and pastoral lands management unit of the Land Resource Management and pastoralists, with reference to the EcOz Environmental Consultants Weed Map. • Field crews will undertake a visual check of seed in clothes and protective gear daily. • Establish clearly sign-posted 'weed blow down areas' and GPS points recorded.
	• impacts on **biodiversity** and **greenhouse gas emissions** due to **changed fire** regimes; and	To protect against the risk of impacts due to changed fire regimes, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Petroleum (Environment) Regulations (2016) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • Northern Territory Weed Management Strategy • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009)

		• API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 Mitigation measures and strategies for impacts due to changed fire regimes on biodiversity include: • Pangaea's Corporate Quality, Health, Safety and Environmental Policy is adhered to (Appendix L). • Bushfires NT will be notified of the appraisal strategy. • A minimum of one 400lt slip-on unit will be located at each well site. • Fire control water pumps and hoses are to be readily accessible, on-site and well maintained. • All items of plant that could discharge sparks must be fitted with spark arresters. • No onsite cutting, welding, grinding or other activities likely to generate fires in the open on days when a total fire ban is proclaimed. • Ensure that all personnel are adequately trained with regard to fire prevention, safety and basic firefighting skills. • Before work such as welding, thermal or oxygen cutting, heating or other fire/spark producing operations are started; the area of the works will be thoroughly wet down. • All field crews will have an additional water fire extinguisher, shovel, rake and fire beater as standard vehicle equipment to let the driver be a relevant first responder. • Car parks and refuelling areas must all be at least 20m from the bush perimeter. • Fire break perimeters are cleared around all drill site locations.

	• a risk of adverse **impacts on fauna** as a result of increased **noise and light** from petroleum operations.	To protect against the risk of adverse impacts on fauna as a result of increased noise and light, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Petroleum (Environment) Regulations (2016) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • Northern Territory Weed Management Strategy • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 Mitigation measures and strategies for adverse impacts on fauna as a result of increased noise from petroleum operations • Pangaea's Corporate Quality, Health, Safety and Environmental Policy is adhered to (Appendix L). • As part of job-site induction prior to arrival on-site, awareness of noise related issues will be provided for relevant staff.

		• Appropriately inform affected pastoralists as specified in the access agreement and providing updated information as required. • All equipment used for mobilisation and powering of stimulation & testing equipment are to be well maintained and fitted with noise attenuation apparatus as standard. • Where practical, all vehicular movements to and from the works site would be made only during daylight hours and/or compliant with land access agreement. • Engines will not be left running when not specifically required. • Individual vehicular trips to and from the works site will be kept to a minimum.
Soil health	There may be a risk that the **chemicals** used in the **drilling** and **hydraulic fracturing process** will have an adverse impact on **soil health**, including as a **result of spills of flowback water**.	To protect against the risk of chemicals used in the drilling and hydraulic fracturing process having an adverse impact on soil health, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Petroleum (Environment) Regulations (2016) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • Northern Territory Weed Management Strategy • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007)

		• API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 A proactive means of avoiding the negative effects of possible spills to the local environment is to create containment systems at all drilling and production locations. Pangaea endorses and employs U.S. best practice in Shale Operations which many of the most respected U.S. oil and gas producers also employ being the use of a combination of liners under the equipment on drilling and production pads with berms or curbs to insure, should a spill occur, that it does not come into contact with the soil or water around it. The liner system needs to be durable to whatever traffic it may need to endure, impervious to fluids leaking through it, and chemically compatible for anything that is likely to come in contact with it. The berm or curb, needs to provide a lateral barrier to anything that may be spilled on the liner and should be of adequate height to capture at least 110% of the largest container which could spill onto it, or capable of capturing the volume of oil and water which could be discharged, or spilled, in the time before a well could be shut-in if something breaks at the wellhead. Natural gas will not spill, but a large variety of tools and processes are available to capture escaping natural gas from production equipment including the wellhead itself. The U.S. Environmental Protection Agency (EPA) has compiled over 40 different mitigation techniques[18] – based on the specific point of fugitive gas emissions – which the U.S. oil and gas industry have embraced and used.

[18] United States Environmental Protection Agency *Oil Spills Prevention and Preparedness Regulations* (27 April 2017) <https://www.epa.gov/oil-spills-prevention-and-preparedness-regulations>.

		The use of multi-well pads for the drilling and production of unconventional natural gas and oil creates an environment where the cost to line and curb or berm to prevent spills, and to capture potential fugitive natural gas emissions becomes cost effective and even, revenue generating. Having multiple wells on a single site creates a very positive economy of scale situation as well as minimising the surface impact over an area. Mitigation measures and strategies for adverse impacts on soil health as a result of: - Spills of flowback water, in the hydraulic fracturing process • Fracture stimulations have been performed on vertical Pangaea wells (Birdum Creek-1 and Wyworrie-1). Initial flow back (clean-up) consists predominantly of stimulation fluid and sand (proppant) from the stimulation operations. Clean-up flow back volumes vary depending on rock mechanics and parameters of the stimulated zone. It is expected that approximately 35-50% of the total injected fluid will be recovered, based on experience from comparative shales in the US. • The clean-up flow (recovered stimulation fluid) is directed to a flare tank or lined flare pit. Once the Appraisal Well begins to recover gas, the flow will be diverted and directed through a separator. The separator will separate the gas, water and potential condensate from the post clean-up flow back. The gas is measured and released from the top of the separator and sent to the flare where it is flared (burned). The water from the separator is also measured and directed to a lined temporary water storage pond (the same pond that was used to hold the water for the fracture treatment). The potential condensate would be measured and directed to a holding tank. • Flaring during testing would be kept to a minimum length of time necessary to establish resource and production parameters. The volumes of gas flared will be recorded. Fugitive emissions from the flow testing equipment will be minimised by pressure testing of lines prior to use to ensure integrity. Migration along the well bore is a potential source of fugitive emissions and this is mitigated by well design and construction methods, particularly the

		presence of cemented casing strings, assessment of the cement quality with logging tools and monitoring the well during flow back. • Following flow back/testing, the recovered fluid in the flare tank or lined flare pit will be transferred into the lined pond and will be left to evaporate. Post-evaporation, pond/pit liners will be removed and disposed of to an appropriately licensed waste disposal facility. The pond and pit are all left to dry out, before being backfilled to return the areas to an appropriate slope (considering the landscape's 'pre-drilling' characteristics). If it appears that the water will not be fully evaporated by the time the wet season approaches the water will be pumped out into an NTRS NT EPA Approved and licenced disposal vehicle before being taken to the nearest appropriately licenced NTRS EPA approved facility for disposal. • The handling and storage of flow back fluids complies with the Schedule of Onshore Petroleum Exploration and Production Requirements 2016, in which formation water and other waste fluids produced from a well shall be disposed of in a manner which does not cause risk to public health or safety or cause the contamination of water or land not specifically designated for waste disposal. <u>Mitigation Measures & Strategies</u> • Pangaea's Corporate Quality, Health, Safety and Environmental Policy is adhered to (Appendix L). • The Ground and Surface Water Management Plan is adhered to. • The provisions and schedules embodied in the NT Waste Management and Pollution Control Act is adhered to. • As part of job-site induction prior to arrival on-site, awareness of surface and groundwater related issues are provided for relevant staff. • Fuels, lubricants and chemicals are stored and handled within containment areas (such as portable bunding, or self bunded) that are designed to prevent the release of spilt substances to the immediate neighbouring environment, in accordance with relevant legislation and standards.

		• Appropriate sedimentation and erosion control measures are put in place at each location. • All surface water runoff will be directed away from the sites to prevent contamination. • Spill kits appropriate to the size of the operation are available at site. • Personnel are advised of the location and use of the spill containment equipment in the site induction. • Refuelling is undertaken within the designated refuelling sites. Where refuelling is required outside the camp sites, the vehicle shall be on flat and stable ground and not within 25m of a watercourse or other riparian area. • The amount of hazardous material stored and used on site shall be kept to a minimum. • Hazardous materials shall be transported, stored and handled in accordance with the requirements of relevant legislation (e.g. Road and Rail Transport (Dangerous Goods) Act 1997, Australian Dangerous Goods Code) and Australian and Industry Standards. • Spills or leaks are immediately reported to the Pangaea Representative on site who will initiate appropriate 'clean up' actions in consultation with the Environmental Management Representative. • In the event of a spill the material will be contained to the smallest area practicable and Emergency Procedures are to be followed.
Aboriginal people and their culture	The **landscape**, **terrestrial ecosystems, plants** and **animals** are central to traditional cultural values. Adverse impacts to these things may have an adverse impact on **Aboriginal cultural values**.	Refer Table 7.5 Aboriginal people and their culture below. Consistent with its Co-existence and Exploration Deed with Native Title parties and the Northern Land Council, Pangaea works closely and collaboratively with the Northern Land Council (NLC) and Traditional Aboriginal Owners (TAOs) prior to undertaking any field activities. This consultation process is prescribed and extensive under the terms of the Deed and includes, amongst others, cultural awareness training, providing detailed plans including locations of activities, likely techniques and major items of equipment to be used, personnel involved, estimated dates of

		activities and the process to be used in avoiding ecologically sensitive areas. Pangaea is required to engage TAOs as part of this process and conduct if required by TAOs a sacred site avoidance survey, to confirm that the activities are not a threat to sites of Aboriginal cultural heritage significance. Native Title parties have the right to appoint qualified representatives during this survey, at the company's cost, and to propose reasonable amendments to any work program prior to commencement. The Deed specifically prevents Pangaea without prior consent from the NLC from entering upon a sacred site or undertaking any activity likely to damage or interfere with a sacred site. The company is also required to inform the NLC if it identifies any sacred, archaeological or historical site or object. The following mitigation measures and strategies are in place to minimise the impact on existing infrastructure and avoid the disturbance of or damage to Aboriginal cultural heritage or culturally sensitive landscapes: • In the event that a suspected sacred site or artefact has been discovered and the activity cannot be altered to avoid the site, work will cease in the area of the discovery AND the person discovering the artefact will notify their supervisor who will ensure that work has ceased and the area(s) is (are) cordoned off with tape. • The PC will notify the Pangaea Representative on site who will request a qualified professional to attend the site and advise on its significance. • Work will not recommence in the area of any discovery until the site has been inspected and the requirements of the Department have been met.
Economic	An adverse impact on **terrestrial ecosystems** may be a risk to **industries** that **co-exist** with the onshore unconventional gas industry, such as agriculture, pastoralism, fisheries and tourism.	To protect against the risk of an adverse impact on terrestrial ecosystems being a risk to industries that co-exist with the onshore unconventional gas industry, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999)

		• Petroleum Act (2011) • Environmental Assessment Act (1994) • Petroleum (Environment) Regulations (2016) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • Maintenance of Pastoral Access Roads Policy 2014 • Road and Pavement Maintenance Policy 2014 • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • Northern Territory Weed Management Strategy • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 The main Beetaloo Sub-basin project area (EP 167/168) occurs across 23 pastoral properties with approximately 77% of the area used for cattle grazing. Data from the Australian Bureau of Statistics showed that domestic stocking density increased from a level near the 1984–1991 average in 1991 to be 185% above this base in 2011[19].

[19] Bastin, G *ACRIS Livestock Density Update 2009-11* (2013) Australian Government <https://www.environment.gov.au/resource/livestock-density-update-2009-2011>.

		Cattle numbers have increased almost continuously since 1992[20]. Pastoral leases and freehold make up ~95% of Pangaea's total tenement area. Pangaea has also engaged in stakeholder (pastoral) liaison over several years to identify issues of concern and find ways to address them. Throughout previous years field operations, Pangaea has engaged with stakeholders on an ongoing basis throughout the life of the project as a way of keeping key stakeholders informed about our activities, educating the community, traditional owners and government about the project. A key feature of leaseholder negotiations, in addition to those stipulations under Sections 65, 81 and 82 of the NT Petroleum Act 2015, has been the focus on implementing the road access, site preparations and logistics programs with minimal disruption to present land uses, lessening impacts on existing infrastructure and integrating with pastoral work, livestock production and annual planning. The voluntary leaseholder access and compensation agreements include a code of conduct of operations with stated conditions of entry, types of petroleum operations, adherence to weed management and erosion prevention protocols, rehabilitation and compensation structures. The agreement generally reflects a focus on impact minimisation, community acceptance and satisfaction. Pangaea are proud to have a proven track record with all pastoralists it has approached with regards to operating through, by and with their cattle stations over the past 5 years. Pangaea have signed a total of 36 Voluntary Access and Compensation Agreements (refer Appendix M for a representative map) since commencing operations in the Northern Territory. This includes pastoralist sign off at the end of each operational year confirming all Pangaea operations were conducted as outlined within the Voluntary Access and Compensation Agreement and also rehabilitated satisfactorily and without negative Quality, Environmental or Safety issues.

[20] Ibid 7.

		Direct impacts on leaseholder and pastoral enterprises are a key concern to Pangaea. Active engagement has provided the foundation for negotiation with the pastoralists and the terms of access to the land and the specific items of compensation are agreed to and listed in the access agreements prior to any activity occurring. Pangaea has so far achieved a win-win situation and built solid working relationships with the pastoralists. The operation of the appraisal project in the region and the perception of the company in the local and wider NT community is an important consideration that remains at the forefront of company policy and Board Directives. The well sites, camp sites and key access routes chosen attempt to minimise impacts on the community (e.g. noise, dust and incidental nuisance) and specific mitigations are put in place where necessary, fostering good faith with the pastoralists and the local community.
Amenity values	The Panel recognises that the Northern Territory has iconic wilderness values as a core part of the Australian outback. There may be a risk that the development of the unconventional gas industry will have an adverse impact on the outback experience (for example, tourism) through infrastructure development (for example, the construction of pipelines and processing plants), and increased traffic, noise and light (from flaring).	To protect against the risk of the development of the unconventional gas industry having an adverse impact on the outback experience, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Petroleum (Environment) Regulations (2016) • Heritage Conservation Act (2008) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • Maintenance of Pastoral Access Roads Policy 2014 • Road and Pavement Maintenance Policy 2014 • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016)

		• Northern Territory Weed Management Strategy • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 Building upon Pangaea's approach to cultural heritage protection, Pangaea contacts the Heritage Branch Department of Lands, Planning and the Environment to discuss the annual Work Program. From this discussion, sites of Aboriginal Archaeological Heritage may be identified to be assessed. Survey of the sites are undertaken (on foot) by an NLC Anthropologist, the Environmental Management Representative and Traditional Aboriginal Owners (TAOs) and custodians. At this time, the TAOs culturally clear all ancillary works (including grading and sheeting of access tracks), establishment of the drill sites, the process of drilling and the reasonable removal of vegetation. It is envisaged that as the works are to impact on such a small area of the Sturt Plateau, the probability for potential impacts on yet to be recorded archaeological sites of significance is extremely low. In addition to the measures described above, Pangaea conducts a search of the NT Heritage Register & the NT Archaeological Site Register, administered by Department of Lands, Planning and the Environment (as defined in the Heritage Act 2011).

Air

Table 7.3 Air from Background and Issues Paper[21]		
Value	**Risk**	**Pangaea Response**
Public health	The possible health risks associated with the release of gases from the hydraulic fracturing process are discussed below in "Public health".	To protect against the possible health risks associated with the release of gases from the hydraulic fracturing process, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Public and Environmental Health Act (2011) • Petroleum (Environment) Regulations (2016) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • Maintenance of Pastoral Access Roads Policy 2014 • Road and Pavement Maintenance Policy 2014 • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • Northern Territory Weed Management Strategy • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009)

[21] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, above n 1, 18.

		• API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process • APPEA Code of Environmental Practice 2008 Dust generation and emissions related to vehicles are the two primary potential impacts relating to any operations. Soils will be mobilised differently and are dependent on prevailing weather conditions such as wind, humidity and precipitation, particle size and topography. Some soils within Pangaea's tenements are considered dispersive. Dust is generated as part of any campaign, however, given the operation is in rural environment, it is unlikely that potential dust producing activities will represent a significant impact to any surrounding or other local land users. Flaring during testing would be kept to a minimum length of time necessary to establish resource and production parameters. The volumes of gas flared will be recorded. Fugitive emissions from the flow testing equipment will be minimised by pressure testing of lines prior to use to ensure integrity. Migration along the well bore is a potential source of fugitive emissions and this is mitigated by well design and construction methods, particularly the presence of cemented casing strings, assessment of the cement quality with logging tools and monitoring the well during flow back. <u>Mitigation Measures & Strategies</u> • Pangaea's Corporate Quality, Health, Safety and Environmental Policy is adhered to (Appendix L). • The Air Quality Management Plan is adhered to. • As part of job-site induction prior to arrival on-site, awareness of air/dust related issues will be provided for relevant staff.

		• Speed limits on access tracks and dirt roads required to limit and minimise dust generation will be clearly communicated to crews. • Appropriately inform affected pastoralists as specified in the access agreement and providing updated information as required. • Where practical, all vehicular movements to and from the works site would be made only during daylight hours and/or compliant with land access agreement. • Engines will not be left running when not specifically required. • Individual vehicular trips to and from the works site will be kept to a minimum. • Smoke generation will be avoided by a strict no burning policy. • Watering of roads when appropriate or when agreed.
Climate change	There may be a risk that greenhouse gases, including hydrocarbons (methane and ethane) and carbon dioxide, will be released during hydraulic fracturing and the associated activities. Emissions may be from sources such as well heads, pipelines, compression stations and final use. The potential contribution of hydraulic fracturing and the associated activities to the burden of greenhouse gas emissions will be assessed by the Panel.	Pangaea refers the Panel to the APPEA submission
Amenity values	There may be a risk that there will be adverse impacts on amenity values such as national parks and rangelands due to gaseous emissions and flaring.	Pangaea refers the Panel to the APPEA submission

Public health

Table 7.4 Public health from Background and Issues Paper[22]		
Value	**Risk**	**Pangaea Response**
Drilling and fracking chemicals	There may be a risk that chemicals used during the drilling and hydraulic fracturing process are harmful to humans and livestock. Further, there may be a risk that those chemicals come into contact with humans or livestock via groundwater or atmospheric pathways. While the overall concentration of harmful chemicals in the water is low, the actual amount of chemicals can be significant and may pose a threat to the environment if not properly managed.	To protect against the risk of chemicals used during the drilling and hydraulic fracturing process being harmful to humans and livestock, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Public and Environmental Health Act (2011) • Northern Territory Environment Protection Authority Act (2012) • Petroleum (Environment) Regulations (2016) • Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act (2016) • Waste Management and Pollution Control Act (2011) • Work Health and Safety (National Uniform Legislation) Act (2011) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007)

[22] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, above n 1, 19.

		• API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 52 Land drilling practices for protection of the environment (R2010) • API RP 53 Recommended practices for blowout prevention equipment systems for drilling wells • API RP 54 Recommended practice for occupational safety for oil and gas well drilling and servicing • API RP 59 Recommended practice for well control operations (R2006) • API RP 100-1 Hydraulic fracturing – well integrity and fracture containment, First edition (2015) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF1 Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines (2009) • API GD HF2 Water management associated with hydraulic fracturing (2010) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • API Standard 65 – Part 2 Isolating potential flow zones during well construction • ISO 14001:2004 Environmental management systems - Standard • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process On Pangaea sites, fuels, lubricants and chemicals are stored and handled within containment areas (such as portable bunding, or self-bunded) that are designed to prevent the release of spilt substances to the immediate neighbouring environment, in accordance with relevant legislation and standards.

		Chemicals onsite are stored and handled in accordance with relevant standards and guidelines. Bulk fuel and chemicals are stored with appropriate secondary containment as required. To safely manage the use of chemicals and fuels and contain recovered stimulation fluids to minimise the environmental footprint of the stimulation and testing program, Pangaea implements the following strategies: • Pumping as low a concentration of chemicals as is needed to perform the treatment. • Requiring that the material handling and safety aspects of these additives, as managed by the contractor, are in accordance with MSDSs and relevant standards and guidelines including AS 1940. • Auditing the contractor's management systems and conduct site inspections to assess the contractor's compliance. • On-site supervision to monitor conduct of the treatments and ensure any incidents are reported and remediated. • Containment of recovered flow back fluids in lined ponds for evaporation of fluids. • Monitoring and sampling of returned fluids. Stimulation fluids are re-circulated down the hole and solids are collected. Much of the fracture fluid remains trapped in the rock underground and some of the additives may become adsorbed to the surface of the rock. • Management of ponds to ensure integrity of containment. • Removal of pond liner to a licenced waste facility following evaporation • Rehabilitation of pond sites post activities. All chemicals used and their maximum concentration in the stimulation fluids are posted on the Department of Primary Industry and Resources website for public

		disclosure, available at https://dpir.nt.gov.au/mining-and-energy/public-environmental-reports/chemical-disclosure-reports[23] Water is the main component of fracture stimulation treatments and forms the vast majority of the fluid injected during fracturing operations, typically around 97%. The proppant is the next largest constituent. Proppant is a granular material, typically sand or small ceramic beads which is mixed in with the fracturing fluids to prop open the fractures and allow gas to flow. In addition to water and proppant, a range of other additives are necessary to ensure successful fracture stimulation. Chemical additives include acid, buffers, biocides, surfactants, iron control agents, corrosion and scale inhibitors, crosslinkers, friction reducers, gelling agents, and gel breakers. Several of these ingredients are essential to maintaining well integrity. The fracturing fluid injected into the well is not uniform throughout the fracturing process. Each task performed during the fracturing operation will use fluid with additives specifically designed for the task. For example, acid is pumped in the initial acid injection phase to clean the well bore. In following phases, the fluid designed to propagate the fractures is injected, initially without proppant, and then proppant is added to the fluid to enter the fractures and hold them open. Gelling agents, or viscosifiers, are used during these phases to increase the viscosity of the fluid and help carry the proppant. Gel breakers and surfactants are added to aid in recovery of the injected fluids from the formation. Most of the chemicals used in fracture fluids are found within products that are used in the home or in industry. While many of the additives used in the fracturing process are hazardous when in their concentrated product form, they are diluted in the water and are present in fracturing fluids in relatively low concentrations. However, even in low concentrations some of these additives need to be handled with care to avoid any potential for impacts on human health or the environment.

[23] Northern Territory Government *Chemical disclosure reports* 2016 <https://dpir.nt.gov.au/mining-and-energy/public-environmental-reports/chemical-disclosure-reports>.

		The State of Pennsylvania enacted the PA Act 13 of 2012 to put best practices in containment of fuel and chemicals used in drilling or completing wells to unconventional targets. The regulated fuel and chemicals include drilling mud, hydraulic oil, diesel fuel, drilling mud additives, hydraulic fracturing additives, and flowback fluids from hydraulic fracturing.[24] Each piece of equipment or the storage containers/sites for these fuels and chemicals must have a containment system specific to the type of equipment or container used. In some cases, a liner under the portion of the drilling and/or production pad can serve multiple potential source of environmental contamination. In each case, the underlying premise is that there is a proactive approach to keeping the potential contaminant off the underlying soil and/or from spilling off the site into adjacent soils and water systems. As stated in the section above, describing liners and their complementary curbs or berms under production facilities, the ability to have multiple wells on a single pad makes these systems more affordable for the operator as well as safer for the surrounding environment. Small mobile equipment, for example a small diesel or gasoline powered generator, often has its own small containment system comprised of curbed, impermeable container which fits neatly under the equipment to catch the small volumes of oil and/or fuel that can result from leaks in the equipment as it ages, or from small spills during re-fuelling. In the case of Pennsylvania, the state has found that not only does Act 13 protect the environment in a practical, cost-affordable way, but a significant number of jobs have been created to manufacture, sell, and, in the case of the liners used under the production equipment, the recycling of large amounts of materials for purposes outside the oil and gas industry[25].

[24] *Act 13*, 58 PA Cons Stat (2012) <http://files.dep.state.pa.us/OilGas/OilGasLandingPageFiles/Act13/>.

[25] Recycling Today Staff, 'Companies to recycle Marcellus Region well liners', *Recycling Today* (online), 14 August 2012 <http://www.recyclingtoday.com/article/marcellus-plastic-liner-recycling2/>.

Hydrocarbons and BTEX	There may be a risk that hydrocarbons associated with the extracted gas come into contact with humans or livestock via groundwater or atmospheric pathways. This may include aromatic hydrocarbons such as benzene, toluene, ethylbenzene and xylenes (BTEX), which have featured prominently in some risk assessments relating to petroleum and unconventional gas extraction, although BTEX is less likely to be a prominent feature of gas extracted from shale deposits. The use of BTEX in drilling and fracking fluids is prohibited in the Northern Territory.	To protect against the risk of hydrocarbons associated with the extracted gas coming into contact with humans or livestock via groundwater or atmospheric pathways, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Public and Environmental Health Act (2011) • Northern Territory Environment Protection Authority Act (2012) • Petroleum (Environment) Regulations (2016) • Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act (2016) • Waste Management and Pollution Control Act (2011) • Work Health and Safety (National Uniform Legislation) Act (2011) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 52 Land drilling practices for protection of the environment (R2010) • API RP 53 Recommended practices for blowout prevention equipment systems for drilling wells • API RP 54 Recommended practice for occupational safety for oil and gas well drilling and servicing • API RP 59 Recommended practice for well control operations (R2006)

		• API RP 100-1 Hydraulic fracturing – well integrity and fracture containment, First edition (2015) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF1 Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines (2009) • API GD HF2 Water management associated with hydraulic fracturing (2010) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • API Standard 65 – Part 2 Isolating potential flow zones during well construction • ISO 14001:2004 Environmental management systems - Standard • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process The use of BTEX in drilling and fracking fluids is prohibited in the Northern Territory[26].
Radioactive substances	There may be a risk that radioactive materials from underground come into contact with humans or livestock as a result of the drilling or hydraulic fracturing process.	Pangaea adheres to Part II, Division 1, 213 'Radioactive Substances[27]' of the NT Schedule of Onshore Petroleum Exploration and Production Requirements (2016).
Mental health and wellbeing	There may be a risk that the mental health and wellbeing of persons could be affected by an unconventional gas project. These factors could include increased costs of living associated with changing property values, access to social services, business failures, increased traffic, effects on the	To protect against the risk of an unconventional gas project affecting the mental health and wellbeing of persons, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011)

[26] Northern Territory Government *Schedule of onshore petroleum exploration and production requirements 2016* Part III Div 3(342)(3).
[27] Ibid Part II Div 1(213).

	natural environment and concerns about the amenity of the local area.	• Environmental Assessment Act (1994) • Public and Environmental Health Act (2011) • Northern Territory Environment Protection Authority Act (2012) • Petroleum (Environment) Regulations (2016) • Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act (2016) • Waste Management and Pollution Control Act (2011) • Work Health and Safety (National Uniform Legislation) Act (2011) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 52 Land drilling practices for protection of the environment (R2010) • API RP 53 Recommended practices for blowout prevention equipment systems for drilling wells • API RP 54 Recommended practice for occupational safety for oil and gas well drilling and servicing • API RP 59 Recommended practice for well control operations (R2006) • API RP 100-1 Hydraulic fracturing – well integrity and fracture containment, First edition (2015) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015)

		• API GD HF1 Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines (2009) • API GD HF2 Water management associated with hydraulic fracturing (2010) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • API Standard 65 – Part 2 Isolating potential flow zones during well construction • ISO 14001:2004 Environmental management systems - Standard • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process
Diesel fumes	There may be a risk of emissions from plant and equipment, such as diesel fumes from drilling equipment and pumps and from off-site increases in road traffic.	To protect against the risk of diesel fuel emissions from plant and equipment, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Public and Environmental Health Act (2011) • Northern Territory Environment Protection Authority Act (2012) • Petroleum (Environment) Regulations (2016) • Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act (2016) • Waste Management and Pollution Control Act (2011) • Work Health and Safety (National Uniform Legislation) Act (2011) • An Explanatory Guide to Petroleum (Environment) • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009)

		• API RP 52 Land drilling practices for protection of the environment (R2010) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • ISO 14001:2004 Environmental management systems - Standard • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process Drilling will be associated with vehicle movement and emissions. The emissions associated with the running of vehicles are unavoidable and the work will be undertaken well away from potential receptors (pastoral land, in a rural environment). Dust generation and emissions related to vehicles are the two primary potential impacts relating to activities. Soils will be mobilised differently and are dependent on prevailing weather conditions such as wind, humidity and precipitation, particle size and topography. Some soils within the tenement are considered dispersive. Dust will be generated as part of activities, however, given the operations are in a rural environment, it is unlikely that potential dust producing activities will represent a significant impact to any surrounding or other local land users. Mitigation measures undertaken include: • Pangaea's Corporate Quality, Health, Safety and Environmental Policy is adhered to (Appendix L). • The Air Quality Management Plan will be adhered to. • As part of job-site induction prior to arrival on-site, awareness of air/dust related issues will be provided for relevant staff. • Speed limits on access tracks required to limit and minimise dust generation will be clearly communicated to crews.

		• Appropriately inform affected pastoralists as specified in the access agreement and providing updated information as required. • Where practical, all vehicular movements to and from the works site would be made only during daylight hours and/or compliant with land access agreement. • Engines will not be left running when not specifically required. • Individual vehicular trips to and from the works site will be kept to a minimum. • Smoke generation will be avoided by a strict no burning policy. • Watering of roads when appropriate or when agreed.
Physical safety	There may be a risk that physical safety may be compromised by factors associated with hydraulic fracturing including road transport accidents and seismic activity.	To protect against the risk of physical safety being compromised by factors associated with hydraulic fracturing, Pangaea adheres to the following Regulations and Practices: • Environment Protection and Biodiversity Conservation Act (1999) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Public and Environmental Health Act (2011) • Northern Territory Environment Protection Authority Act (2012) • Petroleum (Environment) Regulations (2016) • Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act (2016) • Waste Management and Pollution Control Act (2011) • Work Health and Safety (National Uniform Legislation) Act (2011) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • An Explanatory Guide to Petroleum (Environment) regulations

		• NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 52 Land drilling practices for protection of the environment (R2010) • API RP 53 Recommended practices for blowout prevention equipment systems for drilling wells • API RP 54 Recommended practice for occupational safety for oil and gas well drilling and servicing • API RP 59 Recommended practice for well control operations (R2006) • API RP 100-1 Hydraulic fracturing – well integrity and fracture containment, First edition (2015) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF1 Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines (2009) • API GD HF2 Water management associated with hydraulic fracturing (2010) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • API Standard 65 – Part 2 Isolating potential flow zones during well construction • ISO 14001:2004 Environmental management systems - Standard • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process Per regulatory direction to Pangaea by the Northern Territory Department of Primary Industry and Resources, Pangaea commissions and enforces a Traffic Management Plan which is distributed and adhered to by all on site contractors and

		service providers. This comprehensive Traffic Management Plan is completed by a reputable and appropriately qualified contractor and developed for each operation throughout a season as required. All required traffic control measures are implemented in accordance with the TMP (e.g. warning signs, temporary road closures, limited to use of roads). All plant is parked on site and private vehicles of construction personnel are not allowed to obstruct passage of local traffic.

Aboriginal people and their culture

Table 7.5 Aboriginal people and their culture from Background and Issues Paper[28]		
Value	**Risk**	**Pangaea Response**
Land ownership	There may be a risk that hydraulic fracturing or the associated activities will disrupt traditional practices that connect Aboriginal landowning groups with their country and underpin recognition of their ownership of that land.	To protect against the risk of hydraulic fracturing or associated activities disrupting traditional practices that connect Aboriginal landowning groups with their country, Pangaea adheres to the following Regulations and Practices: • Aboriginal Land Rights (Northern Territory) Act 1976 • Native Title Act (1993) • Environment Protection and Biodiversity Conservation Act (1999) • Aboriginal Land Act (2010) • Northern Territory Aboriginal Sacred Sites Act (2013) • Petroleum Act (2011) • Environmental Assessment Act (1994) • Public and Environmental Health Act (2011) • Petroleum (Environment) Regulations (2016) • Heritage Conservation Act (2008) • Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act (2016) • Waste Management and Pollution Control Act (2011) • Fire and Emergency Act (2004) • Plant Health Act (2008) • Soil Conservation and Land Utilisation Act (2009) • Weeds Management Act (2001) • An Explanatory Guide to Petroleum (Environment) regulations

[28] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, above n 1, 20.

		• NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 52 Land drilling practices for protection of the environment (R2010) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • ISO 14001:2004 Environmental management systems - Standard • AS/NZS ISO 31000:2009 Risk Management • HB 203:2006 Environmental Risk Management – principles and process For the Traditional Owners, the land is vested with spiritual significance and is an integral part of their cultural identity. Pangaea's tenements encompass the traditional lands of several Aboriginal language groups and people of each group continue to use the natural resources of the region, protect sites of significance and maintain cultural traditions through ceremony and ritual. Vegetation cover on the Pangaea tenements is moderate to dense, which reduces ground surface visibility, and therefore reduces the potential to identify archaeological evidence, by surface inspection in those areas. Whilst site integrity cannot be assumed, the existence of in-situ cultural materials cannot be ruled out. Based on sacred sites identified in the region site types that may be encountered in undisturbed environments include scarred trees, grinding grooves, artefact scatters and isolated finds. Numerous archaeological sites bear testimony to a long history of Aboriginal occupation. Traditional Owners have obligations to look after their country and

		believe that their relationships with country involve mutual rights and responsibilities. In addition, the Aboriginal history of the area since settlement is closely interwoven with European pastoral history and of this, a rich oral tradition remains. The landscapes in the tenements would have provided a range of resources, including stone raw materials, fauna, flora and water, particularly along the large rivers and creeks all of which may have allowed for sustainable occupation. The activity area has been the subject of an ethnographic sacred site avoidance survey. The Northern Land Council (NLC) develops a report which (in accordance with the Co-Existence and Exploration Deed for EPA 167, 168, 169 and 198) will clears all works to be conducted within the areas identified in the annual Work Program. Pangaea executed a 'Co-Existence and Exploration' Deed ('the Deed') with the NLC and native title owners in December 2012. The Deed frames Pangaea's approach to cultural heritage protection as agreed with the Traditional Owners. The Deed defines Pangaea's Environmental Protection and Rehabilitation requirements to the NLC which includes amongst others Well Design and Construction, Regeneration and Environmental Impact Assessment Plans. Pangaea is required to conduct its activities to minimize the environmental impact including minimizing disturbance to soil, vegetation and fauna, minimize the occurrence of fires, limit vehicular traffic to established roads wherever reasonably possible, ensure the maintenance of the biological diversity of aquatic and terrestrial ecosystems, taking all reasonable steps to ensure that surface and groundwater quality is preserved using best practice technology and best practice management in the petroleum industry. The use of BTEX in any Hydraulic Fracturing is not permitted. The on ground process under the Deed over Pangaea's exploration term has involved surveys of proposed sites undertaken (on foot and by helicopter) by an NLC Anthropologist, the Environmental Management Representative, the Cultural

		Management Consultant and Traditional Aboriginal Owners and custodians. The TAOs clear all ancillary works (including grading and sheeting of access tracks), establishment of the drill pads and seismic lines, the process of drilling, the process of capturing seismic data and the reasonable removal of vegetation. In addition to the measures described above, Pangaea undertakes a search of the NT Heritage Register & the NT Archaeological Site Register, administered by Department of Lands, Planning and the Environment (as defined in the Heritage Act 2011). Pangaea also applies for an Aboriginal Areas Protection Authority certificate for the purposes of any operations.
Benefits	There may be a risk that the development of the industry will occur without short and long term benefits flowing to local Aboriginal communities.	To protect against the risk of development of the industry occurring without short and long term benefits flowing to local Aboriginal communities, Pangaea adheres to the following Regulations and Practices: • Aboriginal Land Rights (Northern Territory) Act 1976 • Native Title Act (1993) • Aboriginal Land Act (2010) • Northern Territory Aboriginal Sacred Sites Act (2013) • Petroleum Act (2011) • Petroleum (Environment) Regulations (2016) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • AS/NZS ISO 31000:2009 Risk Management The Deed defines that Pangaea will identify suitable positions and opportunities for Aboriginal people and notify the NLC to fill these positions. The Deed defines the Employment, Training and Business Opportunities required of Pangaea. In 2015, Pangaea undertook an Indigenous Employment Training Pilot Program in conjunction with the Northern Land Council and selected stakeholders. The 30 day program was a success, with participants achieving Nationally Accredited
Culture, values and traditions	There may be a risk that the above and/or below ground disturbance associated with drilling and hydraulic fracturing or as the result of seismic activity caused by hydraulic fracturing or reinjection of water will have an adverse impact on Aboriginal culture, values and the traditions that connect landowning groups with their country and sustain community cohesion.	
Community wellbeing	The development of the unconventional gas industry may have an adverse impact on the wellbeing of Aboriginal communities.	
Aquatic and terrestrial ecosystems	The development of the unconventional gas industry may have an adverse impact on aquatic and terrestrial ecosystems important to Aboriginal culture.	
Cumulative risks	There may be cumulative risks associated with some or all of the risks identified above.	

		Certificates and qualifications upon completion and were proudly 'work ready'. This program has also been part of a recent industry commercial[29]. Refer attached Appendix N for a Report into the program. This 30 day program was backed by support from NLC Anthropologists and staff for a 6 month period in assisting to select and motivate remote communities to participate in enhancing their skill levels and future employability.

[29] APPEA *Jobs to lift communities* (2016) <https://vimeo.com/174169715>.

Social impacts

Table 7.6 Social impacts from Background and Issues Paper[30]		
Value	**Risk**	**Pangaea Response**
Housing and rents	There may be impacts on local housing, which may decrease or increase rents and house prices as a result of an increased population.	Pangaea refers the Panel to the APPEA submission.
Insurance	There may be a risk that there will be an increase in insurance costs and liabilities of landowners, occupiers, and traditional owners.	Pangaea refers the Panel to the APPEA submission.
Health services	There may be impacts on the local health system (hospitals, health services etc) as a result of an increased population, including that there may be increased health services in remote communities as a result of industry's presence.	Pangaea refers the Panel to the APPEA submission.
Education	There may be an impact on the local education system as a result of an increased population.	Pangaea refers the Panel to the APPEA submission.
Infrastructure	There may be an impact on infrastructure, such as roads, as a result of increased traffic.	To protect against the risk of an impact on infrastructure, such as roads, as a result of increased traffic, Pangaea adheres to the following Regulations and Practices: • Petroleum Act (2011) • Environmental Assessment Act (1994) • Public and Environmental Health Act (2011) • Petroleum (Environment) Regulations (2016) • Control of Roads Act (2008)

[30] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, above n 1, 21.

		• Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act (2016) • Waste Management and Pollution Control Act (2011) • Work Health and Safety (National Uniform Legislation) Act (2011) • Maintenance of Pastoral Access Roads Policy 2014 • Road and Pavement Maintenance Policy 2014 Dependent upon the campaign location, Pangaea agrees a Deed of Release and Indemnity with Genesee & Wyoming Australia (GWA) for the crossing of rail tracks to undertake operations. A GWA accredited Field Inspector/Safety supervisor observes and supervises first instances of all rail track crossings and any operations close to the track or along the rail corridor. APA Group, owner of the Amadeus Gas Pipeline, are notified one month prior to activities of any crossing by heavy equipment over the pipeline. Meetings are held with the NT Department of Transport – Transport Infrastructure Planning Division for the consent of the use of highways and crossings, a Traffic Management Plan and rehabilitation protocol. This includes use of the Stuart Highway and Western Creek Road.
Livelihoods	There may be an impact on peoples' livelihoods.	Pangaea refers the Panel to the APPEA submission.
Long term benefits	There may be a risk that the development of the industry will occur without short and long term benefits flowing to the local community.	Pangaea refers the Panel to the APPEA submission.
Community cohesion	There may be an impact on community cohesion and resilience, particularly in relation to fly-in, fly-out workers.	Pangaea engages with all stakeholders on an ongoing basis throughout the year (both wet and dry seasons) as a way of keeping key stakeholders informed about our activities, educating the community, traditional owners and government about the project. Pangaea has been intimately involved with the local community including leading industry information sessions to the broader local, as well as Darwin Communities.

		Pangaea has also been a long-term sponsor of and supporter of cultural activities such as NT Rodeo's, Ball's and Regional Show's. Pangaea undertakes initial face to face engagement with the community in field events, booth exhibitions and has held dedicated public forums at Katherine Council Chambers, Katherine Mining Association events and local Golf sponsorship days. In 2016, alongside the Katherine Mining Services Association, Pangaea undertook public, community information sessions on hydraulic fracturing and the processes involved in shale gas operations. These sessions were held in Katherine and Darwin and were attended by both community members and business owners who were keen to understand the process and the opportunities. Pangaea adheres to the "NT Way" and seeks to employ locally wherever possible. Pangaea's executives have built relationships with key businesses in Darwin, Katherine, Mataranka and Larrimah and other key areas close to our operations. These relationships have been established in order to recognise mutually beneficial long term benefit for business and community.
Crime	There may be an increase in crime.	Pangaea refers the Panel to the APPEA submission.
Employment	They may be an impact on local employment and skill levels.	Pangaea adheres to the "NT Way" and seeks to employ locally wherever possible. Pangaea's executives have built relationships with key businesses in Darwin, Katherine, Mataranka and Larrimah and other key areas close to our operations. These relationships have been established in order to recognise mutually beneficial long term benefit for business and community. In 2015, Pangaea undertook an Indigenous Employment Training Pilot Program in conjunction with the Northern Land Council and selected stakeholders. The 30 day program was a success, with participants achieving Nationally Accredited Certificates and qualifications upon completion and were proudly 'work ready'. This program has also been part of a recent industry commercial.

		This 30 day program was backed by support from NLC Anthropologists and staff for a 6 month period in assisting to select and motivate remote communities to participate in enhancing their skill levels and future employability. Pangaea has a long term focus towards community integration through working with traditional owners, local content and the government. Examples of the way that Pangaea uses local content include: employing pastoralists in seismic preparation; traditional owners in pathfinding, civil access and construction works; environmental baseline assessment by a leading local NT consultancy; water bore drilling by a local NT driller; and multiple local Landman for pastoralist liaison and management. As a company that values integrity and responsibility to community, Pangaea continues to strive for excellence in its social licence amongst the Traditional Owners, the Pastoralists and the Northern Territory Government and to operate the "Territory Way" across its tenements.
Business	There may be an impact on local business opportunities.	Pangaea adheres to the "NT Way" and seeks to employ locally wherever possible. Pangaea's executives have built relationships with key businesses in Darwin, Katherine, Mataranka and Larrimah and other key areas close to our operations. These relationships have been established in order to recognise mutually beneficial long term benefit for business and community.
Amenity	There may be a risk that the amenity of persons living on the land will be adversely impacted by hydraulic fracturing and its associated activities.	Pangaea refers the Panel to the APPEA submission.

Land access

Table 7.8 Land access from Background and Issues Paper[31]		
Value	**Risk**	**Pangaea Response**
Consultation	There may be a risk that gas companies do not consult adequately with land owners, occupiers, or traditional owners, in gaining access to the land for exploration and extraction purposes.	To protect against the risk of gas companies not adequately consulting with landowners, occupiers or traditional owners, Pangaea adheres to the following Regulations and Practices: • Petroleum Act (2011) • Public and Environmental Health Act (2011) • Northern Territory Environment Protection Authority Act (2012) • Petroleum (Environment) Regulations (2016) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • ANSI/API Bulletin 100-3: Community Engagement Guidelines (2014) • AS/NZS ISO 31000:2009 Risk Management Under the Petroleum (Environment) Regulations, Pangaea follows a consultation process that it has successfully built over the last 5 years with adherence to the NT Government's "Petroleum Exploration Landholder Two Way Communication Consultation Process" flowchart[32]. Pangaea has executed 36 access agreements. Refer Appendix M for a map of cattle stations which have achieved Voluntary Access Agreements and Pastoral Signoff since 2013.

[31] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, above n 1, 23.

[32] NT Department of Primary Industry and Resources *Petroleum exploration – landholder two way communication consultation process* (4 November 2016) <https://nt.gov.au/industry/mining-and-petroleum/land-access-agreements-for-exploration/petroleum-exploration>.

		Following completion of on ground activities and rehabilitation, Pangaea seeks pastoralist sign off as approval that the rehabilitation has been undertaken as agreed under the Access Agreement. The terms and conditions of access agreements between Pangaea and pastoralists are negotiated annually. Communication and liaison between the lease holder and the company is critical for ease of access, transport, and conducting operations. A key feature of leaseholder negotiations, in addition to those stipulations under Sections 65, 81 and 82 of the NT Petroleum Act 2015, has been the focus on implementing the road access, site preparations and logistics programs with minimal disruption to present land uses, lessening impacts on existing infrastructure and integrating with pastoral work, livestock production and annual planning. The voluntary leaseholder access and compensation agreements include a code of conduct of operations with stated conditions of entry, types of petroleum operations, adherence to weed management and erosion prevention protocols, rehabilitation and compensation structures. The agreement generally reflects a focus on impact minimisation, community acceptance and satisfaction. Direct impacts on leaseholder and pastoral enterprises are a key concern to Pangaea. Active engagement has provided the foundation for negotiation with the pastoralists and the terms of access to the land and the specific items of compensation are agreed to and listed in the access agreements prior to any activity occurring. Pangaea has so far achieved a win-win situation and built solid working relationships with the pastoralists. Pangaea's operations in the region and the perception of the company in the local and wider NT community is an important consideration that remains at the forefront of company policy and board direction. The operation areas chosen attempt to minimise impacts on the community (e.g. noise, dust and incidental nuisance) and specific mitigations are put in place where necessary, fostering good faith with the pastoralists and the local community.

Consent	There may be a risk that gas companies enter the land without, where required, obtaining the consent of the landowner, occupier, or traditional owners, causing conflict.	To protect against the risk of gas companies entering the land without obtaining consent where required, Pangaea adheres to the following Regulations and Practices: • Petroleum Act (2011) • Public and Environmental Health Act (2011) • Northern Territory Environment Protection Authority Act (2012) • Petroleum (Environment) Regulations (2016) • An Explanatory Guide to Petroleum (Environment) regulations • NT Schedule of Onshore Petroleum Exploration & Production Requirements (2016) • ANSI/API Bulletin 100-3: Community Engagement Guidelines (2014) • AS/NZS ISO 31000:2009 Risk Management Refer to the above "Consultation" for Pangaea's process for access and to Table 7.5 for consent of traditional owners. Pastoralists in Pangaea's tenements are active in supporting the industry and Pangaea through building community awareness and sharing their experience in working with the industry. The support has manifested through both letter writing to relevant newspapers, as well as both government and industry made television advertisements. Pangaea has built good relationships with our pastoralists through communication and understanding. All pastoralists are invited to meet and discuss Pangaea's on-ground plans for the year ahead both to reassure the pastoralists of the impacts (if any) that may occur and for Pangaea to explain its development plans for the area. From the onset of Pangaea's on-ground exploration, we have worked with the pastoralists in building an acceptable Access Agreement that works for all parties. The pastoralists had a lot of input into the drafting and final terminology of the agreement and, from finalisation in 2012, this agreement is still acceptable and used today.
Conditions	There may be a risk that gas companies and landowners, occupiers, and traditional owners, do not negotiate mutually beneficial conditions associated with any agreement permitting access.	
Compensation	There may be a risk that compensation paid for access and/or disturbance to land will not be adequate. There may be a risk that if there is an incident in the exploration, extraction or production of any gas, the land may not be properly remediated or the land owners, occupiers, or traditional owners may not be adequately compensated.	

		<u>Mitigation Measures & Strategies</u> • Pangaea's Corporate Quality, Health, Safety and Environmental Policy is adhered to (Appendix L). • Pastoralists will be contacted at least two weeks prior to the commencement of Civil Operations on their station. • Site rehabilitation will be undertaken as specified and agreed in the landholder access forms.

Regulatory framework

Table 7.9 Regulatory framework from Background and Issues Paper[33]		
Value	**Risk**	**Pangaea Response**
Failure to protect the environment	There may be a risk the regulatory framework does not adequately protect the environment (water, land, and air) from risks associated with hydraulic fracturing and associated activities.	Pangaea is comfortable that current regulations for the exploration phase meet best practice following the findings and recommendations of Dr Tina Hunter (attached as Appendix O) and Dr Allan Hawke AC[34,35]. Regulations complied with include: Federal • Aboriginal Land Rights (Northern Territory) Act 1976 • Australian Heritage Council Act 2003 • Environment Protection and Biodiversity Conservation Act 1999 • Water Act 2007 • Native Title Act 1993 • Industrial Chemicals (Notification and Assessment) Act 1989 • Corporations Act 2001 and Australian Securities and Investments • Commission Act 2001 • Fair Work Act 2009 • Taxation legislation (various) State • Aboriginal Land Act 2010 • Bushfires Act 2009
Land access	There may be a risk the regulatory framework does not appropriately balance the rights of landowners, occupiers, and traditional owners with those of gas companies.	
Public health	There may be a risk the regulatory framework does not adequately mitigate public health risks associated with the unconventional shale gas industry.	
Aboriginal culture and communities	There may be a risk the regulatory framework does not adequately protect Aboriginal culture, values, traditions and communities from risks associated with the unconventional shale gas industry.	
Social impacts	There may be a risk the regulatory framework does not adequately mitigate the social risks associated with the unconventional shale gas industry.	

[33] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, above n 1, 24.
[34] Dr Allan Hawke AC *Hawke Review I* (2014) <https://denr.nt.gov.au/environment-information/environmental-policy-and-reform/hawke-ii-review>.
[35] Dr Allan Hawke AC *Hawke Review II* (2016) < https://denr.nt.gov.au/environment-information/environmental-policy-and-reform/hawke-ii-review>.

Economic impacts	There may be a risk the regulatory framework does not ensure that any economic benefits are appropriately distributed between the gas companies, the government and the community.	• Control of Roads Act 2008 • Dangerous Goods Act 2012 • Environmental Assessment Act 1994 • Environmental Offences and Penalties Act 2011 • Fire and Emergency Act 2004 • Heritage Conservation Act 2008 • Information Act 2016 • Northern Territory Aboriginal Sacred Sites Act 2013 • Northern Territory Environment Protection Authority Act 2012 • Petroleum (Environment) Regulations 2016 • Petroleum Act 2011 • Plant Health Act 2008 • Public and Environmental Health Act 2011 • Soil Conservation and Land Utilisation Act 2009 • Territory Parks and Wildlife Conservation Act 2011 • Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act 2016 • Waste Management and Pollution Control Act 2011 • Water Act 2011 • Weeds Management Act 2001 • Work Health and Safety (National Uniform Legislation) Act 2011 State Guides • An explanatory guide to Petroleum Environment Regulations • Northern Territory Weed Management Strategy • NT Department of Infrastructure - Maintenance of Pastoral Access Roads Policy 2014 • NT Department of Infrastructure – Road and Pavement Maintenance Policy 2014
Compliance and enforcement	There may be a risk of inadequate monitoring or enforcement of compliance with the regulatory framework. This may arise from, for example, inadequate resourcing of the regulatory agency or inadequate training of relevant officers. There may be a risk that sanctions provided for in the regulatory framework are inadequate or are not utilised by the regulator. There may be a risk that the cost of complying with the regulatory framework is too high for industry and the industry becomes uneconomic.	
Complexity	There may be a risk that the regulatory framework is needlessly complex.	
Regulatory capture	There may be a risk of 'regulatory capture' whereby the regulatory body becomes inappropriately aligned with industry and reluctant to regulate.	
Cumulative risks	There may be cumulative risks associated with some or all of the risks identified above.	

		• NT Department of Health – Fact Sheet 700 'Requirements for Mining and Construction Projects' • Schedule of Onshore Petroleum Exploration and Production Requirements 2016 API Standards • ANSI/API RP 19C Measurement of properties of proppants used in hydraulic fracturing and gravel-packing operations (2008) • API RP 51 Onshore oil and gas production practices for protection of the environment (R2007) • API RP 51R Environmental protection for onshore oil and gas production operations and leases (2009) • API RP 52 Land drilling practices for protection of the environment (R2010) • API RP 53 Recommended practices for blowout prevention equipment systems for drilling wells • API RP 54 Recommended practice for occupational safety for oil and gas well drilling and servicing • API RP 59 Recommended practice for well control operations (R2006) • API RP 67 Recommended practice for oilfield explosive safety • API RP 100-1 Hydraulic fracturing – well integrity and fracture containment, First edition (2015) • API RP 100-2 Managing environmental aspects associated with exploration and production operations including hydraulic fracturing, First edition (2015) • API GD HF1 Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines (2009) • API GD HF2 Water management associated with hydraulic fracturing (2010) • API GD HF3 Practices for mitigating surface impacts associated with hydraulic fracturing • ANSI/API Bulletin 100-3 Community Engagement Guidelines (2014)

		• API Standard 65 – Part 2 Isolating potential flow zones during well construction ISO Standards • ISO 9001:2000 Quality management systems – Standard • ISO 14001:2004 Environmental management systems – Standard • ISO 19011:2011 Guidelines for quality and/or environmental management systems auditing – Guidelines AS/NZS Standards • AS/NZS 5667:1998 Water Quality – Guidance on Sampling of Groundwater • AS/NZS 4360:2004 Risk Management Framework – Standard • AS/NZS ISO 14012:1996 Guidelines for environmental auditing: qualification criteria for environmental auditors • AS/NZS ISO 31000:2009 Risk Management • AS 1940:2004 The storage and handling of flammable and combustible liquids Industry Best Practice • Groundwater Sampling and Analysis – A Field Guide • HB 139-2003 Guidance on systems integration – Guidelines • HB 203:2006 Environmental risk management – principles and processes • APPEA Code of Environmental Practice 2008 • West Australian Onshore Gas Code of Practice for Hydraulic Fracturing • IWCF & IADC well control course credentials Pangaea also acknowledges other inquiries and reports on this and similar subjects around the world and in Australia:

		Prior to the Hawke Report 2014[36] The Australian Council of Learned Academies (ACOLA) Report "Engineering Energy: Unconventional Gas Production A Study of Shale Gas in Australia" 2013[37], found that with appropriate safeguards in place shale gas (unconventional) with the use of fracking represents no greater risk than conventional gas. Although certain regulatory oversight needs to be maintained and adhered to maintain a risk profile which is acceptable and as low as practical (ALARP). The Western Australian Upper House reviewed the issue of fracking, and after two years of examining evidence etc. concluded (November 15) that fracking can be carried out safely if regulated appropriately. It found the impact on human health and the environment were 'negligible' despite widespread concerns about the practice.[38] The South Australian (SA) Natural Resources Committee recently completed a two year Inquiry into unconventional gas and the use of fracking, and issued its final Report on 30 November 2016[39]. Its key recommendation against its first Term of Reference was that unconventional gas (fracking) is unlikely to have any impact on groundwater (aquifers). The UK had a very rigorous inquiry carried out by the Professor Sir Mark Walport UK Chief Scientist; Royal Society and the Royal Academy of Engineering specifically focussing on hydraulic fracturing and shale gas[40].

[36] Dr Allan Hawke AC, above n 35.

[37] Australian Council of Learned Academies *Engineering energy: unconventional gas production* (2013) <http://acola.org.au/wp/project-6/>.

[38] Environment and Public Affairs Committee *Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas* (2013) <http://www.parliament.wa.gov.au/Parliament/commit.nsf/(EvidenceOnly)/6C678FAE3E96186748257BC6002BAF31?opendocument>.

[39] Natural Resources Committee Inquiry into Unconventional Gas (Fracking) in the South East of South Australia Final Report (29 November 2016) <https://www.parliament.sa.gov.au/Committees/Pages/Committees.aspx?CTId=5&CId=175>.

[40] The Royal Society *Final Report – shale gas extraction* (2012) <https://royalsociety.org/topics-policy/projects/shale-gas-extraction/report/>.

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APPENDICES

Appendices have been submitted as separate individual documents.

2016 NT APPRAISAL CAMPAIGN

EP-167 & EP-168

ENVIRONMENTAL MANAGEMENT PLAN

CIVIL OPERATIONS

Prepared For: **Pangaea (NT) Pty Ltd**
Date: **December 2015**
Approved By: **Tim Radburn**
Revision No: **2**

Civil Operations for 2016 NT Appraisal Campaign EP-167 & EP-168

ENVIRONMENTAL MANAGEMENT PLAN

Preparation of this Environmental Management Plan ("EMP") has been completed through a series of meetings and email correspondence, with close consultation involving all concerned parties. This EMP describes the environmental emergency contingencies and mitigation measures that are to be implemented by Pangaea (NT) Pty Ltd ("Pangaea"), its contractors and service providers in EP-167 and EP-168 when undertaking civil preparation works ("Civil Operations") for the 2016 NT Appraisal Campaign.

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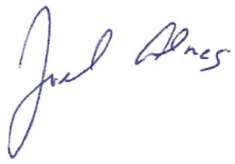
Title:	Civil Operations for 2016 NT Appraisal Campaign EP-167 & EP-168 Environmental Management Plan		

REVISIONS

Rev	Date	Reason For Revision	Author	Initial
0	24-Nov-2015	Initial Issue (Draft)	T Radburn	TR
1	26-Nov-2015	EMR Review	C Hutchinson	CH
2	30-Nov-2015	Final Review	J Alnes S Salhotra M Sullivan D Armstrong	JA SS MS DA

THIS REVISION

Prepared By:		Prepared By:	
Name	Initial/Date	Name	Initial/Date
Tim Radburn	*TR / 30 November 2015*		
Approved For Submission By:	Tim Radburn		1/12/2015

APPROVALS			
Name	**Position**	**Signature**	**Date**
Ray Hall	Managing Director EcOz Environmental Consultants		1/12/2015
Mark Sullivan	Managing Director MS Contracting		1/12/15
Bill Sullivan	HSE Director MS Contracting		1/12/15
David Armstrong	Managing Director Terrabos Consulting		01.12.15
Joel Alnes	Vice President of Exploration Pangaea (NT)		1st Dec 15
Tim Radburn	Executive Director Pangaea (NT)		1/12/15

DISTRIBUTION LIST - Controlled Copies

Organisation	Position	No. of Copies
Pangaea (NT) Pty Ltd	OPERATOR (SYDNEY)	1
Department of Mines and Energy	NT GOVT AUTHORITY	1
Terrabos Consulting	LANDMAN	1
Mark Sullivan Contracting	EARTHWORKS CONTRACTOR	1
EcOz Environmental Services	ENVIRONMENTAL MANAGEMENT	1
Location (each)	SITE OFFICE/CAMP	1
Local Authorities	EMERGENCY SERVICES	1

At least one up-to-date copy shall be maintained and made available at the operating area.

The following matrix has been developed to ensure compliance with the Department of Mines and Energy Guideline – Environmental Plan ("EP") Requirements.

Title in Guideline	Requirement	Section in this document
General	Version number or document reference for the EP	Title page
	Contain a document revision history	Page 2
	Include project proponent details	Page 2
	A document distribution list for the EP	Page 4
Corporate Environmental Policy		Page 14
Environmental Legislation and other requirements		Section 2
Project Activity Description		Section 3
Environment Description	Existing natural physical environment including geography, geology, climate, hydrogeology, hydrology, soils etc.	Section 7
	Existing natural biological environment including bioregions, flora and fauna, birds, fishes, reptiles, mammals, feral animals etc.	Section 7.2
	Cultural environment including Indigenous, European and others.	Section 7.4
	Current socio-economic environment including habitation, recreational and commercial and tourism.	Section 7.3
	Sacred and Cultural Heritage sites	Section 7.4.1
	Protected areas/Conservation Areas	Section 7.4.2
	Rare or endangered flora and fauna	Section 7.4.3
	Areas of significant habitat	Section 7.4.4
	Fire regime	Section 7.4.5
Environmental Risks and Impacts Description and Assessment.		Section 9
Performance Objectives, Standards & Measurement Criteria		Section 10
Implementation Strategy	Operation systems, practices and procedures that: • will be utilised to ensure that environmental impacts and risks are reduced to an agreed and acceptable level; and • are specific to the environmental performance objectives and standards.	Section 11.2
	Establishment of a clear chain of command including roles and responsibilities of personnel for the implementation, management and review of the EP.	Section 11.1
	Measures to ensure that employees and contractors are made aware of their responsibilities and have appropriate competencies and trainings.	Section 11.3

Title in Guideline	Requirement	Section in this document
Implementation Strategy	Planned monitoring, audit, management of non-conformance and review of environmental performance.	Section 11.5
	Specific reference to an appropriate Emergency Response Plan as well as an Oil Spill Plan that the operator has in place.	Section 12
	A recording system that maintains quantitative records of emissions and discharges to the environment which can be monitored and audited against the performance standards and measurement criteria.	Section 11.5
Reporting		Section 11.6
Consultation		Section 11.8

Summary

The objectives of the 2016 NT Appraisal Campaign are to better understand the commercial viability of the natural gas discovered during Pangaea's successful 2013, 2014 and 2015 campaigns in EP-167 and EP-168. The objectives of the Appraisal Campaign are to:

- further delineate the most optimal area within EP-167 and EP-168 to test pilot production of natural gas;
- acquire 3D seismic data to clearly determine the structural fabric of the rocks in this area,
- test geomechanical properties of the rock in both vertical and horizontal domains, and
- gather additional pressure data and gas flow data from wells in order to evaluate the viability to reach commercial flow rates of gas from the middle Velkerri formation.

Pangaea's proposed 2016 NT Appraisal Campaign includes the following operations:

- Civil preparation operations;
- Drilling and stimulation of two wells; and
- Acquisition of ~451 km^2 of 3D seismic.

This EMP focuses on the Civil Operations required as preparation for the 2016 NT Appraisal Campaign.

The 2016 NT Appraisal Campaign operations and associated camp sites are located on pastoral land. The total area of land impacted by this activity will be approximately 1,181 hectares. Each drill pad will be limited to the removal of all vegetation over the 200m x 238m site plus the exclusion zone and fire break, with the camp site and evaporation pond within the drill pad area. The seismic survey will impact approximately 1,175 hectares of land. The catchment dam will impact approximately 125m x 100m of land. The proposed locations will not create any significant long-term impacts on local land use practices nor landforms.

Review of NT Department of Minerals & Energy (DME) flora and fauna threatened species data indicates that the proposed locations will not impact on any known populations of rare or threatened species of native flora or fauna. Site and line selection has been based, in part, on the minimisation of vegetation modification to furthermore mitigate any residual risk of impact on such species or habitat. Consultation with the Northern Land Council (NLC), Traditional Aboriginal Owners (TAOs), and the Aboriginal Areas Protection Authority is underway for receipt of a sacred site avoidance notification, and indication that the activities are not a threat to sites of Aboriginal cultural heritage significance.

This Environmental Management Plan (EMP) has been prepared in line with the relevant DME Guidelines: Environmental Plan (EP) Requirements, Schedule of Onshore Petroleum Exploration and Production Requirements 2012, Onshore Oil and Gas Guiding Principles and Environmental Plan Summary. The provision of this document is aligned with the company's responsibility as per Clauses 109 of the Schedule and is cognizant of consequences embodied in Part V, Divisions 2 and 3 of the NT Petroleum Act, in which the determining authority (DME) is required to consider the likely and actual environmental impacts of the activity.

The information contained within this document is an accurate characterisation of the operational environment within which the Civil Operations are to be conducted. It is the opinion of Pangaea (NT) Pty Ltd that the impacts created by the proposed activity when considered alongside the mitigation strategies in place will create no long-term effect on the localised and regional environment.

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Corporate Environmental Protection Policy

Policy Statement
Pangaea (NT) Pty Ltd ("Pangaea") is committed to the protection and preservation of the environment in the performance of its duties as an Exploration and Production company and provision of expertise to the petroleum resource industry. This commitment is embraced by the company's employees and sub-contractors.

Pangaea activities will be planned and performed in order to avoid or contain at an acceptable level, adverse effects on the environment. These activities will also conform to all statutory requirements.

The purpose of this policy within our organisation is to provide the environmental objectives within our direct daily operations and related activities which must be auditable, and the criteria upon which achievement of those objectives can be assessed, for consideration under the Act.

Policy Details
Based on risks to the environment identified within the activities of Pangaea, the following are environmental objectives relevant to our operations:

1. Avoid disturbance to sites of indigenous and non-indigenous heritage of sociological significance;
2. Minimise disturbance to vegetation and ecological habitat;
3. Avoid disturbance to rare, endangered and vulnerable species; including minimise adverse impact on livestock;
4. Avoid impacts on high biological value or wilderness value areas;
5. Avoid facility and transport spills, including ensuring disposed formation water is oil free and biologically compatible and acceptable;
6. Avoid contamination of stock waters and soils with hydrocarbons or contaminants; and
7. Minimise visual impacts & environmental workforce hazards;

To comply with this policy Pangaea will:

a) Comply with applicable laws and regulations;
b) Where laws and/or regulations do not exist, conduct our operations applying responsible standards at all times, and, where applicable, act within the local environmental policies. Commit to a periodic and regular review of its Environmental Policy in the light of new technology, changing legislation, and recommended industry practices;
c) Assess potential environmental effects before conducting new activities. Encourage concern and respect for the environment. Ensure that employees and contractors are aware of their responsibilities with respect to environmental management and protection; and
d) Ensure contractors understand and adhere to the company's environment policy and standards as a minimum.

Implementation
The Directors are expected to demonstrate that employees and contractors are meeting the environment policy objectives. Environmental matters will form part of Pangaea's regular performance review process. The processes will be supplemented by periodic internal review.

Responsibilities
The Directors and Management Team are accountable for ensuring that this policy is implemented and that its effectiveness is reviewed. This policy will be updated every two years. All Pangaea staff and sub-contractors shall become familiar with, and comply with the environmental policy.

FORMS/DOCUMENTATION RELATED TO THIS POLICY

Pangaea Quality, Heath, Safety and Environment Policy (refer **Appendix A**)
Pangaea Quality Management Systems Manual
Pangaea Quality Health, Safety & Environment Management Systems Manual
Pangaea Risk Management System Manual
STEP Program
Pangaea Corrective and Preventative Action Item Register

REFERENCES

ISO 9001:2000, Quality management systems - Standard
ISO 14001:2004, Environmental management systems - Standard
ISO 19011:2011, Guidelines for quality and/or environmental management systems auditing – Guidelines
AS/NZS 4360:2004, Risk Management Framework – Standard
HB 139-2003, Guidance on Systems Integration – Guidelines

1.0 GENERAL GUIDELINES

1.1 Introduction

This document, the Civil Operations for 2016 NT Appraisal Campaign, EP-167 & EP-168 Environmental Management Plan ("EMP") describes the roles and environmental responsibilities of all personnel. It also acts as a bridging document for principal contractors and details key environmental mitigation measures identified by Pangaea post identification of 'hazards & risks' and emergency response.

This EMP is to be read in conjunction with the Safety Management Plan ("SMP") and Emergency Response Plan ("ERP"), which details the required response in the event of any emergency situation, environmental or otherwise.

The EMP also describes the interface arrangements between operations in the Pangaea Northern Territory ("NT") tenements and Pangaea Head Office, and highlights the technical, logistic and strategic support that is available in environmental emergency situations.

1.2 Proponent

Established in 1997, Pangaea is an independent exploration and production company with a diverse portfolio of oil and natural gas operations across onshore Australia. Pangaea commenced exploration in Queensland with the successful application for petroleum tenements south of Chinchilla. Since then, Pangaea expanded its activities and is now active in a number of areas exploring for and aiming to produce natural gas and oil.

The Operator is Pangaea (NT) Pty Ltd. Pangaea has 82% interest in five Northern Territory permits (EP-167, EP-168, EP-198, EP-169 & EP-305).

1.3 Purpose & Scope of this Environmental Plan

1.3.1 Purpose

The purpose of this EMP is to provide the framework for environmental management of the activities proposed in EP-167 and EP-168 and to detail the control measures to be implemented to ensure that activities are conducted in an environmentally responsible manner. This EMP applies to all activities conducted by Pangaea for the Civil Operations and aims to provide:

SECTION 2: An outline of environmental statutory responsibilities
SECTION 3: A summary of the civil operations program and associated activities
SECTION 7: An outline of the receiving environment
SECTION 9: A summary of Environmental Risks & Hazards
SECTION 10: The Environmental Context and Mitigation measures
SECTION 11: A description of key personnel and responsibilities

1.3.2 Scope

This EMP has been prepared in compliance with the DME Guidelines: Environmental Plan (EP) Requirements, Schedule of Onshore Petroleum Exploration and Production Requirements 2012, Onshore Oil and Gas Guiding Principles and Environmental Plan Summary. This EMP covers all identifiable credible/identified potential environmental issues, mitigation measures, contingencies and emergencies identified considering the Civil Operations.

1.4 Location and Resource Tenure

EP-167 and EP-168 are located approximately 500 km southeast of Darwin in the Northern Territory (NT). The tenements fall within the Victoria-Daly, Roper & Barkley Shires plus the Katherine Municipality. The Civil Operations will be located in the eastern portions of EP-167 and EP-168 in central Northern Territory, as detailed in Figure 1.

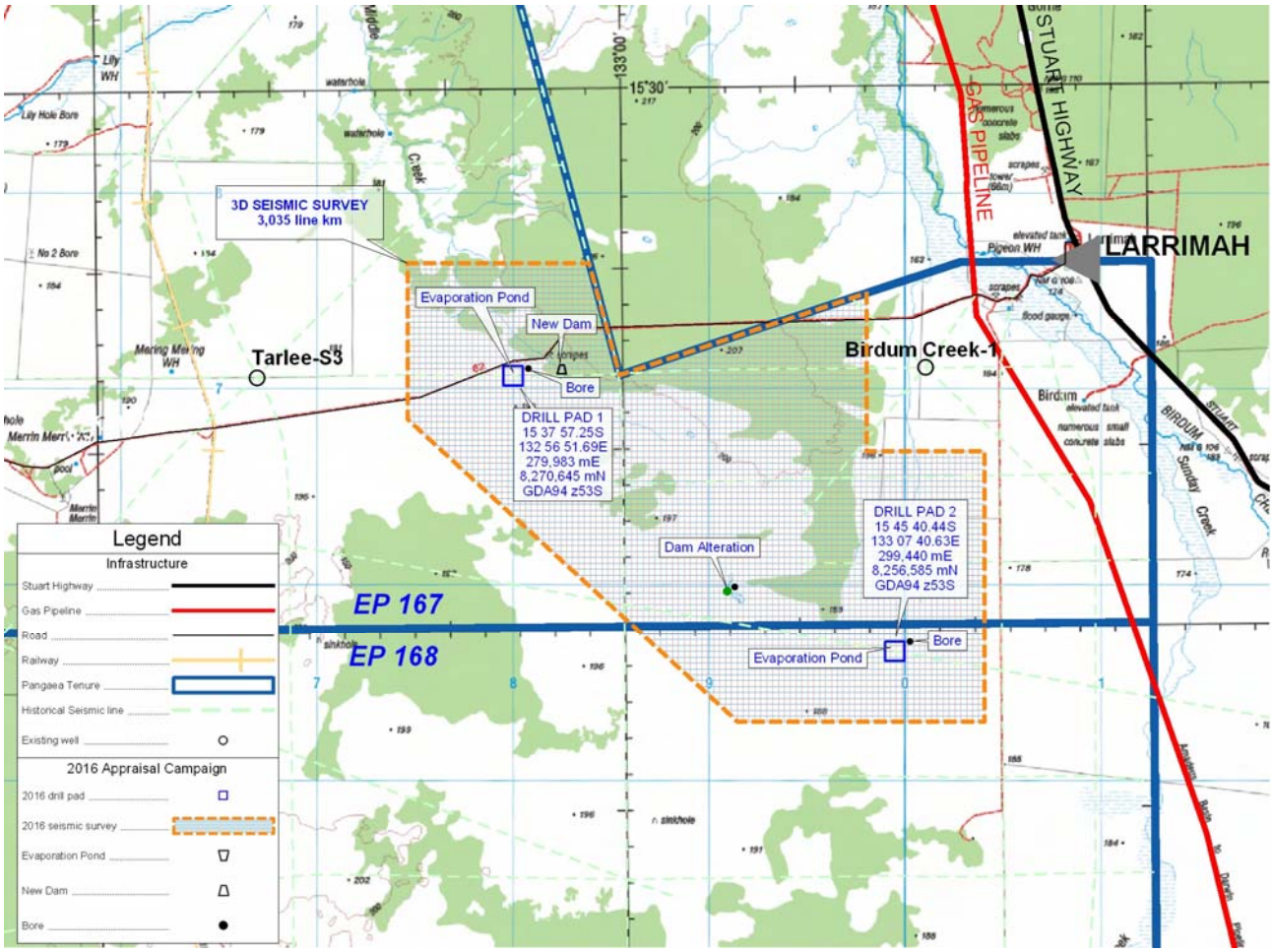


Figure 1: EP-167 & EP-168 showing Civil Operations

1.5 Definitions

Environmental Emergency	An event that causes or has the potential to cause, material or serious harm to the environment.
Material Environmental Harm	An impact to the environment that: (a) is not trivial or negligible in nature; (b) consists of an environmental nuisance of a high impact or on a wide scale; (c) results, or is likely to result, in not more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or (d) results in actual or potential loss or damage to the value of not more than $50,000 or the prescribed amount (whichever is greater).
Serious Environmental Harm	An impact to the environment that: (a) is irreversible or otherwise of a high impact or on a wide scale; (b) damages an aspect of the environment that is of a high conservation value, high cultural value or high community value or is of special significance; (c) results or is likely to result in more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or (d) results in actual or potential loss or damage to the value of more than $50,000 or the prescribed amount (whichever is greater).
Incident Commander	The Pangaea Representative on site who has prime responsibility for the coordination of the emergency response on Pangaea's behalf.
EMR	Environmental Management Representative
OC	Pangaea Operations Coordinator
ED	Pangaea Executive Director
VE	Pangaea Vice-President of Exploration

CEO	Pangaea Chief Executive Officer
Contractor	Any principle contractor operating on a site within the tenement(s)
CMT	Crisis Management Team (Sydney)
DME	Northern Territory Department of Mines and Energy
EMT	Emergency Management Team
Service Provider	Any services provided on site operated by principal contractor
ERO	Emergency Response Officer
ERT	Emergency Response Team
NLC	Northern Land Council
CMC	Cultural Management Consultant

2.0 STATUTORY CONTEXT

A variety of Exploration Permit Conditions and Legislation are relevant to the Civil Operations in preparation for the 2016 NT Appraisal Campaign. The Permit Conditions are discussed throughout this document and **Table 1** summarises the legislation that will be considered in this EMP.

Table 1: Summary of Relevant Legislation

Legislation	Requirements
Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (Cwth)	If threatened species, populations or ecological communities listed under the EPBC Act are likely to be impacted as a result of the Civil Operations activities, it is unnecessary to make a referral to the Environment Minister.
Native Title Act 1993 (Cwth)	The main objects of this Act are: a) to validate past acts, and intermediate period acts, invalidated because of the existence of native title, and to confirm certain rights in accordance with the Commonwealth Native Title Act; and b) to ensure that Northern Territory law is consistent with standards set by the Commonwealth Native Title Act for future dealings affecting native title.
Petroleum Act 2015	The objective of this Act is to provide a legal framework within which persons are encouraged to undertake effective exploration for petroleum and to develop petroleum production so that the optimum value of the resource is returned to the Territory.
NT Schedule of Onshore Petroleum Exploration and Production Requirements 2012	The direction implementing this Schedule applies only to, or in relation to acts, omissions, matters, circumstances or things touching, concerning, arising out of or connected with the exploration or exploitation of the soil and subsoil for petroleum. The Schedule ensures that operations are carried out in a manner that avoids or, where that is not practicable, minimises any adverse impact on the environment and that the holder of a title shall ensure that all his employees and contractors comply with an approved Code of Environmental Practice, or with the APPEA Code of Environmental Practice.
Aboriginal Land Rights (Northern Territory) Act 1976	The Land Rights Act sets out how exploration must be done on Aboriginal land. The Act provides for consultation with traditional land owners and if approved, compensation agreements for exploration activities.
Environmental Assessment Act 2013	The objective of this Act is to ensure that each matter affecting the environment is fully examined and taken into account in, and in relation to: a) the formulation of proposals; and b) the carrying out of works and other projects.

Legislation	Requirements
Heritage Act 2012	The Act provides a system for the identification, assessment, protection and conservation of the Territory's natural and cultural heritage. Such heritage includes fossils, buildings, gardens, ruins, archaeological sites, landscapes, ecosystems, coastlines, plant and animal communities.
Plant Health Act 2008	The objects of this Act are: a) to ensure appropriate actions can be taken for the control of pests; and b) to facilitate the production and trading of plants and plant products that are free from pests.
Weeds Management Act 2001	The purpose of this Act is: a) to prevent the spread of weeds in, into and out of the Territory and to ensure that the management of weeds is an integral component of land management in accordance with the Northern Territory Weeds Management Strategy 1996 – 2005 or any other strategy adopted to control weeds in the Territory; b) to ensure there is community consultation in the creation of weed management plans; and c) to ensure that there is community responsibility in implementing weed management plans.
Waste Management and Pollution Control Act	The objectives of this Act are: a) to protect, and where practicable to restore and enhance the quality of, the Territory environment by: (i) preventing pollution; (ii) reducing the likelihood of pollution occurring; (iii) effectively responding to pollution; (iv) avoiding and reducing the generation of waste; (v) increasing the re-use and re-cycling of waste; and (vi) effectively managing waste disposal; b) to encourage ecologically sustainable development; and c) to facilitate the implementation of national environment protection measures made under the National Environment Protection Council (Northern Territory) Act.
Water Act 2013	This Act introduced in 2013 provides for the investigation, allocation, use, control, protection, management and administration of water resources, and for related purposes.

Legislation	Requirements
Public and Environmental Health Act 2011	The Public and Environmental Health Act 2011 provides a contemporary, flexible framework for monitoring and regulating public and environmental health in the Northern Territory. By way of a summary, the primary objects of the Act that directly relate to the project are: a) to provide a flexible capacity to protect the health of particular individuals and communities in the Territory from emerging environmental conditions, or public and environmental health issues, that may impact on their health and wellbeing; and b) to monitor, assess and control environmental conditions, factors and agents, facilities and equipment and activities, services and products that impact on public and environmental health.
Bushfires Act 2009	An Act relating to the prevention and suppression of bushfires.

Table 2: Summary of Relevant Code of Practice

Code of Practice	Requirements
The Northern Territory Weed Management Strategy	1. Preventing Introduction and Spread of Weeds 2. Ensuring Weed Management is an Integral Part of Land Management 3. Learning More About Weeds in the Territory as an Essential Basis for Land Management 4. Increasing Public Awareness and Education 5. Providing Appropriate Legislation for Weed Management 6. Reviewing Progress in Weed Management
Community Engagement & Development	Specific aims are to: a) outline the benefits to companies and operations of engaging with, and contributing to, the development of communities; b) provide a framework to help operations and companies assess the maturity of their current approach to dealing with communities; c) describe the basic steps involved in effectively planning and managing for community engagement and development; d) set out key principles that should guide these activities; and e) highlight examples of evolving good practice.
Methodology for the Sampling of Ground Waters	This advisory note has been prepared to assist operators in the development and refinement of procedures for the collection and treatment of ground water samples.
NT Department of Health – Fact Sheet 700 "Requirements for Mining & Construction Projects"	This fact sheet has been developed to provide information to proponents of mining and construction projects in the NT with regard to the environmental health requirements of the Department of Health – Environmental Health (DoH).

Code of Practice	Requirements
APPEA Code of Environmental Practice 2008	The code seeks to ensure a standard of performance by reducing impacts to 'as low as reasonably practical and to an acceptable level' is a dynamic measure that will continue to evolve in line with improved risk identification and assessment methods, technological advances, changed circumstances, performance monitoring, government requirements, community expectations and other relevant information. As such, by reducing impacts to as low as reasonably practical, APPEA members will in effect be striving for continuous improvement.
Onshore Oil and Gas Guiding Principles (2015)	The guiding principles are an interim measure and set out the minimum expectations of how industry will conduct itself while a comprehensive review of the Northern Territory's existing regulatory framework is undertaken.

Table 3: Summary of Current Agreements in Place

Agreement	Requirements
Co-Existence and Exploration Deed for EP 167, 168, 169 and 198	The terms and conditions of agreement which has been reached between the Parties (Pangaea NT, Native Title Holders and the Northern Land Council) in relation to the exploration for gas and oil under the Petroleum Act.
Land Access Agreement	The terms and conditions of access agreement is currently being negotiated between the Parties (Pangaea (NT) and the Leaseholders) in relation to the exploration for gas and oil under the Petroleum Act, and is due for completion 1 January 2016.

3.0 PROJECT ACTIVITY DESCRIPTION

3.1 Proposed Project Operations

The objectives of the Civil Operations are to prepare the affected pastoral land for Pangaea's proposed 2016 NT Appraisal Campaign, which includes:

- Drilling and stimulation of two wells; and
- Acquisition of ~451 km^2 of 3D seismic.

The Civil Operations will involve the preparation of all access requirements, drill pads, seismic lines, and supporting infrastructure to enable the 2016 NT Appraisal Campaign operations.

The 2016 NT Appraisal Campaign operations and associated camp sites are located on pastoral land. The total area of land impacted by this activity will be approximately 1,181 hectares. All topsoil and seed bed moved during Civil Operations will be stockpiled separately from overburden. Seed stock will be rilled to the sides of disturbance and will be used in rehabilitation.

Each drill pad will be limited to the removal of all vegetation over the 200m x 238m site plus the exclusion zone and fire break, with the camp site and evaporation pond within the drill pad area. The seismic survey will impact approximately 1,175 hectares of land. The catchment dam will impact approximately 125m x 100m of land. The proposed locations will not create any significant long-term impacts on local land use practices nor landforms.

3.2 Technical Specifications

3.2.1 Access Roads

A total of ~22km of fence lines will require varying degrees of grading and gravel sheeting in order to facilitate effective and safe access to the drill pads. All works on public roads (which includes ~35 km of Larrimah-Western Creek Road, west from the Stuart Highway) will comply with the relevant Acts, Regulations, Guidelines and Codes applicable to the works and comply with the requirements of Authorities with jurisdiction over the works. In particular, the works will conform to the standards and publications quoted throughout Department of Construction & Infrastructure, *Standard Specification for Road Maintenance, 2012*. Works on pastoral land that is not publically accessed will be restored to an agreed condition in accordance with the Petroleum Act.

All gravel material will be obtained from sources of naturally occurring deposits and the required material properties will be achieved by crushing, screening, mixing or other processes necessary. The sub-contractor will ensure that particles are tough, durable and of a tightly binding nature free of organic or other deleterious matter. Materials, wherever practicable, will be obtained from existing borrow pits.

A Traffic Management Plan will be prepared by an independent 3rd party licenced contractor if required by the Department of Infrastructure after consultation between Pangaea and the Department on the work program. All applicable permits will be obtained.

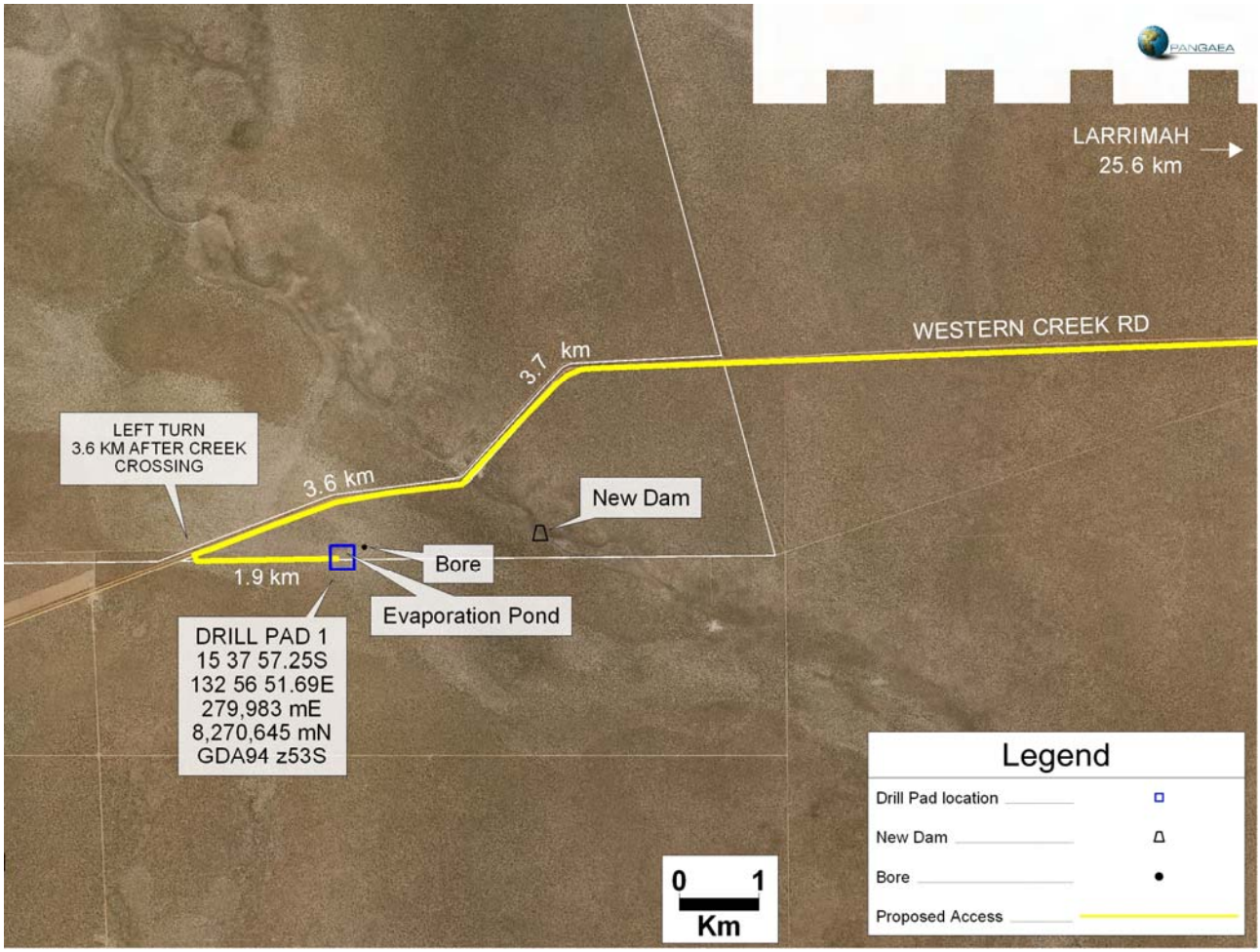


Figure 2: Proposed Access to Drill Pad 1

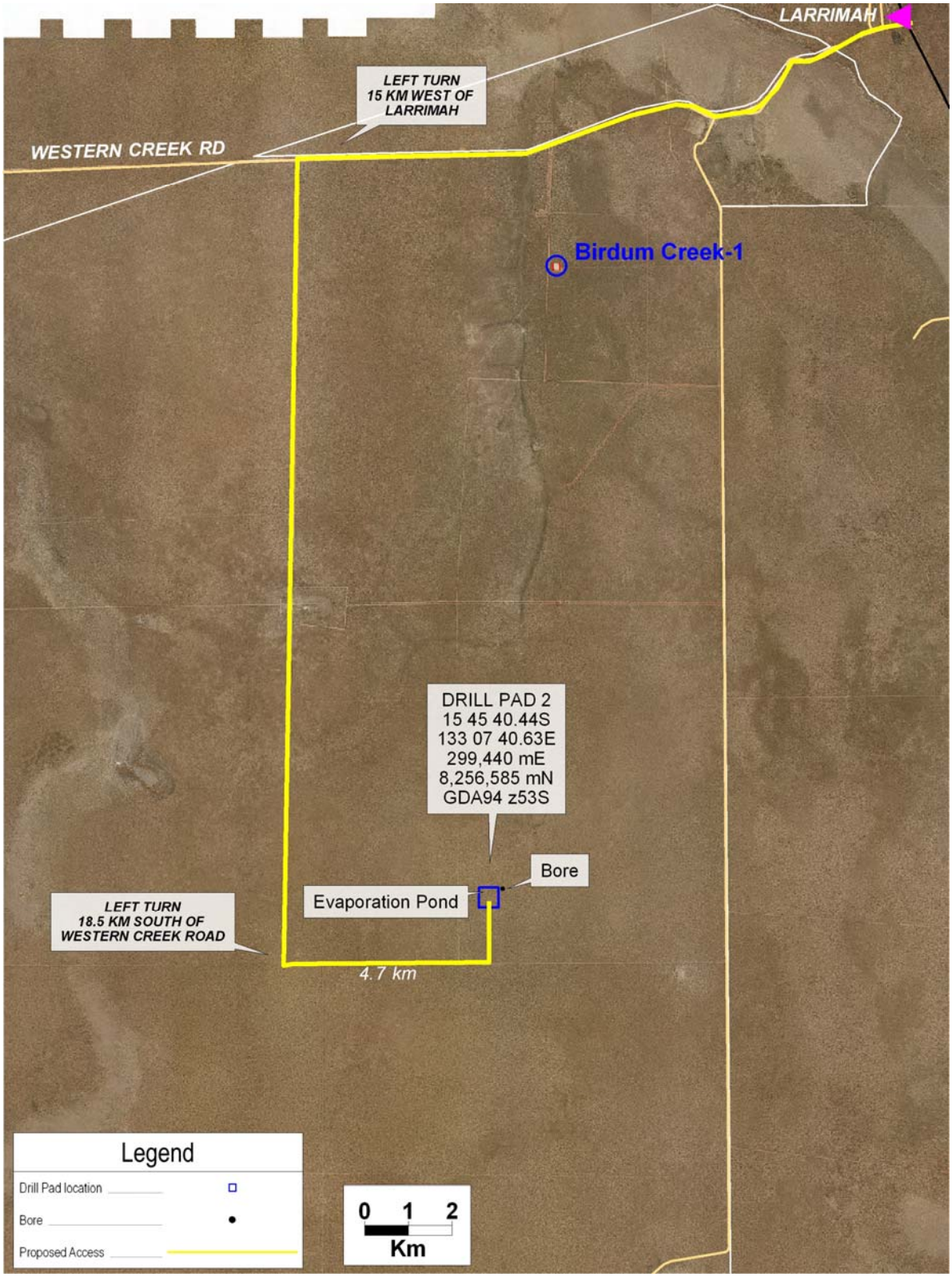


Figure 3: Proposed Access to Drill Pad 2

3.2.2 Drill pad preparation

Drill pad design and construction is designed to maintain a well-drained area suitable for the safe operation of drilling machinery and ancillary equipment in all but the heaviest rainfall. Installation of drainage lines to prevent the retention of meteoric water on or around the site will be included in preliminary earthworks should a requirement be identified. Further consultation with pastoralists in this regard will characterise any site-specific requirements for drainage improvements to be implemented. **Figures 4 & 5** show the proposed layout for the drill pads

The preparation required to provide a suitable drill pad is relatively minor. The preparation activity will be limited to the removal of all vegetation over the 100m x 115m site plus the exclusion zone and fire break, excavation of the flare pit, sumps and the water reserve pit ("turkey's nest") and installation of the surface cellar. A camp site will also be located within close proximity of the drillsite. The preparation activity for the camp site will be limited to the removal of all vegetation over a 60 x 60m site.

The importation of gravels for stability improvement is likely to some degree, however with modern drilling rigs possessing self-levelling hydraulics this will be small quantities spread over very specific areas rather than full pad sheeting. The drill pads will also house the mobile campsite and are only as large as required by safety parameters.

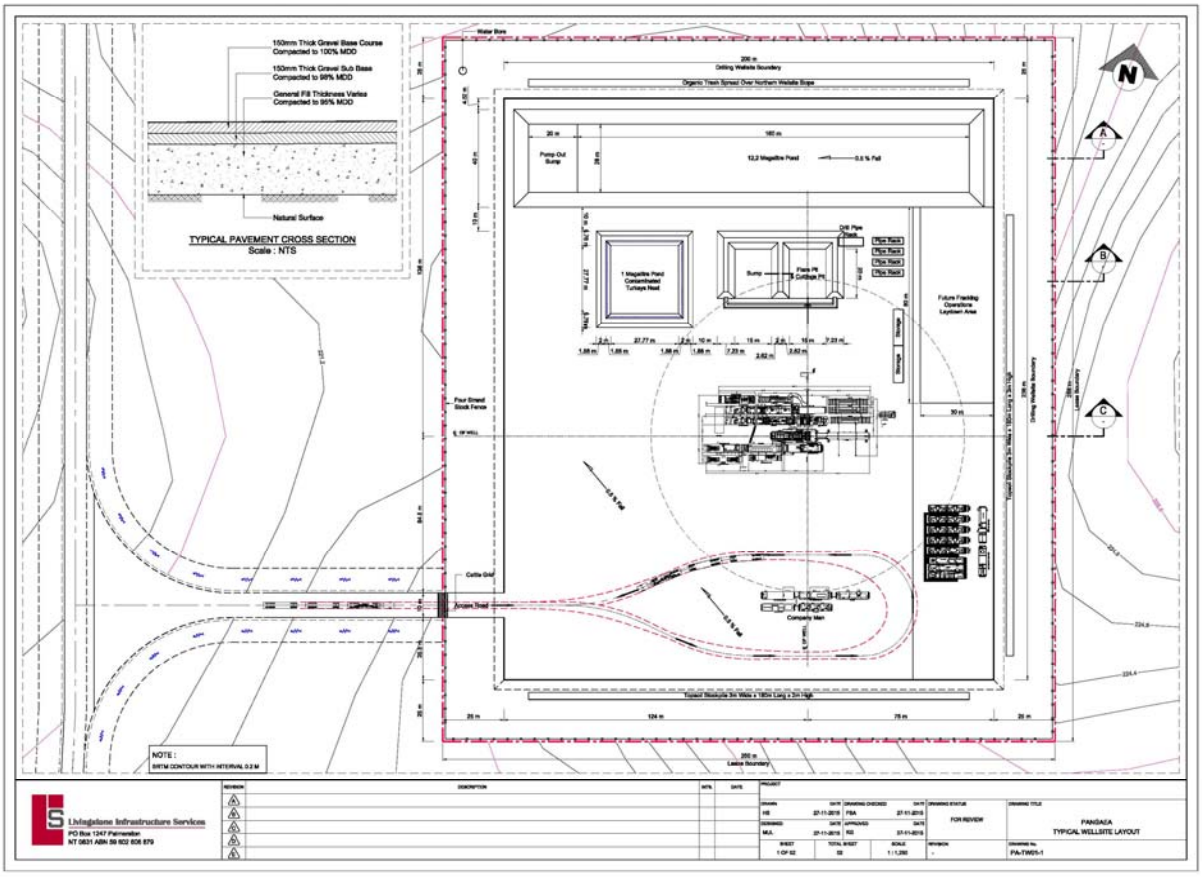


Figure 4: Drill Pad Layout

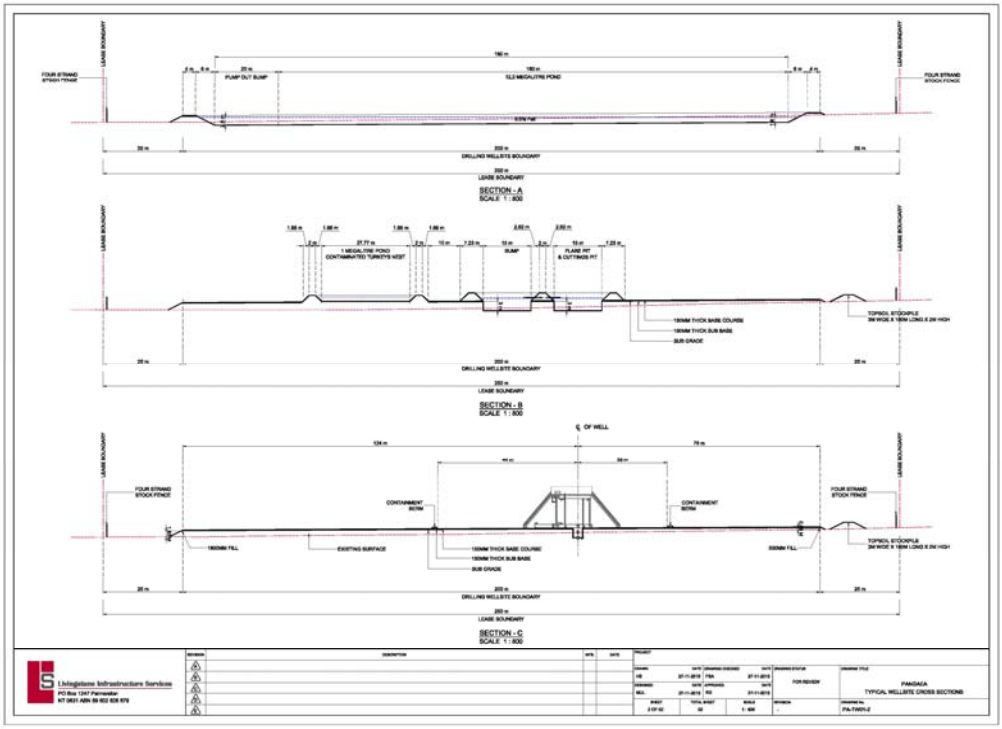


Figure 5: Drill Pad Layout

3.2.3 Seismic Lines

The proposed Birdum Creek Seismic Survey will consist of 3,035 line km covering an area of 451 km^2. This consists of 1,518 km of source lines (~5-6m width, ~4m clearance) and 1,517 km of receiver lines (~4-5m width) and has been designed to achieve ALARP environmental impacts by utilising existing roads, tracks, fire-breaks and fence lines wherever possible. The seismic lines will be fully rehabilitated.

No seismic acquisition is planned for any public road reserve, save 46 crossings of the Western Creek Road. In all cases there will be minimal impact with any works that are designated within the road reserve to be fully communicated to the Department of Infrastructure via the appropriate permitting process.

Scouting, Pegging and Surveying

Scouting involves the use of a GPS by field staff to ensure that the line start and end points are clearly identified and marked. Pegging and surveying involves pre-site inspections, reconnaissance flagging, surveying a path (line) and placing a peg in the ground at set intervals along the line to ensure the correct path is followed when preparing the site and acquiring the seismic data but also to clearly identify “no-go” sensitive sites and pick out localised deviations which minimise environmental impacts. These stages of the program are minimal disturbance activities conducted from a 4WD vehicle, on “quad-bikes” or in some cases on foot.

Line Preparation

Line preparation may include 'stick raking' and vegetation management for technical, safety and visibility reasons. Stick raking displaces logs and large sticks from the chosen line that could create a hazard or barrier. Light grading may be required to smooth over very rough surfaces to make the line trafficable for the vibrators and support vehicles.

Line preparation may also utilise a mulcher to clear vegetation on the seismic line paths. A mulcher cuts the vegetation down to a height of ~200mm and is similar to mowing a lawn. The plant roots and lower stems are relatively unaffected and grow back quickly, but the vibrators and people on foot can move more easily and safely avoid dangerous obstacles which could be hidden in the vegetation. Line mulchers are usually set on the front of small tracked vehicles which allow safe operations with a small, temporary footprint.

Bull-dozers may also be required as a last resort in areas where the terrain is especially rough and inaccessible by grader or front end loader. However, at times, and where possible, the respective 'blades' of the equipment is kept off the ground surface ensuring that root stock and tufted grasses remain in situ wherever possible (minimising potential soil loss through erosion).

Tree clearing is minimised by meandering the lines through heavily wooded areas and savannah woodlands around trees (>200mm Diameter at Breast Height), however some tree losses and trimming is to be expected. Before this occurs, all alternative options will be considered including practical re-routing to avoid clearing.

Where a line crosses a creek, watercourses or depression in the landscape, survey crews will search for naturally cleared crossings (in the immediate area) for which to utilise before the final lines are chosen in the field. Earthworks in riparian areas will be minimised at all times and rehabilitation is to follow immediately post data capture, or as soon as practically possible.

Figure 6: Dozer with stick rake

Figure 7: Photo showing winding seismic lines through vegetation

3.2.4 Water Bores

Two (2) water bores will be drilled as part of the Civil Operations for the 2016 NT Appraisal Campaign. The bores will be located at an appropriate site in close proximity to each drill pad. The water bores will target two significant brackish aquifers to supply water for the Appraisal Campaign operations: the sands of the Jamieson Formation and the basal Cambrian sands.

Table 4: Jamieson Sandstone Reservoir Properties

Well Name	Top	Bottom	Gross	Net	N/G	Av. Phi	Av. VShale	Av. Perm	Phi*H
	[m]	[m]	[m]	[m]		[dec]	[dec]	[mD]	
10% Porosity Cut-off									
Birdum Creek 1	155.1	252.0	96.9	17.68	0.182	0.134	0.097	29.720	2.37
Tarlee 1	373.8	483.7	109.9	70.56	0.642	0.150	0.244	45.568	10.58
Tarlee 2	327.3	430.1	102.8	53.49	0.52	0.129	0.161	23.616	6.89
Tarlee S3	278.8	376.1	97.3	49.10	0.505	0.134	0.190	29.181	6.57
Wyworrie 1	186.1	243.3	57.2	26.52	0.464	0.131	0.089	25.735	3.47

*NOTE: minimum thickness of 1.0m applied.

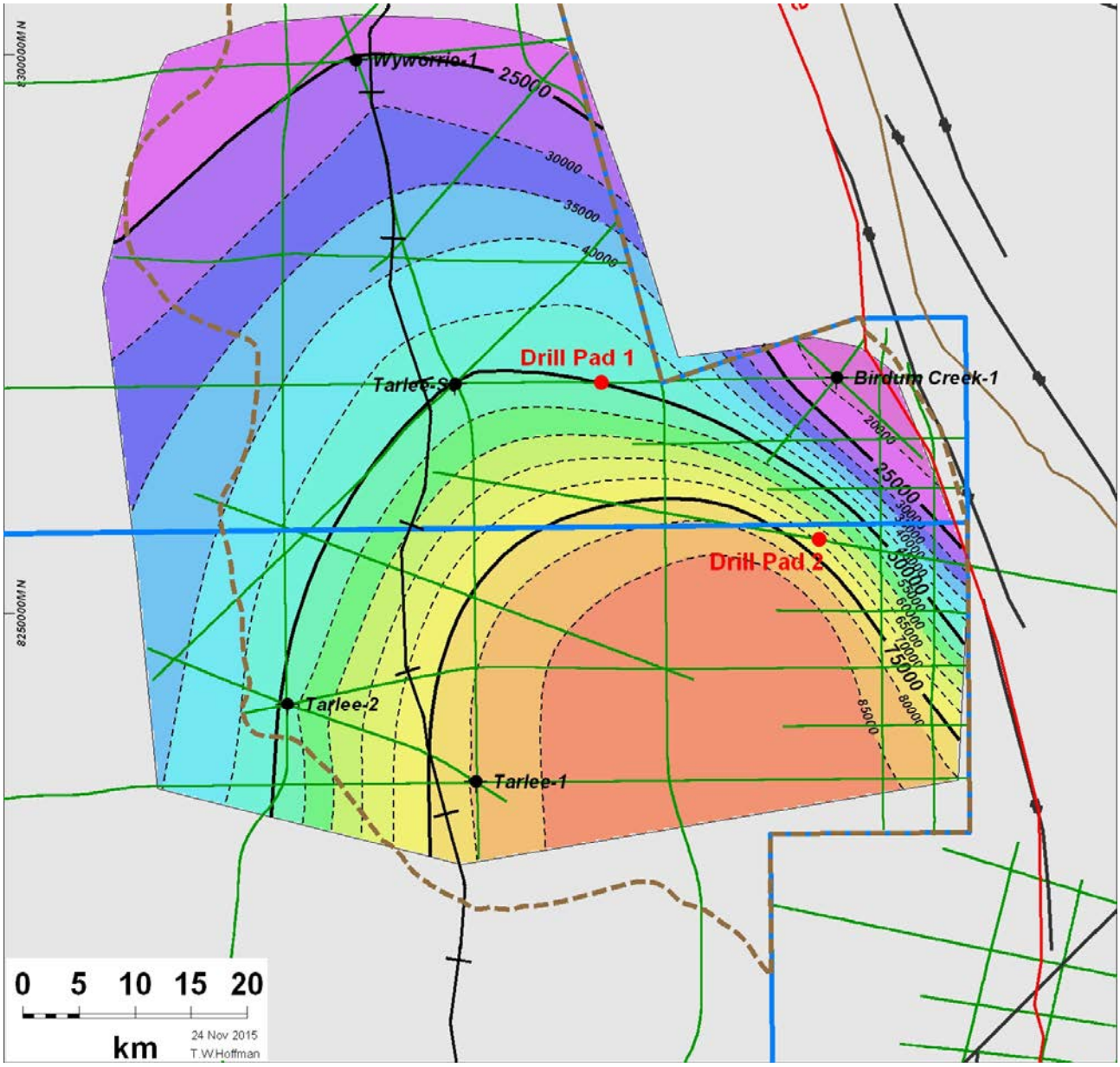


Figure 8: Jamieson Sandstone recoverable bbl / acre (assumes 30% recovery efficiency)

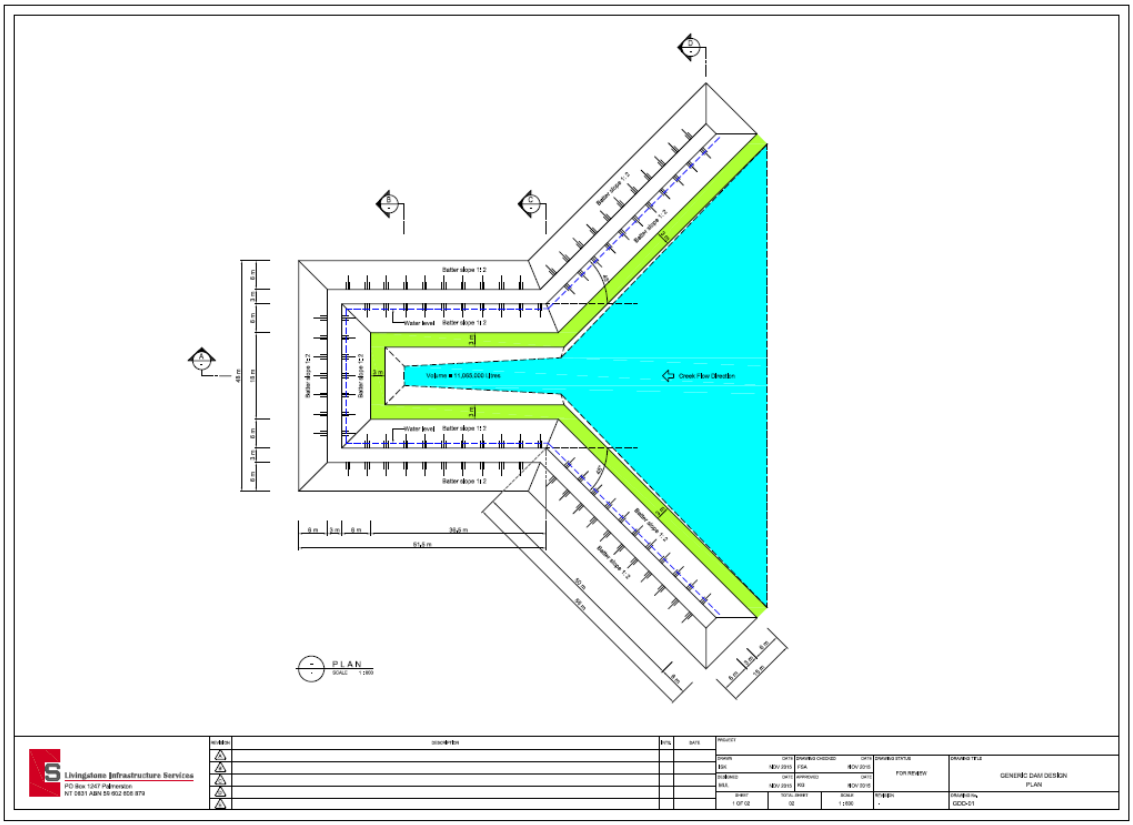
3.2.5 Existing Dam Upgrade (Alteration)

An existing pastoral dam on Birdum Creek station will be altered and upgraded (including new pumps and bore infrastructure) up to 11ML capacity. The existing dam, located at 290 903 m E and 8 256 972 mN on the Birdum Creek station (Pastoral Lease 984, NTP 3050), has current storage capacity of ~1ML. This dam and bore infrastructure upgrade will remain the property of Birdum Creek station, however agreement has been reached between Birdum Creek station and Pangaea for shared use.

Geotechnical surveys will be undertaken to ascertain the suitability of the location for the dam. The results will be included in the geotechnical report.

The dimensions of the dam will be altered to be ~125m (L) x ~98m (W) x ~3-7m (D). The dam alteration has been designed for storage capacity of ~11 ML, with a full storage level of ~11ML. Spillway and outlets have been designed to follow the area's natural hydrology systems.

Figure 9 shows the engineering design of the dam alteration, including detailed spillway and outlet design.



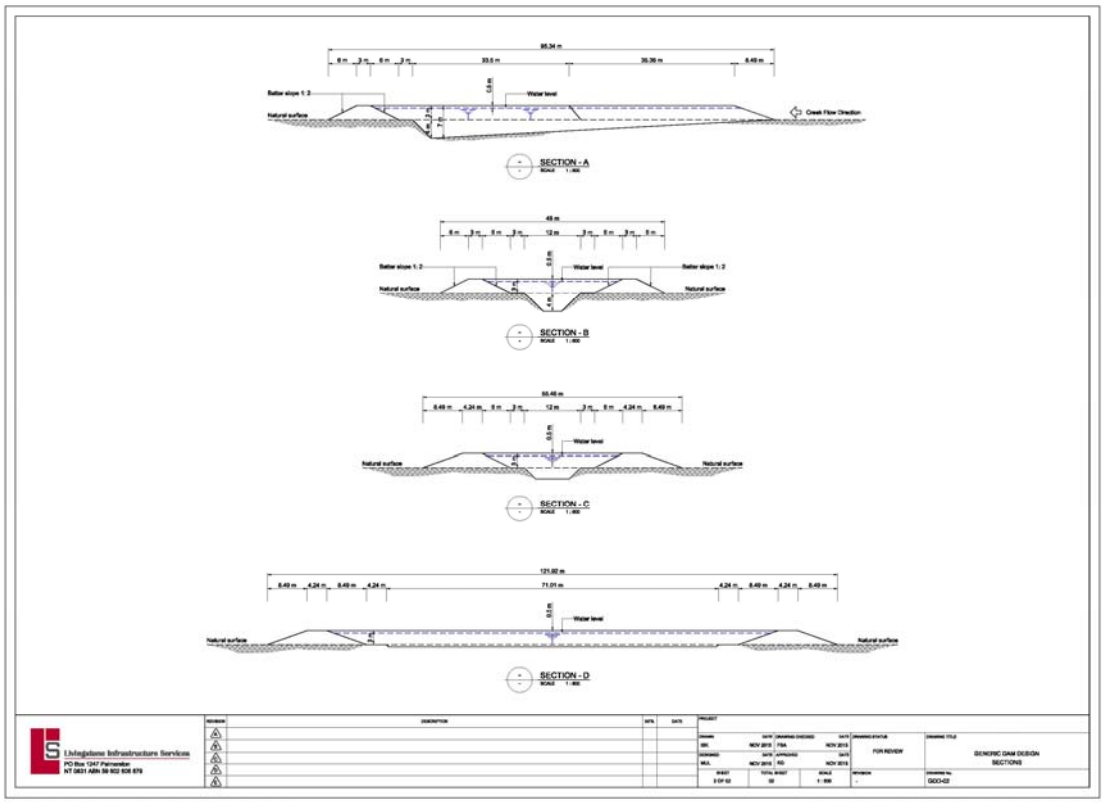


Figure 9: Proposed Dam alteration specification

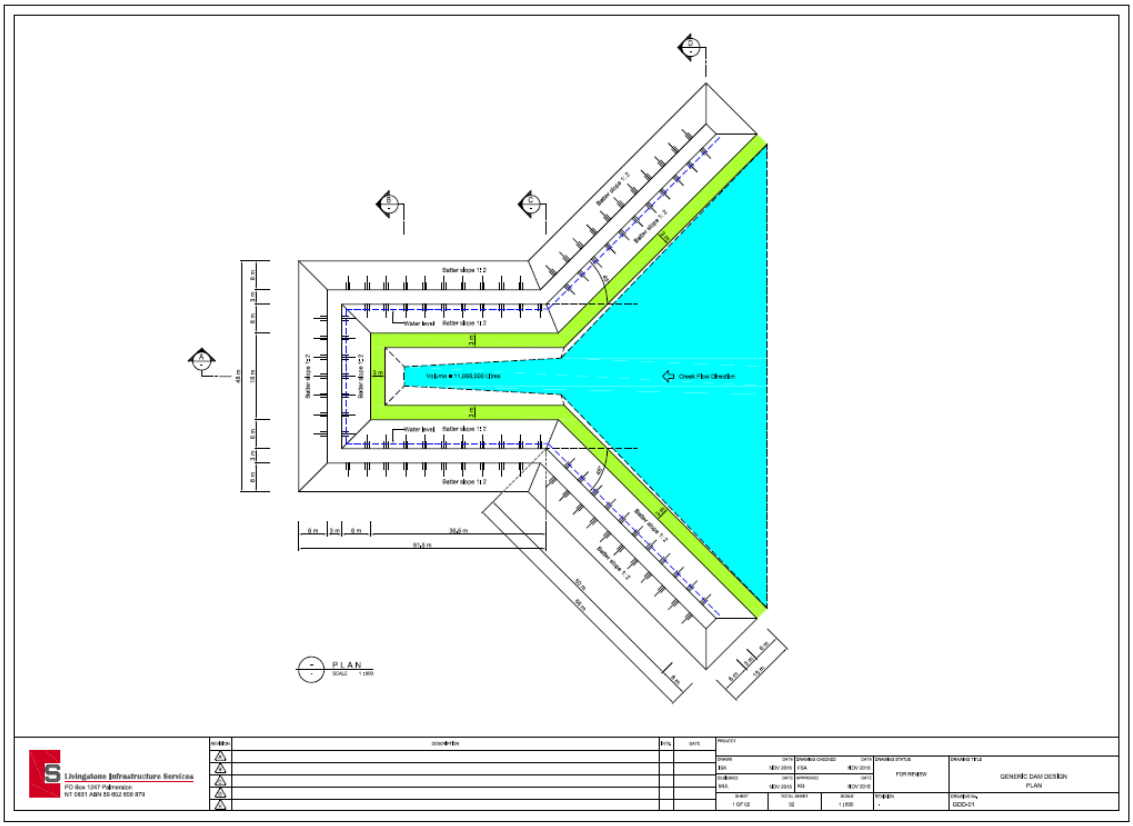
3.2.6 New Dam Construction

A new catchment dam will be constructed on Cow Creek station up to 11ML capacity. The new dam will be located in proximity to the drill pad at 282 609 m E and 8 270 868 mN on the Cow Creek station (Pastoral Lease 1172, NTP 4966). The dam will remain the property of Cow Creek station; however agreement has been reached between Cow Creek station and Pangaea for shared use.

Geotechnical surveys will be undertaken to ascertain the suitability of the location for the dam. The results will be included in the geotechnical report.

The dimensions of the dam will be ~125m (L) x ~98m (W) x ~3-7m (D). The dam has been designed for storage capacity of ~11 ML, with a full storage level of ~11ML. Spillway and outlets have been designed to follow the area's natural hydrology systems.

Figure 10 shows the engineering design of the dam, including detailed spillway and outlet design.



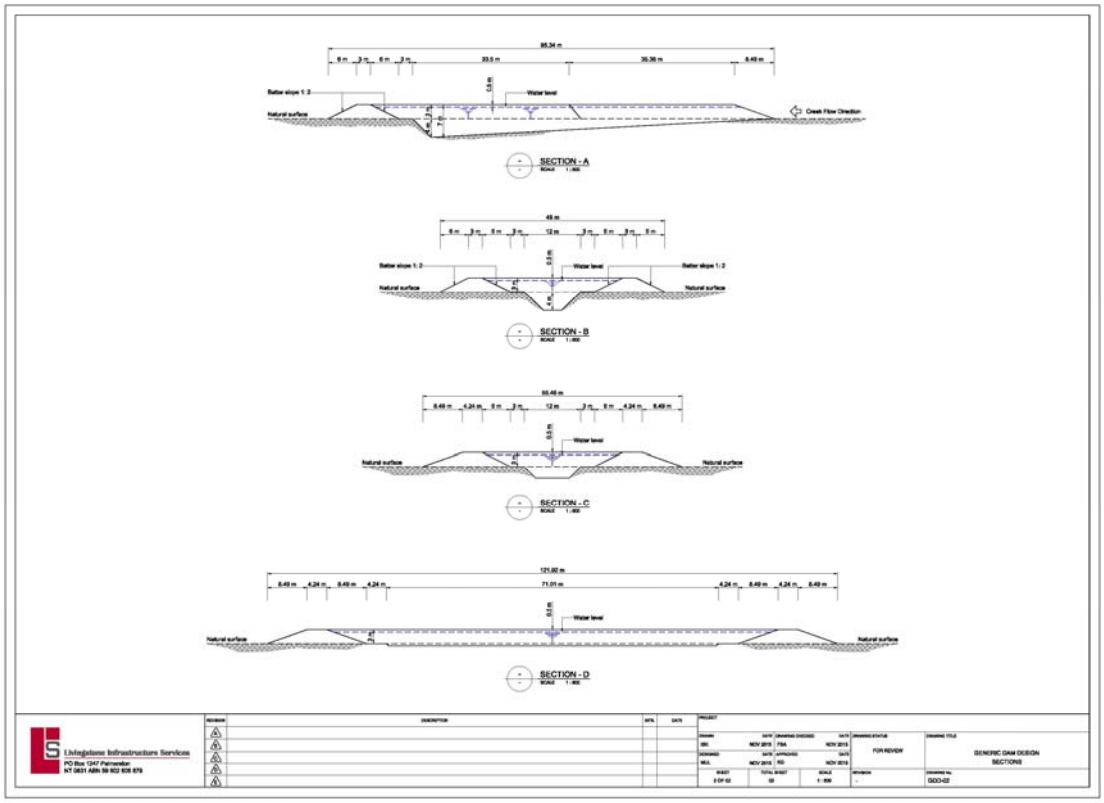


Figure 10: Dam construction specifications

3.2.7 Evaporation Ponds

An evaporation pond will be constructed on the northern edge of each drill pad up to 15ML full storage capacity. The dimensions of the evaporation ponds will be 180m (L) x 40m (W) x 2.5 (D). The evaporation ponds have been designed for storage capacity of 12.2ML.

The evaporation ponds will be fully bunded, lined and fenced and designed for operation throughout the dry and wet seasons. **Figures 4, 5 and 11** show the engineering design of the evaporation ponds.

The Australian Bureau of Meteorology Larrimah Station (Number 014612) historical average (for recorded years 1952 – 2015) has an average rainfall of 859.1 mm in the Larrimah area, as shown in **Figure 12**. The evaporation ponds have been designed taking into consideration a 1-in-50 year rainfall event of 350 mm (refer **Appendix S**). Considering the maximum precipitation and the surface area of the evaporation ponds, **Table 5** shows the volumes of available storage before and after the maximum expected rainfall. An overflow of the evaporation ponds is highly unlikely with the historical average rainfall of 45.1 mm during the months of operation (May – October) (**Figure 12**).

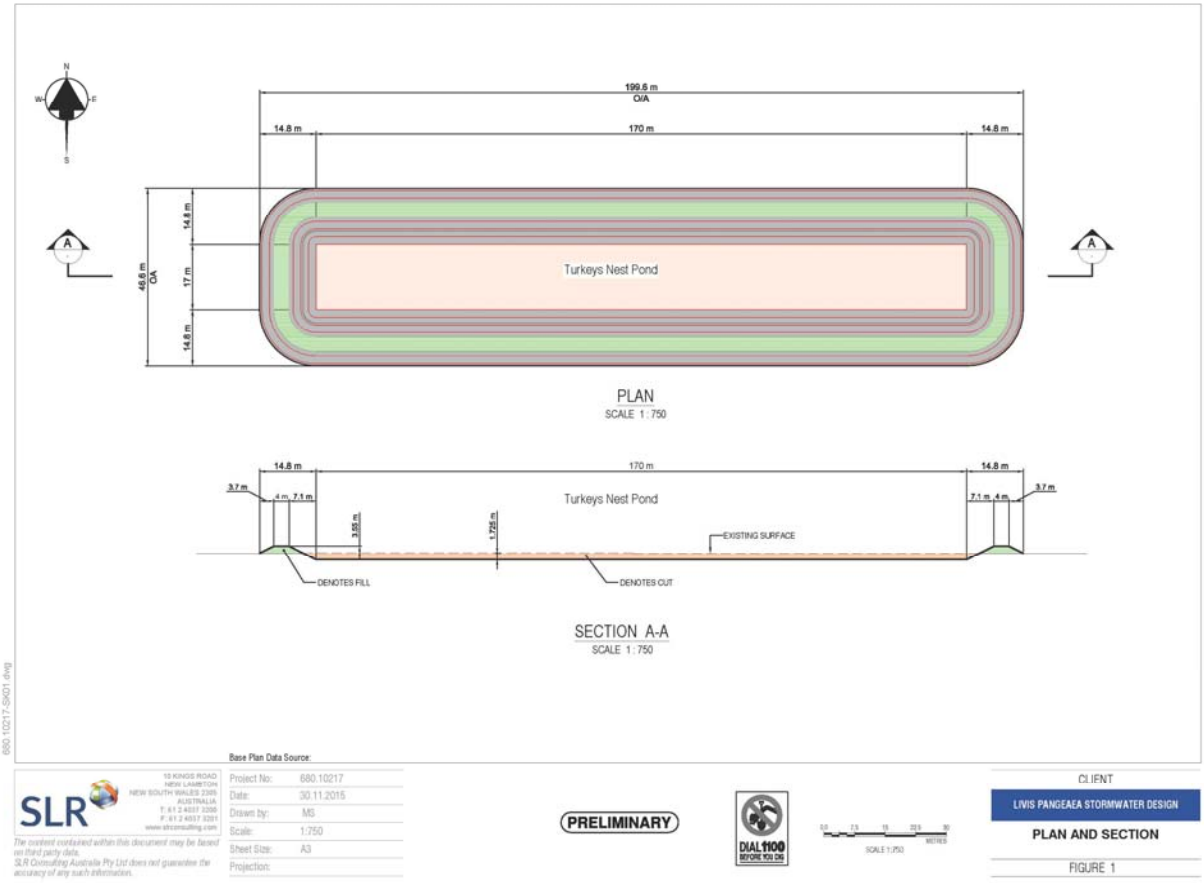


Figure 11: Evaporation Pond Engineering Design

Summary statistics for all years Information about climate statistics

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	208.8	207.3	155.6	31.4	8.6	3.7	2.3	0.6	3.3	26.6	65.6	144.0	859.1
Lowest	50.3	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	328.5
5th %ile	73.5	40.4	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	32.7	520.4
10th %ile	81.1	59.8	26.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	45.7	555.5
Median	189.6	180.1	142.9	10.6	0.0	0.0	0.0	0.0	0.0	11.1	51.5	122.8	815.9
90th %ile	331.5	392.8	298.7	79.1	16.4	1.5	1.1	0.0	12.7	69.6	140.7	246.6	1235.0
95th %ile	473.0	471.2	334.6	117.0	46.0	10.8	7.5	2.7	16.2	105.6	192.5	315.9	1319.2
Highest	604.5	493.2	561.4	341.3	197.2	131.0	61.4	17.2	61.0	169.4	239.9	406.6	1519.0

Figure 12: Bureau of Meteorology Larrimah Station (#014612) All years (1952-2015) Average Monthly Rainfall

Table 5: Evaporation Pond Storage Capacities

Surface Area	Total Capacity Volume	Maximum Expected Rainfall	Expected Evaporation	Available Flowback Storage (Height)		Available Flowback Storage (Volume)	
				Pre-Rain	Post-Rain	Pre-Rain	Post-Rain
5,747 m^2	15 ML	859 mm	2.44 ML	2.49 m	3.35 m	12.01 ML	14.08 ML

3.2.8 Camp

One central camp will be established for the entire Civil Operations program at a pre-cleared site on Western Creek Road (as per the 2015 Campaign). MSC will provide an adequate housing/camp, messing facilities and amenities for ~32 persons for the duration of the Civil Operations. The camp will include the following:

- 1 x Camp Kitchen
- 1 x Kitchen Store & Thawing Room
- 8 x Bunkhouse – 4 rooms per bunkhouse
- 1 x Ablution Block
- 1 x Sewage Treatment Plant

The campsite power supply is generated by a portable generator. Refuelling of the self-contained unit depends upon the camp capacity during operations, however on average on-site refuelling will occur every 2-4 weeks during camp operation. Several daily checks and general monitoring schedules are carried out as per standard operating procedures.

As a minimum a transportable and fully self-contained sewage treatment plant will support the Civil Operations team. An Enviro-Flow unit (or similar) will provide a final water quality suitable for surface irrigation via a sprinkler attachment. The final system will (as a minimum) be selected based upon 300L / person / day. Sludge/solid material will be reduced by anaerobic decomposition and removed from site (via tanker to a licensed facility).

All general waste generated by the campsite operation will be disposed of on a weekly basis to the nearest landfill. The camp site is compliant with NT Department of Health requirements for Mining and Construction Projects.

3.3 Water Supply

Daily consumption per person generally equates to 120 -150 litres per day. Potable water will be obtained from local sources on pastoral properties. MSC will provide two water trucks, one with 13,000 litre capacity for shower/laundry and the other with 9,000 litre capacity for drinking water.

3.4 Timeframes

Civil Operations will begin in January 2016 or as early as weather conditions permit.

3.5 Contractors & Support Companies

Contractor or Service Company	Service	Contact Details
MS Contracting	Earthworks	Mark Sullivan [redacted]
Terrabos Consulting	Pangaea Representative	Dave Armstrong [redacted]
EcOz Environmental Services	Environmental Consultant	Ray Hall [redacted]
Livingstone Infrastructure Services	Engineering and Design	Ken Gardner [redacted]
Veolia Australia & New Zealand	Waste Removal & Disposal	James Prakash [redacted]

3.5.1 Support Facilities

Earthworks Equipment

- Graders
- Water Trucks
- Bulldozer
- Loader
- Rollers
- Excavator
- Side Tippers

Other Vehicles

Including operator, contractor and service companies an approximate 6 vehicles (4 x 4) and a truck will be required for the purpose of transportation of crew, supplies (water, food, equipment) and waste removal from the location.

4.0 REGIONAL WATER BASELINE MONITORING

Pangaea is undertaking an extensive regional water baseline monitoring program that expands over 16 existing pastoral bores and tests a range of pre- and post-existing chemical compositions as well as standing water levels.

Collection of this data will help to:

- Characterise existing groundwater systems' chemical composition;
- Identify levels and quality of bore water within the region; and
- Enable maps and trend plots to be developed by recording standing water levels.

4.1 Methodology

Pangaea, through the engagement of EcOz Environmental Consultants, will continue to periodically assess and monitor regionally extensive registered bores (as per **Appendix R**).

The data (and associated analysis) will form the basis of a baseline assessment of groundwater conditions, including (but not limited to) details on standing water levels, and groundwater quality in the region.

Sampling has been ongoing for three years and will continue to be tested, at a minimum on the full spectrum of testing (per **Appendix R**), on a bi-annual basis. EcOz Environmental Consultants, as part of monthly environmental audits, will continue to monitor electronic downhole water loggers (11), as well as other groundwater, soil, air, flora and fauna conditions.

Testing will be in accordance with a consistent methodology employing best practice techniques and equipment, and appropriate quality assurance and quality control (QAJQC) which ensures that the risk of contamination is minimised in the collection of samples for testing. The development of the methodology was tailored to site specific and operational conditions and draws upon:

1. Groundwater Sampling and Analysis - A Field Guide, Australian Government geoscience Australia, 2009; and
2. AS/NZS 5667:1998 Water Quality - Guidance on Sampling of Groundwater.
3. Surface and Groundwater Characterisation Report – EP167 & EP168

Prior to Pangaea commencing its NT exploration campaign in 2012 very little was known about groundwater conditions in the region as they had not previously been documented. Parameters that are to be measured in the field include pH, specific conductivity, electrical conductivity (EC), temperature, dissolved oxygen (DO) and redox potential (Eh). Field parameters are to be measured in a flow cell to avoid contact and contamination between the groundwater and the atmosphere. Field parameters are to be measured using a multi-parameter meter calibrated against known standards before each use according to manufacturer's requirements. Calibration records are to be kept detailing the date, time and values of each calibration.

Laboratory sampling will test for all elements that are proposed to be used 'down-hole' during the drilling portion of the 2016 NT Appraisal Campaign plus major cations, major anions, alkalinity and hardness, a selection of dissolved metals, methane, nutrients, tannins, silica (reactive), TRH, TPH and BTEXN. Note that the cations/anions and dissolved metal suites will cover the major constituents of bentonite, KCl, NaCl, NaOH and lime (i.e. $CaO/Ca(OH)_2$).

5.0 ACCESS TO LAND

The activities associated with the Civil Operations for the 2016 NT Appraisal Campaign will be carried out on three (3) pastoral station leases (Birdum Creek, Middle Creek and Cow Creek Stations) on the Sturt Plateau. The terms and conditions of access agreements is currently being negotiated and is due for completion 1 January 2016. Communication and liaison between the lease holder and the company is critical for ease of access, transport, and conducting Civil Operations. A key feature of leaseholder negotiations, in addition to those stipulations under Sections 65, 81 and 82 of the NT Petroleum Act 2015, has been the focus on implementing the road access, site preparations and logistics programs with minimal disruption to present land uses, lessening impacts on existing infrastructure and integrating with pastoral work, livestock production and annual planning.

The voluntary leaseholder access and compensation agreements include a code of conduct of operations with stated conditions of entry, types of petroleum operations, adherence to weed management and erosion prevention protocols, rehabilitation and compensation structures. The agreement generally reflects a focus on impact minimisation, community acceptance and satisfaction.

Direct impacts on leaseholder and pastoral enterprises are a key concern to Pangaea. Active engagement has provided the foundation for negotiation with the pastoralists and the terms of access to the land and the specific items of compensation are agreed to and listed in the access agreements prior to any activity occurring.

Pangaea has so far achieved a win-win situation and built solid working relationships with the pastoralists. The operation of the Appraisal Campaign in the region and the perception of the company in the local and wider NT community is an important consideration that remains at the forefront of company policy. The drill pads, seismic lines, camp sites and key access routes chosen attempt to minimise impacts on the community (e.g. noise, dust and incidental nuisance) and specific mitigations are put in place where necessary, fostering good faith with the pastoralists and the local community. All operations as they are currently proposed and assessed in this EMP are currently being reviewed by the NLC and TAOs, with final clearance to be negotiated in January 2016.

6.0 REHABILITATION

At the completion of the 2016 NT Appraisal Campaign activities, rehabilitation can commence as soon as practicable. Specific rehabilitation activities for each of the Appraisal Operations will be detailed in each respective EMP associated with the operation. For the Civil Operations, rehabilitation will be undertaken simultaneously with the rehabilitation of each of the Appraisal Operations.

Rehabilitation would involve the replacement of stockpiled topsoils and overall rehabilitation activity (promoting ground cover by any means deemed appropriate for the Land System). The methods, timing and overall objectives of the rehabilitation program are a specific part of the access and compensation agreement.

A Rehabilitation Plan has been developed for the Civil Operations and is found in **Appendix B**. An Erosion & Sediment Control Plan (**Appendix C**) has also been developed, which builds upon the guidelines developed by the Rehabilitation Plan.

7.0 ENVIRONMENT DESCRIPTION

7.1 Physical Environment

7.1.1 Climate

The region's climate is *'semi-arid tropical, with rainfall concentrated in the wet season months between November and April. Though rainfall can be variable from year to year, there is a distinct gradient of decreasing mean annual falls from 850mm in the north to less than 500mm'* in southern areas of EP-167 & EP-168, with nearly all the rainfall occurring between November and April (see Williams *et al.* 1997[1], Hennessy *et al.* 2004[2]). The mean maximum temperature varies from 27°C in July to 40°C and beyond in November.

7.1.2 Geology

The basin is a Pre-Cambrian Basin that has more than 3,000 metres of sediment column in which the identification of source rocks has been confirmed on the three unconventional oil and gas generating geological formations of the Barney Creek, Kyalla and Velkerri Shale. Each source rock is widespread, with thickness of up to 800 metres.

7.1.3 Soils

EP-167 and EP-168 are located on the Sturt Plateau which forms part of a largely un-dissected, deeply laterised Tertiary surface, covered mainly by red and yellow earth soils. There are also areas of alluvial cracking clays on the Sturt Plateau but they do not feature as often as in the Victoria River region further west (Condon, 1986[3]).

Clear relationships exist between soils and the parent material, drainage and climate in the wider region (which encompasses the Sturt Plateau and the Victoria River districts). In general, well-drained, steep hilly country with rock outcrops tends to have shallow skeletal soils and deeper soils (two to three metres depth) are largely confined to poorly-drained, flatter country (e.g. basalt plains and rises) (Condon, 1986).

Duplex soils are commonly found in the channel banks and levees of major drainage lines. These soils have high pastoral productivity but are typically very susceptible to erosion (Karfs & Trueman, 2005[4]).

[1] Williams, R.J., Cook, G.D., Ludwig, J.L. and Tongway, D.L. (1997). Torch, trees, teeth and tussocks: disturbance in the tropical savannas of the Northern Territory (Australia). In: Frontiers in Ecology. Building the Links. Eds. N. Klomp and I. Lunt. Elsevier, Oxford: pp55-66.
[2] Hennessy, K., Page, C., McInnes, K., Walsh, K., Pittock, B., Bathols, J, and Suppiah, R. (2004). Climate Change in the Northern Territory. Consultancy report for the Northern Territory Department of Infrastructure, Planning and Environment. CSIRO, Melbourne.
[3] Condon, R.A. (1986). A reconnaissance erosion survey of part of the Victoria River District, NT. A consultant's report prepared for the Conservation Commission of the Northern Territory, Darwin. Hassall and Associates Agricultural Consultants, Canberra.
[4] Karfs, R.A. and Trueman, M. (2005) Tracking Changes in the VRD Pastoral District, Northern Territory, Australia — 2005. Report to the Australian Collaborative Rangeland Information System (ACRIS) Management Committee. NT Department of Natural Resources, Environment and the Arts.

7.1.4 Land System

Civil Operations in EP-167 will intersect with the Forrest land system. The Forrest land system consists of gently sloping sandy surfaced plains with few indistinct drainage depressions on sandy red earth soils. Vegetation is dominated by eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Forrest land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening (Northern Territory Government, no date[5]).

Civil Operations in EP-168 will intersect with the Banjo land system. The Banjo land system consists of almost level to gently undulating plains on the plateau surface that lack drainage lines. Consisting of variable depth red earth soils with or without gravel; mixed eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Banjo land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening (Northern Territory Government, no date[6]).

7.1.5 Water

The waterways within the region all offer habitat for aquatic plants and animals as well as important associated riparian vegetation. Riparian vegetation also supports a high species richness of both plants and animals, as they retain moisture for longer periods than surrounding vegetation and provide important food and refuge. The nearest water course to the Civil Operations for the 2016 NT Appraisal Campaign is Birdum Creek. The 3D seismic civil operations will be approximately 6km west of Birdum Creek, with the closest drill pad (Drill Pad 2) being 15km away.

Groundwater

It is estimated that approximately 0.4 ML of water from existing pastoral bores will be required for use within the civil camp. Water for other operations, including civil earthworks and drilling throughout the 2016 NT Appraisal Campaign, will primarily be sourced from brackish aquifer bores and water catchment dams (as per **Section 3**).

7.2 Biological Environment

7.2.1 Bioregions

The Sturt Plateau bioregion comprises 99,719 km² and falls solely within the Northern Territory. The current reserve system does not include representations of the range of environments within the bioregion.

The Sturt Plateau bioregion is currently listed as a high priority conservation area in the Interim Bio-regionalisation of Australia Report due to its under-representation and potential biodiversity (Parks and Wildlife Commission of the Northern Territory, 2005[7]). There are *'some conservation management occurring on some pastoral properties in the bioregion, principally through exclosure fencing of wetland and riparian areas'* (Department of Land & Resource Management, 2014[8]).

[5] Northern Territory Government (no date) Land Condition Guide - Sturt Plateau District, Understanding the productivity of grazing lands. Produced in association with the Northern Territory Cattlemen's Association as part of the Caring for Our Country project "Grazing Land Management – Demonstration, Continuation and Evaluation".
[6] Ibid.
[7] Parks and Wildlife Commission of the Northern Territory (2005) Bullwaddy Conservation Reserve Plan of Management.
[8] Department of Land & Resource Management (2014) Sturt Plateau - Bioregional Description. Downloaded at http://lrm.nt.gov.au/plants-and-animals/herbarium/nature/bioregional/sturtplateau#.U5OiQF5Rf1o

7.2.2 Flora

Vegetation found in the Banjo land system consists of mid-high open woodland of *Eucalptus patellaris, Corymbia terminalis, C. Ferruginea, Erythrophleum chlorostachys, C. dichromophloia* over *Chrysopogon latifolius, Themeda australis* and *Sehima nervosum* (EcOz, 2015[9]).

Vegetation found in the Forrest land system consists of mid-high open woodland of *Corymbia ferruginea, C. terminalis, Eycalyptus tertrodonta, Erythrophleum chlorostachys* over *Triodia pungens, Chrysopogon latifolius* and *Sehima nervosum* (EcOz, 2015).

Most of the bioregion is generally in moderate to good condition, due at least in part to the lack of intensive development. There are minor impacts associated with weeds, feral animals, pastoralism and changed fire regimes (Department of Land & Resource Management, 2014).

Of particular note, within the Sturt Plateau, lancewood often occurs with the restricted, Northern Territory endemic plant, *Macropteranthes kekwickii* (Bullwaddy) interspersed as either a co-dominant or dominant species. These woodlands typically have a dense shady shrub layer, a few vines and creepers and little in the way of grass understorey (Parks and Wildlife Commission of the Northern Territory, 2005).

7.2.3 Weeds

Compared to other grazing regions, the Sturt plateau is relatively weed free. There are limited infestations of bellyache bush (*Jatrophagossypifolia*), devil's claw (*Martyniaannua*), hyptis (*Hyptissuaveolens*) and Sida spp. The spread of weeds is likely to increase if the area becomes more populated and developed (Tropical Savannas CRC, 2014[10]).

A total of 17 weed species have been recorded across EP-167 and EP-168 with the majority of recordings along roadsides or on crossing points of major rivers/creeks (i.e. trafficable areas). Most weeds requiring management attention are usually most prevalent in riparian habitats, are spread by wet season floodwaters or are associated with water-holding black soil areas (Tropical Savannas CRC, 2014).

Weed control works on pastoral land generally take into consideration weed risk (invasiveness, impacts on grazing land/land value and potential distribution) as well as feasibility of control (control costs, current distribution and persistence). Weed prevention and mitigation measures being taken by Pangaea with regards to Civil Operations are detailed in **Appendix N**.

7.2.4 Fauna

The mammal fauna includes unusually abundant populations of the spectacled hare-wallaby (*Lagorchestes conspicillatus*), especially in the lancewood-bullwaddy thickets and the northern nail-tail wallaby (*Onychogalea unguifera*), especially in grasslands and open woodlands along the margins between black-soil plains and red loamy soils (Woinarski and Fisher, 1995[11]).

[9] Flora and Fauna Characterisation Report EcOz Environmental Consultants (2015)
[10] Tropical Savannas CRC (2014) Grazing management issues: Sturt Plateau. Downloaded at http://www.savanna.org.au/vs/vs_plateau.html
[11] Woinarski, J.C.Z., and A. Fisher (1995) Wildlife of Lancewood (*Acacia shirleyi*) thickets and woodlands in northern Australia: 1. Variation in vertebrate species composition across the environmental range occupied by lancewood vegetation in the Northern Territory. Wildlife Research 22: 379-411.

In a description of the 'Victoria Plains Tropical Savanna Ecoregion' (as defined by Thackway and Cresswell 1995[12]) Woinarski (2014)[13] reviews the habitats and distinctive fauna within two IBRAs: 'Sturt Plateau' and 'Ord-Victoria Plains' and notes that reptiles restricted to this ecoregion include *Suta ordensis* and *Varanus kingorum*. The agamid lizard (*Cryptagama aurita*) has a small distribution, concentrated in this region. Some burrowing frogs, most notably *Cyclorana cryptotis* and *C. maculosus*, are largely restricted to the deep red earths of this ecoregion, and may reach extremely high densities when they emerge with the first rains of the wet season (Woinarski, 2014).

The threatened purple-crowned fairy-wren (*Malurus coronatus*) has a major stronghold in riparian vegetation in this ecoregion (Rowley, 1993[14]) and the grasslands and savanna woodlands support a very rich and abundant assemblage of granivorous birds, including the endangered gouldian finch (*Erythrura gouldiae*) (Hilton-Taylor, 2000[15]).

7.3 Socio-Economic Environment

7.3.1 Population Centres

Towns within the Stuart bioregion include Larrimah and Daly Waters.

7.3.2 Land Use

Approximately 77% of the Sturt Plateau bioregion is grazed. Data from the Australian Bureau of Statistics showed that domestic stocking density increased from a level near the 1983–1991 average in 1993 to be 36% above this base in 1997. This (approximate) density was maintained until 2000 and stocking density then increased again in 2001 and 2002 to be 45% above the 1983–1991 average. Apart from these better seasons, the increase was also driven by land use intensification in the bioregion (Australian Government, 2008[16]).

Pastoral leases and freehold make up ~95% of the total tenement area (32,147 km²).

7.3.3 Cultural Heritage

For the Traditional Owners, the land is vested with spiritual significance and is an integral part of their cultural identity. EP-167 and EP-168 encompass the traditional lands of several Aboriginal language groups and people of each group continue to use the natural resources of the region, protect sites of significance and maintain cultural traditions through ceremony and ritual.

Numerous archaeological sites bear testimony to a long history of Aboriginal occupation. Traditional Owners have obligations to look after their country and believe that their relationships with country involve mutual rights and responsibilities. In addition, the Aboriginal history of the area since settlement is closely interwoven with European pastoral history and of this, a rich oral tradition remains.

[12] Thackway, R. and I. D. Cresswell. editors. 1(995) An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves, Version 4.0. Australian Nature Conservation Agency, Canberra.
[13] Woinarski, J. (2014) Review of the Victoria Plains Tropical Savanna Ecoregion. Downloaded at http://www.worldwildlife.org/ecoregions/aa0709
[14] Rowley, I. (1993) The purple-crowned fairy-wren *Malurus coronatus*. I. History, distribution and present status. Emu 93: 220-234.
[15] Hilton-Taylor, C. (2000) The IUCN 2000 Red List of Threatened Species. IUCN, Gland, Switzerland and Cambridge, United Kingdom.
[16] Australian Government (2014) Sturt Plateau Fact Sheet: Rangelands 2008 — Taking the Pulse. Downloaded at http://www.environment.gov.au/system/files/resources/a8015c25-4aa2-4833-ad9c-e98d09e2ab52/files/bioregion-sturt-plateau.pdf

7.4 Environmental and Cultural Sensitivities

7.4.1 Sacred & Cultural Heritage Site Protection

The activity area has been the subject of an ethnographic sacred site avoidance survey. The Northern Land Council (NLC) is currently developing a report which (in accordance with the Co-Existence and Exploration Deed for EPA 167, 168, 169 and 198) will clear all works to be conducted within the areas identified in the 2016 Work Program.

Building upon Pangaea's approach to cultural heritage protection in 2013, 2014 and 2015, survey of the 2016 Appraisal Campaign sites is currently being undertaken (on foot and by helicopter) by an NLC Anthropologist, the EMR, the CMC and Traditional Aboriginal Owners (TAOs) and custodians. The TAOs are currently clearing all ancillary works (including grading and sheeting of access tracks), establishment of the drill pads and seismic lines, the process of drilling, the process of capturing seismic data and the reasonable removal of vegetation.

In addition to the measures described above, Pangaea is currently undertaking a search of the NT Heritage Register & the NT Archaeological Site Register, administered by Department of Lands, Planning and the Environment (as defined in the Heritage Act 2011). Pangaea has applied for an Aboriginal Areas Protection Authority certificate for the purposes of the Civil Operations for the 2016 NT Appraisal Campaign.

7.4.2 Protected Areas

No protected or conservation areas exist within EP-167 or EP-168.

7.4.3 Threatened Flora and Fauna

There has been a relatively large amount of fauna and flora survey work in this bioregion, including the development of a regional conservation plan. By 2005, there were 247 bird species recorded and approximately 1,500 plant taxa recorded (Biodiversity Working Group indicator: Flora surveys).

No ecosystems in this bioregion have been assessed formally for risk category. However, 6 species occurring in the bioregion are listed as threatened at national or Territory level. Of these species, the Civil Operations area is a potentially sensitive area for the Plains Death Adder (*Acanthophis hawkei*)[17]. The Civil Operations area (including access) is not considered potentially sensitive to any other threatened flora or fauna.

A Flora and Fauna Characterisation Report baseline survey was conducted at each of the Civil Operations sites during September 2015. Survey design was guided by the results of the desk-top assessment and online tools including the Commonwealth Protected Matters Online Search Tool. No areas of native vegetation on the sites were identified as belonging to an endangered ecological community (EEC) that is recognised by the Commonwealths Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) and Pangaea acknowledges that there is currently no mechanism for listing Threatened Ecological Communities under NT legislation.

[17] Ibid. 9

7.4.4 Significant Habitat

Riparian Areas & River Corridors

The waterways within the region all offer valuable habitat for aquatic plants and animals as well as important associated riparian vegetation. The Aboriginal cultural values of these areas are of regional and national significance in many areas (DNREAS 2011[18]).

Traditional Owners use the many creeks and rivers for hunting, fishing and the collection of traditional resources such as bush tucker, medicines, fibre, ochre, and timber. Maintenance of access to the land and its resources is critical for Traditional Owners to exercise their responsibilities in relation to land, law and culture (DNREAS 2011).

Riparian vegetation also generally supports a high species richness of both plants and animals as they retain moisture for longer periods than surrounding vegetation and provide important food and refuge. Protection of riparian vegetation from fire is also critical for general river health. 2016 NT Appraisal Campaign sites have been sited to avoid major watercourses for all the reasons above.

Acacia Woodlands – Bullwaddy (*Macropteranthes kekwickii*)

The Bureau of Rural Sciences (2004)[19] noted that *'the conservation of Acacia woodlands is severely under represented with less than 1% conserved in the Territory and 3% nationally'*. The Bullwaddy Conservation Reserve (east of EP-168 - approximately 100 kms east of Daly Waters along the Carpentaria Highway) represents the only declared conservation area within the Sturt Plateau region of the lancewood/bullwaddy vegetation type and is alone in its protection of this unique vegetation type.

Lancewood/Bullwaddy vegetation supports a different suite of animals than the Eucalypt woodlands, common species include the grey-crowned babbler (*Pomatostomus temporalis*), apostle bird (*Struthidea cinerea*) and hooded robin (*Melanodryas cucullata*), which all forage on the ground, and the spectacled hare wallaby (*Lagorchestes conspicillatus*) and northern nail-tail wallaby (*Onychogalea urguifera*), which commonly shelter under the bullwaddy trees during the day. Other vertebrate groups such as frogs and bats have not been comprehensively surveyed to date and further investigation is warranted (Parks and Wildlife Commission, 2005)[20].

The sites associated with the Civil Operations do not traverse, intersect or are close (<2km) to any of the significant habitat zones discussed above.

7.4.5 Fire Regime

EP-167 and EP-168 contain a number of fire sensitive vegetation communities including karst vegetation, riparian communities, sandstone heathlands, and Lancewood/Bullwaddy thickets. Karst vegetation are species and different from the dominant surrounding woodlands.

[18] Department of Natural Resources, Environment, The Arts and Sport, 2011, Judbarra / Gregory National Park and Gregory's Tree Historical Reserve Joint Management Plan. Parks and Wildlife Service of the Northern Territory
[19] Bureau of Rural Sciences (2004) Acacia forests. Forest and Vegetation Sciences Scientific Advice. Department of Agriculture, Fisheries and Forestry, Canberra
[20] Parks & Wildlife Commission of The Northern Territory, 2005, Bullwaddy Conservation Reserve - Plan of Management.

These highly fragmented vegetation types support many fruiting species utilised by flying foxes and birds. The movement of these seed dispersing animals between karst patches and also riparian vegetation facilitates the spread of plants. These vegetation types are most at risk of invasion from woodland species with increased fire frequency, which in turn encourages more frequent fires (Parks and Wildlife Commission, 2005). Fire prevention and mitigation measures being taken by Pangaea are detailed in **Section 10**.

8.0 ENVIRONMENTAL HAZARDS & RISKS

8.1 Determining Environmental Hazards

A Geographic Information System (GIS) desktop analysis of the 2016 NT Appraisal Campaign operational sites was conducted during the planning stage. The placement of each of the sites initially took into account:

- Important vegetation communities (important habitat zones);
- Riparian areas;
- Sensitive soil landscapes;
- Known karst/cave systems and sinkholes; and
- Threatened or endangered fauna and flora data.

The sites were then re-assessed to account for the results of the Cultural Site Clearance process, led by the NLC. Field inspection was used to:

- “Ground-truth” the accuracy of the sites;
- Ensure nil impact on important cultural sites and/or landscapes;
- Collect and collate further data on soils and vegetation types that may warrant moving the sites (i.e. incorporate local knowledge of environmental conditions and sensitivities that the coarse level GIS data did not account for); and
- Identify any further socio-economic impacts that the proposed appraisal program may have on the pastoral lease or the community.

8.2 Determining Environmental Risks

Section 9 is a full description and discussion of the identified hazards and their associated unmitigated risk rating. The unmitigated risk ratings have been developed in consultation with the key personnel identified in Section 11, using industry knowledge that spans all sectors of petroleum exploration expertise, coupled with the desk-top summaries of the receiving environment provided in Section 7.0. The class of risk and likelihood ratings have been assigned using **Table 6.**

All hazards with an Unmitigated Risk Rating equal to or higher than ‘Medium’ have had specific risk management measures developed (Section 10).

Table 6: Environmental Risk Analysis Matrix

ACTUAL / POTENTIAL CONSEQUENCE SEVERITY			0 Remote	1 Highly Unlikely	2 Unlikely	3 Possible	4 Quite Likely	5 Likely
	A+	Catastrophic	0A+	1A+	2A+	3A+	4A+	5A+
	A	Massive	0A	1A	2A	3A	4A	5A
	B	Major	0B	1B	2B	3B	4B	5B
	C	Moderate	0C	1C	2C	3C	4C	5C
	D	Minor	0D	1D	2D	3D	4D	5D
	E	Slight	0E	1E	2E	3E	4E	5E

	SEVERE	Unacceptable - Risk cannot be justified. Go through Risk Reduction Process
	HIGH	Drive risks towards the broadly Acceptable Region
	MEDIUM	Residual risk tolerable only if further risk reduction is impracticable
	LOW	Risk reduction not I kely to be required as resources likely to be grossly disproportionate to the reduction achieved

CONSEQUENCES	People H&S	Eco Environment	Socio Environment	Assets	Legal	Reputation	
	>20 Fatalities (or Permanent Total Disabilities)	Regional scale (>100 km^2). Long term/permanent impact.	Ongoing serious international social issues. Significant damage to structures / items of cultural significance.	>A$1,000 M	Significant prosecution and fines. Very serious litigation including company closure.	International concern. Major ventures terminated. Company at stake.	+A
	4-20 Fatalities (or Permanent Total Disabilities)	Large scale (10-100 km^2). Long-term (decades) impact.	Ongoing serious national social issues. Significant damage to structures / items of cultural significance.	A$100 M - A$1,000 M	Significant prosecution and fines. Very serious litigation including class actions.	Persistent national concern. Long-term 'brand' impact. Major venture / asset operations severely restricted.	A
	1-3 Fatalities (or Permanent Total Disabilities)	Medium scale (1-10 km^2). Medium-term (years) impact.	Ongoing serious local social issues. Significant damage to structures / items of cultural significance.	A$10 M - A$100 M	Major breach of regulation. Major litigation	Medium-term national concern. Minor venture or minor asset operations restricted or curtailed.	B
	Majory Injury / Illness, Permanent Partial Disability or Lost Work Case >4 days.	Medium scale (1-10 km^2). Medium-term (months) impact	Ongoing social issues. Permanent damage to items of cultural significance.	A$1 M - A$10 M	Serious breach of regulation with investigation or report to authority with prosecution and/or moderate find possible.	National bad mention. Short term regional concern. Close scrutiny of asset level operations / future proposals.	C
	Minor Injury / Illness, Restricted Work Case or Lost Work Case <4 days.	Localised (<1 km^2). Short-term (weeks) impact.	Minor medium-term social impacts on local population. Mostly repairable.	A$100 k - A$1 M	Minor legal issues, non-compliances and breaches of regulation.	Short-term local concern. Some impact on asset level non-production activities.	D
	Slight Injury / Illness, First Aid or Medical Treatment Case	Localised (immediate area). Temporary impact (days).	No impact.	<A$100 k	No legal implications	Local mention only. Quickly forgotten. Freedom to operate unaffected.	E
	No Injury.	No impact.	No impact.	A$0	No legal implications	Maintain reputation.	F

	LIKELIHOOD INCREASES →						
LEVEL	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
RATING	**Nil**	**Remote**	**Highly Unlikely**	**Unlikely**	**Possible**	**Quite Likely**	**Likely**
HISTORICAL	Practically Impossible	Unheard of in the industry	Has occurred once or twice in the industry	Has occurred many times in the industry, but not in the Company	Has occurred once or twice in the Company	Has occurred frequently in the Company	Has occurred frequently at the location
FREQUENCY	None	1 in 1000 years	1 in 100 years	1 in 10 years	Yearly	Bi-Annually	Quarterly
PERCENTAGE CHANCE OF OCCURENCE	None	0 001%	0.01%	0.1%	Between 1% and 10%	Between 10% and 50%	>50%

9.0 ENVIRONMENTAL HAZARDS & IMPACTS DESCRIPTION

***Note**: All risks noted below are prior to control measures being implemented. All risks will be managed to As Low As Reasonably Practicable (ALARP).*

9.1 Air Quality

Probability	Likely (5)	**Consequence**	Minor (D)	**Unmitigated Risk Rating**	High (5D)

Dust and emissions will require management during the Civil Operations. The operations will be associated with vehicle movement and emissions. The emissions associated with the running of vehicles are unavoidable and the work will be undertaken well away from potential receptors (pastoral land, in a rural environment).

Dust generation and emissions related to vehicles are the two primary potential impacts relating to the civil operations. Soils will be mobilised differently and are dependent on prevailing weather conditions such as wind, humidity and precipitation, particle size and topography. Some soils within the tenement are considered dispersive.

Dust will be generated as part of the campaign, however, given the operation is in rural environment, it is unlikely that potential dust producing activities will represent a significant impact to any surrounding or other local land users.

9.2 Fuel, Oil & Chemical Management

Probability	Possible (3)	Consequence	Major (B)	Unmitigated Risk Rating	High (3B)

Large quantities of fuels and lubricants are required on the camp site. The portable camp will have a generator capable of 24 hour operation and a fuel cell to sustain that level of operation. NT DoH Requirements for Mining & Constructions Projects are adhered to.

The camp site will be sited to minimise the risk to any sensitive aspects of the environment and away from conduits in the landscape (e.g. close to river or creek banks). Refuelling and emergency response procedures are to be meticulously implemented and spill kits are to be located onsite at all times. Appropriate personnel are to be trained in spill kit use.

9.3 Flora & Fauna

Probability	Possible (3)	Consequence	Minor (D)	Unmitigated Risk Rating	Medium (3D)

The 2016 NT Appraisal Campaign sites have been sited to minimise impacts on important vegetation communities that may be proving important fauna habitat (e.g. Bullwaddy associations, see **Section 0**). No important habitat associations will be impacted by the Civil Operations.

The roads/tracks have been extensively modified by previous human activities and would have limited value for native fauna compared to the extensive areas of native vegetation through which it passes. Impacts would be limited to the removal of some regenerating Eucalypts and Acacia associated with access track and seismic line preparation. There are large quantities of equivalent habitat and resources adjacent to the operations sites, so it is likely that the impact on local populations of native fauna will be minor.

Where not aligned with existing roads and fence lines, the seismic line preparation is likely to disturb existing vegetation in the form of line preparation (light grading to facilitate safe access) however damage to large habitat trees and acacia woodlands (lancewood/Bullwaddy patches) will be prevented by circumnavigating these areas. The seismic line preparation is unlikely to directly harm any fauna as it would disturb a very small area of habitat where clearing has not already occurred and there would be opportunities for fauna to vacate the area. The seismic line preparation would comprise a minor and temporary barrier to movement of fauna, however the scale of vegetation modification is so small that it would be unlikely to isolate any wildlife corridors or otherwise affect the migration or dispersal ability of any fauna.

9.4 Introduction of Weeds

Probability	Possible (3)	Consequence	Moderate (C)	Unmitigated Risk Rating	High (3C)

Weeds can impact negatively on land users and land managers through the effect they may have on environmental, cultural, social or economic values placed on the land. Environmental values and ecosystem functions can be impacted on through the invasion and replacement of native plant species, the altering of habitats for native animals and impact that weeds may have on ecosystem functions such as nutrient and water cycles in addition to changing fire regimes.

There is potential that machinery and vehicles used during the campaign are not weed free, which may result in new infestations being established in the project area. There is also the risk that Civil Operations encounter an area of weed infestation as they move through a pastoral property and transfer that weed onto neighbouring stations as the program progresses.

9.5 Sacred Sites & Cultural Heritage

Probability	Possible (3)	Consequence	Moderate (C)	Unmitigated Risk Rating	High (3C)

All operations as they are currently proposed and assessed in this EMP are currently being reviewed by the NLC and TAOs, with final clearance to be negotiated in January 2016 (**Section 7.4.1**). The landscapes in the tenements would have provided a range of resources, including stone raw materials, fauna, flora and water, particularly along the large rivers and creeks all of which may have allowed for sustainable occupation.

Vegetation cover on the 2016 NT Appraisal Campaign operations sites is moderate to dense, which reduces ground surface visibility, and therefore reduces the potential to identify archaeological evidence, by surface inspection in those areas. Whilst site integrity cannot be assumed, the existence of in-situ cultural materials cannot be ruled out. Based on sacred sites identified in the region site types that may be encountered in undisturbed environments include scarred trees, grinding grooves, artefact scatters and isolated finds.

9.6 Bushfire

Probability	Possible (3)	Consequence	Major (B)	Unmitigated Risk Rating	High (3B)

The Civil Operations sites are located within a fire prone landscape and the activities proposed have the potential to be an ignition source (e.g. vehicles in long grass). Site clearing and seismic line preparation are the activities with the highest potential for starting a bushfire which may result in stock loss, infrastructure damage and loss of available feed on a regional scale. On-site and precautionary measures, site induction and emergency processes will be of paramount importance.

9.7 Soil Disturbance

Probability	Possible (3)	Consequence	Moderate (C)	Unmitigated Risk Rating	High (3C)

The soils generally are related to sporadic steep slopes, high run-on and shallow soils areas of an alluvial origin. Consequently, some soil landscapes are susceptible to erosion from increased traffic load, or in fact, activities that introduce vehicle movement into areas where it previously did not exist. Heavy rains on newly accessed areas are at risk of becoming erosive pathways in the landscape.

9.8 Grading & Gravel Sheeting of Existing Access Roads

Probability	Possible (3)	Consequence	Minor (D)	Unmitigated Risk Rating	Medium (3D)

A total of ~22 km of fence lines will require varying degrees of preparation in order to facilitate effective and safe access to the drill pads. All gravel material will be obtained from sources of naturally occurring deposits and the required material properties will be achieved by crushing, screening, mixing or other processes necessary.

There is a risk that local traffic disruptions will occur on the intersection of pastoral access roads and the Council managed network. There is also a likely loss of regenerating local native vegetation when existing borrow pits are 're-scrapped' and a risk of spreading weeds that may have established in these areas.

9.9 Noise

Probability	Possible (3)	Consequence	Slight (E)	Unmitigated Risk Rating	Medium (3E)

Noise emissions will require management during the campaign. During Civil Operations noise associated with the running of vehicles are unavoidable however, the work will be undertaken well away from potential receptors (pastoral land, in a rural environment). Noise is likely to be a 'nuisance' issue to native fauna, but one of little consequence in the longer term.

9.10 Water Supply & Use

Probability	Possible (3)	Consequence	Minor (D)	Unmitigated Risk Rating	Medium (3D)

Approximately 0.4 ML will be required to run the Civil Operations campsite. Water is to be sourced locally from the bore Tarlee Railway Bore (RN32961) located on Tarlee Station, approximately 8km E of the camp site, as detailed below in Table 7 and trucked to the camp site. Daily consumption per person generally equates to 120 -150 litres per day.

Table 7: Water Bore Details

Bore Name	Tarlee Railway Bore
Bore RN	32961
Station Name	Tarlee
Direction & Approx. km to Camp	8 km W
Proposed Sampling Date	1st week January 2016
Easting Coordinate **Northing Coordinate** ***(GDA/MGA 94)***	264 494 8 267 884
Bore Report details:	
Construction	Steel casing
Total Depth	120m
Screen Settings	54–66m, 96-102m, 108-114m
Diameter	155-206mm
Aquifer Depth	49m–114m
Water Source / Aquifer Origin	Limestone

9.11 Groundwater

Probability	Possible (3)	**Consequence**	Minor (D)	**Unmitigated Risk Rating**	Medium (3D)

Two (2) water bores will be drilled as part of the Civil Operations for the 2016 NT Appraisal Campaign targeting the Jamieson Sandstone brackish water aquifer.

Subsurface Protection:

The bores will be designed to intersect the Jamieson Sandstone brackish water aquifer, which is found at a depth of ~150–300m. The bore will be engineered, designed and completed to meet NT government regulations.

9.12 Waste Management

Probability	Possible (3)	**Consequence**	Minor (D)	**Unmitigated Risk Rating**	Medium (3D)

General refuse will be collected at the camp site and transferred to the closest waste management facility. There is a risk that improper management of waste may attract feral animals to the camp sites. NT DoH Requirements for Mining & Construction Projects are adhered to.

10.0 PERFORMANCE OBJECTIVES & MITIGATION MEASURES

This section outlines the key environmental management issues and their suggested mitigation methods, responsibilities and prioritisation. This also includes the controls that will be implemented during the program to comply with these requirements, and undertake operations in an environmentally responsible manner. All visitors and contractors to the Civil Operations sites and camps must comply with the requirements within this EMP.

Each section possesses an Environmental Performance Objective ("EPO") which relate to the identification and assessment of the environmental impacts and unmitigated risks. Auditing and review of this EMP will consider the implementation of the specific actions as a means of achieving the EPO.

Each EPO has been developed in accordance with Pangaea's Environmental Policy, APPEA Environmental Code of Practice and relevant NT Legislation (**Section 2**).

10.1 Dust & Emissions

EPO	Rural air environment with qualities conducive to suitability for the life, health and wellbeing of humans.
Specific Objective(s)	• Minimise environmental nuisance due to dust for sensitive receptors as a result of appraisal activities. • Minimise greenhouse gas emissions.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** The Air Quality Management Plan (**Appendix O**) will be adhered to. **3.** As part of job-site induction prior to arrival on-site, awareness of air/dust related issues will be provided for relevant staff. **4.** Speed limits on access tracks and dirt roads required to limit and minimise dust generation will be clearly communicated to crews. **5.** Appropriately inform affected pastoralists as specified in the access agreement and providing updated information as required. **6.** Where practical, all vehicular movements to and from the works site would be made only during daylight hours and/or compliant with land access agreement. **7.** Engines will not be left running when not specifically required. **8.** Individual vehicular trips to and from the works site will be kept to a minimum. **9.** Smoke generation will be avoided by a strict no burning policy. **10.** Watering of roads when appropriate or when agreed. **11.** Complaints will be investigated and responded to appropriately in accordance with the Consultation Report (**Appendix H**).
Measurement Criteria	• Complaints in relation to air quality or environmental nuisance. • Any recorded complaints are actioned and closed out. • No fires on site (or in adjacent areas) as a result of project activities. • Maintenance records demostrate regular servicing in accordance with manufacturers requirements.
Records	• All complaints and subsequent actions are recorded in accordance with the Consultation Report (**Appendix H**). • Fortnightly progress reports. • Monthly audit by EMR.

10.2 Land

EPO	The activities associated with Civil Operations will minimise erosion or sediment movement, loss of topsoils or dust.
Specific Objective(s)	• Minimise environmental damage due to soil erosion. • Minimise environmental nuisance as a result of damage to access tracks. • Minimise impacts on overland flow that may result in new erosive pathways.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** The Ground and Surface Water Management Plan (**Appendix Q**) will be adhered to. **3.** The provisions and schedules embodied in the NT Waste Management and Pollution Control Act will be adhered to. **4.** As part of job-site induction prior to arrival on-site, awareness of soil erosion related issues will be provided for relevant staff. **5.** When forming access tracks, minimise disturbance to creek and river banks and any naturally formed depressions. **6.** Vehicles to deviate around creeks, rivers and naturally formed depressions. **7.** Where creek crossings are unavoidable, cross them in a naturally clear area. **8.** Install additional erosion controls in strategic locations to stop or slow water flow along long sections of straight access tracks. **9.** Do not use access roads in wet conditions. **10.** Complaints will be investigated and responded to appropriately in accordance with the Consultation Report.
Measurement Criteria	• Complaints in relation to erosion by pastoralists or Government. • Any recorded complaints are actioned and closed out. • No incidents of bogged vehicles. • Induction records and pre-start operational lists.
Records	• All complaints and subsequent actions are recorded in accordance with the Consultation Report (**Appendix H**). • Fortnightly progress reports. • Monthly audit by EMR.

10.3 Water

EPO	Minimal opportunity for impacts to surface water and groundwater systems.
Specific Objective(s)	• Complete bore holes with consideration of the subsurface environment. • Minimal activities within riparian areas. • Activities to minimise opportunity for impacts on water quality.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** The Ground and Surface Water Management Plan (**Appendix Q**) will be adhered to. **3.** The provisions and schedules embodied in the NT Waste Management and Pollution Control Act will be adhered to. **4.** As part of job-site induction prior to arrival on-site, awareness of surface and groundwater related issues will be provided for relevant staff. **5.** Bore holes will be grouted and completed according to Industry Best Practice sealing requirements. **6.** Fuels, lubricants and chemicals shall be stored and handled within containment areas (such as portable bunding, or self bunded) that are designed to prevent the release of spilt substances to the immediate neighbouring environment, in accordance with relevant legislation and standards. **7.** Appropriate sedimentation and erosion control measures will be put in place at each location. **8.** All surface water runoff will be directed away from the sites to prevent contamination. **9.** Spill kits appropriate to operations of this size will be available at site. **10.** Personnel will be advised of the location and use of the spill containment equipment in the site induction. **11.** Refuelling is to be undertaken within the designated refuelling sites. Where refuelling is required outside the camp sites, the vehicle shall be on flat and stable ground and not within 25m of a watercourse or other riparian area. **12.** The amount of hazardous material stored and used on site shall be kept to a minimum. **13.** Hazardous materials shall be transported, stored and handled in accordance with the requirements of relevant legislation (e.g. Road and Rail Transport (Dangerous Goods) Act 1997, Australian Dangerous Goods Code) and Australian and Industry Standards. **14.** Spills or leaks shall be immediately reported to the Pangaea Representative on site who will initiate appropriate 'clean up' actions in consultation with the EMR. **15.** In the event of a spill the material will be contained to the smallest area practicable and Emergency Procedures are to be followed.
Measurement Criteria	• No recorded spills or accidents. • Induction records and pre-start operational lists. • Water quality test results on existing bores.
Records	• Monthly audit by EMR. • Water testing results.

10.4 Noise

EPO	Ambient noise levels with qualities conducive to suitability for the life, health and wellbeing of humans.
Specific Objective(s)	• Minimise environmental nuisance due to noise for sensitive receptors as a result of Civil Operations activities.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** As part of job-site induction prior to arrival on-site, awareness of noise related issues will be provided for relevant staff. **3.** Appropriately inform affected pastoralists as specified in the access agreement and providing updated information as required. **4.** Where practical, all vehicular movements to and from the works site would be made only during daylight hours and/or compliant with land access agreement. **5.** Engines will not be left running when not specifically required. **6.** Individual vehicular trips to and from the works site will be kept to a minimum. **7.** Complaints will be investigated and responded to appropriately in accordance with the Consultation Report (**Appendix H)**.
Measurement Criteria	• Complaints in relation to noise or environmental nuisance. • Any recorded complaints are actioned and closed out. • Maintenance records demostrate regular servicing in accordance with manufacturers requirements.
Records	• All complaints and subsequent actions are recorded in accordance with the Consultation Report (**Appendix H**). • Fortnightly progress reports. • Monthly audit by EMR.

10.5 Flora & Fauna

EPO	No significant, permanent harm to listed threatened species or their available habitat.
Specific Objective(s)	• Minimise the impact on existing habitat values. • To avoid harm or injury to native fauna.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** The Weed Management Plan (**Appendix N**) will be adhered to. **3.** As part of job-site induction prior to arrival on-site, awareness of flora & fauna related issues will be provided for relevant staff. **4.** Weed/pest inspections of machinery will be undertaken prior to arriving at site. **5.** Machinery will be cleaned of mud and seed prior to arriving at each new site at a designated and bunded area. **6.** Assess the potential impacts on threatened species, populations, ecological communities and their habitats at each site. **7.** Waste material (domestic waste) will be stored in suitable receptacles and disposed of accordingly at municipal managed locations. **8.** Access tracks and seismic lines will be located in areas that will result in minimal ground disturbance and do not impact on threatened flora or fauna, or endangered ecological communities. **9.** Seismic line preparation through vegetated areas (off existing tracks and fence lines) is to be conducted with a regular straight blade or a stick rake. The source lines will not be wider than 5 meters, with the receiver lines not wider than 3 meters. **10.** In areas where the seismic line follows existing tracks and fence lines, a grader may be used to sweep the tracks for more efficient access. **11.** Avoid creation of windrows with mixed logs, branches and cleared grass. **12.** Promote ground cover on bare sites by leaving topsoils in-situ and/or pulling back logs, sticks and pruned branches. **13.** Where required, additional erosion controls will be installed in strategic locations to stop or slow water flow along access tracks and seismic lines. **14.** Provide Civil Operations crew weed field ID guides and training sessions before entering the field. **15.** Avoid areas of known environmental weeds, noxious weeds or problem plants as defined in this EMP, by the weeds unit and pastoral lands management unit of the Land Resource Management and pastoralists, with reference to the EcOz Weed Map. **16.** Civil Operations field crews will undertake a visual check of seed in clothes and protective gear daily. **17.** Establish clearly sign-posted 'weed blow down areas' and GPS points recorded.
Measurement Criteria	• 2016 NT Appraisal Campaign before and after photos of relevant flora areas. • No recorded spills or accidents. • Induction records and pre-start operational lists.
Records	• Daily weed blown down reports. • Induction records and pre-start operational lists. • Fortnightly progress reports. • Monthly audit by EMR.

10.6 Socio-Economic & Community

EPO	To minimise the impact on existing community infrastructure and avoid the disturbance of or damage to Aboriginal cultural heritage or culturally sensitive landscapes.
Specific Objective(s)	• To avoid uncontrolled bush fires occurring on site. • To avoid disturbance of or damage Aboriginal or cultural heritage artefacts or Sacred Sites.
Mitigation Measures & Strategies	**Aboriginal Cultural Heritage** **1.** In the event that a suspected sacred site or artefact has been discovered and the activity cannot be altered to avoid the site, work will cease in the area of the discovery AND the person discovering the artefact will notify their supervisor who will ensure that work has ceased and the area(s) is (are) cordoned off with tape. **2.** The PC will notify the Pangaea Representative on site who will request a qualified professional to attend the site and advise on its significance. **3.** Work will not recommence in the area of any discovery until the site has been inspected and the requirements of the Department have been met. **Bushfire** **4.** Bushfires NT will be notified of the appraisal strategy. **5.** A minimum of one 400lt slip-on unit will be located at the camp site. **6.** Fire control water pumps and hoses are to be readily accessible, on-site and well maintained. **7.** All items of plant that could discharge sparks must be fitted with spark arresters. **8.** No onsite cutting, welding, grinding or other activities likely to generate fires in the open on days when a total fire ban is proclaimed. **9.** Ensure that all personnel are adequately trained with regard to fire prevention, safety and basic firefighting skills. **10.** Before work such as welding, thermal or oxygen cutting, heating or other fire/spark producing operations are started; the area of the works will be thoroughly wet down. **11.** All field crews will have an additional water fire extinguisher, shovel, rake and fire beater as standard vehicle equipment to let the driver be a relevant first responder. **12.** Car parks and refuelling areas must all be at least 20m from the bush perimeter. **Community** **13.** Pastoralists will be contacted two weeks prior to the commencement of Civil Operations on their station. **14.** Site rehabilitation will be undertaken as specified and agreed in the landholder access forms.
Measurement Criteria	• 2016 NT Appraisal Campaign before and after photos of relevant flora areas. • Complaints in relation to air quality, noise or environmental nuisance. • Any recorded complaints are actioned and closed out. • No fires on site (or in adjacent areas) as a result of project activities.
Records	• Fortnightly progress reports. • Monthly audit by EMR.

11.0 IMPLEMENTATION STRATEGY

11.1 Roles & Responsibilities

The Appraisal Campaign project team will consist of the following lead roles:

- Pangaea Representative (PR): **David Armstrong** (Terrabos Consulting)
- Cultural Management Consultant (CMC): **Damian Wall** (Red-Gum Consulting)
- Operations Coordinator (OC): **Sarah Jordan**
- Environmental Management Representative (EMR): **EcOz Environmental Consultants**
- Vice-President of Exploration (VPE): **Joel Alnes**
- Executive Director (ED): **Tim Radburn**

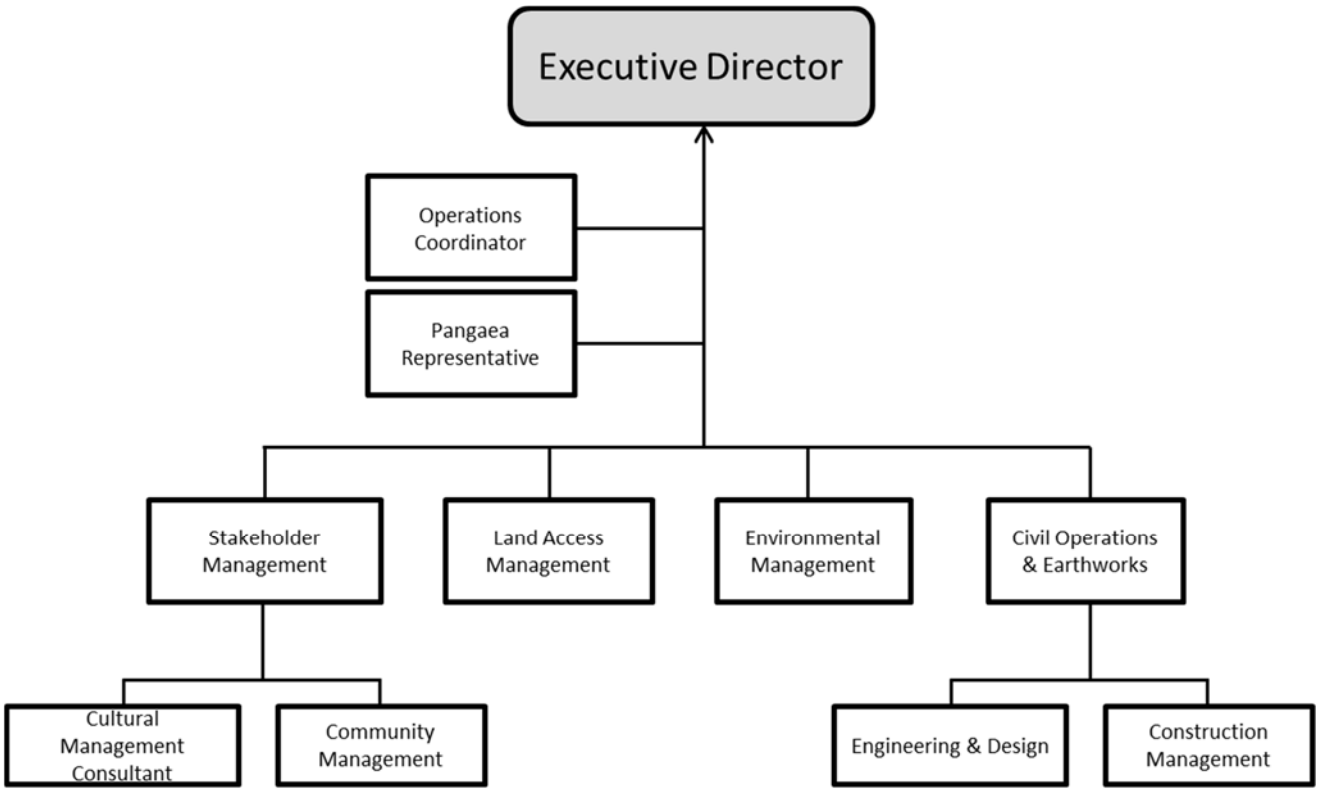


Figure 13: Decision & Communication Flowchart

11.1.1 Pangaea Representative (PR)

- Represent Pangaea in the field.
- Assist in ensuring all contractors and other relevant personnel are inducted prior to commencement of any work.
- Apart from technical QA/QC, the PR will liaise with Civil Operations crew on a daily basis covering both technical and HSE day-to-day issues.
- Ensure the Civil Operations crew are conducting operations in an environmentally friendly manner.
- Includes all QHSE statistics and current operations in the daily reports; and
- Report to the ED.

11.1.2 Cultural Management Consultant (CMC)

- Represents Pangaea in the field with regard to cultural engagement.
- Conducts native title and sacred site clearances in conjunction with Northern Land Council and AAPA.
- Completes infield work program consultation with Traditional Owners.
- Notifies all Pangaea field contractors of sacred site, cultural, artefact and heritage considerations.
- Briefs all Pangaea field personnel at induction meetings on culturally significant awareness requirements.

11.1.3 Operations Coordinator (OC)

- Conduct fortnightly and monthly reporting of all HSE statistics and submit to ED.
- Assist in implementing and maintaining environmental controls.
- Notify the ED of a serious environmental incident, breach of conditions, or serious complaint.

11.1.4 Executive Director (ED)

- Monitoring HSE performance at each stage of the project and on a day-to-day basis.
- Ensuring Emergency Response preparedness for the tenements and individual sites.
- Ensuring all contractual and legislative requirements are satisfied.
- Measuring and monitoring HSE management effectiveness.
- Ensuring adequate resources are planned to address the HSE risks on the tenements and sites.
- Reporting incidents as required.
- Prepare SMP/EMP/ERP and ensure they adequately control the HSE risks involved with the operations and regulatory requirements,
- Manage all stakeholder management, land access management, environmental management and civil operations & earthworks in accordance with SMP/EMP/ERP; and
- Instruct suspension of work if non-compliant with established / agreed operating procedures.

11.1.5 Environmental Management Representative (EMR)

- Management of environmental enquiries/issues as required.
- Conduct the monthly environmental audit during the course of operations.
- Liaise with relevant stakeholders prior to and during each phase of Civil Operations.
- Ensure that Civil Operations activities are conducted in accordance with this plan.
- Ensure that environmental impacts are minimised and protection of environmental values (all threatened species, populations and endangered ecological communities, and aquifers); and
- Participation on consultation committees (if formed).

11.1.6 Principal Contractors & Service Providers

It is the responsibility of any and all Principal Contractors and Service Providers to conduct Civil Operations activities in accordance with this EMP.

11.2 Summary of Operation Systems, Standards, Policies & Procedures

Pangaea will refer to, be guided by and constantly review several operational systems, standards policies and procedures including:

Policies

- Pangaea Quality, Heath, Safety and Environment Policy (**Appendix A**); and
- Document and Information Management Standard (**Appendix J**).

Operational Systems

- Pangaea Quality Management Systems Manual,
- Pangaea Quality Health, Safety & Environment Management Systems Manual; and
- Pangaea Risk Management System Manual.

Procedures

- Incident Investigation Procedure (**Appendix G**),
- STEP Program; and
- Pangaea's Quality Management System – Corrective & Preventative Action Item Register (**Appendix I**).

Standards

- ISO 9001:2000, Quality management systems – Standard,
- ISO 14001:2004, Environmental management systems – Standard,
- ISO 19011:2011, Guidelines for quality and/or environmental management systems auditing – Guidelines,
- AS/NZS 4360:2004, Risk Management Framework – Standard; and
- HB 139-2003, Guidance on Systems Integration – Guidelines.

11.3 Competency, Training & Awareness

All personnel directly involved in environmental management will be appropriately qualified to undertake the tasks of the position to which they are appointed. The ED is responsible for establishing the necessary criteria for each position and verifying the qualifications and experience of all environmental management personnel and for maintaining personnel files containing this data.

Any external contractors or consultants engaged to carry out environmental tasks such as noise, water or air quality monitoring or auditing shall be appropriately qualified, trained and competent. The EMR must demonstrate general compliance with the principles of *AS/NZS ISO 14012:1996 Guidelines for Environmental Auditing: Qualification Criteria for Environmental Auditors.*

11.3.1 Site Induction & Training

The PR, EMR, OC and CMC in consultation with the ED will ensure that all relevant personnel undertake an *environmental induction* before working on-site to minimise all potential environmental impacts. A particular focus will be on the use of spill kits to contain any chemical, fuel or oil spills, cultural heritage protection and prevention of soil erosion. The session is compulsory for all personnel and service providers and will cover:

- Purpose & objectives of the EMP;
- Requirements of due diligence and duty of care;
- Conditions of environmental licences, permits and approvals;
- Environmental emergency response;
- Management and reporting process for environmental incidents;
- Lessons learnt from environmental incidents;
- Environmental controls that are identified in the EMP;
- Weed management and clean down provisions;
- Fire control and prevention;
- Land access;
- Site-specific issues including, but not limited to those detailed in Section 10;
- Environmentally sensitive areas; and
- Cultural Awareness Training.

Records of attendance at the environmental induction will be maintained by the PR.

11.3.2 Induction Register

Records of environmental inductions and training will be maintained on site by the PR including dates, details on training, names of persons trained and trainer details and then sent to the OC in Pangaea's Sydney Office in order to demonstrate compliance with the EMP.

11.3.3 Tool Box Talks

Tool Box Talks will detail cultural heritage and environmental information or instructions that may be required on site on a daily basis. The specified instructions in this regard may be generated from Spot Checks and/or Daily Site Inspections. Records of attendance and topics covered at each meeting will be maintained by the civil contractor.

11.4 Record Keeping

All records associated with environmental management will be stored so that they are readily retrievable and suitably protected from deterioration or loss during the Operations. The following environmental records will be kept by the OC in Pangaea's Sydney Office in order to demonstrate compliance with the EMP:

- Details of qualifications held by individuals primarily responsible for environmental monitoring;
- Monitoring / inspection reports;

- Internal audit reports;
- External audit reports;
- Reports of pollution incidents, other environmental non-conformances, complaints and follow up action;
- Minutes of EMP review meetings;
- Evidence of action taken as a result of such meetings;
- Induction and training records; and
- Records of monitoring by subcontractors against compliance limits.

11.5 Environmental Monitoring & Auditing

The basis of Pangaea's Environmental monitoring program is embodied in spot checks, daily meetings, photo monitoring and monthly site audits. The ED, the EMR, the PR and the OC will all have some responsibility in this regard.

11.5.1 Monthly Audit

The EMR will complete a *Monthly Environmental Inspection Checklist* (**Appendix D**) in consultation with the ED and OC. The OC will maintain a register of all inspections, including the date, time, prevailing weather conditions at the time of inspection and the inspection findings. A Monthly Meeting with relevant Pangaea personnel and Service Providers will be held to discuss the findings of the audit, suggest corrective actions and improvements to the work site or work processes. The monthly audit will be conducted to address the following issues:

- Compliance with statutory obligations;
- Compliance with environmental standards, guidelines, specifications and codes of practice;
- Compliance with the EMP;
- Adequacy of environmental training records;
- Adequacy of environmental records, checklists and document management systems;
- Recording and completion of corrective actions following environmental incidents and complaints;
- Achievement of environmental performance objectives; and
- Implementation of actions from previous audits.

Copies of the monthly audit report will be maintained by the ED. If major problems are identified during the audits, Nonconformity Notifications or Corrective Action Requests may be issued to Service Providers via the ED. Audit results will be made available to the NT Government on request or by schedule that is required.

11.5.2 Spot Checks & Daily Site Inspections

The PR will complete Daily Site Inspections and Spot Checks throughout the Civil Operations to ensure compliance with the directives given in the Tool-box meetings (Section 11.3.3) and no repeat

of any non-conformances identified during the previous monthly audit. The results of the spot checks and daily audits will be kept by the PR and made available to the EMR during the monthly audit.

11.5.3 Photo Monitoring

The EMR in consultation with the ED and the PR will establish photo monitoring points at the Civil Operations sites. Photos of the sites will be stored by the PR and each site will be visited by the EMR at the conclusion of the program.

11.5.4 Third Party Audits

The EMR in consultation with the ED will appoint an external auditor to review the Post Completion Audit. The external auditor must demonstrate general compliance with the principles of AS/NZS ISO 14012:1996 Guidelines for Environmental Auditing: Qualification Criteria for Environmental Auditors.

The external auditor report shall be submitted to the ED and OC and forwarded to Government as required, together with a written response on how all actions and issues raised in the audit will be addressed.

11.6 Reporting

The following section provides details of reporting obligations throughout the campaign.

11.6.1 Fortnightly Reporting

A fortnightly report will be generated by the OC in consultation with the PR and Service Providers. The weekly report summarises:

- Time, cost & quality KPIs; and
- A map of progress.

Copies of the fortnightly report will be maintained by the OC.

11.6.2 Spills or Uncontrolled Discharge of Hydrocarbons

The PR will complete Daily Site Inspections and Spot Checks throughout the Civil Operations. Any and all spills or uncontrolled discharge of hydrocarbons will be recorded and reported immediately, or as soon as practicable, to the EMR. The OC will liaise with the Department through the ED to ensure the timely submission of environmental incident, close-out and external auditing reports. Each report will be provided to the appropriate departmental contact in accordance with the appropriate reporting clause (specific to the incident) of the *NT Schedule of Onshore Petroleum Exploration and Production Requirements 2012.* See clauses 286 – 290.

11.6.3 Other Environmental Incidents & Accidents

The PR will complete Daily Site Inspections and Spot Checks throughout the Civil Operations. Any environmental incidents or accidents will be recorded and reported immediately, or as soon as practicable, to the EMR. The OC will liaise with the Department through the ED to ensure the timely submission of environmental incident, close-out and external auditing reports.

Each report will be provided to the appropriate departmental contact in accordance with the appropriate reporting clause (specific to the incident) of the *NT Schedule of Onshore Petroleum Exploration and Production Requirements 2012.* See clauses 286 – 290.

11.6.4 Monthly QHSE Reporting & Auditing of the EMP

A monthly QHSE report (**Appendix E**) will be generated by the OC in consultation with the ED and Service Providers. The report summarises environmental, health and safety KPIs.

The monthly report will be emailed to the Department of Minerals and Energy in accordance with clauses 712 & 801 of the *NT Schedule of Onshore Petroleum Exploration and Production Requirements 2012*.

11.6.5 Rehabilitation Report

Upon completion of the rehabilitation phase of the project a Rehabilitation Report will be prepared by the EMR and provided to the DME by the Operator in accordance with clause 532 of the *NT Schedule of Onshore Petroleum Exploration and Production Requirements 2012*. The Rehabilitation Report will consider the implementation strategies outlined in the Rehabilitation Plan (**Appendix B**).

11.6.6 General Waste Reporting

General waste reporting will be generated via the General Waste Register in the Waste Management Plan (**Appendix F**). The General Waste Register will be maintained by MS Contracting and a copy is to be kept onsite by the PR until the project is completed. The General Waste Register will record:

a) Type of waste and its classification (according to the Waste Management and Pollution Control Act);

b) Tonnes of waste;

c) Where the waste was disposed of;

d) Date when the waste was disposed of; and

e) Name of the transporter used.

11.6.7 Listed Waste Reporting

Listed waste reporting will be generated via the Listed Waste Register in the Waste Management Plan (**Appendix F**). The Listed Waste Register will be maintained by PR and a copy is to be kept onsite by the PR until the project is completed. The Listed Waste Register will record:

f) Type of waste and its classification (according to the Waste Management and Pollution Control Act);

g) Tonnes of waste;

h) Where the waste was disposed of;

i) Date when the waste was disposed of; and

j) Name of the transporter used.

11.7 Non-conformance and Corrective Action

Environmental non-conformances are defined as:

- Any breach of approvals, permits or licences;
- Any non-compliance with those sections of the EMP that specifically relate to environmental performance and/or any non-compliance with the environmental management measures outlined in the EMP; and/or
- Any other error, misadventure or incident resulting in environmental damage which is significant.

The ED will investigate each non-conformance (with the EMR, OC, PR & relevant Service Providers) in accordance with Pangaea's Incident Investigation Procedures (**Appendix G**).

In the event of an incident causing material or serious environmental harm (which is not specifically planned and managed under this EMP), the Department of Minerals and Energy will be advised by phone as soon as practicable. Pangaea will continue to liaise with the Department to ensure the timely submission of a formal incident investigation report and close-out actions as required, on request or by schedule that is required.

The PR will maintain a register of all non-conformances, which includes date raised, description, reference number and close out status.

Note: material or serious environmental harm equate to a consequence category "D" or above in the Pangaea risk rating matrix.

11.8 Community and Stakeholder Consultation

11.8.1 Stakeholder Consultation

To date, consultation has included discussions with the Northern Land Council (NLC) and the Department of Mines and Energy (DME) in relation to the project. Pangaea has also engaged in stakeholder (pastoral) liaison over several months to identify issues of concern and find ways to address them. Pangaea will continue to engage with stakeholders on an ongoing basis throughout the life of the project as a way of keeping key stakeholders informed about our activities, educating the community, traditional owners and government about the project. (**Appendix P**)

A detailed cultural heritage assessment and clearance process will be undertaken in January 2016 involving representatives of the Traditional Owners including field assessment and development of effective protection measures. All operations as they are currently proposed and assessed in this EMP will be reviewed for cultural clearance by the NLC in close consultation with Traditional Owners in January 2016.

11.8.2 Ongoing Consultation

The ED in consultation with the PR will notify the local Council and relevant government departments of any activities that could cause disruption (e.g. traffic disruptions, temporary detours, changes to property access) at least 14 working days before the work commences.

The OC will ensure all community liaison records are kept. The records will inform a Consultation Report (**Appendix H**) which consists of:

- List of all relevant stakeholders consulted;
- Name and title of persons consulted;

- Issues discussed;
- Specific concerns and interests raised during the consultations; and
- Processes and arrangements for ongoing consultation with relevant stakeholders.

11.8.3 Complaints Handling

All complaints regarding any environmental/community issue caused by the works will be handled in accordance with Pangaea's Quality Management System, using the *Corrective & Preventative Action Item Register* (**Appendix I**) maintained on site by the PR.

This shall capture the details of the complaint, action taken to investigate and if necessary to correct the problem. A register of all project specific complaints and subsequent communications (including records of any telephone calls) shall be kept by the OC and included on the monthly report by the ED.

11.9 Document Control

Pangaea will ensure that all environmental management documents are reviewed and approved for adequacy prior to issue. Documentation associated with the operation of the EMP shall be recorded on a document register in accordance with Pangaea's Document and Information Management Standard (**Appendix J**).

11.10 EMP Review

Pangaea will undertake a complete review of this EMP every 3 months from the start date and then again at the conclusion of operations as defined by this EMP. The review will consider the following issues:

1. Results of any environmental audits;
2. The extent of compliance with EMP environmental performance objectives and targets;
3. Changes to relevant legislation;
4. Any changes in the type and scope of works which has an impact on the environmental requirements of the project;
5. The appropriateness and ease of use of the EMP; and
6. Demonstration that continuous improvement is occurring.

Review results will be maintained by the ED and communicated to the DME on request.

12.0 EMERGENCY RESPONSE PLAN

A review of Civil Operations activities associated with the 2016 NT Appraisal Campaign identified a range of potential environmental emergency scenarios. Generic control measures and the Level of Risk rating *before control measures* are shown in Section 9.0. Detailed control measures for the potential incidents with a medium or above rated risk, are outlined in Section 10.

The following ***Emergency Response Actions*** have been developed for the incidents that have a probability of 'Possible' and a consequence of 'Major'.

12.1 Emergency Response – HIGH Risk Environmental Emergencies

In the event of an environmental emergency within the tenement, the ED is responsible for the overall management of the situation. The PR will manage the immediate emergency with the primary focus on limiting harm to personnel, the environment and lastly equipment, whilst controlling the situation and preventing escalation.

In the event that the emergency escalates, support will be provided by Pangaea with the assistance of the Emergency Management Team (EMT). For all Incident Classification, Tier Activation, Notification Requirements and Contacts relevant to the project, consult the ERP.

See Appendix K for a complete list of Emergency Response Support contacts.

12.1.1 Fire Management Plan

NOTE: No person is obligated to engage in fire-fighting efforts. Fires will only be fought by those who are trained AND confident in doing so.

Raise assistance immediately. See Appendix L for contacts list.

- **DO NOT LEAVE THE SCENE.**
- **If electing not to fight the fire, retreat to a safe distance upwind of the flames and stay with your vehicle.**
- **If flames approach the vehicle,** close all vents and windows, retreat to the floor and cover yourself with a blanket if possible. Wait until the flame front passes, exit the vehicle and extinguish it if possible.
- Always consider your safety and the safety of others first before attempting to contain or extinguish a fire. Fire extinguishers should only be used when safe, trained and confident to do so.
- If it is safe, a direct attack may be made at the front or head of the fire. This is where the rate of spread is fastest but also where the heat, flames and smoke are worst.
- If it is unsafe to attack the head fire then an alternative may be to work along the sides, called flanks, starting at the back and working towards the head fire. A flank approach will generally be a safer tactic as the fire fighters can always retreat to the burnt out ground.
- "Back burning" may be deployed as a containment technique; **this must always be supervised by trained, experienced crew leaders.**
- In an emergency, graders may be used to circumnavigate the burning area and isolate the fuel sources.

13.0 CONCLUSION

This document, the Civil Operations for 2016 NT Appraisal Campaign, EP-167 & EP-168 Environmental Management Plan describes the roles and environmental responsibilities of all personnel. It also acts as a bridging document for principal contractors and details key environmental mitigation measures identified by Pangaea post identification of 'hazards & risks' and emergency response.

The purpose of this EMP is to provide the framework for environmental management of the activities proposed in undertaking the Civil Operations and to detail the control measures to be implemented to ensure that appraisal activities are conducted in an environmentally responsible manner.

The guiding principle in the development of this EMP is one of 'co-existence and responsible land use sharing'. Community consultation, relationship building and educational forums have all been established from earlier petroleum activities (e.g. the seismic survey conducted in 2013, the 2014 NT Exploration Campaign and the 2015 NT Appraisal Campaign). The success of these operations is a testament of the company's commitment to fully engage with all stakeholders and respect their rights and wishes, particularly of the pastoral enterprise holders and the Traditional Owners.

14.0 REFERENCES

Department of Mines and Energy (DME) Guideline: *Environmental Plan Summary*, available online at: http://www.nt.gov.au/d/Minerals_Energy/Content/File/Forms_Guidelines/EnvironmentalPlanSummary.pdf

DME Guidelines: *Environmental Plan (EP) Requirements, Applications for Drilling or Workover Rig Activities*, and *Environmental Plan Summary*, available online at: http://www.nt.gov.au/d/Minerals_Energy/index.cfm?header=Energy%20Forms%20and%20Guidelines#pa

DME *Regulation of Hydraulic Fracturing*, available online at: http://www.nt.gov.au/d/Minerals_Energy/index.cfm?newscat1=&newscat2=&header=Regulation%20of%20Hydraulic%20Fracturing

Northern Territory Legislation (suite) available online at: http://dcm.nt.gov.au/strong_service_delivery/supporting_government/current_northern_territory_legislation_database

15.0 APPENDICES

Appendix A: Quality Health, Safety & Environment Policy

PANGAEA

Quality, Health, Safety and Environmental Policy

Policy Statement

Our commitment to Quality, Health, Safety and Environment (QHSE) governs everything that we do, at all times. At Pangaea (NT) Pty Ltd (Pangaea), we do not want to harm people or the environment and we actively pursue an approach in which risks to people and the environment are adequately managed.

Our principles, vision and commitment to managing quality, health, safety and environment is set down in our QHSE Policy. This Policy guides our strategic and day-to-day operations and actions and serves as a benchmark for evaluating and continually improving our performance.

We are committed to sustainable environmental practices and development as part of our beliefs and values. Pangaea's quality assurance is based on customer satisfaction, supported by best practices and continuous improvement.

Commitment Expectations

It is the policy of Pangaea to conduct its activities in such a way as to:

- Ensure all personnel and contractors act in accordance with their obligations as set out in this Policy.
- Provide adequate information, training and supervision to employees, contractors and stakeholders.
- Comply with all applicable legislation, regulations, statutory obligations and other requirements.
- Seek to achieve the personal commitment of all personnel, contractors and stakeholders to QHSE related workplace practices.
- Design and implement systems, processes and documents aimed to mitigate risks to personnel, property, the environment and quality in alignment with OHSAS 18001, AS/NZS ISO 9001 and ISO 14001.
- Set measurable QHSE objectives and targets for employees, contractors and stakeholders, seeking to continually improve our QHSE performance.
- Incorporate QHSE management practices in all aspects of our operations.
- Be particularly vigilant when working in areas of unique flora and fauna, or in or near areas of historical or culturally important sites or artefacts.
- Endeavour to conserve resources, reduce waste and pollution and eliminate or minimise adverse environmental effects and risks that may be associated with our operations.
- Use consultative mechanisms to facilitate engagement and participation of employees and other parties to enable resolution of QHSE issues.
- Identify, report, investigate and resolve all non-conformances and take action to prevent recurrence.
- Review and revise the QHSE Policy, systems and documents periodically to maintain their relevance.

Responsibilities

This Policy applies to all personnel involved in Pangaea operations and is the foundation to the QHSE Management System.

The Executive Director and supporting management are responsible for the implementation and enforcement of this Policy.

Each employee, contractor, service provider and visitor is responsible for actively supporting this Policy.

Application

This Policy is enacted through legislative compliance and the QHSE Management System.

Tim Radburn

Executive Director
29 October 2015

DOCUMENT NO: QHSE-POL-001 | REVISION: 1.0 | REVIEW DATE: 29/10/2017

Appendix B: Rehabilitation Plan

The following section of the EMP provides a rehabilitation strategy for all sites affected by the Civil Operations for the 2016 NT Appraisal Campaign.

1. Rehabilitation Management Strategy & Objectives

This section of the plan outlines the overall rehabilitation strategy for Civil Operations sites, including descriptions of key components of the rehabilitation strategy integral to the anticipated final landform. The rehabilitation strategy will be flexible to allow for the integration of successful rehabilitation activities, and will be amended if new rehabilitation techniques are developed. The strategy includes the following key aspects:

- An outline of the objectives of the rehabilitation strategy;
- Land-form design and planning (including objectives);
- Progressive rehabilitation requirements for disturbed areas;
- The management of topsoil resources for use in rehabilitation of the site; and
- The rehabilitation monitoring and maintenance requirements that will apply.

1.1 Rehabilitation Objectives

The objectives of the rehabilitation strategy are to ensure that:

a. Rehabilitation activities meet stakeholders expectations and comply with relevant regulatory requirements and/or industry best practices — Rehabilitation of the disturbance areas will be completed in accordance with the Petroleum Act and industry guidelines that outline the timing, objectives, activities required, specific goals and performance criteria to determine when the objectives have been achieved.

b. All non-essential above ground infrastructure established for the purpose of appraisal will be either decommissioned, safely removed or appropriately disposed of at a licenced facility. Where infrastructure is to remain above ground within the dedicated lease, it will be fenced to prevent stock access and managed in accordance with the Pastoral Access Agreement.

c. Opportunities for progressive rehabilitation will be maximised and will be undertaken throughout the life of appraisal activities.

d. The final landform is stable and an acceptable final land-use for the disturbance area is achieved — the Project area will be rehabilitated to a stable, self-sustaining landform with a post-closure land-use comparable to the land-use prior to disturbance; unless an alternate suitable and agreed land-use is identified.

e. The potential for adverse environmental impact is minimised — including but not limited to run-off into local waterways, air quality from dust, soil contamination from hydrocarbons or other chemicals, and minimising further disturbance during rehabilitation activities. Specific objectives, indicators and appropriate closure criteria will be developed during detailed closure planning, that will include where relevant consultation with appropriate stakeholders, including the relevant regulatory agency and landowners.

2. Pre-Appraisal Land Suitability

The land suitability assessment undertaken as part of the initial assessment of the site and access routes, showed that the area has predominantly been used for grazing of beef cattle. The land suitability assessment identified that the Civil Operations belong to one of three Land Systems (Forrest, Brolga or Banjo land system), which have good to moderate quality grazing value.

The Forrest land system (Drill Pad 2, 3D Seismic Survey) consists of gently sloping sandy surfaced plains with few indistinct drainage depressions on sandy red earth soils. Vegetation is dominated by eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential.

The Brolga land system (Drill Pad 1, 3D Seismic Survey) consists of almost level plains with few infilled sink holes with sandy and earth soils. Vegetation is dominated by eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential.

The Banjo land system (3D Seismic Survey) consists of almost level to gently undulating plains on the plateau surface that lack drainage lines. Consisting of variable depth red earth soils with or without gravel; mixed eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Banjo land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening.

3. Conceptual Post-Appraisal Landform

Rehabilitation will generally be designed to achieve a stable final landform compatible with the surrounding environment. Should any slopes exceed 1% cross-fall, additional drainage and re-vegetation works may need to be implemented to achieve sediment and erosion control and groundcover establishment. Re-contouring the drill site area will be undertaken (if necessary) so that it is commensurate with the surrounding natural landforms wherever possible.

It is currently proposed that the final land use for the rehabilitated areas is returned to the pre-disturbance land suitability class, and that maintenance requirements are no greater than that required prior to disturbance.

4. Rehabilitation Procedure

Pangaea's Rehabilitation Procedure *"established minimum standards that are mandatory for rehabilitating disturbed land following operational activities."* The procedure applies to partial rehabilitation for stabilising operating project sites and final closure rehabilitation to stabilise the land following the decommissioning of infrastructure.

The intent of the procedure is to *'facilitate the return of the land to a stable state, where either the former land use or another specified state agreed by the Government and pastoralist, can be resumed."* Rehabilitation objectives include ensuring that the site is safe to humans and wildlife, non-polluting, stable and able to sustain an agreed land use.

5. Rehabilitation Monitoring

Monitoring will be conducted on areas of disturbed land following 2016 NT Appraisal Campaign activities. This procedure establishes an approach for evaluating the successful implementation of rehabilitation activities by monitoring.

Pangaea aims to *"minimise the disturbance to vegetation, land and animals, including native flora and fauna, and pastoral infrastructure and livestock. Any disturbed vegetation or land shall be rehabilitated as soon as practicable to ensure the identified land use can occur."*

Potential monitoring locations chosen in consultation with pastoralists will be the drill pads, specific locations along the access routes and specific seismic line locations. Monitoring will be conducted by suitably skilled and qualified persons and annual reviews of monitoring data will be conducted. Monitoring outcomes will determine whether rehabilitation is underperforming and additional maintenance is required. The following key aspects would be evaluated during monitoring:

a. Soil erosion (and potential exposure of waste materials);

b. Revegetation success;

c. Weed infestation; and

d. Integrity of diversion drains, waterways and erosion and sediment control structures.

Rehabilitation methods will be improved over time as additional knowledge is gained from the monitoring programs and research conducted into the different rehabilitation techniques.

6. Rehabilitation Approaches – Specific Landscape Aspects

Roads & Tracks

Roadways and/or tracks may be required to remain to provide on-going access to monitor rehabilitation. Alternatively, roads and/or tracks may remain on-site if agreed in writing by the pastoralist and/or the relevant government department.

Access roads and tracks that are not required by pastoralists and are not on existing fence lines or public roads will be scalped to approximately 0.3 m below the surface to remove stabilised and compacted material (if relevant). The inert waste will be recycled or disposed of in a suitable location (i.e. a quarry or an approved landfill off-site as appropriate).

Any contaminated or unsuitable material (e.g. gravel) will be removed from the roads and hardstand surfaces and disposed of at an approved location. Minor reshaping work will be undertaken to ensure surface level consistency with the surrounding areas. Any creek crossings will be removed and the pre-existing drainage line re-instated by revegetation and rehabilitation.

Drill Pads

Where possible, topsoil inclusive of vegetative material (removed during site preparation) would be re-spread directly onto the drill pad. Where topsoil resources allow, topsoil would be spread to a nominal minimum depth range of 0.1 to 0.3 m on all areas to be rehabilitated. Top-soiled areas will also be contour-ripped (after topsoil spreading) to create a 'key' between the topsoil and the subsoil. Ripping would ideally be undertaken on the contour and the tynes lifted for approximately 2m every 200 m to reduce the potential for channelised erosion on slopes greater than 10 degrees. Ripping will be undertaken where practical, when soil is dry to achieve best results in fracturing the compacted soils.

Special Treatment Areas

Additional erosion control measures will be considered where necessary, particularly in drainage lines and section of access track that are longer grade slopes. Erosion control measures may include installation of 'Whoa-boys' at regular intervals along the slope and diversion drains to direct water off the access track to prevent rilling from overland flow.

Weed Management

The presence of weed species has a potential major impact on re-vegetation and regeneration outcomes. In addition to this, the presence of weed species within the surrounding land has the potential to significantly impact on the biodiversity value of the rehabilitated area & weed management will be a critical component of the rehabilitation activities. Weeds will be managed across the Campaign area through a series of control measures, including (but not limited to):

- Designated light vehicle roads and track delineated around the site and adequate weed hygiene practices for vehicles operating within rehabilitation areas,
- Herbicide spraying or scalping weeds off topsoil stockpiles prior to re-spreading,
- Undertaking species-specific management for identified key weed species at risk of spread through campaign activities.

If weed control measures are required, they would be undertaken in a manner that minimises soil disturbance. Any use of herbicides would be carried out in accordance with appropriate requirements to minimise the risk of impact on downstream water quality and with approval from the pastoralist to ensure no agricultural organic or export produce certifications are breached.

Records would be maintained of weed infestations, and control programs would be implemented according to accepted management practice for the weed species concerned. All weed management personnel would be trained in the use of herbicides. Herbicides listed under international conventions, such as the World Health Organisation and the Stockholm Convention, would only be used according to the requirements of those conventions.

7. Rehabilitation Completion Criteria

Preliminary success criteria (or completion criteria) for the rehabilitation of the NT 2016 Appraisal Campaign sites and associated infrastructure are performance objectives or standards against which rehabilitation success in achieving a sustainable system for the proposed post-facility life land-use is demonstrated.

Satisfaction and maintenance of the success criteria (as indicated by monitoring results) will demonstrate that the rehabilitated landscape is ready to be relinquished from Pangaea's financial assurance and handed back to stakeholders in a productive and sustainable condition.

The further development of each criterion will be based on results of research, monitoring of progressive rehabilitation areas and risk assessments. Rehabilitation shall be considered successful when the following conditions have been met:

1. The site(s) can be managed for its (their) designated land-use (e.g. consistent with surrounding undisturbed land),
2. Evidence that the agreed rehabilitation criteria have been met,
3. No greater management input is required for site than that of surrounding areas consistent with designated land use; and
4. Written agreement has been attained by the pastoralist and the administering authority.

8. Rehabilitation Maintenance

In the context of this strategy, ‘maintenance’ constitutes any additional erosion & sediment control, re-application of seed to promote ground-cover or further management of weeds is required. However, this management frequency would vary depending on the extent of rehabilitation success and necessary method for mitigating failing rehabilitation.

Appendix C: Erosion & Sediment Control Plan

This Erosion and Sediment Control Plan (ESCP) has been prepared for the land forms present at each of the drill pads.

Mitigation measures will be implemented prior to the start of operations but post vegetation clearing. Installation of controls to minimise erosion, and prevent sediment laden drainage water leaving the drill site before vegetation is not practical or possible given the heavy vegetation cover on the site. Controls will be installed on the same day that clearing operations are completed.

The following sub-headings have been applied considering the *Erosion & Sediment Control Plan Content Factsheet* – developed by NT Department of Natural Resources - Vegetation & Land Management, Natural Resource Management Division 2006.

1. Site Layout Details

Timing of construction	Civil Operations will commence in February 2016 or as early as weather and site conditions permit.
Locality plan	Figure 1 identifies the development site and external catchment area.
Plan scale	Figure 2.
Plans showing the existing topography	Figure 2.
Staging of works	Site clearing and topsoil stripping will occur on consecutive days in February 2016 or as early as weather and site conditions permit.
Locations of all site access points, parking areas, site facilities and on-site roadways/ tracks.	Figures 3 & 4.
Location of site storage and stockpile areas	Figure 2.
Property boundaries & contour levels	Figure 2.
Erosion risk mapping	Each of the land systems identified are gently sloping sandy surfaced plains with few indistinct drainage depressions on sandy red earth soils. Vegetation is dominated by eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential.
Location, type and timing of all drainage, erosion and sediment control measures	Figure 2. All measures are to be removed at the rehabilitation stage.
Maintenance access ramps to major sediment control structures	Not applicable.
Location of disposal sites for trapped sediment	Not applicable. All trapped sediment will be tested for contamination and if uncontaminated, buried when the catch dam is decommissioned – post rehabilitation.
Proposed grades and batter slopes	Figure 2.
Location of erosion control/drainage structures	Figure 2.
Recognised topographic site limitations	None

2. Vegetation Layout Details

General location, nature and condition of existing vegetation	Figure 2.
Location plan of protected trees and bushland	Figure 2.
Natural vegetation to be retained	Figure 2.
Non-disturbance areas and buffer zones	Figure 2.
Revegetation landscape plan	Not applicable.
Limits of clearing.	Figure 2.

3. Soil Properties

Location and limitations of major soil types	Soil types across the sites are generally of variable depth sandy red earth soils with moderate to high erosion hazard.
Identification of all known dispersive soils – including sub-soils	None observed, known or expected at any site.
Drainage depressions – problem soils	Not applicable.
Identification of any Potential Acid Sulphate Soils	None observed, known or expected at any site.

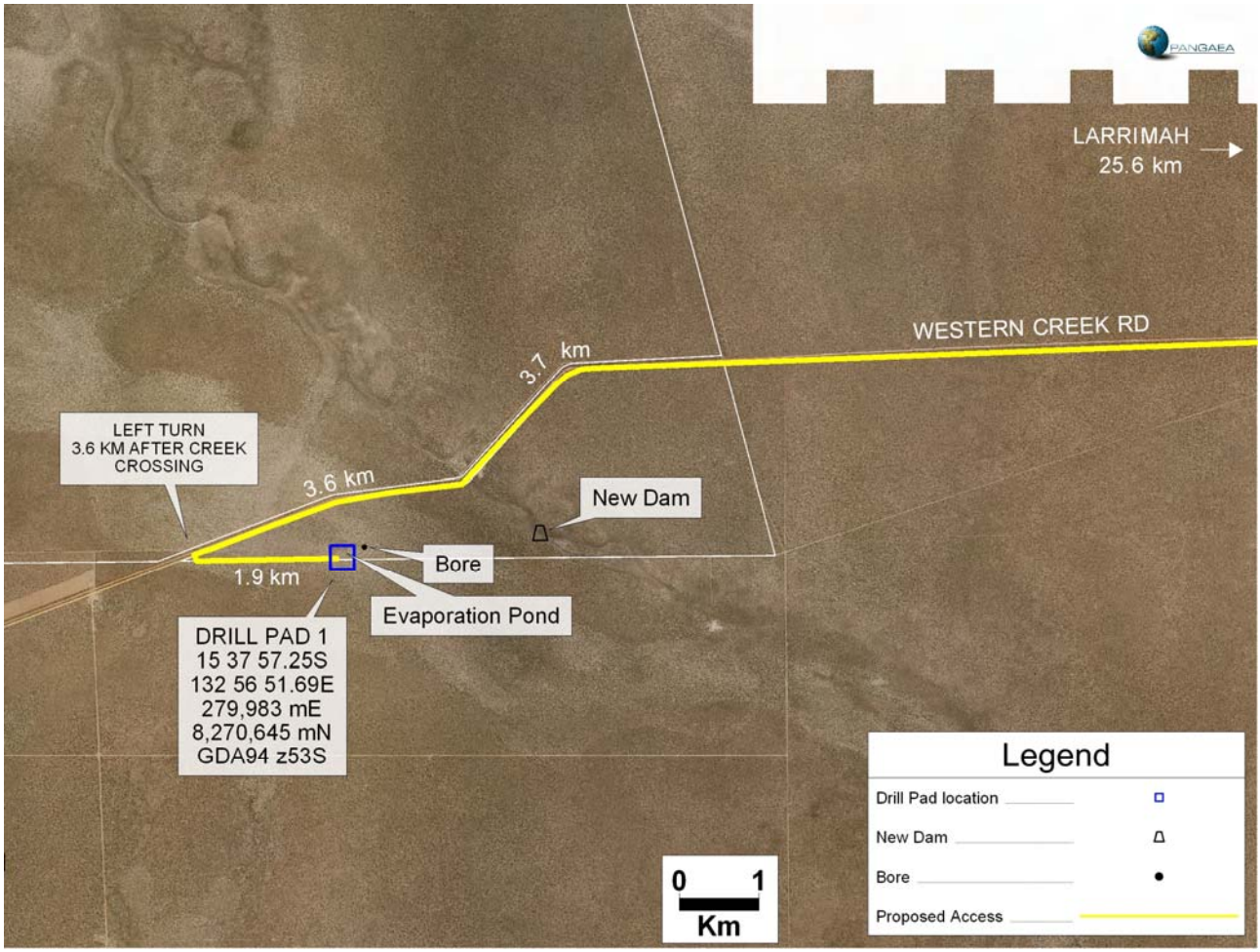


Figure 1: Locality Plan – Drill Pad 1

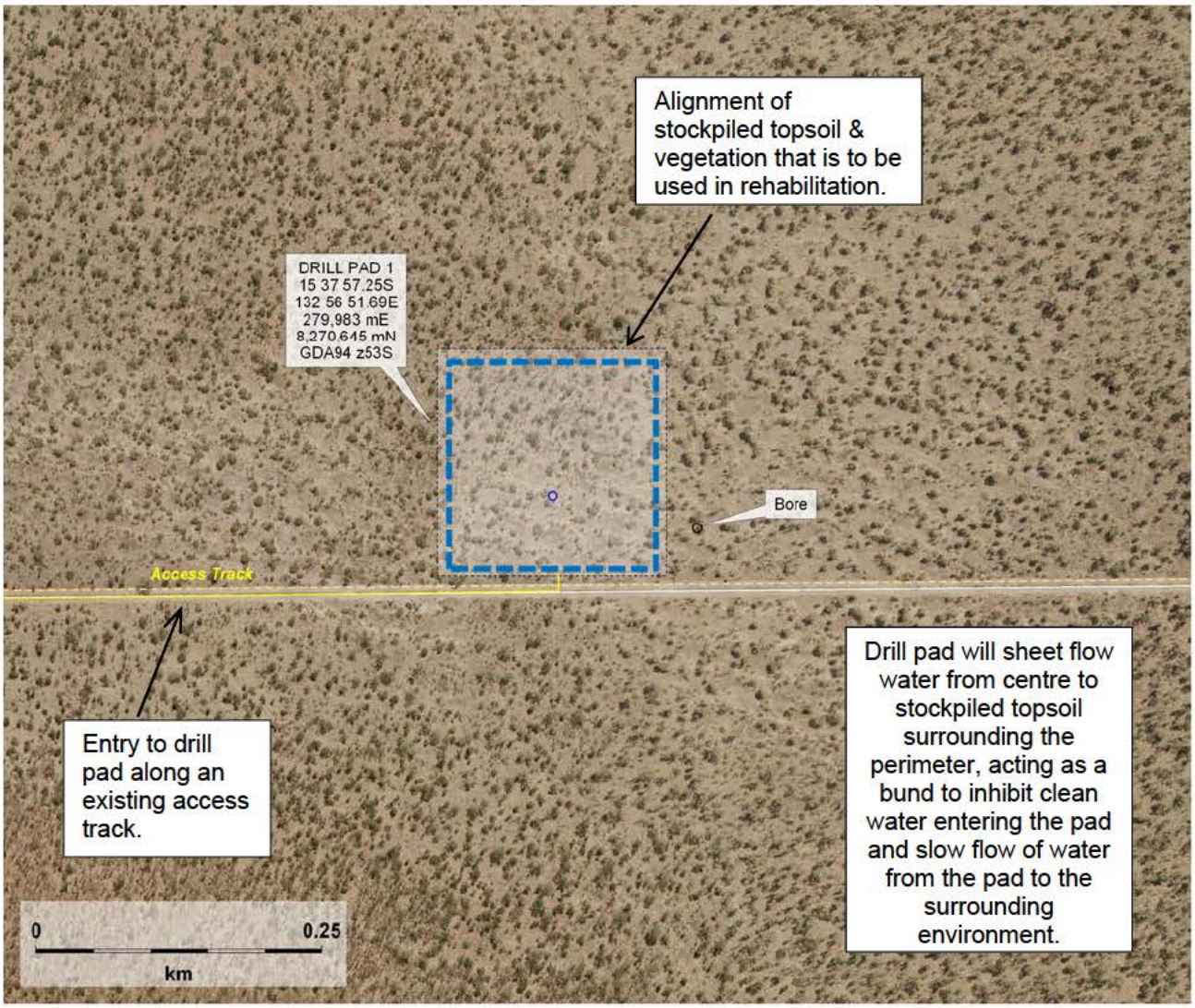


Figure 2: Erosion & Sediment Control Plan – Drill Pad 1

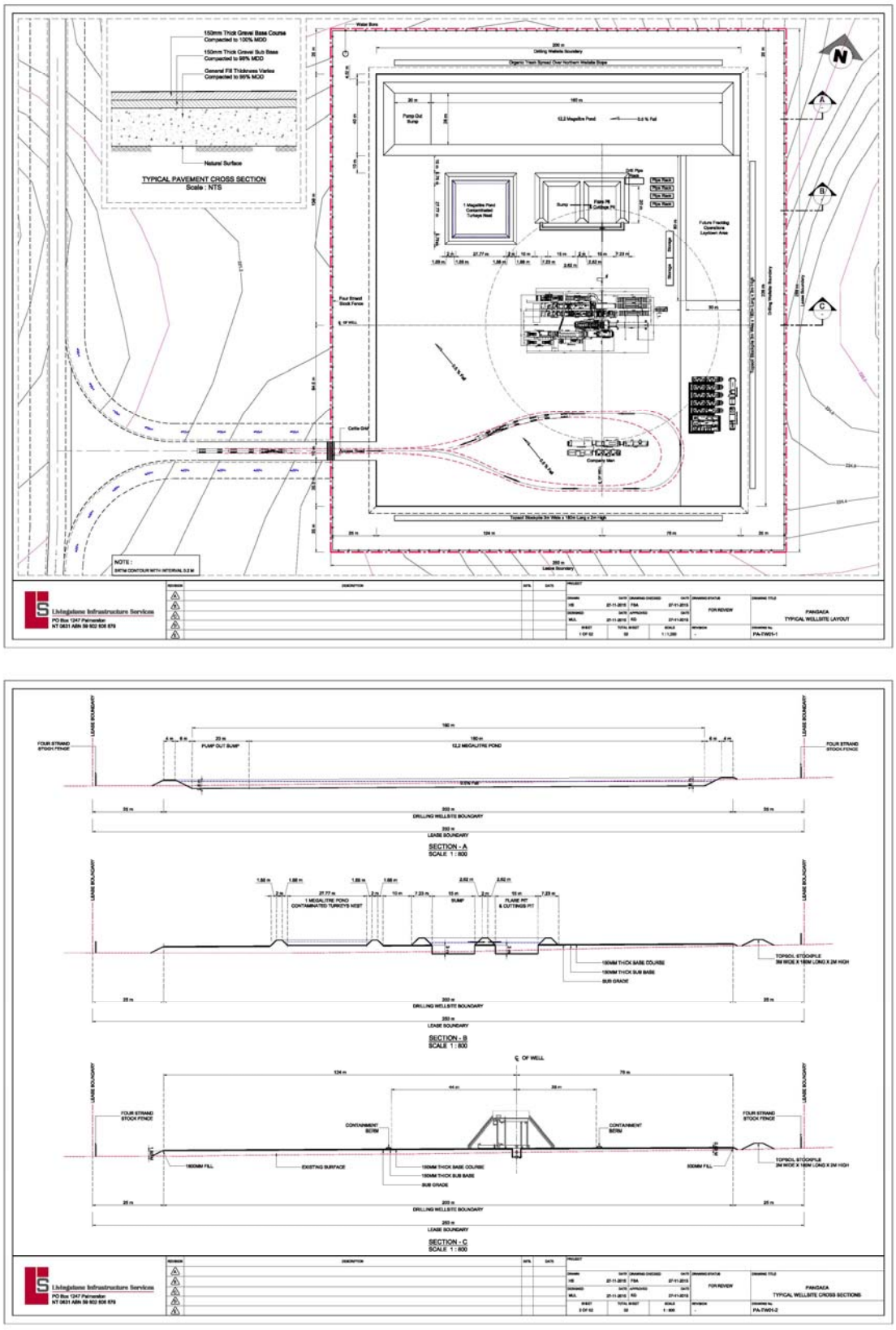


Figure 3: Site Layout – Drill Pad 1

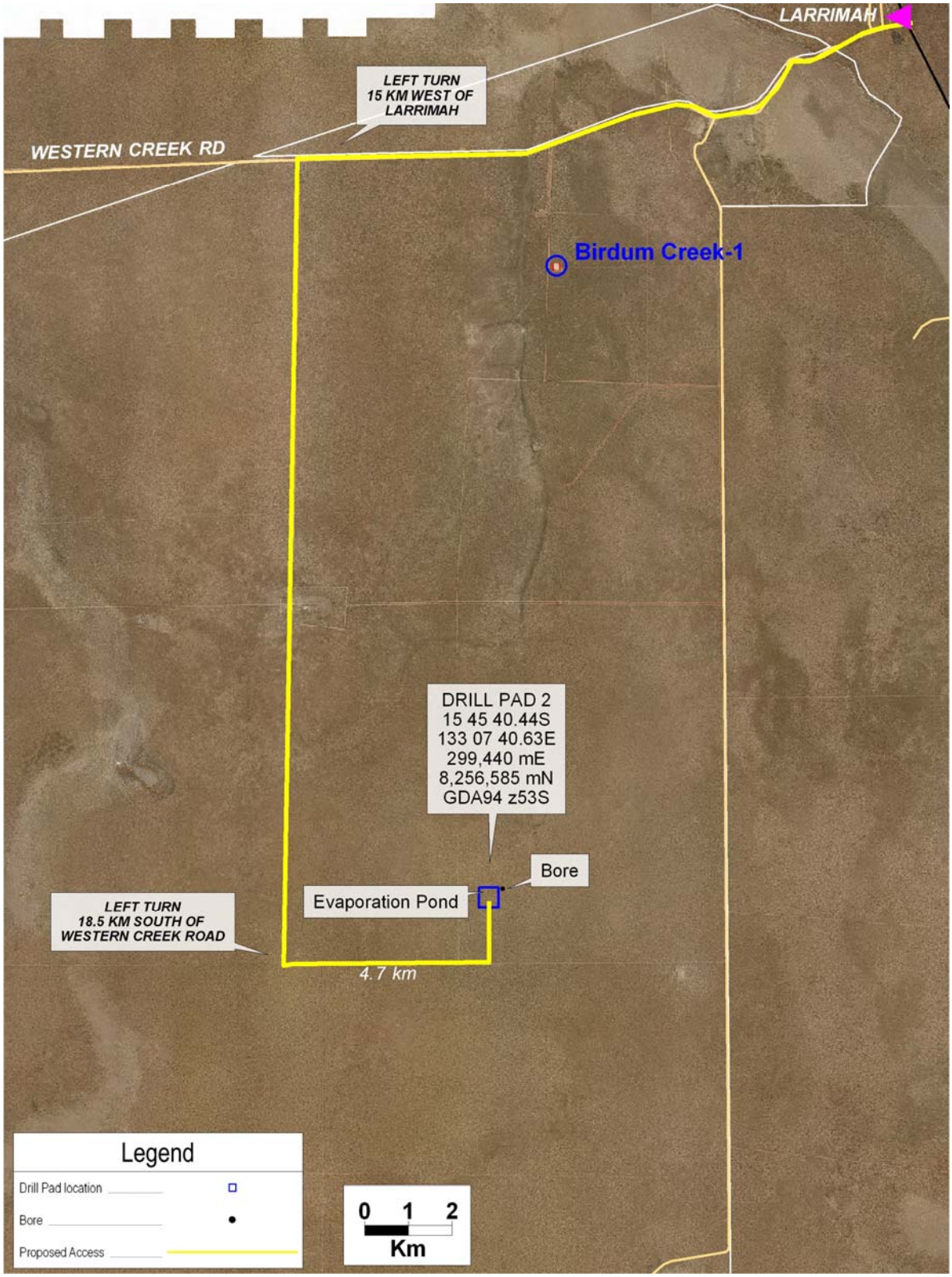


Figure 1: Locality Plan – Drill Pad 2

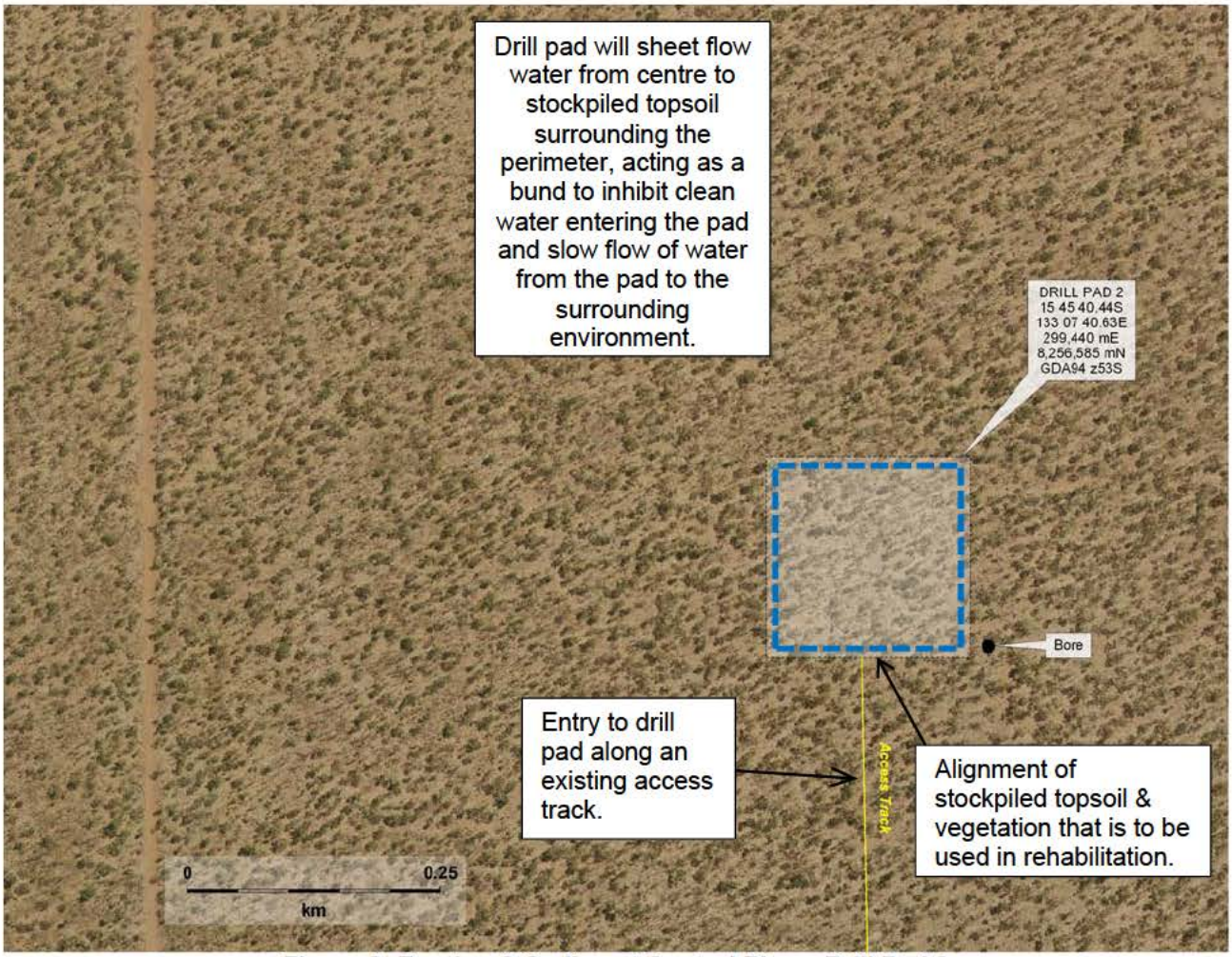


Figure 2: Erosion & Sediment Control Plan – Drill Pad 2

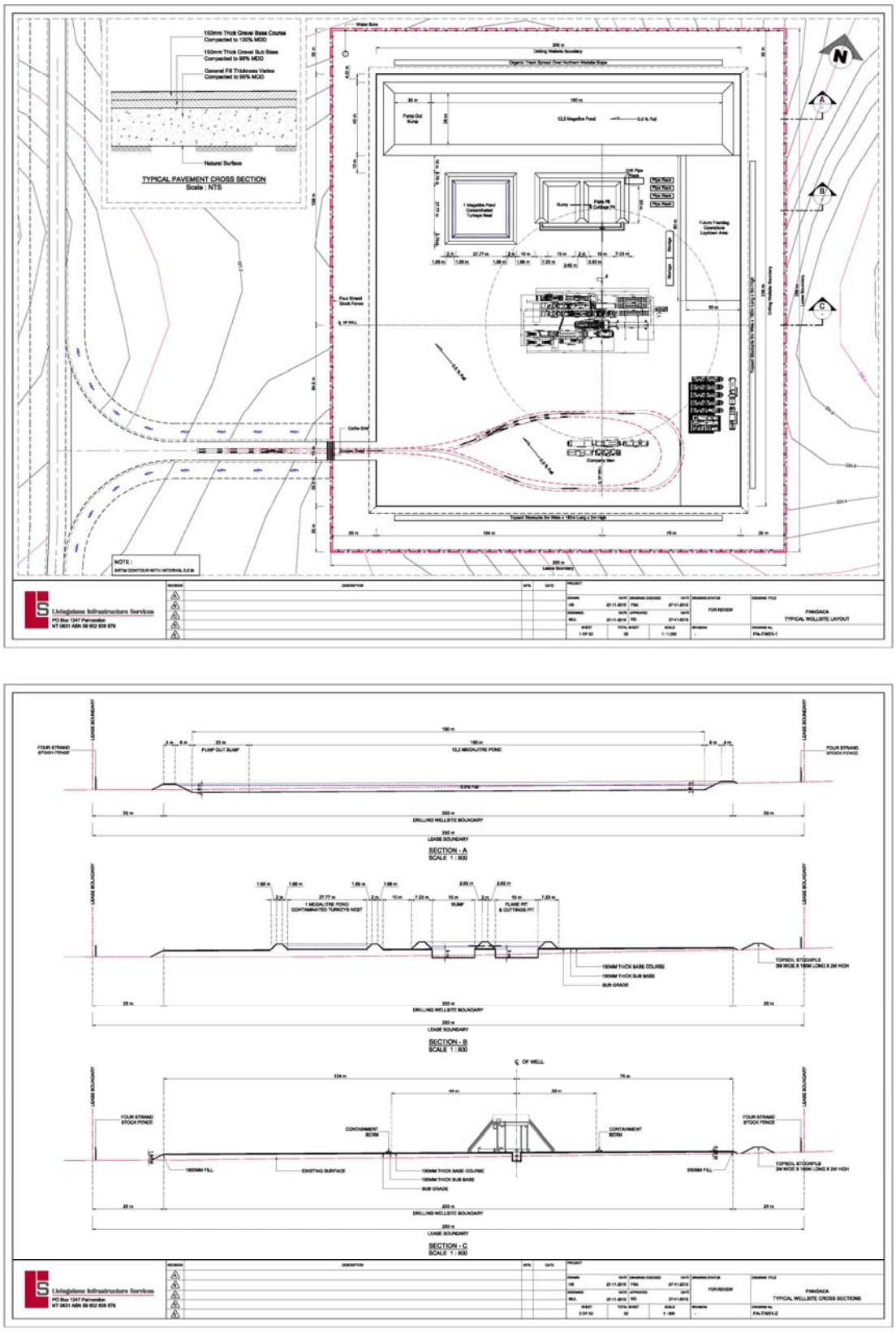


Figure 3: Site Layout – Drill Pad 2

Appendix D: Monthly Environmental Inspection Checklist

Site/Project Name:		**Contract/Job No:**	
Inspected by:		**Date:**	
Designation:		**Time:**	

Weather conditions (tick appropriate boxes):

Fine		Overcast		Light rain		Heavy rain (>15mm)		Light wind		Strong wind (>30km/hr)		Total Fire Ban	

General	Y	N	N/A	Comments & Actions
Site is in a generally tidy condition				
All equipment, materials, etc. contained within work area boundary				
Is site free from obvious signs of construction-related disturbance outside of construction area(s)?				

Soil & Erosion Control	Y	N	N/A	Comments & Actions
Required erosion control measures have been correctly installed and are functional				
Where required, drainage outlets provided with energy dissipaters to minimise erosion				
Works are being scheduled to minimise areas exposed at any one time and plant selected to minimise disturbance				
Areas where activities have ceased are stabilised and are being rehabilitated				
There is minimal dirt on adjacent sealed public roads and dirt is prevented from being tracked onto sealed public roads				
Diversion banks and drains are located appropriately (to reduce run-on)				

Water Quality	Y	N	N/A	Comments & Actions
Water quality in down slope areas appears to be unaffected by works				
Is site free of apparent illegal discharges				
All hazardous materials (e.g. fuels, chemicals, etc) are stored undercover in an impervious bund				
Spill kit is readily accessible				
On-site refuelling of construction plant/vehicles restricted to designated area more than 20m away from waterways				
Is site free from obvious signs of fuel spills, oil leakage, etc from construction plant?				

Noise and Vibration	Y	N	N/A	Comments & Actions
Plant not in use switched off				
There are appropriate noise and vibration controls to activities adjacent to residents and other sensitive receivers				

Air Quality	Y	N	N/A	Comments & Actions
Is site free from obvious signs of dust deposition outside of construction area(s)?				
Haul roads are being kept damp (if required)				
There is spraying for dust control				
Vehicles and machinery do not have visible exhaust for more than 10 seconds				
Burning off is not occurring on site				

Waste Management & Minimisation	Y	N	N/A	Comments & Actions
Waste receptacles accessible, lidded and clearly marked with regard to waste type				
All recyclable material separated as per waste management plan				
Contaminated land is fenced off				

Vegetation	Y	N	N/A	Comments & Actions
All required vegetation protection measures in place and functional				
Are all protected areas clear of obvious signs of construction activity				
Disturbed areas are stabilised and revegetated				

Archaeology/Heritage	Y	N	N/A	Comments & Actions
All required protection measures in place and functional				
Construction materials are not being stored inside heritage protection zones				

Traffic Management	Y	N	N/A	Comments & Actions
All required traffic control measures implemented in accordance with TMP (e.g. warning signs, temporary road closures, limited to use of roads)				
All plant parked on site				
Private vehicles of construction personnel not obstructing passage of local traffic				

Other	Y	N	N/A	Comments & Actions
Access to properties along roads not obstructed				

Other Comments?

EMR: .....

Date: .....

Reviewed by: ..... Project Manager/Site Supervisor: .....

Appendix E: Monthly HSE Report

HSE KEY PERFORMANCE INDICATORS - PANGAEA (NT) 2016

Month: [Insert month] 2016	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
EXPOSURE																																
Personnel on site for this day																																0
Personnel total hours for this day																																**0**
Contractors on site for this month:																																0
Pason																																0
Electrical																																0
I.T																																0
RISK MANAGEMENT																																
Take 5's																																0
Hazob's																																0
JSEA's																																0
Risk Assessments																																0
Work Permits																																0
SWP / Procedures Reviewed																																0
COMMUNICATION																																
Pre Shift Meetings																																0
Toolbox Meetings																																0
Client Meetings Attended																																0
EMERGENCY READYNESS																																
Emergency Drill																																0
Client Drills																																0
INSPECTIONS/AUDITS																																
Pre Spud																																0
Surface Rig Workplace Inspection																																0
Client HSE																																0
Other - Add Comment																																0
INDUCTIONS																																
Employees Rig/Site Induction																																0
Client Visitor Induction																																0
RIG/CAMP/LINE MOVES																																
Infield																																0
Non-Infield																																0
INCIDENT SUMMARY																																
Non-Injury Incidents																																0
Equipment Damage																																0
Near Miss																																0
Environmental																																0
Personal Injury																																0
First Aid Case																																0
Medical Treatment Case																																0
Restricted Work Case																																0
Lost Time Case																																0
Fatality																																0
WASTE MANAGEMENT																																
General Waste (skip loads)																																0
Waste Oils (litres)																																0
Septic waste (litres)																																0
Contaminated Waste (kilograms)																																0

Appendix F: Waste Management Plan

1. Introduction

1.1 Purpose

Throughout the activities proposed during the Civil Operations for the 2016 Appraisal Campaign (including site preparation, drilling, stimulation and testing, seismic acquisition, and rehabilitation) a variety of waste types and waste products will be generated. This Waste Management Plan has been developed in strict adherence to the provisions and schedules in the NT Waste Management and Pollution Control Act and Regulations. Northern Territory Department of Health Requirements for Mining & Construction Projects are also adhered to.

Waste management options identified within this plan will be employed to reduce or avoid impacts due to inappropriate handling of waste. The options examine alternatives that relate to waste minimisation, re-use and recycling of materials instead of disposal. It is intended that the waste products do not adversely impact the environment, human health or the amenity of the area. The purpose of this waste management plan is to:

1. Identify, describe and quantify the various waste products and streams to be generated during the 2016 Appraisal Campaign.
2. Assess the potential impacts to the surrounding environment.
3. Identify options for waste minimisation and management, with specific reference to the waste hierarchy.
4. Develop mitigation measures to minimise any waste impact.

2. General Waste generation

There are a variety of sources of general waste associated with the proposed Civil Operations, however a number of general wastes have been identified which are likely to be generated from site. These include:

- Aerosol cans
- Atmospheric emissions
- Food waste
- General domestic waste and recyclables
- General inert construction waste
- Grey-water
- Medical and first-aid station waste
- Office wastes (paper, cardboard, plastics and wood products from packaging)
- Scrap metals (ferrous and non-ferrous)
- Solvents and chemicals
- Surplus concrete
- Used welding rods
- Vegetation cleared during site preparation works
- Waste adhesives
- Waste antifreeze/radiator coolant
- Waste paints and solvent

2.1 General waste removal

Waste generated that cannot be recycled will be collected in mobile garbage bins and suitably-sized roll-on-roll-off bins with proper waste identification and labels in a designated waste segregation area. These wastes will be removed from the operation and camp sites on a weekly or 'as needed' basis by MS Contracting, and disposed of at an NT EPA licenced municipal pit (either Katherine or Mataranka).

2.2 Wastewater

Wastewater from the site preparation stage may include vehicle and equipment washdown water, stormwater and sewage treatment plant grey-water. Where appropriate, it is intended that stormwater will be transferred to sedimentation pond(s) for reuse on site for dust suppression and irrigation, in accordance with regulatory requirements.

A transportable and fully self-contained sewage treatment plant will support the Civil Operations team. An Enviro-Flow unit (or similar) will provide a final water quality suitable for surface irrigation via a sprinkler attachment. The final system will (as a minimum) be selected based upon 300L / person / day. Sludge/solid material will be reduced by anaerobic decomposition and removed from site (via tanker to a licensed facility).

3. Listed Waste generation

There are a variety of sources of listed waste associated with the proposed Civil Operations, however a number of listed wastes have been identified which are likely to be generated from site. These include:

- Batteries
- Oils and oily wastes from equipment and machinery maintenance and refuelling activities
- Tyres

3.1 Listed Waste Removal

Waste oil, oily rags and oil filters; batteries and tyres will be stored in clearly labelled, bunded areas and transported off-site for recycling by Veolia before being taken to an NT EPA licenced facility for disposal.

4. Potential impacts

The potential impacts associated with non-compliance in waste management could include:

- Land and water contamination from inappropriate storage, handling and disposal of solid and liquid wastes.
- Land and water contamination from spills and releases during handling and transportation.
- Increased populations of vermin from inappropriate storage and handling of waste.
- Odours due to inappropriate storage and handling of waste.
- Water contamination from discharges of contaminated stormwater or sewage treatment effluent.
- Inefficient use of resources.
- Adverse effects to aquatic and terrestrial flora and fauna.

Given Pangaea's track record in effective waste management and proven control measures, construction, operational and decommissioning wastes are considered to present a low risk to the environment and/or public health.

5. Waste Management Plan

The main purpose of waste management is to minimise impacts to the environmental values as outlined in Section 9 of the EMP. Several strategies will be used, principally the implementation of the waste management hierarchy and cleaner production principles. The waste management actions proposed for the Civil Operations are detailed in **Table 1**.

5.1 Objectives and performance indicators

The objectives of this plan are to:
- Minimise contamination of the site.
- Appropriately manage waste generated on-site.
- Avoid wastes entering the site.
- Minimise waste generated from the site.
- Maximise waste recycling and reuse.

The performance indicators for this plan are:
- Zero contaminants or wastes are discharged to land or water on-site.
- Zero unauthorised discharges of contaminants or waste to land or water off-site.
- Minimise the quantity of wastes disposed to a landfill.
- Dispose of all waste appropriately.
- Zero complaints relating to waste management.

5.2 Responsibilities

The persons responsible for compliance with this plan during the Civil Operations and their responsibilities are summarised below.

Throughout the Civil Operations construction phase, the Principal Contractor (MS Contracting) and Service Providers will be the Responsible Persons and will undertake the following:

- Ensure that the requirements of this plan are satisfied.
- Ensure that contractors and any sub-contractors engaged are advised of their responsibilities to undertake their activities required by this plan.
- Ensure that contractors and any sub-contractors engaged are advised of their responsibilities regarding waste management.
- Ensure that the auditing/monitoring program is implemented properly.
- Prepare incident reports and implement corrective actions.
- Ensure appropriate records are kept and maintained on-site.
- Retain a copy of this plan on-site for reference by appropriate personnel and provide a copy of this plan to contractors.
- Recommend additions or changes to this plan based upon experience gained from implementation of the plan.

5.3 General Waste tracking

General waste reporting will be generated via the General Waste Register (**Attachment 1**). The General Waste Register will be maintained by Services Providers and a copy is to be kept onsite by the Pangaea Representative until the project is completed.

The General Waste Register will record the type, amount and location of waste reused, recycled, stockpiled and disposed of plus other data including:

a) Type of waste and its classification (according to the Waste Management and Pollution Control Act);
b) Tonnes of waste;
c) How and where the waste was reused, recycled, stockpiled or disposed of;
d) Date when the waste was reused, recycled, stockpiled or disposed of; and
e) Name of the transporter used.

5.3 Listed Waste tracking

Listed waste reporting will be generated via the Veolia Waste Manifest Form (**Attachment 2**). The Veolia Waste Manifest Form will be maintained by Services Providers and a copy is to be kept onsite by the Pangaea Representative until the project is completed.

The Veolia Waste Manifest Form will record the type, amount and location of waste reused, recycled, stockpiled and disposed of plus other data including:

a) Type of waste and its classification (according to the Waste Management and Pollution Control Act);
b) Tonnes of waste;
c) How and where the waste was reused, recycled, stockpiled or disposed of;
d) Date when the waste was reused, recycled, stockpiled or disposed of; and

5.4 Waste auditing & monitoring

Waste types and quantities will be monitored via the monthly audit conducted by the EMR during the Civil Operations. The purpose of auditing the waste management activities onsite includes:

- Ensure and monitor compliance with approval conditions.
- Assessment of the actual wastes compared to predicted waste types and quantities.
- Monitor potential impacts from wastes.
- Review the waste transportation records.
- Recommend future actions to improve waste management practices.
- Monitor the implementation of the principles of waste management hierarchy.

6. Summary of waste descriptions and management

A summary of waste descriptions and management is provided in Table 1. Veolia is the licensed contractor commissioned according to Part 2, Schedule 2 of the NT Waste Management and Pollution Control Act relevant to the Listed Waste Management Procedures. MS Contracting is the contractor commissioned according to Part 2, Schedule 2 of the NT Waste Management and Pollution Control Act relevant to the General Waste Management Procedures.

Table 1: Summary of wastes and management

Civil Operations Phase

Waste	Characteristic	Management Actions	Responsibility
Batteries	Listed waste	• Store batteries in a bunded area sized to 110% of the capacity. • Veolia will regularly remove and dispose or recycle depending on the quality of the waste.	Mark Sullivan Contracting / Veolia
General waste / Recyclable waste (garbage)	General waste	• Designate an area within the camp site for waste storage. • Areas such as offices, lunch rooms, work-shops, etc. will be serviced with mobile garbage bins. • Several bins will be required for general waste as well as additional bins for co-mingled recycling, such as glass bottles and jars, metal tins and cans, paper and cardboard and plastic bottles. • MS Contracting will supply bins, transport waste, recycle recyclable waste and dispose of non-recyclable waste at the Katherine landfill.	Mark Sullivan Contracting
Grey water and sewage	General waste	• Conduct regular inspections of the portable amenities and grey-water lines to ensure quality objectives are being met.	Mark Sullivan Contracting
Oil, oily rags and oil filters (maintenance)	Listed waste	• Utilise mobile bins for the segregation and storage of oily rags, cleaning rags and cloths, and oil filters. • Veolia will regularly remove and dispose or recycle depending on the quality of the waste.	Mark Sullivan Contracting / Veolia
Overburden, excess on-site material	General waste	• Undertake all stockpiling efficiently and with proper erosion control. • Ensure appropriate sediment and erosion control measures are in place. • All site run-off will be captured in sedimentation ponds for treatment as necessary prior to any release to the environment.	Mark Sullivan Contracting

Waste	Characteristic	Management Actions	Responsibility
Sewage treatment plant solid waste	General waste	• The sewage treatment plant will include contained storage for sewage treatment plant solids and waste. • A regulated waste licenced contractor will transport waste from the site for disposal if required.	Mark Sullivan Contracting
Trees, brush vegetation	Organic material	• Felled trees and branches retained on site where practicable, for erosion control and rehabilitation.	Mark Sullivan Contracting
Tyres	Listed waste	• Designate an area for the storage of tyres. • Veolia will regularly remove and dispose or recycle depending on the quality of the waste.	Mark Sullivan Contracting / Veolia

Attachment 1: General Waste Register

Destination of Excess Materials: ☐ Residential ☐ Commercial ☐ Industrial

Materials on-site		Destination		
		Re-Use & Recycling		Disposal
Type of Material	Estimated or Recorded Volume (m^3) or Area (m^2)	On-Site Specify the proposed reuse or onsite recycling methods	Off-Site Specify the contractor and recycling outlet	Specify contractor and landfill site
General Waste				MS Contracting moves waste to Mataranka or Katherine municipal landfill.
Grey Water & Sewage		Sewage Treatment Plant processed onsite and sprayed.		
Sewage Treatment Plant Solid Waste		Sludge/solid material will be reduced by anaerobic decomposition and removed from site (via tanker to a licensed facility).		

Personnel name: .....

Date: .....

Reviewed by: ..... Project Manager/Site Supervisor: .....

Attachment 2: Veolia Waste Manifest Form

Waste Manifest Form								Return Email - customer.servicent@veolia.com.au				
Company Name			EPA Licence No.				Account Number					
Contact			DATE				Phone No					
Site address for collection							Fax No					
Postal Address							E-mail Address					
	These cells must be completed.							Veolia Environmental Services Office Use Only				
Brand Name	Chemical name. No Abbreviations. (Main Active Ingredient and percentage)	Number of Containers	Container size	Total Volume or Weight	(L = Liquid) (S = Solid) (P = Sludge)	DG Class	UN Number	VES Code	Not acceptable at the VES Treatment Plant (Use X)	MSDS or Equivalent Required (Use X)	Comments	Total Price/s Exc. GST

Appendix G: Incident Investigation Procedure

PANGAEA

Incident Report Form

INCIDENT DETAILS			
Company:		**Location:**	
Report Number:		**Project Number:**	
Date Report Submitted:		**Person Submitting Report:**	
Work Conducted at Time of Incident:			
Equipment/Machinery Involved:			

INCIDENT CLASSIFICATION
(More than one box may be ticked):

☐ First Aid ☐ LTI ☐ MTI ☐ RWC ☐ Non-Conformance
☐ Fatality ☐ Property Damage ☐ Environment ☐ High Potential ☐ Near Miss

DEFINITIONS: LTI = Lost Time Injury RWC = Restrictive Work Case | MTI = Medical Treatment Injury | FAI = First Aid Injury

Is the Incident Reportable to the Regulator?	Choose an item.
If YES, who reported the incident and by what means?	

INCIDENT SEVERITY / PROBABILITY OF RECURRENCE
(use Pangaea Matrix)

Potential Incident Consequence

☐ Minor ☐ Moderate ☐ Serious ☐ Major ☐ Catastrophic

Actual Incident Consequence

☐ Minor ☐ Moderate ☐ Serious ☐ Major ☐ Catastrophic

If the Actual Incident Consequence is Moderate or higher, OR if the Potential Risk is Serious, Major or Catastrophic, a formal incident investigation is required.

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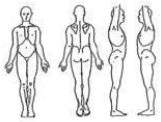
Incident Report Form

BRIEF DESCRIPTION OF INCIDENT	
Potential / Actual Costs:	
☐ Attachments (photos, plans, etc.)	

PERSON(S) INVOLVED IN INCIDENT			
Name:		**Company:**	
Employed Date:		**Time in Current Position:**	
Days into roster **…….……..of……..……..**		**Hours into shift** **……..……..of……..…**	

INCIDENT SUMMARY			
☐ **Injury/Illness**			
Nature of Injury:	Choose an item.	**Nature of Illness:**	Choose an item.
Breakdown Agency:	Choose an item.	**Mechanism of Injury /Illness:**	Choose an item.
Body Location of Injury or Illness: (please circle)	Choose an item. 		
Treatment Provided:			
☐ **Environment**			
Incident Type:	Choose an item.	**Volume of Spill:**	Choose an item.
Type of Spill:	Choose an item.	**Breakdown Agency:**	Choose an item.
☐ **Equipment Damage**			
Equipment Type:		**Equipment Number:**	
Estimated Cost of Damage:	Choose an item.	**Breakdown Agency:**	Choose an item.

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Incident Report Form

WHAT HAPPENED?

Identify the underlying causes that led up to the incident, not just the apparent cause. Systematically evaluate the role of every conceivable causation factor. At the incident scene, look at equipment, materials and the environment. Describe the conditions reviewed here or by checking the contributing factors in the list below.

CONTRIBUTING FACTORS

Equipment Design		Personal Factors		Procedures		Environment	
☐	Not comply with spec	☐	Culpable act	☐	Not available	☐	Visibility
☐	Standard dangerous	☐	Skylarking	☐	Used not sufficient	☐	Wind/rain/dust
☐	Insufficient for task	☐	Lack of supervision	☐	OK but not applied	☐	Uneven/rocky
☐	Poorly maintained	☐	Not trained	☐	JSA not available	☐	Slippery surface
☐	Poorly installed	☐	Training not sufficient	☐	JSA used not sufficient	☐	Restricted area
☐	Uncontrolled Modification	☐	Inexperience	☐	JSA OK not used	☐	Hazardous substance
Safety Equipment		☐	Inattention	☐	Insufficient organisation	☐	Poor house keeping
☐	Missing insufficient	☐	Fatigue/stress	☐	Excessive speed	☐	Extreme temp
☐	Inappropriate	☐	Improper use of equip	☐	Not updated or obsolete	☐	Reptiles/insects
☐	Deliberately bypassed	☐	Drugs or alcohol	☐	Insufficient preparation	☐	Insufficient Logistics
☐	Out of service	☐	Language Barrier	☐	Risk Register not reviewed	☐	Other
☐	Not used						

CONTRIBUTING FACTORS

List the contributing factors identified in the above table:

1.

2.

3.

4.

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Incident Report Form

PREVENTATIVE / CORRECTIVE ACTION		
Preventative/Corrective Action	**Responsible Person**	**Target Completion Date**

SIGN OFF	
Person In Charge / Supervisor Comments: Have the corrective actions been noted in the Action Item Register? Choose an item.	Signature (Must be signed) Date: ...../...../.....
Operations Coordinator Comments:	Signature (Must be signed) Date: ...../...../.....
QHSE Coordinator Comments:	Signature (Must be signed) Date: ...../...../.....
Executive Director Comments:	Signature (Must be signed) Date: ...../...../.....

Appendix H: Consultation Report

PANGAEA

Community Consultation Report

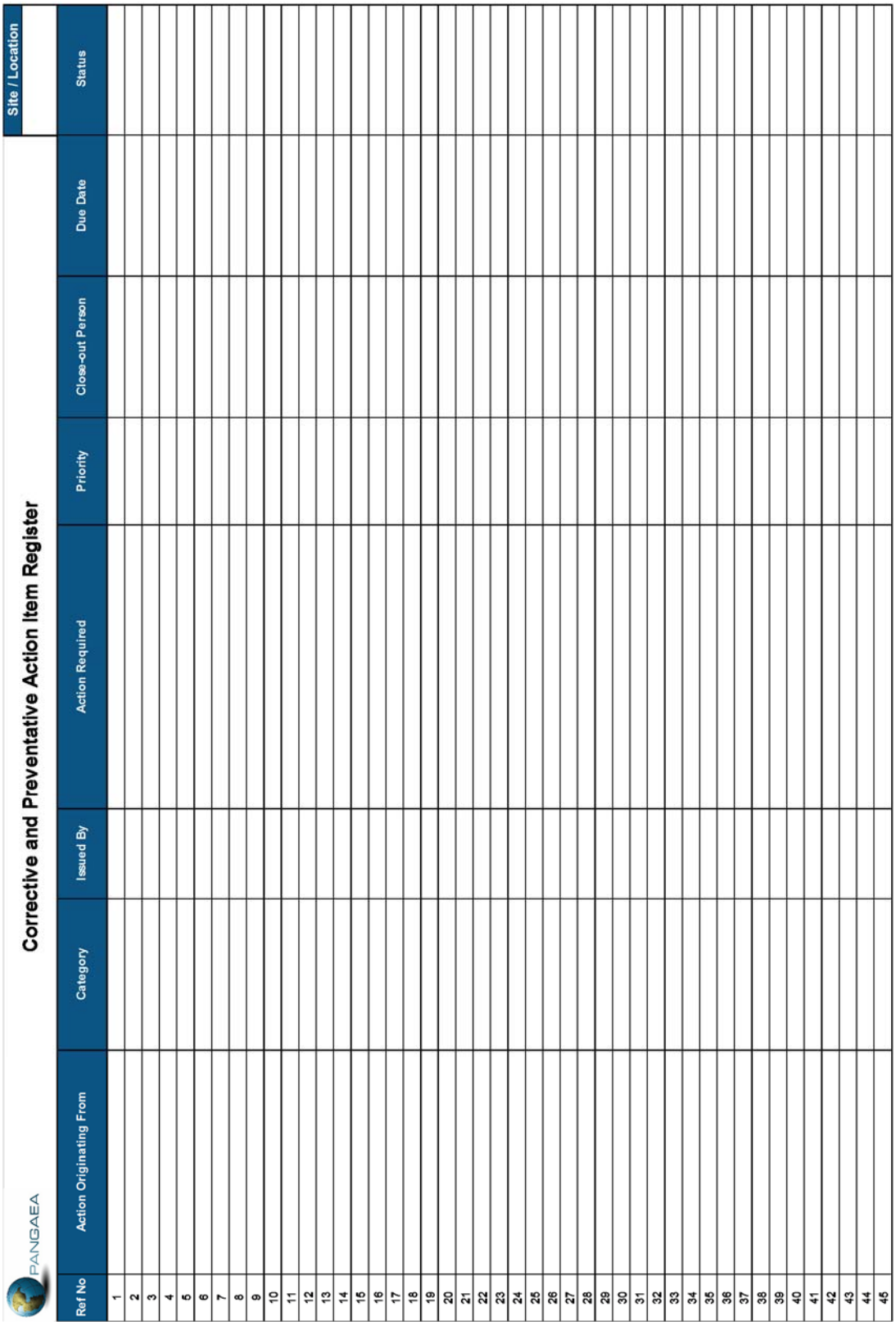
Source:	
Date:	
Location:	
Time:	
Attendees:	

Discussion:

Confidential:

Response / Action Taken:

Appendix I: Corrective and Preventative Action Item Register



Corrective and Preventative Action Item Register

PANGAEA

Site / Location

Ref No	Action Originating From	Category	Issued By	Action Required	Priority	Close-out Person	Due Date	Status
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
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45								

Appendix J: Document and Information Management Standard

Refer to attachment “Appendix J_Document and Information Management Standard.pdf”

Appendix K: Emergency Response Contacts

See NT_EP167-168 Emergency Response Plan as a separate document for complete Emergency Response instructions.

The NT is a unique operating zone with unique government medical structures put in place to deal with medical emergencies. **The major planning factor to be aware of in this region is that these assets are often busy and wait times may be considerable.**

In order to reduce the time from the injury occurring to receiving emergency lifesaving medical treatment, Pangaea will map a concentric helicopter coverage ring around NT operations for emergency evacuation as required.

In the event a medical emergency has occurred and there is immediate threat to life or limb **the Royal Darwin Hospital 24/7 switchboard is the primary contact** for medical emergency response.

The first statement made to the DMO by the IMT Commander should be the following:

"I have a critical medical emergency of *….xxxxx….* and I have a helicopter on standby that can be in my position within 1 hour. Should I instruct my team to mobilise the helicopter?"

The DMO will then say one of the following:

"Yes – Call the helicopter to extract the casualty to Royal Darwin/Katherine Hospital because we have no available resources available within the next 6 hrs and remain on the phone with me to receive further medical direction on patient care'."

Or

"No – Do not call your helicopter in, I have notified Careflight and they will be in your location in 2hrs. Stay on the phone for further patient care direction."

EMERGENCY CALLOUT DIRECTORY	
Royal Darwin HOSPITAL	**08 8922 8888 (ask for DMO immediately)**
If Royal Darwin HOSPITAL is unreachable immediately call 000	
DHCS Katherine	08 8973 9211
Careflight	08 8928 9777 – 1300 655 855
KATHERINE (Postcode 0852)	**Post Office Ph: 08 8972 3663**
NT Fire and Rescue Service	Northern Region Business hrs 08 8946 4107 Southern Region Business hrs 08 8951 6688 After Hours 08 8922 1555
Fire Station Stuart Highway Katherine East 0850	08 8973 8014
State Emergency Services – Duty Officer	131 444
Katherine Local Council LOT 1865 Stuart Highway	08 8972 5500

EMERGENCY SUPPORT SERVICES CONTACTS	
Helicopters	
CLOSEST for NORTHERN STATIONS North Australian Helicopters Victoria Highway, Katherine	Frank Hoare (Chief Pilot) 08 8972 5666
CLOSEST for SOUTHERN STATIONS Mark Sullivan Contracting Flying Fox Station (near Mataranka)	0407 825 966 (08) 8977 4222
CLOSEST for EP(A) 198 ONLY Heli-Muster Scenic Flights VRD	08 8975 0777
North Australian Helicopters: Gorge Road Nitmiluk	08 8972 5666
CAREFLIGHT	
CareFlight Northern Operations (NT) 6 Fenton Ct Eaton (Darwin Airport) NT 0820	Logistics and Coordination Unit (24 hrs): 08 8944 8007
Air Charter	
ChartAir Darwin, International Airport, 0812 Hanger 78, Alice Springs Airport Tindal Airport, Katherine	08 8920 7777 08 8952 6666 1300 790 800
Transport	
Compass Haulage 13 Eldorado Crs, Tennant Creek	08 8962 2122
Earthworks	
Saunders Contracting, Bernard St Katherine Upstill Earthworks, Bernard St Katherine	08 8972 1764 0418 896 127
NT Authorities	
NT EPA The Avenue, Level 2, Suite 201 12 Salonika St Parap	08 8924 4218

EMERGENCY SUPPORT SERVICES CONTACTS	
Department of Mining and Energy Emergency Contacts Paspalis CentrePoint Building 48-50 Smith St Darwin	Petroleum Operations 1300 935 250
Bushfires NT 32 Giles St PO Box 532 Katherine NT 0851	T: (08) 8973 8871 or T: (08) 8973 8872 T: (08) 8973 8870 (VRD) F: (08) 8973 8873 or 8973 8899

MISCELLANEOUS SUPPORT			
Business	**Name**	**Address**	**Phone**
Engineering	Bennet, Eng and Fabrication,	Katherine, NT	0429 674 209
Mechanical	Katherine Regional Mech Services	17 Palmer St, Katherine East, NT	08 8971 1278
Hydraulics	Katherine Hydraulics	Katherine, NT	08 8972 2576
Electrical	DJ Hogan Electrical Contractors	15 Collins Road, Katherine, NT	08 8971 1425
	Whitehouse Furnishers Retravision	9 Second St, Katherine	08 8972 1894
Auto Electrics	Everything Auto Electrical	PO Box 1731, Katherine	0407 796 553
Fencing	Jaeschke Fencing	5114 Collins Road, Katherine, NT	0417 168 954
Signage	Katherine Sign Management	Katherine, NT	08 8972 3214

Appendix L: Pangaea Contacts List

Pangaea (NT) Pty Ltd

Corporate Office
Level 50 Governor Phillips Tower
1 Farrer Place
Sydney, NSW, 2000
Main Switch: (02) 9017 9600
Facsimile: (02) 9017 9699

Sydney Office	Work	Mobile
Sarah Jordan – Operations Coordinator sarah.jordan@pangaea.net.au	02 9017 9633	0412 166 591
Sandy Dimmock – Tenement Administration Sandy.Dimmock@pangaea.net.au	02 9017 9614	0414 726 343
Joel Alnes – Vice President of Exploration Joel.Alnes@pangaea.net.au	02 9017 9641	0448 199 942
Tim Radburn – Executive Director Tim.radburn@pangaea.net.au	02 9017 9622	0402284077

CONTRACTED SERVICES CONTACTS

Name & Position	Work	Mobile
MS Contracting Mark Sullivan General Manager	[redacted]	[redacted]
MS Contracting Bill Sullivan General Manager	[redacted]	[redacted]
Terrabos Consulting Dave Armstrong Pangaea Representative		[redacted]
EcOz Environmental Services Ray Hall Managing Director	[redacted]	[redacted]
Veolia Environmental Services James Prakash Area Sales Representative	[redacted]	[redacted]

Appendix M: Oil Spill Contingency Plan

This Plan should be actioned in the case of any hydrocarbon spill GREATER THAN 100 LITRES

STEP 1: ONSITE PERSONNEL

1.1 **STOP & IDENTIFY** the action(s) or cause(s) of the incident.

1.2 **NOTIFY** your MANAGER/SUPERVISOR

1.3 **SECURE THE AREA, BUND & PREVENT** the hydrocarbons entering waterways and groundwater aquifers. DO NOT traverse across the spill area under any circumstances. Bunds are anything that are impervious (e.g. spill kit materials, geofabric covered soil contour bank, deployed plastic bunds, plastic sleepers).

1.4 **DEPLOY** cotton based absorbing sheet on the spill area only if the site conditions permit (i.e. not wet or raining).

1.5 **NOTIFY** the PANGAEA REPRESENTATIVE (Dave Armstrong, Sat Ph: 0450 943 948, Mob Ph: 0400 567 401) and the NT EPA POLLUTION HOTLINE (Ph: 1800 064 567)

1.6 **IF** the PANGAEA REPRESENTATIVE deems that the incident has already caused or has the potential to cause ***material***[1] or ***serious environment harm***[2] **NOTIFY** the NT Government via the POLLUTION HOTLINE 1800 064 567.

STEP 2: ONSITE PERSONNEL & EMR

2.1 **CLEARLY DELINEATE** the area affected by the spill.

2.2 **PREPARE** an impervious bunded area to receive the excavated, affected soil.

2.2 **EXCAVATE** the affected area under supervision by the EMR. Excavation is to be undertaken at 100mm layers until the hydrocarbon is no longer discernible in the soil profile (on the excavation walls). Stockpiles are to be separated by the excavation stage (100mm, 100-200mm, etc). DO NOT cover the stockpiles if the site is bunded.

2.3 **COLLECT** soil samples from the spill site and the stockpiles. Each sample of approximately 200 grams is to be placed into sterile glass jars, labelled and stored in a cooled esky for transport to a NATA accredited Laboratory. Each sample is to be sampled for:

- Total Recoverable Hydrocarbons – TRH fractions up to the C40 fraction (TRH C6-C40 analysis suite per NEPM guidelines);
- Polycyclic aromatic hydrocarbons (PAHs) – in particular naphthalene; and
- Benzene, toluene, ethyl benzene and xylenes (BTEX).

This Plan should be actioned in the case of any hydrocarbon spill LESS THAN 100 LITRES.

STEP 1: ONSITE PERSONNEL

1.1 **STOP & IDENTIFY** the action(s) or cause(s) of the incident.

1.2 **NOTIFY** your MANAGER/SUPERVISOR

1.3 **SECURE THE AREA, BUND & PREVENT** the hydrocarbons entering waterways and groundwater aquifers. DO NOT traverse across the spill area under any circumstances. Bunds are anything that are impervious (e.g. spill kit materials, geofabric covered soil contour bank, deployed plastic bunds, plastic sleepers).

1.4 **DEPLOY** cotton based absorbing sheet on the spill area only if the site conditions permit (i.e. not wet or raining).

1.5 **NOTIFY** the PANGAEA REPRESENTATIVE (Dave Armstrong, Sat Ph: 0450 943 948, Mob Ph: 0400 567 401)

1.6 **IF** the PANGAEA REPRESENTATIVE deems that the incident has already caused or has the potential to cause ***material***[1] or ***serious environment harm***[2] **NOTIFY** the NT Government via the POLLUTION HOTLINE 1800 064 567.

STEP 2: ONSITE PERSONNEL & EMR

2.1 **CLEARLY DELINEATE** the area affected by the spill.

2.2 **PREPARE** an impervious bunded area to receive the excavated, affected soil.

2.2 **EXCAVATE** the affected area under supervision by the EMR. Excavation is to be undertaken at 100mm layers until the hydrocarbon is no longer discernible in the soil profile (on the excavation walls). Stockpiles are to be separated by the excavation stage (100mm, 100-200mm, etc). DO NOT cover the stockpiles if the site is bunded.

2.3 **DISPOSE** of the affected soil via an NT EPA accredited and licenced company to an accredited facility, upon the advice of the EMR.

2.4 **COLLATE** results. Options from this point forth will require consideration by Management.

[1]***Material environmental harm*** means environmental harm that:

(a) is not trivial or negligible in nature;

(b) consists of an environmental nuisance of a high impact or on a wide scale;

(c) results, or is likely to result, in not more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or

(d) results in actual or potential loss or damage to the value of not more than $50,000 or the prescribed amount (whichever is greater).

[2]***Serious environmental harm means*** environmental harm that is more serious than material environmental harm and includes environmental harm that:

(a) is irreversible or otherwise of a high impact or on a wide scale;

(b) damages an aspect of the environment that is of a high conservation value, high cultural value or high community value or is of special significance;

(c) results or is likely to result in more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or

(d) results in actual or potential loss or damage to the value of more than $50,000 or the prescribed amount (whichever is greater).

Appendix N: Weed Management Plan

This Weed Management Plan (WMP) provides a strategy for preventing the spread of weeds during operations essential to the Civil Operations for the 2016 NT Appraisal Campaign. The WMP has been prepared considering the Northern Territory Weed Management Handbook which aligns with priorities identified in the *Katherine Regional Weed Management Strategy and Action Plan 2005-2010* that was launched in September 2005 by the Katherine Regional Weed Advisory Committee. The WMP considers the mitigation measures listed in Section 10.5 of the EMP.

1. Objectives

A total of 17 weed species have been recorded across EP-167 and EP-168. The majority of these recordings are roadside based or on crossing points of major rivers/creeks (i.e. trafficable areas). Most of the important weeds requiring management attention are usually most prevalent in riparian habitats, are spread by wet season floodwaters or are associated with water-holding black soil areas.

Weed control works on pastoral land generally take into consideration weed risk (invasiveness, impacts on grazing land/land value and potential distribution) as well as feasibility of control (control costs, current distribution and persistence). Importantly, there is also a legal obligation to control all weeds declared under the Weeds Management Act.

The objectives of this WMP are:

a. To ensure appraisal activities including rehabilitation meet stakeholders expectations in the control and prevention of the establishment Class A, B & C weeds as listed in the NT *Weeds Management Act*.
b. To ensure no new weed infestations are established as a direct result of appraisal activities.
c. To ensure appropriate mitigation measures are in place to:
    1. Avoid mapped weed infested areas,
    2. Mitigate against activities that may spread weeds; and
    3. Provide a mechanism to monitor rehabilitated areas to ensure appropriate weed management post appraisal.

2. Weed Management Actions

Action	WHO[21]	WHEN	Measurement criteria
1. As part of job-site induction prior to arrival on-site, weed related issues will be provided for relevant staff. Crew, particularly line preparation and survey to be informed about potential weeds in the area (given field ID guides, training sessions) and importance of blowing down.	EMR, PR	Before	Induction report
2. Interstate machinery and vehicles will be certified 'weed free' by a registered agent before arriving in the EP to begin works and fully blown down before leaving the NT after the program is completed.	MSC	Before / After	Pre-start documentation / Post Completion Audit
3. Areas of known environmental weeds, noxious weeds or problem plants will be avoided by track preparation crews wherever practical. Blow-down areas to be established at exit points of areas known to contain weeds as those areas become accessible, on the basis of: • Known infestations (as recorded by the weeds unit and pastoral lands management unit of the Land Resource Management) and pastoralists, • Identification of weeds in the field, and • Disturbed areas such as previously cleared areas, cattle yards, or borrow pits.	EMR, PR, MSC	During	Daily reports
4. Field crews will undertake a visual check of seed in clothes and protective gear daily. Vegetative matter will be removed and placed in a bin for disposal.	MSC	During	Daily reports
5. Blow-down points may be established at entry / exit points of the station.	PR	During	Daily reports
6. All blow-down areas to be clearly sign-posted and GPS points recorded.	EMR / PR	Before	Monthly Audit
7. Each time a vehicle passes a blow-down point, a visual inspection of the under body and tyres/tracks of the vehicle will be performed, and any vegetation or dirt possibly containing weed seeds will be removed by the person operating the vehicle.	MSC	During	Daily reports
8. Each vehicle will be equipped with a suitable brush to remove possible weed seed containing material.	MSC	During	Daily reports

[21] EMR = Environmental Management Rep, PR = Pangaea Representative, MSC = MS Contracting

Action	WHO	WHEN	Measurement criteria
9. A weed management vehicle will be available and equipped with an air compressor, to mobilise on-site in order to blow-down vehicles or equipment when necessary, particularly those most likely to pick up or transport weed material (bulldozers, survey and rehab vehicles).	PR	During	Daily reports
10. In wet/muddy conditions, water (e.g. from a fire cart) may need to be used to ensure vehicles are free of weeds.	MSC	During	Daily reports
11. Records to be kept of every visual inspection / blow down procedure performed, including date, time, vehicle and operator. Records are to be collected and filed on a monthly basis by the OC.	MSC/ PR/OC	During	Daily reports
12. Any blow-down points that have been identified throughout the operations campaign as potential noxious weed locations are to be bunded off, GPS recorded, photo documented and compiled into a report and submitted to the OC.	MSC/ PR/OC	During	As required

3. Monitoring

Monitoring will be conducted on areas of disturbed land following Civil Operations activities, construction, operating and maintaining plant and equipment at the Project sites. This procedure establishes an approach for evaluating the successful implementation of rehabilitation activities by monitoring.

Pangaea aims to *"minimise the disturbance to vegetation, land and animals, including native flora and fauna, and pastoral infrastructure and livestock. Any disturbed vegetation or land shall be rehabilitated as soon as practicable to ensure the identified land use can occur."*

Monitoring locations will be established by the EMR in consultation with the ED and PR. Monitoring will be conducted by suitably skilled and qualified persons and reviews of monitoring data will be conducted at appropriate times. Monitoring outcomes will determine whether weed management activities have been a success or more attention is required.

4. Maintenance

In the context of this strategy, 'maintenance' constitutes any further management of weeds that is required. However, this management frequency would vary depending on the extent of rehabilitation success and necessary method for mitigating failing rehabilitation.

Appendix O: Air Quality Management Plan

Dust and emissions will require management during the Civil Operations for the 2016 NT Appraisal Campaign. The Civil Operations will be associated with vehicle movement and emissions. The emissions associated with the running of vehicles are unavoidable and the work will be undertaken well away from potential receptors (pastoral land, in a rural environment).

Dust generation and emissions related to vehicles are the two primary potential impacts relating to the appraisal activities. Soils will be mobilised differently and are dependent on prevailing weather conditions such as wind, humidity and precipitation, particle size and topography. Some soils within the tenement are considered dispersive.

Dust will be generated as part of the campaign, however, given the operation is in a rural environment, it is unlikely that potential dust producing activities will represent a significant impact to any surrounding or other local land users. This Air Quality Management Plan (AQMP) considers and builds upon the mitigation measures listed in Section 10.1 of the EMP.

1. Objectives of the AQMP

The purpose of the AQMP is to provide methods to reduce and manage the impacts on air quality during the Civil Operations. This will be achieved by establishing a set of procedures for air quality management to be followed during the course of the Civil Operations. The objectives of the AQMP are:

a) To minimise environmental nuisance due to dust for sensitive receptors as a result of appraisal activities; and
b) To minimise greenhouse gas emissions.

2. Air Quality Management Actions

Action	WHO	WHEN	Measurement criteria
1. As part of job-site induction prior to arrival on-site, awareness of air/dust related issues will be provided for relevant staff.	EMR	Before	Induction attendance
2. Speed limits on access tracks are limited to 40km/hr to limit and minimise dust generation.	MSC	All stages	Record of complaints
3. Appropriately inform affected pastoralists as specified in the access agreement and providing updated information as required.	PR	Before & during	Daily reports
4. No activities will be undertaken outside of the specified access tracks and drill pad.	MSC, PR	During	Daily reports
5. Where practical, all vehicular movements to and from the camp site would be made only during daylight hours and/or compliant with land access agreement.	MSC, PR	All stages	Daily reports
6. Engines will not be left running when not specifically required.	MSC	During	Record of complaints
7. Individual vehicular trips to and from the drill site and along access roads will be kept to a minimum.	Service Providers	All stages	Daily reports
8. Smoke generation will be avoided by a strict no burning policy.	MSC, PR	All stages	Record of complaints
9. Watering of roads and other sites is to occur regularly, when appropriate or when agreed.	MSC	All stages	Record of complaints

Appendix P: Community and Stakeholder Consultation

Consultation has been undertaken with the following stakeholders regarding the appraisal program and will continue during the operations:

Stakeholder	Communication and Consultation	Project Related Issues	Resolution
Broader Community, Focused groups, Land Care Groups	• Initial face to face engagement at field events, booth exhibition (July 2015). • Scheduled meetings, field events and engagement will continue from mid-2016.	• Protection of groundwater, use of water resources, environmental impact to agricultural landscape.	• Tri-partite (Santos, Origin and Pangaea) collaboration approach with APPEA's lead in representing the industry and providing multi-discipline education/information while addressing the community of all the issues regarding the shale gas exploration and related impacts.
Sturt Plateau Pastoralists	• Commencement of Work Program open forum and discussion with Sturt Plateau pastoralists conducted November 2015 and February each program year 2013/14/15. • Close-out meeting and sign-off by pastoralists on operations in November of each program year 2013/14/15. • Voluntary Access and Compensation Agreements completed for 2013/14/15 programs. Expected completion January 2016 for 2016 operations.	• Increase in traffic, noise, increase in road wear, water requirements, camp site locations, weed management, stock management, and fire prevention.	• Access and compensation arrangements directly relating to pastoral concerns with regards to the impact on their pastoral operations. • Face to face negotiations by the company and pastoralists to reach mutually beneficial arrangements to achieve oil and gas industry and pastoral synchronization of operations.
Northern Land Council and Traditional Owners	• Briefing of 2016 Work program to NLC November 10, 2015. • Further briefing of 2016 Work Program to NLC January 2016. • 'On-country' work program meetings with TOs planned January 2016 - March 2016.	• Concerns regarding impact on sacred sites and culturally significant landscapes. Protection of groundwater.	• Presented outline of exploration program and methods. • Cultural survey to be completed with TOs and the site and access culturally cleared January 2016.
Local Governments	• Letters of notification as required by NT regulations on impending exploration activities to be circulated one month before start of exploration activities.	• Increased Traffic along Western Creek Road and Stuart Highway. Transparency and complete information of the activities and related impacts.	• One month prior to operation notification via mail, press or radio release. • Address several phone calls via Q&A explaining the appraisal operations and seismic survey.

Stakeholder	Communication and Consultation	Project Related Issues	Resolution
NT Government DME	• Workshop and half-day session with NTDME Energy Operations and Directorate presenting 2016 Work Program to be held December 2015. • Continuing engagement and presentation to government ministers and Dep't executives during March-April 2016.	• Presentation and clarification of the 2016 appraisal program. EMP draft and associated issues.	• Developed EMP and provided extensive support documentation.
GWA Railway (Rail Tracks)	• Planned March 2016 renew communications and ongoing engagement to secure approval and consent of use of railroad service road.	• Minimal rail tracks crossing during Civil Operations and use of Service Road.	• Amendments to Deed of Release and Indemnity with appropriate terms and conditions.
NT Department of Infrastructure - Transport Infrastructure Planning Division	• Preliminary meetings with Director DoT on consent of use of highways and crossings, TMP and rehabilitation protocol to be held January 2016.	• Use of Stuart Highway, Western Creek Road for mobilization/demobilization of Civil Operations equipment.	• Seeking approval with the condition that there shall be no drilling in NTG Road Reserve.
Northern Territory Cattlemen Association	• Relationship building and continuing engagement and consultation.	• Pastoral station access conditions and biosecurity issues.	• Continuing engagement between Pangaea and the NTCA, as well as APPEA and the NTCA.

Appendix Q: Ground and Surface Water Management Plan

Surface and groundwater (aquifer) considerations are extremely important to the management of Pangaea. The waterways within the region all offer habitat for aquatic plants and animals as well as important associated riparian vegetation and the groundwater systems are very important resources regularly used for pastoral activities.

It is estimated that approximately 0.4 ML of water from existing bores will be required for camp operations.

1. Objectives

To conduct Civil Operations to minimise potential impacts to surface water and groundwater systems and complete the bore holes as to eliminate inter-aquifer leakage and potential for cross contamination of groundwater. This Ground and Surface Water Management Plan (GSWMP) considers and builds upon the mitigation measures listed in Section 10.2 (Land) and 10.3 (Water) of the EMP.

2. Ground and Surface Water Management Actions

Action	WHO	WHEN	Measurement criteria
1. All surface water runoff will be directed away from the bore hole to prevent aquifer contamination. Sediment control measures and site rehabilitation will be completed in accordance with the Environmental Management Plan (EMP) to minimise potential for contamination to the aquifers.	Service Providers	Before	Pre-start audit
2. Site rehabilitation will include appropriate measures as to manage residual fluids and solids management outlined in the Waste Management Plan (Appendix F).	PR	Post	Daily reports
3. Hydrocarbons, lubricant and other chemicals to be stored as outlined in the relevant checklists and equipment checked regularly for leaks.	EMR	During	Monthly audit
4. Site rehabilitation including residual fluids and solids managed as in the Rehabilitation Plan (Appendix B).	MSC, PR	Post	Completion audit
5. The bore holes will be drilled using procedures to prevent borehole inter-aquifer connection during drilling.	Service Providers	During	Daily reports
6. All work is to be conducted within the marked footprint area and the Erosion and Sediment Control Plan (Appendix C) is to be implemented prior to construction works commencing.	EMR	During	Monthly audit
7. Ensure where practicable access to the sites is gained by existing roads and tracks.	MSC, PR	All stages	Record of complaints

Action	WHO	WHEN	Measurement criteria
8. No stockpiles or materials to be placed where they have potential to contaminate watercourses. Minimum distance between stockpiles and watercourses is 100m.	PR, MSC	During	Monthly audit
9. All chemicals, fuels and oils used on site will be appropriately bunded, and spill and oil absorbent materials will be maintained on site.	Service Providers	During	Monthly audit
10. Any soil potentially contaminated by chemicals, oils, or fuels will be collected and disposed of in an approved manner and the site rehabilitated on completion.	Service Providers	During	Daily reports
11. Fuels, lubricants and chemicals shall be stored and handled within containment areas (such as portable bunding) that are designed to prevent the release of spilt substances to the immediate neighboring environment, in accordance with relevant legislation and standards. A spill kit appropriate to operations of this size will be available at site.	Service Providers, EMR	During	Daily reports, Monthly audit
12. Personnel will be advised of the location and use of the spill containment equipment in the site induction.	EMR	Before	Start up meeting
13. Spills or leaks shall be immediately reported to the PR on site and clean up actions initiated.	Service Providers	During	Daily reports
14. In the event of a spill the material will be contained to the smallest area practicable.	Service Providers	During	Daily reports
15. Spilt material and contaminated soils will be treated on site with pastoralist acceptance or removed off-site for disposal at an appropriately licensed facility, as determined in consultation with the NT EPA.	EMR	All Stages	Incident reports

Appendix R: Regional Water Baseline Monitoring Database

Refer to attachment “Appendix R_Regional Water Baseline Monitoring Database.xls”

Appendix S: Engineering Specifications for Evaporation Pond design

SLR

30 November 2015

680.10217 Letter Report_20151130.docx

Livingstone Infrastructure Services
PO Box 1247
Palmerston NT 0831

Attention: Ken Gardner

Dear Ken

LIVIS Pangaea - Larrimah Drill Pad Pond Sizing

SLR were engaged to undertake preliminary sizing calculations for one turkeys nest lined pond at the proposed drill pad site approximately 65km west of Larrimah, Northern Territory.

The design requirements and criteria as advised by the client was for the pond to provide approximately 12ML storage capacity as well as provide sufficient freeboard to be able to contain a 50year ARI design storm event. The pond also had to fit within a 200m wide drill pad.

The results of the calculations and the sizing dimensions of the pond as well as the estimated preliminary earthwork volumes are outlined in Table 1 and Table 2 below. The attached Figure 1 shows the preliminary configuration of the pond.

Table 1: Pond Details

Floor Length x Width	170.0m x 17.0m
Crest Internal TOB Length x Width	184.2m x 31.2m
Crest Width	4m
Internal / External Batter Slopes	1(V):2(H)
Total Depth (floor to crest)	3.55m
Depth of Storage @ TWL	3.00m
Storage Volume @ TWL	12.18ML
Operational Freeboard	0.55m
Depth of Storage @ MTWL (to cater for 50yr ARI event)	3.35m
Storage Volume @ MTWL	14.08ML
Freeboard @ MTWL	0.20m

SLR Consulting Australia Pty Ltd 5 Foelsche Street Darwin NT 0800 Australia
(GPO Box 654 Darwin NT 0801 Australia)
T: 61 8 8998 0100 F: 61 2 9427 8200 E: darwin@slrconsulting.com www.slrconsulting.com
ABN 29 001 584 612

Table 2: Total Preliminary Earthwork Volume for Pond #1

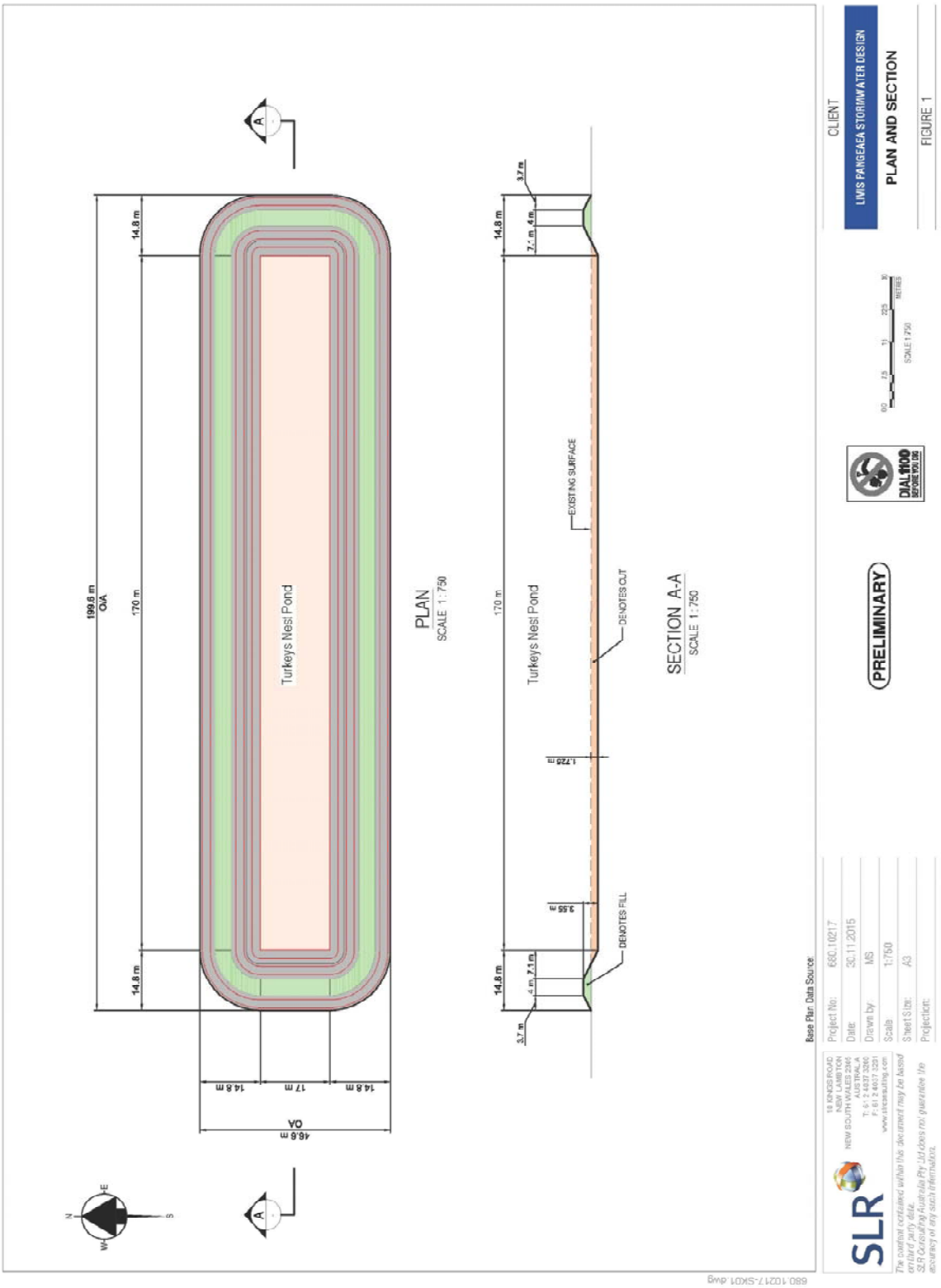
Cut	6,120m^3
Fill (embankment construction)	6,020m^3
Excess	100m^3

Note:
#1. The total preliminary earthwork volume is for the pond as shown in Figure 1 and assumes a level drill pad.

Yours sincerely,

Andrew Behrens

Checked/
Authorised by: MS



PANGAEA

BIRDUM CREEK-1, TARLEE-1, TARLEE-2 & WYWORRIE-1 APPRAISAL WELLS

ENVIRONMENTAL PLAN SUMMARY

TABLE OF CONTENTS

1. INTRODUCTION

EP167 and EP168 are located approximately 350 km southeast of Darwin in the Northern Territory (NT) in the western McArthur Basin. The basin is essentially unexplored for hydrocarbons, either conventional or unconventional, and from a shale gas or oil perspective, there is limited information on thermal maturity, total organic carbon (TOC), porosity, permeability, gas content or saturation. The tenements fall within the Victoria-Daly, Roper-Gulf and Barkly Shires plus the Katherine Municipality.

EP167

Two of the proposed appraisal wells will be located in the south-eastern portion of EP167 in central Northern Territory. The Birdum Creek-1 appraisal well will be located approximately 160 km south-southeast of Katherine. The Wyworrie-1 appraisal well will be located approximately 113 km south-southeast of Katherine.

EP168

Two of the proposed appraisal wells will be located in the central-northern portion of EP168 in central Northern Territory. The Tarlee-1 appraisal well will be located approximately 175 km south-southeast of Katherine. The Tarlee-2 appraisal well will be located approximately 165 km south-southeast of Katherine.

A location map and coordinates of the activity are provided in Figure 1.

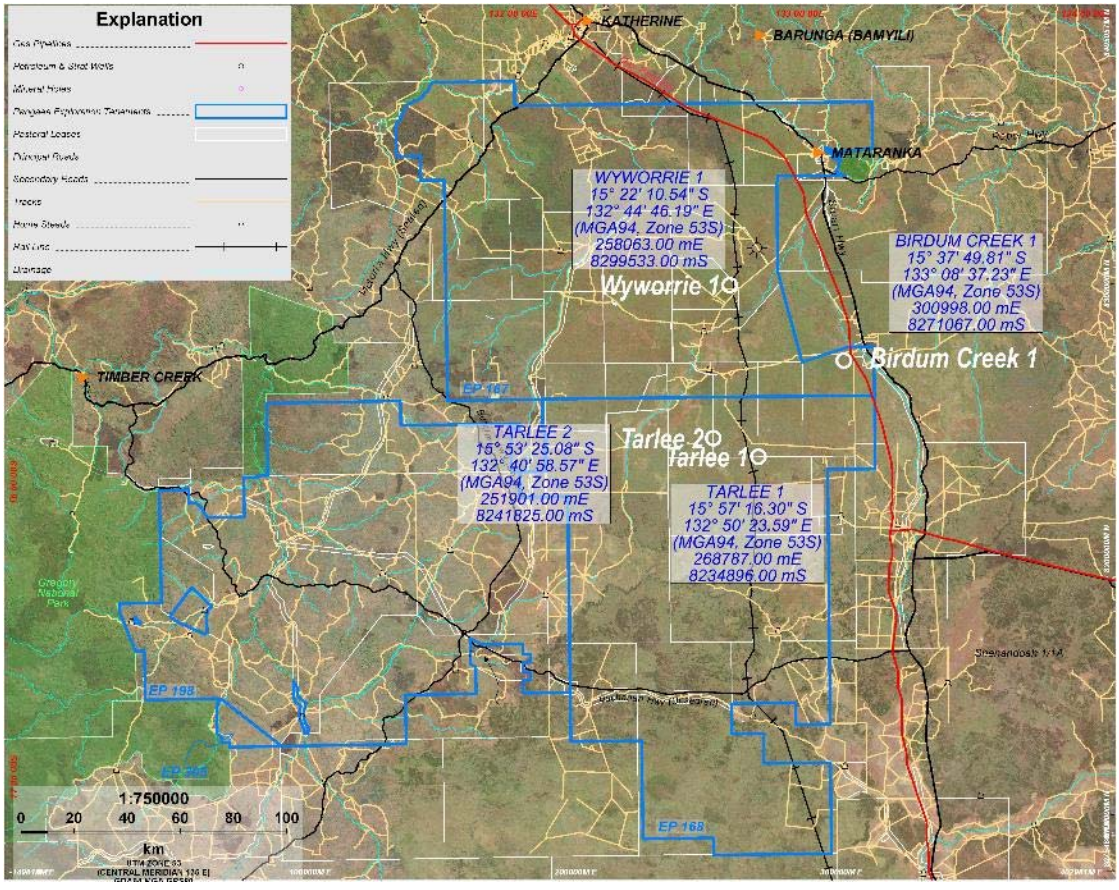


Figure 1: Appraisal Wells within EP167 & EP168

2. DESCRIPTION OF ACTIVITY

The objectives of the Appraisal Wells in EP167 & EP168 are to:

- Identify thick intervals of organic-rich shale within the wet to dry gas hydrocarbon generation windows;
- Confirm the stratigraphy and tie this stratigraphy to the regional seismic interpretation;
- Collect velocity information to improve the time to depth conversion for the regional seismic interpretation;
- Evaluate the thermal maturity, gas content, gas saturation, gas composition, mineralogy, porosity and permeability of the shale units within the Roper Group from core and wireline logs; and
- Collect data to evaluate the geo-mechanical attributes of the rock.

By way of a summary, the evaluation proposed for the Appraisal Well sites will comprise of coring, wireline logging and formation testing operations. The final wells will not be used as production wells. Following testing operations, the wells may be used as a future micro-seismic monitoring bore, cased and suspended or plugged and abandoned.

3. DESCRIPTION OF THE ENVIRONMENT

The region's climate is *'semi-arid tropical, with rainfall concentrated in the wet season months between November and April. Though rainfall can be variable from year to year, there is a distinct gradient of decreasing mean annual falls from 850mm in the north to less than 500mm'* in southern areas of EP167 and EP168, with nearly all the rainfall occurring between November and April (see Williams *et al.* 1997[1], Hennessy *et al.* 2004[2]). The mean maximum temperature varies from 27°C in July to 40°C and beyond in November.

Condition is generally good across much of the bioregion. The drilling campaign in EP-167, inclusive of the access route to the drill sites, will intersect with the Forrest land system. The Forrest land system consists of gently sloping sandy surfaced plains with few indistinct drainage depressions on sandy red earth soils. Vegetation is dominated by eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Forrest land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening (Northern Territory Government, no date[3]).

The drilling campaign in EP-168, inclusive of access routes to the drill sites, will intersect with the Banjo land system. The Banjo land system consists of almost level to gently undulating plains on the plateau surface that lack drainage lines. Consisting of variable depth red earth soils with or without gravel; mixed eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Banjo land system consists of vegetation that has a relatively low forage quality in the dry season although can benefit from strategic burning to manage woody thickening (Northern Territory Government, no date[4]).

[1] Williams, R.J., Cook, G.D., Ludwig, J.L. and Tongway, D.L. (1997). Torch, trees, teeth and tussocks: disturbance in the tropical savannas of the Northern Territory (Australia). In: Frontiers in Ecology. Building the Links. Eds. N. Klomp and I. Lunt. Elsevier, Oxford: pp55-66.

[2] Hennessy, K., Page, C., McInnes, K., Walsh, K., Pittock, B., Bathols, J, and Suppiah, R. (2004). Climate Change in the Northern Territory. Consultancy report for the Northern Territory Department of Infrastructure, Planning and Environment. CSIRO, Melbourne.

[3] Northern Territory Government (no date) Land Condition Guide - Sturt Plateau District; Understanding the productivity of grazing lands. Produced in association with the Northern Territory Cattlemen's Association as part of the Caring for Our Country project "Grazing Land Management – Demonstration, Continuation and Evaluation".

[4] Northern Territory Government (no date) Land Condition Guide - Sturt Plateau District, Understanding the productivity of grazing lands. Produced in association with the Northern Territory Cattlemen's Association as part of the Caring for Our Country project "Grazing Land Management – Demonstration, Continuation and Evaluation".

4. DESCRIPTION OF THE ACTIVITY IN RELATION TO THE ENVIRONMENT

The Appraisal Wells have been designed with due consideration of the surface and subsurface environments. The sites have been selected and will be constructed to avoid large scale levelling and clearance of vegetation.

The drilling operations have been designed to:

- Complete all operations without injuries;
- Isolate permeable zones within the well;
- Maintain separation between potable water aquifers;
- Prevent uncontrolled discharge of water, gas or oil from the well while drilling; and
- Prevent cross flow between potential reservoirs or formations.

These objectives are achieved by the appropriate selection of:

- Surface equipment (including drilling rig and well control equipment);
- Surface facilities/pits for the containment of drilling fluids;
- Casings and setting of casing depths to ensure aquifers are isolated;
- Drilling techniques;
- Down hole technology; and
- Suspension or plug and abandonment procedures.

5. ENVIRONMENTAL RISKS OF PROPOSED ACTIVITY AND CONTROL MEASURES

Fauna and flora

Potential impacts to surrounding flora and fauna at the well sites will be assessed and minimised by measures including weed and pest inspections on all vehicles and personnel clothing prior to arrival at site and the use of signage and appropriate fencing.

Groundwater

The well will be grouted and completed according to industry's best practice for sealing requirements. Any well that encounters an artesian or sub-artesian flow will be sealed to prevent contamination or cross-contamination of aquifers and will be sealed with cement plugs to prevent surface discharge of groundwater. Appropriate sedimentation and erosion control measures will be put in place at the well sites. The amount of hazardous material on site will be kept to a minimum and all materials stored according to regulations.

Noise and surface

Speed limits will be enforced on access tracks to limit and minimise dust and noise generation. Vehicular movements to and from the work sites will be minimised by travel during daylight hours and be compliant with land access agreements. Soil erosion will be minimised by the use of existing tracks, deviating around creeks, river banks and naturally formed depressions and not accessing roads in wet conditions.

Waste management

Waste will be stored in suitable receptacles and disposed of accordingly at municipal managed locations. Hazardous material shall be transported, stored and handled in accordance with the requirements of the relevant legislation and guidelines.

6. CONSULTATION

During the past several months Pangaea has consulted with stakeholders, which has included:

- A detailed cultural heritage assessment and sacred site clearance process with the Northern Land Council and Traditional Owners;
- The negotiation and signing of voluntary access agreements with directly-affected Pastoralists;
- Direct engagement with communities and representative groups at exhibition booths during district and agricultural shows e.g. Katherine District Shows (2014, planned mid-2015);
- Notification to local government councils, police authorities and local businesses of exploration activities; and
- Compliance with legislation and guidelines from the NT Department of Mines and Energy and other regulatory agencies eg. Department of Transport and Department of Infrastructure.

Pangaea's engagement process is aimed to identify and address issues of concern, reach agreement and in general engage in goodwill communication.

Pangaea will continue this process with stakeholders throughout the life of the project.

7. PANGAEA RESOURCES LIAISON PERSONNEL

Sydney Office		
Executive Director	Tim Radburn	Phone: (02) 9017 9600

PANGAEA

2015 AVAGO 2D SEISMIC SURVEY

ENVIRONMENTAL MANAGEMENT PLAN SUMMARY

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1. INTRODUCTION

EP167 and EP168 are located approximately 350 km southeast of Darwin in the Northern Territory (NT) in the western McArthur Basin. The tenements fall within the Victoria-Daly, Roper-Gulf and Barkly Shires plus the Katherine Municipality. All activities described in this EMP Summary are in the Roper-Gulf Shire.

Pangaea intends to acquire approximately 380km of 2D, Vibroseis-sourced seismic data in the area of operations during 2015. This survey, known as the 2015 Avago 2D Seismic Survey, will comprise ten (10) seismic lines and has been designed to minimise impacts on the environment by utilising existing roads, tracks, fire-breaks and fence lines wherever possible.

A location map and coordinates of the activity are provided in Figure 1.

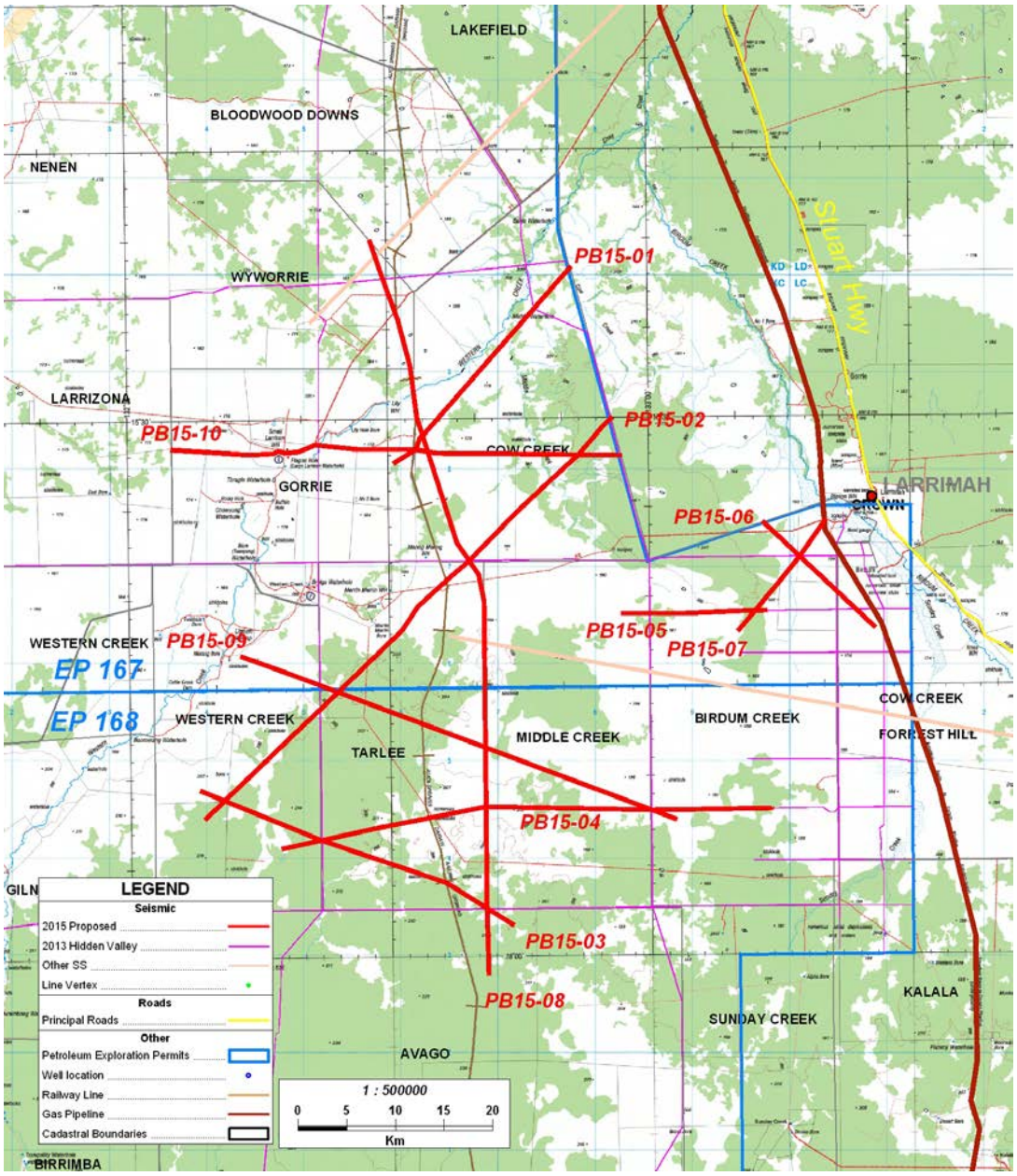

Figure 1: Location of the Avago 2D Seismic Survey

2. DESCRIPTION OF ACTIVITY

The overall objective of the seismic program is to image subsurface geological formations across the stated tenements to increase the understanding of hydrocarbon prospectively within the area. The survey has been designed to image from the surface down to 4,000m of the subsurface to delineate critical areas of geological interest while also avoiding areas of environmental, cultural or archaeological importance.

3. DESCRIPTION OF THE ENVIRONMENT

The region's climate is *'semi-arid tropical, with rainfall concentrated in the wet season months between November and April. Though rainfall can be variable from year to year, there is a distinct gradient of decreasing mean annual falls from 850mm in the north to less than 500mm'* in southern areas of EP167 and EP168, with nearly all the rainfall occurring between November and April (see Williams *et al.* 1997[1], Hennessy *et al.* 2004[2]). The mean maximum temperature varies from 27°C in July to 40°C and beyond in November.

Condition is generally good across much of the bioregion. The portion of the seismic survey in EP-167 will intersect with the Forrest land system. The Forrest land system consists of gently sloping sandy surfaced plains with few indistinct drainage depressions on sandy red earth soils. Vegetation is dominated by eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Forrest land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening (Northern Territory Government, no date[3]).

The portion of the seismic survey in EP-168 will intersect with the Banjo land system. The Banjo land system consists of almost level to gently undulating plains on the plateau surface that lack drainage lines. Consisting of variable depth red earth soils with or without gravel; mixed eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Banjo land system consists of vegetation that has a relatively low forage quality in the dry season although can benefit from strategic burning to manage woody thickening (Northern Territory Government, no date[4]).

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4. DESCRIPTION OF THE ACTIVITY IN RELATION TO THE ENVIRONMENT

The Seismic Survey has been designed with due consideration of the surface and subsurface environments, and to minimise impacts on the environment by utilising existing roads, tracks, fire-breaks and fence lines wherever possible. The operations will utilise one centrally located camp site.

Line preparation may include 'stick raking' and vegetation management for technical, safety and visibility reasons. Stick raking displaces logs and large sticks from the chosen line that could create a hazard or barrier. Light grading may be required to smooth over very rough surfaces to make the line trafficable for the vibrator trucks and support vehicles.

Bull-dozers may also be employed as a last resort in areas where the terrain is especially rough and inaccessible by grader or front end loader. In all cases, equipment is kept off the ground surface ensuring that root stock and tufted grasses remain in situ wherever possible (minimising potential soil loss through erosion). Tree clearing is minimised by meandering the lines through heavily wooded areas and savannah woodlands around trees (>200mm diameter at breast height), however some tree losses and trimming is to be expected. All alternative options will be considered, including practical rerouting, before this occurs.

Where a line crosses a creek, watercourse or depression in the landscape, survey crews will search for naturally cleared crossings (in the immediate area) before the final lines are chosen in the field. Earthworks in riparian areas will be minimised at all times and rehabilitation is to follow immediately post data capture, or as soon as practically possible.

The collection of seismic data involves deploying over 10km of individual seismic nodes spaced every 10m along the lines. Energy waves are sent from vibrator trucks, which reflect off underground rock formations before being recorded by the nodes at the ground surface for analysis. The vibrators advance along the line and vibrate over a period of approximately eight (8) seconds every 10m. The data is downloaded from the nodes and sent to a data processing centre where it is processed to produce images of the subsurface.

5. ENVIRONMENTAL RISKS OF PROPOSED ACTIVITY AND CONTROL MEASURES

Fauna and flora
The seismic lines have been designed to minimise clearing and associated impacts on important vegetation communities that may be proving important fauna habitat. The seismic survey would comprise a minor and temporary barrier to movement of fauna, however the small scale of vegetation modification is unlikely to isolate any wildlife corridors or otherwise affect the migration or dispersal ability of any fauna. Weed and pest inspections on all vehicles & personnel clothing will be undertaken prior to arrival at site and the use of signage and appropriate fencing.

Noise and surface
Speed limits will be enforced on access tracks to limit and minimise dust and noise generation. Vehicular movements to and from the work sites will be minimised by travel during daylight hours and be compliant with land access agreements. Soil erosion will be minimised by the use of existing tracks, deviating around creeks, river banks and naturally formed depressions and not accessing roads in wet conditions.

Waste management
Waste will be stored in suitable receptacles and disposed of accordingly at municipal managed locations. Hazardous material shall be transported, stored and handled in accordance with the requirements of the relevant legislation and guidelines.

6. CONSULTATION

During the past several months Pangaea has consulted with stakeholders, which has included:

- A detailed cultural heritage assessment and sacred site clearance process with the Northern Land Council and Traditional Owners;
- The negotiation and signing of voluntary access agreements with directly-affected Pastoralists;
- Direct engagement with communities and representative groups at exhibition booths during district and agricultural shows e.g. Katherine District Shows.
- Notification to local government councils, police authorities and local businesses of exploration activities; and
- Compliance with legislation and guidelines from the NT Department of Mines and Energy and other regulatory agencies e.g. Department of Transport and Department of Infrastructure.

Pangaea's engagement process is aimed to identify and address issues of concern, reach agreement and in general engage in goodwill communication.

Pangaea will continue this process with stakeholders throughout the life of the project.

7. PANGAEA LIAISON PERSONNEL

Sydney Office		
Executive Director	Tim Radburn	Phone: (02) 9017 9600

STIMULATION & TESTING

EP167

ENVIRONMENTAL MANAGEMENT PLAN

SUMMARY

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1. INTRODUCTION

EP167 is located approximately 400 km southeast of Darwin in the Northern Territory (NT) in the Roper Basin. The tenement falls within the Victoria-Daly, Roper-Gulf and Barkly Shires plus the Katherine Municipality. All activities described in this EMP Summary are in the Roper-Gulf Shire.

Pangaea intends to return to two Appraisal Wells that were completed in July and August 2015 (Birdum Creek-1 and Wyworrie-1 Appraisal Wells) to undertake stimulation and testing operations. The program will utilise tracks on pastoral land for which Pangaea currently have voluntary pastoral access agreements in place. A location map and coordinates of the activity are provided in Figure 1.

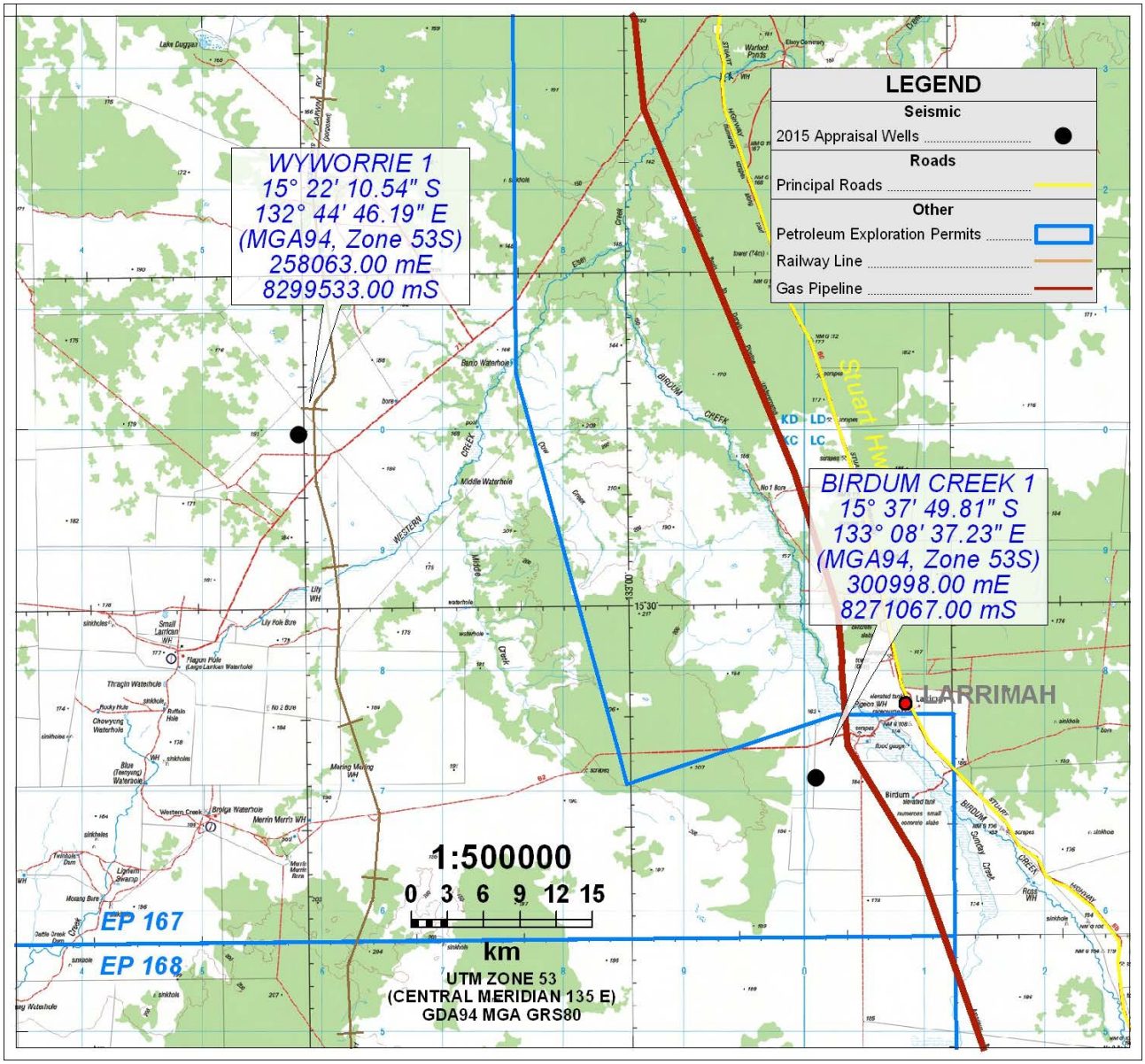

Figure 1: Location of the Appraisal Well sites for Stimulation & Testing Operations

2. DESCRIPTION OF ACTIVITY

Birdum Creek-1 and Wyworrie-1 Appraisal Wells were drilled and suspended in July and August 2015 respectively as part of Pangaea's 2015 Appraisal Campaign, in order to gather further information on stratigraphic and rock properties in EP167. Both Appraisal Wells will undergo stimulation and testing.

The Appraisal Wells have been designed and constructed to accommodate the stimulation process without risk to well integrity. In preparation for the Stimulation & Testing operations, well integrity tests including cement evaluation have been completed on both Appraisal Wells.

The operation will involve the following stages:

- Well preparation including Wireline Logging;
- Pressure testing of the well casing and surface equipment to further ensure wellbore integrity and surface safety;
- Perforation and pumping;
- Testing; and
- Well Suspension – (cement plugged back).

The program has been designed in consultation with local pastoralists and traditional owners to avoid areas of environmental, cultural or archaeological significance.

3. DESCRIPTION OF THE ENVIRONMENT

The region's climate is *'semi-arid tropical, with rainfall concentrated in the wet season months between November and April. Though rainfall can be variable from year to year, there is a distinct gradient of decreasing mean annual falls from 850mm in the north to less than 500mm'* in southern areas of EP167, with nearly all the rainfall occurring between November and April (see Williams *et al.* 1997[1], Hennessy *et al.* 2004[2]). The mean maximum temperature varies from 27°C in July to 40°C and above in November.

Condition is generally good across much of the bioregion. In EP167, the Appraisal Well locations both intersect with the Forrest land system. The Forrest land system consists of gently sloping sandy surfaced plains with few indistinct drainage depressions on sandy red earth soils. Vegetation is dominated by eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Forrest land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening (Northern Territory Government, no date[3]).

[1] Williams, R.J., Cook, G.D., Ludwig, J.L. and Tongway, D.L. (1997). Torch, trees, teeth and tussocks: disturbance in the tropical savannas of the Northern Territory (Australia). In: Frontiers in Ecology. Building the Links. Eds. N. Klomp and I. Lunt. Elsevier, Oxford: pp55-66.
[2] Hennessy, K., Page, C., McInnes, K., Walsh, K., Pittock, B., Bathols, J, and Suppiah, R. (2004). Climate Change in the Northern Territory. Consultancy report for the Northern Territory Department of Infrastructure, Planning and Environment. CSIRO, Melbourne.
[3] Northern Territory Government (no date) Land Condition Guide - Sturt Plateau District; Understanding the productivity of grazing lands. Produced in association with the Northern Territory Cattlemen's Association as part of the Caring for Our Country project "Grazing Land Management – Demonstration, Continuation and Evaluation".

4. DESCRIPTION OF THE ACTIVITY IN RELATION TO THE ENVIRONMENT

The Stimulation and Testing Program has been designed with due consideration of the surface and subsurface environments. To minimise impacts on the environment, existing roads, tracks, fire-breaks and fence lines have been used to access both Appraisal Well locations wherever possible. The operations will utilise one already existing centrally located camp site.

As described previously, both Appraisal Wells have been designed and constructed to accommodate the stimulation process without risk to well integrity.

The first stage of the program involves re-entering the Appraisal Well and undertaking wireline logging operations.

Following this, one (1) fracture stimulation treatment (one stage) will be performed on each Appraisal Well within the target zone. This treatment will consist of perforating the target zone and pumping a mixture of water with conditioning agents and sand (proppant) into the well at a high pressure in order to create and support small fissures through which gas can move into the wellbore.

Most of the conditioning agents used are found among household products or in industry. All fracture fluids and conditioning agents are approved and used in accordance with guidelines set down by the NT EPA, NT Department of Mines and Energy and other regulatory agencies. All fracture fluids and conditioning agents are managed with care to avoid any potential for impact on human health or the environment.

Following the single fracture treatments on both Appraisal Wells, the wells will be opened and 'flowback' consisting of diluted stimulation fluid and sand (from the stimulation operations) will occur. Flowback volumes vary depending on rock mechanics and parameters of the stimulated zone. Based on experience over decades from similar shale testing in the United States, it is expected that approximately 35-50% of the total injected fluid will be recovered.

Following initial flowback, the well will be production tested for up to 10 days for the purpose of observing and measuring flow rates and pressures of natural gas. All operations will be continually monitored and recorded.

The handling and storage of flowback fluids will comply with Clause 112(3) of the Schedule of Onshore Petroleum Exploration and Production Requirements 2012. Recovered fluid in the lined ponds will be pumped out into an NT EPA approved and licenced vehicle before being taken to the nearest NT EPA approved facility.

5. ENVIRONMENTAL RISKS OF PROPOSED ACTIVITY AND CONTROL MEASURES

Fauna and flora

The stimulation and testing program has been designed to ensure minimum impact on local flora and fauna. The stimulation and testing program will potentially be a minor temporary barrier to movement of fauna, however the small scale of the operational footprint (a 100m x 100m drill pad at either location) is unlikely to affect the migration or dispersal ability of fauna. Weed and pest inspections on all vehicles & personnel clothing will be undertaken prior to arrival at the sites and both will be appropriately fenced to minimise any risk to terrestrial species during operations.

Noise and surface

Speed limits will be enforced on access tracks to limit and minimise dust and noise generation. Vehicular movements to and from the work sites will be minimised by travel during daylight hours only and be compliant with land access agreements. Soil erosion will be minimised by the use of existing tracks, deviating around creeks, river banks and naturally formed depressions and not accessing unsealed roads in wet conditions.

Waste and chemical management

Waste will be stored in suitable receptacles and disposed of accordingly at municipal managed locations. Waste materials shall be transported, stored and handled in accordance with the requirements of the relevant legislation and guidelines. Chemicals will be stored and handled in accordance with relevant standards and guidelines and contained within the contractor's equipment.

Pangaea will implement the following strategies:

- Ensure that material handling and safety aspects of conditioning agents are in accordance with relevant Material Safety Data Sheets, relevant standards and guidelines including AS 1940;
- Regular audit of the primary contractor's management systems and operations to ensure compliance with the approved Environmental Management Plan (EMP) for the operations;
- On-site supervision to monitor conduct of operations and ensure any incidents are recorded and dealt with in accordance with the approved EMP;
- Using water, sand and conditioning agents to perform the stimulation operation;
- Containment of recovered flow back fluids in lined ponds;
- Monitoring and sampling of flow back fluids before treatment and/or disposal offsite at a NT EPA approved location;
- Management of flow back containment ponds to ensure their integrity;
- Removal of pond liner and disposal at an NT EPA approved waste facility; and
- Rehabilitation of containment pond sites post activities.

Groundwater

Potable and non-potable aquifers are isolated by several layers of steel casing and cement installed during the drilling process. The well design ensures the structural integrity within the wellbore to isolate the aquifers during stimulation, flowback operations and throughout the life of the well. Prior to the stimulation and testing operations described, well integrity tests have been successfully undertaken at both sites to ensure they maintain their integrity throughout the stimulation operation. Flowback stimulation fluid will be stored in lined and fenced off temporary containment ponds that are to be constructed to ensure no leakage to the environment. The containment ponds will be regularly inspected, bunded with a 1.5m earth wall and approved with an additional 30% over-capacity to avoid the risk of over-flow in the event of heavy rain events.

Pangaea commissioned an independent environmental baseline study to provide a robust record of significant water components such as hydrology, standing water levels and chemical compositions as they existed prior to drilling and stimulation testing. This study covers a large region and provides information both at the regional level and near the areas undergoing stimulation tests. The same methodology will be followed post-stimulation to document any unexpected change, or lack of change, in water conditions from the time of stimulation and testing. Pangaea will continue to assess, extend and analyse these studies throughout the course of its appraisal campaign.

6. CONSULTATION

During 2015, Pangaea has consulted with numerous stakeholders. Key consultation outcomes include:

- A detailed cultural heritage assessment and sacred site clearance process was agreed and completed with the Northern Land Council and Traditional Owners;
- The negotiation and signing of voluntary access agreements with directly-affected Pastoralists;
- Public availability to and direct engagement with communities and representative groups at exhibition booths during district and agricultural shows e.g. Katherine and Tennant Creek District Shows (2014, 2015);
- Notification to local government councils, police authorities and local businesses of exploration activities; and
- Compliance with legislation and guidelines from the NT Department of Mines and Energy and other regulatory agencies e.g. Department of Transport, NT EPA and Department of Infrastructure.

Pangaea's engagement process is aimed to identify and address issues of concern, reach agreement and in general engage in goodwill communication.

Pangaea will continue this process with stakeholders throughout the life of the project.

7. PANGAEA LIAISON PERSONNEL

Sydney Office		
Executive Director	Tim Radburn	Phone: (02) 9017 9600

MANBULLOO-S1

STRATIGRAPHIC DRILL HOLE

ENVIRONMENTAL PLAN SUMMARY

MANBULLOO-S1 STRATIGRAPHIC DRILL HOLE

ENVIRONMENTAL PLAN SUMMARY

TABLE OF CONTENTS

1. INTRODUCTION

EP167 is located approximately 350 km southeast of Darwin in the Northern Territory (NT) in the western McArthur Basin. The basin is essentially unexplored for hydrocarbons, either conventional or unconventional, and from a shale gas or oil perspective, there is limited information on thermal maturity, Total Organic Carbon (TOC), porosity, permeability, gas content or saturation. The tenement falls within the Victoria-Daly, Roper and Barkley Shires plus the Katherine Municipality.

The proposed Manbulloo-S1 stratigraphic drill hole will be located in the north western portion of EP167 in central Northern Territory, approximately 55 km south of Katherine and approximately 50 km west of the Stuart Highway. A location map and coordinates of the activity are provided in Figure 1.

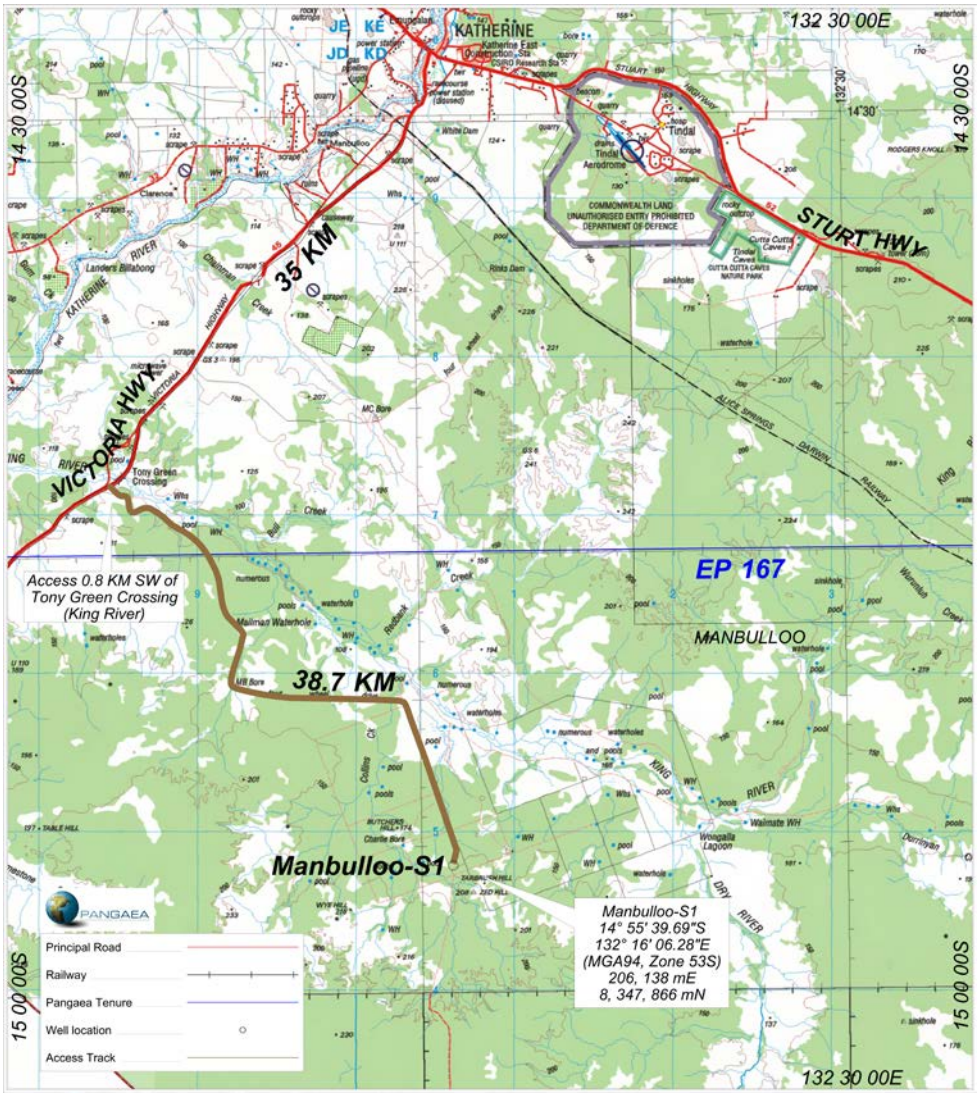

Figure 1: EP-167 Manbulloo-S1 Drill Hole site

2. DESCRIPTION OF ACTIVITY

The objectives of the Manbulloo-S1 Drill Hole in EP167 are to:

- Identify thick intervals of organic-rich shale within the wet to dry gas hydrocarbon generation windows;
- Confirm the stratigraphy and tie this stratigraphy to the regional seismic interpretation;
- Collect velocity information to improve the time to depth conversion for the regional seismic interpretation; and
- Evaluate the thermal maturity, gas content, gas saturation, gas composition, mineralogy, porosity and permeability of the shale units within the McArthur Group from core and wireline logs.

By way of summary, the evaluation proposed for the site will also comprise of coring and wireline logging operations. The final well will not be used to produce oil and gas, therefore Pangaea will plug and abandon Manbulloo-S1 by cementing the well from Total Depth (TD) to surface to isolate all porous formations, aquifers and potential reservoirs.

3. DESCRIPTION OF THE ENVIRONMENT

The region's climate is 'semi-arid tropical, with rainfall concentrated in the wet season months between November and April. Though rainfall can be variable from year to year, there is a distinct gradient of decreasing mean annual falls from 850mm in the north to less than 500mm' in southern areas of EP168, with nearly all the rainfall occurring between November and April[1,2]. The mean maximum temperature varies from 27°C in July to 40°C and beyond in November.

Condition is generally good across much of the bioregion, reflected in a continental stress class score of 5. However, as one of the most fertile areas in northern Australia, and because of its proximity to Darwin and Katherine, the bioregion is one of the most developed in the Northern Territory. About 8% of the region has been cleared for horticultural production or intensive grazing, and more extensive development is being proposed[3].

The Manbulloo-S1 drill site is located within the Tagoman land system. This land system consists of plains and rises on weathered and unweathered Cambrian limestone, sandstone and siltstone with associated sand sheets; sandy and earth soil. Soils are generally of variable depth comprised of red earth soils with gravel. Mixed eucalypt woodlands and perennial grasses grow in this area. The systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Tagoman land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening[4].

[1] Williams et al (1997) 'Torch, trees, teeth and tussocks' in *Frontiers in Ecology, Building the Links*. Eds. N. Klomp and I. Lunt. Elsevier, Oxford: pp55-66.
[2] Hennessy et al (2004) *Climate Change in the Northern Territory*, CSIRO, Melbourne, Victoria.
[3] Department of Land & Resource Management (2014) Daly Basin – Bioregional Description. Downloaded at http://lrm.nt.gov.au/plants-and-animals/herbarium/nature/bioregional/dalybasin#.U5RknV5Rf1o
[4] Northern Territory Government (no date) Land Condition Guide – Sturt Plateau District, Understanding the productivity of grazing lands. Produced in association with the Northern Territory Cattlemen's Association as part of the Caring for Our Country project 'Grazing Land Management – Demonstration, Continuation and Evaluation'.

4. DESCRIPTION OF THE ACTIVITY IN RELATION TO THE ENVIRONMENT

The Manbulloo-S1 stratigraphic drill hole has been designed with due consideration of the surface and subsurface environments. The site has been designed and will be constructed to avoid large scale levelling and clearance of vegetation.

The well has been designed to:

- Isolate permeable zones within the well;
- Protect potable water aquifers;
- Prevent uncontrolled discharge of water, gas or oil from the well while drilling; and
- Prevent cross flow between potential aquifers, reservoirs or formations.

These objectives are achieved by the appropriate selection of:

- Surface equipment (including drilling rig and well control equipment);
- Surface facilities/pits for the containment of drilling fluids;
- Casings and setting of casing depths to ensure aquifers are isolated;
- Drilling techniques;
- Down hole technology; and
- Well completion procedures.

5. ENVIRONMENTAL RISKS OF PROPOSED ACTIVITY AND CONTROL MEASURES

Fauna and flora

Potential impacts to surrounding flora and fauna at the well site will be assessed and reduced by measures including weed and pest inspections on all vehicles and personnel clothing prior to arrival at site, the use of signage and appropriate fencing.

Groundwater

The well will be grouted and completed according to industry best practice sealing requirements. Any well that encounters an artesian or sub-artesian flow will be sealed to prevent contamination or cross-contamination of aquifers and will be sealed with cement plugs to prevent surface discharge of groundwater. Appropriate sedimentation and erosion control measures will be put in place at the well site. The amount of hazardous material stored and used on site shall be kept to a minimum.

Noise and surface

Speed limits will be enforced on access tracks to limit and minimise dust and noise generation. Vehicular movements to and from the work site will be minimised by travel during daylight hours and be compliant with land access agreements. Soil erosion will be minimised by the use of existing tracks, deviating around creeks, river banks and naturally formed depressions and not accessing roads in wet conditions.

Waste management

Waste will be stored in suitable receptacles and disposed of accordingly at municipal managed locations. Hazardous material shall be transported, stored and handled in accordance with the requirements of the relevant legislation and guidelines.

6. CONSULTATION

During the past several months Pangaea has consulted with stakeholders, which has included:

- A detailed cultural heritage assessment and clearance process with the Northern Land Council and Traditional Owners;
- Signing voluntary access agreements with Pastoralists;
- Involvement in joint NTDME-APPEA-CSIRO public forums and information nights held in major towns and centres in NT;
- Notifying local government councils, police authorities and local businesses of exploration activities; and
- Complying with legislation and guidelines from the NT Department of Mines and Energy.

Pangaea's engagement aimed to identify and address any issues of concern, reach agreement and in general engage in goodwill communication.

Pangaea will continue this process with stakeholders throughout the life of the project.

7. PANGAEA RESOURCES LIAISON PERSONNEL

Sydney Office		
External Affairs Manager	[redacted]u	Phone: (02) 9017 9600

TARLEE-S3

STRATIGRAPHIC DRILL HOLE

ENVIRONMENTAL PLAN SUMMARY

TARLEE-S3 STRATIGRAPHIC DRILL HOLE

ENVIRONMENTAL PLAN SUMMARY

TABLE OF CONTENTS

1. INTRODUCTION

EP167 is located approximately 350 km southeast of Darwin in the Northern Territory (NT) in the western McArthur Basin. The basin is essentially unexplored for hydrocarbons, either conventional or unconventional, and from a shale gas or oil perspective, there is limited information on thermal maturity, total organic carbon (TOC), porosity, permeability, gas content or saturation. The tenement falls within the Roper Gulf Shire.

The proposed Tarlee-S3 stratigraphic drill hole will be located in the south-east portion of EP167 in central Northern Territory, approximately 150 km south of Katherine and approximately 40 km west of the town of Larrimah along Stuart Highway. A location map and coordinates of the activity are provided in Figure 1.

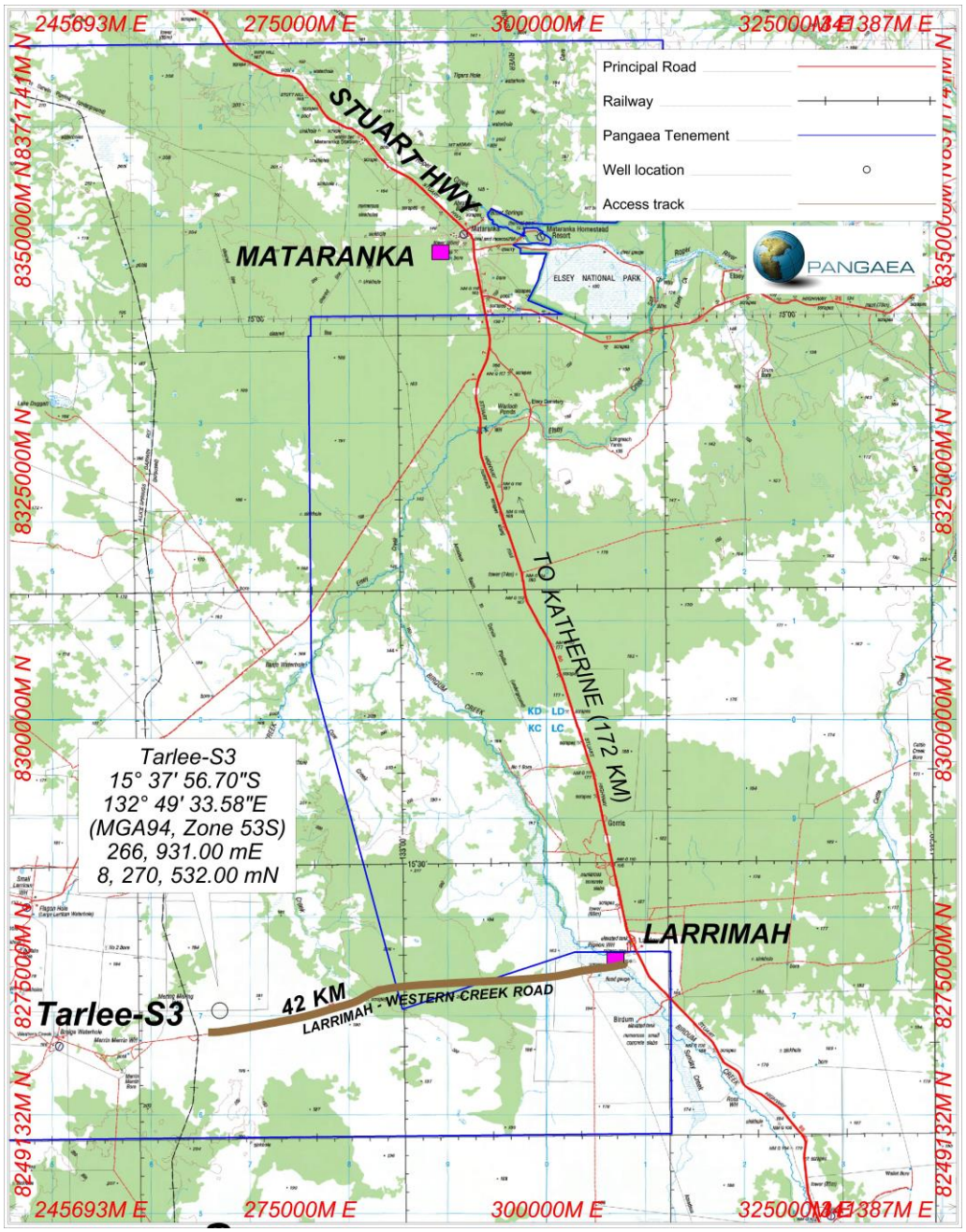

Figure 1: Tarlee-S3 Drill Hole site within EP 167

2. DESCRIPTION OF ACTIVITY

The objectives of the Tarlee-S3 Drill Hole in EP167 are to:

- Identify thick intervals of organic-rich shale within the wet to dry gas hydrocarbon generation windows;
- Confirm the stratigraphy and tie this stratigraphy to the regional seismic interpretation;
- Collect velocity information to improve the time to depth conversion for the regional seismic interpretation; and
- Evaluate the thermal maturity, gas content, gas saturation, gas composition, mineralogy, porosity and permeability of the shale units within the Roper Group from core and wireline logs.

By way of summary, the evaluation methodology and data acquisition will comprise mainly of coring and wireline logging operations. The final well will not be used to produce oil and gas, therefore Pangaea will plug and abandon Tarlee-S3 by setting cement plugs in the well to isolate all porous formations, aquifers and potential reservoirs.

3. DESCRIPTION OF THE ENVIRONMENT

The region's climate is *'semi-arid tropical, with rainfall concentrated in the wet season months between November and April. Though rainfall can be variable from year to year, there is a distinct gradient of decreasing mean annual falls from 850mm in the north to less than 500mm'* in southern areas of the adjacent EP168, with nearly all the rainfall occurring between November and April (see Williams *et al.* 1997[1], Hennessy *et al.* 2004[2]). The mean maximum temperature varies from 27°C in July to 40°C and beyond in November.

Condition is generally good across much of the bioregion, reflected in a continental stress class score of 5. However, as one of the most fertile areas in northern Australia, and because of its proximity to Darwin and Katherine, the bioregion is one of the most developed in the Northern Territory. About 8% of the region has been cleared for horticultural production or intensive grazing, and more extensive development is being proposed[3].

The drilling campaign, inclusive of access routes to the drill sites, will intersect with the Banjo land system. The Banjo land system consists of almost level to gently undulating plains on the plateau surface that lack drainage lines. Consisting of variable depth red earth soils with or without gravel; mixed eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Banjo land system consists of vegetation that has a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening[4].

[1] Williams, R.J., Cook, G.D., Ludwig, J.L. and Tongway, D.L. (1997). Torch, trees, teeth and tussocks: disturbance in the tropical savannas of the Northern Territory (Australia). In: Frontiers in Ecology. Building the Links. Eds. N. Klomp and I. Lunt. Elsevier, Oxford: pp55-66.
[2] Hennessy, K., Page, C., McInnes, K., Walsh, K., Pittock, B., Bathols, J, and Suppiah, R. (2004). Climate Change in the Northern Territory. Consultancy report for the Northern Territory Department of Infrastructure, Planning and Environment. CSIRO, Melbourne.
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[4] Northern Territory Government (no date) Land Condition Guide - Sturt Plateau District, Understanding the productivity of grazing lands. Produced in association with the Northern Territory Cattlemen's Association as part of the Caring for Our Country project "Grazing Land Management – Demonstration, Continuation and Evaluation".

4. DESCRIPTION OF THE ACTIVITY IN RELATION TO THE ENVIRONMENT

The Tarlee-S3 stratigraphic drill hole has been designed with due consideration of the surface and subsurface environments. The site has been selected and will be constructed to avoid large scale levelling and clearance of vegetation.

The drilling operation has been designed to:

- Isolate permeable zones within the well;
- Protect potable water aquifers;
- Prevent uncontrolled discharge of water, gas or oil from the well while drilling; and
- Prevent cross flow between potential aquifers, reservoirs or formations.

These objectives are achieved by the appropriate selection of:

- Surface equipment (including drilling rig and well control equipment);
- Surface facilities/pits for the containment of drilling fluids;
- Casings and setting of casing depths to ensure aquifers are isolated;
- Drilling techniques;
- Down hole technology; and
- Well abandonment procedures.

5. ENVIRONMENTAL RISKS OF PROPOSED ACTIVITY AND CONTROL MEASURES

Fauna and flora
Potential impacts to surrounding flora and fauna at the well site will be assessed and reduced by measures including weed and pest inspections on all vehicles and personnel clothing prior to arrival at site and the use of signage and appropriate fencing.

Groundwater
The well will be grouted and completed according to industry's best practice for sealing, plugging and decommissioning. Any well that encounters an artesian or sub-artesian flow will be sealed to prevent contamination or cross-contamination of aquifers and will be sealed with cement plugs to prevent surface discharge of groundwater. Appropriate sedimentation and erosion control measures will be put in place at the well site. The amount of hazardous material stored and used on site shall be kept to a minimum.

Noise and surface
Speed limits will be enforced on access tracks to limit and minimise dust and noise generation. Vehicular movements to and from the work site will be minimised by travel during daylight hours and be compliant with land access agreements. Soil erosion will be minimised by the use of existing tracks, deviating around creeks, river banks and naturally formed depressions and not accessing roads in wet conditions.

Waste management
Waste will be stored in suitable receptacles and disposed of accordingly at municipal managed locations. Hazardous material shall be transported, stored and handled in accordance with the requirements of the relevant legislation and guidelines.

6. CONSULTATION

During the past several months Pangaea has consulted with stakeholders, which has included:

- A detailed cultural heritage assessment and clearance process with the Northern Land Council and Traditional Owners;
- Negotiating and signing of voluntary access agreements with directly-affected Pastoralists;
- Involvement in joint NTDME-APPEA-CSIRO public forums and information nights held in major towns and centres in NT;
- Direct engagement with communities and focused groups at exhibition booths during district and agricultural shows eg. Katherine District Shows (18-19 July, 2014)
- Notifying local government councils, police authorities and local businesses of exploration activities; and
- Complying with legislation and guidelines from the NT Department of Mines and Energy and other regulatory agencies eg. Dep't of Transport and Dep't of Infrstructure.

Pangaea's engagement process is aimed to identify and address any issues of concern, reach agreement and in general engage in goodwill communication.

Pangaea will continue this process with stakeholders throughout the life of the project.

7. PANGAEA RESOURCES LIAISON PERSONNEL

Sydney Office		
External Affairs Manager	[redacted]	Phone: (02) 9017 9600

2014 NT EXPLORATION CAMPAIGN

HIDDEN_VALLEY-S2

ENVIRONMENTAL MANAGEMENT PLAN

Prepared For: **Pangaea (NT) PTY LTD**
Date: **June 2014**
Approved By:
Revision No: **Final_Revised**

2014 NT Exploration Campaign for Drilling Operations
HIDDEN_VALLEY-S2
ENVIRONMENTAL MANAGEMENT PLAN

Preparation of this Environmental Management Plan ("EMP") has been completed through a series of meetings and email correspondence, with close consultation involving all concerned parties. This EMP describes the environmental emergency contingencies and mitigation measures that are to be implemented by Pangaea (NT) Pty Ltd ("Pangaea"), its contractors and service providers when drilling in EP168 at Hidden_Valley-S2.

DOCUMENT CONTROL STATUS this is a controlled document				
File Path and Name:				
Operator:	Pangaea (NT) Pty Ltd	**Representative:**		
Title:	2014 NT Exploration Campaign, Hidden_Valley-S2 Environmental Management Plan			
REVISIONS				
1 2 Final Final_Revised	24-Mar-2014 27-Mar-2014 10-Apr-2014 13-June-2014	Initial Issue (Draft) Technical additions DME revision DME revision	Damian Wall Damian Wall Damian Wall Sarah Jordan	DW DW DW SJ
Rev	**Date**	**Reason For Revision**	**Author**	**Initial**
THIS REVISION				
Prepared By:		Prepared By:		
Name	Initial/Date	Name	Initial/Date	
S Jordan	SJ 140613			
Approved For Submission By:				

APPROVALS			
Name	**Position**	**Signature**	**Date**
Cesar Gonzalez	Project Coordinator		13/06/14
Tim Radburn	Corp Planning, Logistics & HSE Manager		13/06/14
Ricky Mantaring	Corp External Affairs		13-6-14
Gary Drummond	Director of Operations		
Joel Alnes	Vice-President of Exploration		13-6-14
John O'Neill	Executive Chairman		

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Major Drilling Australia	DRILLING CONTRACTOR	2
TBC	LAND & LOGISTICS REPRESENTATIVE	1
Mark Sullivan Contracting	EARTHWORKS CONTRACTOR	1
Location (each)	SITE OFFICE/CAMP	1
Local Authorities	EMERGENCY SERVICES	1

At least one up-to-date copy shall be maintained and made available at the operating area.

The following matrix has been developed to ensure compliance with the Department of Mines and Energy Guideline – Environmental Plan ("EP") Requirements.

Title in Guideline	Requirement	Section in this document
General	Version number or document reference for the EP	Title page
	Contain a document revision history	Page 2
	Include project proponent details	Page 2
	A document distribution list for the EP	Page 3
Corporate Environmental Policy		Page 11
Environmental Legislation and other requirements		Section 2
Project Activity Description		Section 3
Environment Description	Existing natural physical environment including geography, geology, climate, hydrogeology, hydrology, soils etc.	Section 8
	Existing natural biological environment including bioregions, flora and fauna, birds, fishes, reptiles, mammals, feral animals etc.	Section 8.2
	Cultural environment including Indigenous, European and others.	Section 8.4
	Current socio-economic environment including habitation, recreational and commercial and tourism.	Section 8.3
	Sacred and Cultural Heritage sites	Section 8.4.1
	Protected areas/Conservation Areas	Section 8.4.2
	Rare or endangered flora and fauna	Section 8.4.3
	Areas of significant habitat	Section 8.4.4
	Fire regime	Section 8.4.5
Environmental Risks and Impacts Description and Assessment.		Section 10
Performance Objectives, Standards & Measurement Criteria		Section 11
Implementation Strategy	Operation systems, practices and procedures that: • will be utilised to ensure that environmental impacts and risks are reduced to an agreed and acceptable level; and • are specific to the environmental performance objectives and standards.	Section 12.2
	Establishment of a clear chain of command including roles and responsibilities of personnel for the implementation, management and review of the EP.	Section 12.1
	Measures to ensure that employees and contractors are made aware of their responsibilities and have appropriate competencies and trainings.	Section 12.3

Title in Guideline	Requirement	Section in this document
Implementation Strategy	Planned monitoring, audit, management of non-conformance and review of environmental performance.	Section 12.5
	Specific reference to an appropriate Emergency Response Plan as well as an Oil Spill Plan that the operator has in place.	Section 13
	A recording system that maintains quantitative records of emissions and discharges to the environment which can be monitored and audited against the performance standards and measurement criteria.	Section 12.5
Reporting		Section 12.6
Consultation		Section 12.8

Summary

The objectives of the Hidden_Valley-S2 drill hole are to gather stratigraphic and rock properties data in EP168.

The western McArthur Basin is essentially unexplored for hydrocarbons, either conventional or unconventional, and from a shale gas or oil perspective, there is limited information on thermal maturity, Total Organic Carbon (TOC), porosity, permeability, gas content or saturation. The objectives of the test hole are to:

- identify thick intervals of organic-rich shale within the wet to dry gas hydrocarbon generation windows;
- confirm the stratigraphy and tie this stratigraphy to the regional seismic interpretation;
- collect velocity information in order to improve the time to depth conversion for the regional seismic interpretation; and
- evaluate the thermal maturity, gas content, gas saturation, gas composition, mineralogy, porosity and permeability of the shale units within the McArthur Group from core and wireline logs.

Hidden_Valley-S2 and associated camp site is located on pastoral land. The total area of land impacted by this activity will be approximately 3 hectares, where 1 hectare is used as the drilling pad and the rest as an exclusion/buffer zone. The proposed location will not create any significant long term impacts on local land use practices nor landforms. The test hole drilling is temporary and once completed, the well will be plugged and abandoned with the land being rehabilitated in full. In addition, the camp site component is fully transportable, demountable, self-contained and temporary.

Review of NT Department of Minerals & Energy (DME) flora and fauna threatened species data indicates that the proposed location will not impact on any known populations of rare or threatened species of native flora or fauna. Site selection has been based, in part, on the minimisation of vegetation modification to furthermore mitigate any residual risk of impact on such species or habitat.

Likewise, review of Aboriginal Areas Protection Authority (AAPA) data and consultation with the Northern Land Council (NLC) and Traditional Aboriginal Owners (TAOs) has indicated that the activities are not a threat to sites of Aboriginal cultural heritage significance.

This Environmental Management Plan (EMP) has been prepared in line with the relevant DME Guidelines: Environmental Plan (EP) Requirements, Applications for Drilling or Workover Rig Activities, Schedule of Onshore Petroleum Exploration and Production Requirements 2012 and Environmental Plan Summary. The provision of this document is aligned with the company's responsibility as per Clauses 109 and 112 of the Schedule and is cognizant of consequences embodied in Part V, Divisions 2 and 3 of the NT Petroleum Act, in which the determining authority (DME) is required to consider the likely and actual environmental impacts of the activity.

The information contained within this document is an accurate characterisation of the operational environment within which the activity is to be conducted. It is the opinion of Pangaea (NT) Pty Ltd that the impacts created by the proposed activity when considered alongside the mitigation strategies in place will create no long term effect on the localised and regional environment.

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Corporate Environmental Protection Policy

Policy Statement
Pangaea (NT) Pty Ltd ("Pangaea") is committed to the protection and preservation of the environment in the performance of its duties as an Exploration and Production company and provision of expertise to the petroleum resource industry. This commitment is embraced by the company's employees and sub-contractors.

Pangaea activities will be planned and performed in order to avoid or contain an acceptable level, adverse effects on the environment. These activities will also conform to all statutory requirements.

The purpose of this policy within our organisation is to provide the environmental objectives within our direct daily operations and related activities which must be auditable, and the criteria upon which achievement of those objectives can be assessed, for consideration under the Act.

Policy Details
Based on risks to the environment identified within the activities of Pangaea, the following are environmental objectives relevant to our operations:

1. Avoid disturbance to sites of indigenous and non-indigenous heritage of sociological significance;
2. Minimise disturbance to vegetation and ecological habitat;
3. Avoid disturbance to rare, endangered and vulnerable species; including minimise adverse impact on livestock;
4. Avoid impacts on high biological value or wilderness value areas;
5. Avoid facility and transport spills, including ensuring disposed formation water is oil free and biologically compatible and acceptable;
6. Avoid contamination of stock waters and soils with hydrocarbons or contaminants; and
7. Minimise visual impacts & environmental workforce hazards;

To comply with this policy Pangaea will:

a) Comply with applicable laws and regulations;
b) Where laws and/or regulations do not exist, conduct out operations applying responsible standards at all times, and, where applicable, act within the local environmental policies. Commit to a periodic and regular review of its Environmental Policy in the light of new technology, changing legislation, and recommended industry practices;
c) Assess potential environmental effects before conducting new activities. Encourage concern and respect for the environment. Ensure that employees and contractors are aware of their responsibilities with respect to environmental management and protection; and
d) Ensure contractors understand and adhere to the Pangaea Resources environment policy and standards as a minimum.

Implementation
The Directors are expected to demonstrate that the environment policy objectives are being met by employees and contractors. Environmental matters will form part of Pangaea's regular performance review process. The processes will be supplemented by periodic internal review.

Responsibilities
The Directors and Management Team are accountable for ensuring that this policy is implemented and that its effectiveness is reviewed. This policy will be updated every two years. All Pangaea staff and sub-contractors shall become familiar with, and comply with the environmental policy.

FORMS/DOCUMENTATION RELATED TO THIS POLICY

Pangaea Quality, Heath, Safety and Environment Policy (refer **Appendix A**)
Pangaea Quality Management Systems Manual
Pangaea Quality Health, Safety & Environment Management Systems Manual
Pangaea Risk Management System Manual
STEP Program
Pangaea Quality Action Tracking Register

REFERENCES

ISO 9001:2000, Quality management systems - Standard
ISO 14001:2004, Environmental management systems - Standard
ISO 19011:2011, Guidelines for quality and/or environmental management systems auditing – Guidelines
AS/NZS 4360:2004, Risk Management Framework – Standard
HB 139-2003, Guidance on Systems Integration – Guidelines

1.0 GENERAL GUIDELINES

1.1 Introduction

This document, the 2014 NT Exploration, Hidden_Valley-S2 Environmental Management Plan ("EMP") describes the roles and environmental responsibilities of all personnel. It also acts as a bridging document for principal contractors and details key environmental mitigation measures identified by Pangaea post identification of 'hazards & risks' and emergency response.

This EMP is to be read in conjunction with the Safety Management Plan ("SMP") and Emergency Response Plan ("ERP") which details the required response in the event of any emergency situation, environmental or otherwise.

The EMP also describes the interface arrangements between operations in the Pangaea Northern Territory ("NT") tenements and Pangaea Head Office, and highlights the technical, logistic and strategic support that is available in environmental emergency situations.

1.2 Proponent

Established in 1997, Pangaea is an independent exploration and production company with a diverse portfolio of oil and natural gas operations across onshore Australia. Pangaea commenced exploration in Queensland with the successful application for petroleum tenements south of Chinchilla. Since then, Pangaea expanded its activities and is now active in a number of areas exploring for and aiming to produce natural gas and oil.

The proponent is Pangaea (NT) Pty Ltd. Pangaea has 100% interest in all four NT permits (EP167, EP168, EP198 & EP169).

1.3 Purpose & Scope of this Environmental Plan

1.3.1 Purpose

The purpose of this EMP is to provide the framework for environmental management of the activities proposed in EP168 and to detail the control measures to be implemented to ensure that exploration activities are conducted in an environmentally responsible manner. This EMP applies to all exploration activities conducted by Pangaea at the Hidden_Valley-S2 site and aims to provide:

SECTION 2: An outline of environmental statutory responsibilities
SECTION 3: A summary of the exploration program and associated activities
SECTION 8: An outline of the receiving environment
SECTION 9: A summary of Environmental Risks & Hazards
SECTION 11: The Environmental Context and Mitigation measures
SECTION 12: A description of key personnel and responsibilities

1.3.2 Scope

This EMP has been prepared in compliance with the DME Guidelines: Environmental Plan (EP) Requirements, Applications for Drilling or Workover Rig Activities, and Environmental Plan Summary. This EMP covers all identifiable credible/identified potential environmental issues, mitigation measures, contingencies and emergencies identified considering the Hidden_Valley-S2 drill site.

1.4 Location and Resource Tenure

EP168 is located approximately 500 km southeast of Darwin in the Northern Territory (NT). The tenement falls within the Victoria-Daly, Roper & Barkley Shires plus the Katherine Municipality.

The proposed Hidden_Valley-S2 stratigraphic core well will be located in the central western portion of EP-168 in central Northern Territory, approximately 208 km south-southeast of Katherine and approximately 80 km west of the Stuart Highway

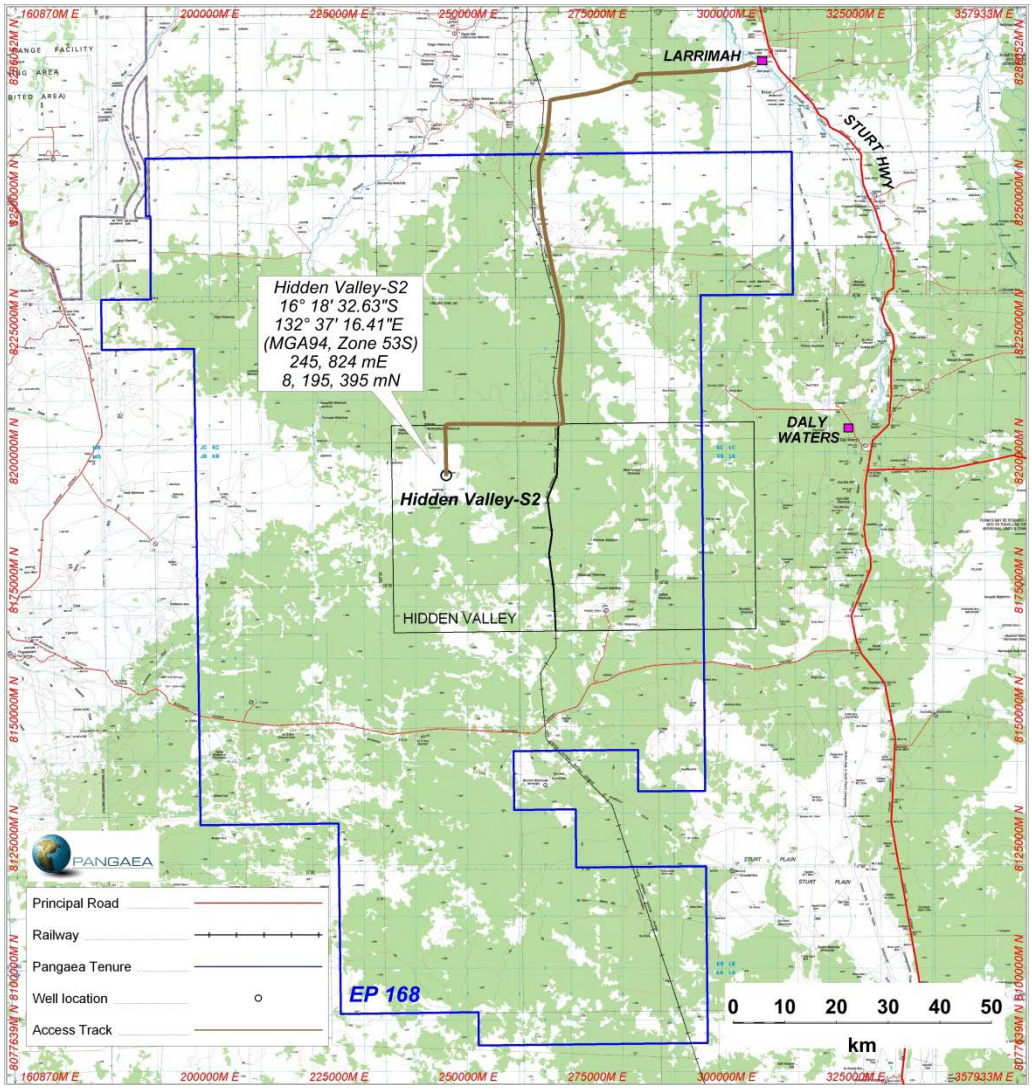


Figure 1: EP168 showing **Hidden_Valley-S2** drill site

1.5 Definitions

Environmental Emergency	An event that causes or has the potential to cause, material or serious harm to the environment.
Material Environmental Harm	An impact to the environmental that: (a) is not trivial or negligible in nature; (b) consists of an environmental nuisance of a high impact or on a wide scale; (c) results, or is likely to result, in not more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or (d) results in actual or potential loss or damage to the value of not more than $50,000 or the prescribed amount (whichever is greater).
Serious Environmental Harm	An impact to the environmental that: (a) is irreversible or otherwise of a high impact or on a wide scale; (b) damages an aspect of the environment that is of a high conservation value, high cultural value or high community value or is of special significance; (c) results or is likely to result in more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or (d) results in actual or potential loss or damage to the value of more than $50,000 or the prescribed amount (whichever is greater).
Incident Commander	The Pangaea Representative on site who has prime responsibility for the coordination of the emergency response on Pangaea's behalf.
EMR	Environmental Management Representative
OC	Pangaea Operations Coordinator
HSEM	Pangaea HSE Manager
ETL	Engineering Team Leader
DoO	Pangaea Director of Operations
VE	Pangaea Vice-President of Exploration

CEO	Pangaea Chief Executive Officer
PR	Pangaea Wellsite Representative
Contactor	Any principle contractor operating on a site within the tenement
CMT	Crisis Management Team (Sydney)
DME	Northern Territory Department of Mines and Energy
EMT	Emergency Management Team
Service Provider	Any services provided on site operated by principal contractor
ERO	Emergency Response Officer
ERT	Emergency Response Team
NLC	Northern Land Council
WR	Pangaea Wellsite Representative
EMR	Pangaea Environment Management Representative

2.0 STATUTORY CONTEXT

A variety of Exploration Permit Conditions and Legislation are relevant to the Hidden_Valley-S2 drill site. The Permit Conditions are discussed throughout this document and **Table 1** summarises the legislation that will be considered in this EMP.

Table 1: Summary of Relevant Legislation

Legislation	Requirements
Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (Cwth)	If threatened species, populations or ecological communities listed under the EPBC Act are likely to be impacted as a result of the exploration drilling activities, it is unnecessary to make a referral to the Environment Minister.
Native Title Act 1993 (Cwth)	The main objects of this Act are: a) to validate past acts, and intermediate period acts, invalidated because of the existence of native title, and to confirm certain rights in accordance with the Commonwealth Native Title Act; and b) to ensure that Northern Territory law is consistent with standards set by the Commonwealth Native Title Act for future dealings affecting native title.
Petroleum Act 2011	The objective of this Act is to provide a legal framework within which persons are encouraged to undertake effective exploration for petroleum and to develop petroleum production so that the optimum value of the resource is returned to the Territory.
Aboriginal Land Rights (Northern Territory) Act 1976	The Land Rights Act sets out how exploration must be done on Aboriginal land. The Act provides for consultation with traditional land owners and if approved, compensation agreements for exploration activities.
Environmental Assessment Act 2013	The object of this Act is to ensure that each matter affecting the environment is fully examined and taken into account in, and in relation to: a) the formulation of proposals; and b) the carrying out of works and other projects
Heritage Conservation Act 1991	The Act provides a system for the identification, assessment, protection and conservation of the Territory's natural and cultural heritage. Such heritage includes fossils, buildings, gardens, ruins, archaeological sites, landscapes, ecosystems, coastlines, plant and animal communities.
Plant Health Act 2008	The objects of this Act are: a) to ensure appropriate actions can be taken for the control of pests; and b) to facilitate the production and trading of plants and plant products that are free from pests.

Legislation	Requirements
Weeds Management Act 2001	The purpose of this Act is: a) to prevent the spread of weeds in, into and out of the Territory and to ensure that the management of weeds is an integral component of land management in accordance with the Northern Territory Weeds Management Strategy 1996 – 2005 or any other strategy adopted to control weeds in the Territory; b) to ensure there is community consultation in the creation of weed management plans; and c) to ensure that there is community responsibility in implementing weed management plans.
Waste Management and Pollution Control Act	The objectives of this Act are: a) to protect, and where practicable to restore and enhance the quality of, the Territory environment by: (i) preventing pollution; (ii) reducing the likelihood of pollution occurring; (iii) effectively responding to pollution; (iv) avoiding and reducing the generation of waste; (v) increasing the re-use and re-cycling of waste; and (vi) effectively managing waste disposal; b) to encourage ecologically sustainable development; and c) to facilitate the implementation of national environment protection measures made under the National Environment Protection Council (Northern Territory) Act.
Water Act 2013	This Act introduced in 2013 provides for the investigation, allocation, use, control, protection, management and administration of water resources, and for related purposes
Public and Environmental Health Act 2011	The Public and Environmental Health Act 2011 provides a contemporary, flexible framework for monitoring and regulating public and environmental health in the Northern Territory. By way of a summary, the primary objects of the Act that directly relate to the project are: a) to provide a flexible capacity to protect the health of particular individuals and communities in the Territory from emerging environmental conditions, or public and environmental health issues, that may impact on their health and wellbeing; and b) to monitor, assess and control environmental conditions, factors and agents, facilities and equipment and activities, services and products that impact on or may impact on public and environmental health.
Bushfires Act 2009	An Act relating to the prevention and suppression of bushfires.

Table 2: Summary of Relevant Code of Practice

Code of Practice	Requirements
The Northern Territory Weed Management Strategy	1. Preventing Introduction and Spread of Weeds 2. Ensuring Weeds Management is an Integral Part of Land Management 3. Learning More About Weeds in the Territory as an Essential Basis for Land Management 4. Increasing Public Awareness and Education 5. Providing Appropriate Legislation for Weed Management 6. Reviewing Progress in Weed Management
Community Engagement & Development	Specific aims are to: a) outline the benefits to companies and operations of engaging with, and contributing to, the development of communities; b) provide a framework to help operations and companies assess the maturity of their current approach to dealing with communities; c) describe the basic steps involved in effectively planning and managing for community engagement and development; d) set out key principles that should guide these activities; and e) highlight examples of evolving good practice.
Methodology for the Sampling of Ground Waters	This advisory note has been prepared to assist operators in the development and refinement of procedures for the collection and treatment of ground water samples.
APPEA Code of Environmental Practice 2008	The code seeks to ensure a standard of performance by reducing impacts to 'as low as reasonably practical and to an acceptable level' is a dynamic measure that will continue to evolve in line with improved risk identification and assessment methods, technological advances, changed circumstances, performance monitoring, government requirements, community expectations and other relevant information. As such, by reducing impacts to as low as reasonably practical, APPEA members will in effect be striving for continuous improvement.

Table 3: Summary of Current Agreements in Place

Agreement	Requirements
Co-Existence and Exploration Deed for *EPA 167, 168, 169 and 198*	The terms and conditions of agreement which has been reached between the Parties (Pangaea NT, Native Title Holders and the Northern Land Council) in relation to the exploration for gas and oil under the Petroleum Act.
Land Access Agreement	The terms and conditions of access agreement which has been reached between the Parties (Pangaea NT and the Leaseholders) in relation to the exploration for gas and oil under the Petroleum Act.

3.0 PROJECT ACTIVITY DESCRIPTION

3.1 Proposed Project Operations

The objectives of the 2014 NT Exploration Campaign on Drilling Operations is to gather stratigraphic and rock properties data by drilling & coring two Stratigraphic core holes and one Exploration well within tenements EP167 & EP168.

The western McArthur Basin is essentially unexplored for hydrocarbons, either conventional or unconventional, and from a shale gas or oil perspective, there is limited information on thermal maturity, Total Organic Carbon (TOC), porosity, permeability, gas content or saturation. The objectives of Hidden_Valley-S2 (stratigraphic hole) are to:

1. Identify thick intervals of organic-rich shale within the wet to dry gas hydrocarbon generation windows.
2. Confirm the stratigraphy and tie this stratigraphy to the regional seismic interpretation.
3. Collect velocity information in order to improve the time to depth conversion for the regional seismic interpretation; and
4. Evaluate the thermal maturity, gas content, gas saturation, gas composition, mineralogy, porosity and permeability of the shale units within the McArthur Group from core and wireline logs.

By way of a summary, the evaluation proposed for the site will also comprise of coring and wireline logging operations. The final well will not be used to produce oil & gas, therefore Pangaea will plug and abandon Hidden_Valley-S2 by cementing the well from Total Depth (TD) to surface to isolate all porous formations, aquifers and potential reservoirs.

Table 4: Hidden_Valley-S2 Well Data Summary

Well Name and Number:	Hidden_Valley-S2
Designation:	Petroleum stratigraphic core well
Permit:	EP-168
Basin:	McArthur Basin
Operator and Titleholder:	Pangaea (NT) Pty Ltd (100%)
Proposed Location: (MGA94, Zone 53)	Latitude 16° 18' 32.63"S (GDA94) Longitude 132° 37' 16.41"E (GDA94) Easting 245,824.00mE (MGA94, Zone 53) Northing 8,195,395.00mN (MGA94, Zone 53)
Property Description:	Portion 2724 – "Hidden Valley"
Seismic Reference:	Hidden Valley PB13 (2013), Line PB13-07, Shotpoint 1133
Predicted Elevation:	261.0 mAMSL
Predicted RT Elevation:	262.2 mAMSL
Anticipated Spud Date:	June 2014
Anticipated Total Well Days:	45.7 (Operational Days)
Drilling Contractor:	Major Drilling Australia Pty Ltd
Rig Name and Type:	UDR5000
Expected Hydrocarbons:	Oil and or gas within carbonaceous shale reservoirs (or natural fractures within the shale formations)
Estimated Total Depth:	1800.0 mRT

3.2 Technical Specifications

3.2.1 Hole Design

Protection of the subsurface environment is an important consideration. The intersection of aquifers from surface to total depth presents various issues to drilling as does the intersection of gas bearing formations. The design of the Hidden_Valley-S2 drill hole provides the mechanism by which the holes can be drilled with due consideration of the subsurface environment. The hole design has several objectives:

- To complete all operations without injuries;
- To protect potable water aquifers from contamination;
- To achieve permanent isolation of the permeable zones within the drill hole;
- To prevent uncontrolled discharge of water and gas or oil from the hole while drilling;
- To prevent cross flow between potential reservoirs or formations;
- To avoid the loss of equipment down hole; and
- To collect stratigraphic and rock properties data from core samples and wireline logging.

These objectives are achieved by the appropriate selection of:

- Surface equipment (including drilling rig and well control equipment);
- Surface facilities/pits for the containment of drilling fluids;
- Casing depths selection to ensure aquifers are isolated;
- Drilling techniques;
- Down hole technology; and
- Plug and abandonment procedures.

In combination, the selection of appropriate equipment and techniques that form the well design is documented in the drilling program for Hidden_Valley-S2. In general the well design for the well includes the following:

1. Surface hole will be drilled with Direct Circulation Air Drilling technique to avoid loss circulation of the drilling fluid and contamination of aquifers. Using air as a drilling fluid will allow drilling through the limestone, which has karst (caves, sinkholes and underground drainage systems) with minimal operational difficulties. Potential additives used during the Air Drilling operations may require minimal injections of a foam agent (biodegradable mixture of surfactants), a mineral oil for lubrication of ‘down-hole’ tools, a corrosion inhibitor and if required a polymer to provide stability if encountering reactive shales.

2. Surface casing will be set in a competent formation, and cemented into place to provide isolation of any fresh-water aquifers near surface from possible saline aquifers or potential hydrocarbon bearing zones. The surface casing also provides structural support for blow out prevention equipment. A formation integrity test will be conducted prior to drilling below the surface casing to ensure that pressured fluids found deeper in the well cannot break down the formation at the shoe and escape to surface in a well control event.

3. The intermediate section of the well will be drilled using Direct Circulation Air Drilling technique to maximize the rate of penetration due to the hardness of the formations being drilled in this section, and to minimize formation damage. Potential additives used during the Air Drilling operations may require minimal injections of a foam agent (biodegradable mixture of surfactants), a mineral oil for lubrication of down-hole tools, a corrosion inhibitor and if required a polymer to provide stability if encountering reactive shales.

4. An intermediate casing string will be cemented in place well to ensure wellbore stability during the coring activities to total depth.

5. Once core point is reached the drilling fluid will be changed over to a water based mud required for coring operations. The water based drilling mud will generally include fluid density additives such as potassium chloride, viscosofiers to help with cuttings lifting, and minor quantities of other additives for loss circulation control, wellbore stability and pH control. The level of fluid in the surface tanks and pits are monitored closely, with personnel residing on the well location to provide 24 hour supervision. The surface tanks and pits will not be permitted to overflow onto the well location.

6. Once drilling is complete, wireline logging will be performed, which allows continuous measurement of formation properties with electrically powered instruments. Measurements include electrical properties (resistivity and conductivity at various frequencies), sonic properties, active and passive nuclear measurements, dimensional measurements of the wellbore, wireline-conveyed sidewall coring tools, and others. For wireline measurements, the logging tool is lowered into the open wellbore on a multiple conductor wireline cable. Once the tool string has reached the bottom of the interval of interest, measurements are taken on the way out of the well bore.

7. The Hidden_Valley-S2 well will be plugged and abandoned following logging operations by completely filling the hole with cement from TD to surface.

3.2.2 Drill Pad

Well pad design and construction is designed to maintain a well-drained area suitable for the safe operation of drilling machinery and ancillary equipment in all but the heaviest rainfall. Installation of drainage lines to prevent the retention of meteoric water on or around the site will be included in preliminary earthworks should a requirement be identified. Further consultation with pastoralists in this regard will characterize any site specific requirements for drainage improvements to be implemented. **Figure 2** shows the proposed layout for Hidden_Valley-S2.

The preparation required to provide a suitable drill pad is relatively minor. The preparation activity will be limited to the removal of all vegetation over the 100m x 115m site plus the exclusion zone and fire break, excavation of the flare pit, sumps and the water reserve pit (“turkey’s nest”) and installation of the surface cellar.

The importation of gravels for stability improvement is likely to some degree, however with modern drilling rigs possessing self-levelling hydraulics this will be small quantities spread over very specific areas rather than full pad sheeting. The well pad will also house the mobile campsite and are only as large as required by safety parameters.

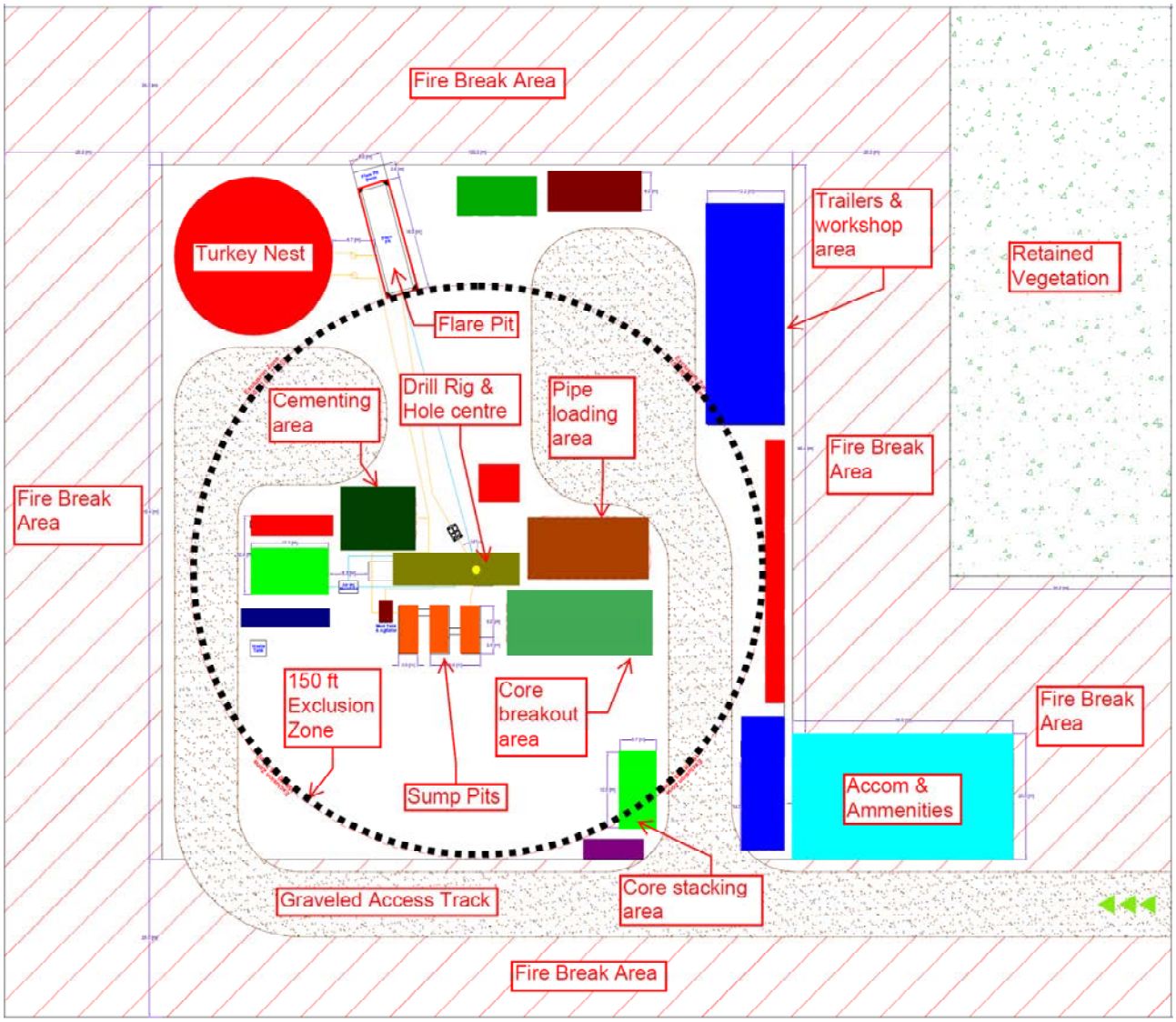


Figure 2: Well Pad Layout – Hidden_Valley-S2

3.2.3 Drilling Operations

Aqueous drilling fluids generally comprise of water and various additives such as food grade viscosifiers, pH stabilizers such as acids and caustics and clay inhibitors. Potassium chloride has been commonly employed to increase density in lightweight drilling fluids. Mixed onsite by the drilling contractor, the mud is usually stored in either integrated mud tanks or purpose built containment pits and introduced into the well during drilling.

The term 'drill cutting' describes the material generated from the drilling activity once removed from the drilling fluids. Varying is size depending on the type of drill bit employed; the cuttings can range in size from coarse sand like material to > 5 mm in diameter. Any gas hydrocarbons that are encountered will be flared at the flare pit while air drilling or if necessary during well control procedures. Any liquid hydrocarbons that are intersected and brought to surface during drilling will be caught in the drilling sumps (mud pit).

At the completion of drilling and plugging/abandonment; sumps (mud pit), flare pit, and turkey's nest are all left to dry out, before being backfilled to return the areas to an appropriate slope (considering the landscape's 'pre-drilling' characteristics). If hydrocarbons were detected during drilling and bought to the surface, the contents of the mud pit will be tested (to determine if the contents are to be considered 'contaminated') and once analysed, appropriate disposal options will be implemented.

3.2.4 Contractors & Support Companies

Contractor or Service Company	Service	Contact Details
Major Drilling	• Drilling Rig Contractor • Air Drilling • Coring • Mud & Chemicals • Cementing	Matthew Metz [redacted] www.majordrilling.com
Weatherford	Wireline Logging	Behzad Marzban [redacted] www.weatherford.com
Mark Sullivan Contracting	Earthworks Contractor	Mark Sullivan [redacted] Po Box 4088, Mataranka NT 0852

3.2.5 Rig & Support Facilities

Major Drilling will provide a UDR5000, which is a very high capacity multi-purpose specialised deep hole drill rig. It is highly effective in diamond coring and rotary drilling techniques. The UDR5000 is well suited for stratigraphic and shallow oil and gas drilling applications.

Mobilisation of the rig will require approximately 17 truckloads, including the Air Drilling Package and all tubulars required for drilling operations. **Table 5** shows the rig specifications.

Air Drilling Package

- 1 x 1150/350 Sullair Compressor
- 1 x 900/350 Sullair Compressor
- 1 x Western Air 1800/900 Compressor/Booster Combo Pack

Rig Crew

- 1 x Rig Manager
- 2 x Drillers
- 2 x Assistant Drillers
- 2 x Derrickman
- 2 x Floorhand
- 2 x Leasehand
- Catering/Camp Staff (2 persons)

Table 5: Rig Specification - UDR5000

Drill Mast	• 12 metre rod pull capacity • Capable of angles from vertical to 60° • Dual point mast pivot frame • 1300mm mast dump • Adjustable plug slide • Mast top platform with finger board for rod racking • Mast racking capacity 3,050 m CHD101 @ 90° • Mast racking capacity 4,100m "N" @ 60°
Diesel Engine	• Cummins N Series • 438 HP @ 1800 RPM • Standard soundproofed canopy to reduce noise
Standard Rotation Head	• UDR two speed top head drive • High - low manual gear change • Stepless speed control • 5 - 201 rpm low gear, 201 – 2250 rpm high gear • Floating spindle design • Oil jet lubricated gears and bearings • Built in 2000psi capacity mud swivel
Rotation Head Output Torque	• 10,180 Nm @ 5 – 210 rpm • 1,298 Nm @ 1500 rpm 859 Nm @ 2250 rpm
Optional Rotation Head	• UDR D30 two speed top head drive • High - low manual gear change • Stepless speed control • 48 - 200 rpm low gear, 200 – 1500 rpm high gear • Floating spindle design • Oil jet lubricated gears and bearings • Built in 2000psi capacity mud swivel
Optional Rotation Head Output Torque	• 25,780 Nm @ 5 – 73 rpm • 3,438 Nm @ 550 rpm • 1,260 Nm @ 1500 rpm
Head Traverse	• Hydraulic cylinder over ropes 2:1 ratio • Maximum speed 23.3 m/min upwards • Maximum speed 18.8 m/min downwards • Hydraulic rotation head rack back
Pull Down	• 130 kN (30,000 lbf)
Pull Out	• 450 kN (100,000 lbf)

Earthworks Equipment

- Graders
- Water Trucks
- Dozer
- Loader
- Rollers
- Excavator
- Side Tippers
- Camp

Other Vehicles

Including operator, contractor and service companies an approximate of 6 vehicles (4 x 4) and a truck will be required for the purpose of transportation of crew, supplies (water, food, drilling equipment).and waste removal from the location.

4.0 GROUNDWATER TESTING

Pangaea has committed to a two phase groundwater testing program. The two phases include 1) a baseline assessment of existing conditions (pre-drilling) and 2) groundwater quality analysis. Collection of this data will help to:

- Characterise existing groundwater systems;
- Identify levels and quality of bore water within the region; and
- Enable maps and trend plots to be developed by recording Standing Water Levels (SWL) at the time of testing.

4.1 Methodology

4.1.1 Pre Assessment

Pangaea, through the engagement of a third party specialist, will assess a 'Bush Bore' located on Hidden Valley Station (approximately 4.5km North-West of the drill site – 244797E / 8196970N). The data (and associated analysis) will form the basis of a baseline assessment of groundwater conditions, including (but not limited to) details on standing water levels, and groundwater quality in the region, prior to any drilling activity as it is proposed in this EMP.

Sampling will be conducted by a third party specialist who will apply a consistent methodology employing best practice techniques and equipment, and appropriate quality assurance and quality control (QAJQC) ensures that the risk of contamination is minimised in the collection of samples for testing. The development of the methodology was tailored to site specific and operational conditions and draws upon:

1. Groundwater Sampling and Analysis- A Field Guide, Australian Government geoscience Australia, 2009; and
2. AS/NZS 5667:1998 Water Quality - Guidance on Sampling of Groundwater.

At the time of finalising the EMP, the salinity of the groundwater at Bush bore was unknown as it has not previously been tested. Parameters that are to be measured in the field include pH, specific conductivity, electrical conductivity (EC), temperature, dissolved oxygen (DO) and redox potential (Eh). Field parameters are to be measured in a flow cell to avoid contact and contamination between the groundwater and the atmosphere. Field parameters are to be measured using a multi-parameter meter and the multi parameter calibrated against known standards before each use according to manufacturer's requirements. Calibration records are to be kept detailing the date, time and values of each calibration.

Laboratory sampling will test for all elements that are proposed to be used 'down-hole' during the drilling campaign. These parameters include major cations, major anions, alkalinity and hardness, a selection of dissolved metals, methane, nutrients, tannins, silica (reactive), TRH, TPH and BTEXN. Note that the cations/anions and dissolved metal suites will cover the major constituents of bentonite, KCl, NaCl, NaOH and lime (i.e. CaO/Ca(OH)2). All Material Safety Data Sheets (MSDS) for all additives used will be submitted as part of the Drilling Program.

4.1.2 During – Active Monitoring

Consistent with 4.1.1 the defined method and scope of monitoring during the campaign will be specified for water testing. This requirement will also be reviewed each calendar year at a minimum.

4.1.3 Post Monitoring

Consistent with 4.1.1 and 4.1.2 the defined method and scope of monitoring post the campaign will be specified for water testing. This requirement will also be reviewed each calendar year at a minimum.

5.0 CIVIL WORKS

5.1 Grading & Gravel Sheeting of Existing Access Roads

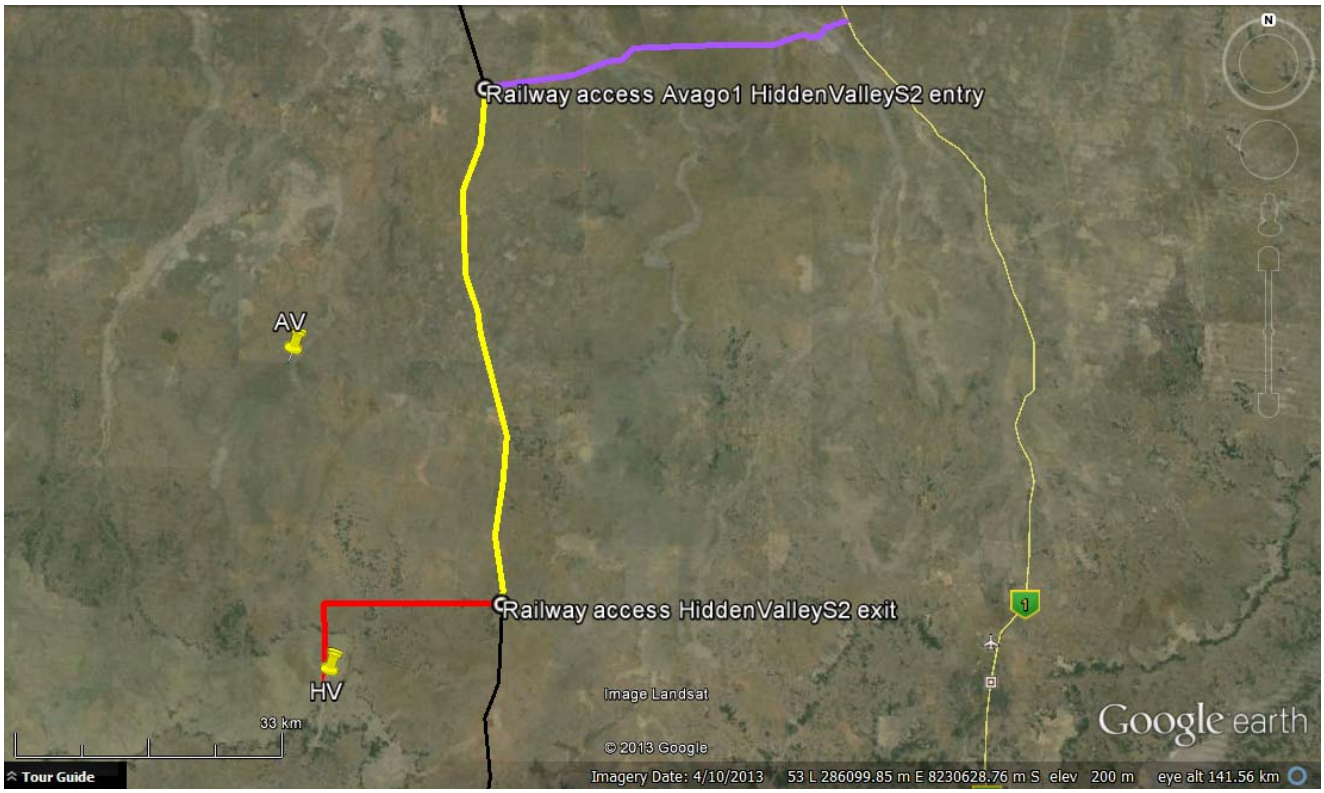
A total of 142 km of established unsealed roads, access tracks and fence lines will require varying degrees of grading and gravel sheeting in order to facilitate effective and safe access to the Hidden_Valley-S2 drill site. All works on public roads (which includes 46km of Weston Creek Larimah Road west from the Stuart Highway) will comply with the relevant Acts, Regulations, Guidelines and Codes applicable to the works and comply with the requirements of Authorities with jurisdiction over the works. In particular, the works will conform to the standards and publications quoted throughout Department of Construction & Infrastructure, *Standard Specification for Road Maintenance, 2012*. Works on pastoral land, that is not publically accessed will be restored to an agreed condition in accordance with the Petroleum Act.

All gravel material will be obtained from sources of naturally occurring deposits and the required material properties will be achieved by crushing, screening, mixing or other processes necessary. The sub-contractor will ensure that particles are tough, durable and of a tightly binding nature free of organic or other deleterious matter. Materials, wherever practicable, will be obtained from existing borrow pits.

A 64km section of the Darwin to Alice Springs Rail Corridor will be used for access to Hidden Valley Station. Application has been made to the NT Government for permission to access the rail corridor for the specific use of rig mobilisation which will cross the railway at a single location (**Figure 3**). On the western side of the rail corridor, 32km of existing fence lines (that were also used for seismic acquisition in 2013) will gain access to the drill site.

A Traffic Management Plan will be prepared by MSC (earthworks contractor) in consultation with Major (Rig Mobilization Contractors). It is likely that a Traffic Management Plan sub-contractor will be engaged to assist in this regard as was the case in the 2013 Seismic program when the primary contractor engaged ACE Traffic Management Solutions, based in Katherine.

Figure 3: Proposed Access to Hidden_Valley S-2



5.2 Drilling Camp

Major Drilling will provide an adequate housing/camp, messing facilities and amenities for 24 persons, which will be sub-contracted from Alluvial Contracting Services and includes the following:

- 1 x Kitchen (Caravan)
- 1 x Kitchen Store & Thawing Room (Caravan)
- 6 x Bunkhouse (Caravan) – 4 rooms per caravan
- 1 x Ablution Block (Caravan)
- 1 x Sewage Treatment Plant

The campsite power supply is generated by a portable generator. Refuelling of the self-contained unit depends upon the camp capacity during operations, however on average on-site refuelling will occur every 2-4 weeks during camp operation. Several daily checks and general monitoring schedules are carried out as per standard operating procedures.

As a minimum a transportable and fully self-contained sewage treatment plant will support the drilling operations team. An Enviro-Flow unit (or similar) will provide a final water quality suitable for surface irrigation via a sprinkler attachment. The final system will (as a minimum) be selected based upon 300L / person / day. Sludge/solid material will be reduced by anaerobic decomposition and removed from site (via tanker to a licensed facility). This is not anticipated to happen during the drill campaign.

All general waste generated by the campsite operation and the on-site facilities at the drilling rigs, will be disposed of through contract with a waste management company out of Katherine on a weekly basis.

5.3 Timeframes

Works on access tracks will begin in May 2014 and the drill site is to be prepared at the same time.

6.0 ACCESS TO LAND

The activities associated with the Hidden_Valley-S2 drill site will be carried out on one (1) pastoral station lease (Hidden Valley Station) on the Sturt Plateau. Critical to the ease of access, transport, and conduct of drilling operations is the leaseholder and company communication and liaison. A key feature of leaseholder negotiations, in addition to those stipulations under Sections 65, 81 and 82 of the NT Petroleum Act 2011, has been the focus on implementing the road access, drill and camp site preparations and logistics program with minimal disruption to present land uses, lessening impacts on existing infrastructure and integrating with pastoral work, livestock production and annual planning.

The voluntary leaseholder access and compensation agreement includes a code of conduct of operations with stated conditions of entry, types of petroleum operations, adherence to weed management and erosion prevention protocols, rehabilitation and compensation structure. The agreement generally reflects a focus on impact minimisation, community acceptance and satisfaction.

Direct impacts on leaseholder and pastoral enterprises are a key concern to Pangaea. Active engagement has provided the foundation for negotiation with the pastoralist and the terms of access to the land and the specific items of compensation are agreed to and listed in the access agreement prior to any activity occurring.

Pangaea has so far achieved a win-win situation and built solid working relationships with the pastoralist. The operation of the exploration project in the region and the perception of the company in the local and wider NT community is an important consideration that remains at the forefront of company policy. The drill site, camp site and key access route chosen attempts to minimise impacts on the community (e.g. noise, dust and incidental nuisance) and specific mitigations are put in place where necessary, fostering good faith with the pastoralist and the local community. All operations as they are currently proposed and assessed in this EMP have also been ‘culturally cleared’ by the NLC and TAOs.

7.0 REHABILITATION

At the completion of the drilling and core collection activities and the plug and abandonment procedures implemented as per the drilling proposal, rehabilitation activity can commence. The campsite may remain in-situ (with the pastoralists agreement) until such time that Pangaea have no further need for the site facilities – upon which time the site will be rehabilitated.

The process includes the removal of the surface cellar, cutting back of surface pipe to cellar depth, the removal of all imported gravel materials (or relocation as directed by the pastoralist), the replacement of stockpiled topsoils and overall rehabilitation activity (promoting ground-cover by any means deemed appropriate for the Land System). The methods, timing and overall objectives of the rehabilitation program are a specific part of the access and compensation agreement.

A Rehabilitation Plan has been developed for the Hidden_Valley-S2 drill site and is found in **Appendix B**.

An Erosion & Sediment Control Plan (**Appendix C**) has also been developed, which builds upon the guidelines developed by the Rehabilitation Plan.

8.0 ENVIRONMENT DESCRIPTION

8.1 Physical Environment

8.1.1 Climate

The region's climate is 'semi-arid tropical, with rainfall concentrated in the wet season months between November and April. Though rainfall can be variable from year to year, there is a distinct gradient of decreasing mean annual falls from 850mm in the north to less than 500mm' in southern areas of EP168, with nearly all the rainfall occurring between November and April (Hennessy et al, 2004; Williams et al, 1997). The mean maximum temperature varies from 27°C in July to 40°C and beyond in November.

8.1.2 Geology

The basin is a Pre-Cambrian Basin that has more than 3,000 metres of sediment column in which the identification of source rocks has been confirmed on the three unconventional oil and gas generating geological formations of the Barney Creek, Kyalla and Velkerri Shale. Each source rock is widespread, with thickness of up to 800 metres. There are also indications that high quality conventional reservoirs could exist.

8.1.3 Soils

EP168 is located on the Sturt Plateau which forms part of a largely un-dissected, deeply laterised Tertiary surface, covered mainly by red and yellow earth soils. There are also areas of alluvial cracking clays on the Sturt Plateau but they do not feature as often as in the Victoria River region further west. Clear relationships exist between soils and the parent material, drainage and climate in the region. Well-drained, steep hilly country with rock outcrops tends to have shallow skeletal soils. Deeper soils (two to three metres depth) are largely confined to poorly-drained, flatter country (e.g. basalt plains and rises). Duplex soils are commonly found in the channel banks and levees of major drainage lines. These soils have high pastoral productivity but are typically very susceptible to erosion.

8.1.4 Land System

The drilling campaign, inclusive of access routes to the drill sites, is likely to intersect with the Banjo land system. The Banjo land system consists of almost level to gently undulating plains on the plateau surface that lack drainage lines. Consisting of variable depth red earth soils with or without gravel; mixed eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Banjo land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening.

8.1.5 Water

The waterways within the region all offer valuable habitat for aquatic plants and animals as well as important associated riparian vegetation. The Aboriginal cultural values of these areas are of outstanding regional and national significance in many areas.

Traditional Owners use the many creeks and rivers for hunting, fishing and the collection of traditional resources such as bush tucker, medicines, fibre, ochre, and timber. Maintenance of access to the land and its resources is critical for Traditional Owners to exercise their responsibilities in relation to land, law and culture.

Riparian vegetation also generally supports a high species richness of both plants and animals. As they retain moisture for longer periods than surrounding vegetation they provide important food and refuge areas. Protection of riparian vegetation from fire is also critical for general river health. Seismic alignments have been designed to avoid major watercourses for all the reasons above. No water from surface watercourses will be used for drilling the Hidden_Valley-S2 hole.

<u>Groundwater</u>
It is estimated that approximately 0.5 ML of water from existing bores will be required at the drill site for drilling & camp operations.

8.2 Biological Environment

8.2.1 Bioregions

The Sturt Plateau bioregion mostly comprises a gently undulating plain underlain by Cretaceous sandstones. Soils are predominantly neutral sandy red and yellow earths. The most extensive vegetation in the bioregion is eucalypt woodland (dominated by variable-barked bloodwood Eucalyptus dichromophloia) with understoreys of mid-height tussock grasses on the plains and soft spinifex & tussock grasses on the ridges. There are also large areas of lancewood (Acacia shirleyi) thickets, bullwaddy (Macropteranthes keckwickii) woodlands, Acacia shrublands on deep sands, and eucalypt open forests - dominated by a range of species including Darwin stringybark (E. tetrodonta) - over tussock grass understorey (Department of Land & Resource Management, 2014).

Most of the bioregion is generally in moderate to good condition, due at least in part to the lack of intensive development. There are pervasive, but generally minor impacts associated with weeds, feral animals, pastoralism and changed fire regimes (Department of Land & Resource Management, 2014). The Sturt Plateau bioregion is currently listed as a high priority conservation area in the Interim Bio-regionalisation of Australia Report due to its under-representation and potential biodiversity (Parks & Wildlife Commission, 2005). However, there is 'some conservation management occurring on some pastoral properties in the bioregion, principally through exclosure fencing of wetland and riparian areas' (Department of Land & Resource Management, 2014).

8.2.2 Flora

The average rainfall for the Sturt Plateau is 640 mm, although annual falls fluctuate between 500 mm and 800 mm. Nearly all the rainfall occurs in the months between November and March. There is a gradual shift in the relative abundance of particular vegetation species from the north (EP167) to south (EP168) such that the latter regions are dominated by a different suite of species to that of the north.

Upper stratum are often dominated by Eucalyptus and on clay soils. Acacia woodlands, dominated primarily by *Acacia shirleyi* (lancewood), are by far the most extensive plant communities throughout the Beetaloo tenements, followed by eucalypt savannah woodlands which typically have a sparse canopy, a dense tall grass understorey supporting seed-eating birds and exposure to frequent fire.

Of particular note, within the Sturt Plateau, lancewood often occurs with the restricted, Northern Territory endemic plant, *Macropteranthes kekwickii* (Bullwaddy) interspersed as either a co-dominant or dominant species. These woodlands typically have a dense shady shrub layer, a few vines and creepers and little in the way of grass understorey.

8.2.3 Weeds

Compared to other grazing regions, the Sturt plateau is relatively weed free. There are limited infestations of bellyache bush (*Jatrophagossypifolia*), devil's claw (*Martyniaannua*), hyptis (*Hyptissuaveolens*) and Sida spp. The spread of weeds however will probably increase as the area becomes more populated and developed.

A total of 17 weed species been recorded in EP168. The majority of these recordings are roadside based or on crossing points of major rivers/creeks (i.e. trafficable areas). Most of the important weeds requiring management attention are usually most prevalent in riparian habitats, are spread by wet season floodwaters or are associated with water-holding black soil areas.

Weed control works on pastoral land generally take into consideration weed risk (invasiveness, impacts on grazing land/land value and potential distribution) as well as feasibility of control (control costs, current distribution and persistence). Importantly, there is also a legal obligation to control all weeds declared under the Weeds Management Act.

Weed prevention and mitigation measures being taken by Pangaea with regards to drilling operations are detailed in **Section 11.0**.

8.2.4 Fauna

This Sturt Plateau doesn't contain especially rich nor distinctive biota. The mammal fauna includes unusually abundant populations of the spectacled hare-wallaby (*Lagorchestes conspicillatus*), especially in the lancewood-bullwaddy thickets (Woinarski and Fisher 1995a), and the northern nailtail wallaby (*Onychogalea unguifera*), especially in grasslands and open woodlands along the margins between black-soil plains and red loamy soils.

Reptiles largely restricted to this ecoregion include *Suta ordensis* and *Varanus kingorum*. The agamid lizard (*Cryptagama aurita*) has a small distribution, concentrated in this region. Some burrowing frogs, most notably *Cyclorana cryptotis* and *C. maculosus*, are largely restricted to the deep red earths of this ecoregion, and may reach extremely high densities when they emerge with the first rains of the wet season.

The threatened purple-crowned fairy-wren (*Malurus coronatus*) has a major stronghold in riparian vegetation in this ecoregion and the grasslands and savanna woodlands support a very rich and abundant assemblage of granivorous birds, including the endangered gouldian finch (*Erythrura gouldiae*).

8.3 Socio-Economic Environment

8.3.1 Population Centres

Towns within the Stuart bioregion include Larrimah and Daly Waters. The pastoralists of the Sturt Plateau are largely new to the area and relatively young by Australian grazier standards. There is a strong sense of community in the region with a free-flow of information about water supplies, grazing management, cattle nutrition and personal development. Improving water supplies (mainly bores but increasingly dams and pipelines) has been a high priority and profitability is dependent on beef price; many stations rely on a healthy live-cattle export market to remain economically viable.

8.3.2 Land Use

Approximately 77% of the Sturt Plateau bioregion area is grazed by cattle. This area has not changed appreciably over the last 20 years. Of the total tenement area (47,362 km^2), pastoral leases and freehold make up 93%; less than 0.1% is reserved for conservation (Elsey National Park and Gregory National Park). There are a total of 40 properties within the Stuart Plateau tenements, most of which are family-held and operated, grazing approximately 300,000 cattle on 3.124 million hectares.

The favourable cattle country is well-developed with fencing and watering points. There has been little clearing except for the cropping/pasture improvement schemes in the northern areas. Land management is based around fire and control of stocking rates. Wild fires are an annual problem although internet access to real-time fire mapping has significantly improved fire management.

8.3.3 Cultural Heritage

For the Traditional Owners, the land is vested with spiritual significance and is an integral part of their cultural identity. EP168 encompasses the traditional lands of several Aboriginal language groups and people of each group continue to use the natural resources of the region, protect sites of significance and maintain cultural traditions through ceremony and ritual.

Numerous archaeological sites bear testimony to a long history of Aboriginal occupation. Traditional Owners have obligations to look after their country and believe that their relationships with country involve mutual rights and responsibilities. In addition, the Aboriginal history of the area since settlement is closely interwoven with European pastoral history and of this, a rich oral tradition remains.

8.4 Environmental and Cultural Sensitivities

8.4.1 Sacred & Cultural Heritage Site Protection

The activity area has been the subject of an ethnographic sacred site avoidance survey. The Northern Land Council (NLC) has developed and provided a report which, in accordance with clause 5.25 of the Co-Existence and Exploration Deed for EPA 167, 168, 169 and 198, does not clear any works conducted outside the areas identified in the 2014 Work Program and does not apply to any substantial modification of works.

Pangaea requested a search of the Aboriginal Areas Protection Authority (AAPA) records to identify potentially culturally sensitive areas as an added measure prior to entering the field. The resultant abstract map, whilst not a definitive way of determining the location of all sacred sites in a given area, was useful in determining the placement of the Hidden_Valley-S2 drill site.

The search of APPA records identified a range of “registered sacred sites” and “recorded sacred sites” together with accompanying Restricted Works Areas that have already been issued an Authority Certificate. In accordance with AAPA’s recommendations, Pangaea has sought further detail in regard to Restricted Works Areas and has viewed numerous Authority Certificates in the Darwin AAPA Office. Pangaea is satisfied that the works described in the EMP (this document) are not at odds with the directive(s) provided by the Authority Certificates.

Survey by helicopter was undertaken by an NLC Anthropologist, the EMR and Traditional Aboriginal Owners (TAOs) and custodians in February 2014. The TAOs have culturally cleared all ancillary works (including grading and sheeting of access tracks), establishment of the drill site, the process of drilling and the reasonable removal of vegetation.

Insofar as reasonably practicable, Pangaea has also avoided landscape features that have a high probability of being culturally significant. The drilling campaign has been communicated to the NLC and TAOs to ensure informed consent and minimise the risk of disturbing a sacred site or culturally significant landscape.

In addition to the measures described above, Pangaea has also conducted a search of the NT Heritage Register & the NT Archaeological Site Register, administered by Department of Lands, Planning and the Environment (as defined in the Heritage Act 2011). The search identified one Declared Heritage Place (Murranji track Surveyor Well's Cairn) within EP168. The Hidden_Valley-S2 site is not located within 50km of this area.

8.4.2 Protected Areas

No protected or conservation areas exist within the EP168.

8.4.3 Threatened Flora and Fauna

According to data obtained from the NT Government (Fauna & Flora Atlas N.T) within the tennement boundary, the following statistics have been recorded. Listed under the Territory Parks and Wildlife Conservation Act 2000 (TPWC Act):

- 15 Near threatened plant species;
- 1 Vulnerable plant species;
- 4 Endangered fauna species;
- 12 Vulnerable fauna species; and
- 27 Near Threatened fauna species.

Listed under the Environment Protection Biodiversity Conservation Act 2007 (EPBC Act):

- 0 listed plant species;
- 1 Critically endangered fauna species;
- 2 Endangered fauna species; and
- 12 Vulnerable fauna species.

EP168 being on the Sturt Plateau, forms an interzone for some species of the arid and tropical fauna of northern Australia. This is reflected in the mammals of the region, with a high diversity of macropods. These range from the red kangaroo, which is adapted to arid areas, to the northern nail-tail wallaby (*Onychogalea urguifera*) and spectacled hare wallaby (*Lagorchestes conspicillatus*) of the sub-tropical grasslands to the more tropical agile wallaby (*Macropus agilis*).

Birds also reflect the overlap between tropical and arid species. Those more commonly found in the arid zone include the ground cuckoo-shrike (*Coracina maxima*), while more typical tropical species include the blue-winged kookaburra (*Dacelo leachii*), rufous-throated honeyeater (*Conopophila rufogalaris*) and crimson finch (*Neochimia phaeton*).

In addition, many animal and plant species in the region are also spiritually significant, either as Dreamings or through being included in Dreaming stories and song cycles. Indeed, there are thousands of individual plants that are regarded as significant features of sacred sites.

A GIS analysis was conducted during the planning stage of the project to assess whether a correlation exists between known threatened species sites, landscape features, vegetation communities and soil landscapes. The initial analysis did not produce a clear enough correlation to justify major alignment alterations, so a proximity analysis was applied using Fauna Atlas data. The base data used to conduct the analysis is observational data within the Northern Territory for mammals, birds, reptiles, frogs and includes date, time and locations of sighting(s) spanning 30 years. The analysis did not result in any significant relocation of the Hidden_Valley-S2 drill site.

8.4.4 Significant Habitat

Riparian Areas & River Corridors

The waterways within the region all offer valuable habitat for aquatic plants and animals as well as important associated riparian vegetation. The Aboriginal cultural values of these areas are of outstanding regional and national significance in many areas.

Traditional Owners use the many creeks and rivers for hunting, fishing and the collection of traditional resources such as bush tucker, medicines, fibre, ochre, and timber. Maintenance of access to the land and its resources is critical for Traditional Owners to exercise their responsibilities in relation to land, law and culture.

Riparian vegetation also generally supports a high species richness of both plants and animals. As they retain moisture for longer periods than surrounding vegetation they provide important food and refuge areas. Protection of riparian vegetation from fire is also critical for general river health. Drill sites have been sited to avoid major watercourses for all the reasons above.

Acacia Woodlands – Bullwaddy (*Macropteranthes kekwickii*)

The conservation of Acacia woodlands is severely under represented with less than 1% conserved in the Territory and 3% nationally (Bureau of Rural Sciences, 2004). In fact, only the Bullwaddy Conservation Reserve (east of EP168 - approximately 100 kms east of Daly Waters along the Carpentaria Highway) represents the only declared conservation area within the Sturt Plateau region of the lancewood/bullwaddy vegetation type and is alone in its protection of this unique vegetation type.

Lancewood/Bullwaddy vegetation supports a different suite of animals than the Eucalypt woodlands, common species include the grey-crowned babbler (*Pomatostomus temporalis*), apostle bird (*Struthidea cinerea*) and hooded robin (*Melanodryas cucullata*), which all forage on the ground, and the spectacled hare wallaby (*Lagorchestes conspicillatus*) and northern nail-tail wallaby (*Onychogalea urguifera*), which commonly shelter under the bullwady trees during the day. Other vertebrate groups such as frogs and bats have not been comprehensively surveyed to date and further investigation is warranted.

8.4.5 Fire Regime

EP168 contains a number of fire sensitive vegetation communities including karst vegetation, riparian communities, sandstone heathlands, and Lancewood/Bullwaddy thickets. Karst vegetation are species and different from the dominant surrounding woodlands. These highly fragmented vegetation types support many fruiting species utilised by flying foxes and birds. The movement of these seed dispersing animals between karst patches and also riparian vegetation facilitates the spread of plants. These vegetation types are most at risk of invasion from woodland species with increased fire frequency, which in turn encourages more frequent fires.

Lancewood/Bullwaddy patches in EP168 consist of long lived species which only reproduces by seed and takes a long time to grow to seed producing age. Recent studies have indicated fire regimes in the landscape are causing significant negative impacts on patches of this vegetation type. This vegetation needs less frequent fire, achieved by burning the more fire tolerant habitats in the landscape, hence proving protection to these patches.

Fire prevention and mitigation measures being taken by Pangaea are detailed in **Section 11**.

9.0 ENVIRONMENTAL HAZARDS & RISKS

9.1 Determining Environmental Hazards

A Geographic Information System (GIS) desktop analysis of the Hidden_Valley-S2 proposed drill site was conducted during the planning stage. The placement of the drill site initially took into account:

- Important vegetation communities (important habitat zones);
- Riparian areas;
- Sensitive soil landscapes;
- Known karst/cave systems and sinkholes; and
- Threatened or endangered fauna and flora data.

The drill site location was then re-assessed to account results of the Cultural Site Clearance process, led by the NLC. Field inspection was used to:

- “Ground-truth” the accuracy of the drill site;
- Ensure nil impact on important cultural sites and/or landscapes;
- Collect and collate further data on soils and vegetation types that may warrant moving the drill site (i.e. incorporate local knowledge of environmental conditions and sensitivities that the coarse level GIS data did not account for); and
- Identify any further socio-economic impacts that the proposed exploration program may have on the pastoral lease or the community.

9.2 Determining Environmental Risks

Section 10 is a full description and discussion of the identified hazards and their associated unmitigated risk rating. The unmitigated risk ratings have been developed in consultation with the key personnel identified in Section 12, using industry knowledge that spans all sectors of petroleum exploration expertise, coupled with the desk-top summaries of the receiving environment provided in Section 8.0. The class of risk and likelihood ratings have been assigned using **Table 6**.

All hazards with an Unmitigated Risk Rating equal to or higher than ‘Medium’ have had specific risk management measures developed (Section 11.0).

Table 6: Environmental Risk Analysis Matrix

			0 Remote	1 Highly Unlikely	2 Unlikely	3 Possible	4 Quite Likely	5 Likely
ACTUAL / POTENTIAL CONSEQUENCE SEVERITY	A+	Catastrophic	0A+	1A+	2A+	3A+	4A+	5A+
	A	Massive	0A	1A	2A	3A	4A	5A
	B	Major	0B	1B	2B	3B	4B	5B
	C	Moderate	0C	1C	2C	3C	4C	5C
	D	Minor	0D	1D	2D	3D	4D	5D
	E	Slight	0E	1E	2E	3E	4E	5E

	SEVERE	Unacceptable - Risk cannot be justified. Go through Risk Reduction Process
	HIGH	Drive risks towards the broadly Acceptable Region
	MEDIUM	Residual risk tolerable only if further risk reduction is impracticable
	LOW	Risk reduction not likely to be required as resources likely to be grossly disproportionate to the reduction achieved

	People H&S	Eco Environment	Socio Environment	Assets	Legal	Reputation	
CONSEQUENCE	>20 Fatalities (or Permanent Total Disabilities)	Regional scale (>100 km^2) Long term/permanent impact	On-going serious international social issues. Significant damage to structures/items of cultural significance	>A $1000M	Significant prosecution and fines Very serious litigation including company closure	International concern. Major ventures terminated. Company at stake.	+A
	4-20 Fatalities (or Permanent Total Disabilities)	Large scale (10-100 km^2) Long term (decades)/impact	On-going serious national social issues. Significant damage to structures/items of cultural significance	A $100M - A $1000M	Significant prosecution and fines Very serious litigation including class actions	Persistent national concern. Long term "brand" impact. Major Venture/asset operations severely restricted.	A
	1-3 Fatalities (or Permanent Total Disabilities)	Medium scale (1-10 km^2) Medium term (years)/impact	On-going serious local social issues. Significant damage to structures/items of cultural significance	A $10M - A $100M	Major breach of regulation Major litigation	Medium term national concern. Minor venture or minor asset operations restricted or curtailed.	B
	Major Injury/Illness, Permanent Partial Disability or Lost Work Case >4 days	Medium scale (1-10 km^2) Medium term (months)/impact	On-going social issues. Permanent damage to items of cultural significance	A $1M - A $10M	Serious breach of regulation with investigation or report to authority with prosecution and/or moderate find possible	National bad mention. Short term regional concern. Close scrutiny of asset level operations/future proposals.	C
	Minor Injury/Illness, Restricted Work Case or Lost Work Case <4 days	Localised(<1 km^2) Short term (weeks) impact	Minor medium term social impacts on local population. Mostly repairable	A $100k - A $1000M	Minor legal issues, non-compliances and breaches or regulation	Short term local concern. Some impact on asset level non-production activities.	D
	Slight Injury/Illness, First Aid or Medical Treatment Case	Localised(immediate area) Temporary impact (days)	No impact	<A $100k	No legal implications	Local mention only. Quickly forgotten. Freedom to operate unaffected	E
	No Injury	No impact	No impact	A $0	No legal implications	Maintain Reputation	F

	LIKELIHOOD INCREASES →						
LEVEL	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
RATING	**Nil**	**Remote**	**Highly Unlikely**	**Unlikely**	**Possible**	**Quite Likely**	**Likely**
HISTORICAL	Practically Impossible	Unheard of in the industry	Has occurred once or twice in the industry	Has occurred many times in the industry, but not in the Company	Has occurred once or twice in the Company	Has occurred frequently in the Company	Has occurred frequently at the location
FREQUENCY	None	1 in 1000 years	1 in 100 years	1 in 10 years	Yearly	Bi-Annually	Quarterly
PERCENTAGE CHANCE OF OCCURENCE	None	0.001%	0 01%	0.1%	Between 1% and 10%	Between 10% and 50%	>50%

10.0 ENVIRONMENTAL HAZARDS & IMPACTS DESCRIPTION

***Note**: All risks noted below are prior to control measures being implemented. All risks will be managed to As Low As Reasonably Practicable (ALARP).*

10.1 Air Quality

Probability	Likely (5)	**Consequence**	Minor (D)	**Unmitigated Risk Rating**	High (5D)

Dust and emissions will require management during the drilling campaign at Hidden_Valley-S2. The drilling will be associated with vehicle movement and emissions. The emissions associated with the running of vehicles are unavoidable and the work will be undertaken well away from potential receptors (pastoral land, in a rural environment).

Dust generation and emissions related to vehicles are the two primary potential impacts relating to the exploration activities. Soils will be mobilised differently and are dependent on prevailing weather conditions such as wind, humidity and precipitation, particle size and topography. Some soils within the tenement are considered dispersive.

Dust will be generated as part of the campaign, however, given the operation is in rural environment, it is unlikely that potential dust producing activities will represent a significant impact to any surrounding or other local land users.

10.2 Fuel, Oil & Chemical Management

Probability	Possible (3)	**Consequence**	Major (B)	**Unmitigated Risk Rating**	High (3B)

Large quantities of fuels and lubricants are required on the drill and the camp site. The portable camp will have a generator capable of 24 hour operation and a fuel cell to sustain that level of operation (**Section 5.0**).

The camp site will be sited to minimise the risk to any sensitive aspects of the environment and away from conduits in the landscape (e.g. close to river or creek banks). Refuelling and emergency response procedures are to be meticulously implemented and spill kits are to be located onsite at all times. Appropriate personnel are to be trained in spill kit use.

10.3 Flora & Fauna

Probability	Possible (3)	**Consequence**	Minor (D)	**Unmitigated Risk Rating**	Medium (3D)

The Hidden_Valley-S2 site has been sited to minimise impacts on important vegetation communities that may be proving important fauna habitat (e.g. Bullwaddy associations, see **Section 8.4.4**). No important habitat associations will be impacted by drill pad preparation.

The roads/tracks have been extensively modified by previous human activities and would have limited value for native fauna compared to the extensive areas of native vegetation through which it passes. Impacts would be limited to the removal of some regenerating Eucalypts and Acacia associated with access track preparation. There are large quantities of equivalent habitat and resources adjacent to the drill site and access roads, so it is likely that the impact on local populations of native fauna will be minor.

The drill site will be fenced (with stock proof fencing) for the duration of the drilling program.

10.4 Introduction of Weeds

Probability	Possible (3)	**Consequence**	Moderate (C)	**Unmitigated Risk Rating**	High (3C)

Weeds can impact negatively on land users and land managers through the effect they may have on environmental, cultural, social or economic values placed on the land. Environmental values and ecosystem functions can be impacted on through the invasion and replacement of native plant species, the altering of habitats for native animals and impact that weeds may have on ecosystem functions such as nutrient and water cycles in addition to changing fire regimes.

There is potential that machinery and vehicles used during the campaign, are not weed free, which may result in new infestations being established in the project area. There is also the risk that drill site preparation activities encounter an area of weed infestation as they move through a pastoral property and transfer that weed onto neighbouring stations as the program progresses.

10.5 Sacred Sites & Cultural Heritage

Probability	Possible (3)	Consequence	Moderate (C)	Unmitigated Risk Rating	High (3C)

The Hidden_Valley-S2 drill site and access roads have been 'culturally cleared' by the NLC and TAOs (**Section 8.4.1**). However, the potential for sites of cultural significance in remote areas of the NT can rarely be entirely discounted. The landscapes in the tenements would have provided a range of resources, including stone raw materials, fauna, flora and water, particularly along the large rivers and creeks all of which may have allowed for sustainable occupation.

Vegetation cover on the drill site is moderate to dense, which reduces ground surface visibility, and therefore reduces the potential to identify archaeological evidence, by surface inspection in those areas. Whilst site integrity cannot be assumed, the existence of in-situ cultural materials cannot be ruled out. Based on sacred sites identified in the region site types that may be encountered in undisturbed environments include scarred trees, grinding grooves, artefact scatters and isolated finds.

10.6 Bushfire

Probability	Possible (3)	Consequence	Major (C)	Unmitigated Risk Rating	High (3C)

The Hidden_Valley-S2 drill site is located within a fire prone landscape and the activities proposed have the potential to be an ignition source (e.g. vehicles in long grass). Drill site clearing is the activity with the highest potential for starting a bushfire which may result in stock loss, infrastructure damage and loss of available feed on a regional scale. On-site and precautionary measures, site induction and emergency processes will be of paramount importance.

10.7 Soil Disturbance

Probability	Possible (3)	Consequence	Moderate (C)	Unmitigated Risk Rating	High (3C)

The soils generally are related to sporadic steep slopes, high run-on and shallow soils areas of an alluvial origin. Consequently, some soil landscapes are susceptible to erosion from increased traffic load, or in fact, activities that introduce vehicle movement into areas where it previously did not exist. Heavy rains on newly accessed areas are at risk of becoming erosive pathways in the landscape.

10.8 Grading & Gravel Sheeting of Existing Access Roads

Probability	Possible (3)	Consequence	Minor (D)	Unmitigated Risk Rating	Medium (3D)

A total of 142 km of established unsealed access tracks and fence lines will require varying degrees of preparation in order to facilitate effective and safe access to the drill site. All gravel material will be obtained from sources of naturally occurring deposits and the required material properties will be achieved by crushing, screening, mixing or other processes necessary.

There is a risk that local traffic disruptions will occur on the intersection of pastoral access roads and the Council managed network. There is also a likely loss of regenerating local native vegetation when existing borrow pits are 're-scrapped' and a risk of spreading weeds that may have established in these areas.

A 64km section of the Darwin to Alice Springs Rail Corridor will be used for access to Hidden Valley Station. Application has been made to the NT Government for permission to access the rail corridor for the specific use of rig mobilisation which will cross the railway at a single location.

10.9 Noise

Probability	Possible (3)	Consequence	Slight (E)	Unmitigated Risk Rating	Medium (3E)

Noise emissions will require management during the campaign. The drilling campaign will be associated with noise and emissions 24 hours a day for the duration of the drilling process on each site. On access roads to the drill site, noise associated with the running of vehicles are unavoidable however, the work will be undertaken well away from potential receptors (pastoral land, in a rural environment). Noise is likely to be a 'nuisance' issue to native fauna, but one of little consequence in the longer term.

10.10 Water Supply & Use

Probability	Possible (3)	Consequence	Minor (D)	Unmitigated Risk Rating	Medium (3D)

Approximately 0.5 ML will be required to drill Hidden_Valley-S2. Water is to be sourced locally from 'Bush Bore' (located approximately 4.5km North-West of the drill site - 244797E / 8196970N) and piped to the drill and camp site. At the camps, daily consumption per person generally equates to 120 -150lt per day.

10.11 Waste Management

Probability	Possible (3)	Consequence	Minor (D)	Unmitigated Risk Rating	Medium (3D)

General refuse will be collected at the camp site and transferred to the closest waste management facility. There is a risk that improper management of waste may attract feral animals to the camp sites. There is also a risk that fuels, chemicals and lubricants are released to the environment.

Aqueous drilling fluids generally comprise of water and various additives such as food grade viscosifiers, pH stabilizers such as acids and caustics and clay inhibitors. Potassium chloride has been commonly employed to increase density in lightweight drilling fluids. Mixed onsite by the drilling contractor, the mud is usually stored in either integrated mud tanks or purpose built containment pits and introduced into the well during drilling.

The term 'drill cutting' describes the material generated from the drilling activity once removed from the drilling fluids. Varying is size depending on the type of drill bit employed; the cuttings can range in size from coarse sand like material to > 5 mm in diameter.

Any liquid hydrocarbons that are intersected and brought to surface during drilling will be caught in the drilling sumps (mud pit). At the completion of drilling and plugging/abandonment; sumps, flare pit, and turkey's nest are all left to dry out, before being backfilled to return the areas to an appropriate slope (considering the landscape's 'pre-drilling' characteristics). If hydrocarbons were detected during drilling and bought to the surface, the contents of the mud pit will be tested (to determine if the contents are to be considered 'contaminated') and once analysed, appropriate disposal options will be implemented.

10.12 Overflow of Drilling Cuttings & Mud

Probability	Unlikely (2)	Consequence	Minor (D)	Unmitigated Risk Rating	Medium (2D)

During air drilling operations all the cuttings and formation water will be sent to the flare pit, which has been designed for a capacity of approximately 1,400 bbl (225,000 L). In the event that water inflow increases the drilling fluid system will be changed to mist/foam to minimize operational problems, but if the water inflow becomes unmanageable at surface the system will have to be changed to water based mud drilling.

When mud drilling, all returns will be directed to two mud sumps with a capacity of approximately 180 bbl (28,500 L) each and a 35 bbl (5,000) L mud tank. The total volume of rock removed from the well its approximately 155 bbl (25,000 L), including the air drilling section and it can all fit in one of the mud sumps. Therefore the risk to have an overflow from the sumps is unlikely.

11.0 PERFORMANCE OBJECTIVES & MITIGATION MEASURES

This section outlines the key environmental management issues and their suggested mitigation methods, responsibilities and prioritisation. This also includes the controls that will be implemented during the program to comply with these requirements, and undertake operations in an environmentally responsible manner. All visitors and contractors to Hidden_Valley-S2 drill site and camp must comply with the requirements within this EMP.

Each section possesses an Environmental Performance Objective ("EPO") which relate to the identification and assessment of the environmental impacts and unmitigated risks. Auditing and review of this EMP will consider the implementation of the specific actions as a means of achieving the EPO.

Each EPO has been developed in accordance with Pangaea's Environmental Policy, APPEA Environmental Code of Practice and relevant NT Legislation (Section 2).

11.1 Air Quality

EPO	Rural air environment with qualities conducive to suitability for the life, health and wellbeing of humans.
Specific Objective(s)	• Minimise environmental nuisance due to dust for sensitive receptors as a result of exploration activities. • Minimise greenhouse gas emissions.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** As part of job-site induction prior to arrival on-site, awareness of air/dust related issues will be provided for relevant staff. **3.** Speed limits on access tracks required to the limit and minimise dust generation will be clearly communicated to crews. **4.** Appropriately inform affected pastoralists as specified in the access agreement and providing updated information as required. **5.** Where practical, all vehicular movements to and from the works site would be made only during daylight hours and/or compliant with land access agreement. **6.** Engines will not be left running when not specifically required. **7.** Individual vehicular trips to and from the works site will be kept to a minimum. **8.** Smoke generation will be avoided by a strict no burning policy. **9.** Watering of roads when appropriate or when agreed. **10.** Complaints will be investigated and responded to appropriately in accordance with the Consultation Report.
Measurement Criteria	• Complaints in relation to air quality or environmental nuisance. • Any recorded complaints are actioned and closed out. • No fires on site (or in adjacent areas) as a result of project activities. • Maintenance records demostrate regular servicing in accordance with manufacturers requirements.
Records	• All complaints and subsequent actions are recorded in accordance with the Consultation Report. • Daily and Weekly progress reports. • Monthly audit by EMR.

11.2 Land

EPO	The activities associated with exploration will minimise erosion or sediment movement, loss of topsoils or dust.
Specific Objective(s)	• Minimise environmental damage due to soil erosion. • Minimise environmental nuisance as a result of damage to access tracks. • Minimise impacts on overland flow that may result in new erosive pathways.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** As part of job-site induction prior to arrival on-site, awareness of soil erosion related issues will be provided for relevant staff. **3.** When forming access tracks, minimise disturbance to creek and river banks and any naturally formed depressions. **4.** Vehicles to deviate around creeks, rivers and naturally formed depressions. **5.** Where creek crossings are unavoidable, cross them in a naturally clear area. **6.** Install 'whoa-boys' in strategic locations to stop or slow water flow along long sections of straight access tracks. **7.** Do not use access roads in wet conditions. **8.** Complaints will be investigated and responded to appropriately in accordance with the Consultation Report.
Measurement Criteria	• Complaints in relation to erosion by pastoralists or Government. • Any recorded complaints are actioned and closed out. • No incidents of bogged vehicles. • Induction records and pre-start operational lists.
Records	• All complaints and subsequent actions are recorded in accordance with the Consultation Report. • Daily and Weekly progress reports. • Monthly audit by EMR.

11.3 Water

EPO	Minimal opportunity for impacts to surface water and groundwater systems.
Specific Objective(s)	• Complete boreholes as to eliminate inter-aquifer leakage and potential for cross contamination of groundwater within the boreholes. • Minimal exploration activities within riparian areas. • Activities to minimise opportunity for impacts on water quality.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** As part of job-site induction prior to arrival on-site, awareness of surface and groundwater related issues will be provided for relevant staff. **3.** Drill holes will be grouted and completed according to Industry Best Practice sealing requirements. **4.** Any drill hole that meets an artesian or sub-artesian flow will be sealed to prevent contamination or cross-contamination of aquifers, and is permanently sealed with cement plugs to prevent surface discharge of groundwater. **5.** Fuels, lubricants and chemicals shall be stored and handled within containment areas (such as portable bunding, or self bunded) that are designed to prevent the release of spilt substances to the immediate neighbouring environment, in accordance with relevant legislation and standards. **6.** Appropriate sedimentation and erosion control measures will be put in place at each drilling location. **7.** All surface water runoff will be directed away from the drill hole to prevent aquifer contamination. **8.** A spill kit appropriate to operations of this size will be available at site. **9.** Personnel will be advised of the location and use of the spill containment equipment in the site induction. **10.** Refuelling is to be undertaken within the designated refuelling sites. Where refuelling is required outside the camp sites, the vehicle shall be on flat and stable ground and not within 25m of a watercourse or other riparian area. **11.** The amount of hazardous material stored and used on site shall be kept to a minimum. **12.** Hazardous materials shall be transported, stored and handled in accordance with the requirements of relevant legislation (e.g. Road and Rail Transport (Dangerous Goods) Act 1997, Australian Dangerous Goods Code) and Australian and Industry Standards. **13.** Spills or leaks shall be immediately reported to the Pangaea Representative on site who will initiate appropriate 'clean up' actions in consultation with the EMR. **14.** In the event of a spill the material will be contained to the smallest area practicable and Emergency Procedures are to be followed.
Measurement Criteria	• No recorded water quality impacts. • No recorded spills or accidents. • Induction records and pre-start operational lists. • Water quality test results on existing bores. • Drilling logs and pressure tests.
Records	• Monthly audit by EMR. • Well completion report. • Water testing results.

11.4 Noise

EPO	Ambient noise levels with qualities conducive to suitability for the life, health and wellbeing of humans.
Specific Objective(s)	• Minimise environmental nuisance due to noise for sensitive receptors as a result of exploration activities. • Periods of noise respite provided throughout the campaign.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** As part of job-site induction prior to arrival on-site, awareness of noise related issues will be provided for relevant staff. **3.** Appropriately inform affected pastoralists as specified in the access agreement and providing updated information as required. **4.** All equipment used for mobilisation and powering of drilling rigs are to be well maintained and fitted with noise attenuation apparatus as standard. **5.** Where practical, all vehicular movements to and from the works site would be made only during daylight hours and/or compliant with land access agreement. **6.** Engines will not be left running when not specifically required. **7.** Individual vehicular trips to and from the works site will be kept to a minimum. **8.** Complaints will be investigated and responded to appropriately in accordance with the Consultation Report.
Measurement Criteria	• Complaints in relation to noise or environmental nuisance. • Any recorded complaints are actioned and closed out. • Maintenance records demostrate regular servicing in accordance with manufacturers requirements.
Records	• All complaints and subsequent actions are recorded in accordance with the Consultation Report. • Daily and Weekly progress reports. • Monthly audit by EMR.

11.5 Flora & Fauna

EPO	No significant, permanent harm to listed threatened species or their available habitat.
Specific Objective(s)	• Minimise environmental nuisance due to noise for sensitive receptors as a result of exploration activities. • Periods of noise respite provided throughout the campaign.
Mitigation Measures & Strategies	**1.** Pangaea's Corporate Environmental Protection Policy will be adhered to. **2.** As part of job-site induction prior to arrival on-site, awareness of flora & fauna related issues will be provided for relevant staff. **3.** Weed/pest inspections of machinery will be undertaken prior to arriving at site. **4.** Machinery will be cleaned of mud and seed prior to arriving at each new site at a designated and bunded area. **5.** Assess the potential impacts on threatened species, populations, ecological communities and their habitats at each drill site. **6.** Waste material (domestic waste) will be stored in suitable receptacles and disposed of accordingly at municipal managed locations. **7.** Access tracks will be located in areas that will result in minimal ground disturbance. **8.** Avoid creation of windrows with mixed logs, branches and cleared grass. **9.** Promote ground cover on bare drill sites by pulling back logs, sticks and pruned branches. **10.** Where required, 'whoa-boys' will be installed in strategic locations to stop or slow water flow along access tracks. **11.** Provide drill pad preparation crew weed field ID guides and training sessions before entering the field. **12.** Avoid areas known environmental weeds, noxious weeds or problem plants as defined in this EMP, by the weeds unit and pastoral lands management unit of the Land Resource Management) and pastoralists. **13.** Drill pad preparation field crews will undertake a visual check of seed in clothes and protective gear daily. **14.** Establish clearly sign-posted 'weed blow down areas' and GPS points recorded.
Measurement Criteria	• Before and after photos of drill sites. • No recorded loss of fauna. • No recorded spills or accidents. • Induction records and pre-start operational lists.
Records	• Daily weed blown down reports. • Induction records and pre-start operational lists. • Daily and Weekly progress reports. • Monthly audit by EMR.

11.6 Socio-Economic & Community

EPO	No significant, permanent harm to listed threatened species or their available habitat.
Specific Objective(s)	• Minimise environmental nuisance due to noise for sensitive receptors as a result of exploration activities. • Periods of noise respite provided throughout the campaign.
Mitigation Measures & Strategies	**Aboriginal Cultural Heritage** **1.** In the event that a suspected sacred site or artefact has been discovered and the activity cannot be altered to avoid the site, work will cease in the area of the discovery AND the person discovering the artefact will notify their supervisor who will ensure that work has ceased and the area(s) is (are) cordoned off with tape. **2.** The PC will notify the Pangaea Representative on site who will request a qualified professional to attend the site and advise on its significance. **3.** Work will not recommence in the area of any discovery until the site has been inspected and the requirements of the Department have been met. **Bushfire** **4.** Bushfires NT will be notified of the exploration strategy. **5.** A minimum of one 400lt slip-on unit will be located at each drill site. **6.** Fire control water pumps and hoses are to be readily accessible, on site and well maintained. **7.** All items of plant that could discharge sparks must be fitted with spark arresters. **8.** No onsite cutting, welding, grinding or other activities likely to generate fires in the open on days when a total fire ban is proclaimed. **9.** Ensure that all personnel are adequately trained with regard to fire prevention, safety and basic firefighting skills. **10.** Before work such as welding, thermal or oxygen cutting, heating or other fire/spark producing operations are started; the area of the works will be thoroughly wet down. **11.** All field crews will have an additional water fire extinguisher, shovel, rake and fire beater as standard vehicle equipment to let the driver be a relevant first responder. **12.** Car parks and refuelling areas must all be at least 20m from the bush perimeter. **Community** **13.** Pastoralists will be contacted one week and within 24hrs of the drillers commencing establishment of the drilling rig. **14.** Drill site rehabilitation will be undertaken as specified and agreed in the landholder access forms.
Measurement Criteria	• Before and after photos of drill sites. • Complaints in relation to air quality, noise or environmental nuisance. • Any recorded complaints are actioned and closed out. • No fires on site (or in adjacent areas) as a result of project activities.
Records	• Daily and Weekly progress reports. • Monthly audit by EMR.

12.0 IMPLEMENTATION STRATEGY

12.1 Roles & Responsibilities

The Hidden_Valley-S2 project team will consist of the following lead roles:

- Wellsite Representative (WR): **TBC**
- Operations Coordinator (OC): **Cesar Gonzalez**
- Land and Logistics Services Representative: **David Armstrong**
- Engineering Team Leader (ETL): **Steve Miller**
- Corp Planning, Logistics and HSE Manager (HSEM): **Tim Radburn**
- Environmental Management Representative (EMR): **Damian Wall**
- Director of Operations (DoO): **Gary Drummond**
- Vice-President of Exploration (VPE): **Joel Alnes**
- Chief Executive Officer (CEO): **Sunil Salhotra**
- Executive Safety Manager: **John O'Neill**

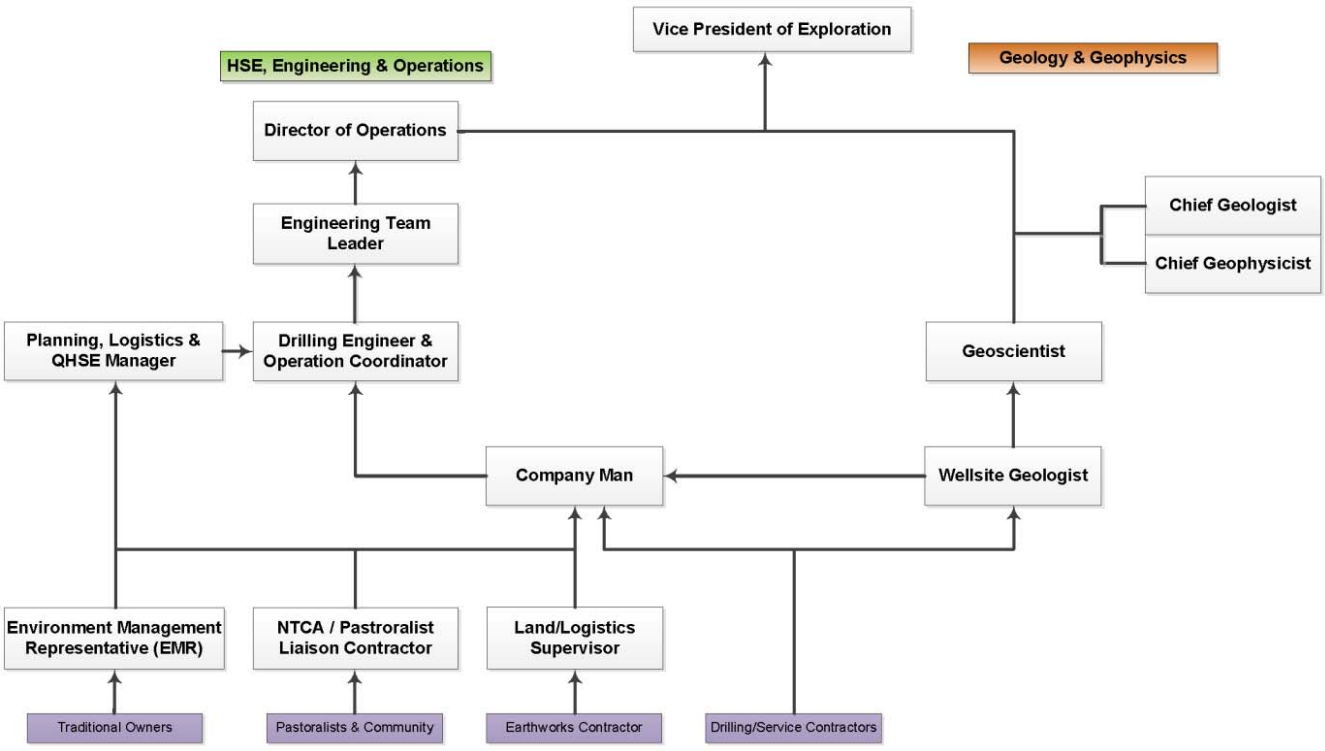


Figure 4: Hidden_Valley-S2 Decision & Communication Flowchart

12.1.1 Wellsite Representative (WR)

- Represent Pangaea Resources in the field.
- Apart from technical QA/QC, the PR will liaise with the well-site geologists, drilling contractor and service companies on a daily basis covering both technical and HSE day-to-day issues.
- Ensure the drilling crew are conducting operations in an environmentally friendly manner.
- Includes all HS and environmental statistics and current operations in the daily reports; and
- Report to the Operations Coordinator (OC) and HSE Manager (HSEM).

12.1.2 Operations Coordinator (OC)

- Plans drilling operations and timing.
- Assist in ensuring all contractors and other relevant personnel are inducted prior to commencement of any work.
- Conduct Daily, weekly and monthly reporting of all HSE statistics and submit to HSEM;
- Assist in implementing and maintaining environmental controls.
- Respond immediately to protect the environment or remediate any environmental harm as soon as practicable in the event of an environmental incident or community complaint; and
- Notify the VPE and HSEM of a serious environmental incident, breach of conditions, or serious complaint.

12.1.3 Corporate Planning, Logistics, HSE Manager (HSEM)

- Monitoring HSE performance at each stage of the project and on a day-to-day basis.
- Ensuring Emergency Response preparedness for the tenement and individual sites.
- Ensuring all contractual and legislative requirements is satisfied.
- Liaise with the OC and EMR regularly.
- Communicate with the VPE as required.
- Measuring and monitoring HSE management effectiveness.
- Ensuring adequate resources are planned to address the HSE risks on the tenement and sites.
- Reporting incidents to the VPE and external parties as required.
- Prepare SMP/EMP/ERP and ensure they adequately control the HSE risks involved with the operations and regulatory requirements; and
- Instruct suspension of work if non-compliant with established / agreed operating procedures.

12.1.4 Environmental Management Representative (EMR)

- Management of all community contact/enquiries/issues.
- Liaise with relevant stakeholders prior to and during each phase of exploration.
- Ensure that exploration activities are conducted in accordance with this plan.
- Ensure that environmental impacts and minimised and protection of environmental values (all threatened species, populations and endangered ecological communities, historical and aboriginal heritage and aquifers); and
- Participation on consultation committees (if formed).

12.1.5 Principal Contractors & Service Providers

It is the responsibility of any and all Principal Contractors and Service Providers to conduct exploration activities in accordance with this plan.

12.2 Summary of Operation Systems, Standards, Policies & Procedures

Pangaea will refer to, be guided by and constantly review several operational systems, standards policies and procedures including:

Policies

- Pangaea Quality, Heath, Safety and Environment Policy (**Appendix A**); and
- Information Management Policy (**Appendix J**).

Operational Systems

- Pangaea Quality Management Systems Manual,
- Pangaea Quality Health, Safety & Environment Management Systems Manual; and
- Pangaea Risk Management System Manual.

Procedures

- Incident Investigation Procedure (**Appendix G**),
- STEP Program; and
- Pangaea's Quality Management System - The Quality Action Tracking Register (**Appendix I**).

Standards

- ISO 9001:2000, Quality management systems – Standard,
- ISO 14001:2004, Environmental management systems – Standard,
- ISO 19011:2011, Guidelines for quality and/or environmental management systems auditing – Guidelines,
- AS/NZS 4360:2004, Risk Management Framework – Standard; and
- HB 139-2003, Guidance on Systems Integration – Guidelines.

12.3 Competency, Training & Awareness

All personnel directly involved in environmental management will be appropriately qualified to undertake the tasks of the position to which they are appointed. The HSEM is responsible for establishing the necessary criteria for each position and verifying the qualifications and experience of all environmental management personnel and for maintaining personnel files containing this data.

Any external contractors or consultants engaged to carry out environmental tasks such as noise, water or air quality monitoring or auditing shall be appropriately qualified, trained and competent. The EMR must demonstrate general compliance with the principles of *AS/NZS ISO 14012:1996 Guidelines for Environmental Auditing: Qualification Criteria for Environmental Auditors.*

12.3.1 Site Induction & Training

The EMR in consultation with the HSEM will ensure that all relevant personnel undertake an *environmental induction* before working on site to minimise all potential environmental impacts. A particular focus will be on the use of spill kits to contain any chemical, fuel or oil spills, cultural heritage protection and prevention of soil erosion. The session is compulsory for all personnel and service providers and will cover:

- Purpose & objectives of the EMP;
- Requirements of due diligence and duty of care;
- Conditions of environmental licences, permits and approvals;
- Environmental emergency response;
- Management and reporting process for environmental incidents;
- Lessons learnt from environmental incidents;
- Environmental controls that are identified in the EMP;
- Weed management and clean down provisions;
- Fire control and prevention;
- Site-specific issues including, but not limited to those detailed in Section 11;
- Environmentally sensitive areas; and
- Cultural Awareness Training.

Records of attendance at the environmental induction will be maintained by the HSEM.

12.3.2 Induction Register

Records of environmental inductions and training will be maintained on site by the WR including dates, details on training, names of persons trained and trainer details.

12.3.3 Service Providers

The WR will undertake surveillance of Service Providers using a Subcontractor Surveillance Form Subcontractor Surveillance Form on a monthly basis, which will record:

- Any environmental issues, non-conformances and general comments from the Weekly Report Form (Section 12.5).
- The duties of each service provider in regards to environmental protection measures as defined by Section 11; and
- The duties that Pangaea will retain for environmental protection of subcontracted work.

12.3.4 Tool Box Talks

Tool Box Talks will detail cultural heritage and environmental information or instructions that may be required on site on a daily basis. The specified instructions in this regard may be generated from Spot Checks and/or Daily Site Inspections. Records of attendance and topics covered at each meeting will be maintained by the WR.

12.4 Record Keeping

All records associated with environmental management will be stored so that they are readily retrievable and suitably protected from deterioration or loss during the Project. The following environmental records will be kept by the OC in the Pangaea's Sydney Office in order to demonstrate compliance with the EMP:

- Details of qualifications held by individuals primarily responsible for environmental monitoring;
- Monitoring / inspection reports;
- Internal audit reports;
- External audit reports;
- Reports of pollution incidents, other environmental non-conformances, complaints and follow up action;
- Minutes of EMP review meetings,
- Evidence of action taken as a result of such meetings;
- Induction and training records; and
- Records of monitoring by subcontractors against compliance limits.

12.5 Environmental Monitoring & Auditing

The basis of Pangaea's Environmental Monitoring program is embodied in spot checks, daily meetings, photo monitoring and monthly site audits. The HSEM, the EMR, the WR and the OC will all have some responsibility in this regard.

12.5.1 Monthly Internal Audit

The EMR will complete a *Monthly Environmental Inspection Checklist* (**Appendix D**) in consultation with the OC and the WR. The WR will maintain a register of all inspections, including the date, time, prevailing weather conditions at the time of inspection and the inspection findings. A Monthly Meeting with relevant Pangaea personnel and Service Providers will be held to discuss the findings of the audit, suggest corrective actions and improvements to the work site or work processes. The monthly audit will be conducted to address the following issues:

- Compliance with statutory obligations;
- Compliance with environmental standards, guidelines, specifications and codes of practice;
- Compliance with the EMP;
- Adequacy of environmental training records;
- Adequacy of environmental records, checklists and document management systems;
- Recording and completion of corrective actions following environmental incidents and complaints;
- Achievement of environmental performance objectives; and
- Implementation of actions from previous audits.

Copies of the monthly audit report will be maintained by the OC. If major problems are identified during the audits, Nonconformity Notifications or Corrective Action Requests may be issued to Service Providers via the HSEM. Audit results will be made available to the NT Government on request or by schedule that is required.

12.5.2 Spot checks & Daily Site Inspections

The WR will complete Daily Site Inspections and Spot Checks throughout the exploration campaign to ensure compliance with the directives given in the Tool-box meetings (Section 12.3.4) and no repeat of any non-conformances identified during the previous monthly audit. The results of the spot checks and daily audits will be kept by the WR and made available to the EMR during the monthly audit.

12.5.3 Photo Monitoring

The EMR in consultation with the HSEM, the WR will establish photo monitoring points at the drill site. Photos of the site will be stored by the WR and each site will be visited by the EMR at the conclusion of the program.

12.5.4 Post-Completion Audit

Within 28 days after completion of the Hidden_Valley-S2 drill campaign, the EMR shall carry out an environmental compliance audit, including site inspection and full review of environmental records, to identify any environmental protection measures which have not yet been finalised. The report shall be submitted to the HSEM and the OC and forwarded to the Government as required, together with a written response on how all actions and issues raised in the audit will be addressed.

12.5.5 Third Party Audits

The EMR in consultation with the HSE Manager will appoint an external auditor to review the Post Completion Audit (Section 10.4). The external auditor must demonstrate general compliance with the principles of AS/NZS ISO 14012:1996 Guidelines for Environmental Auditing: Qualification Criteria for Environmental Auditors.

The external auditor report shall be submitted to the HSEM and OC and forwarded to Government as required, together with a written response on how all actions and issues raised in the audit will be addressed.

12.6 Reporting

12.6.1 Incident Reporting

The WR will complete Daily Site Inspections and Spot Checks throughout the exploration campaign. Any and all incidents will be recorded and reported immediately, or as soon as practicable, to the EMR.

The OC will liaise with the Department to ensure the timely submission of environmental incident, close-out and external auditing reports. Each report will be provided to the appropriate departmental contact by schedule that is required.

12.6.2 Monthly HSE Reporting

A monthly HSE report (**Appendix E**) will be generated by the OC in consultation with the WR, HSEM and Service Providers. The report summarises:

- Environmental, health and safety statistics;
- EHS comments including issues relating to waste management, health, safety and transport;
- Urgent actions required to address identified environmental issues;

The monthly report will be emailed to the Department of Minerals and Energy at the end of each month. Copies of the Monthly HSE report will be maintained by the OC.

12.6.3 Waste Reporting

Waste reporting will be generated via the Waste Register in the Waste Management Plan (**Appendix F**). The Waste Register will be maintained by Services Providers and a copy is to be kept onsite by the WR until the project is completed. The Waste Register will record the type, amount and location of waste reused, recycled, stockpiled and disposed of plus other data including:

a) Type of waste and its classification (according to the Waste Management and Pollution Control Act);
b) Tonnes of waste;
c) How and where the waste was reused, recycled, stockpiled or disposed of;
d) Date when the waste was reused, recycled, stockpiled or disposed of; and
e) Name of the transporter used.

12.7 Non-conformance and Corrective Action

Environmental non-conformances are defined as:

- Any breach of approvals, permits or licences;
- Any non-compliance with those sections of the EMP that specifically relate to environmental performance and/or any non-compliance with the environmental management measures outlined in the EMP; and/or
- Any other error, misadventure or incident resulting in environmental damage which is significant.

The HSEM will investigate each non-conformance (with the EMR, OC, WR & relevant Service Providers) in accordance with Pangaea's Incident Investigation procedures (**Appendix G**).

In the event of an incident causing material or serious environmental harm (which is not specifically planned and managed under this EMP), the Department of Minerals and Energy will be advised by phone as soon as practicable. Pangaea will continue to liaise with the Department to ensure the timely submission of a formal incident investigation report and close-out actions as required, on request or by schedule that is required.

The WR will maintain a register of all non-conformances, which includes date raised, description, reference number and close out status.

Note: material or serious environmental harm equate to a consequence category "D" or above in the Pangaea risk rating matrix.

12.8 Community and Stakeholder Consultation

12.8.1 Stakeholder Consultation

To date, consultation has included discussions with the NT Government, Local Government the Northern Land Council and Pastoralists. Pangaea NT will continue to engage with stakeholders on an ongoing basis as a way of keeping key stakeholders informed about our activities to build on and maintain already well developed working relationships.

A detailed Cultural Clearance process (section 8.4.1) has been undertaken in partnership with Traditional Owners and the NLC, which incorporated detailed field assessment and consultative review of proposed activities.

12.8.2 Ongoing Consultation

The HSEM in consultation with the Land and Logistics Representative will notify the local Council and relevant government departments of any activities that could cause disruption (e.g. Traffic disruptions, temporary detours, changes to property access) at least five working days before the work commences.

The HSEM will ensure all community liaison records are kept. The records will inform a Consultation Report (**Appendix H**) which consists of:

- List of all relevant stakeholders consulted;
- Name and tile of persons consulted;
- Issues discussed;
- Specific concerns and interests raised during the consultations; and
- Processes and arrangements for ongoing consultation with relevant stakeholders.

12.8.3 Complaints Handling

All complaints regarding any environmental/community issue caused by the works will be handled in accordance with P*angaea's Quality Management System, using the Quality Action Tracking Register* (**Appendix I**) maintained on site by the WR.

This shall capture the details of the complaint, action taken to investigate and if necessary to correct the problem. A register of all project specific complaints and subsequent communications (including records of any telephone calls) shall be kept by the OC and included on the monthly report by the HSEM.

12.9 Document Control

Pangaea will ensure that all environmental management documents are reviewed and approved for adequacy prior to issue. Documentation associated with the operation of the EMP shall be recorded on a document register in accordance with Pangaea's Information Management policies and procedures (**Appendix J**).

12.10 EMP Review

Pangaea will undertake a complete review of this EMP every 3 months from the start date and then again at the conclusion of operations as defined by this EMP. The review will consider the following issues:

1. Results of any environmental audits;
2. The extent of compliance with EMP environmental performance objectives and targets;
3. Changes to relevant legislation;
4. Any changes in the type and scope of works which has an impact on the environmental requirements of the project;
5. The appropriateness and ease of use of the EMP; and
6. Demonstration that continuous improvement is occurring.

Review results will be maintained by the HSEM and communicated to the DME on request.

13.0 EMERGENCY RESPONSE PLAN

A review of exploration activities associated with the Hidden_Valley-S2 drill site identified a range of potential environmental emergency scenarios. Generic control measures and the Level of Risk rating *before control measures* are shown in Section 10.0. Detailed control measures for the potential incidents with a medium or above rated risk, are outlined in Section 11.0

The following ***Emergency Response Actions*** have been developed for the incidents that have a probability of 'Possible' and a consequence of 'Major'.

13.1 Emergency Response – HIGH Risk Environmental Emergencies

In the event of an environmental emergency within the tenement, the Project Manager or, if they are not present, the onsite WR is responsible for the overall management of the situation. The contractor Field Supervisor will manage the immediate emergency with the primary focus on limiting harm to personnel, the environment and lastly equipment, whilst controlling the situation and preventing escalation.

In the event that the emergency escalates, support will be provided by Pangaea with the assistance of the Emergency Management Team (EMT). For all Incident Classification, Tier Activation, Notification requirements and contacts relevant to the project, consult the ERP.

See Appendix K for a complete list of Emergency Response Support contacts.

13.1.1 Bushfire

NOTE: No person is obligated to engage in fire-fighting efforts. Fires will only be fought by those who are trained AND confident in doing so.

Raise assistance immediately. See Appendix L for contacts list.

- **DO NOT LEAVE THE SCENE.**
- **If electing not to fight the fire, retreat to a safe distance upwind of the flames and stay with your vehicle.**
- **If flames approach the vehicle,** close all vents and windows, retreat to the floor and cover yourself with a blanket if possible. Wait until the flame front passes, exit the vehicle and extinguish it if possible.
- Always consider your safety and the safety of other first before attempting to contain or extinguish a fire. Fire extinguishers should only be used when safe, trained and confident to do so.
- If it is safe, a direct attack may be made at the front or head of the fire. This is where the rate of spread is fastest but also where the heat, flames and smoke are worst.
- If it is unsafe to attack the head fire then an alternative may be to work along the sides, called flanks, starting at the back and working towards the head fire. A flank approach will generally be a safer tactic as the fire fighters can always retreat to the burnt out ground.
- "Back burning" may be deployed as a containment technique; **this must always be supervised by trained, experienced crew leaders.**
- In an emergency, graders may be used to circumnavigate the burning area and isolate the fuel sources.

13.1.2 Hydrocarbon Spill

1. Immediately following a spill the area should be secured to prevent the hydrocarbons entering waterways and groundwater aquifers (this can usually be achieved by building a bund around the spill).
2. Bunds are anything that is impervious (e.g. geofabric covered soil contour bank, deployed plastic bunds, and plastic sleepers).
3. If the site conditions permit (i.e. not wet or raining), deploy cotton based absorbing sheet on the spill area.
4. Contact the PM. See **Appendix L** for contacts list.
5. Consult the ERP for additional actions that may be required.
6. Review the Oil Spill Contingency Plan in **Appendix M** to ensure all aspects have been addressed to prevent further impact on the environment.

14.0 CONCLUSION

This document, the Hidden_Valley-S2 EMP describes the roles and environmental responsibilities of all personnel. It also acts as a bridging document for principal contractors and details key environmental mitigation measures identified by Pangaea post identification of ‘hazards & risks’ and emergency response.

The purpose of this EMP is to provide the framework for environmental management of the activities proposed in drilling Hidden_Valley-S2 and to detail the control measures to be implemented to ensure that exploration activities are conducted in an environmentally responsible manner.

The guiding principle in the development of this EMP is one of ‘co-existence and responsible land use sharing’. Community consultation, relationship building and educational forums have all been established from earlier petroleum activities (e.g. the seismic survey conducted in 2013). The success of that operation is a testament of the company’s commitment to fully engage with all stakeholders and respect their rights and wishes, particularly of the pastoral enterprise holders and the Traditional Owners.

15.0 REFERENCES

Department of Land and Resource Management (2014), Sturt Plateau – Bioregional Description, available online at: http://lrm.nt.gov.au/plants-and-animals/herbarium/nature/bioregional/sturtplateau#.U5OiQF5Rf1o

Department of Mines and Energy (DME) Guideline: *Environmental Plan Summary*, available online at: http://www.nt.gov.au/d/Minerals_Energy/Content/File/Forms_Guidelines/EnvironmentalPlanSummary.pdf

DME Guidelines: *Environmental Plan (EP) Requirements, Applications for Drilling or Workover Rig Activities*, and *Environmental Plan Summary*, available online at: http://www.nt.gov.au/d/Minerals_Energy/index.cfm?header=Energy%20Forms%20and%20Guidelines#pa

DME *Regulation of Hydraulic Fracturing*, available online at: http://www.nt.gov.au/d/Minerals_Energy/index.cfm?newscat1=&newscat2=&header=Regulation%20of%20Hydraulic%20Fracturing

Hennessy et al (2004), *Climate Change in the Northern Territory*, CSIRO, Melbourne, Victoria.

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16.0 APPENDIX

Appendix A: Quality Health, Safety & Environment Policy

PANGAEA RESOURCES PTY Ltd.

Quality Health, Safety and Environment Policy Statement

Pangaea Resources Pty Ltd (Pangaea) is involved in the exploration and development of hydrocarbons and minerals in Australia and in selected overseas locations.

It is the policy of Pangaea to conduct its activities in such a way as to:

- Comply with all applicable HSE laws and regulations;
- Consider first the health and safety of its employees, customers, contractors, and any third parties who may be affected;
- Ensure employee communication, involvement and consultation in QHSE issues;
- Protect the environment, prevent pollution, and seek improvements in the efficient use of natural resources;
- Ensure that health, safety, and environment matters have equal status with all other primary business objectives;
- Ensure respect for the rights of indigenous people and valuing cultural heritage; and
- Ensure that quality is achieved through:-
  - Continuous improvement of the Quality HSE Management System, its driving policies and procedures to meet the evolving organisational requirements through regular reviews;
  - Quality awareness and skills training appropriate to responsibilities for all employees; and
  - Regular monitoring and audit of information, data and records.

Pangaea will pursue this policy through company strategies and action plans supported by visible management commitment and through the individual contributions of all employees supported by education and training.

All Pangaea managers and supervisors are accountable for the health and safety of those working under their control and are responsible for the promotion and implementation of Pangaea policies, continuous development of job skills, systems, and procedures, in full understanding of the importance of Health, Safety, and Environmental Protection. Pangaea will also foster an awareness of shared responsibility and accountability for the environment.

All staff and contractors:-

- Have a duty of care to act responsibly, take care of themselves and others, not create hazards or increase risks as a result of their actions and cooperate with their supervisors in matters of health and safety; and
- Have the right and responsibility to stop work or refuse to work in situations that may cause HSE harm.

JOHN O'NEILL, EXECUTIVE CHAIRMAN
Pangaea Resources Pty Ltd

Date: 27 June 2012

Company A.C.N. 070 165 025 / ABN 62 070 165 025

Appendix B: Rehabilitation Plan

The following section of the EMP provides a rehabilitation strategy for the drilling and all exploration operations specific to the Hidden_Valley S-2 drill site.

1. Rehabilitation Management Strategy & Objectives

This section of the plan outlines the overall rehabilitation strategy for the Hidden_Valley S-2 well, including descriptions of key components of the rehabilitation strategy integral to the anticipated final landform. The rehabilitation strategy will be flexible to allow for the integration of successful rehabilitation activities, and will be amended if new rehabilitation techniques are developed. The strategy includes the following key aspects:

- An outline of the objectives of the rehabilitation strategy,
- Land-form design and planning (including objectives),
- Progressive rehabilitation requirements for disturbed areas,
- The management of topsoil resources for use in rehabilitation of the site; and
- The rehabilitation monitoring and maintenance requirements that will apply.

1.1 Rehabilitation Objectives

The objectives of the decommissioning and rehabilitation strategy are to ensure that:

a. Decommissioning and rehabilitation activities meet stakeholders expectations and comply with relevant regulatory requirements and/or industry best practices — Decommissioning and rehabilitation of the disturbance areas will be completed in accordance with the Petroleum Act and industry guidelines that outline the timing, objectives, activities required, specific goals and performance criteria to determine when the objectives have been achieved.
b. All above ground infrastructure developed for the purpose of exploration will be decommissioned, safely removed and appropriately disposed of.
c. Opportunities for progressive rehabilitation will be maximised and will be undertaken throughout the life of exploration activities.
d. The final landform is stable and an acceptable final land-use for the disturbance area is achieved — The Project area will be rehabilitated to a stable, self-sustaining landform with a post- closure land-use comparable to the land-use prior to disturbance; unless an alternate suitable and agreed land-use is identified.
e. The potential for adverse environmental impact is minimised — Including but not limited to run-off into local waterways, air quality from dust, soil contamination from hydrocarbons or other chemicals, and minimising further disturbance during rehabilitation activities. Specific objectives, indicators and appropriate closure criteria will be developed during detailed closure planning, that will include where relevant consultation with appropriate stakeholders, including the relevant regulatory agency and landowners.

2. Pre-Exploration Land Suitability

The land suitability assessment undertaken as part of the initial assessment of the site and access routes, showed that the area has predominantly been used for grazing of beef cattle. The land suitability assessment identified a single Land System (Banjo land system) which has good to moderate quality grazing value.

The Banjo land system consists of almost level to gently undulating plains on the plateau surface that lack drainage lines. Consisting of variable depth red earth soils with or without gravel; mixed eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Banjo land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening.

3. Conceptual Post-Exploration Landform

Rehabilitation will generally be designed to achieve a stable final landform compatible with the surrounding environment. Should any slopes exceed 1% cross-fall, additional drainage and revegetation works may need to be implemented to achieve sediment and erosion control and groundcover establishment. Re-contouring the drill site area will be undertaken (if necessary) so that it is commensurate with the surrounding natural landforms wherever possible.

It is currently proposed that the final land use for the rehabilitated areas is returned to the pre-disturbance land suitability class, and that maintenance requirements are no greater than that required prior to disturbance.

4. Rehabilitation Procedure

Pangaea's Rehabilitation Procedure *"established minimum standards that are mandatory for rehabilitating disturbed land following drilling activities, construction, operation and maintenance of plant and equipment at Pangaea NT controlled sites."* The procedure applies to partial rehabilitation for stabilising operating project sites and final closure rehabilitation to stabilise the land following the decommissioning of infrastructure (plugged and abandoned wells etc).

The intent of the procedure is to *'facilitate the return of the land to a stable state, where either the former land use or another specified state agreed by the Government and pastoralist, can be resumed."* Rehabilitation objectives include ensuring that the site is safe to humans and wildlife, non-polluting, stable and able to sustain an agreed land use.

6. Rehabilitation Approaches – Specific Landscape Aspects

Roads & Tracks

Roadways and/or tracks may be required to remain to provide on-going access to monitor rehabilitation. Alternatively, roads and/or tracks may remain on-site if agreed in writing by the pastoralist and/or the relevant government department.

Access roads and tracks that are not required by pastoralists and are not on existing fence lines or public roads will be scalped to approximately 0.3 m below the surface to remove stabilised and compacted material (if relevant). The inert waste will be recycled or disposed of in a suitable location (i.e. a quarry or an approved landfill off-site as appropriate).

Any contaminated or unsuitable material (e.g. gravel) will be removed from the roads and hardstand surfaces and disposed of at an approved location. Minor reshaping work will be undertaken to ensure surface level consistency with the surrounding areas. Any creek crossings will be removed and the pre-existing drainage line re-instated by revegetation and rehabilitation.

Drill Pads

Where possible, topsoil inclusive of vegetative material (removed during site preparation) would be re-spread directly onto the drill pad. Where topsoil resources allow, topsoil would be spread to a nominal minimum depth range of 0.1 to 0.3 m on all areas to be rehabilitated. Top-soiled areas will also be lightly contour-ripped (after topsoil spreading) to create a 'key' between the topsoil and the subsoil. Ripping would ideally be undertaken on the contour and the tynes lifted for approximately 2 m every 200 m to reduce the potential for channelised erosion on slopes greater than 10 degrees. Ripping will be undertaken where practical, when soil is dry to achieve best results in fracturing the compacted soils.

Special Treatment Areas

Additional erosion control measures will be considered where necessary, particularly in drainage lines and section of access track that are longer grade slopes. Erosion control measures may include installation of 'Whoa-boys' at regular intervals along the slope and diversion drains to direct water off the access track to prevent rilling from overland flow.

Weed Management

The presence of weed species has a potential major impact on revegetation and regeneration outcomes. In addition to this, the presence of weed species within the surrounding land has the potential to significantly impact on the biodiversity value of the rehabilitated area & Weed management will be a critical component of the rehabilitation activities. Weeds will be managed across the Project area through a series of control measures, including (but not limited to):

- Designated light vehicle roads and track delineated around the site and adequate weed hygiene practises for vehicles operating within rehabilitation areas,
- Herbicide spraying or scalping weeds off topsoil stockpiles prior to re-spreading,
- Undertaking species-specific management for identified key weed species at risk of spread through Project activities.

If weed control measures are required, they would be undertaken in a manner that minimises soil disturbance. Any use of herbicides would be carried out in accordance with appropriate requirements to minimise the risk of impact on downstream water quality and with approval from the pastoralist to ensure no agricultural organic or export produce certifications are breached

Records would be maintained of weed infestations, and control programs would be implemented according to accepted management practice for the weed species concerned. All weed management personnel would be trained in the use of herbicides. Herbicides listed under international conventions, such as the World Health Organisation and the Stockholm Convention, would only be used according to the requirements of those conventions.

7. Rehabilitation Completion Criteria

Preliminary success criteria (or completion criteria) for the rehabilitation of the Hidden_Valley S-2 well and associated infrastructure are performance objectives or standards against which rehabilitation success in achieving a sustainable system for the proposed post-facility life land use is demonstrated.

Satisfaction and maintenance of the success criteria (as indicated by monitoring results) will demonstrate that the rehabilitated landscape is ready to be relinquished from Pangaea NT's financial assurance and handed back to stakeholders in a productive and sustainable condition.

The further development of each criterion will be based on results of research, monitoring of progressive rehabilitation areas and risk assessments. Rehabilitation shall be considered successful when the following conditions have been met:

1. The site can be managed for its designated land-use (e.g. consistent with surrounding undisturbed land),
2. Evidence that the agreed rehabilitation criteria have been met,
3. No greater management input is required for site than that of surrounding areas consistent with designated land use; and
4. Written agreement has been attained by the pastoralist and the administering authority.

5. Rehabilitation Monitoring

Monitoring will be conducted on areas of disturbed land following drilling activities, construction, operating and maintaining plant and equipment at the Project site. This procedure establishes an approach for evaluating the successful implementation of rehabilitation activities by monitoring.

Pangaea NT aims to *"minimise the disturbance to vegetation, land and animals, including native flora and fauna, and pastoral infrastructure and livestock. Any disturbed vegetation or land shall be rehabilitated as soon as practicable to ensure the identified land use can occur."*

Potential monitoring locations will be the drill site and specific locations along the access route , chosen in consultation with pastoralists. Monitoring will be conducted by suitably skilled and qualified persons and annual reviews of monitoring data will be conducted. Monitoring outcomes will determine whether rehabilitation is underperforming and additional maintenance is required. The following key aspects would be evaluated during monitoring:

a. Soil erosion (and potential exposure of waste materials);
b. Revegetation success;
c. Weed infestation; and
d. Integrity of diversion drains, waterways and erosion and sediment control structures.

Rehabilitation methods will be improved over time as additional knowledge is gained from the monitoring programs and research conducted into the different rehabilitation techniques.

8. Rehabilitation Maintenance

In the context of this strategy, 'maintenance' constitutes any additional erosion & sediment control, re-application of seed to promote ground-cover or further management of weeds is required. However, this management frequency would vary depending on the extent of rehabilitation success and necessary method for mitigating failing rehabilitation.

Appendix C: Erosion & Sediment Control Plan

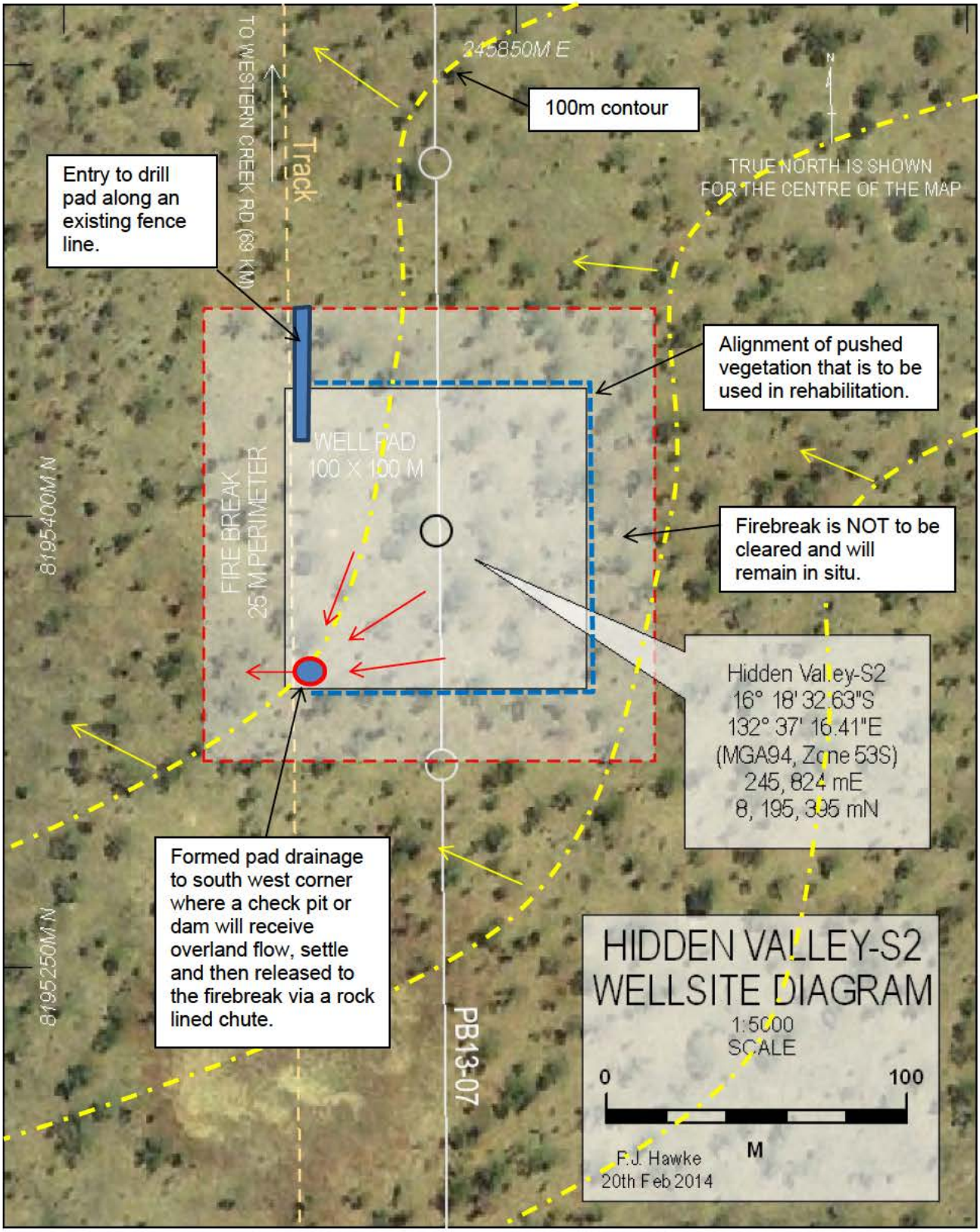
This Erosion and Sediment Control Plan (ESCP) has been prepared for, and is specific to the land forms present at the Hidden_Valley S-2 drill site.

Mitigation measures will be implemented prior to rig mobilisation but post vegetation clearing. Installation of controls to minimise erosion, and prevent sediment laden drainage water leaving the drill site before vegetation is not practical or possible given the heavy vegetation cover on the site. Controls will be installed on the same day that clearing operations are completed.

The following principles will be considered in the planning, design, construction, and operation of the site:

1. Discharge water from drill site will only be permitted at a rate and location that will not result in erosion,
2. All run-off water needs diversion into clean water drainage lines and off site into natural drainage systems,
3. Localised erosion and sediment control and energy dissipation structures may be required,
4. Minimising the area of disturbance and vegetation clearing to only that is required to operate the site safely (in accordance with the Petroleum Act).
5. Any excavated soil is to be stockpiled and used for rehabilitation onsite. Stockpiles will be located away from water sources and in clear areas,
6. Implement best practice erosion and sediment control measures during the implantation of works specified by the Rehabilitation Plan for the site.

Hidden_Valley S-2 ESCP



Appendix D: Monthly Environmental Inspection Checklist

Site/Project Name:		**Contract/Job No:**	
Inspected by:		**Date:**	
Designation:		**Time:**	

Weather conditions (tick appropriate boxes):

Fine		Overcast		Light rain		Heavy rain (>15mm)		Light wind		Strong wind (>30km/hr)		Total Fire Ban	

General	Y	N	N/A	Comments & Actions
Site is in a generally tidy condition				
All equipment, materials, etc contained within work area boundary				
Is site free from obvious signs of construction-related disturbance outside of construction area(s)?				

Soil & Erosion Control	Y	N	N/A	Comments & Actions
Required erosion control measures have been correctly installed and are functional				
Where required, drainage outlets provided with energy dissipaters to minimise erosion				
Works are being scheduled to minimise areas exposed at any one time and plant selected to minimise disturbance				
Areas where activities have ceased are stabilised and are being rehabilitated				
There is minimal dirt on adjacent sealed public roads and dirt is prevented from being tracked onto sealed public roads				
Diversion banks and drains are located appropriately (to reduce run-on)				

Water Quality	Y	N	N/A	Comments & Actions
Water quality in down slope areas appears to be unaffected by works				
Is site free of apparent illegal discharges				
All hazardous materials (e.g. fuels, chemicals, etc) are stored undercover in an impervious bund				
Spill kit is readily accessible				
On-site refuelling of construction plant/vehicles restricted to designated area more than 20m away from waterways				
Is site free from obvious signs of fuel spills, oil leakage, etc from construction plant?				

Noise and Vibration	Y	N	N/A	Comments & Actions
Plant not in use switched off				
There are appropriate noise and vibration controls to activities adjacent to residents and other sensitive receivers				

Air Quality	Y	N	N/A	Comments & Actions
Is site free from obvious signs of dust deposition outside of construction area(s)?				
Haul roads are being kept damp (if required)				
There is spraying for dust control				
Vehicles and machinery do not have visible exhaust for more than 10 seconds				
Burning off is not occurring on site				

Waste Management & Minimisation	Y	N	N/A	Comments & Actions
Waste receptacles accessible, lidded and clearly marked with regard to waste type				
All recyclable material separated as per waste management plan				
Contaminated land is fenced off				

Vegetation	Y	N	N/A	Comments & Actions
All required vegetation protection measures in place and functional				
Are all protected areas clear of obvious signs of construction activity				
Disturbed areas are stabilised and revegetated				

Archaeology/Heritage	Y	N	N/A	Comments & Actions
All required protection measures in place and functional				
Construction materials are not being stored inside heritage protection zones				

Traffic Management	Y	N	N/A	Comments & Actions
All required traffic control measures implemented in accordance with TMP (e.g. warning signs, temporary road closures, limited to use of roads)				
All plant parked on site				
Private vehicles of construction personnel not obstructing passage of local traffic				

Other	Y	N	N/A	Comments & Actions
Access to properties along roads not obstructed				

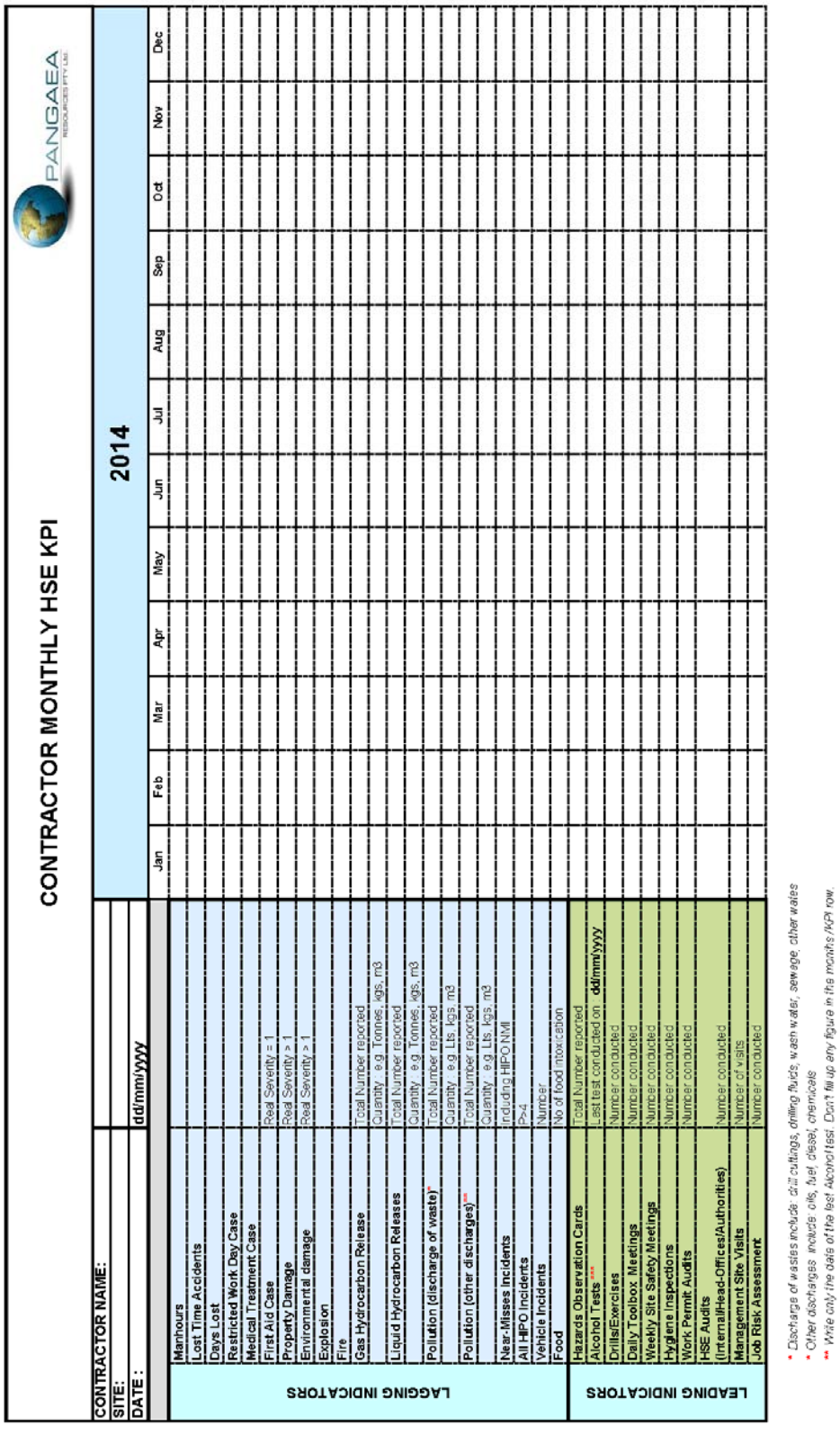
Other Comments?

EMR: .....

Date: .....

Reviewed by: ..... Project Manager/Site Supervisor: .....

Appendix E: Monthly HSE Report



CONTRACTOR MONTHLY HSE KPI

CONTRACTOR NAME:
SITE:
DATE : dd/mm/yyyy

2014

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LAGGING INDICATORS	Manhours												
	Lost Time Accidents												
	Days Lost												
	Restricted Work Day Case												
	Medical Treatment Case												
	First Aid Case	Real Severity = 1											
	Property Damage	Real Severity > 1											
	Environmental damage	Real Severity > 1											
	Explosion												
	Fire												
	Gas Hydrocarbon Release	Total Number reported											
		Quantity e.g Tonnes, kgs, m3											
	Liquid Hydrocarbon Releases	Total Number reported											
		Quantity e.g Tonnes, kgs, m3											
	Pollution (discharge of waste)*	Total Number reported											
		Quantity e.g Lts, kgs, m3											
	Pollution (other discharges)**	Total Number reported											
		Quantity e.g Lts, kgs, m3											
	Near-Misses Incidents	Including HIPO NMI											
	All HIPO Incidents	P>4											
	Vehicle Incidents	Number											
	Food	No of food intoxication											
LEADING INDICATORS	Hazards Observation Cards	Total Number reported											
	Alcohol Tests ***	Last test conducted on dd/mm/yyyy											
	Drills/Exercises	Number conducted											
	Daily Toolbox Meetings	Number conducted											
	Weekly Site Safety Meetings	Number conducted											
	Hygiene Inspections	Number conducted											
	Work Permit Audits	Number conducted											
	HSE Audits (Internal/Head-Offices/Authorities)	Number conducted											
	Management Site Visits	Number of visits											
	Job Risk Assessment	Number conducted											

* Discharge of wastes include: drill cuttings, drilling fluids, wash water, sewage, other wates
* Other discharges include oils, fuel, diesel, chemicals
** Write only the date of the last Alcohol test. Don't fill up any figure in the months /KPI row.

Appendix F: Waste Management Plan

1. Introduction

1.1 Purpose

Throughout the activities proposed at Hidden_Valley-S2 (including site preparation, drilling, P&A and rehabilitation) a variety of waste streams and waste products will be generated.

Waste management options identified within this plan will be employed to reduce or avoid impacts due to inappropriate handling of waste. The options examine alternatives that relate to waste minimisation, re-use and recycling of materials instead of disposal. It is intended that the waste products do not adversely impact the environment, human health or the amenity of the area. The purpose of this waste management plan is to:

1. Identify, describe and quantify the various waste products and streams to be generated during drilling Hidden_Valley-S2.
2. Assess the potential impacts to the surrounding environment.
3. Identify options for waste minimisation and management, with specific reference to the waste hierarchy.
4. Develop mitigation measures to minimise any waste impact.

2. Waste generation

There are a variety of sources of waste associated with the proposed activities at Hidden_Valley-S2, however a number of wastes have been identified which are likely to be generated from site preparation activities, drilling and plug and abandonment stages. These include:

- Vegetation cleared during site preparation works
- Oils and oily wastes from equipment and machinery maintenance and refuelling activities
- Waste paints and solvent
- Waste adhesives
- Aerosol cans
- Waste antifreeze/radiator coolant
- General domestic waste and recyclables
- Office wastes (paper, cardboard, plastics and wood products from packaging)
- Scrap metals (ferrous and non-ferrous)
- Surplus concrete
- Used welding rods
- General inert construction waste
- Grey-water
- Batteries
- Tyres
- Solvents and chemicals
- Medical and first-aid station waste
- Food waste
- Atmospheric emissions

2.1 General waste

Waste generated that cannot be recycled during the construction phase will be collected in mobile garbage bins and suitably-sized roll-on-roll-off bins with proper waste identification and labels in a designated waste segregation area. These wastes will be trucked from the drill site and disposed of at a licenced landfill site (either Katherine or Daly Waters).

2.2 Wastewater

Wastewater from the site preparation stage may include vehicle and equipment washdown water, stormwater and sewage treatment plant grey-water. Where appropriate, it is intended that stormwater will be transferred to sedimentation pond(s) for reuse on site for dust suppression and irrigation, in accordance with regulatory requirements.

A transportable and fully self-contained sewage treatment plant will support the drilling operations team. An Enviro-Flow unit (or similar) will provide a final water quality suitable for surface irrigation via a sprinkler attachment. The final system will (as a minimum) be selected based upon 300L / person / day. Sludge/solid material will be reduced by anaerobic decomposition and removed from site (via tanker to a licensed facility). This is not anticipated to happen during the drill campaign.

2.3 Potentially contaminated wastewater

Any potentially contaminated wastewater will be collected in the sump pits. Such wastewater will be pre-treated in a hydrocarbon sump drum where vapours and condensate will be separated. The condensate will be pumped to the oil and water separator for retrieval of free oil. The separator produces three waste streams – sludge, treated effluent and waste oil.

The sludge will be temporarily stored in a sludge holding tank, pending periodical transport by a licensed contractor for disposal at a licensed waste management facility. Waste oil will also be stored and transported off-site for recycling. The treated effluent from the oil and water separator will be sent to the dissolved air flotation unit and effluent filter to remove any remaining oil.

2.4 Decommissioning wastes

The Hidden_Valley-S2 drill hole will be plugged and abandoned after completion. P&A/decommissioning activities will be carried-out in accordance with a decommissioning plan and will comply with regulatory requirements that are in force at the time of decommissioning and good industry practice.

The overall aim of the decommissioning plan will be to ensure that the site does not pose an on-going risk to public safety or the quality of the environment and fulfils community expectations. The decommissioning plan will be prepared for the drill site before decommissioning work starts, in consultation with regulatory authorities and relevant stakeholders. In preparing the decommissioning plan, Pangaea will aim to demonstrate how it will reduce as far as practicable the amount of waste requiring disposal.

3. Potential impacts

The potential impacts associated with non-compliance in waste management could include:

- Land and water contamination from inappropriate storage, handling and disposal of solid and liquid wastes.
- Land and water contamination from spills and releases during handling and transportation.
- Increased populations of vermin from inappropriate storage and handling of waste.
- Odours due to inappropriate storage and handling of waste.
- Water contamination from discharges of contaminated stormwater or sewage treatment effluent.
- Inefficient use of resources.
- Adverse effects to aquatic and terrestrial flora and fauna.

Given Pangaea's track record in effective waste management and proven control measures, construction, operational and decommissioning wastes are considered to present a low risk to the environment and/or public health.

4. Waste management plan

The main purpose of waste management is to minimise impacts to the environmental values as outlined in Section 8 of the EMP. Several strategies will be used, principally the implementation of the waste management hierarchy and cleaner production principles. The waste management actions proposed for the Hidden_Valley-S2 drill site are detailed in **Table 1**.

4.1 Objectives and performance indicators

The objectives of this plan are to:

- Minimise contamination of the site.
- Appropriately manage waste generated on-site.
- Avoid wastes entering the site.
- Minimise waste generated from the site.
- Maximise waste recycling and reuse.

The performance indicators for this plan are:

- Zero contaminants or wastes are discharged to land or water on-site
- Zero unauthorised discharges of contaminants or waste to land or water off-site
- Minimise the quantity of wastes disposed to a landfill
- Dispose of all waste appropriately
- Zero complaints relating to waste management.

4.2 Responsibilities

The persons responsible for compliance with this plan during the construction period and operational phase and their responsibilities are summarised below.

4.2.1 Site preparation phase

During the site preparation phase, the Principal Contractor and Service Providers will be the Responsible Persons and will undertake the following:

- Ensure that the requirements of this plan are satisfied.
- Ensure that contractors and any sub-contractors engaged are advised of their responsibilities to undertake their activities required by this plan.
- Ensure that contractors and any sub-contractors engaged are advised of their responsibilities regarding waste management.
- Ensure that the auditing/monitoring program is implemented properly.
- Prepare incident reports and implement corrective actions.
- Ensure appropriate records are kept and maintained on-site.
- Retain a copy of this plan on-site for reference by appropriate personnel and provide copy of plan to contractors.
- Recommend additions or changes to this plan based upon experience gained from implementation of the plan.

4.2.2 Drilling phase

During the drilling phase and subsequent de-commissioning period, Pangaea's Wellsite Representative will be the Responsible Person and will undertake the following:

- Ensure that the requirements of this plan are satisfied.
- Ensure that the auditing/monitoring program is implemented properly.
- Prepare incident reports and implement corrective actions.
- Ensure appropriate records are kept and maintained on-site.
- Retain a copy of this plan on-site for reference by appropriate personnel.
- Recommend additions or changes to this plan based upon experience gained from implementation of the plan.

4.3 Waste tracking

Waste reporting will be generated via the Waste Register (**Attachment 1**). The Waste Register will be maintained by Services Providers and a copy is to be kept onsite by the Wellsite Representative until the project is completed.

The Waste Register will record the type, amount and location of waste reused, recycled, stockpiled and disposed of plus other data including:

a) Type of waste and its classification (according to the Waste Management and Pollution Control Act);
b) Tonnes of waste;
c) How and where the waste was reused, recycled, stockpiled or disposed of;
d) Date when the waste was reused, recycled, stockpiled or disposed of; and
e) Name of the transporter used.

4.4 Waste auditing & monitoring

Waste streams and quantities will be monitored via the monthly audit conducted by the EMR during the drilling phase. The purpose of auditing the waste management activities onsite includes:

- Ensure and monitor compliance with approval conditions.
- Assessment of the actual wastes compared to predicted waste streams and quantities.
- Monitor potential impacts from wastes.
- Review the waste transportation records.
- Recommend future actions to improve waste management practices.
- Monitor the implementation of the principles of waste management hierarchy.

5. Summary of waste descriptions and management

A summary of waste descriptions and management is provided in Table 1.

Table 1: Summary of wastes and management

Site Preparation Phase

Waste	Characteristic	Management	Responsibility
Overburden, excess on-site material	Inert waste	• The site prep contractor will: • undertake all stockpiling efficiently and with proper erosion control. • ensure appropriate sediment and erosion control measures are in place. • All site run-off will be captured in sedimentation ponds for treatment as necessary prior to any release to the environment.	Mark Sullivan Contracting
Trees, brush vegetation	Organic material	Felled trees and branches retained on site where practicable, for erosion control and rehabilitation.	Mark Sullivan Contracting
Oil, oily rags and oil filters (maintenance)	Regulated waste	• The site prep contractor will utilise mobile bins for the segregation and storage of oily rags, cleaning rags and cloths, and oil filters. • The construction contractor will engage a licensed waste contractor	Mark Sullivan Contracting
General waste / Recyclable waste (garbage)	General waste	• The site prep contractor will designate an area within the camp site for waste storage. Areas such as offices, lunch rooms, work-shops, etc. will be serviced with mobile garbage bins. Several bins will be required for general waste as well as additional bins for co-mingled recycling, such as glass bottles and jars, metal tins and cans, paper and cardboard and plastic bottles. • A licensed waste management contractor will be contracted to supply bins, transport waste, recycle recyclable waste and dispose of non-recyclable waste most likely at the Katherine landfill.	Mark Sullivan Contracting
Batteries	Regulated waste	• The construction contractor will store batteries in a bunded area sized to 110% of the capacity. • The waste contractor will regularly remove batteries and dispose or recycle depending on the quality of the waste	Mark Sullivan Contracting
Tyres	Regulated waste	• The construction contractor will designate an area for the storage of tyres • The waste contractor will regularly remove batteries and dispose or recycle depending on the quality of the waste	Mark Sullivan Contracting

Waste	Characteristic	Management	Responsibility
Grey water and sewage	Regulated waste	The site prep contractor will conduct regular inspections of the portable amenities and grey-water lines to ensure quality objectives are being met.	Mark Sullivan Contracting
Sewage treatment plant solid waste	Regulated waste	• The sewage treatment plant will include contained storage for sewage treatment plant solids and waste • A regulated waste licensed contractor will transport waste from the site for disposal if required	Mark Sullivan Contracting

Drilling Phase

Waste	Characteristic	Management	Responsibility
Oil, oily rags and oil filters (maintenance)	Regulated waste	• The site prep contractor will utilise mobile bins for the segregation and storage of oily rags, cleaning rags and cloths, and oil filters.	Major Drilling
General waste / Recyclable waste	General waste	• The site prep contractor will designate an area within the camp site for waste storage. Areas such as offices, lunch rooms, work-shops, etc. will be	Major Drilling
Batteries	Regulated waste	• The construction contractor will store batteries in a bunded area sized to 110% of the capacity. • The waste contractor will regularly remove batteries and dispose or recycle depending on the quality of the waste	Major Drilling
Tyres	Regulated waste	• The construction contractor will designate an area for the storage of tyres • The waste contractor will regularly remove batteries and dispose or recycle depending on the quality of the waste	Major Drilling
Grey water and sewage	Regulated waste	The site prep contractor will conduct regular inspections of the portable amenities and grey-water lines to ensure quality objectives are being met.	Major Drilling
Sewage treatment plant solid waste	Regulated waste	• The sewage treatment plant will include contained storage for sewage treatment plant solids and waste • A regulated waste licensed contractor will transport waste from the site for disposal if required	Major Drilling
Sump water containing hydrocarbons	Regulated Waste	• Oily wastewater will be treated by CPI oil/water separator, a dissolved air flotation unit (DAF) and an effluent sand filter. • The sludge will be temporarily stored in a sludge holding tank, pending periodical transport by a licensed contractor for disposal at a licensed waste management facility. • Waste oil will also be stored and transported off-site for recycling • The treated water from the CPI will be sent to the DAF unit and effluent filter to remove any remaining	Major Drilling

Plug & Abandonment / Decommissioning Stage

Waste	Characteristic	Management	Responsibility
Oil, oily rags and oil filters (maintenance)	Regulated waste	• The site prep contractor will utilise mobile bins for the segregation and storage of oily rags, cleaning rags and cloths, and oil filters.	Major Drilling
General waste / Recyclable waste	General waste	• The site prep contractor will designate an area within the camp site for waste storage. Areas such as offices, lunch rooms, work-shops, etc. will be	Major Drilling
Batteries	Regulated waste	• The construction contractor will store batteries in a bunded area sized to 110% of the capacity. • The waste contractor will regularly remove batteries	Major Drilling
Tyres	Regulated waste	• The construction contractor will designate an area for the storage of tyres • The waste contractor will regularly remove batteries	Major Drilling
Grey water and sewage	Regulated waste	• The site prep contractor will conduct regular inspections of the portable amenities and grey-water lines to ensure quality objectives are being met.	Major Drilling
Sewage treatment plant solid	Regulated waste	• The sewage treatment plant will include contained storage for sewage treatment plant solids and waste • A regulated waste licensed contractor will transport	Major Drilling
Contaminated fill	Regulated waste	Decommissioning will be in accordance with the Rehabilitation Plan, regulatory requirements and the pastoral land access agreement.	Major Drilling Mark Sullivan Contracting

Attachment 1: Waste Register

Destination of Excess Materials: ☐ Residential ☐ Commercial ☐ Industrial

Materials on-site		**Destination**		
		Re-Use & Recycling		**Disposal**
Type of Material	Estimated or Recorded Volume (m^3) or Area (m^2)	On-Site Specify the proposed reuse or onsite recycling methods	Off-Site Specify the contractor and recycling outlet	Specify contractor and landfill site

Personnel name: .....

Date: .....

Reviewed by: ..... Project Manager/Site Supervisor: .....

Appendix G: Incident Investigation Procedure

	Document Name	Document Number	Emission	Revision	Duration
PANGAEA	Incident Report Form	F-9-000		17-03-2010	

PANGAEA
Q-HSE INCIDENT REPORT FORM

Company		**Project / Tenement**	
Report Number		**Preliminary Report Number (if applicable)**	
Date report submitted			
Person submitting report			

INCIDENT TYPE
(More than one box may be ticked):

☐ Safety	☐ Health	☐ Environment	☐ Community
☐ Motor vehicle	☐ Property Damage	☐ Regulatory Breach	☐ Quality concern

If Health and / or Safety also specify one or more of the following:-

☐ First Aid	☐ Alternative duties	☐ Medical Treatment Case	☐ LTI
☐ Property Damage	☐ Near Miss	☐ Off The Job	☐ Fatality

If Environment and / or Community also specify one or more of the following:-

☐ Biodiversity	☐ Common Species
☐ Habitat disturbance	☐ Large area impacted / Sensitive Environment
Pollution	☐ Air ☐ Soil ☐ Water ☐ Hazardous Substance / chemical spill (indicate quantity) ☐ Fuel Spill (indicate quantity)
☐ Damage to heritage site	☐ Stakeholder Engagement
☐ Other (give details):	

INCIDENT SEVERITY / PROBABILITY OF RECURRENCE

Actual Incident Consequence - (use Potential / Actual Consequence Severity Matrix – see matrix on the last page)

☐ Negligible	☐ Minor	☐ Moderate	☐ Major	☐ Extreme	☐ Catastrophic

Potential or inherent risk (Steps 1, 2 and 3 on last page)

☐ Low	☐ Medium	☐ High	☐ Extreme

If the Actual Incident Consequence is Moderate or higher, OR if the Potential Risk is High or Extreme, a formal incident investigation is required.

INCIDENT DESCRIPTION

Date		**Time**	
Place			
Potential / Actual costs (state currency)			

Summary:-

Procedure or JSA / JHA used? ☐ No ☐ Yes – details.....

Describe the sequence of events that led to the incident (attach notes/plans/photos as appropriate):

1)
2)
3)

☐ Attachments (photos, plans, etc)

PERSON INJURED / INVOLVED IN INCIDENT

Name		**Date of birth**	
Age			
Days into roster .....of.....	**Hours into shift** .....of.....	**Employed Date**	**Time in current position**

	Document Name	Document Number	Emission	Revision	Duration
PANGAEA	Incident Report Form	F-9-000		17-03-2010	

HAZARD / INCIDENT AGENCY			
SAFETY	☐ Windblown dust	☐ Fire	☐ Electrical (shock, failure)
☐ Welding (slag, flash, etc)	☐ Fumes / chemicals	☐ Natural event	☐ Work environment
☐ Repetitiveness	☐ Trip/Slip	☐ Electricity	☐ Lifting/Carrying
☐ Machinery (plant, mechanical)	☐ Thermal (hot pipes, etc)	☐ Noise	☐ Object falling
☐ Other (give details):			
ENVIRONMENT	☐ Release of dust	☐ Bush fire	☐ Land disturbance
☐ Hydrocarbon spill (oil, solvents, etc)	☐ Spill to contained hard surface	☐ Chemical spill (acids, caustic, etc)	
☐ Process water spill	☐ Generation of noise	☐ Release of gas	☐ Waste disposal
☐ Other (give details):			
QUALITY	☐ Non standard procedure/form in use		
☐ No procedure/form in use	☐ Procedure/form not followed		
☐ Procedure/form incorrect or out of date	☐ Procedure/form/other doc not communicated adequately		
☐ Std job details not adequate	☐ Equipment not calibrated		
☐ Skills / resources not adequate	☐ Other (give details):		

NATURE OF ENVIRONMENTAL IMPACT (if relevant)					
☐ Contamination of land		☐ Contamination of surface water			
☐ Contamination of ground water		☐ Atmospheric pollution			
☐ Spread of weeds / pests		☐ Loss of habitat / biodiversity			
☐ Disturbance of Cultural / European Heritage		☐ Change to visual amenity			
☐ Depletion of natural resources		☐ Non-compliance			
Was it	☐ Widespread	☐ Localized?	Was it	☐ Temporary	☐ Long term?

PROPERTY DAMAGE (if applicable)

If property was damaged provide details of equipment and describe the damage:

WHAT HAPPENED? (Analysing the facts)

Identify the underlying causes that led up to the incident, not just the apparent cause. Systematically evaluate the role of every conceivable causation factor. At the incident scene, look at equipment, materials and the environment. Describe the conditions reviewed here or by checking the contributing factors in the list below.

CONTRIBUTING FACTORS

Equipment Design	Personal Factors	Procedures	Environment
☐ Not comply with spec	☐ Culpable act	☐ Not available	☐ Visibility
☐ Standard dangerous	☐ Skylarking	☐ Used not sufficient	☐ Wind/rain/dust
☐ Insufficient for task	☐ Lack of supervision	☐ OK but not applied	☐ Uneven/rocky
☐ Poorly maintained	☐ Not trained	☐ JSA not available	☐ Slippery surface
☐ Poorly installed	☐ Training not sufficient	☐ JSA used not sufficient	☐ Restricted area
☐ Uncontrolled Modification	☐ Inexperience	☐ JSA OK not used	☐ Hazardous substance
Safety Equipment	☐ Inattention	☐ Insufficient organisation	☐ Poor house keeping
☐ Missing insufficient	☐ Fatigue/stress	☐ Excessive speed	☐ Extreme temp
☐ Inappropriate	☐ Improper use of equip	☐ Not updated or obsolete	☐ Reptiles/insects
☐ Deliberately bypassed	☐ Drugs or alcohol	☐ Insufficient preparation	☐ Insufficient Logistics
☐ Out of service	☐ Language Barrier	☐ Risk Register not reviewed	☐ Other
☐ Not used			

PANGAEA	Document Name	Document Number	Emission	Revision	Duration
	Incident Report Form	F-9-000		17-03-2010	

CONTRIBUTING FACTORS
List the contributing factors identified in the above table:
1.
2.
3.
4.
5.
6.

PREVENTATIVE / CORRECTIVE ACTION

Action Item Register No	Corrective Action	Responsible Person	Target Completion Date

INCIDENT CLASSIFICATIONS

(See guideline for codes)

Employment Classification		Facility Type	
Nature of operation being undertaken		Mechanism of Incident	
Impact of Incident		Receiving Environment.	

SIGN OFF

Person In Charge / Supervisor Comments Have the corrective actions been noted in the Action Item Register? Yes / No	Signature (Must be signed) Date: ...../...../.....
Operations Manager Comments	Signature (Must be signed) Date: ...../...../.....
QHSE Manager Comments	Signature (Must be signed) Date: ...../...../.....
Chief Operating Officer Comments	Signature (Must be signed) Date: ...../...../.....

Appendix H: Consultation Report

Date of Contact:.....Time:……..
Received by (Name):.....Type (Ph, letter, in person)…….....
Others Present:.....

Name of Contact Person:……Address:……..
Phone:……Mobile:……..Email:…….

Nature of Contact:

Observations:

Response/Action Taken:

Form filled out by:……

Pangaea Representative:.....Date: .....

Project Manager/Site Supervisor .....

Appendix I: Quality Action Tracking Register

Quality Action Item Register

Site / Location

Ref no	Action originating from	Category	Issued by	Action Required	Location	Priority	Action Plan / Comment	Close-out Person	Deadline	Status
1										
2										
3										
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Appendix J: Information Management Policy

PANGAEA RESOURCES PTY LTD	Documentation for Records	Policy:	CP-4.060		
		Dates:	Emission	Revision	Duration
			18-07-2012	18-07-2014	2 years
		Section:	Integrated Quality Management Systems		
		Pages :	4 of 5		

1. POLICY STATEMENT

The purpose of this policy is to specify that Pangaea Resources will strive to implement a systematic management of records to protect and preserve them as evidence of actions and to ensure that any authorized person will have access to have access to the information handled by the company in a precise, reliable and whenever it's required.

Pangaea will strive to meet the requirements of the following standard:

- AS ISO 15489 (Set)-2004, Records Management
- AS/NZS 4801 Safety Management Systems
- AS/NZS 4804 Occupational , Health and Safety Systems

2. POLICY DETAILS

Record and document management is a vital component of any QHSE MS.

Records and document Management refers to a system for storing, indexing and retrieving records and documents.

A Record is a document of any medium or format that is created in the course of business to record an activity or event.

Records and documents may be created to:

- Communicate information
- Record information
- Educate

Pangaea is required to keep records relating to:

- Sick leave
- Workers compensation and accidents and injuries in the workplace
- Information and records relating the health and safety of workers
- Copies of confined spaces entry for 30 days from expiry
- Register of hazardous substances
- HSE inductions
- Etc

Pangaea is required to document:

- Accidents and injuries reports
- All HSE policies
- Procedures and Guidelines
- Results of Inspections and Audits
- Risk assessments
- Training and inductions carried out
- Plant design or changes
- Environmental monitoring performed (air, water, soil, etc)

There are more specific obligations in various legislation in each State and Territory. Pangaea is committed to determine which record-keeping obligations apply in the jurisdiction we are operating.

Pangaea shall have a comprehensive record system to document our HSE MS. The records system should be:

- Legible
- Identifiable
- Traceable to the activity, product or services involved
- Maintained in a manner appropriate
- Secure
- Easily accessible

Pangaea will follow the industry best practice to keep records. A reasonable rule is 5 to 7 years. However some records are required to be kept for specific periods. For example, records of injuries and accidents need to be kept for at least 5 years, while employee health surveillance records generally need to be kept for 30 years.

Pangaea follow and have implemented a QMS Document Control Register (Doc : CR-4-000_Rev_A) to makes tracking documents a much faster and easier process.

3. REFERENCE DOCUMENTS

Standards:
AS ISO 15489 (Set)-2004, Records Management
AS/NZS 4801 Safety Management Systems
AS/NZS 4804 Occupational , Health and Safety Systems

Regulations / Acts:
Information Privacy Act 2000
The Privacy Act 1998 (Cth)

Codes of Practices:

Pangaea Resources documents:
CP-16.010 Privacy
CP - 6.010 Freedom of Information
CR-4-000_Rev_A_QMS Document Control Register

Other documents

Appendix K: Emergency Response Contacts

See NT_EP167-168-198 Emergency Response Plan as a separate document for complete Emergency Response instructions.

The NT is a unique operating zone with unique government medical structures put in place to deal with medical emergencies. **The major planning factor to be aware of in this region is that these assets are often busy and wait times may be considerable.**

In order to reduce the time from the injury occurring to receiving emergency lifesaving medical treatment, Pangaea Resources will map a concentric helicopter coverage ring around NT operations for emergency evacuation as required.

In the event a medical emergency has occurred and there is immediate threat to life or limb **the Royal Darwin Hospital 24/7 switchboard is the primary contact** for medical emergency response.

The first statement made to the DMO by the IMT Commander should be the following:

"I have a critical medical emergency of *….xxxxx….* and I have a helicopter on standby that can be in my position within 1 hour. Should I instruct my team to mobilise the helicopter?"

The DMO will then say one of the following:

"Yes – Call the helicopter to extract the casualty to Royal Darwin/Katherine Hospital because we have no available resources available within the next 6 hrs and remain on the phone with me to receive further medical direction on patient care'."

Or

"No – Do not call your helicopter in, I have notified Careflight and they will be in your location in 2hrs. Stay on the phone for further patient care direction."

EMERGENCY CALLOUT DIRECTORY	
Royal Darwin HOSPITAL	**08 8922 8888 (ask for DMO immediately)**
If Royal Darwin HOSPITAL is unreachable immediately call 000	
DHCS Katherine	08 8973 9211
Careflight	08 8928 9777 – 1300 650 654
KATHERINE (Postcode 0852)	**Post Office Ph: 08 8947 3877**
NT Fire and Rescue Service	Northern Region Business hrs 08 8946 4107 Southern Region Business hrs 08 8951 6688 After Hours 08 8922 1555
Fire Station Stuart Highway Katherine East 0850	08 8973 8014
State Emergency Services – Duty Officer	131 444
Katherine Local Council LOT 1865 Stuart Highway	08 8972 5500

EMERGENCY SUPPORT SERVICES CONTACTS	
Helicopters	
CLOSEST for NORTHERN STATIONS North Australian Helicopters Victoria Highway, Katherine	Frank Hoare (Chief Pilot) 08 8972 5666
CLOSEST for SOUTHERN STATIONS Mark Sullivan Contracting Flying Fox Station (near Mataranka)	0407 825 966 (08) 8977 4222
CLOSEST for EP(A) 198 ONLY Heli-Muster Scenic Flights VRD	08 8975 0777
North Australian Helicopters: Gorge Road Nitmiluk	08 8972 5666
CAREFLIGHT	
CareFlight Northern Operations (NT) 6 Fenton Ct Eaton (Darwin Airport) NT 0820	Logistics and Coordination Unit (24 hrs): 08 8944 8007
Air Charter	
ChartAir Darwin, International Airport, 0812 Hanger 78, Alice Springs Airport Tindal Airport, Katherine	08 8920 7777 08 8952 6666 1300 790 800
Transport	
Compass Haulage 13 Eldorado Crs, Tennant Creek	08 8962 2122
Earthworks	
Saunders Contracting, Bernard St Katherine Upstill Earthworks, Bernard St Katherine	08 8972 1764 0418 896 127
NT Authorities	
NT EPA Level 5, Harbour View Plaza 8 McMinn St Darwin	08 8999 3751

EMERGENCY SUPPORT SERVICES CONTACTS	
Department of Mining and Energy Emergency Contacts Paspalis CentrePoint Building 48-50 Smith St Darwin	Petroleum Operations 0401 119 456
Bushfires NT 32 Giles St PO Box 532 Katherine NT 0851	T: (08) 8973 8871 or T: (08) 8973 8872 T: (08) 8973 8870 (VRD) F: (08) 8973 8873 or 8973 8899

MISCELLANEOUS SUPPORT			
Business	**Name**	**Address**	**Phone**
Engineering	Bennet, Eng and Fabrication,	Katherine, NT	0429 674 209
Mechanical	Katherine Regional Mech Services	17 Palmer St, Katherine East, NT	08 8971 1278
Hydraulics	Katherine Hydraulics	Katherine, NT	08 8972 2576
Electrical	DJ Hogan Electrical Contractors	15 Collins Road, Katherine, NT	08 8971 1425
	Whitehouse Furnishers Retravision	9 Second St, Katherine	08 8972 1849
Auto Electrics	Everything Auto Electrical	PO Box 1731, Katherine	0407 796 553
Fencing	Jaeschke Fencing	5114 Collins Road, Katherine, NT	0417 168 954
Signage	Katherine Sign Management	Katherine, NT	08 8971 7304

Appendix L: Pangaea Resources Contacts List

Pangaea Resources Pty Ltd

Corporate Office
Level 50 Governor Phillips Tower
1 Farrer Place
Sydney, NSW, 2000
Main Switch: (02) 9017 9600
Facsimile: (02) 9017 9699

Sydney Office		
[redacted]		
[redacted]		
[redacted]		
[redacted]		
[redacted]		
[redacted]		
[redacted]		
[redacted]		
[redacted]		

CONTRACTED SERVICES CONTACTS

Name & Position	Work	Mobile
Major Drilling Matthew Metz Operations Manager	[redacted]	[redacted]
Weatherford Behzad Marzban Sales Manager	[redacted]	[redacted]
Mark Sullivan Contracting Mark Sullivan General Manager	[redacted]	[redacted]

Field Contacts:

Field Contacts	SAT Phone	Mobile
Pangaea Resources Rogan Corbett Wellsite Representative (Company Man)	[redacted]	[redacted]
Pangaea Resources Randy Laney Senior Wellsite Geologists	[redacted]	[redacted]
Pangaea Resources Peter Hawke Field Geologist	[redacted]	[redacted]
Pangaea Resources Daniel Levy Field Geologist	[redacted]	[redacted]
Major Drilling Rig UDR5000 Drill Location	[redacted]	[redacted]

Appendix M: Oil Spill Contingency Plan

STEP 1: ONSITE PERSONEL

1.1 **STOP & IDENTIFY** the action(s) or cause(s) of the incident.

1.2 **NOTIFY** your SITE MANAGER [INSERT NAME AND MOBILE NUMBER]

1.3 **SECURE THE AREA, BUND & PREVENT** the hydrocarbons entering waterways and groundwater aquifers. DO NOT traverse across the spill area under any circumstances. Bunds are anything that are impervious (e.g. geofabric covered soil contour bank, deployed plastic bunds, plastic sleepers).

1.4 **DEPLOY** cotton based absorbing sheet on the spill area only if the site conditions permit (i.e. not wet or raining).

1.5 **NOTIFY** the WELLSITE REPRESENTATIVE [NAME AND MOBILE NUMBER]

1.6 **IF** the WELLSITE REPRESENTATIVE deems that the incident has already caused or has the potential to cause ***material***[1] or ***serious environment harm***[2] **NOTIFY** the NT Government via the POLLUTION HOTLINE [1800 064 567]

STEP 2: ONSITE PERSONNEL & EMR

2.1 **CLEARLY DELINEATE** the area affected by the spill.

2.2 **PREPARE** a impervious bunded area to receive the excavated, affected soil.

2.2 **EXCAVATE** the affected area under supervision by the EMR. Excavation is to be undertaken at 100mm layers until the hydrocarbon is no longer discernible in the soil profile (on the excavation walls). Stockpiles are to be separated by the excavation stage (100mm, 100-200mm, etc). DO NOT cover the stockpiles if the site is bunded.

2.3 **COLLECT** soil samples from the spill site and the stockpiles. Samples are to be taken with a motorised 100mm auger, which is to be rinsed in deionised water between each sample. Each sample of approximately 200 grams is to be placed into sterile glass jars, labelled and stored in a cooled esky for transport to a NATA accredited Laboratory. Each sample is to be sampled for:

- Petroleum hydrocarbon compounds (TPH) – TPH fractions were analysed up to the C40 fraction including a separate C5-C9 TPH fraction analysis;
- Polycyclic aromatic hydrocarbons (PAHs) – in particular naphthalene; and
- Benzene, toluene, ethyl benzene and xylenes (BTEX).

2.4 **COLLATE** results. Options from this point forth will require consideration by Management.

[1]***Material environmental harm*** means environmental harm that:

(a) is not trivial or negligible in nature;

(b) consists of an environmental nuisance of a high impact or on a wide scale;

(c) results, or is likely to result, in not more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or

(d) results in actual or potential loss or damage to the value of not more than $50,000 or the prescribed amount (whichever is greater).

[2]***Serious environmental harm means*** environmental harm that is more serious than material environmental harm and includes environmental harm that:

(a) is irreversible or otherwise of a high impact or on a wide scale;

(b) damages an aspect of the environment that is of a high conservation value, high cultural value or high community value or is of special significance;

(c) results or is likely to result in more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or

(d) results in actual or potential loss or damage to the value of more than $50,000 or the prescribed amount (whichever is greater).

Surface and Groundwater Characterisation Report

The Region

Sturt Plateau Region NT

Prepared by: EcOz Environmental Consultants

2015

www.ecoz.com.au

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EcOz Pty Ltd.
ABN: 81 143 989 039
Winlow House, 3rd Floor
75 Woods Street
DARWIN NT 0800
GPO Box 381, Darwin NT 0800

Telephone: +61 8 8981 1100
Facsimile: +61 8 8981 1102
Email: ecoz@ecoz.com.au
Internet: www.ecoz.com.au

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Executive Summary

The Client engaged EcOz Environmental Consultants (EcOz) to review existing hydrology and hydrogeology documentation to characterise hydrological conditions within the Region that may need consideration as part of environmental approvals for the progression of project activities from exploration to production. This document is report of that review.

Objective of this report

This document has been designed to be used as a reference document to identify hydrological and hydrogeological values that may be relevant to areas proposed for future exploration and production activities. It provides regional descriptions of hydrological and hydrogeological conditions for the project area (the Region).

Environmental context

The project area occurs across 27 pastoral properties with approximately 77% of the area used for cattle grazing. The majority of the land tenure is pastoral and perpetual pastoral with smaller areas of Government and crown lease perpetual tenure surrounding the towns of Mataranka and Larrimah to the east and the Delamere Air Weapons Range to the west. The majority of the project area occurs within the Sturt Plateau which comprises of a gently undulating plain.

Hydrology and hydrogeology context

Two main systems drain the project area which includes the Western Creek system and the Dry River system. The Western Creek and its tributaries (Middle Creek and Cow Creek) traverse the centre of the project area and join Birdum Creek to the east of the Region eventually joining the Roper River. The Dry River catchment drains the west of the Region and joins the King River at the northern extent of the Region. The Dry River catchment eventually contributes to the Daly River. There is a scarcity of water quality data available for the Western Creek and Dry River systems to be able to accurately characterise these watercourses.

The Cambrian Limestone Aquifer (CLA), which comprises the Tindall Limestone and equivalents forms the watertable aquifer and represents the principal regional groundwater resource over all of the Region and the southern and central sections of the Region. In the north of the Region significant regional aquifer systems occur in the Daly Basin Oolloo Dolostone and local aquifers within the Jinduckin Formation.

Regionally groundwater flows from south to north toward major discharge zones in the Daly Basin. The CLA is separated by a bedrock high immediately west of Larrimah which splits the aquifer into an eastern flow path in the Georgina/Daly Basin and a western flow path in the Wiso/Daly Basin. Groundwater recharge rates are variable across the project area, and depend on soil type, geology, vegetation and topography, as well as the amount of rainfall and other climate variables. Recharge in the project area operates via four mechanisms.

Groundwater discharge occurs in the north-east of the Region, as springs drain into the Roper River at Mataranka form the single known outlet for groundwater discharge from the northern Georgina Basin. Groundwater along the western flow path in the Wiso/Daly Basin discharge as springs in the Flora River on the north-west boundary of the Region.

Water quality in the CLA is generally of potable quality across the project area and is always suitable for stock watering, which constitutes the dominant groundwater use. Two groundwater samples the Client collected from Proterozoic sandstones at depths of 330 m and 742 m on Hidden Valley Station report elevated TDS. In the Beetaloo Basin to the south-east of nearby EP 197 and 198 formation water sourced from the Roper Group (Proterozoic) at depths of 780 – 1 350 m were hyper saline with a TDS range of 19 000 – 95 000 mg/l across five samples.

The Region is within the Daly Roper Water Control District. The north eastern portion of the Region also falls within the existing Katherine water allocation planning area and the proposed Katherine – Oolloo and

Mataranka water allocation planning areas. The recently released Interim Guiding Principles for onshore oil and gas activities require aspects of water management on Petroleum leases to align with the *Water Act* (1992). The guiding principles include requirements that oil and gas activities:

- Apply minimum standards for water bore construction.
- Obtain groundwater extraction licenses when in WCDs or when constructing bores with a yield greater than 15 l/s.
- Ensure any extraction is consistent with relevant Water Allocation Plans (WAPs).
- Ensure potential impacts of water extraction to groundwater and rivers are understood and documented in the Water Management Strategy.
- Ensure landholders are not adversely impacted by reduced water supplies.

Groundwater impact assessment

The literature review identified five broad risks that are associated with oil and gas exploration activities and have the potential to impact on groundwater resources beneath the project area. These risks were analysed using the Source-Pathway-Receptor approach.

Recommendations

- Survey of drainage lines (including measurement of flows and water quality sampling) and riparian vegetation within and immediately downstream of the lease area during the late dry season, to identify streams and habitats that may be dependent on groundwater inputs.
- Implement a surface water monitoring program based on the findings of the drainage line survey, to establish a baseline of seasonal variability in water quality and flows. Sampling should be conducted at key locations within each catchment and ideally at locations both within and downstream of the lease.
- Mapping of sinkholes in the development area – these features have the ability to quickly channel recharge and surface water flow. Any surface contamination due to spillage or overtopping or water storages could quickly mobilise in the groundwater system if it occurs in the vicinity of a sinkhole.
- Verify local flow directions in the marginal volcanic aquifers around the development zone. It is likely these have some relationship / connection with the greater CLA aquifer – at present little is known about the flow dynamics within these aquifers or lateral flow to the CLA.
- Determination of vertical flow relationships between the shallow aquifers (CLA, Olloo Dolostone, Antrim Plateau Volcanics) and the deeper production formations.
- Depending on the source of water for development the impact of extraction on neighbouring users will need to be assessed, as well as the impact on regional groundwater users (horticulture in the north of the Region) and GDEs (Flora and Roper Rivers). These assessments may require modelling to fully characterise the surface water and groundwater processes.
- Existing monitoring bore records and standing water level monitoring data should be reviewed to refine local understanding of recharge processes.
- Baseline water quality should target areas between the development zone and down-gradient receptors. Where relevant this should give particular focus to the location of towns, communities and homesteads dependent on groundwater for potable supply.

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Appendices

1 Introduction

The Client has undertaken appraisal campaigns within the Region during 2013, 2014 and 2015 to establish the availability of natural gas and oil resources for production. Appraisal campaigns have included:

- Civil works for the establishment of access roads and construction of drill pads;
- Drilling and coring operations to install appraisal well drill holes;
- Seismic tiltmeter surveys; and
- Stimulation and testing of drill holes.

The Client has engaged EcOz Environmental Consultants (EcOz) to review existing hydrology and hydrogeology documentation to characterise hydrological conditions within the Region that may need consideration as part of the environmental approvals process for the progression of project activities from exploration to production. This document is report of that review.

1.1 Objectives

This document has been designed to be used as a reference document to identify hydrological and hydrogeological values that may be relevant to areas proposed for exploration and production activities. It provides regional descriptions of hydrological and hydrogeological conditions for the project area (the Region).

The objectives of the ground and surface water characterisation are to:

- Describe the existing environment of the project area (i.e. topography, land use, climate, bioregions and geology).
- Describe the regional hydrological catchment context of the Sturt Plateau and that of the project area.
- Detail the current users of surface water within the project area and its environmental values.
- Describe the known quality of surface water using historic monitoring data.
- Characterise the hydrogeological context of the region including the geology, hydrogeological units and groundwater flow direction.
- Describe the known recharge pathways, recharge rates and discharge processes for the region.
- Describe the known groundwater quality.
- Describe the groundwater dependant ecosystems and connected sensitive environments for the region.
- Describe the current regional groundwater use for community, stock and domestic and irrigated horticulture purposes.
- Describe the regulatory context surrounding groundwater within the region including the occurrence of groundwater control districts.
- Summarise the potential impacts to groundwater.

1.2 Scope of Work and Methodology

The scope of work and methodology for the ground and surface water assessment included:

- Reviewing available geological, hydrological, hydrogeological and environmental reports from the region in order to establish an appreciation of the hydrological and hydrogeological setting of the project area.
- Reviewing hydrological and hydrogeological data held on the department of Land Resource Management (DLRM) water data portal for surface water gauging stations and monitoring bores.
- Analysis of groundwater parameters sampled from existing bores within the project area.
- Identifying the potential risks to groundwater associated with exploration and production activities and summarising the potential impacts on groundwater resources within the project area.

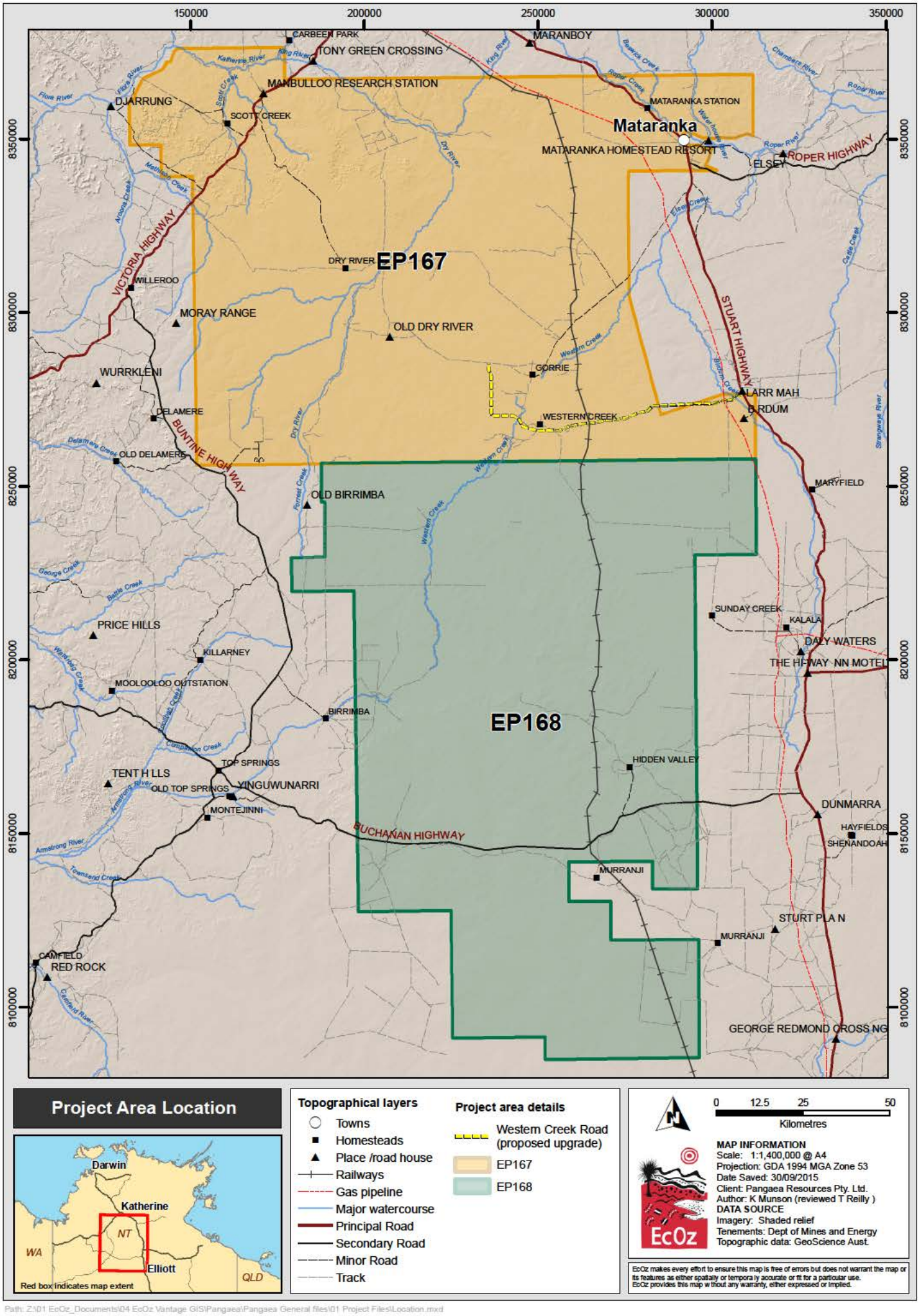

Figure 1-1. Map of project area location (EP 167 and 168)

2 Site Description

2.1 Location and Topography

The project area is located south of Katherine on pastoral land within the Sturt Plateau. The Sturt Plateau covers an area of 98 575 km^2 within central Northern Territory (Australian Government 2014). The towns of Mataranka and Larrimah fall within the project area with Daly Waters located to east of the Region on the Stuart Highway. The community of Wubuluwan is located to the north of Larrimah on the eastern boundary of the Region.

The Sturt Plateau marks part of the divide between flowing watersheds eastward towards the Gulf of Carpentaria; and westward toward the Joseph Bonaparte Gulf and is a relatively featureless, topographically simple elevated plain derived mostly from Tertiary laterite (Woinarski 2015). The land systems within the Sturt Plateau are characterised by gently undulating to almost level plains with few drainage lines and relic flood plains (Woinarski 2015).

2.2 Land Use and Population

The Sturt Plateau is dominated by pastoral land with approximately 77% of the area grazed by cattle. Land tenure is dominated by pastoral and perpetual pastoral leases (Figure 2-1). The project area is located across 27 pastoral stations. Government land is located in the north-east corner of the Region surrounding the town of Mataranka and on the western junction of the Region for the Delamere Air Weapons Range. Large areas of Freehold land are located adjacent to the eastern boundary of the Region over the community of Wubuluwan and adjacent to the southern boundary of the Region.

Using the Australian Bureau of Statistics population figure for 2011, the region of Birdum which includes the communities of Mataranka, Larrimah, Jilkminngan and Daly Waters, has a total population of 654.

2.3 Climate

The Sturt Plateau region experiences two distinct seasons, a dry season from May to September and a wet season from November to March. Bureau of Meteorology (BoM) regional climate data is available for Mataranka Airstrip within the north-east the Region, Daly Waters to the south of the Region, Delamere Weapons Range to the west and Larrimah to the east of the Region. Rainfall is variable across the Sturt Plateau however a spatially averaged median rainfall is 556 mm (1890-2005) (Australian Government 2014).

The closest weather station to the location of exploration activities is Larrimah (station number 014612) (Figure 2-2). Rainfall is concentrated during the wet season, the wettest months are January and February with an average of 208.8 mm and 207.3 mm rain respectively. Temperatures range from an average maximum temperature of 37.9°C in November to average maximum temperature of 29.3°C in June. July is the coolest month with an average minimum temperature of 12.3°C.

Pan evaporation of the Sturt Plateau is relatively stable and ranges from 5 – 11 mm/day (Yin Foo 2002). Evaporation over the wet season averages 1 287 mm while dry season evaporation averages 1 705 mm. Peak evaporation generally occurs between September and November, with evaporation being lowest during October and November. Evaporation in the region generally exceeds rainfall.

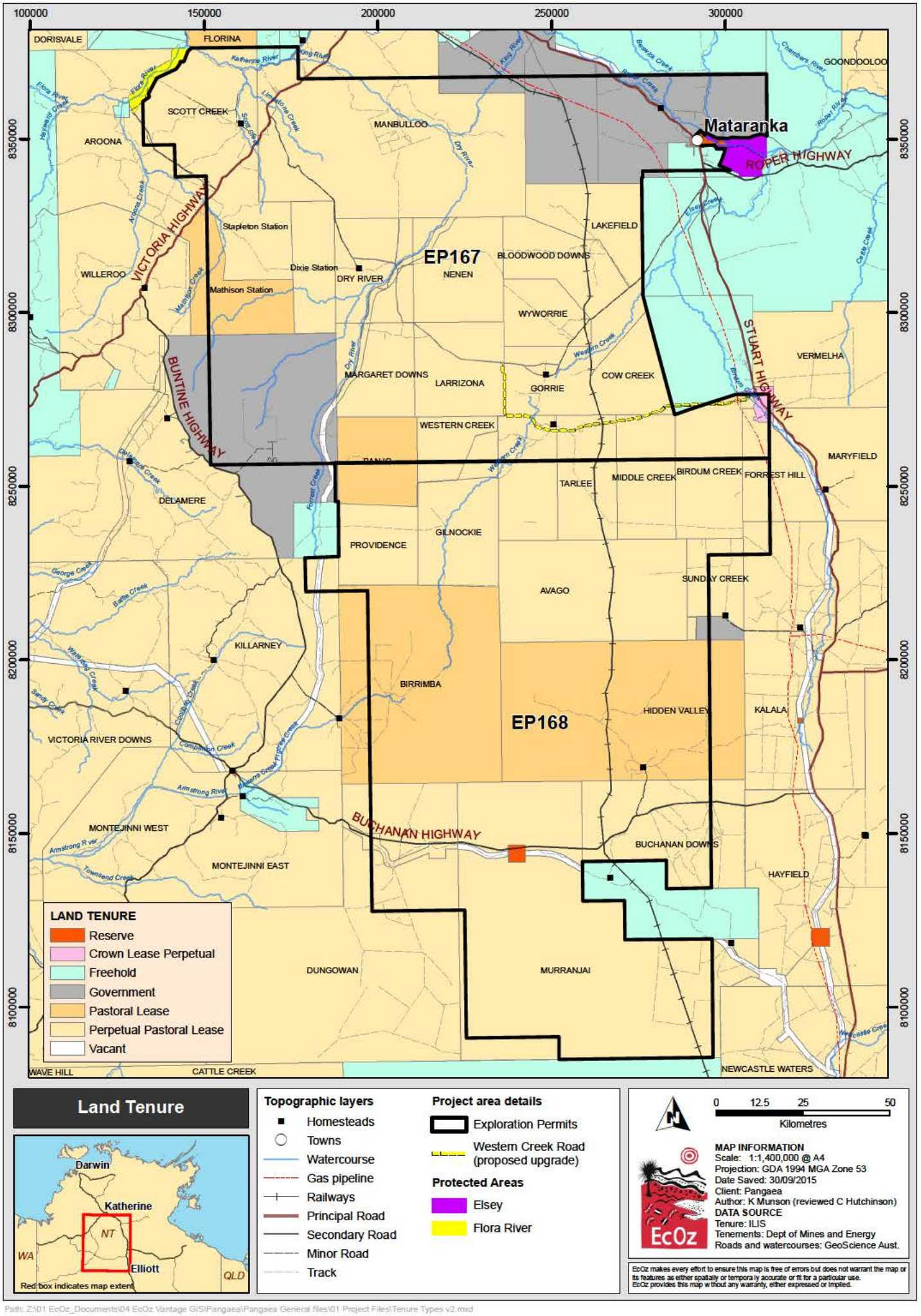

Figure 2-1. Map of land tenure within the project area (and surrounds)

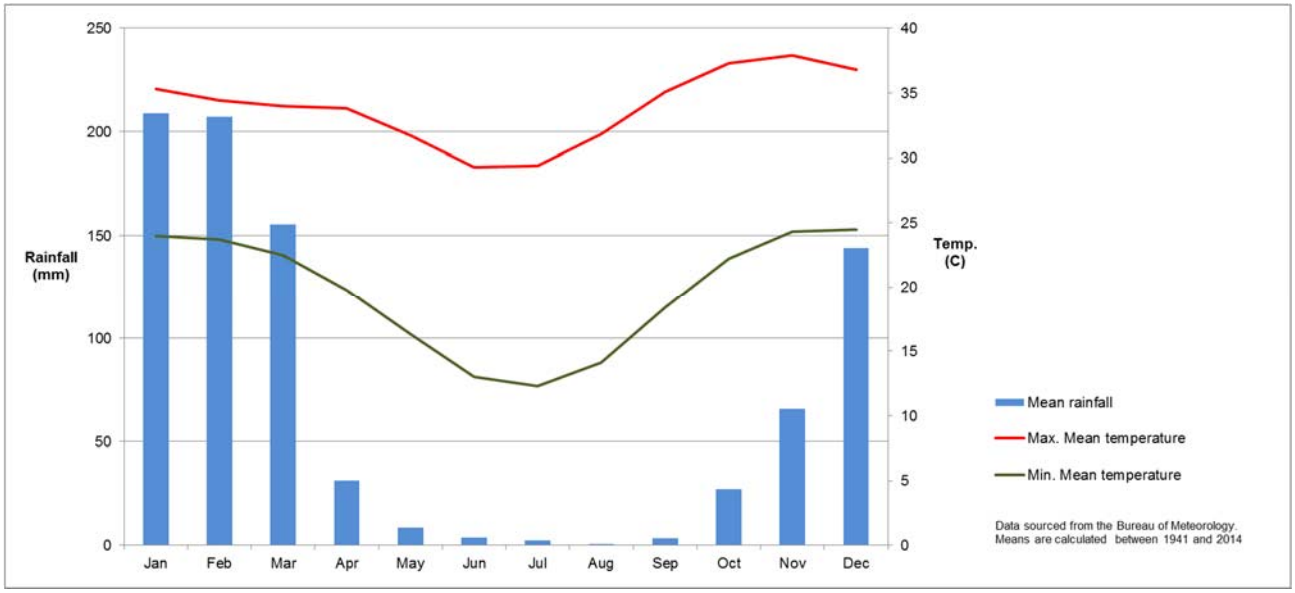

Figure 2-2. Average monthly temperature and rainfall for Larrimah, Northern Territory

2.4 Bioregions

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into units of broadly similar landform, geology and biodiversity (Baker et al. 2005). The project area covers the following bioregions (Figure 2-3);

- Sturt Plateau – The majority of the project area falls within the Sturt Plateau bioregion. This bioregion is comprised of a gently undulating plain. Vegetation is mostly *Eucalyptus dichromophloia* woodlands with spinifex understorey. There are also large areas of Lancewood thickets (*Acacia shirleyi*), Bulwaddy Woodlands (*Macropteranthes kekwickii*) and open Eucalypt woodlands to the north.
- Daly Basin – The northeast section of the Region is within this bioregion. This bioregion is comprised of gently undulating plains and scattered remnant sandstone plateaus. Vegetation includes perennial and annual grass woodland dominated by *Eucalyptus tetrodonta* and *E. miniata*. There are no subregions.
- Ord-Victoria Plain – Only the extreme southeast section of the Region is within this bioregion. This bioregion is comprised of up to four subregions, however only one is represented within the exploration leases. This subregion is comprised of extensive plains with short grass (*Enneapogon* sp.) and other grassland communities on cracking clays.
- Gulf Fall and Uplands – The northwest section of the Region is within this bioregion. This bioregion is comprised of scattered low steep hills on skeletal soils. Vegetation is mostly *E. tetrodonta* and *Corymbia dichromophloia* with a spinifex understorey, and also *E. tectifica* with a tussock grass understorey.
- Mitchell Grass Downs – A very small portion of the southwest section of the Region is within this bioregion. This bioregion is mostly comprised of treeless plains on low cracking clay soils (black soil). Vegetation is mostly Mitchell Grass (*Astreleba* spp), with occasional *E. microtheca* and *Chenopodium auricomum* shrub land.

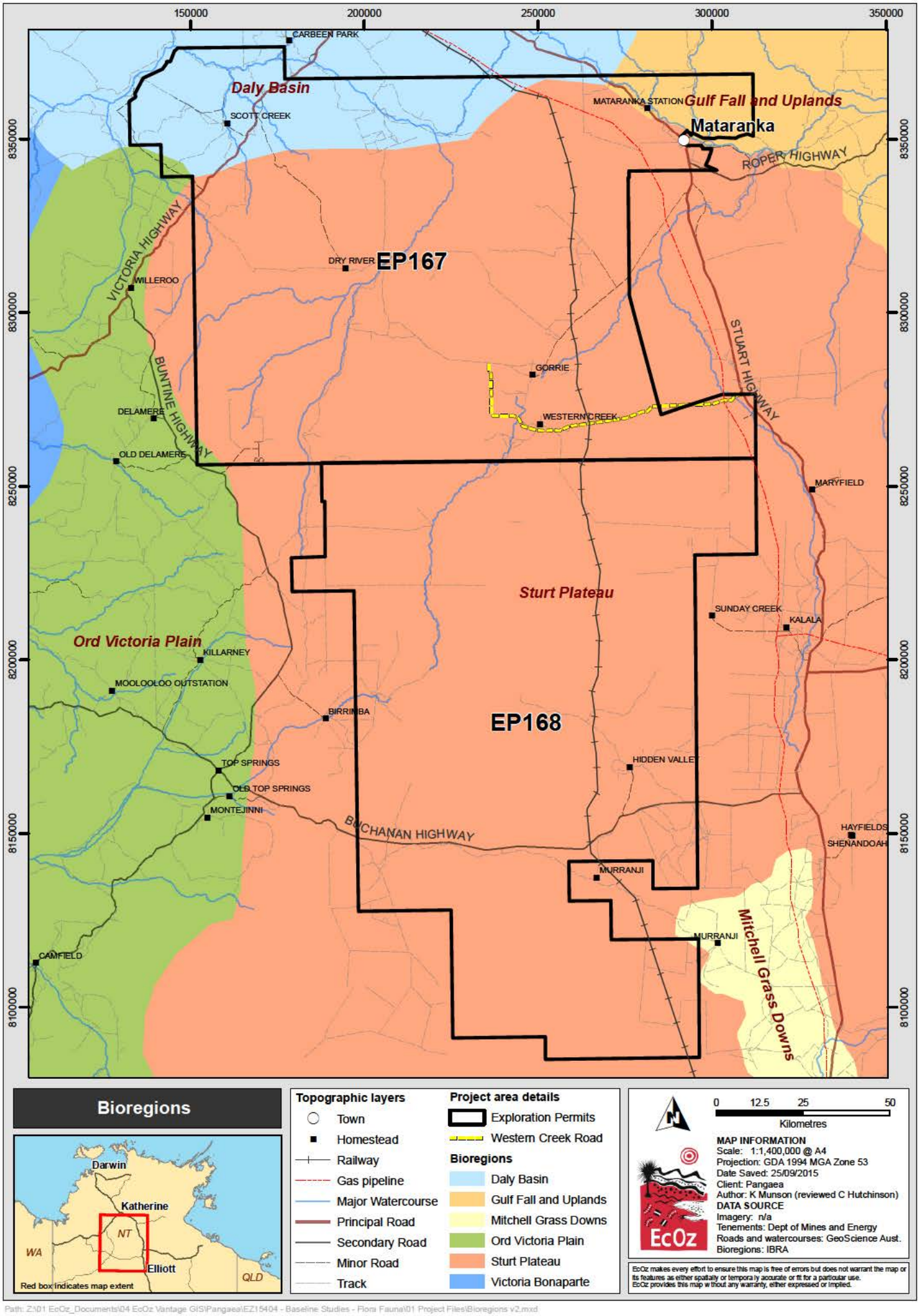

Figure 2-3. Map of bioregions within the project area (and surrounds)

2.5 Geology

2.5.1 Regional Setting

The project area is underlain by Proterozoic rocks of the western McArthur Basin, which rest unconformably on basement rocks of the north Australian Craton. Sediments of the McArthur Basin outcrop north-east of Mataranka but otherwise occur at depth within the project area. The McArthur Basin sequence is thickest along the eastern margin of the project area in an area coincident with the Elsey Gravity Low, also referred to as the Gorrie Sub-basin (Lanigan et al. 1994). The McArthur Basin sequence is estimated to be several thousand metres thick in this area, which is defined by deep blue colours in Figure 2-4. Overlying the McArthur Basin sediments are the extensive flood basalts of the Karlkarindji province, which in turn are capped by the marine sedimentary successions of the Wiso, Daly and Georgina Basins. These basins were originally deposited in the Cambrian as a vast depositional area that covered much of central and northern Australia. The Wiso, Daly and Georgina Basins are laterally continuous but are formally separated where the limestone sequence thins over basement ridges in the Kalkarindji Province volcanics; the basin junctions occur in the centre of the Region. The Georgina/Wiso and Daly Basins are unconformably overlaid by Cretaceous mudstones and sandstones of the Carpentaria Basin, which are discontinuously capped with a thin veneer of laterised Tertiary and Quaternary sediments.

2.5.2 Structure

There is minimal deformation across the south and central regions of the project area where the Palaeozoic Formations (Antrim Plateau Volcanics, Cambrian limestone sequence) and younger sediments (Cretaceous and recent cover) form a flat-lying drape over moderately folded and faulted Proterozoic rocks. The most significant deformation is associated with a basement fault zone that runs along the eastern edge of the project area (see Figure 2-4). This zone is associated with a basement high, the Daly Waters Arch, which separates the thick sequence of Roper Group sediments in the project area from the Beetaloo Basin depocentre to the south-east. At Larrimah the fault zone curves to the north-west, extending through Lakefield and Manbulloo stations in the north of the Region, with the thickest McArthur Group package occurring on the south-western, down-thrown side of the structure. The faults associated with this structure are deep seated and are associated with the Calvert and Leichardt Extension, and the Liebig event (deVries 2006), all of which predate the deposition of the Roper Group. As a result these structures do not commonly extend from the lower McArthur sequences into the shallower Palaeozoic and Mesozoic formations. Exceptions to this observation are the informally named Birdum Creek fault (Yin Foo 2002) and the King River structure (Tickell 2002).

The Birdum Creek fault was identified from mapping of the contact between the limestone and the underlying basalts across the Sturt Plateau (Yin Foo 2002). This work was based on from the gamma logging of 103 shallow bores, as well as ground and aerial geophysics interpretation. The mapping identified a regionally extensive fault which has been tracked from north of the Nenen/Manbulloo boundary to the south as far as the Buchanan Highway. Along the east of the project area the fault approximately aligns with the Birdum Creek system and extends along Daly Waters Creek. The fault is coincident with the deeper Proterozoic structures present along the Daly Waters Arch. The Birdum Creek Fault penetrates the Cambrian limestone sequence and the underlying Antrim Plateau Volcanics. The vertical displacement along the fault is in the order of 200 m in the Larrimah region (Yin Foo 2002). The 1:250 000 Sturt Plateau hydrogeology map (Yin Foo & Matthews 2002) also identifies a shallower fault that displaces the Cambrian limestone and runs in a north-west south-east orientation across Wyworrie, Middle Creek and Sunday Creek stations.

The King River structure is a fault zone identified by Tickell (2002) in the Daly Basin in the north of the Region. The fault zone trends west north-west and has been traced from the King River through to Stray Creek on the western side of the Daly Basin. Displacements are mapped in the Cretaceous Formation and inferred in the Oolloo Dolostone. The King River Structure overlies the Proterozoic fault zone which

suggests that the displacement within the Oolloo Dolostone and Cretaceous sediments may have resulted from the reactivation of deeper basement structures.

2.5.3 Stratigraphy

The McArthur Basin comprises a thick sequence of relatively undeformed sedimentary rocks that are sub-divided into four groups: the Tallawah, McArthur, Nathan and Roper Groups. Within the project area the youngest package, the Roper Group, is the principal target for hydrocarbon exploration. The Roper Group comprises an upward coarsening succession of marine mudstones and sandstones intruded by post-depositional dolerite sills. Roper Group sediments outcrop in the north-east corner of the Region around Mataranka. The thickest sequence occurs in the east of the Region in an area defined by a prominent gravity low. Roper Group sediments are absent to the north (Manbullo Station) and south (Hidden Valley Station) of the gravity low. In the southern McArthur Basin the Roper Group comprises 15 distinct formations with a total estimated thickness of up to 5 000 m (Ahmed & Munson 2013). This study concentrates on the upper Roper Group, that is the Velkerri Formation and overlying formations, the full sequence is described in Ahmed & Munson (2013) and Abbott et al. (2001). The “middle” Velkerri formation contains organic rich mudstone and claystone that represent the primary target for unconventional gas exploration in the project area. This sequence is overlaid by an “upper” organically poor succession of mudstone, claystone and siltstone with minor sandstone interbeds. The shallower Kyalla Formation is separated from the Velkerri Formation by the Moroak Sandstone. The Kyalla Formation comprises a silty mudstone with thin planar interbeds of siltstone and sandstone and forms a secondary target for exploration. The Kyalla Formation is overlaid by the Jamison Sandstone and Hayfield Mudstone, both of which are spatially discontinuous over the project area.

The Roper Group is unconformably overlaid by a Cambrian sedimentary succession, represented by the Wiso Basin and Georgina Basin on the Region and the Daly Basin on the Region. The basal members of this succession are the Bukalara Sandstone and Cox Formation, which have limited extent having only been intersected in the east and north of the project area. These formations are capped by the Kalkarindji Province Volcanics (also referred to as the Antrim Plateau Volcanics), which comprise a series of basalt flows with minor interbedded sandstone and conglomerate. The volcanics are extensive across the project area. The Antrim Plateau Volcanics are overlaid by the Cambrian Limestone succession comprising the basal Tindall Limestone and the Jinduckin Formation in the Daly Basin and their equivalents the Montejinni Limestone and Hooker Creek Formation in the Wiso Basin and the Gum Ridge Formation and Anthony Lagoon Beds in the Georgina Basin. The Tindall Limestone is a massive dolomitised and often karstic limestone sequence with thin mudstone interbeds. The formation is thickest in the north-west and south of the project area where it is closer to the main depositional zones of the Daly and Wiso Basins. It is thinner in the centre of the project area where it overlies a structural high in the underlying Antrim Plateau Volcanics. Significant outcrop occurs in the middle of the Region (Nenen and Manbullo Stations) with smaller surface exposures in the north-east around Mataranka and west of the Region on East Mathison Station (see Figure 2-5). The Jinduckin Formation comprises dolomitic siltstone with interbedded dolomitic sandstone and dolostone. The formation is present in a band of outcrop across the north of the Region and as the Anthony Lagoon Beds south of the Buchannan Highway in the Region. In the Daly Basin the Jinduckin Formation is overlaid by the Oolloo Dolostone, equivalents of this formation do not exist in the Wiso and Georgina Basin. The formation outcrops in the north-west of the Region. The Cambrian Limestone sequence is overlaid by undifferentiated Cretaceous sediments of the Carpentaria Basin. These form a drape of laterised claystone, clay and sandstone across much of the project area. They are divided into an upper mudstone sequence and a thinner basal sandstone sequence. Formation thickness is locally variable due to erosion. Overlying the Cretaceous sediments are limestone deposits of the Birdum Creek Beds, as well as shallow Quaternary colluvial and alluvial deposits.

A summary of the occurrence, thickness and lithology of the Roper Group and overlying formations is provided in Table 2-1. The occurrence and is based on surface outcrop, regional studies and intersections

from exploration wells within the project area. The surface geology showing outcrop of key formations across the project area is provided in Figure 2-5.

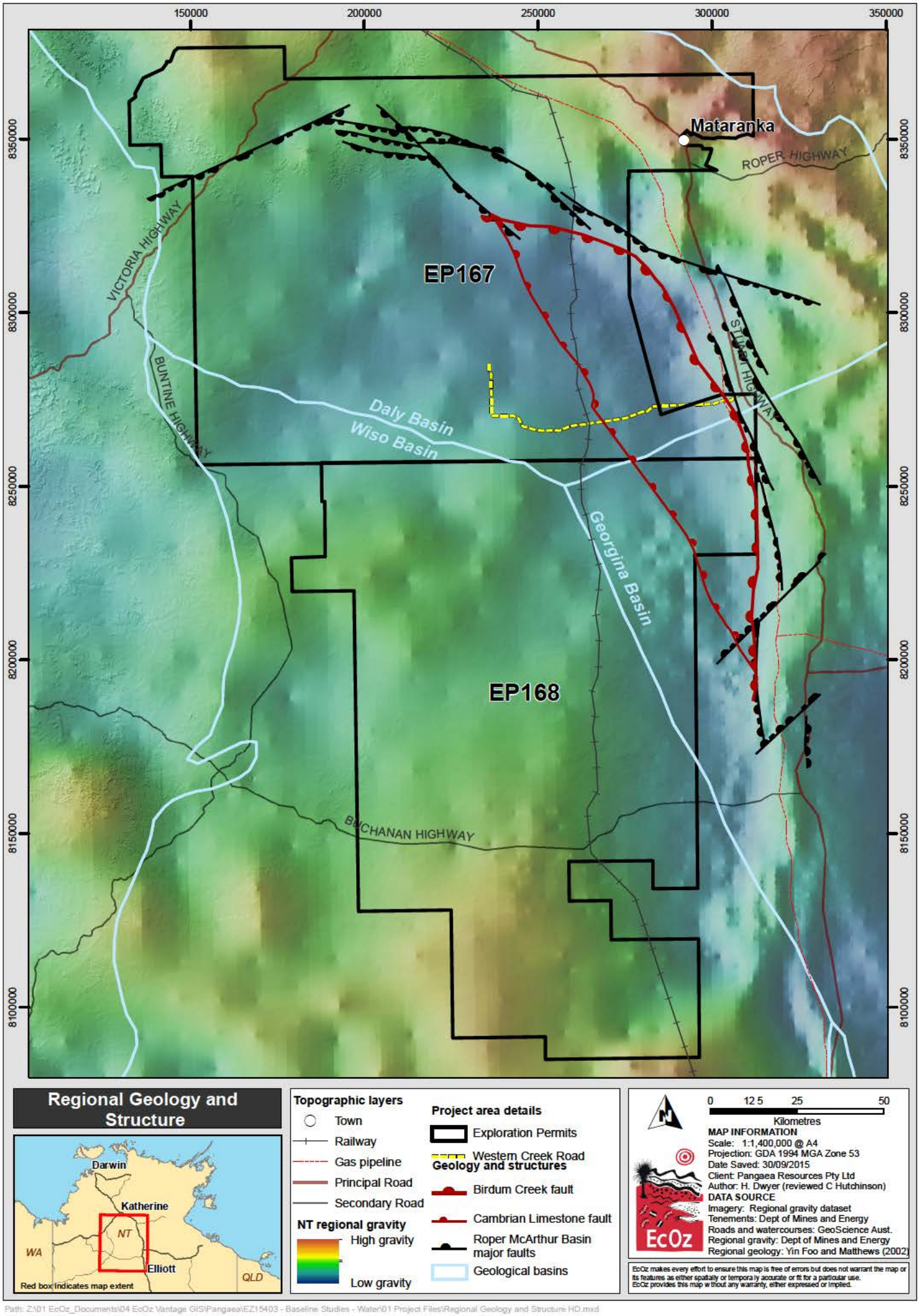

Figure 2-4. Map of regional geology and structure

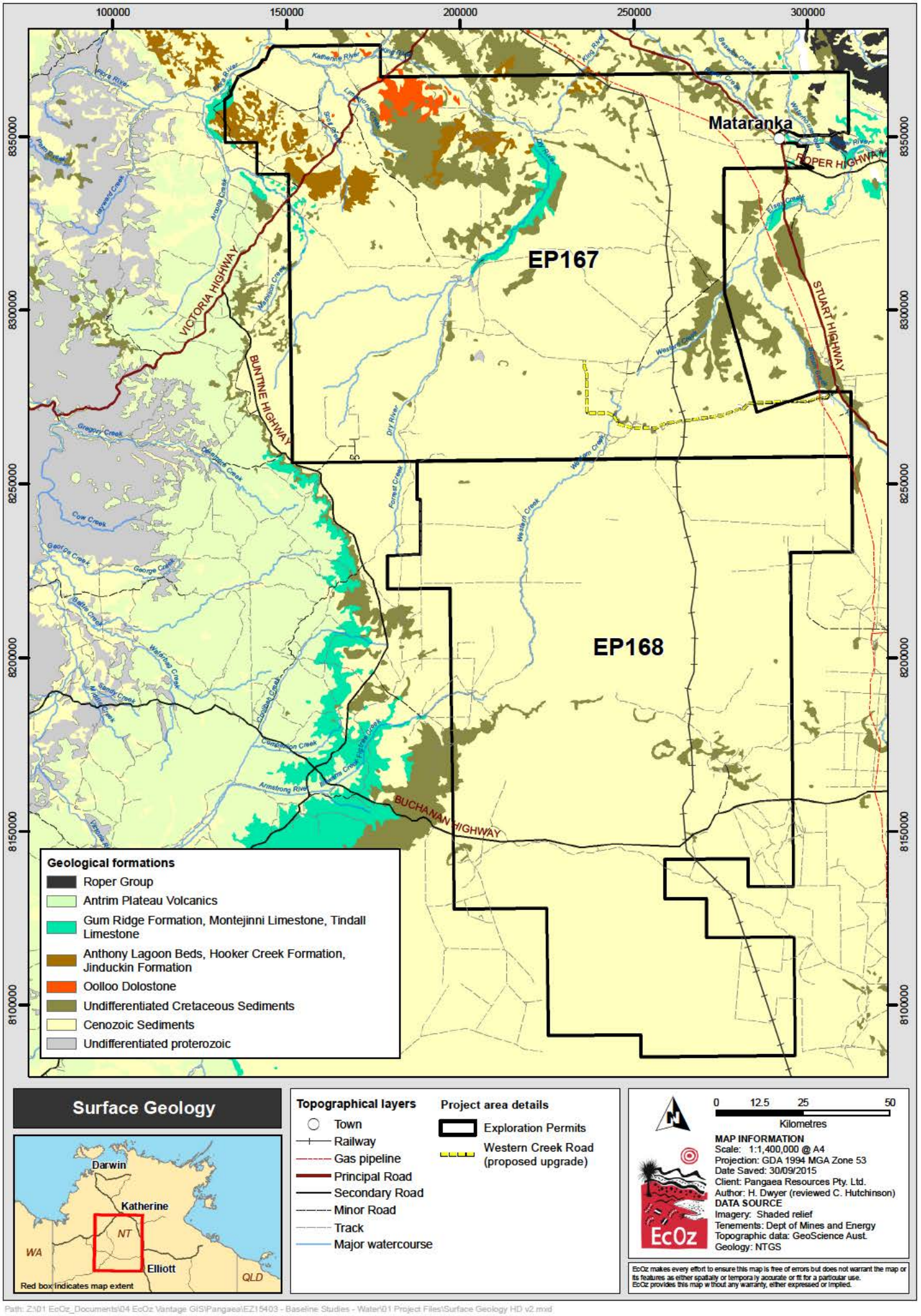

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Figure 2-5. Map of surface geology

Table 2-1. Summary of occurrence, thickness and lithology of the Roper Group and overlying formations

Province	Period/Age	Formation	Lithological Description	Extent/Occurrence	Thickness (m)	Aquifer Status
	CENOZOIC 0 – 66 Ma	Undifferentiated Cenozoic	Laterite, limestone, black soil, alluvial and colluvial deposits (sand, gravels, clay).	Extensive across the Region.	< 25 m	Unsaturated
CARPENTARIA BASIN	CRETACEOUS 66 – 145 Ma	Undifferentiated Cretaceous Sediments	Laterised siltstone and claystone with basal sandstone.	Thickest in the north and east of the Region and south of the Buchannan Highway. Thins in central Sturt Plateau where often only the basal sandstone occurs	0 – 100	Local Aquifer in the north of the Region, unsaturated elsewhere. Aquitard (Local)
DALY BASIN	CAMBRIAN 485 – 541 Ma	Oolloo Dolostone	Fine to medium grained crystalline dolostone.	Only present in the north-west of the Region around the King and Katherine Rivers where it outcrops.	0 – 250*	Aquifer (Regional)
DALY BASIN WISO BAISN GEORGINA BASIN	EDIACARAN – CAMBRIAN 485 – 630 Ma	Jinduckin Formation Hooker Creek Formation Anthony Lagoon Beds	Dolomitic siltstones with interbedded dolomitic sandstone.	Present in the north of the Region where outcrop occurs and subsurface south of the Buchannan Highway in the Region. Absent in central project area.	0 – 356*	Aquifer (Local)
		Tindal Limestone Montejinni Limestone Gum Ridge Formation	Fractured and karstic limestone.	Extensive across project area. Thins in central project area over the structural high in the Antrim Plateau Volcanics. Outcrops in north and north-east of the Region.	< 204*	Aquifer (Regional)
		Antrim Plateau Volcanics	Massive basalt and minor interbedded sandstone.	Extensive across the Region.	101 – 175^	Aquitard (Regional) Aquifer (Local)
		Cox Formation	Fine grained micaceous sandstone, interbedded shale.	Discontinuous. Only intersected in the south-east of the Region	44^	Not Known

Province	Period/Age	Formation	Lithological Description	Extent/Occurrence	Thickness (m)	Aquifer Status
		Bukalara Sandstone	Jointed sandstone and minor siltstone.	No outcrop, discontinuous, intersected in north and south-east of the Region and north-east of the Region.	0 – 97^	Aquifer (Local)
MCARTHUR BASIN ROPER GROUP	NOT KNOWN	Hayfield Mudstone	Mudstone, claystone with minor interbedded fine sandstone.	No outcrop, discontinuous, only intersected in north-east of the Region.	0 – 164^	Aquitard (Local) Aquifer (Local)
		Jamison Sandstone	Very fine to coarse grained quartz sandstone.	No outcrop, discontinuous, intersected in four wells in south-east of the Region and north-east of the Region.	0 – 110^	Aquifer (Local), inferred
	MESO-PROTEROZOIC 1430 – 1500 Ma	Kyalla Formation	Silty mudstone with thin beds of siltstone and sandstone.	No outcrop. Extensive in central east of project area. Absent in the north of the Region and south of the Region.	0 – 730^	Aquitard (Regional)
		Moroak Sandstone	Fractured and cemented fine to coarse grained quartz sandstone.	No outcrop. Extensive in central east of project area. Absent in the north of the Region and south of the Region.	0 – 139^	Aquifer (Local), inferred
		Velkerri Formation	Mudstone, claystone, siltstone.	No outcrop. Extensive in central east of project area. Absent in the north of the Region and south of the Region.	0 – 835^	Aquitard (Regional)

* Maximum thickness estimates derived from regional basin studies with areas outside the Region.

^ Thickness range derived from exploration well intersections.

3 Hydrology

3.1 Regional Catchment Context

The project area is characterised by flat to gently undulating plains on laterised Cretaceous sandstones with little local relief. The drainage systems of the region are considered as weakly developed with waterholes, sinkholes and swamps storing significant proportions of rainfall resulting in relatively low overland flows and eventual stream flow. Multiple non-perennial watercourses traverse the project area and contribute to the Dry River and Western Creek systems. The Western Creek system forms part of the Roper drainage system in the north east of the Sturt Plateau. The Western Creek and its tributaries (Middle Creek and Cow Creek) traverse the centre of the project area and join Birdum Creek to the east of the Region to form Elsey Creek prior to joining the Roper River east of Mataranka. The Dry River catchment drains the west of the Region and joins the King River at the northern extent of the Region. The Dry River catchment eventually contributes to the Daly River with the Katherine, Flora and Fergusson Rivers all merging to the north-west of the project area (Yin Foo 2002). Scarce definition of drainage paths effectively results in localised flood outs, waterholes and swamp areas in the Birdum Creek, Western Creek and Dry River systems. Continuity of flow in these systems occurs only after exceptional rainfall events (Yin Foo 2002). The southern portion of the Region forms part of the Victoria River catchment with a small portion to the west of the Region draining to the Armstrong River system.

Figure 3-1 provides boundaries for the three catchments that encompass the project area (Daly, Roper and Victoria Rivers) and the major drainage pathways for surface water.

3.2 Project Area Hydrology

An assessment was undertaken to determine the physical characteristics of the watercourses that traverse the project area. A review of the NT Department of Land Resource Management (DLRM) Water Data Portal was undertaken to establish the baseline watercourse flow rates. This review identified six historical watercourse flow gauging stations which are relevant to describing the baseline drainage setting of the project area. Four gauging stations (two operational and two closed) are situated on watercourses in the Dry River catchment; G8140011 (Dry River), G8140068 (King River), G8140151 (Mathieson Creek) and G8140214 (Scott Creek). Two gauging stations (one operational and one closed) are situated within the Western Creek catchment; G9030001 (Elsey Creek) and G9030008 (Birdum Creek). All gauging station locations and their proximity to the project area are presented in Figure 3-2, with operational periods and location descriptions are provided in Table 3-1.

Flow data results for each gauging station are presented in Appendix A, which indicates that flow events are sporadic and are not sustained for prolonged periods. Surface water run-off volumes from the project area and relatively low, as represented by the ephemeral Elsey Creek system (G9030001), which contributes relatively low flows to the Roper River system despite having the largest catchment area (Faulks 2001).

Typically, the drainage systems present within the project area are isolated pools in rivers or flood plain waterholes and flow only after adequate saturation of the catchment following significant rainfall events (e.g. wet season monsoons). Yin Foo (2002) estimated that flow would only occur after the catchment had been adequately wet from with initial wetting of the catchment accounting for up to 40% of the total seasonal rainfall each year. The majority of pools and waterholes in proximity to the project area usually dry out by about August or September. An exception to this however, is the perennial waterhole below Warloch Ponds – which is considered to be maintained by a shallow water table (Yin Foo 2002); however this outside of the project area to the east of the Region.

Table 3-1. Watercourse gauging locations within proximity of the Region

Station Number	Catchment	Waterway	Location	Operation Period
G8140011	Daly	Dry River	Manbulloo Station	20/11/1967 – 24/08/2015
G8140068	Daly	King River	D/S Victoria Highway	20/11/1959 – 24/08/2015
G8140151	Daly	Mathieson Creek	D/S Victoria Highway	21/12/1963 – 02/06/1987
G8140214	Daly	Scott Creek	D/S Victoria Highway	09/01/1969 – 02/06/1987
G9030001	Roper	Elsey Creek	At Warloch Ponds	16/02/1967 – 24/08/2015
G9030008	Roper	Birdum Creek	At Railway Bridge	30/06/1971 – 25/06/1978

3.3 Surface Water Quality

There is limited available water quality data for watercourses that traverse the project area, with the NT Department of Land Resource Management (DLRM) Water Data Portal containing occasional water quality data from the King and Katherine Rivers, downstream of Dry River on the Daly system, and at Elsey Creek, downstream from Western Creek on the Roper system. All water quality locations and their proximity to the project area are presented in Figure 3-2, and sampling numbers and location descriptions provided in Table 3-2. Water quality data shows neutral pH across the majority of watercourses. Conductivity is relatively low, except for the Katherine River where the high ionic composition indicates stream flow is supplemented by groundwater of a limestone origin given the high proportion of bicarbonate ions (Table 3-2). There is a scarcity of water quality data available for the Western Creek and Dry River systems to be able to accurately characterise these watercourses. This is possibly attributed to the absence of perennial flow within these systems and also a lack of priority for sampling watercourses in such remote areas. It is likely that given the predominant land use of cattle grazing in the Western Creek and Dry River catchments, water quality will likely be characterised by high suspended solids, high turbidity and high nutrient levels.

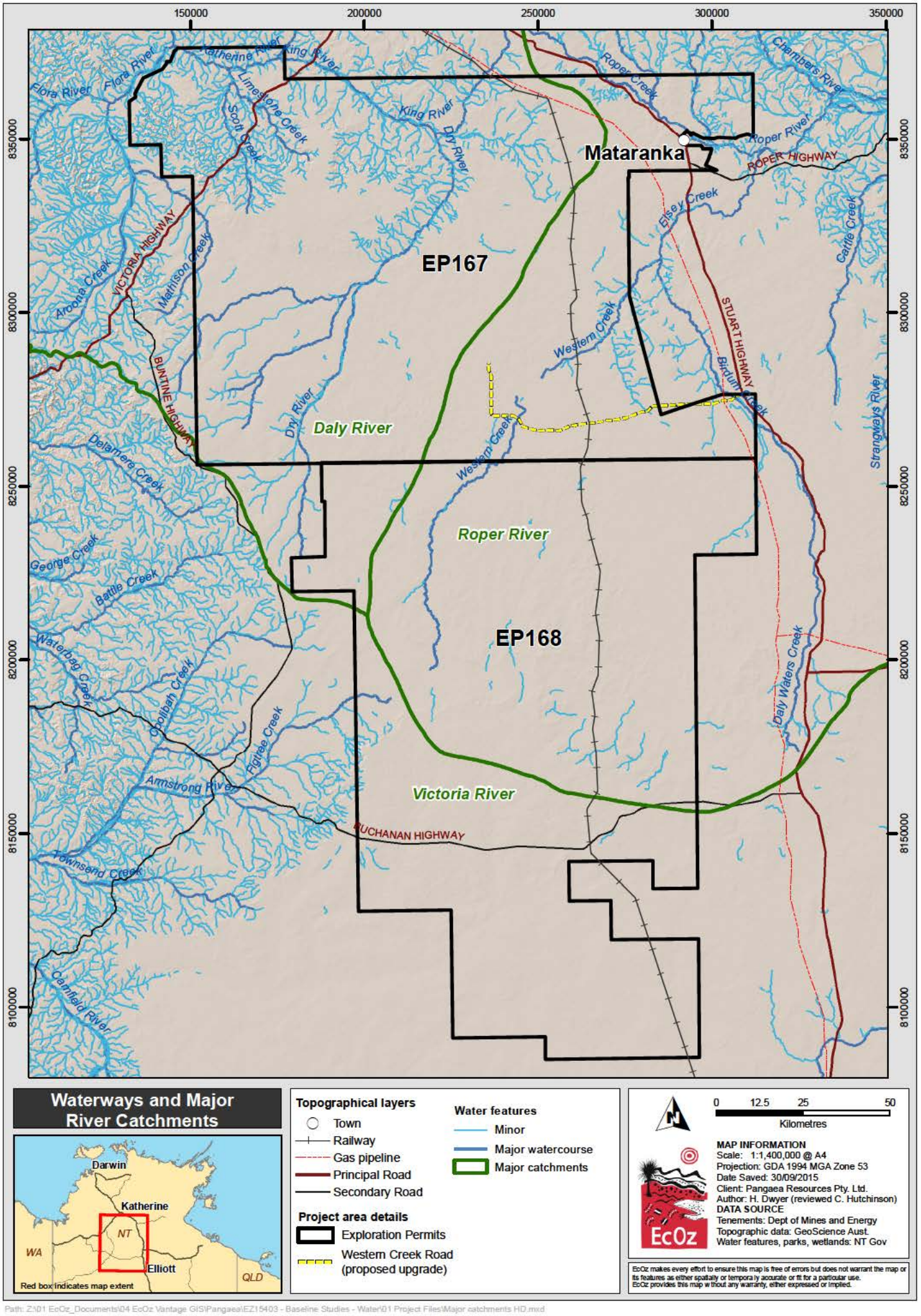

Figure 3-1. Map of the drainage and catchment setting

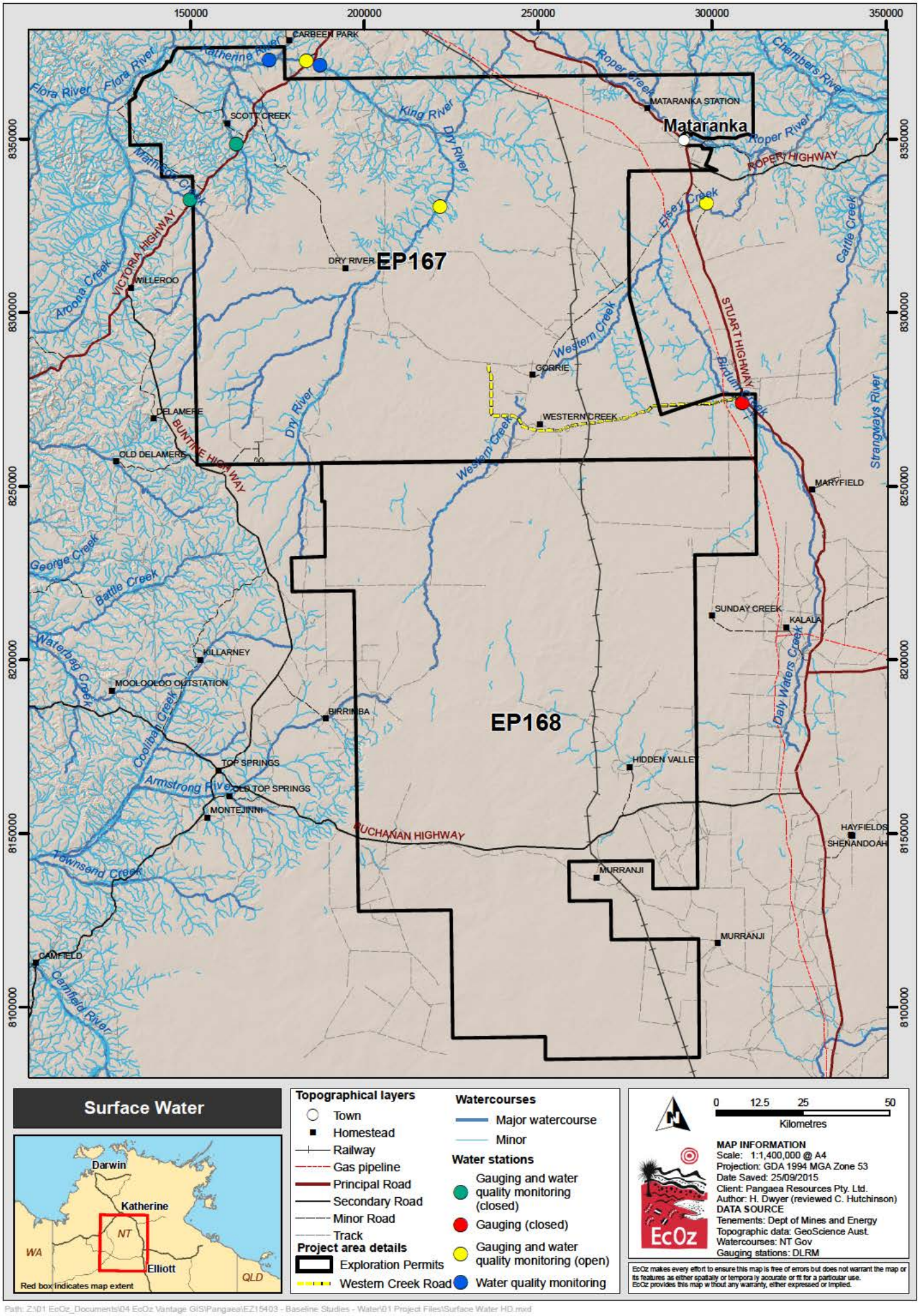

Figure 3-2. Map of surface water gauging stations

Table 3-2. Surface water quality data in proximity to the Region

Station Number	Catchment	Waterway	Location Description	EC (µS/cm)		Turbidity (NTU)		pH		Total Alkalinity		Bicarbonate Alkalinity		Number of records
				Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
G8140011	Daly	Dry River	Manbulloo Station	65	-	-	-	-	-	32	-	39	-	1
G8140064	Daly	King River	U/S Victoria Highway	49	-	6.1	-	7.36	-	-	-	-	-	1
G8140068	Daly	King River	D/S Victoria Highway	131.46	16 – 531	79.77	2.5 - 313	7.03	6.35 – 7.62	29.3	4 - 54	33.06	2 – 51	29
G8140151	Daly	Mathieson Creek	D/S Victoria Highway	36	-	30	-	-	-	19	-	-	-	1
G8140214	Daly	Scott Creek	D/S Victoria Highway	69.33	36 - 125	52.67	33 - 90	-	-	35	17 – 65	79	-	4
G8140303	Daly	Katherine River	D/S of King River junction	511.4	371 - 682	3.80	1 – 15.2	7.83	7.61 – 8.09	216.11	204.2 - 228	233	217 - 249	12
G8145747	Daly	King River	U/S of Katherine River junction	574	426 – 745	2.27	0.89 – 11.6	7.94	7.6 – 8.4	-	-	-	-	14
G9030001	Roper	Elsey Creek	At Warloch Ponds	299.21	65 – 2344	40.84	1 – 246	6.86	6.03 – 7.44	56.33	26 – 129	67.2	32 - 157	14

4 Hydrogeology

4.1 Previous Studies

With the exception of the south-west third of the Region the hydrogeology of the project area is well characterised by regional groundwater investigations. In 2002 the Northern Territory Government Water Resources Division (WRD) completed a three year investigation of water resources on the Sturt Plateau (Yin Foo 2002). The study produced a series 1:250 000 hydrogeology and water resource development maps. Map 1 and the western sections of Maps 2, 3 and 4 cover the central part of the project area. The study employed field and aerial geophysical methods to map the extent and structure of the Antrim Plateau Volcanics and included shallow soil profiling, hydrochemistry and isotope sampling programs (Knapton 2000; Yin Foo & Matthews 2000). The work builds on an earlier regional hydrogeological investigation completed by the Bureau of Mineral Resources (BMR) in the Northern Wiso Basin (Randal 1973).

The Gulf Water Study characterises the hydrology and water resources of the Roper River and Gulf region in five 1:250 000 scale water resource maps (Zaar 2009). The Dumarra-Hodgson River Region sheet is coincident with the south of the Region (Fulton and Zaar 2009). The Gulf Water Study includes the development of a coupled surface water groundwater model for the Roper River catchment, which includes a significant portion of the Region in the groundwater model domain (Knapton 2009). In the west of the Region, beyond the Sturt Plateau, the hydrogeology is described by the Delamere 1:250 000 Hydrogeology Map and explanatory notes (Matthews, 1994). In the north of the the Region there have been a number of studies investigating the water resources of the Daly Basin. Significant regional studies include Groundwater Occurrence in the Oolloo Dolostone (Tickell 2002), Groundwater Resources of the Tindall Limestone (Tickell 2005) and the Northern Australian Sustainable Yields Water in the Daly Region (CSIRO 2009). The Northern Australia Sustainable Yields project employed computer models to assess water resources of the Daly River catchment and aquifers, providing an assessment of the impact of current and future predicted water resource development at key environmental asset locations. The coupled model forming the basis of the assessment is documented in Knapton et al. (2010).

Key hydrogeological maps include the Daly Basin Aquifers 1:500 000 (Tickell 2014), Oolloo Aquifer Water Resources 1:250 000 (Tickell 2011) and the Tindal Aquifer at Mataranka 1:250 000 (Tickell 2013b). Other significant regional groundwater studies and publications outside but in close proximity to the project area include the Water Resources of the Barkly and Gulf Region (Tickell 2003), Water Resources of the Katherine Region and South-west Arnhem Land (George 2002) and 1:250 000 Hydrogeological maps for Wave Hill (Karp 2005a) and Victoria River Downs (Karp 2005b).

Other important studies include investigations of groundwater and surface water interaction at Mataranka (Karp 2008) and Flora River (Karp 1996), modelling studies to assess the impact of extraction at Shenandoah Station on the base flow in the Roper River (Knapton 2004), studies to determine water availability in the Tindall Limestone south of the Roper River (Jolly et al. 2004), the development of a regional model for the Tindal Limestone Aquifer (Knapton et al. 2006) and investigations into groundwater discharge and baseflow in Daly Basin rivers (Jolly 2000).

A number of local groundwater investigations have been completed by Territory and Commonwealth government agencies in the vicinity of the project area. These include water supply assessments along the Victoria Highway (Sanders 1991) and Hayfield and Shenandoah Stations (Tickell 2004), WRD bore completion reports for road water supply bores along the Stuart and Buchanan Highways, the Alexandria stock route excision and the Delamere weapons range, Power and Water Authority (PAWA) water supply investigations (Daly Waters, Larrimah and Mataranka) and water supply drilling for the Alice Springs to Darwin railway extension (Matthews 1998).

4.2 Hydrogeological Units

The Cambrian Limestone Aquifer (CLA), which comprises the Tindall Limestone and equivalents forms the watertable aquifer and represents the principal regional groundwater resource over all of the Region and the southern and central sections of the Region (see Figure 4-1). In the north of the Region significant regional aquifer systems occur in the Daly Basin Oolloo Dolostone and local aquifers within the Jinduckin Formation. In the central east and west of the project area the Tindall Limestone thins over structural highs in the underlying Antrim Plateau Volcanics. Where this occurs the CLA sits above the regional watertable and is unsaturated. In these areas marginal, local scale aquifers are associated with fracture zones and weathering horizons within the Antrim Plateau Volcanics. Local scale aquifers are also present in Cretaceous sediments in the north-west of the Region and in fractured Roper Group sediments where they outcrop to the north-east of Mataranka.

The following sections summarise groundwater resources that occur within the project area in order of most important regional aquifers to the less prospective local scale aquifers.

The CLA - Tindall Limestone, Montejinni Limestone, Gum Ridge Formation (Regional Aquifer)

The CLA comprises massive grey limestone beds that are heavily fractured and commonly karstic. Formation permeability is highly dependent on the development of these dissolution and fracture features. Yields up to 100 l/s have been recorded in irrigation bores around Katherine and Mataranka; however, yields of 10 l/s are more representative where the aquifer is confined by the Jinduckin Formation or Cretaceous mudstones (Tickell 2005). Bore yields are not stratigraphically controlled (i.e. occur within all horizons of the formation), though Jolly (1984) notes the aquifer development has been concentrated around the watertable.

The CLA is continuous across the Region but is not always saturated. Where the aquifer thickness is less than 20 m, aquifer development is limited (Yin Foo & Matthews 2000). The CLA is regionally confined by the Jinduckin Formation in the north of the Region and the Anthony Lagoon Beds south of the Buchannan Highway on the Region. Where the Cretaceous mudstones occur, mostly in the north and south of the project area, they locally confine the CLA. The CLA is unconfined in the centre of the Region where the Tindall Limestone outcrops and in other areas where it is overlaid by Cretaceous sandstones.

The Oolloo Dolostone (Regional Aquifer)

The Oolloo Dolostone is a regional scale aquifer that forms an important agricultural and environmental water source in the Daly Basin. The aquifer comprises two units: an upper massive unit of crystalline dolostone and a lower bedded unit of more fine grained dolostone and sandstone. Tickell (2002) classifies the aquifer as having a moderate to high transmissivity with the highest yields occurring from a karstic zone with enhanced permeability that generally occurs in the top 50 m of the formation. Typical bores yields for the Oolloo Dolostone range from 10 – 40 l/s but rates up to 100 l/s have been recorded.

The Oolloo Dolostone is present where it outcrops on Manbulloo and Scott Creek Stations in the north-west of the Region. Significant recharge occurs in this area and drives a steep local gradient to the north. The regional flow direction in the Oolloo Dolostone aquifer is to the north-west along the axis of the Daly Basin.

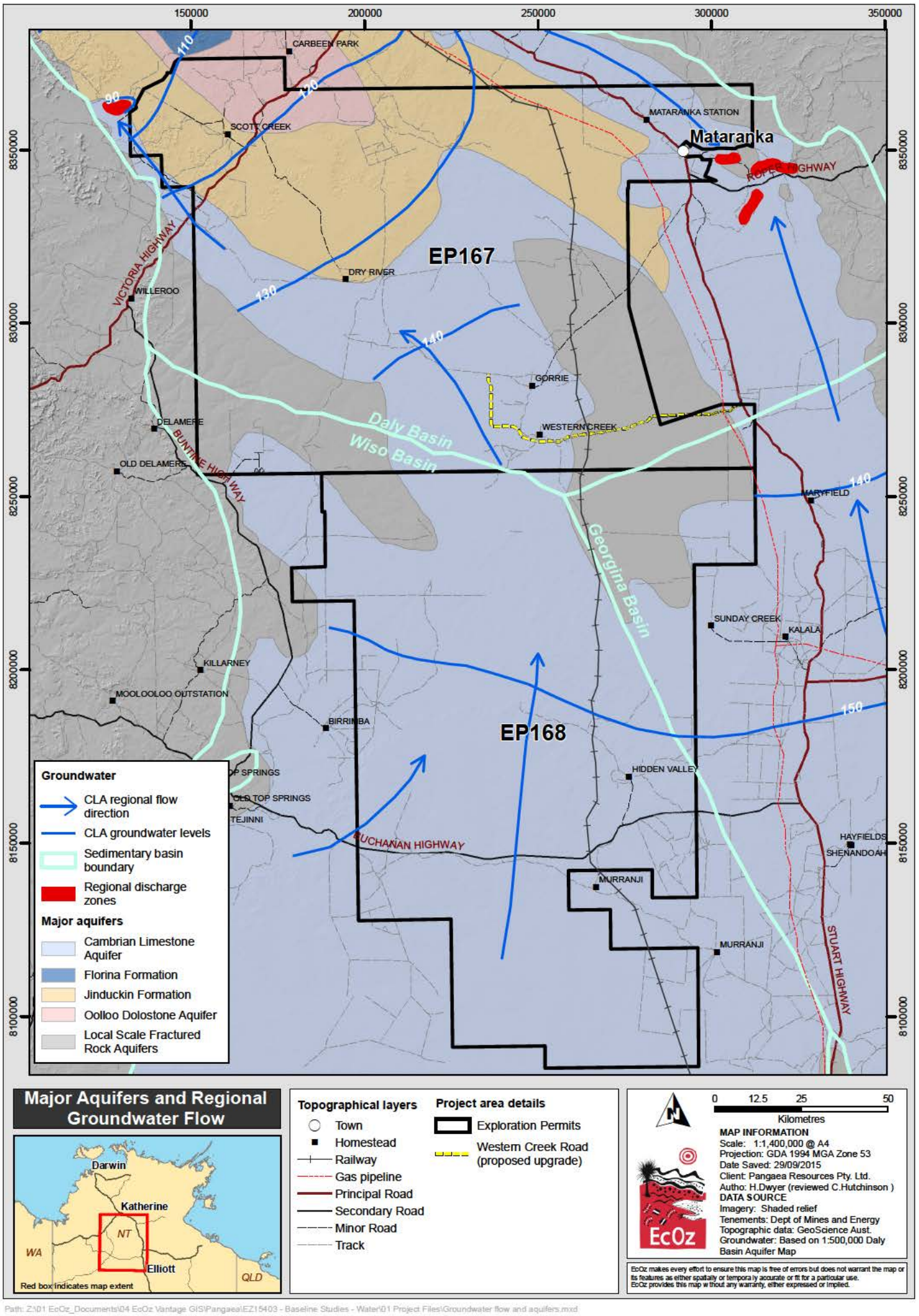

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Figure 4-1. Map of major aquifers and groundwater flow direction

The Jinduckin Formation (Local Aquifer)

The Jinduckin Formation, comprising dolomitic siltstone with interbedded sandstone, forms a local scale aquifer where it occurs in the Daly Basin in the north of the Region. Yields within this aquifer are typically less than 5 l/s but can range up to 20 l/s if cavernous sections are intersected (Tickell 2014). South of this area, on the Sturt Plateau, the Jinduckin Formation is discontinuous having largely been eroded and does not contain notable groundwater resources. The Jinduckin Formation operates as a confining unit for the Tindal Limestone (CLA) in the north of the Region.

Undifferentiated Cretaceous Sediments (Local Aquitard/Local Aquifer)

In the north-west of the Region along the axis of the Daly Basin local aquifers are reported in the basal Cretaceous sandstone. Yields of 2 – 25 l/s have been recorded from fine to medium sandstone, which exhibits good primary porosity (Tickell 2002). Elsewhere in the project area the Cretaceous sediments generally lie above the regional watertable and do not contain permanent groundwater resources. Where present the Cretaceous Mudstone sequence forms a semi-confining to confining unit over the CLA (Tindall Limestone). Variations in thickness and composition of the Cretaceous profile influence recharge mechanisms and rates to the underlying CLA across the project area.

Bukalara Sandstone (Local Aquifer)

No information exists on the groundwater resource potential of the Bukalara Sandstone where it occurs at depth beneath the project area. Regionally, the Bukalara Sandstone comprises quartz sandstone with visible porosity and minor shale interbeds, secondary porosity is likely to be enhanced by evident jointing within the sandstone outcrop (Lanigan et al. 1994). These outcrop areas occur to the east of the project area on Nutwood Downs Station, where the Bukalara Sandstone forms a reliable stock and domestic water supply. Bore yields recorded in this area range from 0.3 – 5 l/s (Fulton & Zaar 2009).

Antrim Plateau Volcanics (Regional Aquitard/Local Aquifer)

The Antrim Plateau Volcanics form a continuous base beneath the Cambrian limestone aquifer across the project area. Thicker sequences of the massive basalt flows have negligible primary porosity and where present the Antrim Plateau Volcanics are considered to form a regional basement to the overlying sedimentary sequence (Tickell 2005; Yin Foo & Matthews 2000). At a local scale the Antrim Plateau Volcanics can form a viable aquifer and the basalt provides a water supply for a number of communities in the greater region including Lajamanu, Minyerri and Bunbidee (Pigeon Hole). Localised aquifer development is commonly dependent on enhanced secondary porosity derived from fault related fracturing (Yin Foo & Matthews 2000).

The Antrim Plateau Volcanics forms a marginal fractured rock aquifer on the Sturt Plateau in the east of the project area. A limited number of constructed bores in this area exclusively screen the basalt sequence. The majority of successful water bores target the unconformable contact between the Antrim Plateau Volcanics and the Gum Ridge Formation or thin sandstone beds within and at the base of the volcanic sequence. High yields (28 l/s) were reported from a 1.5 m cavity at the base of the volcanic succession during the drilling of exploration well Sever. However, expected bore yields for the basalt aquifer are typically less than 0.5 l/s and the formation is considered to have poor groundwater resource potential (Yin Foo & Matthews 2002).

Fractured Proterozoic Rock Aquifers

Fractured and weathered local aquifers occur in the Roper Group formations where they outcrop in the far north-east of the Region around Mataranka. Yin Foo & Mathews (2002) report that most bores drilled into the Proterozoic formations in this area produce useable yields. Bores in the mudstone dominated sequences typically yield less than 0.5 l/s and those tapping fractured sandstone intervals up to 5 l/s.

There is very limited information available relating to the groundwater resource potential of the Roper Group formations where they occur at depth beneath the project area. By inference from lithology and occurrences

in the greater McArthur Basin the fine grained Velkerri Formation, Kyalla Formation and Hayfield Mudstone are likely to act as aquitards and impede vertical flow where thick and undeformed sequences occur. The coarser grained formations (Moroak Sandstone and Jamison Sandstone) potentially contain minor groundwater resources though any aquifers are likely to depend on secondary porosity and be local in nature.

4.3 Groundwater Flow

The regional groundwater flow pattern for the CLA across the project area is presented in Figure 4-1. Regionally groundwater flows from south to north toward major discharge zones in the Daly Basin. The CLA is separated by a bedrock high immediately west of Larrimah which splits the aquifer into an eastern flow path in the Georgina/Daly Basin and a western flow path in the Wiso/Daly Basin (Yin Foo & Matthews 2000; Tickell 2014).

Groundwater along the Georgina Basin flow path emanates several hundred kilometres south-east of the project area where a major flow divide occurs in the CLA (Tickell 2003). Groundwater south-east of this divide flows toward discharge points in the Lawn Hill Creek and the Gregory River in Queensland. Groundwater north-west of the divide flows along the eastern edge of the project area into the Daly Basin and contributes a major flow component of spring discharge between Mataranka and Elsey National Park. Gradients in the CLA in this area are flat-lying averaging around 10 m per 100 km (gradient of 0.0001) and flow rates are in the order of metres/year (Tickell 2003).

In the Wiso Basin, to the west of the bedrock high, the majority of groundwater flow originates from sinkhole recharge on the Sturt Plateau with throughflow from the Wiso basin only providing a small flow component (Yin Foo & Matthews 2000). Regional flow directions in the CLA are to the north through the Region and to the north-west through the Region where groundwater flows toward significant discharge zones in the Flora River (Tickell 2014).

In the central Sturt Plateau a thinner limestone sequence and north-west south-east trending ridges within the underlying Antrim Plateau Volcanics create local flow systems within the CLA. Where these basalt ridges emerge above the watertable groundwater flow is restricted within the valleys reducing the ability of the CLA to transmit regional groundwater flow (Yin Foo & Matthews 2000). This results in steeper groundwater gradients (Tickell 2014) and limits groundwater resource potential at a local scale.

Depth to groundwater in the CLA ranges from over 130 m below ground level to over 10 m above ground level (artesian conditions). The deepest water levels occur in the south of the Region around Hidden Valley station where depth to water can exceed 100 m. Artesian conditions occur in the north of the Region on Manbulloo Station and Scott Creek Station around the King and Katherine Rivers. Tickell (2013c) notes that artesian conditions exist in both the Tindall and Jinduckin Formations in this region.

The north of the Region overlaps with the southern extent of the Oolloo Dolostone aquifer. Recharge occurs on exposed outcrop of the dolostone on Manbulloo station and drives a steep groundwater gradient toward the north (see Tickell 2002; Tickell 2011). Regional flow in this aquifer is to the north-west where discharge provides a major source of dry season flow in the Daly River.

Data is too limited to confidently infer groundwater flow directions within the local aquifers (i.e. Antrim Plateau Volcanics, Jinduckin Formation, Proterozoic fractured rock aquifers) that occur in the project area.

4.4 Recharge Process

Groundwater recharge rates are variable across the project area, and depend on soil type, geology, vegetation and topography, as well as the amount of rainfall and other climate variables. The complex interplay between these parameters means there is not a direct relationship between groundwater recharge rates and rainfall amount across the project area.

The timing and distribution of rainfall over the project area is controlled by the summer monsoon (see Section 2.3). Recharge occurs only in the wet season when rainfall intensity and duration are sufficient to overcome the soil moisture deficit due to evapotranspiration (ET). Recharge leads to the rise in groundwater levels and an increase in discharge to the rivers and at the springs. Recharge in the project area operates via four mechanisms:

- Diffuse recharge, where water is added to the groundwater in excess of soil moisture deficits and evapotranspiration. This occurs by the direct vertical percolation of precipitation through the unsaturated zone, it is thought that this is the dominant mechanism in areas with Cretaceous cover;
- Macro-pores where precipitation is preferentially 'channelled' through the unsaturated zone and has a limited interaction with the unsaturated zone;
- Localised indirect recharge through karstic features such as dolines (sinkholes); and
- Localised indirect recharge along ephemeral drainage lines such as Dry River and the tributaries that feed Elsey Creek.

Studies of recharge in the Daly River Catchment in the north of the project area found that in areas of outcropping Ooloo Limestone macro-pore and indirect recharge accounts for 70% of total recharge and diffuse processes around 30% (Wilson et al. 2006). Tickell (2005) considered that this ratio would be even higher for the Tindall aquifer due to the greater development of sinkholes where this formation outcrops. Due to the significant sinkhole development on the central Sturt Plateau (Yin Foo 2002) recharge in the project area occurs predominantly via preferential infiltration through these karstic features.

In the north-east of the project area, large inter-decadal changes in discharge to the Roper River suggest that most of the recharge input to the groundwater occurs relatively close to the discharge area. This is because discharge from localised systems fluctuates more widely whereas discharge from larger scale systems is much steadier resulting in less variability in discharge (i.e. there is buffering present from the storage in the large groundwater system) (Dahl & Nilsson 2005).

An empirical estimate of the water balance for the Cambrian Limestone aquifer system (Tindall Limestone and Gum Ridge Formation) discharging to the Roper River is presented by Jolly et al. (2004). This analysis was based on three separate methods and determined that recharge ranged from between 5 and 20 mm/yr. Using average annual discharge from the river of 120 000 ML/yr measured at G9030013 (3.8 m^3/s) and an assumed area of recharge (15 000 km^2) the estimated recharge rate was 8 mm/yr. Accounting for the estimated ET losses this was doubled to a value of 16 mm/yr (Jolly et al. 2004). The area contributing to recharge is expected to be half to two thirds smaller than the area identified in 2004 (predominantly within the Roper River catchment), giving a revised diffuse recharge rate in the range of 24 – 32 mm/yr.

In contrast to the Roper River it is expected that approximately 50% of the groundwater derived dry season flow in the Flora River is sourced from recharge to the Tindall Limestone from outside of the Daly River catchment. This recharge occurs across the Sturt Plateau to the south east of the Dry River (Jolly 2002). Yin Foo (2002) investigated recharge processes and rates in this region in the Sturt Plateau Water Resource Investigation. Water quality variation and Carbon-14 groundwater residence times suggest that recharge to the Tindal/Montejinni Limestone is concentrated in the southern and eastern regions of the Sturt Plateau where the Cretaceous sandstone unit is thicker and closer to the surface. Recharge is limited in the south of the project area (Hidden Valley, Birrimba Station and south of the Buchannan Highway) where there is a greater cover of Cretaceous clays. Recharge is also impeded in the north-west of the project area where the Tindall Limestone is confined by the Jinduckin Formation. In the central Sturt Plateau stable isotope data suggests indirect recharge through sinkholes is the dominant recharge mechanism. Sink holes are widespread throughout Sturt Plateau and large sinkholes occur through the central region on Gorrie Station and Avago Station (Yin Foo & Matthews 2000). These range in size up to 800 m long and 0.25 km^2 in area (Chowyung Waterhole on Gorrie Station) and are concentrated in a band running east-west from Middle Creek to the Dry River (Yin Foo & Matthews 2000). Mean annual recharge rate for the Sturt Plateau is estimated at between 6 to 18 mm/year using a groundwater Chloride Mass Balance (CMB) method, this

represents around 1 - 3 % of annual rainfall. Point estimates of recharge using hydrograph analysis in the central Sturt Plateau yielded a recharge rate of 9 mm/year (Yin Foo & Matthews 2000).

In the north of the Region recharge occurs to the Oolloo Dolostone Aquifer where there is exposed outcrop on Manbullo station to the south of the Katherine and King Rivers. Recharge in this area drives a steep groundwater gradient north into the Daly Basin. Recharge is thought to occur as a combination of diffuse recharge, local point source recharge via sinkholes and through streambed infiltration (Tickell 2002). In other areas Cretaceous sediments overlie the dolostone limiting direct recharge. Jolly (2002) estimated recharge rates for the entire Oolloo Dolostone Aquifer - noting that a large proportion of this aquifer occurs north of the Region – at between 40 – 150 mm/year using baseflow data from the Daly River. The higher end of the range represented recharge rates where the aquifer is exposed at the surface in the north-western portion of the Daly Basin. Tickell (2002) estimates average recharge rates to the Oolloo Dolostone using groundwater CMB methods at 40 mm/year.

A summary of recharge processes and rates across the project area is provided in Table 4-1.

Table 4-1. Recharge processes and rates across the Region

Aquifer	Area	Recharge Rate (mm/yr)	Source	Comment
CLA (Tindall, Gum Ridge, Anthony Lagoon Beds)	Mataranka River region NE of the Region	16 – 32	Revised after Jolly et al. (2004)	Local recharge thought to dominate discharge to Roper River. Estimate based on annual discharge in Roper River.
Montejinni Limestone/Tindal Limestone	Central/ Eastern Sturt Plateau	6 – 18	Yin Foo & Matthews (2000)	Recharge dominated by infiltration through sinkholes. Estimate based on CMB and hydrograph analysis.
Montejinni Limestone/Tindal Limestone	South of the Region	Not known	Yin Foo & Matthews (2000)	Recharge limited by Cretaceous clays.
Tindal Limestone	NW of the Region	Not known	Yin Foo & Matthews (2000)	Recharge limited by Jinduckin Formation.
Ooloo Dolostone	NW of the Region	40 – 150 Ave. 40	Jolly (2002) Tickell (2002)	Recharge for entire Ooloo Aqufier based on flow in the Daly River and CMB methods.

4.5 Discharge Processes

In the north-east of the Region, springs drain into the Roper River at Mataranka form the single known outlet for groundwater discharge from the northern Georgina Basin (Tickell 2003). Groundwater along the western flow path in the Wiso/Daly Basin discharge as springs in the Flora River on the north-west boundary of the Region.

Major discharges occur along the headwaters of the Roper River as it intercepts the groundwater flow from the northern Georgina Basin. The groundwater from the CLA discharges along the bed of the river (e.g. Bitter Springs) and via discrete springs (e.g. Rainbow Spring and Fig Tree Spring). Diffuse discharge occurs in the Elsey National Park where the basement approaches the surface forcing groundwater levels above the ground surface (Jolly 2004; Tickell 2005).

Major discharges occur along the headwaters of the Flora River as it intercepts the groundwater flow from the northern Wiso Basin (Jolly et al. 2002; Tickell 2005). Groundwater from the CLA discharges along the bed of the Flora River and via discrete unnamed springs (Karp 1996).

Roper River discharge characteristics

The Roper River is one of the few rivers in northern Australia that exhibits perennial flows. The Roper River is characterised by a four month wet season with significant runoff and an eight month dry season with negligible surface runoff.

The highest mean monthly discharge along the Roper River occurs in March and ranges from 215 000 ML or 83 m³/s downstream of Mataranka Homestead (Elsey National Park) (G9030176) to 1 100 000 ML or 424 m³/s at Red Rock (G9030250). The lowest mean monthly discharge along the Roper River occurs in September and October and ranges from less than 1.5 m³/s downstream of Mataranka Homestead and 3.5 m³/s at Red Rock. It should be noted that cease to flow has been observed at Red Rock.

The average annual discharge of the non-tidal section of the river is based on flows at Red Rock gauging station (G9030250). The average annual discharge 11/08/1966 to 06/01/2009 at this point was 3 289 GL (NRETAS 2009) (Figure 4-2).

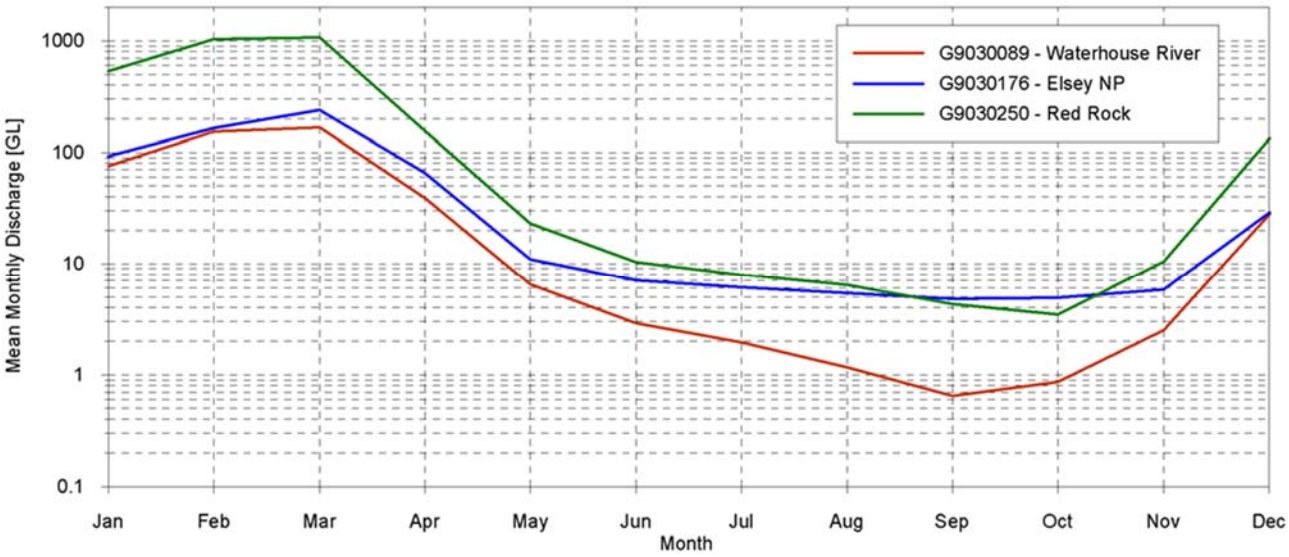

Figure 4-2. Mean monthly discharge for the Waterhouse River and the Roper River D/S Mataranka Homestead (G9030176) and Red Rock GS (G9030250).

Roper River baseflow

During the dry season, aquifers within the Roper River catchment provide approximately 3 – 4 m³/s (95 000 – 126 000 ML/yr) discharge through the river bed and springs as baseflow. In the wet-dry tropics groundwater inflow must be greater than evaporative demand to sustain a year round flow. The baseflow of the Roper River is sourced at its' headwaters where the river intersects the aquifers of the CLA near Mataranka. The southern catchments of the Hodgson, Strangways and Elsey Creek provide little or no baseflow during the dry season. This is due to the underlying geology.

Flora River discharge characteristics

The Flora River is a major tributary of the Daly River, which like the Roper River exhibits perennial flows and is a major discharge point of the CLA of the Wiso and Daly Basins. The Flora River is characterised by a four month wet season with significant runoff and an eight month dry season with negligible surface runoff.

At the end of the dry season the Flora River gains some 2 to 5 m³/s where it crosses the Tindall Limestone. Recent (2009-2015) late dry season flow > 4 m³/s which is approximately 20% of the late dry season flows in the Daly River at Mount Nancar (G8140040) (Figure 4-3).

Karp (1996) identified one main spring and several minor ones along the Flora River. The main spring is located on the south bank of the river about a kilometre downstream of the Mathison Creek junction. It issues from several solution holes in Tindall Limestone. One cavity is two metres above river level and others are below river level. The discharge is difficult to estimate because the spring is partly submerged but it is of the order of 0.5 m³/s. The section of river where groundwater inflow occurs is deep because it has been dammed by a large tufa dam that forms Kathleen Falls.

The highest mean monthly discharge along the Flora River occurs in March and ranges from 350 000 ML or 130 m³/s downstream of Kathleen Falls (G8140044). The lowest mean monthly discharge along the Flora River occurs in September and October and is approximately 4.5 – 5 m³/s upstream of Stoney Creek. The average annual discharge from 02/01/1966 to 01/09/2015 for the Flora River at Kathleen Falls was 1 140 GL (NRETAS 2015).

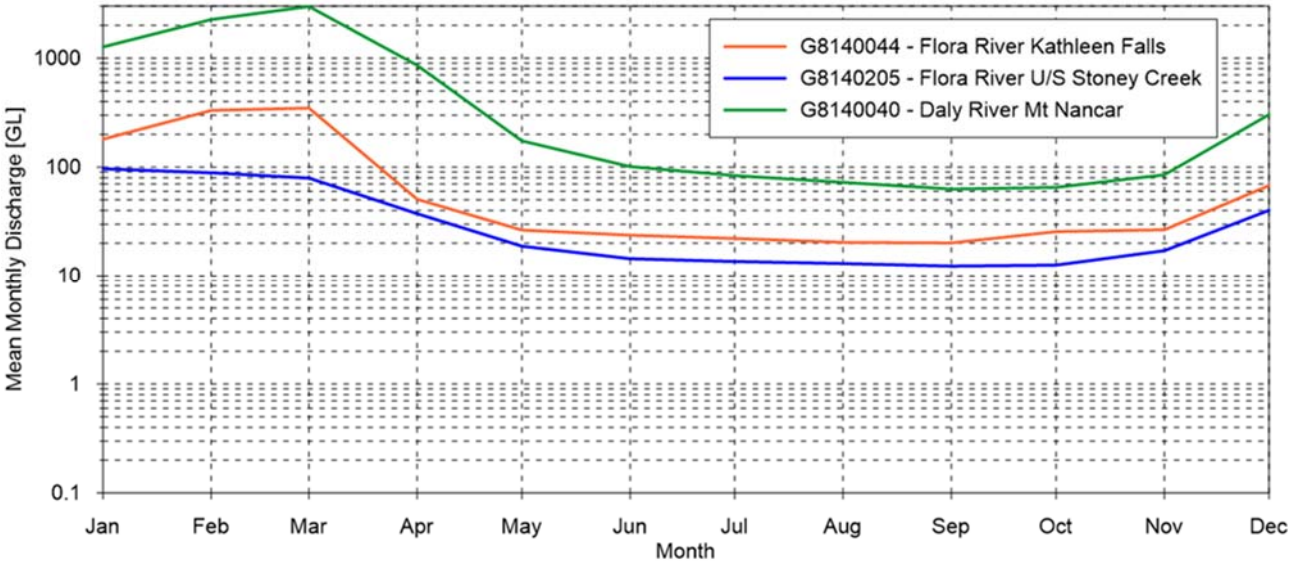

Figure 4-3. Mean monthly discharge for the Flora River at Kathleen Falls (G8140044) and upstream of Stoney Creek (G8140205) and the Daly River at Mt Nancar (G8140040).

Flora River baseflow

During the dry season, aquifers within the Flora River catchment provide approximately 5 – 6 m³/s (158 000 – 190 000 ML/yr) discharge through the river bed and springs as baseflow. The baseflow of the Flora River is sourced at its' headwaters where the river intersects the aquifers of the Tindall Limestone (CLA) in the Giwining / Flora River National Park.

4.6 Groundwater Quality

Water quality in the CLA is generally of potable quality across the project area and is always suitable for stock watering, which constitutes the dominant groundwater use over much of the project area. The Total Dissolved Solids (TDS) of groundwater ranges from around 350 mg/l in the central Stuart Plateau to over 1 200 mg/L in the east of the project area around Larrimah and to the south-east of the Buchannan Highway. Groundwater from the CLA is typically hard with a high alkalinity and a Ca-Mg-HCO_3 water type that is consistent with a carbonate source aquifer.

A zonation of water quality occurs in the CLA across the project that reflects groundwater flow regimes, recharge processes and the mixing of groundwater from different aquifers (Yin Foo & Matthews 2000). The best water quality (around 350 mg/l) occurs in the central project area where indirect recharge through

sinkholes leads to a freshening of the groundwater resource. The water quality increases gradually to around 450 mg/L as the groundwater flows north-west to discharge zones in the Flora Rivers (Yin Foo & Matthews 2000).

A zone of poorer water quality (> 1 000 mg/l) occurs east of the basement high extending along the eastern edge of the project area from Daly Waters to Larrimah. The variable water quality in this area is thought to result from the northward flow of water from the Georgina Basin and mixing with poorer quality groundwater from the overlying Anthony Lagoon Beds - the chemistry in this area has a higher proportion of $Na\text{-}SO_4\text{-}Cl$ which is consistent with the dissolution of evaporite (halite and anhydrite) beds within the Anthony Lagoon Beds (Yin Foo & Matthews 2000). Structural deformation is more significant across this zone relative to the centre of the project area and groundwater mixing is thought occur through fault derived aquifer connection. Yin Foo & Matthews (2000) also suggest that local recharge and dissolution of recent evaporates deposits in drainage lines may be an alternate source of poorer quality groundwater.

In the north of the Region groundwater in the Oolloo Dolostone Aquifer is of very good water quality with a TDS range of 250 – 550 mg/l (Tickell 2002). Minor groundwater resources occur within the Jinduckin Formation in this area, however, little local data exists on water quality for this formation. Where the CLA is unsaturated in the east of the project area, marginal aquifers occur in the Antrim Plateau Volcanics and at the contact with underlying sandstones. Yin Foo & Matthews (2000) report that water quality from this aquifer is generally potable and always suitable for stock watering. Bores constructed in the volcanics to the east of the project area report an average electrical conductivity (EC) of 910 µs/cm (TDS 550 mg/l) and a range of 400 – 1 840 µs/cm (TDS 240 – 1 100 mg/l). Groundwater from the Volcanics can be distinguished from the CLA and Oolloo Dolostone aquifers as it is typically has lower alkalinity, calcium and magnesium and higher relative concentrations of sodium and chloride.

Very limited information is available on the groundwater water quality within the Proterozoic formations that underlie the Antrim Plateau Volcanics. Where these formations outcrop in the north-east corner of the Region water quality is potable, with Yin Foo & Matthews (2000) reporting typical TDS of less than 500 mg/L for sandstone units and up to 1 000 mg/L for shale units. Where these formations occur at depth recharge is more limited and water quality is significantly poorer. Two groundwater samples the Client collected from Proterozoic sandstones on Hidden Valley Station report a TDS of 5 600 mg/l and 7 700 mg/l from depths of 330 m and 742 m respectively. In the Beetaloo Basin to the south-east of the Region formation water sourced from the Roper Group (Proterozoic) at depths of 780 – 1 350 m were hyper saline with a TDS range of 19 000 – 95 000 mg/l across five samples. Similar to the Antrim Plateau Volcanics the water signature of Proterozoic groundwater is Na-Cl and contrasts the $Ca\text{-}Mg\text{-}HCO_3$ signature of the regional limestone aquifers.

4.7 Environmental Dependencies

Surface Water Dependencies

The southern portion of the project area overlies the Sturt Plateau bioregional zone that includes the nationally significant Lake Woods wetlands (wetland types B6 – seasonal/intermittent freshwater lakes, B13 – shrub swamps; shrub-dominated freshwater marsh, shrub carr, alder thicket on inorganic soils, B14 – freshwater swamp forest; seasonally flooded forest, wooded swamps; on inorganic soils and B10 – seasonal/intermittent freshwater ponds and marshes) (Figure 4-4).

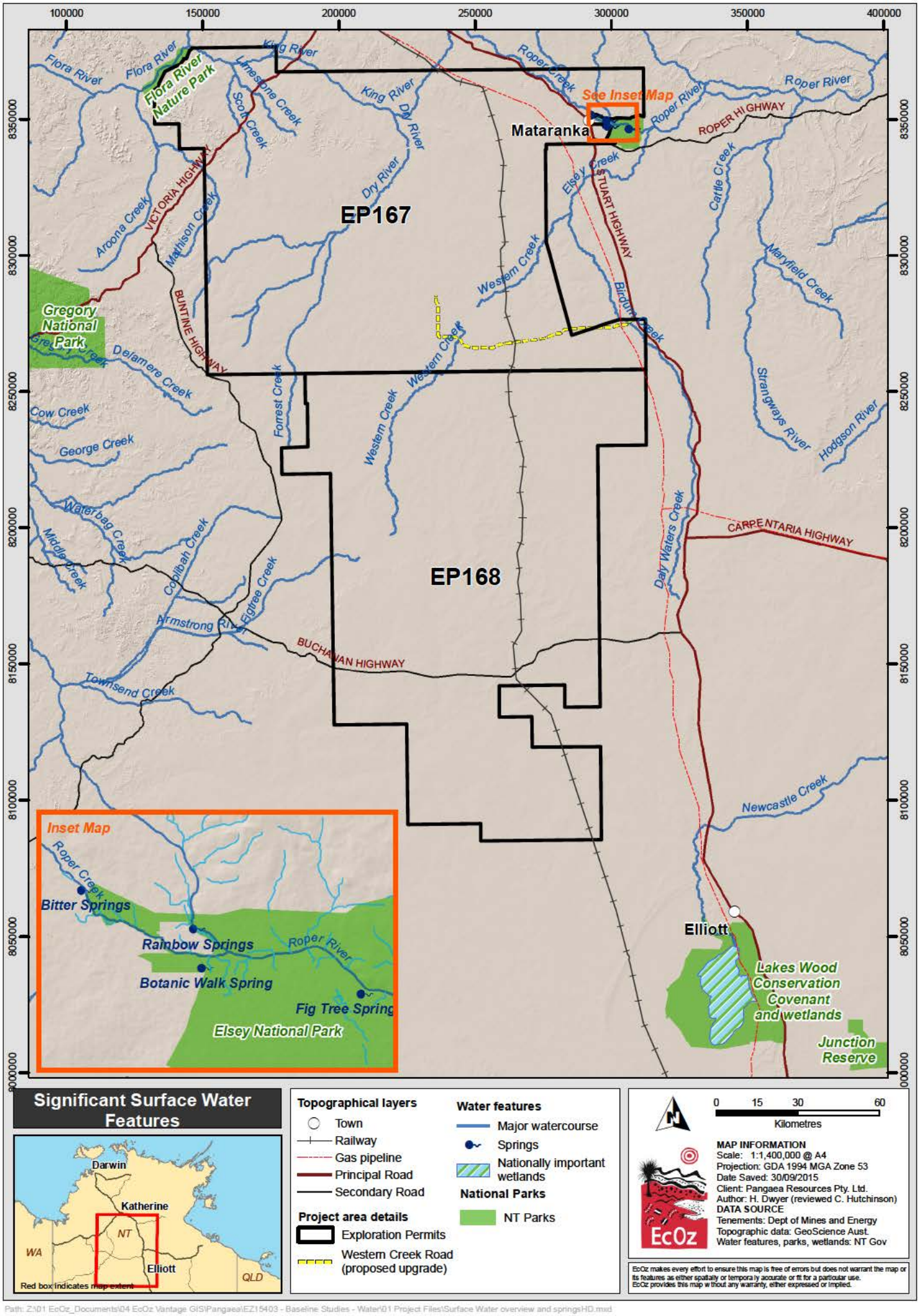

Figure 4-4. Map of significant surface water features

There are also a number of small wetlands associated with the intermittent, land-locked drainage systems in the south of the Sturt Plateau bioregion.

The four relevant criteria for the classification of the Lake Woods wetlands as nationally important are described by Environment Australia (2001) as:

- It is a good example of a wetland type occurring within a biogeographic region in Australia;
- It is a wetland, which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex;
- It is a wetland, which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail; and
- The wetland supports 1% or more of the national populations of any native plant or animal taxa.

Groundwater Dependencies

SKM, (2001) identified six levels of dependency relating to groundwater dependent ecosystems (GDE's). However, all regimes involve:

- The level or pressure of the groundwater;
- The discharge flux of groundwater from an aquifer; and
- The quality of the groundwater.

Figure 4-5 demonstrates how the distribution of vegetation can be controlled by the availability of groundwater. Where the water table approaches the surface a greater density of vegetation is evident and can often be identified using remote sensing products such as MODIS (Moderate Resolution Imaging Spectroradiometer) normalised difference vegetation index Normalised Difference Vegetation Index (NDVI).

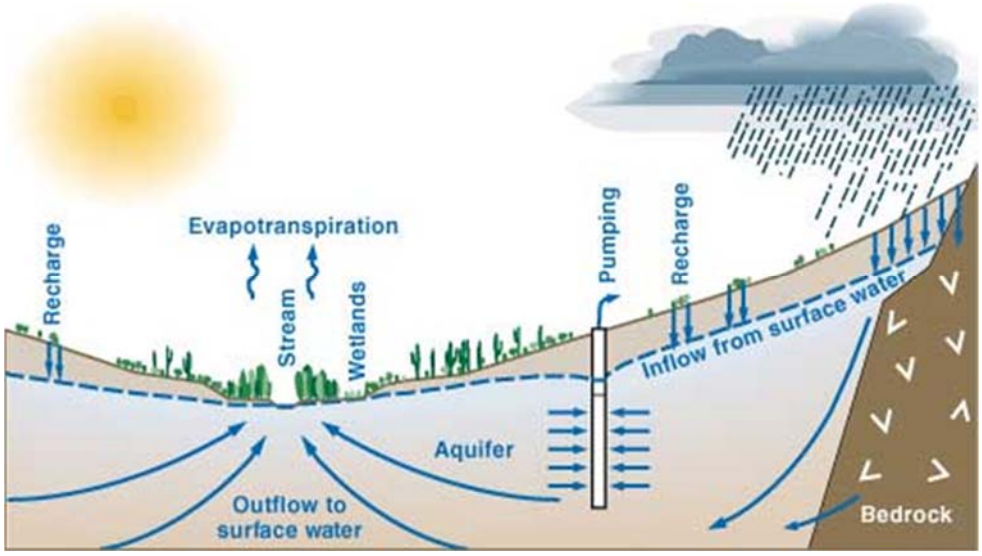

Figure 4-5. Diagram demonstrating recharge, through flow and discharge via evapotranspiration

Based on the criteria above the perennial sections of the rivers and the springs that have been identified in the Roper River catchment could be classified as groundwater dependent. The prominent areas identified as being potential GDEs are presented below.

Elsey National Park

The perennial nature of the spring-fed Roper River, the floristic diversity and restricted range of the riparian vegetation, and the representation of "tufa" formations have been identified as important natural resources within Elsey National Park. The Mataranka Thermal Pools, located within Elsey National Park, are

maintained by permanent thermal springs (Figure 4-4). The pools are fringed mainly by *Livistona rigida*, although *Pandanus* and *Melaleuca spp*. also occur. The *Livistona rigida* palm community has a restricted distribution in the Top End Region and, as such, is considered a special community (Faulks 2001).

Red Lily Lagoon / 57 Mile Waterhole

The Red Lily Lagoon is an area of riparian vegetation associated with wetlands along a 20 km braided section of the Roper River immediately downstream of the major groundwater discharge zone from the Cambrian Limestone Aquifer. It is estimated that ~1 m^3/s is used as evapotranspiration from the Red Lily Lagoon (Knapton 2009).

Flora River National Park

The Flora River is a tributary of the Daly River and a major discharge point of the Cambrian Limestone Aquifer in the Wiso and Daly Basins. At the end of the dry season the Flora River gains some 2 to 5 m^3/s where it crosses the Tindall Limestone. Karp (1996) identified one main spring and several minor ones. The main spring is located on the south bank of the river about a kilometre downstream of the Mathison Creek junction. It issues from several solution holes in Tindall Limestone. One cavity is two metres above river level and others are below river level. The discharge is difficult to estimate because the spring is partly submerged but it is of the order of 0.5 m^3/s. A highly significant characteristic of the Flora River is that groundwater fed base flows varies very little from one Dry season to another.

Recent (2009-2015) late dry season flows have been gauged at > 4 m^3/s which is approximately 20% of the late dry season flows in the Daly River at Mount Nancar (G8140040) and ~60% of the late dry season flows in the Daly River at Dorisvale (G8140067).

http://www.lrm.nt.gov.au/water/water-data-portal

Riparian Vegetation

Based on the broad criteria identified by SKM (2001), much of the riparian vegetation along the fringes of the Roper and Daly Rivers and their tributaries which derive flow from the regional aquifers (i.e. the Flora River) would be classified as groundwater dependent ecosystems as their source during the dry season is derived solely from groundwater. The Flora River is fringed with dense riparian vegetation and dotted with deep pools, and an adjacent area of floodplain and savannah woodland which forms a rich wildlife habitat.

Water use studies along the riparian zone of the Daly River identified that *Melaleuca argentea* (W. Fitzg) and *Barringtonia acutangula* (L. Gaertn) appear to be obligate phreatophytes as they use groundwater almost exclusively and are associated with riverbanks and lower terraces with shallow (<5 m) watertables (O'Grady et al. 2001). Distribution maps of *Melaleuca sp*. for the northern portion of the Northern Territory have been completed at 1:100 000 scale based on air-photo interpretation and field surveys (Brocklehurst & Van Kerckhof 1994).

Riparian lands occupy only a small proportion of the landscape but they frequently have a much higher species richness and abundance of animal life than adjacent habitats. A broad-scale survey of bird distribution in riparian vegetation centred on the mid-reach of rivers with semi-permanent freshwater pools (that is, the Roper, Hodgson and Arnold Rivers within the Roper River catchment), found that despite their relatively small total extent, riparian areas were extremely important for birds (Woinarski et al. 2000). The study concluded that the bird fauna of riparian areas is distinct from that of the surrounding savannas, and this was especially so in lower rainfall areas. Species richness and the total abundance of birds was greater in the riparian zones than in non-riparian zones especially where they contained more extensive cover of rainforest plants and Melaleuca, (Woinarski et al. 2000).

Environmental Water Requirements

No quantification of environmental water requirements has been determined for the Roper River.

No quantification of environmental water requirements have been determined specifically for the Flora River, however, environmental water requirements of the Daly River are documented in Erskine et al. (2003). These water requirements have been used to inform water allocation planning.

Erskine et al. (2003) identified the following minimum streamflows should be adopted at the relevant locations:

- Dorisvale Crossing – 6.2 m^3/s or 536 ML/d
- Oolloo Crossing – 12 m^3/s or 1 037 ML/d
- Mount Nancar – 12 m^3/s or 1 037 ML/d

At discharges greater than the above thresholds but less than those specified as flood events, at least 80% of the streamflow should be protected for the maintenance of streamflow, water quality, flow hydraulics, aquatic habitats, flora and fauna.

At discharges less than the above thresholds, at least 92% of the streamflow at these locations must be protected for the maintenance of critical aquatic habitats and their associated flora and fauna.

Groundwater fed base flows in the Flora River vary very little from one Dry season to another and the river provides approximately 50-60% of this environmental water requirement. The minimum environmental flow requirements were based on the following considerations:

- A minimum discharge of 2 m^3/s or 173 ML/d is required for use by riparian vegetation and for protection of aquatic flora and fauna. It was determined as follows:
    - The water demand of riparian vegetation between Dorisvale and Mount Nancar during extreme water stress when the soil moisture store was completely depleted and groundwater/river water was the only source was calculated by using a stand water use of 5 mm/d for the riparian zone area. O'Grady et al. (2001) found that stand water use by riparian vegetation can exceed 4.8 mm/d and so a maximum value of 5 mm/d was adopted. This water requirement was then assumed to be sourced solely from streamflow as base flow discharge which riparian tree roots can access.
    - Cease-to-flow conditions on the Daly River would have catastrophic consequences for the pig-nosed turtle (Carettochelys insculpta), aquatic plants (*Vallisneria nana* and *Spirogyra sp.*), fish and other aquatic species. Therefore, the Daly River must have additional discharge to that required by riparian vegetation to maintain some refuge aquatic habitat. Georges et al. (2002) classified cease to flow conditions as 'catastrophic' for pig-nosed turtle and flowing water is also required by *Vallisneria nana* and *Spirogyra sp.* Catastrophic conditions for pig-nosed turtles refer to river fragmentation with greatly restricted home range and turtle passage; restricted access to nesting banks; restricted access to feeding grounds; and changed thermal regime which alters sex ratios (Georges et al. 2002). As a result, there is limited to no recruitment during catastrophic conditions. Therefore, not only must the Daly River never cease-to-flow but low streamflows must be high enough to generate sufficient turbulence for the optimum growth of at least *Vallisneria nana* and *Spirogyra sp.*

Minimum streamflows of less than 6.2 m^3/s or 536 ML/d at the Dorisvale gauge were classified as 'bust' conditions for the pig-nosed turtle by Georges et al. (2002) because of some restriction on home range and turtle passage. Such conditions are to be expected but their magnitude and persistence should not be greatly changed so as to ensure the viability of the pig-nosed turtles. Rea et al. (2002) cited streamflows of 10 – 12 m^3/s or 864 – 1 037 ML/d at Oolloo Crossing as the threshold below which there is a sudden decrease in habitat availability for *Vallisneria nana*. Townsend et al. (2002) found that at streamflows of less than 12.5 m^3/s or 1 080 ML/d downstream of Oolloo Crossing the rate of *Spirogyra sp.* biomass loss with reduced streamflow was three times greater than at higher discharges. This is a measure of lost primary production.

4.8 Groundwater Regulation (Water Control Districts)

The *NT Water Act*, which was enacted in 1992 but subsequently amended several times, and the NT Water Regulations, also enacted in 1992, provides the legislative framework for water planning and entitlements for NT water resources. These are implemented under the Water Allocation Planning Framework (WAPF). Under the WAPF there are three levels of administrative area relating to the management of water resources in the Northern Territory.

- Water Control Districts;
- Water Allocation Plan Areas; and
- Water Plan Management Zones.

Water Control Districts provide a basis for administering the management of surface water and groundwater resources covering all aspects of sustainable water resource management including the investigation, use, control, protection and allocation. Water Control Districts (WCD) can be proclaimed in areas where there is a need for close management of water resources. This is to avoid stressing groundwater reserves, river flows or wetlands. Eight Water Control Districts have been declared within the NT for Alice Springs, Daly Roper, Darwin Rural, Gove Peninsula, Great Artesian Basin, Tennant Creek, Ti Tree and Western Davenport regions.

Water Allocation Plan Areas are declared under the NT *Water Act* (1992) and apply to specific water resources within a WCD to ensure that water extraction of the resource is undertaken in a sustainable and equitable manner. Declaration of a water allocation plan establishes the maximum amount of water available for consumption and as part of their development takes into account both the current and estimated future water demands for mining and petroleum extraction. WAPs are informed by detailed technical and scientific assessment as well as extensive community consultation to determine the right balance between competing requirements for water. Four WAP areas currently have declared plans: Alice Springs Water Resource Strategy, Water Allocation Plan for the Tindal Limestone Aquifer – Katherine 2009-2019, the Ti Tree Water Allocation Plan 2009 and the Western Davenport Water Allocation Plan. Five water allocations plans are in progress.

Water Plan Management Zones apply to specific areas located within a Water Allocation Plan Area and is generally established to reduce local short term impacts of extraction. Rules for each zone are defined in water allocation plans to determine how water can be used and/or traded. The boundary extents of DRAFT zones are subject to change. Current maps and spatial data are available for specific water management zones at http://www.lrm.nt.gov.au/water/water_allocation.

Water Regulation Zones within the Region

The Region is within the Daly Roper Water Control District. The location of EP boundaries and the Day-Roper Water Control District are presented below in Figure 4-6. The north eastern portion of the Region also falls within the existing Katherine Water Allocation Planning area and the proposed Katherine – Oolloo and Mataranka Water Allocation Planning areas.

The *Water Act* 1992 does not currently apply to petroleum activities and currently the key legislation relating to water resources on petroleum leases is the *Petroleum Act* 1994 and the Schedule of Onshore Petroleum Exploration and Production Requirements 2012. However, the NT government has recently (August, 2015) released a set Interim Guiding Principles for onshore oil and gas activities. The guidelines require aspects of water management on Petroleum leases to align with the *Water Act* (1992). The guiding principles include requirements that oil and gas activities:

- Apply minimum standards for water bore construction.
- Obtain groundwater extraction licenses when in WCDs or when constructing bores with a yield greater than 15 l/s.

- Ensure any extraction is consistent with relevant Water Allocation Plans (WAPs).
- Ensure potential impacts of water extraction to groundwater and rivers are understood and documented in the Water Management Strategy.
- Ensure landholders are not adversely impacted by reduced water supplies.

The guiding principles also identify specific issues relating to hydraulic fracturing and chemical and waste handling and disposal. Further detail on the onshore oil and gas guiding principles can be obtained from: https://onshoregas.nt.gov.au/environment/onshore-oil-and-gas-guiding-principles.

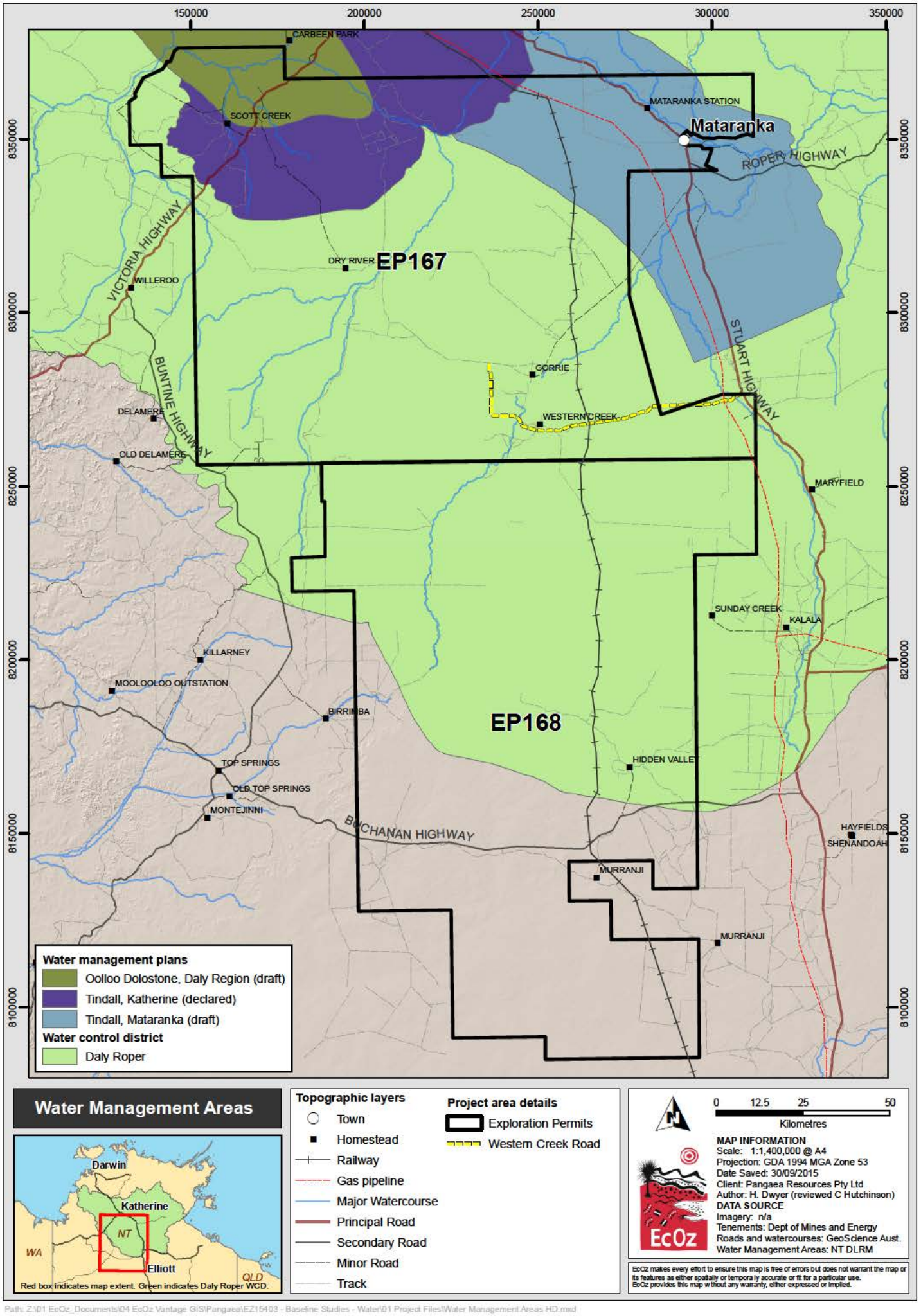

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Figure 4-6. Map of water management areas

5 Regional Water Use

An assessment of usage from the CLA (the main shallow groundwater source) in the project area was undertaken and reported on by Jolly (2004). Irrigated horticulture followed by stock watering are the major uses at present with small town/community supplies such as Mataranka, Larrimah and Daly Waters and outstations. The registered bores in the project area have been classified by their purpose at time of drilling and are presented in Figure 5-1. A total of 475 registered bores have been drilled in the project area with the majority being used for stock watering. The bore yield class for each of the bores within the project area is presented in Figure 5-2 to indicate groundwater extraction capabilities for groundwater users.

Community Water Usage

An estimate of groundwater usage by communities within and in close proximity to the project area is provided in Table 5-1. This is based on per capita water consumption as actual extraction volumes for these communities are not readily available. Typically the daily per capita usage is estimated to be 1 300 – 1 800 litres per person. Using Australian Bureau of Statistics population figures for 2011, the community supplies are of the order of 400 – 500 ML/year (Table 5-1).

Table 5-1. Community water supplies

Town	Population	KL/person/day	ML/year
Mataranka	244	1.68	150
Jilkminngan	280	1.3	125
Daly Waters	80	1.8	53
Larrimah	50	1.8	33
Newcastle Waters and Jingaloo	156	1.8	100
Total	**810**		**461**

Stock and Domestic Water Usage

Stock supplies are more difficult to quantify, due to the limited reporting of stock numbers in the area, but a rough estimate can be made by assuming a stocking rate of approximately 4 – 6 head per km^2 (DPIF 2010). Assuming this stocking rate and an area of 32 300 km^2 (accounting for the combined area of the Region) that there are approximately 130 000 – 194 000 cattle currently watered from the groundwater resources of the CLA. Applying an average consumption of 50 litres/head/day, the stock usage is estimated at between 2 370 and 3 540 ML/year across the project area.

Irrigated Horticulture

Irrigated horticulture forms the major use of groundwater across the project area with extraction focused in the north and north-east of the Region within the Daly Roper Water Control District. As of September 2015, the NTG department of Land Resource Management (DLRM) groundwater extraction license (GWEL) register reports a total licensed extraction of 116 000 ML/year for the Daly Roper Water Control District. This is comprised of 44 000 ML/year for the Tindall, Jinduckin and minor aquifers around the Katherine and Mataranka regions and 72 000 ML/yr for the Oolloo Dolostone Aquifer to north-east of the Region. Note that the licensed allocation volume will be greater than the actual annual licensed groundwater extraction.

Surface Water Use

Surface water resources are predominantly used for stock consumption; however this is restricted to temporary waterholes due to the absence of perennial watercourses through the project area. Given the

ephemeral nature of the watercourses within the project area, stock water in the region is predominantly sourced from groundwater (Yin Foo 2002).

The use of surface water is largely restricted to the wet and early dry season where significant rainfall has occurred to retain water within water bodies. Surface water is progressively depleted with the advancement of the dry season. Some waterholes within the Western and Birdum Creek systems and waterholes on the black soil plains of the Dry River system have the potential to persist perennially (Yin Foo 2002).

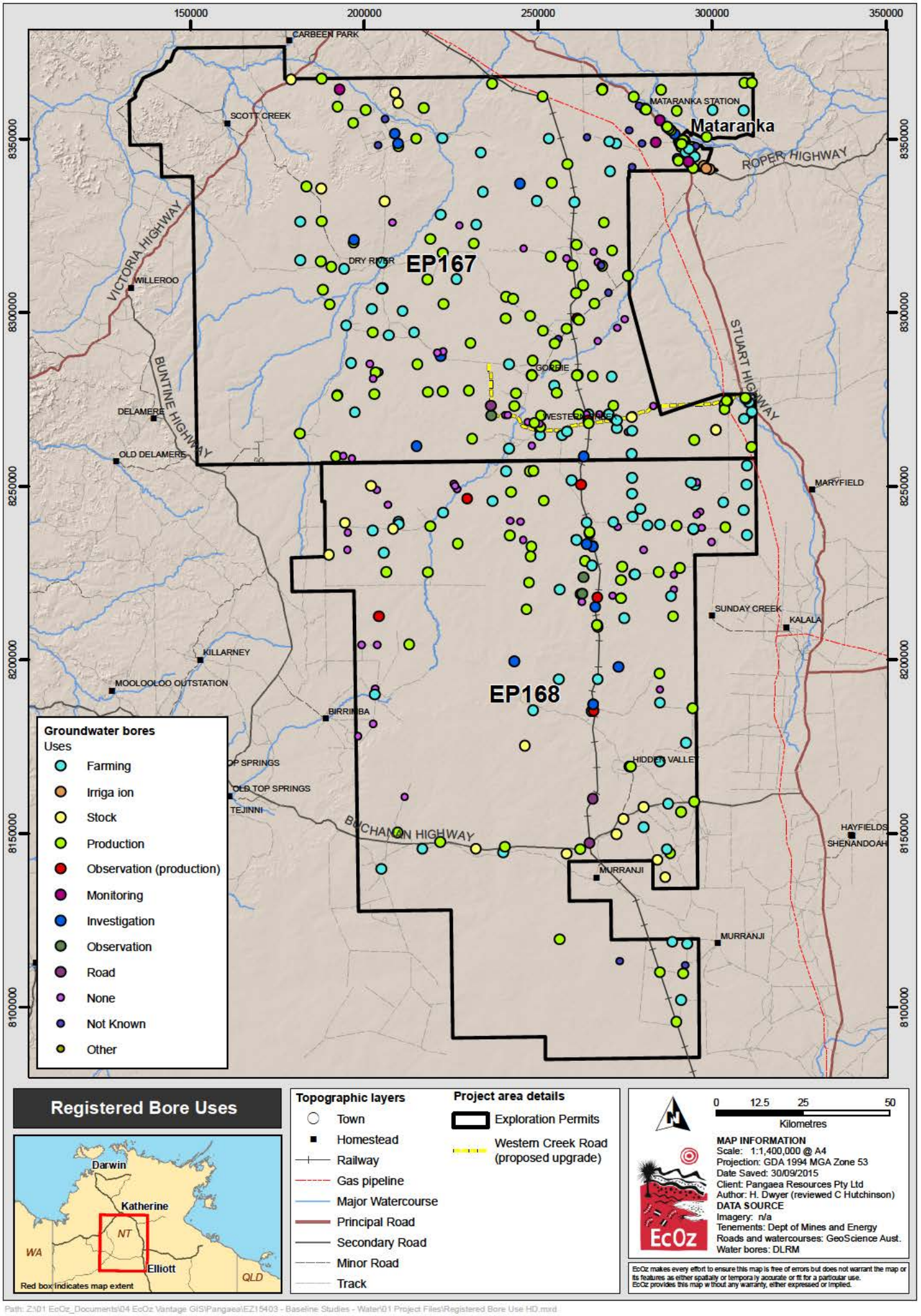

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Figure 5-1. Map of registered bore use

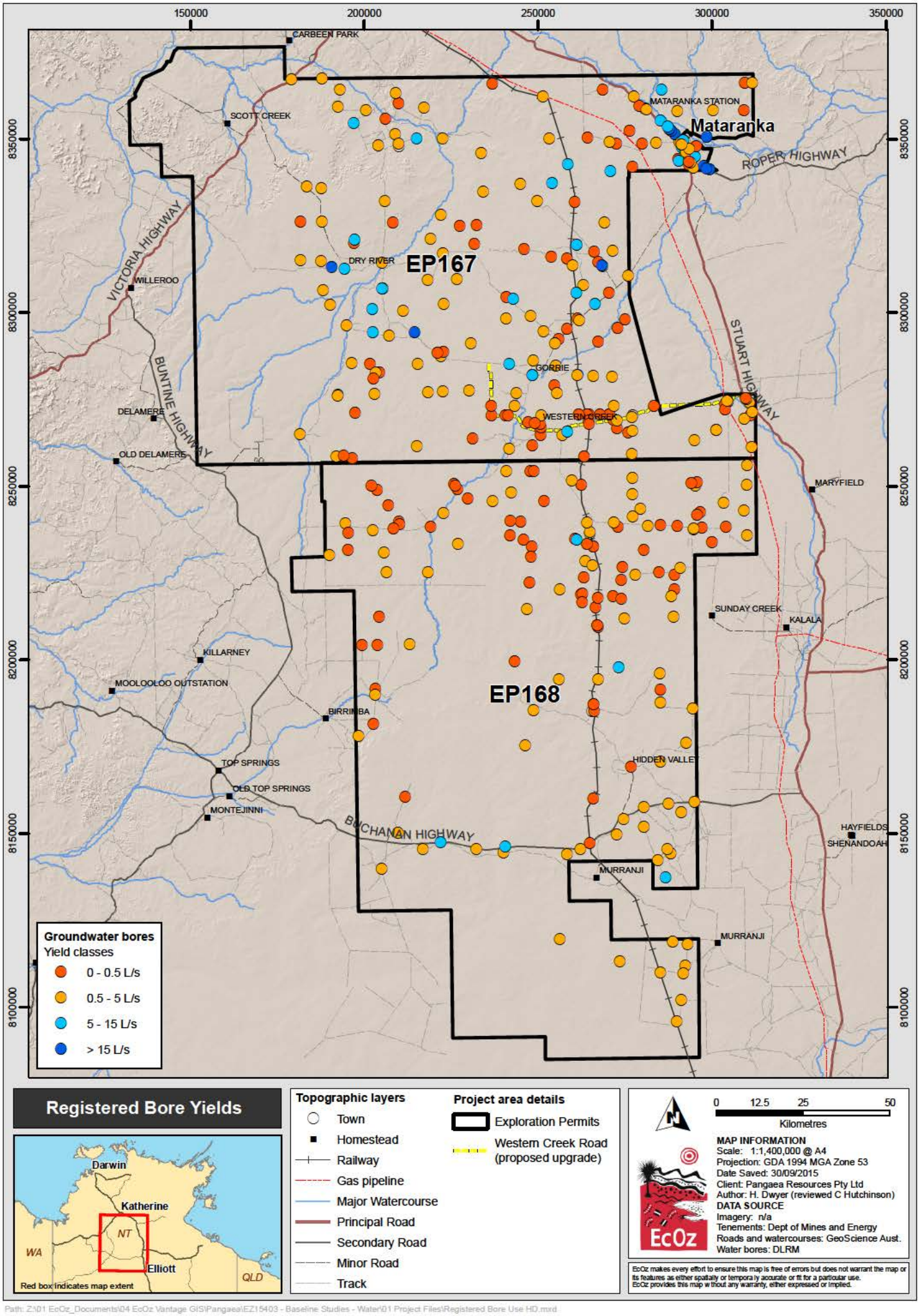

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Figure 5-2. Map of registered bore yield

6 Groundwater Assessment

6.1 Summary of Hydrogeology

The majority of the project is underlain by the Cambrian Limestone Aquifer – this comprises the Tindall Limestone (Daly Basin) over the Region, Montejinni Limestone (Wiso Basin) in the south of the tenements and Gum Ridge Formation (Georgina Basin) in the east. Groundwater flows from south to north across the project area and is split into an eastern and western flow path around a high in the underlying Antrim Plateau Volcanics that occurs in the east of the project area. The western flow path discharges in the Flora River to the immediate north-west of the Region. The eastern flow path discharges in the Roper River at Mataranka. These discharge zones are very significant as they support dry season base flow in the Roper and Daly Rivers. The aquifers are also heavily used for horticulture around Mataranka and Katherine. The majority of recharge for the Roper River discharge zone is considered to occur locally around Mataranka. However, it is estimated that around 50% of discharge for the Flora River is recharged on the Sturt Plateau in the central project area. Recharge in this area occurs through outcropping Tindall Limestone and as point recharge through sinkholes, which are extensively developed through the central Sturt Plateau. The Oolloo Dolostone is another significant regional aquifer that occurs in the north-west of the Region – as with the CLA, the Oolloo Dolostone is important to both horticulture and in maintaining springflow to groundwater dependent ecosystems (GDEs) in the Daly Basin. Recharge to the Oolloo Dolostone occurs where it outcrops in the north-west of the Region. Marginal aquifers occur in the Antrim Plateau Volcanics where they form the watertable aquifer in the east of the project area, in the Jinduckin and Cretaceous formations in the north of the Region and in fractured Roper Group Sediments in the far north-east of the Region around Mataranka.

Groundwater quality in all aquifers is generally of drinking water standard, with the exception of the CLA along the eastern flow path around Daly Waters and Larrimah. Water quality is more marginal in this area but in some areas is still potable and is always suitable for stock watering. Horticulture represents the dominant water use across the project area and is concentrated in the north of the Region around Katherine and Mataranka, and in the Oolloo Dolostone aquifer to the north-west. Stock watering and town water supply form the other significant groundwater uses elsewhere in the project area.

Significant fault zones occur along the eastern edge of the project area and through the north of the Region – these are generally deep seated structures within the basement, however, fault displacements have been identified in the CLA and the Antrim Plateua Volcanics. The Antrim Plateau Volcanics is generally considered as groundwater basement to the CLA and restricts vertical flow between the CLA and deeper formations such as the resource targets within the Roper Group. However, fault zones that penetrate the Roper Group sequence and the Cambrian basalts and limestones may provide pathways for the migration of gas or poorer quality groundwater to the CLA.

6.2 Methodology and Scope

The following groundwater impact assessment aims to identify potential hazards to the local and regional groundwater system resulting from activities directly associated with the Client's oil and gas activities the Region. Impacts have been assessed applying a Source-Pathway-Receptor model. The "Source" is the origin of an impact (e.g. a contaminant spill), the "Pathway" is the means by which the receptor is affected (e.g. infiltration to the watertable and lateral movement through an aquifer), while the "Receptor" is the entity that is affected by the impact (e.g. adjacent groundwater bores). Each of these three elements exist independently but an environmental impact will only occur when the three elements are linked together.

A literature review was completed to establish a list of potential groundwater impacts (Sources) associated with shale gas exploration drilling. This review covered Northern Territory, national and international studies and inquiries into shale gas exploration drilling and hydraulic fracturing activities. The assessment considers the following activities associated with shale gas exploration: drilling and construction of exploration wells,

Diagnostic Fracture Injectivity Tests (DFIT), hydraulic fracture stimulation and well abandonment. The impact assessment is general in nature and is not intended to replace a more detailed and site specific groundwater risk assessment.

6.3 Groundwater Impact Assessment

The literature review identified the following five broad risks that are associated with oil and gas exploration activities and have the potential to impact on groundwater resources beneath the project area:

1. Surface spill or leakage of flow back water, stimulation additives, hydrocarbons, hazardous substances and saline groundwater results in the contamination of groundwater resources.
2. Groundwater extraction required for project activities (civil works, drilling, camp use etc.) results in a decline in groundwater levels which impacts existing groundwater users and/or environmental dependencies.
3. The uncontrolled movement of groundwater from an utilised aquifer to another formation causes a decline in groundwater levels which impacts existing groundwater users and/or environmental dependencies.
4. Cross formational flow of formation water, hydrocarbons (gas and/or liquids) from deeper formations to an utilised aquifer results in groundwater contamination.
5. Hydraulic fracturing induces seismicity which increases connectivity between formations and enhances the potential for cross formational flow of water and hydrocarbons (gas and/or liquids) and results in groundwater contamination.

These risks are analysed in Table 6-1 using the Source-Pathway-Receptor approach. The table also includes a discussion that identifies areas within the project area that are considered higher risk for each impact.

Table 6-1. Groundwater impact assessment summary

Source of Hazard	**Cause/s**	Pathway	**Receptor**	**Description**
Spillage of diesel / stimulation additives / flow back water during transport, storage or transfer onsite. Leakage / overtopping from mud sumps / flare pits / retention ponds.	• Vehicle accident during transport leads to uncontrolled discharge of hydrocarbons / chemicals. • Leakage due to tank / storage integrity breach. • Loss of containment during transfer onsite (leakage from pipes, hoses, fittings etc.). • Uncontrolled surface discharge of formation water / hydrocarbons due to blow out during drilling. • Inadequate storage capacity in mud sumps / flare pits. • Failure of pit / pond liners.	Infiltration of contaminants to watertable and then lateral flow within the aquifer to the receptor/s.	• Groundwater Dependent Ecosystems (GDEs). • Groundwater users.	The risk of this occurring is greatest where there is sinkhole development in the landscape as these features can provide rapid pathways to the watertable, also areas where the CLA outcrops and where it is not confined by the Jinduckin Formation or Cretaceous mudstones. For the CLA the highest risk area is the central Sturt Plateau (the area between the bedrock highs through the centre of the Region). Areas where the Oolloo Dolostone outcrops in the north of the Region also represent higher risk areas.
Pressure reduction resulting from groundwater extraction.	Groundwater extraction for project activities causes the decline of groundwater levels in the Cambrian Limestone Aquifer (CLA) or local aquifer.	Pressure decline is transmitted from production point through the aquifer to the receptor.	• GDEs (spring flow). • Groundwater users.	Potential impacts are impaired capacity (yields) for adjacent groundwater users and reduced environmental flows for connected springs/rivers. The greatest impact on GDEs will occur if groundwater extraction is located in the north of the Region in the vicinity of the Roper River or the Flora River. Over longer time scales (years to decades) large scale extraction from the central Sturt Plateau will also have a pressure impact on spring flow to the Flora River as discharge relies on recharge that occurs in the centre of the project area. Locally, groundwater pressure impacts on existing groundwater users are likely to be most severe in the more marginal, local aquifers (e.g. the Antrim Plateau Volcanics to the west of Larrimah). Impacts to existing users are also more likely in the CLA in the centre of the project area where the aquifer thins over structural highs in the Antrim Plateau Volcanics. Regional flow in the CLA in these areas is restricted by local valleys within the

Source of Hazard	Cause/s	Pathway	Receptor	Description
				basalt.
Pressure reduction resulting from the uncontrolled flow of groundwater from an utilised aquifer to another formation.	• Wellbore failure due to incomplete cement placement or casing failure during operation or post abandonment. • Breach of aquitard by hydraulic fracture propagation.	Pressure decline results from migration of groundwater through failed well. Pressure decline is transmitted from the failure point through the aquifer to the receptor.	• GDEs (spring flow). • Groundwater users.	The magnitude of potential cross flow and the resulting pressure decline is dependent on the relative permeability of the aquifer and the formation receiving the flow, and also the pressure gradient between the two formations. Currently there is very limited information on vertical gradients between shallow aquifers and deeper formations within the project area. Areas of highest concern are located in the north of the Region where artesian (flowing) groundwater conditions are reported in both the CLA and Jinduckin Formation (Tickell 2013c).
Cross formational flow of formation water / hydrocarbons / gas from deeper formations	• Well failure due to incomplete cement placement or casing failure during operation or post abandonment. • Blow out during drilling causes annular leakage. • Breach of aquitard by hydraulic fracture propagation. • Hydraulic fracturing opens pathway through an abandoned exploration well. • Leakage along faults intersected by drilling or connected through induced fracturing.	Transmission pathways from deeper formations which host hydrocarbons and saline formation water include: • Failed or poorly constructed well (including abandoned wells). • Breached aquitard. • Faults.	• GDEs. • Groundwater users.	The risk of contamination of groundwater resources impacting on GDEs (Flora and Roper Rivers) will be most likely and severe if activities occur in the vicinity of the discharge zones. If working outside these areas the risk will be lower because of the longer flow paths and retention times in the regional aquifer. Impacts to existing users/bores is more likely as groundwater extraction for stock watering, horticulture and domestic water supply occurs across the whole project area. The likelihood of cross-formational flow will depend on drilling controls (well construction and integrity testing, blow out protection etc.) and also site specific geological conditions. Key factors will include the extent and thickness of aquitards (low permeability formations) that form a barrier between the gas production zones and shallower aquifers. The Antrim Plateau Volcanics forms one of the key regional aquitards and appears to be extensive beneath the tenements. The risk of cross-formational flow will be greater in areas where there is greater deformation (i.e. faulting), particularly where faults penetrate both the deeper Roper Group and extend through aquitard layers

Source of Hazard	Cause/s	Pathway	Receptor	Description
				into the shallow aquifer systems. Fully penetrating faults can act as conduits between the gas producing zones and the groundwater system. The highest risk areas will be around the eastern edge and through the north of the project area – particularly around Larrimah where faults displacing the volcanics and CLA have been recognised and water quality in the CLA suggests that there may already be mixing of groundwater from different aquifers/depths (Figure 2-4).
Induced seismicity leads to cross formational flow of formation water / hydrocarbons / gas from deeper formations.	Hydraulic fracturing induces local seismicity creating pathways between deeper formations and shallow aquifers.	• Faults. • Failed well construction.	• GDEs. • Groundwater users.	Most induced seismicity associated with fracture stimulation is micro-seismicity and is not of a magnitude capable of deforming formations and creating migration pathways by breaching aquitards. Larger induced seismic events are uncommon and are generally associated with pre-stressed faults (RSRAE 2012). Any potential impacts relating to induced seismicity are more likely to occur in areas where there are existing faults (i.e. to the east and through the north of the project area, see Figure 2-4).

7 Recommendations

7.1 Surface Water

In order to gain a better understanding of the hydrology and water quality in streams draining the lease area, it is recommended that the following field studies be undertaken:

- Survey of drainage lines (including measurement of flows and water quality sampling) and riparian vegetation within and immediately downstream of the lease area during the late dry season, to identify streams and habitats that may be dependent on groundwater inputs.
- Implement a surface water monitoring program based on the findings of the drainage line survey, to establish a baseline of seasonal variability in water quality and flows. Sampling should be conducted at key locations within each catchment and ideally at locations both within and downstream of the lease.

7.2 Groundwater

The requirement for further work will be dependent on the Client refining the project area for further exploration and development towards production activities. Studies that might be required are:

- Mapping of sinkholes in the development area – these features have the ability to quickly channel recharge and surface water flow. Any surface contamination due to spillage or overtopping or water storages could quickly mobilise in the groundwater system if it occurs in the vicinity of a sinkhole.
- Verify local flow directions in the marginal volcanic aquifers around the development zone. It is likely these have some relationship / connection with the greater CLA aquifer – at present little is known about the flow dynamics within these aquifers or lateral flow to the CLA.
- Determination of vertical flow relationships between the shallow aquifers (CLA, Olloo Dolostone, Antrim Plateau Volcanics) and the deeper production formations.
- Depending on the source of water for development the impact of extraction on neighbouring users will need to be assessed, as well as the impact on regional groundwater users (horticulture in the north of the Region) and GDEs (Flora and Roper Rivers). These assessments may require modelling to fully characterise the surface water and groundwater processes.
- Existing monitoring bore records and standing water level monitoring data should be reviewed to refine local understanding of recharge processes.
- Baseline water quality should target areas between the development zone and down-gradient receptors. Where relevant this should give particular focus to the location of towns, communities and homesteads dependent on groundwater for potable supply.

8 Acronyms and References

8.1 Acronyms

BoM	Bureau of Meteorology
BTEXN	Benzene, toluene, ethylbenzene, xylene and naphthalene
CMB	Chloride Mass Balance
CLA	Cambrian Limestone Aquifer
DLRM	Department of Land Resource Management
D/S	Down stream
EC	Electrical conductivity
EP	Exploration Permit
ET	Evapotranspiration
GL	Giga litre
GWEL	Groundwater Extraction Licence
IBRA	Interim Biogeographic Regionalisation for Australia
KL	Kilo litre
km^2	Square kilometres
l/s	Litres per second
Ma	Megaannus
mg/l	Milligrams per litre
ML/day	Mega litres per day
ML/yr	Mega litres per year
mm/yr	Millimetres per year
mm	Millimetres
MODIS	Moderate Resolution Imaging Spectroradiometer
m^3/s	Cubic meters per second
NTU	Nephelometric Turbidity Units
NDVI	Normalised Difference Vegetation Index
PAWA	Power and Water Authority
TDS	Total Dissolved Solids
U/S	Up stream
µS/cm	Micro-Siemens per centimetre
WAPF	Water Allocation Planning Framework
WRD	Water Resources Division
°C	Degrees Celsius

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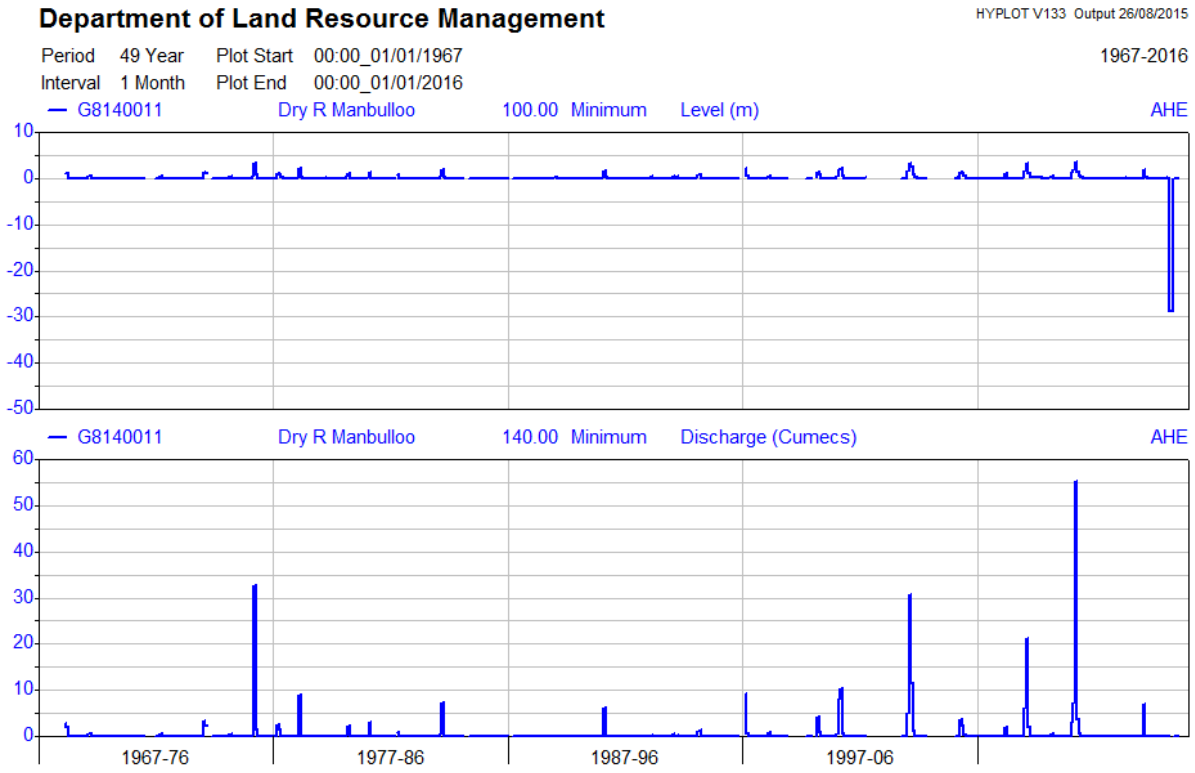
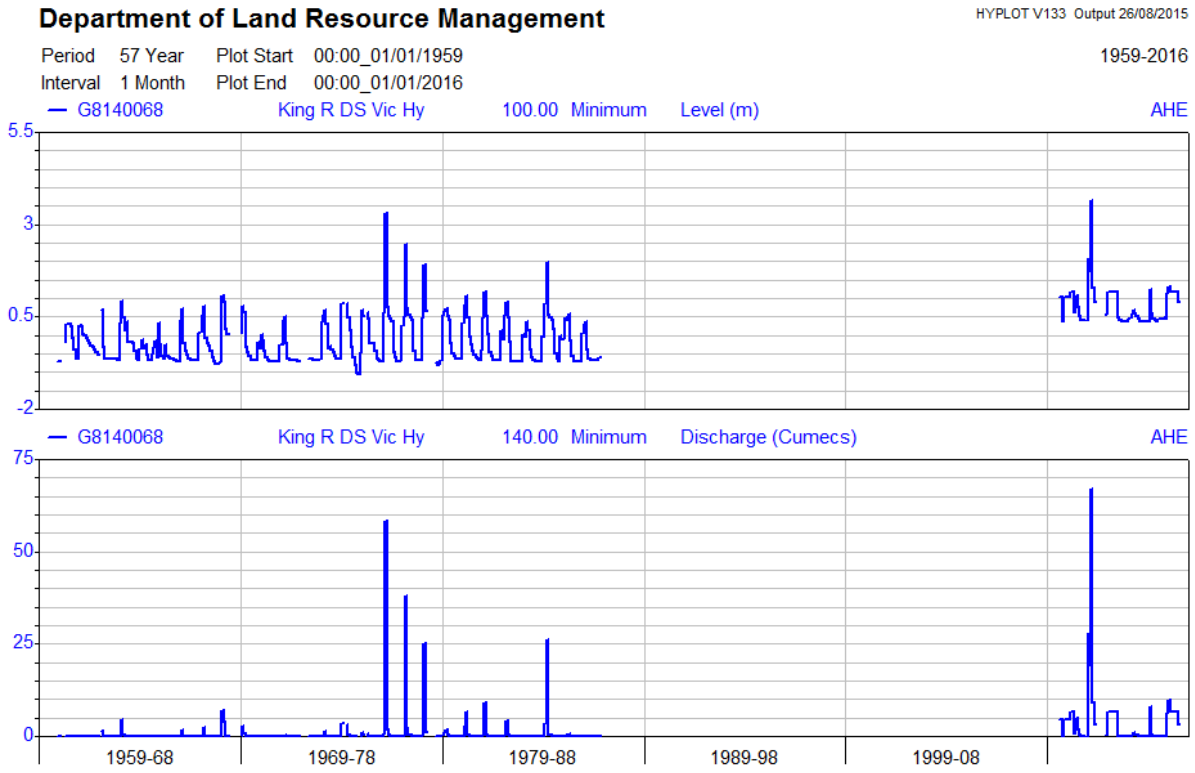
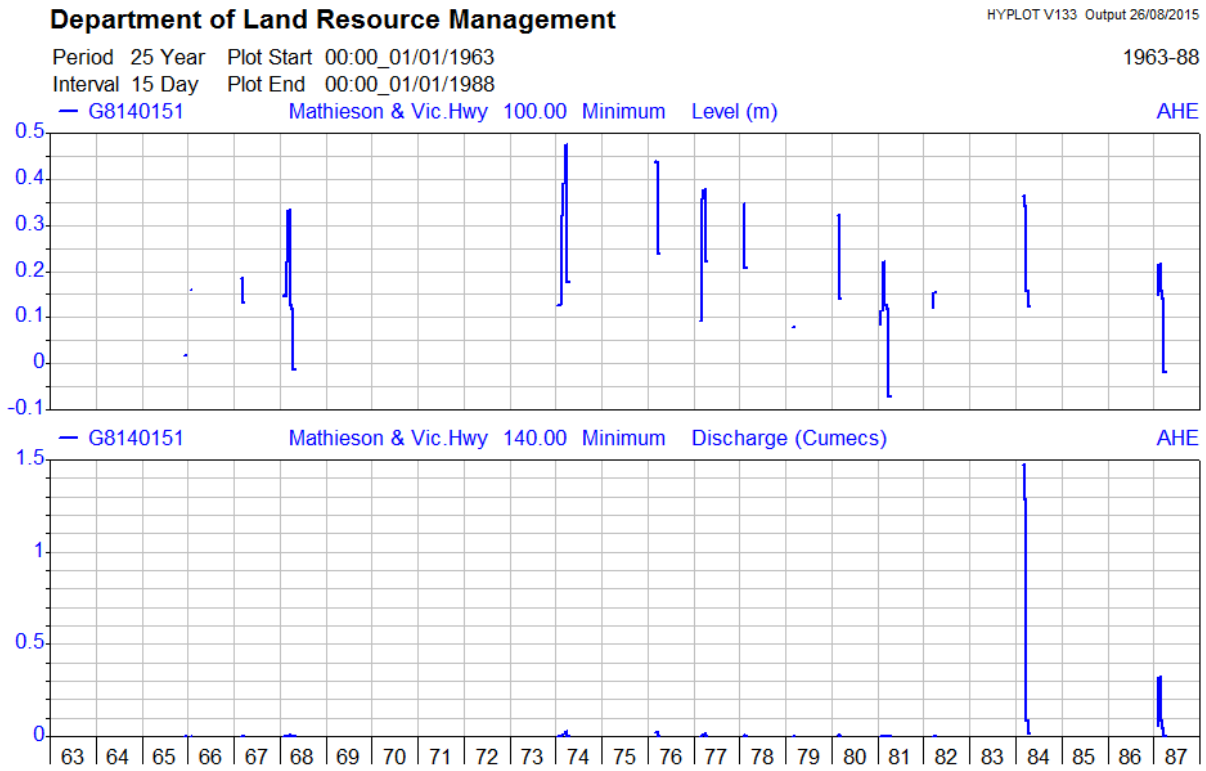
Appendix A – Surface Water Gauging Station Data



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1963-88
Interval 15 Day Plot End 00:00_01/01/1988
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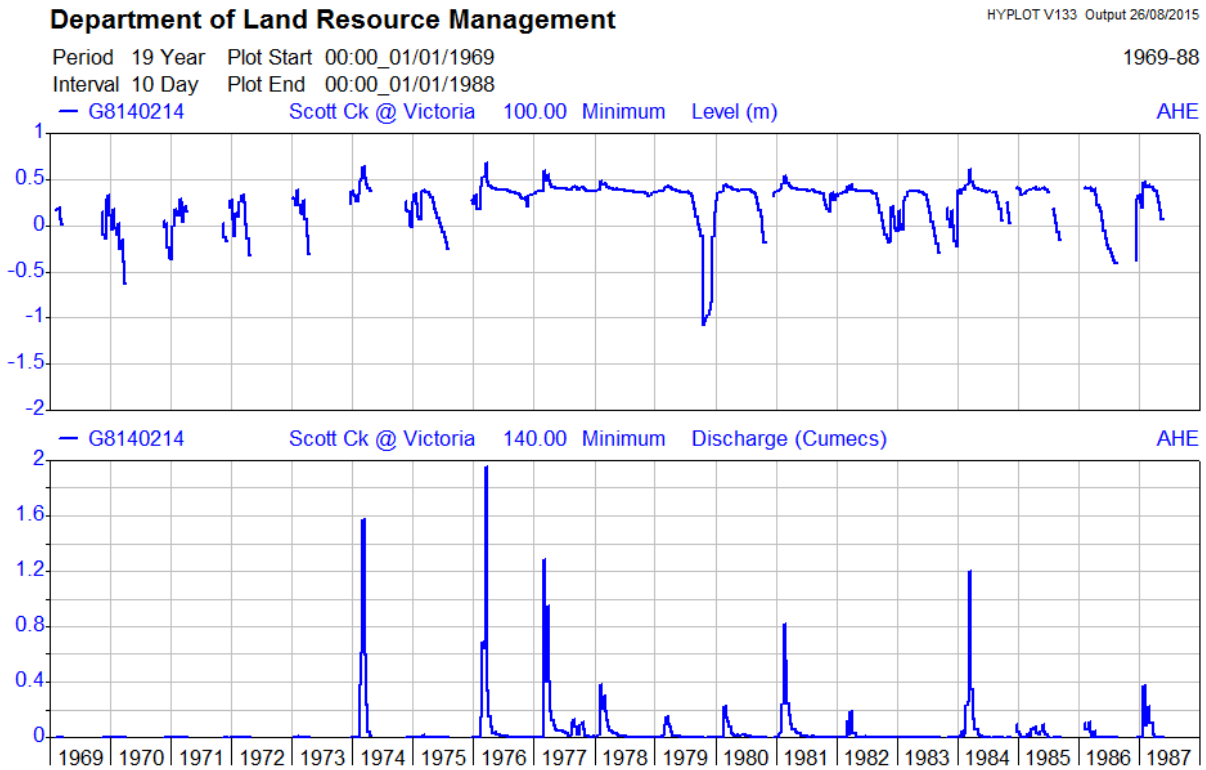
0.5
0.4
0.3
0.2
0.1
0
-0.1
G8140151 Mathieson & Vic.Hwy 140.00 Minimum Discharge (Cumecs) AHE
1.5
1
0.5
0
63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87


Department of Land Resource Management
HYPLOT V133 Output 26/08/2015
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1969-88
Interval 10 Day Plot End 00:00_01/01/1988
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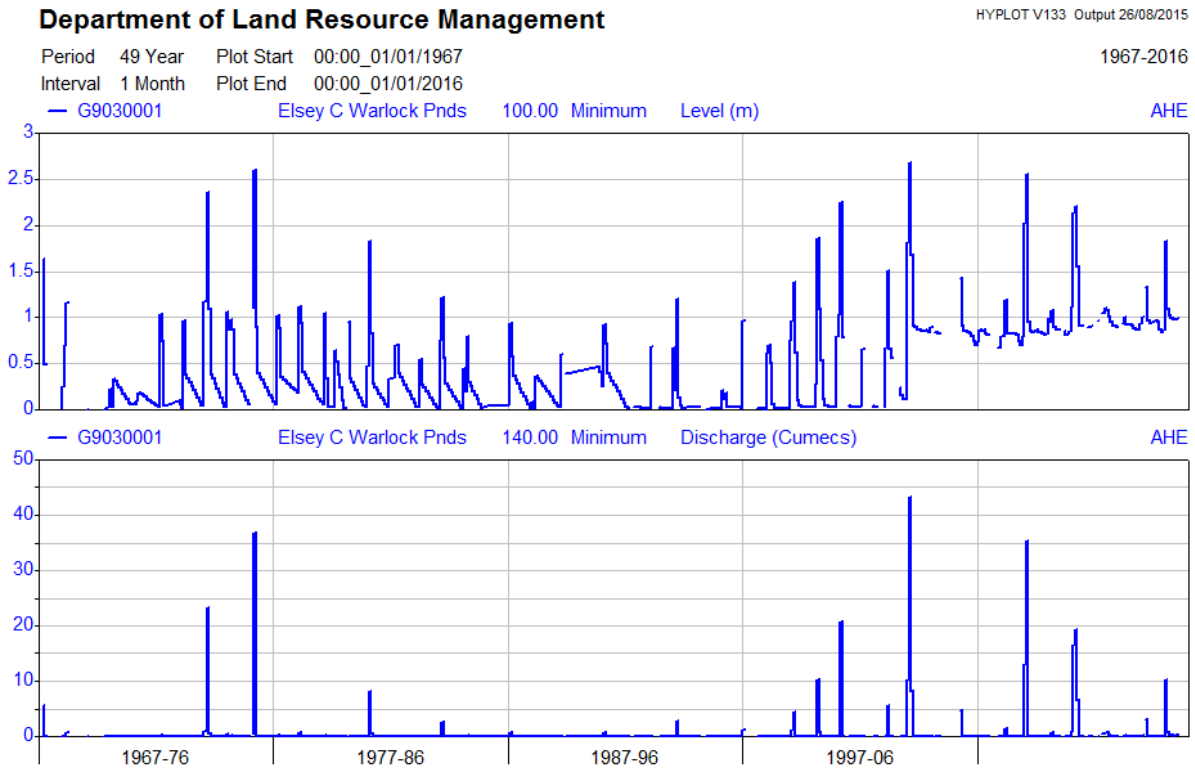
1
0.5
0
-0.5
-1
-1.5
-2
G8140214 Scott Ck @ Victoria 140.00 Minimum Discharge (Cumecs) AHE
2
1.6
1.2
0.8
0.4
0
1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987


Department of Land Resource Management
HYPLOT V133 Output 26/08/2015
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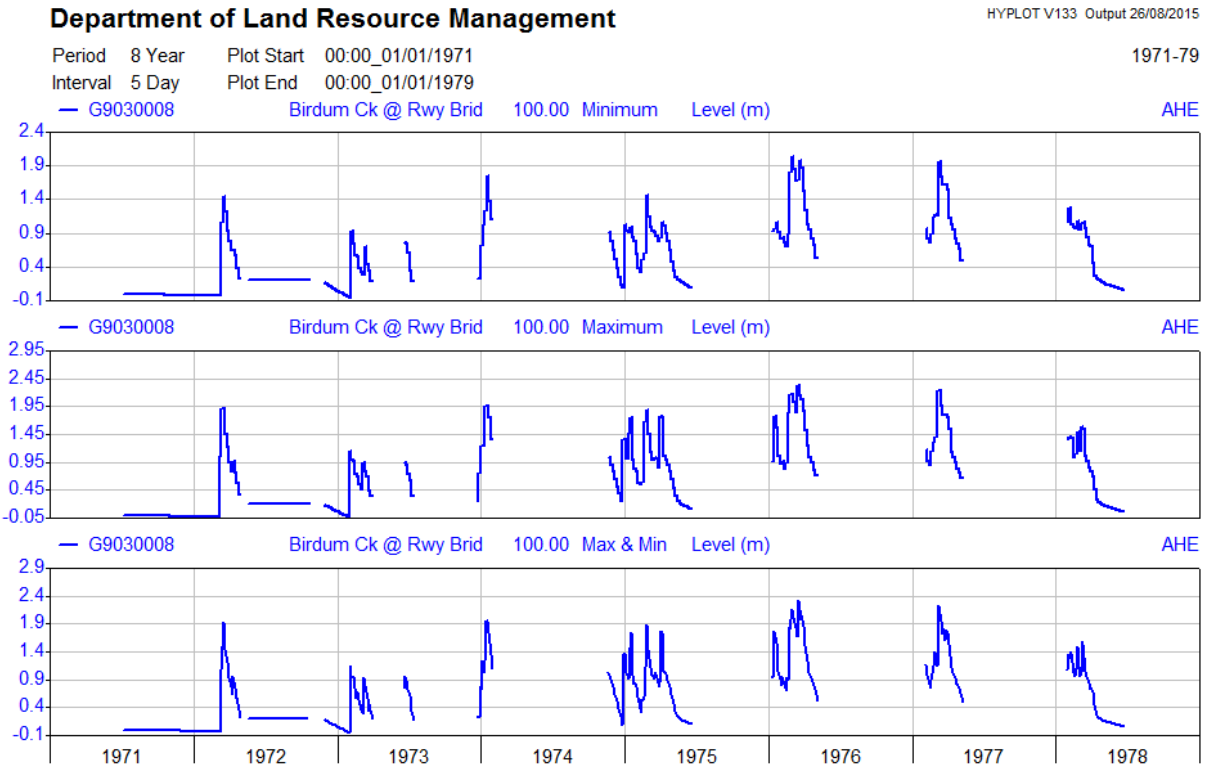
Interval 1 Month Plot End 00:00_01/01/2016
1967-2016
G9030001 Elsey C Warlock Pnds 100.00 Minimum Level (m) AHE
3
2.5
2
1.5
1
0.5
0
G9030001 Elsey C Warlock Pnds 140.00 Minimum Discharge (Cumecs) AHE
50
40
30
20
10
0
1967-76
1977-86
1987-96
1997-06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1971-79
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2.4
1.9
1.4
0.9
0.4
-0.1
G9030008 Birdum Ck @ Rwy Brid 100.00 Maximum Level (m) AHE
2.95
2.45
1.95
1.45
0.95
0.45
-0.05
G9030008 Birdum Ck @ Rwy Brid 100.00 Max & Min Level (m) AHE
2.9
2.4
1.9
1.4
0.9
0.4
-0.1
1971
1972
1973
1974
1975
1976
1977
1978

Flora and Fauna Characterisation Report

EP-167 and EP 168

Sturt Plateau Region NT

Prepared for: Pangaea (NT) Pty Ltd

Prepared by: EcOz Environmental Consultants

2015

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EcOz Pty Ltd.
ABN: 81 143 989 039
Winlow House, 3rd Floor
75 Woods Street
DARWIN NT 0800
GPO Box 381, Darwin NT 0800

Telephone: +61 8 8981 1100
Facsimile: +61 8 8981 1102
Email: ecoz@ecoz.com.au
Internet: www.ecoz.com.au

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Executive Summary

Pangaea (NT) Pty Ltd (Pangaea) has 100% interest in Exploration Permits (EP) 167 and 168 located approximately 500 km southeast of Darwin in the Northern Territory between the Daly River, Wiso and Georgina Basins. Pangaea has undertaken appraisal campaigns within EP 167 and 168 during 2013, 2014 and 2015 to establish the availability of natural gas and oil resources for production.

Pangaea engaged EcOz Environmental Consultants (EcOz) to review existing flora and fauna documentation to characterise biodiversity values within EP 167 and 168 that may need consideration as part of environmental approvals for the progression of project activities from exploration to production. This document is report of that review.

Objective of this report

This flora and fauna characterisation report has been designed to be used as a reference document to identify biodiversity values that may be relevant to areas proposed for exploration or production activities. It provides broad-scale environmental descriptions and an explanation of biodiversity values for the entire project area (the combined permit boundaries of EP 167 and EP 168). The report has been designed to be used as a reference document to identify biodiversity values that may be relevant to areas proposed for exploration or production activities.

Environmental context

The project area occurs across 27 pastoral properties with approximately 77% of the area used for cattle grazing. The majority of the land tenure is pastoral and perpetual pastoral with smaller areas of Government and crown lease perpetual tenure surrounding the towns of Mataranka and Larrimah to the east and the Delamere Air Weapons Range to the west.

The majority of the project area occurs within the Sturt Plateau which comprises of a gently undulating plain. Vegetation is mostly *Eucalyptus dichromophloia* woodlands with spinifex understorey. There are also large areas of Lancewood thickets (*Acacia shirleyi*), Bulwaddy Woodlands (*Macropteranthes kekwickii*) and open *Eucalyptus* woodlands to the north.

Fifty-seven land systems occur within the project area, with most of the landscape complexity being confined to the far north-west and north-east due to variable topography in these parts. The central part of the project area mainly comprises of lateritic plains and rises, alluvial floodplains, and claypans. The southern area is dominated by desert sandplains.

Thirty-three vegetation types occur within the project area according to NVIS 2005 mapping. Broadly, these vegetation types include tussock grasslands, hummock grasslands, Lancewood woodland/forests, Bulwaddy woodlands, Lysiphyllum woodlands, Eucalyptus woodlands/forests, and Melaleuca woodlands/forests. Eucalyptus and Corymbia communities are the dominant broad vegetation type within the project area. Melaleuca communities occur along drainages and alluvial floodplains. The southern area is dominated by Lancewood and Bulwaddy thickets and Spinifex (hummock) grasslands (indicating there is an arid zone influence in this area).

No conservation reserves occur within the project area; however, two conservation parks share a small portion of the northern boundary of EP 167 – Elsey National Park and Flora River Nature Park (Giwining). The Mataranka Thermal Pools Sites of Conservation Significance fall within the north-eastern corner of EP 167, and occurs within Elsey National Park (described above). One EPBC listed threatened ecological community potentially occurs within the far north-east corner of the project area – Arnhem Plateau Sandstone Shrubland Complex.

There are numerous declared weed species and feral animals within the region that will need to be managed via implementation of suitable environmental management plans.

The project area experiences a moderate to low fire frequency, of which many of the burns were late in the season (post June). The majority of the project area has burnt between 1 and 7 times in the past 15 years.

Biodiversity values

The desktop review identified that the project area potentially supports three sensitive vegetation types and populations of 10 threatened species (listed under the *TPWC Act* and/or the *EPBC Act*).

Sensitive vegetation types:

- Riparian vegetation
- Wetlands
- Arnhem Plateau Sandstone Shrubland Complex ('Arnhem Sandstone Complex')

Threatened species:

- Plains Death Adder (*Acanthophis hawkei*)
- Mertens' Water Monitor (*Varanus mertensi*)
- Mitchell's Water Monitor (*Varanus mitchelli*)
- Red Goshawk (*Erythrotriorchis radiatus*)
- Gouldian Finch (*Erythrura gouldiae*)
- Northern Shrike-tit (*Falcunculus frontatus whitei*)
- Partridge Pigeon (*Geophaps smithii smithii*)
- Purple-crowned Fairy-wren (western) (*Malurus coronatus coronatus*)
- Pale Field-rat (*Rattus tunneyi*)
- Greater Bilby (*Macrotis lagotis*)

In general, these values are either sparse across the landscape encompassed by the project area, or they are confined to small areas that are likely outside of the project scope (such as the Arnhem sandstone complex which is located in the far north-east of the project area). Therefore, the location of the proposed works program will determine the level of environmental assessment required. For example, the area proposed for the Western Creek Road upgrade has potential to support four threatened species and two types of sensitive vegetation. Therefore, the road corridor will require onground assessment to confirm the risk to these biodiversity values, and if present, recommend ways to mitigate any impacts.

Several of these biodiversity values are nationally listed matters (i.e. Arnhem Sandstone Complex, Gouldian Finch, Northern Shrike-tit, Red Goshawk, Partridge Pigeon, Purple-crowned Fairy-wren, and Greater Bilby). Consequently, depending on the location of the project footprint, it is possible that the project will trigger the *Environment Protection and Biodiversity Conservation Act 1999* (and therefore Pangaea will be required to submit an EPBC Referral for proposed works).

Recommendations

- For any significant land disturbance from proposed exploration and production activities, carry out a desktop review to determine which (if any) biodiversity values may be impacted. This should be conducted by a qualified environmental scientist.
- If the desktop review identifies potential presence of a (or multiple) biodiversity value(s), conduct a field-based assessment that includes a habitat description of the proposed disturbance area to determine if the site requires specific management mitigations to avoid impacts to significant biodiversity values (e.g. this may include avoiding the area if threatened species are located).
- If proposed works sites are considered to potentially support threatened species populations, it may be relevant to carry out more detailed surveys of the site to better quantify the extent of populations and recommend ways to mitigate impacts to the species.
- As there are many declared weeds in the region (including along Western Creek Road), weed hygiene will be of high priority. The project should not result in spread or introduction of any declared weed species. A comprehensive weed management plan should be implemented.

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Appendices

1 Introduction

Pangaea (NT) Pty Ltd (Pangaea) has 100% interest in Exploration Permits (EP) 167 and 168 located approximately 500 km southeast of Darwin in the Northern Territory between the Daly River, Wiso and Georgina Basins (Figure 1-1).

Pangaea has undertaken appraisal campaigns within EP 167 and 168 during 2013, 2014 and 2015 to establish the availability of natural gas and oil resources for production. Appraisal campaigns have included:

- Civil works for the establishment of access roads and construction of drill pads
- Drilling and coring operations to install appraisal well drill holes
- Seismic tiltmeter surveys
- Stimulation and testing of drill holes.

Pangaea have engaged EcOz Environmental Consultants (EcOz) to review existing flora and fauna documentation to characterise biodiversity values within EP 167 and 168 that may need consideration as part of environmental approvals for the progression of project activities from exploration to production. This document is report of that review.

1.1 Objectives

This report has been designed to be used as a reference document to identify biodiversity values that may be relevant to areas proposed for exploration or production activities. It provides broad-scale environmental descriptions and an explanation of biodiversity values for the entire project area (the combined permit boundaries of EP 167 and EP 168).

The objectives of the flora and fauna characterisation report are to:

- Describe the existing environment of the project area (i.e. climate, bioregion, vegetation types, land systems, flora and fauna records, conservation areas, and fire history).
- Determine which threatened species have potential to occur within the project area, and predict their likelihood of occurrence (based on desktop information).
- Identify and explain biodiversity values that occur, or could potentially occur, with the project area.
- Provide advice into the level of assessment that may be required to gain environmental approvals in relation to biodiversity impacts.

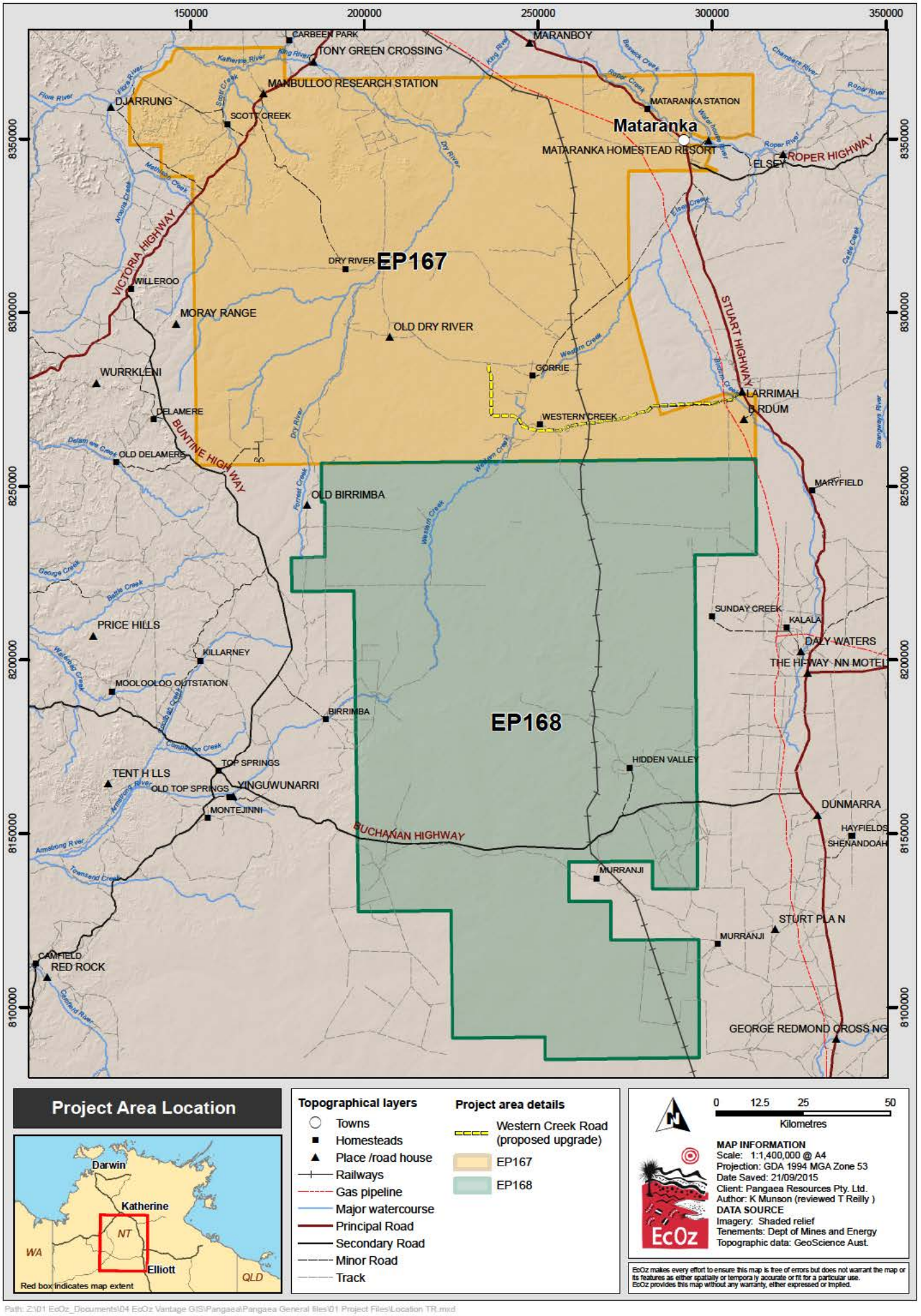


Figure 1-1. Map of project area location (EP 167 and 168)

2 Environmental Context

2.1 Climate

The Sturt Plateau region experiences two distinct seasons, a dry season from May to September and a wet season from November to March. Bureau of Meteorology (BoM) regional climate data is available for Mataranka Airstrip within the north-east EP 167, Daly Waters to the south of EP 168, Delamere Weapons Range to the west and Larrimah to the east of EP 167 and 168. Rainfall is variable across the Sturt Plateau however a spatially averaged median rainfall is 556 mm (1890-2005) (Australian Government 2014).

The closest weather station to the location of exploration activities is Larrimah (station number 014612) (Figure 2-1). Rainfall is concentrated during the wet season, the wettest months are January and February with an average of 208.8 mm and 207.3 mm rain respectively. Temperatures range from an average maximum temperature of 37.9 degrees Celsius (°C) in November to average maximum temperature of 29.3°C in June. July is the coolest month with an average minimum temperature of 12.3°C.

Pan evaporation of the Sturt Plateau is relatively stable and ranges from 5 – 11 mm/day (Yin Foo 2002). Evaporation over the wet season averages 1287 mm while dry season evaporation averages 1705 mm. Peak evaporation generally occurs between September and November, with evaporation being lowest during October and November. Evaporation in the region generally exceeds rainfall.

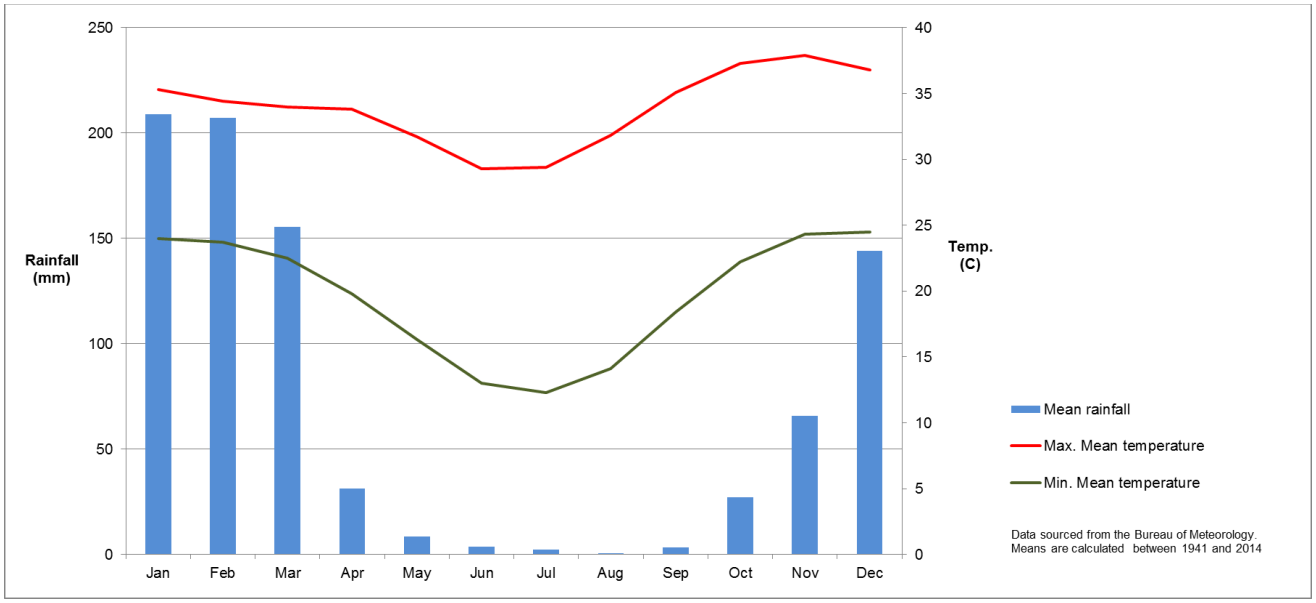


Figure 2-1. Average monthly temperature and rainfall for Larrimah, Northern Territory

2.2 Land use

The Sturt Plateau is dominated by pastoral land with approximately 77% of the area grazed by cattle. Land tenure is dominated by pastoral and perpetual pastoral leases (Figure 2-2). EP 167 and 168 are located across 27 pastoral stations. Government land is located in the north-east corner of EP 167 surrounding the town of Mataranka and on the western junction of EP 167 and 168 for the Delamere Air Weapons Range. Large areas of Freehold land are located adjacent to the eastern boundary of EP 167 over the community of Wubuluwan and adjacent to the southern boundary of EP 168.

2.3 Bioregion

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into units of broadly similar landform, geology and biodiversity (Baker et al. 2005). The exploration lease area covers the following bioregions (Figure 2-3);

- Sturt Plateau – The majority of the lease falls within the Sturt Plateau bioregion. This bioregion is comprised of a gently undulating plain. Vegetation is mostly *Eucalyptus dichromophloia* woodlands with spinifex understorey. There are also large areas of Lancewood thickets (*Acacia shirleyi*), Bulwaddy Woodlands (*Macropteranthes kekwickii*) and open Eucalypt woodlands to the north.
- Daly Basin – The northeast section of EP 167 is within this bioregion. This bioregion is comprised of gently undulating plains and scattered remnant sandstone plateaus. Vegetation includes perennial and annual grass woodland dominated by *Eucalyptus tetrodonta* and *E. miniata*. There are no subregions.
- Ord-Victoria Plain – Only the extreme southeast section of EP 167 is within this bioregion. This bioregion is comprised of up to four subregions, however only one is represented within the exploration leases. This subregion is comprised of extensive plains with short grass (*Enneapogon* sp.) and other grassland communities on cracking clays.
- Gulf Fall and Uplands – The northwest section of EP 167 is within this bioregion. This bioregion is comprised of scattered low steep hills on skeletal soils. Vegetation is mostly *E. tetrodonta* and *Corymbia dichromophloia* with a spinifex understorey, and also *E. tectifica* with a tussock grass understorey.
- Mitchell Grass Downs – A very small portion of the southwest section of EP 168 is within this bioregion. This bioregion is mostly comprised of treeless plains on low cracking clay soils (black soil). Vegetation is mostly Mitchell Grass (*Astreleba* spp), with occasional *E. microtheca* and *Chenopodium auricomum* shrub land.

2.4 Land systems

A Land System is described as “an area, or group of areas, throughout which there is a recurring pattern of topography, soils and vegetation” (Christian & Stewart 1953), which in the NT are mapped at a scale of 1:250,000 or 1:1,000,000. This information is useful for the purpose of flora and fauna characterisation as it can be broadly used to predict if there is potential habitat for species of conservation value. They can also be used to indicate other environmental factors such as seasonal inundation, acid sulphate soils, and groundwater dependant ecosystems.

The project area falls within the northern NT Land Systems, which is a compilation of numerous land system surveys that were mapped at a scale of 1:250,000 (original land system surveys relevant to the project area are Sturt Plateau, Tipperary, Dry River-Willeroo, Roper, ASRIS, and Ord-Victoria). No land unit mapping was available for the project area at the time of writing this document.

Fifty-seven land systems occur within the project area (Figure 2-4; Appendix A) within nine more broadly defined land system classes (Table 2-1). Lateritic plains and rises are the most dominant and variable land system class, as they cover over 50% of the project area and include 20 different land systems.

Table 2-1. Description of land system classes within the project area

Class	Description
Alluvial Floodplains	Alluvial floodplains, swamps, drainage depressions and alluvial fans; sandy, silty and clay soils on Quaternary alluvium.
Basalt Hills	Low hills and hills on basalt, agglomerate and tuff, some dolerite; mostly rock outcrop with surface stone and pockets of clayey soils.
Clay plains	Level to gently undulating clay plains (black soil plains); cracking clay soils.
Desert Sandplains	Level to undulating sandplains with red sands.
Lateritic plains and rises	Plains and rises associated with deeply weathered profiles (laterite) including sand sheets and other depositional products; sandy and earth soils.
Lateritic plateaux	Plateaux, scarps and some rises on deeply weathered sediments; shallow soils with rock outcrops.
Limestone plains and rises	Plains, rises and plateaux on weathered and unweathered Cambrian limestone, dolomite, chalcedony, shale, sandstone and siltstone with associated sand sheets; sandy and earth soils.
Rugged quartz sandstone plateaux and hills	Steep rocky plateaux and hills on quartz sandstone and sandstone; shallow sandy soils and rock outcrop.
Sandstone plains and rises	Plains, rises and plateaux on mostly on sandstone, siltstone, claystone, shale and some limestone; commonly shallow soils with surface stone and rock outcrop.

2.5 Vegetation communities

Thirty-three vegetation types are described to occur within the project area according to NVIS 2005 mapping (Figure 2-5; Appendix B). Broadly, these vegetation types include tussock grasslands, hummock grasslands, Lancewood woodland/forests, Bulwaddy woodlands, Lysiphyllum woodlands, Eucalyptus woodlands/forests, and Melaleuca woodlands/forests.

The dominant vegetation types within EP 167 are Eucalyptus and Corymbia communities (in the plains and undulating hills) and Melaleuca communities (within drainages lowlands, and depressions). EP 168 also supports a large area of Eucalyptus and Corymbia communities and Melaleuca communities to the north; however, the southern area is dominated by Lancewood and Bulwaddy communities and Spinifex (hummock) grasslands (indicating there is an arid zone influence in this area).

2.6 Conservation areas

No national or NT listed conservation areas occur within the project area; however, two parks share a small portion of the northern boundary of EP 167 (Figure 2-2):

- Elsey National Park – Located adjacent to the north-east corner of EP 167. Includes a lush oasis of vegetation within the transition zone between the tropical northern forests and drier savannah regions. This area is listed as a Wetland of National Significance as the tropical springs support large populations of resident and transient water and shorebirds.
- Flora River Nature Park (Giwining) – Located adjacent to the north-west of EP 167. This area is protected as a Nature Park due to its lush vegetation associated with underground springs which feed the Flora River. It is joint-managed with the Wardaman Aboriginal People.

The Mataranka Thermal Pools Sites of Conservation Significance fall within the north-eastern corner of EP 167, and occurs within Elsey National Park (described above).

One Environment Protection and Biodiversity Conservation (EPBC) listed threatened ecological community was identified by the 'Protected Matters Search Tool' to potentially occur within the project area – Arnhem Plateau Sandstone Shrubland Complex. If present, this community will be located in the north-east corner of EP 167 (east of the Stuart Highway).

2.7 Flora and fauna records

A review of the Land Resource Management NT Atlas database revealed that the majority of the project area is 'data poor' (i.e. a low number of records) with most records being concentrated along roads and waterways (Figure 2-6).

An analysis of NT Atlas records determined the following main points for the project area:

Fauna records

- 5 159 fauna records within the project area
- 312 fauna species (including native and introduced species) (11 amphibian, 83 reptile, 176 bird, and 36 mammal).
- 6 species listed as threatened under the *TPWC Act* (Partridge Pigeon, Red Goshawk, Gouldian Finch, Bilby, Mitchell's Water Monitor, and Pale Field-rat).
- 6 species are listed under the *EPBC Act* (Partridge Pigeon, Crested Shrike-tit, Red Goshawk, Gouldian Finch, Bilby, and Gulf Snapping Turtle).
- 16 species listed as Near Threatened under the *TPWC Act* (Australian Bustard, Crested Shrike-tit, Emu, Bush Stone-curlew, Pictorella Mannikin, Hooded Parrot, Spectacled Hare-wallaby, Ghost Bat, Square-tailed Kite, Northern Nailtail Wallaby, Buff-sided Robin, King Brown Snake, Orange Leaf-nosed bat, Western Chestnut Mouse, Northern Brown Bandicoot, and Common Brushtail Possum [Top End]).
- 3 species listed as Data Deficient under the *TPWC Act* (Chestnut-backed Button-quail, Common Blue-Tongued Lizard, and Spotted Tree Monitor).
- 1 species listed as Not Evaluated under the *TPWC Act* (Northern Shovel-nosed Snake)
- 280 species listed as 'Least Concern' under the *TPWC Act*
- 6 species are listed as 'introduced' under the *TPWC Act* (i.e. feral animals) (Swamp Buffalo, Rock Dove, Donkey, Feral Cat, Asian House Gecko, Cane Toad). Of these, Cane Toad and Feral Cat are Key Threatening Process under the *EPBC Act*. There is also a range of other feral species known within the region (Appendix C).

Flora records

- 4 284 flora records within the project area
- 864 flora species (including native and introduced species)
- No species listed as threatened under the *TPWC Act*
- No species are listed under the *EPBC Act*
- 4 species listed as 'Near Threatened' under the *TPWC Act* (*Pittosporum moluccanum*, *Ipomoea argillicola, Rhamphicarpa australiensis*, and *Citrus gracilis*).
- 22 species listed as 'Data Deficient' under the *TPWC Act* (*Heliotropium brachythrix, Cleome tetrandra, Bulbostylis densa, Nesaea striatiflora, Butomopsis latifolia, Najas pseudograminea, Digitaria leucostachya, Ischaemum australe, Whiteochloa multiciliata, Yakirra muelleri, Spermacoce brachystema, Acrachne racemosa, Fimbristylis dolera, Tephrosia crocea, Ectrosia*

schultzii, Sorghum grande, Dodonaea hispidula, Lepturus xerophilus, Phyllanthus sp. narrow tuberculate seeds, *Heliotropium geocharis, Triumfetta ryeae*, and *Isoetes cristata*).

- 775 species listed as 'Least Concern' under the *TPWC Act*
- 15 species listed as 'Infraspecific' under the *TPWC Act*
- 18 species listed as 'Not Evaluated' under the *TPWC Act*
- 30 species are introduced to the Northern Territory. Of these, 16 are declared weed species under the NT *Weeds Management Act* (see located in Figure 2-7). There is also a wide range of other declared and non-declared weed species known within the region (Appendix C).

Threatened species are covered in detail in the project specific 'threatened species likelihood of occurrence assessment' in Section 3.

2.8 Fire history

The majority of the project area has burnt between 1 and 7 times in the past 15 years (Figure 2-8). This constitutes a low to moderate fire frequency, of which many burns are late in the season (post June).

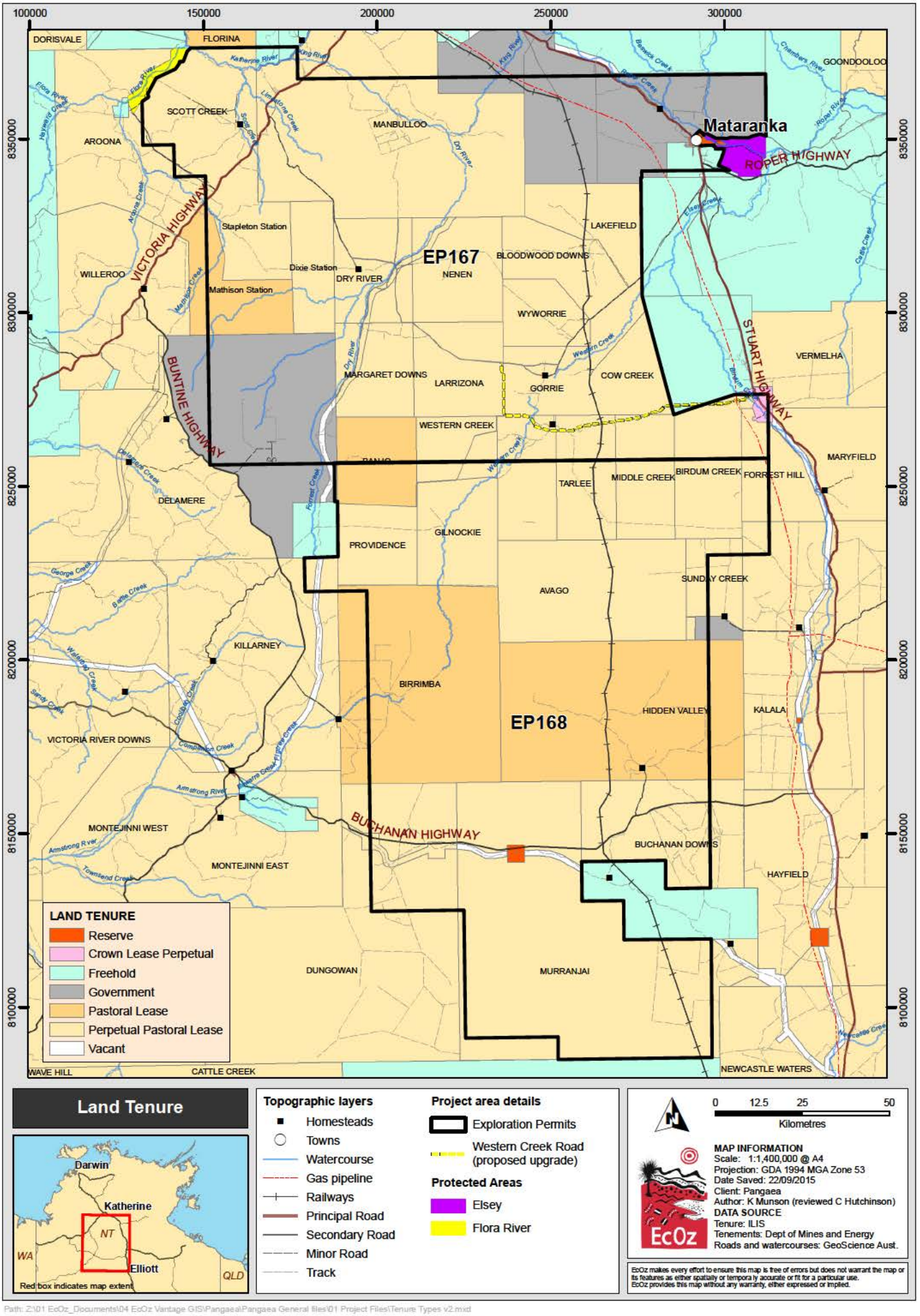


Figure 2-2. Map of land tenure within the project area (and surrounds)

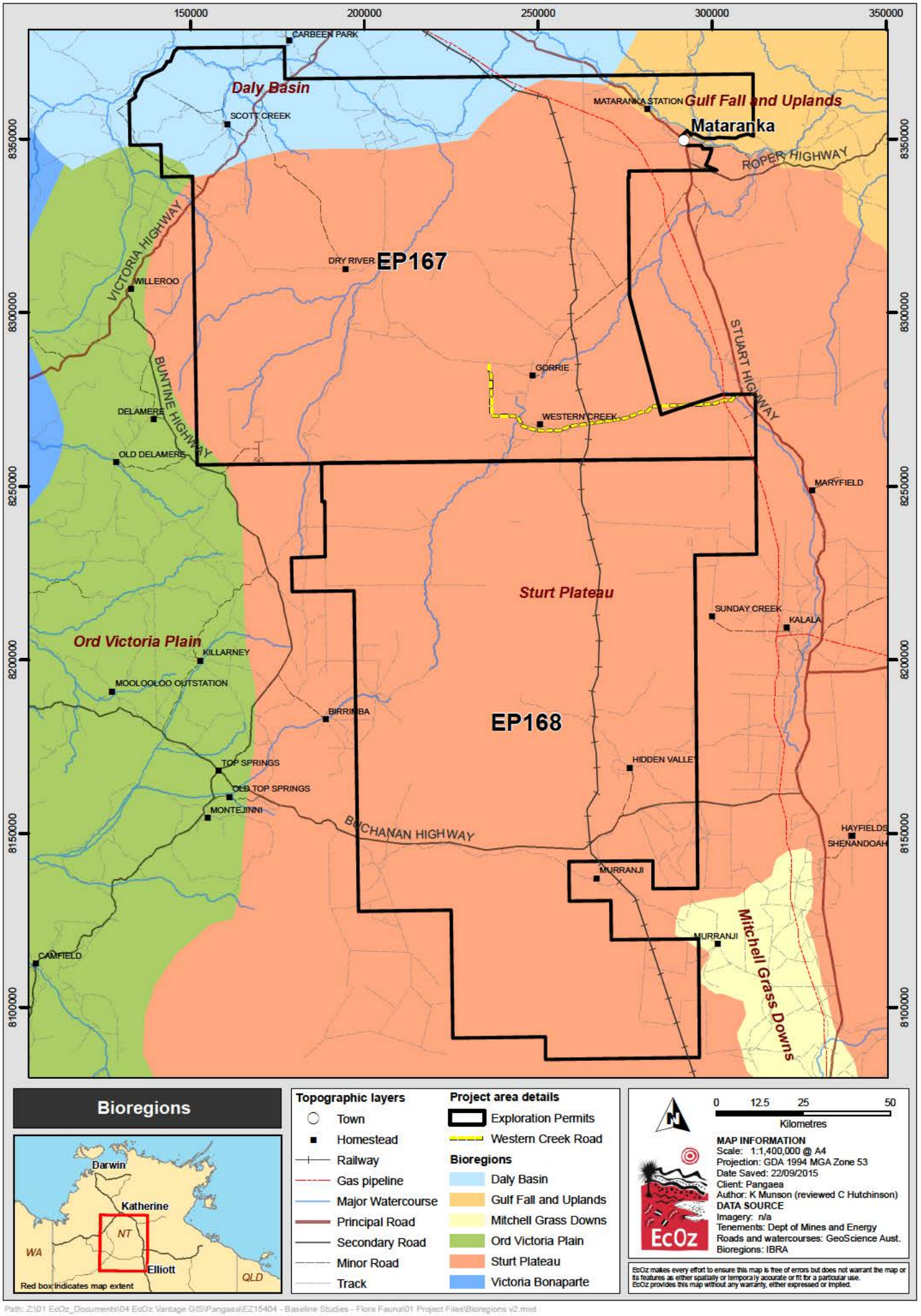


Figure 2-3. Map of bioregions within the project area (and surrounds)

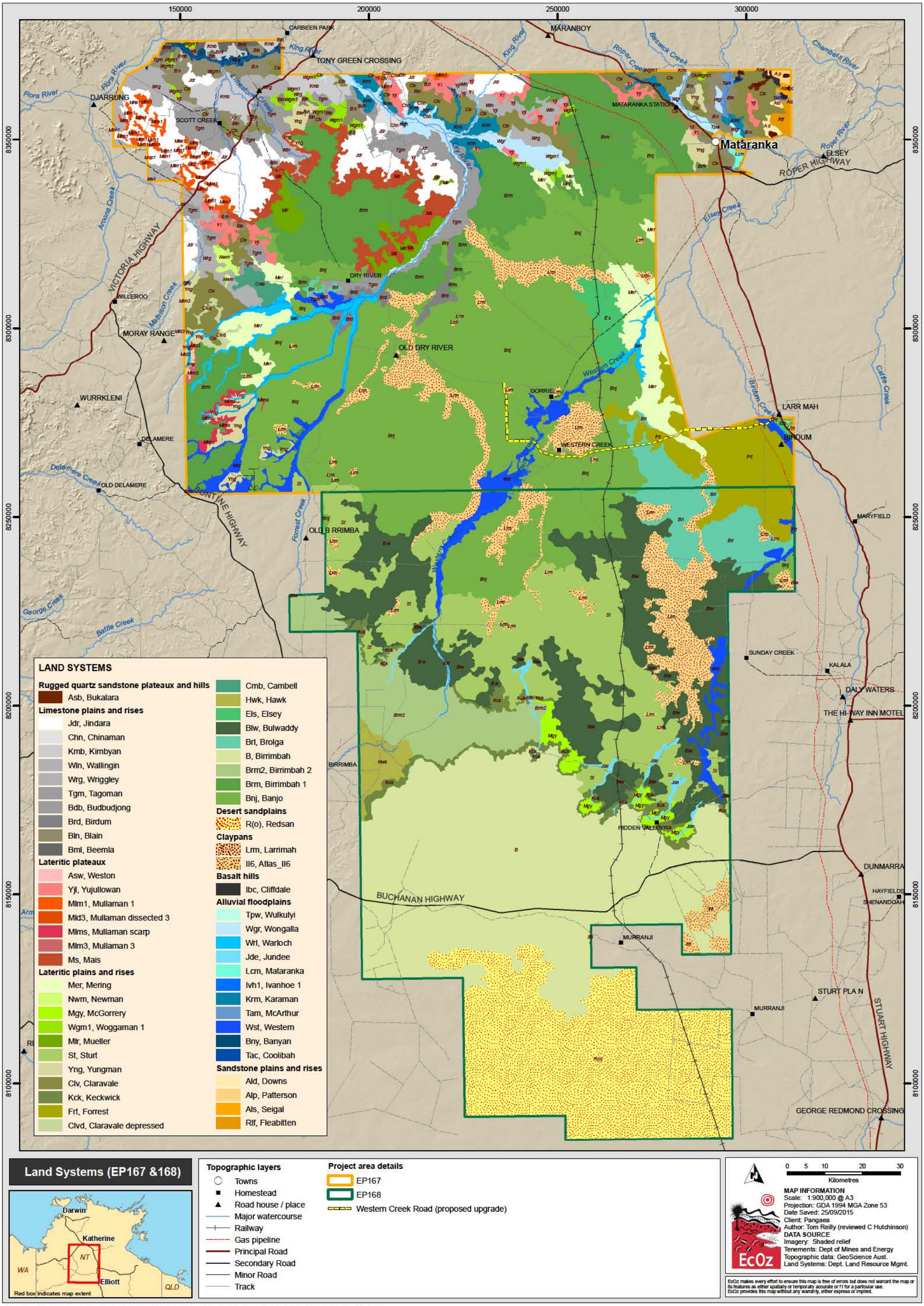
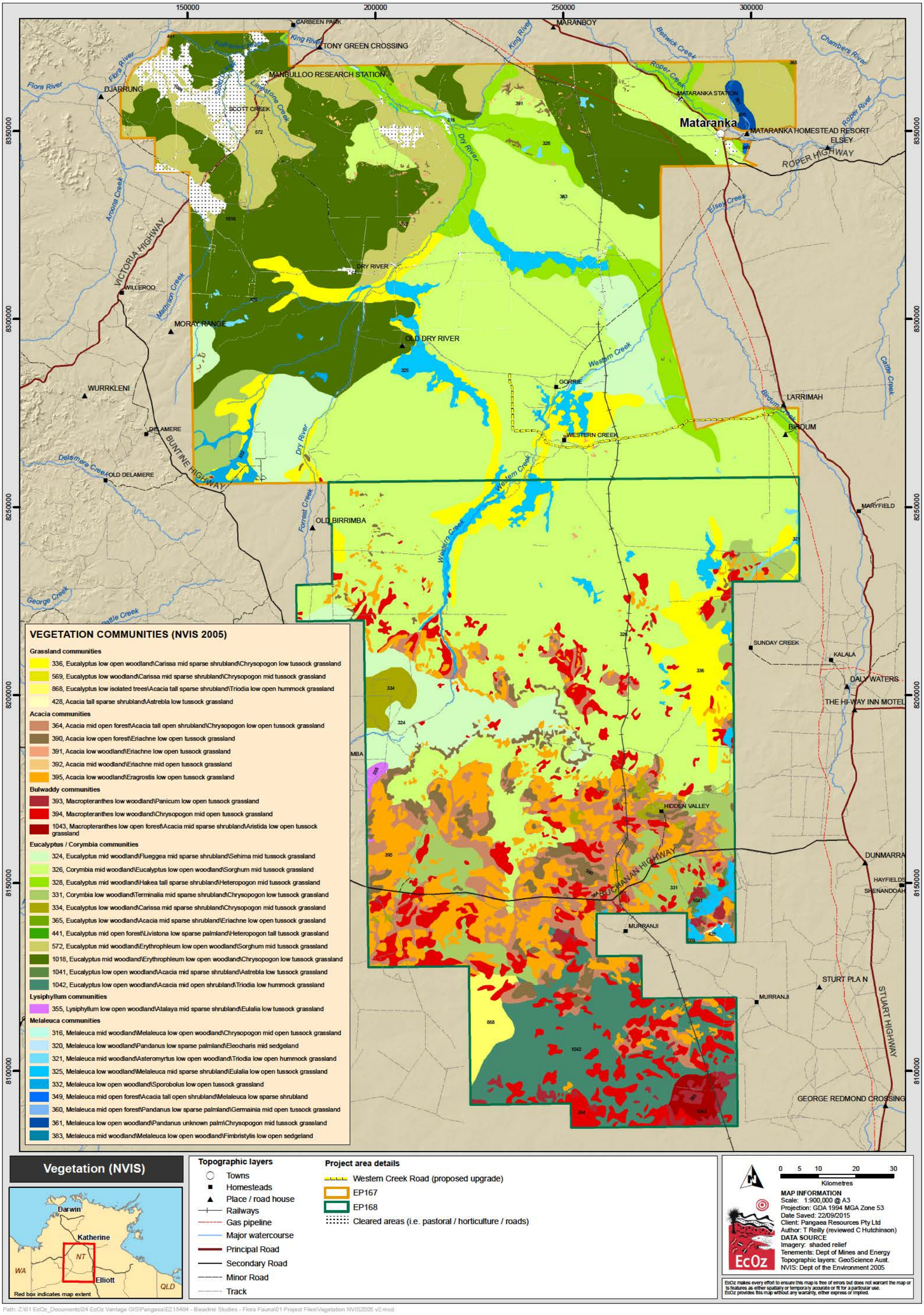


Figure 2-4. Map of land systems within the project area (and surrounds)



VEGETATION COMMUNITIES (NVIS 2005)

Grassland communities

- 336, Eucalyptus low open woodland\Carissa mid sparse shrubland\Chrysopogon low tussock grassland
- 569, Eucalyptus low woodland\Carissa mid sparse shrubland\Chrysopogon mid tussock grassland
- 868, Eucalyptus low isolated trees\Acacia tall sparse shrubland\Triodia low open hummock grassland
- 428, Acacia tall sparse shrubland\Astrebla low tussock grassland

Acacia communities

- 364, Acacia mid open forest\Acacia tall open shrubland\Chrysopogon low open tussock grassland
- 390, Acacia low open forest\Eriachne low open tussock grassland
- 391, Acacia low woodland\Eriachne low open tussock grassland
- 392, Acacia mid woodland\Eriachne mid open tussock grassland
- 395, Acacia low woodland\Eragrostis low open tussock grassland

Bulwaddy communities

- 393, Macropteranthes low woodland\Panicum low open tussock grassland
- 394, Macropteranthes low woodland\Chrysopogon mid open tussock grassland
- 1043, Macropteranthes low open forest\Acacia mid sparse shrubland\Aristida low open tussock grassland

Eucalyptus / Corymbia communities

- 324, Eucalyptus mid woodland\Flueggea mid sparse shrubland\Sehima mid tussock grassland
- 326, Corymbia mid woodland\Eucalyptus low open woodland\Sorghum mid tussock grassland
- 328, Eucalyptus mid woodland\Hakea tall sparse shrubland\Heteropogon mid tussock grassland
- 331, Corymbia low woodland\Terminalia mid sparse shrubland\Chrysopogon low tussock grassland
- 334, Eucalyptus low woodland\Carissa mid sparse shrubland\Chrysopogon mid tussock grassland
- 365, Eucalyptus low woodland\Acacia mid sparse shrubland\Eriachne low open tussock grassland
- 441, Eucalyptus mid open forest\Livistona low sparse palmland\Heteropogon tall tussock grassland
- 572, Eucalyptus mid woodland\Erythrophleum low open woodland\Sorghum mid tussock grassland
- 1018, Eucalyptus mid woodland\Erythrophleum low open woodland\Chrysopogon low tussock grassland
- 1041, Eucalyptus low open woodland\Acacia mid sparse shrubland\Astrebla low tussock grassland
- 1042, Eucalyptus low open woodland\Acacia mid open shrubland\Triodia low hummock grassland

Lysiphyllum communities

- 355, Lysiphyllum low open woodland\Atalaya mid sparse shrubland\Eulalia low tussock grassland

Melaleuca communities

- 316, Melaleuca mid woodland\Melaleuca low open woodland\Chrysopogon mid open tussock grassland
- 320, Melaleuca low woodland\Pandanus low sparse palmland\Eleocharis mid sedgeland
- 321, Melaleuca mid woodland\Asteromyrtus low open woodland\Triodia low open hummock grassland
- 325, Melaleuca low woodland\Melaleuca mid sparse shrubland\Eulalia low open tussock grassland
- 332, Melaleuca low open woodland\Sporobolus low open tussock grassland
- 349, Melaleuca mid open forest\Acacia tall open shrubland\Melaleuca low sparse shrubland
- 360, Melaleuca mid open forest\Pandanus low sparse palmland\Germainia mid open tussock grassland
- 361, Melaleuca low open woodland\Pandanus unknown palm\Chrysopogon mid tussock grassland
- 383, Melaleuca mid woodland\Melaleuca low open woodland\Fimbristylis low open sedgeland

Vegetation (NVIS)

Topographic layers

- Towns
- Homesteads
- Place / road house
- Railways
- Gas pipeline
- Major watercourse
- Principal Road
- Secondary Road
- Minor Road
- Track

Project area details

- Western Creek Road (proposed upgrade)
- EP167
- EP168
- Cleared areas (i.e. pastoral / horticulture / roads)

0 5 10 20 30
Kilometres

MAP INFORMATION
Scale: 1:900,000 @ A3
Projection: GDA 1994 MGA Zone 53
Date Saved: 22/09/2015
Client: Pangaea Resources Pty Ltd
Author: T Reilly (reviewed C Hutchinson)

DATA SOURCE
Imagery: shaded relief
Tenements: Dept of Mines and Energy
Topographic layers: GeoScience Aust.
NVIS: Dept of the Environment 2005

Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\Pangaea\EZ15404 - Baseline Studies - Flora Fauna\01 Project Files\Vegetation NVIS2005 v2.mxd

Figure 2-5. Map of vegetation communities within the project area (and surrounds)

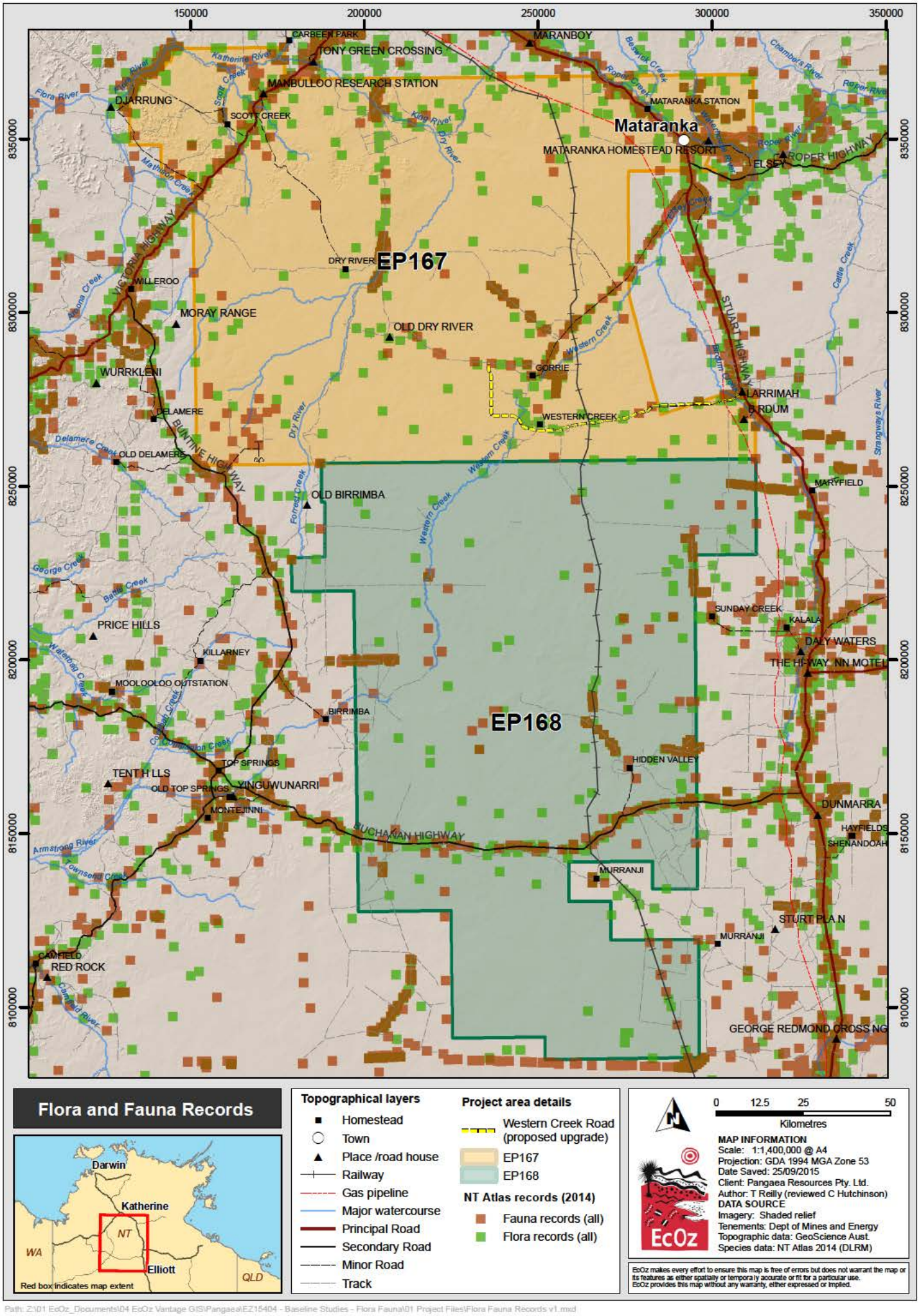


Figure 2-6. Map of NT Atlas flora and fauna records within the project area (and surrounds)

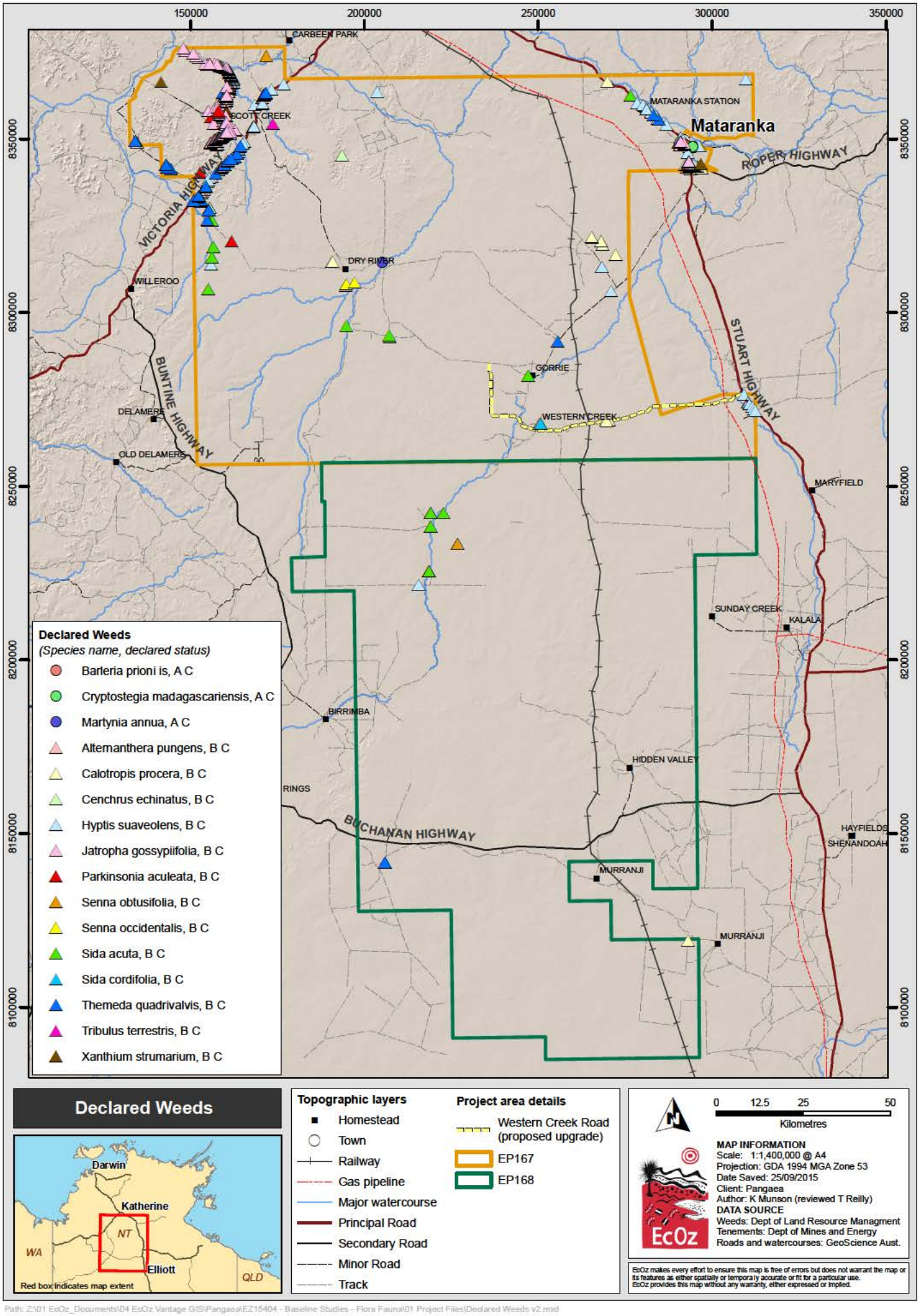
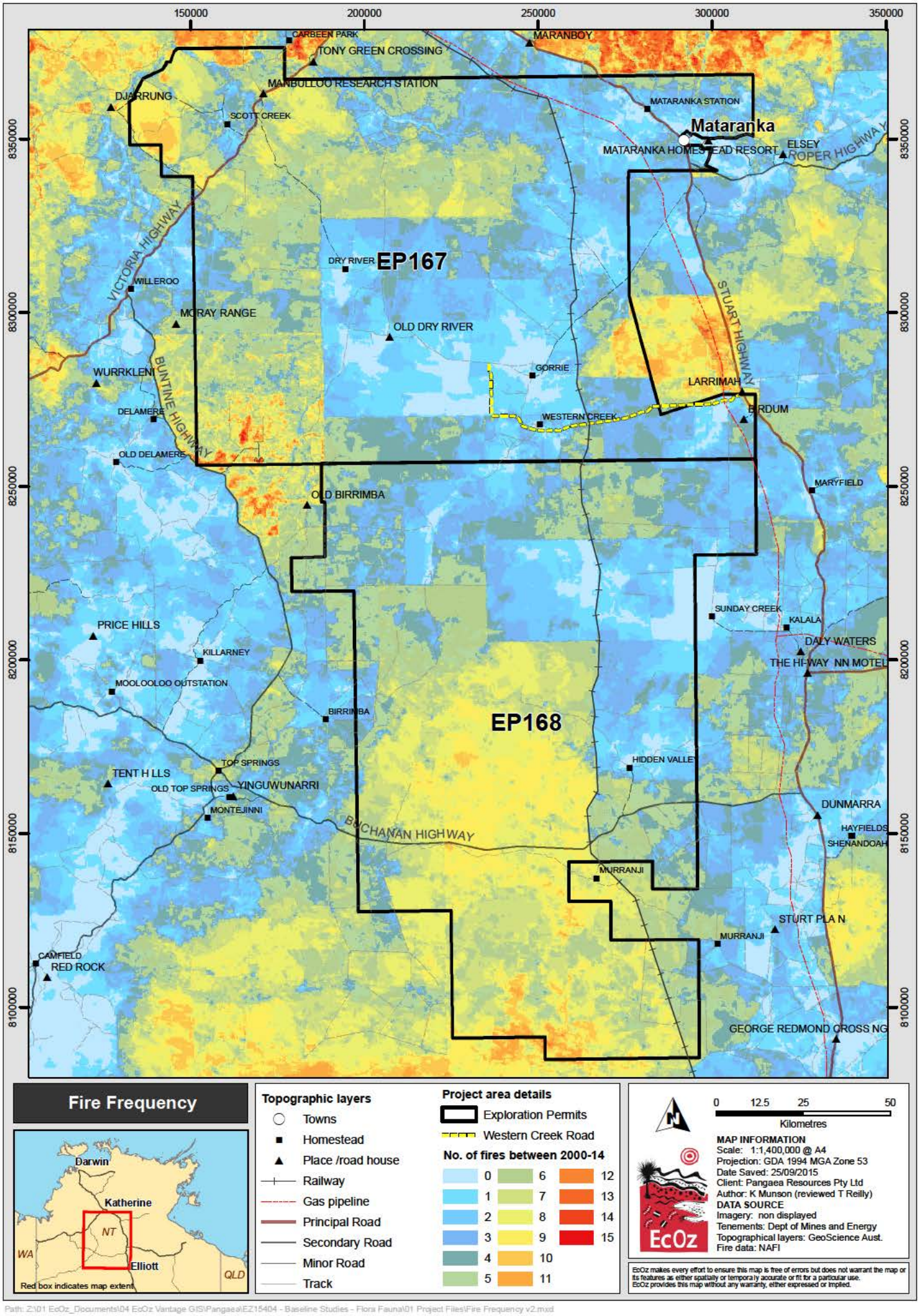


Figure 2-7. Map of declared weed records within the project area (and surrounds)



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\Pangaea\EZ15404 - Baseline Studies - Flora Fauna\01 Project Files\Fire Frequency v2.mxd

Figure 2-8. Map of fire history within the project area (and surrounds)

3 Threatened species 'likelihood of occurrence'

The 'likelihood of occurrence' assessment aims to determine which threatened species have potential to occur within the project area. This assessment is a preliminary assessment; which would potentially need to be confirmed via field work.

Prior to conducting the threatened species 'likelihood of occurrence assessment', the ecological context for the project area (the combined permit boundaries of EP 167 and 168) was established by collating information from previous studies and existing datasets. This included broad-scale reviews of climate data, geomorphology, land system and vegetation mapping, the existing fauna records and known distributions and preferred habitats of fauna species.

A list of fauna and flora that have been recorded or predicted to occur within the project area was compiled from the following sources:

- Northern Territory Fauna Atlas (Department of Land Resource Management) (DLRM).
- Northern Territory NRM Infonet (DLRM) (http://www.lrm.nt.gov.au/infonet).
- EPBC Act Protected Matters Search Tool (http://www.environment.gov.au/epbc/pmst/index.html).

3.1 Background

The International Union for the Conservation of Nature (IUCN) nominates a set of criteria used to identify species at risk of extinction and is used to define categories of risk (Figure 3-1). These criteria and categories are used by both the NT Government to identify threatened species and habitat which are listed under the *TPWC Act* and the Commonwealth Government to identify national threatened species under the *EPBC Act*. The focus of this report is species that are listed as threatened under either the *TPWC Act* or the *EPBC Act* (or both) (i.e. species that are listed as Vulnerable, Endangered, or Critically Endangered).

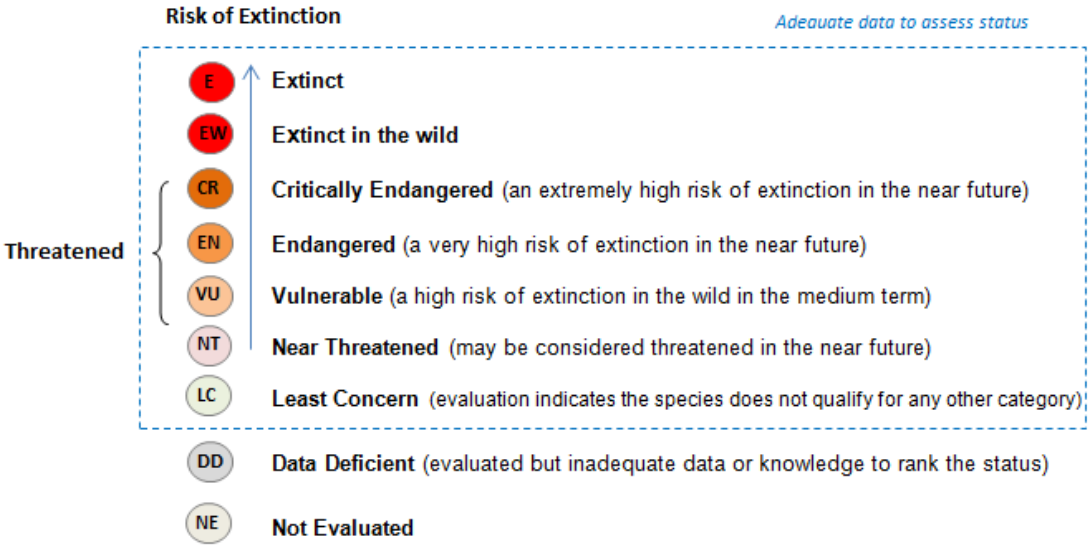


Figure 3-1. The IUCN red list categories of risk for threatened species

(Source: http://www.eoearth.org/article/IUCN_Red_List_Categories_and_Criteria)

3.2 Procedure

The following procedure was used to determine which species should be included in the likelihood of occurrence assessment for the project area, and how the likelihood of occurrence was determined:

1) Identify potential habitat features within the project area using available desktop information (i.e. land unit mapping, existing vegetation mapping, aerial imagery, fire history etc.).
2) Undertake a database review collating all threatened species identified by the NT Atlas, NT NRM Infonet search and EPBC Protected Matters Search Tool report.
3) Include the following details for each species – conservation status (NT and federal), habitat requirements, distribution and number of records within search area (from Infonet report).
4) Apply the following criteria to each species, including justifications for each selected result.
    a. HIGH – it is expected that this species will be detected within the project area because of the presence of suitable habitat, and/or there are recent records (i.e. post-2000) for the species.
    b. MEDIUM – this species may occur within the project area; however, there is reasonable evidence that lowers its likelihood of occurrence (i.e. lack of core habitat, no recent records with the search area, habitat degradation etc.)
    c. LOW – it is not expected that this species is supported within the project area, as there is no suitable habitat for the species and/or current threats at the site are known to have significantly impacted the species.
    d. NONE – there is strong evidence that this species will not occur within the project area.

3.3 Database results

Thirty-five species were identified by the database review (Table 3-1). The results from the data sources are described below.

- **NT NRM Infonet threatened species report (NT Government)**

  This search indicates that 11 threatened species have been previously recorded within the project area, and an additional 29 threatened species within the map grid cells surrounding the project area (Appendix C).

- ***EPBC Act* Protected Matters Search Tool report (Federal Government)**

  This search identified 14 *EPBC*-listed species that may occur (or have suitable habitat) within the project area and/or surrounding area (Appendix D).

  Migratory species are those animals that migrate to Australia and its external territories, or pass through or over Australian territory during their annual migrations. Many migratory species listed under international conventions and agreements that Australia is party to, are protected under the *EPBC Act.* The EPBC protected matters search tool revealed that a total of seven migratory species, all birds; potentially occur within the boundaries of the project area. They are Fork-tailed Swift (*Apus pacificus*), Great Egret (*Ardea alba*), Cattle Egret (*Ardea ibis*), Oriental Plover (*Charadrius veredus*), Oriental Pratincole (*Glareola maldivarum*), Rainbow Bee-eater (*Merops ornatus*), and Eastern Osprey (*Pandion cristatus*).

- **NT Atlas threatened species locations (NT Government)**

  Threatened species data records were mapped for the project area and surrounds to identify actual locations of existing records (Figure 3-2) (last updated by DLRM in 2014).

Table 3-1. Threatened species identified by the database review

Common name	Scientific name	Data Source	EPBC Status	TWPC Status
Reptiles				
Plains Death Adder	*Acanthophis hawkei*	2,3	VU	VU
Gulf Snapping Turtle	*Elseya lavarackorum*	1,2,3	EN	LC
Great Desert Skink	*Liopholis kintorei*	3	VU	VU
Mitchell's Water Monitor	*Varanus mitchelli*	1,2	-	VU
Mertens' Water Monitor	*Varanus mertensi*	1,2	-	VU
Floodplain Monitor	*Varanus panoptes*	2	-	VU
Birds				
White-throated Grasswren	*Amytornis woodwardi*	3	VU	VU
Red Goshawk	*Erythrotriorchis radiatus*	1,2,3	VU	VU
Gouldian Finch	*Erythrura gouldiae*	1,2,3	EN	VU
Crested Shrike-tit	*Falcunculus frontatus whitei*	1,2,3	VU	NT
Partridge Pigeon	*Geophaps smithii smithii*	1,2	VU	VU
Australian Painted Snipe	*Rostratula australis*	2,3	EN	VU
Masked Owl (Northern)	*Tyto novaehollandiae kimberli*	3	VU	VU
Grey Falcon	*Falco hypoleucos*	1,2	-	VU
Painted Honeyeater	*Grantiella picta*	2	VU	VU
Purple-crowned Fairy-wren (VRD)	*Malurus melanocephalus coronatus*	2	VU	VU
Princess Parrot	*Polytelis alexandrae*	2	VU	VU
Curlew Sandpiper	*Calidris ferruginea*	2	VU	-
Mammals				
Northern Quoll	*Dasyurus hallucatus*	2,3	EN	CR
Greater Bilby	*Macrotis lagotis*	1,2,3	VU	VU
Northern Brush-tailed Phascogale	*Phascogale pirata*	3	VU	EN
Pale Field-rat	*Rattus tunneyi*	1,2	-	VU
Bare-rumped Sheath tail Bat	*Saccolaimus saccolaimus*	3	CR	DD
Black-footed Tree-rat	*Mesembriomys gouldii*	2	EN	VU
Carpentarian Antechinus	*Pseudantechinus mimulus*	2	-	VU
Northern Leaf-nosed Bat	*Hipposideros stenotis*	2	VU	-
Common Brushtail Possum (south)	*Trichosurus vulpecula vulpecula*	2	-	EN
Fish				
Freshwater Sawfish	*Pristis pristis*	2,3	VU	VU
Plants				
Armstrong's Cycad	*Cycas armstrongii*	1, 2	-	VU
Venus-hair Fern	*Adiantum capillus-veneris*	2	-	VU
Victoria River Coral Fern	*Gleichenia sp. Victoria River*	2	-	VU
a Spinifex	*Triodia fitzgeraldii*	2	-	VU
Invertebrates				
Victoria Land Snail	*Setobaudinia victoriana*	2	-	VU

Status key: CR = Critically Endangered; EN = Endangered; NT = Near Threatened; VU = Vulnerable; DD = Data Deficient
Data source key: [1] INFONET (within project area); [2] INFONET (surrounding project area); [3] EPBC PMST

3.4 Assessment results

The ecology and distribution of the 33 of the 35 threatened species regarded as potentially occurring within the region were further interrogated based on their current distribution and ecology. Using that information, a preliminary assessment of each of those species' likelihood of occurrence was undertaken (Appendix E).

Two species were omitted from the likelihood analysis as they are considered by Baker et al. (2005) to be extirpated (locally extinct) from the area – Western Quoll (*Dasyurus geoffroyi*), and Golden Bandicoot (*Isoodon auratus*).

3.4.1 EP 167 threatened species likelihood of occurrence assessment

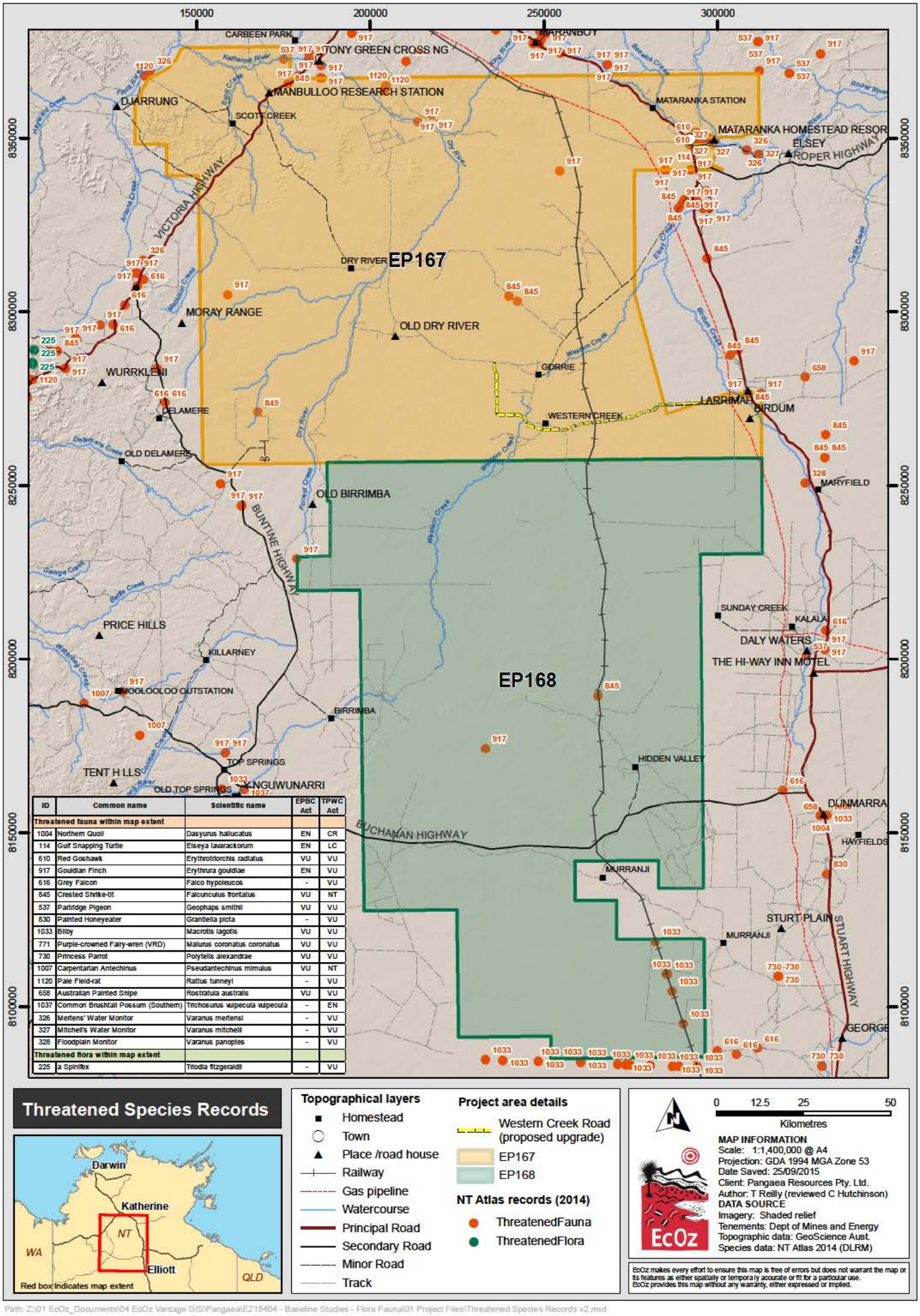
- Four species were ranked as having a **high chance** of occurring within EP 167:
    - Mertens' Water Monitor (*Varanus mertensi*)
    - Red Goshawk (*Erythrotriorchis radiatus*)
    - Gouldian Finch (*Erythrura gouldiae*)
    - Crested Shrike-tit (*Falcunculus frontatus whitei*)
- Five species were ranked as having a **medium chance** of occurring within EP 167:
    - Plains Death Adder (*Acanthophis hawkei*)
    - Mitchell's Water Monitor (*Varanus mitchelli*)
    - Partridge Pigeon (*Geophaps smithii smithii*)
    - Purple-crowned Fairy-wren (western) (*Malurus coronatus coronatus*)
    - Pale Field-rat (*Rattus tunneyi*)
- Thirteen species were ranked as having a **low chance** of occurring within EP 167:
    - Floodplain Monitor (*Varanus panoptes*)
    - White-throated Grasswren (*Amytornis woodwardi*)
    - Grey Falcon (*Falco hypoleucos*)
    - Painted Honeyeater (*Grantiella picta*)
    - Australian Painted Snipe (*Rostratula australis*)
    - Masked Owl (northern) (*Tyto novaehollandiae*)
    - Curlew Sandpiper (*Calidris ferruginea*)
    - Northern Quoll (*Dasyurus hallucatus*)
    - Black-footed Tree-rat (*Mesembriomys gouldii*)
    - Bare-rumped Sheath-tail Bat (*Saccolaimus saccolaimus*)
    - Northern Leaf-nosed Bat (*Hipposideros stenotis*)
    - Freshwater Sawfish (*Pristis pristis*)
    - Victoria's Land Snail (*Setobaudinia victoriana)*
- Eleven species were ranked as having **no chance** of occurring within EP 167:
    - Gulf Snapping Turtle (*Elseya lavarackorum*)
    - Great Desert Skink (*Liopholis kintorei*)
    - Princess Parrot (*Polytelis alexandrae*)
    - Greater Bilby (*Macrotis lagotis*)
    - Northern Brush-tail Phascogale (*Phascogale pirata*)
    - Carpentarian Antechinus (*Pseudantechinus mimulus*)
    - Common Brushtail Possum (southern) (*Trichosurus vulpecula vulpecula*)
    - Venus-Hair Fern (*Adiantum capillus-veneris*)
    - Victoria River Coral Fern (*Gleichenia sp.* Victoria River I.D.Cowie 9193)
    - a spinifex (*Triodia fitzgeraldii*)
    - Armstrong's Cycas (*Cycas armstrongii*)

3.4.2 EP 168 threatened species likelihood of occurrence assessment

- One species was ranked as having a **high chance** of occurring within EP 168:
    - Greater Bilby (*Macrotis lagotis*)
- Two species was ranked as having a **medium chance** of occurring within EP 168.
    - Plains Death Adder (*Acanthophis hawkei*)
    - Crested Shrike-tit (*Falcunculus frontatus whitei*)
- Eight species were ranked as having a **low chance** of occurring within EP 168:
    - Great Desert Skink (*Liopholis kintorei*)
    - Mertens' Water Monitor (*Varanus mertensi*)
    - Red Goshawk (*Erythrotriorchis radiatus*)
    - Gouldian Finch (*Erythrura gouldiae*)
    - Grey Falcon (*Falco hypoleucos*)
    - Princess Parrot (*Polytelis alexandrae*)
    - Australian Painted Snipe (*Rostratula australis*)
    - Pale Field-rat (*Rattus tunneyi*)
- Twenty-two species were ranked as having **no chance** of occurring within EP 168:
    - Gulf Snapping Turtle (*Elseya lavarackorum*)
    - Mitchell's Water Monitor (*Varanus mitchelli*)
    - Floodplain Monitor (*Varanus panoptes*)
    - White-throated Grasswren (*Amytornis woodwardi*)
    - Partridge Pigeon (*Geophaps smithii smithii*)
    - Painted Honeyeater (*Grantiella picta*)
    - Purple-crowned Fairy-wren (western) (*Malurus coronatus coronatus*)
    - Masked Owl (northern) (*Tyto novaehollandiae*)
    - Curlew Sandpiper (*Calidris ferruginea*)
    - Northern Quoll (*Dasyurus hallucatus*)
    - Black-footed Tree-rat (*Mesembriomys gouldii*)
    - Northern Brush-tail Phascogale (*Phascogale pirata*)
    - Bare-rumped Sheath-tail Bat (*Saccolaimus saccolaimus*)
    - Common Brushtail Possum (southern) (*Trichosurus vulpecula vulpecula*)
    - Carpentarian Antechinus (*Pseudantechinus mimulus*)
    - Northern Leaf-nosed Bat (*Hipposideros stenotis*)
    - Venus-Hair Fern (*Adiantum capillus-veneris*)
    - Victoria River Coral Fern (*Gleichenia sp.* Victoria River I.D.Cowie 9193)
    - a spinifex (*Triodia fitzgeraldii*)
    - Armstrong's Cycas (*Cycas armstrongii*)
    - Freshwater Sawfish (*Pristis pristis*)
    - Victoria's Land Snail (*Setobaudinia victoriana)*

3.4.3 Western Creek Road threatened species likelihood of occurrence assessment

- No species were ranked as having a **high chance** of occurring within Western Creek Road:
- Four species were ranked as having a **medium chance** of occurring within Western Creek Road:
    - Crested Shrike-tit (*Falcunculus frontatus whitei*)
    - Mertens' Water Monitor (*Varanus mertensi*)
    - Partridge Pigeon (*Geophaps smithii smithii*)
    - Pale Field-rat (*Rattus tunneyi*)
- Seven species were ranked as having **low chance** of occurring within Western Creek Road:
    - Floodplain Monitor (*Varanus panoptes*)
    - Mitchell's Water Monitor (*Varanus mitchelli*)
    - Floodplain Monitor (*Varanus panoptes*)
    - Red Goshawk (*Erythrotriorchis radiatus*)
    - Gouldian Finch (*Erythrura gouldiae*)
    - Grey Falcon (*Falco hypoleucos*)
    - Australian Painted Snipe (*Rostratula australis*)
- Twenty-two species were ranked as having a **no chance** of occurring within Western Creek Road:
    - Gulf Snapping Turtle (*Elseya lavarackorum*)
    - Plains Death Adder (*Acanthophis hawkei*)
    - Great Desert Skink (*Liopholis kintorei*)
    - White-throated Grasswren (*Amytornis woodwardi*)
    - Painted Honeyeater (*Grantiella picta*)
    - Purple-crowned Fairy-wren (western) (*Malurus coronatus coronatus*)
    - Masked Owl (northern) (*Tyto novaehollandiae*)
    - Curlew Sandpiper (*Calidris ferruginea*)
    - Northern Quoll (*Dasyurus hallucatus*)
    - Greater Bilby (*Macrotis lagotis*)
    - Black-footed Tree-rat (*Mesembriomys gouldii*)
    - Northern Brush-tail Phascogale (*Phascogale pirata*)
    - Bare-rumped Sheath-tail Bat (*Saccolaimus saccolaimus*)
    - Common Brushtail Possum (southern) (*Trichosurus vulpecula vulpecula*)
    - Carpentarian Antechinus (*Pseudantechinus mimulus*)
    - Northern Leaf-nosed Bat (*Hipposideros stenotis*)
    - Venus-Hair Fern (*Adiantum capillus-veneris*)
    - Victoria River Coral Fern (*Gleichenia sp.* Victoria River I.D.Cowie 9193)
    - a spinifex (*Triodia fitzgeraldii*)
    - Armstrong's Cycas (*Cycas armstrongii*)
    - Freshwater Sawfish (*Pristis pristis*)
    - Victoria's Land Snail (*Setobaudinia victoriana)*



ID	Common name	Scientific name	EPBC Act	TPWC Act
Threatened fauna within map extent				
1004	Northern Quoll	Dasyurus hallucatus	EN	CR
114	Gulf Snapping Turtle	Elseya lavarackorum	EN	LC
610	Red Goshawk	Erythrotriorchis radiatus	VU	VU
917	Gouldian Finch	Erythrura gouldiae	EN	VU
616	Grey Falcon	Falco hypoleucos	-	VU
845	Crested Shrike-tit	Falcunculus frontatus	VU	NT
537	Partridge Pigeon	Geophaps smithii	VU	VU
830	Painted Honeyeater	Grantiella picta	-	VU
1033	Bilby	Macrotis lagotis	VU	VU
771	Purple-crowned Fairy-wren (VRD)	Malurus coronatus coronatus	VU	VU
730	Princess Parrot	Polytelis alexandrae	VU	VU
1007	Carpentarian Antechinus	Pseudantechinus mimulus	VU	NT
1120	Pale Field-rat	Rattus tunneyi	-	VU
658	Australian Painted Snipe	Rostratula australis	VU	VU
1037	Common Brushtail Possum (Southern)	Trichosurus vulpecula vulpecula	-	EN
326	Mertens' Water Monitor	Varanus mertensi	-	VU
327	Mitchell's Water Monitor	Varanus mitchelli	-	VU
328	Floodplain Monitor	Varanus panoptes	-	VU
Threatened flora within map extent				
225	a Spinifex	Triodia fitzgeraldii	-	VU

Threatened Species Records

Topographical layers
- Homestead
- Town
- Place /road house
- Railway
- Gas pipeline
- Watercourse
- Principal Road
- Secondary Road
- Minor Road
- Track

Project area details
- Western Creek Road (proposed upgrade)
- EP167
- EP168

NT Atlas records (2014)
- ThreatenedFauna
- ThreatenedFlora

0 12.5 25 50
Kilometres

MAP INFORMATION
Scale: 1:1,400,000 @ A4
Projection: GDA 1994 MGA Zone 53
Date Saved: 25/09/2015
Client: Pangaea Resources Pty. Ltd.
Author: T Reilly (reviewed C Hutchinson)
DATA SOURCE
Imagery: Shaded relief
Tenements: Dept of Mines and Energy
Topographic data: GeoScience Aust.
Species data: NT Atlas 2014 (DLRM)

Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\Pangaea\EZ15404 - Baseline Studies - Flora Fauna\01 Project Files\Threatened Species Records v2.mxd

Figure 3-2. Map of threatened fauna records in the vicinity of EP 167 and 168

4 Biodiversity Values of the Project Area

It can be expected that environmental approvals associated with the progression of this project will require an assessment of the likely risks to biodiversity values. The objective of this section is to undertake a qualitative 'significance' assessment of biodiversity values that have been identified to occur, or likely to occur, within the project area (noting that this is a preliminary assessment based on desktop information at a fairly broad scale). The biodiversity values covered in this section are considered to have potential 'conservation significance' within certain parts of the project area.

Two types of biodiversity values were identified by the desktop review (Section 2 and 3) to potentially occur within the project area:

- Sensitive vegetation types
- Threatened flora and fauna species.

These biodiversity values are discussed in the following sections. For each value, contextual information and recommended assessment plans are provided, which aims to inform project planning to either avoid, or reduce, impacts to biodiversity values (i.e. to reduce the risk to environmental aspects).

4.1 Sensitive vegetation types

Sensitive vegetation types are those considered to be significant under the *Land Clearing Guidelines* (NRETAS 2010), such as monsoon forest, riparian vegetation, mangrove, groundwater dependent ecosystems, and wetlands. These areas are either unique to the region and/or have high biodiversity values. A review of existing vegetation mapping, land systems, and aerial imagery indicates that three sensitive vegetation types could potentially occur within the project area – riparian vegetation, wetlands, and the Arnhem Land sandstone shrubland. A map of potentially sensitive vegetation types within the project area is provided in Figure 4-1.

4.1.1 Riparian vegetation

Riparian vegetation occurs along freshwater waterways (ephemeral or permanent). It is a distinct, closed forest community that creates suitable conditions for a range of species (terrestrial and aquatic) by providing shade (that in turn regulates water temperatures, maintains dissolved oxygen concentrations, and reduces algal bloom) (DLRM 2013). It covers a relatively small land area and provides unique habitat features and dry season refuge for a range of native fauna species (DLRM 2013).

There are four main ephemeral (seasonal) watercourses within the project area – King River, Dry River, Western Creek, and Birdum Creek. These watercourses are associated with land systems classed as 'Alluvial Floodplains'. Within these areas, it is likely that riparian vegetation exists, and it is most likely in direct association with the waterways (but may sometimes also spread out into the floodout of the watercourses). Impacts to waterways will need to be minimised to ensure that any areas of intact riparian vegetation are no degraded.

4.1.2 Wetlands

In the Top End, wetlands are generally considered to be floodplains, lakes, billabongs and swamps (NRETAS 2010). They support distinct vegetation communities that rely on either a permanent or seasonal water supply (Brock 1993). These areas often support a shallow watertable. They are considered to be a sensitive vegetation type as they provide essential habitat for a diverse range of flora and fauna (including threatened and migratory species) and can be easily impacted upon by poor land management and planning.

Available mapping for important wetlands and lakes indicates that none occur within the project area; however, a closer inspection of aerial imagery in areas classed as 'alluvial floodplains' shows that small (likely seasonal) swamps are present. The significance of these swamps may need to be assessed during on ground studies. If possible, impacts to swamps should be avoided.

4.1.3 Rugged sandstone plateaux and hills

The Arnhem Sandstone Complex is listed under the *EPBC Act* as an ecological community of national conservation significance (SEWPAC 2012). Its habitat features are important for a wide range of native flora and fauna (SEWPAC 2012) as they are generally unique and do not occur in other land types. Large-scale hot fires, fire weeds (i.e. Gamba Grass), and feral animals (mainly Feral Cat and Cane Toad) are threatening processes that are having a significant impact on biodiversity values within this habitat type (SEWPAC 2012). According to the *EPBC Act*, a patch of Arnhem Shrubland Complex will be defined as a matter of national environmental significance if it is at least five hectares in size and supports at least four different obligate seeder plants (SEWPAC 2012).

Land system mapping indicates that this habitat type occurs within the Bukalara land system, which is found in the far north-east corner of EP 167 (to the north-east of Mataranka) (equates to approximately 1044 ha). It is likely that comprehensive impact studies will need to be conducted in this area if land disturbance activities are proposed within the Bukalara land system.

4.2 Threatened species

The likelihood of occurrence assessment in Section 3, interrogated 33 threatened species to determine if they had a high, medium, low, or no chance of occurring within the project area. Species that were ranked to have a medium or high chance of occurrence may need consideration during future environmental risk assessment of the project; as there is potential they will be impacted by land disturbance activities such as exploration and production activities within the project area if appropriate mitigations are not applied. Species that were considered to have a low chance of occurrence within the project area are not likely to require specific management mitigations or targeted onground surveys.

Ten threatened species were considered to have a medium to high chance of occurring within the project area, including nine species in EP 167, three species in EP 168, and four species in the vicinity of Western Creek Road.

For each of these species, a brief description of the morphology, ecology, and distribution is provided, followed by an explanation of how the species may be associated with the project area. There potential occurrence within the project area has been predicted for the project area (Figure 4-1) (which is based on available broad-scale land system and vegetation mapping resources).

A three-phase assessment approach has been proposed for each species, which is designed to be applied to areas proposed for exploration or production activities. This involves:

- Phase 1 (initial assessment) – a desk-based habitat assessment which aims to identify which, if any, threatened species' habitats potentially occur within any proposed disturbance areas.
- Phase 2 (if potential habitat is suspected to occur) – a field-based assessment that includes a ground-truthed habitat description of the proposed disturbance area and a 'once off' search for evidence of the target threatened species.
- Phase 3 (if the Phase 2 habitat assessment concludes it is possible that threatened species inhabit the site and if the habitat cannot be avoided from disturbance activities) – field-based targeted surveys for threatened species that possibly inhabit the site. More intensive survey methodology is suggested to provide a more rigorous interrogation of the species likelihood of occurrence, which will therefore inform associated risk assessment and project management.

4.2.1 Mertens' Water Monitor (*Varanus mertensi*)

The Mertens' Water Monitor (*Varanus mertensi*) is a moderately sized (up to 1.1 m) semi-aquatic and arboreal monitor. It occupies edges of freshwater watercourses and lagoons where it forages for aquatic prey (Christian 2004), which mostly includes fish (but may also opportunistically eat other groups such as frogs). It is seldom seen away from freshwater and is often observed on the edges of freshwater creeks. This species breeds in the early dry season. It is found within river systems across of northern Australia from Cape York Peninsula to the Kimberley (Christian 2004a).

The project area falls on the southern edge of the current distribution for the species. The TNRM Infonet report indicates that four records occur within the project area (most recent record from 1996); with an additional six records in the surrounding region (most recent record from 1996).

Mertens' Water Monitor is listed as Vulnerable under the *TPWC Act* and is not listed under the *EPBC Act.* The predicted main driver for its threatened status is due to death associated with predation on the Cane Toad (*Rhinella marina*) (Doody et al. 2006; Doody et al. 2009; Doody et al. 2015; Griffiths and McKay 2005; Shine 2010).

In terms of the project area, potential habitat for Mertens' Water Monitor will be directly associated with watercourses within the alluvial floodplains, and is more likely to occur in the northern waterways of EP 167.

Potential impacts to this species will be associated with degradation of waterways, which includes impacts to water quality and quantity within the creeks, and the condition (and amount) of riparian vegetation.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within alluvial floodplain land systems or crosses waterways.
- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies will also include survey for evidence of Mertens' Water Monitor (i.e. direct observation, presence of prey species, presence of Cane Toad etc.). These surveys should be conducted during or directly after the wet season when water present in the waterways.
- Phase 3: If the habitat assessment indicates it is possible that Mertens' Water Monitor inhabit areas of proposed disturbance, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Standard survey techniques applicable for Mertens' Water Monitor detection are transect surveys and camera trapping along the margins of watercourses. These surveys should be conducted during or directly after the wet season when water is present in the waterways.

If Mertens' Water Monitor are detected (or suspected to occur) within proposed disturbance areas, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. As mitigations for this species are associated with standard waterway management (as impacts to waterways are often a priority for a range of reasons), reducing the risk of impact to this species is generally part of the standard work programs.

Any records of this species will be considered to be significant as they will constitute an "important population" due to it being some of the most southern records of the species in recent times.

4.2.2 Mitchell's Water Monitor (*Varanus mitchelli*)

Mitchell's Water Monitor (*Varanus mitchelli*) is a moderately sized (up to 70 cm) semi-aquatic and arboreal monitor (Ward 2012). It occurs in watercourses, swamps and lagoons within the northern river systems of the Top End, and preys on aquatic insects, fish, small lizards, and frogs.

The project area falls on the southern edge of the current distribution for the species. The TNRM Infonet report indicates that only four records occur within the project area (most recent record from 1978), with a further four records in the surrounding region (most recent record from 1996).

It is listed as Vulnerable under the *TPWC Act* and is not listed under the *EPBC Act*. The highest threat to the species, and the predicted main driver for its threatened status, is the invasion of the Cane Toad, which now occurs across 100% of the current range of Mitchell's Water Monitor. Studies have shown that Mitchell's Water Monitor have had substantial population declines in areas where Cane Toads have established (Doody et al, 2009), as the species is susceptible to Cane Toad toxin and may also deplete potential prey opportunities.

In terms of the project area, potential habitat for Mitchell's Water Monitor will be directly associated with watercourses within the alluvial floodplains, and is more likely to occur in the northern waterways of EP 167.

Potential impacts to this species will be associated with degradation of creeks, which includes impacts to water quality and quantity within the creeks, and the condition (and amount) of riparian vegetation.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within alluvial floodplain land systems or crosses waterways.
- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies will also include survey for evidence of Mitchell's Water Monitor (i.e. direct observation, presence of prey species, presence of Cane Toad etc.). These surveys should be conducted during or directly after the wet season when water is present in the waterways.
- Phase 3: If the habitat assessment indicates it is possible that Mitchell's Water Monitor inhabit the site, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Standard survey techniques applicable for Mitchell's Water Monitor detection are transect surveys and camera trapping along the margins of watercourses. These surveys should be conducted during or directly after the wet season when water present in the waterways.

If Mitchells' Water Monitor are detected (or suspected to occur) within proposed disturbance areas, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. As mitigations for this species are associated with standard waterway management (as impacts to waterways are often a priority for a range of reasons), reducing the risk of impact to this species is generally part of the standard work programs.

Any records of this species will be considered to be significant as they will constitute an "important population" due to it being some of the most southern records of the species in recent times.

4.2.3 Red Goshawk (*Erythrotriorchis radiatus*)

Red Goshawk (*Erythrotriorchis radiatus*) is a large, reddish-brown hawk (Debus and Czechura 1988) that is known to prefer tall open forest and riparian areas in northern Australia (Woinarski 2006). They make

basket-shaped nests in large trees (>20 m in height), typically near riparian zones, and hunt medium-sized birds of which they can forage very large distances (200 km^2) (Aumann and Baker-Gabb 1991). It occurs across northern Australia; however, there are some isolated recent records from the arid zone.

The project area falls within the current distribution for the species. The TNRM Infonet report indicates that 16 records occur within the project area (most recent record from 2008), with an additional 1 record in the surrounding region (from 2008).

Red Goshawk is listed as Vulnerable under the *TPWC Act* and *EPBC Act.* The reason for listing as a threatened species is due to low population numbers and a (observed, projected or inferred) decline in population (Woinarski 2006). The main threat to this species is clearing or degradation of preferred habitat (Garnet et al. 2010).

In terms of the project area, potential habitat for Red Goshawk is restricted to the major watercourses within the alluvial floodplains, and is more likely to be identified in the northern areas of EP 167 due to the presence of larger waterways (support taller trees) and the presence of active nest sites near Mataranka.

Potential impacts to this species will be associated with clearing vegetation for drill pads, roads, and other related infrastructure, with the main direct impact being removal of current (or potential) nest sites. The highest probability of finding nest sites will be in the alluvial floodplain land systems, as these areas are more likely to support large trees that are preferred roost sites for Red Goshawk.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within alluvial floodplain land systems or crosses waterways.
- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies should also include survey for evidence of Red Goshawk (i.e. direct observation, nests searches). These surveys can be conducted at any time of year. Surveys should include a detailed habitat assessment of the site.
- Phase 3: If the habitat assessment indicates it is possible that Red Goshawk inhabit the site (i.e. sighting or suspected nest), and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Standard survey techniques applicable for Red Goshawk detection will be to undertake surveillance (i.e. stake-outs or camera trapping) on the suspected nest sites to determine if they are active, and if they belong to Red Goshawk. Confirmed nest sites will be considered to be significant, and 'flyover' sightings are considered less significant (due to the large forage area of this species). Red Goshawk start nest-building in May, lay eggs from July to September, and fledge young from October to December – therefore the best survey time is late dry to early wet season (Aumann & Baker-Gabb 1991).

The abovementioned methods align with the '*Survey Guidelines for Australia's Threatened Birds*' (Commonwealth of Australia 2010).

If suspected or confirmed Red Goshawk nests are found within the proposed disturbance area, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. It is best that these nests are avoided by at least 200 m, or a surveillance program is conducted to confirm if the nest belongs to Red Goshawk. In all circumstances, it is recommended that removal of large trees within the alluvial floodplain land systems is avoided. This action will lower the chance of impacting the breeding cycle of the Red Goshawk by avoiding potential nest sites.

If Red Goshawk are observed as a 'flyover' species within the project area, this will increase the level survey effort required to ensure that impact to current and potential nest sites is mitigated.

4.2.4 Gouldian Finch (*Erythrura gouldiae*)

The Gouldian Finch (*Erythrura gouldiae*) is small distinctive bird that occurs within north-west Queensland, Top End NT, and the Kimberley (WA). It inhabits two different areas of the landscape on an annual cycle.

In the late wet season and entire dry season (February to October) it occurs in rocky hills that support Eucalyptus species commonly referred to as Snappy Gum or Salmon Gum (which provide suitable hollows for nesting purposes). This period includes their breeding period, which typically occurs from late February to August (Tideman et al. 1999). Nest sites are between two and four kilometres from small permanent waterholes or springs (O'Malley et al. 2006). They feed on annual spear grasses and native sorghum (i.e. *Sorghum* species) during this period.

In the early wet season (November) they move to lowland drainage areas to feed on seeds of grasses such as *Alloteropsis semialata*, *Chrysopogon fallax* and a variety of *Triodia* species (O'Malley et al. 2006; Palmer et al. 2012).

The northern area of the project area falls within the current distribution for the species. The TNRM Infonet report indicates that 44 records occur within the project area (most recent record from 2008), with an additional 100 records in the surrounding region (most recent record from 2008).

Gouldian Finch is listed as Vulnerable under the *TWPC Act* and Endangered under the *EPBC Act*. The main threats to this species are frequent widespread fires, pastoralism, trapping, and parasitic mites. The most significant of these threats is reduced grass seed availability as a result of pastoralism and/or widespread late season fires modifying the understory vegetation.

In terms of the project area, Gouldian Finch breeding habitat may occur within the following land systems – Keckwick, Mueller, and Patterson. Suitable breeding habitat will depend on a number of factors, such as proximity to water supply, presence of suitable hollows, and presence of Sorghum species. The species is only expected to occur (or at least potentially breed) within EP 167. EP 168 is considered to be outside of the potential distribution and existing mapping resources do not indicate that suitable breeding habitat is present.

Potential impacts to this species will be associated with clearing vegetation for drill pads, roads, and other related infrastructure, with the main direct impact being removal of current (or potential) nest sites. If the project clears or modified large areas of feeding habitat, it may also impact on local breeding populations.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within Keckwick, Mueller, and Patterson land systems.
- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies should also include survey for evidence of Gouldian Finch (i.e. direct observation, potential nest sites, viable food resources, proximity to dry season water supply). These surveys can be conducted at any time of year. Surveys should include a detailed habitat assessment of the site.
- Phase 3: If the habitat assessment indicates it is possible that Gouldian Finch inhabit the site, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Standard survey techniques applicable for Gouldian Finch detection will be to undertake surveillance (i.e. stake-outs or camera trapping) on the suspected nest sites to determine if they are active, and if they belong to Gouldian Finch. Confirmed nest sites will be considered to be significant, and potential nest sites will also be considered to be significant if 'flyover' sightings are

observed in the area. These surveys should occur in the late wet to mid dry season to ensure that breeding populations are encountered.

The abovementioned methods align with the '*Survey Guidelines for Australia's Threatened Birds*' (Commonwealth of Australia 2010).

If suspected or confirmed Gouldian Finch breeding habitat is found within the proposed disturbance area, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. Ideally, these areas are avoided by at least 200 m, or a multi-season surveillance program is conducted to confirm if the site is regularly utilised by a population. It is recommended that disturbance of any areas regarded to be potential breeding habitat are avoided (this will reduce the need for onground surveys and possible long term surveillance surveys).

Any records of this species will be considered to be significant as they will constitute an "important population" due to it being some of the most southern records of the species in recent times.

4.2.5 Northern Shrike-tit (*Falcunculus frontatus whitei*)

Northern Shrike-tit (*Falcunculus frontatus whitei*) (also known as the Crested Shrike-tit) is a medium-sized bird that has a patchy distribution throughout northern Australia. They are insectivorous and forage in tree canopies in a range of Eucalyptus and Melaleuca woodlands (Robinson and Woinarski 1992). Breeding occurs in the wet season (Woinarski and Ward 2012). They use calls to communicate with pairs and alert to other about territories, and is particularly vocal during the breeding period.

The project area falls within the current distribution for the species. The TNRM Infonet report indicates that 22 records occur within the project area (most recent record from 2009), with an additional 35 records in the surrounding region (most recent record from 2009).

Northern Shrike-tit is not listed as threatened under the *TWPC Act* and Vulnerable under the *EPBC Act*. In the Northern Territory, there is no evidence of population decline (it is currently listed as Near Threatened).

In terms of the project area, Northern Shrike-tit have been previously identified within with EP 167. As they are known to occupy a range of habitat and vegetation types, and also persist in areas with a variety of fire and grazing histories, it is difficult to clearly defined areas within the project areas where they are most likely to persist. They are considered to potentially be encountered in EP 167 and 168.

Potential impacts to this species will be associated with clearing vegetation for drill pads, roads, and other related infrastructure, with the main direct impact being removal of current nest sites.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within Eucalyptus and Melaleuca woodlands (which is cover a large proportion of the project area).
- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies should also include survey for evidence of Northern Shrike-tit (i.e. direct observation, call playback surveys). Call playback surveys are best undertaken during the wet season (breeding period) as they are more likely to trigger a 'defensive' response. Surveys should include a detailed habitat assessment of the site.
- Phase 3: If the habitat assessment indicates it is possible that Northern Shrike-tit inhabit the site, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Standard survey techniques applicable for Northern Shrike-tit detection will be to undertake surveillance (i.e. stake-outs) and ideally a three day call playback survey (per site).

These surveys should occur during the wet season (breeding period) as they are more likely to trigger a 'defensive' response.

The abovementioned methods align with the '*Survey Guidelines for Australia's Threatened Birds'* (Commonwealth of Australia 2010).

If Northern Shrike-tit are detected (or suspected to occur) within the proposed disturbance area, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. An observation or response to call playback will be considered to be significant; consequently, these areas should be avoided.

Any records of this species will be considered to be significant as they will constitute an "important population" due to it being some of the most southern records of the species in recent times.

4.2.6 Partridge Pigeon (*Geophaps smithii smithii*)

The Partridge Pigeon (*Geophaps smithii smithii*) is a medium-sized grey-brown bird with a conspicuous red eye-patch outlined in white outline and a heavy, black bill. They roost and nest on the ground in the early dry season (Fraser 2001), and generally only fly when disturbed. They occur in lowland Eucalyptus forests and woodlands, primarily dominated by *E. tetrodonta* and *E. miniata* (Garnett et al. 2011). According to research by Fraser (2001) Partridge Pigeon favour a structurally-patchy savannah understorey at a relatively intricate scale. In all seasons Partridge Pigeon prefer to feed in areas that have an open ground layer (e.g. following fire). However, these birds are more likely to nest at sites where there is high vegetation cover.

Partridge Pigeon also require the seeds of certain perennial grasses and some sedges that are available early in the wet season when seed is otherwise scarce, particular the perennial grass species *Alloteropsis semialata* and *Chrysopogon fallax,* which set seed very early in the wet season. The presence of these may be crucial for Partridge Pigeon survival at this time (Fraser 2001). This species is known to lay eggs in all months of the year, although the bulk of nesting occurs in the early to mid-dry season (Fraser 2001).

Historically, they occurred across the Top End (from Kununurra to Borroloola). Currently, its distribution is limited to sub-coastal Northern Territory from Yinberrie Hill in the south, Litchfield NP in the west and (western) Arnhem Land in the east (Garnett et al. 2011).

The project area falls to the south of the current distribution for the species. The TNRM Infonet report indicates that 2 records occur within the project area (most recent record from 1977), with an additional six records in the surrounding region (most recent record from 1977).

Partridge Pigeon is currently listed as Vulnerable under the *TPWC Act* and the *EPBC Act* due to a substantial decline in abundance (Woinarski 2006). The decline of this species is not well defined, but is probably related to a variety of factors such as changes in fire regime (grass composition), invasion of introduced grass species which increase fire threat (i.e. Gamba Grass *Andropogon gayanus* and Mission Grass *Pennisetum polystachion*), predation by Feral Cat (this species is particularly susceptible as it is almost entirely ground-dwelling) and alteration of water sources (Woinarski 2004, Woinarski 2006).

In terms of the project area, Partridge Pigeon are only expected to occur within EP 167 based on current distribution predictions (Garnett et al. 2011), and presence of potential habitat.

Potential impacts to this species will be associated with clearing vegetation for drill pads, roads, and other related infrastructure, with the main direct impact being removal of current nest sites.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within Eucalyptus woodlands, with particular attention to vegetation types that support *Eucalyptus tetrodonta* and *E. miniata*. A review of the fire

history is also important to determine viability of the habitat for the species (i.e. it prefers a variable fire history – not widespread frequent fires).

- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies should also include survey for evidence of Partridge Pigeon (i.e. direct observation, fire mosaic, presence of potential food resources). Surveys should be undertaken in the early dry season as this is the nesting period, which would constitute the highest impact to the species if the project disturbed breeding/nesting habitat. Surveys should include a detailed habitat assessment of the site.
- Phase 3: If the habitat assessment indicates it is possible that Partridge Pigeon inhabit the site, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Standard survey techniques applicable for Partridge Pigeon detection will be to undertake a three day surveillance program (i.e. stake-outs) in the early dry season (for reasons stated above). Camera trapping can also detect this species (T. Reilly pers. comm.); therefore, a 20 day camera surveillance survey is also recommended.

The abovementioned methods align with the '*Survey Guidelines for Australia's Threatened Birds*' (Commonwealth of Australia 2010).

If Partridge Pigeon are detected (or suspected to occur) within the proposed disturbance area, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. Mitigations may include avoiding the area, or possibly conducting land clearing activities outside of the breeding period.

Any records of this species will be considered to be significant as they will constitute an "important population" due to it being some of the most southern records of the species in recent times.

4.2.7 Purple-crowned Fairy-wren (western) (*Malurus coronatus coronatus*)

The Purple-crowned Fairy-wren (*Malurus coronatus coronatus*) is a small bird, but comparably large for a fairy-wren. The male has a purple crown and black eye band, and females have a white eye-ring and red-brown cheek patch (they lack the purple crown) (Ward and Woinarski 2012). They occur in thick riparian vegetation that supports Canegrass and/or Pandanus, or dense patchy shrubs up to 3 m (Ward and Woinarski 2012). They feed on insects and seeds. Breeding can occur throughout the year of which they make nests in Pandanus crowns or clumps of Canegrass (Garnett et al. 2011). Family groups can exceed 6 birds and they remain in contact by bird call (Ward and Woinarski 2012), and for this reason they readily respond to automated call playback survey techniques.

The western subspecies of the Purple-crowed Fairy-wren occurs in the Kimberley (Western Australia) and the Victoria River District (Northern Territory). In the NT, it occurs in the Victoria River catchment of which they are only found along densely vegetated waterways. It is likely that the population in the NT is now totally fragmented from the population in the Kimberley (therefore migration between the populations is not considered possible due to the total extirpation of a central population in the far-east Kimberley) (Garnett et al. 2011).

The northern region of the project area falls within the current distribution for the species. The TNRM Infonet report indicates that no records occur within the project area, and 109 records in the surrounding region (most recent record from 2008).

Purple-crowned Fairy-wren (western) is currently listed as Vulnerable under the *TPWC Act* and the *EPBC Act.* The most significant threat to the species is loss of habitat or degraded habitat via a range of different factors. In the Victoria River District, the main threats to habitat impact are livestock grazing and trampling,

more frequent and intense fires, weed infestations, and nest predation by the exotic Black Rat (*Rattus tunneyi*) (Van Doorn et al. 2015).

In terms of the project area, Purple-crowned Fairy-wren (western) is only expected to occur within EP 167 based on current distribution predictions (Garnett et al. 2011) and presence of potential habitat.

Potential impacts to this species will be associated with degradation of creeks, which includes impacts to water quality and quantity within the creeks, and the condition (and amount) of riparian vegetation.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within alluvial floodplain land systems and waterways, especially in the northern waterways that may be linked with known populations of the species.
- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies should also include survey for evidence of Purple-crowned Fairy-wren (western) (i.e. direct observation, call playback response). Surveys can be undertaken any time of year. Surveys should include a detailed habitat assessment of the site.
- Phase 3: If the habitat assessment indicates it is possible that Purple-crowned Fairy-wren (western) inhabit the site, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Standard survey techniques applicable for Purple-crowned Fairy-wren (western) detection will be to undertake a three day call playback program.

The abovementioned methods align with the '*Survey Guidelines for Australia's Threatened Birds'* (Commonwealth of Australia 2010).

If Purple-crowned Fairy-wren (western) are detected (or suspected to occur) within the proposed disturbance area, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. It is likely that the only mitigations for this species will be avoidance, as Boekel (1979) observed that the species is highly susceptible to habitat disturbance and was shown to not recolonise areas once suitable habitat has recovered.

Any records of this species will be considered to be significant as they will constitute an "important population" due to it being some of the most southern records of the species in recent times.

4.2.8 Plains Death Adder (*Acanthophis hawkei*)

The Plains Death Adder (*Acanthophis hawkei*) is a short and stout snake that grows up to 60 cm. They occur on flat treeless cracking-soils plains (Ward and Phillips 2012). It preys on frogs, reptiles, and rats. They can move up to 1 km in the wet season and retreat into deep soil cracks in the dry season (Ward and Phillips 2012).

Plains Death Adder have been observed within floodplains of the Adelaide, Mary, and Alligator Rivers and on the cracking clay black soils of the Barkley Tableland (Ward and Phillips 2012). There are no records within the project area (according to TNRM report, Appendix C); however, cracking clay black soil plains are present and therefore it is considered as possible to occur.

The project area falls within the distribution for the species. The TNRM Infonet report indicates that no records occur within the project area, and 1 historical record from the surrounding region (from 1968).

Plains Death Adder is currently listed as Vulnerable under the *TPWC Act* and the *EPBC Act.* They are highly susceptible to Cane Toad poison, and as a result, where Cane Toad populations are high, the Plains Death Adder populations have declined sharply (Ward and Phillips 2012).

In terms of the project area, Plains Death Adder they may occur within EP 167 and 168 (based on potential presence of suitable habitat).

Potential impact to this species will be associated with degradation of cracking clay soil plains.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within areas that exhibit cracking clay soil plains. The highest probability of occurrence is within the claypan land systems (Larrimah and Atlas_II6); however, they may also occur in alluvial floodplain land systems that exhibit clay soil depressions or plains (Coolibah, Ivanhoe 1, McArthur, Western, and Wongalla).
- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies should also include survey for evidence of Plains Death Adder (i.e. direct observation). Surveys should be undertaken during the mid to late wet season. Surveys should include a detailed habitat assessment of the site.
- Phase 3: If the habitat assessment indicates it is possible that Plains Death Adder inhabit the site, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Survey techniques applicable for Plains Death Adder detection will be to undertake at least one day/night of nocturnal searching (for the death adder and Cane Toad – a key threat to the species), and possibly a 20 day camera surveillance survey. Surveys should be undertaken during the mid to late wet season.

If Plains Death Adder are detected (or suspected to occur) within the proposed disturbance area, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. In areas where this species is identified, it is likely that the only mitigation will be avoidance of critical habitat.

Any records of this species will be considered to be significant as they will constitute an “important population”, as they have not been observed in this region in the past.

4.2.9 Greater Bilby (*Macrotis lagotis*)

The Greater Bilby (*Macrotis lagotis*) is a large omnivorous burrowing marsupial. It is nocturnal and generally solitary. Typical habitat for the species (in the Northern Territory) consists of sandy soils dominated by hummock grasslands covered predominantly by three species of spinifex, *Triodia basedowii*, *T. pungens* and *T. schinzii* (Pavey 2006). It is found in a fairly wide range of habitats, all associated with the desert sandplains, including stony uplands, lateritic areas, hummock grassland sand plains, mulga scrub and woodlands, drainage depressions and palaeodrainage systems (Southgate 1990). They seem to be strongly associated with lateritic and some other stony areas with sandy soils (containing stone fragments) deep enough to allow burrows to be constructed, and are often within or close to palaeodrainage areas (Southgate 1987). They tend to avoid densely vegetated areas, and a patchwork of different post-fire ages of vegetation is preferred. Fire seems to maintain the sparse vegetation they prefer, and promotes the ephemeral plants used as secondary and primary food sources (Johnson 1989).

The Greater Bilby is not a sedentary species, moving over a wide area according to changing food and vegetation cover conditions (associated with seasons and fires) (Johnson 1989). It is an opportunistic foraging strategy and feeds on seeds, bulbs, and invertebtrates with major dietary components varying across seasons and geographic range (Pavey 2006). Most food is excavated from the soil and holes can be 250 mm in depth. They live in deep burrows excavated in sand that are 2 to 3 meters long, and 100 to

150 mm in diameter, and vacate burrows and reuse old burrows over time. They can breed throughout the year (Pavey 2006).

The current distribution of the species is limited to sandy deserts within the arid and semi-arid zone, with the main population in the Northern Territory being in the Tanami Desert. There are records in the southern region of the Sturt Plateau bioregion and the northern parts of the Great Sandy Desert bioregion.

The southern region of the project area falls within the current distribution for the species. The TNRM Infonet report indicates that 21 records occur within the project area (most recent record from 2011), and an additional eight records in the surrounding region (most recent record from 2011).

Greater Bilby is currently listed as Vulnerable under the *TPWC Act* and the *EPBC Act.* The highest threat to this species is considered to be habitat loss, habitat chance, competition with introduced animals, and predation impacts from introduced animals.

In terms of the project area, Greater Bilby is only expected to occur within EP 168 (based on presence of suitable habitat and recent records). No suitable habitat for the species is present within EP 167.

Potential impacts to this species will be associated with the degradation of desert sand plain land system (Redsan). There have been multiple records in within this land system, with the most recent record from 2011.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within the Redsan land system (desert sand plains) (only occurs within EP 168).
- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies should also include survey for evidence of Greater Bilby (i.e. burrows, diggings, tracks). Surveys can be undertaken any time of year. Surveys should include a detailed habitat assessment of the site.
- Phase 3: If the habitat assessment indicates it is possible that Greater Bilby inhabit the site, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Survey techniques applicable for Greater Bilby detection will be as follows:
    - Spotlighting the site, especially in areas where evidence was located.
    - Installing camera 'traps' (i.e. motion-activated with infra-red for night photography) focused on burrows.
    - Inspection of predator scats (i.e. Feral Cat or Dingo) and nests (i.e. birds of prey) for bones and other evidence.

The abovementioned methods align with the '*Survey Guidelines for Australia's Threatened Mammals*' (Commonwealth of Australia 2011).

If Greater Bilby are detected (or suspected to occur) within the proposed disturbance area, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. In areas where this species is identified, it is likely that the only mitigation will be avoidance of burrows (active or non-active) and areas that are shown to be actively used as foraging grounds.

Any records of this species will be considered to be significant as they will constitute an "important population" due to it being some of the most northern records of the species in recent times.

4.2.10 Pale Field-rat (*Rattus tunneyi*)

The Pale Field-rat (*Rattus tunneyi*) is a medium-sized rodent. They typically occur in lowland Eucalyptus open forests and grasslands that have sandy surface soil characteristics. It has been found to be abundant along creeks or alluvial areas with sandy loam soils (Aplin et al. 2008; Braithwaite and Griffiths 1996) and has also been found in high numbers on hill slopes with rocky or stony surfaces (Woinarski et al. 1992; T. Reilly pers. comm.). It is a nocturnal species that shelters in shallow burrows in loose sandy soils during the day (Aplin et al. 2008). The species' diet consists of grass stems, seeds and roots; and it has a preference for certain species including *Alloteropsis* grass, *Sorghum* seeds, *Pandanus* roots and some sedges (Aplin et al. 2008). Like many other *Rattus sp.*, population numbers can fluctuate substantially with, and between, years (Braithwaite and Griffiths 1996). Young are generally born between January and August (Woinarski et al. 2014).

The distribution of Pale Field-rat within the Northern Territory is limited to the Top End. The northern region of the project area falls within the current distribution for the species. The TNRM Infonet report indicates that there are four records occur within the project area (most recent record from 1998), and an additional five records in the surrounding region (most recent record from 2005). These records are all within the northern part of EP 167.

The Pale Field-rat is currently listed as Vulnerable under the *TPWC Act* and is not listed under the *EPBC Act*. There is a known sharp decline in its abundance (Woinarski et al. 2014). The exact factor for this decline is unknown but it is presumed to be the degradation of its preferred creek line habitats by introduced mammals (Aplin et al. 2008), higher burning frequencies and predation by Feral Cat (Young and Hill 2012).

In terms of the project area, Pale Field-rat may occur within, or along ecotones, of alluvial floodplains adjacent to Eucalyptus communities that have sandy surface soil characteristics. The species is considered to be more likely to occur in EP167, but may occur in the northern area of EP 168, as this area falls close to the southern edge of the known distribution for the species.

To assess the potential risk to this species, the following steps are recommended prior to significant land disturbance from exploration and production activities:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area supports alluvial floodplains adjacent to Eucalyptus communities that have sandy surface soil characteristics.
- Phase 2: If potential habitat is suspected to occur, follow up with onground studies to refine habitat features and update the likelihood of occurrence assessment for the specific disturbance sites. For this species, the onground studies will also include survey for evidence of Pale Field-rat (i.e. burrows, scats, food resources etc.). These surveys can be conducted at any time of year. Surveys should include a detailed habitat assessment of the site.
- Phase 3: If the habitat assessment indicates it is possible that Pale Field-rat inhabit the site, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species likelihood of occurrence. Standard survey techniques applicable for Pale Field-rat detection are a 3-night Elliott trapping program, plus, 20 nights of camera trapping. These surveys can be conducted at any time of year.

If Pale Field-rat are detected (or suspected to occur) within the proposed disturbance area, Pangaea will be required to include appropriate mitigation(s) to reduce the chance of direct impact and degrading suitable habitat – to the satisfaction of the NT EPA. Mitigations may include avoiding areas where they are proven to inhabit.

Any records of this species will be considered to be significant as they will constitute an "important population" due to it being some of the most southern records of the species in recent times.

Sensitive Area	Potential Biodiversity Value
Snappy Gum woodland	Breeding habitat for Gouldian Finch (threatened species)
Alluvial areas	Riparian vegetation, wetlands (sensitive vegetation types) Mertens' Water Monitor, Mitchell's Water Monitor, Red Goshawk, Purple-crowned Fairywren (threatened species)
Desert sandplains	Greater Bilby (threatened species)
Sandstone hills and ridges	On the edge of the 'Arnhem Sandstone Complex' (EPBC threatened ecosystem)
Claypans	Potential habitat for Plains Death Adder (threatened species)

Note that poten ial habitat for three threatened species (Partridge Pigeon, Northern Shrike-tit, and Pale Field-rat) has not been shown on this map as they could occur within a wide range of habitat types. These species are more likley to occur within the northern & central parts of the project area

Potentially Sensitive Areas

Topographical layers
- Homestead
- Town
- Railway
- Gas pipeline
- Watercourse
- Principal Road
- Secondary Road
- Minor Road
- Track

Project area details
- Western Creek Road (proposed upgrade)
- Exploration Permits

Potentially sensitive areas
- Snappy Gum
- Alluvial areas
- Desert Sandplains
- Sandstone Ridges
- Sandstone Hills
- Claypans

0 5 10 20 30
Kilometres

MAP INFORMATION
Scale: 1:900,000 @ A3
Projection: GDA 1994 MGA Zone 53
Date Saved: 25/09/2015
Client: Pangaea Resources Pty. Ltd.
Author: T Reilly (reviewed C Hutchinson)
DATA SOURCE
Imagery: Shaded relief
Tenements: Dept of Mines and Energy
Topographic data: GeoScience Aust.
Sensitive Areas: Land systems, NVIS

Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\Pangaea\EZ15404 - Baseline Studies - Flora Fauna\01 Project Files\Potentially Sensitive Areas v1.mxd

Figure 4-1. Map of Potentially Sensitive Areas within the project area

5 Conclusion

This flora and fauna characterisation report has been designed to be used as a reference document to identify biodiversity values that may be relevant to areas proposed for exploration or production activities. It provides broad-scale environmental descriptions and a detailed review of biodiversity values for the entire project area (EP 167 and EP 168).

In general, this report identifies there is potential for the presence of sensitive vegetation types and threatened species within the project area; subsequently, these may need to be part of environmental risk assessments for future appraisal campaigns (the level of risk will be dependent on location of the appraisal campaigns). However, the biodiversity values mentioned in this document are either associated with habitat types that can be avoided (i.e. swamps) or suitably mitigated through implementation of specifically designed environmental management plans.

5.1 Environmental context

The project area occurs across 27 pastoral properties with approximately 77% of the area used for cattle grazing. The majority of the land tenure is pastoral and perpetual pastoral with smaller areas of Government and crown lease perpetual tenure surrounding the towns of Mataranka and Larrimah to the east and the Delamere Air Weapons Range to the west.

The majority of the project area occurs within the Sturt Plateau which comprises of a gently undulating plain. Vegetation is mostly *Eucalyptus dichromophloia* woodlands with spinifex understorey. There are also large areas of Lancewood thickets (*Acacia shirleyi*), Bulwaddy Woodlands (*Macropteranthes kekwickii*) and open *Eucalyptus* woodlands to the north.

Fifty-seven land systems occur within the project area, with most of the landscape complexity being confined to the far north-west and north-east due to variable topography in these parts. The central part of the project area mainly comprises of lateritic plains and rises, alluvial floodplains, and claypans. The southern area is dominated by desert sandplains.

Thirty-three vegetation types occur within the project area according to NVIS 2005 mapping. Broadly, these vegetation types include tussock grasslands, hummock grasslands, Lancewood woodland/forests, Bulwaddy woodlands, Lysiphyllum woodlands, Eucalyptus woodlands/forests, and Melaleuca woodlands/forests.

Eucalyptus and Corymbia communities are the dominant broad vegetation type within the project area. Melaleuca communities occur along drainages and alluvial floodplains. The southern area is dominated by Lancewood and Bulwaddy thickets and Spinifex (hummock) grasslands (indicating there is an arid zone influence in this area).

No conservation reserves occur within the project area; however, two conservation parks share a small portion of the northern boundary of EP167 – Elsey National Park and Flora River Nature Park (Giwining). The Mataranka Thermal Pools Sites of Conservation Significance fall within the north-eastern corner of EP167, and occurs within Elsey National Park (described above). One EPBC listed threatened ecological community potentially occurs within the far north-east corner of the project area – Arnhem Plateau Sandstone Shrubland Complex.

There are numerous declared weed species and feral animals within the region that will need to be managed via implementation of suitable environmental management plans.

The project area experiences a moderate to low fire frequency, of which many of the burns were late in the season (post June). The majority of the project area has burnt between 1 and 7 times in the past 15 years.

5.2 Biodiversity values

The desktop review identified that the project area potentially supports three sensitive vegetation types and populations of 10 threatened species (listed under the *TPWC Act* and/or the *EPBC Act*).

Sensitive vegetation types:

- Riparian vegetation
- Wetlands
- Arnhem Plateau Sandstone Shrubland Complex ('Arnhem Sandstone Complex')

Threatened species:

- Plains Death Adder (*Acanthophis hawkei*)
- Mertens' Water Monitor (*Varanus mertensi*)
- Mitchell's Water Monitor (*Varanus mitchelli*)
- Red Goshawk (*Erythrotriorchis radiatus*)
- Gouldian Finch (*Erythrura gouldiae*)
- Northern Shrike-tit (*Falcunculus frontatus whitei*)
- Partridge Pigeon (*Geophaps smithii smithii*)
- Purple-crowned Fairy-wren (western) (*Malurus coronatus coronatus*)
- Pale Field-rat (*Rattus tunneyi*)
- Greater Bilby (*Macrotis lagotis*)

These biodiversity values will need to be considered for potential impact as part of environmental approvals.

It is important to note that these values are either sparse across the landscape encompassed by the project area, or they are confined to small areas that are likely outside of the project scope (such as the Arnhem sandstone complex which is located in the far north-east of the project area). Therefore, the location of the proposed works program will determine the level of environmental assessment required. For example, the area proposed for the Western Creek Road upgrade has potential to support four threatened species and two types of sensitive vegetation. Therefore, the road corridor may require onground assessment to confirm the risk to these biodiversity values, and if present, recommend ways to mitigate any impacts.

Several of these biodiversity values are nationally listed matters (i.e. Arnhem Sandstone Complex, Gouldian Finch, Northern Shrike-tit, Red Goshawk, Partridge Pigeon, Purple-crowned Fairy-wren, and Greater Bilby). Consequently, depending on the location of the project footprint, it is possible that the project will trigger the *Environment Protection and Biodiversity Conservation Act 1999* (and therefore Pangaea will be required to submit an EPBC Referral for proposed works).

5.3 Recommendations

- For any significant land disturbance from proposed exploration and production activities, carry out a desktop review to determine which (if any) biodiversity values may be impacted. This should be conducted by a qualified environmental scientist.
- If the desktop review identifies potential presence of a (or multiple) biodiversity value(s), conduct a field-based assessment that includes a habitat description of the proposed disturbance area to determine if the site requires specific management mitigations to avoid impacts to significant biodiversity values (e.g. this may include avoiding the area if threatened species are located).
- If proposed works sites are considered to potentially support threatened species populations, it may be relevant to carry out more detailed surveys of the site to better quantify the extent of populations and recommend ways to mitigate impacts to the species.
- As there are many declared weeds in the region (including along Western Creek Road), weed hygiene will be of high priority. The project should not result in spread or introduction of any declared weed species. A comprehensive weed management plan should be implemented.

6 Acronyms and References

6.1 Acronyms

ASRIS	Australian Soil Resources Information System
BoM	Bureau of Meteorology
DLRM	Department of Land Resource Management
DoE	Department of Environment
EcOz	EcOz Environmental Consultants
EIS	Environmental Impact Statement
EP	Exploration Permit
EPBC Act	Environment Protection and Biodiversity Conservation Act
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for the Conservation of Nature
NRETAS	Natural Resources, Environment and The Arts
NT EPA	Northern Territory Environmental Protection Authority
NT NRM	Northern Territory Natural Resource Management
NVIS	National Vegetation Information System
PMST	Protected Matters Search Tool (associated with the EPBC Act)
SEWPAC	Department of Sustainability, Environment, Water, Population and Communities
TPWC Act	Territory Parks and Wildlife Conservation Act

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Appendix A – Land System Descriptions

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Land System descriptions for the Pangaea Exploration Leases EP167 and EP168

Land System information has been extracted from the Northern Territory Land Systems North (GIS shapefile), which has collated numerous land system surveys to make a single dataset. Land system surveys relevant to this project area - Sturt Plateau, Tipperary, Dry River-Willeroo, Roper, ASRIS, and Ord-Victoria.

Land System	Land form and vegetation
Alluvial Floodplains	
Banyan	***Landform*** – Major river plains; frontage country; dissected by gullies. ***Vegetation*** – Tall woodland of *Eucalyptus tectifica*, *Corymbia foelscheana*, *E. patellaris*, *C. grandifolia* over tropical tall grass (*Themeda australis*, *Sorghum* spp., *Chrysopogon* spp., *Heteropogon contortus*)
Coolibah	***Landform*** – Level to gently undulating plains on unconsolidated transported materials, rarely sedentary ***Vegetation*** – Mid-high open woodland of *Eucalyptus microtheca*, *Excoecaria parvifolia* over *Chrysopogon fallax*, *Sorghum plumosum*, *Aristida* spp.
Ivanhoe 1	***Landform*** – Level alluvial floodplains ***Vegetation*** – Very tall grassland of *Dichanthium* spp., *Sorghum* spp., *Eulalia aurea* with emergent *Eucalyptus microtheca*, *Bauhinia cunninghamii*
Jundee	***Landform*** – Minor braided creek systems on the Sturt Plateau ***Vegetation*** – Tall open woodland of *Corymbia grandifolia*, *Eucalyptus microtheca*, *C. ferruginea*, *C. terminalis*, *E. leucophloia* over a dense grass cover (*Themeda australis*, *Sorghum plumosum*, *Aristida latifolius*)
Karaman	***Landform*** – Tributary alluvial plains with extensive sandy slopes ***Vegetation*** – Tall woodland of *Corymbia papuana*, *C. ferruginea*, *Gyrocarpus americanus*, *Erythrophleum chlorostachys*, *Eucalyptus tectifica* over tropical tall grass (*Sorghum plumosum*, *Sehima nervosum*, *Aristida browniana*)
Mataranka	***Landform*** – Older, partly dissected evaporite deposits ***Vegetation*** – Mid-high open woodland of *Corymbia terminalis*, *Eucalyptus patellaris*, *Terminalia arostrata*, *Brachychiton diversifolius*, *C. confertiflora* over mid-dense to dense grass cover (*Sehima nervosum*, *Heteropogon contortus*, *Themeda triandra*)
McArthur	***Landform*** – Broad or narrow fluvial corridors conducting regional drainage across various land systems towards the coast ***Vegetation*** – Mid-high open woodland of *Corymbia terminalis*, *Eucalyptus microtheca*, *Excoecaria parvifolia*, *Bauhinia cunninghamii*, *C. papuana* over *Chrysopogon spp.*, *Eulalia fulva*, *Iseilema vaginiflorum*
Warloch	***Landform*** – Alluvial floodplains on the Sturt Plateau ***Vegetation*** – Low open woodland of *Eucalyptus microtheca*, *Excoecaria parvifolia*, *Corymbia terminalis*, *E. patellaris* over *Sehima nervosum*, *Heteropogon contortus*
Western	***Landform*** – Active flood plains ***Vegetation*** – Low open woodland of *Eucalyptus microtheca*, *Bauhinia cunninghamii*, *Excoecaria parvifolia*, *Corymbia terminalis*, *C. grandifolia* over *Sorghum plumosum*, *Aristida latifolia*, *Dichanthium fecundum*
Wongalla	***Landform*** – Tributary river plains ***Vegetation*** – Tall closed grassland of *Sorghum plumosum*, *Dichanthium fecundum*, *Sehima nervosum* with a very open woodland (*Eucalyptus microtheca*, *Bauhinia cunninghamii, Acacia bidwillii*)

Land System	Land form and vegetation
Wulkulyi	***Landform*** – Seasonal and perennial swamps and poorly drained, low lying areas ***Vegetation*** – Mid-high woodland of *Melaleuca nervosa*, *M. symphyocarpa*, *Excoecaria parvifolia*, *M. viridiflora*, *Corymbia polycarpa* over *Pseudoraphis spinescens*, *Chrysopogon fallax*, *Sorghum plumosum*
Basalt Hills	
Cliffdale	***Landform*** – Gently undulating to hilly terrain on basalt, dolerite, agglomerate and other volcanic and sometimes non-volcanic rocks ***Vegetation*** – Mid-high open woodland of *Eucalyptus pruinosa*, *E. tectifica*, *Corymbia terminalis*, *Erythrophleum chlorostachys*, *Brachychiton diversifolius* over *Chrysopogon fallax*, *Sehima nervosum*, *Sorghum plumosum*
Claypans	
Atlas_II6	No description available
Larrimah	***Landform*** – Relict flood plains ***Vegetation*** – Tall sparse shrubland of *Carissa lanceolata, Ventilago viminalis*, *Terminalia volucris* with scattered trees (*Bauhinia cunninghamii*, *Atalaya hemiglauca*, *Eucalyptus microtheca*) over *Aristida* spp., *Sorghum* sp, *Astrebla squarrosa*
Desert Sand Plains	
Redsan	No description available
Lateritic Plains and Rises	
Banjo	***Landform*** – Gently undulating to almost level plains ***Vegetation*** – Mid-high open woodland of *Eucalyptus patellaris*, *Corymbia terminalis*, *C. ferruginea*, *Erythrophleum chlorostachys*, *C. dichromophloia* over *Chrysopogon latifolius*, *Themeda australis*, *Sehima nervosum*
Birrimbah	No description available
Birrimbah 1	***Landform*** – Gently undulating plains, predominantly broad gravelly rises and slopes ***Vegetation*** – Mid-high woodland of *Corymbia terminalis*, *Eucalyptus tetrodonta*, *E. tectifica*, *E. patellaris, C. ferruginea* over *Cymbopogon bombycinus*, *Chrysopogon* spp., *Sorghum* spp.
Birrimbah 2	***Landform*** – Gently undulating plains on western margin of the Sturt Plateau ***Vegetation*** – Mid-high open woodland of *Eucalyptus tectifica*, *E. pruinosa*, *Bauhinia cunninghamii*, *Macropteranthes kekwickii*, *Erythrophleum chlorostachys* over *Sehima nervosum*, *Chrysopogon fallax, Themeda triandra*
Brolga	***Landform*** – Almost level plains with few infilled sink holes ***Vegetation*** – Mid-high open woodland of *Corymbia ferruginea*, *Eucalyptus tetrodonta*, *E. miniata*, *C. terminalis*, *Erythrophleum chlorostachys* over *Triodia pungens*, *Sehima nervosum*, *Themeda australis*
Bulwaddy	***Landform*** – Generally undulating rises comprising frequent rises and associated slopes, almost level residual plains and closed clay depressions ***Vegetation*** – Mid-high open woodland of *Eucalyptus patellaris*, *Corymbia ferruginea*, *C. dichromophloia*, *Erythrophleum chlorostachys*, *C. terminalis* over *Sorghum plumosum*, *Sehima nervosum*, *Chrysopogon latifolius*
Cambell	***Landform*** – Low level plains ***Vegetation*** – Mid high woodland of *Corymbia dichromophloia*, *C. ferruginea*,

Land System	Land form and vegetation
	Erythrophleum chlorostachys, *Eucalyptus tetrodonta*, *E. patellaris*, *C. terminalis* over *Triodia bitextura*, *Sehima nervosum* and *Themeda triandra*
Claravale	***Landform*** – Gently undulating sandy terrain ***Vegetation*** – Tall open forest of *Eucalyptus miniata*, *E. tetrodonta*, *Corymbia bleeseri*, *Erythrophleum chlorostachys*, *C. dichromophloia* over spinifex tall grass (*Sorghum* spp., *Sehima nervosum*, *Heteropogon triticeus*)
Claravale depressed	***Landform*** – Colluvial slopes and alluvial drainage floors ***Vegetation*** – Low woodland of *Melaleuca viridiflora*, *Petalostigma* sp, *Grevillea decurrens*, *Cochlospermum* sp and *Petalostigma pubescens* over *Sorghum* sp, *Schizachyrium* sp, *Eriachne* spp.
Elsey	***Landform*** – Gently undulating to almost level plains characterised by large closed depressions ***Vegetation*** – Tall open woodland of *Eucalyptus tetrodonta*, *Erythrophleum chlorostachys*, *Corymbia ferruginea*, *Eucalyptus tectifica*, *C. terminalis* over a moderately dense perennial grass cover (*Triodia pungens*, *Sehima nervosum*, *Chrysopogon* spp.).
Forrest	***Landform*** – Gently sloping sandy surfaced plains with few indistinct drainage depressions ***Vegetation*** – Mid-high open woodland of *Corymbia ferruginea*, *C. terminalis*, *Eucalyptus tetrodonta*, *Erythrophleum chlorostachys* over *Triodia pungens*, *Chrysopogon latifolius*, *Sehima nervosum*
Hawk	***Landform*** – Gently undulating plains on weathered sandstone shale and mudstone ***Vegetation*** – Mid-high open woodland of *Corymbia terminalis*, *E. pruinosa*, *C. grandifolia*, *Gyrocarpus americanus*, *Eucalyptus tectifica* over *Sehima nervosum*, *Sorghum* spp., *Eulalia aurea*
Keckwick	***Landform*** – Low rises and crests along margins of Sturt plateau ***Vegetation*** – Mid-high open forest (*Macropteranthes kekwickii*, *Acacia shirleyi* and *Eucalyptus leucophloia* over *Enneapogon polyphyllus*, *Cymbopogon bombycinus*, *Chrysopogon latifolius*
McGorrery	***Landform*** – Eroded upper catchments ***Vegetation*** – Mid-high open woodland of *Eucalyptus pruinosa*, *Bauhinia cunninghamii*, *Erythrophleum chlorostachys* over *Themeda australis*, *Chrysopogon latifolius*, *Aristida* spp.
Mering	***Landform*** – Undulating low gravely crests and slopes with isolated ridges ***Vegetation*** – Very variable, mid-high open woodland of *Corymbia ferruginea*, *C. terminalis, E. patellaris* over *Triodia bitextura*, *Chrysopogon latifolius*, *Sorghum plumosum*
Mueller	***Landform*** – Undulating low hills and stony slopes ***Vegetation*** – Low open woodland of *Terminalia canescens*, *Eucalyptus leucophloia*, *Erythrophleum chlorostachys* over *Sorghum plumosum*, *Cymbopogon bombycinus*
Newman	***Landform*** – Internal drainage systems ***Vegetation*** – Low woodland of *Melaleuca minutifolia*, *M. viridiflora*, *Terminalia platyptera*, *Erythrophleum chlorostachys*, *Corymbia ferruginea* over *Sorghum* sp, *Schizachyrium* sp, *Eriachne ciliaris*
Sturt	***Landform*** – Level to undulating plains on the Sturt Plateau ***Vegetation*** – Mid-high open woodland of *Eucalyptus patellaris*, *E. argillacea*, *Erythrophleum chlorostachys*, *Corymbia terminalis*, *C. confertiflora* over a dense grass cover (*Chrysopogon latifolius*, *Sehima nervosum*, *Sorghum plumosum*)
Woggaman 1	***Landform*** – Undulating terrain on deeply weathered Cretaceous sandstone and siltstone ***Vegetation*** – Low open forest of *Corymbia ferruginea*, *C. setosa*, *Eucalyptus tetrodonta*,

Land System	Land form and vegetation
	C. confertiflora, *Erythrophleum chlorostachys* over sparse spinifex tall grass (*Sorghum* spp, *Sorghum plumosum*, *Triodia pungens*)
Yungman	***Landform*** – Gently undulating sandy terrain and low hills on deeply weathered Cretaceous sandstone and siltstone ***Vegetation*** – Mid-high open forest of *Eucalyptus tetrodonta*, *Corymbia bleeseri*, *E. miniata*, *Erythrophleum chlorostachys*, *C. ferruginea* over spinifex tall grass (*Triodia pungens*, *Sorghum* spp., *Heteropogon triticeus*)
Mais	***Landform*** – Low broken plateaux with extensive stony surfaces and steep slopes ***Vegetation*** – Mid-high open woodland of *Eucalyptus tectifica*, *Terminalia canescens*, *Erythrophleum chlorostachys*, *Terminalia platyptera* over *Cymbopogon bombycinus*, *Sorghum* spp., *Aristida* spp.
Mullaman 1	***Landform*** – High plateaux with extensive sandy surfaces ***Vegetation*** – Tall open forest of *Eucalyptus tetrodonta*, *E. miniata*, *Corymbia bleeseri*, *Callitris columellaris*, *C. dichromophloia* over spinifex tall-grass (*Triodia pungens*, *Sorghum* spp., *Heteropogon triticeus*)
Mullaman 3	***Landform*** – Margins of the Sturt Plateau with low scarps ***Vegetation*** – Mid-high woodland of *Corymbia dichromophloia*, *Eucalyptus tetrodonta*, *Petalostigma* sp, *Acacia* sp over *Triodia bitextura*, *Chrysopogon latifolius*, *Sorghum plumosum*
Mullaman dissected 3	***Landform*** – Gently undulating plateau margins ***Vegetation*** – Low open woodland of *Eucalyptus tectifica*, *Corymbia foelscheana*, *Erythrophleum chlorostachys*, *C. polysciada*, *Eucalyptus tetrodonta* over *Triodia bitextura*, *Aristida* spp, *Schizachyrium fragile*
Mullaman Scarp	***Landform*** – Gently undulating plateau margins ***Vegetation*** – Mid-high woodland of *Corymbia terminalis*, *Eucalyptus tetrodonta*, *E. tectifica*, *E. patellaris*, *C. ferruginea* over *Cymbopogon bombycinus*, *Chrysopogon* spp., *Sorghum* spp.
Weston	***Landform*** – Dissected plateaux and low hills on weathered Cretaceous sediments with intervening valleys and sandy lower slopes on Kombolgie or Bukalara Sandstones ***Vegetation*** – Mid-high open woodland of *Eucalyptus tetrodonta*, *Corymbia dichromophloia*, *C. kombolgiensis*, *C. bleeseri*, *E. miniata* over *Triodia pungens*, *Chrysopogon fallax*, *Sorghum plumosum*
Yujullowan	***Landform*** – Low broken plateaux with extensive stony surfaces on deeply weathered Cretaceous sandstone and siltstone ***Vegetation*** – Tall open forest of *Corymbia bleeseri*, *Eucalyptus tetrodonta*, *E. miniata*, *C. dichromophloia*, *E. umbrawarrensis* over spinifex tall grass (*Triodia pungens*, *Sorghum* spp., *Heteropogon triticeus*)
Limestone plains and rises	
Beemla	***Landform*** – Undulating plains and rises ***Vegetation*** – Tall open forest of *Eucalyptus tetrodonta*, *E. miniata*, *Corymbia bleeseri*, *Erythrophleum chlorostachys*, *Eucalyptus tectifica* over spinifex tall-grass (*Triodia pungens*, *Sorghum* spp., *Heteropogon triticeus*)
Birdum	***Landform*** – Low broken plateaux with extensive rubble-strewn surfaces ***Vegetation*** – Mid-high open woodland of *Corymbia terminalis*, *Eucalyptus tectifica*, *E. patellaris*, *C. ferruginea*, *E. argillacea*, over *Sehima nervosum*, *Chrysopogon latifolius*, *Themeda australis*
Blain	***Landform*** – Gently sloping sandy plains on colluvium overlying deeply weathered Cambrian sandstone, siltstone and limestone

Land System	Land form and vegetation
	Vegetation – Tall open forest of *Eucalyptus tetrodonta*, *Erythrophleum chlorostachys*, *Corymbia dichromophloia*, *C. foelscheana*, *Eucalyptus miniata* over tropical grass (*Sorghum* spp., *Themeda australis*, *Chrysopogon fallax*)
Budbudjong	***Landform*** – Undulating limestone terrain with scattered low outcrop ***Vegetation*** – Mid-high woodland of *Corymbia foelscheana*, *Eucalyptus tectifica*, *E. argillacea*, *Erythrophleum chlorostachys*, *C. confertiflora* over dense tropical tall grass (*Themeda australis*, *Sorghum plumosum*, *Sehima nervosum*)
Chinaman	***Landform*** – Undulating plains and rises ***Vegetation*** – Low-woodland of *Eucalyptus tectifica*, *Corymbia foelscheana*, *C. confertiflora*, *C. grandifolia*, *E. patellaris* with scattered spinifex grassland (*Sorghum plumosum*, *Chrysopogon* spp., *Sehima nervosum*)
Jindara	***Landform*** – Undulating terrain on weathered and unweathered sandstone, siltstone and limestone ***Vegetation*** – Mid-high woodland of *Eucalyptus tectifica*, *Corymbia foelscheana*, *C. confertiflora*, *C. grandifolia*, *E. patellaris* over tropical tall grass (*Themeda australis*, *Sorghum plumosum*, *Chrysopogon* spp.)
Kimbyan	***Landform*** – Gently undulating plains on Cambrian limestone, sandstone and siltstone ***Vegetation*** – Tall woodland of *Corymbia foelscheana*, *Eucalyptus tectifica*, *C. confertiflora*, *C. grandifolia*, *E. patellaris* over tropical tall grass (*Sorghum plumosum*, *Themeda australis*, Sehima nervosum)
Tagoman	***Landform*** – Gently undulating terrain on Cambrian sandstone, siltstone and limestone ***Vegetation*** – Mid-high woodland of *Eucalyptus tectifica*, *Corymbia foelscheana*, *C.confertiflora*, *Erythrophleum chlorostachys*, *C. grandifolia* over tropical tall grass (*Panicum delicatum*, *Eragrostis* spp., *Eriachne* spp.)
Wallingin	***Landform*** – Gently undulating sandy terrain on deeply weathered sub-horizontally bedded Cretaceous sandstone and siltstone ***Vegetation*** – Low woodland of *Eucalyptus tectifica*, *Corymbia grandifolia*, *Erythrophleum chlorostachys*, *C. foelscheana*, *C. confertiflora* over patchy tropical and spinifex tall grass (*Aristida* spp., *Sorghum plumosum*, *Themeda australis*)
Wriggley	***Landform*** – Plains on relatively unweathered limestone, sandstone and siltstone ***Vegetation*** – Low woodland of *Corymbia foelscheana*, *Eucalyptus tectifica*, *C. confertiflora*, *E. tetrodonta*, *C. grandifolia* over dense tropical tall grass (*Themeda australis*, *Sorghum plumosum*, *Sehima nervosum*, *Heteropogon triticeus*)
Rugged quartz sandstone plateaux and hills	
Bukalara	***Landform*** – Rugged rocky plateaux and steep, linear ridges, on massive sandstones such as the Bukalara and Kombolgie Sandstones ***Vegetation*** – Mid-high open woodland of *Corymbia dichromophloia*, *Eucalyptus miniata*, *E. tetrodonta*, *Erythrophleum chlorostachys* over *Triodia pungens*, *Chrysopogon fallax*, *Eriachne obtusa*
Sandstone plains and rises	
Downs	***Landform*** – Gently undulating plains and rises on mainly fine-grained sandstones ***Vegetation*** – Mid-high woodland of *Melaleuca viridiflora*, *Corymbia polycarpa*, *C. latifolia*, *Erythrophleum chlorostachys*, *Brachychiton diversifolius* over *Chrysopogon fallax*, *Sorghum plumosum*, *Themeda triandra*
Fleabitten	***Landform*** – Gently undulating plain with a sandy lag overlying previously deflated karst limestones (Tindall) ***Vegetation*** – Mid-high open woodland of *Erythrophleum chlorostachys*, *Brachychiton*

Land System	Land form and vegetation
	diversifolius, *Eucalyptus tectifica*, *Corymbia confertiflora*, *C. grandifolia* over mid-dense grass cover (*Chrysopogon fallax*, *Heteropogon contortus*, *Aristida* spp.)
Patterson	***Landform*** – Low hills, rises and undulating areas on reddish platy sandstones and siltstones, often micaceous ***Vegetation*** – Mid -high open woodland of *Eucalyptus leucophloia*, *Acacia shirleyi*, *E. tectifica*, *Corymbia grandifolia*, *C. ferruginea* over very sparse grass cover (*Triodia pungens*, *Eriachne obtusa*, *Chrysopogon fallax*)
Seigal	***Landform*** – Gently undulating to undulating rises with abundant, often linear rocky outcrops ***Vegetation*** – Mid-high open woodland of *Eucalyptus miniata, E. tetrodonta*, *Corymbia ferruginea*, *C. dichromophloia*, *Callitris intratropica* over *Triodia pungens*, *Sorghum plumosum*

Appendix B – Vegetation Type Descriptions (NVIS level 4)

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Vegetation community descriptions (NVIS Level 4) (NVIS 2005)	
Unit	**NVIS description** (NVIS level 4 description top row; landform description bottom row)
Grassland communities	
428	**Astrebla low tussock grassland** - M ^Acacia victoriae, Acacia farnesiana\^shrub\4\r;G+ ^Astrebla pectinata, Iseilema vaginiflorum+/-Iseilema membranaceum\^tussock grass\1\c
	Plains, deep grey cracking clays over tertiary alluvium
336	**Chrysopogon (mixed) low tussock grassland** - U ^Euc microtheca+/-Terminalia platyphylla+/-Ventilago viminalis\^tree\6\r; M ^Carissa lanceolata, Excoecaria parvifolia, Hakea chordophylla\^shrub\3\r;G+ ^Chrysopogon fallax, Aristida latifolia, Eulalia aurea\^tussock grass\1\c
	Associated with floodplains of water courses, heavy grey clay alluvial soils
569	**Chrysopogon (mixed) tussock grassland** - U ^Euc pruinosa+/- Lysiphyllum cunninghamii+/-Euc terminalis\^tree\6\i;M ^Carissa lanceolata\^shrub\3\r;G+ ^Chrysopogon fallax, Iseilema vaginiflorum, Dichanthium fecundum\^tussock grass\2\c
	Flat plains, heavy grey to black cracking clays
868	**Triodia low open hummock grassland** - U ^Euc pruinosa,Corymbia opaca+/-Euc setosa\^tree\6\bi;M ^Acacia stipuligera+/-Grevillea wickhamii\^shrub\4\r;G+ ^Triodia pungens,Triodia schinzii+/-Yakirra australiensis\^hummock grass,tussock grass\1\i
	Red siliceous sandy soils
Acacia communities	
390	**Acacia low open forest** - U+ ^Acacia shirleyi\^tree\6\c;G ^Eriachne ciliata,Schizachyrium fragile,Chrysopogon fallax\^tussock grass\1\i
	Lateritic sandstone outcrops,plateaux,breakaways to north/rises and plains to south;gravelly lithosols,some shallow red,yellow and black earths;well drained
391	**Acacia low woodland** - U+ ^Acacia shirleyi\^tree\6\i;G ^Eriachne ciliata,Paspalidium rarum,Schizachyrium fragile\^tussock grass\1\i
	Lateritic sandstone outcrops,plateaux,breakaways to north/rises and plains to south;gravelly lithosols,some shallow red,yellow and black earths;well drained
395	**Acacia low woodland** - U+ ^Acacia shirleyi,Macropteranthes kekwickii\^tree\6\i;G ^Eragrostis cumingii,Mnesithea formosa,Paspalidium rarum\^tussock grass\1\i
	Lateritic sandstone outcrops,plateaux,breakaways to north/rises and plains to south;gravelly lithosols,some shallow red,yellow and black earths;well drained
364	**Acacia open forest** - U+ ^Acacia shirleyi+/-Macropteranthes kekwickii+/-Corymbia dichromophloia\^tree\7\c;M ^Acacia shirleyi,Flueggea virosa,Acacia lysiphloia\^shrub\4\i;G ^Chrysopogon fallax,Enneapogon oblongus,Aristida pruinosa\^tussock grass\1\i
	Rises with rocky skeletal soils extending onto shallow gravelly sands in drier areas
392	**Acacia woodland** - U+ ^Acacia shirleyi,Euc spp.\^tree\7\i;G ^Eriachne ciliata,Chrysopogon fallax,Paspalidium rarum\^tussock grass\2\i
	Lateritic sandstone outcrops,plateaux,breakaways to north/rises and plains to south;gravelly lithosols,some shallow red,yellow and black earths;well drained
Bulwaddy communities	
394	**Macropteranthes (mixed) low woodland** - U+ ^Macropteranthes kekwickii,Acacia shirleyi\^tree\6\i;G ^Chrysopogon fallax,Paspalidium rarum,Mnesithea formosa\^tussock grass\2\i
	Lateritic sandstone outcrops,plateaux,breakaways to north/rises and plains to south;gravelly lithosols,some shallow red,yellow and black earths;well drained
1043	**Macropteranthes low open forest** - U+ ^Macropteranthes kekwickii,Lysiphyllum cunninghamii,Acacia shirleyi\^tree\6\c;G ^Aristida inaequiglumis,Setaria apiculata,Melhania oblongifolia\^tussock grass,shrub\1\i
	Undulating plains, sandy or gravelly lateritic soils, flankning shallow drainage floors
393	**Macropteranthes low woodland** - U+ ^Macropteranthes kekwickii,Acacia shirleyi\^tree\6\i;G ^Panicum mindanaense,Evolvulus alsinoides\^tussock grass,forb\1\i
	Lateritic sandstone outcrops,plateaux,breakaways to north/rises and plains to south;gravelly lithosols,some shallow red,yellow and black earths;well drained

Vegetation community descriptions (NVIS Level 4) (NVIS 2005)	
Unit	**NVIS description** (NVIS level 4 description top row; landform description bottom row)
Lysiphyllum communities	
355	**Lysiphyllum low open woodland** - U+ ^Lysiphyllum cunninghamii,Euc pruinosa+/-Euc terminalis\^tree\6\r;M ^Atalaya hemiglauca,Acacia lysiphloia+/-Lysiphyllum cunninghamii\^shrub\3\r;G ^Eulalia aurea,Chrysopogon fallax,Sorghum plumosum\^tussock grass\1\c
	Low lying flat to gently undulating plains, poor to moderately drained, medium to heavy clay soils
Eucalyptus / Corymbia communities	
331	**Corymbia low woodland** - U+ ^Cory dichromophloia,Euc leucophloia+/-Corymbia ferruginea\^tree\6\i;M ^Terminalia canescens,Petalostigma pubescens,Erythrophleum chlorostachys\^shrub\3\r;G ^Chrysopogon fallax,Triodia bitextura,Grewia retusifolia\^tussock grass,hummock grass,shrub\1\
	Gently undulating plains, shallow red to yellow, gravelly, sandy earths or stoney sands
326	**Corymbia woodland** - U+ ^Corymbia dichromophloia,Euc tetrodonta,Erythrophleum chlorostachys\^tree\7\i;M Erythrophleum chlorostachys,^Euc tetrodonta,Croton arnhemicus\^tree\6\r;G ^Sorghum intrans,Heteropogon triticeus,Themeda triandra\^tussock grass\2\c
	Flat to gently sloping plains, moderately deep and well drained red earth soils
1042	**Eucalyptus low open woodland** - U+ Lysiphyllum cunninghamii,Corymbia opaca,^Euc pruinosa\^tree\6\r;M Carissa lanceolata,^Acacia lysiphloia,Atalaya hemiglauca\^shrub\3\i;G ^Triodia pungens,Chrysopogon fallax,Enneapogon polyphyllus\tussock grass,^hummock grass\1\c
	Gentle undulating plains, deep sandy yellow earths, lateritic red earths , or deep sands
1041	**Eucalyptus low open woodland** - U+ ^Euc microtheca+/-Lophostemon grandiflorus+/-Ventilago viminalis\^tree\6\r;M ^Acacia holosericea,Atalaya hemiglauca+/-Ventilago viminalis\^shrub\3\r;G Eulalia aurea,Chrysopogon fallax,^Astrebla spp.\^tussock grass\1\c
	Low lying flat plains, fringing water courses and swamps. Light to heavy grey and brown clays, some loamy soil
365	**Eucalyptus low woodland** - U+ Acacia shirleyi,^Euc leucophloia+/-Corymbia dichromophloia\^tree\6\i;M ^Acacia shirleyi,Terminalia canescens,Cochlospermum fraseri\^shrub\3\r;G ^Eriachne obtusa,Brachyachne convergens,Triodia pungens\^tussock grass,hummock grass\1\i
	Crests and slopes of sandstone hills and low hills with rock outcrops, on lateritic breakaways, well drained, gravelly lithosols, some shallow red, yellow and black earths
334	**Eucalyptus low woodland** - U+ ^Euc pruinosa+/-Euc terminalis+/-Melaleuca citrolens\^tree\6\i;M ^Carissa lanceolata,Flueggea virosa subsp. melanthesoides\^shrub\3\r;G ^Chrysopogon fallax,Sehima nervosum+/-Themeda triandra\^tussock grass\2\c
	Flat to gently undulating plains and on lower slopes of hills, deep red or yellow earths, some clayey loam to clay soils
441	**Eucalyptus open forest** - U+ ^Euc miniata,Euc tetrodonta,Erythrophleum chlorostachys\^tree\7\c;M ^Livistona humilis,Cycas armstrongii,Acacia oncinocarpa\^palm,cycad,shrub\6\r;G ^Heteropogon triticeus,Sorghum plumosum,Chrysopogon fallax\^tussock grass\3\c
	Undulating low plateaux and peneplains and rises and upper slopes of ridges. Soils vary from deep, well drained, yellow to red earthy sands, varying amounts of lateritic gravels, shallow, sandier soils are common
572	**Eucalyptus woodland** - U+ ^Euc tectifica,Erythrophleum chlorostachys,Corymbia latifolia\^tree\7\i;M ^Erythrophleum chlorostachys,Terminalia ferdinandiana,Petalostigma pubescens\^tree\6\r;G ^Sorghum spp.,Heteropogon triticeus,Chrysopogon fallax\^tussock grass\2\c
	Undulating rises and plains, extending onto low hills. Soils, moderately drained loams and sandy loams. Some rock outcrops occur on hillier portions

Vegetation community descriptions (NVIS Level 4) (NVIS 2005)	
Unit	**NVIS description** (NVIS level 4 description top row; landform description bottom row)
1018	**Eucalyptus woodland** - U+ ^Euc tetrodonta,Euc miniata,Corymbia bleeseri\^tree\7\i;M ^Erythrophleum chlorostachys,Buchanania obovata,Euc tetrodonta\^tree\6\r;G ^Chrysopogon fallax,Triodia bitextura,Sorghum plumosum\^tussock grass,hummock grass\1\c
	Gently sloping or undulating lateritic plateaux. Soils, sandy or gravelly with some sandy loams and loams, extremely low fertility and moisture holding capacities
328	**Eucalyptus woodland** - U+ ^Euc patellaris,Euc terminalis+/-Euc confertiflora\^tree\7\i;M ^Hakea arborescens,Carissa lanceolata,Planchonia careya\^shrub\4\r;G ^Heteropogon contortus,Chrysopogon fallax,Sehima nervosum\^tussock grass\2\c
	Plains, moderately well drained red earths and clay soils
324	**Eucalyptus woodland** - U+ ^Euc tectifica,Euc terminalis,Erythrophleum chlorostachys\^tree\7\i;M ^Flueggea virosa,Terminalia canescens,Carissa lanceolata\^shrub\3\r;G ^Sehima nervosum,Chrysopogon fallax,Sorghum plumosum\^tussock grass\2\c
	Flat to undulating plains, mainly loam to clay loam soils
Melaleuca communities	
332	**Melaleuca low open woodland** - U+ ^Melaleuca acacioides,Melaleuca viridiflora+/-Acacia leptocarpa\^tree\6\r;G ^Sporobolus virginicus var. minor,Ectrosia leporina,Eriachne obtusa\forb,^tussock grass\1\i
	Low open woodland, plains
361	**Melaleuca low open woodland** - U+ ^Melaleuca viridiflora+/-Euc polycarpa+/-Corymbia latifolia\^tree\6\r;M ^Pandanus spiralis,Livistona humilis,Grevillea pteridifolia\shrub,^palm\4\r;G ^Chrysopogon fallax,Themeda avenacea,Sorghum spp.\^tussock grass\2\c
	Poorly drained sites fringing water courses or in drainage depressions. Soils range from yellow podzolics to yellow earths and gravelly sands
325	**Melaleuca low woodland** - U+ ^Melaleuca citrolens,Melaleuca minutifolia+/-Euc pruinosa\^tree\6\i;M Carissa lanceolata,^Melaleuca citrolens,Melaleuca stenostachya\^shrub\3\r;G ^Eulalia aurea,Chrysopogon fallax,Triodia microstachya\forb,^tussock grass,hummock grass\1\i
	Low woodland/open woodland, plains/relict drainage fringe
320	**Melaleuca low woodland** - U+ ^Melaleuca viridiflora,^Melaleuca cajuputi+/-Melaleuca dealbata\^tree\6\i;M ^Pandanus spiralis,Melaleuca viridiflora,Barringtonia acutangula\tree,^palm\6\r;G ^Eleocharis brassii,Eleocharis sphacelata,Hymenachne acutigluma\forb,^sedge,tussock grass\2\c
	Low woodland, drainage flats
360	**Melaleuca open forest** - U+ ^Melaleuca leucadendra,Melaleuca argentea+/-Melaleuca cajuputi\^tree\7\c;M ^Pandanus spiralis,Barringtonia acutangula,Pandanus aquaticus\tree,^palm\6\r;G ^Germainia truncatiglumis,Vetiveria spp.,Pseudoraphis spinescens\forb,^tussock grass\2\i
	Open-forest, riparian/springs
349	**Melaleuca open forest** - U+ ^Melaleuca cajuputi,Melaleuca acacioides,Timonius timon\^tree\7\c;M ^Acacia ampliceps,Timonius timon,Melaleuca acacioides\^shrub\4\i;G ^Melaleuca cajuputi,Acacia ampliceps,Timonius timon\forb,^shrub\2\r
	Open-forest, depression
316	**Melaleuca woodland** - U+ ^Melaleuca viridiflora,Melaleuca leucadendra+/-Melaleuca argentea\^tree\7\i;M Barringtonia acutangula,^Melaleuca viridiflora,Pandanus aquaticus\^tree,palm\6\r;G ^Chrysopogon fallax,Heteropogon contortus,Pseudoraphis spinescens\forb,^tussock grass\2\i
	Woodland, river/creekline
321	**Melaleuca woodland** - U+ ^Mel nervosa,Mel viridiflora+/-Melaleuca dealbata\^tree,shrub\7\i;M ^Asteromyrtus symphyocarpa,Mel viridiflora,Grevillea pteridifolia\^tree\6\r;G ^Triodia pungens,Pseudoraphis spinescens,Schizachyrium spp.\forb,^hummock grass,tussock grass\1\i
	Low woodland, drainage flats

Vegetation community descriptions (NVIS Level 4) (NVIS 2005)	
Unit	**NVIS description** (NVIS level 4 description top row; landform description bottom row)
383	**Melaleuca woodland** - U+ ^Mel viridiflora,Melaleuca leucadendra+/-Euc polycarpa var. polycarpa\^tree\7\i;M ^Melaleuca viridiflora,Sesbania cannabina,Melaleuca leucadendra\^tree,shrub\6\r;G Pseudoraphis spinescens,^Fimbristylis spp.,Eleocharis dulcis\tussock grass,^sedge\1\i
	Woodland/open-forest, billabongs

Appendix C – TNRM Infonet Threatened Species Report

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Territory Natural Resource Management

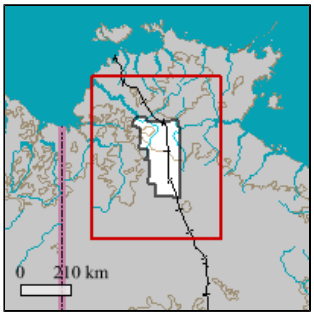
Northern Territory Government

CHARLES DARWIN UNIVERSITY

Areas

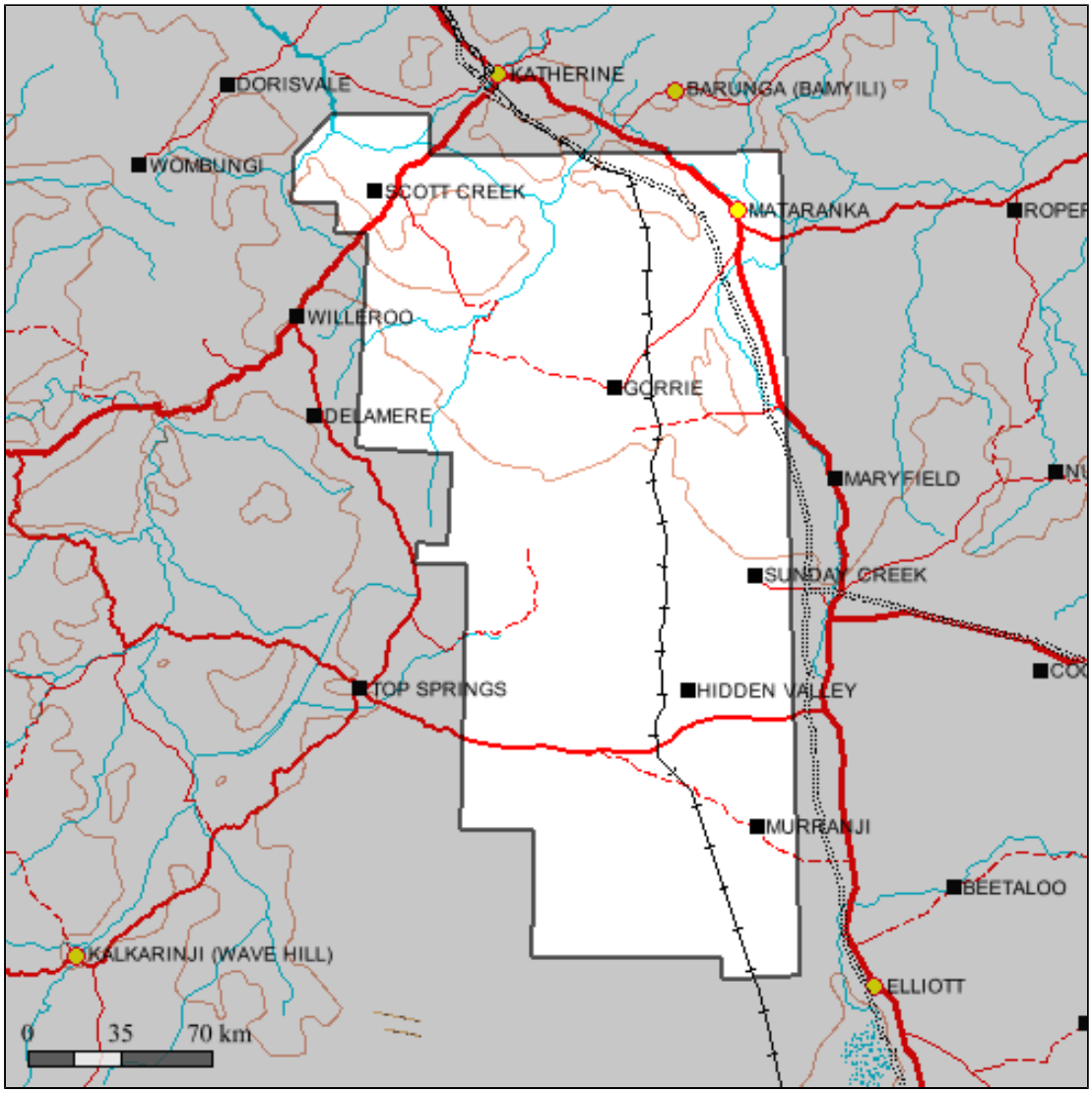
NT NRM Report

Areas



Areas encompasses an area of 40102.82 sq km extending from 14 deg 36.0 min to 17 deg 31.0 min S and 131 deg 33.0 min to 133 deg 17.0 min E.
Areas is located in the Mitchell Grass Downs, Gulf Fall and Uplands, Sturt Plateau, Daly Basin, Ord Victoria Plain, bioregion(s)

Location of Areas



Areas Threatened Species

Threatened species recorded in Areas (Records Updated: Sept 2013)

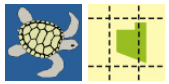
Group	Common Name	Scientific Name	NT Status	National Status	ID	#Observations (Latest)	#Specimens (Latest)	#Surveys (Latest)
Cycads	Armstrong`s Cycad	*Cycas armstrongii*	VU	.	351085	0 (Unknown)	0 (Unknown)	1 (1996)
Reptiles	Gulf Snapping Turtle	*Elseya lavarackorum*	.	EN	351215	0 (Unknown)	1 (Unknown)	0 (Unknown)
Reptiles	Mertens` Water Monitor	*Varanus mertensi*	VU	.	347295	3 (1996)	1 (1978)	0 (Unknown)
Reptiles	Mitchell`s Water Monitor	*Varanus mitchelli*	VU	.	.	0 (Unknown)	4 (1978)	0 (Unknown)
Birds	Partridge Pigeon	*Geophaps smithii*	VU	VU	176384	1 (1977)	1 (1924)	0 (Unknown)
Birds	Red Goshawk	*Erythrotriorchis radiatus*	VU	VU	176391	16 (2008)	0 (Unknown)	0 (Unknown)
Birds	Grey Falcon	*Falco hypoleucos*	VU	.	.	4 (2001)	0 (Unknown)	0 (Unknown)
Birds	Crested Shrike-tit	*Falcunculus frontatus*	.	VU	176377	21 (2009)	0 (Unknown)	1 (2000)
Birds	Gouldian Finch	*Erythrura gouldiae*	VU	EN	176370	43 (2008)	0 (Unknown)	1 (2002)
Mammals	Greater Bilby	*Macrotis lagotis*	VU	VU	177125	21 (2011)	0 (Unknown)	0 (Unknown)
Mammals	Pale Field-rat	*Rattus tunneyi*	VU	.	.	1 (1996)	2 (1998)	1 (1998)

EX = Extinct
EW = Extinct in the Wild
ER = Extinct in the NT
EN = Endangered
EN/VU = One Endangered subspecies/One Vulnerable subspecies
VU=Vulnerable
VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the D number from the tables above for the species of interest.

Areas Threatened Species Grid



Threatened species recorded in the grid cell(s) in which Areas occurs (Records Updated: Sept 2013)

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	Latest Observation Date	#Specimens	Latest Specimen Date	#Surveys	Latest Survey Record
Ferns	Gleicheniaceae	*Gleichenia sp. Victoria River*	Victoria River Coral Fern	VU		0	Unknown	6	2001	0	Unknown
Ferns	Pteridaceae	*Adiantum capillus-veneris*	Venus-hair Fern	VU		0	Unknown	0	Unknown	0	Unknown
Cycads	Cycadaceae	*Cycas armstrongii*	Armstrong`s Cycad	VU		0	Unknown	0	Unknown	4	1999
Flowering Plants	Poaceae	*Triodia fitzgeraldii*	Spinifex	VU		0	Unknown	3	2003	0	Unknown
Snails	Camaenidae	*Setobaudinia victoriana*	Victoria's Land Snail	VU		0	Unknown	0	Unknown	0	Unknown
Fish	Pristidae	*Pristis pristis*	Freshwater Sawfish	VU	VU	0	Unknown	0	Unknown	0	Unknown
Reptiles	Cheluidae	*Elseya lavarackorum*	Gulf Snapping Turtle		EN	0	Unknown	1	Unknown	0	Unknown
Reptiles	Varanidae	*Varanus mertensi*	Mertens` Water Monitor	VU		5	1996	4	1984	1	1991
Reptiles	Varanidae	*Varanus mitchelli*	Mitchell`s Water Monitor	VU		0	Unknown	6	1978	2	1996
Reptiles	Varanidae	*Varanus panoptes*	Yellow-spotted Monitor	VU		1	1991	1	1977	1	1991
Reptiles	Elapidae	*Acanthophis hawkei*	Plains Death Adder	VU	VU	0	Unknown	1	1968	0	Unknown
Birds	Columbidae	*Geophaps smithii*	Partridge Pigeon	VU	VU	5	1977	3	1924	0	Unknown
Birds	Accipitridae	*Erythrotriorchis radiatus*	Red Goshawk	VU	VU	17	2008	0	Unknown	0	Unknown
Birds	Falconidae	*Falco hypoleucos*	Grey Falcon	VU		19	2008	0	Unknown	1	1994
Birds	Rostratulidae	*Rostratula australis*	Australian Painted Snipe	VU	EN	6	2001	0	Unknown	1	1993
Birds	Scolopacidae	*Calidris ferruginea*	Curlew Sandpiper	VU		0	Unknown	0	Unknown	1	1993
Birds	Psittacidae	*Polytelis alexandrae*	Princess Parrot	VU	VU	2	1977	4	1891	0	Unknown
Birds	Maluridae	*Malurus coronatus coronatus*	Purple-crowned Fairy-wren (western)	VU	VU	94	2008	9	1998	6	2001
Birds	Meliphagidae	*Grantiella picta*	Painted Honeyeater	VU		2	2001	0	Unknown	0	Unknown
Birds	Pachycephalidae	*Falcunculus frontatus*	Crested Shrike-tit		VU	54	2009	2	2007	1	2000
Birds	Estrildidae	*Erythrura gouldiae*	Gouldian Finch	VU	EN	132	2008	3	1986	9	2004
Mammals	Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	CR	EN	1	Unknown	1	Unknown	0	Unknown
Mammals	Dasyuridae	*Pseudantechinus mimulus*	Carpentarian Antechinus		VU	2	Unknown	0	Unknown	0	Unknown
Mammals	Peramelidae	*Isoodon auratus*	Golden Bandicoot	EN	VU	1	1969	0	Unknown	0	Unknown
Mammals	Thylacomyidae	*Macrotis lagotis*	Greater Bilby	VU	VU	29	2011	0	Unknown	0	Unknown
Mammals	Phalangeridae	*Trichosurus vulpecula vulpecula*	Common Brushtail Possum (southern)	EN		4	2008	0	Unknown	0	Unknown
Mammals	Hipposideridae	*Hipposideros stenotis*	Northern Leaf-nosed Bat	VU		1	1981	0	Unknown	0	Unknown
Mammals	Muridae	*Mesembriomys gouldii*	Black-footed Tree-rat	VU		2	Unknown	0	Unknown	0	Unknown
Mammals	Muridae	*Rattus tunneyi*	Pale Field-rat	VU		2	1996	4	2005	3	1998

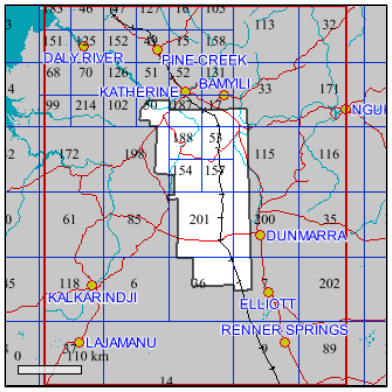
EX = Extinct
EW = Extinct in the Wild
ER = Extinct in the NT
EN = Endangered
EN/VU = One Endangered subspecies/One Vulnerable subspecies

VU=Vulnerable
VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the D number from the tables above for the species of interest.

Species listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap Areas



Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	#Surveys	Latest Record
Martyniaceae	*Martynia annua*	Small Devil`s Claw	*A C*		*MP K2 WA1 WA2 G&M CYP*	1	1999
Fabaceae	*Parkinsonia aculeata*	Parkinsonia	*B C*	*WONS*	*MP K2 WA1 WA4 Q2 G&M CYP DEU NSW SA*	56	2001
Asteraceae	*Parthenium hysterophorus*	Parthenium Weed	*A C*	*WONS*	*MP K0 WA1 WA2 Q2 CYP DEU NSW SA*	0	Unknown
Verbenaceae	*Phyla nodiflora var. nodiflora*	Lippia			*G&M NSW*	4	1999
Fabaceae	*Prosopis pallida*	Mesquite	*A C*	*WONS*	*K2 WA1 WA2 WA4 Q2 G&M NSW SA*	0	Unknown
Combretaceae	*Quisqualis indica*	Rangoon Creeper			*C&E*	0	Unknown
Euphorbiaceae	*Ricinus communis*	Castor Oil Plant	*B C*		*MP CYP NSW*	3	2001
Fabaceae	*Senna obtusifolia*	Sicklepod	*B C*		*WA1 WA2 Q2 G&M CYP DEU*	4	1997
Fabaceae	*Senna occidentalis*	Coffee Senna	*B C*		*G&M DEU*	19	1999
Malvaceae	*Sida acuta*	Spiny-head Sida	*B C*		*WA1 G&M*	7	2008
Malvaceae	*Sida cordifolia*	Flannel Weed	*B C*		*WA1 G&M DEU*	4	2001
Malvaceae	*Sida rhombifolia*	Paddy`s Lucerne	*B C*		*MP G&M DEU*	0	Unknown
Malvaceae	*Sida spinosa*	Spiny Sida			*DEU*	105	2001
Poaceae	*Sorghum almum*	Columbus Grass			*NSW*	0	Unknown
Poaceae	*Sporobolus pyramidalis*	Giant Rat`s Tail Grass			*Q2 G&M CYP NSW*	1	1995
Fabaceae	*Stylosanthes hamata*	Caribbean Stylo			*DEU*	10	2009
Fabaceae	*Stylosanthes humilis*	Townsville Lucerne			*DEU*	3	1995
Poaceae	*Themeda quadrivalvis*	Grader Grass	*B C*		*G&M CYP DEU*	4	2008
Zygophyllaceae	*Tribulus cistoides*	Beach Caltrop	*B C*			0	Unknown
Zygophyllaceae	*Tribulus terrestris*	Caltrop	*B C*		*CYP SA*	8	1997
Poaceae	*Urochloa mosambicensis*	Sabi Grass			*DEU*	2	1995
Poaceae	*Urochloa mutica*	Para Grass			*MP G&M*	3	1999
Fabaceae	*Vachellia farnesiana*	Sweet Acacia			*DEU*	57	2001
Asteraceae	*Xanthium strumarium*	Noogoora Burr	*B C*		*MP WA1 WA2 WA4 DEU NSW SA*	8	2008

Status Codes:

1. NATIONAL STATUS CODES

Alert, Alert List for Environmental Weeds (Please call Exotic Plant Pest Hotline 1800 084 881 if you think you have seen this weed)
Sleeper, National Sleeper Weed
Target,Targeted for eradication. (www landmanager.com.au/view/index.aspx?id=449837)
WONS, Weeds of National Significance

2. NT STATUS CODES

A, NT Class A Weed (to be eradicated)
B, NT Class B Weed (growth & spread to be controlled)
C, NT Class C Weed (not to be introduced) (www landmanager.com.au/view/index.aspx?id=449869)

3. OTHER STATUS CODES

C&E, Csurhes, S. & Edwards, R. (1998) Potential Environmental Weeds in Australia. Candidate Species for Preventative Control. Environment Australia, Canberra (www.landmanager com au/view/index aspx?id=394504)
CYP, Draft Cape York Peninsula Pest Management Plan 2006-2011 (www.landmanager.com.au/view/index.aspx?id=371200)
DEU, Plants listed as environmental weeds by the Desert Uplands Strategic Land Resource
Assessment (www.landmanager com au/view/index aspx?id=332123)
G&M, Grice AC, Martin TG. 2005. The Management of Weeds and Their Impact on Biodiversity in the Rangelands. Cooperative Research Centre (CRC) for Australian Weed Management and CS RO Sustainable Ecosystems. Commonwealth Australia (www.landmanager com au/view/index.aspx?id=163572)
Gr, Groves et al. 2003. Weed categories for natural and agricultural ecosystem management. Bureau of

Rural Sciences (www landmanager.com.au/view/index.aspx?id=388018)
K0, High Priority Weeds not yet established in the Katherine region
K1, High Priority Weeds posing environmental threats in the Katherine region
K2, High Priority Weeds posing existing threats in the Katherine region, as described in the Katherine Regional Weed Management Strategy 2005-2010 (www.landmanager.com.au/view/index.aspx?id=130286)
MP, Northern Territory Parks & Conservation Masterplan (www.landmanager com au/view/index aspx?id=144141)
NAQS, North Australian Quarantine Strategy Target List (www.landmanager com au/view/index aspx?id=449416)
NSW, Declared Noxious Weed in NSW (www.landmanager.com.au/view/index.aspx?id=449983)
Q1, QLD Class 1 Weed (not to be introduced, kept or supplied-
Q2, Class 2 Weed (eradicate where possible, not to be introduced, kept or supplied)
Q3, Qld Class 3 Weed (to be controlled near environmentally sensitive areas- not to be supplied/sold without a permit) (www.landmanager.com.au/view/index.aspx?id=190714)
SA, Declared Plant in South Australia (www landmanager.com.au/view/index.aspx?id=449996)
WeedsAus, Listed as a significant weed by Weeds Australia (www.landmanager.com.au/view/index.aspx?id=14576)
WA1, WA Weed Class P1 (movement prohibited)
WA2, WA Weed Class P2 (aim to eradicate)
WA3, WA Weed Class P3 (control infestations)
WA4, WA Weed Class P4 (prevent spread)
WA5, WA Weed Class P3 (control infestations on public land) (www landmanager.com.au/view/index.aspx?id=449884).

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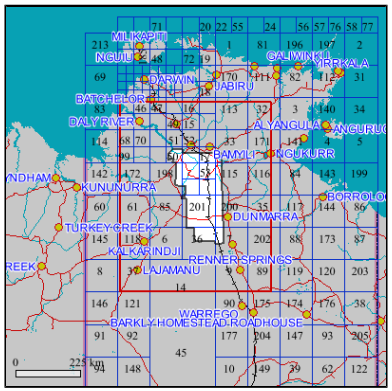
More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the D number from the tables above for the species of interest.

Plants listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap Areas



Areas Weeds and Potential Weeds

Introduced plants recorded in the grid cell(s) in which Areas occurs and that have been identified as problem weeds in one or more locations in northern Australia. Occurrence based on Northern Territory Government databases.

Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	#Surveys	Latest Record
Asteraceae	*Acanthospermum hispidum*	Starburr	*B C*			2	1999
Amaranthaceae	*Alternanthera pungens*	Khaki Weed	*B C*		*DEU NSW SA*	0	Unknown
Meliaceae	*Azadirachta indica*	Neem			*MP K1 C&E G&M CYP WeedsAus*	0	Unknown
Acanthaceae	*Barleria prionitis*	Barleria	*A C*	*ALERT*	*MP K2 C&E G&M*	0	Unknown
Poaceae	*Bothriochloa pertusa*	Indian Bluegrass			*DEU*	0	Unknown
Apocynaceae	*Calotropis procera*	Rubber Bush	*B C (S of 16 5 deg S)*		*WA1 WA2 G&M*	27	1999
Poaceae	*Cenchrus biflorus*	Gallon`s Curse			*NSW*	0	Unknown
Poaceae	*Cenchrus ciliaris*	Buffel Grass			*MP Gr G&M DEU*	0	Unknown
Poaceae	*Cenchrus echinatus*	Mossman River Grass	*B C*		*NSW*	3	1990
Poaceae	*Cenchrus pedicellatus*	Mission Grass (annual)			*WeedsAus*	5	2008
Poaceae	*Cenchrus setiger*	Birdwood Grass			*DEU*	0	Unknown
Poaceae	*Chloris barbata*	Purpletop Chloris			*DEU*	1	1999
Cucurbitaceae	*Citrullus lanatus*	Camel Melon			*G&M*	8	1999
Fabaceae	*Crotalaria goreensis*	Gambia Pea			*MP*	3	1995
Apocynaceae	*Cryptostegia madagascariensis*	Madagascan Rubber Vine	*A C*		*K2 WA1 WA2 Q3 C&E*	0	Unknown
Cucurbitaceae	*Cucumis melo*	Ulcardo Melon			*DEU*	72	2008
Cyperaceae	*Cyperus rotundus*	Nutgrass			*DEU SA*	0	Unknown
Solanaceae	*Datura ferox*	Fierce Thornapple	*A C*		*WA1 WA3 WA4 G&M*	0	Unknown
Fabaceae	*Delonix regia*	Poinciana			*C&E*	0	Unknown
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass			*DEU*	35	2001
Poaceae	*Eragrostis minor*	Smaller Stinkgrass			*DEU*	1	1995
Poaceae	*Eragrostis pilosa*	Soft Lovegrass			*DEU*	0	Unknown
Amaranthaceae	*Gomphrena celosioides*	Gomphrena Weed			*DEU*	0	Unknown
Malvaceae	*Grewia asiatica*	Phassa Plaum			*C&E G&M CYP*	0	Unknown
Lamiaceae	*Hyptis suaveolens*	Hyptis	*B C*		*G&M*	11	2008
Euphorbiaceae	*Jatropha gossypiifolia*	Bellyache Bush	*B C*	*WONS*	*K2 WA1 WA4 Q2 C&E G&M CYP DEU*	3	2008
Malvaceae	*Malachra fasciata var. lineariloba*	Roadside Leafbract			*CYP*	1	1991
Malvaceae	*Malvastrum americanum*	Sp ked Malvastrum			*DEU*	23	2001
Malvaceae	*Malvastrum coromandelianum*	Prickly Malvastrum			*DEU*	1	1995

Areas Introduced Species

Introduced plants in Areas (ordered alphabetically) that have been identified as introduced species in one or more locations in northern Australia.

Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	ID	#Surveys (Latest)	Latest Record
Fabaceae	*Indigofera glandulosa*	Anil				290754	0	Unknown
Euphorbiaceae	*Euphorbia hirta*	Asthma Plant				289244	0	Unknown
Cucurbitaceae	*Momordica charantia*	Balsam Pear				.	0	Unknown
Poaceae	*Cynodon radiatus*	Bermuda Grass				361105	0	Unknown
Fabaceae	*Alysicarpus vaginalis*	Buffalo Clover				298874	0	Unknown
Fabaceae	*Alysicarpus ovalifolius*	Buffalo Clover				288374	2	1999
Fabaceae	*Clitoria ternatea*	Butterfly Pea				289514	0	Unknown
Malvaceae	*Triumfetta pentandra*	Chinese Burr				293204	0	Unknown
Malvaceae	*Triumfetta rhomboidea*	Chinese Burr				293204	0	Unknown
Poaceae	*Dactyloctenium aegyptium*	Coastal Button Grass				289864	0	Unknown
Cucurbitaceae	*Citrullus colocynthis*	Colocynth Melon				289434	0	Unknown
Fabaceae	*Desmodium triflorum*	Creeping Tick-trefoil				289934	0	Unknown
Poaceae	*Eragrostis amabilis*	Delicate Lovegrass				372299	0	Unknown
Urticaceae	*Urtica urens*	Dwarf Nettle				293354	0	Unknown
Fabaceae	*Desmodium tortuosum*	Florida Beggarweed				289934	0	Unknown
Amaranthaceae	*Amaranthus viridis*	Green Amaranth				372033	0	Unknown
Poaceae	*Digitaria bicornis*	Hairy Finger Grass				361165	0	Unknown
Fabaceae	*Indigofera hirsuta*	Hairy Indigo				290754	1	1999
Portulacaceae	*Portulaca pilosa*	Hairy Pigface				292104	0	Unknown
Portulacaceae	*Portulaca pilosa subsp. pilosa*	Hairy Pigface				292104	0	Unknown
Fabaceae	*Lablab purpureus*	Hyacinth Bean				.	0	Unknown
Amaranthaceae	*Alternanthera brasiliana*	Joyweed				360945	0	Unknown
Amaranthaceae	*Aerva javanica*	Kapok Bush				288244	0	Unknown
Verbenaceae	*Lippia alba var. alba*	Lemon Verbena				.	0	Unknown
Poaceae	*Eragrostis amabilis var. amabilis*	Lovegrass				.	0	Unknown
Poaceae	*Eragrostis mexicana*	Mexican Lovegrass				372318	0	Unknown
Portulacaceae	*Portulaca oleracea var. weedy*	Munyeroo				292104	0	Unknown
Portulacaceae	*Portulaca oleracea*	Munyeroo				292104	0	Unknown
Euphorbiaceae	*Euphorbia heterophylla*	Painted Spurge				290344	0	Unknown
Asteraceae	*Bidens pilosa*	Pitch-forks				288774	2	1996
Convolvulaceae	*Ipomoea triloba*	Pitted Morning Glory				290784	0	Unknown
Malvaceae	*Melochia pyramidata*	Pyramid Flower				291234	1	1996
Lythraceae	*Ammannia auriculata*	Redstem				288404	0	Unknown
Malvaceae	*Hibiscus sabdariffa*	Rosella				290614	0	Unknown
Pedaliaceae	*Sesamum orientale*	Sesame Seed				361475	0	Unknown
Poaceae	*Dichanthium annulatum*	Sheda Grass				289944	0	Unknown
Phyllanthaceae	*Phyllanthus amarus*	Six O`clock				291974	0	Unknown
Fabaceae	*Stylosanthes viscosa*	Sticky Stylo				293004	0	Unknown

Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	ID	#Surveys (Latest)	Latest Record
Passifloraceae	*Passiflora foetida*	Stinking Passion Flower				291774	26	1999
Poaceae	*Digitaria ciliaris*	Summer Grass				289974	0	Unknown
Cyperaceae	*Cyperus compressus*	Summer Sedge				289844	0	Unknown
Fabaceae	*Crotalaria juncea*	Sunhemp				289684	0	Unknown
Convolvulaceae	*Ipomoea pes-tigridis*	Tiger`s Foot Morning Glory				290784	0	Unknown
Asteraceae	*Tridax procumbens*	Tridax Daisy				293184	0	Unknown
Fabaceae	*Indigofera tinctoria*	True Indigo				290754	0	Unknown
Fabaceae	*Aeschynomene villosa*	Villose Jointvetch				288254	0	Unknown
Convolvulaceae	*Merremia dissecta var. dissecta*	White Convolvulus Creeper				291254	0	Unknown
Poaceae	*Setaria verticillata*	Whorled Pigeon Grass				371883	0	Unknown
Malvaceae	*Corchorus trilocularis*	Wild Jute				361085	0	Unknown

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

Areas Pest and Potential Pest Animals


Animals with pest potential recorded in the grid cell(s) in which Areas occurs. Occurrence based on Northern Territory Government databases.

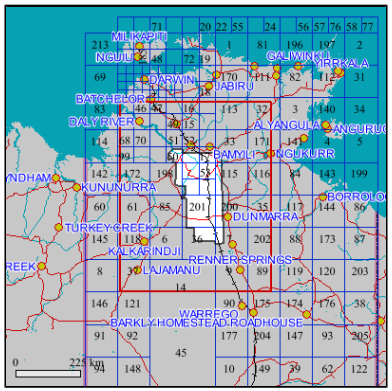
Common Name	Scientific Name	NT Status	National Status	ID	#Observations (Latest)	#Specimens (Latest)	#Surveys (Latest)
Cane Toad	*Rhinella marina*	P	.	183252	8 (2009)	3 (2006)	10 (2010)
Asian House Gecko	*Hemidactylus frenatus*	P	.	188964	2 (1989)	8 (2007)	0 (Unknown)
Rock Dove	*Columba livia*	P	.	183336	2 (1988)	0 (Unknown)	0 (Unknown)
Red-tailed Black-cockatoo	*Calyptorhynchus banksii samueli*	N	.	223765	1 (2009)	0 (Unknown)	0 (Unknown)
Red-tailed Black-cockatoo	*Calyptorhynchus banksii macrorhynchus*	N	.	223765	396 (2010)	9 (1992)	13 (2001)
Sulphur-Crested Cockatoo	*Cacatua galerita*	N	.	223772	252 (2007)	0 (Unknown)	23 (2010)
Agile Wallaby	*Macropus agilis*	N	.	223786	37 (2010)	88 (1982)	22 (2010)
House Mouse	*Mus musculus*	P	.	187720	0 (Unknown)	4 (1996)	2 (1996)
Black Rat	*Rattus rattus*	P	.	183236	1 (1988)	6 (2005)	6 (2008)
Dingo / Wild dog	*Canis lupus*	N	.	183280	28 (2010)	88 (1973)	10 (2010)
Cat	*Felis catus*	P	.	183259	21 (2000)	3 (1971)	2 (1993)
Donkey	*Equus asinus*	P	.	183287	20 (2002)	0 (Unknown)	13 (2008)
Horse	*Equus caballus*	P	.	183315	11 (1990)	0 (Unknown)	0 (Unknown)
Pig	*Sus scrofa*	P	.	183329	8 (1999)	0 (Unknown)	1 (2008)
Camel	*Camelus dromedarius*	P	.	183210	1 (1998)	0 (Unknown)	0 (Unknown)
Swamp Buffalo	*Bubalus bubalis*	P	.	183245	5 (2001)	0 (Unknown)	0 (Unknown)
Cattle	*Bos taurus*	P	.	183266	21 (2010)	0 (Unknown)	9 (2010)

NT STATUS CODES:
Int, Introduced species (all non-prohibited vertebrates, and all other exotic species (www.landmanager com au/view/index aspx?id=280771)
N, Native species with pest potential.
P, Prohibited species (all exotic vertebrates except those listed as non-prohibited (www.landmanager com au/view/index aspx?id=450509)

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the D number from the tables above for the species of interest.

Potential pest animals listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap Areas



Soils and vegetation graphs and tables refer to area of soils and vegetation only. Fire graphs and tables refer to entire selected area including sea if present. Calculations are derived from map images or vector data, and should be taken as a guide only. Accuracy cannot be guaranteed. For small areas, figures should be rounded to the nearest whole number.

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Appendix D – Protected Matters Search Tool Report (*EPBC Act 1999*)

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Australian Government

Department of the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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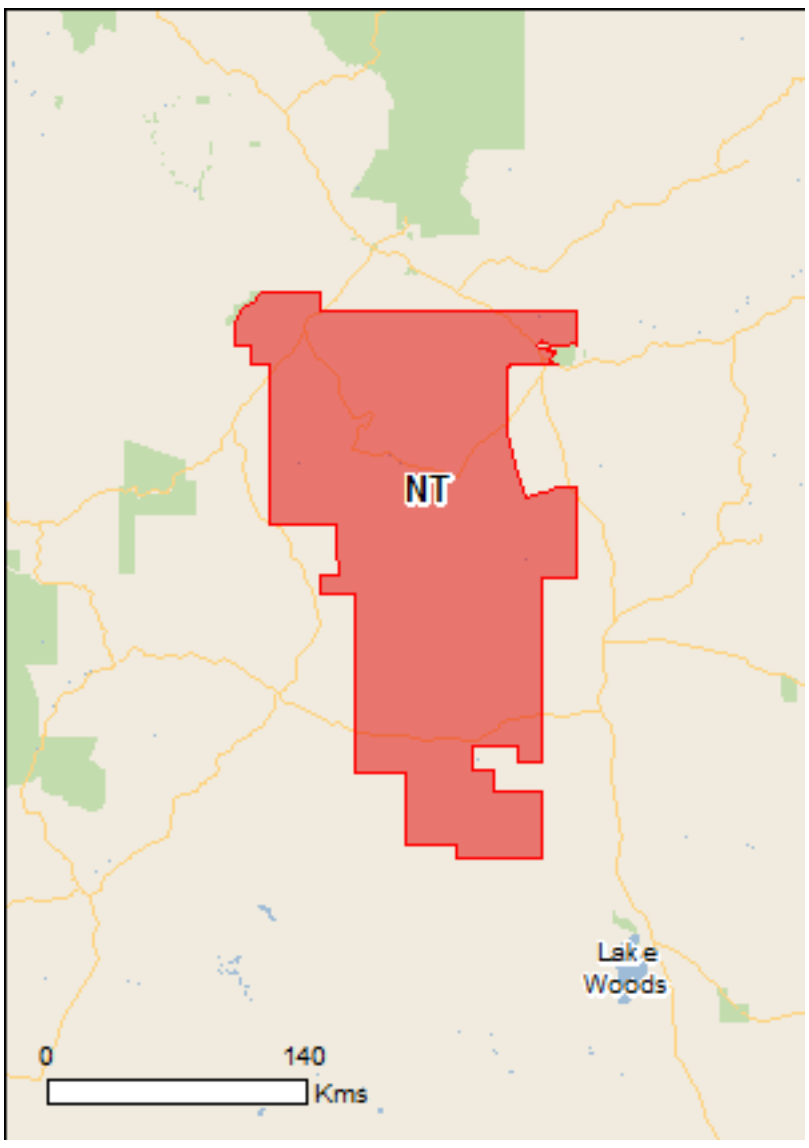

Coordinates

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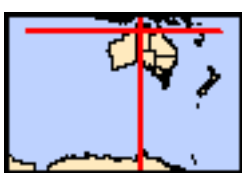

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	14
Listed Migratory Species:	7

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	11
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	2
Regional Forest Agreements:	None
Invasive Species:	26
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Arnhem Plateau Sandstone Shrubland Complex	Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Amytornis woodwardi White-throated Grasswren [564]	Vulnerable	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat known to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Dasyurus hallucatus Northern Quoll [331]	Endangered	Species or species habitat likely to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Phascogale pirata Northern Brush-tailed Phascogale [82954]	Vulnerable	Species or species habitat likely to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheathtail Bat [66889]	Critically Endangered	Species or species habitat may occur within area
Reptiles		

Name	Status	Type of Presence
[Acanthophis hawkei](#)		
Plains Death Adder [83821]	Vulnerable	Species or species habitat likely to occur within area
[Elseya lavarackorum](#)		
Gulf Snapping Turtle [67197]	Endangered	Species or species habitat known to occur within area
[Liopholis kintorei](#)		
Great Desert Skink, Tjakura, Warrarna, Mulyamiji [83160]	Vulnerable	Species or species habitat may occur within area
Sharks		
[Pristis pristis](#)		
Largetooth Sawfish, Freshwater Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
[Apus pacificus](#)		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
[Merops ornatus](#)		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
[Ardea alba](#)		
Great Egret, White Egret [59541]		Species or species habitat known to occur within area
[Ardea ibis](#)		
Cattle Egret [59542]		Species or species habitat may occur within area
[Charadrius veredus](#)		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
[Glareola maldivarum](#)		
Oriental Pratincole [840]		Species or species habitat may occur within area
[Pandion cristatus](#)		
Eastern Osprey [82411]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Director of Property Services Defence Estate
Defence - DELAMERE WEAPONS RANGE

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		

Name	Threatened	Type of Presence
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Reptiles		
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Elsey	NT
Giwining / Flora River	NT

Invasive Species	[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		

Name	Status	Type of Presence
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Bubalus bubalis Water Buffalo, Swamp Buffalo [1]		Species or species habitat likely to occur within area
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Andropogon gayanus Gamba Grass [66895]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush,		Species or species

Name	Status	Type of Presence
Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Mimosa pigra Mimosa, Giant Mimosa, Giant Sensitive Plant, ThornySensitive Plant, Black Mimosa, Catclaw Mimosa, Bashful Plant [11223]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat may occur within area
Pennisetum polystachyon Mission Grass, Perennial Mission Grass, Missiongrass, Feathery Pennisetum, Feather Pennisetum, Thin Napier Grass, West Indian Pennisetum, Blue Buffel Grass [21194]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Vachellia nilotica Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-14.74864526 132.1444187,-14.74866222 133.2510307,-14.91040713 133.2510246,-14.90469523 133.2362117,-14.90628324 133.2317707,-14.9110673 133.2111779,-14.9151233 133.205409,-14.91385044 133.1748652,-14.91321252 133.1580074,-14.91585155 133.1459715,-14.91551761 133.1327216,-14.91508369 133.1168397,-14.90115589 133.0886148,-14.90666987 133.0851469,-14.90697287 133.0850239,-14.90612487 133.0847809,-14.90597688 133.0846959,-14.90576388 133.0839679,-14.90546788 133.0834999,-14.90529988 133.0833979,-14.90441689 133.0829829,-14.9035059 133.0822829,-14.90173291 133.0820009,-14.90079692 133.0814259,-14.90064592 133.0812249,-14.90062893 133.0805649,-14.90028893 133.0799569,-14.90002894 133.0793419,-14.89977994 133.0790029,-14.89978394 133.0788659,-14.89997594 133.0784549,-14.89983394 133.0779549,-14.89968295 133.0777949,-14.89899495 133.0775549,-14.89897695 133.0773879,-14.89906095 133.0772409,-14.89856896 133.0771229,-14.89826196 133.0768399,-14.89800596 133.0765389,-14.89785597 133.0755059,-14.89762197 133.0748649,-14.89746097 133.0746019,-14.89719098 133.0744999,-14.89698098 133.0743069,-14.89680798 133.0742359,-14.89653498 133.0742689,-14.89632898 133.0744029,-14.89614498 133.0746569,-14.89605098 133.0746809,-14.89595098 133.0746629,-14.89588698 133.0746099,-14.89584098 133.0745359,-14.89579199 133.0742629,-14.89574999 133.0741959,-14.89558799 133.0741159,-14.89514499 133.0741449,-14.89483299 133.0741139,-14.89471599 133.0740769,-14.894638 133.0740219,-14.894667 133.0739469,-14.894749 133.0738689,-14.89499599 133.0737609,-14.894777 133.0736819,-14.91163094 133.056835,-14.92331881 133.0694271,-14.92513479 133.0711821,-14.92656178 133.0721631,-14.92811377 133.0729121,-14.92975275 133.0734181,-14.93145374 133.0736731,-14.93366173 133.0738291,-14.93365759 133.1119109,-14.93426159 133.1103349,-14.93465159 133.1089549,-14.93800154 133.1156459,-14.94270451 133.1156379,-14.94286241 133.1400337,-14.94749839 133.1380877,-14.95006237 133.1377118,-14.95559534 133.1358238,-14.95905133 133.1340279,-14.96752828 133.1318439,-14.98551421 133.1222761,-14.99837699 133.1539459,-14.99856742 133.001195,-14.99857456 132.9178695,-15.01643251 132.9178654,-15.01643151 132.9155964,-15.01651351 132.9155964,-15.01651351 132.9155744,-15.14013218 132.9153992,-15.32321491 132.9153704,-15.36098052 132.9254893,-15.47326816 132.9555484,-15.63283321 132.9982487,-15.61796047 133.0452559,-15.60820628 133.0760073,-15.60721936 133.0790843,-15.59856691 133.1068558,-15.58189282 133.1611639,-15.58189279 133.1678648,-15.58192779 133.1678648,-15.58196845 133.2511826,-15.7023377 133.251182,-15.83432534 133.2511874,-15.99862605 133.2511944,-15.99865841 133.0845267,-16.86565489 133.0845453,-16.86566275 132.9628685,-16.79276915 132.9637428,-16.79276188 132.8488579,-16.79276657 132.737328,-16.89558912 132.7373248,-16.89558235 132.8489148,-16.99745176 132.8489027,-16.99750333 133.0845418,-17.30653375 133.0845407,-17.30670367 132.667876,-17.24861588 132.6678776,-17.24861456 132.4178792,-16.91528364 132.4178769,-16.91528307 132.1678788,-16.08195309 132.1678754,-16.08192008 132.0012166,-15.99457445 132.0012186,-15.99219748 132.0909421,-15.84888507 132.0845544,-15.74858371 132.0845511,-15.74857181 131.7512157,-15.13253704 131.7512084,-14.99858392 131.7512068,-14.99858418 131.6678729,-14.91525092 131.667872,-14.91525119 131.5845392,-14.80245463 131.5845408,-14.79056647 131.6021066,-14.7819174 131.6007474,-14.74206908 131.6227519,-14.71839187 131.6746885,-14.70420778 131.6859603,-14.70010075 131.6860313,-14.70016675 131.6957053,-14.67235965 131.7078491,-14.67050765 131.7110721,-14.66530962 131.716406,-14.66532194 132.0011949,-14.74864307 132.0011853,-14.74864511 132.1347612,-14.74864526 132.1444187

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-Department of Primary Industries, Parks, Water and Environment, Tasmania
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-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

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Appendix E – Threatened Species Likelihood of Occurrence Assessment

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Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
REPTILES				
Plains Death Adder *Acanthophis hawkei*	**EPBC status**: Vulnerable **TPWC status**: Vulnerable **Habitat:** Floodplains & cracking soil plains (Webb et al. 2002). **Distribution:** In the NT, it is known from floodplains of the Adelaide, Mary and Alligator Rivers as well as the Barkly Tableland on the NT/ QLD border. **Infonet grid cell records (latest record)**: 1 (1968)	**Medium** • Suitable habitat may be present within EP. • Species not known to occur within the area.	**Medium** • Suitable habitat may be present within EP. • Species not known to occur within the area.	**None** • Suitable habitat does not occur within road corridor. • Species not known to occur within the area.
Gulf Snapping Turtle *Elseya lavarackorum*	**EPBC status**: Endangered **TPWC status:** Least Concern **Habitat:** Major perennial river systems. **Distribution:** This species is known to inhabit multiple river systems which run into the Gulf of Carpentaria (Georges & Adams 1996). Occurs in Calvert and Nicholson River systems. **Infonet grid cell records (latest record)**: 1 (unknown)	**None** • Suitable habitat does not occur within EP. • Outside of known distribution and river catchments.	**None** • Suitable habitat does not occur within EP. • Outside of known distribution and river catchments.	**None** • Suitable habitat does not occur within road corridor. • Outside of known distribution and river catchments.
Great Desert Skink *Liopholis kintorei*	**EPBC status**: Vulnerable **TPWC status:** Vulnerable **Habitat:** The species generally occurs on tall open shrub land and hummock grasslands on red sand plains and sand ridges (Cogger et al. 1993). However, in some locations (e.g. the Gibson Desert) they are found on sand plains with fine gravel. **Distribution:** Currently known from seven populations (McAlpin 2001) but originally known to occur within a broad range extending from the desert parts of south western NT, eastern interior of WA and north western SA (Cogger et al. 1993). The precise habitat range is unknown (McAlpin 2001). **Infonet grid cell records (latest record)**: 0	**None** • Suitable habitat does not occur within EP.	**Low** • Marginal habitat may be present within EP. • If present, species will only occurs within the desert sand-plains land system (Redsan) in the southern region of the EP.	**None** • Suitable habitat does not occur within road corridor.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
Mertens' Water Monitor *Varanus mertensi*	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** This semi-aquatic monitor occupies edges of watercourses and lagoons, but is seldom seen far from water (Christian 2004a). **Distribution:** Across northern Australia from Cape York Peninsula to the Kimberley (Christian 2004a). **Infonet grid cell records (latest record)**: 10 (1996)	**High** • Suitable habitat is present within EP. • There are low numbers of records within the EP	**Low** • Suitable habitat may be present within EP. • South of known distribution.	**Medium** • Suitable habitat may be present within road corridor. • Southern edge of known distribution.
Mitchell's' Water Monitor *Varanus mitchelli*	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** This semi-aquatic monitor occupies edges of watercourses and lagoons, but is seldom seen far from water (Schultz & Doody 2004). **Distribution:** Across northern Australia from Cape York Peninsula to the Kimberley (Schultz & Doody 2004). **Infonet grid cell records (latest record)**: 8 (1996)	**Medium** • Suitable habitat is present within EP. • There are old records within the EP (from 1978).	**None** • Suitable habitat does not occur within EP. • South of known distribution.	**Low** • Suitable habitat is present within road corridor. • South of known distribution.
Floodplain Monitor *Varanus panoptes*	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** Occurs in broad range of habitats - from coastal beaches to savannah woodlands (Christian 2004b). **Distribution:** In the NT, it has been recorded across most of the Top End and the Gulf Region (Christian 2004b). The species has been highly impacted by the invasion of Cane Toads, and is now thought to be locally extinct from areas where Cane Toads persist in high numbers. **Infonet grid cell records (latest record)**: 3 (1997)	**Low** • Suitable habitat is present within EP; however, Cane Toad impact lowers chance that this species is present within EP.	**None** • Outside of known distribution.	**Low** • Suitable habitat is present within EP; however, Cane Toad impact lowers chance that this species is present within EP.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
BIRDS				
White-throated Grasswren *Amytornis woodwardi*	**EPBC status**: Vulnerable **TPWC status**: Vulnerable **Habitat:** Confined to hummock grasslands, sometimes with open shrub land or woodland over storey, mixed among dense boulder fields or sandstone pavements (Schodde 1982; Noske 1992) and escarpment drainage lines. **Distribution:** In the NT, it is patchily distributed from Nitmiluk National Park to western Arnhem Land (Noske 1992). **Infonet grid cell records (latest record)**: 0	**Low** • Suitable habitat may be present within NW corner the EP (Bukalara land system). • Suitable habitat is distant from existing records. • Outside the known species distribution.	**None** • Suitable habitat does not occur within EP. • Outside the known species distribution.	**None** • Suitable habitat does not occur within road corridor. • Outside the known species distribution.
Red Goshawk *Erythrotriorchis radiatus*	**EPBC status**: Vulnerable **TPWC status:** Vulnerable **Habitat:** Prefers tall open eucalypt forest and riparian areas. Nests in large trees, frequently the tallest and most massive in a tall stand, and nest trees are invariably within one km of permanent water (Debus et al.1988; Aumann et al. 1991). **Distribution:** Occurs across much of the northern Australia, from the Kimberley to south-eastern Queensland. **Infonet grid cell records (latest record)**: 17 (2008)	**High** • Suitable habitat is present within EP. • Species has been previously recorded within project area (near Mataranka, in the far NE of the EP. • There are previous records within EP.	**Low** • Marginal habitat may be present within EP. • No previous records within EP.	**Low** • Marginal habitat may be within road corridor (i.e. no large waterways with large trees). • May be encountered as a flyover record. • No previous records within road corridor.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
Gouldian Finch *Erythrura gouldiae*	**EPBC status**: Endangered **TPWC status:** Vulnerable **Habitat:** Prefers annual and perennial grasses (especially Sorghum), a nearby source of surface water and, in the breeding season, unburnt hollow-bearing *Eucalyptus* trees (especially *E. tintinnans, E. brevifolia* and *E. leucophloia*) (Tidemann 1996; Higgins et al. 2006). **Distribution:** Sparsely distributed across northern Australia from the Kimberley to north-central Queensland (Dostine 1998; Franklin 1999; Barrett et al. 2003). It is currently known to occur in significant numbers (> 50 adult birds) at only 10 locations with five occurring in the Northern Territory (O'Malley 2006). **Infonet grid cell records (latest record)**:149 (2008)	**High** • Suitable habitat is present within EP. • Species has been previously recorded within EP, and there has been many observations of the species adjacent to the EP.	**Low** • Suitable breeding habitat does not occur within EP. • May occur as a 'fly over observation' in the northern parts of the EP; however, a review of vegetation types indicates no breeding habitat is available. • There are no existing records in the EP, or in surrounding area. • Southern edge of the species distribution.	**Low** • Suitable breeding habitat does not occur within the road corridor. • May occur as a 'fly over observation' in the northern parts of the EP; however, a review of vegetation types indicates no breeding habitat is available.
Grey Falcon *Falco hypoleucos*	**EPBC status**: Vulnerable **TPWC status:** Near Threatened **Habitat:** Occurs in areas of lightly-timbered lowland plains, typically on inland drainage systems, where the average annual rainfall is less than 500 mm (Ward 2012). **Distribution:** Sparsely distributed through much of the arid and semi-arid areas of Australia but is recorded in all Australian mainland states and territories. In the NT, the majority of records are from the southern half, but there are records in the Darwin region (Ward 2012). **Infonet grid cell records (latest record)**: 20 (2008)	**Low** • Suitable habitat may be present within EP. • Naturally scarce species.	**Low** • Suitable habitat may be present within EP. • Naturally scarce species.	**Low** • Suitable habitat may be present within road corridor. • Naturally scarce species.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
Crested Shrike Tit *Falcunculus frontatus whitei*	**EPBC status**: Vulnerable **TPWC status:** Near Threatened **Habitat:** This subspecies occurs across a range of eucalypt and melaleuca woodlands (Robinson and Woinarski 1992). **Distribution:** In the NT, has been recorded in very low densities in many isolated subpopulations (Garnett & Crowley 2000) between northeast Arnhem land to Kalkarindgi (semi-arid Victoria River District). **Infonet grid cell records (latest record)**: 57 (2009)	**High** • Suitable habitat is present within EP. • There are recent records in the EP.	**Moderate** • Suitable habitat may be present within EP. • No records within the EP; however, it has been recorded in the surrounding area in relatively high numbers.	**Moderate** • Suitable habitat may be present within the road corridor. • No records within the road corridor; however, it has been recorded in the surrounding area in relatively high numbers.
Partridge Pigeon *Geophaps smithii smithii*	**EPBC status**: Vulnerable **TPWC status:** Vulnerable **Habitat:** Occurs in open forests and woodlands with an understorey of grasses (Woinarski 2006). **Distribution:** Occurs throughout the top end of the Northern Territory and the Kimberley region of Western Australia (Woinarski 2006). **Infonet grid cell records (latest record)**: 8 (1977)	**Moderate** • Suitable habitat may be present within EP. • No recent records in the area; however, there are old records within the EP (from 1977 and 1924).	**None** • Suitable habitat does not occur within EP. • Outside of known species distribution.	**Medium** • Marginal habitat may be present within road corridor. • No recent records in the area; however, there are old records within the EP (from 1977 and 1924).
Painted Honeyeater *Grantiella picta*	**EPBC status**: Vulnerable **TPWC status:** Vulnerable **Habitat:** They inhabit *Acacia* and *Eucalyptus*-dominated woodlands and open forest and prefer habitats with more mature trees that host more mistletoes. Breeding times and seasonal movements (south-north) are thought to be governed by the fruiting of mistletoe (Garnett et al. 2011). **Distribution:** Sparsely distributed from southern Victoria and	**Low** • Suitable habitat may be present in EP. • Two close records outside EP (2001). • No breeding is expected to occur.	**None** • Outside of known species distribution.	**None** • Outside of known species distribution.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
	south-eastern South Australia to far northern Queensland and eastern Northern Territory. Most breeding occurs in the inland slopes of south-eastern Australia. There are few records of this species in the NT, mostly from the Barkly Tablelands. No evidence of a breeding population in the NT. **Infonet grid cell records (latest record)**: 2 (2001)			
Purple-crowned Fairy-wren (western) *Malurus coronatus coronatus*	**EPBC status**: Vulnerable **TPWC status:** Vulnerable **Habitat:** Preferred habitat includes thick riparian vegetation typically featuring cane grass and or pandanus, but also dense patchy shrubs in near vicinity of defined river channels and hence less prone to wildfire (Ward & Woinarski 2012). The species can move to less preferred woodland habitat in response to fire and flooding but survival may be compromised in these instances Van Doorn (2007). **Distribution:** The western subspecies occurs from Victoria River through to the Kimberley. Within this range the subspecies are almost entirely restricted to a narrow band around well-defined river channels. The Western Australia populations have been severely reduced. The NT population is probably <5000 breeding individuals with in an extent of 41,000km^2 and an area of occupancy estimated to be <2000km^2. The favoured cane grass habitat within the Victoria River Catchment is fragmented and hence there may be three subpopulations. **Infonet grid cell records (latest record)**: 109 (2008)	**Medium** • Suitable habitat may be present within EP. • No existing records within the EP. • There recent records close to the EP (to the north and northwest).	**None** • Suitable habitat does not occur within the EP. • Outside of known species distribution.	**None** • Suitable habitat does not occur within the road corridor. • Southern edge of the known species distribution.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
Princess Parrot *Polytelis alexandrae*	**EPBC status**: Vulnerable **TPWC status:** Vulnerable **Habitat:** This species occurs in the swales between sand dunes with a shrub layer of vegetation and scattered trees (Pavey 2006). **Distribution:** In the Northern Territory this species if found in the southern section of the Tanami Desert. It also occurs patchily throughout the arid interior of Australia (Pavey 2006). **Infonet grid cell records (latest record)**: 6 (1977)	**None** • Suitable habitat does not occur within EP. • EP is outside of known species distribution.	**Low** • Suitable habitat may be present within the EP (i.e. within the desert sand-plains land system • EP is within known species distribution. • Old records within the surrounding region of the EP (from 1924 and 1977). •	**None** • Suitable habitat does not occur within the road corridor.
Australian Painted Snipe *Rostratula australis* (also known as *Rostratula benghalensis*)	**EPBC status**: Vulnerable **TPWC status:** Vulnerable **Habitat:** Inhabits fringes of permanent and temporary wetlands, swamps and inundated grasslands (Taylor et al. 2013). The species could occur on any shallow ephemeral wetlands in central or southern Northern Territory. **Distribution:** This species is nomadic and scattered across Australia with no predictable occurrence (Rogers 2001). In the NT, it is known from a range of localities with no known resident sites (Taylor et al. 2013). **Infonet grid cell records (latest record)**: 7 (2001)	**Low** • Suitable habitat may be present within the EP. • No existing records within the EP. • Low number of records in the surrounding region.	**Low** • Suitable habitat may be present within the EP. • No existing records within the EP. • Low number of records in the surrounding region	**Low** • Suitable habitat may be present within the road corridor. • No existing records with the road corridor. • Low number of records in the surrounding region.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
Masked Owl (northern) *Tyto novaehollandiae*	**EPBC status**: Vulnerable **TPWC status:** Vulnerable **Habitat:** Occurs mainly in eucalypt tall open forests (especially those dominated by *Eucalyptus miniata* and *E. tetrodonta*), but also roosts in monsoon rainforests, and forages in more open vegetation types, including grasslands (Woinarski & Ward 2006). **Distribution:** In the NT, it is known from the Top End, Kakadu, Cobourg Peninsula (majority of records) and south-west Gulf country (ALA). **Infonet grid cell records (latest record)**: 0	**Low** • Suitable habitat may be present within the EP. • No existing records within the EP. • No existing records in the surrounding region.	**None** • Suitable habitat does not occur within EP.	**None** • Suitable habitat does not occur within road corridor.
Curlew Sandpiper *Calidris ferruginea*	**EPBC status**: Critically Endangered (also marine & migratory) **TPWC status:** Vulnerable **Habitat**: Mainly observed in intertidal mudflats in sheltered coastal areas (i.e. estuaries, bays, inlets and lagoons), and also in non-tidal swamps, lakes and lagoons near the coast, and ponds in salt works and sewage farms (DoE website). They are less common in inland areas in seasonal & perennial water bodies usually along the banks of mud or sand (DoE 2015). Occasionally in floodwaters (Higgins & Davies 1996). **Distribution:** In Australia, they mainly occur on the coast. Can be found inland in smaller numbers (DoE 2015). In the NT, they mostly occur around Darwin, north to Melville Island and Cobourg Peninsula, and east and south-east to Gove Peninsula, Groote Eylandt and Sir Edward Pellew Island. They are recorded inland from Victoria River Downs and around Alice Springs (Higgins & Davies 1996). **Infonet grid cell records (latest record)**: 1 (1993)	**Low** • Suitable habitat may be present within the EP (i.e. alluvial floodplains or claypans, pastoral dams) • No existing records within the EP. • There is a single record (from 1993) in the surrounding region	**None** • Suitable habitat is not expected to occur within EP.	**None** • Suitable habitat is not expected to occur within road corridor.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
MAMMALS				
Northern Quoll *Dasyurus hallucatus*	**EPBC status**: Endangered **TPWC status:** Critically Endangered **Habitat:** Occurs in a wide range of habitats, but the most suitable habitats are rocky areas (Van Dam et al. 2002). It was common in many eucalypt open forests. **Distribution:** Occurs across northern Australia in five regional populations. In the NT, most records are from central and western Top End (Van Dam et al. 2002). Population restriction has been highly influenced by the establishment of Cane Toads (*Rhinella marina*). **Infonet grid cell records (latest record)**: 2 (unknown)	**Low** • Suitable habitat may be present within the EP. • Southern limit of potential distribution. • No existing records within the EP. • Low number of records in the surrounding region. • Cane Toads impact in the area (major threat to the species)	**None** • Suitable habitat does not occur within EP. • Outside of known species distribution.	**None** • Suitable habitat does not occur within road corridor. • Outside of known species distribution.
Greater Bilby *Macrotis lagotis*	**EPBC status**: Vulnerable **TPWC status:** Vulnerable **Habitat:** Found in hummock grasslands on sandy soils with a preference for drainage lines (Southgate 1990). **Distribution:** Historically this species was widespread in arid Australia. Currently in the Northern Territory its strong holds are in the Tanami Desert (Pavey 2006). **Infonet grid cell records (latest record)**: 6 (2011)	**None** • Suitable habitat does not occur within EP. • Outside of known species distribution.	**High** • Suitable habitat is present within EP. • There are recent records within the southern region of the EP (from 2011), within the Desert Sandplains land system (Redsan).	**None** • Suitable habitat does not occur within EP. • Outside of known species distribution.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
Black-footed Tree-rat *Mesembriomys gouldii*	**EPBC status**: Endangered **TPWC status:** Vulnerable **Habitat:** Inhabits tropical woodlands and open forests. This nocturnal animal shelters in tree hollows and Pandanus stands during the day (Hill 2012). **Distribution:** Known extent for this species is: the Top End of the NT, the Kimberley in the Western Australia and area between Cape York Peninsula and Townsville in Queensland (Hill 2012). This species has remained relatively abundant in the Darwin rural area (Price et al. 2005). **Infonet grid cell records (latest record)**: 2 (unknown year)	**Low** • Marginal habitat is present within EP. • Southern limit of species distribution. • No existing records within the EP. • Low number of records in the surrounding region.	**None** • Suitable habitat is not expected to occur within EP.	**None** • Suitable habitat is not expected occur within road corridor.
Northern Brush-tailed Phascogale *Phascogale pirata*	**EPBC status**: Vulnerable **TPWC status:** Endangered **Habitat:** No detailed studies are known from the Northern Territory, but its ecology is probably similar to that reported for its temperate relatives (Rhind 1998). Most records are from open forests dominated by *Eucalyptus miniata* & *E. tetrodonta*. **Distribution:** This species was known to occur throughout the Top End, with most records coming from Kakadu National Park (Woinarski & Ward 2006). **Infonet grid cell records (latest record)**: 0	**None** • Outside of known species distribution.	**None** • Outside of known species distribution.	**None** • Outside of known species distribution.
Pale Field-rat *Rattus tunneyi*	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** Historically occurred in a wide range of habitats, but is now primarily found in dense vegetation along creeks (Aplin et al. 2008). Also known to inhabit rocky hillsides. **Distribution:** Occurs in the higher rainfall areas of northern	**Medium** • Suitable habitat may be present in EP. • There are 4 records within the EP (latest from 1998).	**Low** • Although, it is possible that suitable habitat does occur this area is outside of the currently known distribution.	**Medium** • Suitable habitat may be present within the road corridor. • Low number of records in the

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
	Australia, extending from Kimberley to south-eastern Queensland, including the Top End of the Northern Territory (Braithwaite et al. 1996). **Infonet grid cell records (latest record)**: 9 (2005)	• Low number of records in the surrounding region. • Southern edge of known distribution.	• If present, will be confined to northern region of the EP.	surrounding region. • Southern edge of known species population.
Bare-rumped Sheath tail Bat *Saccolaimus saccolaimus*	**EPBC status**: Critically Endangered **TPWC status**: Data deficient **Habitat:** NT records are from Pandanus Woodland and eucalypt tall open forests (Friend & Braithwaite 1986; Churchill 1998). Roosts in tree hollows and caves (Duncan et al. 1999). **Distribution:** This species is known to from scattered localities throughout top end of the Northern Territory and also North-Eastern Queensland (Milne et al 2009). **Infonet grid cell records (latest record)**: 0	**Low** • Suitable habitat may be present within the EP. • No records within the EP or in the surrounding region.	**None** • Suitable habitat does not occur within EP. • No records within the EP or in the surrounding region.	**None** • Suitable habitat does not occur within road corridor. • No records within the road corridor or in the surrounding region.
Common Brushtail Possum (southern) *Trichosurus vulpecula vulpecula*	**EPBC status**: Not listed **TPWC status:** Endangered **Habitat:** In Central Australia, the it now occupies riverine habitat that is close to rocky outcrops and moist gullies within the ranges or rocky slopes (Kerle et al. 1992). **Distribution:** Occurs in isolated populations in the southern NT. It formerly had a much more extensive distribution in the NT that included most of the Tanami and Great Sandy Deserts across to the Western Australian border at Lake Mackay and Kintore, south to Charlotte Waters, east to the Todd and Hale River floodouts in the Simpson Desert, and as far north as the Murchinson Ranges (Pavey and Ward 2012). **Infonet grid cell records (latest record)**: 4 (2008)	**None** • Outside of known species distribution. • Suitable habitat is not expected to occur within EP.	**None** • Outside of known species distribution. • Suitable habitat is not expected to occur within EP.	**None** • Outside of known species distribution. • Suitable habitat is not expected to occur within road corridor.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
Carpentarian Antechinus *Pseudantechinus mimulus*	**EPBC status**: Critically Endangered **TPWC status**: Data deficient **Habitat:** The few records of this species show a preference for a range of vegetation types associated with a high cover of rocks and boulders. **Distribution:** At the present time this species is only known from Sir Edward Pellew group of islands in the Northern Territory (Kitchener 1991; Johnson & Kerle 1991; Taylor et al. 2004). Current mainland records are known from around Mount Isa (Wonarksi 2004) and Pungalina Station (Woinarski & Ward 2012). **Infonet grid cell records (latest record)**: 2 (unknown)	**None** • Outside of species distribution. • Suitable habitat may be present within the EP (in the far NE). • There are two unconfirmed records within the surrounding region (no records within the EP).	**None** • Outside of species distribution. • Suitable habitat does not occur within EP. • No records within the EP or in the surrounding region.	**None** • Outside of species distribution. • Suitable habitat does not occur within road corridor. • No records within the road corridor or in the surrounding region.
Northern Leaf-nosed Bat *Hipposideros stenotis*	**EPBC status**: not listed **TPWC status**: Vulnerable **Habitat:** Prefers rocky outcrops. It roosts in shallow caves, boulder piles and disused mines, and forages in a wide range of habitats including monsoon vine thickets, woodlands and open grasslands (Milne 2012). **Distribution:** In the NT, this species has been recorded at a few locations associated with high sandstone escarpments in the Top End region. It also occurs in the Kimberley and in Qld around the southern Gulf of Carpentaria (Milne 2012). **Infonet grid cell records (latest record)**: 1 (1981)	**Low** • Suitable habitat may be present within the EP (in the far NE). • No records within the EP. • One historic record in the surrounding region.	**None** • Suitable habitat does not occur within EP. • No records within the EP or in the surrounding region.	**None** • Suitable habitat does not occur within road corridor. • No records within the road corridor or in the surrounding region.
PLANTS				
Venus-hair Fern *Adiantum capillus-veneris*	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** The species grows on limestone or sandstone rock,	**None** • Suitable habitat does not occur within EP.	**None** • Suitable habitat does not occur within EP.	**None** • Suitable habitat does not occur within the

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
	or on alkaline soils (Kerrigan & Albrecht 2007). **Distribution:** This fern occurs in all Australian states except for Tasmania and the ACT. In the NT the species has been recorded at Jasper Gorge and at one location in Gregory National Park (Short et al. 2011). **Infonet grid cell records (latest record)**: 0			road corridor.
Victoria River Coral Fern *Gleichenia sp.* Victoria River (I.D.Cowie 9193)	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** Grows in seepage areas at the base of sandstone scarps or rock overhangs (Chinnock & Bell 1998). **Distribution:** The species has only been recorded in the Victoria River Gorge (Kerrigan & Cowie 2006a). **Infonet grid cell records (latest record)**: 0	**None** • Suitable habitat does not occur within EP.	**None** • Suitable habitat does not occur within EP.	**None** • Suitable habitat does not occur within the road corridor.
a Spinifex *Triodia fitzgeraldii*	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** Occurs on a rocky cliff top at the edge of a laterite plateau and the top of a scree slope. Has been collected from a small gully at the top of a plateau (Kerrigan & Cowie 2006b). **Distribution:** Known from one location in the Victoria River district (Kerrigan & Cowie 2006b). **Infonet grid cell records (latest record)**: 0	**None** • Suitable habitat does not occur within EP.	**None** • Suitable habitat does not occur within EP.	**None** • Suitable habitat does not occur within the road corridor.
Armstrong's Cycad *Cycas armstrongii*	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** This species occurs in open grassy woodland where adequate drainage appears to be a limiting factor (Kerrigan et al. 2006).	**None** • Outside of known species distribution.	**None** • Outside of known species distribution.	**None** • Outside of known species distribution.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
	Distribution: Endemic to the Top End of the Northern Territory with populations on the Tiwi Islands and Cobourg Peninsula (Kerrigan et al. 2006). **Infonet grid cell records (latest record)**: 4 (1999)			
FISH				
Freshwater Sawfish *Pristis pristis*	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** Juveniles and sub-adults predominantly occur in rivers and estuaries, while large mature animals tend to occur more often in coastal and offshore waters up to 25 m depth (Giles et al. 2006; Stevens et al. 2005). **Distribution:** This is known from several drainages in northern Australia from Western Australia to Queensland. Known from several drainages in northern Australia from WA to Qld. In the NT currently known from the Adelaide, Alligator (East and South), Daly, Darwin, Goomadeer, McArthur, Robinson & Victoria Rivers (Larson et al. 2007). **Infonet grid cell records (latest record)**: 0	**Low** • Outside of known species distribution. • No records within surrounding region. • Waterways within EP are not considered large enough for the species.	**None** • Outside of known species distribution. • EP does not have suitable waterways for this species.	**None** • Outside of known species distribution.
INVERTEBRATES				
Victoria's Land Snail *Setobaudinia victoriana*	**EPBC status**: Not listed **TPWC status:** Vulnerable **Habitat:** Known populations occur in leaf litter at the base of large limestone boulders in a marshy sink (Wilson et al. 2006).	**Low** • Suitable habitat may be present within the NW region of the EP.	**None** • Suitable habitat does not occur within EP. • Distant from existing	**None** • Suitable habitat does not occur within the road corridor.

Threatened species 'Likelihood of Occurrence' Assessment for the Pangaea Resources project area (EP 167 and 168)				
Species name	**Species details**	**Likelihood of occurrence within lease boundary**		
		EP167	**EP168**	**Western Creek Road**
	Distribution: Only known from a few populations adjacent to the Victoria Highway, SW of Katherine (Wilson et al. 2006). **Infonet grid cell records (latest record)**: 0	• EP is close to the existing records of the species • Highly restricted species, unlikely to occur in other catchments.	records.	• Distant from existing records.

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Analyte	Units	LOR	ANZECC 2000 Guideline *95% Freshwater Ecosystem Protection*	Australian Drinking Water Guidelines (Health)	Australian Drinking Water Guidelines (Asthetic)	NEPM 1999 Agricultural Uses Irrigation	ANZECC Primary Industry (Short Term Irrigation)	Gorrie Station KTM	Western Creek Station	Avago St RIBBONE	Birdum House Bore	Tarlee-1 Sump	Wyworrie Station House Bore
Bore Registration Number (RN)								**RN030873**	**RN031926**	**RN035130**	**RN024616**	**Sump**	**RN023859**
Sample Date								**13/05/2015**	**13/05/2015**	**12/05/2015**	**12/05/2015**	**24/08/2015**	**25/08/2015**
Bore Depth													
Depth in metres below ground level	mbgl	-	-	-	-			-	-	-	-	0	
Standing water level	mbgl											0	46.70
Map Coordinates													
Zone	-	-	-	-	-			53	53	53	53	53	53
Easting	-	-	-	-	-			261540	251647	261090	304595	268726	251431
Northing	-	-	-	-	-			8297590	8245529	8134533	8274348	8234860	8294719
Field Parameters													
Temperature	°C	-	-	-	-			33.2	33.4	32.7	33.7	37.9	31.8
pH	pH units	-	-	-	-			7.24	6.70	6.66	6.73	9.32	6.83
Electrical Conductivity	mS/cm	-	-	-	-			0.530	0.817	0.812	1.685	38.09	0.866
Total Dissolved Solids	g/L	-	-	-	-			0.348	0.532	0.528	1.095	24.61	0.563
Salinity	ppt	-	-	-	-			0.3	0.4	0.4	0.8	24	0.4
Dissolved Oxygen	%sat	-	-	-	-			9.9	33.6	13.5	8.1	4.25	48.7
Oxidation Reduction Potential	mV	-	-	-	-			43	5	178	105	41	134
Turbidity	NTU	-	-	-	-			1.15	3.62	0.49	15.3	OVR	0.57
EA065: Total Hardness as CaCO3													
Total Hardness as CaCO3	mg/L	1	-	-	200			200	456	440	564	388	468
ED009: Anions													
Bromide	mg/L	0.01	-	-	-			<0.005	<0.005	<0.005	1.36	<0.500	0.091
ED037P: Alkalinity by PC Titrator													
Bicarbonate Alkalinity as CaCO3	mg/L	1	-	-	-			252	402	403	460	826	401
Carbonate Alkalinity as CaCO3	mg/L	1	-	-	-			<1	<1	<1	<1	57	<1
Hydroxide Alkalinity as CaCO3	mg/L	1	-	-	-			<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	-	-	-			252	402	403	460	883	401
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA													
Sulfate as SO4 - Turbidimetric	mg/L	1	-	-	250			<1	11	2	134	522	<1
ED045G: Chloride Discrete analyser													
Chloride	mg/L	1	-	-	250			13	8	8	202	8150	25
ED093F: Dissolved Major Cations													
Calcium	mg/L	1	-	-	-			49	130	120	142	142	143
Magnesium	mg/L	1	-	-	-			19	32	34	51	8	27
Potassium	mg/L	1	-	-	-			2	3	3	15	11600	2
Sodium	mg/L	1	-	-	180			46	8	9	140	1690	15
EG020F: Dissolved Metals by ICP-MS													
Aluminium	mg/L	0.01	0.055	-	0.2		20	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
Arsenic	mg/L	0.001	-	0.01	-		2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	0.001	-	2	-			0.012	0.066	0.042	0.071	0.057	0.021
Boron	mg/L	0.05	0.37	4	-		0.5	0.13	<0.05	0.05	0.2	<0.05	<0.05
Cadmium	mg/L	0.0001	0.0002	0.002	-		0.05	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	-	0.05	-		1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	0.0014	2	1		5	<0.001	<0.001	0.002	0.01	<0.001	0.005
Iron	mg/L	0.05	-	-	0.3		10	<0.05	0.4	<0.05	0.13	<0.05	<0.05
Lead	mg/L	0.001	0.0034	0.01	-		5	<0.001	<0.001	0.002	0.01	<0.001	<0.001
Manganese	mg/L	0.001	1.9	0.5	0.1		10	0.003	0.034	<0.001	0.007	0.003	<0.001
Nickel	mg/L	0.001	0.011	0.02	-		2	<0.001	0.005	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	0.011	0.01	-		0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	-	-	-			0.104	0.092	0.069	0.365	0.101	0.107
Zinc	mg/L	0.005	0.008	-	3		5	<0.005	0.016	0.197	0.378	<0.005	0.009
EG035F: Dissolved Mercury by FIMS													
Mercury	mg/L	0.0001	0.0006	-	0.001			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052G: Silica by Discrete Analyser													
Reactive Silica	mg/L	0.1	-	-	-			49.5	33.9	38.3	42.6	16.9	57.3
EK040P: Fluoride by PC Titrator													
Fluoride	mg/L	0.1	-	1.5	-			0.3	0.3	0.2	0.2	0.8	0.2
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser													
Nitrite + Nitrate as N	mg/L	0.01	-	-	-			0.08	0.1	0.08	0.33	<0.01	0.16
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser													
Total Kjeldahl Nitrogen as N	mg/L	0.1	-	-	-			<0.1	<0.1	<0.1	<0.1	118	<0.1
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser													
Total Nitrogen as N	mg/L	0.1	-	-	-		25	<0.1	0.1	<0.1	0.3	118	0.2
EK067G: Total Phosphorus as P by Discrete Analyser													
Total Phosphorus as P	mg/L	0.01	-	-	-		0.8	0.01	<0.01	<0.01	<0.01	47.8	<0.01
EN055: Ionic Balance													
Ionic Balance	%	0.01	-	-	-			5.74	5.89	5.34	0.22	18.9	7.18
Total Anions	meq/L	0.01	-	-	-			5.4	8.49	8.32	17.7	258	8.72
Total Cations	meq/L	0.01	-	-	-			6.06	9.54	9.25	17.8	378	10.1
EP011: Tannin													
Tannins	mg/L	2	-	-	-			<2	<2	<2	<2	<200	<2
EP033: C1 - C4 Hydrocarbon Gases													
Methane	µg/L	10	-	-	-			38	<10	<10	<10	<10	<10
EP080/071: Total Petroleum Hydrocarbons													
C10 - C14 Fraction	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
C10 - C36 Fraction (sum)	µg/L	50	-	-	-			<50	<50	<50	<50	27400	<50
C15 - C28 Fraction	µg/L	100	-	-	-			<100	<100	<100	<100	24700	<100
C29 - C36 Fraction	µg/L	50	-	-	-			<50	<50	<50	<50	2700	<50
C6 - C9 Fraction	µg/L	20	-	-	-			<20	<20	<20	<20	30	<20
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013													
>C10 - C16 Fraction	µg/L	100	-	-	-			<100	<100	<100	<100	860	<100
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100	-	-	-			<100	<100	<100	<100	860	<100
>C10 - C40 Fraction (sum)	µg/L	100	-	-	-			<100	<100	<100	<100	28400	<100
>C16 - C34 Fraction	µg/L	100	-	-	-			<100	<100	<100	<100	25600	<100
>C34 - C40 Fraction	µg/L	100	-	-	-			<100	<100	<100	<100	1960	<100
C6 - C10 Fraction	µg/L	20	-	-	-			<20	<20	<20	<20	30	<20
C6 - C10 Fraction minus BTEX (F1)	µg/L	20	-	-	-			<20	<20	<20	<20	30	<20
EP080: BTEXN													
Benzene	µg/L	1	950	1	1			<1	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	2	-	300	3			<2	<2	<2	<2	<2	<2
Naphthalene	µg/L	5	16	-	-			<2	<2	<2	<2	<5	<5
Sum of BTEX	µg/L	1	-	-	-			<5	<5	<5	<5	<1	<1

Analyte	Units	LOR	ANZECC 2000 Guideline *95% Freshwater Ecosystem Protection*	Australian Drinking Water Guidelines (Health)	Australian Drinking Water Guidelines (Asthetic)	NEPM 1999 Agricultural Uses Irrigation	ANZECC Primary Industry (Short Term Irrigation)	Gorrie Station KTM	Western Creek Station	Avago St RIBBONE	Birdum House Bore	Tarlee-1 Sump	Wyworrie Station House Bore
Bore Registration Number (RN)								RN030873	RN031926	RN035130	RN024616	Sump	RN023859
Sample Date								13/05/2015	13/05/2015	12/05/2015	12/05/2015	24/08/2015	25/08/2015
Toluene	µg/L	2	-	800	25			<2	<2	<2	<2	<2	<2
Total Xylenes	µg/L	2	-	600	20			<1	<1	<1	<1	<2	<2
meta- & para-Xylene	µg/L	2	-	-	-			<2	<2	<2	<2	<2	<2
ortho-Xylene	µg/L	2	350	-	-			<2	<2	<2	<2	<2	<2
EP080S: TPH(V)/BTEX Surrogates													
1.2-Dichloroethane-D4	%	surrogate	-	-	-			46	46	46	44	93.4	94.8
4-Bromofluorobenzene	%	surrogate	-	-	-			59	58	59	52	96.2	97.2
Toluene-D8	%	surrogate	-	-	-			61	60	61	59	92	112
EP074A: Monocyclic Aromatic Hydrocarbons													
1.2.4-Trimethylbenzene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.3.5-Trimethylbenzene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Isopropylbenzene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
n-Butylbenzene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
n-Propylbenzene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
p-Isopropyltoluene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
sec-Butylbenzene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Styrene	µg/L	5	-	30	4			<5	<5	<5	<5	<5	<5
tert-Butylbenzene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
EP074B: Oxygenated Compounds													
2-Butanone (MEK)	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
2-Hexanone (MBK)	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
4-Methyl-2-pentanone (MIBK)	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
Vinyl Acetate	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
EP074C: Sulfonated Compounds													
Carbon disulfide	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
EP074D: Fumigants													
1.2-Dibromoethane (EDB)	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.2-Dichloropropane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
2.2-Dichloropropane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
cis-1.3-Dichloropropylene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
trans-1.3-Dichloropropylene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
EP074E: Halogenated Aliphatic Compounds													
1.1.1.2-Tetrachloroethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.1.1-Trichloroethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.1.2.2-Tetrachloroethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.1.2-Trichloroethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.1-Dichloroethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.1-Dichloroethene	µg/L	5	-	30	-			<5	<5	<5	<5	<5	<5
1.1-Dichloropropylene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.2.3-Trichloropropane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.2-Dibromo-3-chloropropane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
1.2-Dichloroethane	µg/L	5	-	3	-			<5	<5	<5	<5	<5	<5
1.3-Dichloropropane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Bromomethane	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
Carbon Tetrachloride	µg/L	5	-	3	-			<5	<5	<5	<5	<5	<5
Chloroethane	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
Chloromethane	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
cis-1.2-Dichloroethene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
cis-1.4-Dichloro-2-butene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Dibromomethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Dichlorodifluoromethane	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
Hexachlorobutadiene	µg/L	5	-	0.7	-			<5	<5	<5	<5	<5	<5
Iodomethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Pentachloroethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Tetrachloroethene	µg/L	5	-	50	-			<5	<5	<5	<5	<5	<5
trans-1.2-Dichloroethene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
trans-1.4-Dichloro-2-butene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Trichloroethene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Trichlorofluoromethane	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
Vinyl chloride	µg/L	50	-	-	-			<50	<50	<50	<50	<50	<50
EP074F: Halogenated Aromatic Compounds													
1.2.3-Trichlorobenzene	µg/L	5	10	-	-			<5	<5	<5	<5	<5	<5
1.2.4-Trichlorobenzene	µg/L	5	170	-	-			<5	<5	<5	<5	<5	<5
1.2-Dichlorobenzene	µg/L	5	160	1500	1			<5	<5	<5	<5	<5	<5
1.3-Dichlorobenzene	µg/L	5	260	-	20			<5	<5	<5	<5	<5	<5
1.4-Dichlorobenzene	µg/L	5	60	40	0.3			<5	<5	<5	<5	<5	<5
2-Chlorotoluene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
4-Chlorotoluene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Bromobenzene	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Chlorobenzene	µg/L	5	-	300	10			<5	<5	<5	<5	<5	<5
EP074G: Trihalomethanes													
Bromodichloromethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Bromoform	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Chloroform	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
Dibromochloromethane	µg/L	5	-	-	-			<5	<5	<5	<5	<5	<5
EP074S: VOC Surrogates													
1.2-Dichloroethane-D4	µg/L	surrogate	-	-	-			45	44	45	42	90.5	115
4-Bromofluorobenzene	µg/L	surrogate	-	-	-			52	53	53	50	86.9	108
Toluene-D8	µg/L	surrogate	-	-	-			60	59	60	58	113	120
EP075(SIM)A: Phenolic Compounds													
2.4.5-Trichlorophenol	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4.6-Trichlorophenol	µg/L	1	-	20	2			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dichlorophenol	µg/L	1	160	200	0.3			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dimethylphenol	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.6-Dichlorophenol	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1	490	300	0.1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Nitrophenol	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3- & 4-Methylphenol	µg/L	2	-	-	-			<2.0	<2.0	<2.0	<2.0	3.2	<2.0
4-Chloro-3-methylphenol	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	2	-	10	-			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0

Analyte	Units	LOR	ANZECC 2000 Guideline *95% Freshwater Ecosystem Protection*	Australian Drinking Water Guidelines (Health)	Australian Drinking Water Guidelines (Asthetic)	NEPM 1999 Agricultural Uses Irrigation	ANZECC Primary Industry (Short Term Irrigation)	Gorrie Station KTM	Western Creek Station	Avago St RIBBONE	Birdum House Bore	Tarlee-1 Sump	Wyworrie Station House Bore
Bore Registration Number (RN)								RN030873	RN031926	RN035130	RN024616	Sump	RN023859
Sample Date								13/05/2015	13/05/2015	12/05/2015	12/05/2015	24/08/2015	25/08/2015
Phenol	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	6.8	<1.0
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons													
Acenaphthene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	µg/L	0.5	-	0.01	-			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ (zero)	µg/L	0.5	-	-	-			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(b+j)fluoranthene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Indeno(1.2.3.cd)pyrene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Naphthalene	µg/L	1	-	-	-			1.4	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	µg/L	1	-	-	-			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5	-	-	-			1.4	<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates													
2.4.6-Tribromophenol	µg/L	surrogate	-	-	-			4.1	5.5	4.7	5.3	27.3	52.6
2-Chlorophenol-D4	µg/L	surrogate	-	-	-			5	5.1	4.4	4.9	35	60.8
Phenol-d6	µg/L	surrogate	-	-	-			2.2	2.2	1.8	2.3	30.2	30.8
EP075(SIM)T: PAH Surrogates													
2-Fluorobiphenyl	µg/L	surrogate	-	-	-			6.8	6.6	5.9	7	75.4	75.7
4-Terphenyl-d14	µg/L	surrogate	-	-	-			6.5	6.4	5.9	7.3	43	75
Anthracene-d10	µg/L	surrogate	-	-	-			7.6	6.4	8.8	7.4	65.9	70.6

Analyte	Units	LOR	Wyworrie Station	Wyworrie Flare Pit	Gorrie Station KTM	Gorrie Station Emma Bore	Tarlee-2 Sump	Tarlee-2 Flare Pit	Western Creek Station	Western Creek	Tarlee House Bore	Middle Creek Bore 2	Birdum Pit
Bore Registration Number (RN)			RN031382	Flare Pit	RN030873	RN031630	Sump	Flare Pit	RN031926	RN036336	RN035146 (called RN05928 on COC)	RN035138	Pit
Sample Date			25/08/2015	25/08/2015	25/08/2015	25/08/2015	25/08/2015	25/08/2015	25/08/2015	26/08/2015	26/08/2015	26/08/2015	26/08/2015
Bore Depth													
Depth in metres below ground level	mbgl	-		0			0	0					0
Standing water level	mbgl		50.64	0.00	Logger	34.80	0	0	Logger	29.75	44.00	51.37	0.00
Map Coordinates													
Zone	-	-	53	53	53	53	53	53	53	53	53	53	53
Easting	-	-	247662	258063	261540	248284	251942	251942	251647	248284	258312	276918	301008
Northing	-	-	8298836	8299533	8297590	8261572	8241833	8241833	8245529	8261572	8265665	8259271	8271008
Field Parameters													
Temperature	°C	-	32.1	29.8	32.6	33.2	32.7	31.1	32.8	28	32.1	34.4	32.5
pH	pH units	-	6.77	7.42	7.28	6.79	7.85	7.94	6.9	7.39	6.84	7.53	7.45
Electrical Conductivity	mS/cm	-	0.942	37.34	0.52	0.807	14.02	13.88	0 83	4.376	0.989	10.04	44
Total Dissolved Solids	g/L	-	0.613	24.46	0.341	0.463	9.1	9.02	0.539	2.842	0.643	6.53	28.5
Salinity	ppt	-	0.5	23.5	0.3	0.3	8	8	0.4	2.3	0.5	5.6	28.1
Dissolved Oxygen	%sat	-	26.4	2.11	36.2	31.3	16.6	7.2	36.7	29.5	5.57	63	18.2
Oxidation Reduction Potential	mV	-	18	89	34	72	26	10	67	120	8	136	133
Turbidity	NTU	-	10	OVR	1.19	6	565	199	6 68	99.4	1.14	3.39	82.2
EA065: Total Hardness as CaCO3													
Total Hardness as CaCO3	mg/L	1	488	856	209	418	314	1220	446	379	478	1310	1640
ED009: Anions													
Bromide	mg/L	0.01	0.102	13.4	0.041	0.066	<2.50	19.4	0.045	4.79	0.162	4.61	7.69
ED037P: Alkalinity by PC Titrator													
Bicarbonate Alkalinity as CaCO3	mg/L	1	409	971	253	385	344	241	402	263	430	4	2260
Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	409	971	253	385	344	241	402	263	430	4	2260
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA													
Sulfate as SO4 - Turbidimetric	mg/L	1	30	207	<1	<1	285	39	8	6	6	<1	351
ED045G: Chloride Discrete analyser													
Chloride	mg/L	1	29	11400	8	18	3870	4580	8	1320	38	3430	12800
ED093F: Dissolved Major Cations													
Calcium	mg/L	1	131	280	49	146	93	372	126	109	122	485	515
Magnesium	mg/L	1	39	38	21	13	20	70	32	26	42	24	85
Potassium	mg/L	1	2	9910	2	<1	3540	372	3	15	3	6	10700
Sodium	mg/L	1	26	2480	39	20	449	2180	9	753	23	1550	3140
EG020F: Dissolved Metals by ICP-MS													
Aluminium	mg/L	0.01	<0.01	3.99	<0.01	<0.01	0.1	0.48	<0.01	0.03	<0.01	<0.01	<0.10
Arsenic	mg/L	0.001	<0.001	<0.010	<0.001	<0.001	0.007	0.003	<0.001	<0.001	<0.001	<0.001	<0.010
Barium	mg/L	0.001	0.021	4.99	0.012	0.057	0.292	5.54	0.065	1.72	0.032	0.214	2.43
Boron	mg/L	0.05	0.21	0.39	0.06	0.09	0.09	1.42	<0.05	1.38	0.07	1.78	0.86
Cadmium	mg/L	0.0001	<0.0001	<0.0010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0013
Chromium	mg/L	0.001	<0.001	0.104	<0.001	<0.001	0.146	0.002	<0.001	<0.001	<0.001	<0.001	0.086
Copper	mg/L	0.001	<0.001	<0.010	<0.001	<0.001	0.035	0.005	<0.001	<0.001	<0.001	<0.001	<0.010
Iron	mg/L	0.05	0.65	1.33	<0.05	2.12	0.09	0.27	0.67	1.53	<0.05	2.32	<0.10
Lead	mg/L	0.001	<0.001	<0.010	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.010
Manganese	mg/L	0.001	0.006	0.787	0.005	0.048	0.034	0.192	0.02	0.136	<0.001	0.321	1.72
Nickel	mg/L	0.001	<0.001	0.019	<0.001	<0.001	0.016	0.006	<0.001	0.001	<0.001	<0.001	0.01
Selenium	mg/L	0.01	<0.01	<0.10	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.10
Strontium	mg/L	0.001	0.146	3.93	0.081	0.158	0.794	7.03	0.097	1.37	0.087	2.96	3.07
Zinc	mg/L	0.005	0.006	0.131	<0.005	<0.005	0.044	0.022	0.009	<0.005	0.009	0.012	<0.050
EG035F: Dissolved Mercury by FIMS													
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052G: Silica by Discrete Analyser													
Reactive Silica	mg/L	0.1	59.7	22.5	51.2	64.5	43.5	26 8	35	29.7	43.2	1.34	55 3
EK040P: Fluoride by PC Titrator													
Fluoride	mg/L	0.1	0.2	1.4	0.3	0.3	0.4	1	0.2	0.7	0.3	0.4	1.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser													
Nitrite + Nitrate as N	mg/L	0.01	0.02	<0.01	0.06	<0.01	<0.01	<0.01	0.07	<0.01	1.16	<0.01	0.01
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser													
Total Kjeldahl Nitrogen as N	mg/L	0.1	<0.1	20.1	<0.1	<0.1	35.4	14.9	<0.1	1.5	<0.1	<0.1	42.8
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser													
Total Nitrogen as N	mg/L	0.1	<0.1	20.1	<0.1	<0.1	35.4	14.9	<0.1	1.5	1.2	<0.1	42.8
EK067G: Total Phosphorus as P by Discrete Analyser													
Total Phosphorus as P	mg/L	0.01	<0.01	2 29	<0.01	<0.01	10.7	1.21	<0.01	0.11	<0.01	0.01	1.45
EN055: Ionic Balance													
Ionic Balance	%	0.01	6.41	4 66	5.7	5.91	2.26	2.33	5.44	2.29	4.1	1.61	3.5
Total Anions	meq/L	0.01	9.61	345	5.28	8.2	122	135	8.42	42.6	9.79	96.8	414
Total Cations	meq/L	0.01	10 9	378	5.92	9.22	116	129	9 39	40.7	10.6	93.8	443
EP011: Tannin													
Tannins	mg/L	2	<2	<10	<2	<2	4	<2	<2	<2	<2	<2	49
EP033: C1 - C4 Hydrocarbon Gases													
Methane	µg/L	10	<10	24	<10	47	<10	<10	<10	2210	<10	493	242
EP080/071: Total Petroleum Hydrocarbons													
C10 - C14 Fraction	µg/L	50	<50	4380	<50	<50	230	580	<50	<50	<50	<50	320
C10 - C36 Fraction (sum)	µg/L	50	<50	15700	<50	<50	7580	7860	<50	<50	<50	<50	1170
C15 - C28 Fraction	µg/L	100	<100	8810	<100	<100	5120	5820	<100	<100	<100	<100	510
C29 - C36 Fraction	µg/L	50	<50	2500	<50	<50	2230	1460	<50	<50	<50	<50	340
C6 - C9 Fraction	µg/L	20	<20	<20	<20	<20	<20	30	<20	<20	<20	<20	<100
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013													
>C10 - C16 Fraction	µg/L	100	<100	5100	<100	<100	320	650	<100	<100	<100	<100	390
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100	<100	5100	<100	<100	320	650	<100	<100	<100	<100	390
>C10 - C40 Fraction (sum)	µg/L	100	<100	16300	<100	<100	7510	7880	<100	<100	<100	<100	1380
>C16 - C34 Fraction	µg/L	100	<100	9400	<100	<100	6870	6680	<100	<100	<100	<100	610
>C34 - C40 Fraction	µg/L	100	<100	1820	<100	<100	320	550	<100	<100	<100	<100	380
C6 - C10 Fraction	µg/L	20	<20	<20	<20	<20	<20	40	<20	<20	<20	<20	<100
C6 - C10 Fraction minus BTEX (F1)	µg/L	20	<20	<20	<20	<20	<20	40	<20	<20	<20	<20	<100
EP080: BTEXN													
Benzene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5
Ethylbenzene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<5
Naphthalene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sum of BTEX	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5

Analyte	Units	LOR	Wyworrie Station	Wyworrie Flare Pit	Gorrie Station KTM	Gorrie Station Emma Bore	Tarlee-2 Sump	Tarlee-2 Flare Pit	Western Creek Station	Western Creek	Tarlee House Bore	Middle Creek Bore 2	Birdum Pit
Bore Registration Number (RN)			RN031382	Flare Pit	RN030873	RN031630	Sump	Flare Pit	RN031926	RN036336	RN035146 (called RN05928 on COC)	RN035138	Pit
Sample Date			25/08/2015	25/08/2015	25/08/2015	25/08/2015	25/08/2015	25/08/2015	25/08/2015	26/08/2015	26/08/2015	26/08/2015	26/08/2015
Toluene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<5
Total Xylenes	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<5
meta- & para-Xylene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<5
ortho-Xylene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<5
EP080S: TPH(V)/BTEX Surrogates													
1.2-Dichloroethane-D4	%	surrogate	96 2	126	101	100	123	114	115	112	135	124	121
4-Bromofluorobenzene	%	surrogate	97.5	124	92.9	89	115	110	113	106	109	118	126
Toluene-D8	%	surrogate	108	119	110	104	103	95.7	95.8	90.2	94	102	112
EP074A: Monocyclic Aromatic Hydrocarbons													
1.2.4-Trimethylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.3.5-Trimethylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Isopropylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
n-Butylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
n-Propylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
p-Isopropyltoluene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
sec-Butylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Styrene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
tert-Butylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
EP074B: Oxygenated Compounds													
2-Butanone (MEK)	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	140
2-Hexanone (MBK)	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
4-Methyl-2-pentanone (MIBK)	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Vinyl Acetate	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
EP074C: Sulfonated Compounds													
Carbon disulfide	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	108
EP074D: Fumigants													
1.2-Dibromoethane (EDB)	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
2.2-Dichloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.3-Dichloropropylene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.3-Dichloropropylene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
EP074E: Halogenated Aliphatic Compounds													
1.1.1.2-Tetrachloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.1-Trichloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2.2-Tetrachloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2-Trichloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloropropylene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.3-Trichloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromo-3-chloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromomethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Carbon Tetrachloride	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloroethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Chloromethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
cis-1.2-Dichloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.4-Dichloro-2-butene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dibromomethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dichlorodifluoromethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Hexachlorobutadiene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Iodomethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pentachloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.2-Dichloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.4-Dichloro-2-butene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trichlorofluoromethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Vinyl chloride	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
EP074F: Halogenated Aromatic Compounds													
1.2.3-Trichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.4-Dichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Chlorotoluene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
4-Chlorotoluene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
EP074G: Trihalomethanes													
Bromodichloromethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloroform	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dibromochloromethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
EP074S: VOC Surrogates													
1.2-Dichloroethane-D4	µg/L	surrogate	122	112	124	122	119	110	111	109	131	120	108
4-Bromofluorobenzene	µg/L	surrogate	108	106	106	100	104	98.9	102	96.1	97.6	106	108
Toluene-D8	µg/L	surrogate	115	129	119	113	127	118	118	111	116	125	122
EP075(SIM)A: Phenolic Compounds													
2.4.5-Trichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4.6-Trichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dimethylphenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.6-Dichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1	<1.0	2.7	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.4
2-Nitrophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3- & 4-Methylphenol	µg/L	2	<2.0	5.5	<2.0	<2.0	<2.0	2.3	<2.0	<2.0	<2.0	<2.0	8.2
4-Chloro-3-methylphenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0

Analyte	Units	LOR	Wyworrie Station	Wyworrie Flare Pit	Gorrie Station KTM	Gorrie Station Emma Bore	Tarlee-2 Sump	Tarlee-2 Flare Pit	Western Creek Station	Western Creek	Tarlee House Bore	Middle Creek Bore 2	Birdum Pit
Bore Registration Number (RN)			RN031382	Flare Pit	RN030873	RN031630	Sump	Flare Pit	RN031926	RN036336	RN035146 (called RN05928 on COC)	RN035138	Pit
Sample Date			25/08/2015	25/08/2015	25/08/2015	25/08/2015	25/08/2015	25/08/2015	25/08/2015	26/08/2015	26/08/2015	26/08/2015	26/08/2015
Phenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	2.2	<1.0	<1.0	<1.0	<1.0	<1.0	18.2
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons													
Acenaphthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ (zero)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(b+j)fluoranthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Indeno(1.2.3.cd)pyrene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Naphthalene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates													
2.4.6-Tribromophenol	µg/L	surrogate	53 8	62.5	51.8	51.3	56.7	67.5	51.2	42.6	61.2	59	50.6
2-Chlorophenol-D4	µg/L	surrogate	58.7	45.8	64.8	59.5	47.7	57.7	60.2	53.7	66.4	61.1	43 9
Phenol-d6	µg/L	surrogate	30.5	26.9	31.5	29.5	26.2	33 2	29.2	26.3	31.5	30.6	27 3
EP075(SIM)T: PAH Surrogates													
2-Fluorobiphenyl	µg/L	surrogate	76 6	78.6	78.8	71.6	82.8	93	76.7	75.1	83.9	77	70
4-Terphenyl-d14	µg/L	surrogate	77.7	81.1	79.7	79	75.3	85	76.9	73.8	81.8	78.4	65.5
Anthracene-d10	µg/L	surrogate	72.7	73.2	75.5	72.7	67.9	77 8	72.3	69	78.7	72.3	57.7

Analyte	Units	LOR	Birdum	Birdum House Bore	Avago St RIBBONE	Cow Creek Station	Tarlee Railway Bore	Gorrie Station KTM	Avago St RIBBONE	Birdum House Bore
Bore Registration Number (RN)			RN036919 (called RN024616 on COC)	RN024616 (called Birdum House on COC)	RN035130	RN033135	RN032961	RN030873	RN035130	RN024616 (called Birdum House on COC)
Sample Date			26/08/2015	26/08/2015	27/08/2015	27/08/2015	27/08/2015	17/11/2015	17/11/2015	17/11/2015
Bore Depth										
Depth in metres below ground level	mbgl	-								
Standing water level	mbgl		Logger	Mono pump	61.00	30.17	Logger			
Map Coordinates										
Zone	-	-	53	53	53	53	53	53	53	53
Easting	-	-	304595	304595	261090	271769	264619	261540	261090	304595
Northing	-	-	8274348	8274348	8134533	8273192	8268055	8297590	8134533	8274348
Field Parameters										
Temperature	°C	-	33 3	32	31.5	32.8	30.4	38 6	32.2	31.9
pH	pH units	-	7.19	6 91	6.9	6.92	7.66	6.89	6 68	6.63
Electrical Conductivity	mS/cm	-	0.627	16.82	0.813	0.749	0.765	0.538	0.866	1.759
Total Dissolved Solids	g/L	-	0.407	1.093	0.529	0.487	0.497	0.359	0.563	1.143
Salinity	ppt	-	0.3	0.8	0.4	0.4	0.4	0.3	0.4	0.9
Dissolved Oxygen	%sat	-	48 6	35.7	35.8	58.6	80.5	33 6	17.2	16.3
Oxidation Reduction Potential	mV	-	116	73	125	66	7	50.6	5	7.43
Turbidity	NTU	-	7.37	3.74	28.7	3.37	2.15	1.93	1.9	0.42
EA065: Total Hardness as CaCO3										
Total Hardness as CaCO3	mg/L	1	292	587	459	402	392	205	439	610
ED009: Anions										
Bromide	mg/L	0.01	0.037	0.832	0.043	0.046	0.111	0.057	0.05	1.09
ED037P: Alkalinity by PC Titrator										
Bicarbonate Alkalinity as CaCO3	mg/L	1	295	454	404	382	342	259	424	477
Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	295	454	404	382	342	259	424	477
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA										
Sulfate as SO4 - Turbidimetric	mg/L	1	<1	135	1	<1	3	<1	1	137
ED045G: Chloride Discrete analyser										
Chloride	mg/L	1	12	191	8	18	31	7	8	194
ED093F: Dissolved Major Cations										
Calcium	mg/L	1	74	146	123	133	101	49	118	160
Magnesium	mg/L	1	26	54	37	17	34	20	35	51
Potassium	mg/L	1	2	15	3	<1	2	2	3	14
Sodium	mg/L	1	30	139	10	11	21	40	10	143
EG020F: Dissolved Metals by ICP-MS										
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	0.001	0.109	0.077	0.043	0.181	0.013	0.013	0.042	0.073
Boron	mg/L	0.05	<0.05	0 21	<0.05	<0.05	0.05	0.08	<0.05	0.17
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.002	0.004	<0.001
Iron	mg/L	0.05	<0.05	0.14	<0.05	<0.05	<0.05	<0.05	0.3	0.62
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	<0.001	0.004	0.011	<0.001	<0.001	0.006	0.005	0.008
Nickel	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	0.196	0.382	0.073	0.167	0.117	0.084	0.068	0.364
Zinc	mg/L	0.005	0.037	0.59	0.664	0.007	<0.005	0.006	0.727	0.201
EG035F: Dissolved Mercury by FIMS										
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052G: Silica by Discrete Analyser										
Reactive Silica	mg/L	0.1	57.4	43.5	37.4	98.2	63.3	49.4	36.8	41.4
EK040P: Fluoride by PC Titrator										
Fluoride	mg/L	0.1	0.2	0.3	0.2	0.6	0.2	0.3	0.3	0.2
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser										
Nitrite + Nitrate as N	mg/L	0.01	0.08	0.3	0.07	0.67	0.03	0.1	0.1	0.26
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser										
Total Kjeldahl Nitrogen as N	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser										
Total Nitrogen as N	mg/L	0.1	<0.1	0.3	<0.1	0.7	0.1	0.1	0.1	0.3
EK067G: Total Phosphorus as P by Discrete Analyser										
Total Phosphorus as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.01
EN055: Ionic Balance										
Ionic Balance	%	0.01	7.12	2.52	7.66	2.28	6.24	4.52	3.14	2.48
Total Anions	meq/L	0.01	6.23	17.3	8.32	8.14	7.77	5.37	8.72	17.8
Total Cations	meq/L	0.01	7.19	18.2	9.69	8.51	8.8	5.88	9 28	18.8
EP011: Tannin										
Tannins	mg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
EP033: C1 - C4 Hydrocarbon Gases										
Methane	µg/L	10	<10	<10	21	<10	<10	2	2	<1
EP080/071: Total Petroleum Hydrocarbons										
C10 - C14 Fraction	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
C10 - C36 Fraction (sum)	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
C15 - C28 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100
C29 - C36 Fraction	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
C6 - C9 Fraction	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013										
>C10 - C16 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum)	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100
>C16 - C34 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100
>C34 - C40 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100
C6 - C10 Fraction	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20
C6 - C10 Fraction minus BTEX (F1)	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20
EP080: BTEXN										
Benzene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
Naphthalene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Sum of BTEX	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1

Analyte	Units	LOR	Birdum	Birdum House Bore	Avago St RIBBONE	Cow Creek Station	Tarlee Railway Bore	Gorrie Station KTM	Avago St RIBBONE	Birdum House Bore
Bore Registration Number (RN)			RN036919 (called RN024616 on COC)	RN024616 (called Birdum House on COC)	RN035130	RN033135	RN032961	RN030873	RN035130	RN024616 (called Birdum House on COC)
Sample Date			26/08/2015	26/08/2015	27/08/2015	27/08/2015	27/08/2015	17/11/2015	17/11/2015	17/11/2015
Toluene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
meta- & para-Xylene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
ortho-Xylene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2
EP080S: TPH(V)/BTEX Surrogates										
1.2-Dichloroethane-D4	%	surrogate	114	122	114	105	104	96.4	96.7	103
4-Bromofluorobenzene	%	surrogate	111	119	108	100	102	97	101	108
Toluene-D8	%	surrogate	95 2	105	92.6	91.6	88.6	109	111	120
EP074A: Monocyclic Aromatic Hydrocarbons										
1.2.4-Trimethylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.3.5-Trimethylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Isopropylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
n-Butylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
n-Propylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
p-Isopropyltoluene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
sec-Butylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Styrene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
tert-Butylbenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
EP074B: Oxygenated Compounds										
2-Butanone (MEK)	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
2-Hexanone (MBK)	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
4-Methyl-2-pentanone (MIBK)	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
Vinyl Acetate	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
EP074C: Sulfonated Compounds										
Carbon disulfide	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
EP074D: Fumigants										
1.2-Dibromoethane (EDB)	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
2.2-Dichloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.3-Dichloropropylene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.3-Dichloropropylene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
EP074E: Halogenated Aliphatic Compounds										
1.1.1.2-Tetrachloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.1-Trichloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2.2-Tetrachloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2-Trichloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloropropylene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.3-Trichloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromo-3-chloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichloropropane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Bromomethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
Carbon Tetrachloride	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Chloroethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
Chloromethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
cis-1.2-Dichloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.4-Dichloro-2-butene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Dibromomethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Dichlorodifluoromethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
Hexachlorobutadiene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Iodomethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Pentachloroethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.2-Dichloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.4-Dichloro-2-butene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Trichlorofluoromethane	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
Vinyl chloride	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50
EP074F: Halogenated Aromatic Compounds										
1.2.3-Trichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
1.4-Dichlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
2-Chlorotoluene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
4-Chlorotoluene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Bromobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Chlorobenzene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
EP074G: Trihalomethanes										
Bromodichloromethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Chloroform	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
Dibromochloromethane	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5
EP074S: VOC Surrogates										
1.2-Dichloroethane-D4	µg/L	surrogate	110	118	110	102	101	80.2	80.7	86.3
4-Bromofluorobenzene	µg/L	surrogate	99 9	107	97.2	89.6	91.5	87 3	90.4	97.1
Toluene-D8	µg/L	surrogate	117	128	114	113	109	92.9	96	103
EP075(SIM)A: Phenolic Compounds										
2.4.5-Trichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4.6-Trichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dimethylphenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.6-Dichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Nitrophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3- & 4-Methylphenol	µg/L	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
4-Chloro-3-methylphenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0

Analyte	Units	LOR	Birdum	Birdum House Bore	Avago St RIBBONE	Cow Creek Station	Tarlee Railway Bore	Gorrie Station KTM	Avago St RIBBONE	Birdum House Bore
Bore Registration Number (RN)			RN036919 (called RN024616 on COC)	RN024616 (called Birdum House on COC)	RN035130	RN033135	RN032961	RN030873	RN035130	RN024616 (called Birdum House on COC)
Sample Date			26/08/2015	26/08/2015	27/08/2015	27/08/2015	27/08/2015	17/11/2015	17/11/2015	17/11/2015
Phenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons										
Acenaphthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ (zero)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(b+j)fluoranthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Indeno(1.2.3.cd)pyrene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Naphthalene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates										
2.4.6-Tribromophenol	µg/L	surrogate	51.1	42.6	54.4	48.2	41	67 9	60.2	65.2
2-Chlorophenol-D4	µg/L	surrogate	60 9	52.2	64.7	57.8	49.8	62	53.1	59.5
Phenol-d6	µg/L	surrogate	29 8	25.3	31	28.3	23.1	28 9	29.2	28.6
EP075(SIM)T: PAH Surrogates										
2-Fluorobiphenyl	µg/L	surrogate	77 9	60.1	75	70.9	70.3	70 8	64.6	68
4-Terphenyl-d14	µg/L	surrogate	76	66.7	76.2	70.9	69.1	58.5	55.4	60.7
Anthracene-d10	µg/L	surrogate	74 3	61.7	72.2	66.4	64.6	71.4	64.8	70.8

Improving the Water Efficiency of Unconventional Development

Joe Lima
Director, Environmental Sustainability

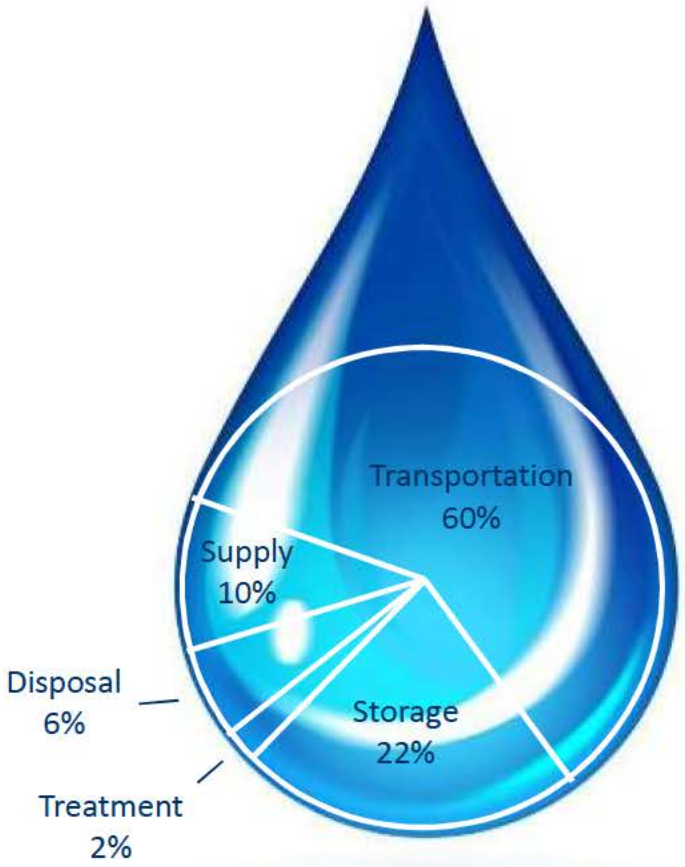
Schlumberger

Water Requirements by Energy Resource

Energy Resource	Range of Gallons of Water Used per MMBTU of Energy Produced
Marcellus Gas Well	1.30
Coal with No Slurry Transport	2 to 8
Coal with Slurry Transport	13 to 32
Nuclear (Uranium Ready to Use in a Power Plant)	8 to 14
Conventional Oil	8 to 20
Synfuel – Coal Gasification	11 to 26
Oil Shale	22 to 56
Tar Sands	27 to 68
Synfuel – Fischer Tropsch Synthesis (from Coal)	41 to 60
Enhanced Oil Recovery	21 to 2,500
Biofuels (Irrigated Corn Ethanol, Irrigated Soy Biodiesel)	>2,500

Source: From Chesapeake Fact Sheet with Data from GWPC, DOE

How About the Water…



Direct Annual Use for Hydraulic Fracturing

- Over 90 Billion Gallons in United States
- Average of 2.6 Million Gallons per Well
- Total Associated Costs over $6.4B

Best Practices Include

- Recycling of Flowback
- Alternate Sources of Water

Tight Gas Sands, Piceance Basin, Colorado USA

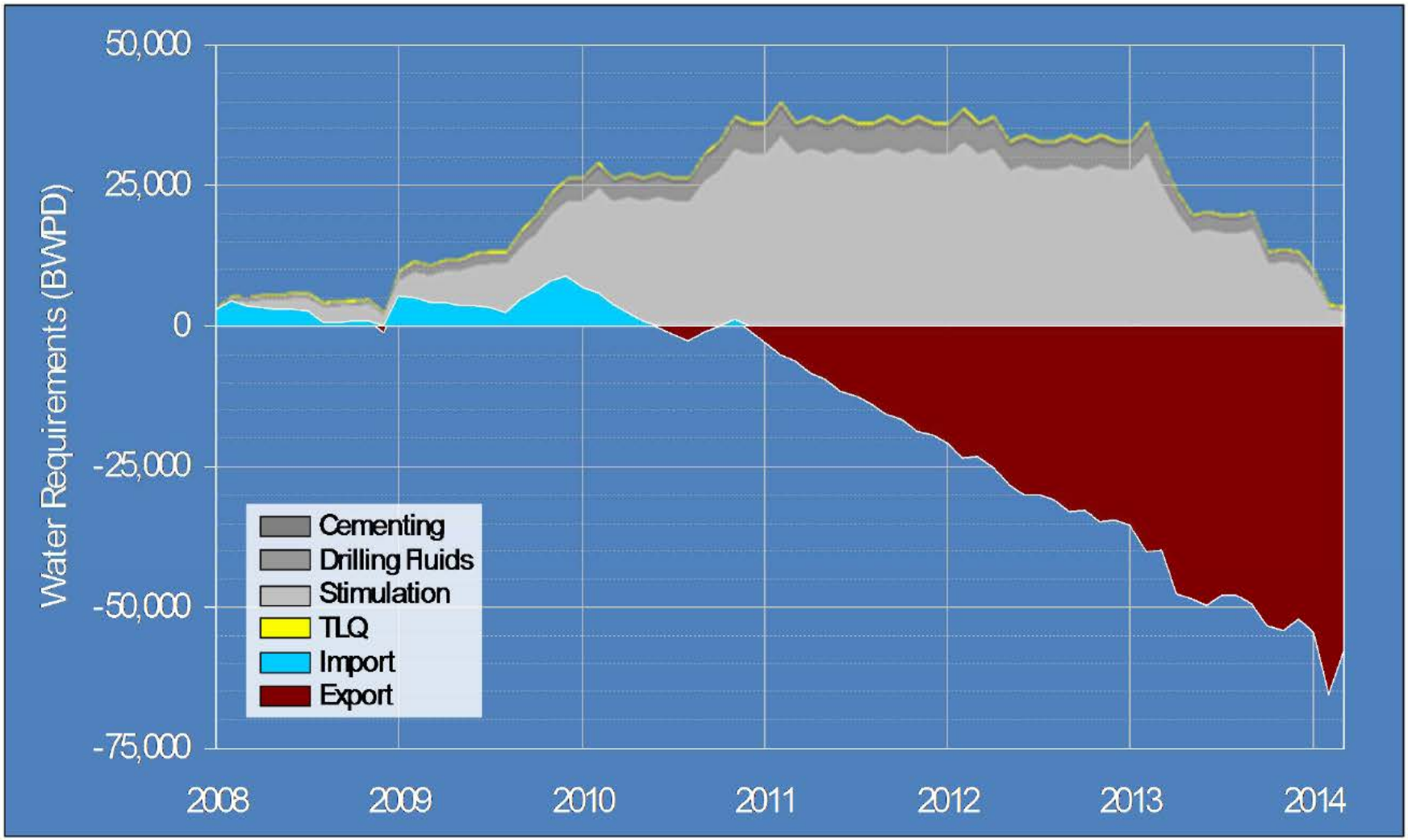
Surface Management with Direction Drilling

0 0.5 1

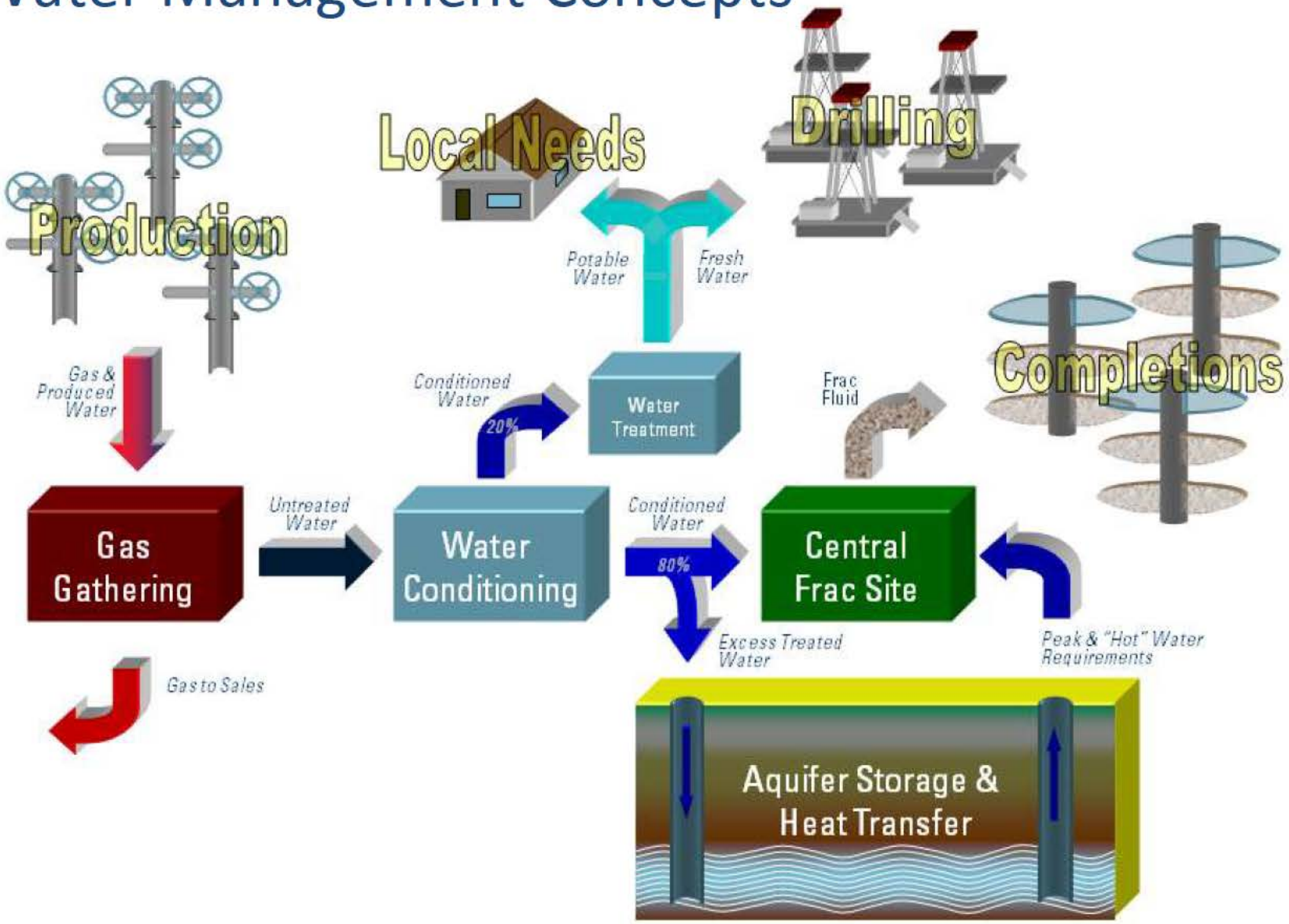
kilometers

s

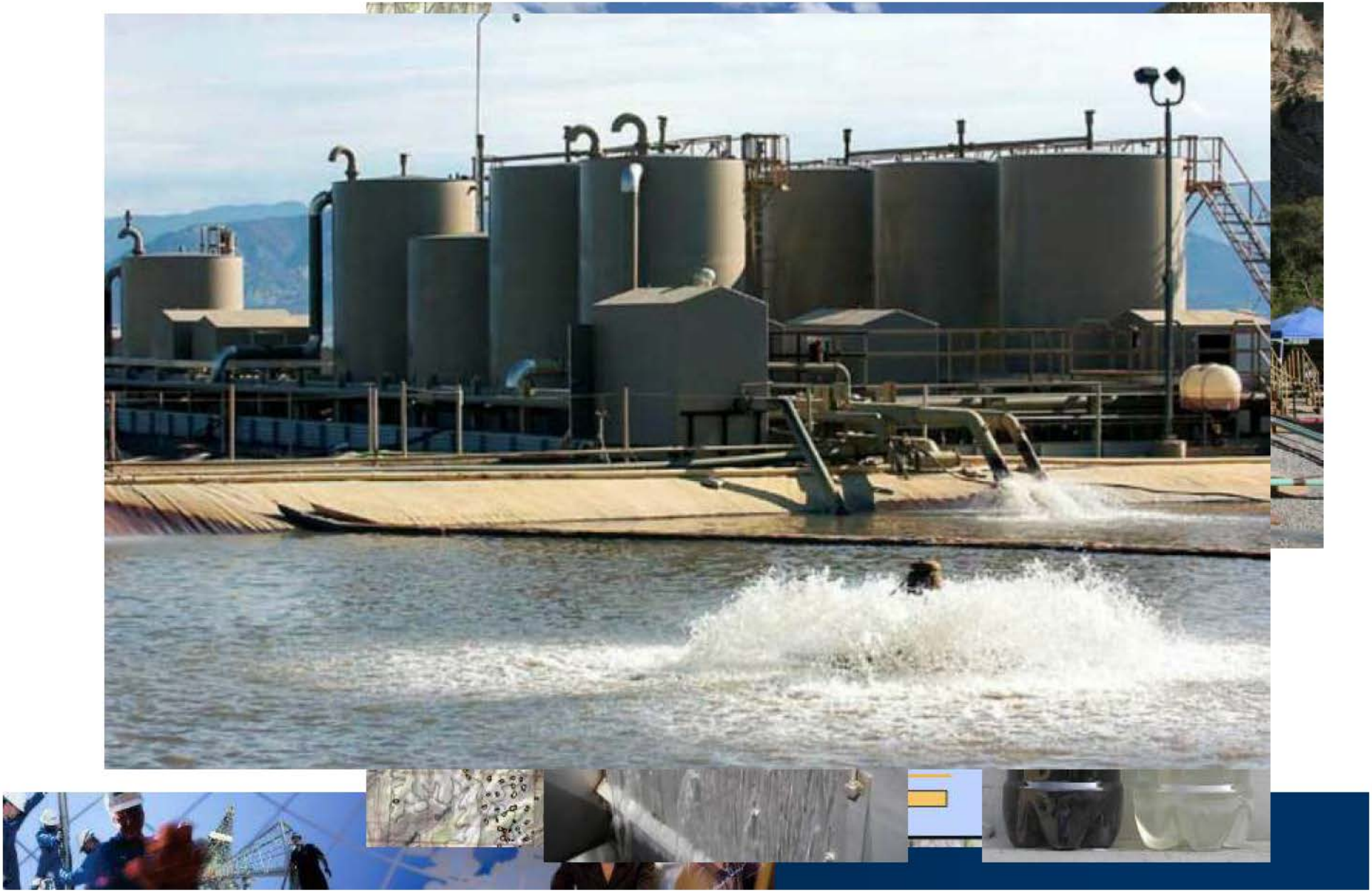
Water Requirements



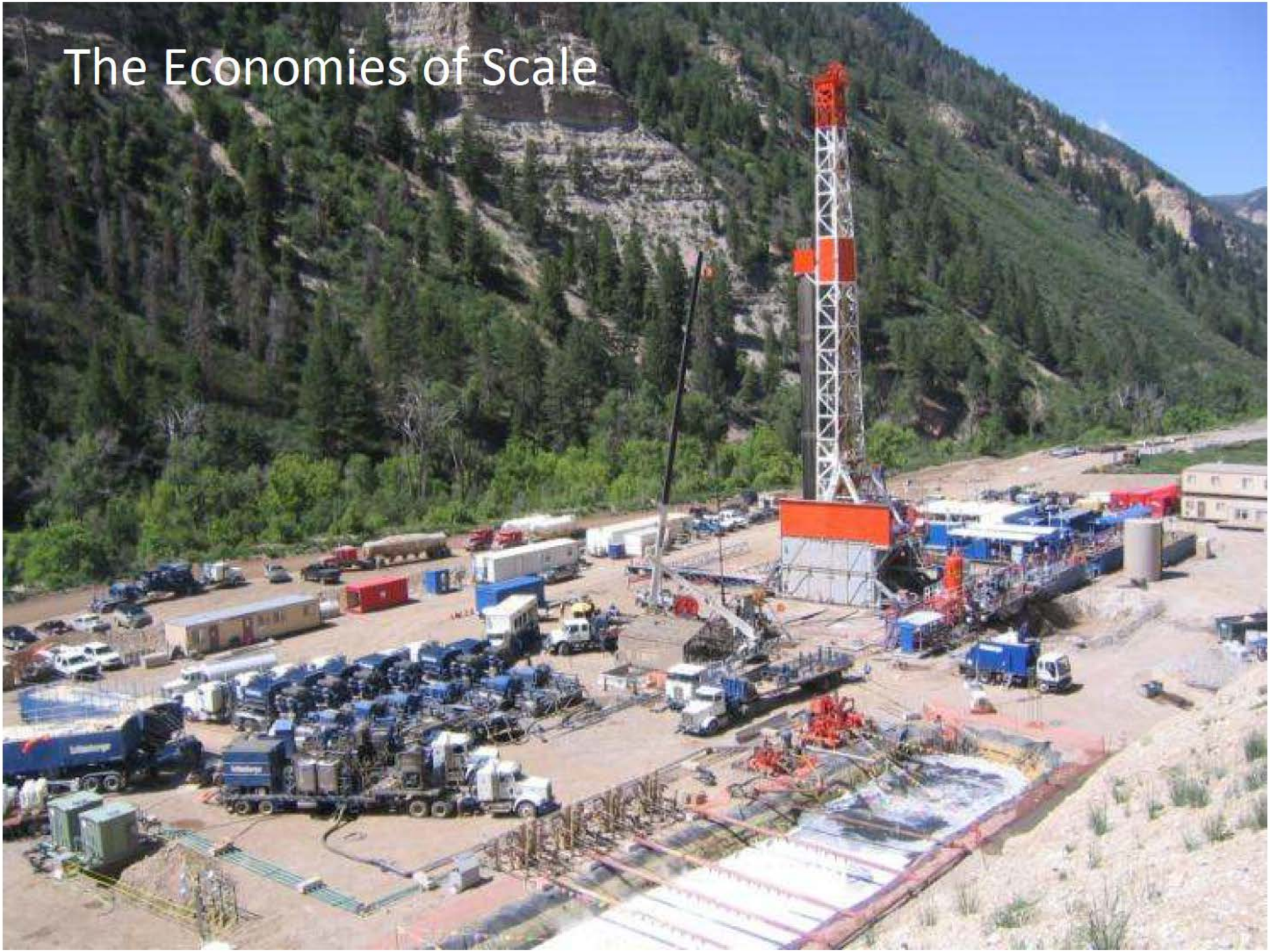
Water Management Concepts



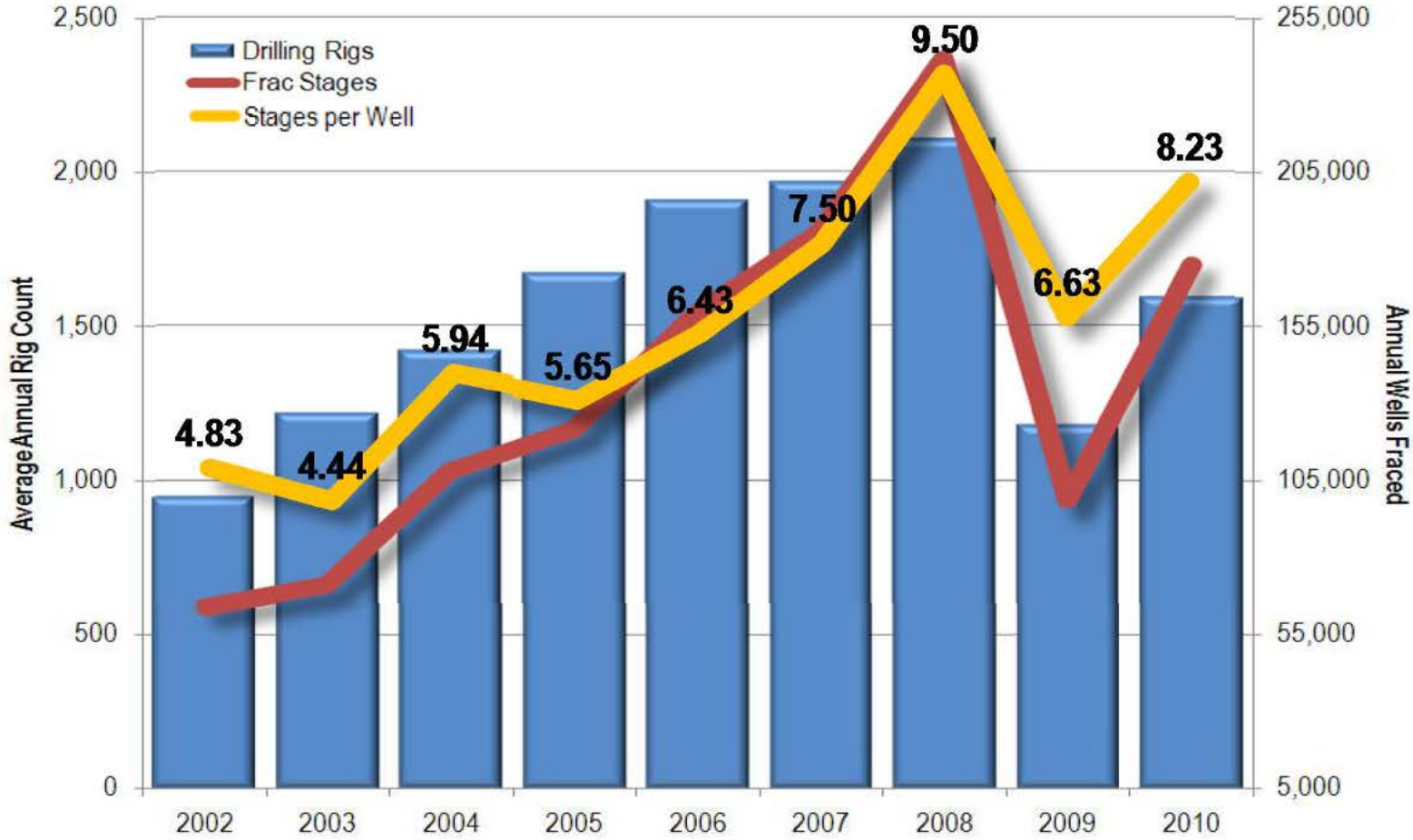
Water Management



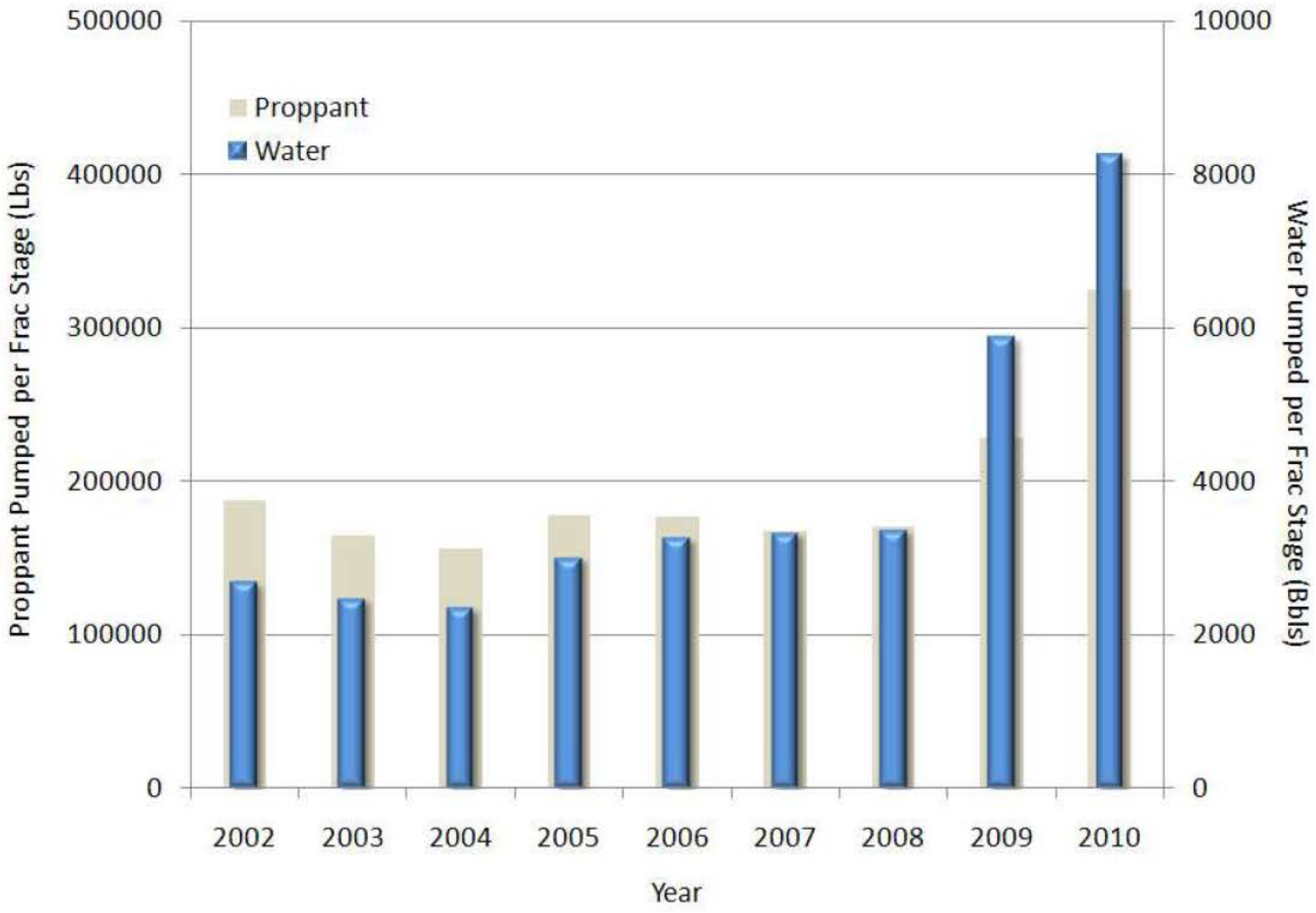
The Economies of Scale



US Land Drilling & Completion Intensity

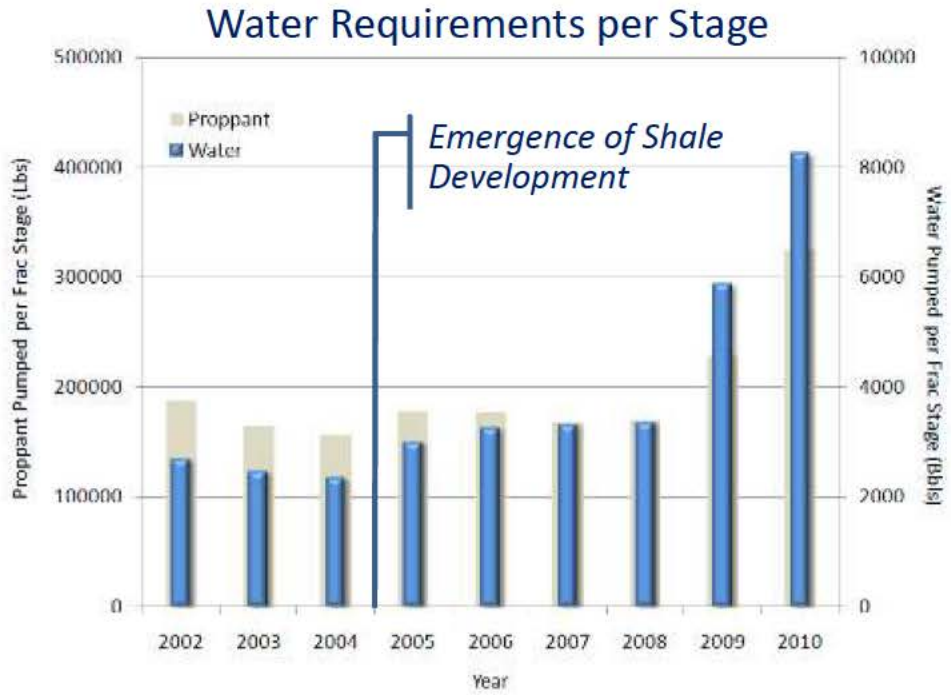


US Land Fracturing… Prop & Water by Stage



Frac Water Quality Drivers

- Historically, Fresh Water Availability Not an Issue
  - Chemical Compatibility Based off Ample Availability of High Quality Water
  - Usually Concerned with Salt, pH & Iron
- Shale Development & Corresponding Political Pressures on Place Focus on Water Usage
  - Poor Quality Water OK with Slickwater Type Treatments
  - Reuse Dictated by Flowback
- Shale Oil Development Requires High Viscosity Fluids
  - Large Quantity of Produced Water Available
  - Water Quality an Issue Again



Hydraulic Fracturing Water Requirements

1994 – Arkoma

Tight Gas Sands

Single Stage, Vertical Well
Crosslinked Fracs
45 to 60 BPM
250,000 Lbs of Prop
600,000 Gal of Water

- Fresh Water with No Recycling / Reuse
- High Quality / Low TDS, Iron, etc for Frac Chemistry

2004 – Barnett

Shale Gas

15-30 Stage, Horizontal Well
Slickwater Fracs
100 to 120 BPM
4,000,000 Lbs of Prop
4,000,000 Gal of Water

- Fresh Water with > 10% Recycling / Reuse
- Low Quality Due to Simplicity of Chemistry

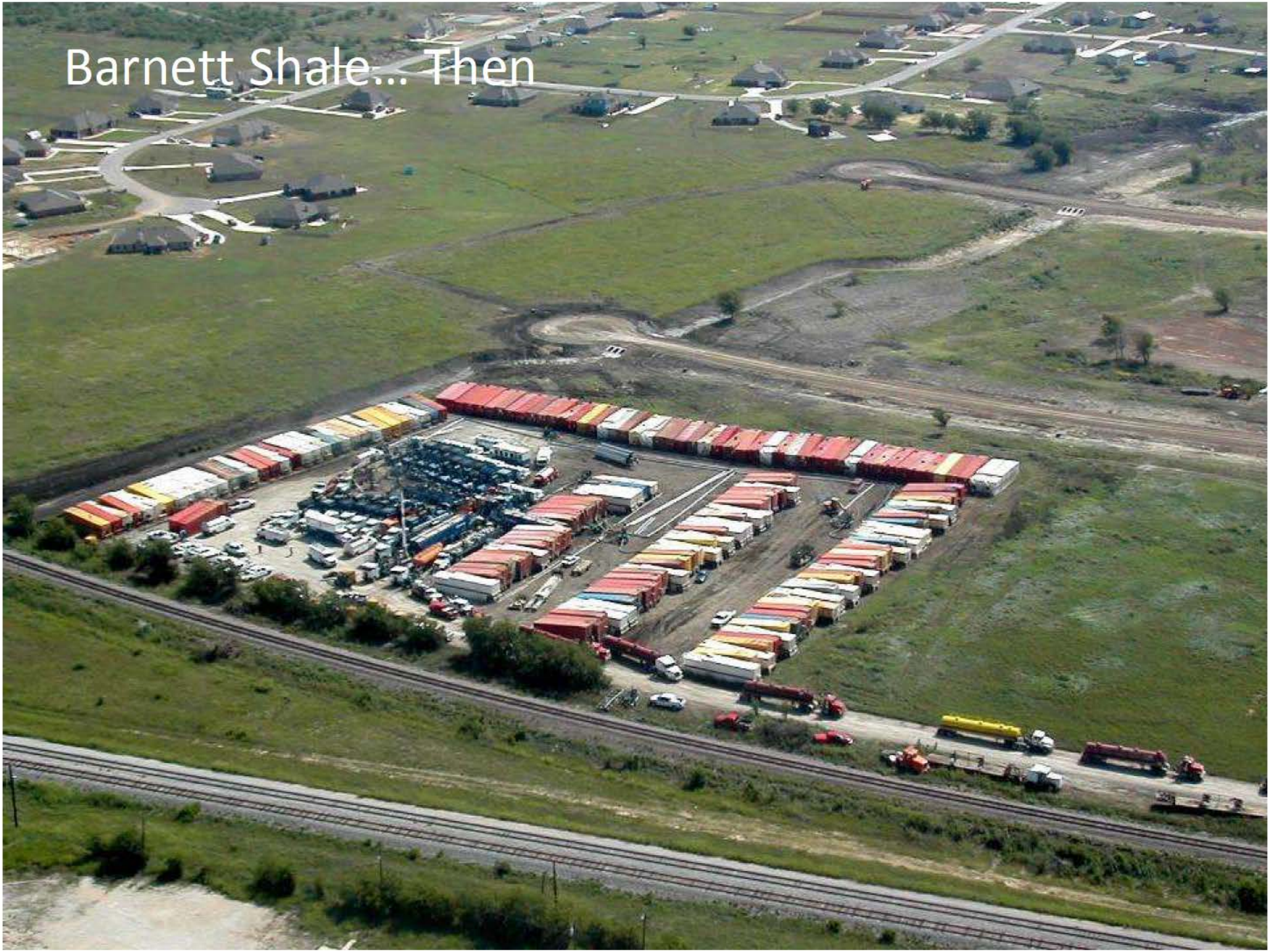
2014 – Bakken

Shale Oil

30-40 Stage, Horizontal Well
Crosslinked Fracs
30 to 40 BPM
2,500,000 Lbs of Prop
2,500,000 Gal of Water

- Fresh Water with > 10% Recycling / Reuse
- New Chemistry Allows for Use of Low Quality Water

Barnett Shale… Then




Barnett Shale… Now

Water Consumption & Reuse by Key Basins

	Frac Water (MM Gallons)	Annual Wells	% Recycled
Bakken	2.5	2281	5%
Barnett	2.8	660	7%
Central Rockies	3.0	1743	50%
Eagle Ford	5.1	4257	10%
Fayetteville	4.9	674	7%
Granite Wash	5.5	896	20%
Haynesville	5.6	368	6%
Marcellus	5.6	1485	85%
Mississippi Lime	2.2	1046	2%
Niobrara	3.3	909	6%
Permian	4.0	2073	2%
Woodford	5.5	619	20%
OVERALL		17011	**11%**

And Flowback Water Quality Varies by Play

Constituent	Units	Marcellus	Bakken	Haynesville	Piceance	Eagle Ford
Alkalinity as CaCO3	mg/L	260	270	320	930	335
Chlorides	mg/L	51,870	58,680	48,400	19,880	11,000
Calcium	mg/L	5,780	4,340	8,180	1,570	255
Magnesium	mg/L	410	720	640	190	50
Sodium	mg/L	24,350	26,200	23,770	10,550	7,515
Potassium	mg/L	195	1,720	635	280	0
Iron	mg/L	30	50	70	30	15
Barium	mg/L	2,900	10	920	220	1
Strontium	mg/L	2,160	710	1,600	40	50
Total Suspended Solids	mg/L	3,070	510	530	840	770
Total Dissolved Solids	mg/L	87,020	89,120	95,770	38,960	19,150

Water Treatment Considerations

- Total Suspended Solids (TDS) Removal & Disinfection
- Hardness Removal… Ca, Mg, Ba, Sr, Fe, etc
- Oil & Grease Removal
- Total Dissolved Solids (TSS) Removal… Desalination
- Management of Mass Quantities of Water…
  - Water Collection (Piping, Trucking, Pre Treatment Storage, etc)
  - Waste Disposal (Post Treatment)
  - Finished Water Storage
  - Delivery to Wellsite
  - …

No Single Treatment Technology…

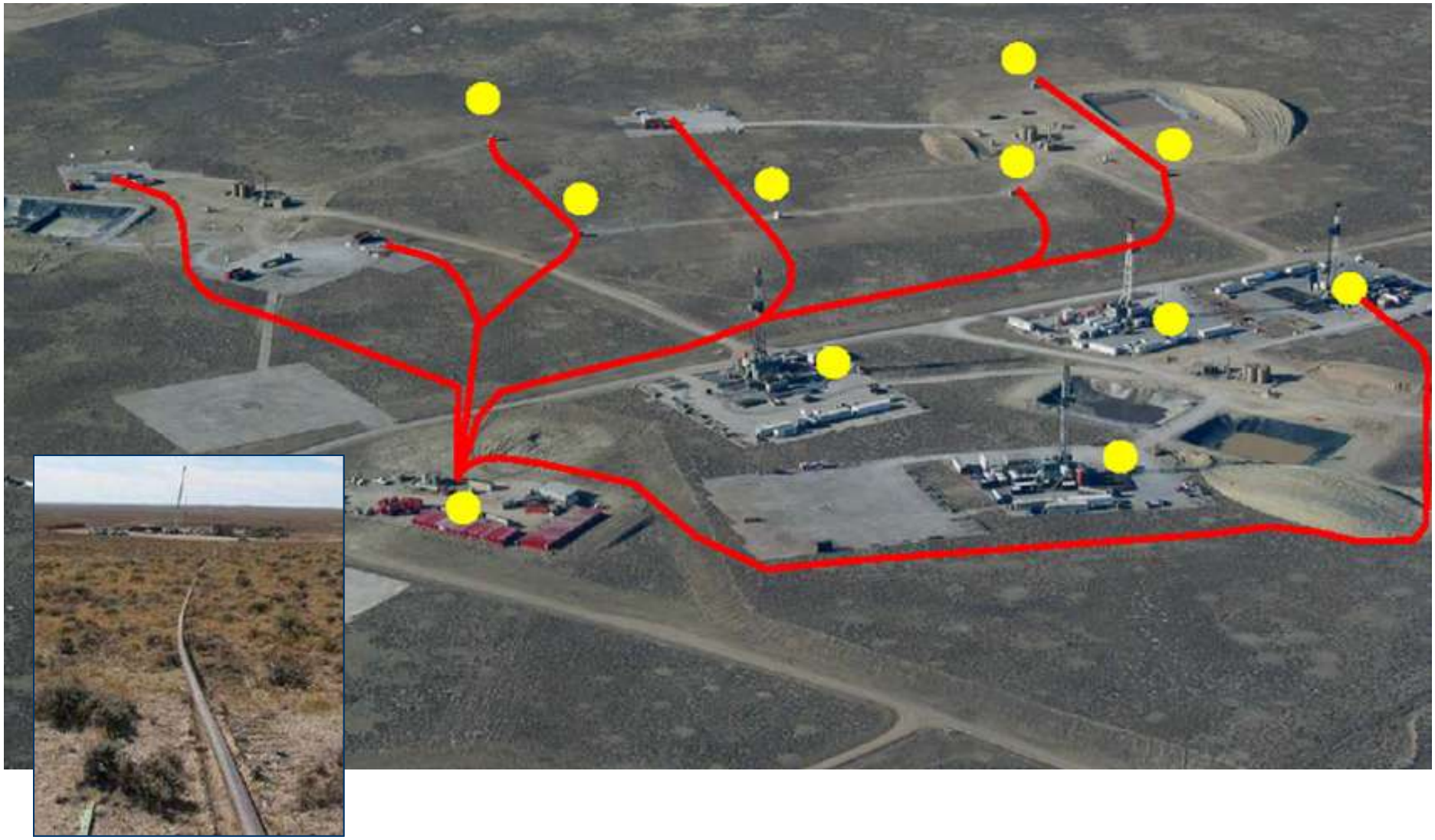
	Reverse / Forward Osmosis	Biological	Electro-Coagulation	Evaporation/ Distillation (MVR)	Filtration / Advanced Filtration (UF, MMF, NF)	Ozone / Ultra-Violet / Chlorine Dioxide	Chemical Precipitation / Ion Exchange	Dissolved Air Flotation (DAF)
Total Dissolved Solids (TDS)	✓			✓			Partial Removal	
Total Suspended Solids (TSS)		Partial Removal	✓		✓	Ozone Aids Removal	Partial Removal	✓
Total Organic Carbon (TOC)	✓	✓	Partial Removal		Partial Removal	Partial Removal		Partial Removal
Multivalent cations (Ca, Mg, Fe)			Minimal Removal		Partial Removal		✓	Partial Removal
VOCs / HAPs	Partial Removal	✓	Minimal Removal		✓	Ozone Aids Removal		Partial Removal
Bacteria	✓	✓		✓	Partial Removal	✓		
Limitations	Rigorous Pre-Treatment Required. RO<40K, FO <120K ppm TDS; FO still experimental	Not suitable for high TDS; susceptible to upsets & colony regeneration takes time	Requires very consistent / stable influent water quality ; Can have high ($) electrical requirements	High Energy Required, Cost, Rigorous Pre-Treatment. Can handle <150K ppm TDS	Pretreatment required; backwash water to reprocess	UV not applicable in turbid waters; high demand for O3; neither provide residual	Can have large chemical demand and solids processing / landfilling $	Requires consistent / stable influent water quality; Provides good first cut

… But Ask Yourself… What's My Goal

Before Treatment

After Treatment

… What Logistics Are Involved



… And What Are Your Sources for Makeup Water

Water Sourcing:

- Municipal
- Water Wells: Shallow and Deep
- Ponds, Streams and Rivers
- AMD, Waste Waters
- Re-use / Treatment
- Sea Water

Environment:

- Concern about Depletion of Reservoirs
- Impacts the Aquatic Life
- Footprint

Transportation:

- Number of Trucks: 12,000 Bbls = 100 Trucks
- Piping the System

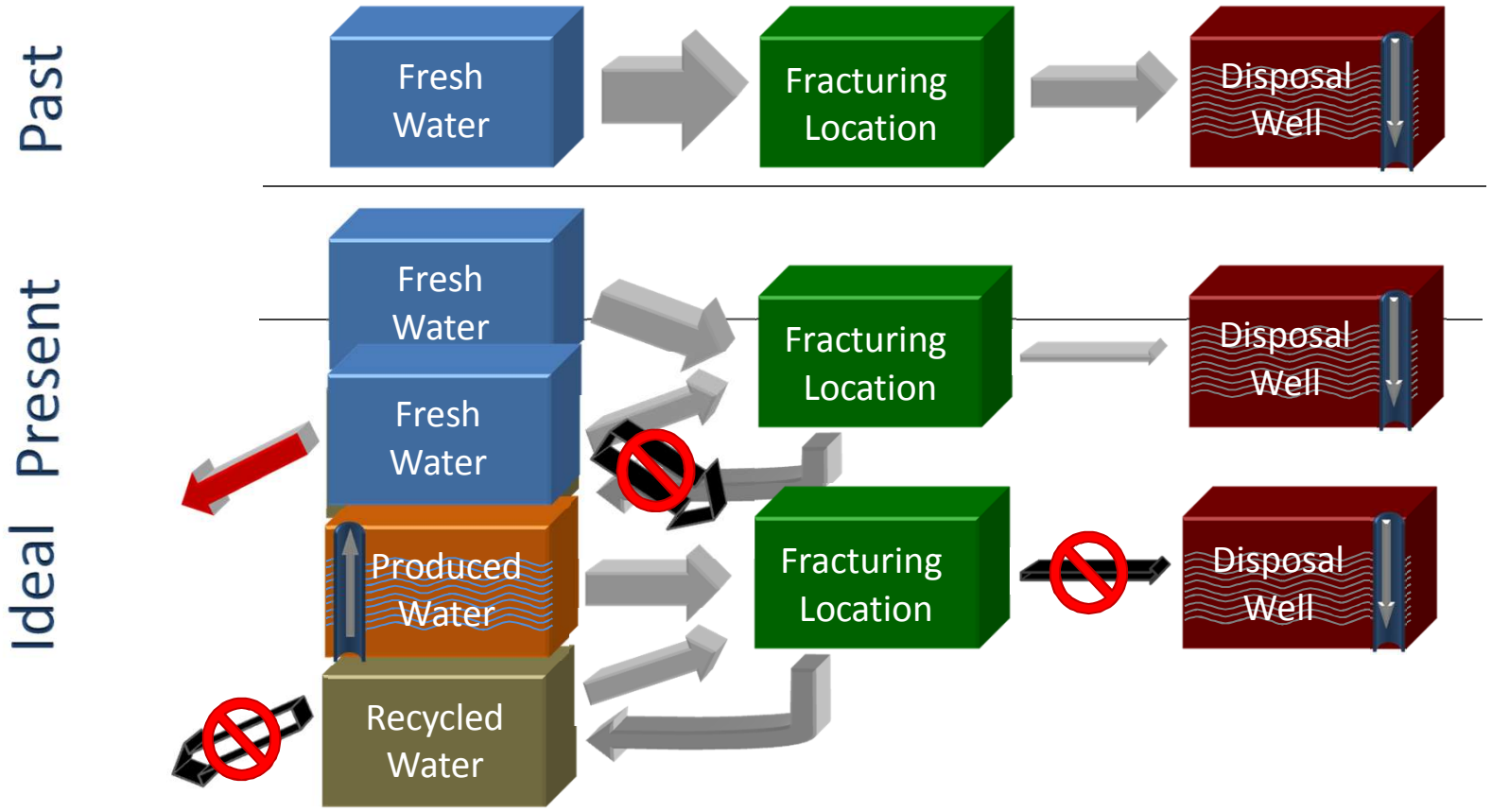
Water Storage

- Use of Ponds, Impoundments, Frac Tanks
- Temporary and Re-usable above Ground Tanks

Regulations

- Ultimate Drivers for Permits of Water Sourcing
- Dictate Discharge Criteria

Water Sourcing for Hydraulic Fracturing



Today's Approach

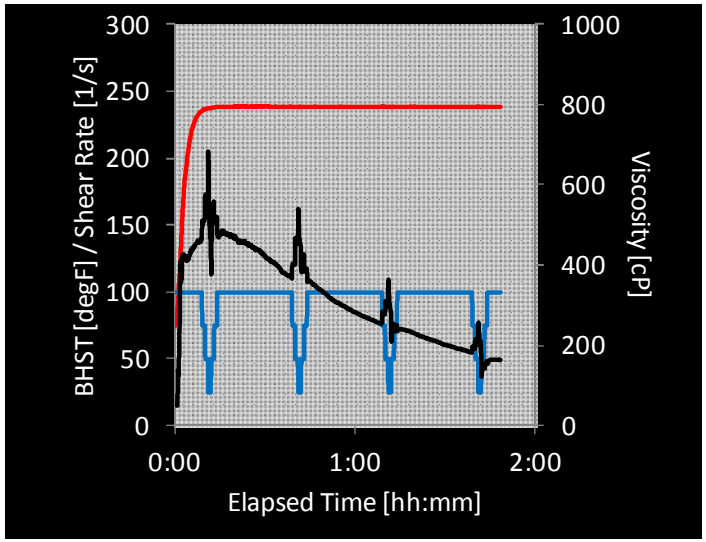
- Reduced Water Requirements & Intelligent Treatment Design
- Alternative Crosslinking Mechanisms for Oil Plays
- Tolerance Built into Chemistry for High TDS
- Still Required:
  - Treat for Bacteria as Needed
  - Determine Scaling Tendencies

Recent Example:

- Fraced Bakken Wells with 100% Connate Water from Offset Producers
- 28% to 32% Salinity
- Inherent Variation in Water Quality
- No Water Treatment
- Fracs Placed without Incident

Water Sourcing for Hydraulic Fracturing

Cation	Sample 1
Sodium	80423
Calcium	18938
Potassium	6800
Magnesium	889
Iron	82.29
Boron	364
pH	5.68
SG	1.187
TDS	275000



Final Thoughts…

Quality, Health, Safety and Environmental Policy

Policy Statement

Our commitment to Quality, Health, Safety and Environment (QHSE) governs everything that we do, at all times. At Pangaea (NT) Pty Ltd (Pangaea), we do not want to harm people or the environment and we actively pursue an approach in which risks to people and the environment are adequately managed.

Our principles, vision and commitment to managing quality, health, safety and environment is set down in our QHSE Policy. This Policy guides our strategic and day-to-day operations and actions and serves as a benchmark for evaluating and continually improving our performance.

We are committed to sustainable environmental practices and development as part of our beliefs and values. Pangaea's quality assurance is based on customer satisfaction, supported by best practices and continuous improvement.

Commitment Expectations

It is the policy of Pangaea to conduct its activities in such a way as to:

- Ensure all personnel and contractors act in accordance with their obligations as set out in this Policy.
- Provide adequate information, training and supervision to employees, contractors and stakeholders.
- Comply with all applicable legislation, regulations, statutory obligations and other requirements.
- Seek to achieve the personal commitment of all personnel, contractors and stakeholders to QHSE related workplace practices.
- Design and implement systems, processes and documents aimed to mitigate risks to personnel, property, the environment and quality in alignment with OHSAS 18001, AS/NZS ISO 9001 and ISO 14001.
- Set measurable QHSE objectives and targets for employees, contractors and stakeholders, seeking to continually improve our QHSE performance.
- Incorporate QHSE management practices in all aspects of our operations.
- Be particularly vigilant when working in areas of unique flora and fauna, or in or near areas of historical or culturally important sites or artefacts.
- Endeavour to conserve resources, reduce waste and pollution and eliminate or minimise adverse environmental effects and risks that may be associated with our operations.
- Use consultative mechanisms to facilitate engagement and participation of employees and other parties to enable resolution of QHSE issues.
- Identify, report, investigate and resolve all non-conformances and take action to prevent recurrence.
- Review and revise the QHSE Policy, systems and documents periodically to maintain their relevance.

Responsibilities

This Policy applies to all personnel involved in Pangaea operations and is the foundation to the QHSE Management System.

The Executive Director and supporting management are responsible for the implementation and enforcement of this Policy.

Each employee, contractor, service provider and visitor is responsible for actively supporting this Policy.

Application

This Policy is enacted through legislative compliance and the QHSE Management System.

Tim Radburn

Executive Director
29 October 2015

131E 132E 133E 134E

15S 16S 17S

KATHERINE

LEGEND

Infrastructure

Principal Road

Railway

Pipeline

Executed Voluntary Access Agreement

Pangaea (NT) Tenement

Pangaea (NT) Relinquished Area

EP 167

EP 168

EP 198

EP 305

Victoria Highway

Buntine Highway

Buchanan Highway

Stuart Highway

1:1000000

0 20 40 60 80 100

km

UTM ZONE 53
(CENTRAL MERIDIAN 135 E)
GDA94 MGA GRS80

Indigenous Employment Training Pilot Program

Program Synopsis & Review
September 2015

Written & compiled by Damian Wall of Red-Gum Environmental Consulting Pty Ltd

Reference:
Wall, D.J., 2015, Pilot *Indigenous Employment Training Pilot Program: Program Synopsis & Review, September 2015*. Pangaea (NT) Pty Ltd, Sydney, NSW 2000.

Enquiries about this report can be directed to:

The Executive Director
Pangaea Resources

Level 50, 1 Farrer Place, Governor Phillip Tower
Sydney NSW 2000 Australia

Phone: [redacted]
Fax:
Email:

Front cover art "Biddy Country", 2013, screen print by Jimmy Wavehill. Jimmy is a Senior Elder overseeing the implementation of the program described herein. The symbols in this print are those used as body painting on the torso during ceremony.The design tells the story of how the white cockatoo (pankara) follows the kangaroo (wampana) and, whenever the kangaroo stops to rest at the waterhole, the cockatoo wakes him and warns him to keep moving as he is being followed by Tjanpa, a tall spirit man with two spears.

Indigenous Employment Training Pilot Program

Program Synopsis & Review
September 2015

Executive Summary

Pangaea (NT) Pty Ltd ("Pangaea") has been exploring for oil and gas, south of Katherine in the Northern Territory's Sturt Plateau since 2012.

Success depends on the resources and then having the capability to access them in a way that has 'nil-impact' on the natural and cultural environment. Our aim is to use the economic development of the resources to bring training and employment to remote areas of the Territory and so create opportunities and higher living standards for local Aboriginal people who are uniquely capable of the cultural and environmental management of land within the Pangaea tenements. Pangaea, working through our service delivery partners, believes that the local people can contribute to, and benefit from, participation in the Territory's new growth industry.

All our local operations are conducted under a Co-Existence & Exploration Deed ("the Deed") agreed with the Northern Land Council ("NLC") on behalf of the Native Title Holders. Pangaea considers vital the collaborative participation of the NLC and we take great pride in the partnership approach we have developed. Pangaea would especially like to acknowledge the NLC for its assistance in delivering the Indigenous Employment Training Pilot Program ("the Program") during 2015.

The knowledge provided by the NLC over the last 3 years has been invaluable.

Likewise our success would not have been possible without the involvement of local business & industry, particularly Mark Sullivan Contracting Pty Ltd (MSC). MSC is to be congratulated for its professionalism and commitment to delivering employment and training outcomes at the training facility - *Flying Fox Centre of Excellence*.

A vital part of making the training and employment sustainable is that the Program design provides an appropriate level of support to participants after transition from training to employment, or from training to higher education. This additional level of support has proved to be a critical element for ensuring *meaningful employment* beyond initial training outcomes.

Pangaea sees this year's program as the first step towards providing long-term employment to many younger First Australians who want to continue to care-for-country in our Territory exploration tenements – especially on the Sturt Plateau. As a company, we acknowledge the importance of land as 'mother' and wish to ensure that younger generations of the country also understand our commitment to 'walk together' and 'walk lightly' into the future.

Pangaea is grateful for the support provided by Elders and spokespersons from the *Liwaja*, *Wubalawun* and *Jalalabayin* peoples. We thank them for their continuing guidance and acknowledge that it is only through our partnership and the training and employment of local people, that we can all share the benefits of the Territory's economic development.

Tim Radburn
Pangaea (NT) Pty Ltd

A Cooperative Partnership

The Northern Land Council has worked closely with Territory employment service providers and, industry groups to provide a clear pathway to employment in the resources/civil industry. The Indigenous Employment Training Pilot Program, sponsored by Pangaea (NT) has provided an effective training and employment program built around 'hands-on' training and life-skills support to create a model program.

We believe the program's success will be found in long-term employment that is possible because of the close partnership that has been created between private enterprises, the resources industry and traditional Aboriginal owners of the areas where they operate.

In the case of Pangaea, a close partnership between the company, local contractors and the NLC enabled the development of a program to identify and train a group of cadets with the special cultural knowledge and support of the traditional owners of the land. The program has been designed to ensure that young people have the opportunity to work 'on their country' while having the support network of family during placement.

In early 2015, the NLC helped Pangaea begin a round of consultation with senior Elders and spokespersons from each of the three family groups (*Liwaja*, *Wubalawun* and *Jalalabayin* people) on whose country its 2015 exploration campaign was being conducted. The meetings introduced the Program opportunity, but most importantly, engaged with 'Mentors' from each family group who could assist in selecting the most appropriate candidates from their extended families to take advantage of the training and employment opportunity.

The model of linking 'country to candidates' is essential for success. The over-riding sense of responsibility for country - and each other - in a family group was critical to ensuring completion rates and enthusiasm. In the future it also means that the land has been respected and its value preserved for future traditional owners.

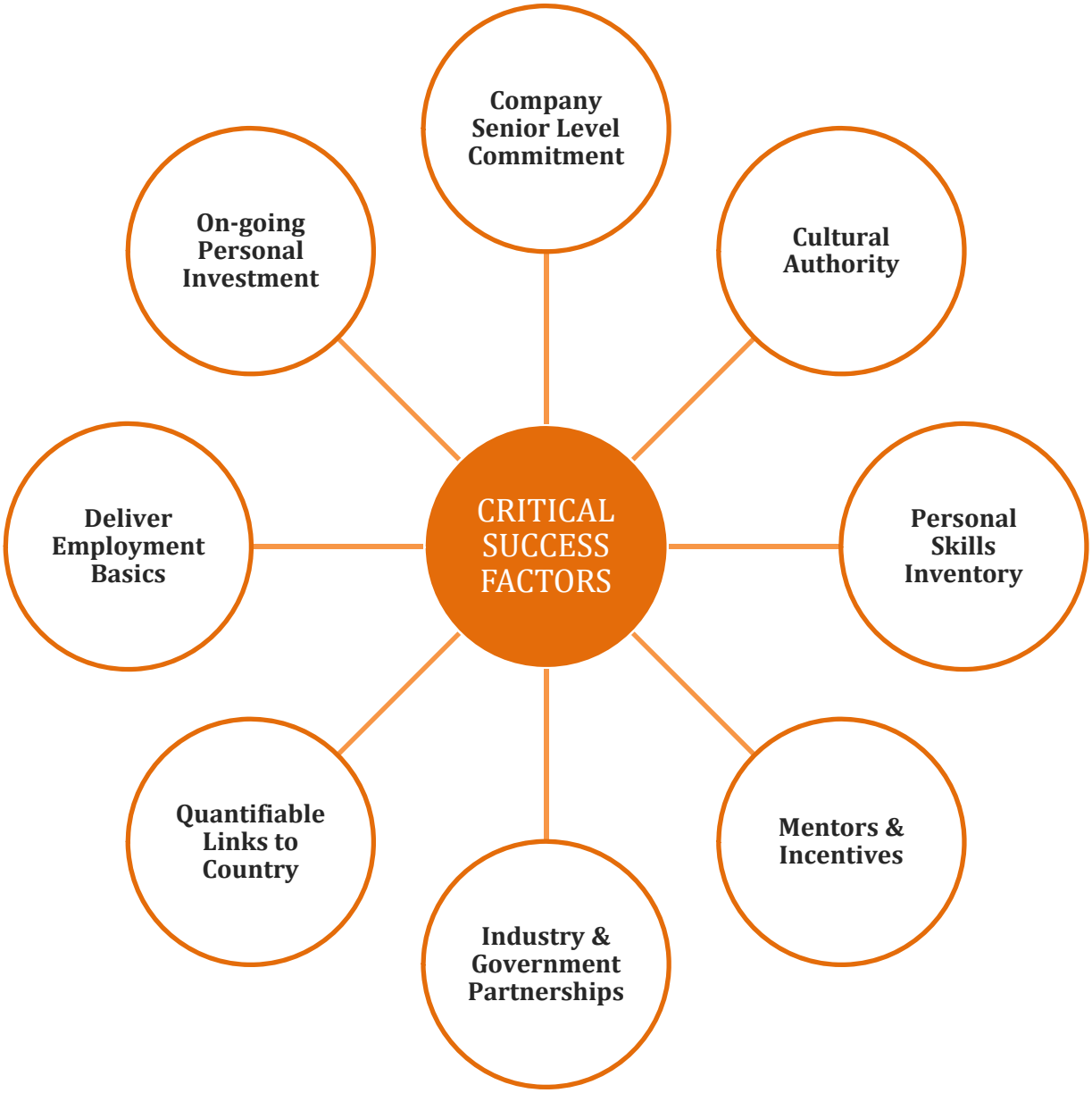
The NLC's aim is to promote employment opportunities for traditional owners and training is a vital first step. But there also needs to be job opportunities. The Pangaea drilling project, and others like it, are creating jobs which are needed to ensure that these training opportunities lead to the social, cultural and economic benefits that we need for our communities.

With the slow-down in other mining projects the NLC's Jobs and Careers Service (JACS) has faced difficulties promoting local employment opportunities. The Pangaea Project has been a great boost and potentially holds great opportunity for traditional Aboriginal owners to employ their knowledge in managing their own country in the future.

Leanne Liddle

Northern Land Council

CRITICAL SUCCESS FACTORS



PROGRAM DESIGN & IMPLEMENTATION

Develop Program training package considering realistic objectives that are directly relatable to future employment opportunities

- Top-End-Training
- Pangaea (NT) Pty Ltd
- Mark Sullivan Contracting

Communicate goals and objectives to key project partners

- Northern Land Council

Communicate 'rules, conditions & expectations' of participants to Senior Elders of family groups and request their assistance to identify eligible persons

- Northern Land Council
- Pangaea (NT) Pty Ltd

COORDINATION & SELECTION PHASE

Identify and engage 'Mentors' from each family to select willing & eligible participants	Engage NLC to collect individuals as directed by the Mentors	Deliver participants to pre-deployment location for debrief session

PRE-DEPLOYMENT PHASE

Clearly explain expectations, rules & consequences of non-conforming with them	Conduct Drug & Alcohol testing and collect clothing sizes for PPE	Ensure participants take responsibility for CDEP and Centrelink obligations

TRAINING PHASE

Camp life induction, personal hygiene instruction, house-keeping demonstration	Daily pre-start talks involving all participants and trainers	Daily liaison between Mentors and Trainers

Introduction

Pangaea developed and delivered a program of industry-specific training targeted to the local Traditional Owners. It aimed to provide participants with the minimum entry-level skills to for employment within the Pangaea tenements beyond 2015.

The Program included 'soft skills' associated with confidence building and self-esteem, communication and workplace discipline which are helpful for their personal development and employment whatever their future vocation.

This report:

1. Presents the results of Pangaea's Indigenous Employment Training Pilot Program
2. Describes the adopted principles that guided the program
3. Describes the program delivery
4. Highlights a pathway for future improvement; and
5. Reports on program experiences.

1. Results of the Indigenous Employment Training Pilot Program

Mark Sullivan Contracting Pty Ltd (MSC) in close partnership with Top End Training have delivered on-site and on-the-job, industry specific training to twelve participants via two separate fifteen-day placements at Flying Fox Station located within Pangaea exploration tenements.

At completion, all twelve participants achieved a *Certificate 1 in Resources & Infrastructure Operations*. Additionally, the participants all received credentials in related work place competencies:

- **12** participants achieved competency tickets for *Operate Roller & Compactor*,
- **12** participants achieved competency tickets for *Conduct Tractor Operations*,
- **12** participants achieved competency tickets for *Conduct Civil Operations Skid Steer/Loaded Operations*,
- **12** participants achieved competency tickets for *Conduct Operations with Integrated Tool Carrier*; and
- **12** participants achieved competency tickets for *Operate a 4 Wheel drive vehicle*.

Further, the Program has successfully delivered necessary *preconditions* for achieving employment, including:

- Work readiness support by providing 100+ hours driver time that can be used by participants to obtain their Drivers License 'Learner' permits and delivery of HLTAID002 Provide Basic Emergency First Aid,
- Participant mentoring that has extended beyond short-term goals to a 'career focus' that considers life goals and future aspirations.
- Development of a work ready attitude, consideration of realistic target setting and self-evaluation.

Following individual assessment throughout the Program, MSC have offered five participants placements in *Training Cadetships* to continue development of the basic skills obtained through the program. The cadetships will focus on developing civil and mechanical skill sets that are directly required to support the infrastructure and other projects currently

being developed in the Territory, by Pangaea and others in the years ahead.

2. Adopted program design principles

- Deliver training that is 'job related' and culturally appropriate.
- Collaboration with Indigenous Elders & Mentors who have 'cultural authority'.
- Identify and address personal barriers and learning difficulties.
- Motivate participants and encourage decisions that enhance their individual employability.
- Clear communication of program goals to partners and participants.
- Provide post program support to encourage the participant to take personal responsibility for their future.

Job related & culturally appropriate training

Pangaea and local contractor MSC have developed a strong corporate partnership. From this base a range of new, industry-focused collaborations between a range of NT service providers, employers and trainers will be created. With the involvement of the NLC, Pangaea have fostered an environment based on *mutual assistance and respect* which has been critical to broadening the reach of the program, while maintaining interest and support amongst our Traditional Owner partners.

The program has been based on developing civil construction skills – readying the participants to take advantage of work opportunities that Pangaea foresees (on their country) as we move forward in the NT.

Collaboration with Indigenous Elders and Mentors who have 'cultural authority'

Our relationship with Traditional Owners from *Liwaja*, *Wubalawun* and *Jalalabayin* family groups is strong and critical to our continued success in the NT.

Program design included a process of communicating our goals and program requirements to Senior Elders before the program was offered to participants. With their help and guidance, Pangaea was able to:

- Identify 'Mentors' from each family group that would be able to actively recruit participants that are most likely to make the most of their opportunity.
- Ensure a clear agreement was reached in-so-far as working on each others' country was concerned.
- Ensure that the wider community and relatives understood the importance of remaining at distance and supporting the participants while they attended training

Identify & address personal barriers and learning difficulties.

Individual assessment of participants before, during and after training is critical to success. Without an understanding of the individual – a clear employment outcome is unlikely.

Pangaea undertook regular individual interviews with participants and with their trainers to understand:

- Personal motivations,
- Previous training and experience levels,
- Numeracy and literacy issues if any,
- Aspirations and goals; and
- Limitations to successful achievement of the training program.

Motivate participants and encourage decisions that enhance their individual employability

Pangaea considers it important that the program is not 'training for training's sake'. Making the training relevant to both the participant and the anticipated job opportunities in the Pangaea tenements benefits all parties.

To this end and mindful of MSC's growing need for skilled employees for their other contracts (aside of Pangaea) the program included specific *competencies* to supplement more generic workplace skills.

The competencies list was also, in part, determined by the results of individual interviews with participants that were used to develop an appreciation of the applicant's goals, aspirations and expectations.

Clear communication of program goals to partners and participants

Pangaea, MSC and the NLC went to great lengths to clearly communicate the program goals and expectations about what can be achieved from the program – upfront to both program participants and program deliverers. A clear understanding of the intended 'end-point' was vital to ensuring we had participants in the correct frame-of-mind before leaving home and family.

Post program support encourages the participant to take personal responsibility for their future.

Pangaea had put processes in place to support participants - who successfully completed the program - to be kept informed of opportunities for employment that might arise.

Our partnerships with NT service providers and the NLC are critical to a seamless transition from the training environment to full-time employment. Barriers at this point in the journey cause delays, undermine participants' confidence and dampen their enthusiasm for continued employment leading to a loss of skills and wasted training resources.

Through the Mentors, cultural authority was used to encourage younger participants to make life changes beyond this program and to continue on the road to employment basics with credentials like Driver's Licenses and Senior First Aid certificates.

3. Program delivery

Pangaea and our service providers, MSC and Top End Training understood that the success of the program (for all our best intentions and carefully considered design) ultimately comes down to how well it is delivered and how engaging it is for participants.

To maintain participant interest, the Program must be in part implemented 'on-country' and focus on real-life civil skills.

The program offered a mix of 'in-class', 'hands-on' and 'on-country' lessons. All sessions were assessable by *Top End Training* in some form and were an extension of the course work defined by the Level 1 certificate.

Participants were actively involved in:

- White Card (Work Safely in the Construction Industry) training
- Use of GPS to locate access routes to defined locations around drilling sites in the field
- Heavy machinery operation in a controlled environment
- Task orientated construction of a lay-down pad for storage equipment
- Clearing of re-growth
- Road formation activities

- Welding and grinding and construction of farm infrastructure
- Pump maintenance and repair
- Machinery maintenance and repair.

Relationships were key to the success of the program. The relationship between the trainers and participants, the participants *and* the Mentors and the Mentors and the trainers ALL need to based on respect and patience. Ultimately, all relationships were defined differently – but none were *more* important that others. The Pangaea approach relied heavily on the importance and support networks of 'family', the desire to work on-country so that they are 'work-ready' when future opportunities present.

Work placement was divided into two 15 day programs delivered at Flying Fox Station – the MSC Centre for Training Excellence – and in the Pangaea tenements.

The location of the training was remote and not on either family groups' country – which proved an important consideration. Trainees were encouraged to develop friendships outside their own family groups, by the Mentors, who had the cultural authority to make that happen. Camp life harmony was of paramount importance and was achieved via this model. Work on country was even divided amongst family members with an equal numbers from each group travelling to site, working and living together without incident.

The program adopted a 'learn-by-do' philosophy as recommended by our Traditional Owner collaborators and Senior Elders. It maximised the hands on experience which makes the training more meaningful.

The MSC approach to work safety, environmental protection and industry best practice was promoted throughout the training – constantly reinforced by strict camp life rules, start-up and pre-work meetings on a daily basis. The intent was to encourage and develop a range of behaviours that underpin the MSC work culture and hopefully develop future employees that are future assets to the company.

At the end of the first 15 day program, a feedback session identified that the participants felt too much time was spent being idle while other participants used equipment. TET and MSC consequently changed their delivery model in the second placement period to ensure that smaller teams were assigned different tasks concurrently - rotating between the tasks, ensuring full occupation of their time.

4. Program improvement

Pangaea, in-conjunction with our NT service providers and program partners will fully evaluate the success of the 2015 program – involving all our project collaborators (MSC, TET, Senior Elders & Mentors and the NLC).

Individual discussions with participants are key to identifying if expectations were met, exceeded or otherwise. It is also a valuable exercise in assessing attitude change, social development and personal growth in the participants themselves.

Pangaea has already determined that:

- Program participants must be assisted with literacy and numeracy skills, health and nutrition awareness, and education on ZERO tolerance on drugs and alcohol in the petroleum industry.
- To be adequately prepared for placement in the civil construction industry, training and development to at least Cert 3 level is most desirable.
- The *Mentor approach* created a culture of family support amongst participants and integrating training with work 'on-country' is a key to maintaining participant focus and dedication to future programs.

- More effort is to be made on affording and encouraging *female* participants to attend future training opportunities.
- Employability is key. Future programs should infuse a degree of basic self-promotion (e.g. CV writing) and life essentials (e.g. Drivers License theory).

5. Program experiences

"I thought the training was good. The best thing about it was driving the machines and meeting new people. The only thing I thought would have been better was to be able to spend more time at Tarlee and driving newer machines"

- Liam McIlwain, Participant

Liam has previously been a Process Technician at Batchelor Nickel, coal and copper mine with Compass Resources and also held positions with John Holland constructing the new cancer ward at Darwin Royal Hospital. He completed a Certificate II in Mining and Manifest when working at Jabaru Mine with geo-technicians conducting core sample tests.

He has a Heavy Rigid truck and loader licence and 6 years experience working for the ADF at Robinson barracks, Shoal Bay, in security detail. Liam graduated with a Certificate 1 in Resources & Infrastructure Operations, all the civil competencies offered and Basic Emergency First Aid.

"I really want to get my tickets for the loader, bobcat and roller. Wouldn't mind doing a bit of welding because I'd like to start an apprenticeship as mechanical fitter"

- Edmund Shandley, Participant

Edmund has had previously held trainee positions with large companies including Rio Tinto and at Argyle mine in WA. He has successfully completed a drill and blast course and 2 years of a 4 year Mechanical Fitter apprenticeship. Edmund graduated with a Certificate 1 in Resources & Infrastructure Operations, all the civil competencies offered and Basic Emergency First Aid.

Edmund also accepted a place in the Trainee Cadetship offered by MSC which will begin in late 2015.

"The best part of the training was actually learning how to use the machinery! Not just reading about how to use it. I was also happy to work at Tarlee and learn how to use a GPS to locate the spots around the drill site."

- George Maroney, Participant

George is straight from High School, Casuarina Senior College Darwin, where he completed Year 11. George enjoys machinery operation but is also highly suited a technical or field assessment based career. George would like to become a cultural field liaison in the future as he wants to go through lore and learn about country in the Birdum area.

"The best part of my time here was making new friends, sitting around the fire trading stories, getting on the machines and learning new things when working as a team."

– Aquinas Johns, Participant

Aquinas (aka "AJ") completed Year 10 at Kunnanurra High School and left school to work with a Ranger Group, conducting Wildlife monitoring, Conservation and Land Management activities. AJ has completed

training in Melbourne for Export Abattoirs, as a slaughter man and has existing Competency Tickets for front end loader, backhoe and grader operation – plus a Working at Heights qualification. AJ is directly related to senior Traditional Owners in Birdum and in the Tanami.

AJ graduated with a Certificate 1 in Resources & Infrastructure Operations, all the civil competencies offered and Basic Emergency First Aid. AJ also accepted a place in the Trainee Cadetship offered by MSC which will begin in late 2015.

"The operating of machines has been one of the main keys to the success of this course so far. Without the ability to allow the boys to operate machines we would not be able to hold their attention span for the required bookwork for their white cards.

"Taking the boys in groups of three with an Elder over to the civil camp at Tarlee has been a valuable learning experience for them. They were subjected to an initial camp induction, as per MSC regulations and then had to create a very basic JSA, they were also required to attend the daily prestart meeting with the rest of the camp staff and required to undergo random BAC test as per MSC regulation.

"Having the boys in a remote bush environment puts a little twinkle in eye of all of them and they really enjoyed the job (and the tucker)."

– Kevin Maddigan, Trainer, MSC.

Kevin assisted with the first 15 day placement and focused on in-field delivery of the program and machinery operation.

"The boys are a very pleasant mob. They are always courteous and leave their rooms cleaner than most that come through here! They are a credit to their families and I hope they do well".

– Margaret, Kitchen Manager, MSC.

Margaret is a veteran camp kitchen and camp manager who was present for the duration of the program.

"We've had our challenges, our good days and bad days but overall had a very pleasing experience here at the Fox.

"The participants now need to take on some personal responsibility for their own futures and use this start to launch into a career."

– Murray Lauritsen, Senior Trainer, Top End Training.

Murray has delivered both 15-day placements and all Competency Modules offered during the program.

In pictures....

REVIEW OF THE DRAFT PETROLEUM (ENVIRONMENT) REGULATIONS

An independent assessment of the Regulations against best practice regulation of environmental aspects arising from petroleum activities involving ground disturbance

Dr Tina Hunter
March 2016

Distribution

This report has been prepared for the sole use of the Northern Territory Department of Mines and Energy (NT DME). The distribution of this report is at the discretion of the NT DME.

Author

Role	Name
Primary Author	Dr Tina Hunter

Revision Log

Revision date	Revision description
16 March 2016	Draft Report (v1) is provided to NT DME
19 March 2016	NT DME and Author meet to discuss report (Alice Springs, Australia)
4 April 2016	Revised report (v 2) is provided to NT DME for comment
5 April 2016	Author concludes final report
7 April 2016	Final report provided to NT DME

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1. EXECUTIVE SUMMARY

The draft *Petroleum (Environment) Regulations* that are analysed in this report have been drafted to address the regulation of petroleum operations in the Northern Territory. They are a solid regulatory tool for future petroleum activities, and represent a quantum leap from the Northern Territory regulations of old. They herald in a new era of objective-based regulation, which has been assessed by the World Bank to be the most suitable form of regulation to foster petroleum development. In addition, these Regulations are the first for onshore petroleum to implement the concepts of Ecologically Sustainable Development, and for that the Northern Territory Department of Mines and Energy should be applauded.

The fundamental aspects of the Regulations are sound, and the use of risk-based regulation is a welcomed addition in regulating petroleum activities. Such risk-based regulation will ensure environmental harm will be minimised, and give the Northern Territory government enhanced scope and the capacity to implement best practice in the regulation of petroleum activities in the Northern Territory.

The Regulations need to be supplemented by detailed Guidelines, which will need to be developed once the regulations are completed. These Guidelines need to provide an overview of the approval process of the Environment Management Plan (EMP), which lies at the heart of the Regulations, and the requirements for the content of the EMP.

The success of the implementation of these sound regulations depends on continued resourcing of the Regulator, the Energy Directorate. This means that as onshore petroleum activities increase, staffing levels at the Regulator will also need to increase.

Dr Tina Hunter

6 April, 2016

2. BACKGROUND AND AIM OF REPORT

3.1 Background

Since the late 2000's, interest in shale gas in the Northern Territory has rapidly increased. Such interest has been the direct result of the success of shale gas and shale oil[1] extraction in the USA, which today contributes roughly 13 million barrels of oil equivalent per day (boe/d)[2]. At the heart of the extraction of shale gas is the process of hydraulic fracturing (HF), also known as 'fraccing'. This process is required in order to improve connectivity between the pore space in the geology, in order for the gas to flow into the production zone of the wellbore and to the surface. The scale of such operations in the USA has been enormous, with HF used in the completion of approximately 37,000 wells in the USA annually, and a total well count of over 1.7 million wells to 2014.[3]

Such extraction of shale gas and oil in the USA has also been assessed to have environmental impacts. These environmental impacts have ranged from surface impacts of activities (including ground disturbance, localised impacts)[4] to increased seismicity (particularly in Oklahoma as a result of HF water disposal in orphan wells),[5] and rare well blowouts causing the leaking of formation fluids and gas.[6] The use of HF as a technique to produce shale gas has raised community concern, heightened by the US movies *Gasland* (2010) and *Gasland 2* (2013), which cast aspersions on the HF process and the chemicals used. In Australia, an episode of *Four Corners*, which aired on 21 February 2011, similarly raised concerns within the Australian community. The concerns raised by the Australian community include the safety of the HF process (especially for human health), its impact on the use of and sources of

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[1] For the purposes of this report a reference to shale gas will also mean a reference to shale oil, which is produced using the same techniques form the same well if oil is present. It does not, however, include a reference to oil shale, which is exploited using the process of pyrolysis

[2] U.S. Energy Information Administration (EIA), 2014 production

[3] Baker Hughes, *Baker Hughes Well Count* (2014) http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-wellcountus

[4] George E King, Hydraulic Fracturing 101: what every Representative, environmentalist, regulator, reporter, investor, university researcher, neighbour and engineer should know about estimating frac risk and improving frac performance in unconventional gas and oil wells (2012) *Society of Petroleum Engineers Paper 15296.*

[5] See Reuters, *Ohio Links Fracking to Earthquakes, announces tougher rules* April 11, 2014 http://www.reuters.com/article/2014/04/11/us-ohio-fracking-earthquakes-idUSBREA3A1J620140411 last accessed 9 June 2014; and Ohio Department of Natural Resources, *Ohio Announces Tougher Permit Conditions for Drilling Activities Near Faults and Areas of Seismic Activity* (2014) http://ohiodnr.gov/news/post/ohio-announces-tougher- permit-conditions-for-drilling-activities-near-faults-and-areas-of-seismic-activity last accessed 9 June 2014.

[6] Such as the incident at Cherry Creek in North Dakota in 2014. Reuters, Update 2 – *Oil Well in North Dakota Out of Control, Leaking* Friday, 14 February, 2014 http://www.reuters.com/article/2014/02/14/energy-crude-blowout-idUSL2N0LJ15820140214 last accessed 26 May 2014. For an analysis of the Cherry Creek blowout see Tina Hunter and John Paterson, 'Prevention of and Response to Shale Gas Well Incidents: An Assessment of the Current UK Regulatory Framework for Shale Gas Activities (2014) 3 *Oil Gas and Energy Law Journal (Special Issue Governance of Unconventional Gas Outside the United States of America)* at https://www.ogel.org/article.asp?key=3473 last accessed 12 March 2016. For a discussion on blowout rates see George E King and Daniel E King, Environmental risk arising from well construction failure: difference between barrier and well failure, and estimates of failure frequency across common well types, locations and well age (2013) *Society of Petroleum Engineers Paper 166142.*

water, and the environmental effects of the process. Other concerns in the community have included the capacity for shale gas extraction and agriculture to co-exist, and the land access issues associated with the grant of a license (either petroleum exploration or production license).

Such community concerns have been embraced by a number of Australian governments, including the Northern Territory government. On the heels of an assessment of the capacity of the Western Australian regulatory framework to regulate shale gas operations,[7] an assessment of the Northern Territory regulatory framework was undertaken by this author, Dr Tina Hunter (the NT Report).[8] As part of the NT Report, 26 recommendations were made to the Northern Territory government.[9] The Northern Territory has government responded to these recommendations, with information regarding both the initial response and progress publically available.[10] A number of recommendations regarding the environment were made in the NT report, including the following:

> *Recommendation 1: The NT Department of Resources should mandate full, transparent disclosure of all chemicals used in NT fraccing operations. This disclosure should be made available on the NTDoR web site, and should provide detailed information on the chemicals used and location of use.*
>
> *Recommendation 2: Given the unique climate, landforms and biodiversity of the NT, preservation of these natural features of the NT should be afforded complete environmental protection to ensure that these unique landscapes are preserved and maintained.*
>
> *Recommendation 16: The NTDoR draft environmental regulations for the protection of the environment with respect to onshore petroleum activities, including the regulation of unconventional gas resource activities. The drafting of these regulations should be high priority.*

The Northern Territory government accepted these recommendations, and in 2014 commenced drafting the *Petroleum (Environment) Regulations* (the Regulations).

The drafting of the regulations was given further impetus and guidance with the release of the *Report of the Inquiry into Hydraulic Fracturing in the Northern Territory* by Dr Allan Hawke (Hawke Report No. 1) in November 2014, and the *Review into the Environmental Assessment and Approval Processes in the Northern Territory,* also by Dr Allan Hawke (Hawke Report

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[7] Tina Hunter, *Regulation of shale, coal seam and tight gas activities in Western Australia: an analysis of the capacity of the* Petroleum and Geothermal Energy Act 1967 (WA) *to regulate onshore acuities in Western Australia* (2011). http://www.dmp.wa.gov.au/Documents/Petroleum/PD-SBD-NST-116D.pdf last accessed 11 March 2016.

[8] Tina Hunter, *The capacity of the current legal framework to regulate the development of onshore shale, tight and coal seam gas in the Northern Territory* (2012).

[9] Department of Mines and energy, *Legislation Review – Petroleum* (2015) http://www.nt.gov.au/d/Minerals_Energy/?header=Legislation%20Review%20-%20Petroleum last accessed 9 March 2016.

[10] Department of Mines and energy, *Legislation Review – Petroleum* (2015) http://www.nt.gov.au/d/Minerals_Energy/?header=Legislation%20Review%20-%20Petroleum last accessed 9 March 2016.

No. 2) in May 2015. In Hawke Report No. 1, the top issues raised by concerned citizens, in order of frequency were:

- water contamination;
- social, cultural and environmental impacts;
- water use;
- rivers and aquifers;
- health concerns;
- short term benefits;
- long term impacts;
- moratorium;
- monitoring and compliance;
- fugitive emissions;
- chemical usage; and
- the regulatory regime

In response to both the NT Report and the Hawke Reports, the Northern Territory Department of Mines and Energy (NTDME) has undertaken the drafting of *Petroleum (Environment) Regulations* to address the issues raised and recommendations. After considering the Hawke report and extensive public consultation, the Northern Territory Government accepted the six recommendations of the Hawke Report No. 1, being:

1. That the environmental risks associated with hydraulic fracturing can be managed effectively subject to the creation of a *robust* regulatory regime.
2. The substantive weight of agreed expert opinion leads the Inquiry to find that there is no justification whatsoever for the imposition of a moratorium of hydraulic fracturing in the Territory.
3. That the NT Government forms a Cabinet Sub-Committee to oversee the work required for the Territory to set the standard for a *best practice* regulatory regime.
4. That the NT Environmental Assessment Act be restructured in light of the Report and the proposed bilateral agreements with the Commonwealth Government on environmental assessments and approvals under the Commonwealth Environmental Protection and Biodiversity Conservation Act.
5. That the NT Government considers aligning the petroleum and mineral royalty frameworks.
6. That the NT Government proposes, through the Council of Australian Governments' (COAG) Standing Council on Energy and Resources, that the Australian Council of Learned Academies host a workshop of international academies to consider their collective findings, learn from each other and identify the findings shared by all of the academies.

3.2 Aim of Report

The aim of this report is to provide an independent review of the draft *Petroleum (Environment) Regulations* against contemporary best practice regulation of environmental aspects arising from petroleum activities that involve ground disturbance.

3. SCOPE OF THE REVIEW

This report will under take the review of the *Petroleum (Environment) Regulations* to assess whether the regulations meet the following objectives:

1. ensure that the regulations are enforceable and that the mechanisms to enforce compliance are effective;
2. risks and impacts of petroleum activities are identified and reduced to as low as reasonably practicable (ALARP);
3. ensure that petroleum activities are undertaken in a manner consistent with the principles of ecologically sustainable development (ESD);
4. any unnecessary requirements and red/green tape are identified.

In addition, the following additional policy tools will be assessed in this review:

1. Balanced Environment Strategy; and
2. Onshore oil and gas guiding principles.

The outcomes of the review will contain specific conclusions and recommendations that will be utilised to guide the development of best practice regulations.

Appropriate staff from the Northern Territory Energy Directorate were consulted for this report.

4. METHODOLOGY

In undertaking this review a number of standard legal review methodology is used. Given that this review seeks to assess whether the draft Petroleum (Environment) Regulations (the Regulations) are best practice regulations, an assessment of the concept of best practice will be undertaken.

In order to assess the regulations, empirical doctrinal methodology has been adopted. This methodology involves analysis that undertakes a systematic exposition of the regulations, including an analysis to identify gaps and areas of future development. In addition, the methodology will include reform-oriented analysis, where an extensive evaluation of the regulations will be made, and recommendations for change advocated where the regulations are found wanting.

5. BEST PRACTICE REGULATION IN PETROLEUM ACTIVITIES

Best practice is a term that is vague, and subjective. What exactly is ‘best’? What is best for one set of circumstances may not be best for another, thereby making the term elusive. The concept of best practice in regulation is examined by Bretschneider, who attempts to determine the necessary and sufficient conditions for the identification of ‘true best

practice'[11]. According to Bretschneider, the term best 'practice' implies that best occurs when compared to an alternative course of action, where the practice is designed to achieve some deliberative end.

The closest we get to some type of definition is from the Australian office of Best Practice Regulation, who notes that good regulation should be *robust*, enable the regulator to maintain appropriate control over decision-making processes, implement policy quickly where necessary, and ensure that ultimate responsibility lies with ministers, departments and regulators[12]. Such a description is akin to that of Hale,[13] who describes the best regulatory framework for petroleum as one that is 'robust'. Robust is defined as a regulating regime whose basic design principles stay the same over time, or are restored after a challenge, but whose detailed operationalization adapts to changing demands and situations. [14] Recommendation no. 1 of the Hawke Report No. 1 suggests that the environmental risks associated with HF can be managed subject to the creation of a *robust regulatory regime.* Therefore, it is suggested that robustness (as defined by Hale) be a measure for how well the NT regulatory framework manages the environmental effects of HF.

The issue of best practice in shale gas operations in the UK was discussed in the UK shale gas report after the Preese Hall seismic event. [15] The report concluded that shale gas extraction in the UK could be effectively managed as long as operational best practices are implemented and enforced through regulation. [16] Best practice forms the core of the recommendations for effective shale gas extraction in the UK: Best practice to be implemented for risk management,[17] information sharing and dissemination to improve risk assessment and promote best practice across the industry,[18] and mechanisms to learn from operational and regulatory best practice internationally.[19]

The *UK Task Force on Shale Gas* has also considered the use of the concepts of robustness and best practice framework in the regulation of shale gas activities in the UK. [20] It

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[11] Stuart Bretschneider, Fredrick J Marc-Auroele Jr., and Jiannan Wu 'Best Practices Research: A Methodological Guide for the Perplexed' (2005) 15 (2) *Journal of Public Administration Research and Theory* 307-323, 309.

[12] Office of Best Practice Regulation, *Annual Report 2006-7* (2007), 1.

[13] Andrew Hale, 'Advancing Robust Regulation: Reflections and Lessons to be Learned' in Lindøe, Preben; Baram, Michael, and Renn, Ortwin; *Risk Governance of Offshore Oil and Gas Operations* (2015).

[14] Andrew Hale, 'Advancing Robust Regulation: Reflections and Lessons to be Learned' in Lindøe, Preben; Baram, Michael, and Renn, Ortwin; *Risk Governance of Offshore Oil and Gas Operations* (2015).

[15] Royal Society and the Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing* (2012).

[16] Royal Society and the Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing* (2012), p ??

[17] Royal Society and the Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing* (2012), p 7.

[18] Royal Society and the Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing* (2012) p 7.

[19] Royal Society and the Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing* (2012), p 7.

[20] Task Force on Shale Gas, *Final Conclusions and Recommendations* (2016) https://darkroom.taskforceonshalegas.uk/original/d6f5f84dbfecbe9c22bddbc7f93d31bc:cb2ee01d6a9d7

recommends that the UK government commit to ensuring that the regulatory system for the shale gas industry is robust and fully resourced. It sees the current system as fit for purpose, but as the industry grows, ensures that the regulatory regime is robust and best practice.

In applying the concept of best practice, there are three types of 'best practice': regulatory best practice, policy best practice and operational best practice. Best practice regulation has also been considered by academics. Mumford, in his paper *Best Practice Regulation: Setting targets and detecting vulnerabilities*, draws upon Australian Treasury, OECD, APEC and World Bank principles, as well as principles that have been adopted in the UK, Australia, USA and New Zealand to outline the attributes of best practice regulation. Attributes he identifies include proportionality, flexibility, predictability, transparency and capability. Yet still, he fails to *define* what best practice regulation is. We know what it comprises, but can't actually define it. Best practice in regulation has also been considered by the OECD, [21] which sees itself as a leader in developing best practice principles for regulation and regulators. Yet in its best practice publications the OECD fail to actually define what best practice is. Rather, the OECD publications are intended to provide members with the *tools* to develop best practice frameworks, although what constitutes a best practice framework continues to remain elusive, at least within the world of OECD.

Operational best practice relates to the use of best practice standards in individual operations within shale gas development in order to achieve best practice regulation. Examples of best practice include the use of standards, guidelines and practices. In the International Energy Agency study on shale gas,[22] consideration was given to the concept of best practice. The report concluded there was a need for best practice in well design and construction to control the hazard of leak of fluids into shallow aquifers.[23]

The issue of best practice in regulation and in standards has come to feature prominently in the last five years as a number of countries, particularly Australia and the UK, seek to develop their unconventional petroleum resources (UPR).[24] Within shale gas operations, particularly that of hydraulic fracturing, the use of best practice as a standard arises again and again. In recent years, several bodies (both national and international) have produced guidelines in best practice for various aspects of shale gas activities. Such bodies include:

- International Association of Oil and Gas Producers (OGP)
- International Petroleum Industry Environmental Conservation Association (IPIECA)
- Det Norsk Veritas (DNV)
- UK Onshore Operators Group (UKOOG)

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a96cd7d10262971d586/task-force-on-shale-gas-final-conclusions-and-recommendations.pdf last accessed 11 March 2016.

[21] OECD, *Best Practice Principles for Regulatory Policy: The Governance of Regulators* (2012)

[22] International Energy Agency, *golden Rules for a Golden Age of Gas: World Energy Outlook Special report on unconventional gas* (2012)

[23] International Energy Agency, *golden Rules for a Golden Age of Gas: World Energy Outlook Special report on unconventional gas* (2012), p 37.

[24] Unconventional petroleum resources include oil and gas, from shale and coal seams. Often it is referred to as coal seam gas and shale gas, but can also include shale oil but not oil shale, which is produced from a kerogenic process such as pyrolysis, hydrogenation or thermal dissolution).

- American Petroleum Institute (API)
- State Review of Oil and Natural Gas Environmental Regulation (STRONGER).

The UK government has established a roadmap document for best practice in onshore oil and gas development in the UK.[25] This document is a strange mixture of regulatory practice (whether best or not is not assessed), and best practice in operations. The roadmap is intended as a reference for those wishing to understand SG extraction, as well as those in the industry.

The Northern Territory government seeks to implement world's 'best practice' operating environment for onshore gas industry.[26] This goal of achieving best practice has been set through the acceptance and adoption of recommendation no. 3 of Hawke Report No. 1, which recommends that the Northern Territory government forms a Cabinet Subcommittee to oversee the work required for the Territory to set the standard for a best practice regulatory regime. The NT government has not clarified as to how this regulatory framework will be achieved. Will it be through the use of operational best practice?

Recommendation 1: That the Northern Territory government clarify what they mean when implementing 'best practice regulation'. Is 'best practice' that of regulatory best practice, operational best practice or both? In undertaking this clarification, the Northern Territory government should also determine a method of best practice, and a metric for assessing whether the regulation is 'best practice'. An examination of international best practice standards would assist in understanding operational best practice within best practice regulation.

6. ASSESSMENT OF PROPOSED ENVIRONMENTREGULATIONS

7.1 Regulations and ecologically sustainable development

The Northern Territory government seeks to regulate onshore oil and gas activities according to the principles of ecologically sustainable development, adopting the following:

1. Decision-making integrates both long and short term economic, environmental social and equitable considerations;
2. Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reasons for postponing measures to prevent environmental degradation;
3. The principles of inter-generational equity should apply;
4. The conservation of biological diversity should be a fundamental consideration in decision-making; and

[25] Department of Energy and Climate Change, *Onshore oil and gas exploration in the UK: Regulation and best practice* (2015) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/503067/Onshore_UK_oil_and_gas_exploration_England_Dec15.pdf accessed 2 March 2016.

[26] Northern Territory Government, *Media Release: Government on track to implement world's 'best practice' operating environment for onshore gas industry* 5 March 2016, http://newsroom.nt.gov.au/mediaRelease/18384 last accessed 15 March 2016.

5. Improved valuation, pricing and incentive mechanisms should be promoted.[27]

In order for the principles of ESD to be implemented within the Regulations, the definition of ESD will be the same as the definition in the *Environmental Protection and Biodiversity Conservation Act 1999* Commonwealth).

Recommendation 2: That the Northern Territory clearly state that the definition of ESD is the same as that in the Environmental Protection and Biodiversity Conservation Act 1999 (Commonwealth) in the Environment Guidelines .

Assuming that the definition for ESD is that defined in r 5, in order for the regulations to implement the principles of ESD, they require a focus on both economic and social considerations as well as intergenerational equity (IGE) within a framework that applies the precautionary principle. Part of the application of socio-economic considerations and IGE is ensuring that petroleum exploration and development activities occur alongside, and in consideration of other activities that currently exist in the Northern Territory or may do so in the future. The current draft regulations (v6) attempt to do this through r 9 – stakeholder engagement. Under this regulation, the interest holder is required to give the stakeholder sufficient information to enable the stakeholder to make an informed assessment about the environmental impacts and the consequences of a particular activity on the affected stakeholders' future functions, interests or activities. There is also a requirement for an appropriate period of engagement, including corresponding with, discussing, consulting and collaborating with affected stakeholders.

These requirements under r 9 are at direct odds with the principles of ESD, particularly that of IGE and socio-economic development. Effectively the requirements in r 9 (1) (a) at present, as stated, are directing the affected stakeholders to consider the environmental impacts of a petroleum activity on the affected stakeholder's functions interests and activities, and discuss, collaborate consult and correspond with the interest holder about these impacts. There is no provision for an affected stakeholder to negotiate regarding the impacts, or a legal requirement for the interest holder to alter or ameliorate their activity if it causes an impact. This effectively places the interests of the petroleum interest holder above those with other interests, including agriculture. Considering the importance of agriculture to the Northern Territory, engagement with stakeholders should include negotiation regarding the impact of the activity. Furthermore, in order for petroleum development and other land-based activities to co-exist, there needs to be full consultation and negotiation, not merely engagement.

Recommendation 3: In order to implement the principles of ecologically sustainable development (ESD), which include the consideration of the interests of interest holders and affected stakeholders the relevant Minister must take into account the principles of ESD when approving an Environmental Management Plan, of which consultation feedback forms a part.

[27] *Petroleum (Environment) Regulations* v6,.

7.2 Overview of content of the Regulations

The Northern Territory government has undertaken the difficult task of writing objective-based regulations out of a prescriptive schedule, whilst undergoing intense scrutiny. The move to objective-based regulation is essential. Previous incidents world-wide (especially Piper Alpha and Deepwater Horizon) have illustrated that prescriptive regulation lacks the flexibility necessary to respond economic and technological changes in the extraction of petroleum.

By and large, the regulations are sound. The regulations are objective based, and clear in their intent.

In order to deliver operational best practice, there needs to be some stipulation of the content of an environment plan. The current required content of the plan is set out in r 8, which requires a summary (r 8 (3) (a)) and comprehensive information (r 8 (3) (b) about

- each regulated activity to be carried out under the plan;
- the location of each regulated activity;
- the environment that may be affected by each activity;
- the environmental impacts and risks of each activity;
- the arrangements for ongoing monitoring of the interest holder's environmental performance;
- the stakeholder engagement undertaken and plans for further stakeholder engagement; and
- any other matters necessary to be included to meet the approval criteria under 8 (3) (b) (i).

in addition, the criteria for assessment are set out as objectives in r 10.

The placing of the information required into Schedule 1 of the Regulations seeks to consolidate all of the provisions for the requirements of the Environmental Management Plan in one area, as this will be easier for interest holders and the Regulator to identify what must be included in the EMP. Since this Schedule is part of the Regulations, they will have the full enforceability of subordinate legislation, as ensured by r 8(3)(b) and 10 (1)(a). Regulation 10 provides that a plan will only be approved if the information in the Schedule is included.

Recommendation 4: The structure of the Regulations should provide the interest holder and the Regulator with clear direction as to the requirements of the EMP in order to ensure that the Regulations implement best practice regulation and reduce regulatory burden for industry.

7.3 Risk identification and mitigation/reduction

7.3.1 Definition of ALARP

The role of the Regulations is to provide clarity to interest holders regarding the requirements for both the EMP and environmental protection under the Petroleum Act. The NTDME has adopted an objective-based approach to environmental regulation, which is to be applauded. The objectives of the Regulations have been clearly outlined under r 3, which requires that a regulated activity is carried out in a manner that is consistent with the principles of ESD, the impacts and risks are reduced to as low as reasonably practicable (ALARP), and of an acceptable level (defined in r 4 as an ‘environmental objective’). The regulations also require that the approval criteria require that a plan must demonstrate that the environmental impacts

and risks are reduced to ALARP and an acceptable level. Neither ALARP or acceptable is defined in r 4 of the Regulations, and this is an oversight.

The standard reasonably practicable needs to be defined correctly in the Regulations in order for the application of ALARP to achieve true risk reduction. If you reduce the risk to ALARP then it will be acceptable, because the risk has been reduced to its lowest.

The confusion may arise due to a general lack of understanding of what 'reasonably practicable' means. The term *reasonably practicable* was defined in the case Edwards v National Coal Board:[28]

> Reasonably practicable is a narrower term than 'physically possible' and implies that a computation must be made... in which the quantum of risk is placed in one scale and the sacrifice involved in the measures necessary for averting the risk (whether in time, trouble or money) is placed in the other and that, if it be shown that there is a great disproportion between them – the risk being insignificant in relation to the sacrifice – the person upon whom the obligation is imposed discharges the onus which is upon him.

In order to require risk to be reduced to ALARP as a criteria for assessing the EMP, it is essential that *reasonably practicable* be defined. In no other Australian legislation (Commonwealth or Western Australia) is this term defined correctly. Without the correct definition and application, true risk reduction will not occur. In order to define the concept of ALARP, consideration should be given to the definition and implementation of *reasonably practicable* by the UK Health and Safety Executive.

Recommendation 5: The regulations should be altered to define the concept of 'reasonably practicable', in line with the UK HSE definition, where reasonably practicable is defined as 'balancing the level of risk against the measures needed to control the real risk in terms of money, time or trouble. However, you do not need to take action if it would be grossly disproportionate to the level of risk'. Further, the requirement of reducing impacts and risks to ***acceptable*** *in r 3 (b) (ii) should be removed, as it is superfluous when ALARP is correctly applied.*

7.3.2 Good oilfield practice inconsistent with ALARP

The use of the requirement 'good oilfield practice' (GOP) in regulations that utilise ALARP is contraindicated. Regulation 10 (b) (iii) uses GOP as an approval criterion for the EMP. This is a different standard to that to ALARP, and the two are incompatible. ALARP seeks to reduce risk, whereas GOP 'means all those practices and procedures that are generally accepted as good and safe in the carrying on of that exploration or those operations, as the case be.[29] This is different standard. One is risk reduction; the other introduces the term 'accepted as good and safe', and is of a lower standard.

Recommendation 6: the Regulations should be altered to remove the concept of good oilfield practice as an approval criterion. Regulation 10 (b) (iii) should be removed.

[28] Edwards v National Coal Board, 1(1949) 1 All ER 743.

[29] Defined in in Section 5 (1) of the NT Petroleum Act.

7.4 Legal status and enforceability of regulations

As subordinate legislation, the regulations are enforceable. However any soft law instruments, such as guidelines, schedules and the like are not. Their legal status is that of advisory. Therefore is it critical that all enforceable legal requirements are contained within the regulations. This is the greatest challenge of implementing object-based regulation rather than prescriptive regulation. There is an urge to define and list what is required (prescriptive) rather than to state objectives. Where uncertainty occurs, Regulations should be drafted to a higher degree of generality to ensure the objective encompasses the requirements. The use of reducing risk to ALARP is an excellent objective-based tool to ensure that all requirements are encompassed. Drafters of the regulations should be wary of 'listing' requirements.

Throughout the regulations, the legally responsible person is that of the interest holder. The interest holder is defined in r 4 as the person holding a petroleum interest or a person who has submitted the EMP relating to the activity under r 7 (2). A petroleum interest is defined in s5 of the *Petroleum Act* as an exploration permit, retention licence, production licence or access authority. One concern that has been raised in the drafting of such regulations in other jurisdictions is whether enforceability of a breach of a plan extends to contractors and subcontractors. Therefore, there needs to be clarification that when a requirement for compliance stipulates an interest holder, the application of the requirements for the EMP extend to contractors and subcontractors.

Recommendation 7: The Regulations should clearly state that any liability and responsibility that applies to an interest holder extends to a subcontractor engaged by the interest holder to perform an obligation.

The use of the *Schedule of Onshore Petroleum Exploration and Production Requirements 2012* (the 2012 Schedule) in conjunction with the Regulations should be eliminated as soon as is practicable. As noted in the 2011 assessment of the Western Australian onshore petroleum regulatory framework,[30] the schedule, by itself, has no enforceability, since it is neither subordinate legislation or delegated legislation. If the requirements of clauses 612 (Measurement of Produced Petroleum and Water) and 628 (Restoration of Lands) of the 2012 Schedule remained as part of the regulatory framework, they would not have the same legal force as that of the Regulations. This may undermine the objectives of the Regulations (ESD and reduce risk to ALARP), but would also undermine best practice and impact on the social licence to operate. It is accepted that until the legislative reform is completed and the *Petroleum (Resource Management and Administration) Regulations* are implemented, there will be legacy issues regarding the 2012 Schedule. However, whilst there is a legislative gap until legislative reform is completed, the rigorous application of process and the skill and dedication of staff provides assurance that the current processes are adequate to protect the environment.

[30] Tina Hunter, *Regulation of shale, coal seam and tight gas activities in Western Australia: an analysis of the capacity of the* Petroleum and Geothermal Energy Act 1967 (WA) *to regulate onshore acuities in Western Australia* (2011). http://www.dmp.wa.gov.au/Documents/Petroleum/PD-SBD-NST-116D.pdf last accessed 11 March 2016.

Recommendation 8: Upon the completion of legislative reform, all provisions for regulation of activities should be contained within the Act and subordinate regulations. The DME should ensure a smooth transition from the 2012 Schedule to compliance with the new regulations.

7.5 Assessment of regulations: Regulatory burden, green tape and red tape.

The alteration of the structure of the regulations from v5 to v6, which is also a departure from the equivalent Western Australia regulations, may impose a regulatory burden for those interest holders who are undertaking petroleum interests in both Western Australia and the Northern Territory. This departure from a similar structure goes against the concept of best practice iterated in the COAG Best Practice Handbook.

7.6 Other issues identified

7.6.1 Contingency plans

The Regulations require an emergency contingency plan in s 8 of Schedule 1 of the Regulations, and includes arrangements for responding to emergencies or potential emergences. However, there is no specific plan requirement such as a spill plan. This is most unusual and similar regulation (such as Western Australia) specifically requires a spill contingency plan. Under the Western Australia Regulations, r 12 requires an oil spill contingency plan. Indeed, version 5 of the regulations required an oil spill contingency plan under r 34. However, given that this is shale gas, there is often little or no oil spilled. Rather it is release of gas, and also formation fluid/drilling fluid that poses an environmental threat. Importantly, very few jurisdictions worldwide require the formation of detailed plans for ALL response situations, such as the uncontrolled release of chemicals, gas, or formation fluid. Still even less, as illustrated by both Montara and Deepwater Horizon, have a coordinated response plan to respond to a loss of well control. This is unacceptable, and does not fit with the concepts of ESD.

There are a number of contingency plans that should be specified in the Regulations and in the Regulations guidelines, and should include:

- *Hydrocarbon spill response plan*, for the accidental release of oil, gas or condensate;
- *Chemical spill response plan*, for instances where chemicals in their undiluted form are accidentally released into the environment;
- *Fluid spill response plan*, for instances where formation fluid or returned water is spilled;
- *Well control response plan*, to enable a coordinated and organised response in the extremely unlikely event of a well blowout or loss of well control.

Recommendation 10: The Regulations should be altered to specify the requirement for appropriate response plans, which should be detailed in the Guidelines.

7.6.2 Well integrity and well approval

Many of the environmental impacts associated with petroleum activities arise due to issues with the well (for example underground water contamination, fluid spills, blowouts, etc.). It is therefore prudent that an EMP should not be approved without an approved well operations management plan. The requirement for approval of an EMP should be contingent upon the

approval of a WOMP. In 2014 an Environment Plan (EP) was approved for HF of several wells (Y3 and Y4) in the Canning Basin on Yawuru Country where the prior cementing of the wells had been found to be faulty.[31] Although the WOMP approval required remediation of the wells, nonetheless the approval of the EP caused concern and consternation amongst indigenous landholders.[32] The requirement for WOMP approval prior to consent to undertake drilling is a prerequisite in both the UK (offshore and onshore) and Norway, and represents best practice.

Recommendation 11: The Petroleum Environment Regulations should clarify that consent to drill requires the approval of both an EMP and approval of the WOMP.

Every 'robust' or best practice system (both conventional and unconventional, offshore and onshore) relies on a well inspection to ensure that wells are constructed to a standard that minimises risk of failure/blowout. Those jurisdictions that are recognised as demonstrating best practice, especially Norway and UK, require well inspection during both well construction and well completion. Similarly, in most jurisdictions in the US, the well is 'approved by a certified well engineer. Similar to building inspections, such inspection and approval of a well provides certainty and accountability regarding well integrity.

As demonstrated in the Montara incident, inexperienced or unfamiliar operators may not complete a well to the standard required and approved in the WOMP. By requiring inspection, this will not only ensure that wells are constructed and completed in a manner that represents ESD and best practice, but will also provide assurance to the public that the source of much of the environmental harm requires independent verification. The regulator must be satisfied that the well inspection is performed by a certified well engineer in accordance with an accredited procedure and may wish to audit the process from time to time to ensure its effectiveness. This inspection and approval can be completed by either Northern Territory DME or a third party certifier such as the not for profit organisations Det Norske Veritas (DNV). Given the importance of well inspection, this requirement should be considered during the drafting of the relevant regulations.

Recommendation 12: Well inspection by an independent certified third party inspector should be a mandatory component of the regulatory regime for drilling, and should be considered during the drafting of the relevant regulations.

7.6.3 Definitions

Many definitions required in the regulations appear in the body of the Regulations. In some instances, the definition is included in r 4 (definitions) with a cross reference to the regulation that contains the definition (for example, in r 4 *infringement notice* refers the reader to r 44). However, this has not been consistently applied, and so some definitions are contained in r 4, and some are not. For example, the definition of facility is contained in r 6 (4), but not in r 4.

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[31] Yawuru Expert Group, *Peer Review of TGS14 Environment Plan (Rev_0, 1, 2, 3 and 4)* (2014) http://www.yawuru.com/wp-content/uploads/2014/07/Yawuru-Expert-Group-Consolidated-Report-on-Buru-Energys-TGS14-program-ID-48650.pdf last accessed 12 March 2016.

[32] Yawuru Expert Group, *Peer Review of TGS14 Environment Plan (Rev_0, 1, 2, 3 and 4)* (2014) http://www.yawuru.com/wp-content/uploads/2014/07/Yawuru-Expert-Group-Consolidated-Report-on-Buru-Energys-TGS14-program-ID-48650.pdf last accessed 12 March 2016.

In addition, there are some definitions that are critical, such as 'petroleum interest', which is defined in the Petroleum Act. The regulations would be more comprehensive and better served if definitions that are found outside of the Regulations (i.e. in the Principal Act) are defined within the Regulations.

Recommendation 13: The definitions in r 4 should include a reference to all definitions found in the Regulations. Where applicable definitions are found in another act, the definition should be included in r 4 of the Regulations with reference to the primary legislation.

7. ASSESSMENT OF ADDITIONAL REGULATORY TOOLS

8.1 Balanced Environment Strategy

The *Balanced Environmental Strategy* discusses the framework for balancing protection and sustainable use to maintain a healthy and resilient environment. It reiterates the commitment to maintaining a healthy and resilient environment, recognising that the Territorian way of life is heavily dependent upon the environment, with a reliance on mining and pastoralism. It includes the following topics:

- Framework for balanced environments;
- Goal for balanced environment; and
- How the balanced environment will be achieved.

The framework values include stewardship, balancing environmental, social and economic factors, engagement and IGE. It is expected that these principles will be implemented through the Regulations, in order to balance the needs of the petroleum industry with the interests and needs of other land users.

However, as outlined in section 5.1 above, whilst there is engagement with affected stakeholders, there is little consideration of minimising the impact of the activity on the affected stakeholder. In practical terms that means there is less likely to be balance and rather there will be the domination of one industry (petroleum) over other industries. Under the concept of IGE it is important to realise that other activities that have been utilising the land for generations (particularly cattle and other forms of agriculture) need to be considered in the development of petroleum resources.

The non-renewable nature of petroleum means that the activity can only occur once. This differs markedly to agricultural activities which produce renewable resources, and which provide intergenerational equity. The balanced environmental strategy, and the implementation of that strategy should consider and apply these principles. Long after the petroleum resources have been depleted, the land, if sufficiently nurtured and cared for under a balanced approach to resource development, will continue to provide livelihoods for generations of Territorians. An examination of the principles of resource development in Norway, with stewardship of fishing resources in relation to the development of offshore petroleum provides an excellent example of how balance can be accomplished.

8.2 Onshore Oil and Gas guiding principles

The guiding principles are designed to inform the reader (presumably the public and stakeholders) the principles under which petroleum activities are being undertaken. They are divided into ten sections and cover the following:

- Well Design, Construction and operation
- Water management
- Land access
- Air and noise emissions
- Community and social impacts
- General operations
- Hydraulic fracturing
- Chemical and waste handling and management
- Rehabilitation and decommissioning
- Local content

These principles represent a good start in guiding the public in the principles that guide operators and interest holders in how to conduct operations within the Northern Territory. In addition, the principles should be revised to include how all decisions will be underpinned by the principles of ESD and reducing risk to ALARP.

8. CONCLUSION

The Northern Territory government is to be commended for implementing the principles of ecologically sustainable development, and trying to balance the development of an industry that will contribute to the economic life of the territory with existing industries and activities, especially agriculture. This is by no means easy, and throughout the world, many governments have attempted this and failed.

The draft regulations represent the commencement of the path to sound regulations, where the principles of best practice are utilised to implement a regulatory framework that is robust, as such, a robust regime is one whose basic design principles stay the same over time, or are restored after a challenge, but whose detailed operationalization adapts to changing demands and situations. Therefore, it is important that the Northern Territory government design a robust set of regulations from the beginning, ones that are objective-based, but with sufficient clarity in the objectives to ensure that they implement the principles of ecologically sustainable development within a risk identification and mitigation framework.

The regulations to date are a sound framework, and with the implementations of the recommendations, will represent best practice in regulating onshore oil and gas activities.

9. RECOMMENDATIONS

Recommendation 1: That the Northern Territory government clarify what they mean when implementing 'best practice regulation'. Is 'best practice' that of regulatory best

practice, operational best practice or both? In undertaking this clarification, the Northern Territory government should also determine a method of best practice, and a metric for assessing whether the regulation is 'best practice'. An examination of international best practice standards would assist in understanding operational best practice within best practice regulation.

Recommendation 2: That the Northern Territory clearly state that the definition of ESD is the same as that in the Environmental Protection and Biodiversity Conservation Act 1999 (Commonwealth) in the Environment Guidelines.

Recommendation 3: In order to implement the principles of ecologically sustainable development (ESD), which include the consideration of the interests of interest holders and affected stakeholders the relevant Minister must take into account the principles of ESD when approving an Environmental Management Plan, of which consultation feedback forms a part.

Recommendation 4: The structure of the Regulations should provide the interest holder and the Regulator with clear direction as to the requirements of the EMP in order to ensure that the Regulations implement best practice regulation and reduce regulatory burden for industry.

Recommendation 5: The regulations should be altered to define the concept of 'reasonably practicable, in line with the UK HSE definition, where reasonably practicable is defined as 'balancing the level of risk against the measures needed to control the real risk in terms of money, time or trouble. However, you do not need to take action if it would be grossly disproportionate to the level of risk'. Further, the requirement of reducing impacts and risks to ***acceptable*** *in r 3 (b) (ii) should be removed, as it is superfluous when ALARP is correctly applied.*

Recommendation 6: the Regulations should be altered to remove the concept of good oilfield practice as an approval criterion. Regulation 10 (b) (iii) should be removed.

Recommendation 7: The Regulations should clearly state that any liability and responsibility that applies to an interest holder extends to a subcontractor engaged by the interest holder to perform an obligation.

Recommendation 8: Upon the completion of legislative reform, all provisions for regulation of activities should be contained within the Act and subordinate regulations. Given the need for Resource Management and Administration Regulations, transition provisions regarding the 2012 Schedule should be incorporated into the Regulations.

Recommendation 9: Schedule 1 of the Regulations should be altered to specify the requirement for appropriate response plans, which should be detailed in the Guidelines

Recommendation 10: The Petroleum Environment Regulations should clarify that consent to drill requires the approval of both an EMP and approval of the WOMP.

Recommendation 11: Well inspection by an independent certified third party inspector should be a mandatory component of the regulatory regime for drilling, and should be considered during the drafting of the relevant regulations.

Recommendation 12: The definitions in r 4 should include a reference to all definitions found in the regulations. Where applicable definitions are found in another act, the definition should be included in r 4 of the Regulations.