



# East Kalgoorlie Solar and Wind Farm Surface Water Assessment

Prepared for:

**Northern Star Resources Ltd**

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AQ2 Pty Ltd  
Ground Floor, 1 Howard Street  
Perth WA 6000 Australia  
Tel +61 8 9322 9733  
[www.aq2.com.au](http://www.aq2.com.au)

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<b>Prepared by:</b>	AQ2 Pty Ltd ABN: 38 164 858 075	<b>Prepared for:</b>	Northern Star Resources Ltd ABN: 43 092 832 892
<b>T:</b>	(08) 9322 9733	<b>T:</b>	(08) 9080 6654
<b>E:</b>	tamar.haviv@aq2.com.au	<b>E:</b>	BmcGillvary@nsrltd.com
<b>W:</b>	www.aq2.com.au	<b>W:</b>	www.nsrltd.com
<b>Author:</b>	Tamar Haviv		
<b>Reviewed:</b>	Mark Nicholls		
<b>Approved:</b>	Mark Nicholls		
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## 1. INTRODUCTION

### 1.1 Background

Northern Star operates gold mines within the Goldfields region of Western Australia, including the Kalgoorlie Production Centre, which consists of the KCGM Operations, Carosue Dam Operations and Kalgoorlie Operations. Northern Star is proposing to develop a solar and wind farm in proximity to the KCGM Operations to the east of Kalgoorlie to support power supply for its surrounding operations. As part of the project development (East Kalgoorlie Solar and Wind Farm; EKWF), a surface water assessment of the proposed EKWF area is required to identify any potential surface water risks due to the project and recommend any management measures to reduce identify risks.

### 1.2 Project Layout

The Project layout is within a development envelope of approximately 23km<sup>2</sup>, as shown in Figure 1.1 and referred to as the EKWF development envelope. Within the development envelope, disturbance corridors are proposed which cover a total of 33 wind turbine stations, each spaced several hundred metres apart, and a solar farm with a footprint area of about 2km<sup>2</sup>. Each wind turbine location consists of the wind turbine foundation footprint, plus an adjacent cleared laydown area. An access track will be constructed between the network of wind turbine footprints, with cabling connecting the wind turbines and the solar farm also following the access track alignment.

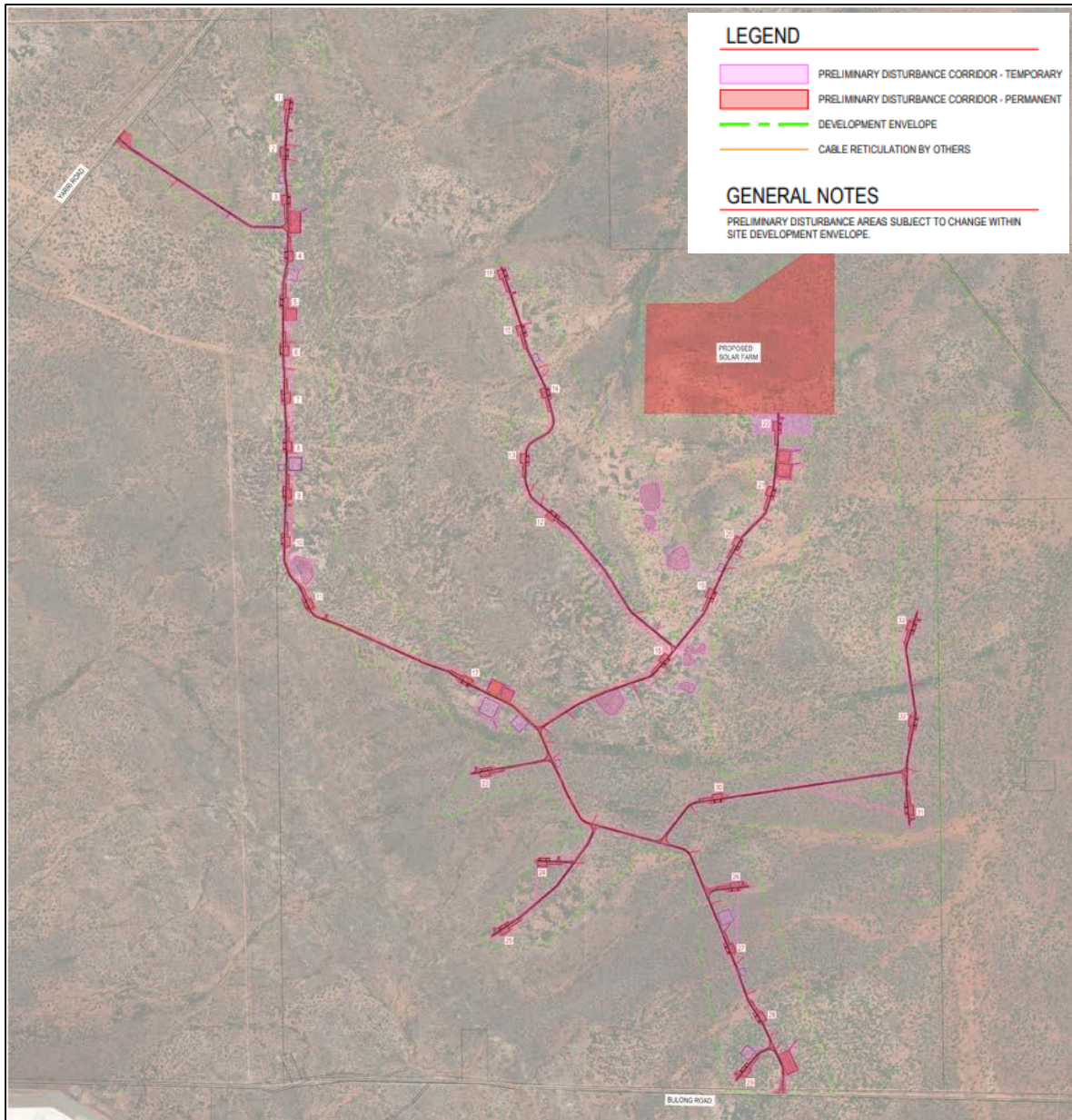


Figure 1.1 Northern Star Solar and Wind Project Layout (source: Icubed Consulting)

## 2. HYDROLOGY OVERVIEW

### 2.1 Regional Hydrology

Project is located within the Goldfields Region of Western Australia, approximately 15km northeast of Kalgoorlie (Figure 2.1). The site lies within the overall Reaside-Ponton catchment which is an extensive regional catchment. The Project is located close to the top of this catchment divide with runoff draining to the north towards a salt lake system located adjacent to Kanowna. Potentially, this lake system could overflow and report to the east to Lake Yindarigooda, a large ephemeral salt lake.

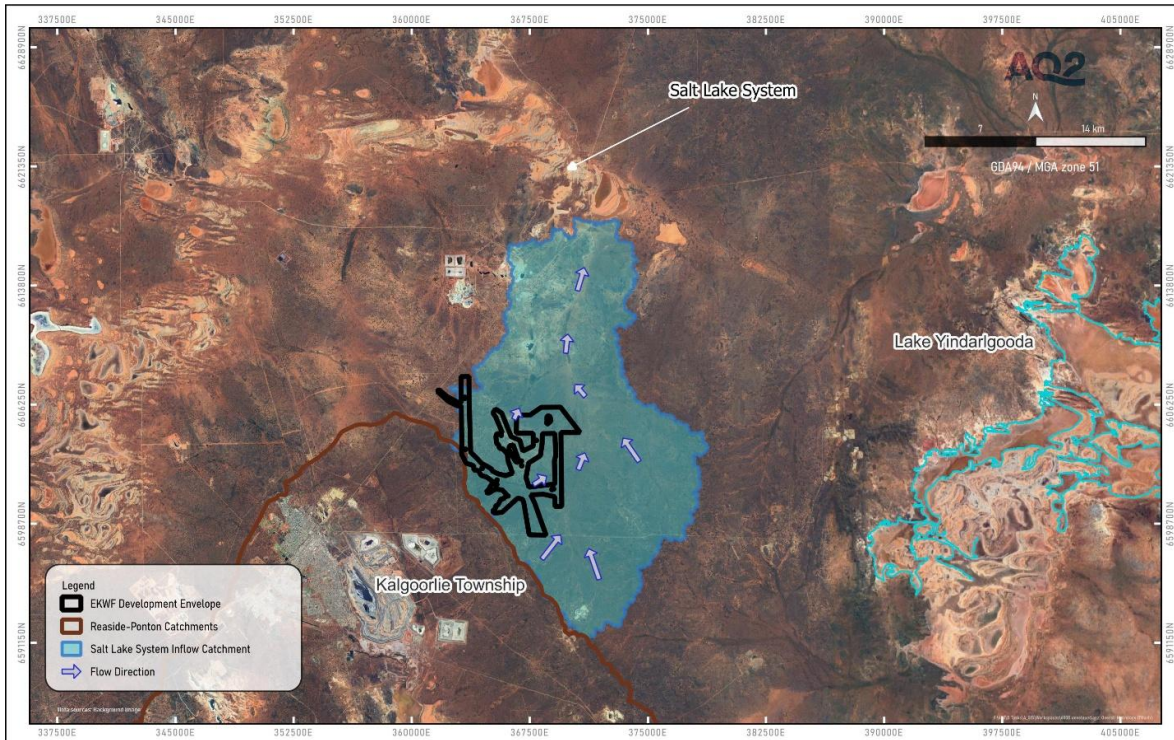


Figure 2.1 Regional Hydrology

### 2.2 Project Hydrology

The Project is located at the foot of an elevated range to the west, with the highest point in the range adjacent to the project being 410mRL, compared to the typical elevation of the Project being between 360mRL and 400mRL. East of the project, there is a drainage channel (called Main Drainage Channel for the purposes of this report) which would convey runoff from the Project area northwards (refer Figure 2.2). Terrain data and satellite imagery indicate that several smaller drainage paths traverse the proposed project location, draining west to east to the Main Drainage Channel. The catchment area of the Main Drainage Channel is shown in Figure 2.2.

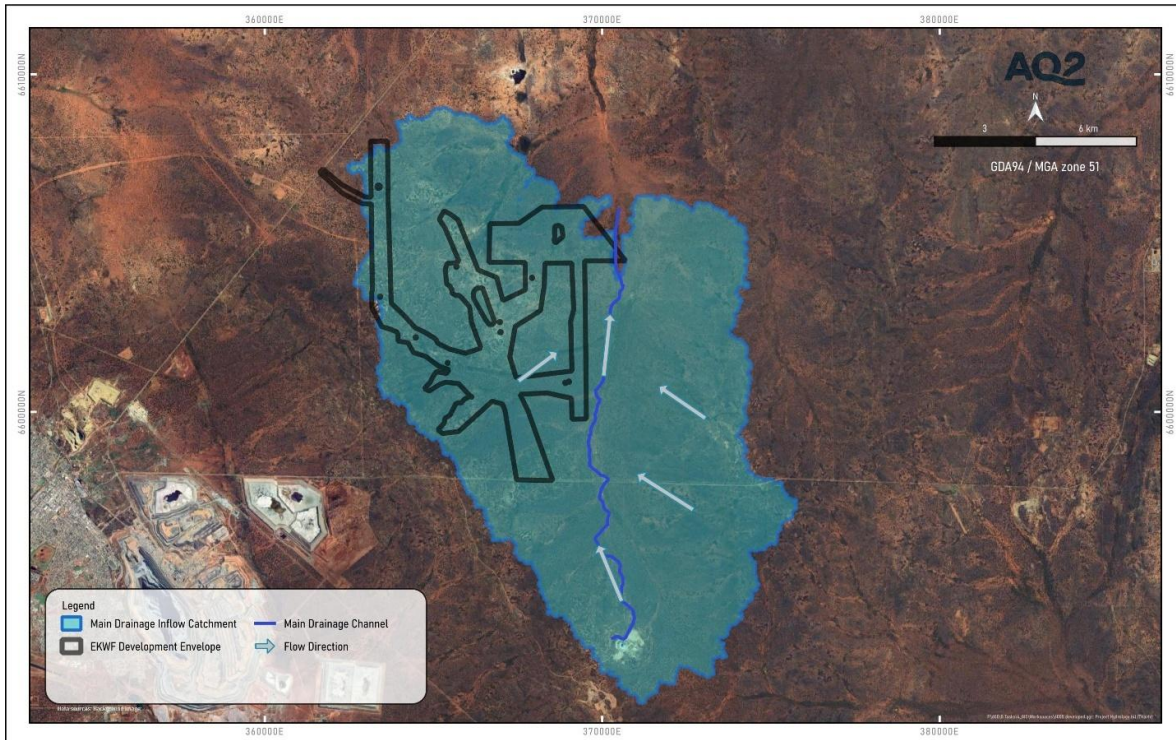


Figure 2.2 Project Hydrology

### 3. CLIMATE

The Project area is classified as having a Köppen, climate classification of arid climate with dry, hot summers and cold winters (Bureau of Meteorology (2025)). Annual rainfall can vary significantly in this area, ranging from a minimum of 100mm to a maximum of over 500mm in single year (530.8mm in 1992). The average annual rainfall at Kalgoorlie-Boulder Airport (BoM Site number 012038) is 265.7mm, and average evaporation exceeds average rainfall in most months of the year.

#### 3.1 Design Rainfall (IFDs)

Australian Rainfall and Runoff (ARR) (Ball, et. Al 2019) recommends the use of Annual Exceedance Probability (AEP) defining flood probability, so has been adopted throughout this report. AEP is defined as the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage. This new terminology supersedes the Annual Recurrence Interval (ARI) terminology adopted in the earlier revision of ARR (Institution of Engineers, Australia 1987). The relationship between ARI and AEP is defined below:

$$AEP = 1 - \exp\left(\frac{-1}{ARI}\right)$$

For example, a 1 in 100 ARI event would occur on average once every 100 years and has 1% chance of occurring in a particular year (i.e. 1% AEP), The assessment presented in this report was based on the 1% AEP design event.

Table 3.1 IFD at Wind and Solar Farm ( 121.6201 (E), -30.701 (S))

Duration	50%	20%	10%	5%	2%	1%
5 min	4.65	7.22	9.17	11.2	14.3	16.9
10 min	6.81	10.6	13.5	16.7	21.3	25.2
15 min	8.24	12.9	16.4	20.2	25.7	30.5
20 min	9.31	14.5	18.5	22.8	29	34.3
30 min	10.9	16.9	21.5	26.5	33.7	39.8
45 min	12.6	19.5	24.8	30.4	38.6	45.5
1 hour	13.9	21.4	27.2	33.3	42.3	49.8
2 hour	17.2	26.6	33.7	41.2	52.4	61.8
3 hour	19.5	30.1	38.2	46.8	59.6	70.4
4.5 hour	21.9	34.1	43.4	53.4	68.2	80.8
6 hour	23.9	37.2	47.6	58.8	75.3	89.4
9 hour	26.8	42.2	54.3	67.5	86.9	104
12 hour	29.1	46.1	59.6	74.6	96.3	115
18 hour	32.6	52	67.8	85.6	111	133
24 hour	35.1	56.5	74	93.9	122	147
30 hour	37.1	60	79	101	131	158
36 hour	38.7	62.9	83	106	138	166
48 hour	41.3	67.3	89.1	114	149	180

Duration	50%	20%	10%	5%	2%	1%
72 hour	44.6	73	96.9	124	163	197
96 hour	46.7	76.4	101	130	171	206
120 hour	48.2	78.6	104	133	175	212
144 hour	49.2	79.9	105	135	177	215
168 hour	49.9	80.8	106	135	179	217

## 4. FLOODING ASSESSMENT

To evaluate the hydrology of the project area and assess the potential impacts of the proposed EKWF, a two-dimensional (2D) flood model was constructed.

The extent of the 2D flood model matched the provided detailed terrain data and covered the extent of the EKWF disturbance envelope. The model accounted for rainfall over the model domain plus inflows to the model domains from external catchments.

### 4.1 Hydrological Assessment

The 2D model domain compared with the catchment divides is shown in Figure 4.1. The model domain extends past the western boundary of the surface water catchment, but runoff can report to the Main Drainage Channel from catchments external to the model located to the south and east of the model domain (Catchment A). Catchment A represents an area of 90km<sup>2</sup>.

To simulate flows through the model domain, the following hydraulic assessments were completed:

- For the purposes of simplifying the model, runoff from Catchment A has all be added to the model at the Main Drainage Channel on the southern model boundary.
- The runoff from Catchment A has been estimated using the Flavell Regional Flood Frequency Procedure (Flavell, 2012), with an estimated peak 1% AEP runoff rate of 190m<sup>3</sup>/s. while accounting for potential climate change impacts as per the Australian Rainfall and Runoff Guidelines (ARR 2024). This rate was applied to the model (conservatively) as a continuous inflow rate throughout the model simulation.
- A rain-on-grid routine was run over the model domain to simulate local runoff reporting to the Main Drainage Channel. A 6-hour nested frequency storm using 1% AEP rainfall depths was used to simulate the rainfall event. To account for climate change, the Long- Term (2080 period) Medium RCP4.5 was used, as the basis for selection of the climate change multiplier for (ARR2024) for location. With a rainfall depth increased with the rainfall depths increased by 24% to account for climate change, Australian Rainfall and Runoff Guidelines (ARR 2024). A rainfall loss of 67.8% (increased by 13%).
- Catchment A and the rain-on-grid routine are applied simultaneously.

### 4.2 Surface Water 2D Model Build

A 2D flood model was developed using HEC-RAS V6.7 modelling software. A summary of the model build is as follows:

- A 50 x 50m calculation grid was used across the whole 2D model extent.
- The terrain data used in the model was provided by Northern Star (19 March 2025). A section of the Main Drainage Channel was not covered by the LiDAR data (Figure 4.2). To allow the flows through the Main Drainage Channel to be simulated, SRTM data was sourced and stitched in with the LiDAR data. The SRTM data did not have sufficient resolution to define the low flow channel of the Main Drainage Channel so the SRTM was further modified to include a nominal channel to allow Main Drainage Channel flow to be conveyed through the SRTM data section in the model. As such, the predicted flood regime characteristics within the SRTM area are not considered to be reliable but have been included in the model only to allow Main Drainage Channel flows to continue through the model domain.
- Manning's n roughness coefficient of 0.06 was adopted across the whole model domain.
- Inflow from the upstream catchment (Catchment A) was applied as a constant inflow to the model boundary as shown in Figure 4.3.

- A rain-on-grid method was used to simulate runoff for the 1% AEP nested frequency storm across the 2D model domain.
- Variable timestep was used, which is calculated internally by the model using a maximum Courant Number of 1.

### 4.3 2D Flood Model Results

1% AEP baseline flood predictions from the 2D model are presented in Figure 4.4 (flood depth) and Figure 4.5 (flood velocity).

The 1% AEP flood model predictions indicate the following:

- The flow regime across the Project is characterised by concentrated sheet flow within poorly defined drainage corridors.
- A large portion of the wind turbine network (the western branch of the network) is located close to the catchment drainage divide and is unlikely to encounter any significant drainage issues.
- The access track and cable network associated with the wind turbines cross some of the tributaries to the Main Drainage Channel. These tributaries are typically shallow (<300mm) concentrated sheetflow areas.
- The majority of the proposed wind turbine footings are located outside of areas with predicted flood depths exceeding 100mm.
- The solar farm footprint is located within an area with a low flood risk. The catchment for the shallow sheetflow drainage path shown within the solar farm footprint is within the solar farm boundary.
- The flow velocities within the area of proposed development are relatively low (typically < 1m/s) outside of the area of flooding

The extent and depth of flooding, and the velocity of floodwaters, will be decreased in runoff events associated with smaller, more frequent rainfall events.

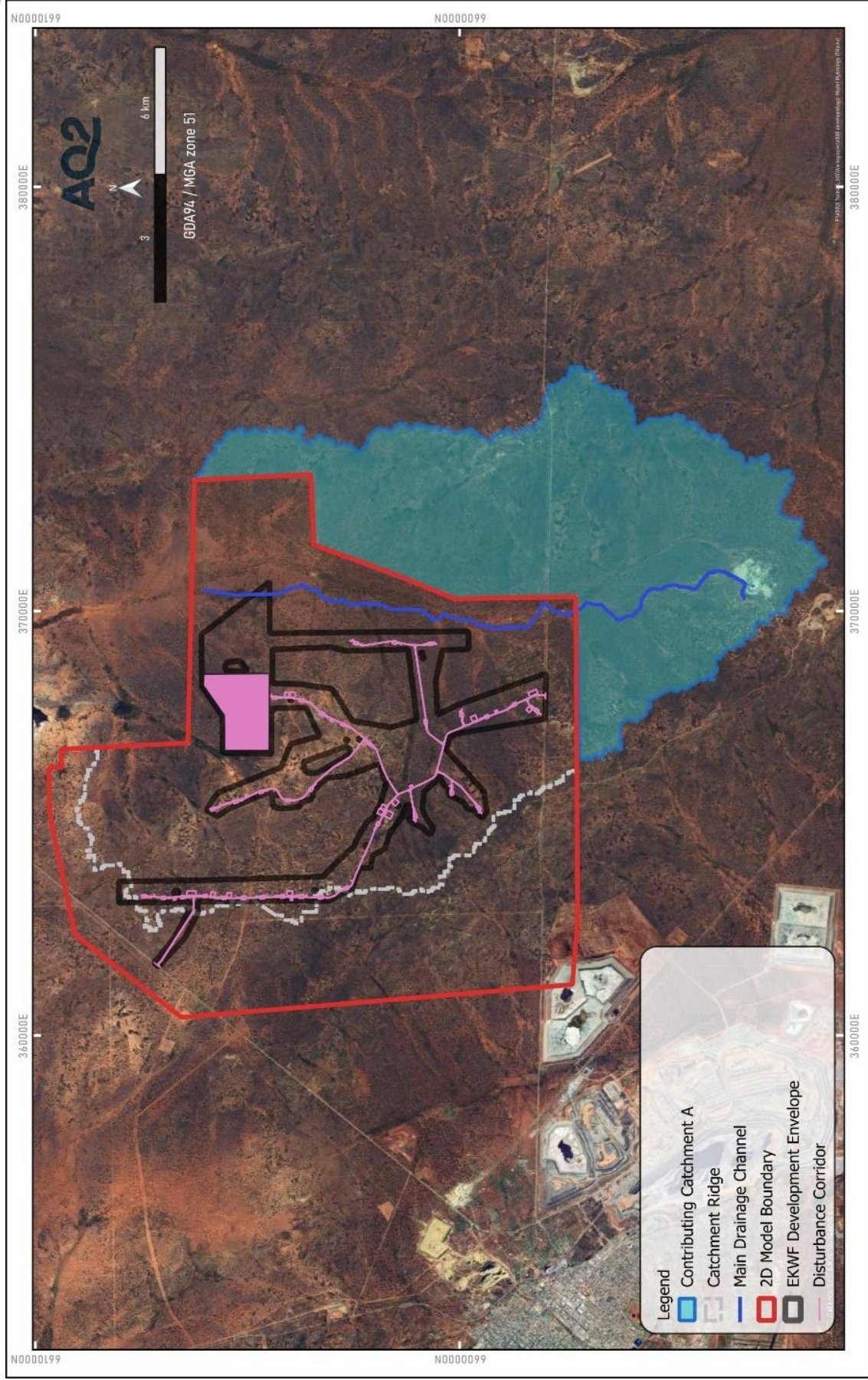


Figure 4.1 Model Contributing Upstream Catchment



Figure 4.2 Lidar and SRTM realignment location

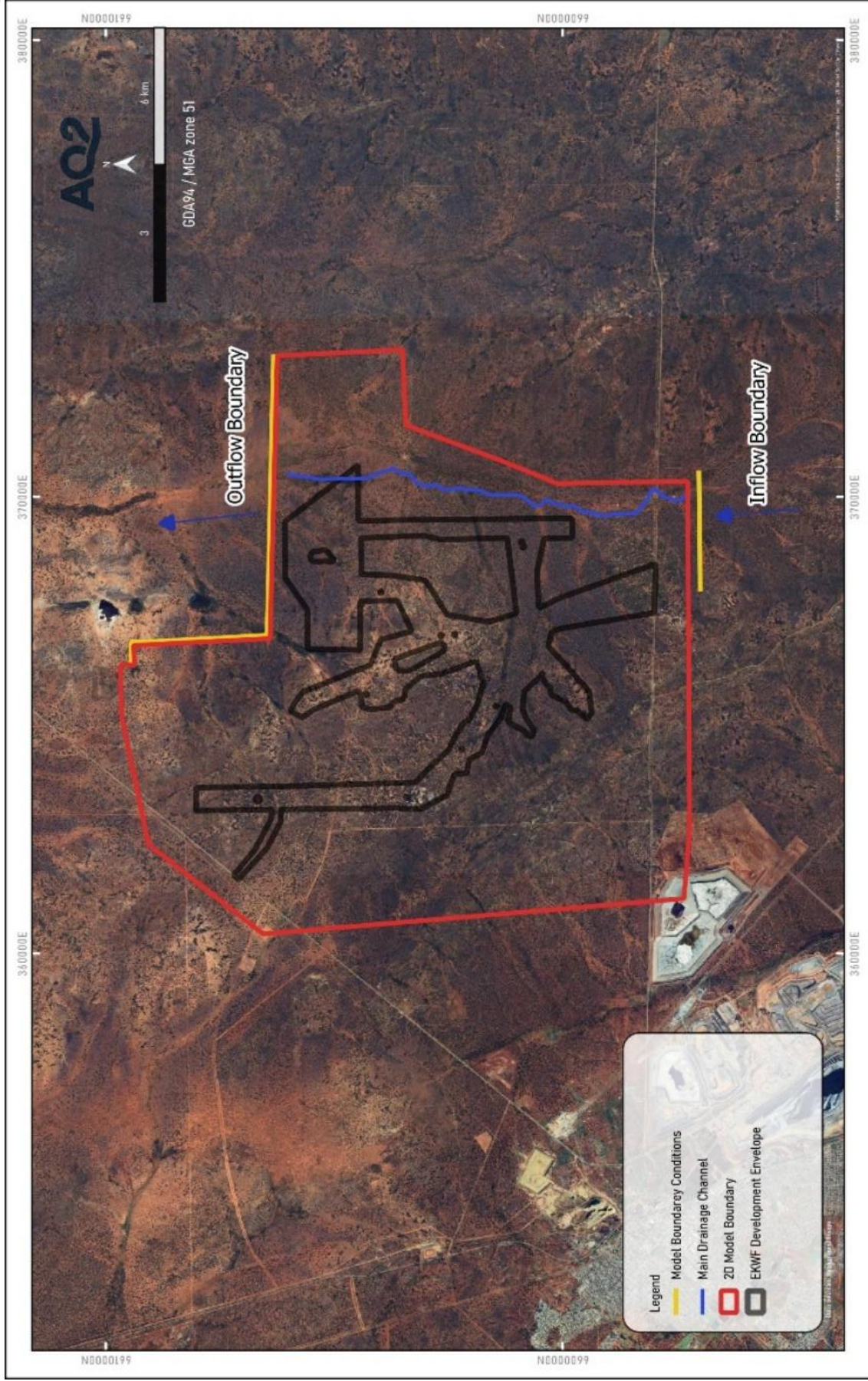


Figure 4.3 2D Model Setup

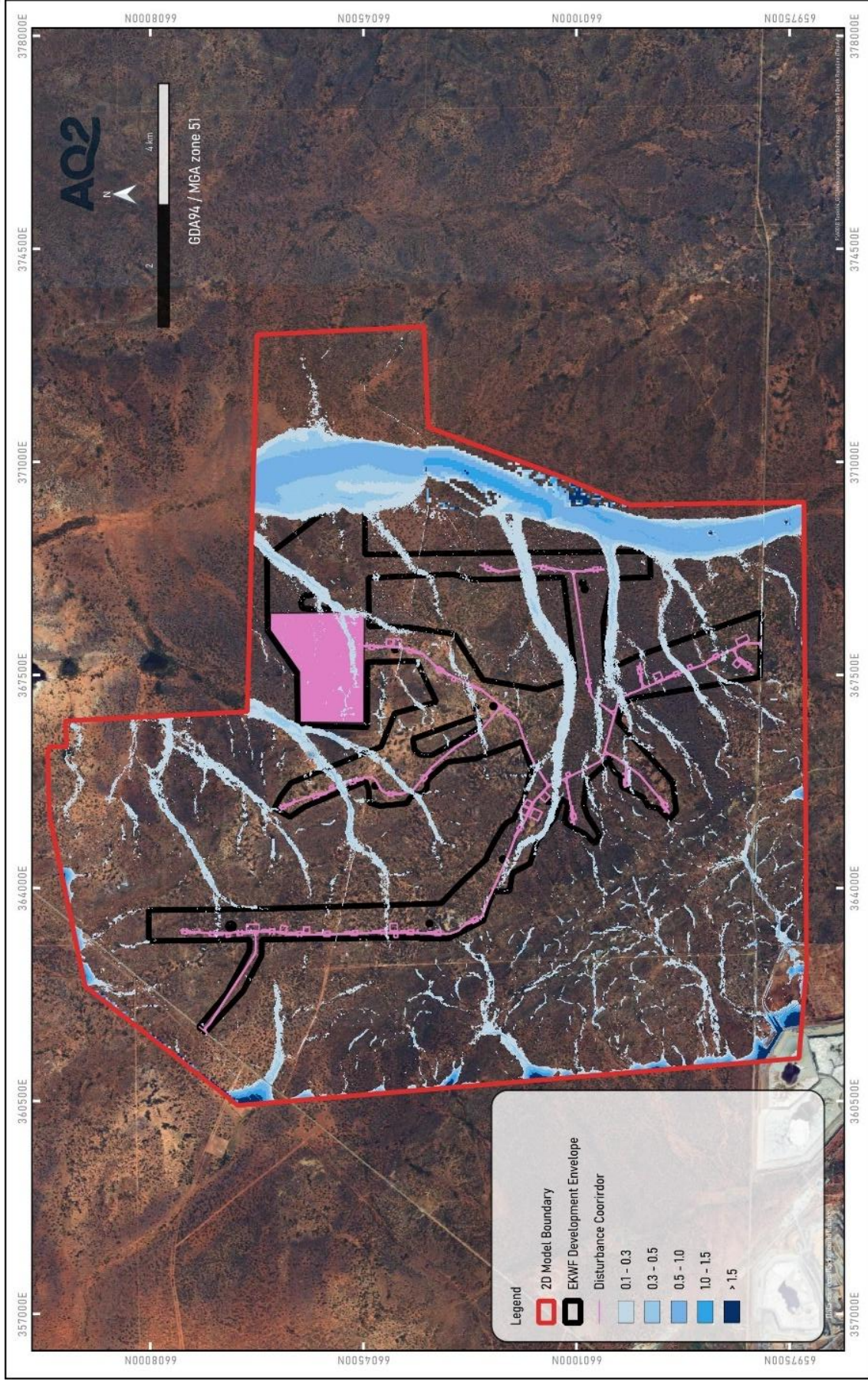


Figure 4.4 1%AEP Baseline Flood Depth

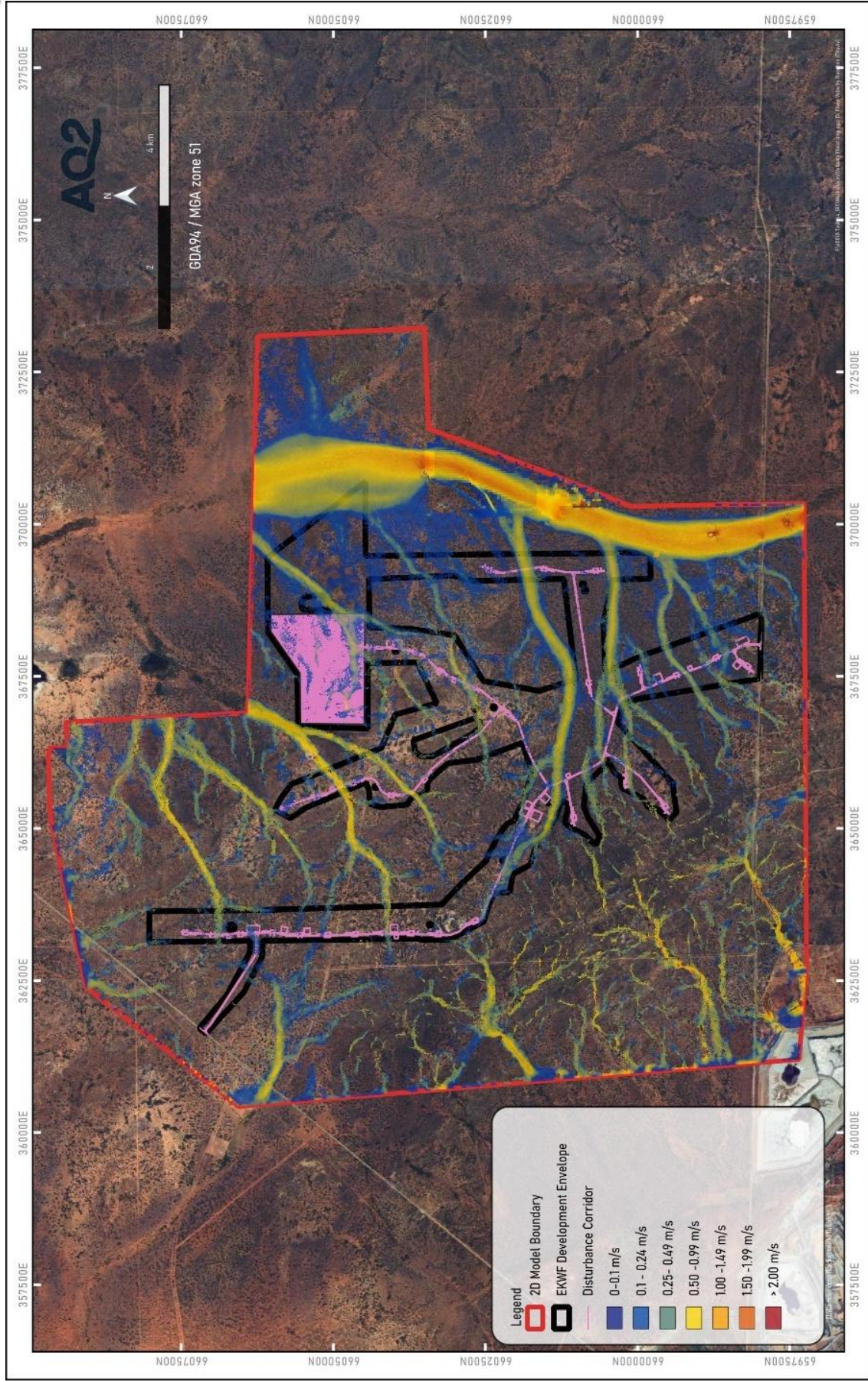


Figure 4.5 1%AEP Baseline Flood Velocity

## 5. HYDROLOGICAL IMPACT AND RISK ASSESSMENT

### 5.1 Impact Identification

The potential impacts of the EKWF to the hydrological environment, and of the hydrological environment to the EKWF have been identified. The following potential impacts have been grouped as follows:

- Modification of the existing hydrological regime, by increasing or decreasing water availability and flood levels within the environment.
- Increased risk of erosion and subsequent sedimentation in downstream areas.
- Degradation of water quality through the discharge of chemicals.
- Impact to constructed infrastructure.

The potential impacts for each of these categories are discussed further below and the risks associated with these potential impacts are assessed and discussed in 5.1.1 to 5.1.4.

#### 5.1.1 Modification to the Hydrological Regime

The Project is unlikely to result in significant changes to the existing hydrological regime, given the majority of the proposed disturbance corridor is located outside of areas that are susceptible to flooding. The following potential impacts have been considered:

- Solar farm area is likely to generate a higher volume of runoff than the existing land surface, given the installation of impervious solar panels. Although the existing water is unlikely to have any direct impacts to the environment, there is an indirect risk of increased erosion within the solar farm footprint and immediately downstream of the solar farm (refer to the following section).
- The access tracks cross the shallow sheetflow drainage areas and may result in a reduction of flow downstream of the tracks and ponding upstream of the tracks.

#### 5.1.2 Increased Erosion Risk

As discussed above, the installation of the solar farm may result in an increased risk of erosion from runoff from the solar panel and from increased total runoff from the solar farm footprint.

#### 5.1.3 Impacts to Water Quality (Chemical)

There is the potential for contamination of surface water runoff if there are leaks of hydrocarbons (and other chemicals) during the construction of the wind and solar farm and maintenance of the wind turbines.

#### 5.1.4 Impacts to the Project of the Hydrological Regime

Mapping of flood modelling predictions for the 1% AEP flood event have indicated that there is limited risk of significant flooding occurring within the solar farm footprint or at the proposed footings for the wind turbines. The management of any minor flooding in these locations is being addressed by the designers of the wind and solar farm.

### 5.2 Risk Assessment

The previous section identified the potential impacts of the Project on the hydrological regime. The following section assesses the inherent risk of the Project to hydrological and environmental receptors in the surrounding area, and the residual risk following application of any proposed mitigation measures (where risks are significant).

The hydrological risk assessment has been completed by adopting the NSR semi-quantitative risk matrix template (shown in Appendix A). Application of the matrix involves rating each impact with respect to:

- The plausible consequence of the impact resulting from the proposed infrastructure or activity.
- The likelihood of the adverse impact occurring.

NSR has provided descriptors for each of the consequence and likelihood aspects of the risk assessment, which have been adapted for this assessment.

The likelihood of an impact occurring is focused on the frequency or probability of different scale rain events (i.e. Annual Exceedance Probability or AEP) during the expected life of the Project. The Likelihood rating ranges from Rare to Almost Certain.

The components of the Risk Matrix include “Likelihood Descriptors”, “Consequence Descriptors” and the Risk Matrix table that cross-references the likelihood and consequence categories to determine the overall risk level.

### 5.2.1 Inherent Unmitigated Hydrological Risks

The evaluation of Inherent Risks associated with the Project have been considered in relation to the objectives for different EPA Environmental Factors. Of these, the ‘Inland Waters’ factors are the most relevant for this assessment, and an excerpt is shown below.

**Table 1: Objectives for environmental factors**

Factor	Objective
Biodiversity	To maintain representation, diversity, viability and ecological function at the species, population and community level.
Water Resources	To maintain the hydrological regimes, quality and quantity of groundwater and surface water to the extent that existing and potential uses, including ecosystem maintenance, are protected.
Land and Soils	To maintain the quality of land and soils so that environmental values are protected.
Rehabilitation and Mine Closure	Mining activities are rehabilitated and closed in a manner to make them physically safe to humans and animals, geo-technically stable, geo-chemically non-polluting/non-contaminating, and capable of sustaining an agreed post-mining land use, and without unacceptable liability to the State.

Source: EPA, 2023

An Inherent Risk Matrix (Appendix A) was developed and includes a combined Risk Rating for each of the identified potential impacts for the development, which accounts for both the consequence and likelihood of the impact event

### 5.2.2 Risks and Proposed Management

- Within Appendix A, the majority of the risks are low, with a couple of risks which are rated “Medium”. The following key risks were considered to have an unmitigated risk, which were rated as “Medium”:R3: Access tracks blocking flow paths – this risk can be reduced to a rating of “Low” by ensuring the track is constructed at grade, or as a floodway, to ensure runoff isn’t blocked by the track. If the track is built up above the natural ground surface, culverts should be installed to ensure runoff can continue downstream past the road.

- R4: Erosion due to runoff from the solar panels – this can be reduced to a rating of “Low” if the base material used beneath the solar farm is non-erosive taking into account the force of runoff from the solar panel faces. Alternatively, a collector bund could be installed along the downstream boundary of the solar farm to pass runoff through a sediment basin prior to release downstream.
- R5: Spillage of hydrocarbons and other chemicals during construction and maintenance activities – this can be reduced to a rating of “Low” by following typical hazardous substance handling procedures and using spill kits to clean up any spilled material immediately after spillage occurs.

## 6. CONCLUSION

The EKWS Project layout appears to avoid encroachment into the 1% AEP flood plain of the Main Drainage Line, and there are limited hydrological risks from the Project to the hydrological environment, and from the hydrological environment to the Project. 2D flood modelling was completed to estimate the flood extents from the local catchment and the upstream catchment of the Main Drainage Line.

Although the risks are typically rated as Low, a couple of Medium risks were identified. These risks could be easily managed by the following mitigation measures:

- Constructing an access track at the same level as the ground surface to allow surface water flow downstream. Alternatively, if access tracks are built up, installation of culverts can allow surface water to flow. The drainage lines, which may be impacted by the access tracks, are minor, concentrated shallow sheetflow areas.
- Ensuring that the earthpad on which the solar farm is constructed is non-erosive from runoff from the solar panel surfaces. Alternatively, a sediment collection bund could be installed downstream of the solar farm and divert runoff through a sediment basin prior to discharge to the downstream environment.
- Managing hydrocarbons and other chemicals to ensure contamination of the downstream environment doesn't occur.

## 7. REFERENCES

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