FLORA AND VEGETATION IMPACT ASSESSMENT

LAKE DISAPPOINTMENT POTASH PROJECT

Prepared For

Reward Minerals Limited

October 2018

FINAL

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Glossary

Acronym	Description
ANCA	Australian Nature Conservation Agency.
BAM Act	Biosecurity and Agriculture Management Act 2007, WA Government.
BC	Botanica Consulting.
BoM	Bureau of Meteorology.
CALM	Department of Conservation and Land Management (now DBCA), WA Government.
DAFWA	Department of Agriculture and Food (now DPIRD), WA Government.
DEC	Department of Environment and Conservation (now DBCA), WA Government.
DER	Department of Environment Regulation (now DWER), WA Government.
DMIRS	Department of Mines, Industry Regulation and Safety (formerly DMP), WA Government
DMP	Department of Mines and Petroleum (now DMIRS), WA Government.
DotEE	Department of the Environment and Energy (formerly DSEWPaC), Australian Government.
DoW	Department of Water (now DWER), WA Government.
DPaW	Department of Parks and Wildlife (now DBCA), WA Government.
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (now DotE, formerly DEH, DEWHA), Australian Government.
EP Act	Environmental Protection Act 1986, WA Government.
EP Regulations	Environmental Protection (Clearing of Native Vegetation) Regulations 2004, WA Government.
EPA	Environmental Protection Authority (now DWER), WA Government.
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999, Australian Government.
ESA	Environmentally Sensitive Area.
ET	Evapotranspiration.

Acronym	Description
GDE	Groundwater Dependent Ecosystem.
Ha	Hectare (10,000 square metres).
IBRA	Interim Biogeographic Regionalisation for Australia.
IUCN	International Union for the Conservation of Nature and Natural Resources – commonly known as the World Conservation Union.
Km	Kilometre (1,000 metres).
LDP Project	Lake Disappointment Potash Project (including Talawana Track)
MVG	Major Vegetation Groups.
NDVI	Normalised Difference Vegetation Index.
NDWI	Normalised Difference Wetness Index.
NVIS	National Vegetation Information System.
PEC	Priority Ecological Community.
Reward	Reward Minerals Limited.
TEC	Threatened Ecological Community.
WA	Western Australia.
WAHERB	Western Australian Herbarium.
WC Act	Wildlife Conservation Act 1950, WA Government.

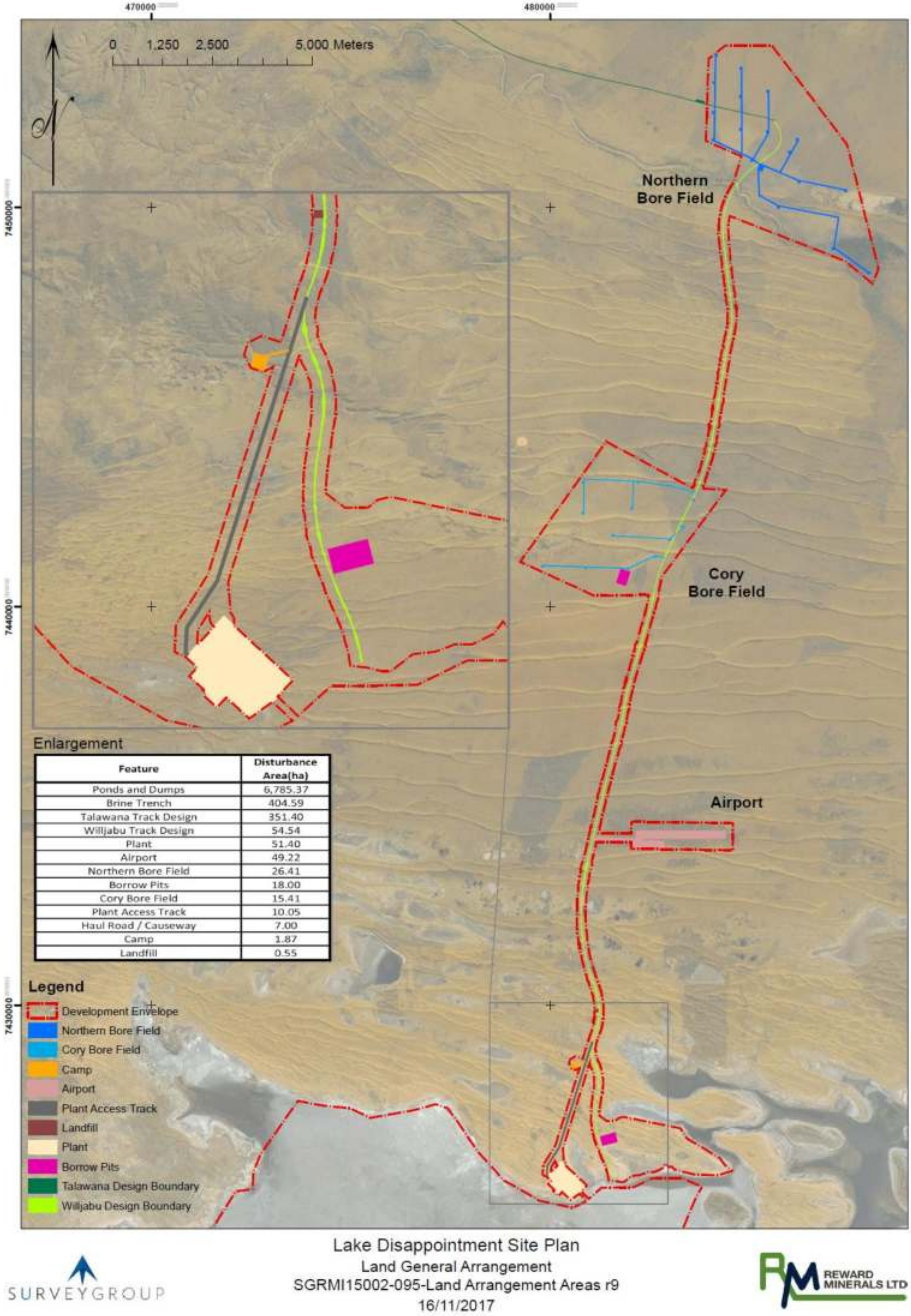
1 Introduction and Project Overview

Reward Minerals Limited (Reward) proposes to abstract potassium-rich brines from sediments associated with Lake Disappointment, approximately 320 km east of the town of Newman WA and to produce sulphate of potash by means of solar evaporation of the brine. The proposal includes the construction and use of associated mine infrastructure including brine trenches, water supply bore fields, a processing plant, an airstrip, an accommodation camp and roads. Waste salt would be stored in permanent stockpiles on the Lake Disappointment playa. The development envelope (encompassing the mining project area and Talawana track) covers a total area of ~39,977 ha. The disturbance footprint covers a total area of ~7,776 ha. Details on the disturbance footprint are provided in Table 1-1. Maps of the disturbance footprint and development envelope[1] are provided in Figure 1-1 to Figure 1-3.

Table 1-1: Lake Disappointment Potash Project Disturbance Footprint

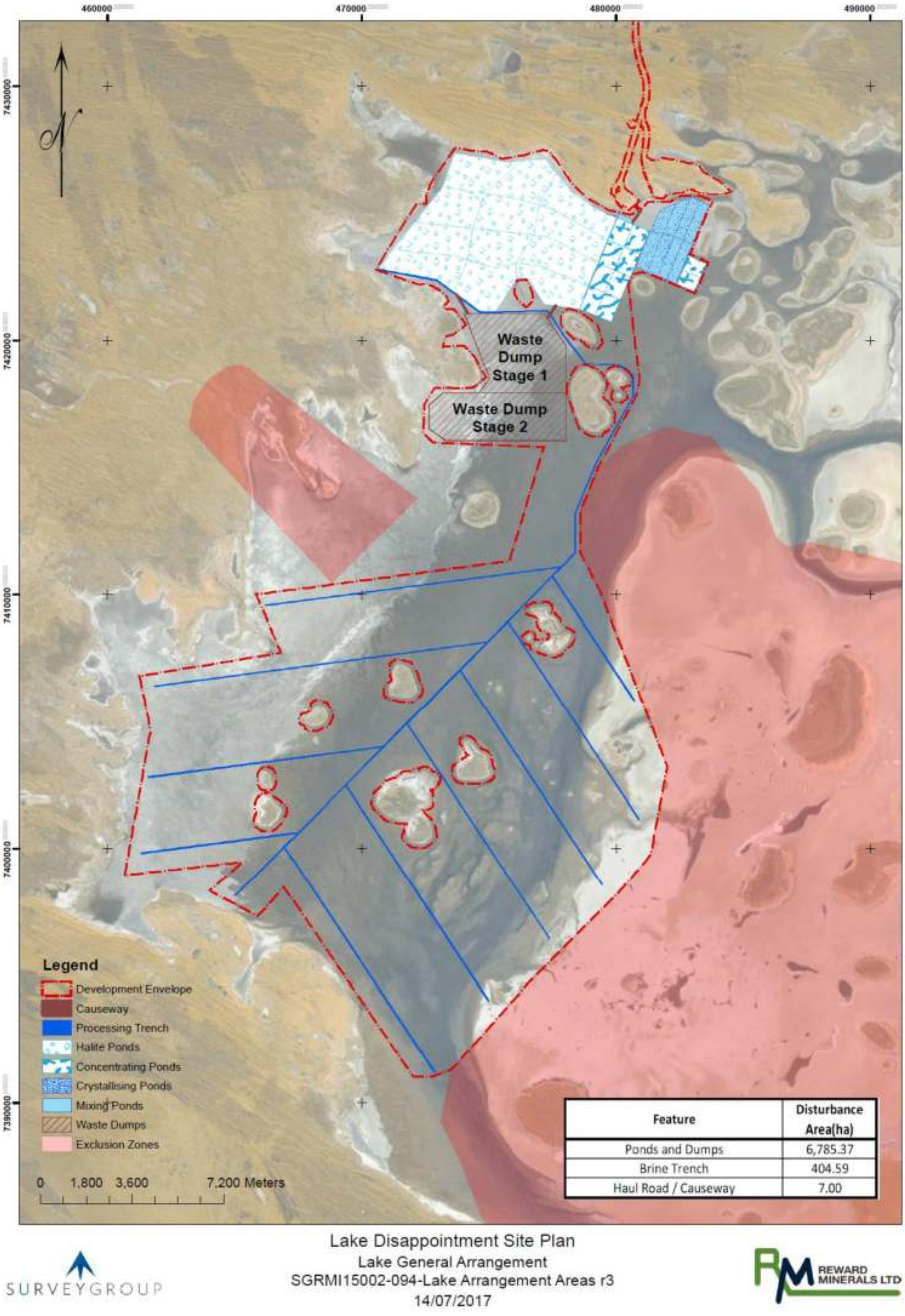
Feature	Disturbance Footprint (ha)[2]
Ponds and Dumps	6785
Brine Trenches	405
Talawana Track	351
Willjabu Track	55
Plant	51
Airport	49
Northern Bore Field	26
Cory Bore Field	15
Borrow Pits	18
Plant Access Track	10
Haul Road / Causeway	7
Camp	2
Landfill	1
TOTAL	**7776**

[1] Development envelope of Talawana track exactly coincides with the Talawana track disturbance footprint
[2] Existing clearing of Talawana track and Willjabu track included in disturbance footprint calculations (that is, the disturbance footprint area includes both the existing cleared formation and proposed new clearing for upgrade of the tracks)



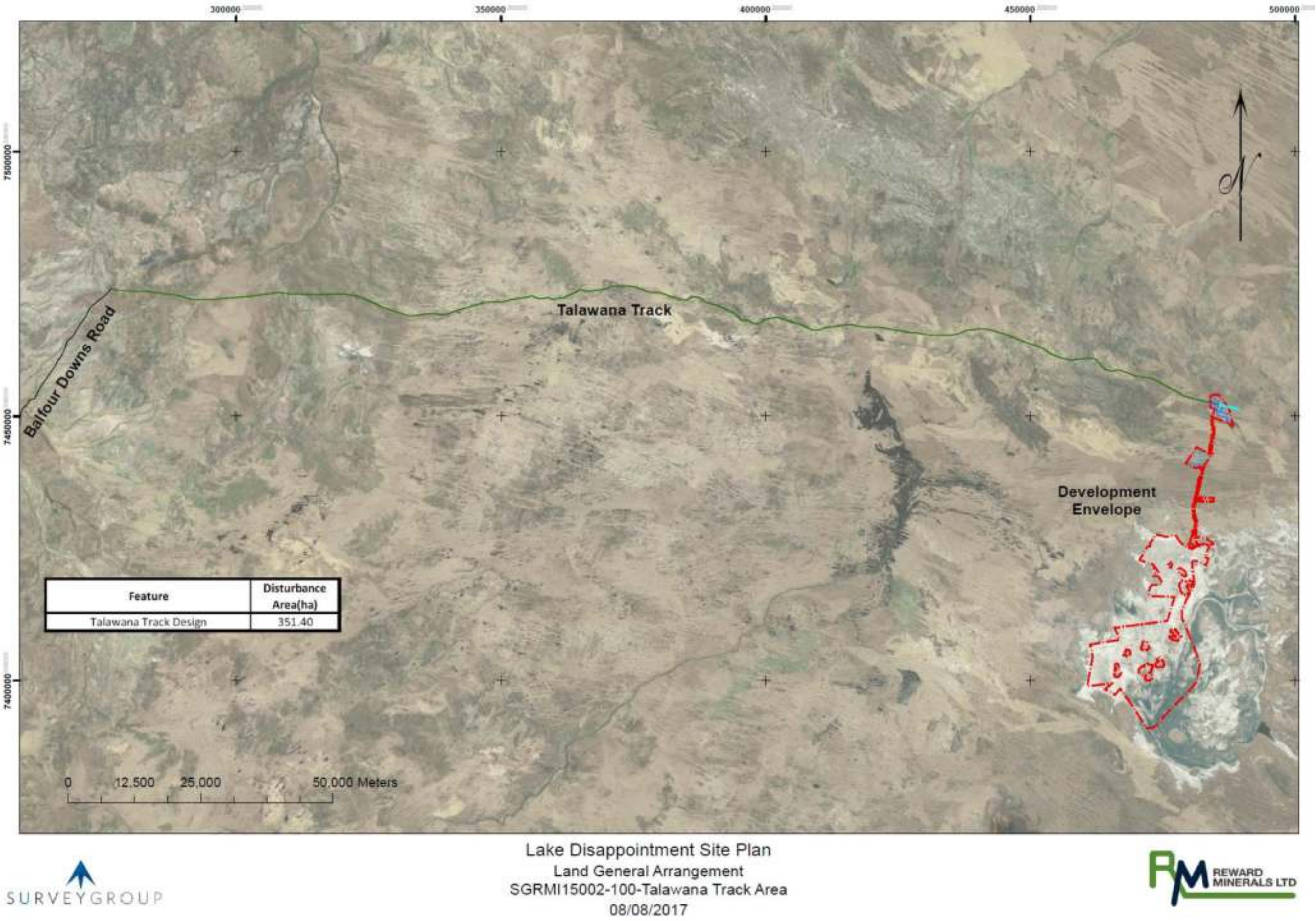
Feature	Disturbance Area(ha)
Ponds and Dumps	6,785.37
Brine Trench	404.59
Talawana Track Design	351.40
Willjabu Track Design	54.54
Plant	51.40
Airport	49.22
Northern Bore Field	26.41
Borrow Pits	18.00
Cory Bore Field	15.41
Plant Access Track	10.05
Haul Road / Causeway	7.00
Camp	1.87
Landfill	0.55

Figure 1-1: Lake Disappointment Potash Project-Land Arrangement Site Plan



Feature	Disturbance Area(ha)
Ponds and Dumps	6,785.37
Brine Trench	404.59
Haul Road / Causeway	7.00

Figure 1-2: Lake Disappointment Potash Project-Lake Arrangement Site Plan



Feature	Disturbance Area(ha)
Talawana Track Design	351.40

Figure 1-3: Lake Disappointment Potash Project-Talawana Track Site Plan

2 Objectives

The objectives of the flora and vegetation impact assessment were to:

- Describe the existing flora and vegetation within the disturbance footprint/ development envelope including its significance within a wider regional context.
- Provide comprehensive mapping of vegetation types and significant flora in relation to the proposed disturbance footprint/ development envelope including maps depicting vegetation boundaries overlying aerial photography.
- Describe the local and regional conservation significance of each vegetation type. Identify those vegetation types which are likely to be groundwater dependent ecosystems (GDE). Provide details of the methodology used in the identification and mapping of GDEs.
- Assess the potential direct impacts associated with the proposal on the flora and vegetation within the disturbance footprint/ development envelope using a quantitative assessment that addresses numbers and proportions of individuals, populations and associations in the local and regional context; especially those species and communities of conservation significance.
- Assess the potential indirect impacts associated with the proposal on the flora and vegetation within the disturbance footprint/ development envelope.
- Assess whether the impacts of the proposed development on flora and vegetation trigger a requirement for offsets in order to satisfy the EPA *WA Environmental Offsets Policy* (2011) and *WA Environmental Offsets Guidelines* (2014).

3 Flora and Vegetation within the Development Envelope/ Disturbance Footprint

A Level 2 flora survey was conducted by Botanica Consulting (BC) over a total area of 134,800 ha, encompassing the entire development envelope and disturbance footprint. Fourteen vegetation types were identified within the disturbance footprint (eleven of which are located within the development envelope encompassing the mining operations area). The total area of each vegetation type within the disturbance footprint and development envelope is listed in Table 3-1 below. Vegetation within the development envelope covered an area of 3875[3] ha (accounts for 10% of the total development envelope). Vegetation within the disturbance footprint covered an area of 410[3] ha (accounts for 5% of the total disturbance footprint). The remaining area (35,934 ha of the development envelope and 7198 ha of disturbance footprint) is situated on the Lake Disappointment playa surface in areas devoid of vascular vegetation, algae and other non-vascular macrophytes (Bennelongia, 2017). Maps showing the development envelope in relation to terrestrial vegetation types identified in the flora and vegetation survey conducted by Botanica Consulting are provided in Figure 4 to Figure 3-5. An assessment of the direct impacts on each vegetation type at a local (based on total area surveyed by BC, 2017) and regional scale (based on *2017 Statewide Vegetation Statistics* (DPaW, 2017) is provided in Table 3-2.

Table 3-1: Vegetation Types within the development envelope and disturbance footprint

		DISTURBANCE FOOTPRINT		DEVELOPMENT ENVELOPE	
Vegetation Type	**Vegetation Code**	**Total Area (ha)**	**Total Area (%)**	**Total Area (ha)**	**Total Area (%)**
Heath of mixed *Tecticornia* spp. on salt lake edge	CD-CSSSF1	0	0.00	56	0.14
Open mixed herbs in clay-loam depression	CD-OGHSR1	3	0.03	34	0.09
Low forest of *Allocasuarina decaisneana* over open scrub of *Acacia/ Grevillea* and mid-dense hummock grass of *Triodia basedowii* on sand dunes/ swales	D-CFW1	6	0.08	6	0.02
Open low woodland of *Corymbia opaca* over low scrub of *Acacia/Grevillea* spp. and mid-dense hummock grass of *Triodia basedowii* on sand dunes/ swales Scrub of *Acacia/Eremophila/Grevillea* spp. over mid-dense hummock grass of *Triodia basedowii* on sand dunes/ swales	D-HG (D-HG1 & D-HG2 inclusive)	257	3.30	1753	4.38
Open low woodland of *Eucalyptus camaldulensis/ Corymbia* spp. over mid-dense hummock grass of *Triodia* spp. in creekline	OD-EW1	33	0.43	628	1.57
Low woodland of *Acacia* spp. over low scrub of *Senna artemisioides* and mixed dwarf scrub in drainage depression	OD-AFW1	3	0.04	102	0.25
Low woodland of *Hakea lorea/ Melaleuca glomerata* over low heath of *Fimbristylis eremophila* in drainage depression	OD-OS1	0	0.00	2	0.01
Open low woodland of *Corymbia* spp./ *Hakea lorea* over low scrub of *Acacia* spp. and mid-dense hummock grass of *Triodia* spp. in sandplain	P-HG (P-HG1 & P-HG2 inclusive)	83	1.06	1253	3.14

[3] Excludes 168ha previously cleared for the Talawana track and area covered by un-vegetated parts of the salt lake

		DISTURBANCE FOOTPRINT		DEVELOPMENT ENVELOPE	
Vegetation Type	**Vegetation Code**	**Total Area (ha)**	**Total Area (%)**	**Total Area (ha)**	**Total Area (%)**
Open shrub mallee of *Eucalyptus gamophylla/ E. kingsmillii* subsp. *kingsmillii* over low scrub of *Acacia bivenosa* and mid-dense hummock grass of *Triodia basedowii* in sandplain					
Scrub of *Acacia* spp. over mixed low scrub and mid-dense hummock grass of *Triodia pungens* on rocky hillslope	RH-AFW1	12	0.15	12	0.03
Open shrub mallee of *Eucalyptus gamophylla/ E. kingsmillii* subsp. *kingsmillii* over low scrub of Acacia/ *Grevillea* spp. and mid-dense hummock grass of *Triodia* spp. on rocky hillslope	RH-MWS1	6	0.08	22	0.05
Low woodland of *Acacia* spp. over low scrub of *Eremophila/ Senna* spp. and mid-dense hummock grass of *Triodia basedowii* on rocky plain	RP-AFW1	5	0.07	5	0.01
Open low woodland of *Corymbia aspera* over low scrub of *Acacia* spp. and mid-dense hummock grass of *Triodia basedowii* on rocky plain	RP-HG1	3	0.03	3	0.01
TOTAL (Vegetation)		**410**	**5**	**3875**	**10**
Cleared Vegetation (Talawana track)	CV	168	2.2	168	0.4
Salt Lake (not vegetated)	CD-SL (Lake Disappointment)	7198	92.6	35,934	90.0
TOTAL (Cleared Vegetation/ Playa)		**7366**	**95**	**36,102**	**90**
TOTAL (Vegetation and Cleared Vegetation/ Playa)		**7776**	**100**	**39,977**	**100**

Table 3-2: Area of Direct Impact to Vegetation-Local and Regional Scale

<table>
<tr><th colspan="2">Local Floristic Communities</th><th colspan="5">Local Impacts</th><th>Regional Floristic Communities</th><th colspan="6">Regional Impacts</th></tr>
<tr><th>Vegetation Description</th><th>Vegetation Code</th><th>Total Area - Development Envelope (ha)</th><th>Total Area- Disturbance Footprint (ha)</th><th>Total Area- survey area (ha)</th><th>% local habitat (survey area) intersected by Development Envelope</th><th>% local habitat (survey area) proposed to be impacted- Disturbance Footprint</th><th>Pre-European Vegetation</th><th>Total Area in PIL1 subregion (ha)</th><th>Total Area in PIL2 subregion (ha)</th><th>Total Area in LSD1 subregion (ha)</th><th>Total Area in LSD2 subregion (ha)</th><th>% regional habitat intersected by Development Envelope</th><th>% regional habitat proposed to be impacted (Disturbance Footprint)</th></tr>
<tr><td>Heath of mixed Tecticornia spp. on salt lake edge</td><td>CD-CSSSF1</td><td>56</td><td>0</td><td>5984</td><td>0.94</td><td>0.00</td><td>Little Sandy Desert 125-Bare areas; salt lakes</td><td></td><td></td><td>979.85</td><td>225,060.80</td><td>0.0248</td><td>0.0000</td></tr>
<tr><td>Open mixed herbs in clay-loam depression</td><td>CD-OGHSR1</td><td>34</td><td>3</td><td>478</td><td>7.18</td><td>0.56</td><td>Little Sandy Desert 134-Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex (on) sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills</td><td>828.54</td><td>99.81</td><td>10003.11</td><td>7,363,935.12</td><td>0.0005</td><td>0.0000</td></tr>
<tr><td>Low forest of Allocasuarina decaisneana over open scrub of Acacia/ Grevillea and mid-dense hummock grass of Triodia basedowii on sand dunes/ swales</td><td>D-CFW1</td><td>6</td><td>6</td><td>642</td><td>0.93</td><td>0.94</td><td>Little Sandy Desert 194-Hummock grasslands, tree steppe; desert oak & hard spinifex between sandhills</td><td></td><td></td><td></td><td>59,063.95</td><td>0.0102</td><td>0.0102</td></tr>
<tr><td>Open low woodland of Corymbia opaca over low scrub of Acacia/Grevillea spp. and mid-dense hummock grass of Triodia basedowii on sand dunes/ swales</td><td>D-HG1</td><td rowspan="2">1753</td><td rowspan="2">257</td><td rowspan="2">36,118</td><td rowspan="2">4.85</td><td rowspan="2">0.71</td><td>Little Sandy Desert 134-Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex (on) sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills</td><td>828.54</td><td>99.81</td><td>10003.11</td><td>7,363,935.12</td><td>0.0238</td><td>0.0032</td></tr>
<tr><td>Scrub of Acacia/Eremophila/Grevillea spp. over mid-dense hummock grass of Triodia basedowii on sand dunes/ swales</td><td>D-HG2</td><td>Little Sandy Desert 158-Hummock grasslands, shrub steppe; kanji over Triodia basedowii</td><td></td><td></td><td>178,188.03</td><td>49274.46</td><td>0.7707</td><td>0.1130</td></tr>
<tr><td>Low woodland of Acacia spp. over low scrub of Senna artemisioides and mixed dwarf scrub in drainage depression</td><td>OD-AFW1</td><td>102</td><td>3</td><td>516</td><td>19.77</td><td>0.58</td><td>Little Sandy Desert 99-Hummock grasslands, shrub steppe; Acacia coriacea & Hakea over hard spinifex Triodia basedowii</td><td></td><td></td><td>398,672.56</td><td>65,175.27</td><td>0.0220</td><td>0.0006</td></tr>
<tr><td rowspan="3">Open low woodland of Eucalyptus camaldulensis/ Corymbia spp. over mid-dense hummock grass of Triodia spp. in creekline</td><td rowspan="3">OD-EW1</td><td rowspan="3">628[4]</td><td rowspan="3">33[5]</td><td rowspan="3">3029</td><td rowspan="3">20.73</td><td rowspan="3">1.09</td><td>Little Sandy Desert 99-Hummock grasslands, shrub steppe; Acacia coriacea & Hakea over hard spinifex Triodia basedowii</td><td></td><td></td><td>398,672.56</td><td>65,175.27</td><td>0.1354</td><td>0.0071</td></tr>
<tr><td>Little Sandy Desert 117-Hummock grasslands, grass steppe; soft spinifex</td><td></td><td></td><td>191412.37</td><td>95838.81</td><td>0.2186</td><td>0.0115</td></tr>
<tr><td>Little Sandy Desert 134-Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex (on) sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills</td><td>828.54</td><td>99.81</td><td>10003.11</td><td>7,363,935.12</td><td>0.0085</td><td>0.0004</td></tr>
</table>

[4] 616 ha of OD-EW1 within the development envelope is associated with McKay creek. The remaining area is associated with un-named, non-perennial drainage lines
[5] 22 ha of OD-EW1 within the disturbance footprint is associated with McKay creek. The remaining area is associated with un-named, non-perennial drainage lines

Local Floristic Communities		Local Impacts					Regional Floristic Communities	Regional Impacts					
Vegetation Description	**Vegetation Code**	**Total Area - Development Envelope (ha)**	**Total Area-Disturbance Footprint (ha)**	**Total Area-survey area (ha)**	**% local habitat (survey area) intersected by Development Envelope**	**% local habitat (survey area) proposed to be impacted-Disturbance Footprint**	**Pre-European Vegetation**	**Total Area in PIL1 subregion (ha)**	**Total Area in PIL2 subregion (ha)**	**Total Area in LSD1 subregion (ha)**	**Total Area in LSD2 subregion (ha)**	**% regional habitat intersected by Development Envelope**	**% regional habitat proposed to be impacted (Disturbance Footprint)**
Low woodland of *Hakea lorea/ Melaleuca glomerata* over low heath of *Fimbristylis eremophila* in drainage depression	OD-OS1	2	0	698	0.29	0.00	Little Sandy Desert 99-Hummock grasslands, shrub steppe; Acacia coriacea & Hakea over hard spinifex Triodia basedowii			398,672.56	65,175.27	0.0004	0.0000
Open low woodland of *Corymbia* spp./ *Hakea lorea* over low scrub of *Acacia* spp. and mid-dense hummock grass of *Triodia* spp. in sandplain	P-HG1	1253	83	11162	11.23	0.74	Abydos Plain – Chichester 111-Hummock grasslands, shrub steppe; Eucalyptus gamophylla over hard spinifex	80,894.59	24482.23			1.1891	0.0788
							Little Sandy Desert 99-Hummock grasslands, shrub steppe; Acacia coriacea & Hakea over hard spinifex Triodia basedowii			398,672.56	65,175.27	0.2710	0.0179
Open shrub mallee of *Eucalyptus gamophylla/ E. kingsmillii* subsp. *kingsmillii* over low scrub of *Acacia bivenosa* and mid-dense hummock grass of *Triodia basedowii* in sandplain	P-HG2						Little Sandy Desert 134-Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex (on) sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills	828.54	99.81	10003.11	7,363,935.12	0.0170	0.0011
							Little Sandy Desert 158-Hummock grasslands, shrub steppe; kanji over Triodia basedowii			178,188.03	49274.46	0.5509	0.0365
Scrub of *Acacia* spp. over mixed low scrub and mid-dense hummock grass of *Triodia pungens* on rocky hillslope	RH-AFW1	12	12	1077	1.11	1.11	Little Sandy Desert 99-Hummock grasslands, shrub steppe; Acacia coriacea & Hakea over hard spinifex Triodia basedowii			398,672.56	65,175.27	0.0026	0.0026
							Little Sandy Desert 134-Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex (on) sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills	828.54	99.81	10003.11	7,363,935.12	0.0002	0.0002
Open shrub mallee of *Eucalyptus gamophylla/ E. kingsmillii* subsp. *kingsmillii* over low scrub of *Acacia/ Grevillea* spp. and mid-dense hummock grass of *Triodia* spp. on rocky hillslope	RH-MWS1	22	6	1356	1.62	0.45	Little Sandy Desert 99-Hummock grasslands, shrub steppe; Acacia coriacea & Hakea over hard spinifex Triodia basedowii			398,672.56	65,175.27	0.0047	0.0013
							Little Sandy Desert 134-Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex (on) sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills	828.54	99.81	10003.11	7,363,935.12	0.0003	0.0001

Local Floristic Communities		Local Impacts					Regional Floristic Communities	Regional Impacts					
Vegetation Description	**Vegetation Code**	**Total Area - Development Envelope (ha)**	**Total Area- Disturbance Footprint (ha)**	**Total Area- survey area (ha)**	**% local habitat (survey area) intersected by Development Envelope**	**% local habitat (survey area) proposed to be impacted- Disturbance Footprint**	**Pre-European Vegetation**	**Total Area in PIL1 subregion (ha)**	**Total Area in PIL2 subregion (ha)**	**Total Area in LSD1 subregion (ha)**	**Total Area in LSD2 subregion (ha)**	**% regional habitat intersected by Development Envelope**	**% regional habitat proposed to be impacted (Disturbance Footprint)**
							Abydos Plain – Chichester 111-Hummock grasslands, shrub steppe; Eucalyptus gamophylla over hard spinifex	80,894.59	24482.23			0.0209	0.0058
Low woodland of *Acacia* spp. over low scrub of *Eremophila/ Senna* spp. and mid-dense hummock grass of *Triodia basedowii* on rocky plain	RP-AFW1	5	5	1572	0.32	0.33	Little Sandy Desert 99-Hummock grasslands, shrub steppe; Acacia coriacea & Hakea over hard spinifex Triodia basedowii			398,672.56	65,175.27	0.0011	0.0011
							Little Sandy Desert 134-Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex (on) sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills	828.54	99.81	10003.11	7,363,935.12	0.0001	0.0001
Open low woodland of *Corymbia aspera* over low scrub of *Acacia* spp. and mid-dense hummock grass of *Triodia basedowii* on rocky plain	RP-HG1	3	3	1639	0.18	0.16	Little Sandy Desert 158-Hummock grasslands, shrub steppe; kanji over Triodia basedowii			178,188.03	49274.46	0.0013	0.0012
							Little Sandy Desert 99-Hummock grasslands, shrub steppe; Acacia coriacea & Hakea over hard spinifex Triodia basedowii			398,672.56	65,175.27	0.0006	0.0006
							Little Sandy Desert 134-Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex (on) sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills	828.54	99.81	10003.11	7,363,935.12	0.0000	0.0000
TOTAL VEGETATION		**3875**	**410**	**64,271**	**N/A**	**N/A**		**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Cleared Vegetation	CV	168	168	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Salt Lake	CD-SL1	35,934	7198	70529	50.95	10.21	Little Sandy Desert 125-Bare areas; salt lakes	N/A	N/A	979.85	225,060.80	15.8971	3.1844
TOTAL CLEARED VEGETATION/ PLAYA		**36,102**	**7364**	**70,529**	**N/A**	**N/A**		**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
TOTAL PROJECT		**39,977**	**7776**	**134,800**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

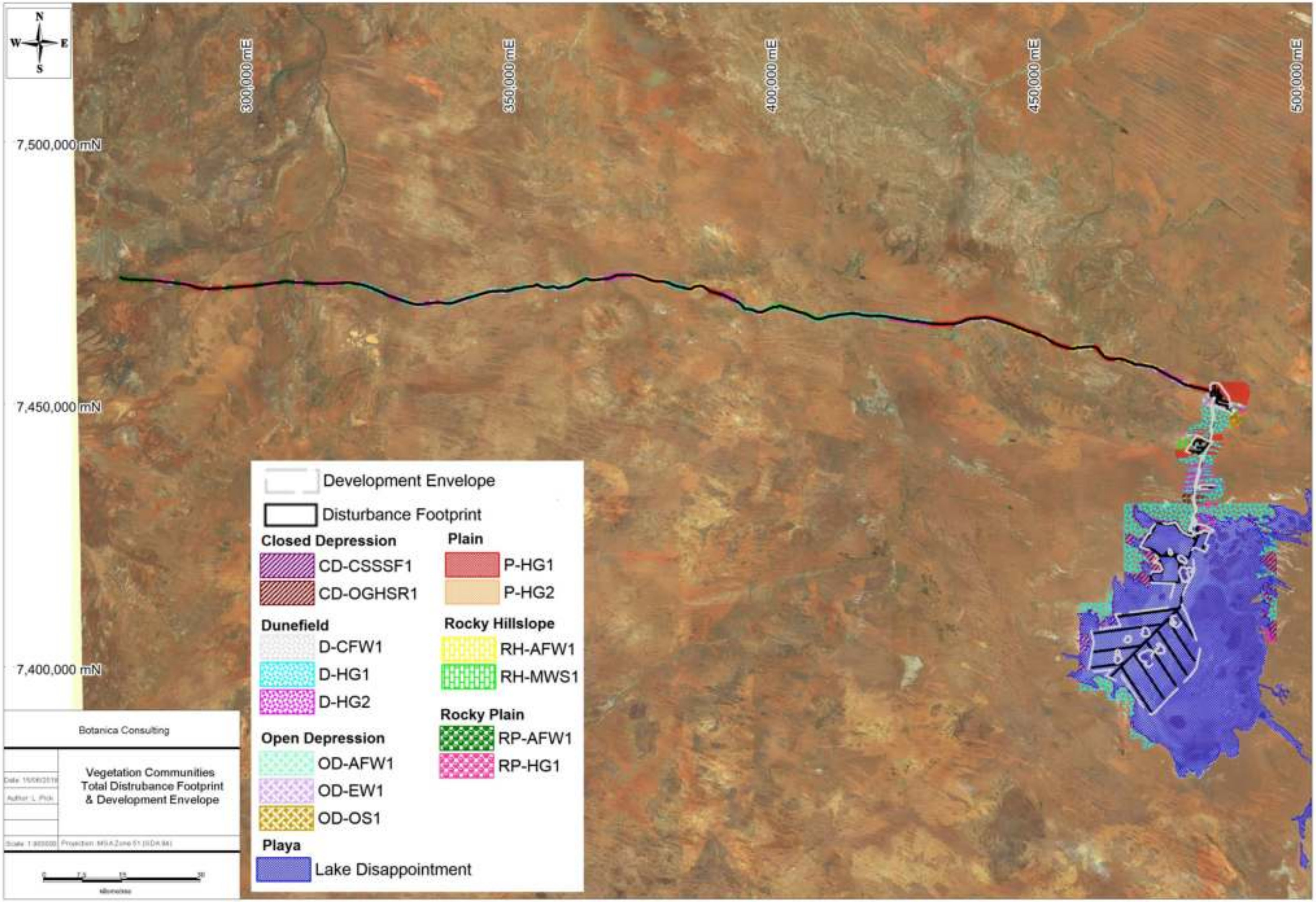


Figure 3-1: Total Disturbance Footprint/ Development Envelope and Vegetation Communities[6]

[6] The development envelope for the Talawana track exactly coincides with the disturbance footprint

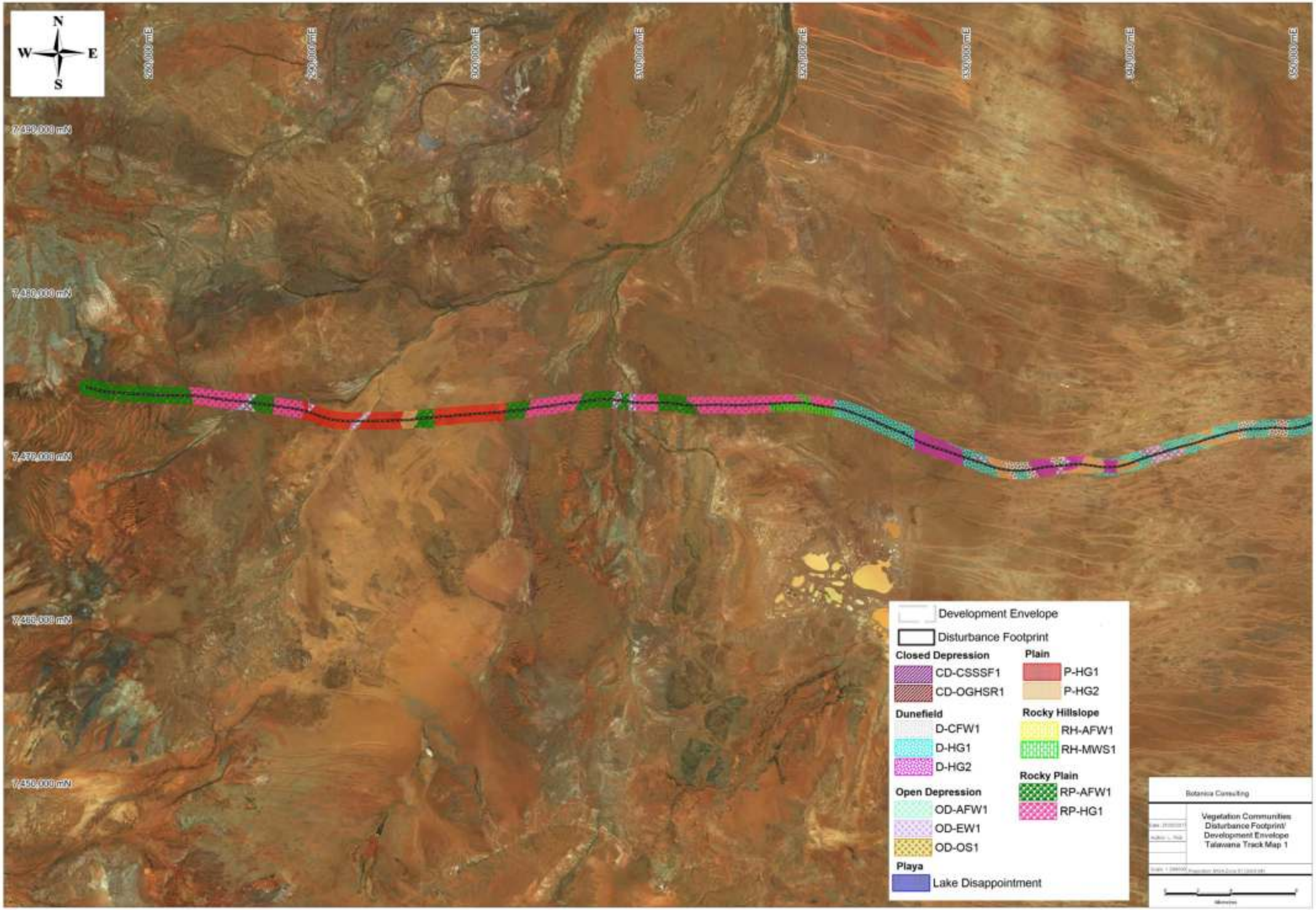


Figure 3-2: Disturbance Footprint/ Development Envelope and Vegetation Communities (Talawana Track-western end) Map 1

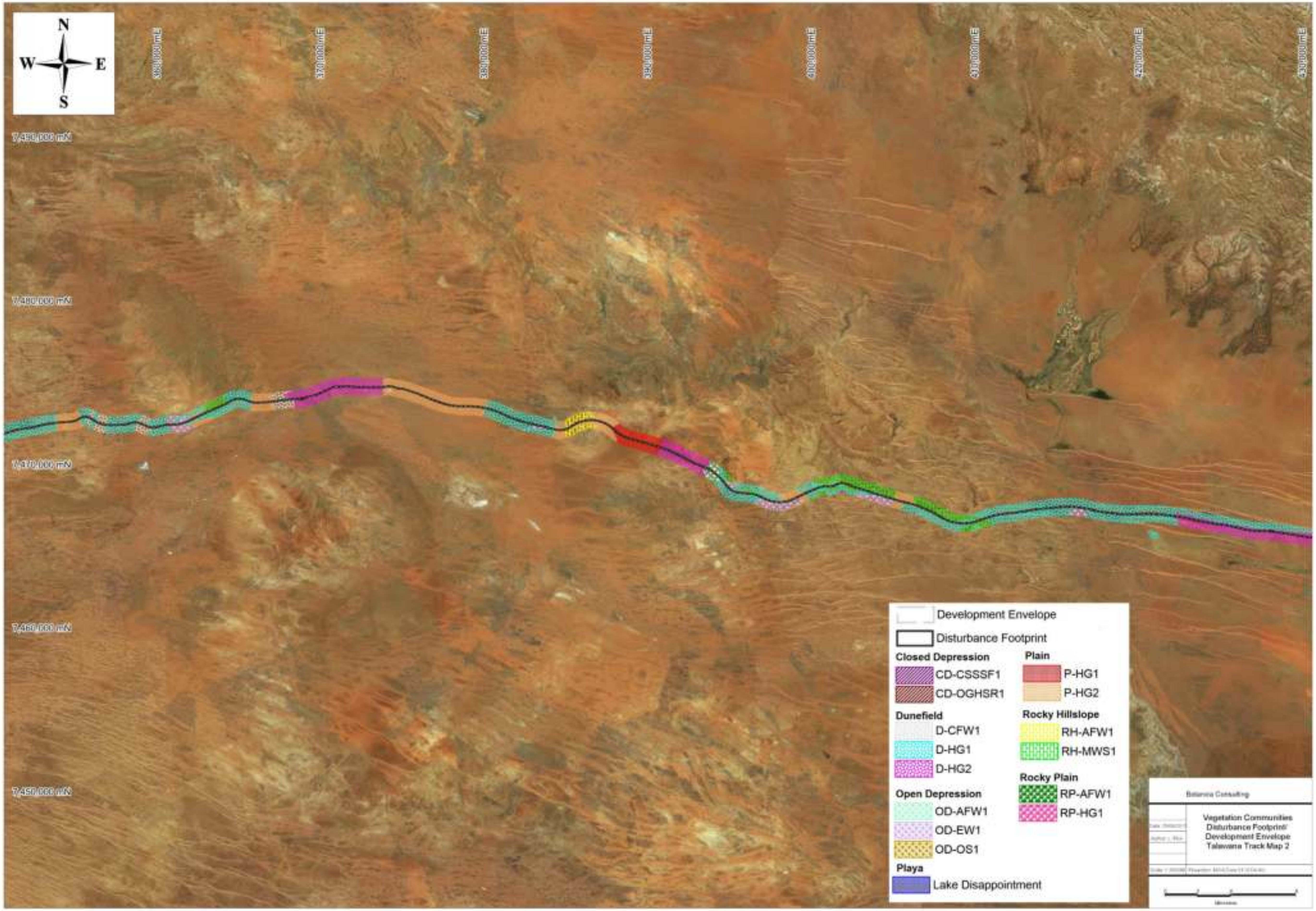


Figure 3-3: Disturbance Footprint/ Development Envelope and Vegetation Communities (Talawana Track mid-section) Map 2

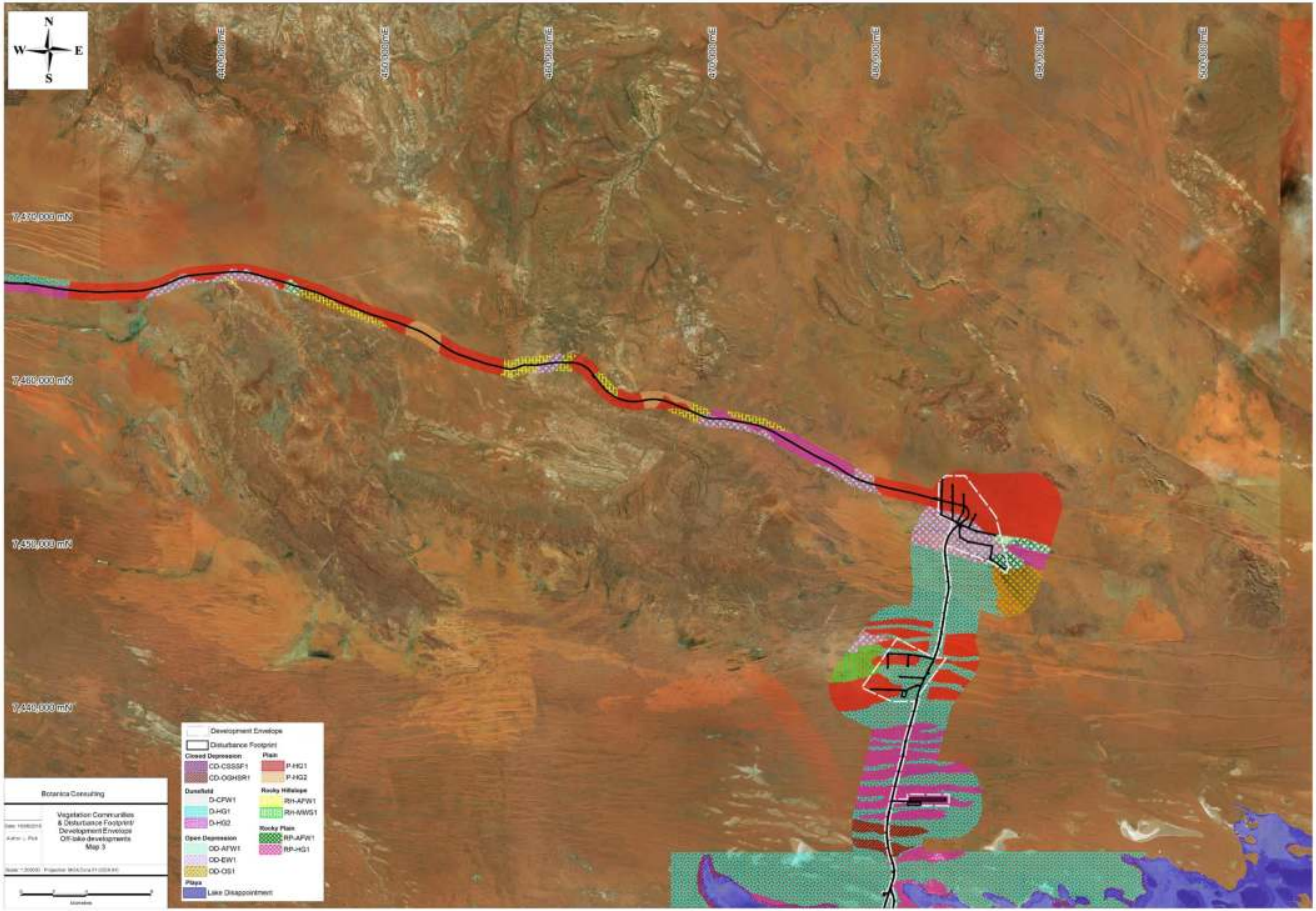


Figure 3-4: Disturbance Footprint/ Development Envelope and Vegetation Communities (Talawana Track-eastern end & off-lake developments) Map 3

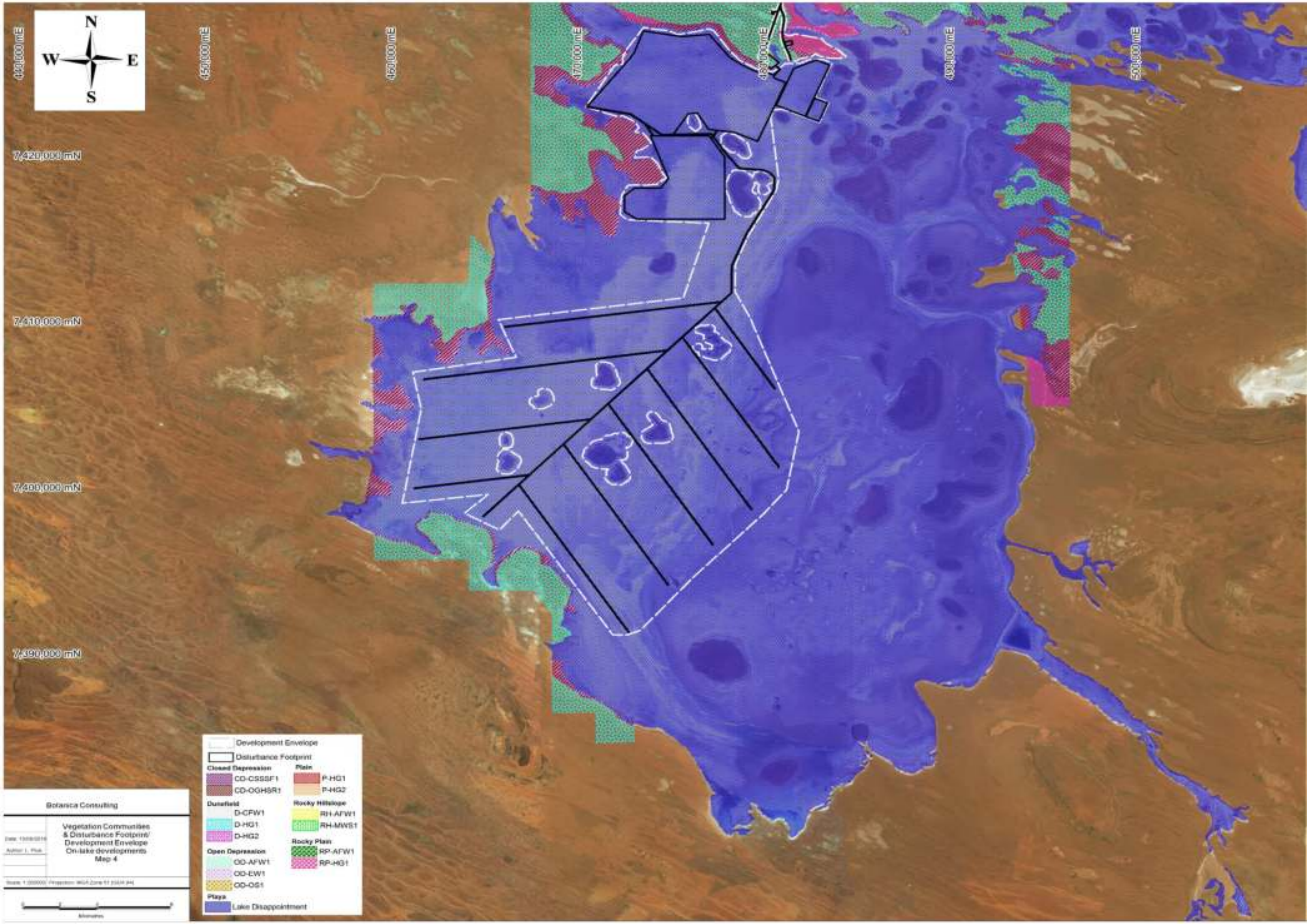


Figure 3-5: Disturbance Footprint/ Development Envelope and Vegetation Communities (on-lake developments) Map 4

4 Conservation Areas

A map showing conservation areas in relation to the development envelope/ disturbance footprint is provided in Figure 4-1.

4.1 Matters of National Environmental Significance

None of the following matters of national environmental significance as defined by the Commonwealth *EPBC Act 1999* were identified within the development envelope/ disturbance footprint:

- world heritage properties
- national heritage places
- wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed)
- nationally threatened species and ecological communities
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mining) a water resource, in relation to coal seam gas development and large coal mining development.

Lake Disappointment is listed by the Department of the Environment and Energy (DotEE) as a Nationally Important Wetland of Western Australia; however, it is not listed as a Ramsar Wetland (Internationally Important Wetland) under Commonwealth legislation.

4.2 Matters of State Environmental Significance

No Threatened Ecological Communities (TEC) or Threatened Flora listed under the Western Australian *Environmental Protection (EP) Act 1986* and *Wildlife Conservation (WC) Act 1950* were recorded within the project development envelope or the proposed disturbance footprint.

No Priority Ecological Communities (PEC) as listed by the DPaW (now DBCA) were recorded within the development envelope/ disturbance footprint. The nearest PEC is the Priority 3 Ecological Community '*Riparian vegetation including phreatophytic species associated with creek lines and watercourses of Rudall River''* (described as semi-permanent pools along courses of Rudall River (DPaW, 2016b)), which is located approximately 20 km north of development envelope. No ecosystems listed under the IUCN Red list of Ecosystems occur within the development envelope/ disturbance footprint.

Approximately 6,997 ha of the development envelope and 67.2 ha of the disturbance footprint is located within the proposed Lake Disappointment Nature Reserve (listed under the EPA Red Book recommendations for Conservation Reserves 1975-1993) which covers an area of 366,700 ha (Figure 4-1). The Lake Disappointment Nature Reserve was first listed in the EPA Red Book as an area of proposed conservation and proposed in the DPaW Goldfields, Regional Management Plan 1994-2004 however the recommendation was for the proposal to be deferred and addressed in the Pilbara Regional Management Plan. To date this proposed reserve has not been gazetted.

A 4.4 km portion of the Talawana track intersects the most southern boundary of the Karlamilyi (Rudall River) National Park (i.e. 4.4 km of the development envelope is located within the National Park). However, no clearing is required within the National Park, as the existing Talawana track will be used.

Approximately 35,990 ha of the development envelope and 7,202 ha of the disturbance footprint is located in an ESA (declared as an ESA under the EP Act as a *'defined wetland and the area within 50 metres of the wetland. Defined wetlands include Ramsar wetlands, conservation category wetlands and nationally important wetlands*) which encompasses the entire boundary of Lake Disappointment.

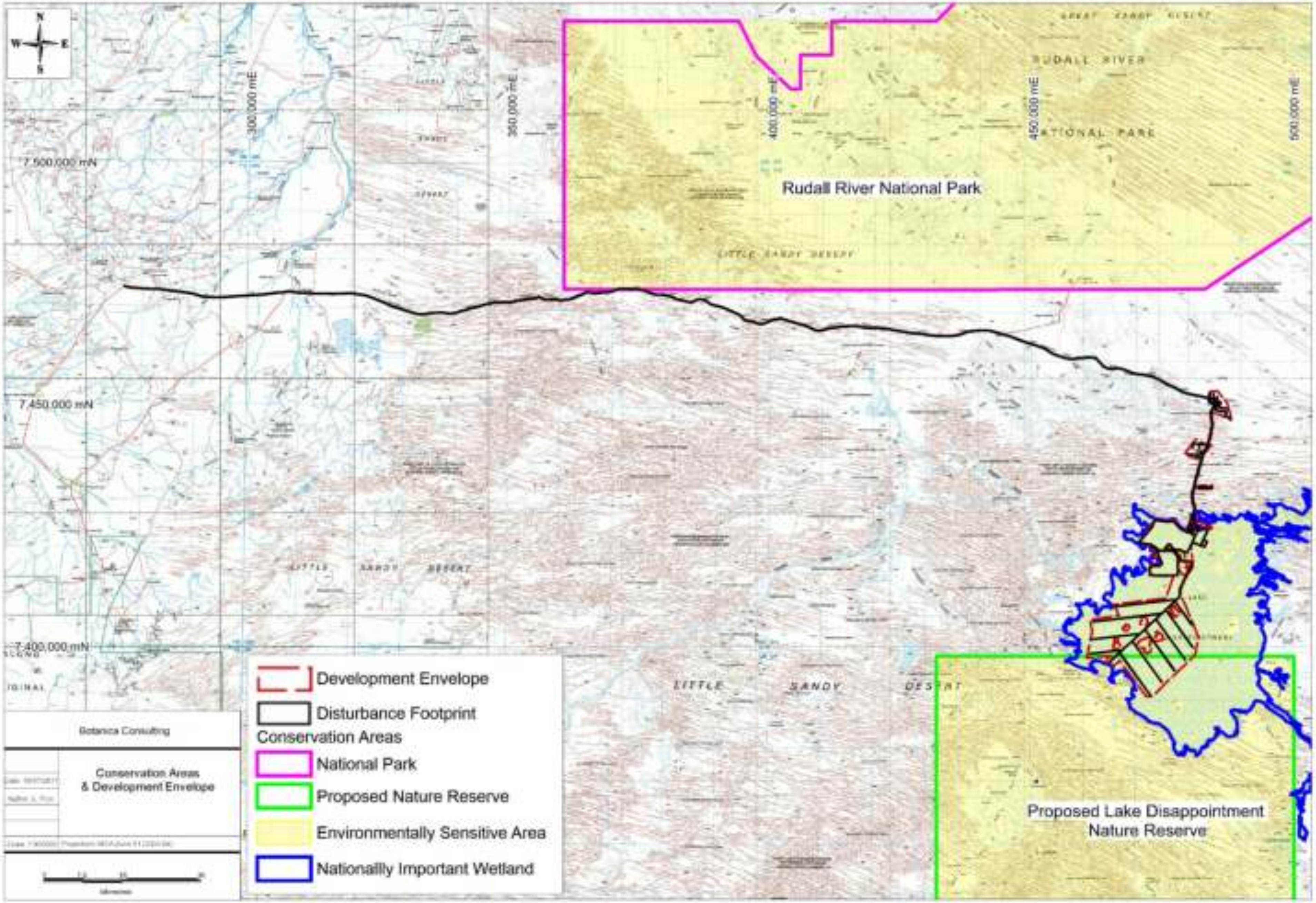


Figure 4-1: Regional map of the conservation areas in relation to the Disturbance Footprint/ Development Envelope

5 Flora and Vegetation of Local and Regional Conservation Significance

As defined in the DPaW/ EPA *Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment* (DPaW/ EPA, 2016), flora and vegetation may be considered significant for a range of reasons, including, but not limited to the following criteria:

Flora
- identified as threatened or priority species
- locally endemic or association with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems)
- new species or anomalous features that indicate a potential new species
- representative of the range of a species (particularly, at the extremes of range recently discovered range extensions, or isolated outliers of the main range)
- unusual species, including restricted subspecies, varieties or naturally occurring hybrids
- relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Vegetation
- identified as threatened or priority ecological communities
- restricted distribution
- large degree of historical impact from threatening processes
- a role as a refuge
- providing an important function required to maintain ecological integrity of a significant ecosystem.

An assessment of the potential conservation significance of flora/ vegetation within the development envelope/ disturbance footprint is summarized in Table 5-1.

Table 5-1: Assessment of conservation significant flora/ vegetation of each vegetation type

Vegetation Type	Conservation Significant Flora	Conservation Significant Vegetation
Heath of mixed *Tecticornia* spp. on Salt Lake edge (CD-CSSF1)	One Priority 1 Flora taxon Three potentially new species Potential Aquatic Groundwater Dependent Ecosystem[7]	Potential Aquatic Groundwater Dependent Ecosystem[5]
Open mixed herbs in clay-loam depression (CD-OGHSR1)	No conservation significant flora identified	No conservation significant vegetation identified
Low forest of *Allocasuarina decaisneana* over open scrub of *Acacia/ Grevillea* and mid-dense hummock grass of *Triodia basedowii* on sand dunes/ swales (D-CFW1)	No conservation significant flora identified	No conservation significant vegetation identified
Open low woodland of *Corymbia opaca* over low scrub of *Acacia/Grevillea* spp. and mid-dense hummock grass of *Triodia basedowii* on sand dunes/ swales (D-HG1)	No conservation significant flora identified	No conservation significant vegetation identified
Scrub of *Acacia/Eremophila/Grevillea* spp. over mid-dense hummock grass of *Triodia basedowii* on sand dunes/ swales (D-HG2)	No conservation significant flora identified	No conservation significant vegetation identified
Open low woodland of *Eucalyptus camaldulensis/ Corymbia* spp. over mid-dense hummock grass of *Triodia* spp. in creekline (OD-EW1)	Potential Terrestrial Groundwater Dependent Ecosystem[8]	Potential Terrestrial Groundwater Dependent Ecosystem[6]
Low woodland of *Acacia* spp. over low scrub of *Senna artemisioides* and mixed dwarf scrub in drainage depression (OD-AFW1)	No conservation significant flora identified	No conservation significant vegetation identified

[7] Due to association with water feature (i.e. playa).
[8] Due to association with *Eucalyptus camaldulensis* (River Red gum)
Further assessments conducted to determine whether vegetation is groundwater dependent are described in Section 5.2.1.

Vegetation Type	Conservation Significant Flora	Conservation Significant Vegetation
Low woodland of *Hakea lorea/ Melaleuca glomerata* over low heath of *Fimbristylis eremophila* in drainage depression (OD-OS1)	No conservation significant flora identified	No conservation significant vegetation identified
Open low woodland of *Corymbia* spp./ *Hakea lorea* over low scrub of *Acacia* spp. and mid-dense hummock grass of *Triodia* spp. in sandplain (P-HG1)	No conservation significant flora identified	No conservation significant vegetation identified
Open shrub mallee of *Eucalyptus gamophylla/ E. kingsmillii* subsp. *kingsmillii* over low scrub of *Acacia bivenosa* and mid-dense hummock grass of *Triodia basedowii* in sandplain (P-HG2)	No conservation significant flora identified	No conservation significant vegetation identified
Scrub of *Acacia* spp. over mixed low scrub and mid-dense hummock grass of *Triodia pungens* on rocky hillslope (RH-AFW1)	No conservation significant flora identified	No conservation significant vegetation identified
Open shrub mallee of *Eucalyptus gamophylla/ E. kingsmillii* subsp. *kingsmillii* over low scrub of *Acacia/ Grevillea* spp. and mid-dense hummock grass of *Triodia* spp. on rocky hillslope (RH-MWS1)	No conservation significant flora identified	No conservation significant vegetation identified
Low woodland of *Acacia* spp. over low scrub of *Eremophila/ Senna* spp. and mid-dense hummock grass of *Triodia basedowii* on rocky plain (RP-AFW1)	No conservation significant flora identified	No conservation significant vegetation identified
Open low woodland of *Corymbia aspera* over low scrub of *Acacia* spp. and mid-dense hummock grass of *Triodia basedowii* on rocky plain (RP-HG1)	No conservation significant flora identified	No conservation significant vegetation identified

Two vegetation types within the development envelope/ disturbance footprint were identified as possibly having flora/ vegetation of conservation significance:

1. Heath of mixed *Tecticornia* spp. on Salt Lake edge (CD-CSSSF1); and
2. Open low woodland of *Eucalyptus camaldulensis/ Corymbia* spp. over mid-dense hummock grass of *Triodia* spp. in creekline (OD-EW1).

The criteria used as the basis for this classification were:

CD-CSSSF1

- presence of a Priority 1 Flora taxon;
- three potentially new *Tecticornia* species; and
- potential aquatic groundwater dependent ecosystem.

OD-EW1

- potential terrestrial groundwater dependent ecosystem.

CD-CSSSF1 occupies an area of 56 ha within the development envelope (0.14% of the total development envelope). CD-CSSSF1 is not located within the disturbance footprint. On a regional scale, 0.0248% of this vegetation type is located within the development envelope, based on distribution of this vegetation association within the Rudall (LSD1) and Trainor (LSD2) subregions of the Little Sandy Desert Bioregion.

OD-EW1 occupies an area of 628 ha within the development envelope (1.57% of the total development envelope) and 33 ha within the direct disturbance footprint (0.43% of the total disturbance footprint). As specified in Table 3-2, 1.09% of this vegetation type (as recorded during baseline surveys) is proposed to be directly impacted (within disturbance footprint) at a local scale. On a regional scale, 0.019% of this vegetation type is proposed to be impacted (within disturbance footprint), based on distribution of this vegetation association within the Rudall (LSD1) and Trainor (LSD2) subregions of the Little Sandy Desert Bioregion; Chichester (PIL1) and Fortescue Plains (PIL2) subregion of the Pilbara Bioregion.

The remaining vegetation types identified within the development envelope/ disturbance footprint are not considered to be of local or regional conservation significance, according to the flora/ vegetation conservation significance categories listed above.

Further discussion on flora/ vegetation of conservation significance is presented below. A discussion of potential indirect impacts, including those arising from changes in groundwater regimes, is presented in Section 6.

5.1 Flora of Conservation Significance

The following flora of conservation significance were identified within the Heath of mixed *Tecticornia* spp. on Salt Lake edge (CD-CSSSF1):

1. *Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al KS 867)-Priority 1 Taxon
2. *Tecticornia* sp. nov A (as identified by K.A Shepherd 867)-Potentially new species
3. *Tecticornia* sp. nov B (as identified by K.A Shepherd 867)-Potentially new species
4. *Tecticornia* aff. *calyptrata* (as identified by K.A Shepherd 867)- Potentially new species

No flora of conservation significance were identified within the remaining vegetation types.

A map showing the locations of flora and vegetation of conservation significance in relation to the disturbance footprint/ development envelope is provided in Figure 5-2.

Tecticornia aff. *calyptrata* was identified by *Tecticornia* specialist Dr Kelly Shepherd as a potentially distinct taxon related to *Tecticornia calyptrata,* however further taxonomic work is required to confirm if it should be supported as a distinct taxon. Until the question of whether or not this plant is a potentially distinct taxon is resolved, it is provisionally considered to be of Conservation Significance.

Tecticornia sp. nov. A (related to the ‘ovate seed aggregate’ in the *T. halocnemoides* complex) and *Tecticornia* sp. nov. B (related to the ‘round seed aggregate’ in the *T. halocnemoides* complex) are currently undescribed taxa and are provisionally considered to be of conservation significance, as they represent potentially new taxa.

Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867) is not endemic to Lake Disappointment. Records of Tecticornia sp Sunshine Lake (K.A. Shepherd et al. KS 867) exist from the Murchison and Little Sandy Desert Region as shown in Figure 5-1.

Figure 5-1: Distribution of Tecticornia sp Sunshine Lake (K.A. Shepherd et al. KS 867) (Florabase, accessed 30 June 2017)

Opportunistic sampling of *Tecticornia* was conducted by Botanica Consulting at Lake Blanche and Lake Dora within the Karlamilyi (Rudall River) National Park, located approximately 92km and 115km north of Lake Disappointment respectively. The works were conducted under Regulation 4 permit; PILCALMR4-007/2016.

Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867) P1 was recorded within the samphire vegetation surrounding Lake Blanche (specimen identification conducted by Kelly Shepherd, 18th January 2017). This taxon was the dominant samphire on the western shoreline of Lake Blanche (Figure 5-3).

Two undescribed *Tecticornia* taxa were recorded at Lake Dora (tentatively referred to as *Tecticornia* sp. nov 1 and *Tecticornia* sp. nov 2 by taxonomic specialist Kelly Shepherd). These taxa were the co-dominant Samphire on the western shore of Lake Dora. Taxonomic assessments conducted by Kelly Shepherd identified that *Tecticornia* sp. nov 1 was the same taxon as *Tecticornia* sp. Nov B recorded at Lake Disappointment. There were no specimens of *Tecticornia* sp. Nov A recorded at Lake Dora or Lake Blanche.

An assessment on the flora of conservation significance recorded within the development envelope and disturbance footprint is provided in Table 5-2.

Table 5-2: Flora of Conservation Significance

Taxon	No. plants within development envelope	No. plants within disturbance footprint	No. plants in local area (within 20km)	No. populations[9] in local area (within 20km)	No. populations in regional area (within 100km)	Development Envelope % impact on local populations[10]	Disturbance Footprint % impact on local populations
Tecticornia aff. *calyptrata*	1	0	758	11	11	0.13	0.00
Tecticornia sp. nov. A	3	0	1741	6	6	0.17	0.00
Tecticornia sp. nov. B	0	0	1050	3	5	0.00	0.00
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867) P1	287	0	46,445	4	9	0.62	0.00

[9] Separate populations determined based on occurrence of plants >500m apart
[10] Refers to the percentage of plants within development envelope in relation to the total number of plants recorded within 20km of the development envelope

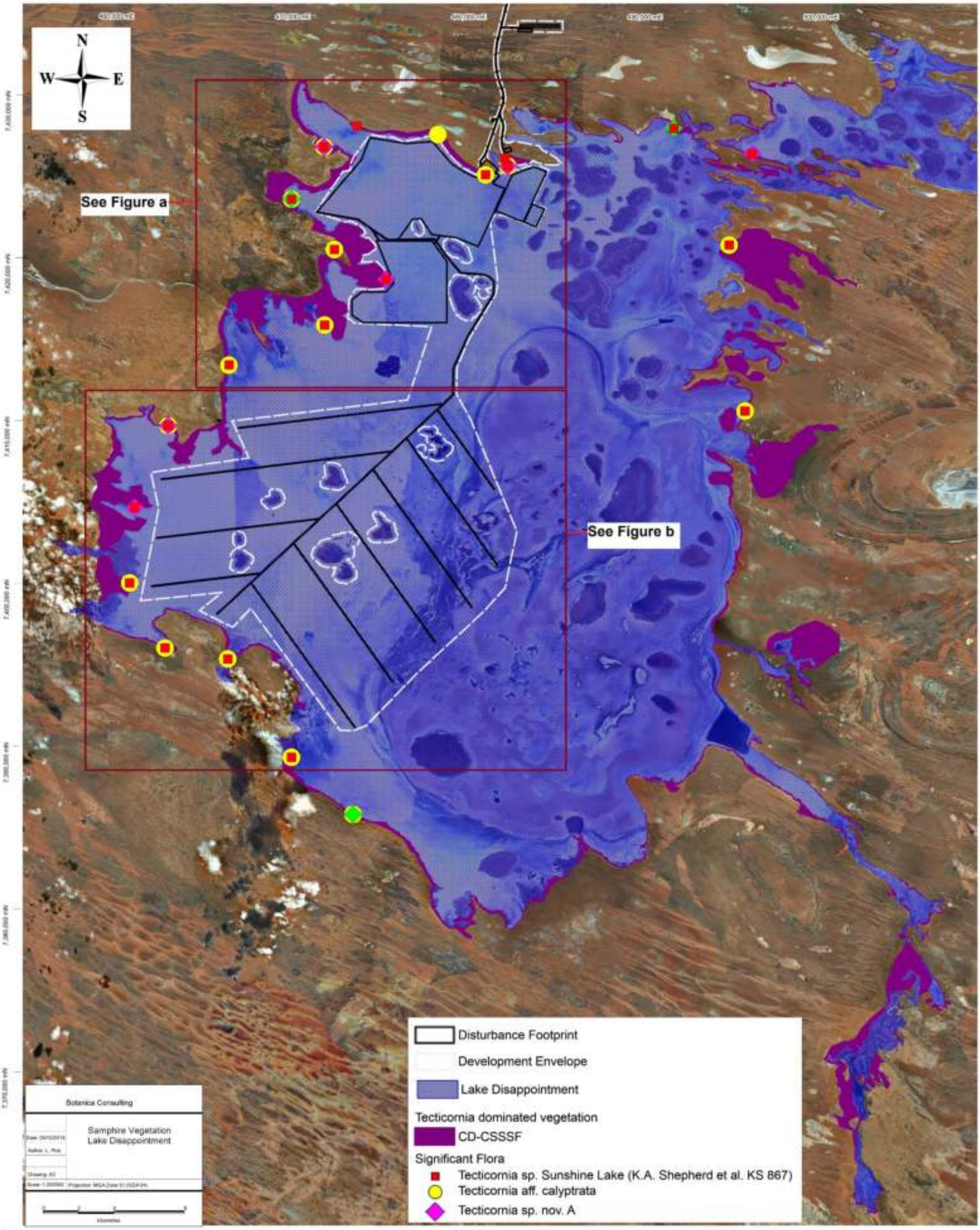
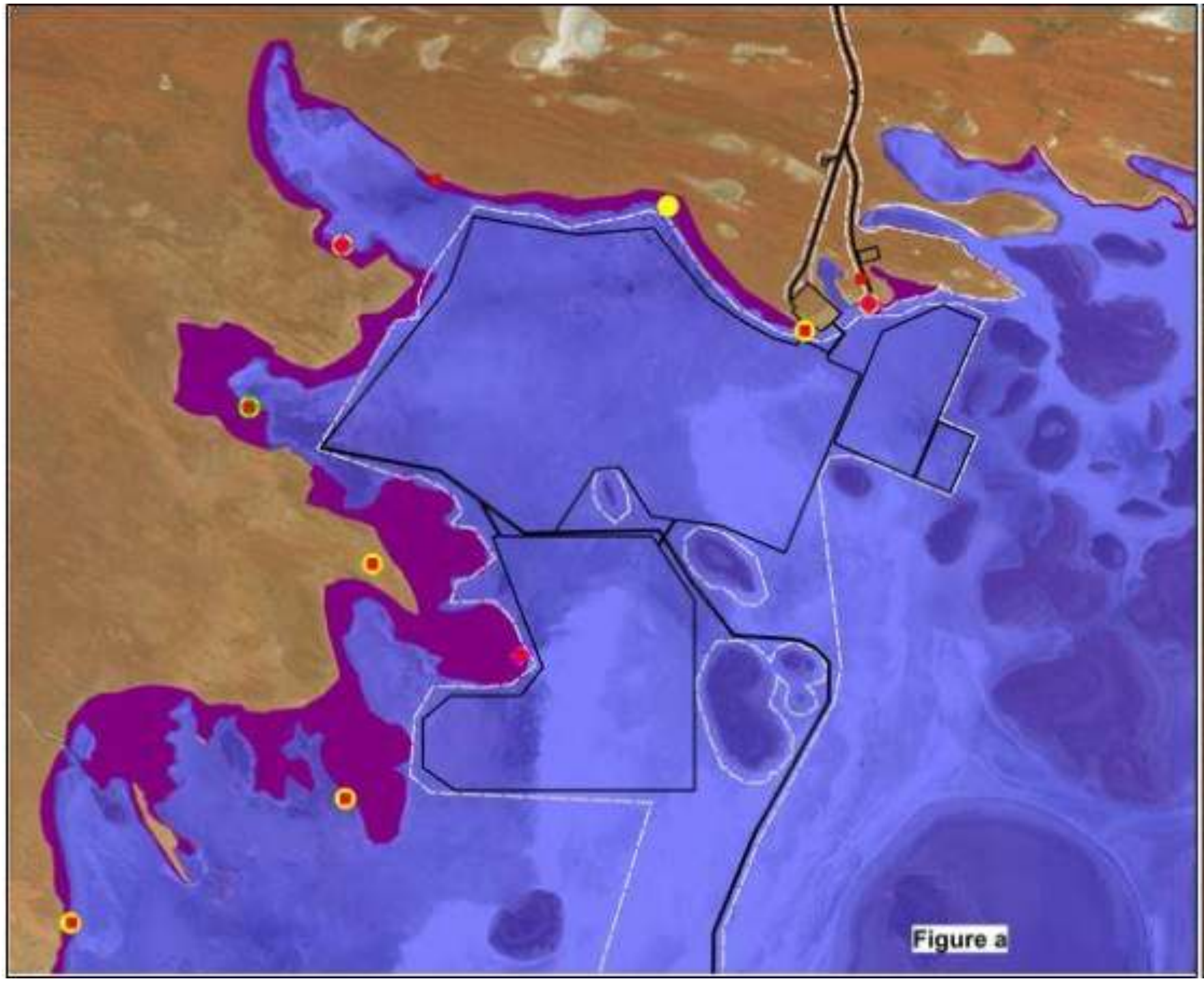


Figure 5-2: Flora of Conservation Significance in relation to the Disturbance Footprint/ Development Envelope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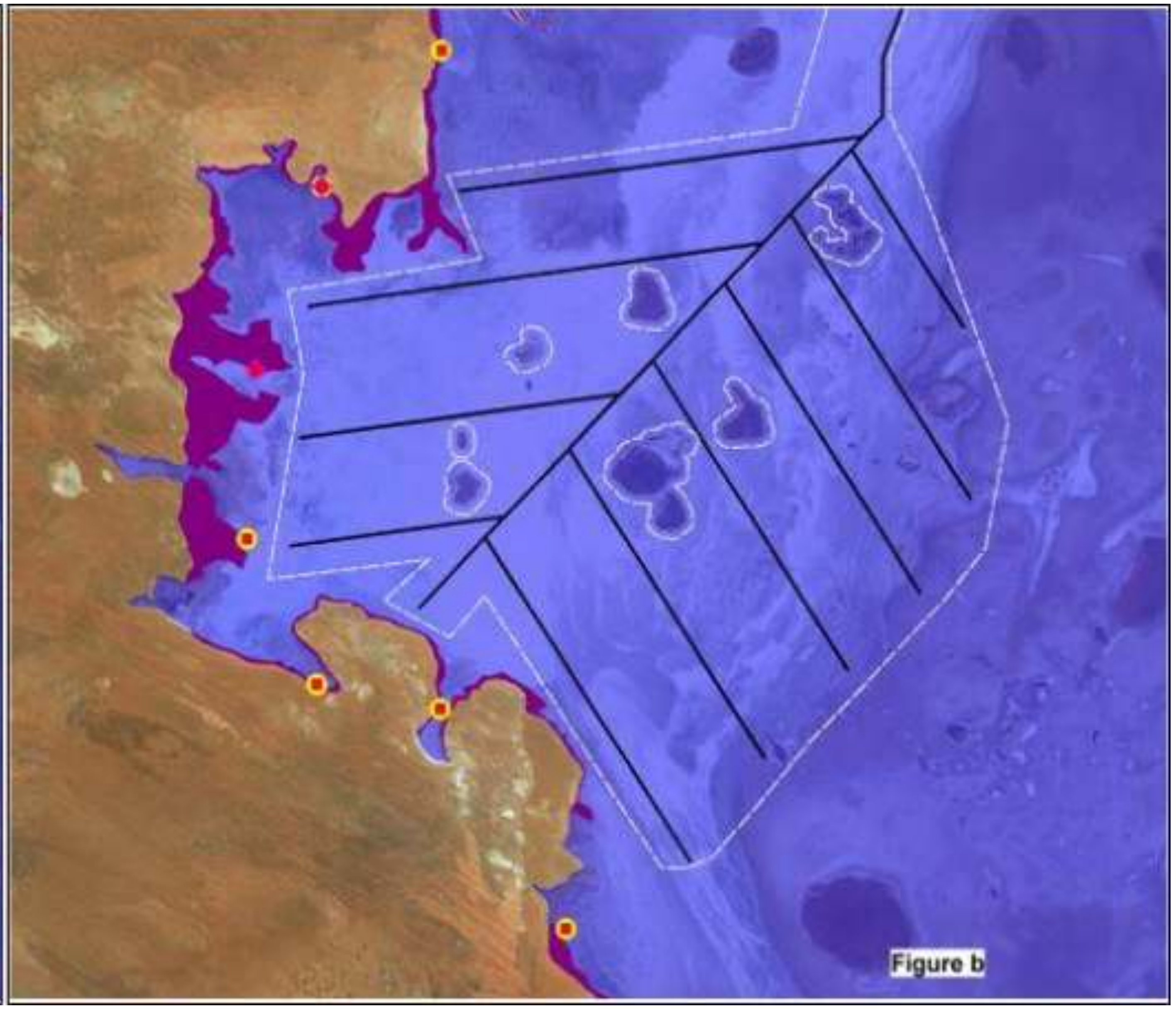
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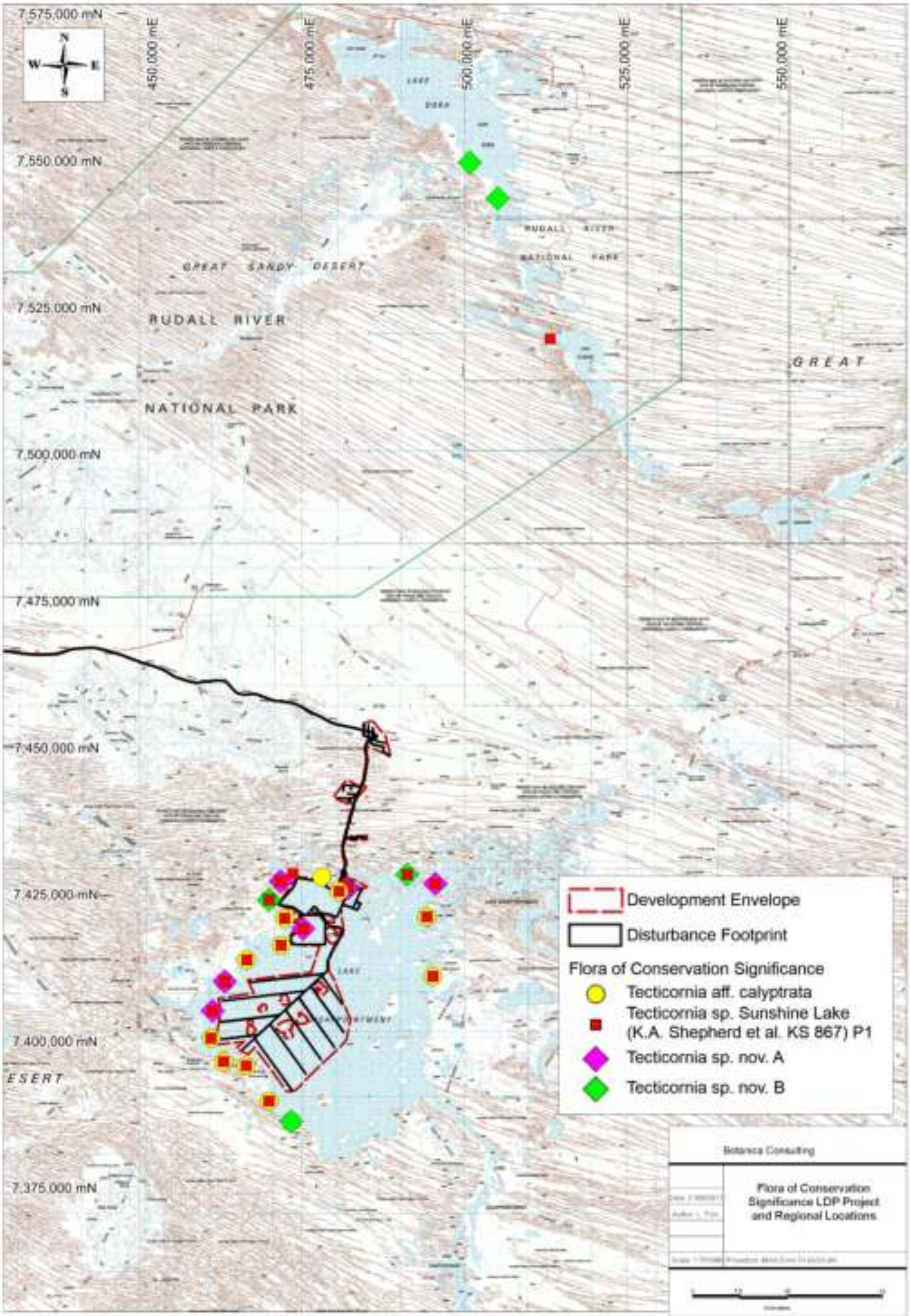


Figure 5-3: Regional *Tecticornia* of Conservation Significance recorded by Botanica Consulting

5.2 Vegetation of Conservation Significance

5.2.1 Groundwater Dependence Assessment

A Groundwater Dependent Ecosystem (GDE) refers to *natural ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis, so as to maintain their communities of plants and animals, ecosystem processes and ecosystem services* (Geoscience Australia, 2017). According to the BoM *Atlas of Groundwater Dependent Ecosystems* (BoM, 2017b) database, the LDP Project includes two potential GDE classes:

Aquatic ecosystems that rely on the surface expression of groundwater–this includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs.

Terrestrial ecosystems that rely on the subsurface presence of groundwater–this includes all vegetation ecosystems.

The BoM *Atlas of Groundwater Dependent Ecosystems* database results indicate a high potential for interaction with groundwater for the aquatic GDE (Lake Disappointment). According to the Bureau of Meteorology, high potential for groundwater interaction means that "*there is a strong possibility that ecosystems are interacting with groundwater"* (Australian Government, 2012).

The BoM *Atlas of Groundwater Dependent Ecosystems* database results indicate a low potential for interaction with groundwater for the terrestrial GDEs (vegetation surrounding Lake Disappointment). According to the Bureau of Meteorology, low potential for groundwater interaction means that "*ecosystems are relatively unlikely to be interacting with groundwater. This includes ecosystems that are not interacting with groundwater"* (Australian Government, 2012).

GDE Potential categories specified in the BoM database are based on the physical landscape and ecosystem characteristics as specified by the following rules (Australian Government, 2012):

Rule 1: Vegetation that demonstrates an evapotranspiration that is higher than rainfall is more likely to be using groundwater.

Rule 2: Vegetation that intersects with a spring is likely to be using groundwater.

Rule 3: Vegetation is more likely to be using groundwater in areas where the watertable is shallow.

Rule 4: Vegetation growing in areas where water stored in the unsaturated zone is limited, is more likely to be using groundwater.

Rule 5: Certain vegetation communities are more likely to access groundwater than others.

BoM's GDE potential assessment does not convey the confidence of the prediction, or the reliability of the GDE potential result. This is conveyed using the 'Lines of Evidence' attribute which indicates the amount of evidence (number of rules listed above that could be applied) used in determining the GDE potential for each ecosystem polygon. Details on the 'Lines of Evidence' was not available on the database. It is not clear which rule or rules served as the basis for classifying samphire vegetation in the Lake Disappointment area as potentially groundwater dependent.

A description of the potential GDEs within the LDP Project is provided in Table 5-3 and Figure 5-4.

Table 5-3: Potential GDEs within the Lake Disappointment Project survey area (BoM, 2017)

GDE Class	Aquatic GDE	Terrestrial GDE
GDE Potential	High Potential for groundwater interaction	Low Potential for groundwater interaction
Ecosystem Description	Lake Disappointment (Savory Creek) System	Gently undulating gravelly hardpan plains and dissected slopes supporting groved mulga shrublands and hard spinifex. Gravelly sandplains and occasional sand dunes supporting hard spinifex grasslands. Hardpan plains with large linear gravelly sand banks supporting acacia shrublands with soft and hard spinifex. Hills and ranges of sedimentary rocks supporting hard spinifex grasslands. Low calcrete platforms and plains supporting shrubby hard spinifex grasslands. Sandplains and occasional dunes supporting shrubby hard spinifex grasslands. Sandplains with linear and reticulate dunes supporting shrubby hard and soft spinifex grasslands. Hummock grasslands, shrub steppe; *Acacia coriacea* & Hakea over hard spinifex, *Triodia basedowii* Hummock grasslands, shrub steppe; kanji over *Triodia basedowii* Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex on sandhills / Hummock grasslands, shrub steppe; mixed shrub

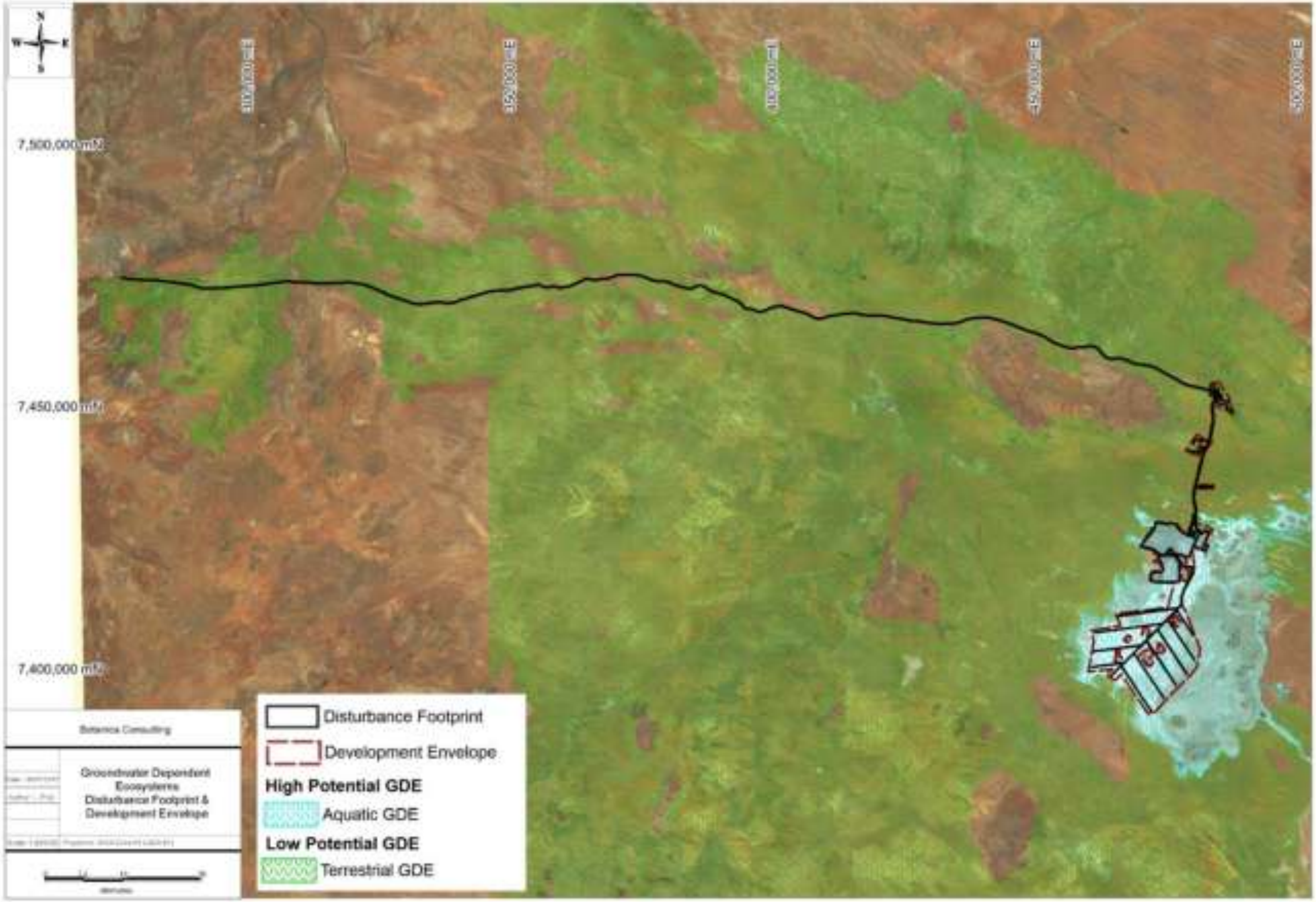


Figure 5-4: Potential for Groundwater Dependent Ecosystems within the Lake Disappointment Potash Project (BoM, 2017)[11]

[11] Ecosystem extent shown in the map does not necessarily show the spatial extent of groundwater use. Rather, the ecosystem polygons should be interpreted as showing the area within which groundwater interaction may be occurring (Australian Government, 2012).

In order to develop a more site-specific understanding of potential groundwater dependency, Reward commissioned an assessment of groundwater dependence of vegetation types identified in the flora and vegetation survey (BC, 2017) through analysis of remote sensing data (i.e. use of MODIS and LandsatTM), consistent with remote sensing techniques used in the BoM National assessment. The assessment was conducted using the Groundwater-dependent Ecosystem Mapping (GEM) method proposed by Barron *et al* (2012). Normalised Difference Vegetation Index (NDVI) and Normalised Difference Wetness Index (NDWI or Wetness Index) and ET (Actual Evapotranspiration) data to support the analysis were provided by Hydrobiology (2017). The years 2004, 2006 and 2008 were chosen for analysis of Landsat 4-5 imagery based on suitable dry season conditions and availability of high-quality cloud-free imagery. ET data was obtained from the NCI WIRADA dataset. A copy of the Hydrobiology technical memorandum is provided in Attachment 1.

NDVI provides a reliable measure of chlorophyll content or greenness of the vegetation. It is suggested that unvarying, high NDVI values are typically experienced in vegetation that has access to groundwater, and this relationship can often be more apparent at the end of the dry season when water is limited e.g. Barron *et al* 2012). Groundwater-dependent vegetation (GDE) is commonly associated with higher rates of ET, hence by calculating ET it may be possible to identify potential GDEs, especially when taken in concert with the NDVI and NDWI measures (Guerschman *et al*. 2009).

5.2.1.1 Methods

NDVI and NDWI Method

The general approach to identification of potential GDEs followed Barron *et al.* (2012) – "*Mapping groundwater-dependent ecosystems using remote sensing measures of vegetation and moisture dynamics*". This involved using multi-spectral imagery to derive NDVI and NDWI parameters using the red, near infrared and short-wave infrared bands (as described in Barron *et al.* 2012). Images from the end of the wet season (Feb-April) until the end of the dry season (Sept-Nov) were obtained for three years (2004, 2006 and 2008). These years were chosen based on a combination of an extended dry spell of several months (rainfall records from Telfer Aero) and suitable cloud-free imagery available for the whole study area. Imagery was obtained for a temporal frequency of monthly where possible. Raw imagery in GeoTIFF format was downloaded from the USGS website and Bands 3, 4 and 5 (Table 5-4) were imported into the Manifold GIS software package for processing. Each image was clipped to a standard coverage area and the NDVI and Wetness values calculated using Python scripting within the Manifold software. Vegetation data provided by BC was used to select zones for generation of statistics by vegetation type. Full descriptive statistics were generated for the 2006 study year and average values for the 2004 and 2008 study years, for each image (Table 8).

Descriptive statistics were generated by exporting the NDVI/Wetness values for each vegetation type, for each image, into Excel. Averages were generated within Manifold GIS. Figure 5-5 provides background information on the vegetation types analysed.

Table 5-4: Landsat 4-5 Thematic mapper band information

Bands	Wavelength (micrometers)	Resolution (meters)
Band 3 - Red	0.63-0.69	30
Band 4 - Near Infrared (NIR)	0.76-0.90	30
Band 5 - Shortwave Infrared (SWIR) 1	1.55-1.75	30

Table 5-5: Number of images processed by year

Year	Number of NDVI images	Number of Wetness images	Total
2004	8	8	16
2006	9	9	18
2008	8	8	16
TOTAL	**25**	**25**	**50**

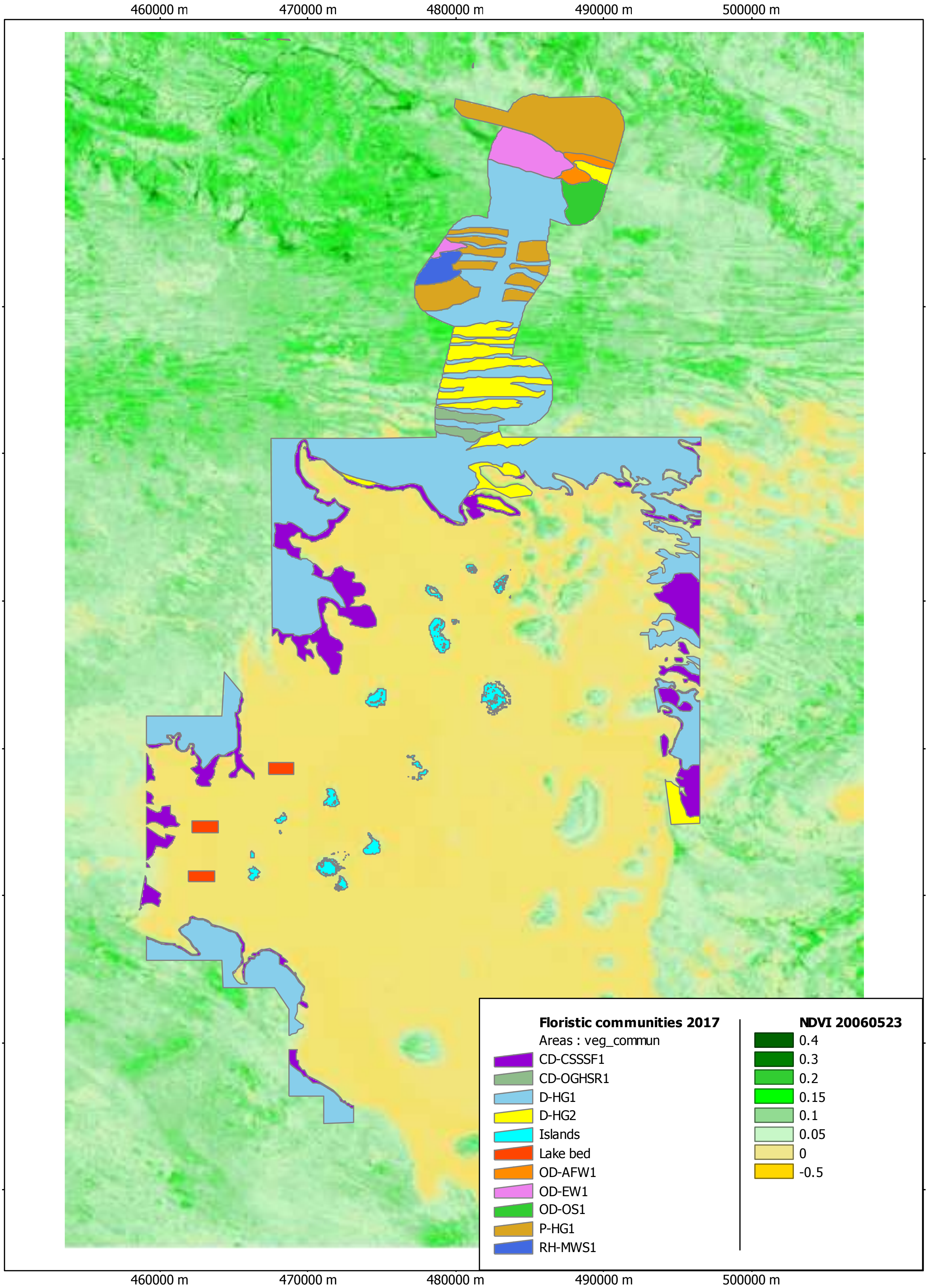


Figure 5-5: Map of vegetation communities used in the NDVI/Wetness analysis (Hydrobiology, 2017)

Evapotranspiration Method

Estimates of actual evapotranspiration (AET) were calculated for the study area using satellite imagery from the 'CSIRO MODIS reflectance based scaling evapotranspiration' (CMRSET) data set (250 m resolution). This data set was developed by Guerschman *et al.* (2009) and it provides an estimate of AET across Australia, based on MODIS reflectance and short wave infra-red data, and gridded meteorological surfaces.

In brief, the CMRSET algorithm uses reflectance data from the MODIS satellite to calculate ET across the Australian continent. AET is calculated from potential ET (PET) by applying a 'crop factor' which incorporates the enhanced vegetation index (EVI) and global vegetation moisture index (GVMI). The algorithm was calibrated by comparing estimated AET with measured AET from seven eddy covariance towers around Australia covering a variety of landscapes (forest, savannah, grassland, floodplain and lake). CMRSET was further validated by comparing estimated AET with 'surrogate AET' (precipitation minus streamflow) in 227 unimpaired catchments around Australia (Guerschman *et al.* 2009).

A cautious approach is required when attempting to make inference about the presence of GDE from AET for several reasons. The first being that the amount of ET for a given vegetation type can be influenced by other factors such as vegetation health, leaf area index and how drought tolerant the vegetation type is (Gonzalez 2015, Woods *et al*. 2016). Secondly the calibration method used for the CMRSET was conducted in areas with rainfall of greater than 250 mm and not in low rainfall areas like the study area. Thirdly, Van Dijk *et al*. 2015 found that this method gave poor results for salt lakes, as it has a tendency to overestimate ET from salt lakes, however he also suggested that results for areas other than salt lakes are more robust and the ET values potentially more representative of what is actually happening.

Raw imagery in .nc format was downloaded from the NCI (National Computational Infrastructure) website and imported into QGIS software package for processing. A vegetation community (Floristic community) map provided by Reward Minerals (produced by Botanica) was used to generate statistics by vegetation type for 2004, 2006 and 2008 (Table 5-6). Descriptive statistics were generated by exporting the ET values for each vegetation type, for each image, into Excel.

Table 5-6: Number of images processed by year

Year	Number of ET images
2004	11
2006	10
2008	11
TOTAL	**32**

Calculation of Estimated Groundwater Evapotranspiration

Groundwater evapotranspiration (ETg) refers to the water losses from groundwater due to transpiration, direct water uptake through roots from GDEs, and direct evaporation (e.g. from any wet surface including soil or land surface). Groundwater-dependent vegetation is commonly associated with a comparatively higher rate of evapotranspiration (ETg), hence by identifying areas where ETg exceeds rainfall on an annual basis it is possible to predict potential GDEs (O'Grady *et al*. 2011). It is important to know that this method is a simplification of the soil-water system and does not include a direct measure of evaporation. Eamus *et al*. 2015 estimated that the average error associated with this method was about 12%, however it is likely to be much greater in environments where groundwater is expressed at the surface and / or where moist soil is present i.e. salt lakes and wetlands. In these types of environments there will be greater groundwater expression and hence higher evaporation, and it is highly likely that these high ET values are not due to the presence of GDE but due to limitations of the method. Hence caution needs to be applied when making inference about GDEs associated with groundwater expressed at the surface. The rainfall data used for this calculation came from the Telfer rain gauge station which is approximately 200 km from the study site; this data was used because it is the closest and most complete data set that was available.

The spatial resolution of the ET data allows for a pixel size of 250m². The vegetation in the project area can be highly patchy and may not completely fill a pixel, hence other components (for example, bare soil or water surfaces) will be incorporated into the calculations. This limitation needs to be considered when interpreting the ET results.

Groundwater evapotranspiration (ETg) can be calculated from satellite imagery using NDVI and rainfall using the following formula in which NDVI* is the peak season normalised NDVI. It is important to remember that these ETg figures are estimates More accurate ET estimates are possible if the model is calibrated using measured local values of soil moisture, evaporation and other meteorological variables.

5.2.1.2 Results

Barron *et al*. (2012) assessed the presence of potential GDE by plotting the relative magnitude of NDVI change over the dry season, with those vegetation communities with the least change in greenness most likely to be supplemented by water sources other than rainfall (i.e. groundwater or perched surface water). A summary of the vegetation groupings proposed by Barron *et al* (2012) based on NDVI/NDWI signatures is provided in Table 5-7. Those vegetation communities with relatively higher NDVI and NDWI values and with the least change in greenness (LC1) are most likely to be supplemented by water sources other than rainfall (i.e. groundwater or perched surface water).

Table 5-7: Summary of spectral characteristics and land classification groupings

Land classification category*	Description
LC1	Non-drying vegetation – consistently high NDVI and NDWI values: potential GDEs
LC2	Slow-drying vegetation – diminishing access to groundwater. Vegetation shows some level of greenness and wetness reduction after a prolonged dry period: in the absence of precipitation, these areas are also potential GDEs
LC3	Fast-drying vegetation – greenness and wetness indicator values can be dramatically reduced at the end of a prolonged drying period due to the complete depletion of soil moisture stores. Root zone is often disconnected to groundwater: not groundwater dependent
LC4	Water surfaces - areas that exhibit no or low variation in water content and greenness (similar to non-drying vegetation), but where wetness is consistently high and greenness is consistently low over the dry season are identified as permanent open water bodies.
LC5	Areas that exhibit invariant but low greenness are not expected to be associated with groundwater-dependent ecosystems. Category may include areas of sparse vegetation and bare soil patches.

Note: Land classifications and descriptions based on Barron *et al*, 2012

Figure 5-6 provides a plot of the late wet season NDVI value (x-axis) against the late dry season NDVI (y-axis) for each floristic community identified in the study area for each of three years (2004, 2006 and 2008). Figure 5-7 shows the 'end of dry season wetness index (NDWI)' plotted against the 'end of wet season wetness index'. Vegetation units that deviate most from the 1:1 line are classified as 'fast-drying vegetation' (Barron *et al*, 2012) and are very unlikely to be groundwater dependent. Vegetation units with relatively high and unvarying NDVI values, which closely follow the 1:1 plot line are inferred to have a continuing source of water (i.e., are considered to be more likely to be groundwater dependent). Units with consistently low and unvarying NDVI may represent permanent water or wetland surfaces (if they also show high and unvarying NDWI signatures and high ET) or may correspond to sparse vegetation or bare soil (if they have lower NDWI and low cumulative ET).

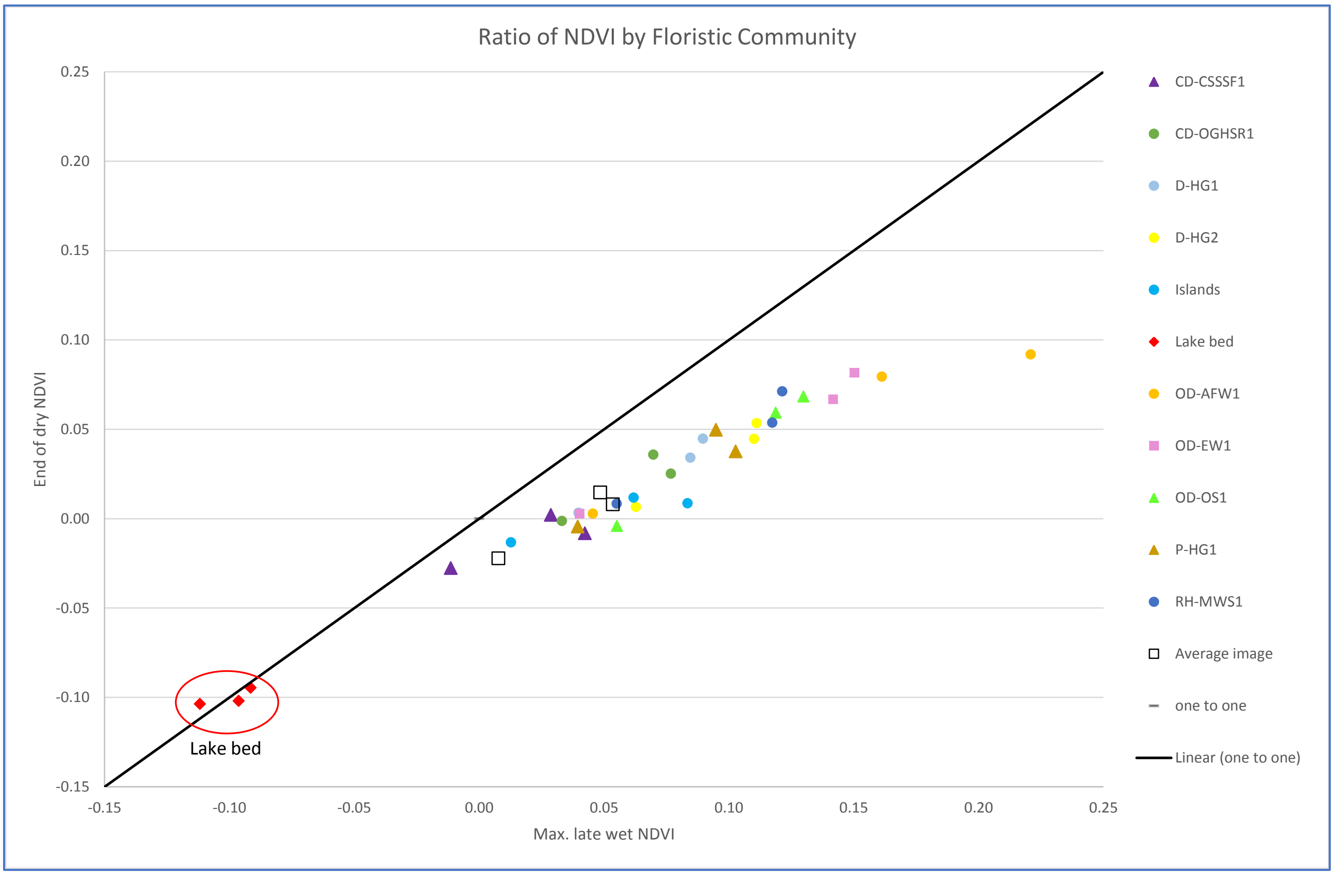


Figure 5-6: Change rate for NDVI values from late wet to end of dry season (Hydrobiology, 2017)

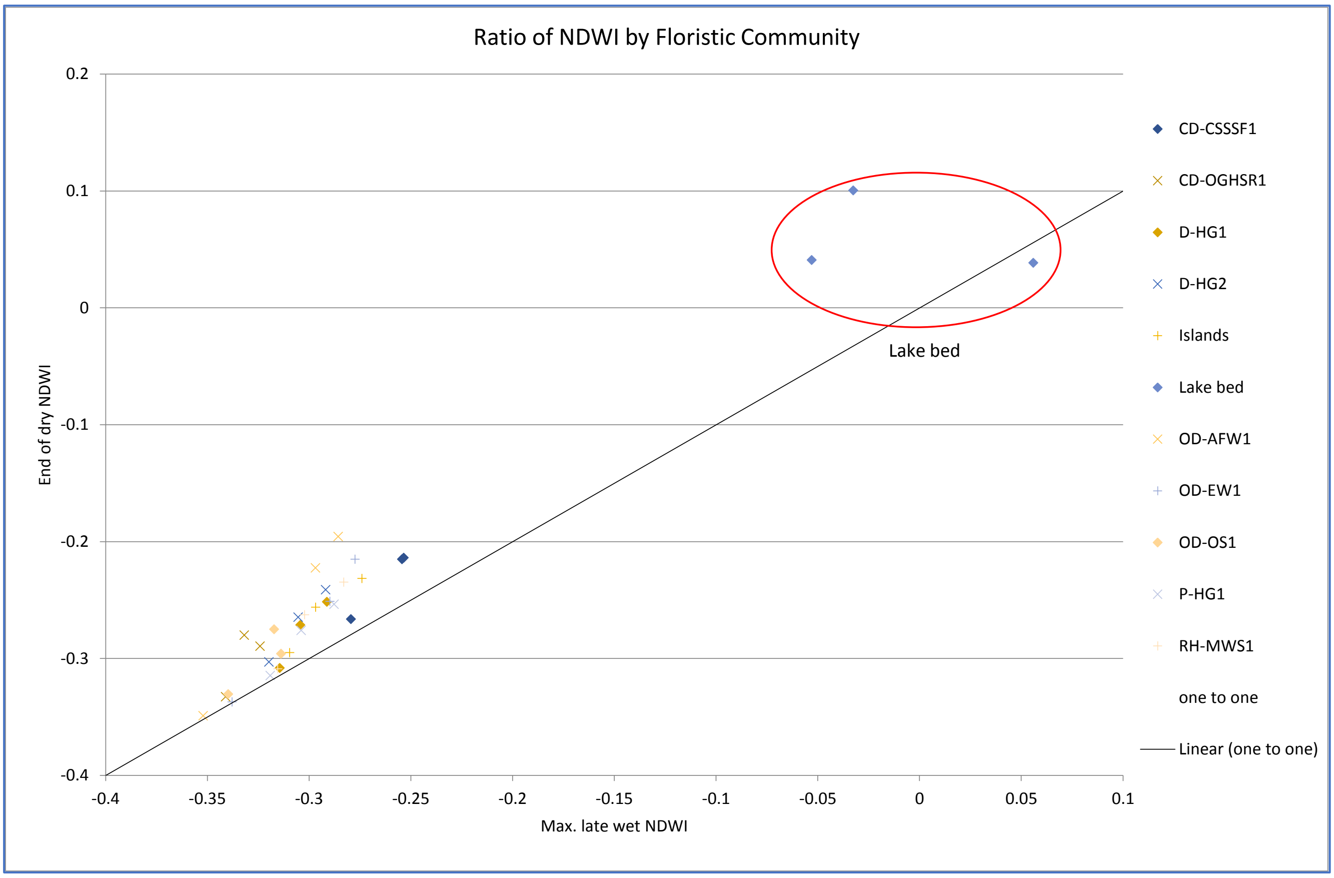


Figure 5-7: Change rate for NDWI values from late wet to end of dry season (Hydrobiology, 2017)

None of the vegetation types mapped at Lake Disappointment showed consistently high values of greenness (NDVI) and wetness (NDWI). Unvegetated parts of the playa surface showed spectral signatures typical of water surfaces (LC4), with low greenness and high wetness (NDWI) compared to the vegetated surfaces. All vegetation units (except for the playa surface) fell below the 1:1 trend line on the NDVI wet season:dry season plot, indicating some measure of reduction of greenness over the dry season. This suggests that none of the vegetation units meets the criteria for "non-drying vegetation" (LC1). Vegetation units that deviate most from the 1:1 line are classified as "LC3 fast-drying vegetation" (Barron *et al*, 2012) and are unlikely to be groundwater dependent (in the sense of being vegetation that has a root system able to access a permanently saturated zone). The vegetation units that plotted furthest from the 1:1 NDVI line were OD-AFW1 and OD-EW1. The cumulative ET supports this result with neither of these vegetation groups recording high ET losses (Figure 5-8 and Figure 5-9).

The vegetation units that showed the least deviation from the 1:1 NDVI wet season:dry season plot were CD-CSSSF1 (Heath of mixed Tecticornia spp. on salt lake edge) and CD-OGHSR1 (Open mixed herbs in clay-loam depression). These vegetation units were characterized by low and relatively invariant greenness (Hydrobiology, 2017) and provisionally classified as "LC5" type vegetation (Table 5-7). There is a possibility that the sparseness of vegetation, particularly in the CD-CSSSF1 community, is lowering the NDVI response over the dry season. The NDVI pixels are an average of 30 m × 30 m, which includes any bare ground between plants. CD-CSSF1 was the only vegetation community to show consistently high ET rates (Figure 5-8). However, it is important to note that evaporation from groundwater is dependent on the water table depth and hence ET is expected to be greater where the water table is shallower. It is also important to note the limited spatial resolution of this data which allows for a pixel size of 250m^2. The typical width of the CD-CSSSF1 is in the order of 100m to 3000m and the distribution of plants is extremely patchy; consequently, it is highly likely that ET values will be overestimated because lake bed components (i.e. presence of open water or moist soil resulting in high ET rates) will be inadvertently included in the ET calculations for that pixel.

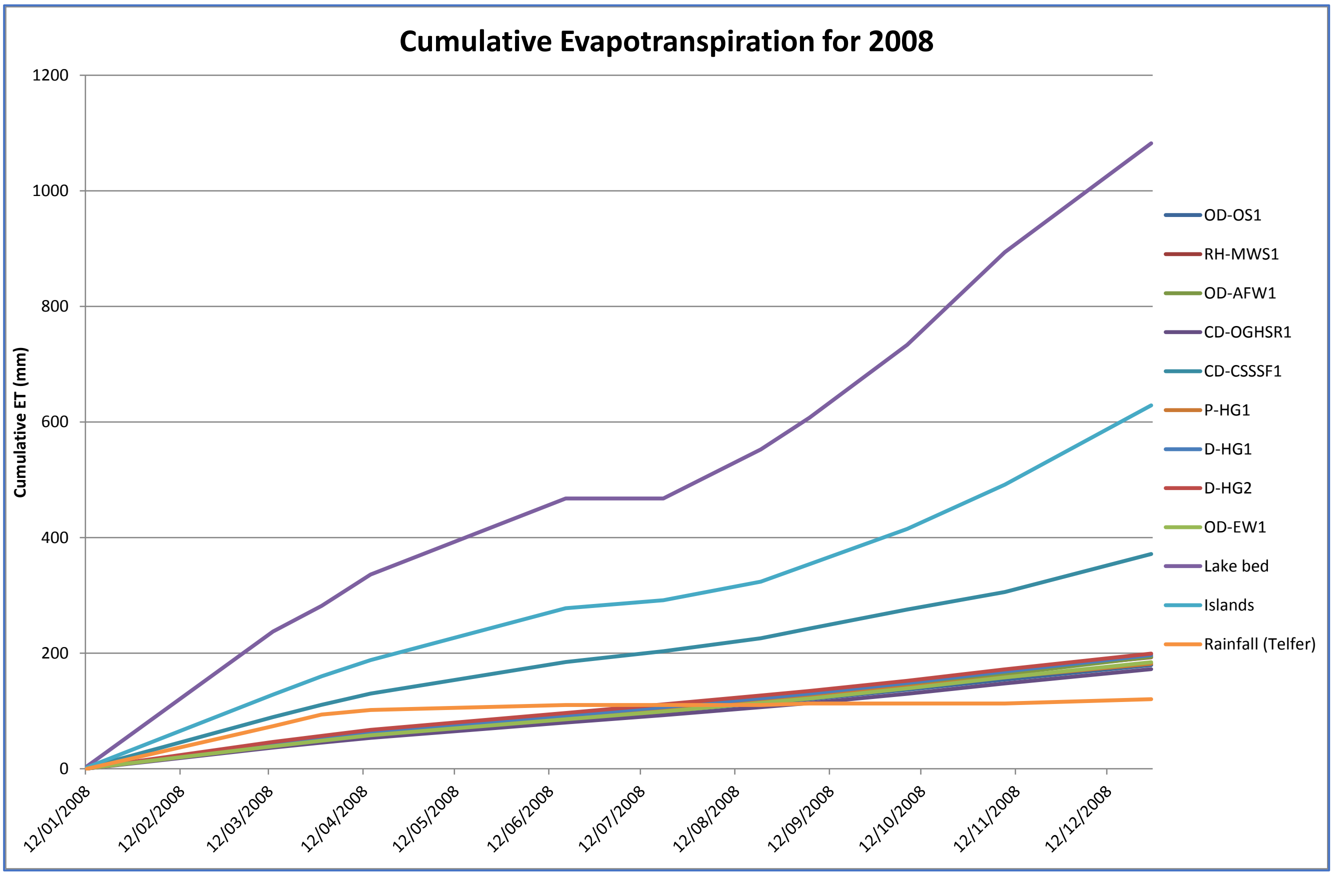


Figure 5-8: Cumulative Median Evapotranspiration for each vegetation type (Hydrobiology, 2017)

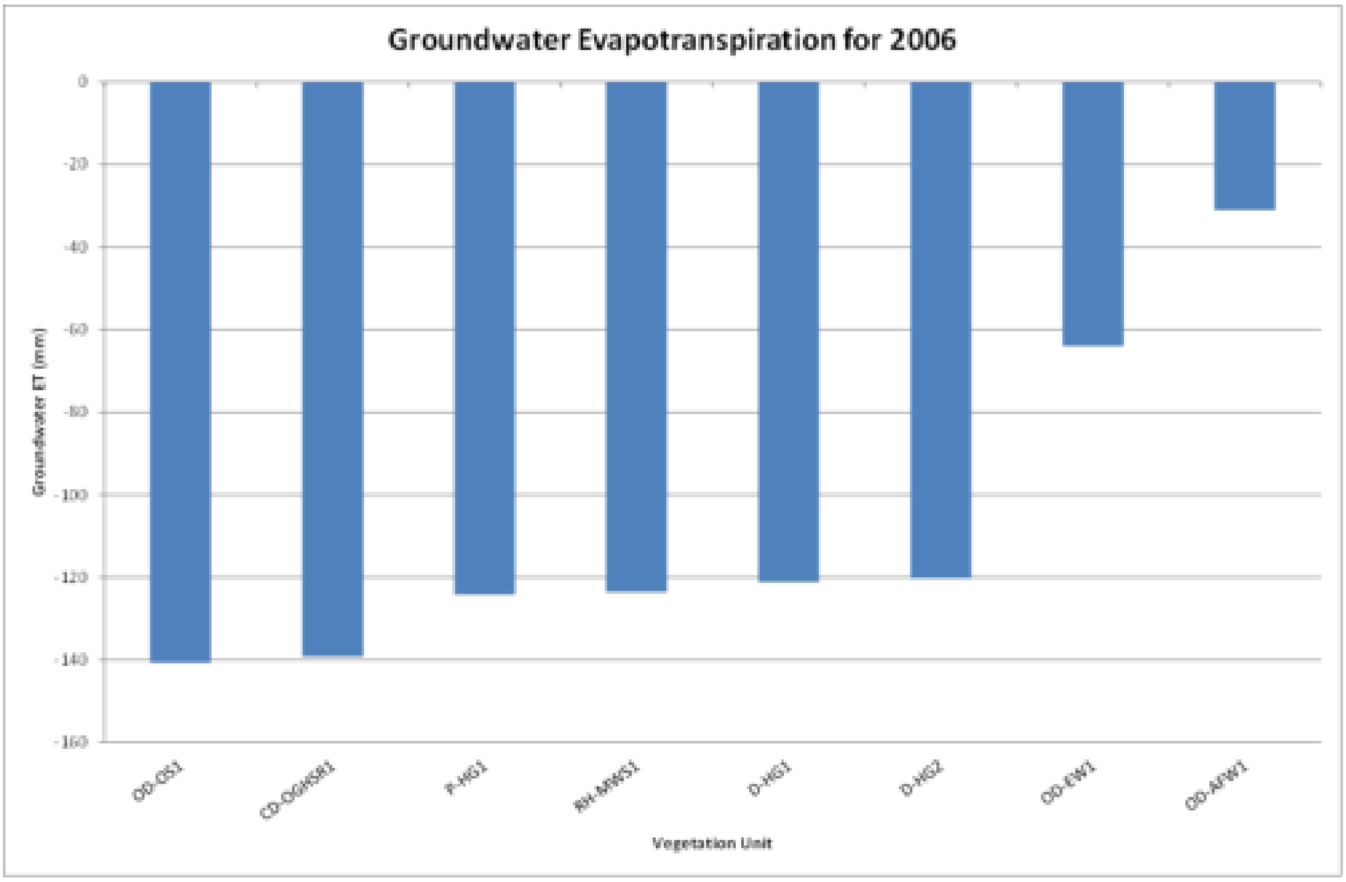


Figure 5-9: Estimated groundwater evapotranspiration for each vegetation unit (2006) (Hydrobiology, 2017)[12]

Calculations on the probability of inflow dependence (pID) using methods recently devised by Doody *et al.* 2017 were conducted to estimate the probability of vegetation using groundwater during dry seasons. Table 5-8 shows the ratio and probability of inflow dependence of each vegetation unit (with the exception of salt lake units)[10]. These results indicate that there is low likelihood of pronounced groundwater dependency in the vegetation units of the LDP Project.

Table 5-8: The probability of inflow dependence for each vegetation unit for 2006

Floristic Community	ET/Rainfall Ratio	pIDE (%)*
OD-OS1	0.59	0%
CD-OGHSR1	0.53	0%
P-HG1	0.62	5%
RH-MWS1	0.68	6%
D-HG1	0.63	5%
D-HG2	0.65	6%
OD-EW1	0.83	10%
OD-AFW1	0.92	20%

* The higher the probability, the higher the chance a landscape accesses water from an alternative source other than rainfall.

The results of the spectral analysis conducted by Hydrobiology (2017) are summarised as follows:

- No vegetation unit showed consistently high and unvarying NDVI and NDWI indices (the spectral signature typically associated with groundwater dependent vegetation).
- One vegetation unit (CD-CSSSF1) showed low, but relatively constant NDVI values and moderate, but variable, NDWI values (but with lower and less variable wetness than the playa surface). Typically, this signature would indicate areas of sparse vegetation or bare soil.
- There are methodological issues that limit the application of ET estimation on salt lakes. These limitations constrained the use of ET methods in estimating the likelihood of groundwater dependence of vegetation on islands or in close proximity to the playa.

[12] No results are provided for the lake surface, for vegetation on islands on the lake or for vegetation units occurring mainly within 250m of the playa edge, as recent work by van Dijk et al (2015) has shown that the CMRSET method is unreliable for salt lake systems and is known to overestimate evapotranspiration

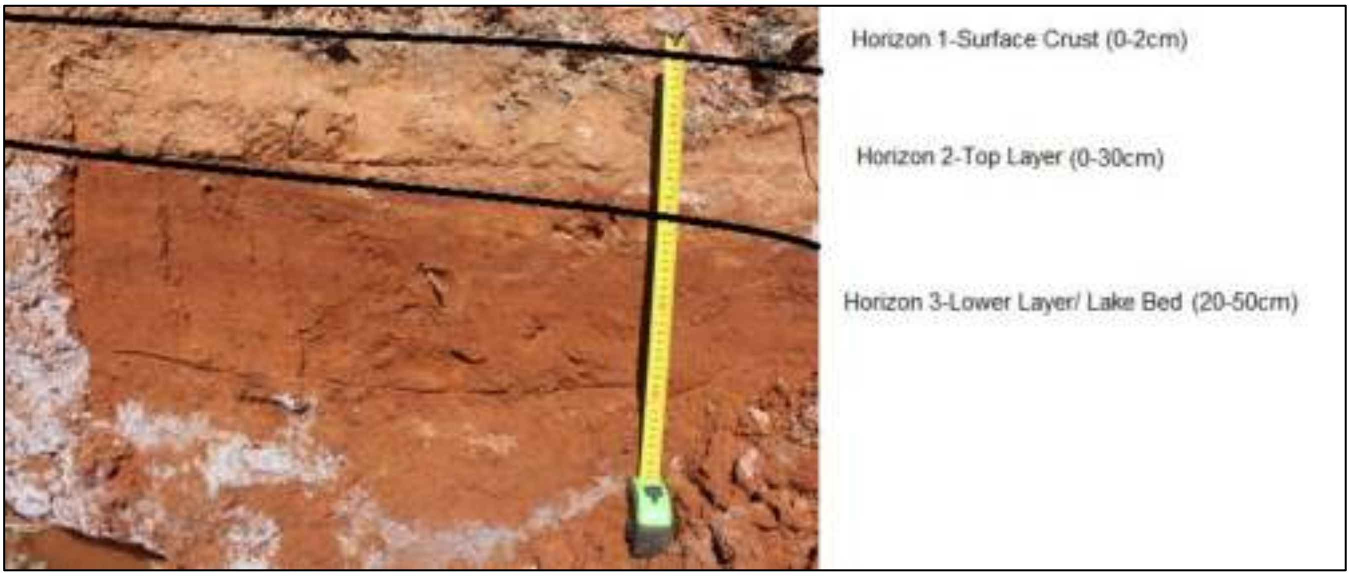
- For vegetation units not closely associated with the salt lake, estimated evapotranspiration and groundwater evaporation amounts generally did not exceed rainfall, further supporting the conclusion that these units are unlikely to be strongly groundwater dependent.
- Vegetation units associated with McKay creek (OD-EW1 and OD-AFW1) and its delta (discussed in further detail in Section 5.2.4) showed the highest probability of 'inflow dependence' at 10% and 20% probability, respectively.

5.2.2 Samphire/ Riparian Zone Soil & Roots Assessments

To further understand the samphire vegetation of Lake Disappointment and assess potential for GDE, an assessment of the soils and root structure of *Tecticornia* of Lake Disappointment was conducted by BC; *Soil Characterisation and Assessment on Tecticornia root structure of the Lake Disappointment riparian zone.* A copy of this report is provided in Attachment 2. Results of the assessment are summarized below.

The soils of Lake Disappointment comprised three soil horizons:

- **Horizon 1-**Surface crust (0-2cm). Firm salt encrusted (crystalline salts) accumulated on the surface. Light brown/ orange fine sand to sandy loam.
- **Horizon 2**-Top Layer (0-30cm). Red-brown/ orange fine sand to sandy loam. Presence of coarse gypsum material (non-uniform distribution). Location of total root structure. Low-moderate water retention.
- **Horizon 3-** Lower Layer/ Lake Bed (20-50cm). Red-brown fine sand to sandy clay loam. No roots present. Solid/ dense structure. Groundwater was encountered about 65cm below natural surface.



Results of Dynamic Cone Penetrometer (DCP) investigations conducted by Pendragon Environmental Solutions, (2016) identified the surficial sands and salts (Horizon 1-2) overlie a low to medium plasticity silty clay (Horizon 3) to a depth of at least 3m (the full depth of DCP testing). Generally, the materials increased in strength with depth, with the clays becoming consolidated and dense between 0.8m and 1.0m below surface.

Hydrology assessments by Global Groundwater (2017) identified the lake sediments are divided into the following hydrostratigraphic units:

- Upper lake bed unit – Groundwater in reworked gypsiferous sand deposits (Qh). The unit is frequently highly permeable with permeability dominated by secondary interconnected porosity of thin gypsum beds.
- Aeolian sand unit - Groundwater in discontinuous aeolian deposits (Qpe). An aquifer, when saturated, groundwater is held within primary porosity. Occurs as isolated sections within the upper lake bed sequence and surrounding the lake.
- Lower lake bed unit – Groundwater in the consolidated alluvial/lacustrine sequence (Q/Tpl). – Mostly low permeability clay with rare thin disconnected zones of gypsum with development of secondary porosity.

All soil samples recovered from the Tecticornia root zone were characterised as neutral to slightly alkaline (pH 1:5 soil extract, 7.8-8.5) and highly saline (EC 1:5 soil extract, 600-2500 mS/m). All soil horizons recorded low organic carbon levels (<1%) and low total nitrogen levels (<1%). There was minimal difference in the chemical properties of soils within each of the soil horizons, regardless of position in relation to the lake edge/ bare lake surface.

The different *Tecticornia* specimens had a consistent root structure consisting of a main root (tap root) with multiple lateral roots extending from the tap root (extending horizontally). There were no adventitious (above ground roots) present (Plate 2). *Tecticornia* roots were restricted to the upper soil layer (0-30cm) which comprised fine sand to sandy loam soils notwithstanding increasing moisture content with depth (Plate 2). While the lateral root development at 20-30cm depth suggests growth retardation at that depth, the soil salinity data is too variable to establish that this is due to an increasing salinity profile.

Plate 1: Image of *Tecticornia* root structure

Plate 2: Image of *Tecticornia* root depth

5.2.3 Samphire/ Riparian Zone Vegetation and Hydrology Assessments

Samphires are able to withstand hostile environments (i.e. high salinity soils/ waterlogged saline land) by having different adaptions to reduce salt accumulation (e.g. vacuoles, large succulent stems), enabling osmotic flow of water from the soils in hypersaline water. Samphires are also adapted to withstand droughts by having reduced leaf surface area and increased water storage (i.e. storing water in stems). Reducing the surface area of green photosynthetic tissues (i.e. having succulent stems rather than leaves) limits the amount of water lost during transpiration (University of Western Australia, 2012).

In order to assess any potential impacts of the lake based operational activities of the LDP Project, BC were commissioned by Reward to develop an annual riparian vegetation monitoring programme. The objective of the monitoring programme was to annually assess the biodiversity (species diversity, species density, plant abundance and vegetation cover) and health (using health rating scale; 1-dead/ no live vegetation to 5-excellent) of native riparian vegetation immediately surrounding the LDP Project. This information was used to provide baseline data on riparian vegetation and assess whether lake-based exploration activities were having an impact on the surrounding riparian vegetation (for example, as a result of increased dust generation). In April 2013, BC established fifteen monitoring sites (transects) and three control sites (located >3km from exploration program) within riparian vegetation along the lake perimeter (avoiding Aboriginal Heritage exclusion zones). Monitoring has been conducted annually since 2013. A location map of the riparian monitoring program is provided in Figure 5-10.

Figure 5-10: Riparian Vegetation Monitoring Program and Piezometers

A summary of monitoring results is provided below and shown in Figure 5-11 and Figure 5-12.

The impact sites have maintained a constant level of mean species diversity from 2013 to 2016 (two species per 10m²). Mean species diversity of the control sites increased in 2014 and have remained constant at this level to 2016 (3 species per 10m²). Mean species density of the control sites has shown a continued decline since 2013, decreasing by 34 plants/ 10m² in 2016. Species density of the impact sites decreased slightly since 2013, by 3 plants/ 10m². Mean vegetation cover of the impact and control sites have shown a continual decline over the monitoring period, reducing by 1.4% and 2.8% respectively from 2013 to 2016. Mean health condition remained constant for the impact and control sites from 2013 to 2015; however, in 2016 mean health condition has decreased for both sites to a mean condition rating of 2-Poor/Declining vegetation health.

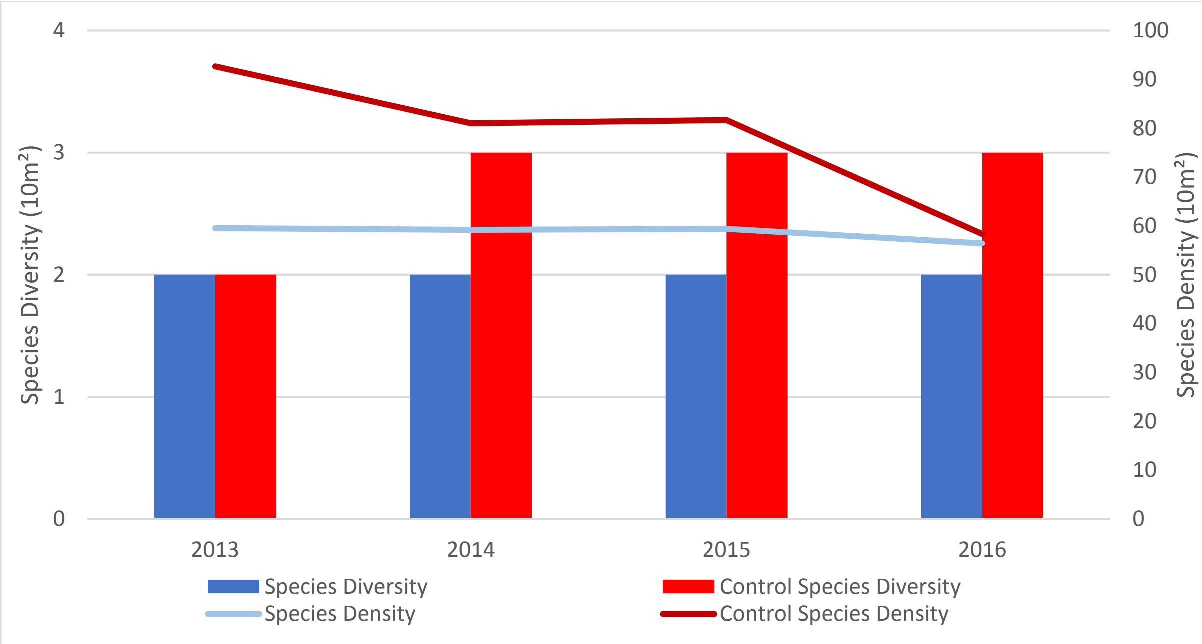


Figure 5-11: Riparian Vegetation Monitoring Species Diversity and Species Density (2013-2016)

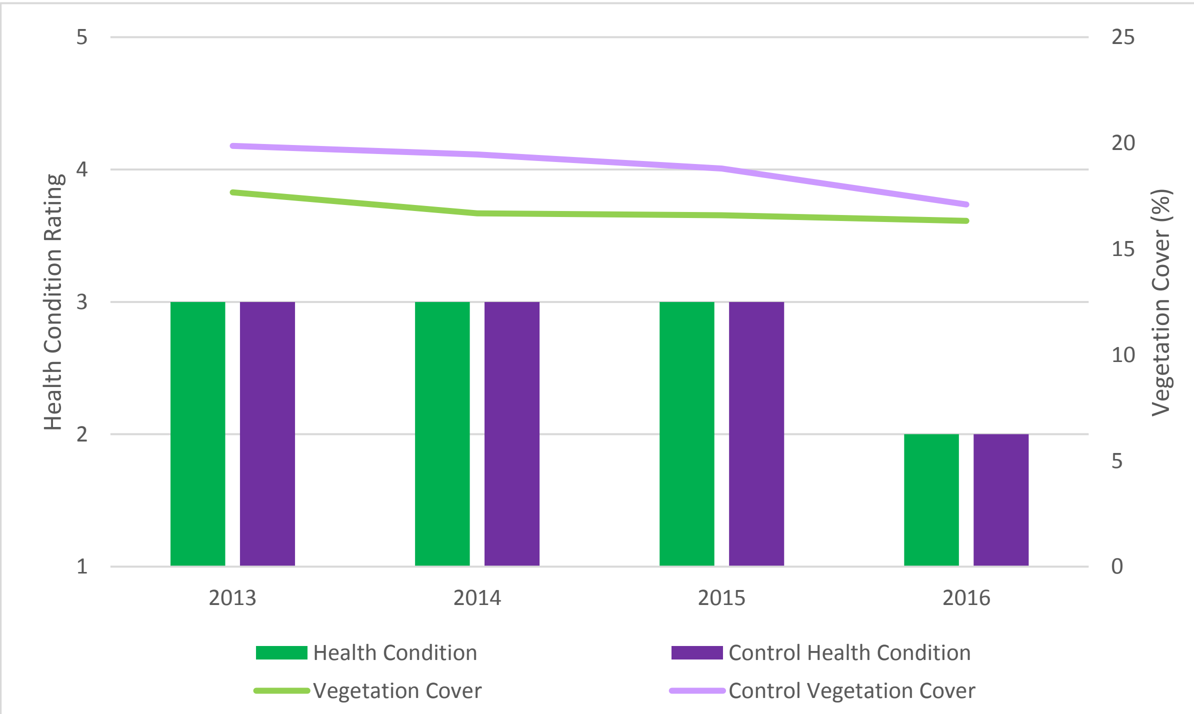


Figure 5-12: Riparian Vegetation Monitoring Health Condition and Vegetation Cover (2013-2016)

As shown in Figure 5-13, annual rainfall was above average for the first two years on monitoring (2013/2014) and below average for the past two years of monitoring (2015/2016). Results of the monitoring program suggest that the decline in health condition and species density/ vegetation cover is a result of climatic factors rather than potential impacts from the lake based exploration activities, as reductions were recorded for both the impact and control sites (control sites in fact recorded the highest reduction in species density and vegetation cover). The samphire vegetation has shown signs of stress in 2016, a notably dry year with annual rainfall received at Telfer only 52% of the long term mean rainfall (2016 annual rainfall recorded at 191.6mm, compared to the long term mean of 363mm). A comparison of vegetation condition of one of the control sites between above average and below average rainfall years (2013 and 2016) is shown in Plate 3.

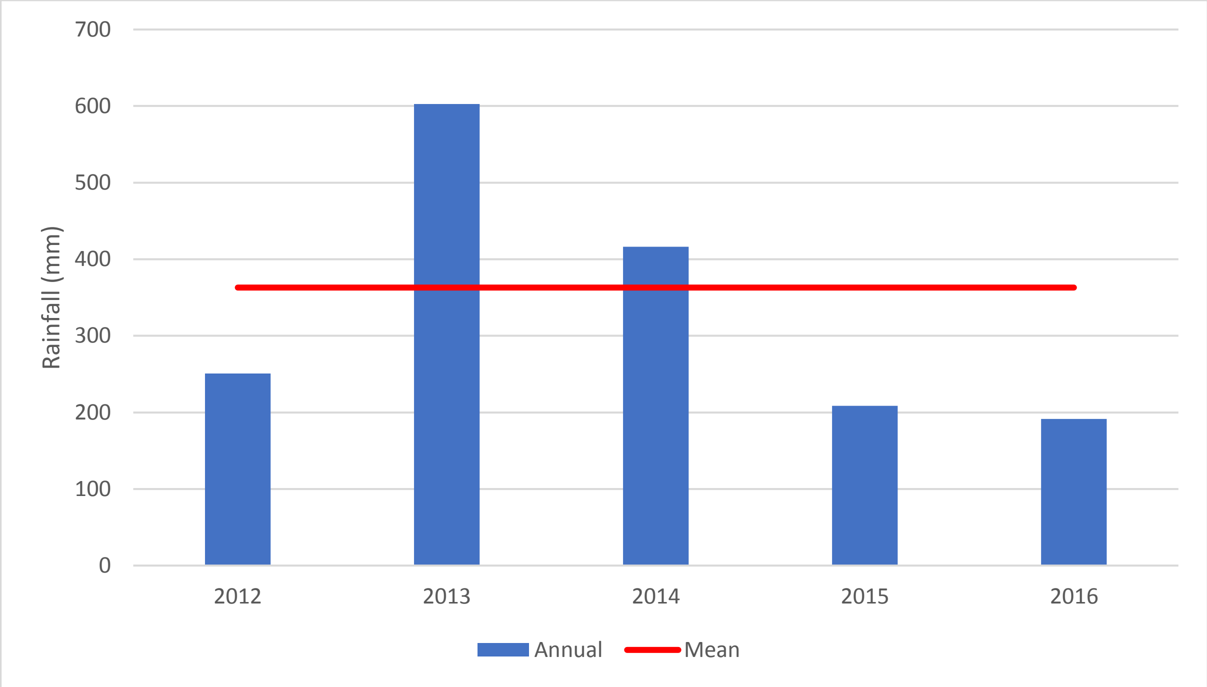


Figure 5-13: Annual rainfall for Telfer Aero Weather Station (#13030) 2012-2016 (BoM, 2017b)

Plate 3: Riparian Monitoring Site T15 (Control Site) in 2013-wet period (left) and 2016-dry period (right)

Hydrogeological assessments conducted by Global Groundwater (2017) determined the largest water input into the lake is from rainfall and to a lesser extent from surface water runoff, however surface water inputs are highly variable (Figure 5-14). Recharge from rainfall (annual rainfall of approximately 300mm per annum) is unknown, but likely very high due to the osmotic effect. The osmotic effect is the tendency of water, to pass through a semipermeable membrane (the lake surface) into a solution where the concentration is higher, thus equalizing the concentrations (Global Groundwater, 2017).

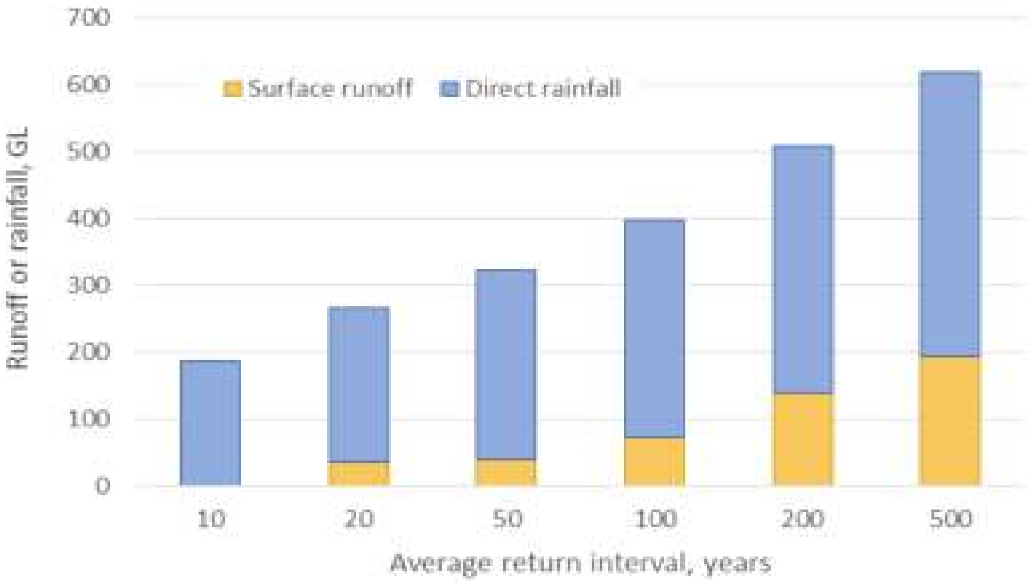


Figure 5-14: Rainfall and runoff contributions to playa – various return intervals (Knight Piésold, 2017)

Five monitoring bores (piezometers) were installed on Lake Disappointment in 2016 (see Figure 5-10 for location of piezometers), to measure Static Water Levels (SWL). SWL have been monitored quarterly since September 2016 with results provided Table 5-9 below. Results indicate a natural SWL ranging between 0.2m and 1m below ground level (bgl). During dry periods, the levels remain relatively steady but following a rainfall event can respond quickly and rise 0.2 to 0.3m. The stability of the groundwater levels indicates that the depth to which evaporation can remove water from the lake is relatively shallow and likely extinguished at less than 1 mgbl (Global Groundwater, 2017).

During the 2016 riparian monitoring period (September 2016) SWL ranged from 0.47m to 0.67m (below *Tecticornia* root depth; 0.2-0.3m). As shown in Figure 5-13, this was during a dry period.

Table 5-9: Static Water Levels 2016-2017 (Global Groundwater, 2017)

Piezo ID	Date	stickup (cm)	Raw SWL (cm)	Corrected SWL (cm)
T4B1	23/09/2016	41	88.4	47.4
T4B2	23/09/2016	57	113.7	56.7
T4B3	23/09/2016	71.2	136	64.8
T4B4	23/09/2016	60.1	127	66.9

Piezo ID	Date	stickup (cm)	Raw SWL (cm)	Corrected SWL (cm)
T4B1	9/12/2016	41	87.9	46.9
T4B2	9/12/2016	57	114.4	57.4
T4B3	9/12/2016	71.2	137.7	66.5
T4B4	9/12/2016	60.1	129.4	69.3
T4B5	9/12/2016	43	152.4	109.4

Piezo ID	Date	stickup (cm)	Raw SWL (cm)	Corrected SWL (cm)
T4B1	28/04/2017	41	62	21
T4B2	28/04/2017	57	83	26
T4B3	28/04/2017	71.2	102.5	31.3
T4B4	28/04/2017	60.1	92	31.9
T4B5	28/04/2017	43	102	59

The Lake Disappointment playa surface is dry most of the time. Wetting events mostly occur in summer (January to March). Wetting events sufficient to cause ponding on the playa surface do not occur every year. It is relatively rare for water deeper than 0.1m to be present on the lake surface for more than about 2 months in any given year (Figure 5-15).

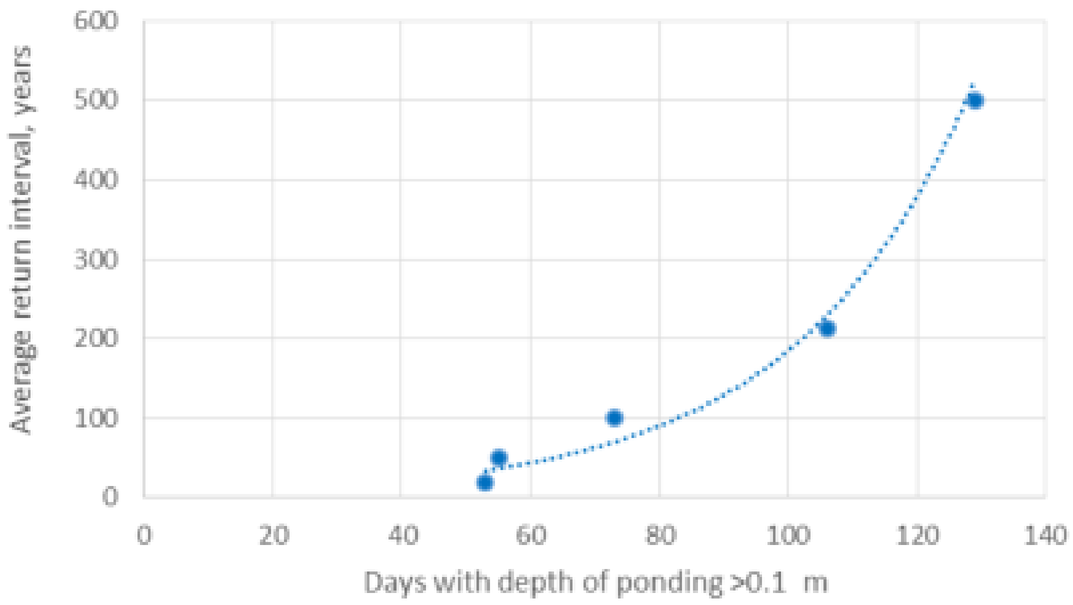


Figure 5-15: Ponding duration vs average return interval (Knight Piésold, 2017)

5.2.4 McKay Creek Vegetation and Hydrology Assessments

Vegetation of McKay creek was identified as Open low woodland of *Eucalyptus camaldulensis/ Corymbia* spp. over mid-dense hummock grass of *Triodia* spp. in creekline (OD-EW1). *E. camaldulensis* is adapted to episodic flooding and drought. Literature suggests its water requirements exceed those provided by rainfall alone and are usually met by the trees accessing groundwater[13] (Doody *et al*., 2009; 2014a). As an adaptation to arid and semi-arid environments, *E. camaldulensis* is opportunistic in its water use, sourcing water according to osmotic and matric water potential (Doody *et al.,* 2009). Water sources include fresh to moderately saline groundwater, lateral bank recharge and overbank flooding, which replenish floodplain groundwater (Doody *et al.,* 2009; 2014b).

Hydrogeological assessments of the McKay creek area (within the proposed Northern bore field) were conducted by Strategic Water Management (2017a) with additional assessments conducted by SRK Consulting (2018). The following four primary hydrostratigraphic units have been established for the Northern Bore Field area and are shown conceptually in Figure 5-16:

- Layer 1 – a shallow, spatially limited alluvial aquifer associated with MacKay Creek (i.e. the MacKay Creek Alluvial System)
- Layer 2 – a 50 m thick, extensive sequence of dense clay which forms an aquitard between the shallow and deeper aquifers

[13] dependent on groundwater availability and quality

- Layer 3 – an unconsolidated sand and gravel layer underlying the clay deposits, typically 25–30 m thick and of unknown lateral extent
- Layer 4 – fractured bedrock.

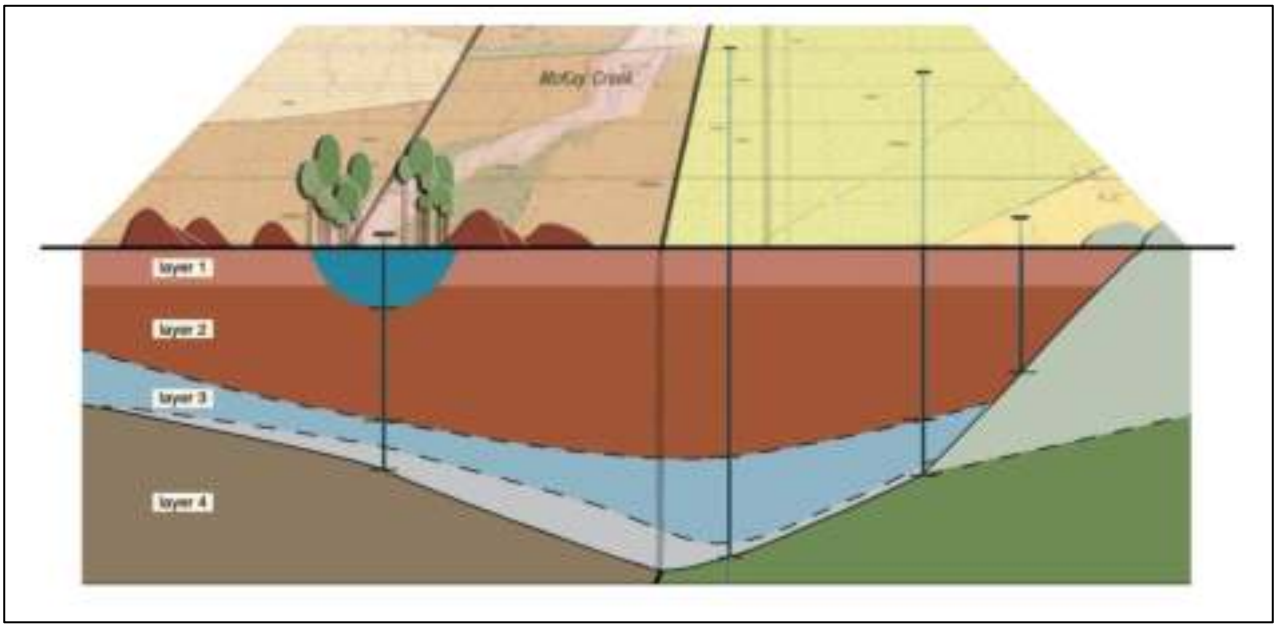


Figure 5-16: Conceptual hydrostratigraphy of the Northern Bore Field area (SRK, 2018)

The second layer within the Quaternary / Tertiary sequence acts as an aquiclude, restricting movement of groundwater between the Layer 1 shallow aquifer and the Layer 3 deeper aquifer. The lack of interaction between Layer 1 and Layer 3 is evident in the difference in hydrochemistry between the two layers and is also indicated by the different groundwater levels and groundwater dynamics of the two layers. The electrical conductivity of the groundwater within the unconfined surface aquifer can be very fresh with a conductivity typically 400 to 600µS/cm, consistent with short term streamflow after rainfall. The conductivity of the groundwater from Layer 3 is much higher at 14000 µS/cm, indicating a far longer residence time.

Ten monitoring bores were installed at McKay creek in 2016 to measure Static Water Levels (SWL). SWL have been monitored since November 2016 with results provided in Table 5-10 below. The SWL in the area is between 11 to 13mbgl. Available data suggests that at depths greater than 10m, groundwater dependency decreases and/or is minimal (Eamus *et al.,* 2006a).

Table 5-10: Static Water Levels 2016-2017 (Strategic Water Management, 2017a)

Date	P12	P14	P15	P26	P27	P29	P30	P34	P35	P43
Ground Surface ~366-367m RL										
4/11/2016	345.19	346.89	345.15	No data	348.92	349.91	351.61	348.82	349.66	351.46
4/02/2017	345.13	347.10	345.10	351.60	348.95	349.88	351.63	348.74	349.61	351.52
4/05/2017	345.06	347.23	345.72	350.02	349.08	349.75	351.48	349.15	349.63	351.38
4/08/2017	344.85	347.49	346.52	349.76	No data	349.82	351.58	349.43	349.88	351.47

Within the first layer of the Northern bore field is the delta zone of McKay creek (area which lies within the last of the dunes heading north from Lake Disappointment before the flat sand plain). The evidence from the water level response within this zone indicates that the delta area acts as a significant reservoir for shallow storage of surface recharge. The retention of water within this shallow reservoir enables the large eucalypts and other trees and shrubs to thrive not just during the wet but year-round until recharged by inflow from the next rainfall event on the McKay Range (Strategic Water Management, 2017a).

5.2.4.1 Conclusion

Based on the results of the assessments detailed above, none of the vegetation types within the LDP Project, including samphire vegetation (CD-CSSSF1) and vegetation associated with McKay creek (OD-EW1) are considered to be groundwater dependent ecosystems, in the sense of having access to permanent access to the groundwater table or its associated capillary zone. However, the vegetation associated with McKay creek is likely to be reliant on periodic inflow of surface water along McKay creek, which intermittently recharges the shallow unconfined sediments of the McKay creek delta.

6 Potential Indirect Impacts

6.1 Hydrological Impacts-Lake Based Activities

6.1.1 Surface Water

The most significant risk to surface hydrological processes (and subsequent potential impact to flora and vegetation associated with Lake Disappointment) arises from the possibility that the establishment of on-playa infrastructure (trenches, causeways, ponds, halite dumps) could alter flooding regimes in one or more of the following ways:

- Depth of flooding - The development of the LD project includes the construction of a number of ponds and other infrastructure on Lake Disappointment. As such, the lake will lose some water storage capacity, which could – theoretically - increase the flood levels resulting from storm events.
- Distribution of wetting - The infrastructure (in particular the infiltration trenches) will impact the flow patterns on the playa surface.
- Duration of wetting – Establishment of ponds, dumps and other barriers to water movement could affect how long water ponds in a particular part of the playa.
- Velocity of flow - The modification of flow patterns could cause localised changes in the rate of water flow, causing erosion or sediment deposition.

The predicted changes in surface water flow that would result from establishment of on-playa infrastructure are illustrated in Figure 6-1.

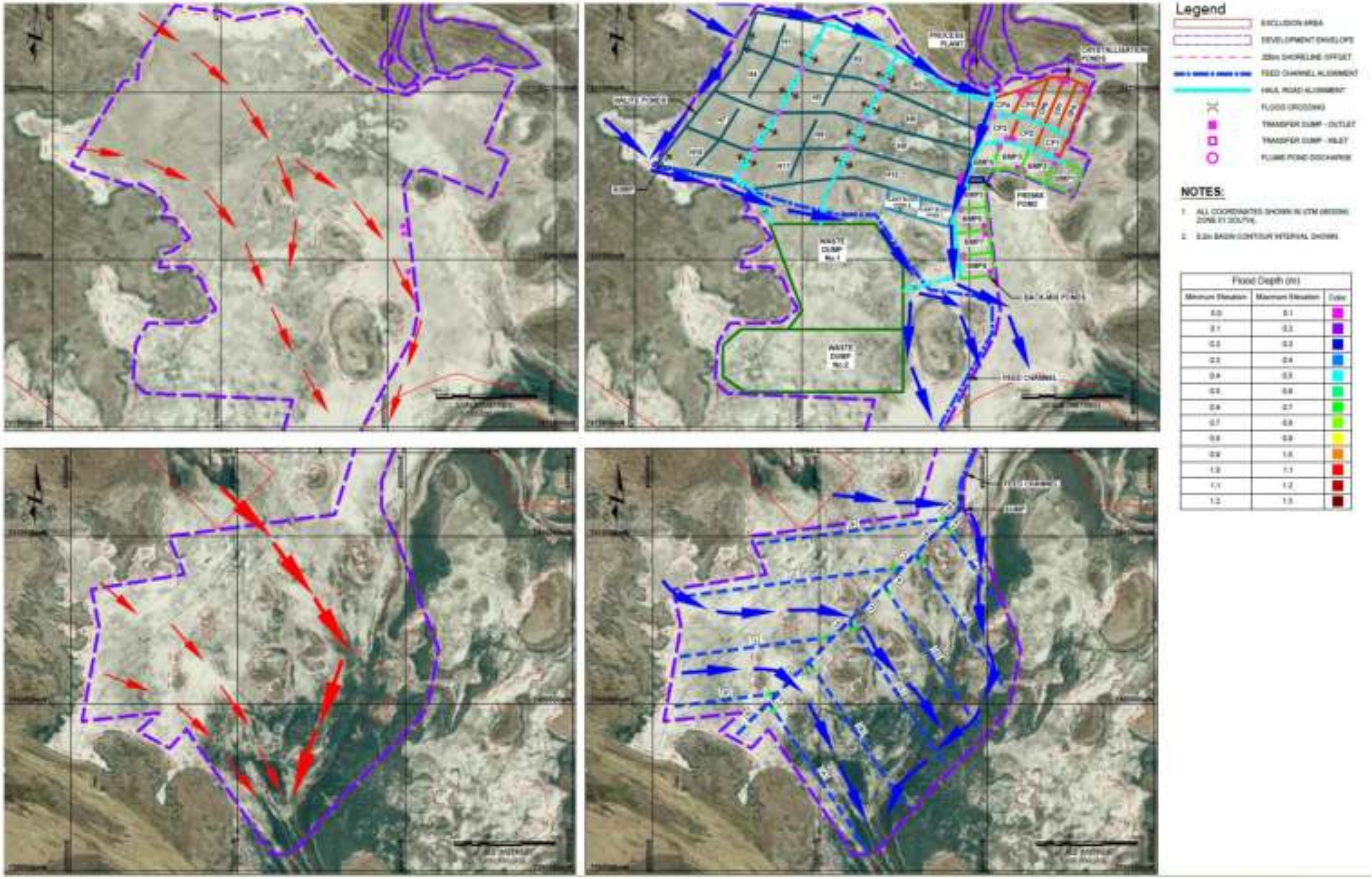


Figure 6-1: Surface water flows without (left) and with (right) proposed ponds and salt dumps (Knight Piésold, 2017)

6.1.1.1 Potential for changed flooding regimes

Flood modelling has been conducted to evaluate whether the establishment of evaporation ponds and other on-playa infrastructure (with a maximum footprint of up to 7197 ha) could result in greater flooding depths on the playa, as a result of the area occupied by project infrastructure or "backwater effects" due to restriction of surface flows (Knight Piésold, 2017).

Potential impacts on ponding depths were assessed by developing a stage storage model of the lake with and without project infrastructure in place (Knight Piésold, 2017). The stage storage model was then used to estimate the new flood level for 72-hour storms with a range of return intervals. As shown in Table 6-1, the increase in the flood level when infrastructure is present is very small.

Table 6-1: Predicted increases in flood depths post-development (Knight Piésold, 2017)

Annual Exceedance Probability (AEP), %	Average Return Interval (ARI), years	Predicted increase in flood level, m
5	20	0.000
2	50	0.000
1	100	0.000
0.2	500	0.010
Cyclone Rusty	212	0.004

For a 1 in 500-year flood the predicted increase in ponding depth is in the order of 10 mm. For an event delivering flows similar to those recorded during severe tropical Cyclone Rusty in 2013 (which corresponded to a 1 in 212-year flood event), the estimated increase in ponding depth across the playa would be approximately 4 mm, compared to the depth of ponding predicted to occur if there were no project infrastructure present.

Seasonal variation in inundation is thought to have an important effect on the establishment and persistence of plant communities in the riparian zone of salt lakes (English and Colmer, 2011; Konnerup *et al*, 2015; Purvis *et al*, 2009). Although vegetation in the riparian zone is generally salt tolerant, different species show widely varying responses to submergence. Sensitivity to submergence in some riparian species, including members of the genus Tecticornia, may be greater than sensitivity to drought (Marchesini *et al*, 2014; Konnerup *et al*, 2015; Van Etten and Vellekoop, 2009). Because of the complexity and variability of the physiological responses of riparian vegetation to inundation, Reward has sought to protect riparian vegetation by establishing a minimum 200 m buffer zone between the nearest lake edge vegetation and any on-playa project infrastructure. Coupled with the engineered drainage measures to be developed, the buffer zone will help to reduce the likelihood of increased duration or depth of inundation. This will help protect those Tecticornia species which may be especially sensitive to the effects of low oxygen conditions and osmotic stress that can develop with prolonged submergence.

6.1.2 Groundwater

Hydrogeological assessments were conducted by Global Groundwater (2017) to determine potential drawdown from the brine trenches. To simulate the greatest potential impact (worst case scenario) the transient simulation was run for 10 years without recharge with all water being sourced from storage within the model. This scenario represents a period of 10 years without significant rain or surface water inflow on, or into the lake, which based on recent observed weather patterns is considered highly unlikely. A map showing the model output drawdown extent in relation to Tecticornia dominated vegetation is provided in Figure 6-2. The following conclusions can be drawn from the development of the conceptual and numerical models:

- Although groundwater inflow contributes in the order of 17 GL to the lake annually (25% of the project abstraction), water inputs to the lake are dominated by rainfall, which on average exceeds abstraction by an order of magnitude.
- The water level in the lake is relatively stable with fluctuations in the order of half a metre indicating a quasi-equilibrium between inputs and evaporation at this depth.
- The model simulates an environment with no recharge over a period of 10 years, which is highly unlikely given recent rainfall and as such represents a worst-case scenario. This scenario results in a change in water levels (drawdown) at the lake margins of between 10 cm and 30 cm, based on the trench design presented This impact extends approximately 3.8 km from the nearest trench. Drawdown of between 30 and 70 cm extends approximately 1.7 km from the nearest trench.

- The distance of drawdown from the trench increases with time between recharge events. One year after a significant recharge event, drawdown of between 10 cm and 30 cm extends approximately 1 km from the nearest trench.
- Pumping from bores in the weathered basement shows a confined response to pumping indicating poor connection with the upper lake bed sequence. Modelling based on a leaky aquitard show the response to pumping in the upper lakebed sequence after one year is around 50 cm at a radius of 500 m from the bore.

An assessment on the area of samphire vegetation (CD-CSSSF) within the modelled drawdown contours is provided in Table 6-2. It is important to note that the modelling represents the maximum possible drawdown, based on a ten year no-recharge scenario which is unlikely to occur. Also from the previous assessments specified in Section 5.2.1 to 5.2.3, samphire vegetation has not been identified as groundwater dependent and any potential drawdown is considered unlikely to impact on samphire vegetation. None of the Tecticornia species considered to be of conservation significance (specified in Section 5.1) are located within the maximum drawdown extent (i.e. not located within zone of 0.7-1.7m drawdown).

Table 6-2: Area of samphire vegetation within Brine Trench potential zone of influence (groundwater drawdown)

Samphire vegetation within potential drawdown	Ha area	% of total samphire vegetation
Extent of Tecticornia-dominated vegetation (CD-CSSSF) within 0.1 m – 0.3 m groundwater drawdown contour	1749.2	15
Extent of Tecticornia-dominated vegetation (CD-CSSSF) within 0.3 m – 0.7 m groundwater drawdown contour	1071.5	9
Extent of Tecticornia-dominated vegetation (CD-CSSSF) within 0.7-1.7m groundwater drawdown contour	185.6	2
Total extent of Tecticornia-dominated vegetation (CD-CSSSF) within groundwater drawdown (0.1-1.7m)	3006.3	26
Total estimated extent of Tecticornia-dominated vegetation (CD-CSSSF) in Lake Disappointment riparian zone (based on aerial imagery)	11703	

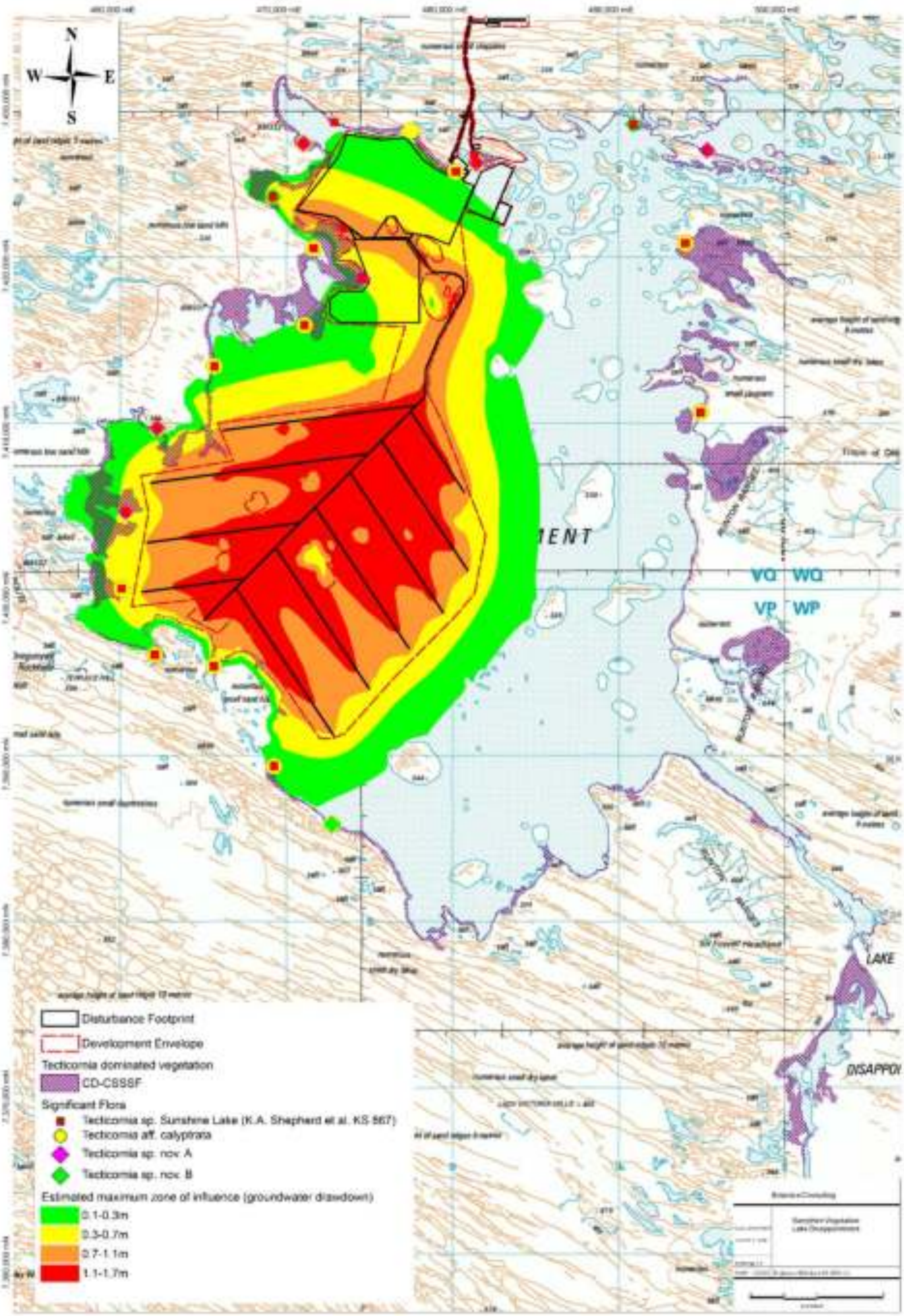


Figure 6-2: Potential drawdown in relation to Tecticornia dominated vegetation and Tecticornia of conservation significance (model output 10 year no recharge-obtained from Global Groundwater, 2017).

6.2 Hydrological Impacts-Off Lake Activities

6.2.1 Surface Water

Establishment of off-playa infrastructure, including access roads and associated drainage and/or pipelines is much less likely to interfere with existing hydrological processes. No part of the proposed processing plant site or other support infrastructure (accommodation village, airstrip, borrow pit) lies within the 1 in 100 year flood zone of any watercourse. The existing access tracks, the Willjabu and Talawana Tracks, cross a number of ephemeral watercourse – most notably McKay Creek and some upgrades of the existing tracks and associated drainage structures are likely to be required to maintain safe access and to accommodate occasional flood events. Reward does not propose any works that would modify flows along McKay Creek.

6.2.2 Groundwater

Reward proposes to extract and process in the order of 2000 L/s (63 GL per year) of potash brine from Lake Disappointment. In order to process the brine and provide freshwater for all other elements of the operation up to 3.5GL/year of freshwater is required. A programme of groundwater exploration identified two prospective areas to the north of Lake Disappointment, these areas have been named as the Cory bore field and the Northern bore field (refer to Figure 1-1 for location map). 1.5GL/year is proposed to be obtained from the Cory bore field, with the remaining 2GL/year to be obtained from the Northern bore field. H2 hydrogeological assessments (in accordance with Department of Water and Environment *Operational Policy 5.12*) have been conducted by Strategic Water Management (2017a; 2017b). Following assessments conducted by Strategic Water Management, additional assessments were conducted by SRK Consulting (2018).

Drawdown estimates were developed by SRK for the Northern and Cory Bore Fields based on the hydraulic parameters developed from the pumping test program completed for the site. The estimates were developed using the Theis (1935) methodology, assuming pumping at maximum proposed licensed rates for the life of the Project (30 years), and assuming no recharge to the aquifer for the entire life of the Project. The extents of the drawdowns are therefore highly conservative, and considered to be much larger than will be observed during operations. Drawdown estimates are also developed assuming a homogeneous, isotropic aquifer with radial flow, and therefore do not account for the known anisotropy of the host aquifers or for any potential hydraulic barriers.

The estimated drawdown curves for both bore fields indicate most of the impact will be restricted to the area near the bores. Although estimates of drawdown extend for large distances, this is largely due to the exclusion of recharge from the calculations and is not considered reflective of expected conditions during operation of the bore fields. Furthermore, it is unlikely that the respective bores will be pumped at maximum licensed amounts for the duration of the Project life. Based on the developed drawdown estimates and the east–west trend of geological units in the area, interference between bore fields due to pumping is not anticipated.

Based on the responses of bores to pumping and the known hydraulic parameters, it is anticipated that water levels would recover to 90% of original levels within 10 years of cessation of pumping (SRK, 2018).

6.2.2.1 Cory Bore Field

Results of the Hydrogeological assessment conducted for the Cory bore field are summarised as follows:

- Hydrogeological assessments indicate that, in the absence of recharge, the cone of depression will be 2m at a distance of up to 2.5km and maximum 5m bswl immediately surrounding bores, as shown in Figure 6-3. This response is typical of a fractured rock aquifer.
- Natural SWL is approximately 10m below ground level at the end of the dry season.
- Recharge to the Cory bore field area is via direct infiltration from rainfall and groundwater throughflow, there are no surface drainage features within the bore field area and runoff from the dunes is assumed to be negligible. Assessments indicate the volume of water recharging the Cory bore field in an average year via rainfall is 170ML/year. Throughflow per year is estimated at 0.5GL/year[14].
- The groundwater in the Cory bore field can be described as brackish with a typical TDS of 2500mg/L. Unsurprisingly given the regional environment with episodic rainfall and high evaporation the hydrochemistry is dominated by Sodium Chloride.
- Over the course of the proposed 20-year life of operations at the LDP Project, a total of 45GL is proposed to be abstracted from the Cory bore field. The impact of this abstraction on the regional groundwater resource will result in the removal of groundwater from storage as estimates of annual recharge are less than the proposed abstraction.

[14] assuming the hydraulic gradient is NW – SE and the width of the sandstone aquifer is 5000m along the NW – SE plane

- The large extent of the aquifer and the significant volume held in storage regionally implies that the hydraulic head created from pumping will be equalised quickly once pumping has permanently ceased, full recovery will occur within 3 to 5 years (Strategic Water Management, 2017b; SRK, 2018).
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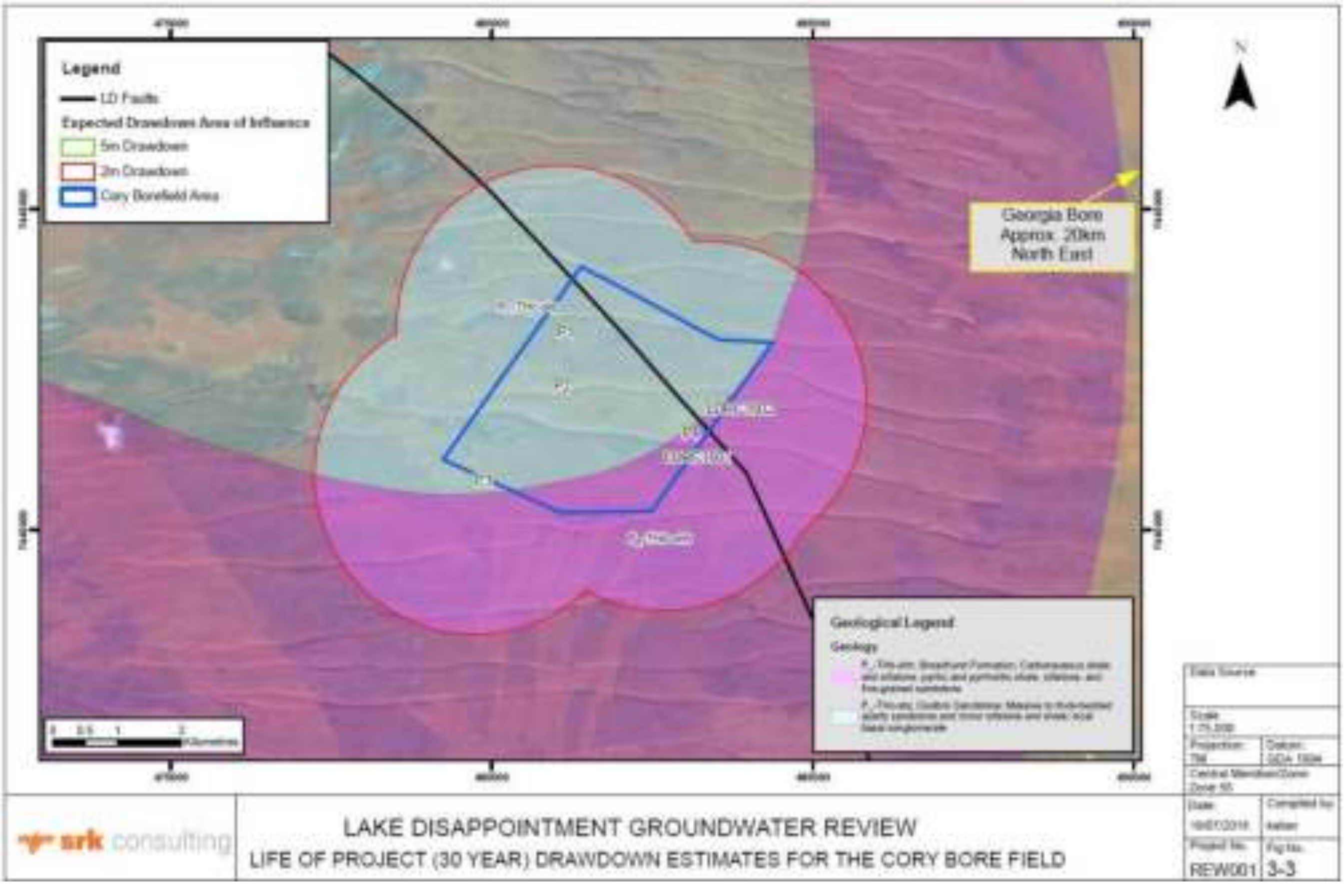

Figure 6-3: Cory Borefield – Drawdown estimates over life of project (SRK, 2018)

6.2.2.2 Northern Bore Field

Results of the Hydrogeological assessment conducted for the Northern bore field are summarised as follows:

- Natural SWL is approximately 11 to 13m below ground level.
- Proposed production bores at the Northern bore field would draw up to 2GLpa of brackish to saline water (TDS range from 2200 mg/L to 17000 mg/L) from the basal layer of Tertiary sands and sandy clay overlying the McKay fault zone. The nominated area of the Northern bore field represents only a small proportion of the overall Tertiary cover and the projected strike of the fault in the project locality.
- The proposed Northern production bore field will consist of up to 18 production bores, each with one monitoring bore screened in the target aquifer and a short monitoring bore screened in the upper aquifer. Production bores would be screened in the basal sand layer below the intermediate clayey aquiclude.
- Numerical modelling of the proposed Northern bore field predicts that groundwater abstraction from the confined Tertiary aquifer will result in the removal of groundwater from storage. Pumping from storage will create a pressure drop within the aquifer, which will draw water towards the pumping bores, creating a cone of depression within the confined aquifer. The modelling shows the cone of depression developing for the first 10 years of operation then stabilising. The model predicts that abstraction of water from the confined aquifer will result in minimal drawdown (less than 1 m) in the unconfined superficial (Layer 1) aquifer. The estimated maximum drawdown is determined to be 10m bswl immediately surrounding bores, with the estimated maximum extent of groundwater drawdown in the Layer 3 aquifer of 5m which extends over a radius of approximately 6 km, as shown in Figure 6-4 (Strategic Water Management, 2017a; SRK, 2018).

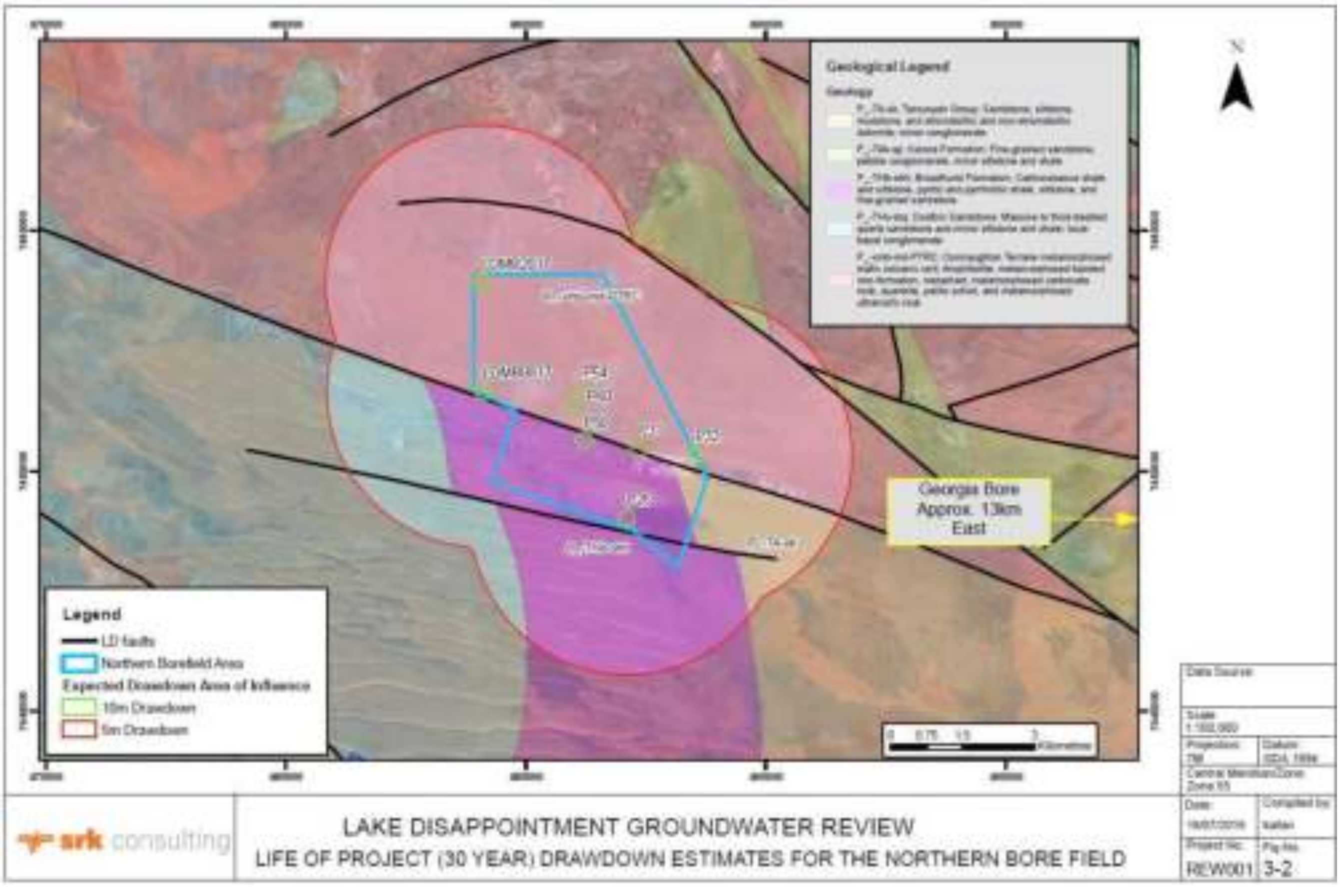

Figure 6-4: Northern Borefield – Drawdown estimates over life of project (SRK, 2018)

As the McKay creek is "perched" (i.e. water levels of the Layer 3 groundwater aquifer are well below the bed of the McKay creek), McKay creek is not affected by water levels in the underlying confined and consequently will not change in response to ground water abstraction in the underlying confined aquifer. No water will be abstracted from the creek or from the shallow unconfined aquifer immediately underlying the creekbed. The shallow aquifer system in which McKay creek and the delta zone occurs, is wholly dominated by creek flow driven by annual rainfall.

An assessment on the area of McKay creek vegetation (OD-EW1) and all other native vegetation within the modelled drawdown contours is provided in Table 6-3. It is important to note that the modelling represents the maximum possible drawdown, based on a ten year no-recharge scenario which is unlikely to occur. Also from the previous assessments specified in Section 5.2.1 and 5.2.4, no vegetation has not been identified as groundwater dependent and any potential drawdown is considered unlikely to impact on vegetation.

Table 6-3: Area of McKay creek vegetation and other native vegetation within Bore Fields potential zone of influence (groundwater drawdown)

McKay Creek Vegetation (Northern Bore field)	Ha area	% of total McKay creek vegetation
Extent of OD-EW1 within 5m groundwater drawdown contour	1478	30
Extent of OD-EW1 within 10m groundwater drawdown contour	27.2	1
Total extent of OD-EW1 within groundwater drawdown (5-10m)	1505.2	31
Total estimated extent of OD-EW1 vegetation at McKay Creek (based on aerial imagery)	4899	

McKay Creek (Cory Bore field)	Ha area	% of total McKay creek vegetation
Extent of OD-EW1 within 2m groundwater drawdown contour	0	0
Extent of OD-EW1 within 5m groundwater drawdown contour	0	0
Total extent of OD-EW1 within groundwater drawdown (2-5m)	0	0
Total extent of OD-EW1 vegetation at McKay Creek (based on aerial imagery)	4899	

All Vegetation (Northern Bore field)	Ha area	% of total vegetation within local survey area
Extent of native vegetation within 5m groundwater drawdown contour	8420	13
Extent of native vegetation within 10m groundwater drawdown contour	73	0
Total extent of native vegetation within groundwater drawdown (5-10m)	8493	13
Total extent of native vegetation (based on flora survey)	64,271	

All Vegetation (Cory Bore field)	Ha	% of total vegetation within local survey area
Extent of native vegetation within 2m groundwater drawdown contour	4597	7
Extent of native vegetation within 5m groundwater drawdown contour	0.8	0
Total extent of native vegetation within groundwater drawdown (2-5m)	4597.8	7
Total extent of native vegetation (based on flora survey)	64,271	

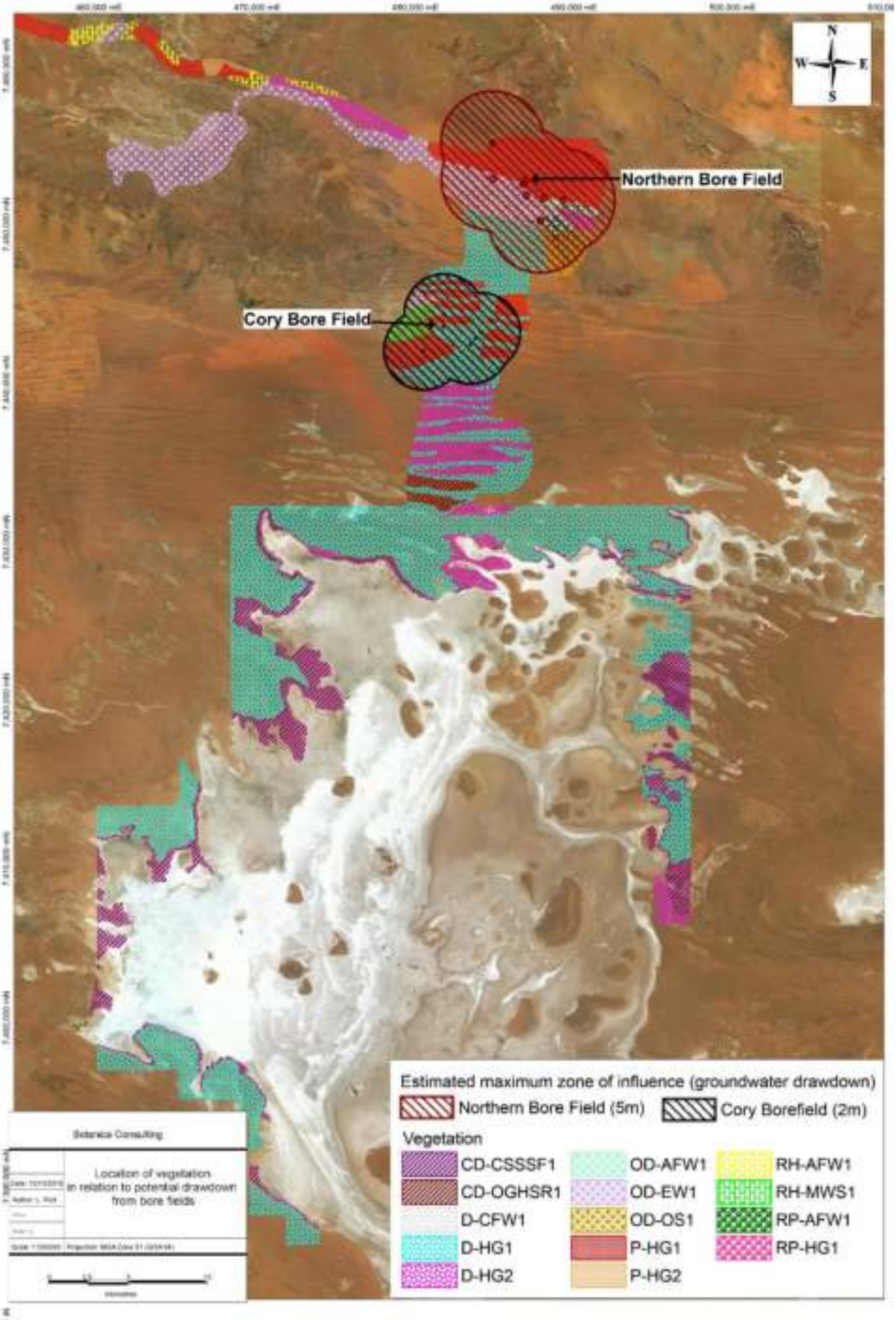

Figure 6-5: Vegetation in relation to Bore Fields potential zone of influence (groundwater drawdown)

6.3 Dust Impacts

In order to assess any potential impacts of vehicle use in the Lake Disappointment Potash Project on sand dune vegetation, a sand dune vegetation monitoring programme was developed. The objective of the monitoring programme was to assess the biodiversity and health of native vegetation immediately surrounding the site access track (within 250m of track[15]) to determine whether use of the site access track is having an impact on the surrounding vegetation. In April 2013 ten monitoring sites (quadrats) and ten control sites were established on the ridges of sand dunes along the Lake Disappointment site access track (Figure 6-6). These sites have been monitored annually from 2013 to 2016.

A summary of monitoring results is shown in Figure 6-7 and Figure 6-8. Mean species diversity ($10m^2$), species density ($10m^2$) and vegetation cover (%) of the impact sites and control sites have all increased since 2013. The 2016 results show there has been no detrimental reduction in species diversity, species density, vegetation cover or health rating recorded in the impact sites. The slight variation in biodiversity parameters over the monitoring period appears to be attributed to climatic factors rather than potential impacts (any decline recorded for both the impact and control sites). The monitoring program indicates that vehicle traffic is having little to no indirect effect on sand dune vegetation.

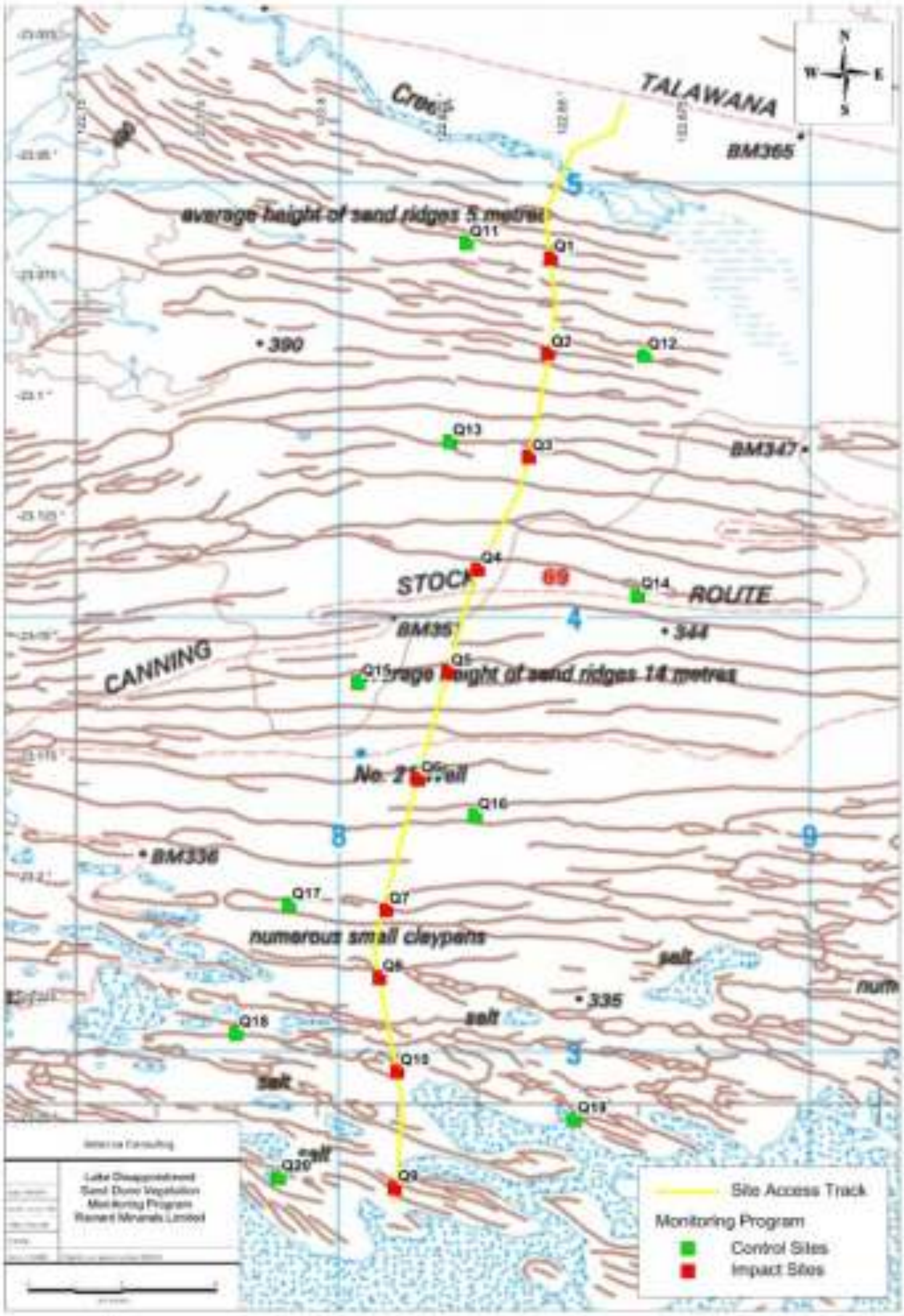

Figure 6-6: Map of sand dune vegetation monitoring sites Lake Disappointment

[15] Quadrats were established within 20m of the site access track

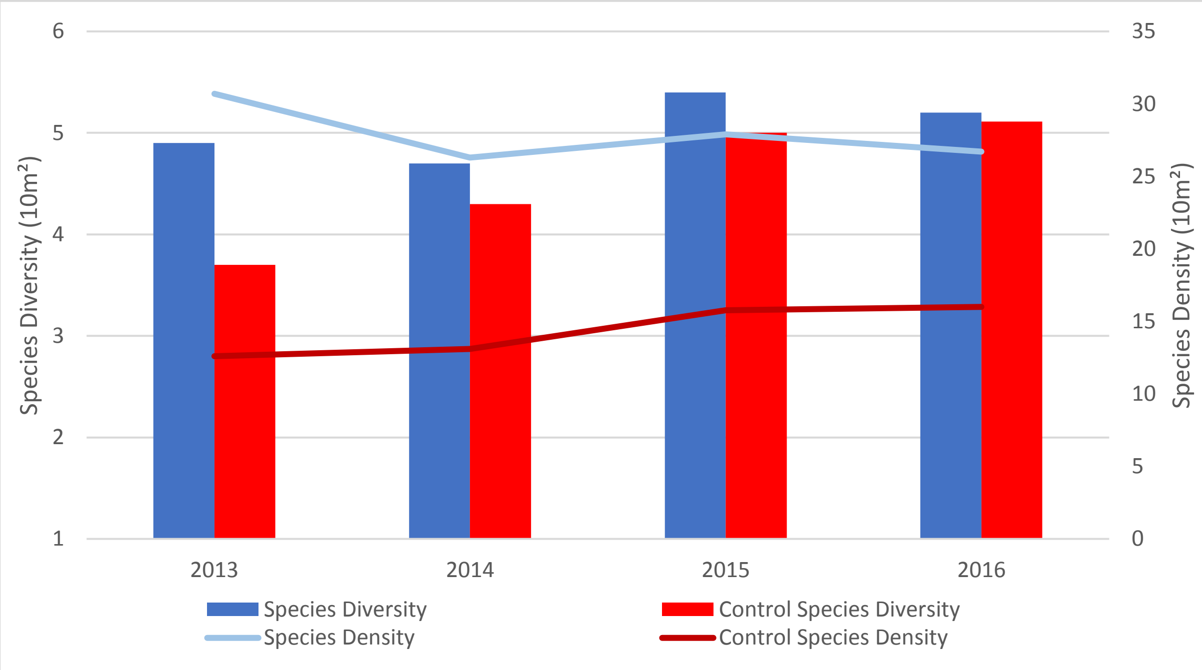

Figure 6-7: Sand Dune Vegetation Monitoring Species Diversity and Species Density (2013-2016)

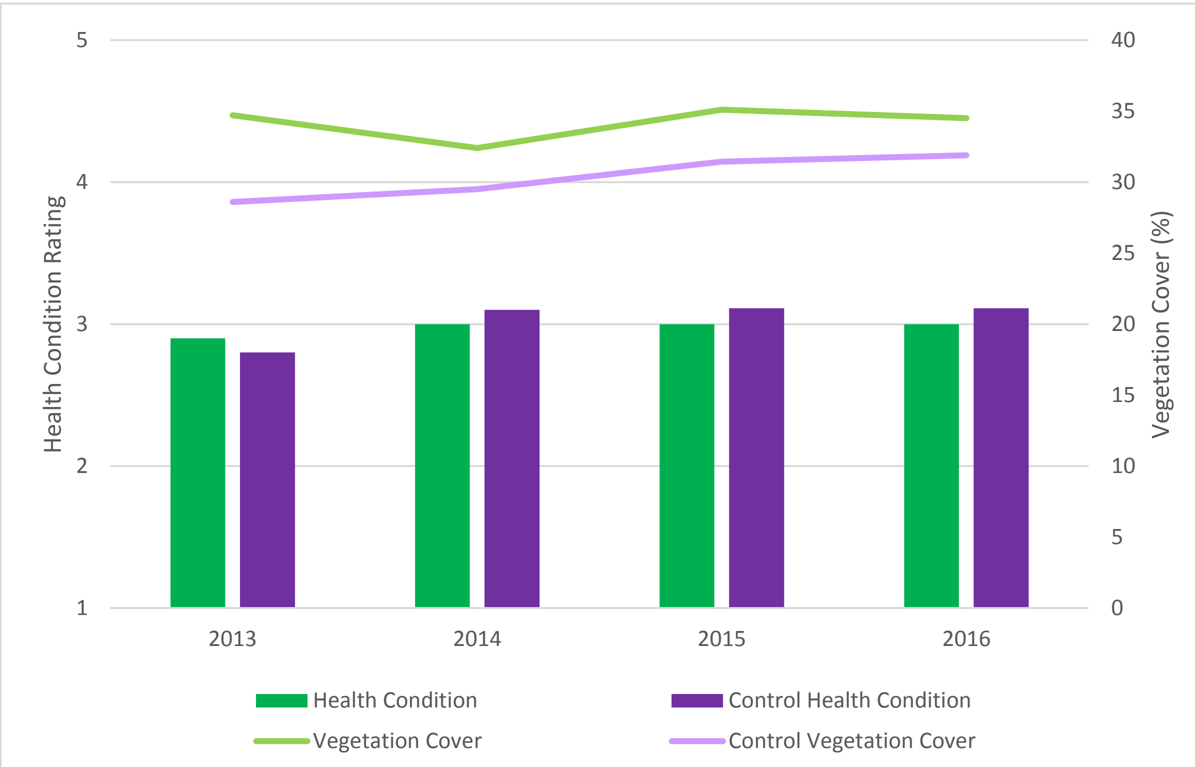

Figure 6-8: Sand Dune Vegetation Monitoring Health Condition and Vegetation Cover (2013-2016)

There is little risk of dust generation associated with brine processing, as it is a wet process. Stockpiled halite typically forms a surface crust and is not susceptible to wind erosion. The main potential for dust impacts on vegetation is from wheel generated dust associated with vehicular traffic on access roads landward of the playa.

The area of native vegetation within 50m either side of the site access roads (conservative estimate of the maximum potential dust deposition from vehicle travel on site access roads) is 2499 ha of vegetation, which represents 6.2% of the total development envelope. As shown in the previous monitoring described above, there has been no adverse impacts to vegetation within 20m of the site access tracks. No samphire vegetation/ conservation significant flora are located within a 50m radius of the site access roads (Figure 6-9).

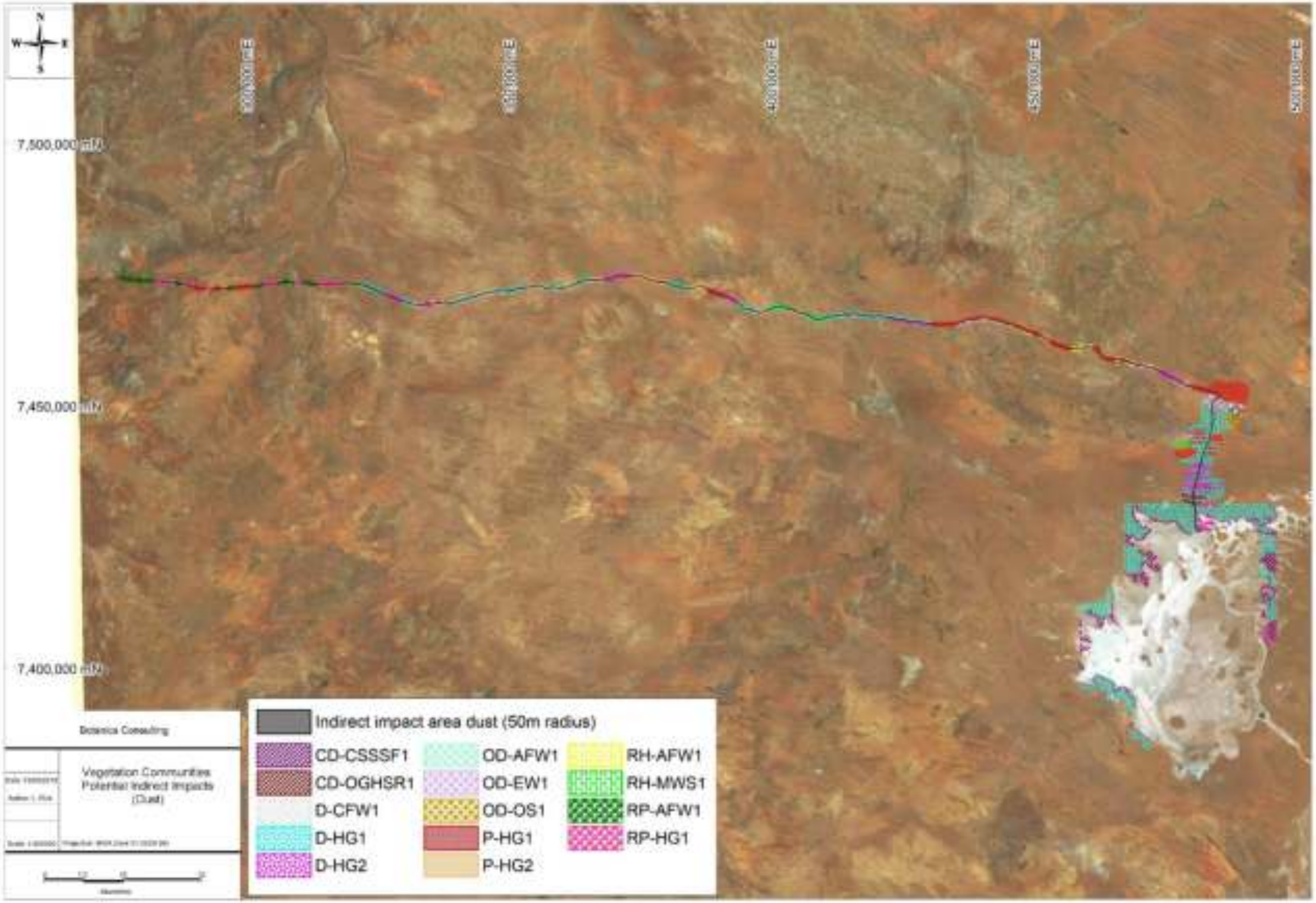

Figure 6-9: Area of native vegetation within 50m of site access roads (potential dust generation)

7 Environmental Offsets

An assessment on the potential requirement for offsets for impacts to flora and vegetation impacts of the LDP Project was conducted in accordance with the EPA's residual impact significance model (Table 7-1). Based on the model, significant residual impacts include those that:

- affect rare and endangered plants (such as declared rare flora and threatened species that are protected by statute),
- areas within the formal conservation reserve system,
- important environmental systems and species that are protected under international agreements (such as Ramsar listed wetlands) and
- areas that are already defined as being critically impacted in a cumulative context.

Impacts may also be significant if, for example, they could cause plants or animals to become rare or endangered, or they affect vegetation which provides important ecological functions.

Based on the assessment, no environmental offsets for flora and vegetation are required as development of the project:

- Will not impact any rare and endangered plants (such as declared rare flora and threatened species that are protected by statute),
- Will not impact any Threatened or Priority Ecological Communities.
- Will not have a significant impact on Priority Flora and is unlikely to alter the conservation status of *Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al KS 867). This taxon is not endemic to Lake Disappointment and is well represented outside of the project within the Murchison and Little Sandy Desert Bioregion.
- Will not significantly reduce the extent of pre-European vegetation. Vegetation associations do not represent remnant vegetation (retain 99% to 100% of the original pre-European extent) and cumulative impacts are insignificant.

Table 7-1: Environmental Offset Requirement Assessment

Residual Impacts	Significant residual impacts that will require an offset	Assessment	Significant residual impacts that may require an offset	Assessment	Outcome
Threatened Flora	***Impact to or removal of buffers or other areas necessary to maintain ecological processes and functions for Threatened flora under the WC Act or EPBC Act***	No Threatened Flora listed under the WC Act or EPBC Act within the development envelope	***Impact likely to result in a plant species being listed as Threatened under the WC Act or EPBC Act***	5% of the total disturbance footprint is vegetated. One Priority 1 Flora taxon; *Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al KS 867) was identified (no *Tecticornia* within the disturbance footprint, 287 plants recorded within development envelope; total of 46,455 plants within 20km radius of project). This taxon is not endemic to Lake Disappointment and is well represented outside of the project within the Murchison and Little Sandy Desert Bioregion. Project implementation is unlikely to alter the conservation status of *Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al KS 867).	No offset required
Threatened Ecological Communities	***Impact to or removal of habitat necessary to maintain ecological communities declared as environmentally sensitive areas (ESA) under the WC Act or TEC under the EPBC Act***	The entire boundary of Lake Disappointment is listed as an ESA (declared as an ESA under the EP Act as a *'defined wetland and the area within 50 metres of the wetland. Defined wetlands include Ramsar wetlands, conservation category wetlands and nationally important wetlands*). No significant impact to flora/ vegetation associated with Lake Disappointment from direct or indirect impacts. No Threatened Ecological Communities exist within the project area	***Impact likely to results in an ecological community being declared as environmentally sensitive under the WC Act or TEC under the EPBC Act***	No Threatened or Priority Ecological Communities identified within the project area. The entire boundary of Lake Disappointment is listed as an ESA (declared as a 'defined wetland'). No significant impact to flora/ vegetation associated with Lake Disappointment is likely to arise from direct or indirect impacts of project implementation.	No offset required
Remnant Vegetation	***Impacts where the existing vegetation is highly cleared (such as vegetation complexes with <30% of its pre-clearing extent remaining in a bioregion***	None of the vegetation in the project area retain <30% of the pre-European vegetation extent (as specified in the flora report (BC, 2017a). All vegetation associations retain 99-100% of the pre-European extent. Development of the project will not significantly reduce the extent of any pre-European vegetation association.	***Impact to landscapes where the existing vegetation is required to maintain ecosystem services, impact causes a high degree of fragmentation***	Existing vegetation is not highly fragmented and not representative of remnant vegetation (All vegetation associations retain 99-100% of the pre-European extent). Area has been subject to only minor existing disturbance from Talawana track and Wiljadji track. Project implementation will not cause a high degree of fragmentation. Ecosystem services which rely on vegetation are unlikely to be discernibly altered by project implementation.	No offset required
Wetlands and Waterways	***Impact to or removal of buffers necessary to maintain conservation wetlands (such as EPP wetlands, Ramsar Wetlands, Conservation Category Wetlands)***	Lake Disappointment is listed as a Nationally Important Wetland. No significant impact to flora/ vegetation associated with Lake Disappointment from direct or indirect impacts.	***Clearing of native vegetation that is water or wetland dependent (such as damplands and floodplains)***	No groundwater dependent ecosystems within the project area. Project implementation would result in clearing of up to 36 ha of vegetation associated with ephemeral drainage lines and/or a creek line delta. This represents less than 2% of the extent of creekline / delta habitat surveyed during baseline surveys of the project locality and would not materially alter ecosystem function.	No offset required
Conservation Areas	***Impacts to areas reserved under statute or managed for the purpose of conservation (eg. National Parks, Marine Parks, Bush Forever Sites, Conservation Covenants)***	A 4.4 km portion of the existing Talawana track intersects the most southern boundary of the Karlamilyi (Rudall River) National Park (i.e. 4.4 km of the development envelope is located within the National Park). However, no clearing is required within the National Park, as the existing Talawana track will be used.	***Impacts to ecological linkages between conservation areas, contributing to the maintenance or restorability of one or more key ecological processes required to sustain the conservation areas or expanding the functional size of an existing conservation area or partially compensation for less than ideal shape***	Project area is located south of the Karlamilyi (Rudall River) National Park. Project implementation would have no material effect on ecological linkages between the Karlamilyi National Park and the proposed (not gazetted) Lake Disappointment Nature Reserve.	No offset required
High Biological Diversity	***Significant impacts to areas recognized as having high biological value (e.g. nationally or international recognized biodiversity hotspots)***	Project area is not located within a national or internationally recognized biodiversity hotspot.	***Impacts to vegetation communities or flora species that representative of high biodiversity, have a higher diversity than other examples of and ecological community in a bioregion, or is in 'degraded' condition yet is in better condition than other vegetation of the same ecological community in the local area***	Vegetation that would be impacted by project implementation is not of high biological diversity	No offset required

8 Summary

- 10% of the total development envelope and 5% of the total disturbance footprint is vegetated. The remaining area is situated on the Lake Disappointment playa surface in areas devoid of vascular vegetation, algae and other non-vascular macrophytes.
- No TEC or PEC were recorded within the project development envelope or the proposed disturbance footprint. No ecosystems listed under the IUCN Red list of Ecosystems occur within the development envelope/ disturbance footprint. No clearing is proposed within the Karlamilyi (Rudall River) National Park.
- Two vegetation types within the development envelope/ disturbance footprint were identified as possibly having flora/ vegetation of conservation significance: CD-CSSSF1 and OD-EW1.
- CD-CSSSF1 occupies an area of 56 ha within the development envelope (0.14% of the total development envelope). CD-CSSSF1 is not located within the disturbance footprint.
- OD-EW1 occupies an area of 628 ha within the development envelope (1.57% of the total development envelope) and 33 ha within the direct disturbance footprint (0.43% of the total disturbance footprint).
- One Priority 1 Flora taxon and three potentially new *Tecticornia* species were identified within CD-CSSSF1. No Flora of conservation significance are located within the disturbance footprint.
- Results of GDE assessments indicate that none of the vegetation types within the LDP Project, including samphire vegetation (CD-CSSSF1) and vegetation associated with McKay creek (OD-EW1) are considered to be groundwater dependent ecosystems.
- Potential indirect impacts to vegetation (i.e. from alteration of groundwater table, surface water flows and dust deposition) from both lake-based and off-lake developments are minimal. For a 1 in 500-year flood, the predicted increase in ponding depth of Lake Disappointment is in the order of 10 mm. Maximum expected groundwater drawdown for Lake Disappointment (based on worst case scenario with no recharge over a period of 10 years) is 1.7m, resulting from brine abstraction. Maximum expected groundwater drawdown for the Cory and Northern bore field are 5m and 10m respectively, immediately surrounding the bores. The maximum expected drawdown for the shallow aquifer associated with McKay creek is 1m.
- There are no significant residual impacts to flora and vegetation of the LDP Project. Subsequently no environmental offsets for flora and vegetation are required.

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ATTACHMENT 1: LAKE DISAPPOINTMENT NDVI, NDWI AND ET CALCULATIONS (HYDROBIOLOGY, 2017)

ATTACHMENT 2: SOIL CHARACTERISATION AND ASSESSMENT ON TECTICORNIA ROOT STRUCTURE OF THE LAKE DISAPPOINTMENT RIPARIAN ZONE (BC, 2017)