Hydrological (Surface Water) Investigation and Assessment

Lake Disappointment

Reward Minerals

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Report

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Table of Contents

Executive Summary 6

1. Introduction 7

1.1 Objectives 7

1.2 Scope of Work 8

2. Legislative/Regulatory Context 9

3. Hydrological Assessment 13

3.1 Catchments 13

3.2 Rainfall Runoff 13

3.3 Flooding 16

3.3.1 Flooding 16

3.3.2 Backwater 19

3.4 Risk Assessment 19

3.4.1 Assessment Framework 19

3.4.2 Hazard Identification and Assessment 19

4. Regional Climate and Rainfall 22

4.1 Regional Climate and Rainfall 22

4.2 Historic and Predicted Future Cyclonic Activity 22

5. Surface Water Ponding and Distribution 24

5.1 Methodology 24

5.2 Results 27

5.2.1 Geographical Distribution of Surface Water 27

5.2.2 Temporal Characteristics of Ponding 32

5.2.3 Historic Precipitation and Ponding 33

6. Conclusions and Recommendations 41

Glossary and Abbreviations 42

References 43

Figures

Figure 1.1: Locality Map. 7

Figure 2.1: Savory Creek and Rudall River Catchments. 9

Figure 2.2: Savory Creek and Rudall River Wild River Catchments. 10

Figure 2.3: Lake Disappointment/Savory Creek Wetland System. 11

Figure 2.4: Existing and Proposed Conservation Areas. 12

Figure 3.1: Regional Contour Plan. 14

Figure 3.2: Regional Catchments. 15

Figure 3.3: Flooding of Lake Disappointment in March 2004 16

Figure 3.4: Conceptual Hydrological Model of Lake Disappointment. 20
Figure 5.1: Lake Hollows. 25
Figure 5.2: Areas of Investigation and Sample Locations. 26
Figure 5.3: Surface Water Distribution. 28
Figure 5.4: Topography. 29
Figure 5.5: MODIS Images, Pre-and-Post Cyclone Rusty, 2013. 30
Figure 5.6: Seasonal Changes. 31

Tables

Table 3.1: Cumulative Rainfall Evaporation Water Balances. 18
Table 3.2: Risk Evaluation and Management Actions. 21
Table 4.1: Little Sandy Desert Region Mean Monthly Rainfall. 22
Table 5.1: Weighted Sum of Mean *Wet* Observations. 33
Table 5.2: Cyclonic Events and Presence/Ponding of Surface Water at Lake Disappointment. 35

Appendices

Appendix A: Risk Assessment Framework.
Appendix B: Statistical Analysis of Landsat Imagery.
Appendix C: Telfer Aero Weather Station Data.

Executive Summary

Background

Pendragon Environmental Solutions Pty Ltd was engaged by Reward Minerals to undertake hydrological (surface water) investigations and assessments at Lake Disappointment to ascertain whether the proposed new infrastructure (evaporation ponds, halite waste disposal and brine abstraction trenches), to exploit the *in situ* Sulfate of Potassium resource, within the confines of the lake, will interfere with the hydrological function of the lake and its tributaries.

Objectives and Scope of Work

The objectives of the current hydrogeological program of work are to:

- Enhance the understanding of the hydrological behaviour of Lake Disappointment.
- Provide insight into the historic temporal and spatial distribution of surface water at Lake Disappointment

The following tasks were completed to achieve the above mentioned objectives:

- Summarise hydrological conditions at the lake.

Conclusions and Recommendations

Based upon the findings of this investigation, it can be concluded that:

- Construction of infrastructure on Lake Disappointment to exploit the Sulfate of Potassium resource will not materially impact on the hydrological function of the lake.
- The inlets and primary drainage channels of Savory Creek and the unnamed south-eastern tributary are located within exclusion zones and will not be interfered with.
- Further (relative) wetting of the region may occur in future due to a projected increase in the intensity of cyclonic events and eastward shift in cyclone tracks.
- The majority of the western portion of Lake Disappointment (where the proposed new mine infrastructure will be located) contained surface water in less than or 20% of the observations made between 1987 and 2014. Areas which contained ponded water most frequently are confined to a channel towards the centre and through the eastern/north-eastern and south-western extremities of the lake.
- Surface water ponding occurs most frequently during February and March. Analytical results suggest that the proportion of wet observations remain fairly constant between April and July, before decreasing between the months of August and November and increasing from December to February.
- Flood levels will not increase, thus flooding will not have a significant effect on the local and regional environment as a consequence of operations. The risk of flooding is considered acceptable.

Taking due cognisance of the above, it is recommended that:

- The hydrological impacts be reviewed upon and included in the final design.
- A detailed surface water monitoring program, including Savory Creek (a P1 Wild River), be implemented to facilitate development of appropriate mitigation measures, if required, in consultation with pertinent Stakeholders to ensure that river values (ecological, water quality, scientific and rarity) are upheld. The monitoring parameters should include local rainfall: quantity and intensity and surface water ponding: (location, depth, duration and water quality).

1. Introduction

Pendragon Environmental Solutions was engaged by Reward Minerals Ltd to undertake a desktop hydrological investigation of Lake Disappointment, in the Pilbara Region of Western Australia. Lake Disappointment is an ephemeral salt lake, some 1,355.7km² in extent, located approximately 340km east of Newman (Figure 1.1). Infrastructure associated with the proposed exploitation of the Sulfate of Potassium resource to be constructed within the perimeter of the lake includes:

- Evaporation ponds some 3,700ha in extent.
- Halite waste disposal area some 3,300ha in extent.
- Some 200km of trenches up to 6m deep and 6m wide at the top.

The trenches will extend across most of the western portion of the lake whilst the evaporation ponds and disposal area will be confined to the north-western portion. This study was commissioned to enhance an understanding of the hydrology at and surrounding the lake and to provide insight into the historic temporal and spatial distribution of surface water at Lake Disappointment.

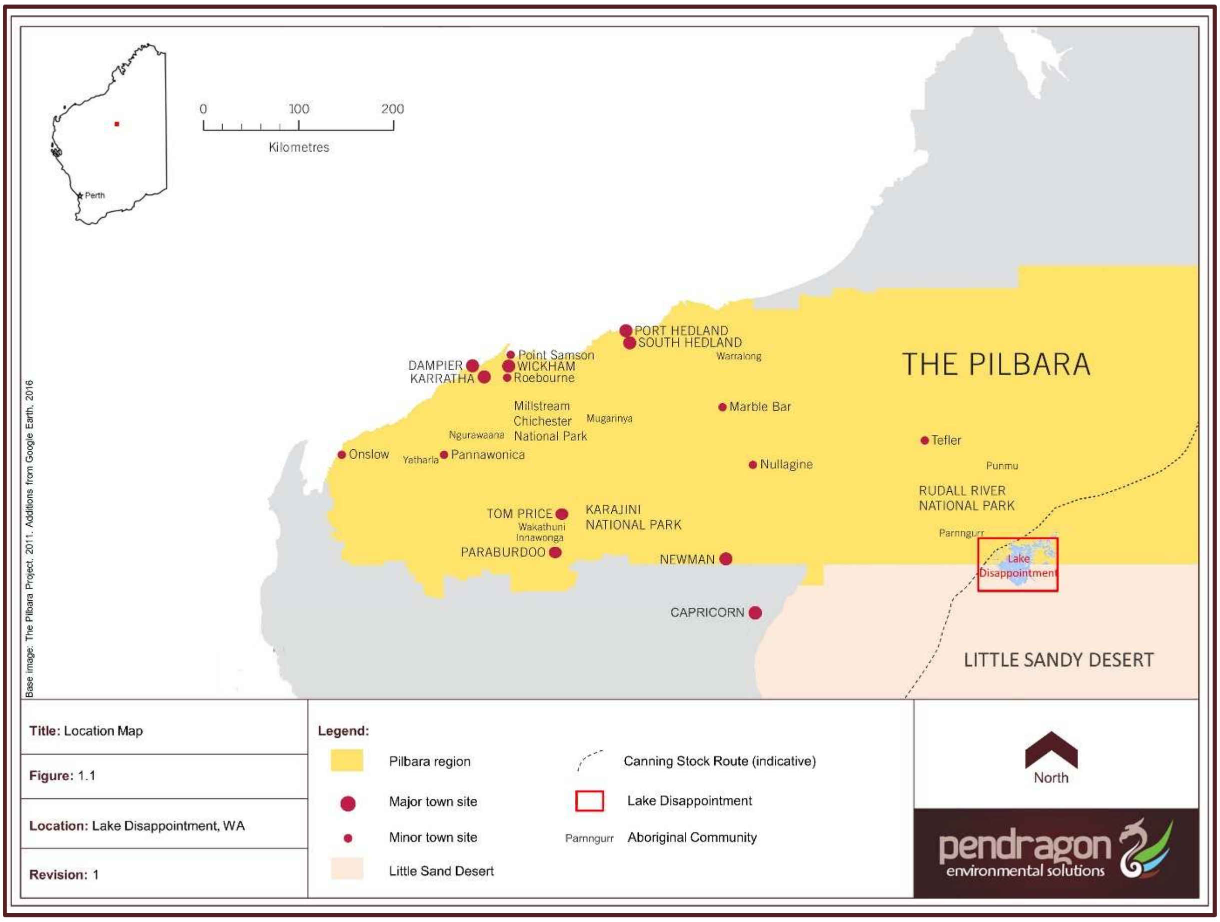


Figure 1.1: Locality Map.

1.1 Objectives

The objectives of this investigation are:

- Provide an overview of the regulatory/statutory context relating to surface water at Lake Disappointment.

- Provide an overview of the hydrology at Lake Disappointment.
- Provide an overview of climate and precipitation (historic and projected) at Lake Disappointment.
- Define the areas within the perimeter of Lake Disappointment where surface water has a tendency to accumulate and thus provide habitat for migratory birds.
- Determine the temporal characteristics of ponding, namely when water is generally present and the approximate duration of this presence in each instance.
- Identify knowledge/data gaps pertaining to the above.

1.2 Scope of Work

The scope of works for this investigation includes:

- Ascertain sources of information regarding hydrology, climate and rainfall at Lake Disappointment.
- Process/interpret data and produce a comprehendible hydrological report presenting findings.
- Undertake a gap analysis and make recommendations regarding further investigation(s), if required.

2. Legislative/Regulatory Context

Lake Disappointment, one of the largest playa lakes in Western Australia, is located at the lowest point of a catchment 600km (east-west) by 500km (north-south). A major tributary, Savory Creek, is still intermittently active but most other drainage channels are dry (Beard, 2005). *Except for occasional rocky ranges the country is dominated by linear sand ridges which are vegetated with spiny grasses.*

Beard postulates that:

- *The catchment features a major palaeochannel, the Disappointment Palaeoriver, extending due south from the lake and receiving tributaries from both east and west. It is situated along the geological boundary between Proterozoic rocks of the Western Shield and Phanerozoic sedimentary rocks to the east.*
- *Lake Disappointment has no outlet and there are no obvious sign of one.*
- *Whilst earlier authors favoured a connection to the Percival Palaeoriver to the north* (Figure 2.1) *and an outlet running north-east from the Lake and then north to Lake Winifred, the Disappointment Palaeoriver continued to the north-west to join Savory Creek, then passing north to join the Rudall River which would have been the lower course of a major river draining the whole Disappointment catchment.*
- *Subsequent disruption of drainage was caused by either tectonic movement during the Miocene or slight uplift of the ridges to the north, sinking of a basin at the lake, or both.*

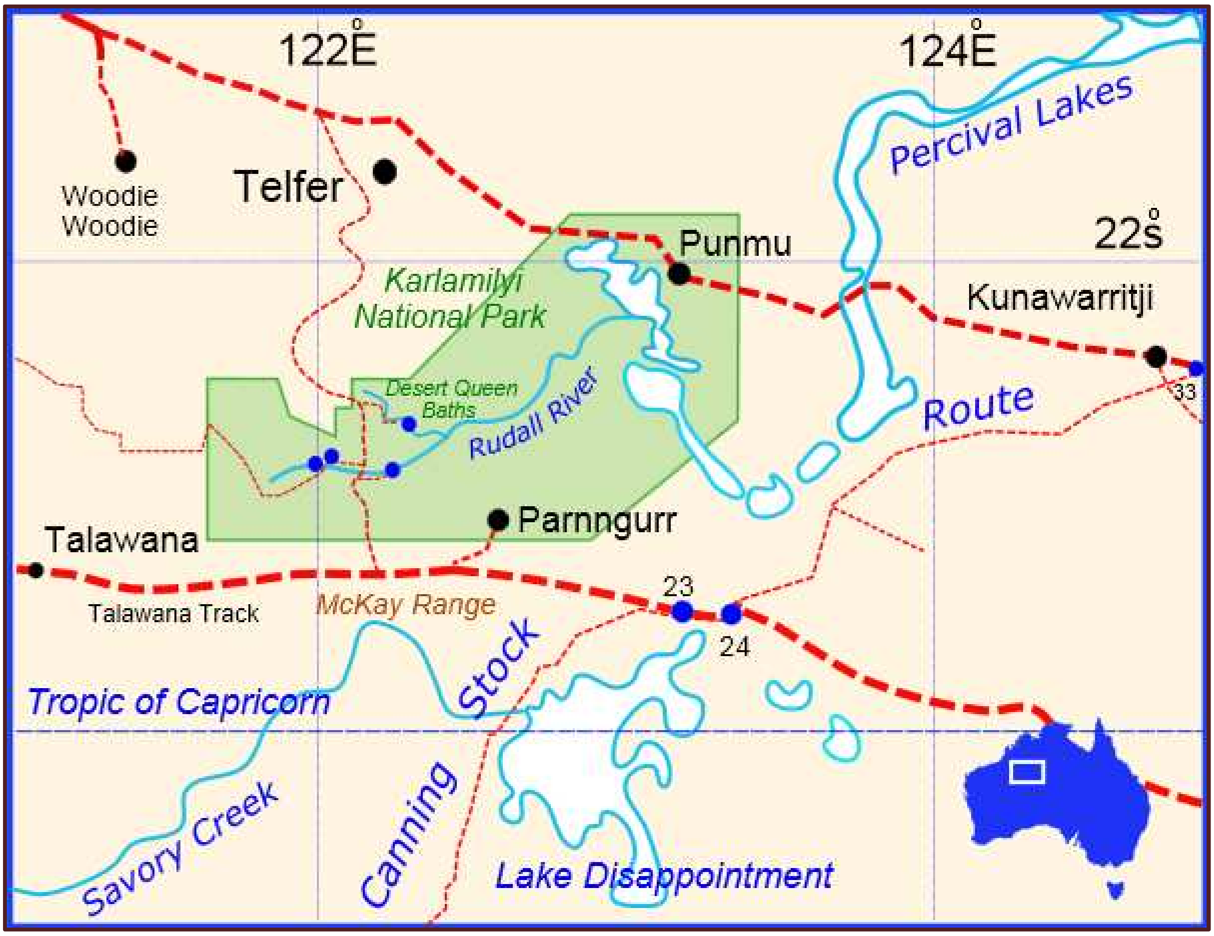


Figure 2.1: Savory Creek and Rudall River Catchments.
(by Summerdrought; https://commons.wikimedia.org/w/index.php?curid=47604771).

The primary legislation regulating the use of water and modification of drainage lines or other catchment features at Lake Disappointment is the *Rights in Water and Irrigation Act 1914* (RIWI Act). The lake lies within a proclaimed groundwater area under the RIWI Act and as such abstraction of groundwater requires a licence from the Department of Water (DoW). Water reserves, catchment areas and underground water pollution control areas are collectively known as public drinking water source areas (PDWSAs; DoW, 2016). These areas are proclaimed under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909* (WA MWSSD Act) or the *Country Areas Water Supply Act 1947* (WA CAWS Act). Whilst Lake Disappointment is not located within a proclaimed area surface water area, provisions of the CAWS Act which establish a framework for regulating clearing and other activities that could impact water quality in surface water catchments, may be relevant.

Lake Disappointment and its tributaries lie within the Savory Creek catchment. Since the lake has no outflow it does not impact on the Rudall River Catchment to the north; however, both these catchments are classified as Priority 1 *wild rivers* (Figure 2.2). Wild rivers are defined as:

those rivers which are undisturbed by the impacts of modern technological society. They remain undammed and exist in catchments where biological and hydrological processes continue without significant disturbance. They occur in a variety of landscapes, and may be permanent, seasonal or dry watercourses that flow or only flow occasionally (Water and Rivers Commission, 1999).

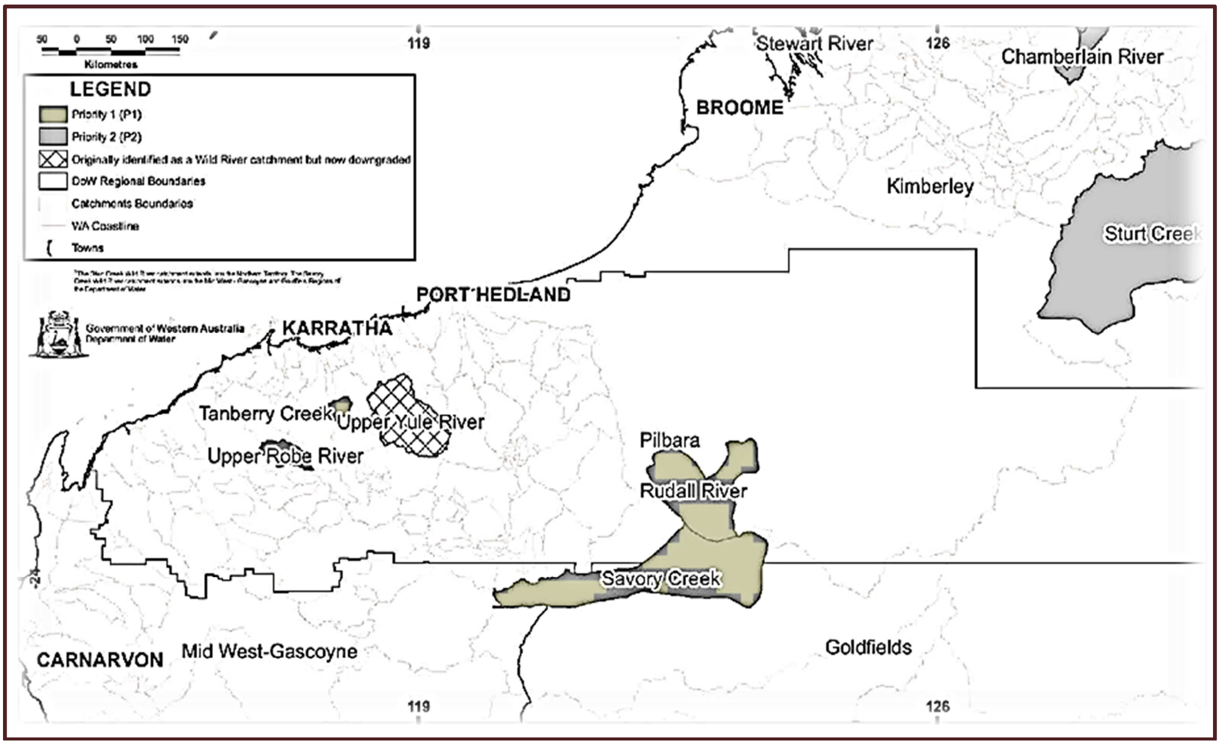


Figure 2.2: Savory Creek and Rudall River Wild River Catchments.

These rivers are afforded a high level of regulatory protection. The Department of Water aims to protect wild river systems chiefly by limiting impacts to waterways and foreshore areas and by seeking to maintain natural flow regimes, hydrological connections and ecological functions (DoW, 2009). The original framework proposed for management of wild rivers (Conservation Guidelines for the Management of Wild River Values, Australian Heritage Commission, 1998) did not categorically exclude exploration or mining from wild river catchments, noting that: *while these activities can impact on wild river values, under certain circumstances and if undertaken under stringent conditions, it may be possible to conduct them within wild river catchments without significant impacts on wild river values*. The DoW enforces a coordinated and cooperative approach by all relevant land and water managers, both private and public, to protect wild rivers (DoW, 2009). The potential impact to Wild Rivers should thus be considered in consultation with all pertinent stakeholders during the planning phase of the project, and appropriate mitigation measures are to be developed to ensure that river values (ecological, water quality, scientific and rarity) are upheld. It should be noted that the Rudall River is located within lands managed by the Department of Parks and Wildlife (DPaW; Crown Reserve: 34607). The DoW 2009 *Water Notes for River Management* stipulates that *wild rivers in the conservation estate are managed by the Department of Environment and Conservation* (now DPaW), thus DPaW may be regarded as a Stakeholder in relation to this matter.

Lake Disappointment itself and the associated Savory Creek system are listed in the Directory of Nationally Important Wetlands (http://www.environment.gov.au/water/wetlands/australian-wetlands-database); the directory does not differentiate between Lake Disappointment and the Savory Creek drainage system (Figure 2.3).

Figure 2.3: Lake Disappointment/Savory Creek Wetland System.
(as shown in the Protected Matters search tool map).

The grounds for listing as nationally important wetlands, are that these landscape features provide:

- A good example of a wetland type occurring within a biogeographical region in Australia.
- Important habitat for animals at a vulnerable stage in their life cycles, or a refuge when adverse conditions (such as drought) prevail.

Neither Savory Creek nor Lake Disappointment is listed as a wetland under the Ramsar Convention, and accordingly neither is protected under the *Commonwealth Environment Protection and*

Biodiversity Conservation Act 1999 (EPBC Act) as a *wetland of international importance*. The EPBC Act may nonetheless apply to the proposed activities at Lake Disappointment as several fauna species protected under the Act have been recorded during baseline surveys.

The Lake Disappointment area has protected status under the Western Australian *Environmental Protection Act 1986* and subsidiary regulations. As a wetland, the playa meets the definition of an *environmentally sensitive area*, which means that special considerations apply in relation to land clearing. The listing of the Rudall River/Savory Creek system in the Directory of Nationally Important Wetlands confers a special status under Schedule 1 of the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. In addition, parts of the southern end of Lake Disappointment have been recommended for reservation as a conservation reserve (Figure 2.4), although gazettal under the *Land Administration Act 1997* has not yet occurred. Nevertheless, once gazetted as a reserve it does not automatically exclude mining activities.

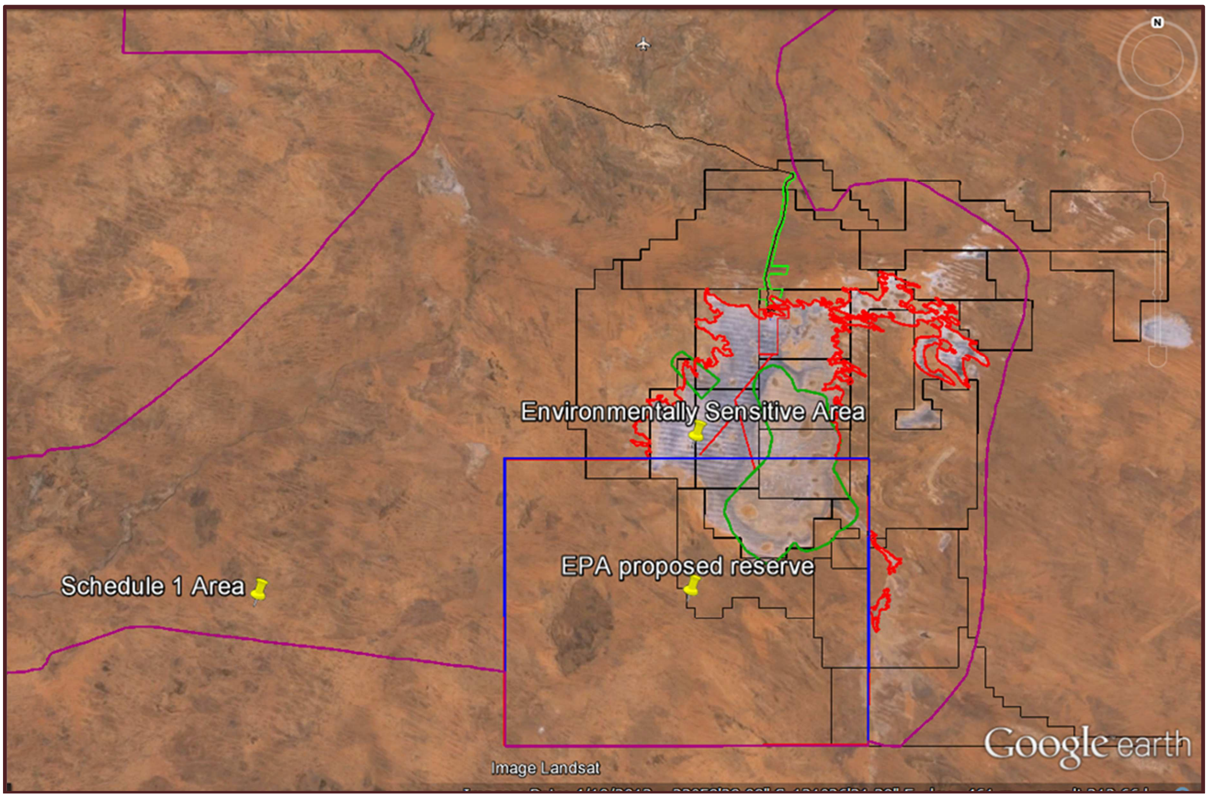


Figure 2.4: Existing and Proposed Conservation Areas.

3. Hydrological Assessment

This preliminary assessment of the anticipated flooding and recharge from runoff and immediate rainfall has been based upon regional topographic data and local survey data across the lake and riparian zone.

3.1 Catchments

Topographic data, including regional contour maps (1:250,000 topographic maps), were obtained from Geoscience Australia. Eight sheets, including Gunanya, Madley, Paterson Range, Rudall, Runton, Sahara, Tabletop and Trainor were used to generate the regional contour map (Figure 3.1) at 50m intervals. This large contour interval is appropriate for large scale indicative regional catchment mapping (Figure 3.2), however, high resolution topographic data such as airborne laser altimetry or LiDAR data is required to increase model accuracy.

Figure 3.1 illustrates that Lake Disappointment receives runoff from the west (Savory Creek) and south (a series of narrow linear shaped lakes drain into the south-east). Whilst Lake Disappointment has no surface outlet (Beard, 2005), it seems that the catchment may discharge through paleo-channels (Geoscience, 2014) in the north-east towards Lake Winifred and the Rudall River drainage system.

ArcGIS, amongst other mapping tools, has been used to merge sheets into a single regional map which delineates the regional catchments (Figure 3.2). There are three large regional catchments:

- The southern (red) catchment: 24,494km² in extent drains from the south, along the eastern margin of Lake Disappointment and discharges into the lake.
- The western catchment (green): 26,160km² in extent, drains Savory Creek, which enters Lake Disappointment at the north-western perimeter.
- The north eastern catchment (orange): 58,793km² in extent. Whilst regional topographic information suggests that this catchment is the recipient of water discharging from Lake Disappointment, Daniel Tenardi of Reward Minerals (*personal communication*) notes that he has not witnessed evidence to this effect during several incidences of flooding over the past four years. This catchment contains Lake Winifred and the Rudall River, which discharges to Lake Dora (Magee, 2009).

3.2 Rainfall Runoff

Lake Disappointment is located in the Western Plateau region of Western Australia and there are no flow or water quality gauging stations located within close proximity. The modern active drainage at the margin of the region includes the rivers of the Kimberley Block, which flow to the sea via the Fitzroy and Ord Rivers, and Pilbara Rivers which trend north to northwest in structurally controlled valleys towards the Indian Ocean (Magee, 2009). The Rudall River, which is 120km in length and contains fresh water when the creeks and river are running, flows eastwards from the Pilbara to the Great Sandy Desert and terminates at Lake Dora. Savory Creek, located southwest of Rudall River, is some 280km long and also flows in an easterly direction and discharges into Lake Disappointment. Savory Creek may expand to a width of around 150m during extreme rainfall events/periods, or occasionally flood out to a width of up to 2km. Similarly, the Sturt Creek flows parallel to the south-east Kimberley margin and terminates in the Great Sandy Desert at Lake Gregory. These active

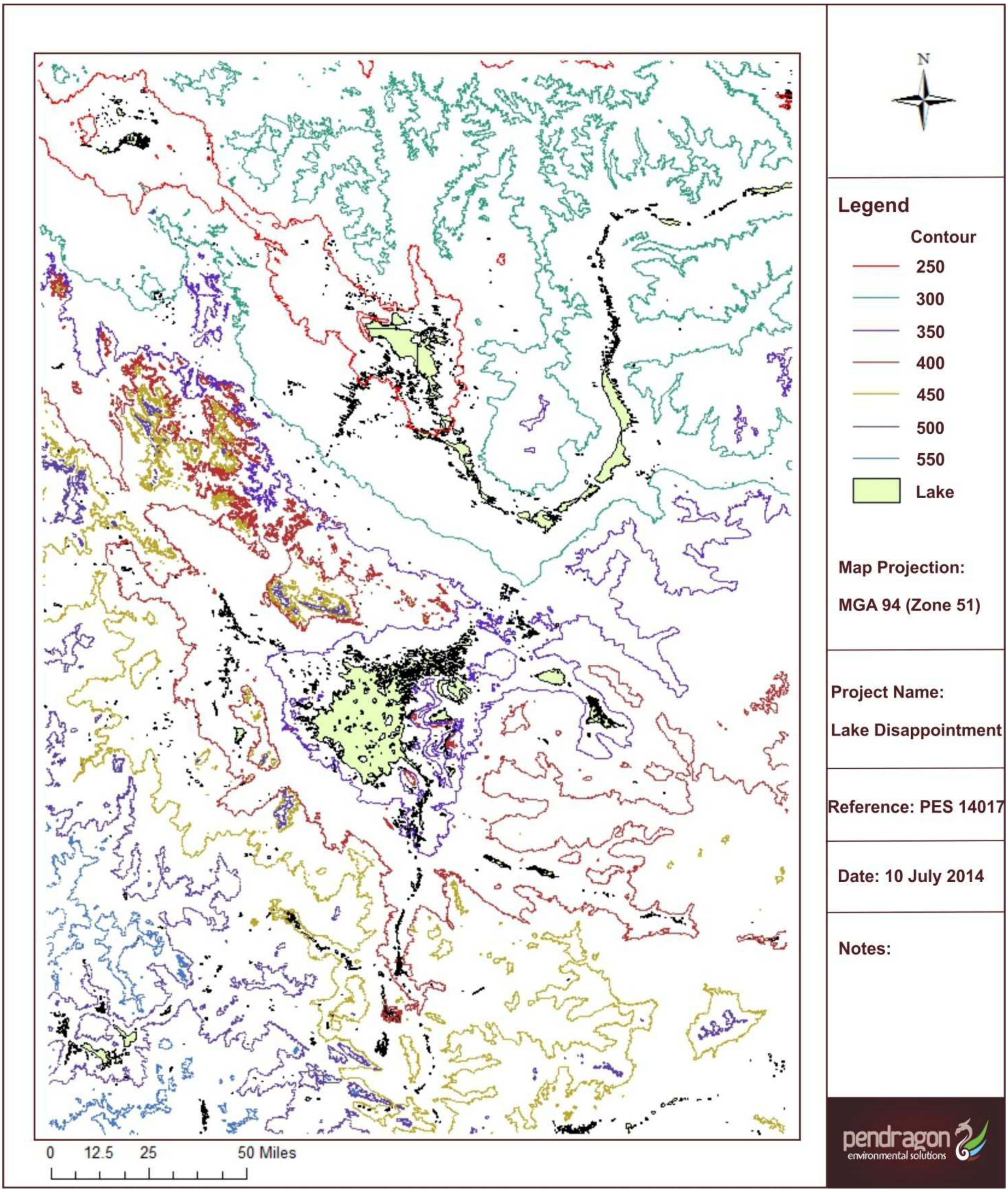


Figure 3.1: Regional Contour Plan.

drainages, in receipt of episodic cyclonic rainfall, connect with two large paleovalley systems, which drain the Canning Basin and Great Sandy Desert, the Canning and Mandora paleovalleys (Beard, 1973).

In 2013 Tropical Cyclone Rusty resulted in extensive flooding after some 250mm to 300mm of rainfall over three days (Figure 3.3). It is estimated that following this event, the lake (1,356km^2 in extent) contained some 542.3GL of water at an average depth of 0.4m (estimated from Landsat Imagery and survey data). Whilst it is uncertain whether the catchments to the west and south have contributed,

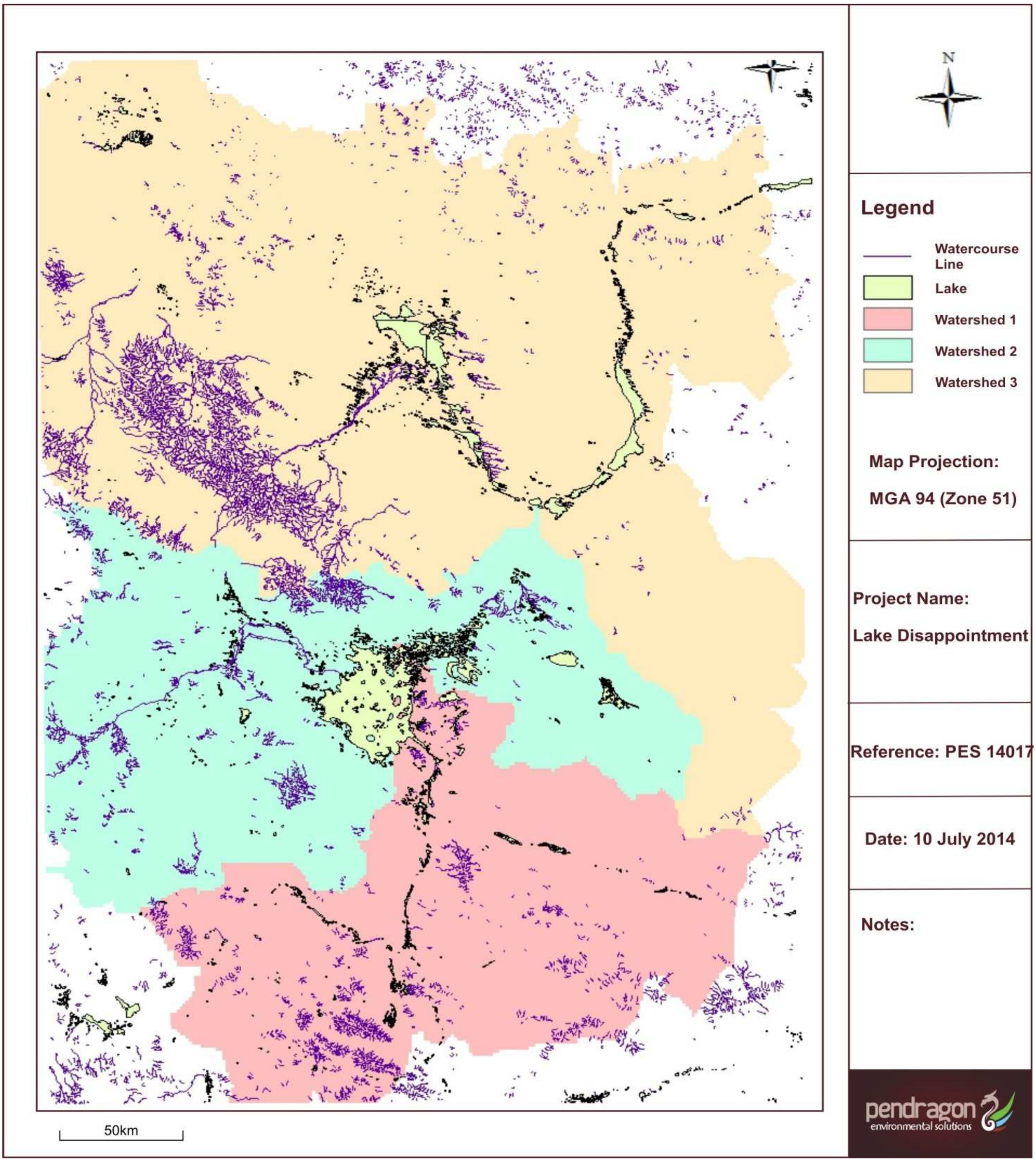


Figure 3.2: Regional Catchments.

the runoff presents only 3.6% of the total rainfall (300mm over the western and southern catchments some 50,654km^2 in extent).

Since most of the catchments are covered by dunes, it seems more likely that only portions of the catchments contributed to the rain-runoff. Catchment mean annual runoff may account for as little as 2% to 3% of the rainfall (Parsons and Abrahams, 1994) whilst the coefficient of runoff may be as low as 0.1 (Bishop and Pillans, 2010) due to the responsiveness of the sand dunes covering most of the western and southern catchments. Consequently only rain in excess of 30mm across the entire western and southern catchment areas will cause inflow into the lake. Taking due cognisance of the variability of rainfall and low coefficient of runoff across large dune catchments, it is unlikely that the

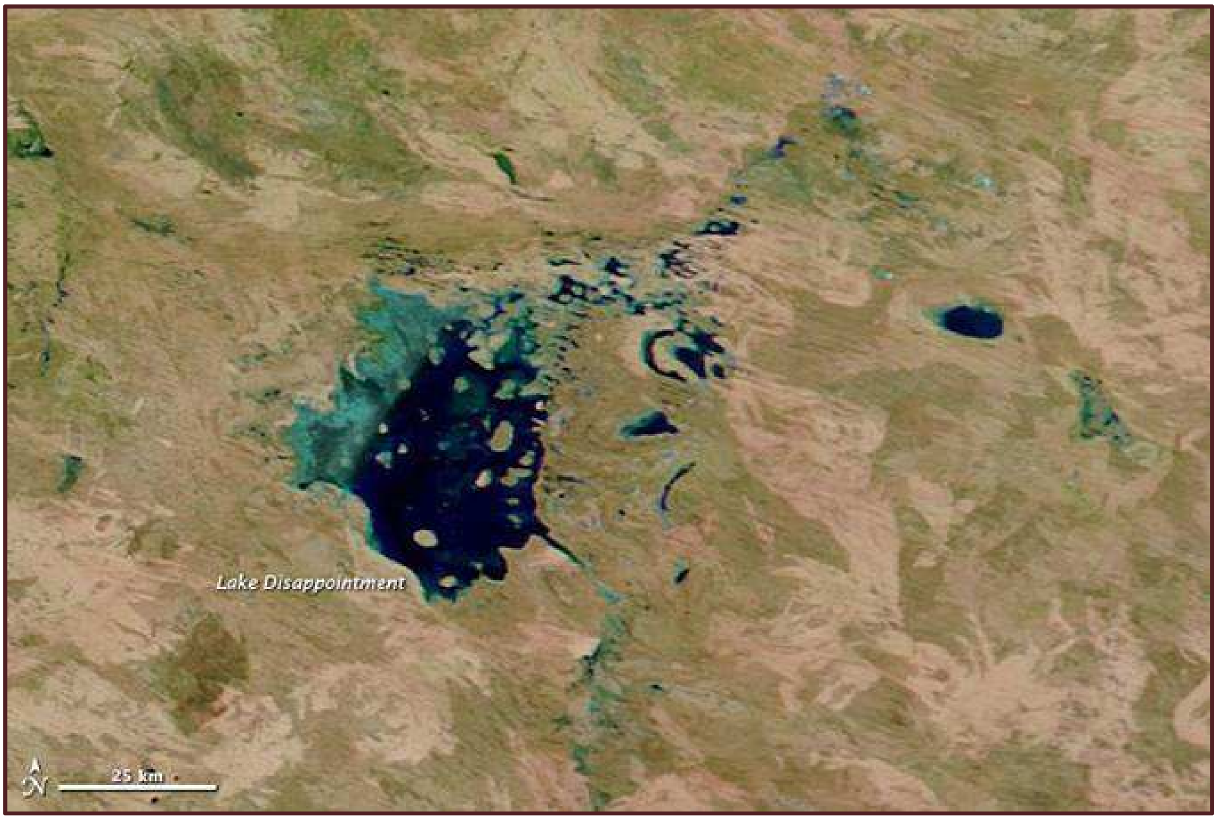


Figure 3.3: Flooding of Lake Disappointment in March 2004.

lake receive runoff from the catchments further than a few kilometres away. Recent observations of rainfall-runoff at the lake seem to support this observation i.e. flooding and/or ponding at the lake occur after a significant rain cyclonic event or several smaller events.

3.3 Flooding

3.3.1 Flooding

The proposed new infrastructure at Lake Disappointment will include:

- Evaporation ponds some 3,700ha in extent contained within 1m to 2m high embankments.
- Halite waste disposal area some 3,300ha in extent and dump 8m high.
- Some 200km of trenches up to 6m deep and 6m wide at the top.

The proposed new infrastructure will cover no more than 5% of the surface area of the lake (1,356km^2). The volume of lake (reduction of flood volume) that will be occupied by the evaporation ponds (embankments total approximately 56km in length and 4m wide at base) and the halite waste dump to a flood depth of 0.4m totals some 13 million m^3. The volume of trenches (increased flood volume) totals some 4 million m^3. The residual reduction of 9 million m^3 in flood volume will cause a rise of some 7mm across the area of the lake. It is estimated at *worst case* i.e. when their total volumes are excluded from the total available volume for flooding, that the proposed new evaporation ponds and halite dump may cause a rise of 21mm which is less than the daily rate of evaporation.

The Bureau of Meteorology tropical cyclone mapping system indicates that cyclones which have passed within a 200km radius (approximate radius of pertinent regional catchments) of Lake Disappointment, tended to track from north/north-north-west to south/south-south-east. As a consequence and in the absence of available local rainfall data, data from the Telfer and Parnngurr Weather Stations, both of which are north-north-west of Lake Disappointment, have been assumed to provide indicative information pertaining to historic precipitation. The Telfer and Parnngurr Weather Stations are located some 200km and 56km respectively from Lake Disappointment, thus variation in precipitation at these locations in contrast to the lake is expected.

There is a risk of flooding, particularly between the months of December and March. The most significant rainfall events recorded to date at the Telfer Weather Station are:

- 18th December 1993: 202mm. A total of 296mm was recorded for the month, all of which occurred over 2 days.
- 29th March 2004: 200mm. A total of 414mm was recorded for the month, all of which occurred over 2 days.
- 28th February 2013: 177mm. A total of 300mm was recorded for the month, all of which occurred over 3 days.

The event on the 29th March 2004 equates to an event with a recurrence interval of once in 50 years (50-year ARI, Average Recurrence Interval, with an annual exceedance probability, AEP, the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year, of between 1% and 2%) having a rainfall intensity of 8.3mm/hr. The depth of water as a consequence of this event was estimated (using Landsat imagery and survey data) at approximately 1.0m across the central portion of the lake. At the northern shore where the evaporation ponds are to be constructed, the maximum water depth was estimated conservatively between 0.4m and 0.8m. Thus embankments at between 1.5m and 2.0m will not be impacted by such an event and there will be a freeboard of at least 0.7m.

The water level inside the evaporation ponds, and consequently the risk of overflow from the ponds to the shoreline, depends on the operating parameters and allowances for rainfall. With a mean depth of 0.3m brine in the ponds and the highest daily rainfall at about 0.2m, there is a freeboard of some 1.0m when the embankments are 1.5m high. Cumulative water balances (Table 3.1) for average and highest monthly rainfalls indicate that there is a water deficit at the lake.

Other factors currently under consideration are:

Runoff Thresholds

Until a threshold is reached a given large rainfall event may not produce any runoff, whilst a relatively small rainfall event can generate large runoff once the threshold is reached. Understanding the rainfall-runoff threshold helps us identify stream flow initiation processes and their consequential impact. Rainfall-runoff thresholds have never been thoroughly studied in the Pilbara (CSIRO, 2013).

The amount and intensity of rain required to initiate runoff depends on antecedent soil moisture conditions, the structure and texture of the soil, infiltration capacities, vegetation, topography and surface properties such as micro-depressions that may impede overland flow reaching the stream. These thresholds, particularly in semi-arid areas such as the Pilbara, are strongly influenced by the fact that the potential evaporation over the region is much greater than rainfall over almost any time period other than around major rainfall events. The mean daily potential evaporation reaches a maximum of just over 7mm/day in the summer months, substantially greater than the mean daily value of rainfall of less than 2mm/day in January and just over 2 mm/day in February, the wettest months of the year (CSIRO, 2013). Thus over almost most time periods a substantial soil moisture deficit accumulates and creates ample storage for water infiltration during rainfall events. Averaged over the

Table 3.1: Cumulative Rainfall Evaporation Water Balances.

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly Rainfall	52.1	103.8	75.5	19.6	18.9	13.9	12.9	5.3	2.4	2.8	16.2	47.9
Mean Daily Evaporation	14.3	12.9	12.3	10.7	7.8	6.4	6.9	8.4	11.2	14.2	15.5	15.1
Adjusted Daily Evaporation	10.0	9.0	8.6	7.5	5.5	4.5	4.8	5.9	7.8	9.9	10.9	10.6
Adjusted Monthly Evaporation	310.3	252.8	266.9	224.7	169.3	134.4	149.7	176.4	243.0	298.2	336.4	317.1
Net Evaporation	-258.2	-149.0	-191.4	-205.1	-150.4	-120.5	-136.8	-171.1	-240.6	-295.4	-320.2	-269.2
Cumulative Evaporation	-258.2	-407.3	-598.7	-803.8	-954.1	-1,074.6	-1,211.5	-1,382.6	-1,623.2	-1,918.6	-2,238.7	-2,507.9
Highest Monthly Rainfall	173	344.3	466	115.2	141.2	101	86	55.6	24	29.4	137.2	296
Mean Daily Evaporation	14.3	12.9	12.3	10.7	7.8	6.4	6.9	8.4	11.2	14.2	15.5	15.1
Adjusted Daily Evaporation	10.0	9.0	8.6	7.5	5.5	4.5	4.8	5.9	7.8	9.9	10.9	10.6
Adjusted Monthly Evaporation	310.3	252.8	266.9	224.7	169.3	134.4	149.7	176.4	243.0	298.2	336.4	317.1
Net Evaporation	-137.3	91.5	199.1	-109.5	-28.1	-33.4	-63.7	-120.8	-219.0	-268.8	-199.2	-21.1
Cumulative Evaporation	-137.3	-45.9	153.2	43.7	15.7	-17.7	-81.4	-202.3	-421.3	-690.1	-889.2	-910.3
All values are in mm.												

assessment area, rainfall in excess of potential evaporation occurs for fewer than 20 days per year. However, as well as temporal variability, rainfall is highly variable spatially. The infiltration capacity of the soil is a significant determinant of runoff generation. Thus the texture and surface condition of the soil, land use and vegetation can all influence runoff generation thresholds, and consequently they may well be spatially and temporally variable.

For two stations in the Pilbara (CSIRO, 2013), despite the large difference in catchment area and location, on an annual basis runoff generation thresholds are about 200mm, and monthly thresholds are about 100mm. While there are marked differences in rainfalls in flow events, and in the size of flow events, the rainfall required to stimulate flow varies between 23mm and 54mm. Given the characteristics of the catchment and lake sediments, rainfall required to generate runoff at Lake Disappointment is likely to be around 50mm at the upper end of the above range.

3.3.2 Backwater

Potential impacts by backwater (damming of water upstream of the proposed new infrastructure) on flooding of the riparian zone are currently being assessed. Preliminary assessments indicate that a 200m buffer zone between the infrastructure and the shoreline provide ample flow path to divert rain and runoff around the proposed new infrastructure.

3.4 Risk Assessment

3.4.1 Assessment Framework

The environmental factors (EPA, 2015) with reference to surface water include Hydrological Processes, Inland Waters Environmental Quality and Rehabilitation and Decommissioning. The primary objectives are to ensure that the quality of surface water is maintained to protect environmental values, ecological and social, and existing and potential uses to facilitate decommissioning and closure in an ecologically sustainable manner. To achieve these objectives, appropriate management of mining (brine abstraction and evaporation) and waste disposal will be required.

The key risks for mining and processing pertain to:

- The likelihood and consequence of constructing the proposed new infrastructure on the lake bed and consequently the hydrological function of the lake.
- Potential factors that may impact on sensitive receptors and require on-going management.

A risk assessment was undertaken in strict accordance with the Risk Assessment Process (Appendix A: DER, 2015) to assess:

In view of the above, the single most important factor seems to be the potential for increased flooding, particularly in the riparian zone which provides habitat for tecticornia. Water quality investigations and assessments including the bio-availability and toxicity of metals are currently under investigation and are therefore not included in this report yet. Nevertheless, preliminary assessments indicated that the proposed activity is unlikely to impact water quality.

3.4.2 Hazard Identification and Assessment

Primary and secondary hazards of increased flooding include potentially elevated flood levels in the riparian zone over a relatively short duration. Assuming the evaporation ponds at the northern shore of the lake are contained within 2m high embankments with a 200m buffer zone and that the waste halite stockpile is some 8m high, coupled with trenches to abstract the near surface brines, calculations of volumes and taking due cognisance of the parameters of the conceptual model illustrated in Figure 3.4, indicated that the likely impact to shorelines from flood will be moderate at *worst case*, if any.

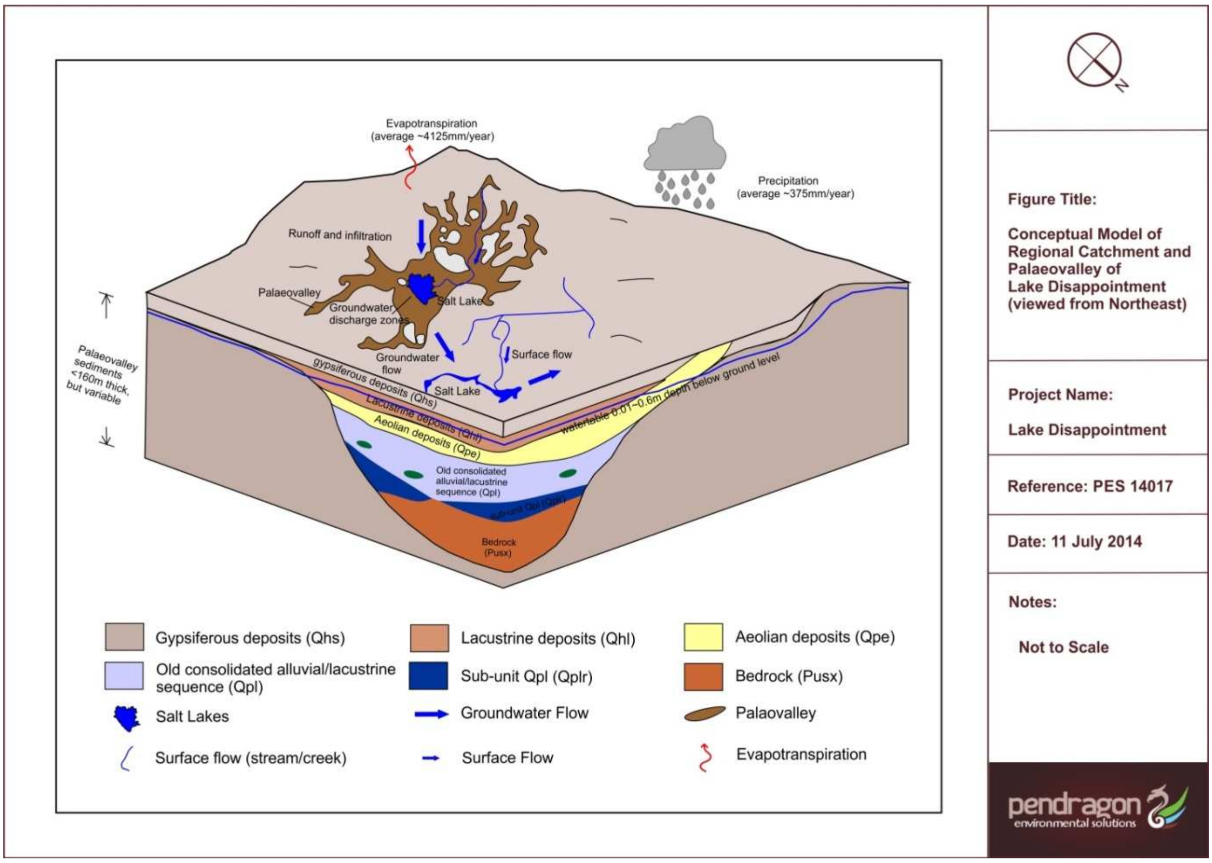


Figure 3.4: Conceptual Hydrological Model of Lake Disappointment.

A site-specific risk impact and mitigation assessment appears in Table 3.5.

Table 3.2: Risk Identification, Assessment and Controls.

Key Activity: Constructing Evaporation Ponds, Halite Disposal Dump and Brine Abstraction Trenches on the bed and within the perimeter of Lake Disappointment.								
Identification					**Analysis of Pathway/Receptor**			**Evaluation of Impact**
Risk Type	**Event**	**Pathway**	**Receptors**	**Controls**	**Potential Impact**	**Consequence on Receptor**	**Likelihood of Consequence**	**Level of Risk/ Impact on Receptor**
Flooding	Normal	Temporary increased: Flooding of lake and riparian zone Backwater (damming of flood water by infrastructure)	Lake bed: Migratory Birds Riparian Zone: Tecticornia	Monitoring impact and water quality	Ecosystem health: increased level of flooding in riparian zone and tecticornia	Moderate	Unlikely	Moderate risk: acceptable
	Significant rain or cyclonic event: increased flooding			In addition to the above: ▪ Use buffers of no less than 200m ▪ Offset: volume of ponds and waste dump versus trenches ▪ Cease abstraction from trenches until flood waters receded				
Surface water quality including metal toxicity	Construction (disturbance) and operations	Rainfall/flooding	Lake	**To be confirmed following further investigation and assessment.** Excavations in accordance with engineering designs to limit disturbance and footprint. Minimize areas of disturbance/footprint and maintain exclusion zones.	Metal toxicity	Moderate	Unlikely	Moderate risk: acceptable
Return of halite, bitterns (evaporate solution with smaller concentrations of Sulfate of Potassium – the product) and saline process water to a naturally hyper-saline lake. **No chemicals are used in the processing plant and washing/process water comprises local saline ground water treated by reverse osmosis.** **Ground water dependent ecosystems, other than tecticornia that rely on rain-runoff, are absent.**								

4. Regional Climate and Rainfall

At the time of undertaking this investigation and assessment, climate/rainfall data specific to Lake Disappointment was not available. As a consequence, the information below has been gleaned from regional studies and assessments of long term weather patterns, reconstruction of past Pilbara climatic conditions and anticipated future trends.

4.1 Regional Climate and Rainfall

The climate of the Little Sandy Desert bioregion is arid with summer-dominant rainfall (Department of Environment, 2008); spatially averaged median rainfall (1890 to 2005) for the region is 178mm (April to March rainfall year).

Regional data (BoM, 2010) indicates that January and December are typically the warmest months with mean maximum temperatures of 38.7℃ and 37.4℃ respectively. The coolest period occurs between June and August. Regional mean rainfall (Table 4.1; BoM, 2010) shows rainfall to be highest between January and March with the highest mean in February (54mm) and lowest in September (4mm).

Table 4.1: Little Sandy Desert Region Mean Monthly Rainfall.

Month:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
ẋ rainfall (mm)	31	54	33	23	16	15	12	7	4	6	13	24	237
Data from Australian Bureau of Meteorology (2010).													

4.2 Historic and Predicted Future Cyclonic Activity

A collaborative study regarding changes in tropical cyclone activity over north-west Western Australia over the past circa fifty years, and projected cyclonic behaviour for the next fifty years was undertaken in 2015 (Diandong *et al*, 2015). Key findings indicate the following in relation to tropical cyclone activity over the past fifty years:

- Cyclonic events in north-west Western Australia are particularly erratic, with time series modelling failing to produce detection of statistically robust trends due to strong natural variability.
- Whilst the number of cyclonic events did not increase noticeably over the past fifty years, the intensity of events has.
- The mean tracks of landfall tropical cyclones has shifted inland by approximately 1° (to the east) since 1986, due primarily to the expansion of the subtropical high.
- Relatively fewer landfalls occurred in north-west Western Australia and more landfalls in Northern Australia during the second period of the study (due to the origin of the landfalls over the region of interest).
- The north-west Western Australian basin is sensitive to climate change. The 500hPa geopotential height expanded pole-ward, which is a robust signal of atmospheric warming. As the total air mass did not change, the only mechanism that can globally raise the 500hPa geopotential height contour

is thermal expansion of the atmosphere.

Based upon the findings of this study, it may be hypothesised that potential further (relative) wettening of Lake Disappointment may occur in future due to an eastward shift in cyclonic tracks coupled with an increase in the intensity of cyclonic events. A study undertaken by the CSIRO (based upon data from 1961 to 2012) provides additional support for this hypothesis showing an increasing trend in annual rainfall through eastern parts of the Pilbara and decrease in rainfall through western regions (CSIRO, 2015). Although the wind speed of cyclones is seen to reduce significantly following landfall, the moisture residual can be picked up by mid-latitude disturbances and produce significant rainfall (Wang *et al.*, 2009).

5. Surface Water Ponding and Distribution

This section details an investigation into the historic temporal and spatial distribution of surface water at Lake Disappointment to ascertain whether the proposed new infrastructure (evaporation ponds, halite waste disposal area and brine abstraction trenches) on the lake will interfere with the hydrological function of the lake and its tributaries.

5.1 Methodology

In the absence of monitoring data and observations, this investigation involved the assessment of the presence and distribution of surface water on the lake over a twenty-seven year period using Landsat satellite imagery. Satellite imagery prior to 1987 has been excluded due to a lack of accessible data and/or image quality.

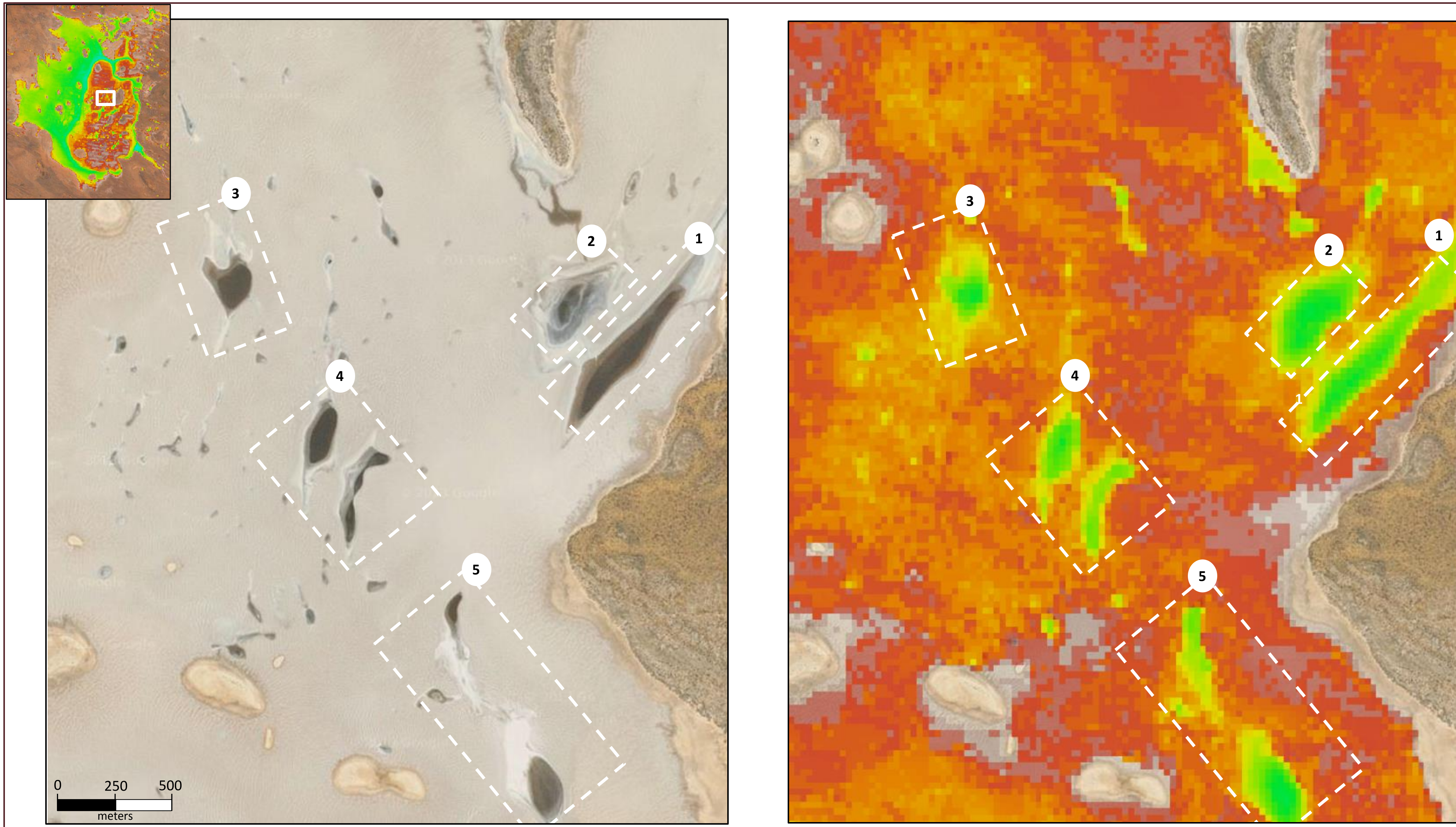
The *Water Observation from Space* (WOfS) system of Geosciences Australia was employed as the primary tool in determining the temporal and spatial distribution of surface water on the lake. WOfS provides Australia wide data on the frequency of wetting at a twenty-five metre pixel resolution and adopts an algorithm based on a decision tree classifier and a comparison methodology using logistic regression (Mueller *et al*, 2015). Pixels have been categorised by the percentage of observations during which water was present, the number of times the location was observed clearly and the confidence of observations.

Uncertainty and Limitations

The WOfS decision tree classifier performs best where water bodies extend over a large area and the surrounding environment is free from built infrastructure and/or vegetation (such as bushland/forest); thus the conditions at Lake Disappointment are favourable in terms of optimising the accuracy of the classifier. However, numerous pixels from the eastern/south-eastern region of the lake have been masked, indicating poor observational quality (i.e. failure to pass a series of automated quality tests or a fault in the Landsat images; Mueller *et al.*, 2015). Field observations made by Daniel Tenardi of Reward Minerals (*personal communications*) reveal that sediments through this eastern/south-eastern region are comparatively light in colour due to the presence of gypsum at the surface, which is exclusive to this area of the lake. The potential for terrain shadow is also greater through this region due to the high density of islands. Whilst the exact cause of poor observational quality at pixels through the eastern/south-eastern region of the lake is unclear, the aforementioned may serve as contributing factors.

Review of Landsat imagery indicates a number of potential hollows through the eastern/south-eastern area of the lake (although the variation in surface levels at these points is yet to be confirmed; Figure 5.1). There is a greater degree of certainty and contiguity associated with WOfS data from these hollows. In order to avoid the under-representation of water presence through this region, inferences regarding the presence/absence of water will be made from data associated with the hollows.

Owing to the size of Lake Disappointment and the high resolution of observation pixels (0.0625 km^2), feasibly only data from select locations can be processed with regional inferences made based upon this data. The assessment of pixels was undertaken at locations shown in Figure 5.2 in the interest of prioritising areas where: mining activities will occur; waterbirds are known/likely to occur/breed and; water is most likely to accumulate based upon topographic characteristics, field observations and WOfS data mapping.



Title: Lake Disappointment- Eastern Hollows

Figure: 5.1

Location: Lake Disappointment

Revision: 1

Explanatory Notes:

This image on the right has been developed based upon multi-decadal Landsat satellite imagery obtained from *Geoscience Australia,* the image on the left is a 2015 Google Earth aerial photograph.

The framed, numbered features are interpreted as hollows in the lakebed. WOfS data associated with these hollows are not interrupted by masked pixels seen through surrounding areas.

- X Water not detected
- Water detected in 1% of observations (includes flooding and misclassified shadows)
- Water detected in 5% of observations (includes flooding and misclassified shadows)
- Water detected in 20% of observations (includes flooding and misclassified shadows)
- Water detected in 50% of observations
- Water detected in 80% of observations (includes flooding and misclassified shadows)
- Water detected always

NORTH

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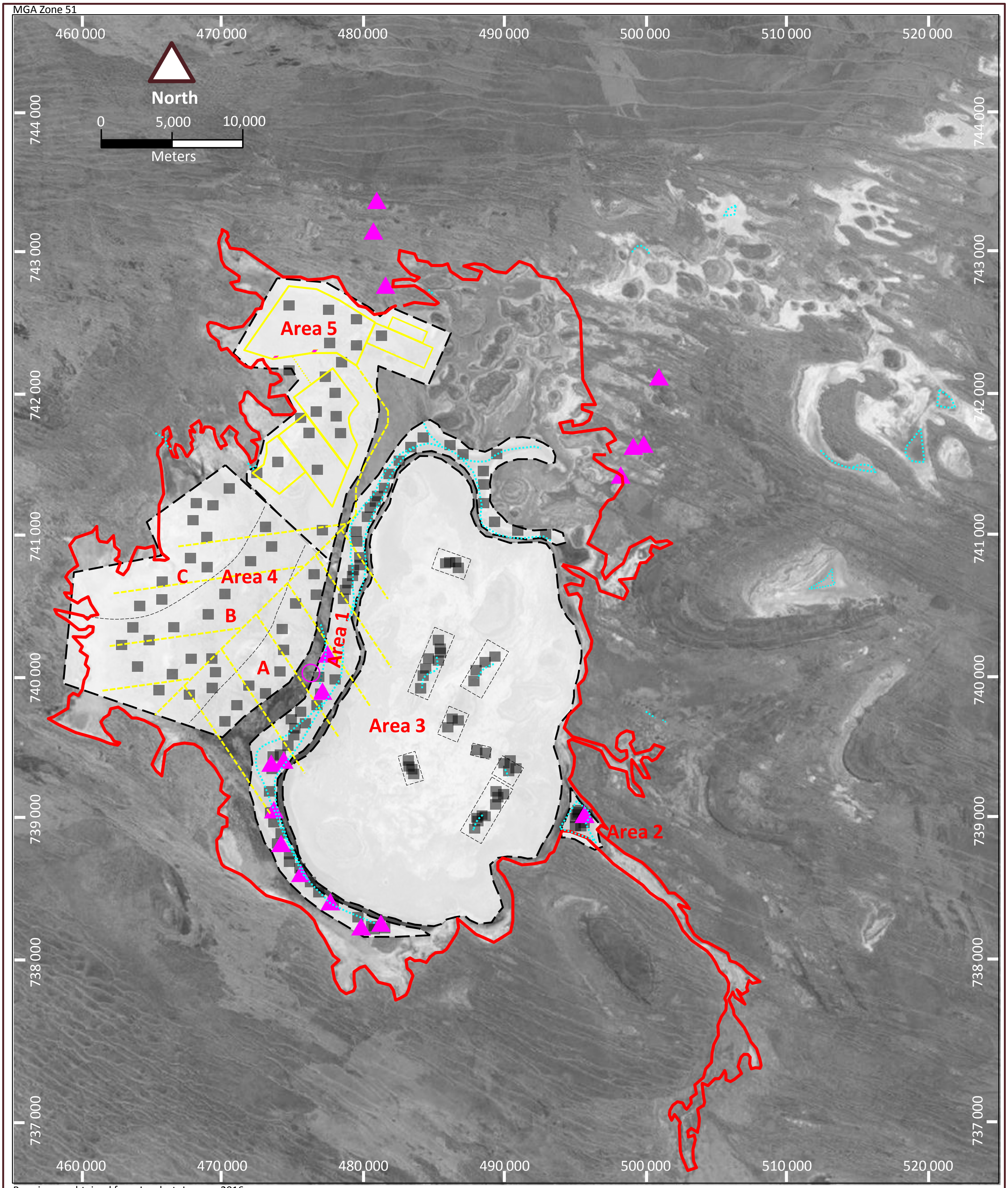
Data gleaned from Geosciences Australia. 2015. Water Observation from Space (WOfS). Landsat imagery. Geoscience Australia, Canberra.



Base image obtained from Landsat, January 2016.

Title: Investigation Areas

Figure: 5.2

Location: Lake Disappointment

Revision: 1

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Legend:

- Banded Stilt(s) Observed- May 2013
- Water ponded most frequently[1]
- Proposed mining infrastructure[2]
- Sample pixel location
- Investigation area boundary
- Area 1 Area Identification
- A Sub-area(s)
- Banded Stilt breeding site (July 2015).

Notes:

Banded Stilt survey data provided by G. Harwood on behalf of Novo Resources (February, 2016).

[1]Refer to Section 5 of accompanying report.

[2]Refer to Figure 5.3 for further detail.

Data Interpretation

To assess the temporal characteristics of ponding, data from pixels which fall within the areas of interest have been randomly selected and subject to statistical analysis. Where areas of interest are of significant size and contain variations in the topography and frequency of surface water (as indicated by WOfS classification system) sub-areas have been incorporated (Figure 5.2).

To establish the months during which surface water is likely to be present, the following analysis was undertaken: pixel data from 1987 to 2014 was arranged in chronological order by location, an observation of *wet* was assigned a value of 1 and *dry* a value of 0. The mean number of *wet* observations made during each month was calculated at each location, and weighted in accordance with the total number of observations made during that month. The statistical significance of the variations between mean observational values were calculated between locations, and between months by means of single factor ANOVA testing, whereby a p-value of ≤0.05 was regarded as indicating a significant difference. The approximate duration of ponding (as indicated by WOfS data) was investigated by assessing the length of consecutive *wet* observations and cross-referencing dates of lengthy ponding against Bureau of Meteorology (BoM) rainfall data.

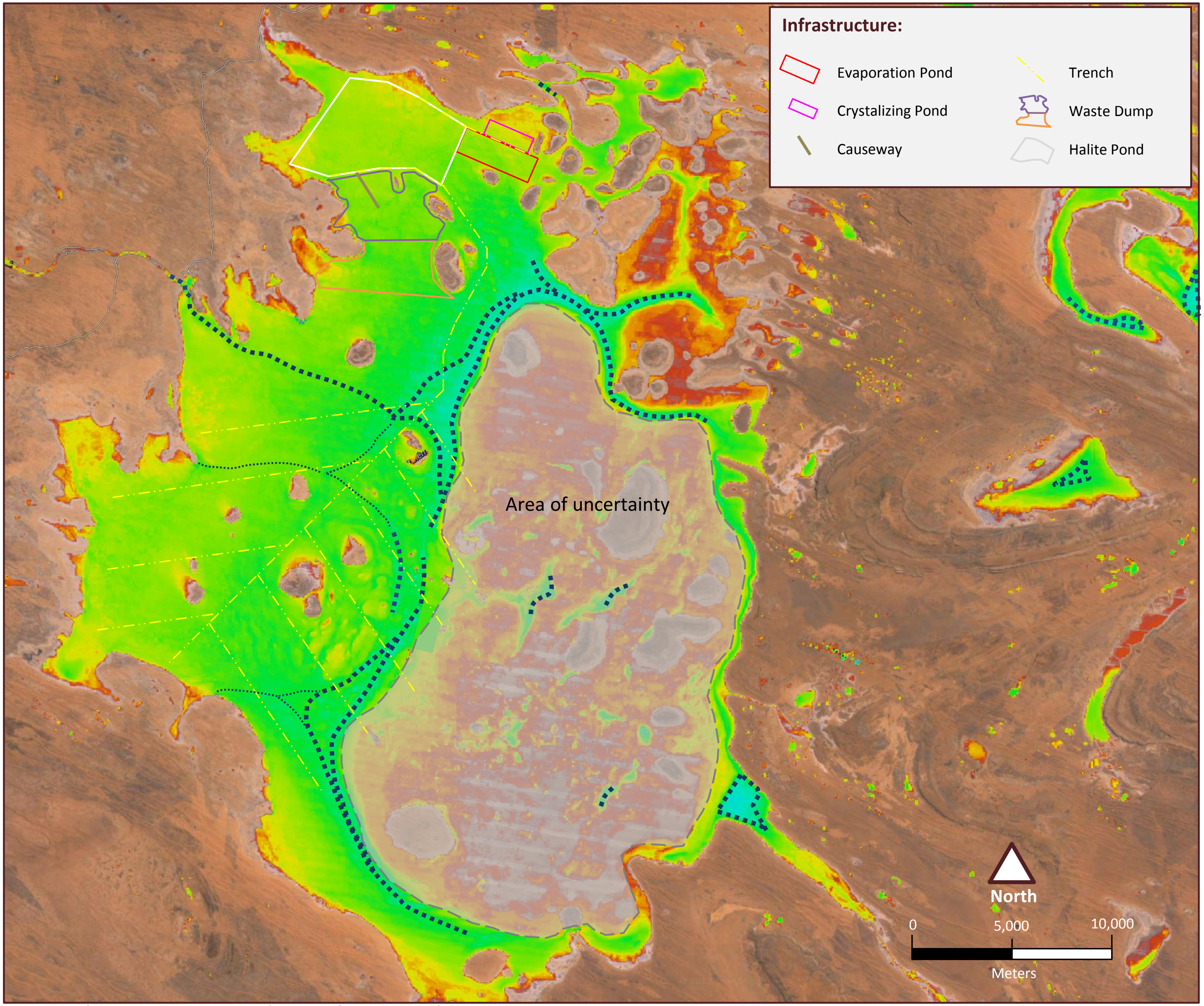
5.2 Results

5.2.1 Geographical Distribution of Surface Water

A review of WOfS data indicated that the majority of the western portion of Lake Disappointment (where new infrastructure will be located) contained surface water during approximately ≤20% of observations made between 1987 and 2014 (Figure 5.3). The percentage of observations during which water was present declines approaching the western, north-western and south-western perimeters of the lake, which is consistent with the regional topography (Figure 5.4).

Daniel Tenardi of Reward Minerals confirmed (*personal communications*) that generally the eastern half (exclusion zone) of Lake Disappointment may contain water more frequently and to greater depths than the western portion. Moderate Resolution Imaging Spectro-radiometer (MODIS) imagery prior to and following Tropical Cyclone Rusty in 2013 (Figure 5.5) also supports these observations. The pre- and post-cyclone MODIS images indicated that following a cyclonic event, surface water will be present across the eastern area of the lake before submerging the western portion.

A review of three time-sequence Landsat 7 ETM+ images from July 1999 to January 2000 provided insight into the seasonal variations in surface water dispersion at the lake (Figure 5.6; Geosciences Australia, 2015). The 15 July 1999 image depicts water in the east/north-east flowing from the Savory Creek inlet. Comparatively shallow water appears to be present through the eastern region of the lake, with a deeper channel parallel to the southern perimeter. The majority of the western half of the lake contains comparatively little water. The 3 October 1999 image indicates that in general the lateral extent and depth of surface water is less than that observed in July. Water remains at certain locations along the Savory Creek inflow and toward the south eastern perimeter of the lake. The remainder of the lake appears to be predominantly dry. By 7 January 2000, the lateral dispersion and depth of water is markedly greater than that observed in July and October. Precipitation data from the nearest pertinent/available location (Telfer Weather Station) does not indicate any significant (>26mm for more than 1 consecutive day) rainfall events between the 3 October 1999 and 7 January 2000. The January image depicts shallower waters through the eastern/south-eastern (opposed to western) region of the lake. This interpretation contradicts that of the July image (which shows more water dispersed through the eastern region), topography and observations made by site personal. It thus seems that the lighter colouring through this area (possibly caused by the gypsum field) in the January



Base image from Google Earth, 2015. Surface water frequency data from Geosciences Australia, 2015.

Notes:

This image is to be regarded as indicative only and should be viewed in conjunction with Section 5 of the accompanying report Lake Disappointment: *Hydrological Assessment* (Pendragon Environmental Solutions, 2016).

This image has been developed upon multi-decadal Landsat satellite imagery and water pooling data obtained from Geosciences Australia (2015).

[1] Includes flooding and misclassified shadows.

Legend:

- Water not detected
- Water detected in 1% of observations[1]
- Water detected in 5% of observations[1]
- Water detected in 20% of observations[1]
- Water detected in 50% of observations
- Water detected in 80% of observations[1]
- Water detected always
- Water most frequently observed (indicative primary flow channels)
- Potential secondary flow path

Title: Surface Water Distribution

Figure: 5.3

Location: Lake Disappointment

Revision: 1

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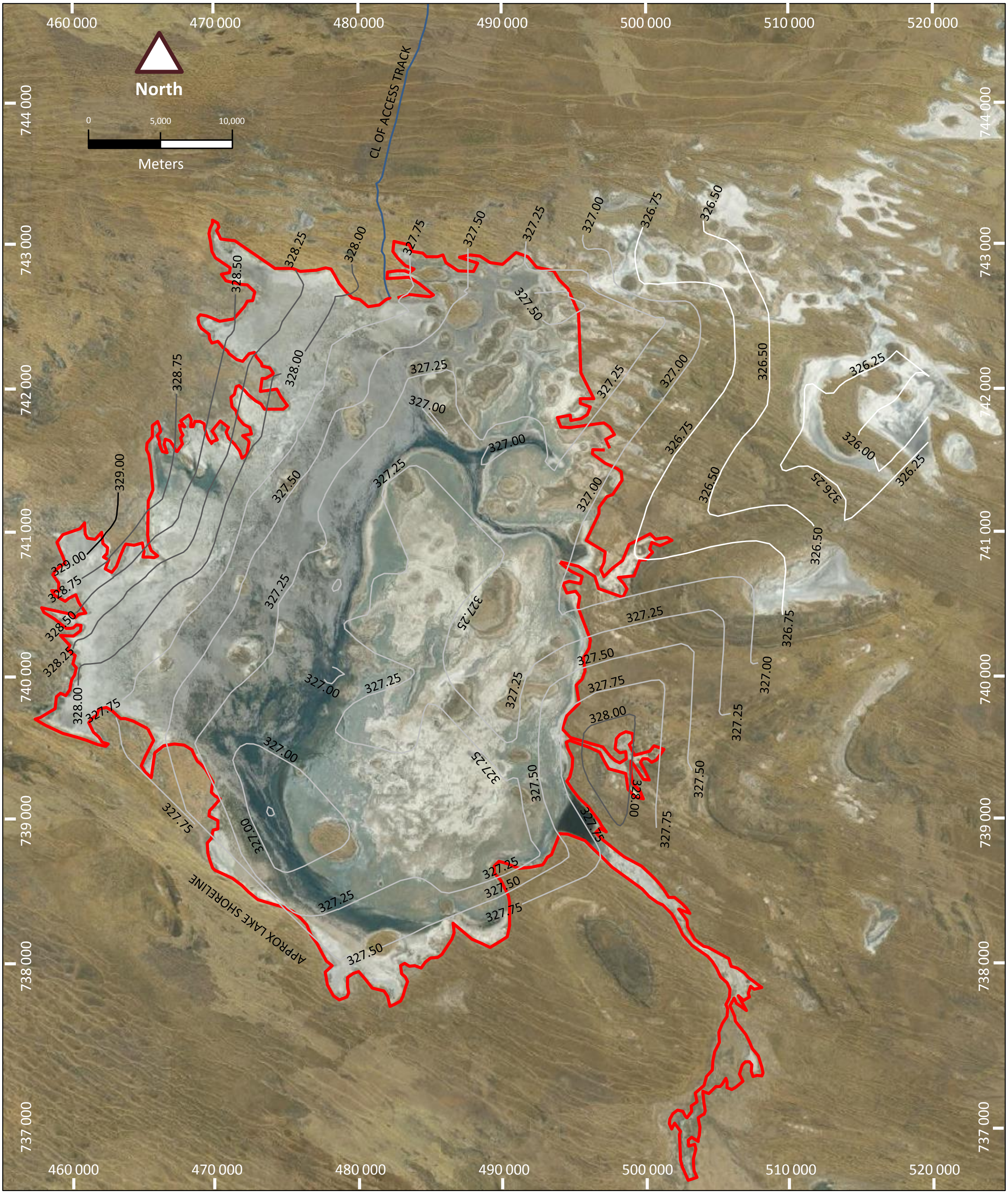

Title: Topography

Figure: 5.4

Location: Lake Disappointment

Revision: 1

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Legend:

Height Range (AHD)

Contour Colour

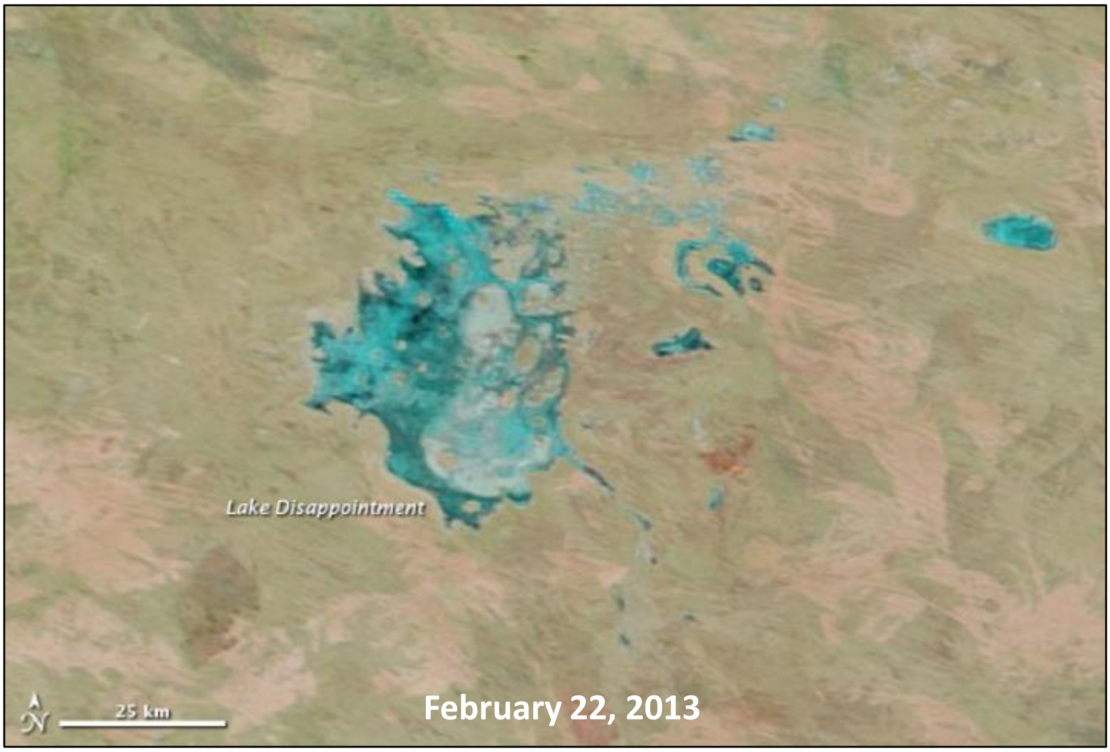
Contour Colour	Height Range (AHD)
Black	329.00 – 329.99
Dark grey	328.00 – 328.99
Light grey	327.00 – 327.99
White	326.00 – 326.99

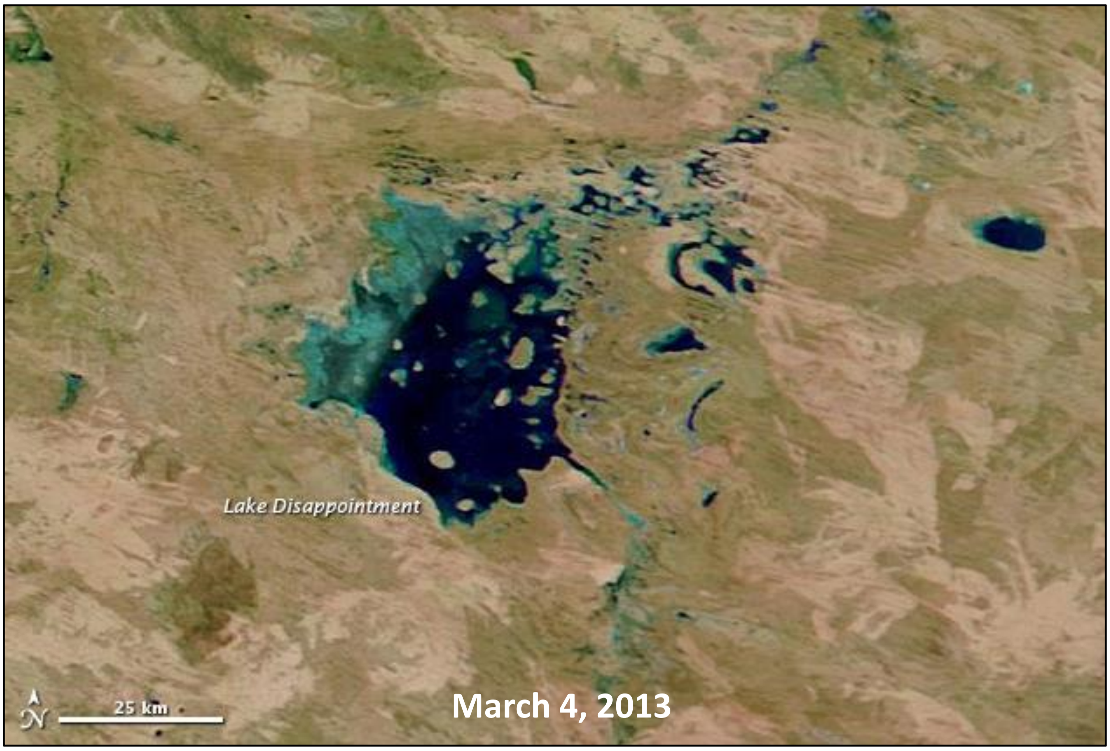
Notes:

Survey data obtained from Reward Minerals Ltd. Survey completed by Survey Group, December 2015.

Base image obtained from Google Earth, January 2016

MGA Zone 51





Title: Pre and Post Cyclone

Figure: 5.5

Location: Lake Disappointment

Revision: 1

Notes:

"The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured the top image on March 4, 2013. For comparison, the bottom image shows conditions observed on February 22, 2013. These images use a combination of visible and infrared light to better distinguish between water and land. Water varies in colour from pale blue-green to navy, and darker shades of blue indicate greater water depths. Vegetation is green and bare ground is earth-toned" (NASA, 2015).

The overall darker colours of the March 4 image may result from a different angle of the satellite sensor, but changes in the lake are unmistakable. Water depths are clearly greater in Lake Disappointment in early March, as indicated by the darker shades of blue. Water depths also increased in other regional water bodies after Cyclone Rusty's rains (NASA, 2015).

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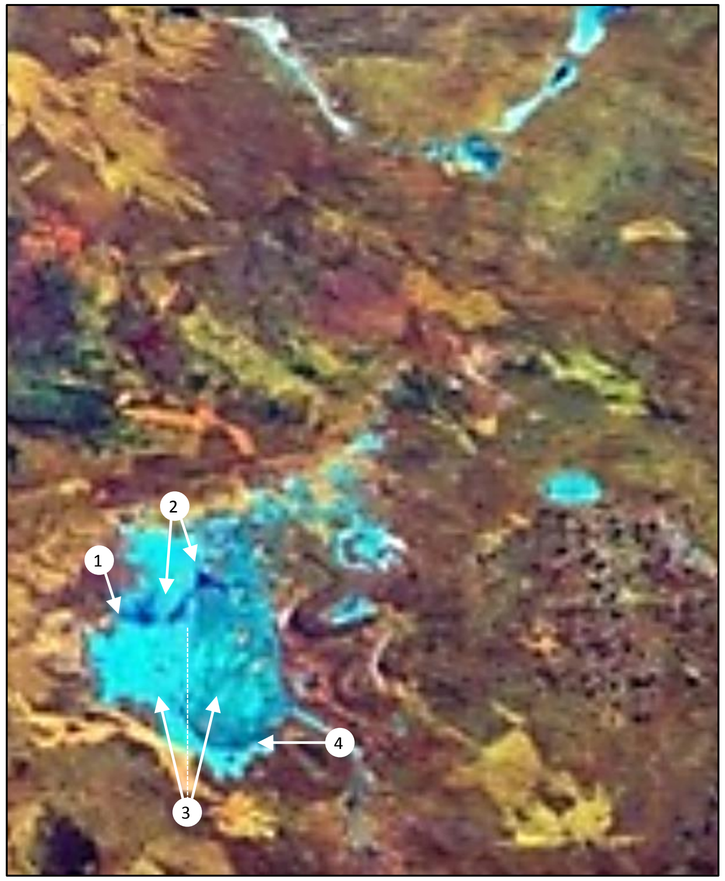
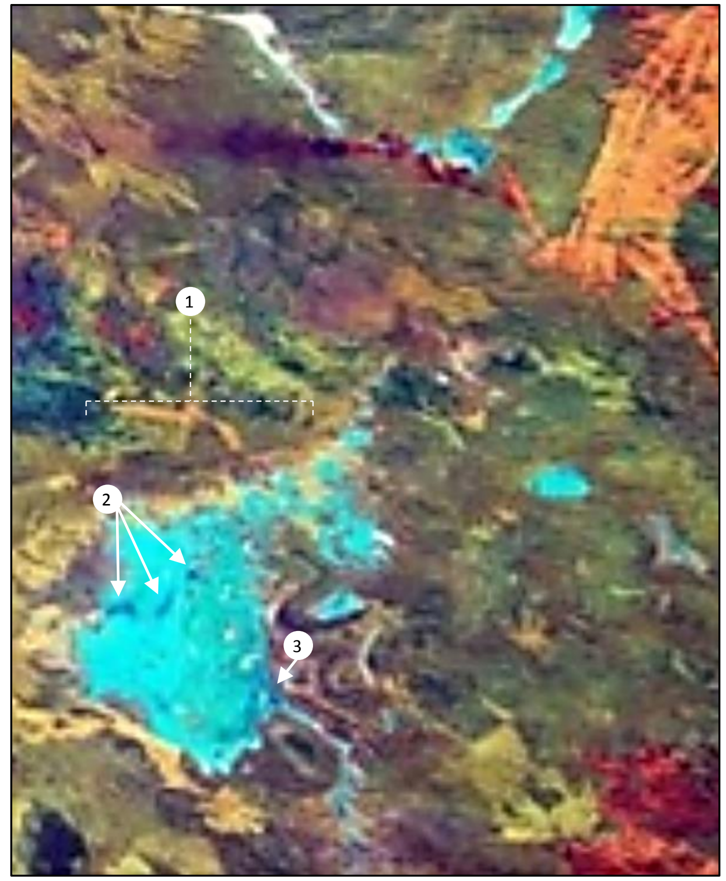
Images obtained from NASA Earth Observatory http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=80569



15 July 1999

Observations:

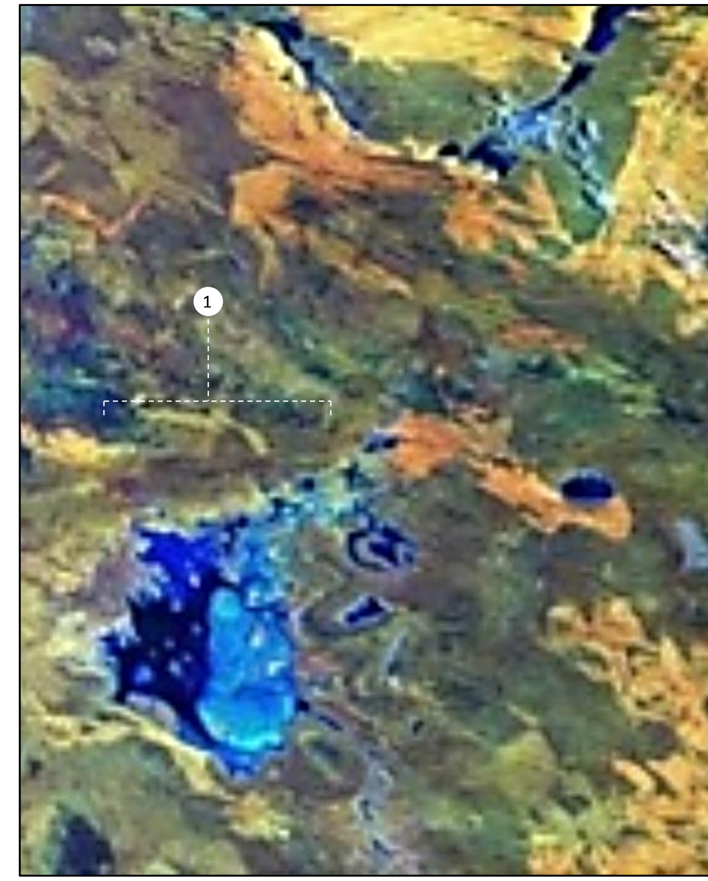
1. Water entering from Savory Creek.
2. Water extending east/north-east from Savory Creek inlet.
3. Depth and lateral extent of water greater through eastern (opposed to western) side of lake.
4. Deeper channel of water inset from southern boundary of lake.



3 October 1999

Observations:

1. In general, lateral extent and depth of surface water is less than that seen on 15 July 1999.
2. Water remaining at certain locations along Savory Creek inflow path.
3. Water remaining toward south-eastern perimeter of lake.



7 January 2000

Observations:

Lighter colouring (denoting shallower waters) through the eastern opposed to western region of the lake does not coincide with topography nor field observations, and is believed to be a processing error attributed to colour variation in sediments through these areas. Refer to Section X of accompanying report for details.

1. In general, lateral extent and depth of surface water is greater than both January and July observations.

Title: Seasonal Images

Figure: 5.6

Location: Lake Disappointment

Revision: 1

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Notes:

Images generated with fixed band multispectral scanning radiometer. Spectral information is interpreted as biophysical properties (such as surface water depth).

Colour variation in sediments through the eastern and western regions of Lake Disappointment are believed to result in a misrepresentation of relative surface water depths (refer to Sections 5.1 of accompanying report). As a result, the Landsat 7 ETM+ image from 7 January 2000 is not regarded as providing a reliable indication of surface water depth/distribution at Lake Disappointment.

Images from Commonwealth of Australia (Geoscience Australia) 2015, Canberra.

Image not scaled.

Legend:

The depth of surface water is indicated by the tone of blue, with darker tones denoting greater water depths.

Landsat 7 ETM+ image, is the result of a misinterpretation of spectral information due to the lighter colour of sediments in this region (see Section 4.1: Uncertainty and Limitations).

WOfS data suggests that water has a tendency to accumulate in a north-south channel toward the centre of the lake (Figure 5.3). Water was present at pixels along this channel in some 40% to 50% of observations, indicating ponding here more frequently than in the immediately surrounding areas. Whilst there is uncertainty regarding the frequency of water presence through the eastern area of the lake (Section 4.1), this observation is supported by the 2013 post-cyclone MODIS image (Figure 5.6), which shows darker colouration along this channel, denoting water to greater depths than other areas of the lake. In addition to this central channel, water was also observed comparatively frequently (40% to 55% of observations) at the following locations:

- Toward the north-western perimeter of the lake extending approximately 850m inwards from the Savory Creek inflow.
- At a pool with a surface area of approximately 3km² toward the south-eastern inflow of the unnamed tributary (i.e. at the topographic low point along the south-eastern perimeter).
- Toward the centre of hollows which exist at multiple locations through the eastern region of the lake.
- Within smaller salt bands beyond the north-eastern boundary of Lake Disappointment (down topographic gradient from Lake Disappointment).

All areas where ponding is considered to occur most frequently are highlighted in Figure 5.3.

5.2.2 Temporal Characteristics of Ponding

Owing to the significant size of Lake Disappointment and topographic variations across the lake (amongst other factors) there are inter-regional disparities pertaining to when and for how long surface water has been present. The findings of an analytical assessment (Appendix B) of data are discussed below.

The weighted sum of mean observation values by month indicates that Lake Disappointment has most frequently contained ponding during February and March (Table 5.3). Analytical results suggest that the proportion of *wet* observations remain fairly constant between April and July, before decreasing between the months of August and November and increasing from December to February. In addition, a small spike in the number of wet locations during the month of June is evident. As cyclonic events are not typically encountered during June and considering the subsequent decline in the proportion of wet locations in the months following, this spike is likely attributed to shallow water from non-cyclonic intensity events, which does not remain on the lake for an extended period.

With the exception of Area Two, there was significant variation (p=<0.05) in the number of *wet* days between sample locations in each area of investigation, indicating that water does not accumulate uniformly through these areas but rather occurs more/less frequently at certain locations. This is not surprising given the large expanse of the areas investigated and the effect of wind. There is also significant variation between months in relation to the number of *wet/dry* observations (p=<0.05) which supports the observation that water is not consistently present in any of the areas of investigation. The geographical extent of Area Two is significantly less than that of the other areas of investigation; thus there was little inter-location variation in the number of *wet* observations (p=>0.05) indicating that ponding is fairly consistent across this area. The variation in observational values between months was significant (p= 8.72×10^{-54}), albeit markedly lower than that of other areas (p= $\geq 1.2 \times 10^{-114}$) which suggests that surface water is more consistently present in Area Two.

Table 5.1: Weighted Sum of Mean *Wet* Observations.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Weighted sum of ẋ values	53	91	84	64	66	71	65	54	44	37	31	41
Percentages relate to WOfS observations between 1987 and 2012 (Geosciences Australia, 2015).												

5.2.3 Historic Precipitation and Ponding

Tropical cyclones which passed within 200km of Lake Disappointment between 1974 (first year of available rainfall data at Telfer Station) and 2006/07 (final year of available cyclone tracking data) are summarised in Table 5.2, alongside WOfS data observations for the coinciding period. Cross-referencing of Telfer Weather Station rainfall data with WOfS observations indicates that not all periods of ponding could be correlated to a rainfall event; thus to acquire a greater understanding of the relationship between precipitation and ponding, local rainfall data is required.

Owing to the duration between WOfS observations (ranges from 1 day to >28 days), there may be a lag between the actual and reported date at which ponding commenced and/or ceased. In addition, the duration of ponding may be overestimated where consecutive *wet* observations are made over an extended period (i.e. locations may become dry and re-wet during an unobserved period, which would not be registered as a separate ponding event). The findings/conclusions below should thus be regarded as indicative only.

Observations in Table 5.2 suggest the following:

- Not all cyclonic events which pass within a 200km radius of Lake Disappointment eventuate in rainfall and/or ponding on the lake. It is anticipated that in some instances, the intensity of rainfall decreases to a level which is not sufficient to cause ponding prior-to/upon reaching the lake (Cyclone Annette, 1994; Cyclone Gertie, 1995).

  The following general observations regarding a cyclonic event and rainfall apply:

  - Rainfall from a cyclonic event depends upon speed of movement, storm size and degree of vertical wind shear. Large, slow moving and non-sheared cyclones produce the heaviest rains. The intensity of a cyclone appears to have little bearing on its potential for rainfall over land but satellite measurements over the last several years show that more intense tropical cyclones produce noticeably more rainfall over water (US Federal Emergency Management Agency, 2005).
  - As a cyclone intensifies heavier rainfall become more concentrated around its centre (Rodgers and Adler, 2008). Rainfall is found to be heaviest in the cyclone's inner core, whether it be the eye-wall or central dense overcast, within a degree latitude of the centre, with lesser amounts farther away from the centre (Riehl, 1954). Riehl calculated that 863mm of rainfall per day can be expected within one-half degree, or 56 km, of the centre of a mature tropical cyclone. Many cyclones progress at a forward motion of around 20km/hr which would limit the duration of this excessive rainfall to around one-quarter of a day yielding 216mm of rainfall. Whilst this applies (US Weather Prediction Centre, 2013) over water (sea), within 160 km of the coastline and away from large topographic features (mountains), the amount of rainfall and the cyclone itself decrease rapidly as it moves farther inland and is cut off from its supply of warmth and moisture (the ocean).

- There are periods of significant ponding which cannot be tied to a cyclonic event within a 200km radius of Lake Disappointment. For example, extensive (both geographically and temporally) ponding occurred in mid-April 1988, early February 1998, December 1999 and March 2004, however the BoM cyclone tracker does not indicate any cyclonic events having occurred within close proximity to these dates. In some instances, these ponding events can be correlated to significant rainfall (not registered as a tropical cyclone) at Telfer weather station, for example, in February of 1998, a number of notable rainfall events, up to a daily maximum of 87mm, were recorded between the 2nd of February and 18th of March. Other ponding events, such as that of mid-April 1988, cannot be tied to notable rainfall using the Telfer station data. The reasons for this lack of correlation is not known; however, hypothesised scenarios include:

  - Significant rainfall (or several smaller events close to each other) occurred locally at Lake Disappointment but not further afield. This is possible given that the Telfer Station is some 200km north-north-west of the lake.
  - Ponding at the lake was the result of significant rainfall and subsequent inflow from surrounding catchments (without rainfall at Telfer).
  - A lack of WOfS data from these periods gave the illusion of significant ponding when in actual fact there was not, but rather a series of short wet intervals, which without consistent/frequent observations, present as one long ponding event.

- During/following cyclonic events which were associated with ponding at Lake Disappointment, the proportion of *wet* sample locations in investigation areas toward the western shoreline (Sub-area C of Area 4; Area 5), increased least frequently (see Cyclone Naomi, 1993; Cyclone George, 2007).
- Findings support observations made in Section 4.2.1 regarding areas in which water accumulates (i.e. those areas identified in Section 4.2.1 are indicated as possessing the greatest duration of ponding following a cyclonic event).

Table 5.2: Cyclonic Events and Presence/Ponding of Surface Water at Lake Disappointment.

Cyclone	Year	Start Date	End Date	Rainfall Observations (Telfer Station)	WOfS Data Observations	
					Proportion of Wet Locations Pre/Post Cyclone	Post-Cyclone Ponding Duration
Leo	1977	24th Mar	28th Mar	16.4mm of rain in total over cyclone period (5.4mm and 11.0mm on the 27th and 28th March respectively). Following cyclone, 24.6mm was recorded on the 1st April.	No WOfS data available for this period.	
Vern	1978	27th Jan	3rd Feb	84.4mm in total over cyclone period (to a daily maximum of 32.9mm on 2nd February). In addition, 22.5mm was recoded on the 26th February.		
Dean	1980	27th Jan	4th Feb	93.8mm of rain in total over cyclone period (to a daily maximum of 46.6mm on 1st February). Intermittent periods of significant rainfall was noted following event, until 20th February.		
Jane	1983	2nd Jan	10th Jan	119.8mm was recorded from the 9th to 10th January.		
Ken	1983	28th Feb	6th Mar	No rainfall recoded during this period. No significant rainfall (daily maximum 8.4mm on 10th March) encountered surrounding these dates.		
Lena	1983	2nd Apr	9th Apr	No significant rainfall encountered during this period (daily maximum 3.8mm on 8th April). However, 53.6mm was recorded over the 3 days preceding this event.		
Frank	1984	19th Dec	28th Dec	24mm recorded on the 20th December, no other significant rain events occurred during or in close proximity to these dates.		
Elise	1987	22nd Feb	27th Feb	Total of 73.8mm recorded between the 24th and 27th February, 63.2mm of which fell on the 26th February.		
Naomi	1993	15th Dec	18th Dec	287mm recorded over cyclone period, with 84mm and 202.4mm on the 17th and 18th	**Area One:** Proportion of wet sample locations increased from approximately 45% to 98% between the 20th and 29th of	**Area One:** Ponding duration varies throughout. Sample locations toward the centre of the lake remained wet

Cyclone	Year	Start Date	End Date	Rainfall Observations (Telfer Station)	WOfS Data Observations	
					Proportion of Wet Locations Pre/Post Cyclone	Post-Cyclone Ponding Duration
				December respectively.	December. 100% of sample locations were reported as wet during the observation made on the 5th January 1994.	for up to 11 months, whilst locations toward the north-eastern forked area remained wet for 3-4 months.
					Area Two: 100% of sample locations were wet preluding Cyclone Naomi. Samples had been wet since the observation made on the 10th May 1993.	**Area Two:** Samples from Area Two remained wet for between 1 and 2 (outer samples) to 10 (inner samples) months following this event.
					Area Three: Proportion of wet sample locations increased from approximately 39% (wet since observation made 19th May 1993) to 97% between the 20th and 29th of December 1993.	**Area Three:** Large degree of variation in the duration of ponding following this event, with certain locations remaining wet for 1-2 weeks, whilst other locations (primarily those toward the centre of hollows) remained wet 10-11 months. In general, samples from hollows toward the northern end of Area 3 remained wet for longer than those at the southern end.
					Area Four: The magnitude of the percentage increase in wet sample locations appears to decline approaching the western boundary of the lake. In sub-area A the proportion of wet sample locations increased from approximately 45% to 100% between the 20th and 29th of December 1993, in sub-area B the proportion increased from 25% to 83% between the 2nd November and the 20th December 1993 and in sub-area C (the most western sub-area), samples were generally dry prior to and following Cyclone Naomi (sample locations which were wet, only remained so for a single observation).	**Area Four:** Samples from sub-area A (lowest sub-area within Area Four), generally remained wet for a period of 1-2 weeks. However, samples located nearest to Area One remained wet for up to 10 months. Samples from sub-area B generally remained wet for 1-2 weeks (i.e. for one observation).

Cyclone	Year	Start Date	End Date	Rainfall Observations (Telfer Station)	WOfS Data Observations	
					Proportion of Wet Locations Pre/Post Cyclone	Post-Cyclone Ponding Duration
					Area Five: The proportion of wet observations was not seen to increase following Cyclone Namoi. A small proportion of (16%) of sample locations were wet in observations preceding this event, this percentage remained consistent during observations made between the 15th and 29th December, before eventually declining following the cyclone period.	**Area Five:** N/A
Annette	1994	13th Dec	20th Dec	96.3mm recorded over cyclone period, 94.2mm of which was on the 19th December. A second high intensity event occurred three days following the cyclone with 40.8mm recorded om the 23rd December.	Data for this period is somewhat limited, however available data does not indicate ponding associated with this event. Sample locations through all investigation areas remained dry for an extended period (upward of 14 months) from early December 1994. Cyclone Anette appears to have passed directly over Lake Disappointment and whilst precipitation data from the Telfer station does indicate significant rainfall, Lake Disappointment is some 184km inland from this station, and the intensity of rainfall associated with this event was significantly lower than that of Cyclone Namoi (287mm in 2 days). Thus this lack of correlation may be attributed to the cyclone intensity having declined to a level which was not sufficient to cause ponding upon reaching Lake Disappointment.	
Gertie	1995	17th Dec	24th Dec	101.8mm recorded over cyclone period, 81.8mm of which was on the 21st December. Preceding the cyclone, 107.5mm was recorded between the 8th and 14th December, with 59mm and 32.5mm on the 10th and 11th December respectively.	Data for this period is limited (no observations made between the 24th November 1994 and 20th January 1995). Available data does not indicate ponding associated with this event. Cyclone Gertie tracked east-south-east, toward the 200km search radius extremity from Lake Disappointment. Whilst the duration of heavy rainfall was significant, the intensity of events was again lower than that observed during Cyclone Naomi. Thus this lack of correlation may be attributed to the cyclone intensity having declined to a level which was not sufficient to cause ponding upon reaching Lake Disappointment.	
Terri Wylva Abigail	2001 2001 2001	28th Jan 14th Feb 24TH Feb	31st Jan 22nd Feb 8th Mar	No significant rainfall occurred during cyclone period (daily maximum of 5mm on the 31st January). Preceding cyclone, 73mm was recorded between the 24th and 26th January, 55mm of which fell on the 24th February. In addition, 26mm fell on the 1st February.	**Area One:** Proportion of wet locations increased from 61% (wet since observation made on the 22nd November 2000) to 71% between the 16th and 25th of January. Between the 25th January and 10th February, the proportion of wet locations increased to 88%.	**Area One:** The duration of ponding following this event generally ranged from 1-2 months at sample locations toward the southern end of area one. Sample locations from the northern mid-region of the lake (i.e. approximately in-line with the Savory

Cyclone	Year	Start Date	End Date	Rainfall Observations (Telfer Station)	WOfS Data Observations	
					Proportion of Wet Locations Pre/Post Cyclone	Post-Cyclone Ponding Duration
				121mm recorded over cyclone period, of which 35mm and 56mm was on the 16th and 21st February respectively. With the exception of 25mm on the 4th March, no days of significant rainfall occurred during this period.		Creek inflow) were generally wet proceeding this event (from observation on the 22nd November 2000), with some remaining wet until the early January 2002.
					Area Two: Proportion of wet locations increased from 0 to 100% between the 16th and 25th of January.	**Area Two:** The duration of ponding was approximately 2-2.5 months and was fairly consistent throughout sample locations (i.e. majority of sample locations were dry by observation made on 21st March 2001).
					Area Three: Proportion of wet locations increased from approximately 40% to 70% between the 16th and 25th of January.	**Area Three:** The duration of ponding ranged throughout from ≤16 days to approximately 1-2 months. Longest ponding occurred toward the centre of larger hollows.
					Area Four: Proportion of wet locations increased through all sub-areas. The total percentage of wet locations increased from approximately 5% to 79% between the 16th and 25th of January. This figure increased to 95% between the 25th January and the 10th February.	**Area Four:** The duration of ponding was approximately 2-7 weeks and was fairly consistent throughout Area 4.
					Area Five: The proportion of wet samples from the within/surrounding the proposed waste dump areas increased from approximately 40% (wet from observation made on the 22nd November 2000) to 60% between the 16th and 25th of January. This proportion increased to 80% between the 25th January and 10th February, and to 100% by the observation made on the 14th March 2001.	**Area Five:** The duration of ponding ranged between sample locations. The majority of samples at/surrounding the proposed waste dump areas became dry between observations on the 21st and 30th of March. The duration of ponding at these locations ranged from approximately 1-4 weeks to 2-2.5

Cyclone	Year	Start Date	End Date	Rainfall Observations (Telfer Station)	WOfS Data Observations	
					Proportion of Wet Locations Pre/Post Cyclone	Post-Cyclone Ponding Duration
					Prior to this cyclonic event, approximately 40% of sample locations within the vicinity of the proposed halite and concentrating pond were wet. This proportion did not increase until the observation made on the 14th March (previous observation was on the 26th February), at which point 100% of samples were noted as being wet.	months. Majority of samples at/surrounding the proposed halite and concentrating ponds were dry by the observation made on the 6th April, with ponding durations ranging from 1-4 weeks.
George	2007	27th Feb	12th Mar	184mm recorded over cyclone period, with 93mm, 25mm and 49mm on the 10th, 11th and 12th March respectively. In addition, 73mm was recorded on the 13th March and intermittent periods of high intensity rainfall (up to 70mm in a day) were noted up until the 28th March.	**Area One:** 25% of sample locations were wet prior to this event (as per observation made on the 26th February 2007). By the observation made on the 15th March 2007, 84% of sample locations were wet.	**Area One:** The duration of ponding varied significantly throughout Area One, with the majority of locations remaining wet for approximately two months. Most sample locations were dry by the observation made 26th May 2007. A small proportion of samples (around 5%) remained wet until 20th January 2008. These samples were located toward the northern mid-region of the lake (i.e. approximately in-line with the Savory Creek inflow path).
					Area Two: Proportion of wet locations increased from 13% to 93% between the 26th February and 14th March 2007. By the observation made on the 7th April 2007, 100% of sample locations were wet.	**Area Two:** The duration of ponding was approximately two months and was fairly consistent throughout sample locations. 100% of sample locations were dry by the observation made on the 25th May 2007.
					Area Three: Proportion of wet locations increased from approximately 20% to 85% between the 26th February and 14th March.	**Area Three:** The duration of ponding was typically between 3-4 weeks, however certain locations (namely those from the centre of the most south-eastern hollow) remained wet for up to 2 months.

Cyclone	Year	Start Date	End Date	Rainfall Observations (Telfer Station)	WOfS Data Observations	
					Proportion of Wet Locations Pre/Post Cyclone	Post-Cyclone Ponding Duration
					Area Four: A total (all sub-areas) of 5% of sample locations were wet on the 26th February. This value remained consistent during observations made on the 6th, 7th and 14th of March. On the 15th March the proportion of wet locations increased throughout all sub-areas, totalling 47% of all sample locations.	**Area Four:** Ponding duration at locations within Sub-area A ranged from 3-4.5 weeks. Sample locations through Sub-areas B and C remained wet for 2-3.5 weeks.
					Area Five: The proportion of wet locations increased from approximately 14% to 48% between the 26th February and 7th March. Sample locations which became wet, appear to be randomly dispersed throughout Area 5 (i.e. not from one specific region).	**Area Five**: Locations which became wet remained so for approximately 3 weeks.

6. Conclusions and Recommendations

Based upon the findings of this investigation, it can be concluded that:

- Construction of infrastructure on Lake Disappointment to exploit the Sulfate of Potassium resource will not materially impact on the hydrological function of the lake.
- The inlets and primary drainage channels of Savory Creek and the unnamed south-eastern tributary are located within exclusion zones and will not be interfered with.
- Flood levels will not increase, thus flooding will not have a significant effect on the local and regional environment as a consequence of operations.
- Further (relative) wetting of the region may occur in future due to a projected increase in the intensity of cyclonic events and eastward shift in cyclone tracks.
- The majority of the western portion of Lake Disappointment (where the proposed new mine infrastructure will be located) contained surface water in less than or 20% of the observations made between 1987 and 2014. Areas which contained ponded water most frequently are confined to a channel towards the centre and through the eastern/north-eastern and south-western extremities of the lake.
- Surface water ponding occurs most frequently during February and March. Analytical results suggest that the proportion of wet observations remain fairly constant between April and July, before decreasing between the months of August and November and increasing from December to February.

Taking due cognisance of the above, it is recommended that:

- The hydrological impacts be reviewed upon and included in the final design.
- A detailed surface water monitoring program, including Savory Creek (a P1 Wild River), be implemented to facilitate development of appropriate mitigation measures, if required, in consultation with pertinent Stakeholders to ensure that river values (ecological, water quality, scientific and rarity) are upheld. The monitoring parameters should include local rainfall: quantity and intensity and surface water ponding: (location, depth, duration and water quality).

Glossary and Abbreviations

AHD	Australian Height Datum
BoM	Bureau of Meterology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DER	Department Environment Regulation Western Australia
DMP	Department of Mines and Petroleum Western Australia
DoW	Department of Water Western Australia
SoP	Sulfate of Potassium
WOfS	Water Observation from Space
Units	
s	second
min	minute
hr	hour
d	day
mm	millimetre
m	metre
km	kilometre
^{o}C	degree Celcius
%	percentage

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Appendices

Appendix A: Risk Assessment Framework.

Appendix B: Statistical Analysis of Landsat Imagery.

Appendix C: Telfer Aero Weather Station Data.

Appendix A: Risk Assessment Framework.

Environmental Risk Assessment Framework

In accordance with the framework of the *Department Environment Regulation, Western Australia, for Division 3, Part V, Environmental Protection Act 1986,* December 2015.

Objective

To be in line with the Department of Environment Regulation's (DER) environmental risk assessment framework for works approvals and licences issued under Division 3, Part V of the *Environmental Protection Act 1986* (EP Act).

Apply a risk-based approach to ensure that there is not an unacceptable risk of harm to public health and/or the environment.

Background

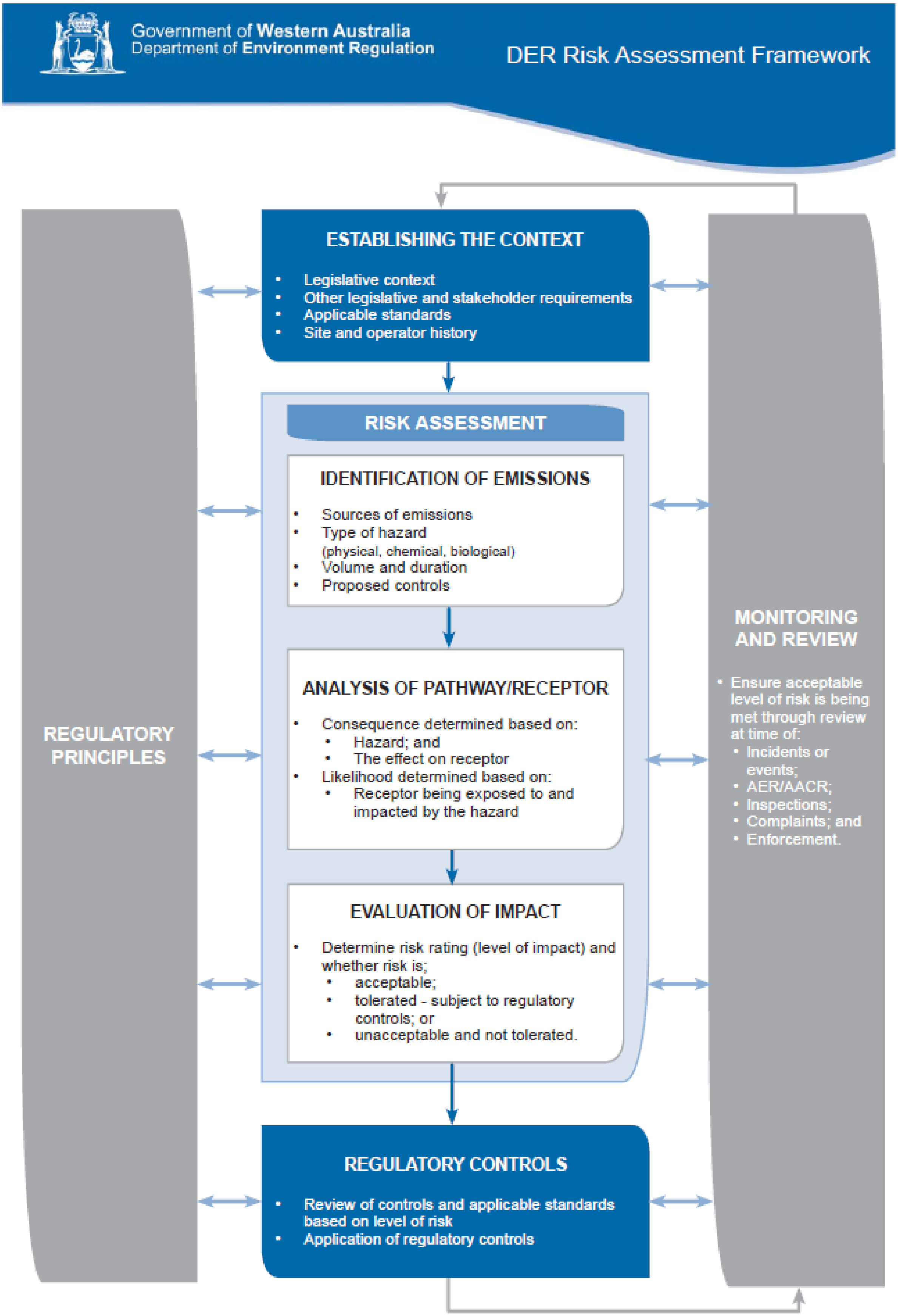
The environmental risk assessment framework has been developed to ensure a systematic approach in assessing risk through establishing the context, identification, analysis, evaluation, treatment and ongoing monitoring of risk generally in accordance with the following Australian/New Zealand Standards:

- *AS/NZS ISO 31000:2009 Risk management – Principles and Guidelines.*
- *AS/NZS 4360:1999 Risk Management.*
- *HB 203:2012 Managing Environment-Related Risk.*

Guidance

1. Assess the risk in accordance with the Risk Assessment Process consistent with AS/NZS ISO 31000:2009 and as set out in **Appendix 1.** The Risk Assessment Process involves the consideration of the following:
   a) establishing the context;
   b) identification;
   c) analysis of pathway/receptor (consequence and likelihood);
   d) evaluation of impact; and
   e) treatment and ongoing monitoring.
2. In the identification process, undertake an assessment of the hazard based on the type, nature and toxicity of the aspect in accordance with **Appendix 2**.
3. In undertaking the analysis of the pathway/receptor, undertake an assessment of the consequence and likelihood of the effect on the receptor in accordance with the Risk Assessment Criteria set out in **Appendix 2** and with regard to health and ecosystem criteria set out in **Appendix 5**.
4. Rate the risks in accordance with the Risk Assessment Matrix in **Appendix 2**.
5. Treat the risks in accordance with the Risk Treatment Matrix set out in **Appendix 3**.
6. Document the assessment of risks in accordance with the risk assessment template set out in **Appendix 4**.
7. Consider monitoring and review as part of the risk management process and should be undertaken for the purposes of:
   (a) ensuring that controls are effective and efficient in both design and operation;
   (b) obtaining further information to improve future risk assessments;
   (c) identifying emerging risks;
   (d) analysing and learning from events or incidents; and
   (e) detecting changes to context or risk itself which may require revision of risk treatment and ratings.

Appendix 1 – Risk Assessment Process



Appendix 2 – Risk Assessment Matrix and Criteria

DER will determine the risk of adverse impact to public health and the environment based on the evaluation of consequence and likelihood will be used to establish the risk rating based on the Risk Assessment Matrix below (which is consistent with DER's risk assessment set out in DER's Corporate Policy Statement No.7 – *Operational Risk Management*), applying the Risk Assessment Criteria defined in the tables below.

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Severe
Almost Certain	Moderate	High	High	Extreme	Extreme
Likely	Moderate	Moderate	High	High	Extreme
Possible	Low	Moderate	Moderate	High	Extreme
Unlikely	Low	Moderate	Moderate	Moderate	High
Rare	Low	Low	Moderate	Moderate	High

Likelihood[1]	
The following criteria will be used to determine the likelihood of the risk / opportunity occurring.	
Almost Certain	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Possible	The event could occur at some time
Unlikely	The event is unlikely to occur
Rare	The event may only occur in exceptional circumstances

Consequence[2]		
The following criteria will be used to determine the consequences of a risk occurring:		
	Public Health	**Ecosystem/Environmental**
Severe	• Loss of life • Exposure to hazard with permanent prolonged adverse health effects expected to large population • Health criteria is significantly exceeded	• Irreversible impact to significant high value or sensitive ecosystem expected • Irreversible and significant impact on a wide scale • Total loss of a threatened species expected • Ecosystem criteria is significantly exceeded
Major	• Exposure to hazard with permanent prolonged adverse health effects expected to small population • Significant impact to amenity for extended periods expected to large population • Health criteria is exceeded	• Long-term impact to significant high value or sensitive ecosystem expected • Long-term impact on a wide scale • Adverse impact to a listed species expected • Ecosystem criteria is exceeded
Moderate	• Exposure to hazard with short-term adverse health effects expected requiring treatment • Impact to amenity expected for short periods to large population • Health criteria is at risk of not being met	• Minor and short-term impact to high value or sensitive ecosystem expected • Off-site impacts at a local scale • Ecosystem criteria is at risk of not being met
Minor	• Exposure to hazard with short-term adverse health effects expected • Impact to amenity expected for short periods to small population • Health criteria are likely to be met	• Moderate to minor impact to ecosystem component (physical, chemical or biological) • Minor off-site impacts at a local scale • Ecosystem criteria are likely to be met
Insignificant	• No detectable impacts to health • No detectable impacts to amenity • Health criteria met	• None or insignificant impact to ecosystem component (physical, chemical or biological) expected with no effect on ecosystem function • Ecosystem criteria met

[1] Likelihood is the probability or likelihood of a consequence occurring and takes into consideration:

- the hazard occurring;

- the receptor being exposed to the hazard through a pathway; and
- the receptor being adversely impacted by the hazard

[Reference: *Health Risk Assessment (Scoping) Guidelines*, Department of Health (2010)]

Methods for determining likelihood include using records of historical events, monitoring data, research, expert opinions, previous experience and/or predictive modelling. Predictive modelling involves detailed mathematical models (including groundwater models, surface water models and air dispersion models).

In determining likelihood, consideration will be applied to the fitness and competency of the operator with regard to:

- compliance history including formal sanctions and notices issued, number and nature of non-compliances; and
- operating history including experience, and market and industry reputation.

2 DER has established proxy Health and Ecosystem criteria which will be referred to when determining consequence from emissions and the effect on receptors as set out in Appendix 5.

The type and toxicity of emissions are identified in the Health and Ecosystem criteria.

The Health and Ecosystem criteria are based primarily on:

- ANZECC & ARMCANZ (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality, which provides for water quality guidelines on a range of toxicants for the protection of fresh and marine waters based on the desired level of protection;
- NHMRC & ARMCANZ (2011), Australian Drinking Water Guidelines, which provides for a range of water quality parameters for the protection of drinking water source areas for public health;
- DoH (2014), Contaminated Sites Ground and Surface Water Chemical Screening Guidelines;
- National Environment Protection (Ambient Air Quality) Measure (2003);
- National Environment Protection (Air Toxics) Measure 2011; and
- Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (Department of Environment and Conservation (DEC) NSW, 2005).

Deviation from criteria may be appropriate to allow for higher or lower level of controls based on the risk to, and the environmental value of, the receiving environment. Any deviation sought below the proxy criteria is required to demonstrate that the level of impact to the environmental value will be acceptable.

In situations where there is no Health and Ecosystem criteria defined within Appendix 5, reference to alternative approaches/ methodology outlined in the referenced guidelines or to alternative published standards/guidelines must be made.

Appendix 3 – Risk Treatment Matrix

Following the risk rating process set out in Appendix 2, DER will determine risk acceptability with corresponding treatments, as shown in Figure 1 below.

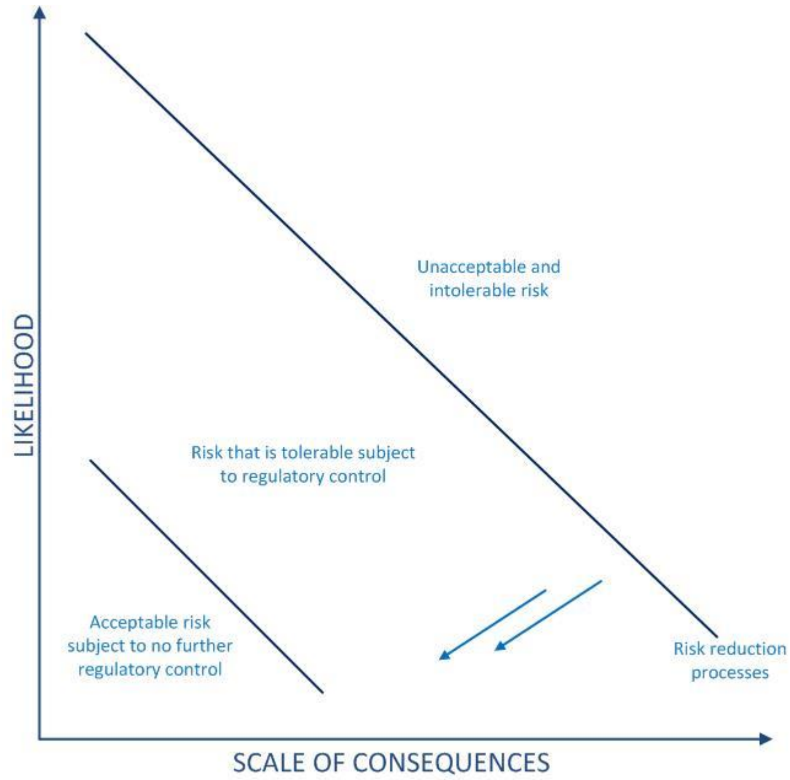


Figure 1 – Risk acceptability and tolerability with regulatory controls

DER will treat risks in accordance with the Risk Treatment Matrix below:

Risk Rating	Acceptability	Treatment
Extreme	Unacceptable	Risks will not be tolerated. DER will refuse proposals.
High	Acceptable subject to primary and secondary controls	Risks will be subject to multiple regulatory controls including primary and secondary controls. This will include both outcome-based and management conditions.
Moderate	Acceptable, generally subject to primary controls	Risks will be subject to regulatory controls with a preference for outcome-based conditions where practical and appropriate.
Low	Acceptable, generally not controlled	Risks are acceptable and will generally not be subject to regulatory controls.

Appendix 4 – Risk Assessment Template

The following risk assessment template reflects the fundamental concept of risk assessment that there must be plausible evidence of an exposure pathway linking the hazard source and the receptor (Department of Health (Cwth 2012), *Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards*).

Source of emission and discharge		**Pathway**	**Receptor**	**Proponent controls**	**Potential Impact**	**Consequence on receptor**	**Likelihood of consequence**	**Level of risk/ adverse impact on receptor**
Emission (type and quantity)	**Emission event (normal/upset)**							
Type of emission and quantity *(volume, concentration, duration and toxicity)*	*Describe the emission event:* - *Normal; and* - *Upset conditions*	*Description of pathway in relation to hazard coming into contact with receptor based on:* - *Air* - *Water* - *Land* ***(factor influencing likelihood of risk occurring)***	*Description of receptor and location in relation to premises*	*Description of controls to prevent or mitigate impact:* *Separation Distance control* *Specifications* *Operational control(s)* *Assessment control(s)* *Monitoring control(s)*	*Description of the potential impact to the receptor from the hazard with regard to controls being implemented.* *(Public Health - acute/chronic impact; and* *Ecosystem – acute/chronic/ bioaccumulation and persistence)* ***(factor influencing consequence of risk)***	*Insignificant/ Minor/Moderate/ Major*	*Almost certain/Likely/ Possible/ Unlikely/Rare*	*Low/Moderate/ High*

Appendix B: Statistical Analysis of Landsat Imagery.

Area																		
Sub-area																		
Sample Location:	122.78	122.77	122.77	122.76	122.76	122.76	122.76	122.76	122.75	122.75	122.75	122.74	122.74	122.74	122.74	122.74	122.75	122.75
	-23.64	-23.63	-23.63	-23.63	-23.62	-23.62	-23.62	-23.61	-23.61	-23.60	-23.59	-23.59	-23.58	-23.56	-23.56	-23.55	-23.55	-23.54
Month																		
Jan	0.42	0.62	0.43	0.36	0.53	0.44	0.36	0.86	0.41	0.54	0.69	0.49	0.68	0.59	0.59	0.47	0.64	0.60
Feb	0.82	0.84	0.66	0.60	0.90	0.85	0.72	0.67	0.74	0.73	1.01	0.93	0.98	0.90	0.93	0.93	0.95	0.96
Mar	0.88	0.86	0.71	0.85	0.91	0.95	0.91	0.94	0.96	0.72	0.83	1.05	0.98	0.88	0.96	0.98	0.96	0.95
Apr	0.43	0.47	0.38	0.34	0.42	0.39	0.37	0.50	0.53	0.37	0.43	0.37	0.42	0.51	0.47	0.53	0.47	0.41
May	0.56	0.50	0.49	0.48	0.45	0.44	0.45	0.51	0.65	0.41	0.35	0.44	0.50	0.49	0.45	0.51	0.49	0.55
Jun	0.44	0.30	0.30	0.44	0.40	0.37	0.37	0.39	0.49	0.34	0.27	0.27	0.41	0.33	0.33	0.40	0.43	0.49
Jul	0.52	0.50	0.44	0.42	0.51	0.40	0.40	0.57	0.58	0.43	0.38	0.57	0.54	0.49	0.44	0.52	0.69	0.69
Aug	0.56	0.44	0.43	0.38	0.45	0.43	0.43	0.49	0.46	0.39	0.39	0.57	0.36	0.45	0.36	0.49	0.52	0.43
Sep	0.51	0.33	0.52	0.33	0.24	0.33	0.31	0.38	0.33	0.24	0.30	0.31	0.24	0.27	0.30	0.26	0.27	0.19
Oct	0.37	0.23	0.38	0.38	0.33	0.39	0.32	0.20	0.19	0.27	0.33	0.27	0.22	0.23	0.24	0.13	0.28	0.27
Nov	0.15	0.16	0.26	0.20	0.28	0.18	0.07	0.38	0.03	0.38	0.30	0.25	0.11	0.15	0.23	0.18	0.26	0.26
Dec	0.21	0.28	0.29	0.13	0.28	0.19	0.12	0.35	0.13	0.31	0.26	0.16	0.13	0.26	0.19	0.13	0.29	0.24

Area	Area One																		
Sub-area																			
Sample Location:	122.75	122.76	122.75	122.76	122.77	122.77	122.78	122.79	122.79	122.79	122.80	122.80	122.80	122.79	122.80	122.80	122.80	122.80	122.81
	-23.54	-23.54	-23.53	-23.53	-23.52	-23.52	-23.51	-23.46	-23.45	-23.45	-23.45	-23.44	-23.44	-23.46	-23.43	-23.42	-23.41	-23.41	-23.40
Month																			
Jan	0.75	0.44	0.67	0.77	0.58	0.63	0.67	0.31	0.56	0.31	0.56	0.46	0.72	0.63	0.62	0.49	0.53	0.56	0.46
Feb	0.81	0.87	0.90	0.95	0.90	0.76	0.85	0.63	0.76	0.69	0.87	0.69	0.93	0.88	0.90	0.90	0.82	0.99	0.85
Mar	1.01	0.96	0.88	0.93	1.08	0.99	1.00	0.77	0.86	0.76	1.03	0.84	1.00	0.91	1.03	0.90	0.91	1.05	0.90
Apr	0.46	0.39	0.41	0.57	0.57	0.49	0.45	0.46	0.49	0.51	0.58	0.49	0.45	0.54	0.50	0.54	0.61	0.49	0.54
May	0.40	0.41	0.46	0.57	0.60	0.56	0.65	0.67	0.55	0.49	0.66	0.56	0.56	0.60	0.61	0.52	0.54	0.65	0.62
Jun	0.37	0.53	0.46	0.47	0.46	0.53	0.44	0.46	0.50	0.44	0.51	0.39	0.39	0.53	0.57	0.44	0.46	0.79	0.63
Jul	0.38	0.50	0.54	0.52	0.50	0.55	0.64	0.60	0.56	0.54	0.63	0.46	0.43	0.62	0.55	0.57	0.51	0.75	0.73
Aug	0.42	0.43	0.59	0.54	0.48	0.53	0.68	0.60	0.51	0.48	0.66	0.45	0.40	0.56	0.55	0.57	0.53	0.67	0.72
Sep	0.38	0.29	0.39	0.38	0.31	0.46	0.43	0.50	0.39	0.24	0.36	0.19	0.33	0.33	0.31	0.23	0.29	0.42	0.39
Oct	0.37	0.30	0.30	0.27	0.24	0.34	0.34	0.33	0.32	0.18	0.27	0.18	0.22	0.20	0.27	0.19	0.25	0.29	0.34
Nov	0.28	0.25	0.43	0.31	0.21	0.38	0.31	0.20	0.15	0.03	0.30	0.18	0.18	0.30	0.36	0.26	0.28	0.34	0.23
Dec	0.32	0.26	0.44	0.34	0.31	0.38	0.28	0.24	0.22	0.12	0.25	0.24	0.28	0.41	0.28	0.26	0.22	0.37	0.22

Area														
Sub-area														
Sample Location:	122.81	122.81	122.82	122.83	122.84	122.85	122.86	122.88	122.87	122.87	122.87	122.88	122.90	122.92
	-23.39	-23.39	-23.38	-23.37	-23.37	-23.37	-23.37	-23.37	-23.39	-23.39	-23.40	-23.41	-23.42	-23.42
Month														
Jan	0.62	0.72	0.57	0.70	0.58	0.67	0.63	0.42	0.58	0.74	0.41	0.40	0.43	0.23
Feb	0.90	0.85	0.87	1.03	0.76	1.07	0.90	0.71	0.99	1.01	0.80	0.54	0.66	0.60
Mar	1.03	0.84	0.90	1.18	0.98	1.07	0.75	0.89	1.08	1.18	1.01	0.77	0.81	0.69
Apr	0.59	0.62	0.64	0.66	0.53	0.55	0.47	0.42	0.50	0.50	0.47	0.42	0.46	0.39
May	0.61	0.57	0.65	0.66	0.54	0.62	0.52	0.63	0.51	0.61	0.41	0.63	0.44	0.44
Jun	0.61	0.64	0.60	0.59	0.51	0.64	0.54	0.49	0.59	0.56	0.50	0.53	0.54	0.46
Jul	0.69	0.63	0.60	0.65	0.69	0.64	0.56	0.63	0.61	0.65	0.48	0.61	0.65	0.54
Aug	0.68	0.63	0.63	0.63	0.60	0.67	0.59	0.63	0.52	0.64	0.54	0.63	0.66	0.47
Sep	0.44	0.45	0.38	0.35	0.39	0.52	0.38	0.51	0.21	0.37	0.30	0.42	0.37	0.27
Oct	0.30	0.35	0.27	0.28	0.28	0.39	0.23	0.39	0.19	0.39	0.20	0.29	0.28	0.19
Nov	0.23	0.44	0.21	0.26	0.38	0.25	0.15	0.23	0.34	0.48	0.13	0.26	0.41	0.13
Dec	0.41	0.47	0.31	0.35	0.35	0.28	0.24	0.34	0.28	0.37	0.19	0.18	0.32	0.18

Area	Area Two														
Sub-area															
Sample Location:	122.94	122.94	122.94	122.93	122.94	122.94	122.94	122.94	122.94	122.94	122.94	122.94	122.94	122.94	122.94
	-23.59	-23.59	-23.60	-23.59	-23.59	-23.59	-23.60	-23.59	-23.59	-23.59	-23.59	-23.59	-23.59	-23.59	-23.59
Month															
Jan	0.27	0.20	0.31	0.26	0.35	0.32	0.42	0.47	0.36	0.39	0.27	0.32	0.38	0.31	0.32
Feb	0.43	0.42	0.52	0.45	0.43	0.43	0.53	0.48	0.40	0.38	0.43	0.55	0.44	0.45	0.40
Mar	0.51	0.46	0.51	0.49	0.53	0.53	0.48	0.52	0.50	0.49	0.49	0.50	0.45	0.44	0.47
Apr	0.44	0.45	0.51	0.59	0.59	0.52	0.48	0.58	0.48	0.42	0.43	0.48	0.43	0.44	0.47
May	0.61	0.58	0.68	0.74	0.73	0.66	0.69	0.67	0.73	0.71	0.62	0.59	0.62	0.54	0.59
Jun	0.59	0.48	0.62	0.63	0.70	0.59	0.62	0.60	0.60	0.63	0.60	0.58	0.59	0.52	0.53
Jul	0.51	0.49	0.57	0.64	0.65	0.59	0.59	0.62	0.59	0.65	0.50	0.55	0.57	0.49	0.56
Aug	0.57	0.47	0.56	0.58	0.58	0.58	0.54	0.62	0.54	0.61	0.54	0.58	0.60	0.50	0.59
Sep	0.38	0.31	0.36	0.42	0.40	0.43	0.36	0.45	0.36	0.36	0.38	0.40	0.32	0.40	0.36
Oct	0.26	0.18	0.28	0.27	0.42	0.36	0.31	0.40	0.39	0.36	0.29	0.22	0.37	0.29	0.29
Nov	0.27	0.13	0.18	0.21	0.30	0.24	0.22	0.29	0.37	0.45	0.30	0.10	0.36	0.15	0.30
Dec	0.35	0.21	0.22	0.32	0.43	0.30	0.35	0.36	0.43	0.48	0.38	0.22	0.43	0.26	0.45

Area	Area Three										
Sub-area	One							Two			
Sample Location:	122.8874	122.8868	122.8853	122.8781	122.8745	122.8717	122.8714	122.8927	122.8908	122.8935	122.8927
	-23.5747	-23.5788	-23.5802	-23.5859	-23.5865	-23.59	-23.593	-23.5593	-23.561	-23.5617	-23.5637
Month											
Jan	0.15	0.21	0.21	0.09	0.11	0.15	0.22	0.21	0.11	0.17	0.25
Feb	0.10	0.19	0.34	0.25	0.30	0.36	0.35	0.26	0.22	0.26	0.30
Mar	0.16	0.23	0.28	0.22	0.31	0.38	0.43	0.38	0.23	0.28	0.33
Apr	0.20	0.25	0.23	0.25	0.35	0.38	0.31	0.49	0.31	0.25	0.22
May	0.31	0.27	0.37	0.25	0.41	0.37	0.32	0.49	0.40	0.29	0.23
Jun	0.26	0.21	0.27	0.30	0.44	0.35	0.28	0.36	0.51	0.32	0.22
Jul	0.27	0.24	0.29	0.37	0.45	0.41	0.36	0.39	0.43	0.22	0.27
Aug	0.23	0.27	0.24	0.33	0.44	0.33	0.39	0.37	0.41	0.27	0.32
Sep	0.16	0.25	0.30	0.28	0.36	0.39	0.39	0.33	0.41	0.30	0.31
Oct	0.18	0.20	0.15	0.12	0.19	0.19	0.20	0.25	0.18	0.13	0.17
Nov	0.17	0.17	0.07	0.07	0.18	0.21	0.15	0.22	0.06	0.10	0.18
Dec	0.17	0.19	0.19	0.13	0.13	0.22	0.17	0.19	0.17	0.29	0.23

Sub-area	Three		Four			Five			Six			
Sample Location:	122.8709	122.875	122.83	122.8273	122.828	122.8518	122.8554	122.8571	122.8542	122.8688	122.875	122.8805
	-23.5518	-23.553	23.56	23.56324	23.56497	23.5368	23.53366	23.53318	23.50879	23.50375	23.49887	23.49572
Month												
Jan	0.18	0.21	0.15	0.29	0.25	0.20	0.22	0.09	0.11	0.16	0.25	0.24
Feb	0.26	0.36	0.23	0.39	0.27	0.23	0.22	0.17	0.18	0.13	0.22	0.38
Mar	0.38	0.31	0.32	0.38	0.38	0.32	0.33	0.33	0.17	0.22	0.32	0.45
Apr	0.36	0.39	0.24	0.36	0.26	0.32	0.34	0.18	0.24	0.34	0.34	0.41
May	0.33	0.40	0.25	0.55	0.41	0.44	0.45	0.27	0.29	0.40	0.43	0.40
Jun	0.27	0.38	0.30	0.48	0.32	0.46	0.43	0.20	0.38	0.40	0.44	0.42
Jul	0.37	0.49	0.39	0.48	0.38	0.42	0.45	0.24	0.43	0.38	0.44	0.39
Aug	0.35	0.46	0.35	0.46	0.33	0.34	0.35	0.22	0.40	0.39	0.39	0.36
Sep	0.36	0.31	0.26	0.48	0.38	0.30	0.31	0.19	0.39	0.43	0.45	0.36
Oct	0.29	0.12	0.24	0.38	0.26	0.28	0.39	0.19	0.30	0.31	0.37	0.27
Nov	0.22	0.06	0.19	0.38	0.21	0.17	0.36	0.15	0.12	0.18	0.31	0.19
Dec	0.16	0.18	0.14	0.35	0.14	0.14	0.19	0.13	0.13	0.23	0.35	0.26

Sub-area	Seven							Eight		
Sample Location:	122.8326	122.8348	122.8362	122.8384	122.8444	122.845	122.845	122.8546	122.8522	122.8503
	23.51508	23.50863	23.50375	23.49855	23.49698	23.49336	23.48895	23.44124	23.44061	23.44014
Month										
Jan	0.16	0.18	0.15	0.21	0.33	0.16	0.11	0.28	0.21	0.06
Feb	0.21	0.23	0.36	0.23	0.35	0.29	0.21	0.32	0.29	0.18
Mar	0.33	0.36	0.38	0.38	0.43	0.31	0.28	0.28	0.34	0.28
Apr	0.26	0.33	0.36	0.32	0.42	0.34	0.35	0.31	0.31	0.32
May	0.39	0.43	0.37	0.35	0.52	0.43	0.33	0.37	0.32	0.38
Jun	0.49	0.42	0.41	0.42	0.54	0.44	0.22	0.40	0.21	0.21
Jul	0.47	0.57	0.48	0.49	0.58	0.53	0.31	0.41	0.32	0.37
Aug	0.40	0.59	0.40	0.47	0.53	0.51	0.26	0.38	0.28	0.34
Sep	0.31	0.30	0.33	0.34	0.47	0.44	0.17	0.34	0.24	0.25
Oct	0.21	0.30	0.27	0.34	0.47	0.28	0.16	0.33	0.27	0.25
Nov	0.24	0.21	0.12	0.19	0.43	0.16	0.08	0.21	0.11	0.09
Dec	0.16	0.31	0.09	0.21	0.43	0.14	0.06	0.16	0.09	0.06

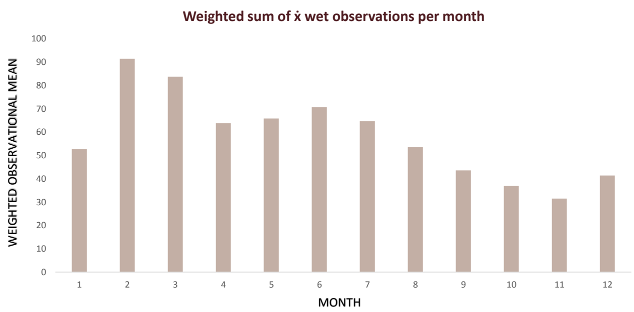
Area											
Sub-area	**A**										
Sample Location:	**122.7693**	**122.7675**	**122.7703**	**122.7517**	**122.739**	**122.7442**	**122.7401**	**122.7219**	**122.7315**	**122.7219**	**122.7157**
	-23.4214	**-23.4409**	**-23.4614**	**-23.4633**	**-23.4809**	**-23.4935**	**-23.5052**	**-23.5146**	**-23.5247**	**-23.5294**	**-23.5329**
Month											
Jan	0.17	0.12	0.17	0.12	0.19	0.09	0.10	0.13	0.08	0.24	0.25
Feb	0.31	0.31	0.29	0.29	0.32	0.17	0.32	0.25	0.23	0.23	0.29
Mar	0.33	0.36	0.34	0.31	0.21	0.21	0.33	0.28	0.28	0.27	0.32
Apr	0.35	0.36	0.36	0.33	0.31	0.27	0.22	0.27	0.27	0.17	0.36
May	0.34	0.24	0.32	0.43	0.32	0.17	0.19	0.18	0.19	0.18	0.23
Jun	0.38	0.26	0.27	0.33	0.31	0.15	0.19	0.21	0.25	0.23	0.35
Jul	0.36	0.29	0.34	0.26	0.37	0.22	0.30	0.29	0.33	0.35	0.43
Aug	0.33	0.27	0.31	0.28	0.30	0.19	0.25	0.22	0.31	0.24	0.23
Sep	0.15	0.16	0.15	0.19	0.21	0.15	0.10	0.06	0.13	0.08	0.18
Oct	0.16	0.11	0.10	0.18	0.25	0.16	0.08	0.03	0.09	0.03	0.10
Nov	0.12	0.08	0.04	0.09	0.21	0.08	0.15	0.03	0.07	0.06	0.11
Dec	0.16	0.14	0.19	0.08	0.19	0.03	0.03	0.08	0.08	0.10	0.10

Area	Area Four											
Sub-area	B											
Sample Location:	122.727	122.7205	122.6954	122.7016	122.7016	122.6838	122.6721	122.6831	122.6954	122.6937	122.7305	122.7061
	-23.416	-23.4305	-23.4998	-23.508	-23.5168	-23.4992	-23.508	-23.5174	-23.4683	-23.4422	-23.4258	-23.4595
Month												
Jan	0.07	0.12	0.17	0.19	0.12	0.10	0.12	0.19	0.09	0.21	0.09	0.15
Feb	0.23	0.22	0.32	0.27	0.30	0.18	0.18	0.32	0.12	0.19	0.25	0.21
Mar	0.18	0.17	0.24	0.32	0.29	0.20	0.21	0.22	0.29	0.19	0.29	0.31
Apr	0.20	0.19	0.22	0.22	0.30	0.30	0.22	0.27	0.22	0.17	0.28	0.18
May	0.19	0.16	0.19	0.27	0.26	0.18	0.20	0.22	0.26	0.12	0.23	0.14
Jun	0.17	0.14	0.21	0.30	0.21	0.19	0.16	0.32	0.12	0.11	0.22	0.14
Jul	0.19	0.20	0.28	0.37	0.27	0.21	0.19	0.31	0.20	0.18	0.16	0.19
Aug	0.12	0.08	0.15	0.26	0.20	0.13	0.17	0.22	0.16	0.08	0.07	0.17
Sep	0.11	0.05	0.06	0.24	0.15	0.07	0.14	0.16	0.04	0.03	0.09	0.08
Oct	0.11	0.02	0.01	0.22	0.11	0.07	0.09	0.12	0.04	0.00	0.12	0.04
Nov	0.12	0.16	0.11	0.28	0.13	0.08	0.09	0.10	0.07	0.03	0.15	0.07
Dec	0.06	0.21	0.10	0.30	0.21	0.09	0.12	0.16	0.05	0.08	0.13	0.12

Area															
Sub-area	C														
Sample Location:	122.6676	122.6494	122.6412	122.6553	122.6463	122.6573	122.6717	122.6666	122.6687	122.6838	122.6927	122.6858	122.6968	122.6913	122.7023
	-23.5124	-23.5027	-23.4872	-23.4853	-23.4803	-23.4746	-23.4721	-23.4636	-23.4491	-23.4375	-23.4236	-23.4129	-23.4041	-23.3937	-23.3874
Month															
Jan	0.19	0.04	0.08	0.09	0.09	0.12	0.09	0.09	0.15	0.10	0.06	0.07	0.10	0.06	0.09
Feb	0.19	0.16	0.19	0.10	0.17	0.08	0.10	0.10	0.16	0.09	0.05	0.06	0.14	0.10	0.13
Mar	0.22	0.12	0.24	0.17	0.23	0.19	0.19	0.17	0.24	0.14	0.12	0.06	0.12	0.12	0.20
Apr	0.23	0.15	0.28	0.22	0.20	0.22	0.14	0.16	0.22	0.11	0.10	0.13	0.19	0.20	0.23
May	0.13	0.08	0.22	0.17	0.16	0.24	0.13	0.12	0.13	0.11	0.06	0.11	0.16	0.15	0.13
Jun	0.21	0.14	0.23	0.15	0.16	0.26	0.11	0.12	0.12	0.06	0.09	0.11	0.19	0.15	0.26
Jul	0.24	0.10	0.17	0.27	0.21	0.26	0.11	0.14	0.14	0.08	0.10	0.06	0.18	0.13	0.19
Aug	0.23	0.10	0.13	0.22	0.13	0.18	0.04	0.08	0.16	0.11	0.05	0.08	0.14	0.13	0.11
Sep	0.18	0.09	0.10	0.11	0.08	0.14	0.03	0.06	0.16	0.09	0.05	0.02	0.13	0.03	0.10
Oct	0.04	0.04	0.06	0.04	0.00	0.03	0.01	0.04	0.15	0.03	0.03	0.06	0.04	0.03	0.07
Nov	0.08	0.09	0.06	0.01	0.04	0.04	0.03	0.09	0.08	0.08	0.01	0.03	0.10	0.07	0.09
Dec	0.18	0.08	0.17	0.09	0.09	0.08	0.09	0.08	0.13	0.08	0.06	0.17	0.13	0.08	0.10

Area	Area Five																				
Sub-area	Waste Dump Areas												SG Halite and Ponds								
Sample Location:	122.763	122.755	122.760	122.781	122.777	122.716	122.736	122.767	122.780	122.778	122.772	122.747	122.784	122.772	122.792	122.786	122.778	122.747	122.8238	122.8118	122.8018
	-23.3486	-23.3530	-23.3615	-23.3615	-23.3533	-23.3795	-23.3814	-23.3836	-23.3231	-23.3369	-23.3269	-23.3234	-23.3086	-23.3067	-23.2991	-23.2919	-23.2887	-23.2846	-23.2954	-23.2907	-23.296
Month																					
Jan	0.09	0.06	0.06	0.11	0.17	0.08	0.11	0.31	0.08	0.26	0.13	0.10	0.02	0.01	0.08	0.03	0.08	0.06	0.00	0.01	0.08
Feb	0.27	0.12	0.10	0.29	0.31	0.12	0.22	0.40	0.18	0.30	0.19	0.12	0.04	0.09	0.25	0.06	0.16	0.12	0.04	0.05	0.18
Mar	0.20	0.14	0.19	0.29	0.24	0.19	0.21	0.33	0.17	0.21	0.19	0.17	0.16	0.16	0.18	0.16	0.19	0.11	0.16	0.11	0.24
Apr	0.27	0.20	0.30	0.32	0.22	0.22	0.20	0.24	0.18	0.26	0.26	0.20	0.20	0.15	0.22	0.22	0.24	0.17	0.08	0.10	0.20
May	0.26	0.14	0.19	0.28	0.19	0.11	0.16	0.30	0.14	0.20	0.34	0.13	0.18	0.06	0.24	0.25	0.24	0.18	0.09	0.11	0.22
Jun	0.22	0.19	0.22	0.31	0.30	0.10	0.14	0.32	0.23	0.27	0.42	0.22	0.19	0.06	0.30	0.20	0.25	0.16	0.02	0.09	0.20
Jul	0.29	0.20	0.36	0.39	0.33	0.12	0.11	0.34	0.27	0.27	0.42	0.26	0.22	0.13	0.28	0.13	0.22	0.20	0.04	0.06	0.13
Aug	0.25	0.17	0.30	0.39	0.31	0.02	0.01	0.39	0.21	0.22	0.39	0.19	0.20	0.15	0.17	0.12	0.11	0.08	0.00	0.04	0.07
Sep	0.16	0.07	0.21	0.30	0.27	0.01	0.01	0.32	0.15	0.18	0.30	0.14	0.17	0.06	0.16	0.10	0.10	0.08	0.06	0.03	0.09
Oct	0.16	0.08	0.21	0.17	0.19	0.04	0.00	0.19	0.11	0.15	0.18	0.08	0.18	0.08	0.06	0.12	0.10	0.04	0.07	0.04	0.08
Nov	0.10	0.06	0.18	0.16	0.19	0.10	0.15	0.19	0.01	0.09	0.17	0.06	0.00	0.07	0.08	0.11	0.09	0.10	0.06	0.01	0.16
Dec	0.12	0.01	0.12	0.18	0.14	0.03	0.13	0.25	0.12	0.06	0.14	0.13	0.01	0.05	0.08	0.06	0.05	0.14	0.03	0.00	0.08

Area Sub-area Sample Location:	No. Observations	Weighted Sum by Month
Month		
Jan	87	52.67
Feb	76	91.39
Mar	93	83.69
Apr	87	63.79
May	92	65.80
Jun	80	70.70
Jul	98	64.70
Aug	108	53.65
Sep	95	43.56
Oct	88	36.93
Nov	89	31.48
Dec	76	41.37



Appendix C: Telfer Aero Weather Station Data.

Note: Owing to the quantity of rainfall data, only days where ≥5mm occurred are displayed here.

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	1974	1	29	16
13030	1975	1	8	6
13030	1975	1	9	7.4
13030	1975	1	22	2.8
13030	1975	1	28	15.2
13030	1975	1	30	11.2
13030	1976	1	10	21.6
13030	1977	1	14	6.6
13030	1978	1	13	6.2
13030	1978	1	18	19.8
13030	1978	1	26	22.5
13030	1978	1	27	8.4
13030	1978	1	31	17.4
13030	1979	1	12	7.6
13030	1980	1	31	26
13030	1981	1	11	7.4
13030	1981	1	17	17.4
13030	1981	1	19	29.8
13030	1982	1	19	11.4
13030	1982	1	20	23.7
13030	1982	1	31	9.4
13030	1983	1	10	119.8
13030	1983	1	28	7.8
13030	1984	1	25	18
13030	1984	1	26	15
13030	1985	1	19	10
13030	1986	1	1	16.2
13030	1986	1	2	15.4
13030	1986	1	6	5.8
13030	1986	1	26	14.4
13030	1987	1	10	19.4
13030	1987	1	20	18
13030	1988	1	11	6.2
13030	1990	1	18	46
13030	1990	1	28	9.4
13030	1991	1	26	20
13030	1992	1	6	6.6
13030	1992	1	7	10.2
13030	1992	1	24	33.6
13030	1992	1	31	29.4
13030	1993	1	22	6
13030	1994	1	18	12
13030	1995	1	17	5.2
13030	1997	1	1	20
13030	1997	1	9	14

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	1997	1	23	14
13030	1997	1	25	26
13030	1997	1	27	24
13030	1998	1	10	30
13030	1998	1	28	10
13030	1999	1	9	19
13030	1999	1	14	22
13030	1999	1	15	11
13030	1999	1	16	20
13030	1999	1	19	14
13030	1999	1	31	6
13030	2000	1	2	6
13030	2000	1	29	1
13030	2000	1	30	11
13030	2001	1	6	6
13030	2001	1	17	20
13030	2001	1	24	55
13030	2001	1	26	15
13030	2001	1	31	5
13030	2002	1	17	9
13030	2002	1	27	14
13030	2003	1	25	12.6
13030	2003	1	26	17
13030	2006	1	1	27
13030	2006	1	24	26
13030	2006	1	26	35
13030	2006	1	27	39
13030	2006	1	29	7
13030	2007	1	4	65
13030	2007	1	14	7
13030	2009	1	24	20.8
13030	2009	1	27	13.6
13030	2010	1	24	6.6
13030	2011	1	2	17.8
13030	2011	1	20	9.6
13030	2011	1	22	8.6
13030	2011	1	29	5.6
13030	2012	1	3	8.2
13030	2012	1	6	17.2
13030	2012	1	11	5.6
13030	2012	1	12	15
13030	2012	1	13	18.6
13030	2012	1	14	6
13030	2012	1	17	35.2
13030	2012	1	22	17.6
13030	2013	1	3	5.6
13030	2013	1	14	5.6

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	2013	1	15	4.8
13030	2013	1	17	16
13030	2013	1	18	15.8
13030	2014	1	19	7.4
13030	2014	1	20	63.6
13030	2014	1	21	39.2
13030	2014	1	22	32
13030	2014	1	26	13.8
13030	2014	1	27	7.4
13030	2015	1	11	18.6
13030	2015	1	25	35
13030	2015	1	30	7.2
13030	2015	1	31	8.8
13030	2016	1	26	22.2
13030	2016	1	28	27.4
13030	1974	2	9	18
13030	1975	2	18	13
13030	1976	2	23	67.2
13030	1976	2	27	9.5
13030	1977	2	7	5.4
13030	1977	2	20	6.8
13030	1978	2	1	6.4
13030	1978	2	2	32.9
13030	1978	2	3	7.4
13030	1978	2	4	11.4
13030	1978	2	11	15.3
13030	1979	2	12	22.2
13030	1979	2	18	12
13030	1979	2	19	13.2
13030	1980	2	1	46.6
13030	1980	2	2	12
13030	1980	2	3	8
13030	1980	2	7	5.6
13030	1980	2	8	12.6
13030	1980	2	15	13.2
13030	1980	2	16	26.6
13030	1980	2	17	34
13030	1980	2	18	68.4
13030	1980	2	19	9.8
13030	1980	2	20	30.4
13030	1981	2	1	6.2
13030	1981	2	3	9.2
13030	1981	2	4	66
13030	1981	2	10	12.6
13030	1981	2	14	41
13030	1981	2	15	53.4
13030	1981	2	18	45.6

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	1981	2	19	33
13030	1981	2	20	26.8
13030	1982	2	16	35
13030	1982	2	19	6.8
13030	1982	2	20	29.4
13030	1982	2	23	5.2
13030	1982	2	24	18.4
13030	1982	2	26	9.4
13030	1982	2	27	28.8
13030	1982	2	28	63.4
13030	1983	2	2	7.2
13030	1984	2	22	9
13030	1984	2	29	24.2
13030	1985	2	7	5.6
13030	1985	2	11	8.4
13030	1986	2	18	5.8
13030	1986	2	21	26.2
13030	1986	2	27	10
13030	1987	2	1	19.4
13030	1987	2	3	6.6
13030	1987	2	4	9.4
13030	1987	2	5	8.2
13030	1987	2	11	17.2
13030	1987	2	12	9.8
13030	1987	2	25	5.2
13030	1987	2	26	63.2
13030	1988	2	1	7.4
13030	1988	2	2	10.6
13030	1988	2	6	16.6
13030	1989	2	19	7.6
13030	1989	2	28	4.2
13030	1990	2	19	9.8
13030	1990	2	25	8.2
13030	1993	2	2	7
13030	1993	2	3	10
13030	1993	2	4	112.2
13030	1993	2	5	14
13030	1993	2	8	7
13030	1994	2	15	29
13030	1994	2	20	31.6
13030	1994	2	22	38
13030	1994	2	23	4.8
13030	1994	2	28	5.6
13030	1995	2	4	18
13030	1995	2	5	24
13030	1995	2	9	50
13030	1995	2	12	68.5

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	1995	2	13	28
13030	1995	2	16	93
13030	1995	2	18	17
13030	1995	2	19	15
13030	1995	2	24	8.2
13030	1996	2	4	5
13030	1996	2	20	22
13030	1997	2	1	38
13030	1997	2	2	16
13030	1997	2	5	16
13030	1997	2	8	51
13030	1997	2	11	46
13030	1997	2	16	21
13030	1998	2	2	87
13030	1998	2	3	48
13030	1999	2	2	11
13030	1999	2	4	16
13030	1999	2	5	8
13030	1999	2	9	15
13030	1999	2	11	5
13030	1999	2	19	13
13030	1999	2	20	5
13030	1999	2	21	29
13030	1999	2	22	72
13030	1999	2	23	28
13030	2000	2	18	30
13030	2000	2	19	61
13030	2000	2	21	20
13030	2000	2	26	63
13030	2000	2	27	21
13030	2001	2	1	26
13030	2001	2	9	27
13030	2001	2	14	15
13030	2001	2	16	35
13030	2001	2	20	9
13030	2001	2	21	56
13030	2002	2	2	60
13030	2002	2	3	15
13030	2002	2	6	32
13030	2002	2	7	15
13030	2002	2	13	8
13030	2002	2	25	15
13030	2002	2	26	44
13030	2002	2	27	9
13030	2003	2	2	11
13030	2003	2	13	6
13030	2003	2	23	11

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	2003	2	25	10
13030	2003	2	28	10
13030	2004	2	2	8
13030	2004	2	13	49
13030	2004	2	16	35
13030	2004	2	20	44
13030	2004	2	21	8
13030	2004	2	22	17
13030	2004	2	26	10
13030	2004	2	27	9
13030	2004	2	28	9
13030	2005	2	22	6
13030	2006	2	8	26
13030	2006	2	9	6
13030	2006	2	24	9
13030	2006	2	27	7
13030	2008	2	1	5
13030	2008	2	8	11
13030	2008	2	10	10
13030	2008	2	23	22.6
13030	2009	2	20	5
13030	2009	2	21	27
13030	2009	2	27	9.2
13030	2009	2	28	15.8
13030	2010	2	2	22.6
13030	2010	2	9	8.4
13030	2010	2	10	6.8
13030	2011	2	3	5.4
13030	2011	2	4	5.6
13030	2011	2	9	5.2
13030	2011	2	12	30.2
13030	2011	2	15	18.2
13030	2011	2	16	10
13030	2011	2	19	10.2
13030	2011	2	23	10.8
13030	2013	2	15	15
13030	2013	2	21	7.2
13030	2013	2	26	28.8
13030	2013	2	27	68.8
13030	2013	2	28	177
13030	2014	2	11	98.2
13030	2014	2	12	42.2
13030	2015	2	3	7
13030	2015	2	4	7
13030	2015	2	26	7.6
13030	2016	2	1	5.6
13030	1975	3	23	7.8

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	1975	3	24	8.2
13030	1975	3	30	5
13030	1976	3	1	12.6
13030	1976	3	2	11.6
13030	1976	3	3	11
13030	1976	3	7	26.6
13030	1976	3	8	24.4
13030	1976	3	9	18.2
13030	1977	3	27	5.4
13030	1977	3	28	11
13030	1977	3	30	5.2
13030	1978	3	3	14.2
13030	1978	3	12	9.8
13030	1978	3	14	7
13030	1978	3	31	12.8
13030	1979	3	2	18.4
13030	1979	3	5	11
13030	1979	3	12	26.6
13030	1980	3	22	12.2
13030	1981	3	1	16
13030	1981	3	22	11.4
13030	1981	3	24	5.6
13030	1982	3	5	5
13030	1982	3	19	11.8
13030	1983	3	10	8.4
13030	1983	3	20	24
13030	1983	3	30	27.4
13030	1983	3	31	11.4
13030	1984	3	1	27.4
13030	1984	3	8	17.2
13030	1984	3	9	38
13030	1985	3	7	11
13030	1985	3	9	5
13030	1985	3	10	14
13030	1985	3	11	19.2
13030	1985	3	12	48.8
13030	1986	3	4	8.4
13030	1986	3	5	1.8
13030	1986	3	6	2.8
13030	1988	3	14	10.6
13030	1988	3	26	7
13030	1988	3	29	13.8
13030	1988	3	30	91.2
13030	1989	3	24	36.2
13030	1989	3	29	8.2
13030	1992	3	29	43
13030	1992	3	30	22

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	1995	3	21	16
13030	1995	3	22	34.4
13030	1995	3	23	13
13030	1996	3	7	7
13030	1996	3	12	10
13030	1996	3	13	73.4
13030	1996	3	14	8
13030	1998	3	7	37
13030	1998	3	18	43
13030	1998	3	28	7
13030	2000	3	5	11
13030	2000	3	6	47
13030	2000	3	9	18
13030	2000	3	10	97
13030	2000	3	13	6
13030	2000	3	15	8
13030	2000	3	17	33
13030	2000	3	26	27
13030	2001	3	4	25
13030	2001	3	5	5
13030	2001	3	11	15
13030	2001	3	18	9
13030	2002	3	1	70
13030	2003	3	1	175
13030	2003	3	2	62
13030	2004	3	1	30
13030	2004	3	28	159.4
13030	2004	3	29	199.6
13030	2004	3	30	9.8
13030	2005	3	4	13
13030	2005	3	26	12
13030	2006	3	12	5
13030	2006	3	13	25
13030	2006	3	14	38
13030	2006	3	15	5
13030	2006	3	31	9
13030	2007	3	3	9
13030	2007	3	9	5
13030	2007	3	10	93
13030	2007	3	11	25
13030	2007	3	12	49
13030	2007	3	13	73
13030	2007	3	18	62
13030	2007	3	22	29
13030	2007	3	27	39
13030	2007	3	28	70
13030	2007	3	31	6

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	2008	3	24	13
13030	2009	3	4	25.6
13030	2011	3	1	86.8
13030	2011	3	5	15.6
13030	2011	3	8	8.8
13030	2011	3	9	48
13030	2011	3	16	20.2
13030	2011	3	19	9.4
13030	2012	3	16	6.4
13030	2012	3	17	30.6
13030	2012	3	18	17.6
13030	2015	3	4	17.6
13030	2015	3	17	5
13030	1974	4	3	6.2
13030	1974	4	7	36.2
13030	1974	4	8	26.6
13030	1974	4	16	15.4
13030	1977	4	1	24.6
13030	1977	4	21	12.4
13030	1979	4	29	5.8
13030	1980	4	19	14.4
13030	1980	4	21	19.6
13030	1983	4	1	14.8
13030	1983	4	25	11.8
13030	1984	4	27	14.8
13030	1985	4	20	19.2
13030	1985	4	22	5.6
13030	1992	4	13	11
13030	1992	4	28	29.4
13030	1996	4	12	5
13030	1998	4	15	5
13030	1999	4	8	25
13030	1999	4	9	58
13030	1999	4	13	11
13030	2000	4	4	60
13030	2000	4	5	13
13030	2000	4	15	17
13030	2000	4	18	17
13030	2003	4	10	10
13030	2004	4	4	13
13030	2006	4	17	52
13030	2008	4	2	7
13030	2011	4	7	40
13030	2011	4	8	72.8
13030	2013	4	3	18.4
13030	2015	4	21	16.4
13030	1974	5	2	8.4

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	1974	5	5	7.6
13030	1977	5	14	12.2
13030	1978	5	10	20
13030	1978	5	11	6
13030	1978	5	14	14.8
13030	1978	5	15	29.8
13030	1978	5	22	5.8
13030	1979	5	3	20
13030	1979	5	13	13.8
13030	1979	5	19	6.2
13030	1979	5	21	11
13030	1981	5	26	5.8
13030	1982	5	21	20.2
13030	1988	5	10	18.8
13030	1988	5	11	28.2
13030	1988	5	14	44
13030	1988	5	22	30
13030	1990	5	15	7.8
13030	1993	5	2	9
13030	1993	5	4	20.8
13030	1997	5	9	49
13030	1997	5	10	49
13030	1997	5	11	5
13030	2000	5	22	15
13030	2000	5	24	48
13030	2004	5	13	13
13030	2004	5	16	8
13030	2004	5	22	9
13030	2004	5	23	12
13030	2004	5	31	11
13030	2009	5	27	14.4
13030	2010	5	19	38.6
13030	2011	5	7	7.8
13030	2013	5	15	11.8
13030	2013	5	20	8
13030	2013	5	21	12.6
13030	2015	5	22	22.4
13030	2015	5	25	5.2
13030	1975	6	23	13.4
13030	1975	6	28	5
13030	1978	6	25	7
13030	1979	6	8	7.4
13030	1986	6	6	11.6
13030	1986	6	7	7.8
13030	1986	6	19	8.4
13030	1989	6	8	5.6
13030	1989	6	9	21.4

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	1989	6	19	11.4
13030	1991	6	7	7.6
13030	1991	6	14	27.7
13030	1993	6	10	22.4
13030	1995	6	13	20.4
13030	1996	6	19	6
13030	1996	6	21	7
13030	1998	6	13	16
13030	1998	6	18	17
13030	1998	6	19	33
13030	1999	6	6	5
13030	1999	6	12	24
13030	1999	6	14	7
13030	1999	6	15	14
13030	2001	6	12	24
13030	2005	6	18	13
13030	2008	6	11	5.8
13030	2013	6	3	15
13030	2013	6	4	25
13030	2013	6	5	11.8
13030	2013	6	19	9.8
13030	2013	6	26	29.6
13030	1974	7	29	5.2
13030	1974	7	30	6.3
13030	1975	7	3	6.1
13030	1978	7	6	44
13030	1980	7	12	10
13030	1980	7	28	18.4
13030	1981	7	7	7.4
13030	1981	7	8	6
13030	1986	7	10	9.2
13030	1986	7	21	27.2
13030	1986	7	22	39.8
13030	1991	7	20	7.2
13030	1998	7	1	8
13030	1998	7	2	22
13030	1998	7	16	7
13030	2001	7	14	28
13030	2001	7	15	43
13030	2005	7	11	56
13030	2005	7	12	30
13030	2007	7	16	9
13030	2010	7	5	54
13030	2010	7	9	11
13030	2011	7	13	10.8
13030	2014	7	13	13
13030	1978	8	1	25

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	1978	8	2	12
13030	1978	8	3	6.6
13030	1978	8	6	9.8
13030	1984	8	20	5.4
13030	1993	8	14	47.4
13030	1997	8	6	9
13030	1997	8	31	8
13030	1998	8	2	47
13030	2003	8	12	7
13030	1974	9	7	5.1
13030	1982	9	21	15.4
13030	1984	9	10	13.4
13030	1984	9	28	10.4
13030	2010	9	15	15.8
13030	1974	10	14	7.5
13030	1976	10	9	7.8
13030	1978	10	28	12
13030	1986	10	1	5.6
13030	1999	10	29	19
13030	2011	10	22	5.6
13030	2011	10	31	21.6
13030	1974	11	23	16.8
13030	1975	11	15	6.2
13030	1980	11	21	12.8
13030	1983	11	11	13.2
13030	1983	11	30	120.6
13030	1984	11	29	10.6
13030	1985	11	19	6
13030	1985	11	20	49.6
13030	1986	11	3	6.2
13030	1987	11	6	6.4
13030	1988	11	14	8.6
13030	1988	11	18	11.6
13030	1990	11	21	10.8
13030	1993	11	6	8.4
13030	1995	11	18	6.6
13030	1995	11	19	5.8
13030	1996	11	23	10
13030	2000	11	21	47
13030	2003	11	25	6
13030	2004	11	22	41
13030	2009	11	7	8.4
13030	2009	11	8	24.4
13030	2011	11	1	30.2
13030	2011	11	21	34.2
13030	2012	11	25	16
13030	2014	11	14	7.2

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	2014	11	18	15.2
13030	1974	12	9	7.8
13030	1974	12	24	16.4
13030	1975	12	7	9
13030	1975	12	17	50.8
13030	1977	12	5	16
13030	1981	12	10	9.3
13030	1981	12	12	8.8
13030	1982	12	16	66
13030	1984	12	3	5
13030	1984	12	4	23.4
13030	1984	12	6	5.4
13030	1984	12	20	24
13030	1985	12	31	42
13030	1986	12	15	5.2
13030	1987	12	11	9.6
13030	1987	12	12	8.3
13030	1987	12	25	5.8
13030	1988	12	17	11.8
13030	1989	12	13	17
13030	1989	12	26	16
13030	1993	12	17	84
13030	1993	12	18	202.4
13030	1994	12	8	12.4
13030	1994	12	19	94.2
13030	1994	12	23	40.8
13030	1995	12	10	59
13030	1995	12	11	32.4
13030	1995	12	13	9.2
13030	1995	12	17	14
13030	1995	12	20	6
13030	1995	12	21	81.8
13030	1996	12	20	7
13030	1996	12	31	47
13030	1997	12	6	23
13030	1997	12	7	9
13030	1997	12	20	31
13030	1998	12	3	9
13030	1998	12	6	7
13030	1998	12	15	7
13030	1998	12	27	25
13030	1999	12	5	12
13030	1999	12	11	14
13030	1999	12	13	6
13030	1999	12	14	26
13030	1999	12	16	5
13030	2000	12	8	7

Bureau of Meteorology station number	Year	Month	Day	Rainfall amount (millimetres)
13030	2000	12	9	17
13030	2000	12	10	44
13030	2002	12	16	5
13030	2004	12	8	6
13030	2004	12	12	5
13030	2004	12	13	5
13030	2005	12	20	15
13030	2005	12	21	13
13030	2005	12	30	12
13030	2005	12	31	46
13030	2006	12	2	7
13030	2006	12	3	13
13030	2006	12	17	5
13030	2007	12	10	19
13030	2009	12	21	18.6
13030	2009	12	22	28.2
13030	2009	12	23	33.4
13030	2010	12	20	39.6
13030	2011	12	30	14.4
13030	2012	12	6	5
13030	2012	12	25	6.4
13030	2013	12	6	5.4
13030	2013	12	7	18
13030	2013	12	10	6.2
13030	2013	12	11	11.2
13030	2013	12	22	6.4
13030	2013	12	23	36.8
13030	2014	12	11	5
13030	2014	12	13	5
13030	2014	12	20	16.8
13030	2015	12	19	9.4