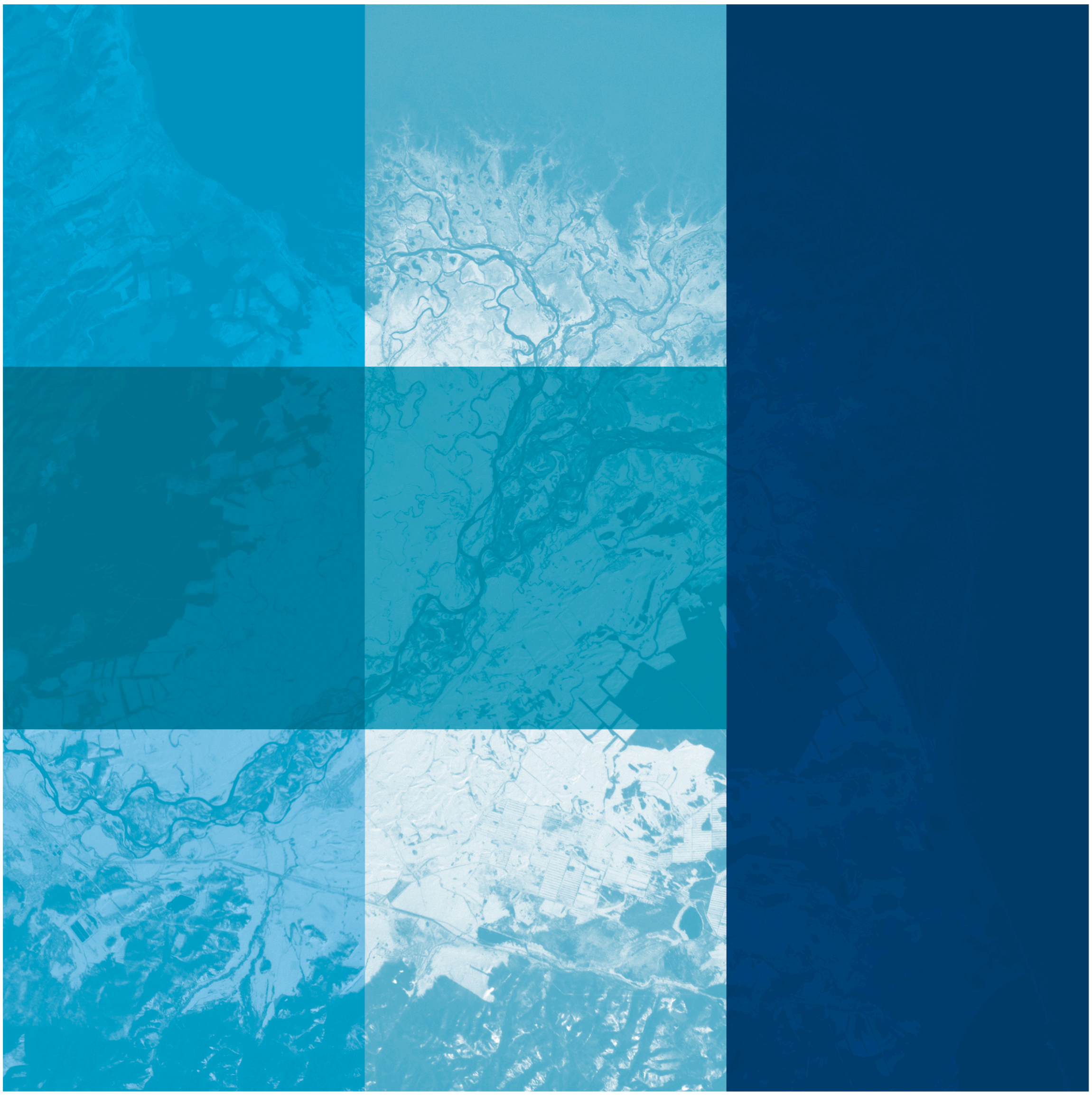
ATTACHMENT 4



WRS Bioproducts Karratha hydrology study

Client: WRS Bioproducts Karratha

Job number: J0100152

Date: 24 October 2023

Executive Summary

Background and scope

WRS Bioproducts are planning to develop an algal processing plant at Karratha. The project involves construction of shallow lakes for cultivating algae, a small process plant for initial product treatment and an access road. The site is located near the outlet of a defined drainage line, 7 Mile Creek, on the edge of the Nickol Bay tidal zone and is inundated in tides and storm surge events. To allow development to proceed, flow from 7 Mile Creek and interaction with local drainage, tides and storm surge needs to be managed.

This report presents a hydrology investigation and stormwater management plan which will inform site design and operation and contribute to the planning and approvals process. The study addressed:

- Management of flows from 7 Mile Creek;
- Management of excess water in the lakes;
- Flood management and drainage for the access road; and
- Management of flood risk for the burrow pits during construction.

Management of flows from 7 Mile Creek

A number of options for management of flows from 7 Mile Creek were evaluated. The preferred option diverts 7 Mile Creek to the east along the southern side of the proposed lake infrastructure.

A staged approach to development is suggested to manage current access limitations to a quarry reserve just south of the lake embankment. This option involves approximately 2 ha of levelling of a low ridge that intersects the location of the pond embankment and assumes that a levee, formed by part of Millars Road and the southern pond boundary, to divert 7 Mile Creek flow is in place. Stage 1 is expected to be required for two to five years before the ultimate preferred option is constructed.

Stage 1 works will allow events up to the 10% AEP flow from 7 Mile Creek, should any occur during the two to five year period, to be safely conveyed to the south of the ponds allowing development to proceed in the short term.

The ultimate preferred option involves levelling a larger area of the ridge to accommodate and safely convey larger events (1% AEP). This cut is necessary to manage flow velocities in the diversion flow path south of the lake embankment and peak water levels upstream of the diversion.

Detailed hydraulic modelling for the ultimate development of this option indicates that floodwater levels at the outlet of 7 Mile Creek increase due to the ponding effect of the access road and southern lake embankment acting as a levee. Peak water levels in the area for the 1% AEP event are predicted to increase from existing levels of 2.8 – 3.7 m AHD to 4.0 – 4.2 m AHD with the proposed works in place. The increased water level is consistent with existing patterns of inundation in the area resulting from natural flood flows and tidal movement and does not result in increased flood risk to the airport nor surrounding urban or industrial infrastructure. Flood water still reaches the estuary system to the northeast of proposed lake infrastructure and tidal activity in the area is unaffected.

Velocities in the floodplain south of the lake embankment increase compared to the broad spreading flow seen in the existing situation due to a constricted flow path in this area but are still consistent to velocities currently observed in the area. Areas of the southern embankment with elevated flow velocity in large events are flagged as requiring scour protection.

The extent of impact on depth and velocity extends upstream to near Millars Road but does not impact the road itself. Impacts extend to the estuarine network east of the lakes but there is no impact on the areas hydrology. Flooding and stormwater drainage in Karratha and road infrastructure to the southwest are unaffected. Flooding resulting from 7 Mile creek in the area between the lakes and airport is eliminated.

Accordingly, it is considered that the proposed works will not adversely affect flood characteristics nor hydrology of the area.

Management of excess water in the lakes

Under normal operating conditions, the lakes will have adequate freeboard to contain rainfall events up to at least the seven day 1% AEP design event. This water can be discharged using the lakes' supply channel network.

Storm surge events greater than 10 % AEP have the potential to inundate the lakes. Assuming no damage to infrastructure, the full volume of the lakes to the top of the embankment will need to be drained before the lakes can be refilled with saline water and for algal production to recommence. This could be via the harvesting channels supplemented with discharge via temporary breach of the lake wall.

Access roads

For the preferred site layout, the access road runs from Millers Road east to the lake embankment then follows the embankment north to the area of the plant site. The section from Millars Road to the lake embankment acts as a levee, diverting flows in 7 Mile Creek to the east.

The remainder of the road alongside the lake embankment is assumed to be at or close to ground surface. this section of the road will interact with storm surge as well as tidal flows. Locally sourced stormwater will drain along the edge of the road toward the north, crossing the road if it extends to rejoin Millars Road.

Detailed design of the access road should consider management of stormwater and tidal flows.

Flood risk for burrow pits

Two borrow pits are proposed for the preferred site layout - north and west. The intent is to use these to source material for construction of the lake embankments and other site infrastructure. During construction, they will be protected from tide water ingress by temporary levees, which will be removed once excavation is complete.

Drainage of stormwater and oceanic water past these levees needs to be considered. Depending on the construction period, this may simply involve timing of the work during a dry period. Culverts may be required if water is likely to pond against the levees.

Detailed design and planning for the borrow pits should consider timing and water drainage.

Conclusions and recommendations

The proposed development allows diversion of 7 Mile Creek, management of stormwater external and internal to the lakes and road access without adversely affecting local flood risk or the hydrology of the wider estuarine area.

While the proposed diversion increases predicted flood depths in the area south of the lake embankment and new section of Millars Road this has no negative impact on surrounding rural and industrial activity, the remaining Millars Road, the airport nor on the environment.

Modelling identified some areas with elevated flow velocity – scour risk in these areas can be managed using scour protection.

It is recommended that detailed civil design of proposed lake infrastructure and the Millars Road upgrade develop civil design details along the principals presented in this report. This includes consideration of:

- Staged levelling of the ridge south of the lake embankment;
- Scour protection along the section of Millars Road and the southern lake embankment that act as a levee;
- Setting crest levels and freeboard for the section of Millars Road and the southern lake embankment that act as a levee;
- Stormwater and tidal water management for the section of Millars Road that crosses the estuarine area from the northeastern corner of the proposed lakes; and
- Management of flood risk for the construction phase of the borrow pits.

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Tables

1. Introduction

1.1 Background

WRS Bioproducts are planning to develop an algal processing plant at Karratha. The project involves installation of shallow lakes for cultivating algae with a small process plant for initial product treatment.

The proposed site is located near the airport at Karratha, on the edge of the Nicol Bay tidal zone. Seven Mile Creek discharges to the tidal zone at the southern edge of the proposed site. The site location is shown in Figure 1. To allow development to proceed, flow from 7 Mile Creek and interaction with local drainage, tides and storm surge need to be managed.

A number of options for the site layout are under investigation by WRS Bioproducts. The preferred proposed site layout (SK-084) is shown in Figure 2. Proposed site infrastructure extends across Lots 4229 and 301 and part of Lot 267.

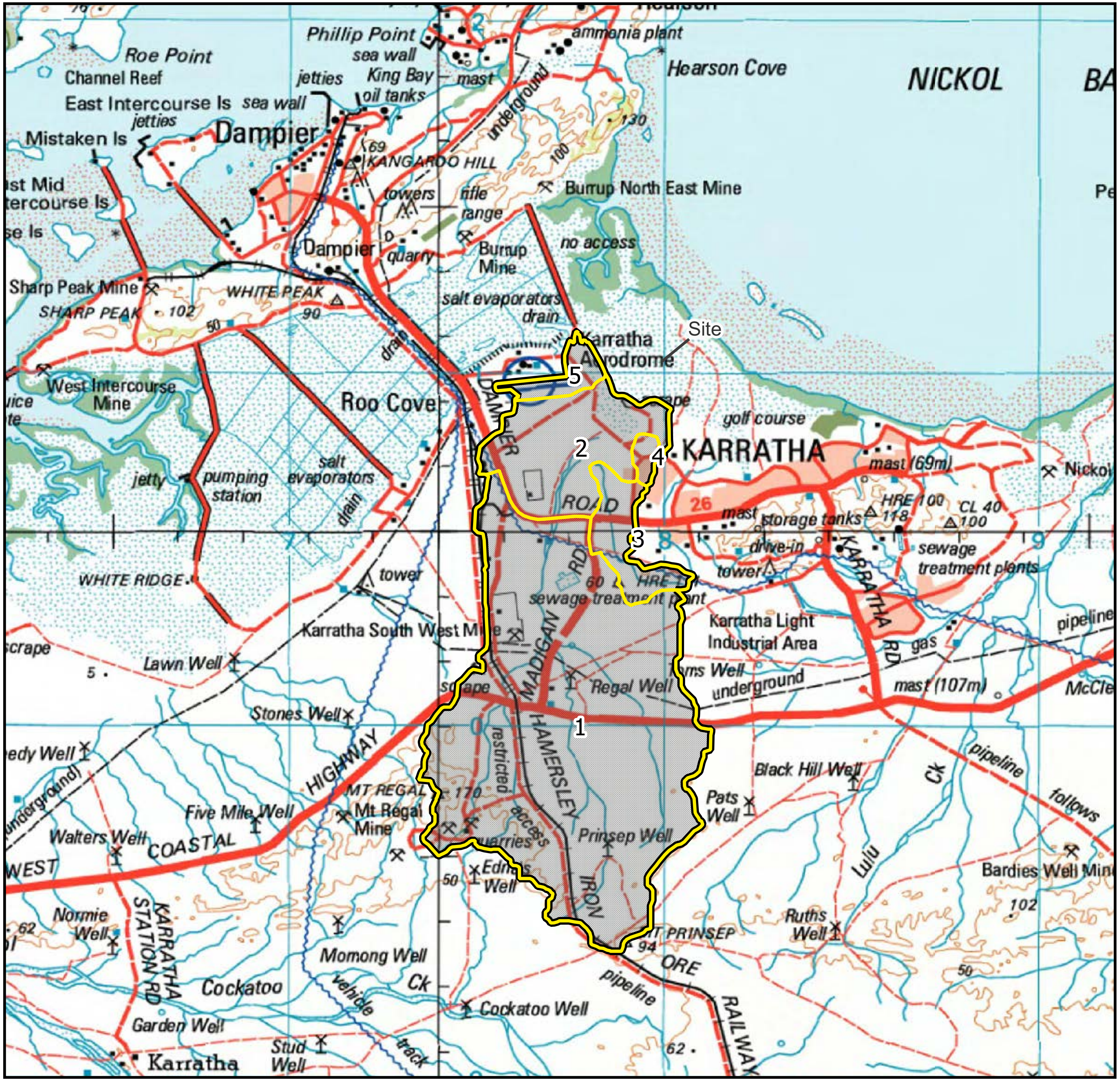
Millars Road and the airport runway lie to the west of the site.

The hydrological study is needed to address the City of Karratha requirements for a hydrology investigation report and stormwater management plan. Results of the study will also inform site design and operation.

WRS Bioproducts require advice on:

- Management of flows from 7 Mile Creek;
- Overall site stormwater drainage, including lake overtopping and downstream control of overflow; and
- Flood risk for the burrow pits during construction.

This report presents the results of the hydrology study.



Legend

Proposed infrastructure

1 Catchments

Data source:
Imagery, 250K - Geoscience Australia
Infrastructure - WRS Bioproducts
Hydrologia - catchments

Location

Map sheet location

N

3 6 9 km

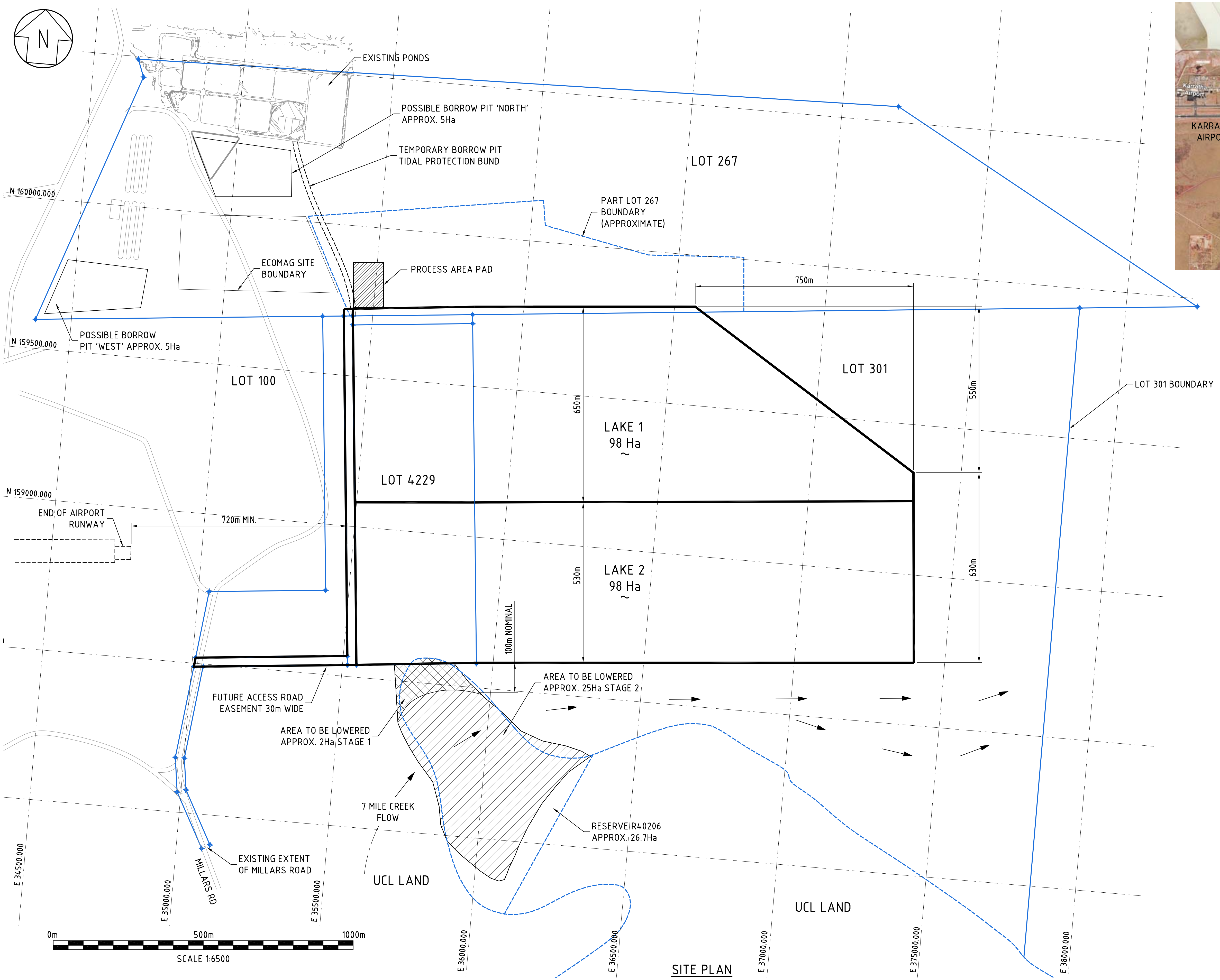
WRS Bioproducts

Hydrologia

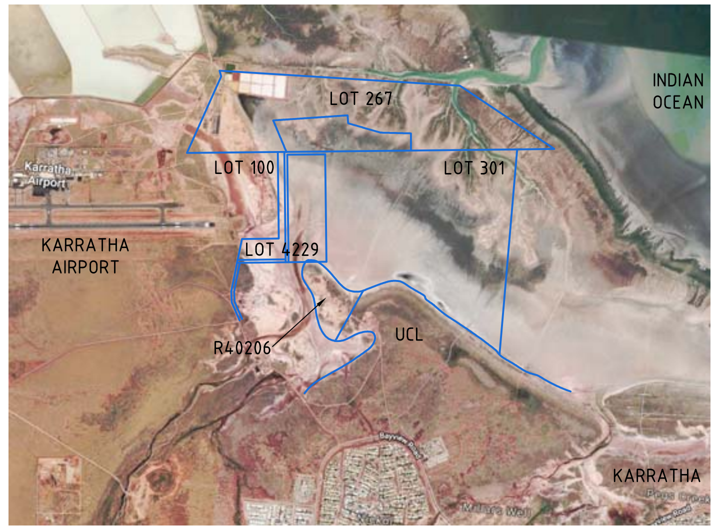
Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 1
Project location and catchments

COMPILED: Hydrologia	DATE: 19/06/2023	LOCON: PERTH	A4	SCALE: 1:120,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 01.pdf			
DOCUMENT NAME: J0100152_Map 01.qgz				



SITE PLAN



LOCATION PLAN

SCALE 1:40000

PRELIMINARY ONLY
NOT FOR CONSTRUCTION

NOTE:

1. ALL DIMENSIONS & AREAS ARE APPROXIMATE ONLY

LEGEND

- LEASE & GOVERNMENT BOUNDARIES
- AREA OF RESERVE TO BE LOWERED STAGE 1
- AREA OF RESERVE TO BE LOWERED STAGE 2

Figure 2

WRS Bioproducts

REFERENCES

DRG. No.	TITLE

REVISIONS

No.	BY	DATE	CHK	APP	DESCRIPTION
C	TS	23.10.23	BC		PRELIMINARY
B	TS	4.10.23	BC		PRELIMINARY
A	TS	7.9.23	BC		PRELIMINARY

ALL DIMENSIONS IN MILLIMETRES U.N.O.
DO NOT SCALE

SCALE : 1:6500

	NAME	DATE
DESIGNED	H. ROSEN	7.9.23
DRAWN	T. SVATIK	7.9.23
CHECKED		
APPROVED		

DRAWING TITLE

WRS BIOPRODUCTS PTY LTD
CONCEPTUAL SITE UTILISATION - RAINSTORM LEASE
ALGAL PONDS & PROCESSING PLANT
PROPOSED SITE PLAN 2 x 98Ha LAKES

DRAWING NUMBER

APP-SK-084

DRG. REV. M/F: A B C

A1

10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm

Consultants No:

1.2 Scope of work

The scope of work was, for WRS Bioproducts' planned development at Karratha, to:

- Undertake a hydrology investigation report and stormwater management plan as required by the City of Karratha under its Development Approval.

This involved:

- Characterising flooding conditions at the proposed site; and
- Developing a stormwater management plan that addresses:
  - Management of flows from 7 Mile Creek;
  - Management of excess water in the lakes;
  - Flood management and drainage for the access road; and
  - Management of flood risk for the burrow pits during construction.

The deliverable is this report.

1.3 Summary of methods

The work was undertaken in the following stages:

- Source data;
- Modelling; and
- Reporting.

Source data

The following data were used in the project:

- Site infrastructure layout, supplied by WRS Bioproducts;
- Topography for the extent of the hydraulic model domain, supplied by Landgate;
- Regional topographic data (SRTM DEM-H) for the extent of 7 Mile Creek and local catchments, supplied by Geoscience Australia;
- Design rainfall data supplied by Australian rainfall and Runoff (ARR 2019) and the Bureau of Meteorology (BoM 2022a); and
- Other data and reports, as referenced in this report.

The topography used for the hydraulic model was a 1 m digital elevation model (DEM) derived from 0.1 m high resolution aerial imagery flown on 16 November 2021, supplied by Landgate. The data set has a reported horizontal accuracy of 1 m and vertical accuracy of 0.4 m. The topographic data did not capture ground surface where there was water present during the aerial survey. This included the tidal creeks, Nickol Bay and part of the estuary between the ponds and airport. Topography in these areas was manually adjusted to represent an assumed ground/bathymetry surface.

The topography used for the catchment hydrology modelling was a nation-wide DEM supplied by Geoscience Australia (GA 2011). The DEM was derived from Shuttle Radar Topography Mission data acquired by NASA in February 2000. The version of DEM used was a one second hydrologically enforced digital elevation model (SRTM DEM-H). This dataset captures flow paths based on SRTM elevations and mapped stream lines and supports delineation of catchments and related hydrological attributes. The dataset has a spatial resolution of approximately 30 m and a vertical accuracy of up to 7.6 m. The DEM has an approximately 30 m wide rectangular cell.

Modelling

The modelling was undertaken using separate hydrology and flood hydraulic models. The intent of the modelling was to characterise flood flows at the site to inform site layout planning and the stormwater management plan. The main source of flood flows for the site is 7 Mile Creek. Local catchments, including part of the Karratha suburb of Nickol, contribute to the 7 Mile Creek flow in the lower reaches. The 7 Mile Creek catchment to the location of the WRS Bioproducts site was delineated and hydrology was modelled based on the SRTM-H topographic data. Hydrographs from this hydrology model were input to a two-dimensional hydraulic model of the site, built using the modified Landgate topography.

Modelling assumptions and methodology are summarised below. Model parameter values are detailed in Appendix A.

Hydrology

The Mike SHE model (DHI 2022) was used to characterise catchment hydrology. A number of prior studies and regional methods (RFFE 2016) were used to help inform the hydrologic modelling, but the Mike SHE results were adopted for use with the hydraulic modelling.

Mike SHE is a detailed catchment hydrology model. A rain-on-grid approach was used to represent overland and channel flow. The model was initially parameterised using the available data and based on experience applying the model in similar environments. Design rainfall patterns were derived referring to procedures given in Ball, *et al.* (2016) and rainfall totals were taken from BoM (2022a). Geoscience Australia SRTM-H topographic data was used.

The resulting peak flows predicted for 7 Mile Creek to the Dampier Highway were considerably smaller than predictions given in previous studies (GHD 2009 and JDA 2012). The City of Karratha directed that peak flows similar to those given in the GHD (2009) and JDA (2012) studies be adopted for use in this Hydrologia study. Accordingly, the Mike SHE model was recalibrated to approximately reproduce these flows. Similar data to those used in the JDA and GHD studies (1987 IFD data from BoM 2023, rainfall loss rates and flow resistance) was used in the recalibration.

Hydrographs for 10% and 1% annual exceedance probability (AEP) events were derived for the total catchment to the edge of the hydraulic model domain. These flows were input to the hydraulic model as hydrographs.

Site hydraulics – flood modelling

A two dimensional hydraulic model (Mike 21FM, DHI 2022) was used to characterise flooding resulting from flows in 7 Mile Creek at the site. The model was built using the modified Landgate DEM.

The model domain extended some 2 km upstream of the proposed site infrastructure to above Millar's Road, to allow an inflow boundary to be set and to assess the extent of impacts of proposed management of flood flows in 7 Mile Creek. The domain extended to the estuarine channel network to the east of the site and Nickol Bay to the east. Constant velocity and free outflow boundaries were located on the downstream edges of the model domain to allow flows to exit the model, approximating normal flow conditions.

Two oceanic conditions were represented:

- No tide or storm surge tailwater, i.e., the area of the proposed site was dry, used for the design of site infrastructure; the 10% and 1% AEP events were simulated using this condition; and

- A constant ocean level of 4.9 m AHD, representing a storm surge of approximately 5% AEP; the 1% AEP flood event was simulated using this condition.

The storm surge scenario was based on advice given in JDA (2012), which considers a 1% AEP would be coincident with peak water level resulting from a 20 year average recurrence interval (ARI) storm surge event. A constant storm surge level was modelled.

Hydrographs from the hydrology assessment were input to the model at the upstream boundary. The model was run until peak flow conditions were encountered across the model domain and the instantaneous peak water level, depth and velocity extracted for use in the project analysis and reporting.

The model was initially setup to represent existing topography (i.e., as represented by the topographic data). This topography was then modified to represent earthworks associated with key project infrastructure and the model was rerun to assess impacts of the proposed infrastructure on flood patterns, depth and velocity.

As land condition across the model domain is largely constant (mudflat), a constant resistance (Manning's M) was used varied across the domain to represent the main flow and vegetation conditions.

Site hydraulics – tidal

The hydraulic model used in the flood hydraulic modelling was adapted to model tidal flow through the area of the proposed site infrastructure to size culverts in any access roads that affect natural tidal and stormwater flows. The culverts were located and sized to allow tidal water to cross the access road over a reasonable period. These culverts also allowed locally generated stormwater upstream of the access road to drain to the ocean.

For this model, the domain covered the estuarine network to the north of the site. The downstream boundary was the main estuary channel. The Landgate topographic dataset was manually modified to approximately represent bathymetry of the estuary channels that were not accurately represented in the Landgate data. The downstream boundary was set as a tide trace, generated for the ocean near the site the period 18 to 26 April 2022 using the Mike by DHI tool Tidal Prediction of Heights (DHI 2022). This period was selected to represent a spring tide time series with a range of high and low tidal ranges.

The upstream boundary was set to no flow.

Evaporation from the mesh surface was allowed. A typical summer value of 9.9 mm (February, BoM station 005061, BoM 2022b) was used.

Stormwater management

The stormwater management plan was developed considering local topography, layout of site infrastructure and results of the hydraulic modelling. Tide and storm surge levels were taken from published sources (JDA 2012).

Reporting

The study methodology and mapped results are presented in this report.

1.4 Limitations

General

This report has been prepared by Hydrologia Pty Ltd for WRS Bioproducts Pty Ltd and may only be used and relied on by WRS Bioproducts Pty Ltd for the purpose agreed between Hydrologia Pty Ltd and WRS Bioproducts Pty Ltd as set out in Section 1.2 of this report.

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Model Results

Flood magnitude predictions have a probability of occurrence. For example, a predicted 1% (or 1 in 100) AEP flood extent has a 1% probability of occurring or being exceeded in any given year. A flood of this magnitude could occur more than once in a year.

Floods greater than 1% AEP can occur. During such floods, impacts from flooding could be greater than indicated in this study. Conversely properties within the study area can be affected by floods of a lesser magnitude.

Predicted flood level, depth and velocity is predicted based on the available data and on assumptions and limitations described in our report. These results should be read in conjunction with this report.

The Mike SHE model was recalibrated to peak flows given in (GHD 2009 and JDA 2012) at the instruction of the City of Karratha. The intent of the recalibrated flows is to test the design of flood management infrastructure at the proposed site under flow conditions similar to historical flow estimates. Neither these flows nor model parameterisation method should be relied upon for any other purpose.

2. Catchment hydrology

2.1 Introduction

This section describes the hydrology of the catchment reporting to the WRS Bioproducts site and presents the design flow estimates used in the hydraulic model. Flow predictions from other studies are presented for comparison.

Results of the hydraulic modelling are given in Section 4.

2.2 Catchments and drainage

The WRS Bioproducts site extends across the alluvial fan for 7 Mile Creek on the edge of the Nickol Bay tidal zone. The site is inundated to various degrees during tides and storm surges, depending on the magnitude of the oceanic event.

A number of catchments contribute flow to the area of the WRS Bioproducts site. Catchments are summarised in Table 1 and mapped in Figure 1. The catchment for the main 7 Mile creek streamline contributes the majority of streamflow to the area. Smaller catchments contribute flow from the areas of the airport, part of the Karratha suburb of Nickol and for Madigan Creek.

The 7 Mile Creek catchment extends some 15 km to the south. In the lower reaches, a main defined and incised channel forms. The creek crossed the Dampier Highway 4 km upstream of the site and Millars Road just upstream.

The creek enters the tidal flat just south of the proposed location of the WRS bioproducts lakes. Existing drainage and topography at the site is mapped in Figure 3. Proposed site infrastructure is overlain for reference.

The Creek's channel is defined just upstream of the tidal flats, entering from the southwest. The channel then turns north and dissipates into a broad alluvial fan through the area of the proposed lakes. A low, stony ridge extends from the east into the tidal flat area, acting to divert the channel north. The existing ground level through the area of the proposed lakes is about 2 m AHD.

A small estuary lies just east of the end of the airport runway. The estuary is connected to the tidal flats near the 7 Mile Creek outlet via a small channel that crosses Millars Road. This estuary receives stormwater flow from the area of the airport via a network of constructed drains and can receive flood inflows from the main 7 Mile Creek streamline and from high tides and storm surge.

A summary of the catchments contributing to the hydraulic model domain is given in Table 1. Catchments are mapped on Figure 1.

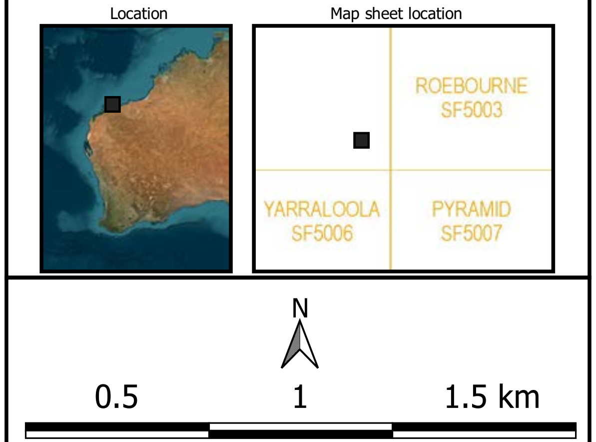
Table 1 Catchment details

Catchment name	Catchment number	Area (km^2)	Comment
7 Mile Ck to Dampier Hwy	1	61.7	7 Mile Creek to Dampier Highway.
Lower 7 Mile Ck	2	12.3	7 Mile Creek from Dampier Highway to the site, excluding subcatchments 4 and 5.
Madigan Ck	3	4.4	Madigan Creek subcatchment, discharging to 7 Mile Creek just upstream of the site.
Nickol	4	0.8	Subcatchment covering part of the Karratha suburb of Nickol, discharging via a drain to the tidal flats.
Airport	5	2.1	Subcatchment covering the airport, drained via series of constructed drains to an estuary just west of the airport that is connected to the tidal flats.
Total		81.3	Total catchment to the site.

Legend

- Proposed infrastructure
- 1 m contours
- Drainage lines

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Drainage lines - Hydrologia
Contours - Landgate



WRS Bioproducts

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Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 3
Existing topography and drainage

COMPILED: Hydrologia	DATE: 19/06/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 03.pdf			
DOCUMENT NAME: J0100152_Map 02.qgz				

2.3 Previous studies

The hydrology of 7 Mile Creek has been described in a number of past studies.

The Karratha Coastal Vulnerability Study (JDA 2012) reported flows in 7 Mile Creek at the Dampier Highway. An assessment for the Karratha Support Industry Estate (GHD 2009) also reported flow predictions at the Dampier Highway. Both studies were informed by streamflow gauging records at catchments in the region. These reported flows are given in Table 2.

Predictions derived using the current Australian Rainfall and Runoff regional method (RFFE 2016) are also given in Table 2. This method has also been developed using streamflow gauging records in the region but with a more recent and longer record of measurement that the earlier studies.

There is substantial variation between the reported flows and the RFFE method. For example, the 1% AEP flow varies between 707 m^3/s (JDA 2012) and 159 m^3/s (RFFE 2016) for 7 Mile Creek at the Dampier Highway.

Table 2 Previous design flood flow estimates

Catchment name	Area (km^2)	Peak flow (m^3/s) for AEP (%)					
		10	1	10	1	10	1
		JDA (2012)*		GHD (2009)**		RFFE (2016)	
7 Mile Ck to Dampier Hwy	61.7	218	707	217	627	60	159
7 Mile Ck to site	81.3	-	-	-	-	74	196

* taken from JDA (2012) Attachment II Table 9, XP-Storm model; ** taken from JDA (2012).

Predicted oceanic water levels reported in the Karratha Coastal Vulnerability Study (JDA 2012) for locations near the proposed site are listed in Table 3. Levels for storm surge alone and flooding including storm surge are provided in JDA (2012) and summarised in Table 3. A constant storm surge level corresponding to one fifth of the flood probability is assumed as tailwater for the flood modelling results. For example, the 1% AEP flood level includes the 5% storm surge level.

Highest astronomical tide at Karratha is 2.5 m AHD (JDA 2012).

Table 3 Storm surge water levels

Scenario	Water level (m AHD) for AEP (%), ARI (1 in y)						
	0.2%	0.5%	1%	5%	10%	39.35%	50%
	1 in 500 y	1 in 200 y	1 in 100 y	1 in 19.5 y	1 in 9.49 y	1 in 2 y	1 in 1.44 y
Storm surge	7.4[1]	7.0[2]	6.6[3]	4.9[4]	2.8[5]	2.3[6]	2.15[4]
Flooding, including storm surge			6.8[7]		2.9[8]		

Water levels are taken from JDA (2012): 1 – Attachment IV, Figure 12, location K2; 2 – Attachment IV, Figure 11, location K2; 3– Attachment IV, Figure 10, location K2; 4 – interpolated for location K2; 5 – Attachment IV, Figure 9, location K2; 6 – Attachment IV, Figure 8, location K2; 7 – main report, Figure 11, location T41; 8 – Appendix B, Figure 10, location T41.

2.4 Adopted design flows

Design flows for the 7 Mile Creek catchment, for input into the hydraulic model, were modelled using a Mike SHE model. Key parameter values for this model were calibrated to peak flows given in GHD (2009) and JDA (2012). Adopted design flows are listed in Table 4.

Hydrographs from the Mike SHE model were input to the hydraulic model, described in Section 4.

Table 4 Adopted design flows

Catchment name	Area (km^2)	Peak flow (m^3/s) for AEP (%)	
		10	1
7 Mile Ck to Dampier Hwy	61.7	220	715
7 Mile Ck to site	81.3	234	857

3. Stormwater management

3.1 Introduction

This section discusses management of storm and flood water in the lakes, at site access roads, the plant site, for the burrow pits during construction and for management of flows from 7 Mile Creek.

Detailed hydraulic modelling for the proposed layout is given in Section 4.

3.2 Management of flows from 7 Mile Creek

Seven Mile Creek discharges to the flat estuary through the area of the proposed lakes, plant area and access road. To allow development to proceed, flow from 7 Mile Creek needs to be allowed to discharge to the estuary while managing interaction between floodwater level and velocity and site infrastructure.

There are a number of options for management of 7 Mile Creek flow. The creek can be diverted around the southern extent of site infrastructure, discharging to the estuary channel network to the east. Alternatively, the main existing flow path to the west of the lake infrastructure, which will cross the access road, can be maintained, discharging to the Dampier Salt brine channel and estuary network to the north. A combination of the eastern and western flow paths can also be adopted.

All site layout options and variations were assessed considering impacts on flood flows and levels. This included varying the size and shape of the lakes and varying the proportion of 7 Mile Creek flows passing to the east and north.

The preferred site layout (SK-084) diverts flow to the east along the southern side of the proposed lake infrastructure. This option is shown in Figure 2. The creek's flow paths for this option are indicated in Figure 4.

The preferred option involves levelling a low stony ridge that occurs just south of the lake embankment. This ground modification is necessary to manage flow velocities in the diversion flow path and peak water levels upstream of the diversion.

A staged approach to development is suggested to manage current access limitations to the area of the ridge. This would involve limiting disturbance to this area while allowing safe conveyance of floodwater in smaller events. Once access is resolved, expected within two to five years, the area can be reshaped to the ultimate footprint.

Stage 1 involves approximately 2 ha of levelling of the ridge. This area is shown on Figure 2. This option assumes that a levee formed by part of Millars Road and the southern pond boundary to divert 7 Mile Creek flow is in place. Detailed modelling of Stage 1, presented in Section 4, demonstrates that a flood of up to 10% AEP magnitude will be safely conveyed south of the ponds. Peak flood depths and velocity remain within levels consistent with the ultimate design and existing conditions.

Any staged area of cut greater than this minimum area (for example 15 ha) will reduce the risk of scour occurring and lower peak water levels should an event be experienced during the two to five year period. Once access is resolved, the ultimate cut area should be established.

The ultimate preferred option involves levelling a larger area of the ridge to accommodate and safely convey larger events (1% AEP). Detailed modelling for the ultimate option (SK-

084) is given in Section 4. The modelling shows that the preferred option does not result in increased flood risk to the airport nor surrounding urban or industrial infrastructure.

Scour risk for the general estuarine area with the ultimate scenario is low, but parts of the southern lake embankment should be protected against impinging scour risk. Areas requiring consideration of scour protection are marked on Figure 4.

The area requiring protection relates to predicted higher velocity midway along the southern side of the pond walls due to a constriction formed by the landform in the UCL to the south. The modelling indicates lower velocities along the remainder of the pond embankment and road where they act as a levee. These areas are less likely to require scour protection.

Protection could take the form of soil modification, rock armouring or other hard facing.

3.3 Lakes

Under normal operating conditions, the lakes will contain saline water for processing at a nominal depth of 0.4 m. This gives a freeboard to the top of the lake embankment of 1.2 to 1.4 m (assuming an embankment crest level of 4 m AHD). During periods of extended rainfall or as a result of overtopping during storm surge events, additional water could accumulate or be retained in the lakes. The magnitude of inflow to the lakes from rainfall and storm surge is different.

The level of water accumulating in the lakes from rainfall only will depend on the intensity and duration of rainfall and management of lake water level. The seven day design rainfall total for the site (BoM 2022a) is 0.218 and 0.389 m for 10 and 1% AEP events respectively. Ignoring evaporation or controlled discharge from the lakes, this easily fits within the freeboard to the top of the embankment (1.2 to 1.4 m). Greater rainfall totals might be received over longer periods but longer periods also allow controlled discharge and evaporation to have more effect in lowering lake water levels. Controlled discharge could be via the harvesting channels, discharging to the estuary to the north of the site. Water could enter the harvesting channels either via the saline water collection system (pipes) and/or via high-flow spillways over the inner lake embankment.

Storm surge events greater than 10 % AEP have the potential to inundate the lakes. Assuming no damage to the infrastructure, the full volume of the lakes to the top of the embankment will need to be drained before the lakes can be refilled with saline water and for algal production to recommence. This could be via the harvesting channels supplemented with discharge via temporary breach of the lake wall.

3.4 Access roads

For the preferred site layout (Figure 2), a road is required for access to the plant area, at the northeast corner of the lakes. This road is shown on the Figure 2 as a concept; details of the road will be finalised in future stages of the project.

The road runs from Millers Road east to the lake embankment then follows the embankment north to the area of the plant site. It is assumed that the road will then reconnect to the existing Millars Road, but no details are available at this time of this section of the alignment.

For the purposes of this study, the road level was set at 4.5 m AHD (as this section will act as a levee, diverting flows in 7 Mile Creek to the east.) from the existing Millars Road to the lake embankment.

The remainder of the road alongside the western lake embankment is assumed to be at or close to ground surface. Hydraulic modelling (described in Section 4) for the preferred option indicates that this section of the road will interact with storm surge as well as tidal flows. Locally sourced stormwater will drain along the edge of the road toward the north, crossing the road if it extends to rejoin Millars Road.

Proposed drainage flow paths and the section of road that acts as a levee are shown on Figure 4.

A crossing will be required to allow local stormwater, tidal water and residual flood water from 7 Mile Creek to drain across the access road if it extends from the lake embankment to Millars Road. As this road alignment is not known at this time, a detailed assessment of this crossing cannot be made at this time. However, previous assessment of a road in this area indicated that a crossing with the following indicative details would allow tidal water and stormwater to cross the road and drain the area upstream of the road in a reasonable time:

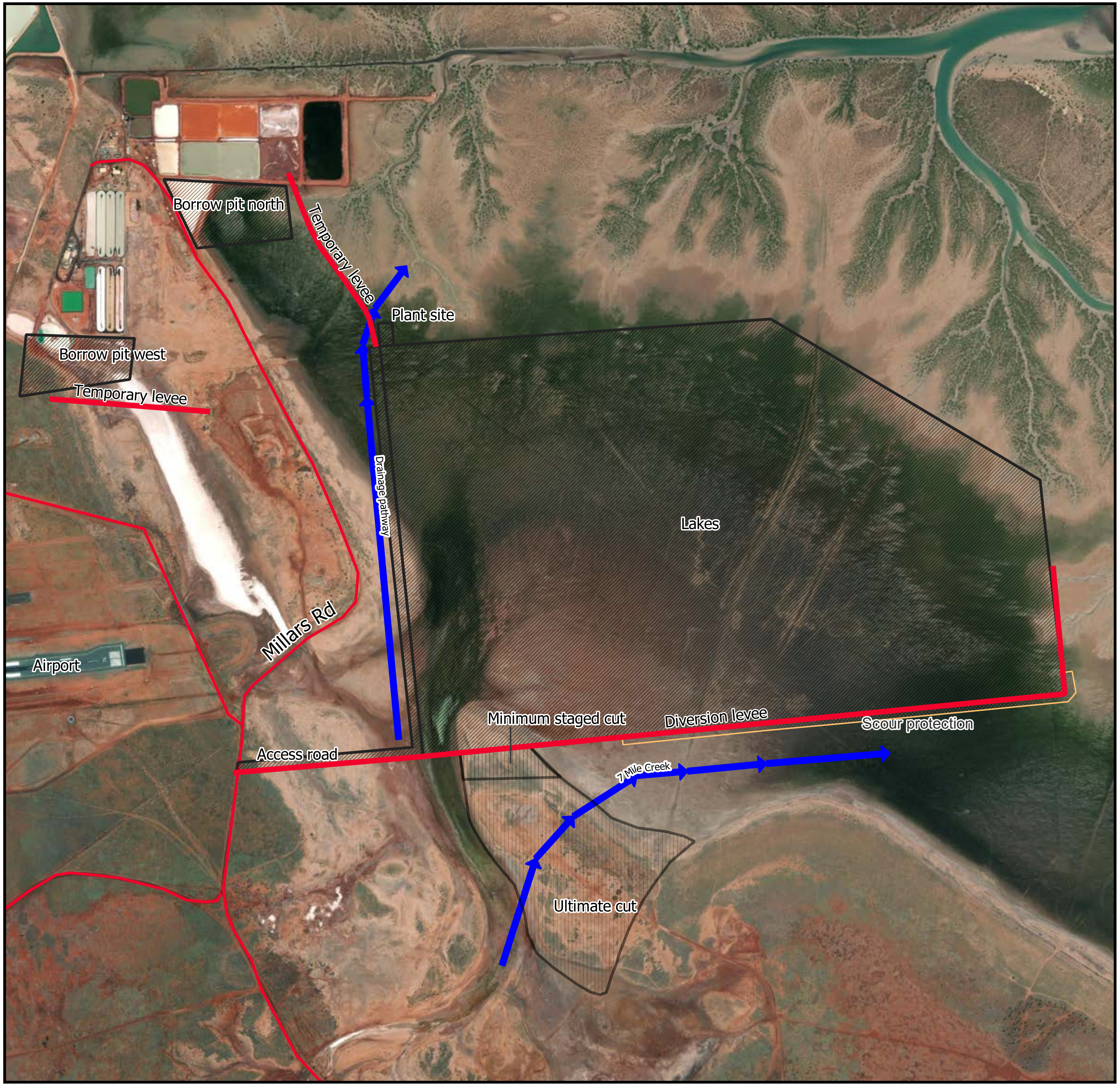
- 3 barrels of 0.5 m high * 0.75 m wide reinforced concrete box culvert; and
- 44 m long floodway with crest level of 2.5 m AHD.

A pathway along the north western edge of the access road needs to be maintained to allow for drainage of stormwater and oceanic water collecting in the area. This pathway is marked on Figure 4.

3.5 Borrow pits

Two borrow pits are proposed for the preferred option - north and west. The intent is to use these to source material for construction of the lake embankments and other site infrastructure. During construction, they will be protected from tide water ingress by temporary levees, which will be removed once the excavation is complete. Indicative levee locations are marked on Figure 4.

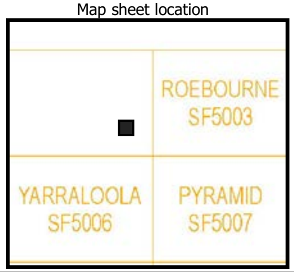
Drainage of stormwater and oceanic water past these levees needs to be considered. Depending on the construction period, this may simply be timing of the work during a dry period. Culverts may be required if water is likely to pond against the levees.



Legend

- Proposed infrastructure
- Proposed levees
- Proposed diversions & drainage

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts/Hydrologia



N

300 600 900 m

WRS Bioproducts Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 4
Stormwater management concept

COMPILED: Hydrologia	DATE: 27/09/2023	LOCON: PERTH	A4	SCALE: 1:17,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 04.pdf			
DOCUMENT NAME: J0100152 Map 07.qgz				

4. Hydraulic modelling

4.1 Introduction

This section presents results of flood modelling for the site. A review of existing flooding characteristics for the area is given. Impact of the Stage 1 works and the preferred site layout (drawing SK-084, Figure 2) on flooding characteristics of the area is then assessed.

Flooding is modelled for two oceanic conditions – 'dry' and with a 5% AEP (4.9 m AHD) storm surge. The dry scenario assumes no tide or storm surge tailwater, i.e., the area of the proposed site is dry. This is to give a better indication of the natural flow paths for floodwater from 7 Mile Creek and potential impacts of the proposed site infrastructure. As the site is low-lying and flat and as most of the site infrastructure is inundated in storm surge events, the effect of terrestrial flooding is not evident in the modelled results.

The storm surge scenario gives an indication of flooding for a 1% AEP event and coincident storm surge event based on the advice given in JDA (2012).

Stormwater management for the lakes, borrow pits and roads and management of effects of storm surge on the lakes is discussed in Section 3.

4.2 Existing flooding

Topography of ground through the area of the proposed site is largely flat, with a level of about 2 m AHD. Existing topography for the site is mapped in Figure 3 and tide and storm surge levels are given in Section 2.3. The site is inundated in larger tides and storm surge events.

Seven Mile Creek enters the area of the site in a defined channel that dissipates into the estuarine area. Flow from the creek spreads across the flat area of the proposed site then drains to the ocean via a network of defined estuary channels to the east and north.

The estuarine area is bounded by a low ridge to the south and higher ground to the west. The southern ridge rises to 7 m AHD just south of the site and serves to divert the 7 Mile Creek channel north.

The higher ground to the west (levels of 5 to 7 m AHD) is where Millars Road currently runs. A low-lying area (levels less than 3 m AHD) lies to the west before the ground level rises to the airport. This low-lying area is connected to the main estuary area via a floodway crossing over Millars Road and is probably inundated in higher tides and storm surge events. The eastern end of the airport runway is 5 m AHD and is inundated in larger storm surge events.

Predicted peak flood levels for existing conditions for the 10 and 1% AEP events, assuming no storm surge tailwater, is shown in Figures 5 and 6. Proposed site infrastructure is overlain for reference.

These results show the dissipation of flood water from the 7 Mile Creek outlet spreading in shallow flow through the area of the proposed lakes. The deepest and fastest flows are in the southwest corner of the lakes, then floodwater spreads and dissipates toward the northeast. Peak flow depth varies from 1.0 m to 0.4 m for the 10% AEP event; 1.2 m to 0.3 m for the 1% AEP event. Peak velocity varies from 1.0 m/s to 0. 3 m/s for the 10% AEP event; 1.6 m/s to 0.3 m/s for the 1% AEP event.

Predicted flood levels and velocities for the 1% AEP event with 4.9 m AHD tailwater, representing a combined flood and storm surge event, are shown in Figure 7. At this level, the floodplain is inundated to depths of 2 to 3 m. Flows from 7 Mile Creek rapidly dissipate into the inundated area.

Legend

- Proposed infrastructure
- Model domain
- 0.25 m water level contours (m)

Depth 10% AEP (m)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia

Location

Map sheet location

N

500 1,000 1,500 m

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 5a
Predicted flooding, existing – 10% AEP depth

COMPILED: Hydrologia	DATE: 19/06/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 05.pdf			
DOCUMENT NAME: J0100152 Map 03.qgz				

Legend

Proposed infrastructure

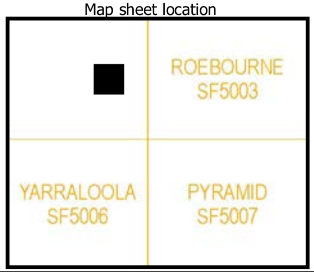
Model domain

0.25 m water level contours (m)

Velocity 10% AEP (m/s)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery, 250K - Geoscience Australia
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia



N

500 1,000 1,500 m

WRS Bioproducts

Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 5b
Predicted flooding, existing – 10% AEP velocity

COMPILED: Hydrologia	DATE: 19/06/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 05.pdf			
DOCUMENT NAME: J0100152 Map 03.qgz				

Legend

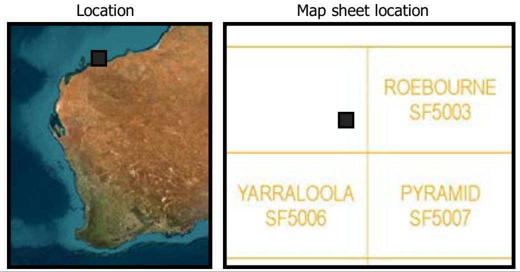
Proposed infrastructure

Model domain

0.25 m water level contours (m)

Depth 1% AEP (m)
<= 0.1
0.1 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 - 3.5
> 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia



N

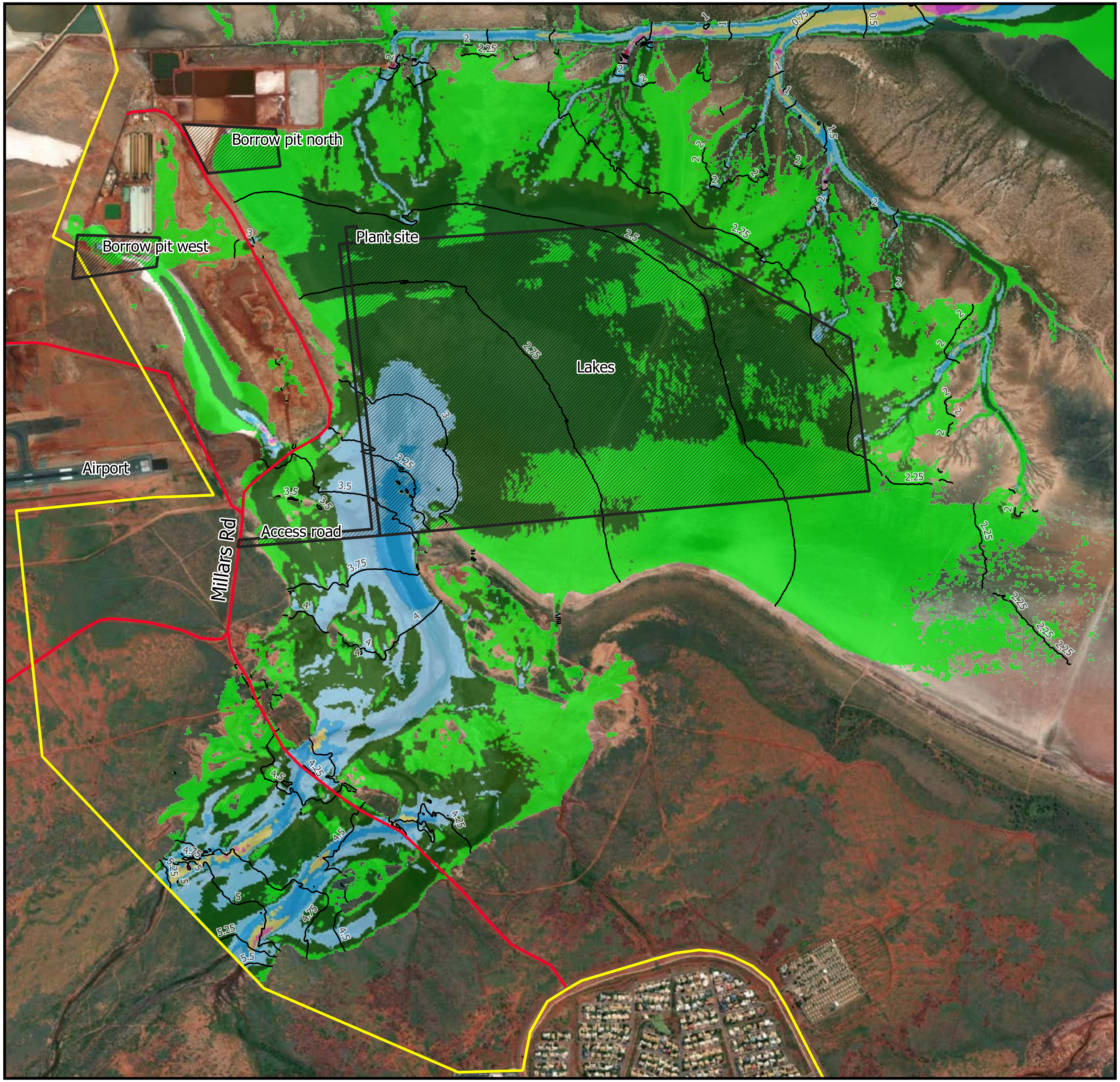
500 1,000 1,500 m

WRS Bioproducts Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 6a
Predicted flooding, existing – 1% depth

COMPILED: Hydrologia	DATE: 19/06/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 06.pdf			
DOCUMENT NAME: J0100152 Map 04.qgz				



Legend

- Proposed infrastructure
- Model domain
- 0.25 m water level contours (m)

Velocity 1% AEP (m/s)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia

Location

Map sheet location

N

500 1,000 1,500 m

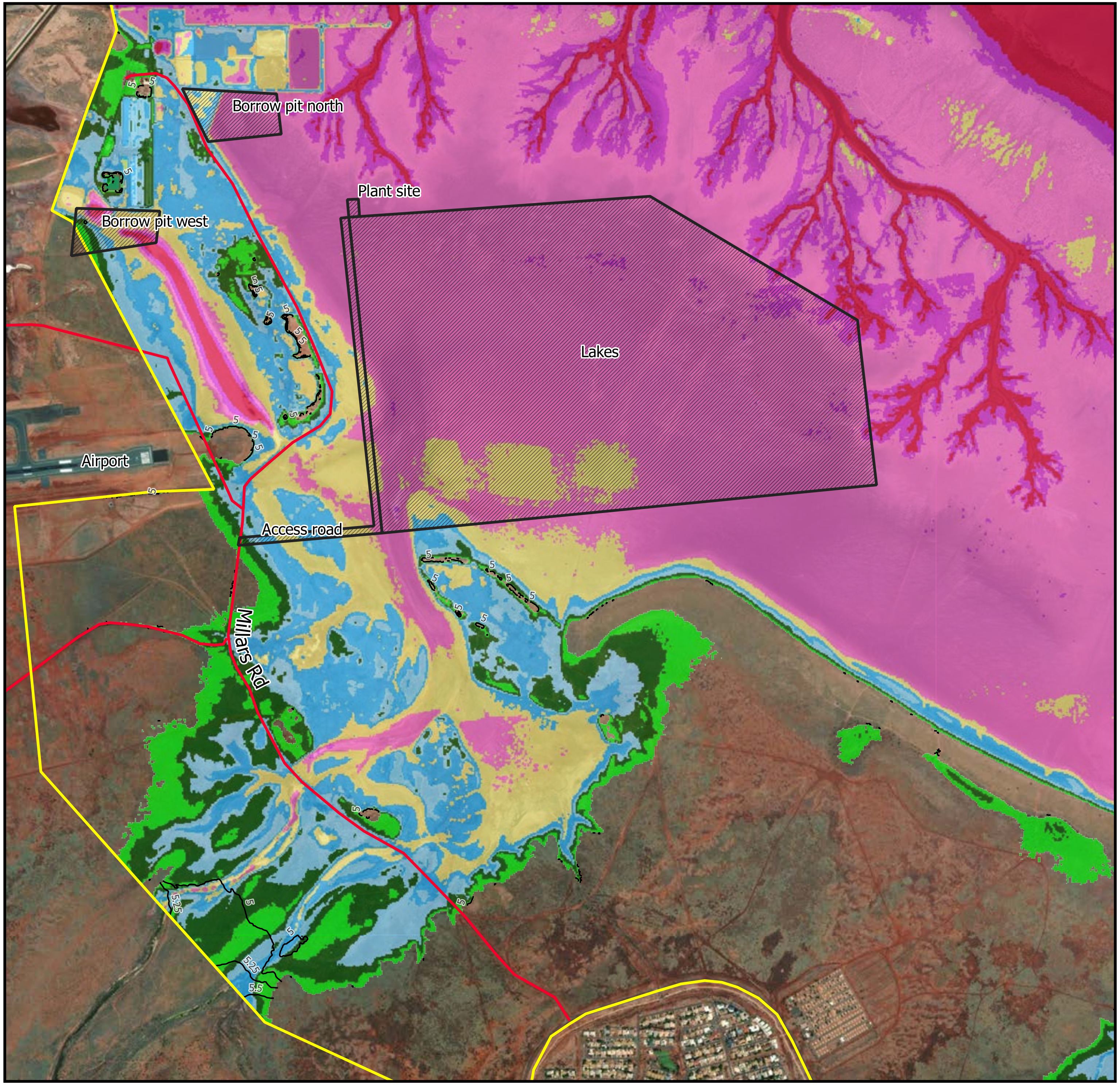
WRS Bioproducts

Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 6b
Predicted flooding, existing – 1% velocity

COMPILED: Hydrologia	DATE: 19/06/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 06.pdf			
DOCUMENT NAME: J0100152 Map 04.qgz				



Legend

Proposed infrastructure

Model domain

0.25 m water level contours (m)

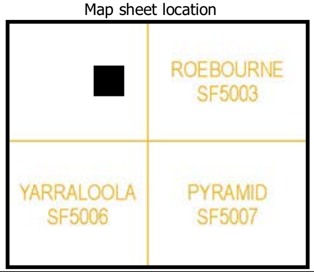
Depth 1% AEP (m)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia

Location

Map sheet location



N

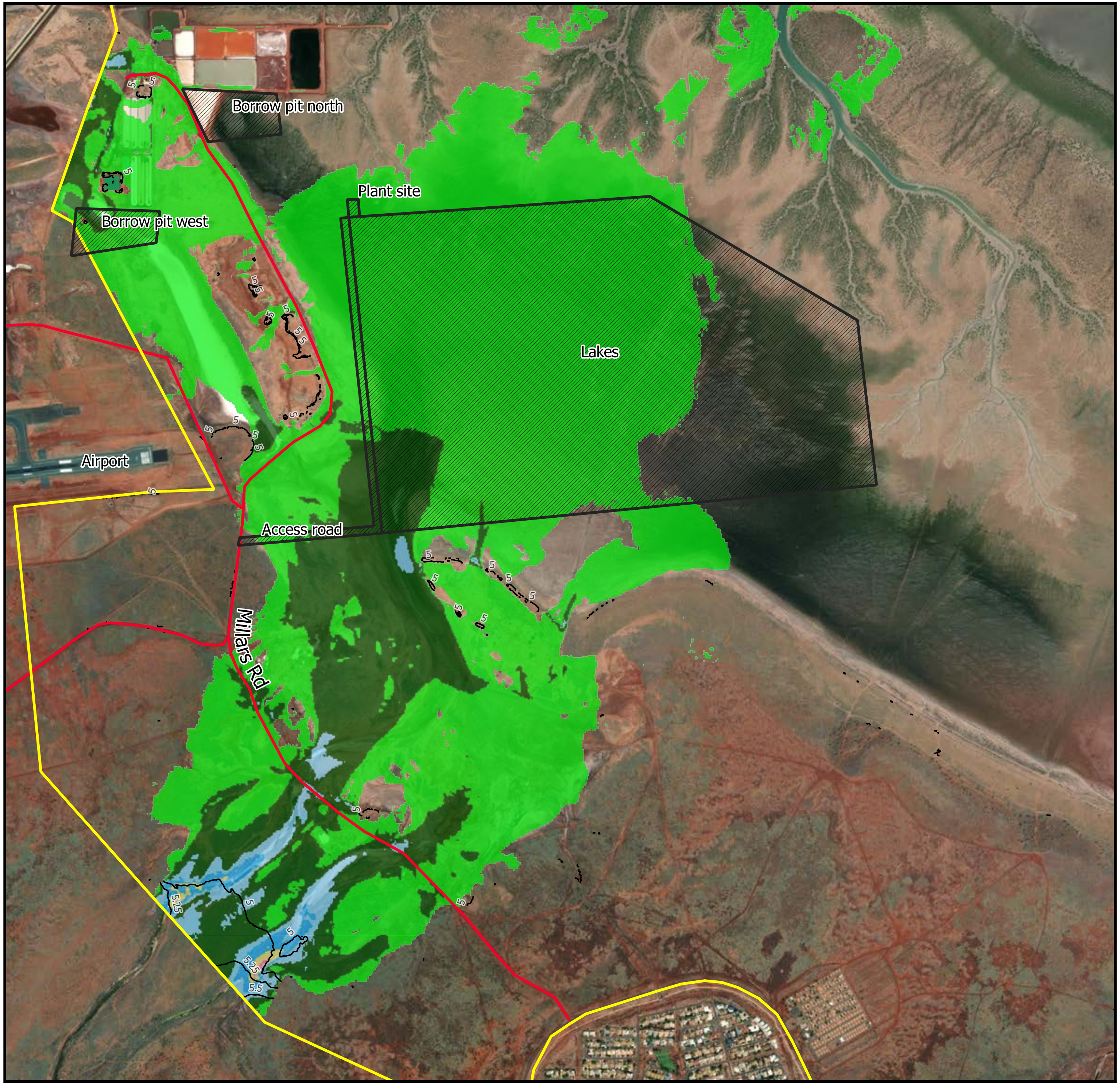
500 1,000 1,500 m

WRS Bioproducts Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 7a
Predicted flooding, existing – 1% AEP, 4.9 m AHD storm surge depth

COMPILED: Hydrologia	DATE: 31/08/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 07.pdf			
DOCUMENT NAME: J0100152 Map 08.qgz				



Legend

Proposed infrastructure

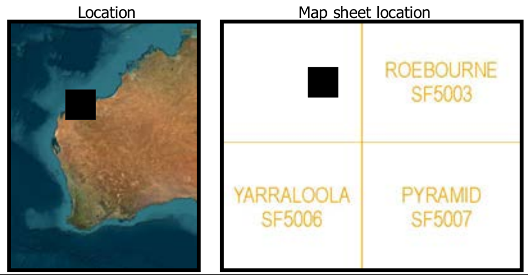
Model domain

0.25 m water level contours (m)

Velocity 1% AEP (m/s)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery, 250K - Geoscience Australia
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia



N

500 1,000 1,500 m

WRS Bioproducts Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 7b
Predicted flooding, existing – 1% AEP, 4.9 m AHD storm surge velocity

COMPILED: Hydrologia	DATE: 31/08/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 07.pdf			
DOCUMENT NAME: J0100152 Map 08.qgz				

4.3 Flooding with Stage 1 layout

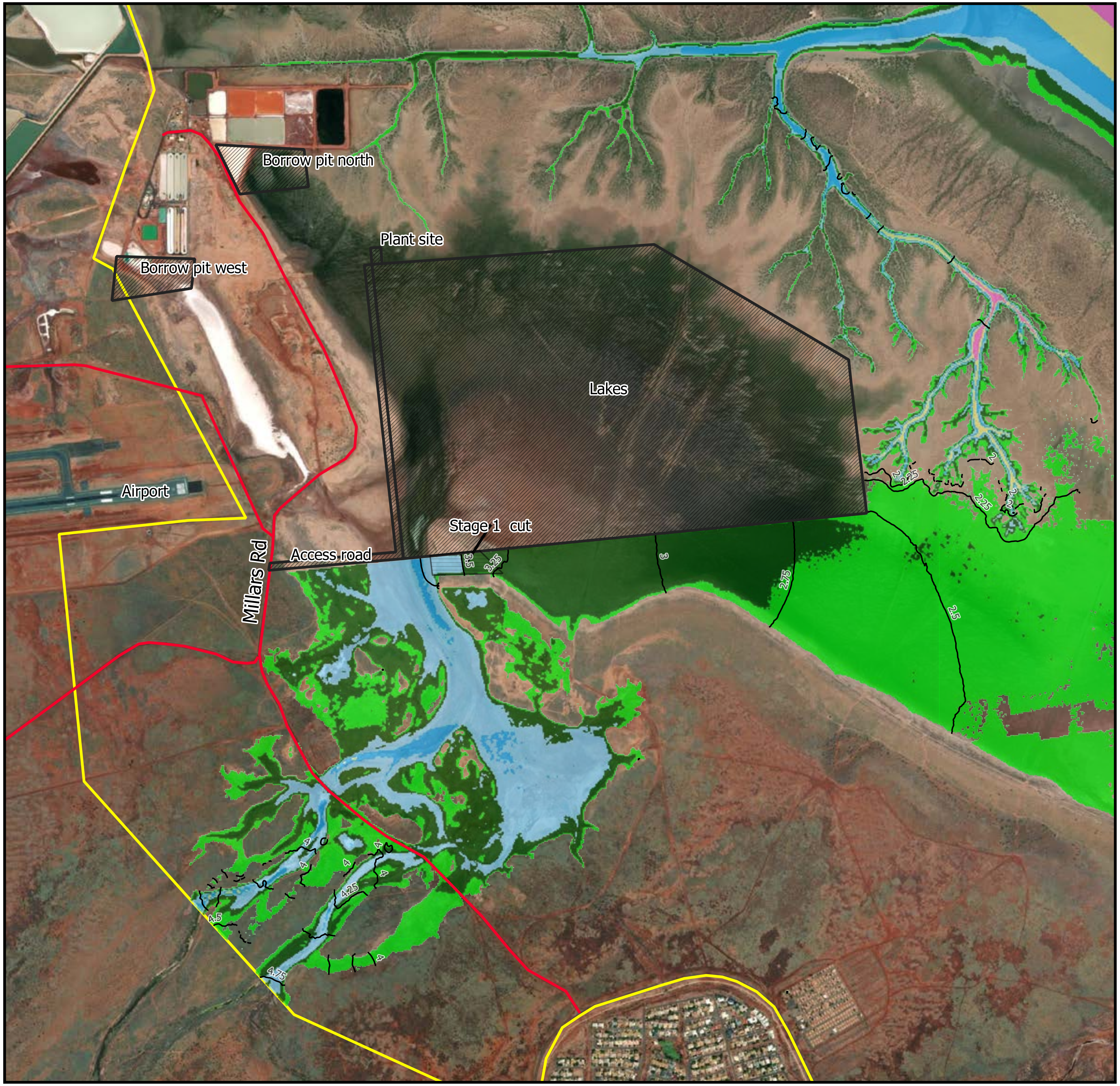
Predicted peak flood depth, velocity and water level contours for the proposed Stage 1 works for the 10% AEP event are shown in Figure 8.

The intent of this stage is to temporally allow a flood to be conveyed south of the ponds until the full area of cut associated with the preferred site layout can be implemented. For this scenario it was assumed that the road and pond embankment were acting as a levee, blocking 7 Mile Creek flow to the north.

Stage 1 is expected to be in place for two to five years. The average chance of receiving a 10% AEP event over this period varies from approximately 20% to 40%.

The modelling indicates that the 10% APE flow will pass through the 2 ha area of cut at peak velocities up to 1.5 m/s. This is within the range seen for the existing environment. In addition, the cut area will be into rock or rocky material so is expected to be resistant to scour. Accordingly, scour risk is low for this option.

Peak water levels upstream of the area of cut reach 3.8 m AHD with this option. This is within the design operating range for the final layout of the preferred option and does not pose a flood risk to the airport nor surrounding urban or industrial infrastructure.



Legend

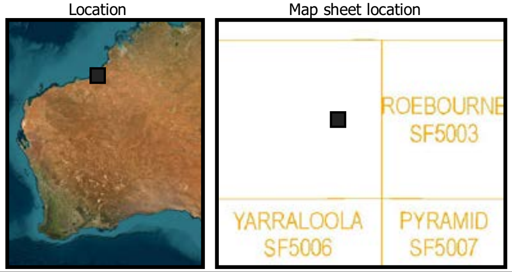
Proposed infrastructure

Model domain

0.25 m water level contours (m)

Depth 10% AEP (m)
- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia



N

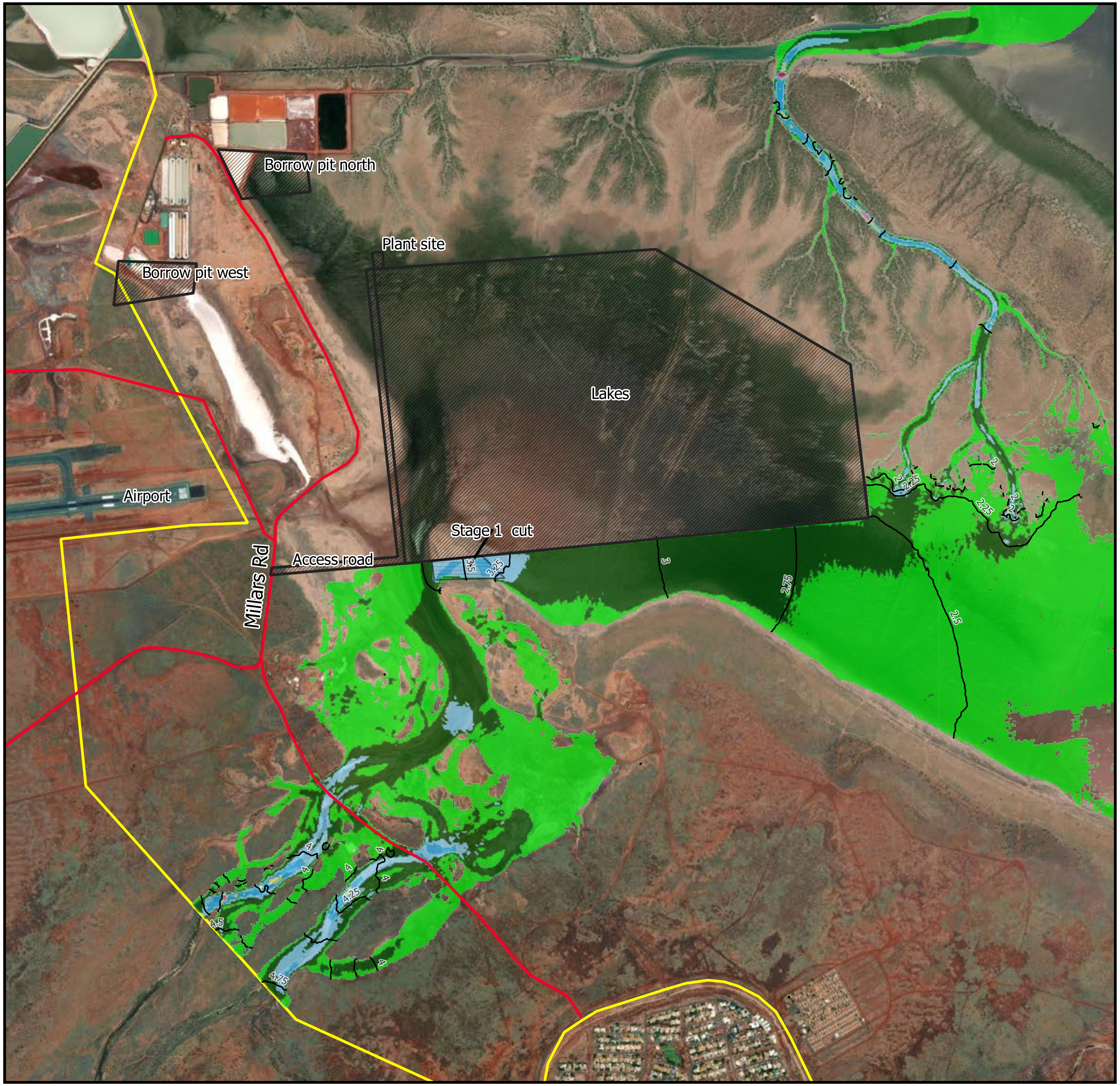
500 1,000 1,500 m

WRS Bioproducts Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 8a
Predicted flooding, Stage 1 – 10% AEP depth

COMPILED: Hydrologia	DATE:23/10/22023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 08.pdf			
DOCUMENT NAME: J0100152 Map 05.qgz				



Legend

Proposed infrastructure

Model domain

0.25 m water level contours (m)

Velocity 10% AEP (m/s)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia

N

500 1,000 1,500 m

WRS Bioproducts Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 8b
Predicted flooding, Stage 1 – 10% AEP velocity

COMPILED: Hydrologia	DATE: 23/10/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 07.pdf		
DOCUMENT NAME: J0100152 Map 05.qgz			

4.4 Flooding with the preferred site layout

Predicted peak flood depth, velocity and water level contours with the preferred site layout (SK-084) and no tailwater are shown for the 10% and 1% design events in Figures 9 and 10. Results for the storm surge scenario (4.9 m AHD tailwater) are shown in Figure 11.

Predicted difference in peak flood depth and velocity is mapped in Figure 12 for the 1% AEP event with no tailwater. Data shows predictions for the preferred scenario minus existing conditions. A positive value indicates proposed works lead to an increased in peak depth/velocity. A negative value shows a decline. The area of the lakes are flood free for the preferred scenario so are not shown on this difference mapping.

With the preferred site layout, the access road and southern lake embankment act as a levee, blocking flow from 7 Mile creek toward the north. Flow is diverted to the east, returning to the estuary drainage system east of the lakes.

Peak water levels at the creek outlet increase with the preferred site layout compared to existing conditions - by up to approximately 0.2 – 0.7 m for the 10% AEP event and 0.5 – 1.2 m for the 1% AEP event. This corresponds to peak water levels of 3.7 – 4.0 m AHD for the proposed scenario for the 1% AEP event. The increased water level is consistent with existing patterns of inundation in the area resulting from flood flows and tidal movement and does not result in increased flood risk to the airport nor surrounding urban or industrial infrastructure. Accordingly, it is considered that the proposed works will not adversely affect the flood characteristics nor hydrology of the area.

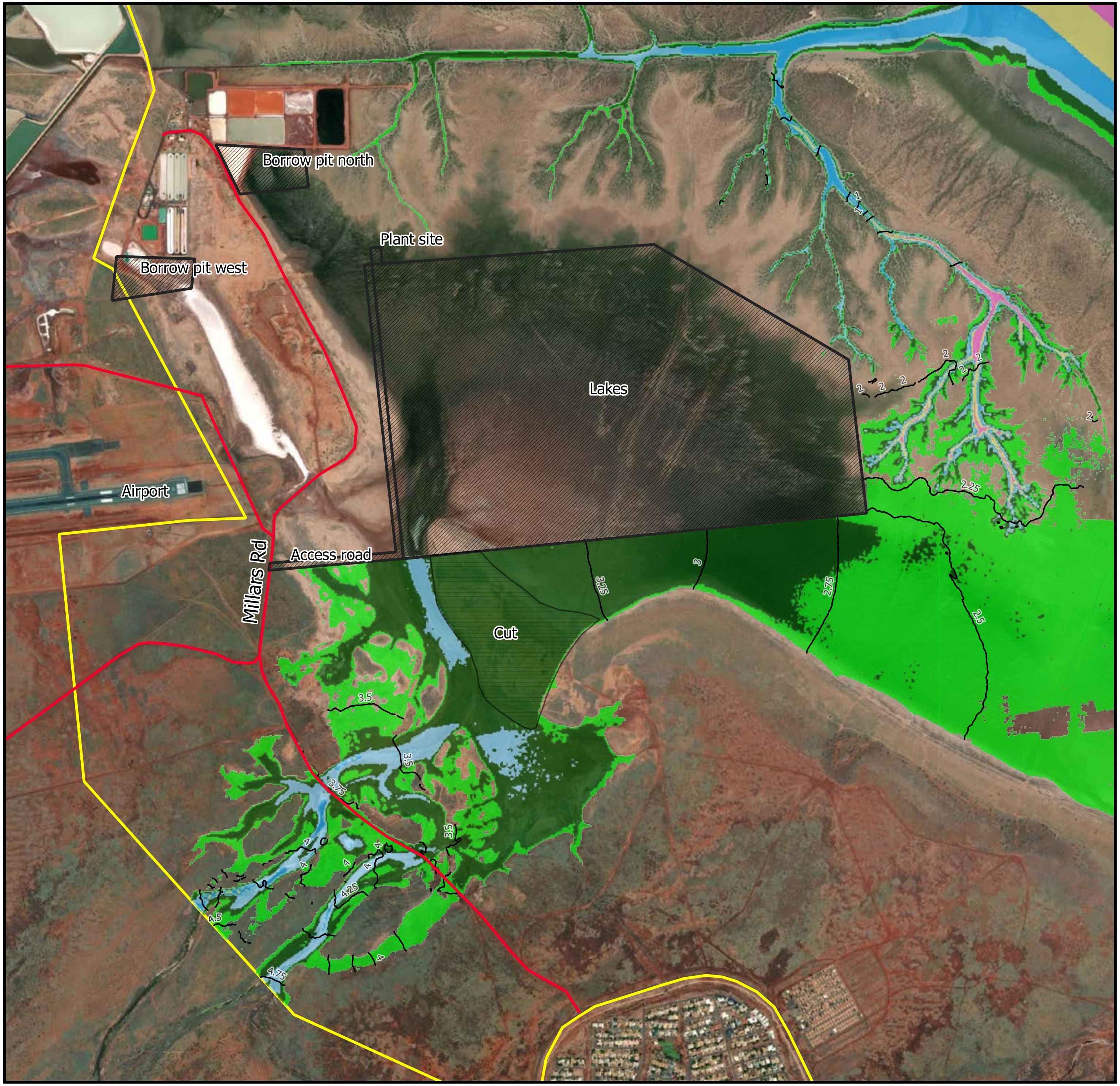
Peak flow velocities reduce in the main 7 Mile Creek flow path upstream of the lakes toward Millars Road decrease due to the effects increased water depths at the point where the creek is diverted east by the access road and lake embankment. However, velocities along the lake embankment to the east increase compared to the broad spreading flow seen in the existing situation due to a constricted flow path in this area. Even, so velocities still only reach the peaks predicted for the existing scenario at the southeast corner of the proposed lakes – 1.0 – 1.2 m/s for the 10% AEP event and 1.7 - 2.0 m/s for the 1% AEP event. There is limited scour evident (based on aerial imagery) in the existing floodplain. As predicted velocities for the proposed scenario are generally similar to predictions for existing, conditions, it is considered that the proposed condition does not lead to an elevated scour risk.

However, due to the chance impinging scour against the lake embankment, it is suggested that parts of the southern edge of the lake embankment are protected from scour. This level of protection should ensure that the diverted 7 Mile Creek and downstream floodplain is stable in even large events. Areas identified for scour protection are marked on Figure 4.

The extent of impact on depth and velocity extends upstream to near the existing Millars Road alignment but does not impact the road itself. The proposed new section of Millars Road, as modelled, will be elevated and flood free in the 1% AEP event. This is a considerable improvement on the existing road alignment, sections of which are inundated in even small flood events. Impacts extend to the estuarine network east of the lakes. The noticeable impact on depths extends further to the east than for velocity, largely due to model resolution. Flooding and stormwater drainage in Karratha and road infrastructure to the southwest are unaffected. Flooding resulting from 7 Mile creek in the area between the lakes and airport is eliminated.

Flood water still reaches the estuary system to the northeast of proposed lake infrastructure and tidal activity in the area is unaffected.

Results for the storm surge scenario (4.9 m AHD tailwater) show that the lakes and Millars Road are inundated. Flows from 7 Mile Creek flood across the entire floodplain area and the road and lake infrastructure has little impact on peak flood depths and velocities compared with the existing situation.



Legend

Proposed infrastructure

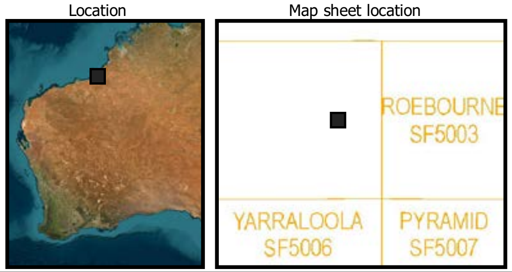
Model domain

0.25 m water level contours (m)

Depth 10% AEP (m)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia



N

500 1,000 1,500 m

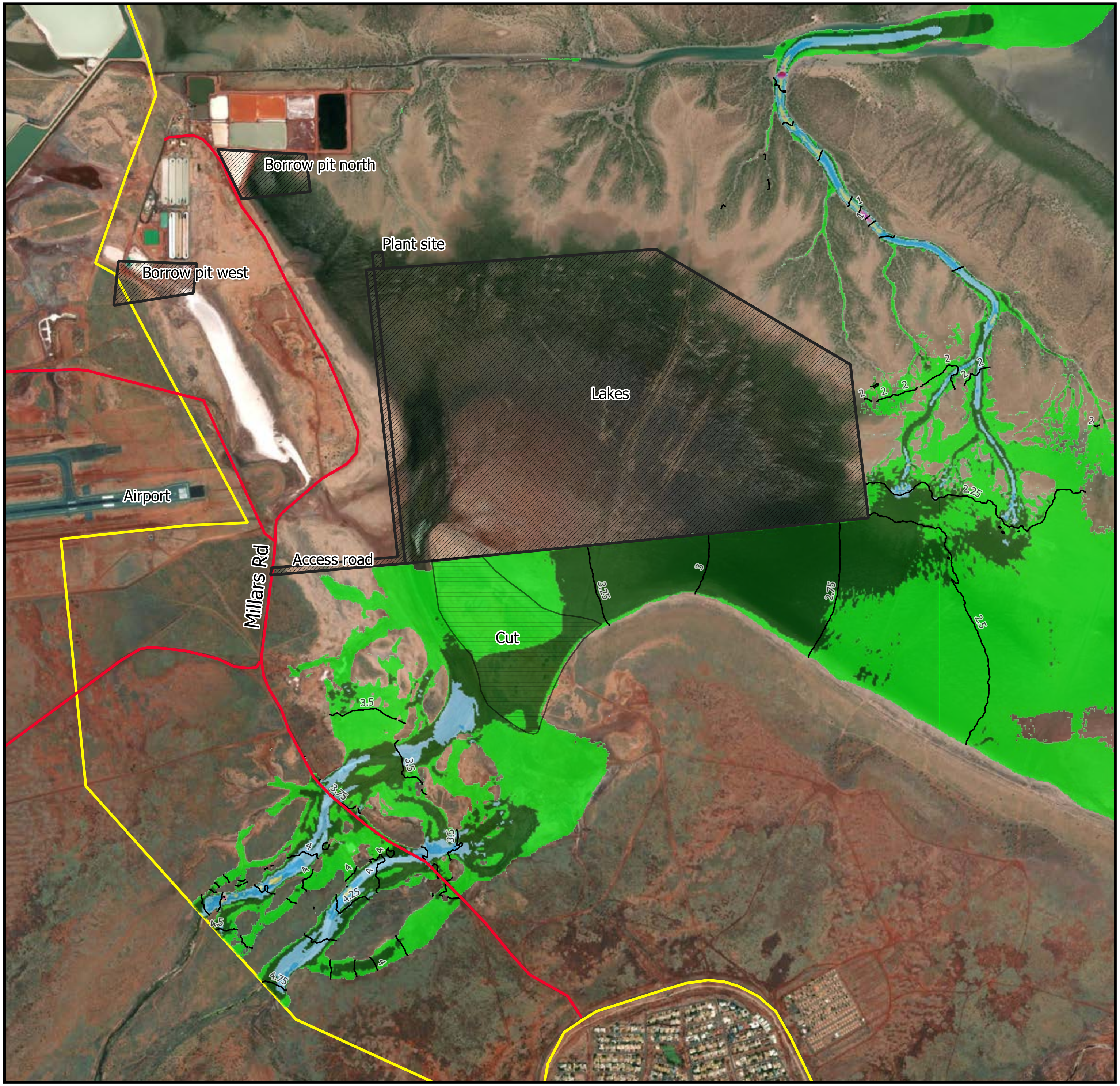
WRS Bioproducts

Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 9a
Predicted flooding, preferred option – 10% AEP depth

COMPILED: Hydrologia	DATE: 23/10/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 08.pdf			
DOCUMENT NAME: J0100152_Map 05.qgz				



Legend

Proposed infrastructure

Model domain

0.25 m water level contours (m)

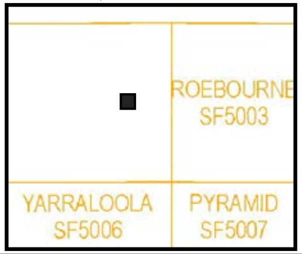
Velocity 10% AEP (m/s)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia

Location

Map sheet location



N

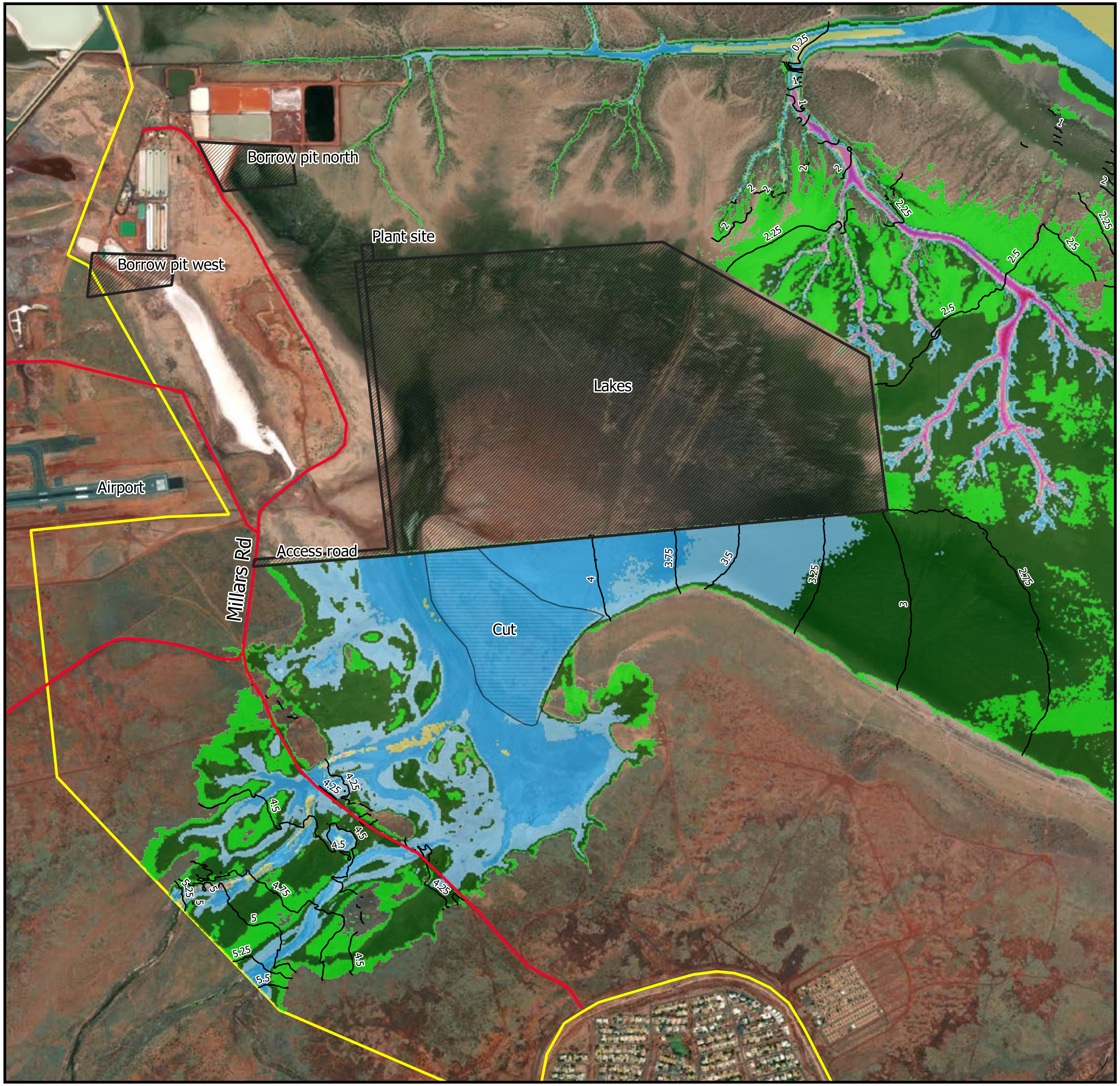
500 1,000 1,500 m

WRS Bioproducts Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 9b
Predicted flooding, preferred option – 10% AEP velocity

COMPILED: Hydrologia	DATE: 23/10/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 07.pdf			
DOCUMENT NAME: J0100152 Map 05.qgz				



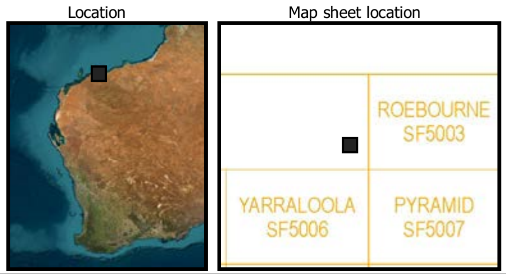
Legend

Proposed infrastructure	
Model domain	
0.25 m water level contours (m)	

Depth 1% AEP (m)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia



N

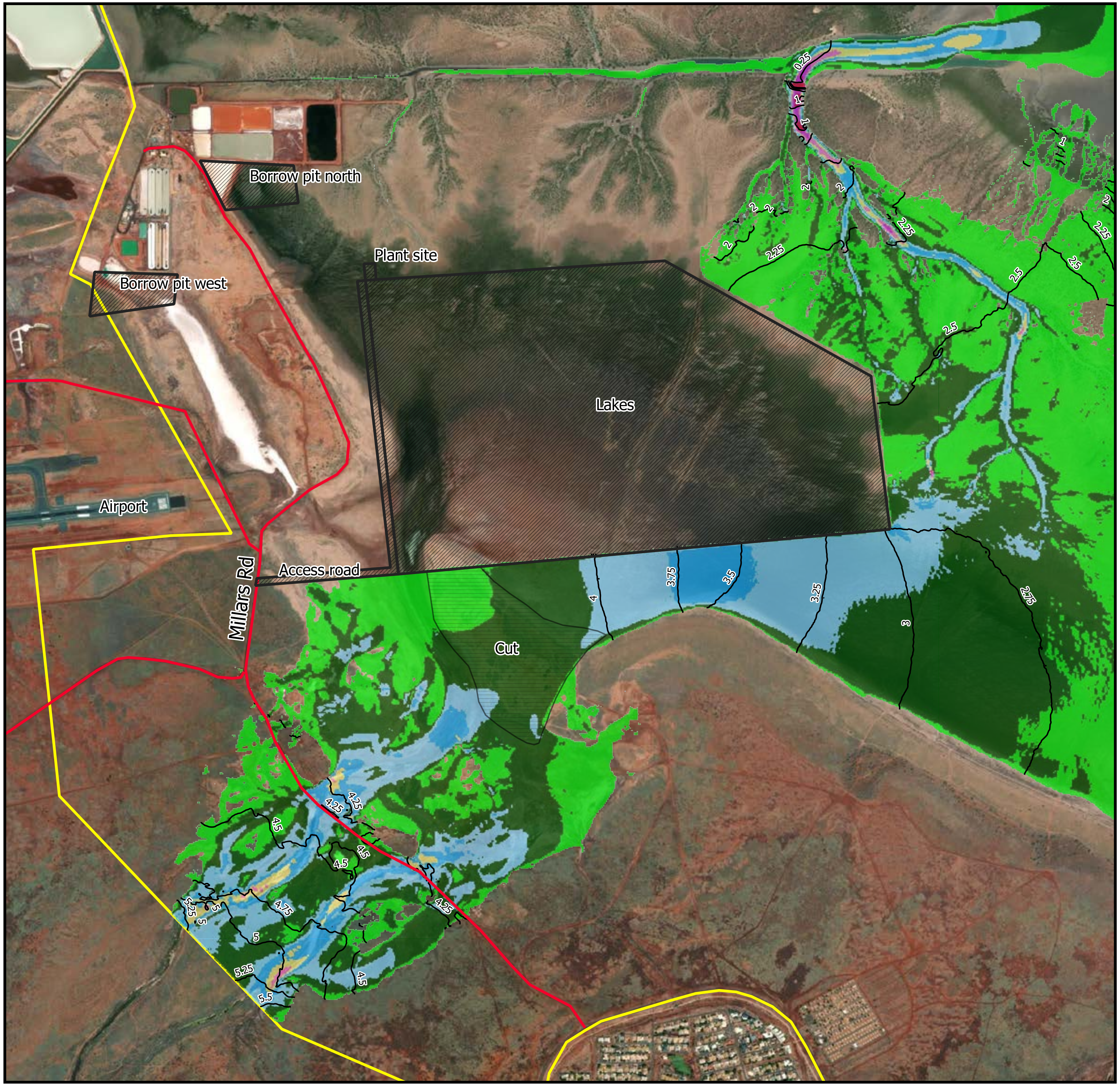
400 800 1,200 m

WRS Bioproducts
Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 10a
Predicted flooding, preferred option – 1% AEP depth

COMPILED: Hydrologia	DATE: 23/10/2023	LOCON: PERTH	A4	SCALE: 1:17,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 09.pdf			
DOCUMENT NAME: J0100152 Map 06.qgz				



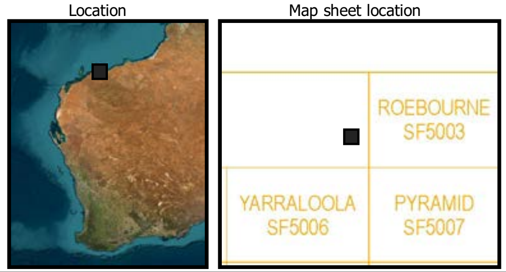
Legend

- Proposed infrastructure
- Model domain
- 0.25 m water level contours (m)

Velocity 1% AEP (m/s)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia



N

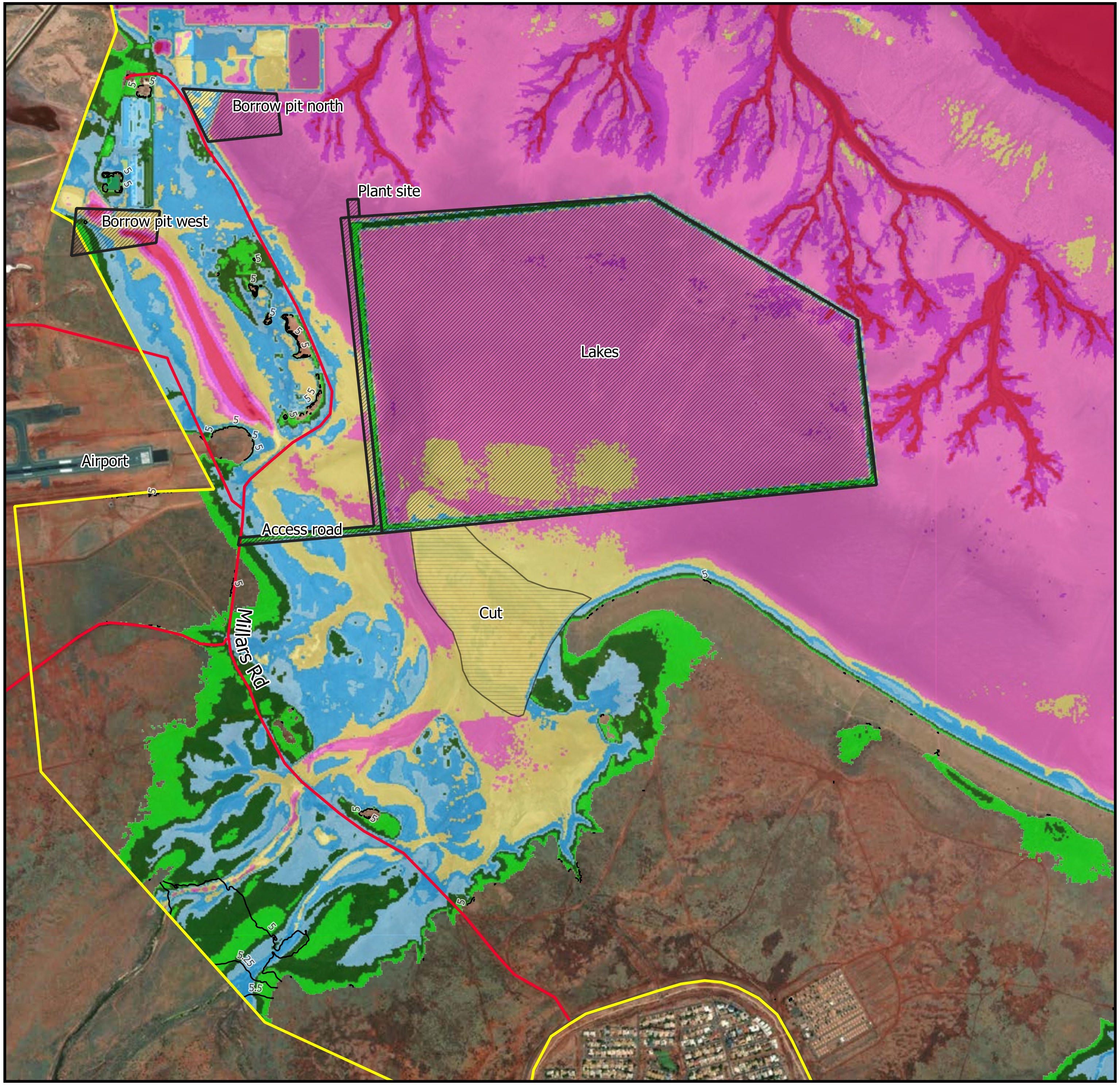
400 800 1,200 m

WRS Bioproducts
Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 10b
Predicted flooding, preferred option – 1% AEP velocity

COMPILED: Hydrologia	DATE: 23/10/2023	LOCON: PERTH	A4	SCALE: 1:17,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 09.pdf			
DOCUMENT NAME: J0100152 Map 06.qgz				



Legend

- Proposed infrastructure
- Model domain
- 0.25 m water level contours (m)

Depth 1% AEP (m)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia

Location

Map sheet location

N

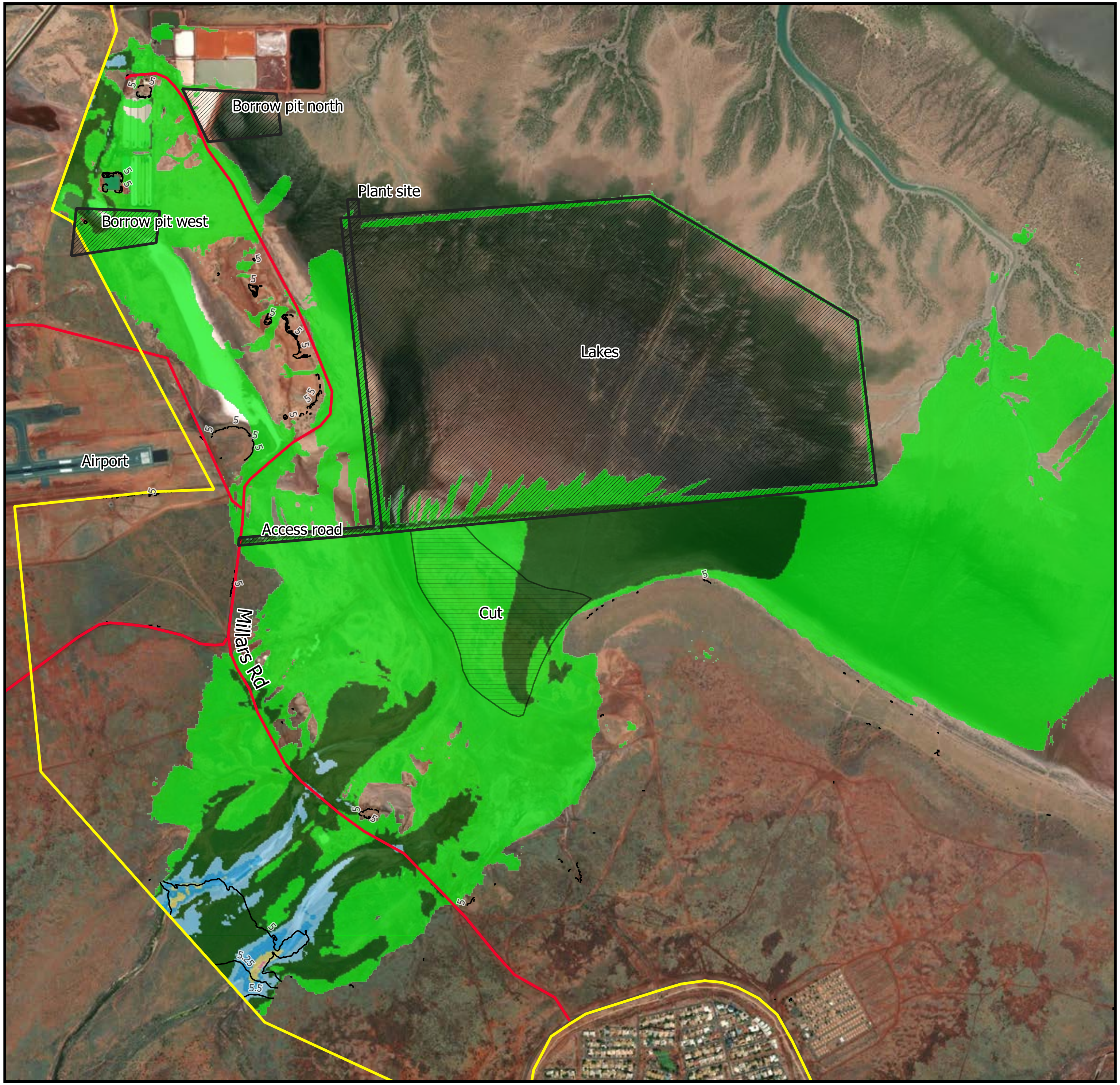
500 1,000 1,500 m

WRS Bioproducts Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 11a
Predicted flooding, preferred option – 1% AEP, 4.9 m AHD storm surge depth

COMPILED: Hydrologia	DATE: 23/10/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 10.pdf			
DOCUMENT NAME: J0100152 Map 09.qgz				



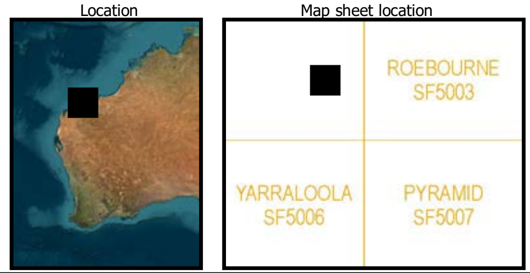
Legend

- Proposed infrastructure
- Model domain
- 0.25 m water level contours (m)

Velocity 1% AEP (m/s)

- <= 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- > 3.5

Data source:
Imagery, 250K - Geoscience Australia
Infrastructure - WRS Bioproducts
Model domain, results - Hydrologia



N

500 1,000 1,500 m

WRS Bioproducts Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 11b
Predicted flooding, preferred option – 1% AEP, 4.9 m AHD storm surge velocity

COMPILED: Hydrologia	DATE: 23/10/2023	LOCON: PERTH	A4	SCALE: 1:22,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 10.pdf			
DOCUMENT NAME: J0100152 Map 09.qgz				

Legend

Proposed infrastructure

Model domain

Depth difference (preferred option - existing) 1% AEP (m)

- < 1
- -1 - -0.5
- -0.5 - -0.05
- -0.05 - 0.05
- 0.05 - 0.5
- 0.5 - 1
- > 1

Data source:
Imagery - ESRI
Infrastructure - WRS Bioproducts
Model domain, data - Hydrologia

N

500 1,000 1,500 2,000 m

WRS Bioproducts

Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 12a
Predicted flood difference – 1% AEP, dry depth

COMPILED: Hydrologia	DATE: 20/06/2023	LOCON: PERTH	A4	SCALE: 1:40,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 11.pdf			
DOCUMENT NAME: J0100152 Map 10.qgz				

Legend

Proposed infrastructure

Model domain

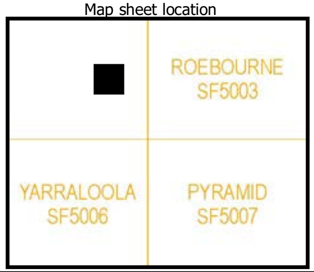
Velocity difference (preferred option - existing) 1% AEP (m/s)

- < 1
- -1 - -0.5
- -0.5 - -0.05
- -0.05 - 0.05
- 0.05 - 0.5
- 0.5 - 1
- > 1

Data source:
Imagery, 250K - Geoscience Australia
Infrastructure - WRS Bioproducts
Model domain, data - Hydrologia

Location

Map sheet location



N

500 1,000 1,500 2,000 m

WRS Bioproducts

Hydrologia

Project: WRS Bioproducts Karratha hydrology study
Job No: J0100152

Figure 12b
Predicted flood difference – 1% AEP, dry velocity

COMPILED: Hydrologia	DATE: 20/06/2023	LOCON: PERTH	A4	SCALE: 1:40,000
GDA 2020 MGA 50	PLAN No: J0100152 Fig 11.pdf			
DOCUMENT NAME: J0100152 Map 10.qgz				

5. Conclusions and recommendations

5.1 Conclusions

The proposed development allows diversion of 7 Mile Creek, management of stormwater external and internal to the lakes and road access without adversely affecting local flood risk or the hydrology of the wider estuarine area.

While the proposed diversion increases predicted flood depths in the area south of the lake embankment and new section of Millars Road this has no negative impact on surrounding rural and industrial activity, the remaining Millars Road, the airport nor on the environment. Modelling identified some areas with elevated flow velocity – scour risk in these areas can be managed using scour protection.

5.2 Recommendations

It is recommended that detailed civil design of proposed lake infrastructure and the Millars Road upgrade develop civil design details along the principals presented in this report. This includes consideration of:

- Staged levelling of the ridge south of the lake embankment;
- Scour protection along the section of Millars Road and the southern lake embankment that act as a levee and in the areas flagged as having elevated velocity;
- Setting crest levels and freeboard for the section of Millars Road and the southern lake embankment that act as a levee;
- Stormwater and tidal water management for the section of Millars Road that crosses the estuarine area from the northeastern corner of the proposed lakes; and
- Management of flood risk for the construction phase of the borrow pits.

6. References

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Appendices

Appendix A - Model parameter values

Model parameter values

Mike SHE release 2021.

Simulation specification:

- Domain covered the 7 Mile Creek catchment and local catchments contributing to the site;
- Overland flow represented using Mike SHE rain-on-grid, 50 m square grid, topography derived from the SRTM dataset;
- Mike SHE overland flow resistance:
  - Initial parameterisation:
    - Manning's M of 20;
  - Parametrised to GHD (2009) and JDA (2012):
    - Manning's M of 58.8;
- Design rainfall:
  - Initial parameterisation:
    - Design rainfall from 2016 IFD data (BoM 2022);
    - Temporal patterns: 10% AEP: 18 h, Pat09, 1% AEP: 18 h, Pat03;
  - Parametrised to GHD (2009) and JDA (2012):
    - Design rainfall from 1987 IFD data (BoM 2023);
    - Temporal patterns: 10% AEP: 3 h, 1% AEP: 3 h;
  - Potential impact of climate change has not been considered.
- Loss model:
  - 2 Layer UZ and evapotranspiration;
  - Evaporation 9.9 mm/day;
  - Detention storage:
  - Initial parameterisation:
    - 10% AEP: 30.0 mm, 1% AEP: 50.0 mm;
  - Parametrised to GHD (2009) and JDA (2012):
    - 10% AEP: 20.0 mm, 1% AEP: 24.0 mm;
  - UZ hydraulic conductivity varied spatially based on Geoscience Australia shallow geology mapping (GA 2012): 10% and 1% AEP: 0.5, 1.5, 5.0, 1.0, 15 mm/h.

Mike 21 hydraulic model

Software:

Mike 21 FM release 2021.

Simulation specification:

Mike 21 flexible mesh.

The model domain covered the area of interest and for sufficient distance up and downstream to allow impacts to be assessed and boundaries to be set. The model was constructed to allow comparison between scenarios (i.e., existing conditions and proposed options). Built infrastructure and other topographic features not characterised in the topographic data are not specifically represented.

The following key parameter values were adopted:

- Flexible mesh (10 m^2 maximum element size) derived from the Landgate topographic data and proposed design details; other constructed.
- Drying depth of 0.005 m and wetting depth of 0.01 m; and
- Resistance (Manning's M) was held constant across the domain at M = 40.0 for flood simulation, 20 for tidal simulations;
- Boundaries:
    - Dry scenario - Upstream boundary – hydrographs from the hydrology model for 10% and 1% AEP, downstream boundary – constant velocity, initial water level 0 m AHD; and
    - Storm surge scenario - Upstream boundary – hydrographs from the hydrology model for 10% and 1% AEP, downstream boundary – constant velocity and free outflow, initial water level 4.9 m AHD.