Environmental Assessment and Management Plan

Upper Gascoyne Waste Management Facility Development

Prepared for Shire of Upper Gascoyne

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1 Introduction

The Shire of Upper Gascoyne (the Shire) operates the Gascoyne Waste Management Facility (the Site), located on Vested Crown Land on Wansborough Road Road, 1 kilometre (km) south of Gascoyne Junction, in the Gascoyne region. The Site's existing landfill is reaching its operational capacity, and the Site requires expansion to maintain current operations and accommodate future waste management activities. The Project involves the closure of the currently operating landfill and the development of a new waste management facility that complies with the *WA Environment Protection Regulations 2002* (Rural Landfill Regulations) through the acquisition of Unallocated Crown Land adjacent to the existing Site. The proposed waste management facility aims to provide long term waste management to the Gascoyne Junction township and surrounding commercial businesses and industry. The expanded Site will include a putrescible landfill, an inert landfill and a Community Recycling Centre (CRC) with a household hazardous waste shed.

A Works Approval from the Department of Water and Environmental Regulation (DWER) is required to construct a new integrated waste management facility. This Environmental Assessment and Management Plan (EAMP) has been prepared to support the Works Approval application for the Site development works by outlining the existing environmental attributes, detailed designs, proposed construction works, and environmental management measures to be implemented.

1.1 Report Objectives

The key objectives of the EAMP are to:

- Provide the design, construction and operational details of the new landfill facility;
- Outline the environmental aspects requiring management;
- Describe the proposed environmental management measures;
- Undertake a residual risk assessment in accordance with the DWER's *Guidance Statement: Risk Assessments* (2017); and
- Demonstrate that the proposed management measures adequately manage potential environmental risks.

1.2 Scope of the Report

To satisfy the objectives outlined in Section 1.1, this report contains the following sections:

- Section 2: Site Information
- Section 3: Environmental Attributes
- Section 4: Social Attributes
- Section 5: Infrastructure Layout & Design
- Section 6: Infrastructure Operational Aspects
- Section 7: Environmental Aspects and Management
- Section 8: Post Closure Management
- Section 9: Residual Risk Assessment
- Section 10: Conclusion.

2 Site Information

The following sections provide an overview of the key aspects of the Site, including its location, registration, surrounding land uses, and sensitive receptors.

2.1 Site Location and Access

The Site is located approximately 170km east of Carnarvon, and 1,050km north of Perth. The Site is approximately 1km from Gascoyne Junction town and is accessed through Pimbee Road. The existing Site covers an area of 29,000m^2 and is on vested crown land. The expanded reserve covers an area of 737,000m^2, however only a portion of the reserve has been allocated for the Project.

A summary of the Site details is provided in Table 2-1.

Table 2-1: Site Details

Detail	Description
Land Description	Lot 561 on Plan 72451
Crown Reserve	Class “C” Reserve 52428
Street Address	Wansborough Road, Upper Gascoyne
Primary Interest Holder	Shire of Upper Gascoyne
Registration Number	R2338/2012/1

A locality plan of the Site is provided in Figure 1, in Appendix A.

2.2 Current and Future Activities

The following sections provide an overview of the current and future activities at the Site.

2.2.1 Current Activities

The existing landfill is a Class II putrescible landfill registered as a Category 89 prescribed premises and can accept up to a combined total of 5,000 tonnes per annum of waste. The Site currently accepts kerbside and commercial waste and has a designated area for the stockpiling of recyclable materials. Materials accepted on Site include:

- Municipal Solid Waste (MSW);
- Commercial and Industrial (C&I) waste;
- Construction and Demolition (C&D) waste;
- Scrap metal; and
- Green waste.

The main component of the Site is the refuse disposal area, which includes active landfill cells for current waste disposal which is accessed by members of the community in addition to household rubbish collection trucks. The existing Site has closed cells that are no longer receiving waste and a historic septic waste disposal area which is no longer in use.

The Site is unmanned and there are no restrictions on community access, with weekly inspections being carried out to monitor conditions.

2.2.2 Need for Expansion

The existing Site is nearing its capacity, and identifying suitable areas for expansion has become increasingly difficult due to incomplete records. The construction of new landfill trenches is further complicated by the Site's limited footprint and the absence of accurate historical data, making it difficult to locate unutilised areas of the site for landfilling.

The current Site layout is located close to ephemeral flow lines for surface water, and it is the Shire's preference to relocate activities further from these flow lines to further mitigate potential environmental impacts.

Finally, the residential footprint of Upper Gascoyne is projected to increase in the coming years due to commitments to build homes and commercial properties in the town from the Department of Biodiversity, Conservation and Attractions (DBCA) and multiple mining companies.

2.2.3 Future Activities

The Shire is planning to expand the existing Site boundary and construct a new putrescible landfill, inert landfill and CRC. This new facility will cater to municipal and commercial waste streams in the region.

The CRC has a number of dedicated single-material storage areas which include the following:

- Scrap metal stockpile area;
- Green waste stockpile area;
- White goods/bulky item stockpile area;
- C&D stockpile area;
- Treated pallets/timber stockpile areas;
- Battery and waste oil storage shed/s;
- Road base/aggregate stockpile area.

Drawing W-101 available in Appendix B provides an overview of the current Site layout, including the expanded reserve boundary and the expansion development area.

2.2.4 Waste Quantities

Historic putrescible waste acceptance volumes have not been collected at the Site as there is no weighbridge and the low waste acceptance volume does not require waste volumes to be reported to the DWER. Waste generation is often closely linked with population, and the growth rate in a population can be used as a substitute for the growth rate in waste generation. This approach can be used to generate estimated landfill tonnages and average annual growth from Australian Bureau of Statistics (ABS) census data.

A representative from the Shire has indicated that the Site currently serves 40 people, and the Shire anticipates an additional 8 houses to be constructed within the town between 2024 and 2039. It is assumed that each household will have an average of 4 residents, this the number of people the Site serves to 72 by 2040.

The per capita waste generation rate was calculated by using the current population and an estimated annual waste acceptance tonnage provided by a Shire Representative. This generation rate was used to calculate the volume taken up to dispose of this waste, referred to as airspace. To calculate airspace consumption a waste compaction factor and volume of cover soil used must be calculated. The waste compaction factor was estimated to be 0.35 tonnes per cubic metre (t/m^3) based on the availability of plant equipment on Site which can compact waste. The volume of cover soils used has been estimated to be 50%, this is based on the volume of waste accepted and the frequency that waste must be covered as outlined in the WA Rural Landfill Guidelines.

Table 2-2 outlines the values used to calculate the airspace consumption rate.

Table 2-2: Generation Estimate

Aspect	Value
Estimate Waste Generation per Capita	2 Tonnes/year
Waste Compaction Factor	0.35 t/m^3
Cover Soil	50%
Airspace Consumption per Capita (including cover soils)	11.43 m^3/year

The airspace consumption rate per capita, as presented in Table 2-2, was then applied to the projected future population for the Shire to determine an annual landfill airspace consumption rate. The annual airspace consumption rate is presented in Table 2-3.

Table 2-3: Landfill Annual Fill Rate

Year	Estimated Population	Airspace Consumption Rate (m^3/year)
2025	42	475
2030	51	578
2035	62	703
2040	72	823
2045	72	823
2050	72	823
2055	72	823
Total (2025-2055)		**22,683**

The detailed waste generation modelling is presented in Appendix C.

2.3 Site Registration

The Site is classified as a Category 89 prescribed premises under Part 2 of Schedule 1 of the *Environmental Protection Regulations 1987*.

The Site is registered to accept:

- Putrescible Waste;

- Clean and uncontaminated fill;
- Inert Waste Type 1 (non-hazardous, non-biodegradable wastes);
- Inert Waste Type 2 (waste consisting of stable non-biodegradable organic materials); and
- Special Waste Type 1 (asbestos and asbestos cement products).

Details of the prescribed premises category are listed in Table 2-4.

Table 2-4: Current Prescribed Premises Categories

Category No.	Name	Description	Production or Design Capacity (per annum)	Expected Throughput (per annum)
89	Putrescible Landfill Site	Premises on which waste (as determined by reference to the waste type set out in the document entitled "Landfill Waste Classification and Waste Definitions 1996" published by the Chief Executive Officer, as amended from time to time) is accepted for burial	More than 20 but less than 5,000 tonnes	144 tonnes

A Works Approval application for the construction of the facility will be submitted under Part V of the *Environmental Protection Act 1986* and will include an allowance for time-limited operations to enable the expansion areas to be used as soon as possible.

It is not expected that the waste management activities will require the Site be licence as acceptance volumes will not exceed the limits outlined in Schedule 1 of the *Environmental Protection Regulations 1987.*

2.4 Zoning and Surrounding Land Use

The Site is located within the Shire of Upper Gascoyne. The existing reserve is located at Lot 561 on Deposited Plan 72451 and is subject to Class 'C' Crown Reserve 52428, set aside for the purpose of 'Waste Disposal Site'. Land adjacent to existing reserve is Unallocated Crown Land (UCL) PIN 11240241.

DPLH has recommended excising a portion of the UCL to the east and south of the existing Site and adding it to the adjoining Reserve 52428. The Shire is currently in the process of acquiring this portion of UCL, of which 161,000m^2 has been allocated for expansion of the waste management facility.

The planning scheme of the Site and surrounding area is outlined in Figure 2, in Appendix A. The expanded reserve, and development expansion boundary are outlined in Drawing W-101, found in Appendix B.

2.5 Native Title

Under Australian Law, Native Title is a form of land title that recognizes the unique connections Aboriginal groups have to the land. Native Title exists where Aboriginal people have maintained a traditional connection to their land and waters, since sovereignty, and where acts of government have not removed it. Under the Native Title Act 1993 a Native Title determination confirms the rights and

interests of Indigenous people to land and waters according to their traditional laws and customs. This determination grants the Native Title holders certain rights over the land, which can influence how the land is used and developed.

A review of the National Native Titles Tribunal *National Native Title Register* indicates that non-exclusive Native Title rights and interests are shown to exist over both the existing Site and the proposed expansion area (UCL PIN 11240241), as per the Gnulli, Gnulli #2 and Gnulli #3 - Yinggarda, Baiyungu and Thalanyji People Determination.

As part of acquiring the UCL, the Shire is required to enter into an Indigenous Land Use Agreement (ILUA) with the Registered Native Title Body Corporation, the Yinggarda Aboriginal Corporation. This process is ongoing.

2.6 Sensitive Receptors

The Environmental Protection Authority (EPA's) *Guidance Statement No. 3 – Separation Distances between Industrial and Sensitive Land Uses (2005)* (Guidance Statement 3) contains the recommended separation distances between industrial activities, including waste management facilities, and sensitive land uses. Sensitive land uses are defined by the EPA as those that are sensitive to industrial emissions and include residential developments, schools, hospitals, shopping centres and other public areas and buildings. Table 2-5 provides the recommended minimum separation distances between sensitive land uses and the Prescribed Premises categories for which the Site is currently registered.

Table 2-5: Recommended Separation Distances between Industrial and Sensitive Land Uses

Category No.	Industry	Impacts					Recommended Separation Distance
		Gaseous	Noise	Dust	Odour	Risk	
89	**Class II or III putrescible landfill Site**	✓	✓	✓	✓		500m for subdivisions 150m for single residences 35m internal buffer from Site boundary

The expanded Site meets all separation distance requirements as summarised in Guidance Statement 3. The nearest sensitive receptors to the expanded Site are residential properties, located 531m to the northeast and 736m to the southeast of the Site, and the Gascoyne Junction Community Resource Centre, located 549m to the northeast of the Site.

The location of these identified sensitive receptors are presented in Figure 3, in Appendix A.

3 Environmental Attributes

The following section outlines the key environmental attributes of the Site, that are particularly relevant to the expended Site's design, including climate, topography, geology, hydrogeology (groundwater), hydrology (surface water) and other key attributes.

3.1 Climate

The Site experiences a moderate arid tropical climate, with very hot summers and warm winters. According to the Gascoyne Development Commission, the region receives approximately 320 days of sunshine each year. During the warmer months from December through to March, there is frequent cyclonic activity and tropical lows drawing in from the northwest coast.

The closest Bureau of Meteorology (BOM) weather station with long-term data is Gascoyne Junction (Station 006022), approximately 1km west of the Site. The prevailing wind information was sourced from this weather station. However, the data for temperature, rainfall and pan evaporation data had limited quality. Therefore, these parameters have been sourced using the Scientific Information for Land Owners (SILO), a database of Australian climate data from 1889 to the present day that is hosted by the Queensland Department of Environment and Science (DES). It provides daily meteorological datasets for a range of climate variables in ready-to-use formats suitable for biophysical modelling, research, and climate applications. The datasets are constructed from observational data obtained from BOM, using mathematical interpolation techniques to infill gaps in time series and construct spatial grids. The spatial grid selected (Latitude: -25.05, Longitude: 115.2) encompasses the Site in its entirety.

Climate data is discussed in further detail in the following sections.

3.1.1 Rainfall

Being in a tropical-arid zone, rainfall is seasonal with higher rainfall generally in the months of December to March due to cyclonic activity, meaning rainfall volumes vary greatly. Table 3-1 presents a summary of SILO's rainfall records for the past 50 years, from 1973 to 2023.

Table 3-1: Rainfall Overview in Millimetres (1973-2023)

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	18	36	29	19	22	28	24	12	4	4	5	8	**210**
90th Percentile	0	88	9	46	24	22	30	13	0	42	108	0	**381**
Highest	16	293	18	1	134	25	36	5	2	15	3	0	**547**

The mean annual rainfall for the Site is calculated as 210 millimetres (mm) with the highest recorded annual rainfall at 547mm, which occurred in 2021.

3.1.2 Temperature

Table 3-2 presents a summary of SILO's maximum and minimum temperature records for the past 50 years, from 1973 to 2023.

Table 3-2: Maximum and Minimum Temperatures at Gascoyne Junction (1973-2023)

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Maximum Temperature (°C)	40	39	37	33	28	24	23	25	28	32	34	38	**32**
Mean Minimum Temperature (°C)	24	25	23	19	14	11	10	11	13	16	19	22	**17**

The highest average maximum temperature is 40°C in January, whilst the lowest average minimum temperature is 10°C in July.

3.1.3 Pan Evaporation

The approximate average daily pan evaporation rates for the Site are based on the calculated monthly rates from SILO. Table 3-3 outlines the average pan evaporation data, from 1973 to 2023.

Table 3-3: Pan Evaporation Average Data for the Site in Millimetres (1973-2023)

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Monthly (mm)	367	308	296	212	156	113	118	154	211	285	323	366	**2,909**
Daily (mm)	12	10	10	7	5	4	4	5	7	9	10	12	

The daily average pan evaporation ranges from 3mm to 12mm and monthly from 113mm to 367mm. The average total annual pan evaporation for the Site is calculated as 2,909mm. This is a significant potential evaporation rate that is approximately five times the wettest rainfall year experienced at Site.

3.1.4 Humidity

BOM data suggests that the Site experiences a relatively low humidity year-round due to the Site's semi-arid climate. Table 3-4 shows the morning, afternoon and calculated average humidity at Gascoyne Junction (006022) from 1940 to 2010.

Table 3-4: Morning and Afternoon Relative Humidity at Gascoyne Junction (006022)

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean 9am Relative Humidity (%)	42	46	45	51	58	68	67	58	49	43	40	40	**51**
Mean 3pm Relative Humidity (%)	20	24	24	29	34	42	40	33	25	21	20	18	**28**

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Humidity (%)	31	35	35	40	46	55	54	46	37	32	30	29	**40**

As can be seen from the data in the table, the Site experiences relatively low humidity in the summer months, with the highest mean humidity occurring during June, and the lowest occurring during December.

3.1.5 Wind

Wind speed is measured as the average speed of the wind measured over a ten-minute interval before the time of observation and is measured ten metres above the ground. Diagram 3-1 indicates that winds are predominantly easterly in the morning (9am), and easterly or westerly direction in the afternoon (3pm). Wind speed generally increases in the afternoon, with average speeds rarely above 30km/h.

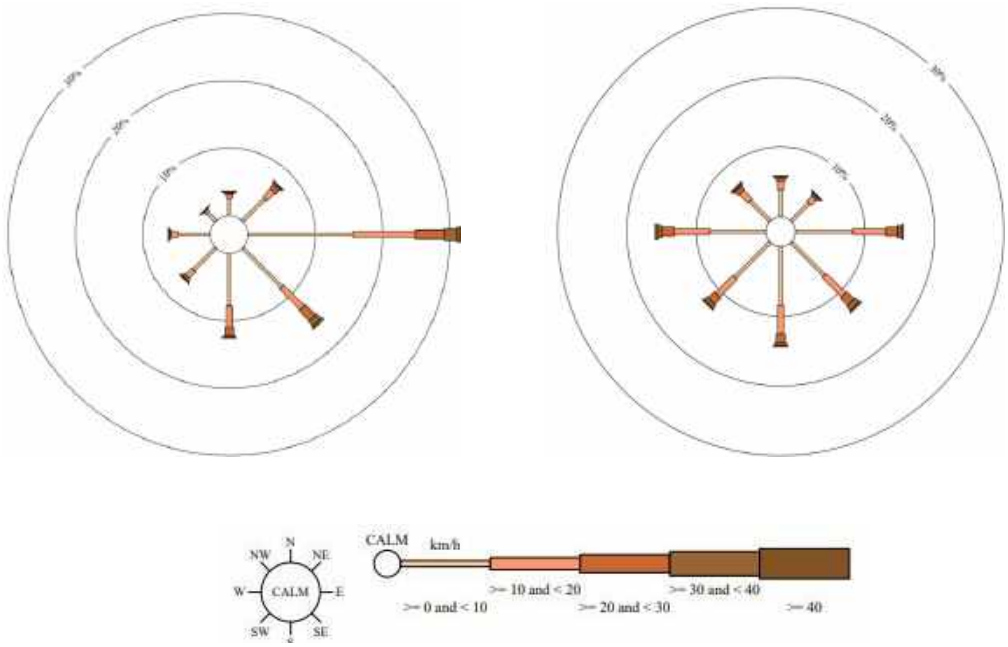

Diagram 3-1: Average Wind Rose Data for 9am (left) and 3pm (right)

3.2 Topography

Topography at the expanded Site is relatively flat, with natural ground elevations ranging from 139mAHD in the north to northwest of the Site to 146mAHD in the south of the Site. There are two raised landforms in the southern portion of the expanded reserve that reach heights of 144.5m and 146m, with the lowest point within the expanded reserve being towards the north at 141.5m.

The general topography of the Site is shown in Figure 4, presented in Appendix A, with further details provided in Drawing C-100 in Appendix B.

3.3 Geology

The Gascoyne region is predominantly comprised of wide alluvial valleys that form the drainage basins for the surrounding rivers. The area is characterised by extensive alluvial plains, and low sedimentary ranges with red dune belts. Much of the region is covered by a large sedimentary basin known as the Carnarvon Basin.

The surface geology of the Site is shown in Figure 4, presented in Appendix A.

3.3.1 Soil Testing

Following consultation with the DWER, the Shire was advised that soil characterisation testing should be undertaken to ensure the ground is suitable for unlined trenches and evaporation ponds. Soil testing was carried out on four samples from the Site at Western Geotechnical and Laboratory Services, a NATA accredited laboratory in Perth, Western Australia.

Testing determined that soil is predominately Silty SAND (SM) up to a depth of 3.0m, followed by Sandy CLAY (CL) to the maximum of investigated depth of 4.0m. The permeability values for the samples are low and decrease with time and depth, indicating that the ground is suitable for the construction of unlined trenches and evaporation ponds.

3.4 Hydrology

Surface water systems in the region are generally ephemeral. Mapping indicates that there is a minor watercourse that runs along the western boundary of the existing reserve which is a tributary of the Gascoyne River. The Gascoyne River a potable water zone. Gascoyne River is a delta system that only flows every 2-3 years and is located approximately 1.5km to the north of the Site. Figure 5, shown in Appendix A, show the surface water bodies surrounding the Site.

Discussions with Shire representatives and observations of vegetation growth at the Site may indicate the presence of three additional ephemeral watercourses that direct flow through the Site to the Gascoyne River. Drawing W-400 in Appendix B outlines the additional water courses within the Site.

Disaster mapping indicates that both the existing and expanded reserve are located entirely within 1-in-100 Annual Exceedance Probability (AEP) Floodplain Development Control Area. However, the Local Planning Scheme (LPS) identifies that the Gascoyne River Floodplain does not extend to the existing and expanded reserves. Additionally, anecdotal evidence from the Shire confirmed that during a 1-in-100-year flood event, which occurred in 2010, the water levels were true to the Gascoyne River Floodplain boundaries outlined in the LPS.

Disaster mapping of the Site is shown in Figure 7, presented in Appendix A.

3.5 Hydrogeology

The Site is located within the Gascoyne Proclaimed Groundwater Area, as defined under the Rights in Water and Irrigation Act 1914 (RIWI Act). Under section 26D of the Act any construction or alteration of non-artesian wells must be conducted under a licence.

The Gascoyne Junction Water Reserve is located 740m north of the Site and is classified by the DWER as a Priority 1 protected area. Activities in Priority 1 protected areas are highly restricted to avoid

water quality risks. The Gascoyne River is located within the Gascoyne Junction Water Reserve and tributaries of the Gascoyne River are located at the Site.

The groundwater level is estimated to be greater than 4 meters below ground level (mbgl), based on previous excavations at the Site and the relative lower elevation of the surrounding area. Additionally, the Gascoyne Junction GJ 1/22 Bore Completion Report shows that the groundwater elevation within GJ 1/22 Bore, located on Gregory St approximately 1km from the Site, is 20.9mbgl.

The hydrogeology mapping of the Site is shown in Figure 6, presented in Appendix A.

3.6 Bushfire Prone Areas

Disaster mapping from Landgate indicates that the Site is within a Bushfire Prone Area, shown in Figure 7, presented in Appendix A.

3.7 Flora and Fauna

3.7.1 Threatened and Priority Fauna

A search of the Department of Biodiversity, Conservation and Attraction's (DBCA's) database indicated that there were no records of threatened or priority fauna being present at the Site; however, several species were identified in areas surrounding the Site, as described in Table 3-5.

Table 3-5: Threatened and Priority Fauna

Type/Classification	Species	Distance from Site
Specially protected species	Common Sandpiper	900m north
Specially protected species	Glossy Ibis	1,200m northwest

Threatened and priority fauna mapping is presented in Figure 8, in Appendix A.

3.7.2 Declared Rare and Priority Flora

The DBCA's Threatened and Priority Flora Database indicate that there are no rare or priority flora present within or directly surrounding the Site. Several specially protected species have been identified to the north of the Site, in proximity to the Gascoyne River, and to the northwest of the Site on the other side of the Gascoyne Junction townsite. The species identified are listed in Table 3-6.

Table 3-6: Rare and Priority Flora

Type/Classification	Species	Distance from Site
Priority 1 Flora	Rhodanthe ascendens	1,100m northwest
Priority 2 Flora	Bergia auriculata	1,400m northwest
Priority 3 Flora	Abutilon sp. Pritzelianum	500m north
Priority 3 Flora	Grevillea subterlineata	1,400m northwest

Threatened and priority flora mapping is presented in Figure 8, in Appendix A.

3.7.3 Threatened and Priority Ecological Communities

A search of the DBCA's Priority Ecological Communities (PECs) database indicate that the Jingle Land System PEC is located within the northeast corner of the expanded reserve of the Site. However, the proposed development expansion does not overlap with the PEC.

PEC mapping is presented in Figure 8, in Appendix A.

3.8 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are declared in Environmental Protection (Clearing of Native Vegetation) Regulations 2004 as areas that cover any and/or all of the following conservation significant areas:

- A declared World Heritage property as defined in section 13 of the Environment Protection and Biodiversity Conservation Act 1999;
- An area that is included on the Register of the National Estate, because of its natural heritage value under the Australian Heritage Council Act 2003;
- A defined wetland and the area within 50 metres of the wetland;
- The area covered by vegetation within 50 metres of rare (threatened) flora, to the extent to which the vegetation is continuous with the vegetation in which the rare (threatened) flora is located;
- The area covered by a TEC;
- A Bush Forever site listed in "Bush Forever" Volumes 1 and 2 (2000), published by the Western Australia Planning Commission, except to the extent to which the site is approved to be developed by the Western Australia Planning Commission;
- The areas covered by the Environmental Protection (Gnangara Mound Crown Land) Policy 1992;
- The areas covered by the Environmental Protection (Western Swamp Tortoise Habitat) Policy 2002;
- The areas covered by the lakes to which the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 applies; and
- Protected wetlands as defined in the Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998.

There are no ESAs within or directly surrounding the Site. The closest ESA is the Kennedy Range National Park, located 17km to the northeast of the Site.

4 Social Attributes

4.1 Aboriginal Heritage

A search of the DPLH's Aboriginal Heritage Places dataset identified that the Site has no known Aboriginal Cultural Heritage within its boundaries. The following Registered Sites are in proximity to the Site:

- DPLH39200: Gascoyne and Lyons River is located 460m north of the Site;
- DPLH15913: Deep Creek – Gascoyne Junction is located 3km to the northeast of the Site;
- DPLH8853: NATGAS209 is located 2km to the northwest of the Site; and
- DPLH8854: NATGAS210 is located 2km to the northwest of the Site.

It is possible that items or areas of cultural significance may occur at the Site. It is recommended that the relevant traditional owner groups, the Yinggarda Aboriginal Corporation, are engaged in discussions regarding the development and the preferred method to proceed. At this stage, it is anticipated that this will not prohibit the development of the Site.

The aboriginal heritage aspects for the Site and surrounding areas are shown in Figure 9 in Appendix A.

4.2 European Heritage

A search of the Heritage Council WA – Local Heritage Survey dataset identified no known European or post-colonial heritage values within the Site.

4.3 Mining Tenements

A review of the Department of Mines, Industry Regulation and Safety (DMIRS) mining tenement data indicated that the Site is not located within any category of mining tenement. The nearest exploration mining tenement is located 1.5km to the northeast of the Site.

5 Infrastructure Layout and Design

Talis has developed Conceptual Site Design and drawings, in consultation with the Shire, to determine the location of all future site activities.

The infrastructure included in the Conceptual Site Design layout include:

- Landfill trenches for putrescible waste;
- Landfill cell for inert waste;
- Asbestos Monocell;
- Liquid Waste Ponds;
- CRC for the stockpiling of recyclable materials; and
- Daily cover stockpile areas.

5.1 Landfill Design

The following sections outline the design considerations, details, and the operational measures that will be incorporated over the landfill facility's anticipated lifespan.

5.1.1 Putrescible Landfill

The putrescible landfill design has been based on the waste quantities discussed in Section 2.2.4 and best practice design principals. To minimise environmental impact landfill trenches have been designed to be operational for approximately 2 years. Lifespan has been calculated based on an average annual airspace consumption rate, meaning trench lifespan in initial years is expected to be greater than 2 years and will decrease as consumption increases. It is estimated that 15 trenches will be required to meet the demand of a 30-year landfill operational capacity. The required volume for each landfill trench was determined based on the estimated total airspace consumption over the 30-year period.

The required landfill trench volume and depth was then used to calculate an appropriate length and width of the landfill. A width of 8m and length of 84m was chosen to suit the in-situ characteristics of the Site and design criteria, including waste collection vehicle access and minimisation of the effects of wind and surface water flow. Landfill slopes will be vertical along the north, east and southern walls, this is based on existing operations at the Site. The western side of the trenches will feature a 1:10 ramp for vehicle access.

Drawing C-106 in Appendix B shows the typical details for the putrescible landfill.

5.1.2 Inert Landfill

Inert landfill sizing has been based on the size of the existing landfill at the Site, which has been in operation since 1999. It is assumed that using a similar area to the existing inert landfill area used will provide adequate disposal capacity for a 30-year lifespan.

The proposed inert landfill dimensions are 95m long by 56m wide. Landfill slopes will be vertical along the north, east and southern walls, based on existing operations at the Site. The inert landfill will feature a 1:10 (V:H) access ramp that is 6m wide to allow collection vehicle access while maximising

the operational capacity. The access ramp will feature safety bunding along the ramp edge to prevent vehicle roll-over.

Drawing C-107 in Appendix B shows the typical details for the inert landfill.

5.1.3 Proposed Final Fill Profile

It is proposed that each landfill will be filled to 0.5m below ground level to minimise wind blow litter and comply with the WA Rural Landfill Regulations. It is anticipated that putrescible landfill trenches will be covered within a year of completion at a maximum. The inert facility will be progressively capped as required, with final capping occurring at the end of operations within the landfill.

Drawing W-106 and W-107 in Appendix B show the typical final waste fill profile for the putrescible and inert landfills.

5.1.4 Landfill Base

The base for each landfill will consist of in-situ soils. Soil characterisation testing completed at the Site, discussed in Section 3.3.1, indicate that the geology is suitable for the construction of unlined trenches. The base of any landfill operations will be 3.5m below the surrounding natural ground level.

5.1.5 Landfill Bunds

Landfill bunds will be constructed around the perimeter of the active landfill operations to retain waste and water that has come into contact with the waste, as well as divert water from coming in contact with waste. The landfill bunds will be 0.5m high, a minimum of 3m wide at 1:4 (H:V) slopes, and will be constructed of non-dispersive site-won soils.

Drawing W-106 in Appendix B shows the putrescible landfill's layout and typical bund details. Drawing W-107 in Appendix B shows the inert landfill's layout and typical bund detail.

5.1.6 Layout and Siting

The layout and siting of each landfill trench is also important to ensure compliance with the WA Rural Landfill Regulations and to maintain adequate environmental controls.

A temporary stock fence will surround each landfill trench and will be relocated from a completed trench following the conclusion of landfilling and prior to landfilling commencing in the next trench. This fence will be located at a minimum 3m from the edge of the landfill bund. This fence is intended to deter most fauna from accessing the landfill, to act as a security measure to restrict access from unauthorised personnel, and to contain windblown litter to within the landfill facility boundary.

Each landfill trench will have a maximum width of 13m to allow easy compliance with the tipping area restrictions outlined in the WA Rural Landfill Regulations.

5.1.7 Void Space Modelling

Void Space Modelling has been undertaken to determine the required filling capacity for the proposed landfills using the calculated landfill sizing outlined in Sections 5.1.1 and 5.1.2. This will allow the Shire to understand the required footprint for a variety of landfill trench lifespans and provide the ability to plan the construction of additional trenches over the Site's lifespan.

For the purposes of this modelling, the density of putrescible waste after placement is assumed to be 0.35t/m^3 and the cover material requirements to be 50% of the total available void space volume, increased from common industry standard to account for the additional cover requirements outlined in Section 6.7. Based on a rectangular, 8m wide, 84m long and 3.5m deep trench, with a 1:10 access ramp, the void space and lifespans for the landfill trenches are presented in Table 5-1.

The density of inert waste is assumed to be 1 t/m^3 and the cover material requirements be 20% of the total available void space volume. Assuming the Inert Landfill is 56m wide, 95m long and 3.5m deep, with a 6m wide, 1:10 (V:H) access ramp, the void space and lifespans for the landfill is presented in Table 5-1.

Table 5-1: Estimated Landfill Lifespans and Void Space

Facility	Landfill Lifespan	Total Void Space (m^3)	Net Void Space (ex. Cover Soils) (m^3)
Putrescible Landfill (per Trench)	2 years	1,526	763
Total Putrescible Landfill (15 Trenches)	30 years	22,890	11,445
Inert Landfill Cell	30 years	12,530	12,530
Total	**30**	**24,738**	**36,946**

Waste modelling undertaken shows that an estimated 39,606m^3 of void space will be required over the approximately 30-year lifespan of the Site.

It is critical that landfill operators monitor the waste inputs and ensure that accurate records are maintained. These inputs should be reviewed annually in conjunction with the void space consumption within each landfill to determine landfill compaction and consumption rates and to monitor the required landfill void and siting.

5.1.8 Cap Design

The proposed capping system for the landfill facilities at the Site is as follows, in order of construction, from bottom to top:

- 500mm Regulating Layer;
- 500mm Clay Layer; and
- 500mm of Revegetation Layer.

The layers will mostly consist of site-won material from the excavation works from the development of the landfill facilities. An additional capping layer of 200mm of green waste mulch can placed by the Shire, if available. This will promote the growth of the vegetation on the surface of the capping system, which will help minimise erosion.

The elements of this capping system are discussed in further detail in the following sub-sections, with the design shown in Drawings W-106 and W-107, available in Appendix B.

5.1.8.1 *Regulating Layer*

The preferred design approach for the capping system is the utilisation of a 500mm thick regulating bedding layer, consisting of site-won material to provide a smooth firm subgrade for installation of the Clay Layer. The material for the Regulating Layer may be sourced from existing stockpiles of excavated soils created during the development of the Site, or from construction of the surface water pond.

5.1.8.2 *Clay Layer*

The 500mm thick low permeability Clay Layer will be formed from clayey material won from the excavation works landfill development, or from the development of the surface water pond. It is recommended that the clay material be compacted, when feasible, to reduce its permeability.

5.1.8.3 *Restoration Layer*

The 500mm Revegetation Layer will mostly consist of site-won material from the excavation works during the landfill development, or from construction of the surface water pond. Due to the low-risk nature of the landfill facilities, it is anticipated that wind-blown seed will be adequate for establishing a vegetation layer, however this may be supplemented with tube stock planting or application of a seed mix in areas where natural vegetation is taking longer to establish. The application of grass/seed mix, where undertaken, should be based on species native to the region.

5.1.9 Final Restoration Profile

Drawings W-106 and W-107 show the final restoration profile for the putrescible and inert landfill facilities, based on its proposed final fill profiles and capping system design. The profile for the putrescible landfill has a maximum height of 143.5mAHD, which is approximately 1m above existing ground levels, while the inert landfill has a maximum height of 144.4mAHD, which is approximately 1.4m above existing ground levels.

The landfill cap will feature slopes of 1:20 (V:H) above the waste mass and slopes of 1:3 at the edge of the capping footprint. These slopes will encourage surface water shedding away from the waste mass.

The proposed final restoration profiles at each site provide the following key outcomes:

- The encapsulation of all waste disposed across the landfill site;
- Facilitate the conventional rehabilitation of each site through compliance with the Rural Landfill Regulations;
- The development of a best practice landfill profile and side slopes which will:
    - Promote the natural flow of surface water off the landfill, minimising pooling and infiltration;
    - Facilitate the development of a typical perimeter drain, where relevant, to cater for surface water across the capped landfill;
    - Ensure the long-term stability and integrity of the capping system and environmental control systems (surface water management);
    - Minimise the long-term maintenance requirements of the capping system;
    - Provide an aesthetically acceptable landform long-term and support further post-closure land uses; and

- Facilitate phased capping.

5.2 Liquid Waste Ponds

As part of the facility expansion the Shire is developing Liquid Waste Ponds for the treatment of septage waste and Reverse Osmosis wastewater. The construction of these ponds is not included in this works approval application; however, have been mentioned within this report to provide an understanding of Site layout.

The layout of the proposed septage facility is presented in Drawing W-105, with typical pond details shown in Drawing W-302, presented in Appendix B. No drawings have been provided for the Reverse Osmosis wastewater disposal facility; however, location is outlined in Drawing W-101, presented in Appendix B.

5.3 Asbestos Monocell

Asbestos is not expected to be accepted at the Site under normal operations. However, as a contingency, an asbestos disposal area and asbestos cell design have been outlined. In the event asbestos needs to be accepted, arrangements must be made with the Shire at least two weeks in advance, to allow for the construction of the monocell. Asbestos will only be accepted by appointment, and each load must be declared for inspection by Site staff to determine whether it meets the acceptance criteria. The Shire will only accept double-wrapped domestic quantities of non-friable asbestos-containing materials (i.e., under 10m² in size).

Soils excavated during the cell's construction will be used to cap the cell with a 1m layer of restoration soils. The restoration profile of the capped monocell will be shaped to encourage surface water runoff and reduce water percolation into the cell.

The location of the proposed Asbestos Monocell is shown in Drawing W-101, with typical details of the proposed monocell shown in Drawing W-107, available in Appendix B.

5.4 Community Recycling Centre

The CRC is a best practice facility to allow the community to drop-off a variety of materials for reuse, recycling or disposal. The proposed layout of the facility considered a range of aspects to ensure the efficient operation, use of available space, future expansion and alignment with the Waste Hierarchy (i.e., Reuse, Recycle, Recover and Disposal). The CRC contains designated Drop-off areas for a variety of material types that can be accessed by the community, Shire staff and contractors to service each area of the CRC.

The CRC incorporates the following key components:

- Scrap metal stockpile area;
- Greenwaste stockpile area;
- White goods/bulky item stockpile area;
- Treated pallets/timber stockpile areas;
- Battery and waste oil storage shed/s; and
- Road base/aggregate (materials) stockpile area.

The proposed conceptual layout of the CRC within the Site is shown in Drawing W-102, shown in Appendix B.

5.4.1 Recycling Drop-off Area

The Recycling Drop-off Area for recyclables and bulk waste, including scrap metal, green waste, white goods, treated pallets and timer, and materials laydown are to be constructed together with an access road along the south of the areas to allow for the drop-off and collection of vehicles.

Due to the low-level of activity at the Site a service area has not been included in the CRC drop-off area, and both community and Shire staff will use the same access points for the stockpiles.

The purpose of the Recycling Drop-off Area is to facilitate the temporary storage of these materials received from domestic customers prior to their collection by material recyclers. The total area of the drop-off is 8,110m^2, and has been sized to allow for higher volumes of stockpiled materials to be stored to make collection more viable.

5.4.2 Household Hazardous Waste Facility

A Household Hazardous Waste (HHW) Facility will be developed at the CRC for the safe acceptance and storage of hazardous materials generated from households. This facility will provide visitors with a free and safe drop-off facility for problematic wastes and, therefore, ensure that these materials are treated appropriately and diverted from landfill.

The HHW Facility will consist of a shed, which will be enclosed, covered and lockable. HHW storage receptacles are proposed to be self-bunded proprietary storage cabinets under a roof canopy and placed on a concrete hardstand. The HHW Facility will include a 2.5m wide canopy on its front for undercover drop-off of materials.

All HHW receptacles will be designed to meet the following Australian Standards, which will support the safe and efficient management of these materials:

- Australian Standard 1940-2004 *The Storage and handling of flammable and combustible liquids*; and
- Australian Standard 3780-2008 *The Storage and Handling of Corrosive Substances.*

Adequate ventilation will be installed to ensure materials do not overheat. The hazardous materials will be removed periodically by a private contractor and taken to a suitably licenced facility.

At the detailed design stage, the HHW Facility will be designed in accordance with the DWER *Guidelines for the design and operation of facilities for the acceptance and storage of household hazardous waste* (August 2013).

5.5 Surface Water Management System

Environmental risks associated with leachate and surface water at the Site will be managed through the development of a Surface Water Management System (SWMS), which will be designed to meet two key objectives including minimising leachate generation and proactively managing surface water. These objectives and the design features incorporated to achieve them are shown in Table 5-2.

Table 5-2: Objectives and Associated Design Features of the Surface Water Management System

Objective	Design Feature
Minimise Leachate Generation	Implement a site-specific capping and SWMS over the landfill.
	Develop a perimeter drainage system that: • Maintains connectivity with the capping system; and • Includes strategically located discharge points away from the waste mass.
	Locate long-term surface water discharge points.
Proactively Manage Surface Water	Incorporate measures into the capping system to direct surface water from the landfill cap to the discharge points.
	Ensure the SWMS is appropriately sized to manage a 1-in-20-year Annual Exceedance Probability (AEP) storm event.
	Establish controlled discharge points for surface water.

The design for the final capping system at the Site incorporates surface water management infrastructure to prevent the infiltration of surface water into the waste mass and thereby preventing the production of leachate over time.

The Site only accepts non-putrescible wastes and is considered to have a very low environmental risk profile. For these reasons, a formal SWMS at the Site is proposed, with runoff from the capping system following the boundary of the Site and draining into a surface water pond.

5.5.1 Key Infrastructure

The following sections discuss the proposed key surface water infrastructure at the Site.

The SWMS design is outlined in Drawing W-103, shown in Appendix B.

5.5.1.1 *Perimeter Swales*

Perimeter swales will run around the boundary of each landfill area and will be used solely to collect surface water that sheds from the landfill's restoration profile following permanent capping works. These drains will connect to a new surface water attenuation pond, which is discussed further in Section 5.5.1.2. These drains will be clean earth channels which will be constructed progressively as the landfill is permanently capped.

5.5.1.2 *Surface Water Pond*

A surface water pond will be constructed in the northeast corner of the Site, at the lowest level to allow for surface water to drain via gravity from the remainder of the Site. The pond will be constructed with a 250mm compacted subgrade layer using onsite soil material.

5.5.2 Surface Water Modelling

The SWMS has been designed to contain and control surface water runoff from a 24-hour, 1-in-20-year AEP storm event, at a minimum, with contingency for a larger 24-hour, 1-in-50 year AEP storm event. The proposed surface water management infrastructure consists of perimeter swales and a

surface water pond. To determine the appropriate design for this infrastructure, modelling was undertaken using a Microsoft Excel surface water pond and drainage swale sizing algorithm based on local climate data including rainfall depth and intensity.

Modelling for the Site's SWMS sizing is presented in Appendix D.

5.5.2.1 *Catchment Area*

The catchment area covers the development areas across the Site. This catchment was based on topographical data, the design of the landfill areas and other supporting infrastructure. The following sections discuss the design criteria for the catchment.

Runoff Coefficient

Based on the geology of the Site, the surface soils are considered to be sand and sandy silts. The landfill capping will be constructed with site-won soils which will have a grade of approximately 5%. Using the Queensland Urban Drainage Manual[1], the runoff coefficient for graded clay soils at a gradient of 0-10% is 0.5, and this value was used for modelling purposes.

Catchment Design Summary

Table 5-3 summarises the design details of the catchment areas considered for the SWMS.

Table 5-3: Summary of Catchment Areas

Catchment	Area (m^3)	Runoff Coefficient
Catchment A	22,647	0.5
Catchment B	10,930	0.5
Catchment C	17,535	0.5
Catchment D	34,220	0.5
Total	**85,332**	**0.5**

The catchment areas identified in Table 5-3 were utilised to calculate the required capacity of the surface water pond and assisted in determining the recommended geometry of swale system to transfer surface water run-off to this pond.

5.5.3 Surface Water Infrastructure Design

The following sections describe the modelling results and the finalised design characteristics of the key infrastructure proposed for the SWMS.

Typical SWMS details are shown in Drawing W-301, presented in Appendix B.

5.5.3.1 *Swale System*

The swales should have a general trapezoidal design shown in Figure 5-1.

[1] Queensland Urban Drainage Manual. 4th Edition. Institute of Public Works Engineering Australasia, Queensland.

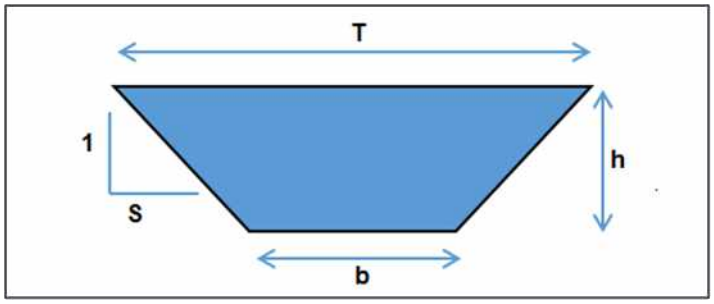

Figure 5-1: Swale Geometry

To simplify the swale system, all swales will feature the same design, which is presented in Table 5-4, with the dimensions corresponding to the swale shown in Figure 5-1.

Table 5-4: Proposed Swale Design

Design	S	b (m)	T (m)	h (m)
A	3	1	7	1

5.5.3.2 *Surface Water Pond*

Table 5-5 outlines the key design criteria for the proposed surface water pond, which is illustrated in Drawings W-106 and W-303 provided in Appendix A.

Table 5-5: Summary of Surface Water Pond Design Criteria

Approx. Dimensions [LxWxh] (m)	Side Slopes (V:H)	Surface Area (m^2)	Operational Pond Capacity* (m^3)	Required Capacity (m^3)
				1:20, 24hr
60 x 70 x 2.5	1:2.5	8,100	6,579	5,905

The pond has been designed to handle a 1-in-20-year, 24-hour storm event during regular operation, with contingency for a 1-in-50-year, 24-hour storm event. This pond is an improvement from the Site's current informal SWMS and provides significant attenuation before the surface water runoff overflows offsite. Calculations for the sizing of the surface water ponds and conveyance network are presented in Appendix D.

5.5.3.3 *Surface Water Bund*

A surface water bund shall be installed to protect the landfill facilities from external floodwaters. The continuous bund shall be neatly formed from suitable excavated material. The surface water bund will continuous along the western edge of the Site, as shown in Drawing W-101, presented in Appendix B. The surface water bund is proposed to be 1m high, and 8m wide with 1:4 (H:V) slopes, and will be constructed of non-dispersive site-won soils.

5.6 Supporting Infrastructure

The following sections discuss the proposed supporting infrastructure at the Site.

5.6.1 Fire Management

5.6.1.1 *Offsite*

Due to the Site's location, there is a potential for offsite bushfires to occur. Extreme fire weather conditions, including low humidity, high temperatures, high winds, and cured vegetation will increase the likelihood of a bushfire occurring. Impacts from offsite bushfires will be limited to ember attack in most cases. Consequential fires from ember attack can occur in many locations, particularly in the green waste stockpile, flammable stored waste such as tyres, mattresses and debris.

A 3-meter firebreak will be constructed and maintained around the boundary of the Site.

5.6.1.2 *Onsite*

A daily cover stockpile will be maintained in proximity to the active landfilling areas and to be used to smother a fire in the event that one occurs in a landfill trench. It is recommended that signage is installed on Site to inform visitors of the reporting and fire management procedures.

The HHW Facility will have a fire alarm system capable of detecting smoke, fire and carbon monoxide levels and linked to a building management system. Any sections within the HHW Facility shall be separated by full height fire walls to achieve minimum 60-minute fire rating and each section shall contain a 60-minute fire rated ceiling.

5.6.2 All Other Supporting Infrastructure

Other infrastructure required to support the operation and environmental management of the Site include the provision of access roads, services areas, and a temporary fence.

5.7 Project Timeline

The current estimated project timeline is shown in Table 5-6 based on the assumption that the DWER can complete the works approval assessment within the current target timeframe of 80 days. The timeframe shown in Table 5-6 includes the environmental approvals, procurement, and construction phases for the Site.

Table 5-6: Project Timeline

Enter ILUA with the Yinggarda Aboriginal Corporation	In Progress	June 2025
Acquire UCL for the expanded reserve	In Progress	September 2025
Works Approval Assessment	October 2025	December 2025
Construction	January 2026	June 2055

5.8 Time Limited Operations

The Shire requests that the DWER grant approval for time limited operations for the Site expansion until such time a Works Approval is granted. It is understood that the maximum period for time limited operations is 180 days and therefore the Shire wish to seek this timeframe to mitigate any potential risks associated with delays during the assessment stage for the amended Licence application. This request has been reflected within Part 4 of the DWER Application form. As it is the Shire's aim to

establish the new Site infrastructure as soon as possible, the time limited operations period will ensure the Site is operational as soon as it is constructed, in accordance with the Works Approval conditions and detailed designs.

6 Operational Aspects

The implementation of appropriate management practices will ensure the successful management of landfill operations whilst minimising the risk of any long-term environmental impacts. The key factors for ensuring effective landfill management include:

- Maintaining a small tip face/working face as far as practicable;
- Appropriate unloading techniques;
- Inspection of tip face;
- Correct waste placement/deposition;
- Compaction of waste; and
- Daily covering of waste with suitable material and thickness.

To ensure the waste management facility is operated effectively and efficiently, the following section outlines the requirements for the active tip face size, unloading techniques, waste placement including compaction and cover requirements, disposal activities during adverse weather conditions and phasing of filling.

6.1 Phasing of Filling

For the putrescible landfill each trench should be developed with adequate time to allow the smooth transition of landfill operations and relocation of environmental controls such as the temporary stock fence.

6.2 Waste Measurement

As the Site lacks a weighbridge, throughput at the Site will be measured on a volumetric basis. For each load delivered to the landfill facilities, the following should be recorded:

- Date;
- Waste type; and
- Bin size.

Waste will be measured using the methodology outlined in Section 3.1 of the 'Approved manner for estimating the volume or weight of waste received at and disposed of to landfills', under Regulation 3 of the *Waste Avoidance and Resource Recovery Levy Regulations 2008*.

Waste deposition records should be reviewed annually to ensure that waste generation and available void space are aligned, and to ensure that waste deposition is within the limits of the landfill regulations.

6.3 Tip Face Size

Waste deposited at the active tip face will be managed to ensure it does not exceed 8m in length or 2m in height, in general accordance with the WA Rural Landfill Regulations. The tipping face should be kept as small as practicably possible to minimise leachate generation and reduce the required cover soil amounts.

6.4 Unloading

Unloading shall occur within 5m of the active tip face to minimise unnecessary handling. Unloading will be undertaken at a suitable height to minimise the generation of dust, windblown waste and to maintain a tidy working area.

6.5 Inspection at Tip Face

Due to the size of the facility, inspection of the tip face during disposal by operators is not feasible; however, regular inspections of the tip face will be conducted to ensure that disposal practices are maintained and to manage incorrect disposal where possible. Waste collection vehicles will deposit waste in the designated unloading area, ensuring the working area is safe and addressing any hazards prior to disposal. During regular inspections, designated Site personnel will visually inspect the tip face to identify any unacceptable waste types. If non-conforming waste is identified, it will be removed from the tip face, and arrangements made for appropriate disposal.

6.6 Water Bodies

The pooling of water within the trench may attract vermin. The Site operators will attempt to clear any such water bodies around the active tip face. Compaction and daily covering of material will help to alleviate the generation of water bodies forming within the waste mass.

6.7 Waste Placement and Compaction

In general, the preferred method for the placement of waste is as follows:

- Unloading the waste at the head of respective tipping areas;
- Pushing waste to the tip face using the front-end loader;
- Spreading and compacting waste in 500mm thick layers to form a 2m deep platform;
- Development of a level platform across the landfill width until the other side is reached; and
- Repetition of this procedure until the pre-settlement final fill landfill profile is reached.

Once waste activities are completed for a certain area, cover material is applied in line with Section 6.8. This cover is applied to:

- Prevent windblown litter;
- Reduce pests such as dingoes, rodents and birds; and
- Reduce stormwater ingress into the waste mass.

To maintain vehicular access to the tip-face, it is essential that the waste compaction is kept as high as possible. If sufficient waste compaction is not achieved, it may be necessary to apply additional clean fill to allow access to the tip-face for the waste delivery vehicles. Bulky objects which are difficult to bury can be placed at the base of the tip face and then covered from above.

There will no compaction of the waste within the inert landfill. All asbestos waste will be placed and buried immediately, with further details provided in Section 7.4.

6.8 Initial and Intermediate Cover

An initial layer of suitable cover material is progressively applied to exposed waste on the top of the active landfill area. The proposed requirements for cover materials are summarised in Table 6-1.

Table 6-1: Site Cover Requirements

Waste Type	Material	Depth	Timescales
Clean Fill	No Cover Required		
Inert Waste Type 1			
Putrescible Waste	Type 1 Inert Waste, Soil or Clay	300mm	Weekly.
Inert Waste Type 2		150mm	As soon as practicable after deposition.
Special Waste Type 1		1,000mm	Immediately after deposition.

The covering of waste will assist with minimising odour, windblown litter, attraction of vermin, fire risk and general amenity. The Site Operator must ensure that there are sufficient quantities of cover material available to cover the waste on a weekly basis. The cover material used may be sourced from suitable materials available onsite. The cover materials that can be used include soils free of rocks and deleterious material with a diameter greater than the thickness of the cover soil layer.

A 500mm layer of low permeability soils must be applied over landfill trenches at the conclusion of landfilling operations in that trench to act as a temporary cap prior to installation of a final capping system. This layer can act as the Regulating Layer as discussed in Section 5.1.8.1.

6.9 Material Balance

A Material Balance is the calculation of the volume of materials required to carry out engineering works, daily cover activities for the landfill and its final restoration and comparing these quantities to the volume of material which can be retrieved from the Site.

Calculations have been undertaken to determine the material required throughout the life of the waste management facility for:

- Landfill construction;
- Daily cover material, which is assumed as 50% of the total landfill void; and
- Surface water pond construction.

Table 6-2 shows the approximate material balance required for the Site.

Table 6-2: Approximate Material Balance Calculations for the Site

Stage	Material Gained from Excavation	Cover Soil (m^3)	Capping Material Required (m^3)	Net Balance
Putrescible Landfill (per Trench)	+1,526	-763	-1,008	-245
Total Putrescible Landfill (15 Trenches)	+22,890	-11,445	-15,120	-3,675

Stage	Material Gained from Excavation	Cover Soil (m^3)	Capping Material Required (m^3)	Net Balance
Inert Landfill	+12,530	0	-9,393	+3,137
Surface Water Pond	+1,877	0	0	+1,877
Total	**+37,297**	**-11,445**	**-24,513**	**+1,339**

As shown in Table 6-2, the Site can theoretically achieve a material balance, with the excess soils to be used for the surface water and safety bunds around an active trench.

It should be noted that the total Material Balance requirement is sensitive to the amount of cover soils used during operations and will therefore be monitored by the Shire to ensure that sufficient soils are stockpiled at the Site.

6.10 Stability

The stability of the landfill is a key factor that can impact on the integrity of the landfill's environmental controls. To ensure the stability of waste and to minimise short-term settlement, waste should be levelled and compacted soon after initial placement and repeatedly, when possible. The aspects affecting compaction include the nature of waste material, weight of the compacting plant, number of passes and depth of layer/lift. No more than 0.5m of waste should be compacted at any time and three to five passes of the compaction equipment should be undertaken to maximise compaction and minimise settlement. Following compaction, the waste mass should be stable, with large bulky items such as pallets and boxes adequately crushed to maximise void space utilisation.

The slope of the working face can impact on waste compaction, manoeuvrability, quantity of cover required and water drainage. Typically, the working face should be no steeper than 1:3 (V:H) to allow compacting plant to traverse the face.

6.11 Adverse Weather Conditions

During periods of high winds and heavy rainfall events, the placement of waste will cease until the designated Shire personnel deems it safe and acceptable to recommence works. Adverse weather conditions can result in the generation of leachate, litter and dust as well as general safety issues.

6.12 Inspections

Regularly inspect trench walls and landfill bunds during construction, after rain or prolonged exposure, to detect signs of instability (e.g., cracks or sloughing). Ensure proper drainage around the Site to prevent water accumulation, which can impact wall stability.

6.12.1 Fence Inspections

A fence inspection should be undertaken at the Site monthly. The entirety of the fence line should be inspected to ensure it is free of wind-blown litter and that no holes are present.

6.12.2 Full Site Inspections

Full Site inspections should be undertaken at the Site monthly. The purpose of these full Site inspections is to inspect Site infrastructure to identify non-conformances and implement corrective actions where necessary. A monthly Site inspection template has been developed to ensure appropriate areas are reviewed and recorded.

At a minimum, Site inspections should review the items described in Table 6-3.

Table 6-3: Proposed Full Site Inspection Contents

Item	Description
Landfill	• Road and hardstand areas intact / repairs or rectification required; • All signage and traffic control operating effectively (i.e., signs installed, in good condition, correct position and updated information; • Intermediate cover applied to filled areas; • Tip face being kept to minimum size and shaped for minimum cover placing; • No evidence of leachate generation within landfill area and / or leachate eruption through landfill batters; • No evidence of litter beyond the active tipping area; • No evidence of bird, vermin and / or feral animal activity; • No signs of dust generation; and • No noticeable odours present.
General Site	• Site vegetation control (i.e., no evidence of noxious weed infestations); • Sediment and Erosion control structures in place and in functional condition (as required); • Site firebreaks maintained; and • No evidence of contamination outside of operational areas.
Security	• Perimeter fencing in a sound and functional condition.
Other	• General observations; and • Identification of items not otherwise listed in the sections above.

7 Environmental Aspects and Management

The key environmental aspects requiring consideration and management during the construction and operation of the Site include the following:

- Odour
- Noise
- Dust
- Stormwater
- Groundwater
- Leachate
- Landfill Gas
- Litter
- Traffic
- Vermin and Fauna
- Fire
- Security; and
- Stability

To ensure the potential environmental impacts that may occur during construction or operation of waste management facility will be appropriately managed and minimised, the Shire will implement a variety of engineering and management measures to ensure the potential environmental impacts that may occur during construction or operation of the waste management facility will be appropriately managed and minimised. It is noted that the proposed works see waste management activities relocated further from sensitive receptors, and thus risk levels are likely to decrease for the Site.

The engineering and management measures to be used at the Site are described in the following sections.

7.1 Odour

Odour emissions may arise from the acceptance of putrescible wastes. Odour emissions will be generated from the natural decomposition of putrescible waste that will be disposed onsite. However, as this has not been an issue at the existing Site it is unlikely that the expansion will result in significant odour impacts off site. Given the increase in separation distance from sensitive receptors and the low putrescible waste fraction, it is anticipated that the risk will be low.

Although the Site meets the recommended separation distances, a range of management measures will be implemented to ensure that the generation of odour at the Site is appropriately minimised and managed:

- Operations are the landfill are expected to occur approximately once per week;
- Waste will be covered regularly as outlined in Section 6.8; and
- Odour levels will be monitored by Site staff, and action taken if required.

It is anticipated that these odour management measures will enable the Shire to appropriately manage potential odour impacts at the site.

7.2 Noise

Noise emissions associated with the project has the potential to result in noise impacts. Noise emissions will be generated from construction, the plant during waste deposition and covering, and from road and engine noise generated from vehicles entering and exiting the Site. However, as this has not been an issue at the existing Site and operations will remaining largely the same, the expansion of the Site is not anticipated to significantly increase noise emissions on site.

Noise emissions will be produced during construction and operational activities. As mentioned previously, there are several sources of noise associated with the proposed activities including equipment and vehicle movements. To ensure that noise emissions are minimised, the following noise emission management measures will be implemented:

- The nearest sensitive receptor for the Site, will be approximately 0.8km away, and it is not expected that any sensitive receptors will be constructed any closer to the Site;
- Vehicles will be restricted to a maximum speed of 30km/hr unless otherwise signed;
- Noise reducing workplace procedures will be adopted such as slow unloading of materials from the lowest height possible;
- All materials handling will be confined to the designated areas;
- All equipment and machinery will be maintained in good working condition; and
- Staff and visitors will be provided with appropriate personal protective clothing (PPE) to mitigate any noise impacts associated with the Site activities.

The above noise mitigation measures are anticipated to be sufficient to appropriately manage noise emissions and ensure compliance with the Noise Regulations.

7.3 Dust

Dust will be generated during the construction of the landfill and during the operation of the facility, namely:

- Earthworks;
- Construction of infrastructure;
- Vehicle movements once the landfill is operational; and
- Material handling activities (loading and unloading, etc).

The generation of dust is anticipated to occur mainly during the construction phase of a landfill trench. To manage the generation of dust, the Shire will implement the following management measures:

- Operations will cease during periods of high winds;
- Vehicles will be restricted to a maximum speed of 30km/hr; and
- All waste loads are to be covered during transport.

It is anticipated that the implementation of the engineering and management measures listed above will be sufficient to manage dust at the site.

7.4 Asbestos

Asbestos is a hazardous fibrous substance which can occur within waste materials, particularly C&D wastes such as building rubble. Asbestos poses a potential risk if fibres become airborne and are breathed into the lungs. Serious health impacts may occur, often as a result of significant exposure to asbestos, including mesothelioma, lung cancer and asbestosis.

To manage the generation of asbestos dust, the Shire will implement the following management measures:

- Acceptance will be by appointment only, with 20-days notices;
- Waste material must be double wrapped by the customer and inspected by Shire staff; and
- Asbestos waste will be capped with a minimum 1m layer of suitable soil material.

It is anticipated that these management measures, in addition to the dust management measures outlined in Section 7.3, will appropriately manage asbestos waste within the Site.

7.5 Surface Water

Surface water, or stormwater, will be generated as a result of precipitation falling onto the Site. If surface water comes into contact with waste material at the Site, it can generate leachate. Therefore, water should be directed away from the active tipping area wherever possible.

To ensure that surface water is appropriately managed at the Site, the following management measures will be adopted:

- Use of landfill bunds to prevent stormwater from entering the landfill trench;
- The SWMS, including:
  - Surface water swales;
  - Surface water bunds; and
  - Surface water pond.

It is anticipated that these management measures will appropriately manage potential stormwater within the Site.

7.6 Groundwater

Groundwater may be impacted by leachate percolating through in-situ ground and may also cause landfill inundation if the separation distance is inadequate. The regional depth to groundwater is understood to be well in excess of the 3m requirement of the WA Rural Landfill Regulations and will allow for minimal impacts to groundwater from Site operations.

7.7 Leachate

Leachate may be generated by putrescible wastes, and by water coming into contact with waste material. This liquid has the potential to impact groundwater quality and surface water quality if not correctly managed.

As outlined in Section 2.2.4, the Site accepts a small annual quantity of putrescible waste. Additionally, climate conditions at the Site are arid, with low annual average rainfall and low relative humidity year-round as discussed in Section 3.1. The addition of a low-permeability layer on top of the landfill following closure will decrease long-term infiltration and ensure that the minimal leachate generation potential is maintained post-closure. The combination of these factors results in a dry waste mass, with minimal leachate generation potential.

These management measures are adequate for the management of the leachate risk at the Site.

7.8 Landfill Gas

As outlined in Section 2.2.4, the Site accepts a very low quantity of putrescible waste annually, and the conditions at the Site result in a very dry waste mass. These factors not only reduce leachate generation from the landfilled putrescible waste, but also landfill gas generation, which is dependent on the moisture content within the waste. Therefore, a dry waste mass with a low putrescible fraction is not anticipated to produce significant quantities of landfill gas.

Landfill gas can cause an asphyxiation and explosion risk, particularly when it accumulates in subsurface services such as utility pipes and basements. The remote location of the landfill ensures that there are no receptors or pathways for exposure of landfill gas, significantly reducing the risk.

7.9 Litter

Litter may be generated as a result of transporting and handling waste, particularly during windy conditions. As well as reducing visual amenity, litter can attract vermin to the Site, which may affect surrounding land uses if these vermin migrate offsite.

To ensure that the generation of litter is minimised and appropriately managed at the Site, the following management measures will be implemented:

- All waste will be unloaded as close to the ground as possible, and will be covered weekly;
- All waste loads entering the Site will be covered to prevent uncontrolled release of litter;
- A temporary fence will be installed to prevent any litter escaping;
- The temporary fence will be inspected regularly, and any maintenance works scheduled accordingly;
- Any litter generated around the Site and along the fence lines will be collected on a regular basis as part of routine procedures; and
- Wind-blown litter will be collected as soon as practicable.

These management measures will enable appropriate management of litter at the Site.

7.10 Traffic

Onsite traffic movements have the potential to generate noise, dust and create an occupational health and safety risk to staff. The following traffic movements are anticipated to occur onsite:

- Front-end loader and other vehicles for waste deposition and cover; and
- Light-vehicle access for community drop-off and servicing from staff.

The small volumes of waste generated at the Site will result in minimal operational waste movements. This, in addition to traffic management measures, will minimise the additional traffic impacts at the Site as far as practicable.

It is noted that the existing roads are currently unsealed; however, the Shire has plans to seal these roads which will reduce dust and noise at the Site.

7.11 Vermin and Feral Animals

Vermin and fauna such as rats, mice, birds, insects, cats and dingoes may be attracted to waste management facilities particularly those with poor housekeeping practices. If uncontrolled, vermin can present a health risk to staff and surrounding land users.

The acceptance of waste (particularly putrescible waste) can attract vermin which has the potential to impact local health of staff and nearby land users. To control potential vermin issues, the Site proposes to adopt the following management measures:

- The generation of odour and litter will be minimised through the implementation of appropriate management measures (see Sections 7.1 and Section 7.9);
- All waste loads will be covered during transport;
- General waste will be covered as soon as practicable following deposition, and putrescible waste will be covered weekly.
- A temporary fence will be installed, monitored and maintained on a regular basis;
- Any suspected and/or known shelters or breeding grounds for vermin on the site will be eliminated;
- The Shire uses professional services to maintain a regular trapping and culling regime, as well as managing Shire owned traps; and
- The Shire contributes to a local bio-security group that manages feral animals.

Through the adoption of the vermin management measures set out above, any potential adverse impacts associated with the proposed operations are anticipated to be adequately managed.

7.12 Fire

Fires may occur through faulty equipment, machinery, waste acceptance, landfill fires or arson. Fire management measures will be implemented to ensure this risk is mitigated.

Fire management measures will be undertaken as outlined in the *Gascoyne Junction Landfill: Landfill Environmental Management Plan* and have also been included in the design of the landfill, including:

- A 3m firebreak to allow access for firefighting;
- Separation of combustible and non-combustible materials;
- Fuel reduction including firebreak and mulching of green waste;
- Regular compaction of waste to reduce void space and oxygen availability, lowering the risk of fire;
- Inspect incoming waste for "hot loads" when possible (e.g., smouldering materials, improperly extinguished ashes);
- Cover soils stockpile near the active tip face that can be used to smother a fire; and
- Temporary fence around the perimeter of the operational landfills.

Additionally, the Shire staff oversee the Bush Fire Brigade, which involves efforts in bush fire prevention, suppression, and managing the necessary equipment. Both staff and equipment are readily accessible for fire management and control.

These management measures will enable the Shire to appropriately manage a fire if it was to occur at the Site.

7.13 Security

A temporary fence will fully extend around each active landfill. To ensure the security of the Site is not compromised the fence will be installed and relocated for all landfill trenches.

It is anticipated that the measures listed above will be sufficient to ensure the security of the Site is maintained during operations.

7.14 Stability

Consideration has also been given to the stability of the putrescible and inert landfills. Settlement often occurs from the uneven degradation of putrescible wastes and can be amplified when waste is uncompacted over large waste depths. To manage the risks associated with stability, the Site will feature the following risk management measures:

- A low putrescible waste fraction and overall low depth of waste material within each trench;
- Waste compaction during deposition; and
- Significant soil surcharge of minimum 1.3m at Site closure.

It is anticipated that these measures will be more than adequate to manage the stability risk at the Site during operation and post-closure.

8 Residual Risk Assessment

The risk assessment outlined in this section is conducted to assess the environmental, public health and amenity risks associated with various aspects of ongoing landfill development and operation. The risk assessment framework is adapted from the Department of Water and Environmental Regulation's (DWER) *Risk Assessments, Part V, Division 3, Environmental Protection Act 1986 (WA)*, and is detailed in the sections below.

8.1 Methodology

The objective of the risk assessment is to ensure the potential environmental and social risks associated with the operation and closure of the landfill are understood and managed appropriately to confirm suitable management measures are in place and there is no unacceptable residual risk. The sections below identify 'source-pathway-receptor' scenarios to determine the level of risk before, and after management measures have been implemented.

8.1.1 Source of Contamination or Harm

For the purpose of this assessment, a source is defined as a primary risk with the potential to cause significant contamination or harm to the environment. With regards to the environment and public health, sources and its potential hazards which may arise have been identified and are shown in Table 8-1.

Table 8-1: Sources of Contamination or Harm

Source	Description	Risk Description
Landfill Gas	Compounds within the gas which are asphyxiant	Carbon Dioxide and Methane can replace oxygen and accumulates in enclosed areas, inadvertently causing an asphyxiation risk to humans and fauna
	Compounds within the gas which are explosive	Methane is explosive and flammable at 5-15% v/v in surplus oxygen which causes a risk to human health and infrastructure
	Compounds within the gas that are toxic	Hydrogen Sulfide can be fatal in concentrations greater than 500ppm[2]
	Compounds within the gas that are ecotoxic	Methane at 45% v/v and Carbon Dioxide at 5-10% v/v cause stress in the root zone
Leachate	Chemically contaminated solution generated by rainwater mixing with waste or through decomposition of organic or liquid waste inputs	Leachate commonly contains ammonia, ammoniacal nitrogen and total nitrogen which can impact water sources and those who rely on them

[2] International Programme on Chemical Safety and World Health Organisation, 2003, Concise international Chemical Assessment Document 53 – Hydrogen Sulphide: Human Health Aspects

Source	Description	Risk Description
Stormwater	Surface water generated by rainfall	Improper management can lead to generation of leachate, erosion, and damage to infrastructure
Dust	Fine particles that can be blown in the wind.	Dust causes reduced visual amenity and can be dangerous if it includes asbestos fibres
Exposed Waste	Waste material that is physically exposed.	Increased risk of leachate generation in addition to harm or sickness if physical contact or consumption occurs
Litter	Light waste materials that can blow in the wind.	Reduced visual amenity and may easily travel beyond the Site's boundary
Odour	Odour emissions from landfill gas or open tip face	Reduced amenity due to smell
Physical Aspects	Surface irregularities which pose a health and safety threat to end users	Trip, slip or fall hazards from uneven surfaces
	Unstable design or shape of the landfill.	Unstable profiles that may cause landslides or slope failures
Noise	Sounds emitted from vehicles and plant onsite	Noise emissions can reduce amenity on and immediately surrounding the Site
Fire	Potential for fires from waste materials or faulty equipment	Fire is a large risk to human and environmental health, and can cause damage to Site infrastructure
Vermin and Fauna	Animals attracted to the landfill by odour or exposed waste	Vermin and feral animals may cause nuisance and present health risks
Security	Restriction of access to the Site	Unauthorised personnel may access the Site, resulting in a security risk to the Site facilities, plant and equipment
Traffic	Vehicle movements around the Site	Possibility for vehicles to collide with Site personnel, structures or other vehicles. Poor design of traffic flow and operations can lead to unpredictable traffic routes and create safety hazards onsite

8.1.2 Pathways of Potential Contamination or Harm

For the purpose of this assessment, a pathway for a hazard is defined as the route by which potential contamination or harm can migrate. The key migration pathways generally include the following:

- Air through which lightweight materials such as dust and litter, odour and landfill gas travel;
- Surface along which the sources of contamination or harm can travel or be present at (e.g. surface water runoff, litter, persons walking or working over the surface); and
- Sub-surface whereby the underlying soils, bedrock, aquifers and infrastructure permit gas and leachate migration towards the receptors.

8.1.3 Receptors of Potential Contamination or Harm

For the purpose of this assessment, a receptor is defined as the location where the impact of the contamination or harm is registered. The possible receptors of the contamination or harm caused by the hazards identified are summarised in Table 8-2.

Table 8-2: Generic Receptors that may be Impacted by Potential Contamination or Harm

Receptor	Description of the Receptor
Surrounding Land Users	People who work or live beyond the boundary of the Site. Some of these are referred to as sensitive receptors.
Site Users	Persons authorised to traverse across the Site, including: • Operational staff; • Contractors carrying out maintenance or monitoring; and • Visitors inspecting the site.
Buildings/Infrastructure	Buildings or infrastructure that are semi-permanently or permanently occupied and used for work or residential purposes.
Vegetation and Flora	Vegetation on and surrounding the Site.
Fauna	Fauna species whose habitats are within or surrounding the Site.
Groundwater	Groundwater that exists beneath the landfill either as a local perched system or as a regional aquifer from which a water supply may be extracted for industrial or potable purposes.
Surface Water	Permanent or semi-permanent surface water which provides a habitat for flora and fauna.

As discussed in Sections 2.5, there are no surrounding land users, buildings or infrastructure within the immediate vicinity of the Site. Therefore, these receptors have not been considered when undertaking the risk assessment.

8.2 Risk Rating Matrix

To assess the various risks, the potential hazards identified in Table 8-1 were classified according to the risk assessment matrix shown in Table 8-5. This risk assessment matrix considers the consequence and likelihood of the risk, the definitions of which can be seen below in Table 8-3 and Table 8-4 below. Table 8-6 shows the appropriate risk treatments for each risk level.

Table 8-3: Consequence of Risk Occurring†

Consequence	Environment	Public Health* and Amenity (i.e. air and water quality, noise, & odour)
Severe	• On-site impacts: catastrophic • Off-site impacts local scale: high level or above • Off-site impacts wider scale: mid-level or above • Mid to long term or permanent impact to an area of high conservation value or special significance^ • Specific Consequence Criteria (for environment) are significantly exceeded	• Loss of life • Adverse health effects: high level or ongoing medical treatment • Specific Consequence Criteria (for public health) are significantly exceeded • Local scale impacts: permanent loss of amenity
Major	• On-site impacts: high level • Off-site impacts local scale: mid-level • Off-site impacts wider scale: low level • Short term impact to an area of high conservation value or special significance^ • Specific Consequence Criteria (for environment) are exceeded	• Adverse health effects: mid-level or frequent medical treatment • Specific Consequence Criteria (for public health) are exceeded • Local scale impacts: high level impact to amenity
Moderate	• On-site impacts: mid-level • Off-site impacts local scale: low level • Off-site impacts wider scale: minimal • Specific Consequence Criteria (for environment) are at risk of not being met	• Adverse health effects: low level or occasional medical treatment • Specific Consequence Criteria (for public health) are at risk of not being met • Local scale impacts: mid-level impact to amenity
Minor	• On-site impacts: low level • Off-site impacts local scale: minimal • Off-site impacts wider scale: not detectable • Specific Consequence Criteria (for environment) likely to be met	• Specific Consequence Criteria (for public health) are likely to be met • Local scale impacts: low level impact to amenity
Slight	• On-site impact: minimal • Specific Consequence Criteria (for environment) met	• Local scale: minimal impacts to amenity • Specific Consequence Criteria (for public health) criteria met

^ Determination of areas of high conservation value or special significance should be informed by the Guidance Statement: Environmental Siting

** In applying public health criteria, DWER may have regard to the Department of Health's, Health Risk Assessment (Scoping) Guidelines*

† From DWER Guidance Statement: Risk Assessments rev. V2 February 2017 "on-site" means within the prescribed premises boundary

Table 8-4: Likelihood

Likelihood	The following criteria will be used to determine the likelihood of the risk event occurring.
Almost Certain	The risk event is expected to occur in most circumstances
Likely	The risk event will probably occur in most circumstances
Possible	The risk event could occur at some time
Unlikely	The risk event will probably not occur in most circumstances
Rare	The risk event may only occur in exceptional circumstances

The risk matrix in Table 8-5 below combines the level of likelihood and consequence to determine the level of associated risk.

Table 8-5: Risk Assessment Matrix

		Consequence				
		Slight	**Minor**	**Moderate**	**Major**	**Severe**
Probability	**Almost Certain**	Medium	High	High	Extreme	Extreme
	Likely	Medium	Medium	High	High	Extreme
	Possible	Low	Medium	Medium	High	Extreme
	Unlikely	Low	Medium	Medium	Medium	High
	Rare	Low	Low	Medium	Medium	High

Table 8-6 from the Guidance Statement: Risk Assessments by DWER outlines the acceptability and treatment of the risk levels.

Table 8-6: Risk Treatment Table†

Rating of Risk Event	Acceptability	Treatment
Extreme	Unacceptable	Risk event will not be tolerated. DWER may refuse application.
High	May be acceptable. Subject to multiple regulatory controls	Risk event may be tolerated and may be subject to multiple regulatory controls. This may include both outcome-based and management conditions.
Medium	Acceptable, generally subject to regulatory controls	Risk event is tolerable and is likely to be subject to some regulatory controls. A preference for outcome-based conditions where practical and appropriate will be applied.

Rating of Risk Event	Acceptability	Treatment
Low	Acceptable, generally not controlled	Risk event is acceptable and will generally not be subject to regulatory controls.

† From DWER Guidance Statement: Risk Assessments rev. V2 February 2017

8.3 Risk Profile

Risk management measures refer to the key management strategies that will be adapted onsite to ensure that all hazards and potential risks identified are controlled to an appropriate level, and that strategies are in place to react to any potential incidents or accidents. In most cases these risk management measures decrease the probability and/or consequence of the identified hazards, thus lowering the risk rating. Table 8-7 presents a summary of the 'source-pathway-receptor' scenarios identified in the risk assessment process. The table includes risks both before and after the successful implementation of the proposed engineering and management measures prescribed within this EAMP.

Table 8-7: Residual Risk Profile

Source of Concern	Receptor	Pathway	Risk Description	Probability	Consequence	Risk Rating	Management Measures	Revised Probability	Revised Consequence	Revised Risk Rating
Odour	Site Users	Fugitive Emissions	Lowered amenity due to odour	Likely	Minor	Medium	• Operations at the landfills are expected to occur only approximately one or two times per week; • Waste will be covered regularly as outlined in Section 6.8; and • Odour levels will be continuously monitored by Site staff, and action taken if required.	Rare	Slight	Low
		Subsurface Migration		Possible	Minor	Medium		Rare	Slight	Low
Landfill Gas	Site Users	Fugitive Emissions	Toxicity from trace gasses, predominantly hydrogen sulphide.	Landfill gas will be unable to accumulate next to the landfill as it will oxidise and disperse. No subsurface pathways exist in the vicinity of the landfill.			• The risk is adequately managed via the design of the landfills and minimal landfill gas generation from the small, dry waste mass.	Landfill gas will be unable to accumulate next to the landfills as it will oxidise and disperse. No subsurface pathways exist in the vicinity of the landfills.		
		Subsurface Migration								
	Site Users	Fugitive Emissions	Asphyxiation from high carbon dioxide levels, explosion, and fire risk from methane between 5 and 15% v/v							
		Subsurface Migration								
	Site Infrastructure	Subsurface Migration	Explosion and fire risk from methane between 5-15% v/v							
	Flora	Subsurface Migration	Root stress from carbon dioxide levels between 5-10% v/v							
Leachate	Site Users	Migration via surface water runoff	Contact with or consumption of leachate	Unlikely	Moderate	Medium	• The landfills base will consist suitable Site-won soils to mitigate any leachate seepage into the environment; • The landfills perimeter will be bunded to contain any leachate generated; • The landfills floor will be sloped away from the entrance into the landfill; • Waste will be covered as outlined in Section 6.8; • Putrescible waste will be covered by cover soils weekly; • Separation from groundwater is expected to be greater than 3m below landfills base; • Following the completion of waste disposal, the landfills will be capped by a 500mm Compacted Clay liner.	Rare	Minor	Low
	Flora			Unlikely	Minor	Medium		Rare	Minor	Low
	Fauna			Unlikely	Moderate	Medium		Rare	Slight	Low
	Ground Water	Migration via groundwater		Unlikely	Minor	Medium		Rare	Minor	Low
	Surface Water	Migration via surface water runoff		Unlikely	Moderate	Medium		Rare	Minor	Low

Source of Concern	Receptor	Pathway	Risk Description	Probability	Consequence	Risk Rating	Management Measures	Revised Probability	Revised Consequence	Revised Risk Rating
Dust	Site Users	Dust blown in the wind	Reduced visual amenity	Likely	Minor	Medium	• Operations will cease during periods of high winds; • Vehicles will be restricted to a maximum speed of 30km/hr; and • All waste loads are to be covered during transport.	Rare	Minor	Low
Exposed Waste	Site Users	Direct contact with exposed waste	Coming into contact with waste	Possible	Moderate	Medium	• Waste will be covered as per the requirements listed in Section 6.8; • The landfills will be capped as outlined in Section 5.1.8, preventing physical contact with the waste; • Fencing surrounding the active landfill facilities will prevent access from unauthorised personnel and fauna; and • Landfill bunds will be constructed around the active landfills to prevent surface water from coming in contact with exposed waste.	The proposed capping system, will cover all waste, breaking the exposure pathway and eliminating risk. The proposed landfill bunds will divert surface water from the active landfills minimizing the volume of water entering the landfill, breaking the exposure pathway and minimising risk.		
	Fauna		Consumption of the waste	Unlikely	Moderate	Medium				
	Surface Water		Coming into contact with waste	Possible	Moderate	Medium				
Litter	Site Users	Litter blown in the wind	Reduced visual amenity	Almost Certain	Slight	Medium	• All waste will be unloaded as close to the ground as possible, and will be covered weekly; • All waste loads entering the Site will be covered to prevent uncontrolled release of litter; • A temporary fence will be installed to prevent any litter escaping; • The temporary fence will be inspected regularly, and any maintenance works scheduled accordingly; • Any litter generated around the Site and along the fence lines will be collected on a regular basis as part of routine procedures; • Wind-blown litter will be collected as soon as practicable.	The proposed capping system and daily cover, will cover all waste, preventing any windblown litter. Additionally temporary fencing will contain litter. Therefore, the exposure pathway is broken and the risk is eliminated.		
	Fauna		Consumption of the litter	Unlikely	Moderate	Medium				
	Surface Water	Litter transported by surface water flow or wind	Coming into contact with waste	Possible	Moderate	Medium				
Physical Aspects	Site Users	Surface irregularities and unstable surfaces	Trip hazard	Possible	Moderate	Medium	• Fencing surrounding active landfills will prevent access from unauthorised personnel; • A low putrescible waste fraction and overall low volume of waste material;	Rare	Minor	Low
			Erosion & landfill slope failures	Unlikely	Major	Medium		Rare	Minor	Low

Source of Concern	Receptor	Pathway	Risk Description	Probability	Consequence	Risk Rating	Management Measures	Revised Probability	Revised Consequence	Revised Risk Rating
							• Waste bench heights of a maximum 2m; • Waste compaction during deposition.			
Noise	Site Users	Noise travels through the air	Reduced Amenity and long-term exposure health risks	Likely	Moderate	High	• No sensitive receptors are expected to be constructed any closer than 500m to the Site; • Vehicles will be restricted to a maximum speed of 30km/hr; • Noise reducing workplace procedures will be adopted such as slow unloading of materials from the lowest height possible; • All materials handling will be confined to the designated areas; • All equipment and machinery will be maintained in good working condition; and • Staff and visitors will be provided with appropriate personal protective clothing (PPE) to mitigate any noise impacts associated with the site activities.	Possible	Slight	Low
	Sensitive Receptors		Reduced Amenity	Possible	Minor	Medium		Rare	Slight	Low
Traffic	Site Users	Collisions with vehicles	Human health risks	Unlikely	Severe	High	• The small volumes of waste generated at the Site will result in minimal operational waste movements, estimated to average two to three times per week.	Rare	Minor	Low
	Site Infrastructure		Damage to infrastructure	Possible	Minor	Medium		Rare	Minor	Low
Vermin and Fauna	Site Users	Animals attracted to the waste mass	Amenity and human health risk	Likely	Minor	Medium	• The generation of odour and litter will be minimised through the implementation of appropriate management measures (see Sections 7.1 and Section 7.9); • Regular litter collections will be undertaken onsite; • All waste loads will be covered during transport; • Putrescible waste will be covered weekly; • A temporary fence will be installed, monitored and maintained; and • Should any vermin issues be experienced, professional services will be utilised to eradicate vermin at the site.	Unlikely	Slight	Low
	Sensitive Receptors		Amenity and human health risk	Unlikely	Minor	Medium		Rare	Slight	Low
Fire	Site Users	Contact with fire	Human health risk or fatality from fire	Rare	Severe	High	• A 3m firebreak will be maintained to allow access for firefighting; • Small landfill trench size and dispersed trench location to minimise the risk of fire spreading; • Cover soil stockpile near the active tip face that can be used to smother a fire; and • Temporary fence around the perimeter of the active landfills.	Rare	Minor	Low
	Site Infrastructure		Damage to infrastructure from fire	Rare	Moderate	Medium		Rare	Minor	Low

Source of Concern	Receptor	Pathway	Risk Description	Probability	Consequence	Risk Rating	Management Measures	Revised Probability	Revised Consequence	Revised Risk Rating
Security	Site Infrastructure	Trespassers and unauthorised entrants	Damage from vandalism or misuse of Site	Unlikely	Minor	Medium	• Temporary fence will be installed and relocated for all landfill trenches.	Rare	Slight	Low

9 Conclusion

The Shire wishes to expand its Category 89 landfill to meet its waste management needs. The landfill will exist within the expanded boundary reserve and will consist of the following:

- Unlined landfill trenches for putrescible waste;
- Unlined landfill for inert waste;
- Asbestos Monocell;
- Liquid Waste Ponds;
- CRC for the stockpiling of recyclable materials; and
- Daily cover stockpile areas.

The key potential environmental impacts associated with the construction and operation of the waste management facility that were considered include:

- Odour;
- Noise;
- Dust;
- Stormwater;
- Groundwater;
- Leachate;
- Landfill Gas;
- Litter;
- Traffic;
- Vermin and Fauna;
- Fire;
- Security; and
- Stability.

The design of the Site has been developed to ensure all these environmental and social impacts are managed appropriately, and that the design and operations comply with the WA Rural Landfill Regulations. Based on the design, proposed engineering and environmental management measures and low residual risk, the Shire believes that the construction and operation of the waste management facility can be achieved in a manner that ensures that these potential impacts can be minimised and managed appropriately.

APPENDIX A
Figures

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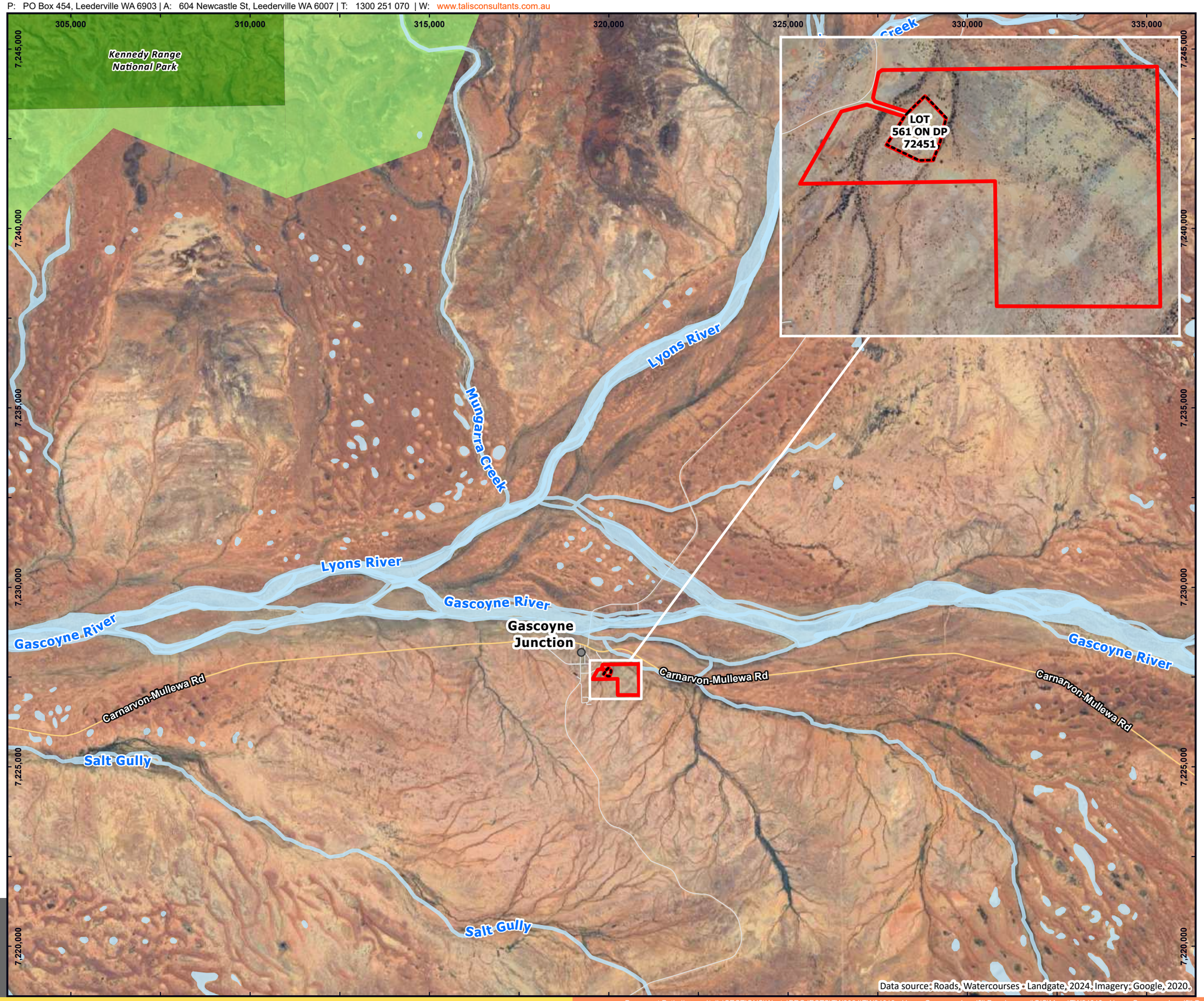

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451
- Watercourses

Legislated Lands and Waters

- National Park
- UCL - Section 33(2)

Western Australian Roads

- Main Road
- Minor Road

LOCALITY

0 200 400 600 800 1,000 km

LOCALITY

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N

0 1 2 3 4 km

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:100,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

talis consultants

Figure 01

Document Path: \\server\talis\SECTIONS\Waste\PROJECTS\TW2024\TW24019 - Upper Gascoyne Landfill Development\GIS\Maps\TW24019 - Upper Gascoyne Landfill Development\TW24019 - Upper Gascoyne Landfill Development.aprx

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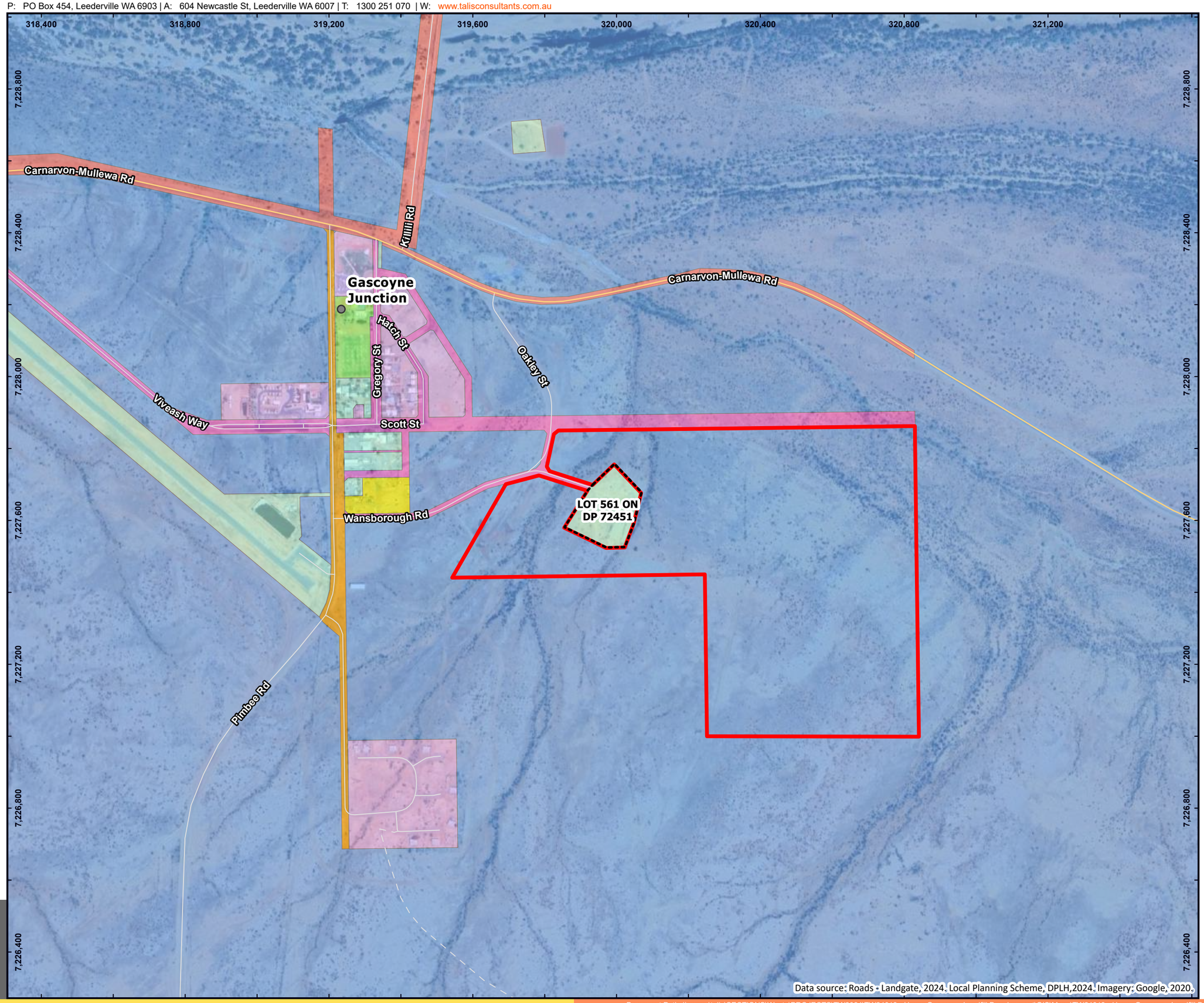

Data source: Roads - Landgate, 2024. Local Planning Scheme, DPLH,2024. Imagery: Google, 2020.

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Local Planning Scheme

- Light industry
- Local distributor road
- Local road
- Primary distributor road
- Public open space
- Public purposes
- Rural
- Rural townsite

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY

0 200 400 600 800 1,000 km

ZONING

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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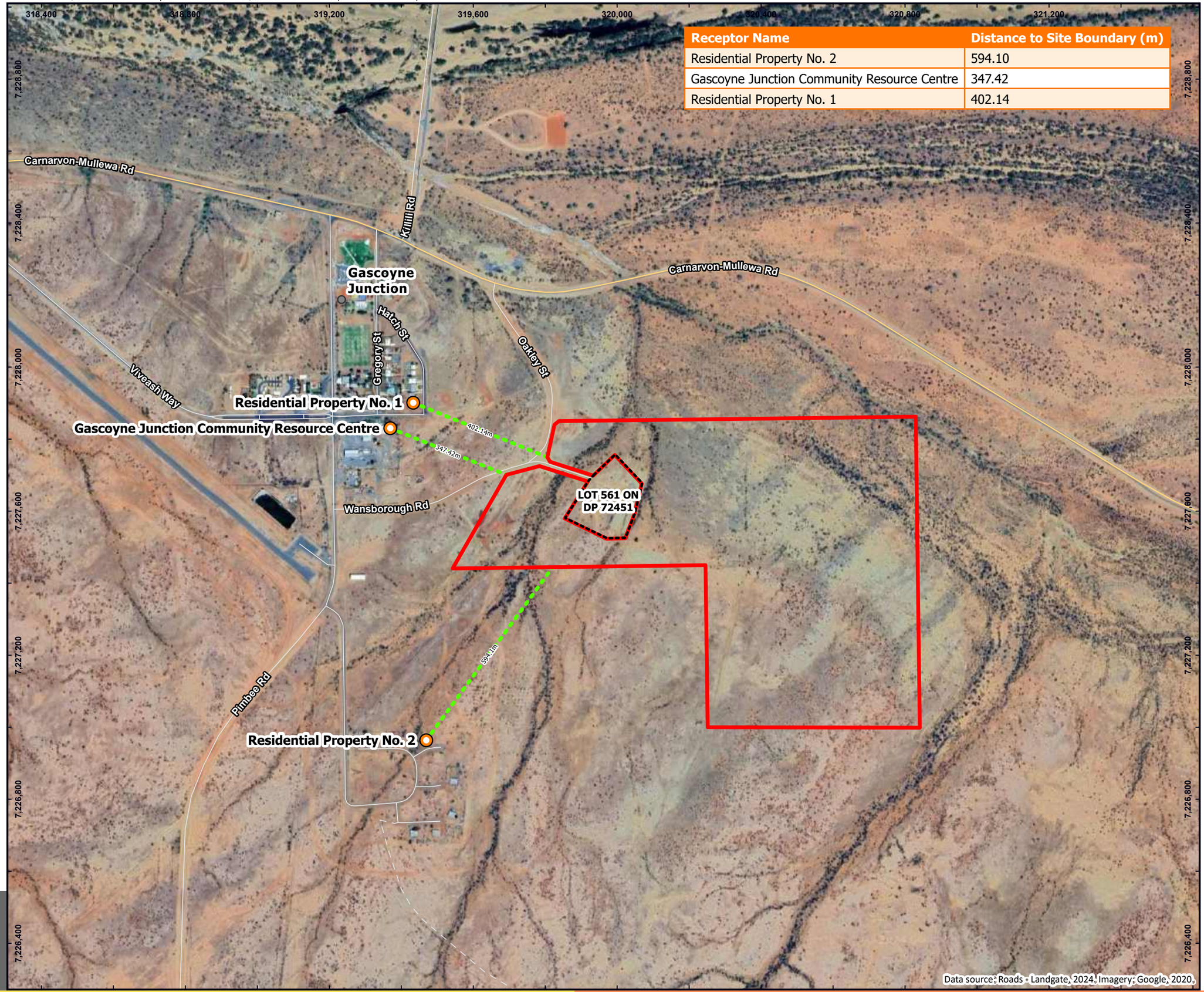
Figure 02

Document Path: \\server\talis\SECTIONS\Waste\PROJECTS\TW2024\TW24019 - Upper Gascoyne Landfill Development\GIS\Maps\TW24019 - Upper Gascoyne Landfill Development\TW24019 - Upper Gascoyne Landfill Development.aprx

P: PO Box 454, Leederville WA 6903 | A: 604 Newcastle St, Leederville WA 6007 | T: 1300 251 070 | W: www.talisconsultants.com.au

Receptor Name	Distance to Site Boundary (m)
Residential Property No. 2	594.10
Gascoyne Junction Community Resource Centre	347.42
Residential Property No. 1	402.14



LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Separation Distances

- Sensitive Receptors
- Separation Distances

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY

0 200 400 600 800 1,000 km

SENSITIVE RECEPTORS

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 03

Document Path: \\server\talis\SECTIONS\Waste\PROJECTS\TW2024\TW24019 - Upper Gascoyne Landfill Development\GIS\Maps\TW24019 - Upper Gascoyne Landfill Development\TW24019 - Upper Gascoyne Landfill Development.aprx

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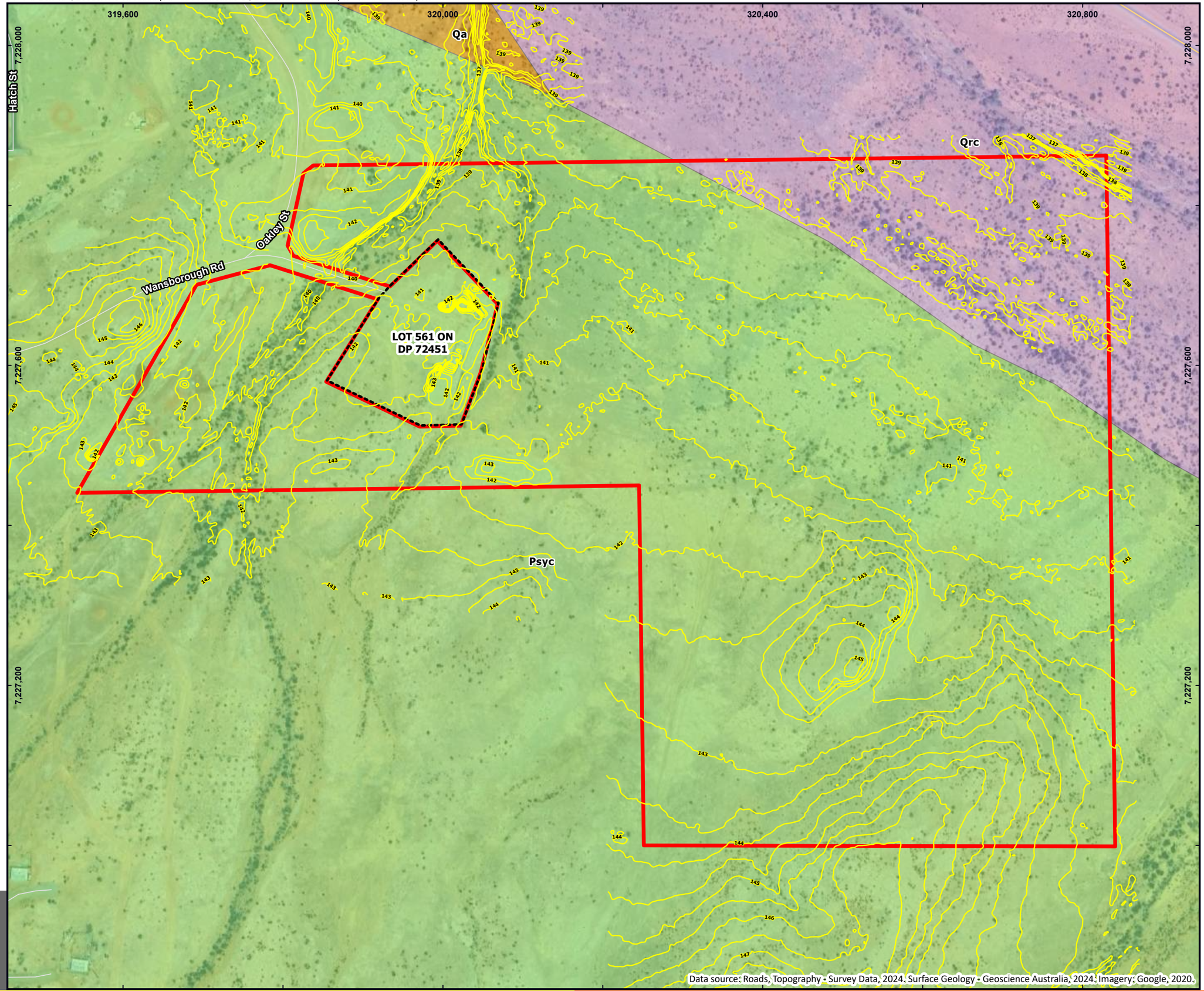

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451
- 0.5m Contours (m AHD)

Surface Geology (GA)

- Psyc: Quartz wacke, siltstone, carbonaceous siltstone and shale, locally fossiliferous.
- Qa: Channel and flood plain alluvium; gravel, sand, silt, clay; may be locally calcreted
- Qrc: Colluvium and/or residual deposits, sheetwash, talus, scree; boulder, gravel, sand; may include minor alluvial or sand plain deposits, local calcrete and reworked laterite

Western Australian Roads

- Main Road
- Minor Road

LOCALITY

0 200 400 600 800 1,000 km

TOPOGRAPHY & GEOLOGY

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N

0 50 100 150 200 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:4,500

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 04

Data source: Roads, Topography - Survey Data, 2024. Surface Geology - Geoscience Australia, 2024. Imagery: Google, 2020.

Document Path: \\server\talis\SECTIONS\Waste\PROJECTS\TW2024\TW24019 - Upper Gascoyne Landfill Development\GIS\Maps\TW24019 - Upper Gascoyne Landfill Development\TW24019 - Upper Gascoyne Landfill Development.aprx

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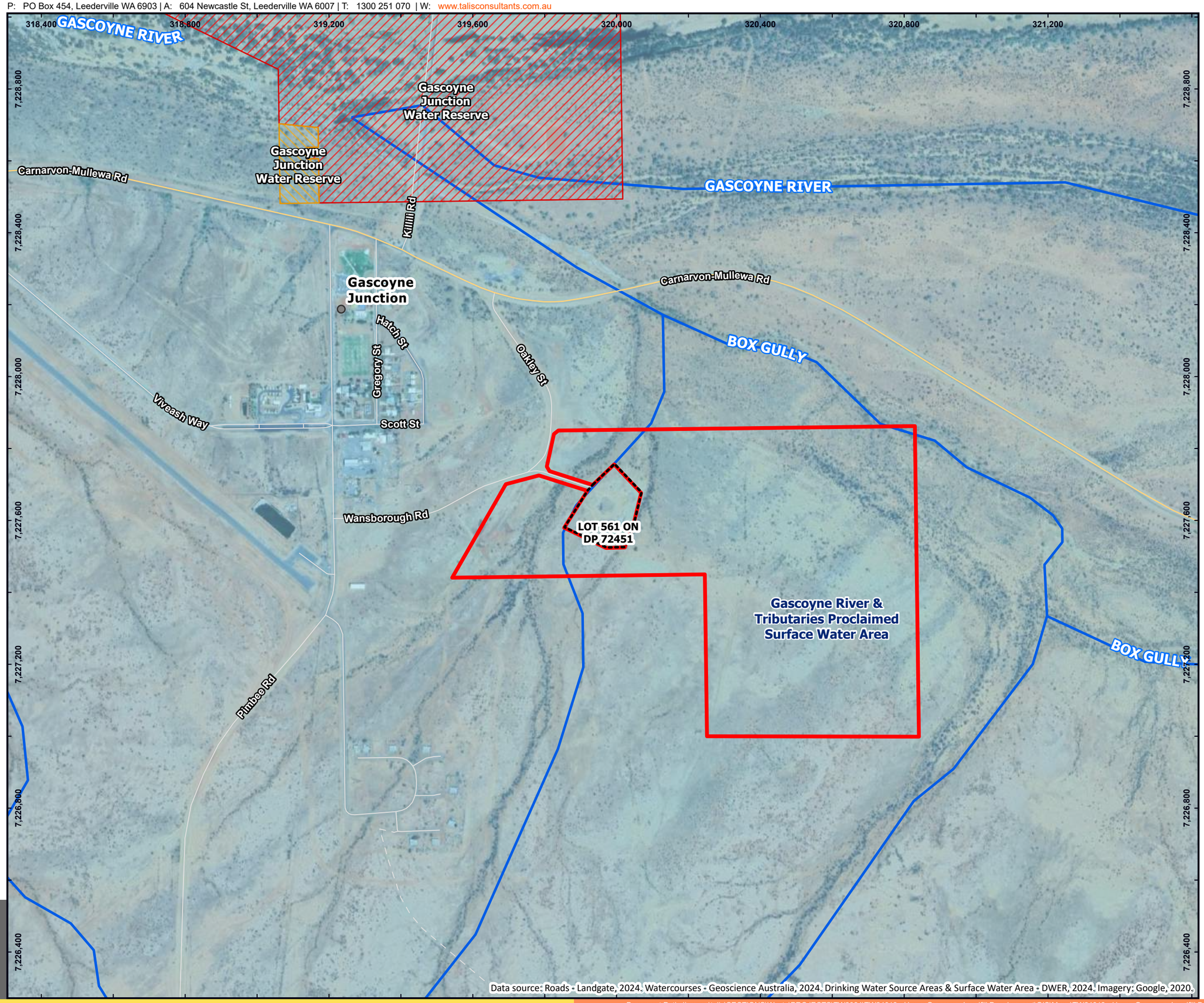


Data source: Roads - Landgate, 2024. Watercourses - Geoscience Australia, 2024. Drinking Water Source Areas & Surface Water Area - DWER, 2024. Imagery: Google, 2020.

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Hydrography

- Minor Watercourse
- Surface Water Area

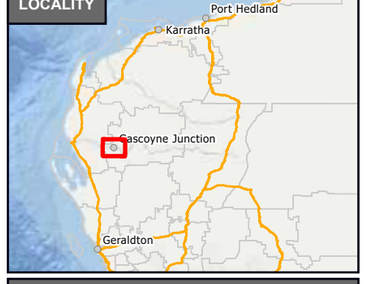
Public Drinking Water Source Areas

- Protection Area - P1
- Protection Area - P2

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY



km
0 200 400 600 800 1,000

HYDROLOGY

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N
m
0 100 200 300 400

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 05

Document Path: \\server\talis\SECTIONS\Waste\PROJECTS\TW2024\TW24019 - Upper Gascoyne Landfill Development\GIS\Maps\TW24019 - Upper Gascoyne Landfill Development\TW24019 - Upper Gascoyne Landfill Development.aprx

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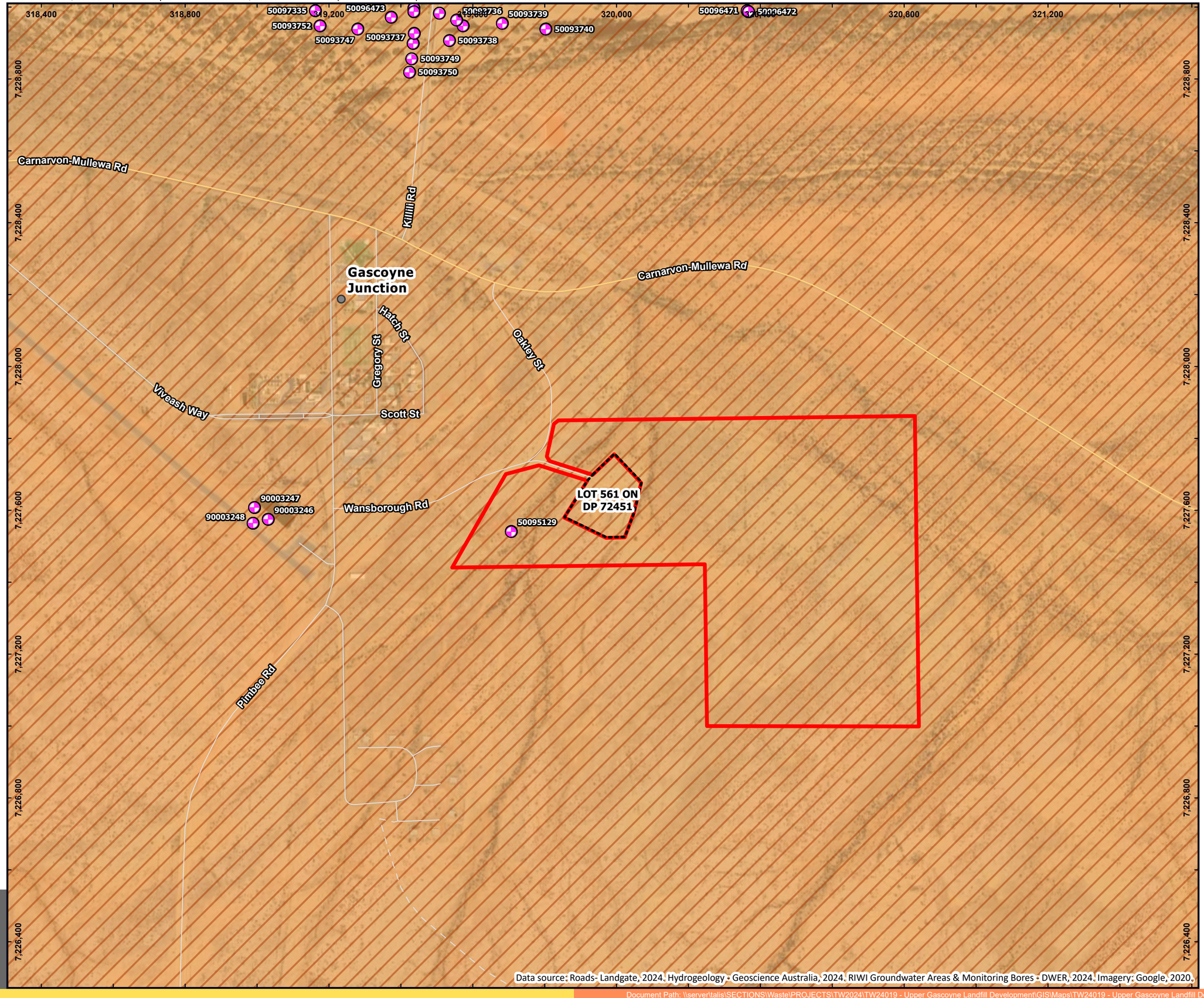


Data source: Roads- Landgate, 2024. Hydrogeology - Geoscience Australia, 2024. RIWI Groundwater Areas & Monitoring Bores - DWER, 2024. Imagery: Google, 2020.

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Hydrogeology

- Gascoyne Proclaimed Groundwater Area
- Porous, extensive highly productive aquifers

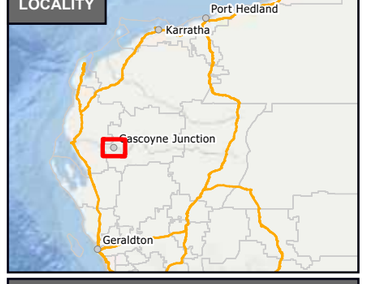
Groundwater Monitoring Bores

- Unknown Status

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY



0 200 400 600 800 1,000 km

HYDROGEOLOGY

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N 0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	18/07/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 06

Document Path: \\server\talis\SECTIONS\Waste\PROJECTS\TW2024\TW24019 - Upper Gascoyne Landfill Development\GIS\Maps\TW24019 - Upper Gascoyne Landfill Development\TW24019 - Upper Gascoyne Landfill Development.aprx

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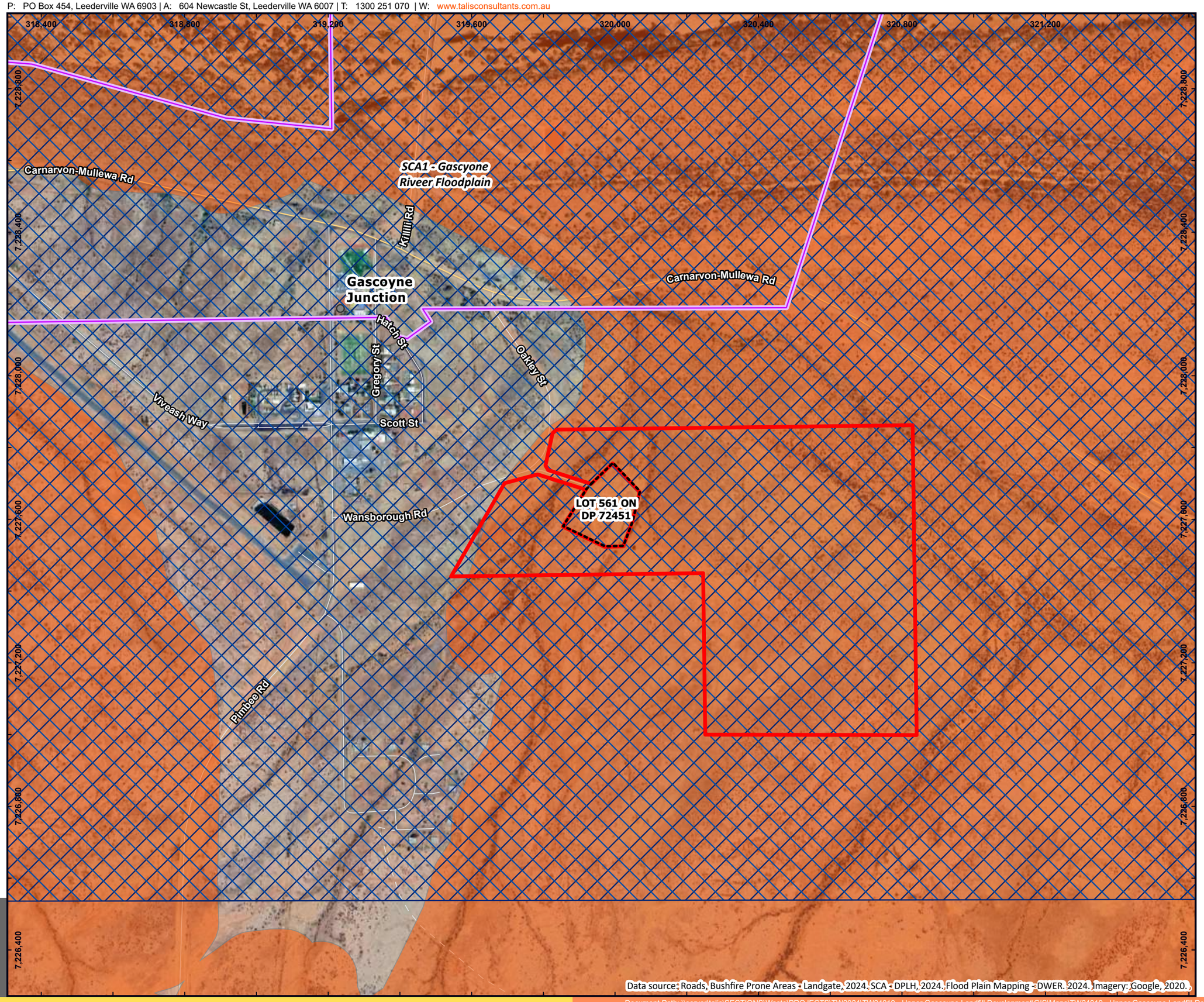

LEGEND

- Proposed Boundary Expansion
- Special Control Areas
- Lot 561 on Plan 72451
- 1 in 100 1 AEP Floodplain Development Control Area
- Bushfire Prone Areas

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY

0 200 400 600 800 1,000 km

DISASTER MAPPING

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	13/12/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 07

Data source: Roads, Bushfire Prone Areas - Landgate, 2024. SCA - DPLH, 2024. Flood Plain Mapping - DWER. 2024. Imagery: Google, 2020.

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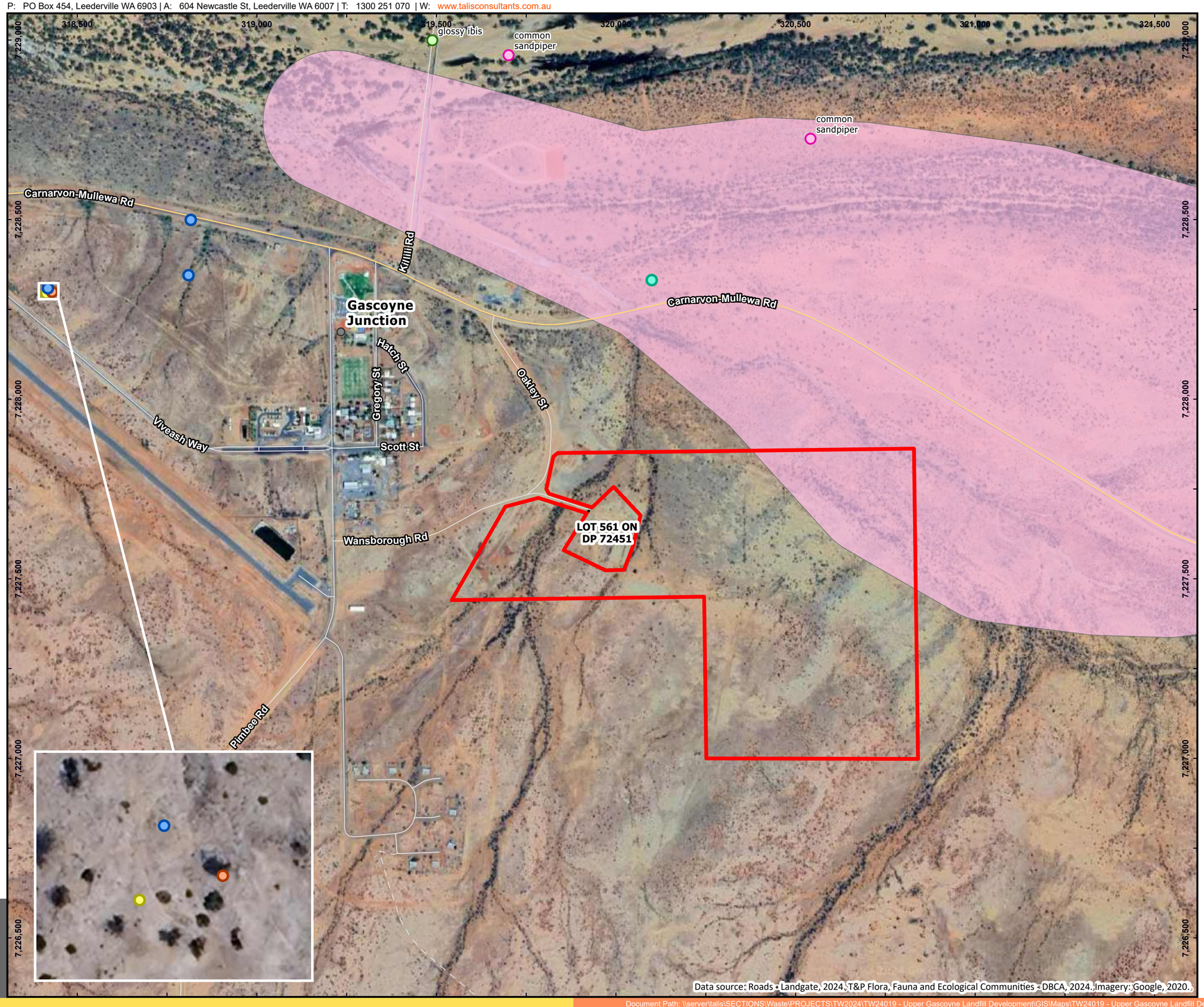


Data source: Roads - Landgate, 2024. T&P Flora, Fauna and Ecological Communities - DBCA, 2024. Imagery: Google, 2020.

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Threatened & Priority Flora

Priority 1
- Rhodanthe ascendens

Priority 2
- Bergia auriculata

Priority 3
- Abutilon sp. Pritzelianum (S. van Leeuwen 5095)
- 3: Grevillea subterlineata

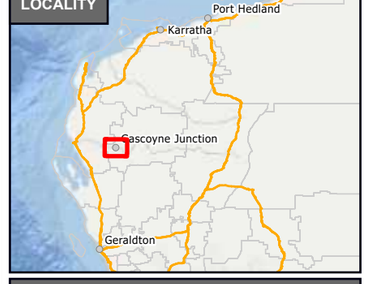
Threatened & Priority Fauna

Migratory Species
- common sandpiper
- glossy ibis

Priority Ecological Communities
- Jingle Land System

Western Australian Roads
- Main Road
- Minor Road
- Other

LOCALITY



km
0 200 400 600 800 1,000

THREATENED & PRIORITY FLORA, FAUNA AND ECOLOGICAL COMMUNITIES

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N
m
0 100 200 300 400

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	B Roelofse	Date:	8/11/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 08

Document Path: \\server\talis\SECTIONS\Waste\PROJECTS\TW2024\TW24019 - Upper Gascoyne Landfill Development\GIS\Maps\TW24019 - Upper Gascoyne Landfill Development\TW24019 - Upper Gascoyne Landfill Development.aprx

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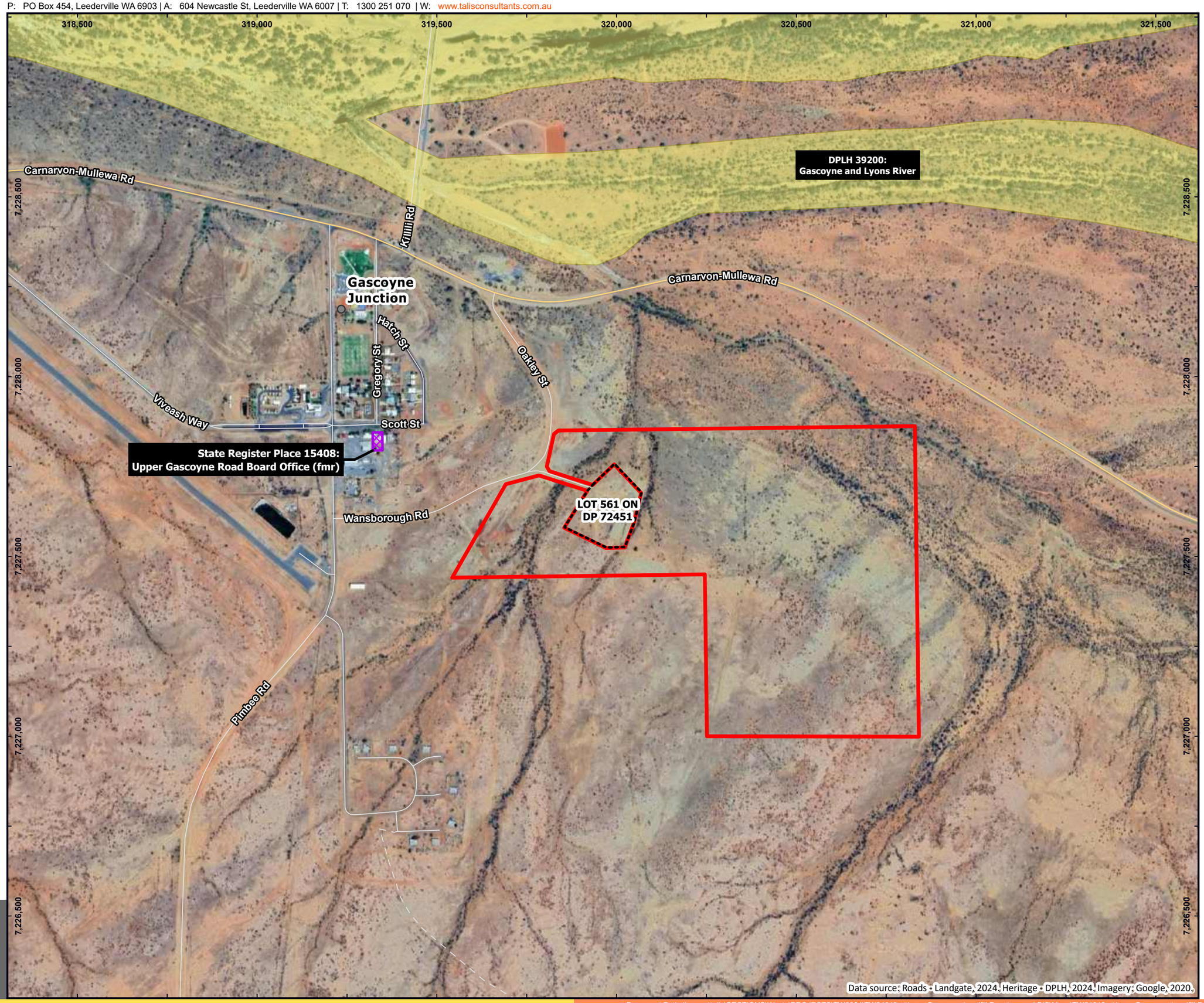

Data source: Roads - Landgate, 2024. Heritage - DPLH, 2024. Imagery: Google, 2020.

LEGEND

- Proposed Boundary Expansion
- Lot 561 on Plan 72451

Aboriginal Heritage

- Registered Aboriginal Heritage Place

European / Local Heritage

- Heritage Council WA State Register

Western Australian Roads

- Main Road
- Minor Road
- Other

LOCALITY

0 200 400 600 800 1,000 km

HERITAGE

Upper Gascoyne Landfill Development

Environmental Assessment & Management Plan

Shire of Upper Gascoyne

N

0 100 200 300 400 m

Coordinate System: GDA2020 MGA Zone 50
Scale @ A3: 1:10,000

Prepared:	E Jackson	Date:	13/12/2024
Reviewed:	B Hughes	Revision:	B
Project:	TW24019		

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Figure 09

Document Path: \\server\talis\SECTIONS\Waste\PROJECTS\TW2024\TW24019 - Upper Gascoyne Landfill Development\GIS\Maps\TW24019 - Upper Gascoyne Landfill Development\TW24019 - Upper Gascoyne Landfill Development.aprx

APPENDIX B
Drawings

Drawing W-000: Cover Sheet

Drawing W-100: Existing Site Layout and Topography

Drawing W-101: Proposed Site Layout

Drawing W-102: Proposed Community Recycling Centre Layout

Drawing W-103: Proposed Surface Water Management System

Drawing W-104: Proposed Rehabilitation Profile

Drawing W-105: Proposed Liquid Waste Facility

Drawing W-106: Proposed Putrescible Landfill Details

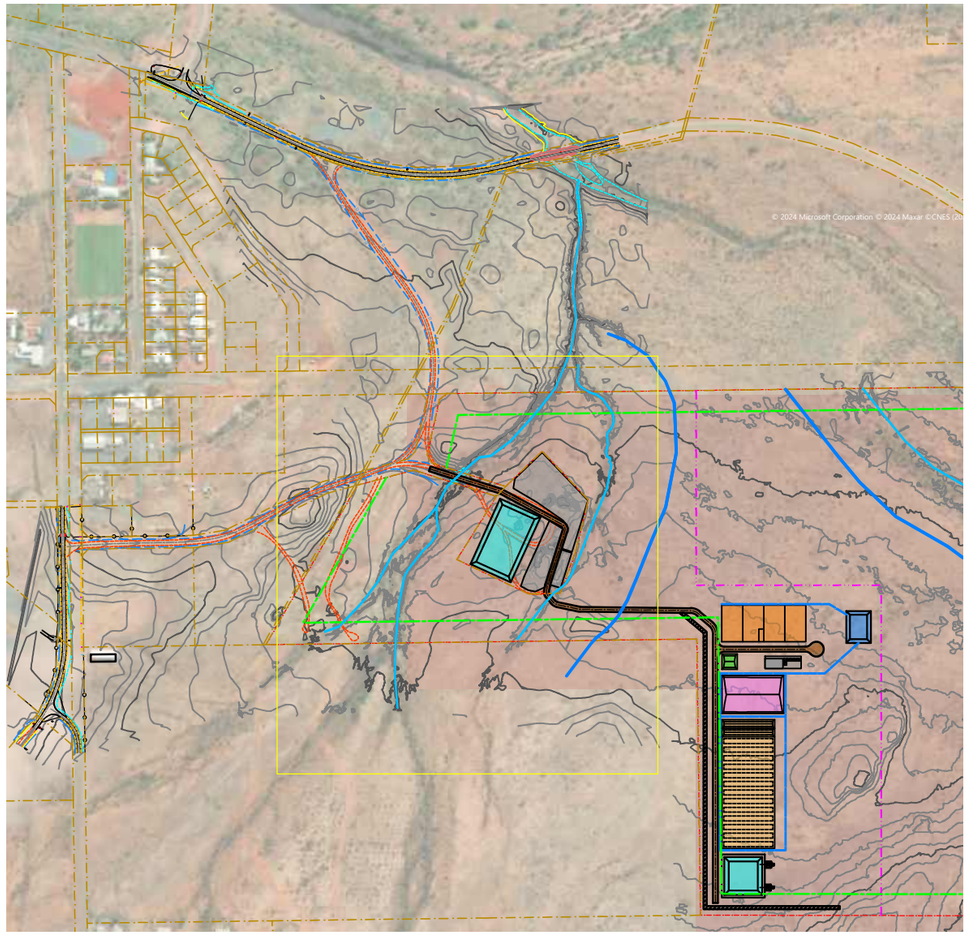
Drawing W-107: Inert Landfill and Asbestos Details

Drawing W-301: Typical Surface Water System Details

Drawing W-302: Typical Liquid Waste Facility Details

Drawing W-400: Combined Site Constraints

UPPER GASCOYNE LANDFILL DEVELOPMENT



LOCALITY PLAN
SCALE: N.T.S

Sheet List Table	
Sheet Number	Sheet Title
W-000	Cover Sheet
W-100	Existing Site Layout and Topography
W-101	Proposed Site Layout
W-102	Proposed Community Recycling Centre Layout
W-103	Proposed Surface Water Management System
W-104	Proposed Rehabilitation Profile
W-106	Proposed Putrescible Landfill Details
W-107	Inert Landfill and Asbestos Details
W-301	Typical Surface Water System Details
W-302	Typical Liquid Waste Facility Details
W-400	Combined Site Constraints

SURVEY REFERENCE: QUANTUM SURVEYS **DATE:** 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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Client: Shire of UPPER GASCOYNE

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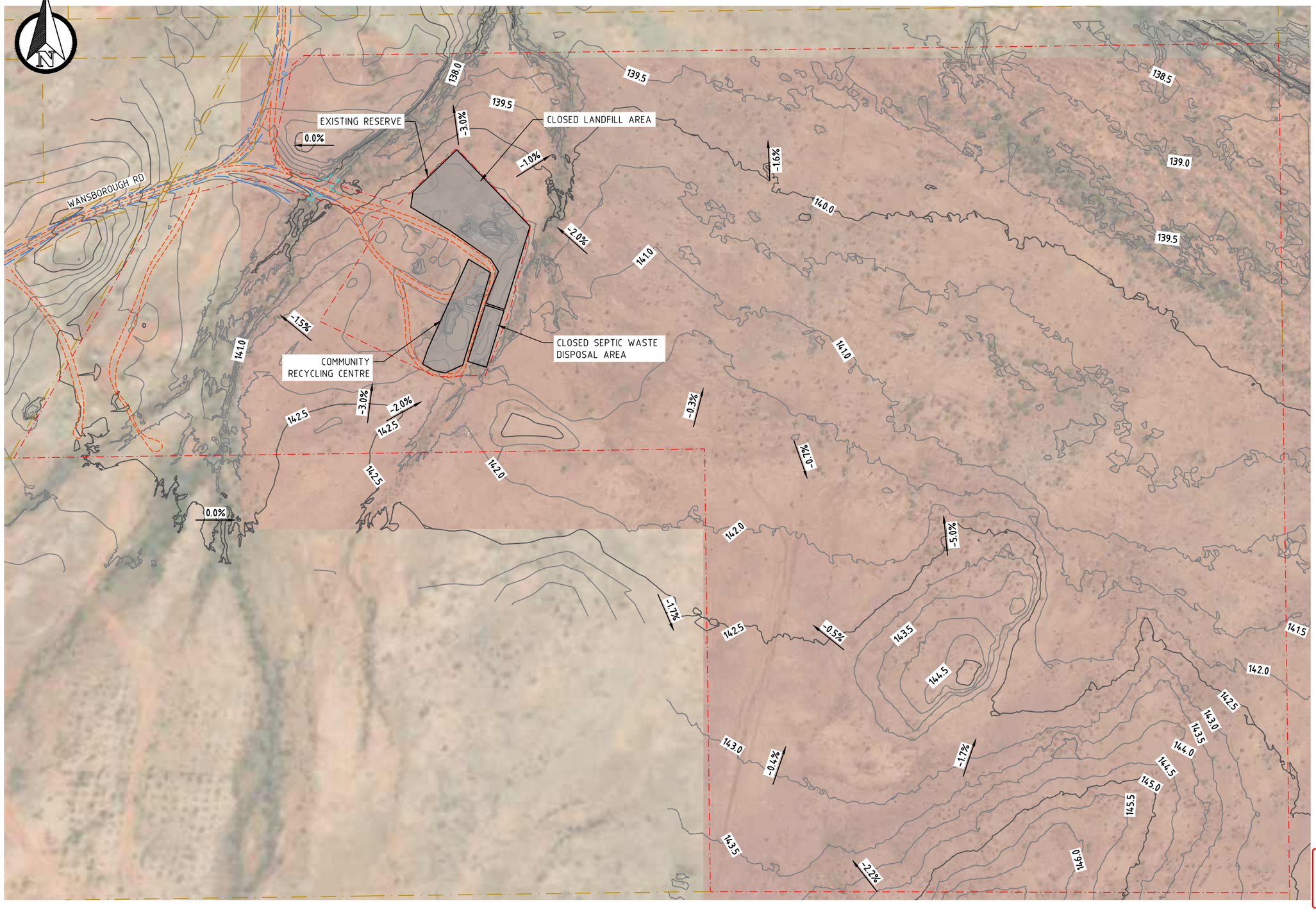
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: COVER SHEET

Scale: AS SHOWN @ A3	Date: 05.11.2024	
Drawn: JS	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-000	Rev: A
Filename: TW24019.DWG		



LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- EXISTING ROAD CENTERLINE

PRELIMINARY ONLY
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80m 0m 80m 160m

1:4000 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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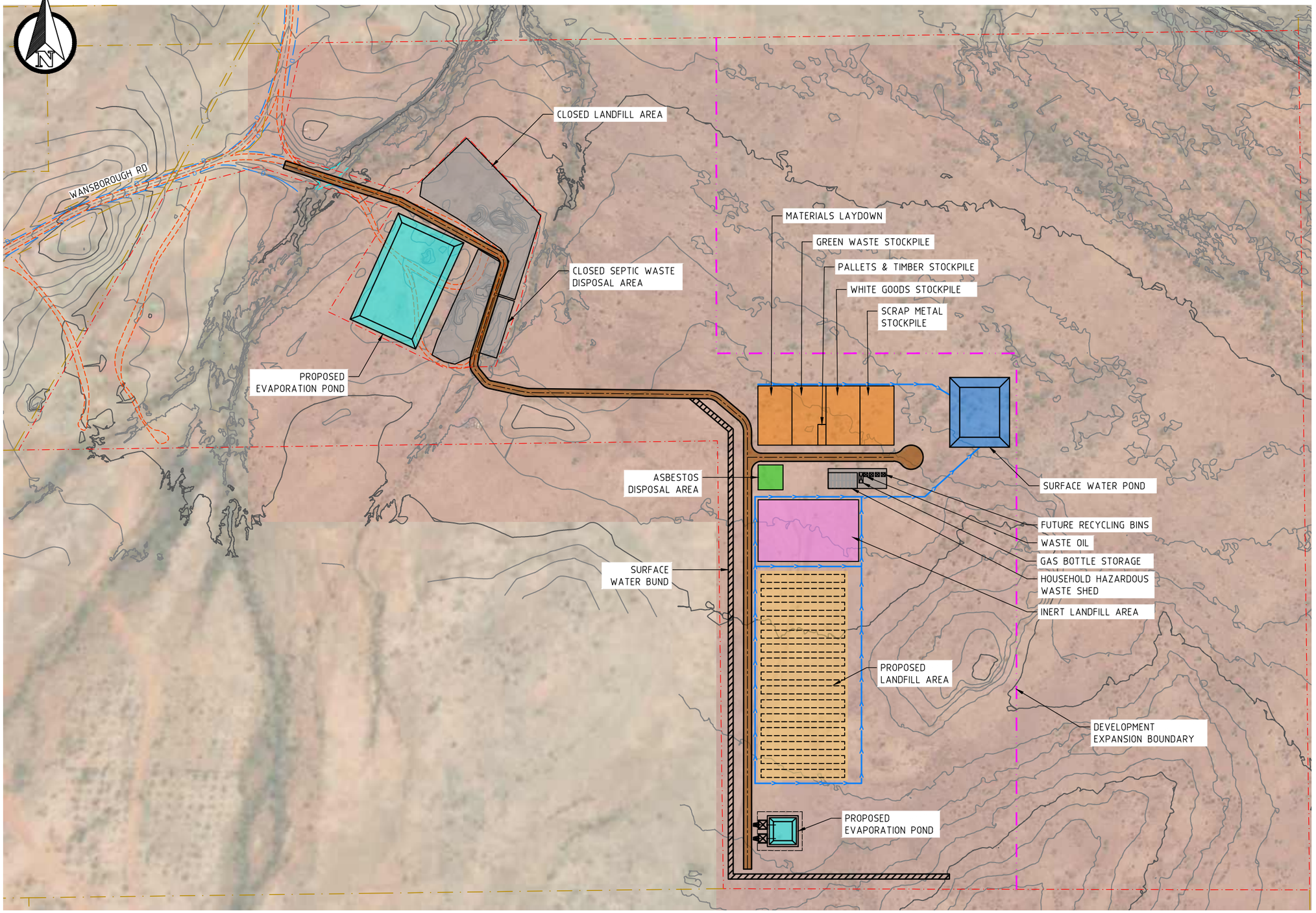
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	12.04.2024	VS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: EXISTING SITE LAYOUT AND TOPOGRAPHY

Scale: 1:4000 @ A3 | Date: 12.04.2024
Drawn: VS | Checked: AB | Approved:
Job No: TW24019 | Drg. No: W-100 | Rev: A
Filename: TW24019.DWG



LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- EXISTING ROAD CENTERLINE
- PROPOSED EVAPORATION POND
- PROPOSED SURFACE WATER POND
- PROPOSED SWALE
- PROPOSED LANDFILL AREA
- PROPOSED INERT LANDFILL AREA
- PROPOSED COMMUNITY RECYCLING CENTRE
- PROPOSED ASBESTOS DISPOSAL AREA
- PROPOSED UNSEALED ROAD
- PROPOSED BUILDING AREA
- PROPOSED BINS
- PROPOSED ROAD CENTERLINE
- DEVELOPMENT EXPANSION BOUNDARY
- PROPOSED SURFACE WATER BUND

PRELIMINARY ONLY
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80m 0m 80m 160m

1:4000 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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Client: Shire of UPPER GASCOYNE

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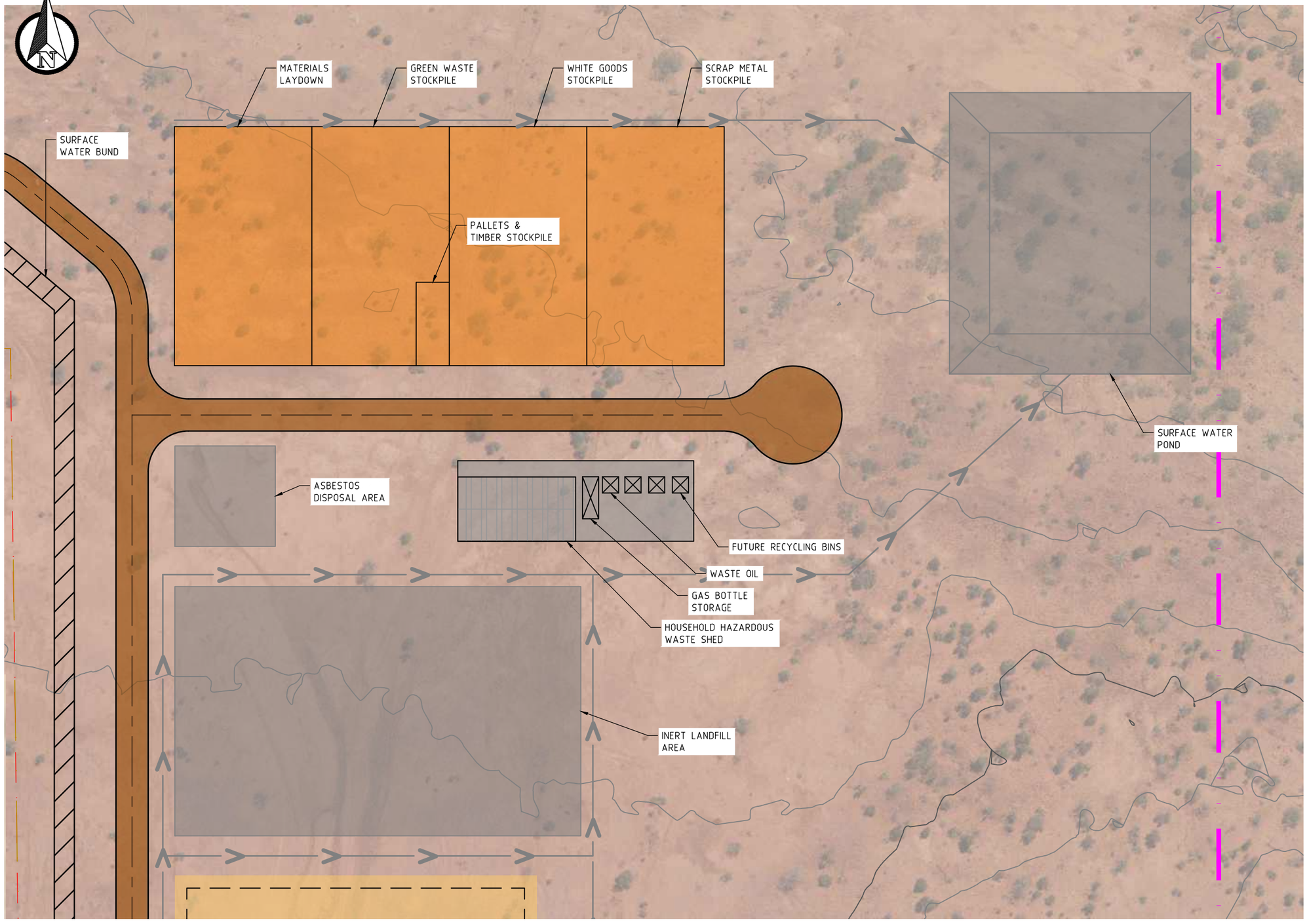
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED SITE LAYOUT

Scale: 1:4000 @ A3		Date: 05.11.2024	
Drawn: JS	Checked: AB	Approved:	
Job No: TW24019	Drg. No: W-101	Rev: A	
Filename: TW24019.DWG			



LEGEND:

- CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- PROPOSED COMMUNITY RECYCLING CENTRE
- PROPOSED UNSEALED ROAD
- DEVELOPMENT EXPANSION BOUNDARY
- PROPOSED SURFACE WATER BUND

PRELIMINARY ONLY
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20m 0m 20m 40m

1:1000 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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Client: Shire of UPPER GASCOYNE

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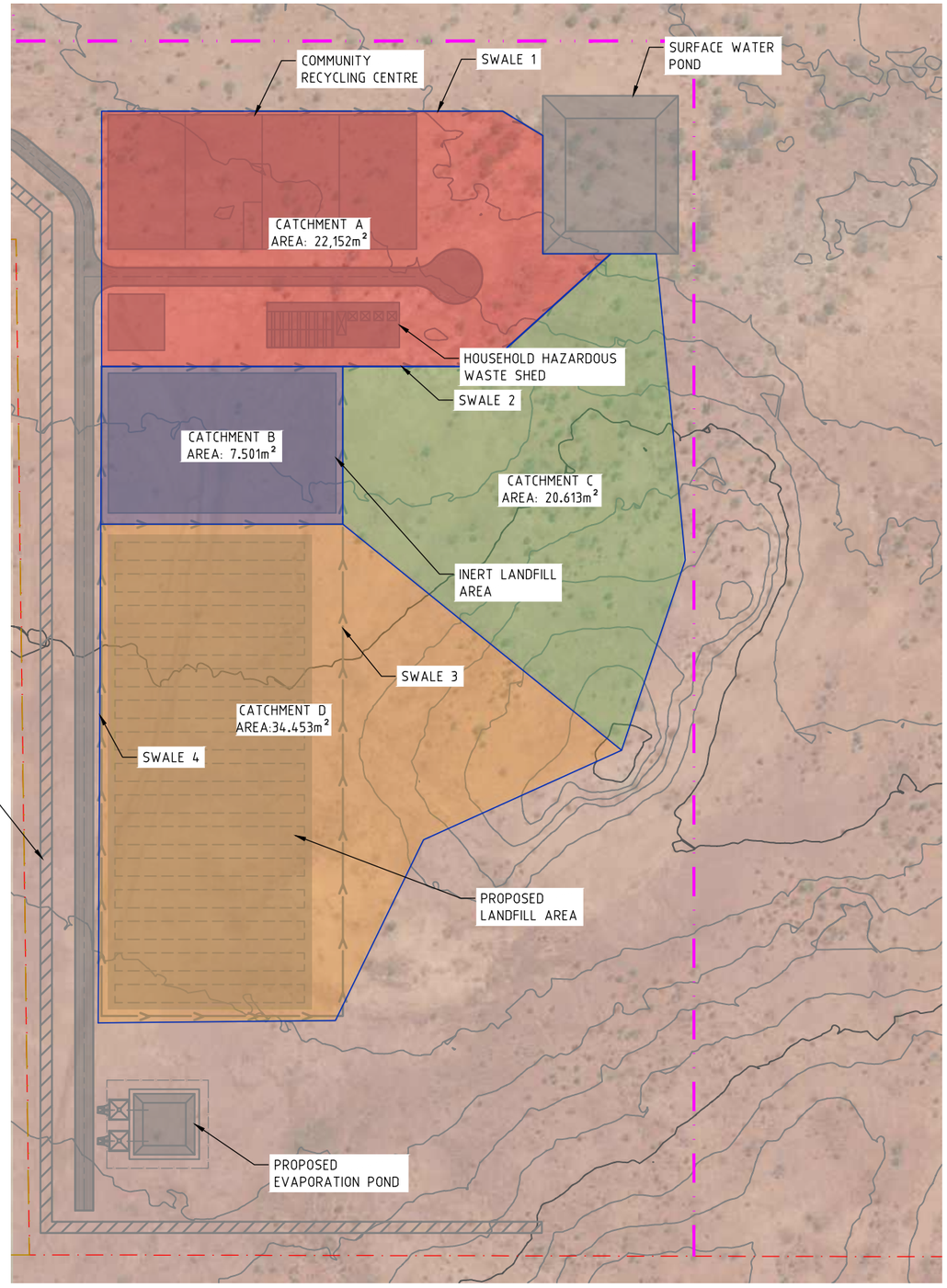
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED COMMUNITY RECYCLING CENTRE LAYOUT

Scale: 1:1000 @ A3 | Date: 05.11.2024
Drawn: JS | Checked: AB | Approved:
Job No: TW24019 | Drg. No: W-102 | Rev: A
Filename: TW24019.DWG



LEGEND:

- CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- SWALE
- SURFACE WATER POND
- SURFACE WATER CATCHMENT A
- SURFACE WATER CATCHMENT B
- SURFACE WATER CATCHMENT C
- SURFACE WATER CATCHMENT D
- DEVELOPMENT EXPANSION BOUNDARY

PRELIMINARY ONLY
NOT FOR CONSTRUCTION

50m 0m 50m 100m

1:2500 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS **DATE:** 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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Client: Shire of UPPER GASCOYNE

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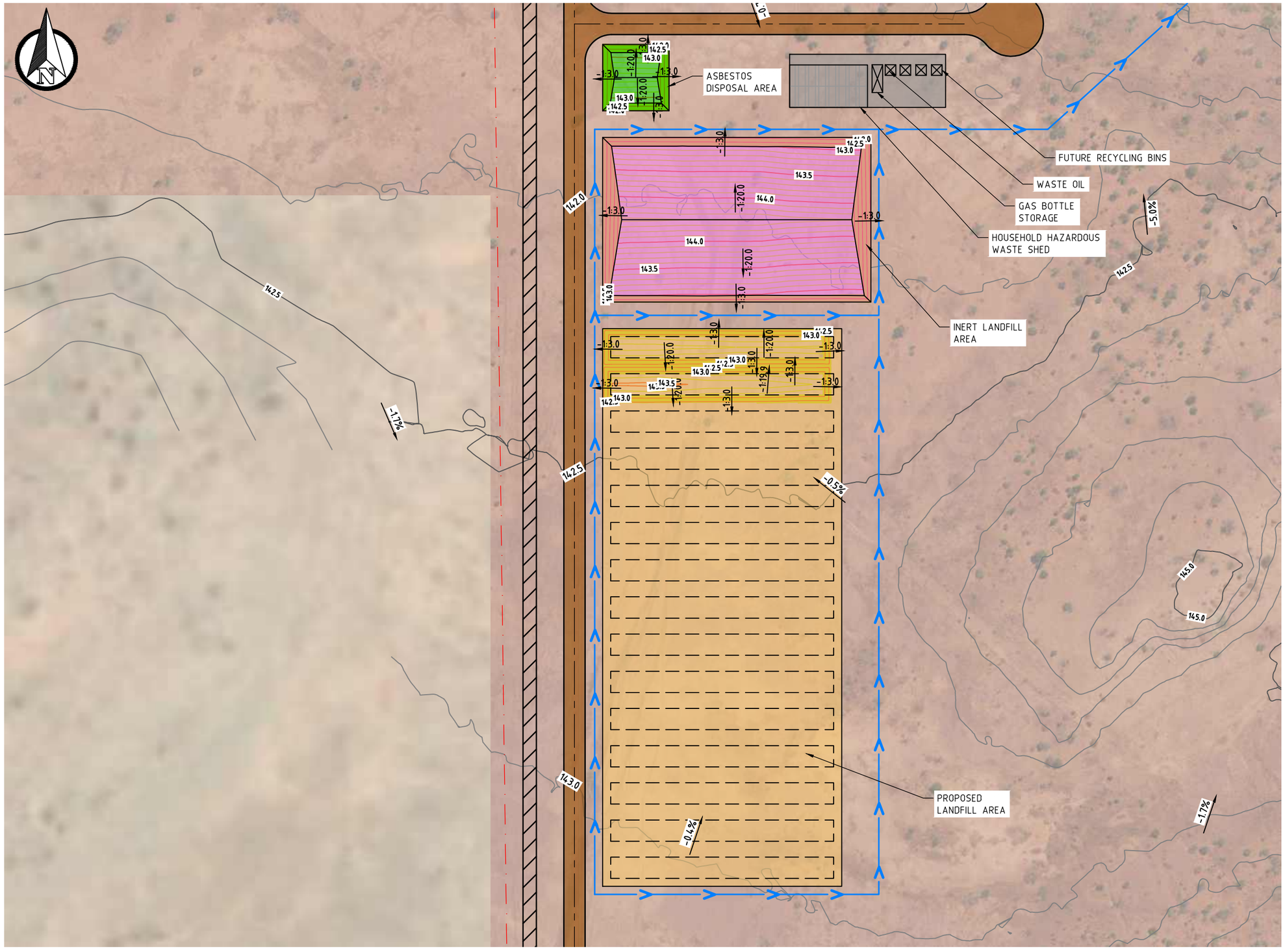
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED SURFACE WATER MANAGEMENT SYSTEM

Scale: 1:2500 @ A3 | Date: 05.11.2024
Drawn: JS | Checked: AB | Approved:
Job No: TW24019 | Drg. No: W-103 | Rev: A
Filename: TW24019.DWG



LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- EXISTING ROAD CENTERLINE
- PROPOSED EVAPORATION POND
- PROPOSED SURFACE WATER POND
- PROPOSED SWALE
- PROPOSED LANDFILL AREA
- PROPOSED INERT LANDFILL AREA
- PROPOSED COMMUNITY RECYCLING CENTRE
- PROPOSED ASBESTOS DISPOSAL AREA
- PROPOSED UNSEALED ROAD
- PROPOSED BUILDING AREA
- PROPOSED BINS
- PROPOSED ROAD CENTERLINE
- DEVELOPMENT EXPANSION BOUNDARY
- PROPOSED SURFACE WATER BUND

PRELIMINARY ONLY
NOT FOR CONSTRUCTION

30m 0m 30m 60m

1:1500 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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Client: Shire of UPPER GASCOYNE

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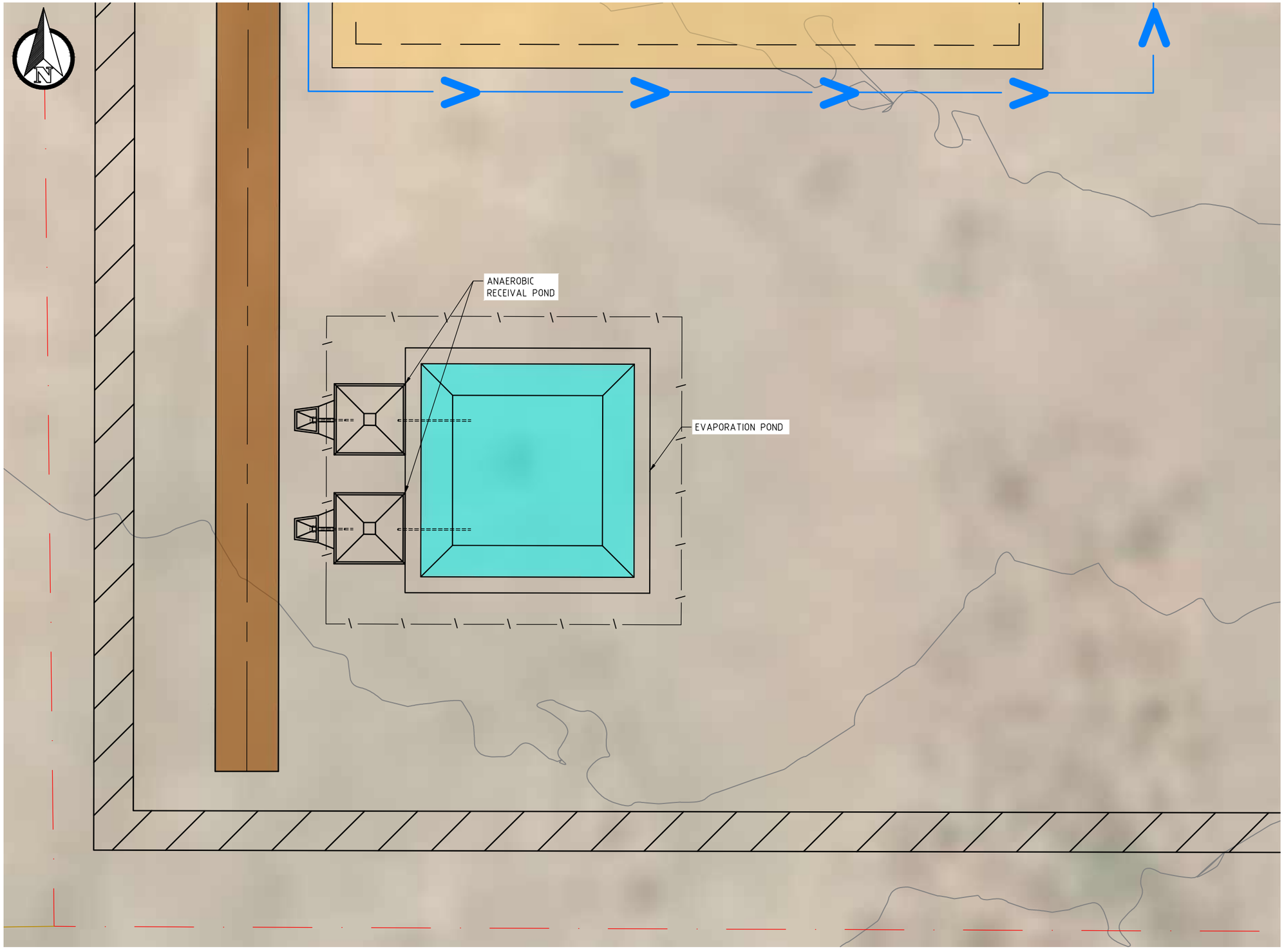
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	29.11.2024	YJ	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED REHABILITATION PROFILE

Scale: 1:1500 @ A3 | Date: 05.11.2024
Drawn: YJ | Checked: AB | Approved:
Job No: TW24019 | Drg. No: W-104 | Rev: A
Filename: TW24019.DWG



LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- EXISTING ROAD CENTERLINE
- PROPOSED EVAPORATION POND
- PROPOSED SURFACE WATER POND
- PROPOSED SWALE
- PROPOSED LANDFILL AREA
- PROPOSED INERT LANDFILL AREA
- PROPOSED COMMUNITY RECYCLING CENTRE
- PROPOSED ASBESTOS DISPOSAL AREA
- PROPOSED UNSEALED ROAD
- PROPOSED BUILDING AREA
- PROPOSED BINS
- PROPOSED ROAD CENTERLINE
- DEVELOPMENT EXPANSION BOUNDARY
- PROPOSED SURFACE WATER BUND
- NEW FENCE

PRELIMINARY ONLY
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10m 0m 10m 20m

1:500 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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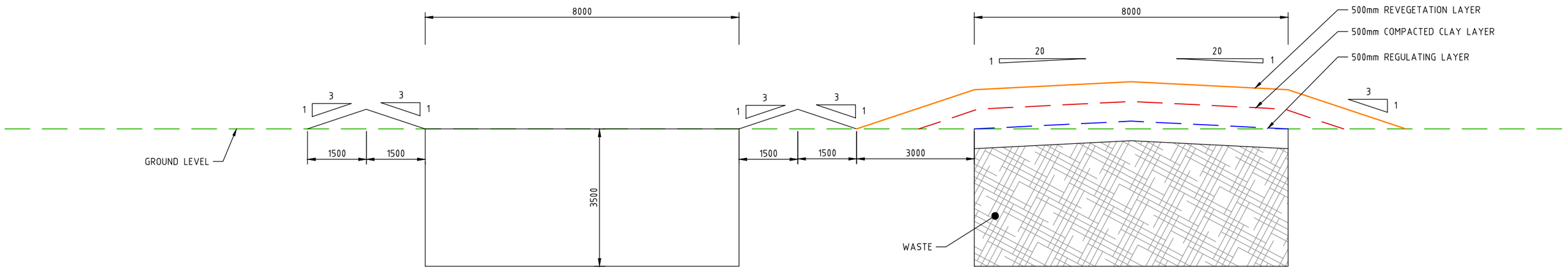
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	10.12.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: PROPOSED LIQUID WASTE FACILITY

Scale: 1:500 @ A3		Date: 10.12.2024	
Drawn: JS	Checked: AB	Approved:	
Job No: TW24019	Drg. No: W-105	Rev: A	
Filename: TW24019.DWG			



ACTIVE LANDFILL TRENCH N-S

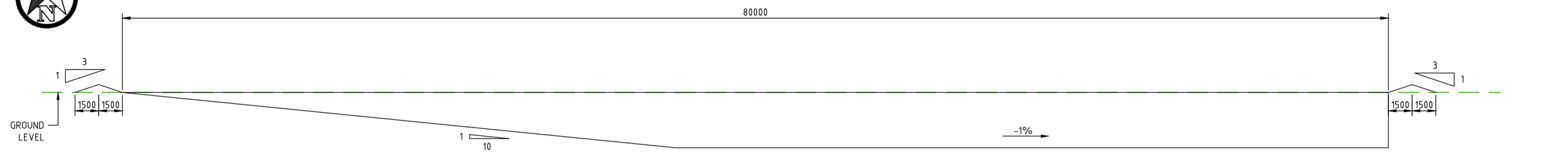
SCALE: 1:100

CAPPED LANDFILL TRENCH N-S

SCALE: 1:100

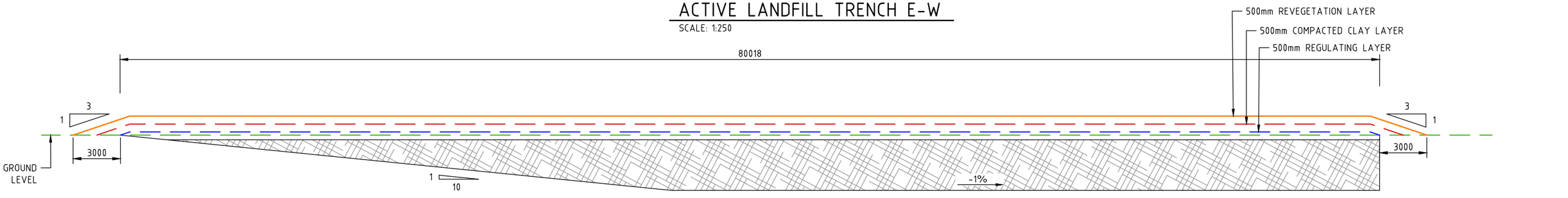
2.0m 0m 2.0m 4.0m

1:100 @ A3



ACTIVE LANDFILL TRENCH E-W

SCALE: 1:250



CAPPED LANDFILL TRENCH E-W

SCALE: 1:250

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5m 0m 5m 10m

1:250 @ A3

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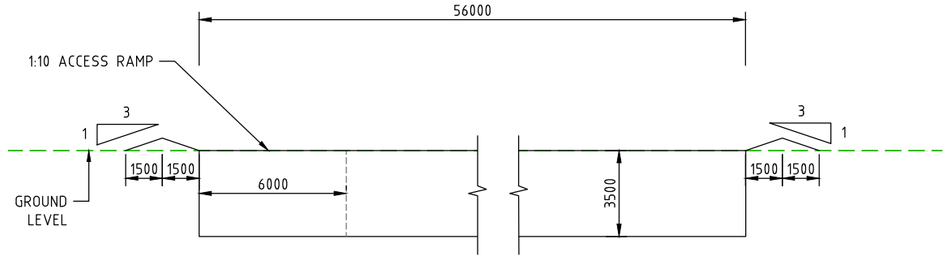
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	29.11.2024	YJ	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

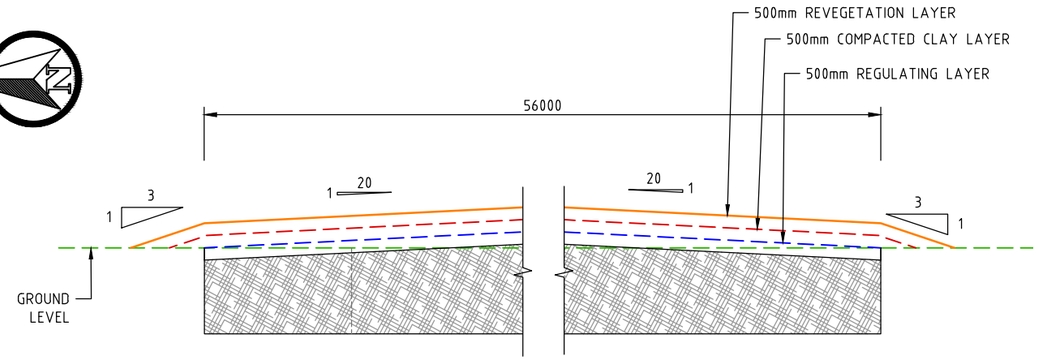
Title: PROPOSED PUTRESCIBLE LANDFILL DETAILS

Scale: AS SHOWN @ A3		Date: 05.11.2024	
Drawn: YJ	Checked: AB	Approved:	
Job No: TW24019	Drg. No: W-106	Rev: A	
Filename: TW24019.DWG			



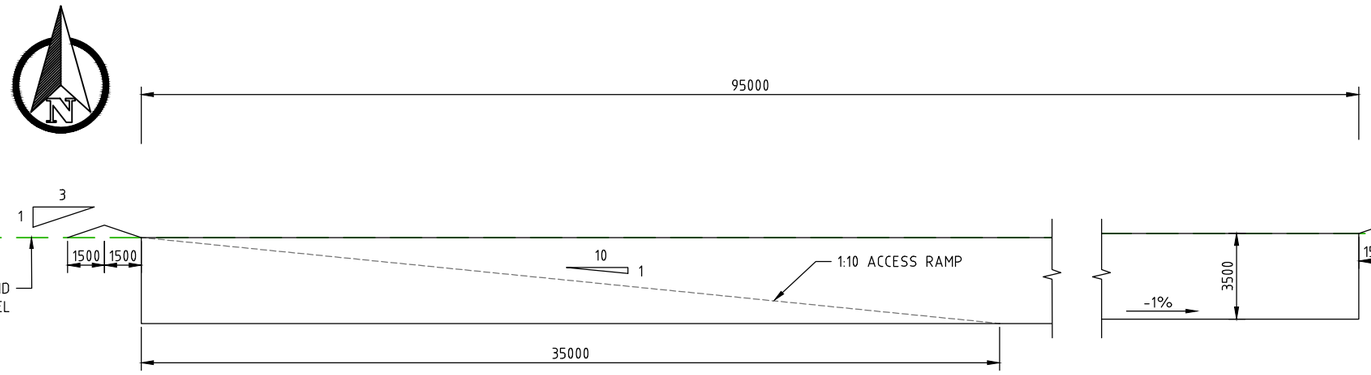
ACTIVE INERT LANDFILL TRENCH N-S

SCALE: 1:250



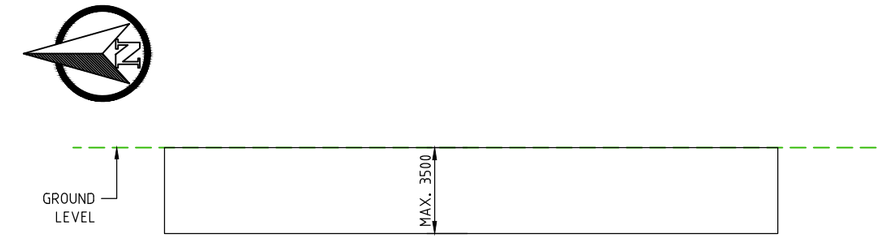
CAPPED INERT LANDFILL TRENCH N-S

SCALE: 1:250



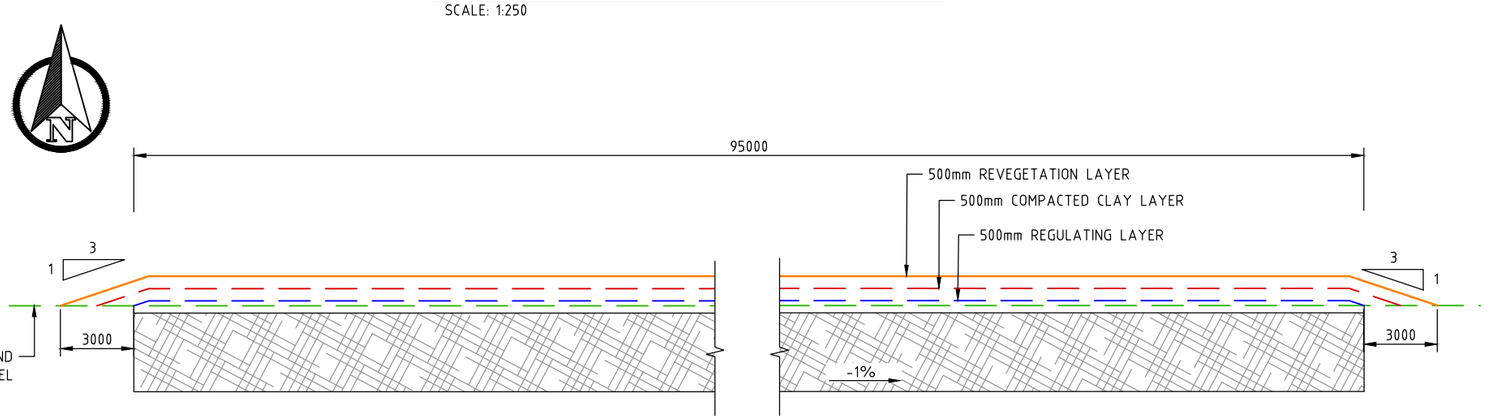
ACTIVE INERT LANDFILL TRENCH E-W

SCALE: 1:250



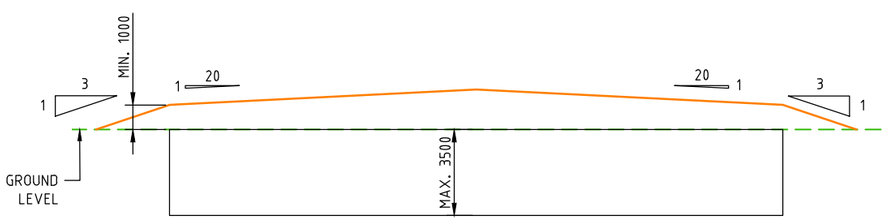
TYPICAL ASBESTOS DETAILS

SCALE: 1:250



CAPPED INERT LANDFILL TRENCH E-W

SCALE: 1:250



ASBESTOS CAPPING DETAILS

SCALE: 1:250

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5m 0m 5m 10m
1:250 @ A3

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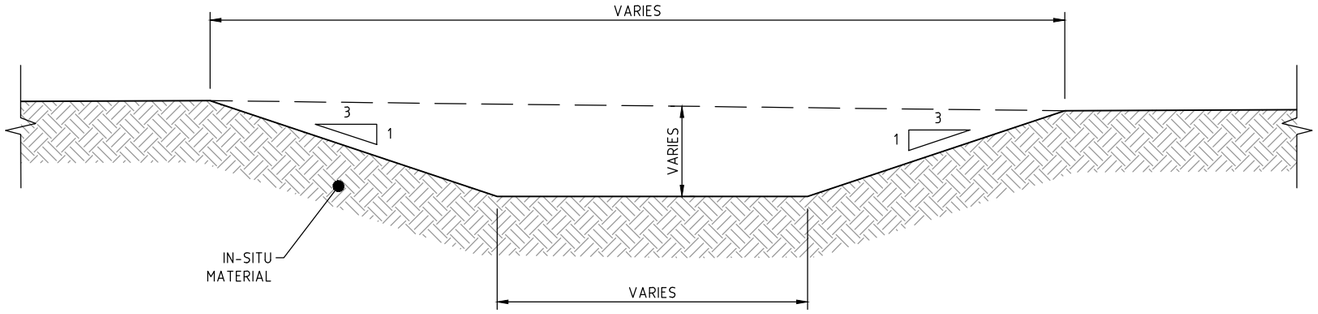
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	29.11.2024	YJ	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

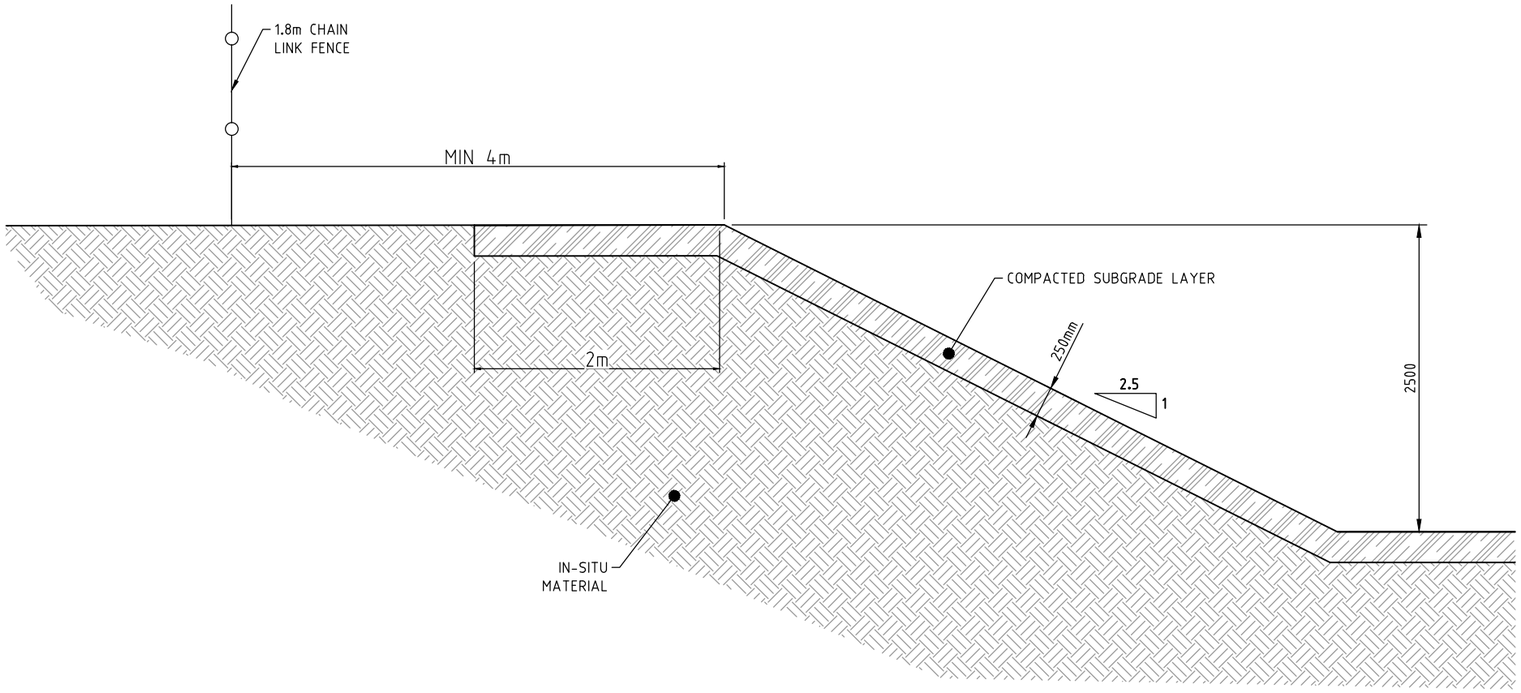
Title: INERT LANDFILL AND ASBESTOS DETAILS

Scale: AS SHOWN @ A3		Date: 05.11.2024	
Drawn: YJ	Checked: AB	Approved:	
Job No: TW24019	Drg. No: W-107	Rev: A	
Filename: TW24019.DWG			



TYPICAL DETAIL - DRAINAGE SWALE

SCALE: 1:50



TYPICAL SECTION - SURFACE WATER POND

SCALE: 1:50

PRELIMINARY ONLY
NOT FOR CONSTRUCTION

1.0m 0m 1.0m 2.0m

1:50 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS **DATE:** 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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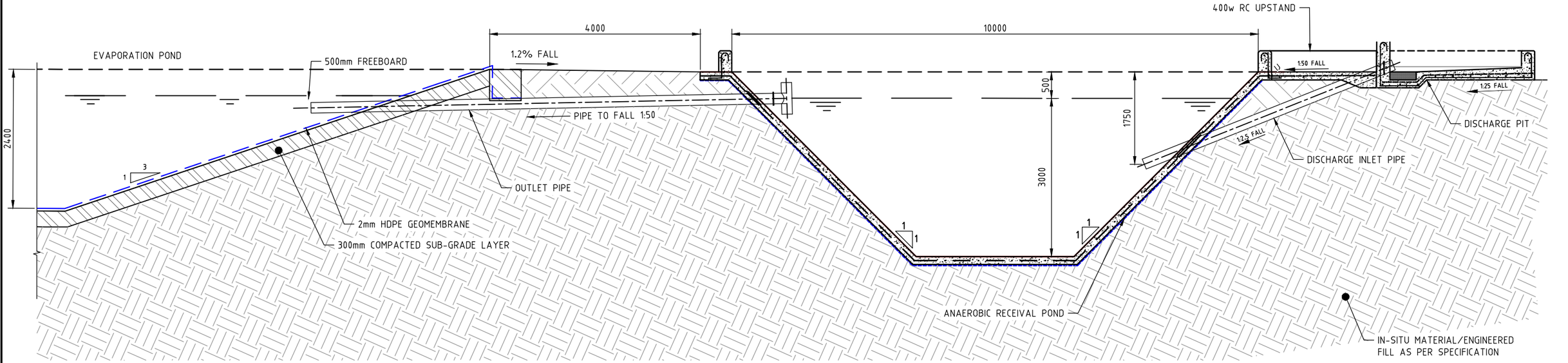
A	05.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: TYPICAL SURFACE WATER SYSTEM DETAILS

Scale: 1:50 @ A3		Date: 05.11.2024	
Drawn: JS	Checked: AB	Approved:	
Job No: TW24019	Drg. No: W-301	Rev: A	
Filename: TW24019.DWG			

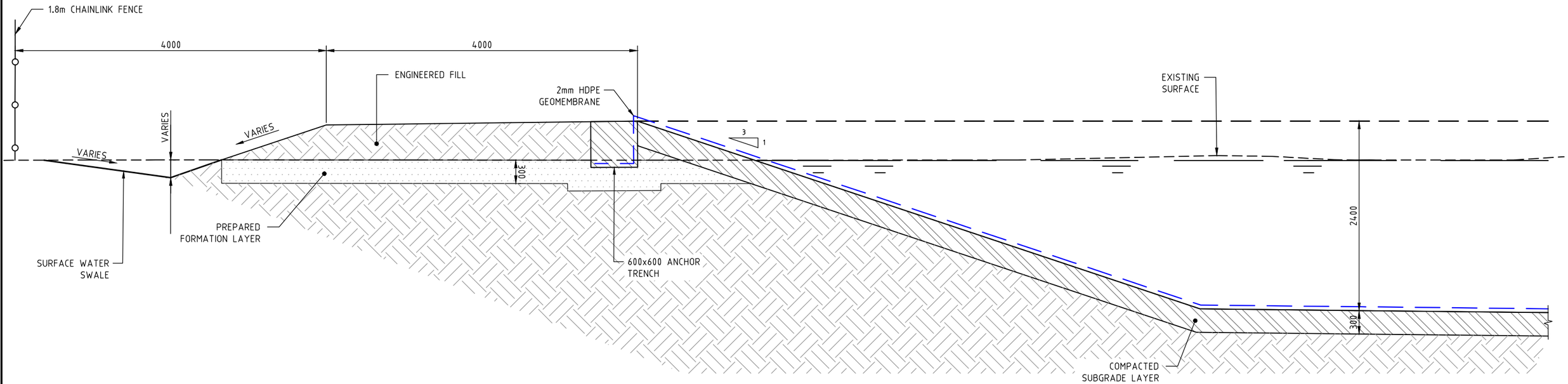


EVAPORATION POND CROSS-SECTION

SCALE: 1:75

1.5m 0m 1.5m 3.0m

1:75 @ A3



TYPICAL DETAIL - POND EMBANKMENT

SCALE: 1:50

1.0m 0m 1.0m 2.0m

1:50 @ A3

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SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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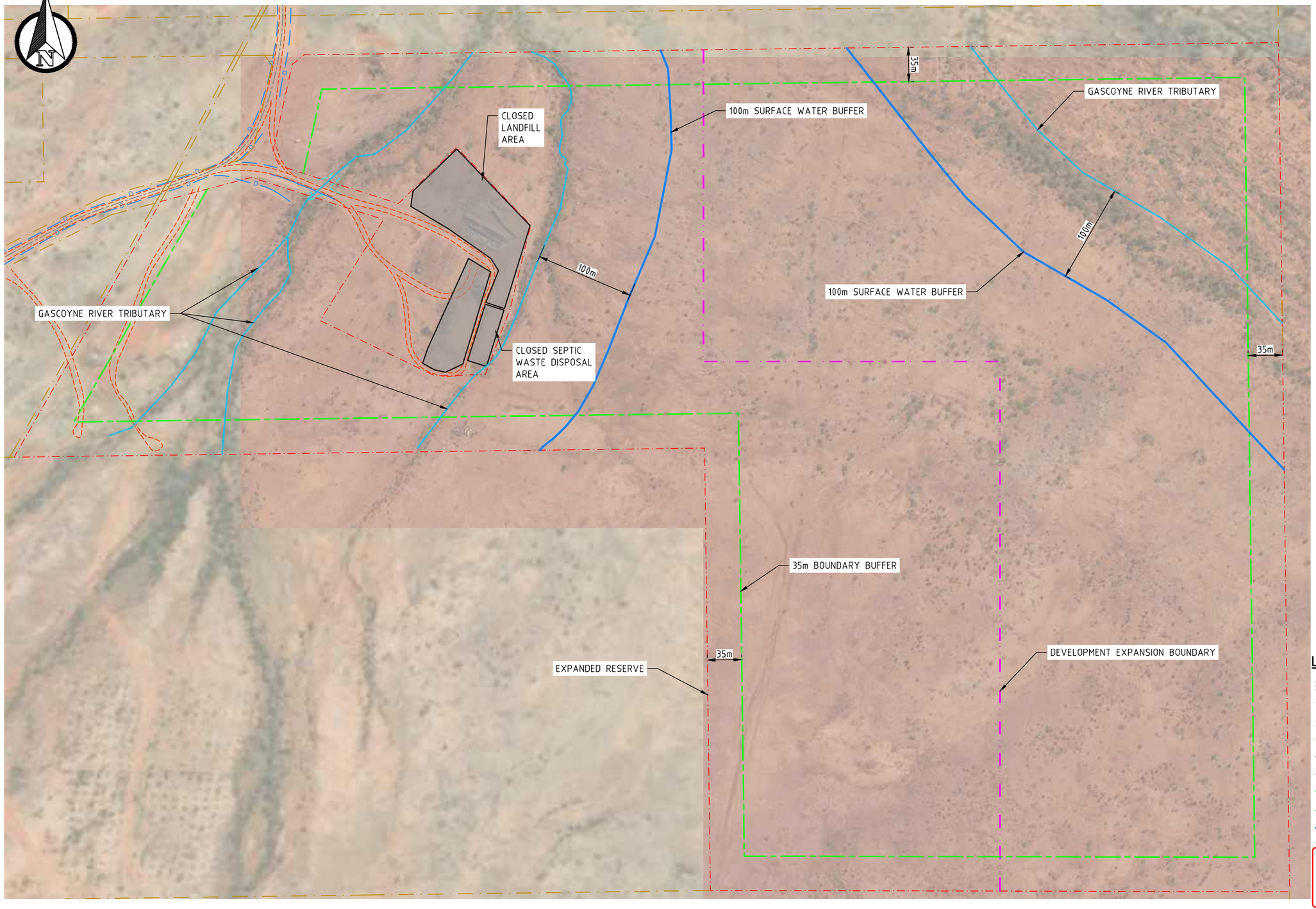
No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	29.11.2024	YJ	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: TYPICAL LIQUID WASTE FACILITY DETAILS

Scale: AS SHOWN @ A3	Date: 05.11.2024	
Drawn: YJ	Checked: AB	Approved:
Job No: TW24019	Drg. No: W-302	Rev: A
Filename: TW24019.DWG		



LEGEND:

- EXISTING CONTOUR LINES
- CADASTRAL BOUNDARY
- EXISTING UNSEALED ROAD
- EXPANDED RESERVE
- EXISTING RESERVE
- DEVELOPMENT EXPANSION BOUNDARY
- 35m BOUNDARY BUFFER
- GASCOYNE RIVER TRIBUTARY
- 100m SURFACE WATER BUFFER

PRELIMINARY ONLY
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80m 0m 80m 160m

1:4000 @ A3

SURVEY REFERENCE: QUANTUM SURVEYS DATE: 27.07.2023
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM
HORIZONTAL DATUM: MGA 2020 ZONE 50

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No.	Date	Drwn.	Chk.	Amendment / Issue	App.
A	18.11.2024	JS	AB	PRELIMINARY ISSUE	

Project: UPPER GASCOYNE LANDFILL DEVELOPMENT

Title: COMBINED SITE CONSTRAINTS

Scale: 1:4000 @ A3		Date: 18.11.2024	
Drawn: JS	Checked: AB	Approved:	
Job No: TW24019	Drg. No: W-400	Rev: A	
Filename: TW24019.DWG			

APPENDIX C

Waste Projections and Void Space Modelling

Table 1.1 - Upper Gascoyne Waste Management Facility Serviced Population

Year	Population	Annual Growth Rate	Source
2024	40	Shire Repr.	Shire rep.
2039	72	4.00%	4 person/household * 8

Table 1.2 - Serviced Population Data Gascoyne

Year	Population	Growth Rate	Source
2024	40		Shire rep.
2025	42	4.0%	
2026	43	4.0%	
2027	45	4.0%	
2028	47	4.0%	
2029	49	4.0%	
2030	51	4.0%	
2031	53	4.0%	
2032	55	4.0%	
2033	57	4.0%	
2034		4.0%	
2035	0	4.0%	
2036	0	4.0%	
2037	0	4.0%	
2038	0	4.0%	
2039	0	0.0%	Assumed that population
2040	0	0.0%	
2041	0	0.0%	
2042	0	0.0%	
2043	0	0.0%	
2044	0	0.0%	
2045	0	0.0%	
2046	0	0.0%	
2047	0	0.0%	
2048	0	0.0%	
2049	0	0.0%	
2050	0	0.0%	
2051	0	0.0%	
2052	0	0.0%	
2053	0	0.0%	
2054	0	0.0%	
2055	0	0.0%	
Average Growth Rate		**1.9%**	

NOTES:

The Shire has indicated that the Site currently serves 40 people, and anticipates an additional 8 houses to be constructed within the town between 2024 and 2039. Assuming that each household will have an average of 4 residents, this increases the number of people the Site services to 72 people by 2040.

The per capita waste generation rate was calculated by using the current population and an estimated annual waste acceptance tonnage. Generation rate was then used to calculate the airspace consumption. The waste compaction factor was estimated to be 0.35 based on the availability of plant equipment on Site. The volume of cover soils used has been estimated to be 50%, based on the volume of waste accepted and the frequency that waste must be covered.

The airspace consumption rate was applied to the estimated population to provide the estimated landfill airspace volume consumed per year. Using an estimated trench lifespan of 2 years, the required cell capacity was calculated and landfill trenches sized to meet this capacity.

Table 1.3 - Generation Estimates

Scenario		Unit	Source
Estimated Annual Acceptance	80.00	Tonnes/year	Shire Repr.
Estimated currently serviced population	40	units	Shire Repr.
Estimate Waste Generation per Capita	2.00	Tonnes/year	
Waste Compaction Factor	0.35	Tonnes/m^3	Est.
Cover Soil	50%	% of total Void	Est.
Airspace consumption per Capita (inc cover soils)	11.43	m^3/year	

Table 1.4 - Landfill Facility Sizing Factors

Aspect		Unit	Source
Sizing Criteria			
Approximate Trenches Lifespan	2.00	years	BPEM Guidance
Landfill Lifespan	30.00	years	
Number of Trenches Required	15.0	unit	
Total Fill (2025-55)	5,030	m^3	
Required Trench Capacity	**335**	**m^3**	
Trench Dimensions			
Length	84	m	
Base Length [inc. 1:10 access ramp]	49	m	
Width	8.00	m	
Base Width	8	m	Allows collectin vehicle access
Depth	3.5	m	Assumes groundwater exceeds 7.5mbgl
Slope (1:V)	0		
Approximate Trench Capacity	**1,526**	**m^3**	
Supporting Infrastructure Dimensions			
Capping final height	1	m	
Landfill bund width	3		
Capping Width Required (1:3)	3	m	
Facility Dimensions			
Landfill Facility Length (E-W)	90	m	
Landfill Facility Width (N-S)	210	m	
Landfill Facility Area	18,900	m^2	

Table 1.5 - Landfill Fill Rate Estimates

Year	Estimated Population	Estimated Generation Tonnes/year	Airspace Consumption Rate m^3/year
2024	40	80	457
2025	42	83	475
2026	43	87	494
2027	45	90	514
2028	47	94	535
2029	49	97	556
2030	51	101	578
2031	53	105	601
2032	55	109	625
2033	57	114	650
2034	0	0	0
2035	0	0	0
2036	0	0	0
2037	0	0	0
2038	0	0	0
2039	0	0	0
2040	0	0	0
2041	0	0	0
2042	0	0	0
2043	0	0	0
2044	0	0	0
2045	0	0	0
2046	0	0	0
2047	0	0	0
2048	0	0	0
2049	0	0	0
2050	0	0	0
2051	0	0	0
2052	0	0	0
2053	0	0	0
2054	0	0	0
2055	0	0	0
Total (2025-2055)		**880**	**5,030**

Table 2.1 - Generation Estimates

Scenario		Unit	Source
Estimated Required Facility Area	6500	m^2	Previous operations
Waste Compaction Factor	1.00	Tonnes/m^3	Estimate
Cover Soil	0%	% of total Void	Estimate

Table 2.2 - Inert Landfill Sizing Factors

Scenario		Unit	Source
Sizing Criteria			
Landfill Lifespan	30.00	years	
Number of Cells Required	1.0	unit	
Cell Dimensions			
Length	95	m	
Base Length [inc. 1:10 access ramp]	60	m	
Width	56	m	
Base Width	56	m	
Depth	3.5	m	Assumes groundwater exceeds 7.5mbgl
Slope (1:V)	0		DMIRS *Excavation Code of Practice*
Approximate Cell Capacity		**m^3**	
Supporting Infrastructure Dimensions			
Capping final height	1	m	
Landfill bund width	3		
Capping Width Required (1:3)	3	m	Based on 1:5 slope from edge of waste
Facility Dimensions			
Landfill Facility Length (E-W)	101	m	
Landfill Facility Width (N-S)	62	m	
Landfill Facility Area	6,262	m^2	

Table 3.1 - Void Space Modelling

Stage	Available Void Space (m^3)	Net Void Space ex. Cover Soils (m^3)	Landfill Capaity (years)
Putrescible Landfill (1)	1,526	763	2
Putrescible Landfill (15)	22,890	11,445	30
Inert Landfill	0	0	30
Total	24,416	12,208	30

Table 3.2 - Material Balance

Stage	Material Gained from Excavation	Cover Soil (m^3)	Capping Material Required (m^3)	Total Material Requirement (m^3)	Net Balance
Putrescible Landfill (1)	1,526	763	1,008	1,771	-245
Putrescible Landfill Facility	22,890	11,445	15,120	26,565	-3,675
Inert Landfill Facility	0	0	9,393	9,393	-9,393
Surface Water Pond	1,877	0	0	0	1,877
Total	24,767	11,445	24,513	35,958	-11,191

APPENDIX D
Surface Water Modelling

Table 1.1: Site Details

Site Location:	Upper Gascoyne
Latitutde:	-25.05607
Longitude:	115.21589

Notes:
Data from BOM's IFDs (2016):
http://www.bom.gov.au/water/designRainfalls/revised-ifd/

Table 1.2 Rainfall AEP

Annual Exceedance Probability		Rainfall (mm)							
Duration		63.2%	50.0%	20.0%	10.0%	5.0%	2.0%	1.0%	4.00%
Hours	BoM	1:1	1:2	1:5	1:10	1:20	1:50	1:100	1:25
0.02	**1 min**	1.18	1.42	2.23	2.85	3.52	4.52	5.38	3.687
0.03	**2 min**	1.94	2.34	3.69	4.71	5.8	7.34	8.62	6.057
0.05	**3 min**	2.72	3.27	5.15	6.58	8.1	10.3	12.1	8.467
0.07	**4 min**	3.44	4.13	6.5	8.3	10.2	13	15.4	10.67
0.08	**5 min**	4.1	4.91	7.73	9.88	12.2	15.6	18.5	12.77
0.17	**10 min**	6.65	7.95	12.5	16	19.8	25.4	30.3	20.73
0.25	**15 min**	8.42	10.1	15.8	20.2	25.1	32.3	38.4	26.3
0.33	**20 min**	9.75	11.7	18.3	23.5	29.1	37.4	44.5	30.48
0.42	**25 min**	10.8	12.9	20.3	26	32.3	41.5	49.4	33.83
0.50	**30 min**	11.7	14	22	28.2	34.9	44.9	53.4	36.57
0.75	**45 min**	13.7	16.4	25.9	33.1	41	52.6	62.6	42.93
1.00	**1 hour**	15.1	18.2	28.7	36.8	45.5	58.4	69.4	47.65
1.50	**1.5 hour**	17.3	20.8	32.9	42.2	52.3	67.1	79.7	54.77
2.00	**2 hour**	18.9	22.8	36.1	46.4	57.5	73.9	87.9	60.23
3.00	**3 hour**	21.4	25.8	41	52.8	65.6	84.6	101	68.77
4.50	**4.5 hour**	24.2	29.1	46.5	60	74.8	97	116	78.5
6.00	**6 hour**	26.3	31.7	50.7	65.7	82.2	107	129	86.33
9.00	**9 hour**	29.5	35.6	57.2	74.5	93.7	123	149	98.58
12.00	**12 hour**	31.8	38.4	62.1	81.3	103	135	164	108.3
18.00	**18 hour**	35.2	42.5	69.3	91.2	116	154	187	122.3
24.00	**24 hour**	37.4	45.3	74.3	98.2	126	167	204	132.8
30.00	**30 hour**	39	47.3	78	104	133	176	215	140.2
36.00	**36 hour**	40.3	48.9	80.9	108	138	184	224	145.7
48.00	**48 hour**	42	51.1	85.1	114	147	194	237	154.8
72.00	**72 hour**	44	53.8	90.2	121	156	205	249	164.2
96.00	**96 hour**	45.3	55.5	93.1	124	160	210	253	168.3
120.00	**120 hour**	46.4	56.9	95.2	127	162	212	255	170.3
144.00	**144 hour**	47.5	58.2	97	128	163	213	255	171.3
168.00	**168 hour**	48.6	59.5	98.5	130	164	213	255	172.2

Table 1.3 IFD Coefficients

AEP Coefficients (Coefficients Tab)							
	63%	50%	20%	10%	5%	2%	1%
	1:1	1:2	1:5	1:10	1:20	1:50	1:100
C_0	1.686E-01	3.482E-01	8.002E-01	1.047E+00	1.260E+00	1.509E+00	1.682E+00
C_1	5.523E-01	5.738E-01	5.936E-01	5.858E-01	5.696E-01	5.159E-01	4.720E-01
C_2	3.371E-01	3.113E-01	2.858E-01	2.933E-01	3.107E-01	3.750E-01	4.275E-01
C_3	-1.701E-01	-1.590E-01	-1.472E-01	-1.496E-01	-1.561E-01	-1.840E-01	-2.068E-01
C_4	3.254E-02	3.036E-02	2.785E-02	2.811E-02	2.915E-02	3.470E-02	3.922E-02
C_5	-2.846E-03	-2.644E-03	-2.389E-03	-2.385E-03	-2.450E-03	-2.957E-03	-3.371E-03
C_6	9.404E-05	8.698E-05	7.702E-05	7.576E-05	7.675E-05	9.403E-05	1.081E-04

Table 2.1 Catchment Summary

Catchments	Area (m^2)	Catchment Surface	Comments	Runoff Coefficient	1:20 Year Runoff
Catchment A	22,647	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%		0.5	1,427
Catchment B	10,930	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%		0.5	689
Catchment C	17,535	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%		0.5	1,105
Catchment D	34,220	Graded or No Plant Cover, Clayey Soil, Flat, 0 - 5%		0.5	2,156
Catchment E				0	0
Catchment F				0	0
Catchment G				0	0
Catchment H				0	0
Catchment I				0	0
Catchment J				0	0
Catchment K				0	0
Catchment L				0	0
Catchment M				0	0
Catchment N				0	0
Catchment O				0	0
Catchment P				0	0

Total Area (m^2)	85,332	Composite Runoff Coefficient	0.500

Table 2.2 Surface Water Movement Summary

Aspect		Catchment A	Catchment B	Catchment C	Catchment D
Swale Surface Water Movement	1st Swale	Swale 1	Swale 2	Swale 2	Swale 3
	2nd Swale				Swale 4
	3rd Swale				Swale 2
	4th Swale				
	5th Swale				
	6th Swale				
Overland Flow (over waste mass)	Flow Length (m)	220	183	176	250
	ΔRL (mAHD)	3	2	7	6
	Slope	0.014	0.011	0.040	0.024
	Surface Material	Smooth bare soil	Smooth bare soil	Smooth bare soil	Smooth bare soil
	Kerby's Roughness Factor	0.10	0.10	0.10	0.10
	Time of Conc., Tc-o	16.735	16.176	11.725	15.554

NOTES:
Slope = ΔRL/ΔFlow Length
Tc-o = K*((L*N)^0.467)*(S^-0.235)
K=constant; =1.44 for SI L=flow length (m) N=Kerby's roughness S = Slope

Table 4.1 Swale Design Characteristics and Modelling Results

Aspect	Swale 1	Swale 2	Swale 3	Swale 4
Swale Flow Timing				
Flow Length (m)	211	315	395	323
ΔRL (mAHD)	1	1	1.5	1.5
Slope	0.005	0.003	0.004	0.005
Swale Material	Earth channel - clean	Earth channel - clean	Earth channel - clean	Earth channel - clean
Manning's Coefficient	0.022	0.022	0.022	0.022
Time of Conc., Tc-h	9.432	14.982	16.646	13.194
Combined Flows				
Min. Total Concentration Time, Tc (min)	26.17	26.71	32.20	28.75
Intensity for Min. Tc (mm/hr)	115.52	114.19	102.43	109.47
Flow Rate for Min. Tc (m^3/hr)	1,308	3,579	1,753	1,873
Peak Flow Rate for Min. Tc (m^3/hr)	1,308	3,579	1,753	1,873
Comments				
Swale Geometry	**1**	**2**	**3**	**4**
Swale Bottom Width (m)	1	1	1	1
Depth of Flow w/o Freeboard (m)	0.5	0.5	0.5	0.5
LHS Slope (1:H)	3	3	3	3
RHS Slope (1:H)	3	3	3	3
Freeboard (m)	0.5	0.5	0.5	0.5
Freeboard included?	YES	YES	YES	YES
Top width, T (m)	7	7	7	7
Design Depth inc. Freeboard (m)	1	1	1	1
Swale Area, As (m^2)	4.000	4.000	4.000	4.000
Wetted Perimeter, Pw (m)	7.32	7.32	7.32	7.32
Hydraulic Radius, Rh (m)	0.55	0.55	0.55	0.55
Hydraulic Depth, Dh (m)	0.57	0.57	0.57	0.57
Flow				
Manning's coefficient, n	0.022	0.022	0.022	0.022
Maximum Velocity, V (m/s)	2.09	1.71	1.87	2.07
Minimum Flow, Q (m^3/s)	8.36	6.84	7.49	8.28
Minimum Flow, Q (m^3/h)	30,106	24,640	26,949	29,801
Factor of Safety	**23.02**	**6.88**	**15.38**	**15.91**
Froude Number, Fr	0.88	0.72	0.79	0.87
Nature of Flow	**Subcritical**	**Subcritical**	**Subcritical**	**Subcritical**
Reynolds Number, Re (channel)	638,915	522,912	571,914	632,453
Flow Type	**Turbulent**	**Turbulent**	**Turbulent**	**Turbulent**

Table 4.2 Swale Design Event & IFD Coefficients

Design Period	1:100
C_0	1.6820911
C_1	0.47203836
C_2	0.42746368
C_3	-0.20680352
C_4	0.039223228
C_5	-0.003370929
C_6	0.000108108

Table 3.1 Pond Design Events

Minimum Design Event	
Design Period	1:20
Storm Duration	24 hour
Total Rainfall (mm)	126
Maximum Design Event	
Design Period	1:50
Storm Duration	24 hour
Total Rainfall (mm)	167

NOTES:
Volume of Pond:
$V=(h/6)*((LxW)+((W+W_b)*(L+L_b))+(L_b*W_b))$

Table 3.2 SW Movement into Ponds

	Pond 1
Catchment A	YES
Catchment B	YES
Catchment C	YES
Catchment D	YES
Catchment E	
Catchment F	
Catchment G	
Catchment H	
Catchment I	
Catchment J	
Catchment K	
Catchment L	
Catchment M	
Catchment N	
Catchment O	
Catchment P	

Table 3.3 Pond Design Details

Aspect	Pond 1
W (m)	60
L (m)	70
h (m)	2.5
Side Slope (1:V)	2.5
Freeboard (m)	0.3
Base Width (m)	47.5
Base Length (m)	57.5
Operational Width (m)	58.5
Operational Length (m)	68.5
Pond Catchment Area (m^2)	4,200
Operational Capacity (m^3)	7,368
Total Capacity (m^3)	8,599

Table 3.4 Pond Capacity Checks

Aspect	Pond 1
Catchment Area (m^2)	85,332
Runoff Coefficient	0.50
Minimum Storage Requirement (m^3)	5,905
Storage Check	**PASS**
Maximum Storage Requirement (m^3)	7,827
Storage Check	**PASS**

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