North Star Proposed Extension: Significant Flora and Riparian Vegetation Risk Assessment

PREPARED FOR FORTESCUE METALS GROUP LTD | September 2023

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Executive Summary

Fortescue Ltd (FMG, formerly Fortescue Metals Group Ltd) operates the existing North Star Magnetite Project, located approximately 110 km southeast of Port Hedland in the Pilbara region of Western Australia. FMG are currently planning an extension of mining activities; the North Star Extension (NSE) Project (the Proposed Amendment). The Proposed Amendment will involve the construction and operation of an open cut iron ore mine site (NSE pits), the extension of the existing waste rock dump (WRD) and associated infrastructure. This will result in changes to surface hydrology within the NSE Mine Pit Catchment, the Site 12 Pool Catchment, and the WRD Catchment. Stantec Australia Pty Ltd (Stantec) was commissioned by FMG to conduct a risk assessment of potential impacts to potential riparian vegetation and significant flora species from changes in surface hydrology from the Proposed Amendment for two of the three catchments, the Site 12 Pool Catchment and the WRD Catchment. Surface hydrology in the NSE Mine Pit Catchment has not been modelled and is therefore excluded from the risk assessment of potential impacts to potential riparian vegetation and significant flora species.

A literature review identified the mapped extent of riparian vegetation and the Priority 1 (P1) species Themeda sp. Panorama (J. Nelson et al. NS 102) (P1) within the Site 12 Pool Catchment and the WRD Catchment , potentially at risk from hydrological impacts. Risk rankings (extreme, high, medium or low) are assigned based on a framework that considered the following:

- previous hydrological modelling predicting changes in peak flow rates and peak flood level depths;
- ecological preferences and inferred tolerance limits for flora and vegetation, where available;
- area of riparian vegetation that may be impacted by changes, according to customised vegetation condition and health ratings; and
- likelihood of loss of individuals (number of records) of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1), from predicted impacts.

The results of the risk assessment (as summarised in **Table ES 1**) found that inherent risk assigned to riparian vegetation within the catchment areas includes:

- **High** risk for 4.49 ha, **Medium** risk for 4.29 ha and **Negligible** risk for 120.93 ha of mapped potential riparian vegetation under the 50% AEP event;
- **Medium** risk for 3.68 ha, **Low** risk for 12.68 ha and **Negligible** risk for 113.33 ha of mapped potential riparian vegetation under the 10% AEP event; and
- **Medium** risk for 1.36 ha, **Low** risk for 26.28 and **Negligible** risk for 102.06 ha of mapped potential riparian vegetation under the 1% AEP event.

All of the mapped riparian vegetation for which the risk assessment from changes in surface hydrology was conducted occurs within the NSE WRD Catchment. Zones of high risk to riparian vegetation in the NSE WRD Catchment occur in small, isolated areas and are typically less than 100 m^2, occurring on the outer flanks of the mapped riparian vegetation area. Riparian vegetation has also been mapped throughout the NSE Mine Pit Catchment, however no inferences on risk can be made due to a lack of cumulative surface hydrology modelling.

Although the runoff volume from the developed NSE Mine Pit Catchment is expected to be reduced, it is unlikely to significantly impact the health of fringing riparian vegetation, including riparian vegetation at Mundagoora Pool and Pool_SWGV. It is expected that Mundagoora Pool will still fill rapidly following regular flow, irrespective of a potential reduction in runoff.

Under the 50% AEP modelled event for the NSE WRD Catchment 4.49 ha or 3.5% of potential riparian vegetation (mapped extent within the catchment) was assigned as **High** risk. This area occurs approximately 2 km immediately downstream of the WRD where surface flow will no longer be received post development. It occurs in areas where the potential riparian vegetation was once wet during baseline levels and is now dry in the post development scenario, posing a risk to the persistence of riparian vegetation. Areas assigned a **Medium** risk comprise 4.29 ha (3.3% of the mapped potential riparian vegetation). The remaining 120.93 ha, which represents 93.2% of the mapped potential riparian vegetation within the WRD Catchment, was assigned a **Negligible** risk under the 50% AEP event.

Under the modelled 10% AEP flood scenario, across the majority of the NSE WRD Catchment (87.4% of mapped potential riparian vegetation), the risk to riparian vegetation is expected to be **Negligible**. **Low** risk for areas mapped as riparian vegetation (12.68 ha or 9.8%), commences approximately 2 km downstream of the WRD. In this area, flood depths will only decrease in the order of 50 cm to 20 cm as floodwaters from other parts of the catchment and surface water from adjacent sub-catchments contribute to system flows during larger less frequent events. A medium risk was assigned to just 3.68 ha, 2.8% of mapped potential riparian vegetation within the WRD Catchment under the 10% AEP flood scenario.

The risk to riparian vegetation is further reduced during larger (less frequent) rainfall and flow events, with **Low** risk for 26.28ha or 20.3% of potential riparian vegetation (mapped extent within the NSE WRD catchment) downstream of the NSE WRD Catchment, and **Negligible** risk for 102.06 ha or 78.7% of mapped potential riparian vegetation under the 1% AEP event where the relative impacts to riparian are also reduced during larger (less frequent) rainfall and flow events.

All of the records of the significant flora species Themeda sp. Panorama (J. Nelson et al. NS 102) (P1) for which the risk assessment from changes in surface hydrology was conducted occur within the Site 12 Pool Catchment. Themeda sp. Panorama (J. Nelson et al. NS 102) (P1) has also been recorded throughout the NSE Mine Pit Catchment, however no inferences on risk can be made due to a lack of cumulative surface hydrology modelling. There are no records of Themeda sp. Panorama (J. Nelson et al. NS 102) (P1) south of the WRD within the WRD Catchment

In contrast to riparian vegetation, the significant flora species *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) may be susceptible to waterlogging, where surface water flows or flooding depth increases for extended periods. However, assuming the landform is relatively well-drained, and surface water flows occur at low velocity, episodic increases in surface water flows are unlikely to have a detrimental effect to populations of this species.

The 50% AEP results in a **Medium** risk to 396 locations of *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) within the modelled extent, where water levels increase. 91 locations were assigned a **Negligible** risk across the Site 12 Pool Catchment.

The 10% AEP event (Worley 2024), results in a **Low** level of inherent risk assigned to 454 locations of *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) due to water levels increasing. The length of time that water persists in these locations is not known.

The 1% AEP is the least applicable scenario for assessing risk to *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) due to the actual nature of the extreme flood event and the assigned inherent risk may not apply. However, more broadly, infrastructure development that may contribute to changes in the surface hydrological regime (mining pits or WRD landforms) are located near the catchment divide, limiting potential impacts to vegetation and flora. Impacts to areas of potential riparian vegetation also typically reduce downstream and are less evident during infrequent intensive rainfall and flow events in both catchments. This risk assessment is considered conservative and does not consider design mitigation measures that may reduce predicted impacts. The areas that are assigned higher risk rankings are considered conservative and are based on inherent risk without consideration of the implementation of appropriate mitigation measures outlined in the Iron Bridge Surface Water Management Plan. Given the high variability of the Pilbara environment, flora and vegetation are adapted to seasonal and interannual changes, within tolerance limits, therefore higher risk rankings are considered conservative.

Table ES 1: Overall areas of inherent risk ratings applied for both catchments (Site 12 Pool Catchment and WRD Catchment)

Risk Rating	Potential Riparian Vegetation Area (ha)			Justification	Risk Rating	*Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) Records (no of individuals)			Justification
Peak flood depth scenario	**50% AEP**	**10% AEP**	**1% AEP**		**Peak flood depth scenario**	**50% AEP[1]**	**10%AEP[2]**	**1% AEP[3]**	
High	4.49	0.00	0.00	***High*** *inherent Risk assigned within approximately 2 km immediately downstream of the WRD in areas where the potential riparian vegetation is subject to increased dryness and a reduction in flow rate in the post development scenario.*	High	0 (0)	0 (0)	0 (0)	*There are no records or individuals of Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) at **High** inherent risk from change in peak flood depth.
Medium	4.29	3.68	1.36	*Due to change in peak flood depth downstream of the WRD in areas where potential riparian vegetation is subject to increased dryness and reduced flow rate.*	Medium	396 (7,076)	0 (0)	0 (0)	*Due to the potential for waterlogging to occur within 2km north of the WRD (with a conservative approach taken due to a lack of scientific information). The length of time that water persists in these locations is not known. The following range of change in peak flood depth occurs for locations identified at* ***Medium*** *inherent risk:* • 50% (-0.43 to 0.43m) • 10% (0.3m to 0.99m) • 1% (0.6m to 2m).
Low	-	12.68	26.28	*Due to a minimal change in reduction in peak flood depth.*	Low	0 (0)	454 (8,371)	472 (8,820)	*Due to a minimal change in reduction in peak flood depth.*
Negligible	120.93	113.33	102.06	*Due to a negligible change in peak flood depth, or change occurring within range of natural fluctuations.*	Negligible	91 (4,349)	33 (3,054)	15 (2,605)	*These records of Themeda sp. Panorama (J. Nelson et al. NS 102) (P1) were either outside the extent of the model or above the predicted flood levels, therefore inherent risk could not be assigned*.
TOTAL	**129.70**			NA	**TOTAL**	**487 (11,425)**			N/A

[1] 50% AEP- 13, [2] 10% AEP: 0, [3] 1% AEP: 0: number of locations that were dry at baseline and now wet (subject to potential water pooling).

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Abbreviations

Abbreviation	Definition
AEP	Annual Exceedance Probability
ARF	Areal Reduction Factors
BAP	Bioregional Assessment Program
BC Act	*Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
CR	Critically Endangered
DCCEEW	Department of Climate Change, Energy, the Environment and Water
EN	Endangered
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FMG	Fortescue Metals Group Ltd
GDE	Groundwater Dependent Ecosystems
GDE Atlas	Groundwater Dependent Ecosystem Atlas
GDV	Groundwater dependent vegetation
IBRA	Interim Biogeographic Regionalisation for Australia
NSE	North Star Extension
RORB	Rainfall-runoff Modelling
T	Threatened
VU	Vulnerable
WAH	Western Australian Herbarium
WRD	Waste Rock Dump

1 Introduction

1.1 Project Description

Fortescue Ltd (FMG, formerly Fortescue Metals Group Ltd) operates the existing North Star Magnetite Project located approximately 110 kilometres (km) southeast of Port Hedland in the Pilbara region of Western Australia (**Figure 1-1**). The North Star Magnetite Project (the Approved Proposal) comprises an open cut iron ore mine and associated infrastructure, including roads, administration buildings, accommodation camp, aerodrome, borefield and slurry / raw water pipelines.

FMG are currently planning an extension of mining activities for the Approved Proposal, referred to as the North Star Extension (NSE) Project (the Proposed Amendment). The Proposed Amendment was referred to the Environmental Protection Authority (EPA) under section (s.) 38 of the *Environmental Protection Act 1986* (EP Act) in July 2022, as related impacts may have a significant effect on the environment. The Proposed Amendment will involve the construction and operation of an open cut iron ore mine site (NSE Mine Pits) and associated infrastructure (WRD, roads, administration buildings, accommodation camp, aerodrome, borefield and slurry pipeline) (FMG 2022).

The Proposed Amendment will result in changes to surface hydrology within the NSE Mine Pit Catchment, the Site 12 Pool Catchment, and the WRD Catchment. Stantec Australia Pty Ltd (Stantec) was commissioned by FMG to conduct a risk assessment of potential impacts to riparian vegetation and significant flora species, which may be affected by changes in surface water from the Proposed Amendment. The risk assessment considered a hydrological assessment undertaken by Worley (NSE WRD Catchment) (Worley 2024) and FMG (Site 12 Pool Catchment) (FMG 2025), and vegetation mapping completed by Ecoscape (2023) which was extrapolated outside of the tenement boundary.

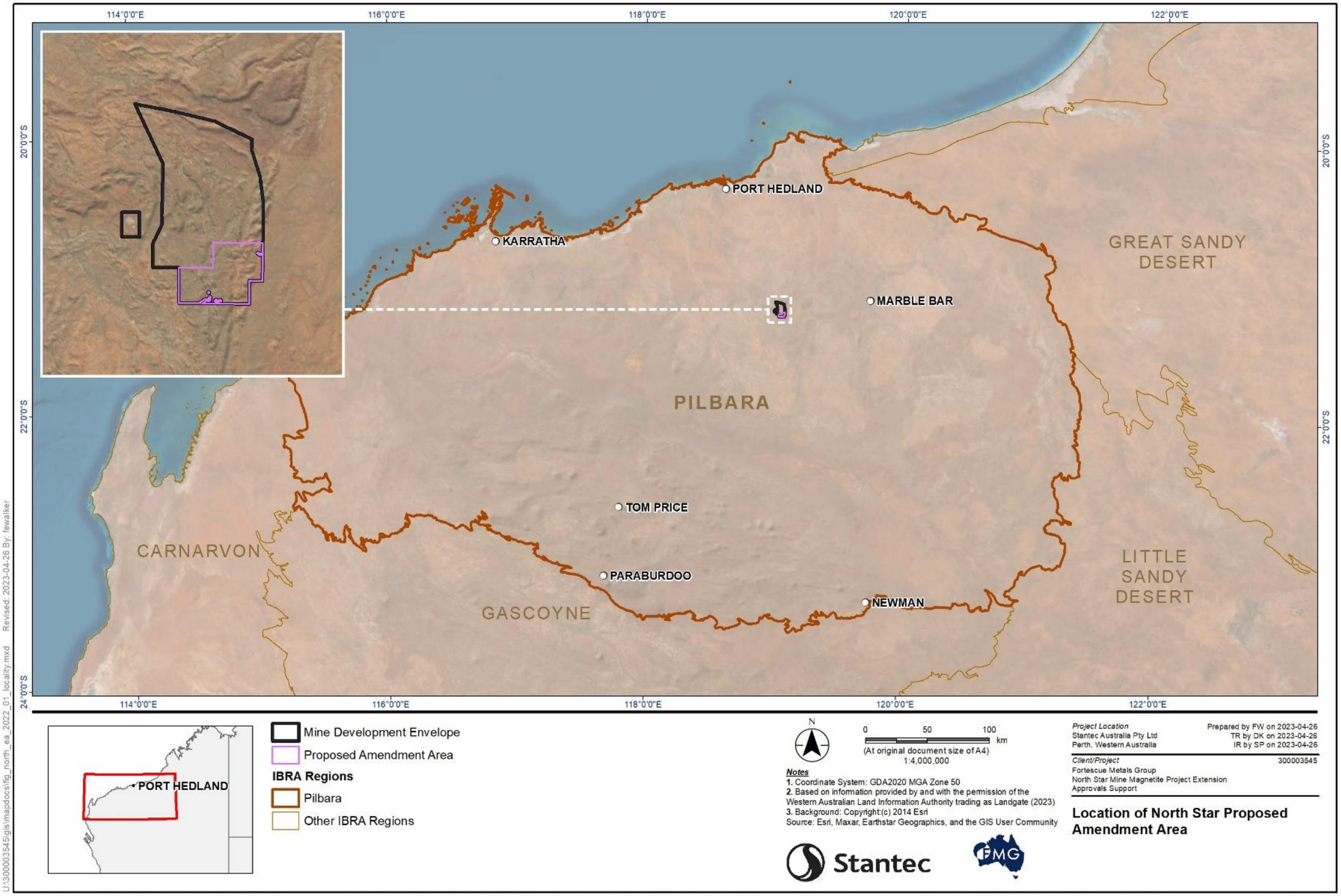

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Figure 1-1 Location of the NSE Proposed Amendment.

1.2 Existing Environment

1.2.1 Biogeographic Location

The Interim Biogeographic Regionalisation for Australia (IBRA) is a bioregional framework that divides Australia into 89 biogeographic regions and 419 subregions on the basis of climate, geology, landforms, vegetation, and fauna (Thackway and Cresswell 1995). The Pilbara bioregion encompasses approximately 17,850,000 ha in northern Western Australia (McKenzie *et al.* 2009). The Approved Proposal is located within the Chichester subregion (PIL1) of the Pilbara bioregion, which spans 9,044,560 ha. The Chichester subregion (PIL 1) comprises the northern section of the Pilbara Craton. Undulating Archaean granite and basalt plains include significant areas of basaltic ranges. Plains support a shrub steppe characterised by *Acacia inaequilatera* over *Triodia wiseana* (*Triodia pungens*) hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on ranges. Drainage occurs to the north via numerous rivers such as the De Grey, Oakover, Nullagine, Shaw, Yule, and Sherlock rivers (Kendrick and McKenzie 2001).

1.2.2 Landforms, Hydrogeology and Surface Hydrology

The Pilbara bioregion is characterised by vast coastal plains and inland mountain ranges with cliffs and deep gorges (DCCEEW 2023), and several major rivers including the Fortescue and De Grey Rivers. The episodic nature of intense summer rainfall events, which may include cyclonic systems, combines with the rocky middle and upper landscape features to produces high energy and volume river flows, over a relatively short duration (Lyons 2015). In the lowlands, the rivers have broader, convoluted channels that flow after heavy rainfall (Lyons 2015). No major rivers occur within the Proposed Amendment, however the drainage systems of the Turner River, Shelley River, Shaw River, Gillam Creek and McPhee Creek occur within the local region (DTA 2022).

The local topography of the Proposed Amendment is similar to the area of the Approved Proposal, comprising numerous ephemeral drainages. The mine pits for the Proposed Amendment are located within the upper catchment of the Turner River. Runoff from the area is directed towards several minor ephemeral tributaries that feed the Turner River approximately 30 km downstream to the west.

The eastern side of the ore body, where the waste rock dump (WRD), associated with the Proposed Amendment is located, slopes more gradually to several ephemeral tributaries within the Shaw River catchment. The main channel of the Shaw River runs in a northerly direction. The nearest ephemeral minor creek (Honeyeater Creek) is located approximately 10 km from the Proposed Amendment Area.

Within the vicinity of the Proposed Amendment and Approved Proposal there are several pools and numerous creeks and tributaries (**Figure 1-2**). The Proposed Amendment comprises the three catchment areas, two of which, comprising the Site 12 Pool Catchment and the WRD Catchment, were used for cumulative surface hydrology modelling (**Figure 1-2**).

1.2.3 Climate

The climate of the Pilbara bioregion, in which the Approved Proposal and Proposed Amendment lies, has two distinct seasons; a hot wet summer and a mild dry winter. Annual rainfall in the bioregion can range from 350 mm in the northeast to less than 250 mm in the south and east. It can also be highly variable, with the eastern Pilbara bioregion mostly influenced by tropical and monsoonal weather systems, while the western Pilbara bioregion is also influenced by southern mid-latitude weather systems such as cold fronts (Sudmeyer 2016).

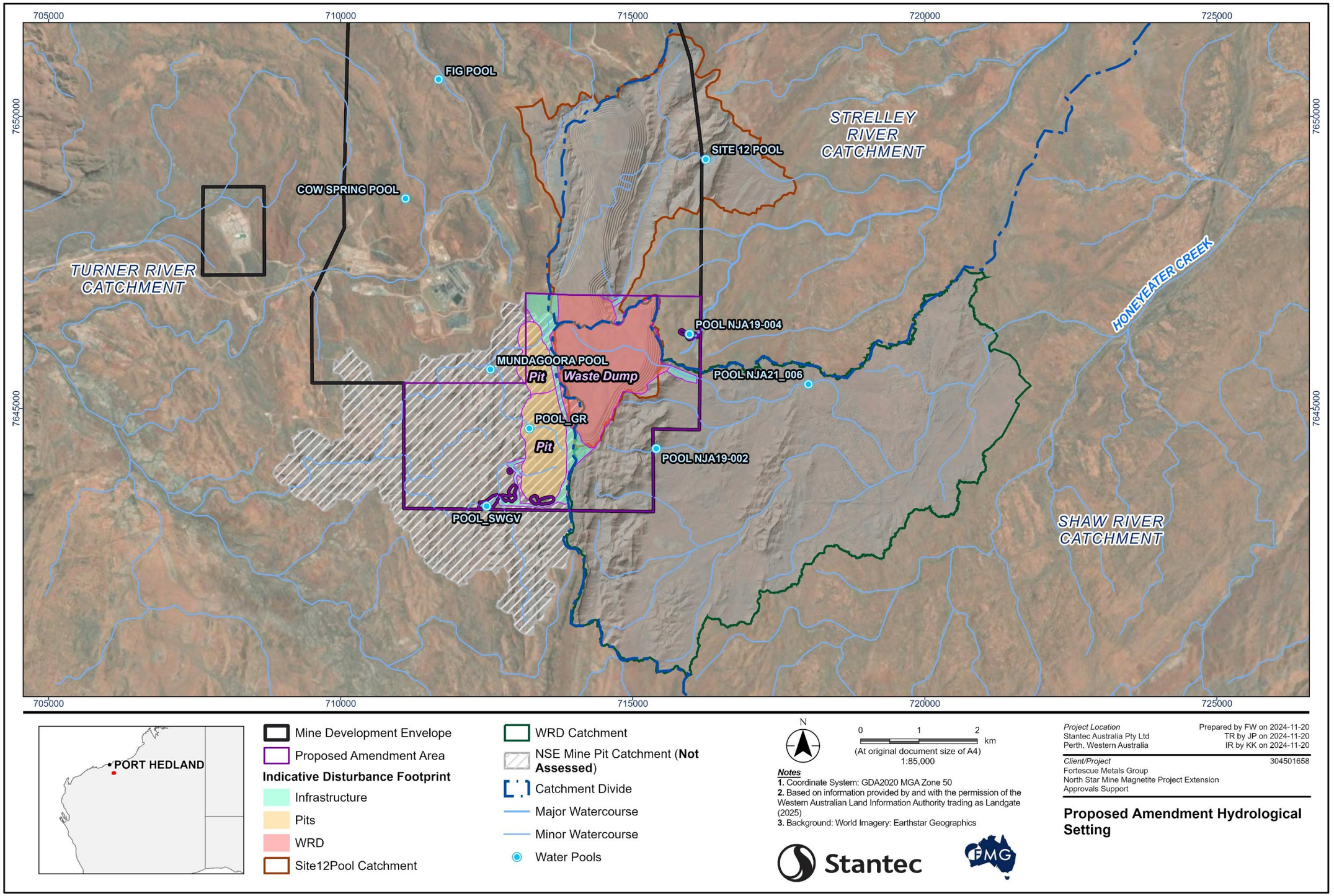

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Figure 1-2: Proposed Amendment hydrological setting.

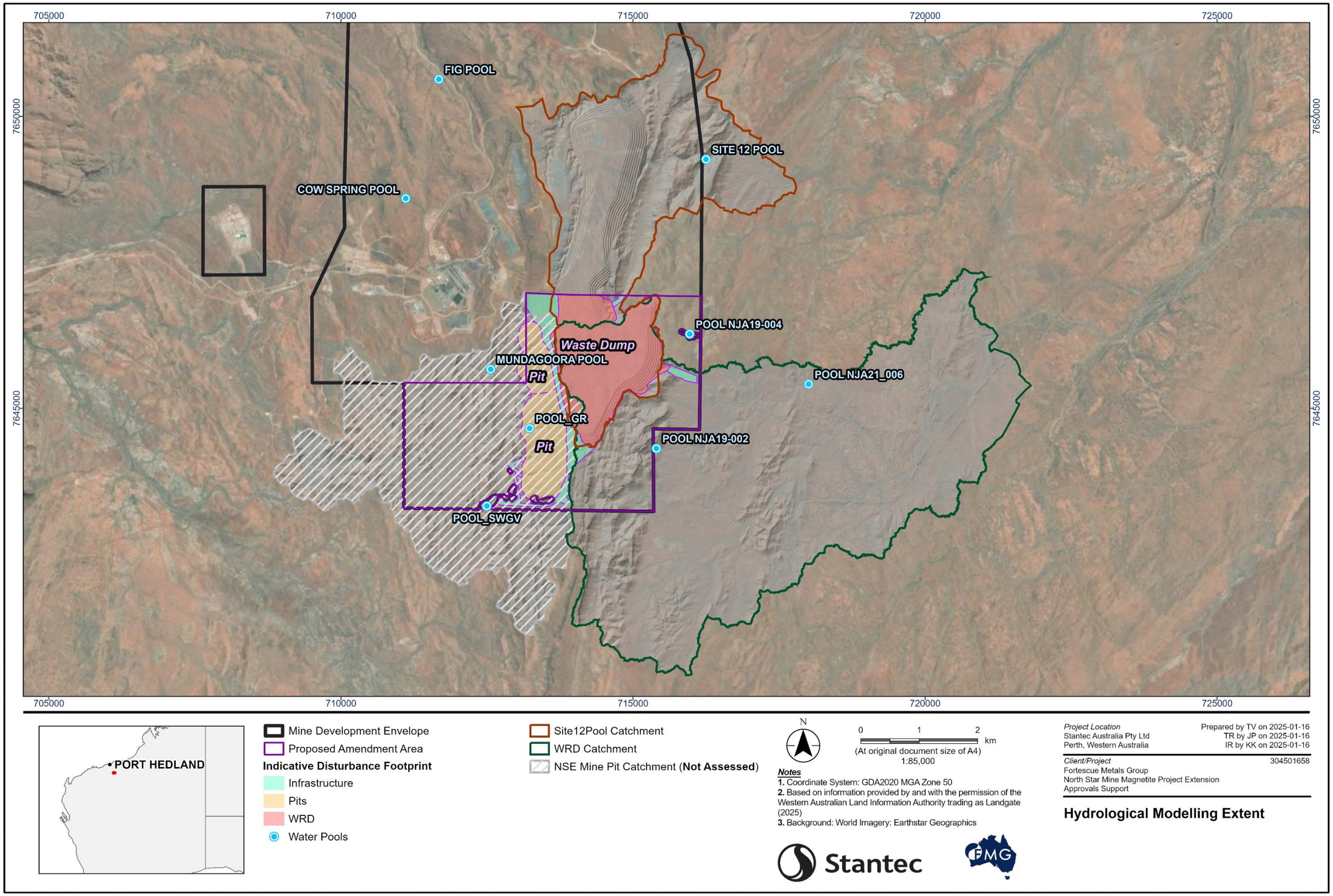

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Figure 1-3: Hydrological model extent in relation to the Proposed Amendment area and NSE Site 12 Pool and WRD Catchments (FMG 2025; Worley 2024).

1.2.4 Significant Vegetation

According to the EPA Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016), vegetation may be considered significant for a range of reasons, including:

- where vegetation is identified as threatened ecological communities (TECs) or priority ecological communities (PECs);
- where vegetation represents a restricted distribution; the degree of historical impact from threatening processes to vegetation;
- where vegetation provides important refuge; and
- where vegetation provides an important function required to maintain ecological integrity of a significant ecosystem, for example Groundwater Dependent Vegetation (GDV).

Within the Proposed Amendment area one vegetation type has been identified that may be susceptible to changing surface hydrology, including areas with the potential to support riparian vegetation, and one significant flora species, *Themeda* sp. Panorama P1 (J. Nelson et al. NS 102) (Ecoscape 2023). These are discussed in further detail below.

1.2.5 Significant Flora

Significant flora include listed Threatened species and within Western Australia, Priority flora species. Threatened flora species are listed by the Western Australian Department of Biodiversity Conservation and Attractions (DBCA) and are protected under the provisions of the *Biodiversity Conservation Act 2016* (BC Act). Some State-listed Threatened flora are provided additional protection, and are also listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).Threatened flora may be defined as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) under section 19(1) of the BC Act (**Table 1-1**).

Table 1-1: Categories of Threatened flora.

Code	Description
CR	Taxa that are facing an extremely high risk of extinction in the wild in the immediate future
EN	Taxa that are facing a very high risk of extinction in the wild in the near future
VU	Taxa that are facing a high risk of extinction in the wild in the medium-term future

Priority flora are populations that are geographically restricted or threatened by local processes, or where there is insufficient information to assign the species to one of the three Threatened categories. Priority flora typically qualify as being of special conservation interest and have a greater level of protection than unlisted species. Definitions and criteria for Western Australian Priority flora species are provided in **Table 1-2**.

Table 1-2: Categories of Priority flora.

Code	Description
P1	Priority 1 species may be defined as: species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
P2	Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g., national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat. Such species are in urgent need of further survey.
P3	Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
P4	(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

These significant flora categories and definitions have been applied where relevant to the Approved Proposal and the Proposed Amendment, based on flora and vegetation studies completed. This information has informed the risk assessment and is outlined in the Methods (**Section 2**), with a summary of key findings presented in the Literature Review (**Section 3**) of this report.

1.2.6 Riparian and Surface Flow Dependent Vegetation

Riparian vegetation may be broadly defined as the assemblages of flora species associated with rivers, creeks and wetlands (Kauffman and Krueger 1984). Riparian vegetation typically also occurs in transition zones between active drainage lines or wetland areas and the surrounding habitats of higher topography. Riparian vegetation may access a range of water sources including rainfall, soil water (the vadose zone of the soil profile), surface or stream water and groundwater (Dawson and Ehleringer 1991). Riparian vegetation can also be sensitive to changes in hydrological regimes, due to association with higher water availability within the root zone, compared to the surrounding landscape, (Horton *et al.* 2001).

Surface flow dependent vegetation may include both the hyporheic zone (the region beneath and alongside a stream bed where there is a mixing of surface water and shallow groundwater), and the flanking transition zone between the active channel and the surrounding uplands (Hayashi and Roseberry 2002). Surface flow dependent vegetation can also occur within and along smaller drainage lines in which surface water flows infiltrate into the soil.

2 Methods

2.1 Desktop Review

A desktop review of relevant information for significant vegetation and flora species for the North Star Magnetite Project (the Approved Proposal) and the Proposed Amendment was undertaken to inform this risk assessment to gain an understanding of environmental values and potential environmental receptors susceptible to changes in surface water flow, post development. Information from the following sources was reviewed by Stantec and summarised within this report, where applicable to the risk assessment:

- North Star Extension – Site 12 Pool Catchment Waterways Assessment (FMG 2025)
- North Star Extension – Hydrological Impact Assessment Report: Waterways (Worley 2024);
- North Star Extension Flora and Vegetation Survey Ecoscape (2023); and
- North Star Magnetite Project Environmental Review Document (FMG 2022).

The results of the literature review are presented in **Section 3** of this Assessment.

2.2 Risk Assessment

2.2.1 Riparian Vegetation Mapping

Vegetation mapping, which included mapping the extent of riparian vegetation was undertaken by Ecoscape (2023). However, the potential impacts of changes to surface water hydrology extend beyond tenement boundaries, with the potential to impact riparian vegetation downstream. The existing potential riparian vegetation mapping (Ecoscape 2023) did not encompass the entire hydrological model extent in all catchments, with refinement and/or extrapolation completed by Stantec for the NSE WRD Catchment.

In areas where potential riparian vegetation mapping was not available for the WRD Catchment, a desktop analysis of aerial imagery was undertaken by an experienced botanist to extrapolate areas of potential riparian vegetation. Areas proposed for development were omitted from the analysis.

2.2.2 Risk Assessment

The available mapping and information of riparian vegetation and significant flora was reviewed for the Proposed Amendment area. Only significant species that may rely on surface flows or groundwater were considered for the risk assessment, detailed in the results of the Literature Review (**Section 3**).

The risk assessment was based on an adapted risk framework based on (DWER 2017) and was modified to assign areas of inherent risk to sensitive receptors (areas mapped with the potential to support riparian vegetation and conservation significant flora with the potential to be impacted from changes in surface water hydrology).

Likelihood ratings (**Table 2-2**) were assigned based on the likelihood of a modelled flood event occurring (**Table 2-1**) as described in (Ball *et al.* 2019).

Table 2-1: Frequency Terminology for Flood Events

Frequency Descriptor (Ball *et al.* 2019)	**Frequent**				**Rare**		
Annual Exceedance Probability (AEP)	63.2%	50%	20%	10%	5%	2%	1%
Interval (ARI)	**1yr**	1.44 yr	4.48 yr	9.49 yr	20 yr	50 yr	100 yr

Consequence rankings were assigned by an experienced botanist, Daniel Roocke, Bachelor of Science (Botany & Ecology) (background in botany, ecology and horticulture with over 14 years' botanical experience, specialising in the Pilbara bioregion). Consequence was expressed as potential impacts (**Table 2-3)** and consequence ratings were assigned based on inferred changes in the condition or loss of individuals, for both riparian vegetation and populations of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) recorded within the modelled extent, due to modelled changes in surface water hydrology, post development (**Table 2-3**).

The consequence scores for change in peak flood depth for areas with the potential to support riparian vegetation and known locations of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) are provided in **Table 2-3**.These scores

considered the potential extent of impacts from a change in peak flood depth to riparian vegetation health (through drying or a significant increase in peak flood level depth occurring post development). The potential consequence to *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) took into consideration effects from modelled change in peak flood level using the species general ecology (inferred habitat preferences, plant height and elevation within the landscape), and the inferred tolerance limits of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) from waterlogging (**Table 2-3**). Consequence scores were based on modelled changes to peak flood depth from baseline levels (**Section 3.2**).

Consequence score assigned to areas of potential riparian vegetation (**Table 2-3**) are defined as follows:

- Moderate: **Mid-level Impact:** result in a moderate decline in overall condition of riparian vegetation (**Table 2-1**), leading to moderate (estimated 20-50%) loss of dominant native species.
- Minor: **Low- level Impact:** result in a minor decline in overall condition of riparian vegetation, or minor (estimated <20%) localised loss of dominant native species.
- Slight: **Minimal Impact**: Limited impact to riparian vegetation/ or individuals.
- Negligible: **Negligible Impact**: No impact expected to occur. Change within range of natural fluctuations.

Consequence score assigned to areas coinciding with *Themeda* sp. Panorama records **(Table 2-3**) are defined as follows:

- Major: **High-level impact**: result in a substantial decline in plant health, or substantial (estimated 40-80%) loss of individuals, resulting in decline in the local population.
- Moderate: **Mid-level Impact:** result in a moderate decline in plant health, or moderate (estimated 10-40%) loss of individuals expected to occur.
- Minor: **Low- level Impact:** result in minor decline in plant health, or minor (estimated <10%) loss of individuals.
- Slight: **Minimal Impact**: Limited impact to plant health/ no loss of individuals expected to occur

Risk rankings - extreme (15-25), high (5-16), medium (3-9), or low (1-3) - were applied according to the risk matrix (**Table 2-4)** once risk scores were calculated based on likelihood and consequence. An extra consequence score of 'Negligible' (0) has been assigned where change is expected to be within the range of natural fluctuations or negligible consequence is expected to occur.

The acceptability of risk and regulatory control was also considered for the risk assessment, recommended by DWER (2017) and summarised in **Table 2-5**. Risks classified as moderate or above are likely to require some form of regulatory control, and those with a severe risk following the implementation of management and mitigation measures are unlikely to be accepted by DWER/ EPA.

Table 2-2: Likelihood Ratings (based on (DWER 2017)

Level	Ranking	Description	Frequency based on modelled scenario (FMG 2025; Worley 2024)
5	**Almost Certain**	Common Occurrence	63.2 % AEP scenario
4	**Likely**	Will Occur Frequently	20%- 50% AEP scenario, 1.44yr Interval (ARI)
3	**Possible**	Might occur	5-10% AEP Scenario, 20yr to 9.49yr Interval (ARI)
2	**Unlikely**	Very Infrequently	2% AEP Scenario, 50yr Interval (ARI)
1	**Rare**	Exceptional Circumstances	1% AEP scenario, 100yr Interval (ARI)

Table 2-3: Consequence ratings assigned for change in peak flood depth (m) from baseline level post development.

Change in Peak Flood Depth (m) from Baseline Level	Riparian Vegetation	*Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1)*
Was wet, now dry	Moderate	Minor
< -1.00 WL decrease	Moderate	Minor
-1.00 - -0.75 WL decrease	Minor	Minor

Change in Peak Flood Depth (m) from Baseline Level	Riparian Vegetation	*Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1)*
-0.75 - -0.50 WL decrease	Minor	Slight
-0.50 - -0.20 WL decrease	Slight	Slight
-0.20 - -0.10 WL decrease	Negligible	Slight
-0.10 - 0.10 WL decrease	Negligible	Slight
0.10 - 0.25 WL increase	Negligible	Minor
0.25 - 0.50 WL increase	Slight	Minor
0.50 - 0.75 WL increase	Slight	Moderate
0.75 - 1.00 WL increase	Slight	Moderate
>1.00 WL increase	Minor	Major
Was dry, now wet	Minor	For any Themeda sp. Panorama (J. Nelson et al. NS 102) (P1) points that were classified “was dry, now wet”, the baseline flood depth was assumed to be 0m. Therefore, the flood depth difference calculated for these points was based on the development scenario flood depth. (consequence ratings were then assigned according to calculated change in peak flood depth (m) from baseline level, aligning with those represented in this table).

Table 2-4: Risk Rating Matrix (based on (DWER 2017)

Risk Rating			Consequence				
		0 (Negligible)	**1 (Slight)**	**2 (Minor)**	**3 (Moderate)**	**4 (Major)**	**5 (Severe)**
Likelihood	**5 (Almost Certain)**	0 (No risk)	5 (Medium)	10 (High)	15 (High)	20 (Extreme)	25 (Extreme)
	4 (Likely)	0 (No risk)	4 (Medium)	8 (Medium)	12 (High)	16 (High)	20 (Extreme)
	3 (Possible)	0 (No risk)	3 (Low)	6 (Medium)	9 (Medium)	12 (High)	15 (Extreme)
	2 (Unlikely)	0 (No risk)	2 (Low)	4 (Medium)	6 (Medium)	8 (Medium)	10 (High)
	1 (Rare)	0 (No risk)	1 (Low)	2 (Low)	3 (Medium)	4 (Medium)	5 (High)

Table 2-5: Risk acceptability and recommended controls, based on (DWER 2017).

Risk Rating	Acceptability of Risk	Treatment
Extreme	Unacceptable	Risk unlikely to be tolerated by DWER.
High	May be acceptable	Risk event will be tolerated and may be subject to multiple regulatory controls.
Medium	Acceptable	Risk event is tolerable and is likely to be subject to some regulatory controls.
Low	Acceptable	Risk event is acceptable and will generally not be subject to regulatory controls.

2.2.3 Vegetation Condition and Plant Health

Regulatory guidance is less prescriptive on scales for the assessment of plant health (the appearance and vigour of individuals, as opposed to the community perspective captured in the vegetation condition assessment). Environmental monitoring and assessment programs typically implement customised plant health scales or use adaptations of published literature focusing on plant health. The health of riparian flora may be assessed using the customised scale provided in **Table 2-6,** which is based on Keighery *et al.* (1994). These definitions were applied to the consequence scores defined for areas of potential riparian vegetation (**Table 2-3**).

Table 2-6: Customised plant health assessment scale (Keighery *et al.* 1994).

Score	Description	Detailed Attributes
5	Excellent	• Plants appears vigorous and green • Very little leaf senescence or defoliation • Negligible vegetative death • Negligible indication of herbivory or insect damage
4	Good	• Not lush, but generally considered healthy without being vigorous (foliage 61% to 80% of what would be expected in 'excellent' health) • Some discolouration of leaves • Minimal death (<20%) • Occasional or minor herbivory or insect damage
3	Fair	• Moderately sparse foliage (41% to 60% of what would be expected in 'excellent' health) • Moderate discolouration of leaves • Occasional death • Moderate herbivory or insect damage
2	Poor	• Supporting very sparse foliage (5% to 40% of what would be expected in 'excellent' health) • Obvious discolouration of leaves • Substantial death • Major herbivory or insect damage
1	Dead	• Beyond regenerative ability • Dead vegetative material throughout • >95% defoliated

2.3 Limitations

The risk assessment is subject to the following limitations:

- Peak flows generated by TUFLOW have been validated against RORB results at the reporting locations within the NSE Site 12 Pool Catchment and WRD Catchment. For areas outside of these locations (especially minor catchments) caution should be used when reviewing the results from TUFLOW.
- Surface hydrology for the NSE Pit Catchment was not part of the scope of this assessment. No inferences on risk have been made in this catchment for riparian vegetation and significant species Themeda sp. Panorama (J. Nelson et al. NS 102) (P1).
- This risk assessment is based on inherent risk and control or mitigation measures, such as culverts or drainage infrastructure were not considered within hydrological modelling or the risk assessment, meaning that risk assigned is conservative in nature.
- The risk assessment was prepared using the spatial layers for proposed pits, infrastructure and hydrological modelling provided by FMG. Any proposed changes to the hydrological modelling require a revision of the risk assessment such as undertaken following the updated modelling (Worley 2024).
- Levels of risk of impact are theoretical in nature and have been assigned based on advice provided by relevant expert botanists, however there is a lack of scientific study into the tolerance of changes to surface water hydrology with respect to *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) and a lesser extent riparian vegetation. The risk assessment is extremely conservative in light of the existing literature regarding the interactions between native plant taxa and changes in surface water hydrology.
- There is insufficient information available to definitively define species' tolerance to changes in surface water hydrology for *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1). Risk has been assigned based on limited available contextual information and should therefore be considered theoretical in nature. As a result, any risk assigned to *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) should be considered extremely conservative.
- Given *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) is an undescribed species with only a phrase name and four representative voucher records lodged at the WAH, when subject to taxonomic review and formal naming, there is a slight chance that it may actually represent more than one taxa with the Proposed Amendment population differing from others.
- The results and conclusions of the risk assessment are limited to the available information at the time of writing.

3 Results

3.1 Literature Review

3.1.1 Flora and Vegetation Surveys

Ecoscape (2023) conducted a flora and vegetation survey and consolidation of previous survey data for the Proposed Amendment. The key findings were as follows:

- A total of 201 vascular flora species, including four significant flora were recorded (one of which represented a previously undescribed taxa);
- No vegetation types were considered analogous to Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs);
- One vegetation type EvApTl was identified which was representative of potential groundwater dependent vegetation (GDV) (Ecoscape (2023). GDEs in the Pilbara are generally determined to be vegetation associated with riparian areas and vegetation type EvApTl has the potential to support riparian vegetation (Ecoscape (2023).
- No vegetation or landforms consistent with sheet flow dependent vegetation were recorded (species of the Mulga group, the collective term for constituents of the *Acacia aneura* complex, which was only recorded within one quadrat).

3.1.2 Riparian Vegetation

Ecoscape (2023) recorded one vegetation type associated with drainage lines within the Proposed Amendment that are considered strongly representative of riparian vegetation given the presence of *Eucalyptus victrix* (**Figure 3-1**).

The vegetation was described as:

- *Eucalyptus victrix* and *Corymbia hamersleyana* low open woodland over *Acacia pyrifolia* var. pyrifolia, *Acacia tumida* var. pilbarensis and *Petalostylis labicheoides* mid sparse shrubland over *Triodia longiceps*, *Cymbopogon ambiguus* and *Stemodia grossa* low open hummock/tussock grassland/forbland, and coded 'EvApTl'.

There are six pools associated with the Proposed Amendment and one permanent pool downstream of the NSE mine pits that potentially contain riparian vegetation (Figure 1-3):

- Pool_SWGV - located approximately 1 km downstream of the southern NSE mine pit;
- Pool at NJA21_006 - this pool is located approximately 3 km east, downstream of the WRD along ephemeral creeks;
- Pool_GR - a typical plunge pool (this pool occurs in the infrastructure footprint and is not considered further in this assessment;
- Pool at NJA19-002 - this pool is located approximately 1.5km east, downstream of the WRD;
- Pool at NJA19-004 - this is situated outside of the modelling extent; and
- Site 12 Pool - located approximately 3 km upstream of the WRD.

One additional permanent surface water pool (Mundagoora Pool), which supports potential riparian vegetation is subject to changes in surface water flow from the Proposed Amendment and is located within the Mine Pit Catchment, approximately 1 km downstream of the NSE mine pits. The mapped extent including survey and desktop mapping of potential riparian vegetation within the Mine Pit and WRD Catchments are shown in **Figure 3-1.**

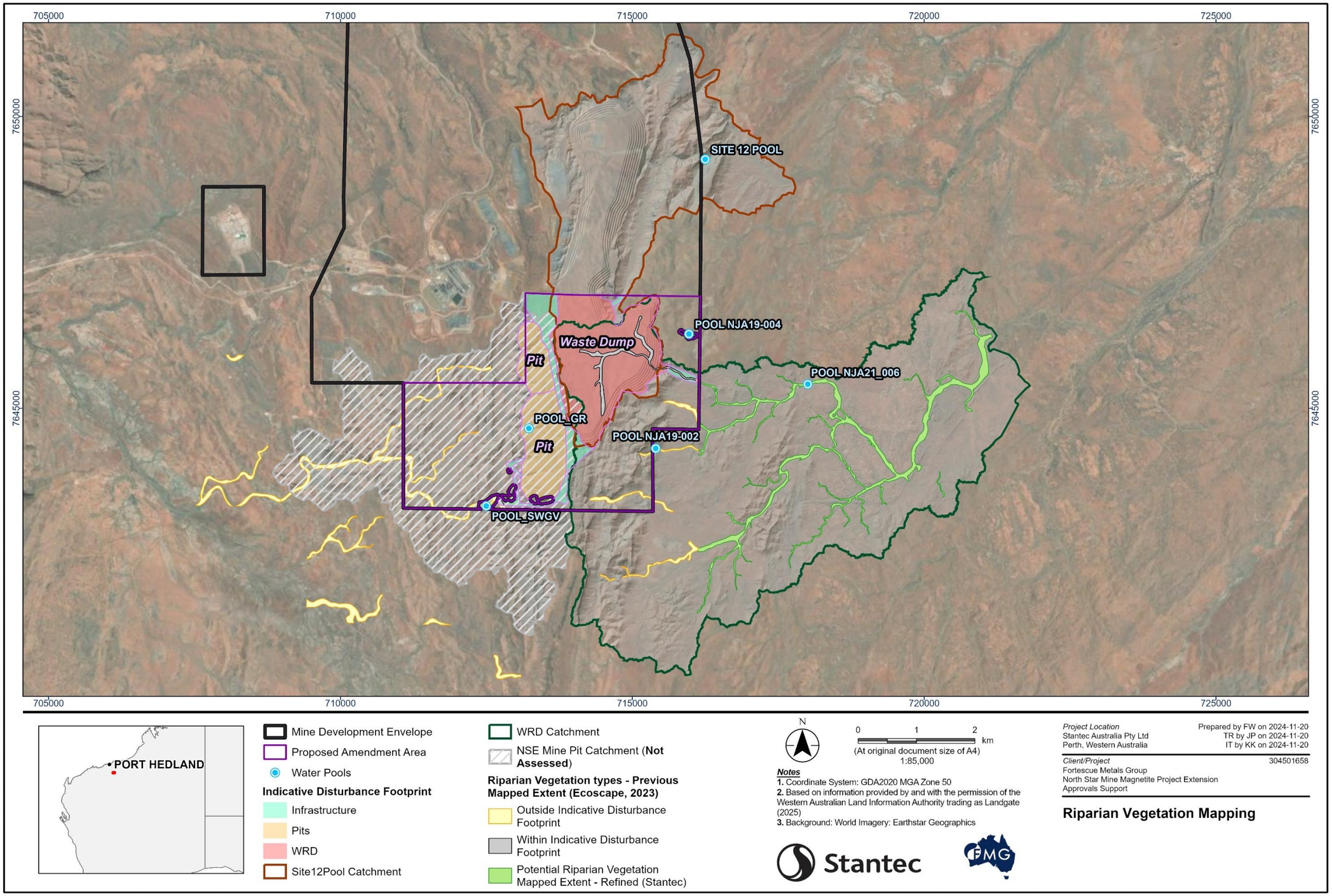

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Figure 3-1: Riparian vegetation mapping in the NSE Site 12 Pool, and WRD Catchment.

3.1.3 Significant Flora

One Threatened flora species, *Quoya zonalis* and three State-listed Priority flora were recorded during previous surveys for the Approved Proposal and the Proposed Amendment (Ecoscape 2023) presented in **Table 3-1**. Most of these flora are considered to represent xerophytes (plants that are adapted to dry environments), and were recorded in well drained landscapes such as hill slopes and shallow, skeletal soils (WAH 2023).

During these surveys, records of a previously undescribed taxa were collected and originally listed as '*Themeda* sp'. Subsequent taxonomic studies determined the specimens to represent *Themeda* sp. Panorama (J. Nelson et al. NS 102), with a Priority 1 conservation classification applied. This taxon has yet to be formally described and retains its 'phrase name' nomenclature:, however, it was recorded from drainage lines (Ecoscape 2023). The four significant flora species are described in more detail below.

Table 3-1: Significant flora previously recorded during surveys for the Proposed Amendment.

Taxa	Classification	Description (WAH 2023)
Quoya zonalis	Threatened	Shrub growing to 1 m. Occurs on rocky ironstone hill slopes, steep ironstone gorges, skeletal red/brown clay.
Themeda sp. Panorama (J. Nelson et al. NS 102)	Priority 1	Perennial tussock grass.
Triodia basitricha	Priority 3	Hummock grass occurring on brown clay-loam over ironstone, stony plains, rocky rises/flats/hills and low rises.
Ptilotus mollis	Priority 4	Compact, perennial shrub occurring on stony hills and screes.

3.1.3.1 Quoya zonalis (T)

Quoya zonalis (T), (previously known as *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) is known to primarily inhabit cliffs and crests of hills, and it commonly grows along rocky slopes associated with various geology (RTIO and WAH 2015). Ecoscape (2023) documented the common habitat within the Proposed Amendment where *Quoya zonalis* (T) was recorded was high in the landscape on rocky conglomerate sandstone, granite or ironstone with only skeletal soil.

Quoya zonalis' main habitat is not in creeklines or other riparian areas with surface water flows. Therefore, any changes to surface water flows are unlikely to affect the majority of individuals and populations of this species as they do not occur in landforms that are relevant to these changes (Ecoscape 2023).

Isolated individual *Quoya zonalis* plants may occur in rocky creeklines high in the landscape, however, given the slope within these landforms, water is unlikely to significantly pool and cause flooding and potential waterlogging causing plant death. Reduced surface water flow is unlikely to significantly impact any of the individuals that may occur in riparian areas as the species on the whole is likely to be adapted to soils with low availability of free water (Ecoscape 2023).

In addition, the Conservation Advice for *Quoya zonalis* (T), prepared under the *EPBC Act 1999*, does not indicate any hydrological requirements or responses for this species, including listed threats (TSSC 2017). Therefore, *Quoya zonalis* (T) has not been considered further in the risk assessment.

3.1.3.2 Themeda sp. Panorama (J. Nelson et al. NS 102) (P1)

During the Ecoscape (2023) survey, *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) was recorded in habitat described as steep, rocky south facing slope, located in close proximity to a permanent waterhole and shallow soil among exposed bedrock and boulders. Specimens of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) have been lodged at the Western Australian Herbarium (WAH).

Themeda sp. Panorama (J. Nelson *et al*. NS 102) (P1) was recorded from four vegetation types (Ecoscape 2023), of which only one is considered to have the potential to support riparian vegetation based on the presence of *Eucalyptus victrix* (**Table 3-2**).

Table 3-2: Vegetation types supporting records of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1).

Vegetation Type Code	Dominant Species	Typical Landform and Vegetation Classification
AiTw	*Acacia inaequilatera* *Triodia wiseana*	Hillslopes Xerophytic vegetation
ApTp	*Acacia pyrifolia* *Triodia pungens*	Floodplains and low undulating hills Xerophytic and/or mesic vegetation
ElAtTw1	*Eucalyptus leucophloia subsp. leucophloia* *Acacia tumida* var. *pilbarensis* *Grevillea wickhamii* *Triodia wiseana*	Hillslopes Xerophytic and/or mesic vegetation
EvApTl	*Eucalyptus victrix, Corymbia hamersleyana* *Acacia pyrifolia* var. *pyrifolia* *Acacia tumida* var. *pilbarensis* *Petalostylis labicheoides, Triodia longiceps*	Minor to moderate drainage, riparian zone Facultative phreatophyte or vadophyte (*E.victrix*) Xerophytic and/or mesic vegetation

Note: grey shading indicates vegetation type indicative of the presence of Eucalyptus vitrix.

Themeda sp. Panorama (J. Nelson *et al*. NS 102) (P1) has similarities to *Themeda avenacea* and *Themeda triandra* including morphology and typical habitat preferences (P. Jayasekera pers. comm.) (WAH 2023). These species are described as occurring in savanna and grassland, and are specifically not considered as wetland species (Arthan *et al.* 2022). However, within the Proposed Amendment area *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1), was recorded within habitats that included drainage lines (ecologia 2023; Ecoscape 2023).

Themeda triandra is highly responsive to fluctuations in rainfall during the growing season, however, cannot take advantage of very high rainfall (Snyman *et al.* 2013). Based on this general physiological observation for a common species of the genus, and the recorded habitats associated with populations of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1), Ecoscape (2023) surmised this taxon to be:

- likely to be susceptible to waterlogging that may occur when surface water flows are increased and either localised (or general) flooding occurs, or the soil profile near the surface remains wet for extended periods, and potentially even for short periods; and
- less likely to be significantly affected by reduced surface water flows although, over a longer time period, plant vigour may decrease as energy stores in the root system are depleted.

It is not possible to predict the response of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) to episodic increases in surface water flow if waterlogging does not occur (Ecoscape 2023). However, assuming the landform is relatively well-drained, the water flows at a low velocity, and the soil profile in the root zone is not saturated for sustained periods, episodic increases in surface water flow is considered unlikely to have a detrimental effect to populations of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1).

While there is no detailed information available on the physiology of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1), it is likely to be similar to other *Themeda* species. There is no conclusive information available that the populations of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) in the proposed Amendment represent a wetland species. In addition, based on photographs presented in Ecoscape (2023), it is likely that any naturally occurring surface water within the drainage lines supporting *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) would be highly ephemeral. Therefore, this taxon could be assumed to be similar to *Themeda triandra,* which uses water when it is occasionally abundant and becomes semi-dormant when soil moisture is low (Male *et al.* 2022).

Based on some assumptions made on what is the known physiology of other *Themeda* species (and the descriptions of habitats associated with the four specimens lodged at the WAH), *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) is likely to be shallow-rooted and highly unlikely to be able to access groundwater and is therefore unlikely to be groundwater dependent. Consequently, changes to groundwater depth are unlikely to affect this species unless plant death arises from waterlogging.

Some records of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) in the Proposed Amendment area are associated with minor to moderate-sized drainage lines, and it may be inferred that changes to surface water flows have the potential to impact the species (**Figure 3-2**). Therefore, the risk assessment has taken into consideration the habitat and relevant records of *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) within proximity to the Proposed Amendment, which appears to be more mesic than the habitats described for specimens lodged at the WAH.

3.1.3.3 Triodia basitricha (P3)

Triodia basitricha (P3) typically occurs on rocky hills (WAH 2023) and has not been reported as occurring in association with significant riparian vegetation areas (creeks, rivers), although it does occur in the minor gullies that transport rainwater (for short periods). *Triodia* species are not known to be tolerant of waterlogging, noting that waterlogging is unlikely to occur in the usual habitat of *Triodia basitricha* (P3) within the Proposed Amendment. However, if there are significant changes to the landform that lead to water retention it is likely that *Triodia basitricha* (P3) would succumb to waterlogging and die (Ecoscape 2023). Based on the information currently available, *Triodia basitricha* (P3) has not been considered further in the risk assessment.

3.1.3.4 Ptilotus mollis (P4)

The preferred habitat of *Ptilotus mollis* (P4) does not include areas of riparian vegetation or other areas where water flows or pools (WAH 2023). Therefore, it is unlikely to be subject to changes in surface water flow unless there are significant landscape changes (Ecoscape 2023).

Based on general physiological understanding, it is highly unlikely that decreases in surface water flow from the Proposed Amendment would significantly affect *Ptilotus mollis* (P4). However, if water pooling occurred within its habitat it would be anticipated that this species may be susceptible to waterlogging causing death (Ecoscape 2023). Based on the information currently available, *Ptilotus mollis* (P4) has not been considered further in the risk assessment.

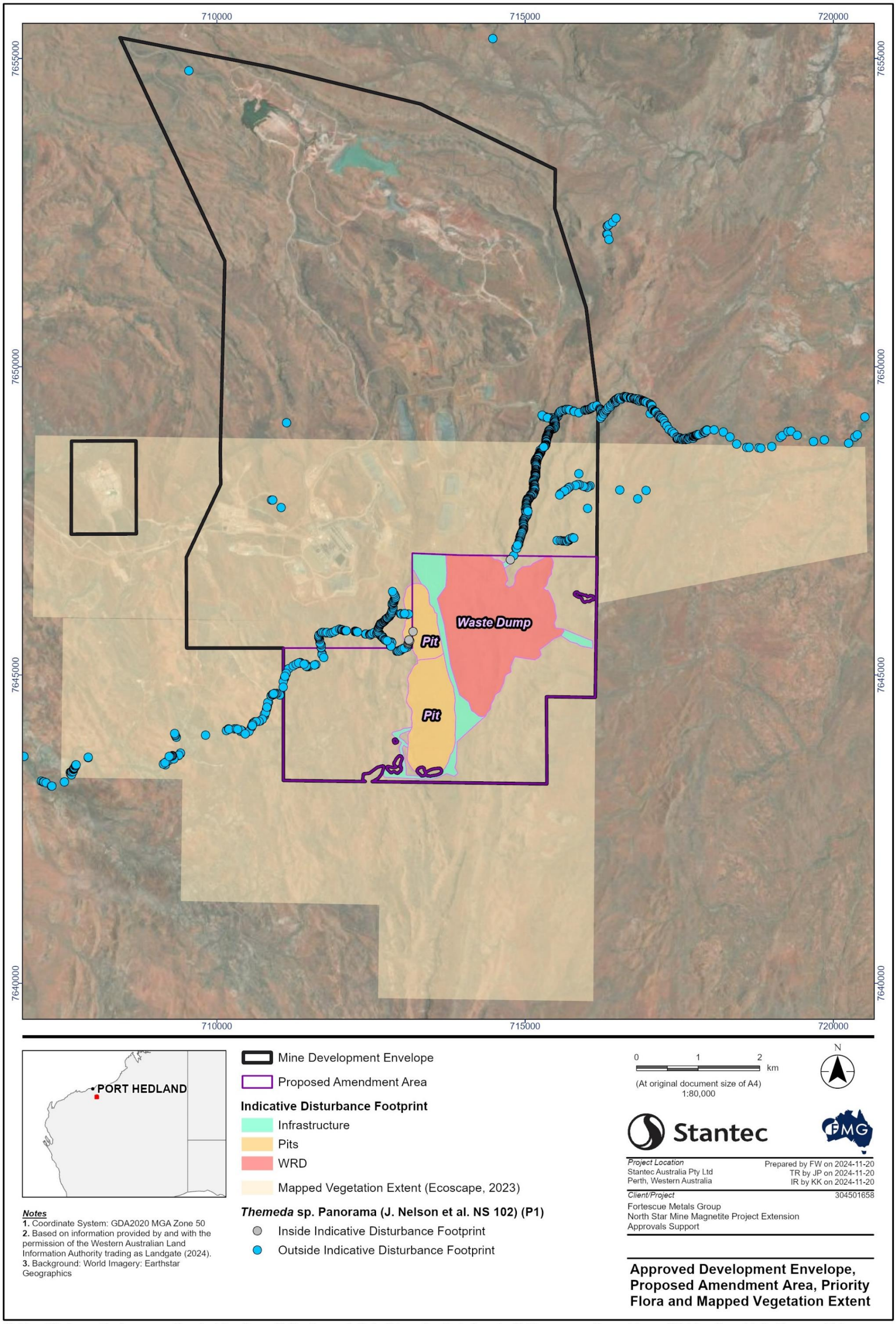

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Figure 3-2: *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) records in relation to the Proposed Amendment area.

3.2 Hydrological Modelling

A baseline hydrology and surface water impact assessment was completed for the Proposed Amendment (Worley 2024), and updated for the Site 12 Pool Catchment (FMG 2025), to predict potential impacts to the surface water regime from development of the North Star Expansion (NSE) mine pits and associated infrastructure within the Proposed Amendment Development Envelope. The most notable difference in the updated modelling (FMG 2025) includes the separation of the northern areas of the WRD Catchment into the new Site 12 Pool Catchment. The surface water impact assessment which was based on previous TUFLOW 2D hydraulic models completed for the WRD Catchment (Worley 2024), has been used to inform the vegetation risk assessment. The model extents for both the NSE Site 12 Pool and WRD Catchments are shown in **Figure 1-3**. Surface water is modelled for the post development scenario examining the changes in peak flood depth with the 50%, 10% and 1% scenarios shown in **Figure 3-3**, **Figure 3-4, and Figure 3-5**.

Key findings from the hydrological assessment (Worley 2024) for the Site 12 Pool Catchment include:

- The WRD infrastructure is predicted to result in a reduction in surface water flows to the downstream environment of the Site 12 Pool Catchment.
- TUFLOW modelling for the Site 12 Pool Catchment shows that during 10% to 1% AEP events, flood levels decrease, generally by less than 0.25 m across the majority of the waterway downstream of the WRD infrastructure compared to the baseline scenario
- Larger reductions of up to 1 m are shown to occur near the mine tenement boundary, immediately downstream of the NSE WRD, however these reductions are highly localised and restricted to a small area.

Key findings from the hydrological assessment (FMG 2025; Worley 2024) for the WRD Catchment include:

- The WRD infrastructure is predicted to result in a reduction in surface water flows to the downstream environment of the NSE WRD Catchment. There is an approximate 10% reduction in 10% to 1% AEP peak flows at the major confluence of catchments 7.8 km downstream of the NSE WRD compared to the baseline scenario (**Figure 3-4, Figure 3-5**).
- Larger reductions of 89 to 90% are shown to occur at the mine tenement boundary, which is located immediately downstream of the NSE WRD.
- TUFLOW modelling for the NSE WRD Catchment shows 10% to 1% AEP flood levels decrease by up to 1.8 m immediately downstream of the NSE WRD compared to the baseline scenario.

Areas removed from the catchment due to proposed mining pits or WRD landforms are generally located near the catchment divides, limiting surface water impacts. Impacts generally reduce downstream as the proportion of area removed relative to the total catchment area decreases. The relative impacts are also reduced during larger (less frequent) rainfall and flow events.

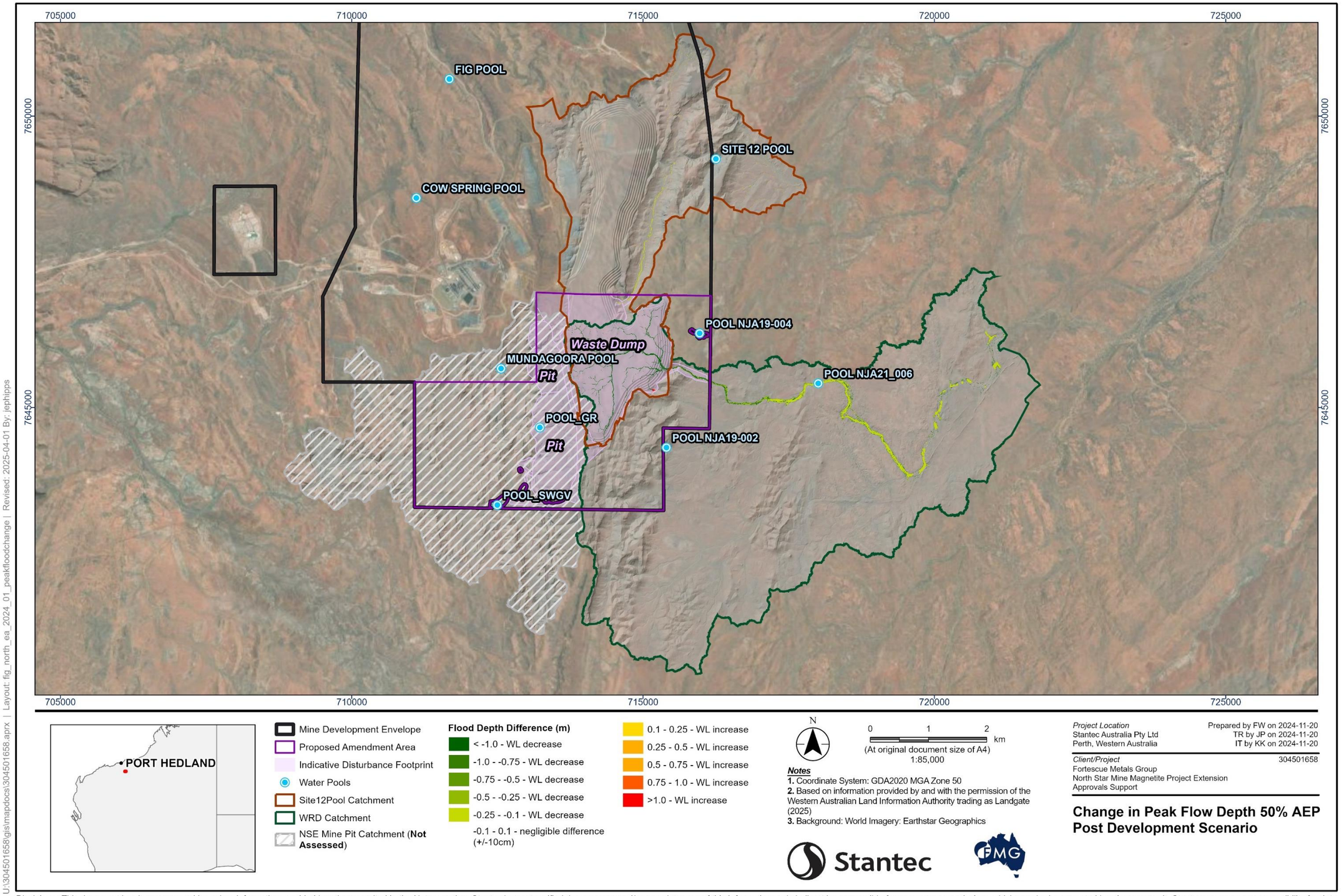

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Figure 3-3: Change in Peak Flow Depth 50% AEP Post Development Scenario

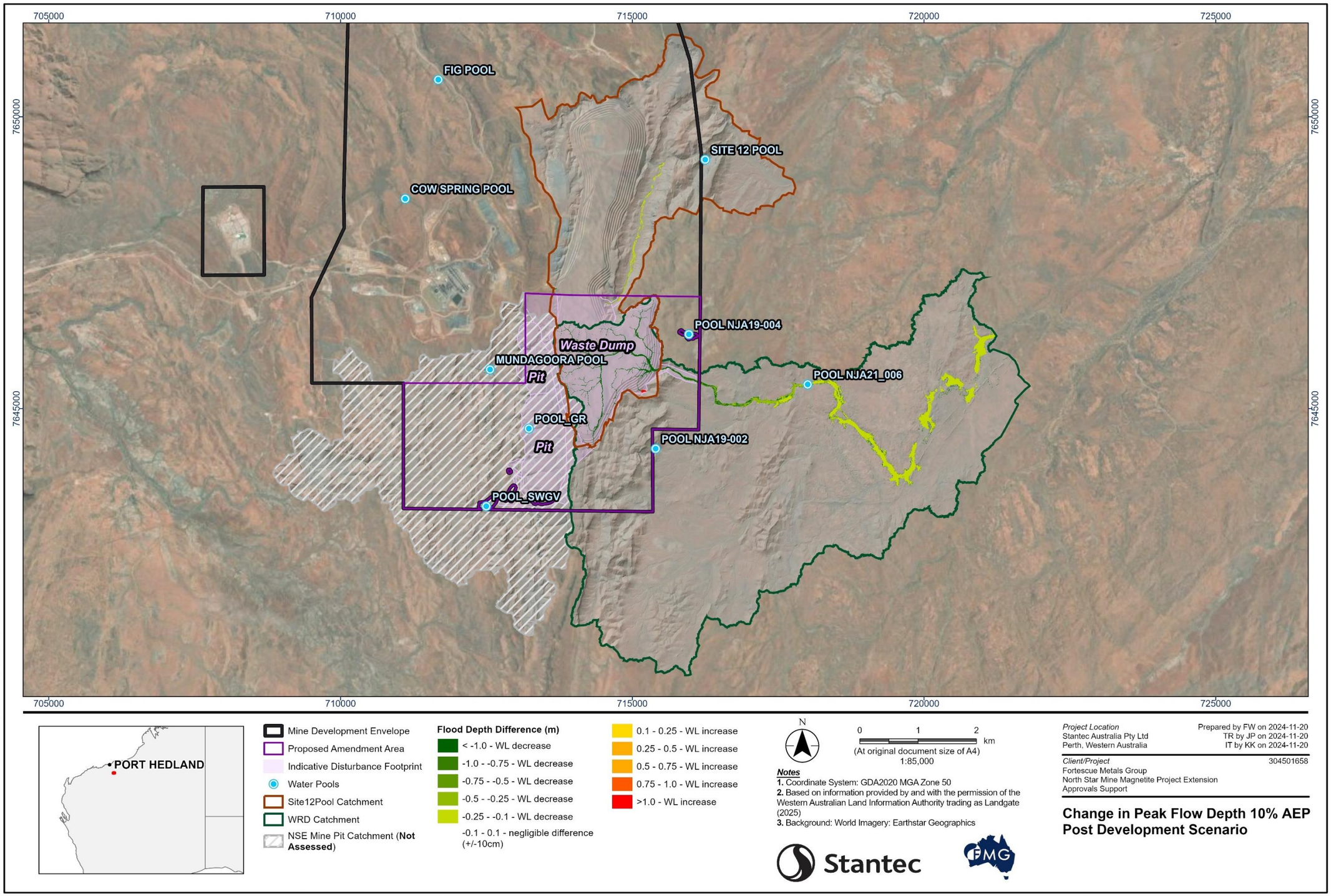

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Figure 3-4: Change in Peak Flow Depth 10% AEP Post Development Scenario

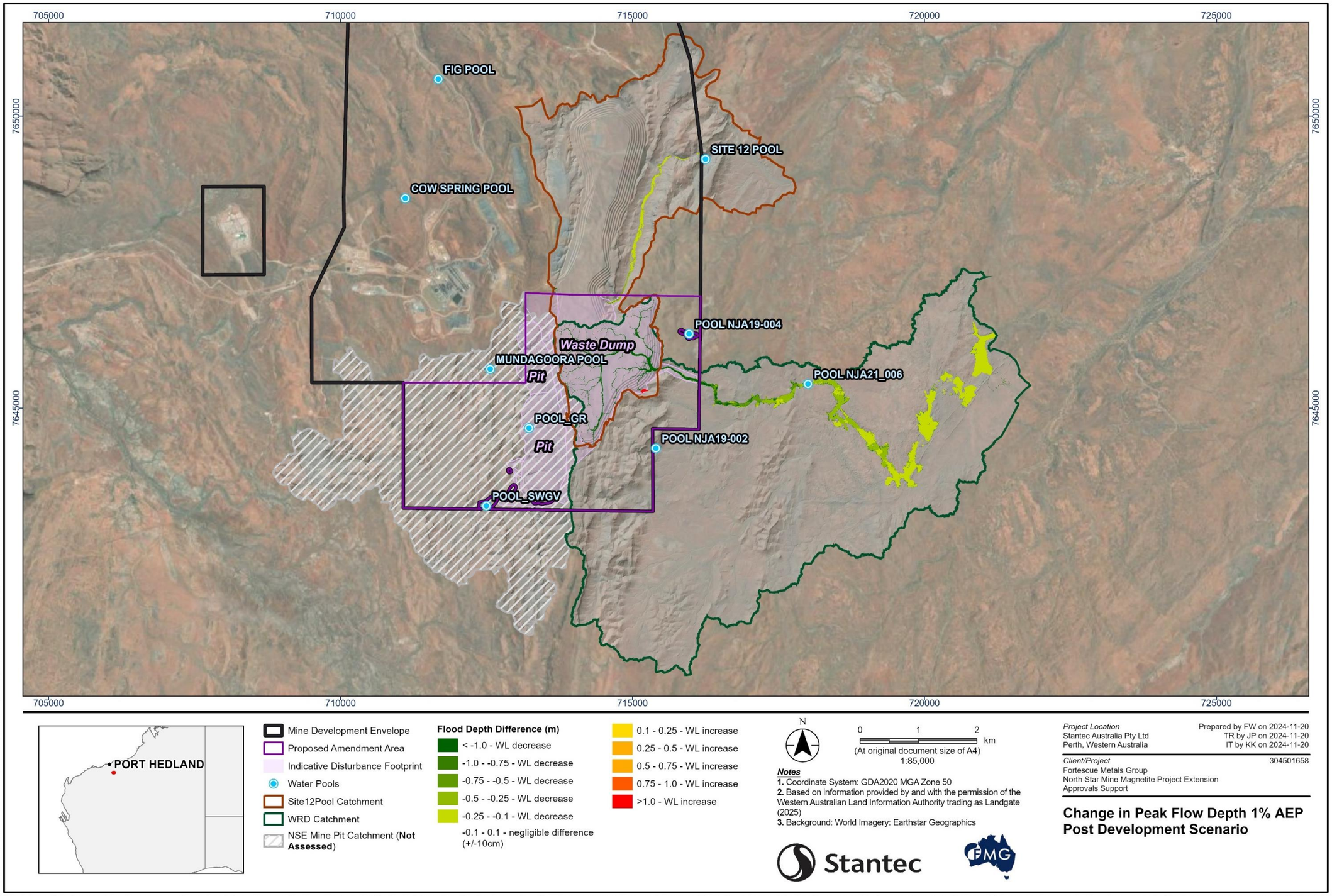

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Figure 3-5: Change in Peak Flow Depth 1% AEP Post Development Scenario

3.3 Risk Assessment

Based on the findings of the literature review and hydrological modelling (FMG 2025; Worley 2024), the risk assessment considered impacts to riparian vegetation and the P1 species *Themeda* sp. Panorama (J. Nelson et al. NS 102) in the NSE Site 12 Pool and WRD Catchments, which may be impacted by changes in surface water hydrology (**Section 3.2**).

The key sensitive receptors susceptible to a change in surface water flow from the Proposed Amendment include:

- *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) and
- Areas with the potential to support riparian vegetation.

Key threats identified for riparian vegetation include:

- A reduction in peak flood level, where an area with the potential to support riparian vegetation was wet and is now dry post development, due to the dependence of riparian vegetation for higher water availability within the root zone, compared to the surrounding landscape.

Key threats identified for *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) include:

- Increase in pooling of water or increase in water depth with the potential to cause waterlogging for *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1).
- Reduction in peak flood depth.

The risk assessment was conducted according to the two separate catchment areas; NSE Site 12 Pool and WRD Catchment. The risk assessment for the NSE Site 12 Pool and WRD Catchments is discussed in detail in **Section 3.3.1** and **Section 3.3.2**, respectively.

The scenarios considered most relevant (most likely to occur) for the risk assessment is the 50% AEP scenario and the 10% AEP scenario with a frequency of occurrence (ARI of 1.44 years and 9.49 years respectively). The least likely scenario is the 1% AEP flood event representing an extreme event occurring in exceptional circumstances ARI of 100 years (shown in **Appendix A**).

Risk presented within this assessment relates to inherent risk, prior to the implementation of mitigation measures and controls.

3.3.1 NSE Site 12 Pool Catchment

3.3.1.1 Riparian Vegetation

No riparian vegetation was identified in the NSE Site 12 Pool catchment by Ecoscape (2023) and an extrapolation of the riparian vegetation mapping by Stantec was not undertaken for this catchment. Risk rankings to areas with the potential to support riparian vegetation from a change in peak flood depth can therefore not be applied. Although slight reductions in the peak flood depth (m) from baseline level are observed in the waterway downstream of the WRD in the NSE Site 12 Pool catchment, potential impacts to riparian vegetation are expected to be negligible.

3.3.1.2 *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1)

Themeda sp. Panorama (J. Nelson et al. NS 102) (P1) populations within the NSE Site 12 Pool Catchment, to the north of the WRD, are assigned an inherent risk of **Medium** under the 50% AEP modelled scenario (**Figure 3-6),** and an inherent risk of **Low** for the 10% AEP (**Figure 3-8)** and 1% AEP **(Figure A 1**) modelled scenarios. This is due to increased wetting and the potential for waterlogging to occur (with a conservative approach taken due to a lack of scientific information). A slight consequence level is assigned to areas of Medium inherent risk where a **minimal impact** (limited impact to plant health/no loss of individuals expected to occur). The post development scenarios are as follows:

- The 50% AEP (**Figure 3-6**) results in a **Medium** risk to 396 locations (61.9% of known individuals) of known *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) (**Table 3-3**) attributed to where pooling occurs within areas intersecting *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) post development, in areas that were once dry and are now wet (13 records) as well as which were already identified as wet in the baseline model. 91 locations (38.1% of known individuals) of known *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) are located either outside of the modelled flood extent or above the predicted flood level and as such were assigned a **Negligible** risk.
- 10% AEP (**Figure 3-8**) floods (Worley 2024), result in a **Low** risk to 454 locations (73.3% of known individuals) within the modelled extent of *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1), due to a change in peak flood depth from baseline level occurring within the areas intersecting the *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1). No records coincided with areas that were once dry and are now wet (**Table 3-3**). 33 locations (26.7% of known individuals) are located either outside of the modelled flood extent or above the predicted flood level and as such were assigned a **Negligible** risk.
- The 1% AEP event (**Figure A 1**) for change in peak flood depth are rare in frequency and represent an extreme event. The inherent risk applied to *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) occurrences north of the WRD was assessed as **Low** risk to 472 locations (77.2% of known individuals) under this scenario given the lower likelihood of

occurrence due to a change in peak flood depth from baseline level occurring in areas intersecting the *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1). No records coincided with areas that were once dry and are now wet (**Table 3-3**) However, due to the actual nature of the extreme the assigned inherent risk may not apply. 15 locations (22.8% of known individuals) are located either outside of the modelled flood extent or above the predicted flood level and as such were assigned a **Negligible** risk.

Table 3-3: Population (number of individuals) of *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) at inherent risk due to modelled changes in peak flood depth (for various scenarios) post development for the NSE Site 12 Pool Catchment.

Risk Ranking	50% AEP[1]		10% AEP[2]		1% AEP[3]	
	Number of locations (number of individuals)	% of number of locations (% of known individuals)	Number of locations (number of individuals)	% of number of locations (% of known individuals)	Number of locations (number of individuals)	% of number of locations (% of known individuals)
Extreme	0 (0)	0% (0%)	0 (0)	0% (0%)	0 (0)	0% (0%)
High	0 (0)	0% (0%)	0 (0)	0% (0%)	0 (0)	0% (0%)
Medium	396 (7,076)	81.3% (61.9%)	0 (0)	0% (0%)	0 (0)	0% (0%)
Low	0 (0)	0% (0%)	454 (8,371)	93.2% (73.3%)	472 (8,820)	96.9% (77.2%)
Negligible	91 (4,349)	18.7% (38.1%)	33 (3,054)	6.8% (26.7%)	15 (2,605)	3.1% (22.8%)
Total	487 (11,425)	100% (100%)	487 (11,425)	100% (100%)	487 (11,425)	100% (100%)

[1]50% (13 records), [2]10% (0 records), [3]1% (0 records) – number of records of *Themeda* sp. *Panorama* (J. Nelson et al. NS 102) (P1) that were subject to increased wetting conditions that were dry at baseline and are now wet post development.

[1] 50% (91 records),[2]10% (33 records), [3] 1% (15 records) - number of records of *Themeda* sp. *Panorama* (J. Nelson et al. NS 102) (P1) that were either outside the extent of the model or above the predicted flood levels, therefore inherent risk can't be assigned.

3.3.1.3 Water Pools

Site 12 Pool, east of the WRD, in the Site 12 Pool Catchment may contain fringing riparian vegetation. However, no riparian vegetation was mapped in the NSE Site 12 Pool catchment by Ecoscape (2023) and an extension of the vegetation mapping was not undertaken for this catchment. Although slight reductions in the peak flood depth (m) from baseline level are observed in the waterway downstream of the WRD in the NSE Site 12 Pool catchment, potential impacts to the Site 12 Pool are expected to be negligible.

3.3.2 NSE WRD Catchment

3.3.2.1 Riparian Vegetation

The risk rankings to areas with the potential to support riparian vegetation from a change in peak flood depth were also applied to areas with the potential to support riparian vegetation in the main drainage line downstream of the WRD. The relative impacts are also reduced during larger (less frequent) rainfall and flow events. The **inherent risk** rankings to areas with potential riparian vegetation from a change in peak flood depth **Table 3-4** are categorised as follows:

- **High** risk for 4.49 ha or 3.5 % of potential riparian vegetation (mapped extent within the catchment) within approximately 2 km immediately downstream of the WRD in areas where the potential riparian vegetation was once wet during baseline levels and is now dry in the post development scenario, and **Medium** risk for 4.29 ha or 3.3% of mapped potential riparian vegetation under the 50% AEP event where water levels decrease to a maximum reduction of -0.2m and areas of increased dryness occur within areas that were wet now dry post development. The majority, 120.93 ha or 93.2%, of mapped potential riparian vegetation held **Negligible** risk (**Figure 3-7**).
- **Medium** risk for 3.68 ha or 2.8% of potential riparian vegetation (mapped extent within the catchment) downstream of the NSE WRD Catchment in areas where there is a considerable reduction in peak flow rate and where the potential riparian vegetation was once wet during baseline levels and is now dry in the post development scenario **(Figure 3-9**). A **Low** risk for 12.68 ha or 9.8% of mapped potential riparian vegetation under the 10% AEP event, (**Figure 3-9)**. **Low** risk for areas mapped as riparian vegetation commences approximately 2 km downstream of the WRD. In this area, flood depths will only decrease in the order of 50 cm to 20 cm as floodwaters from other parts of the catchment and surface water from adjacent sub-catchments contribute to system flows during larger less frequent events. **Negligible** risk for 113.33 ha or 87.4% of mapped potential riparian vegetation under the 10% AEP event.
- The risk to riparian vegetation is further reduced during larger (less frequent) rainfall and flow events, with **Medium** risk for 1.36 ha or 1.0% of potential riparian vegetation (mapped extent within the catchment), **Low** risk for 26.28 ha or 20.3% of mapped potential riparian vegetation downstream of the NSE WRD Catchment, and **Negligible** risk for 102.06 ha or 78.7% of mapped potential riparian vegetation under the 1% AEP event **(Figure A 2**) where the relative impacts to riparian are also reduced during larger (less frequent) rainfall and flow events.

Table 3-4: Area (ha) of inherent risk for areas with potential to support riparian vegetation due to modelled changes in peak flood depth (for various scenarios) post development for the WRD Catchment.

Risk Ranking	50% AEP		10% AEP		1% AEP	
	Total number of ha*	% mapped extent NSE Mine Catchment	Total number of ha*	% mapped extent NSE Mine Catchment	Total number of ha*	% mapped extent NSE Mine Catchment
Extreme	0	0%	0	0%	-	0%
High	4.49	3.5%	0	0%	0	0%
Medium	4.29	3.3%	3.68	2.8%	1.36	1.0%
Low	-	0%	12.68	9.8%	26.28	20.3%
Negligible	120.93	93.2%	113.33	87.4%	102.06	78.7%
TOTAL	**129.7**	**100%**	**129.7**	**100%**	**129.7**	**100%**

* Total number of hectares of inherent risk assigned to areas of potential riparian vegetation is inclusive of fringing riparian vegetation surrounding pools.

3.3.2.2 *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1)

No *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) have been recorded south of the WRD within the WRD Catchment, with no risk to this species as a result of changes in surface hydrology post development.

3.3.2.3 Water Pools

Smaller ephemeral pools with potential riparian vegetation (NJA21-006, NJA19-002 and NJA19-004) are assigned the following inherent risk categories from reduction in peak flood depth for these scenarios (the riparian vegetation mapping did not define the extent of potential fringing riparian vegetation surrounding the pools and therefore the total number of hectares of inherent risk calculated for areas of potential riparian vegetation within the NSE WRD Catchment (**Table 3-4**) is inclusive of areas of risk assigned to fringing riparian vegetation surrounding pools):

- NJA21-006: **Medium** (flood depth difference -0.30m assigned at the central point (NJA21-006 includes a series of ephemeral pools along an approximately 0.4km long creek.) for the 50% AEP scenario (**Figure 3-7**) which is assigned a slight consequence rating (a slight consequence level is assigned to areas of **Medium** inherent risk where a minimal impact is predicted (limited to plant health/no loss of individuals expected to occur)), **Low** (-0.34m reduction in peak flood depth post development) for the 10% AEP (**Figure 3-9)**), and **Low** (-0.50m reduction in peak flood depth post development), for the 1% AEP scenario (**Figure A 2).**
- NJA19-002: **Negligible** for all AEP scenarios **(Figure 3-7**, **Figure 3-9** and **Figure A 2)** as the change of peak flood depth is likely to fall within natural fluctuations.
- NJA19-004: This pool is outside the modelled extent.

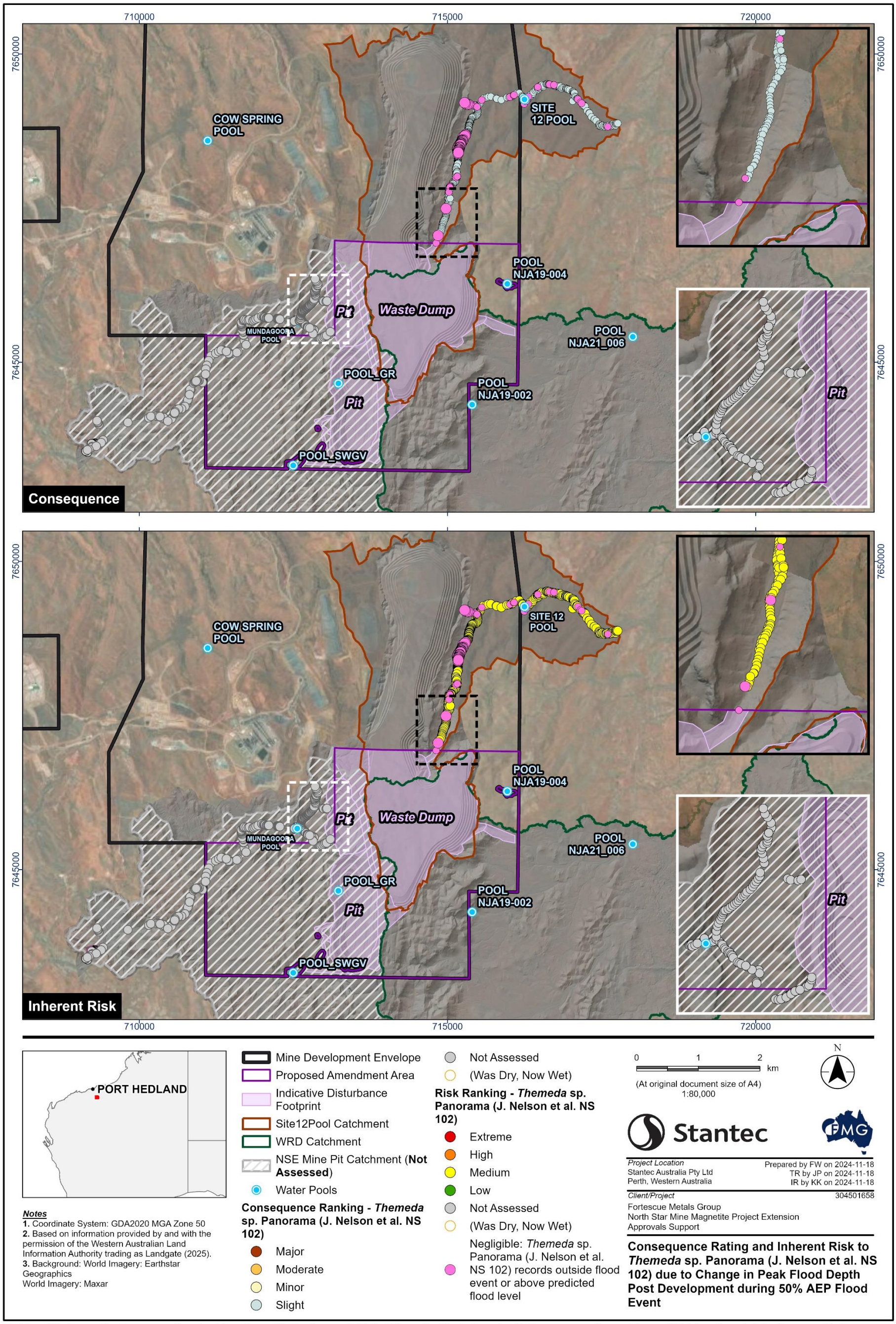

Figure 3-6: Inherent Risk to *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) due to change in peak flood depth (50% AEP), post-development scenario.

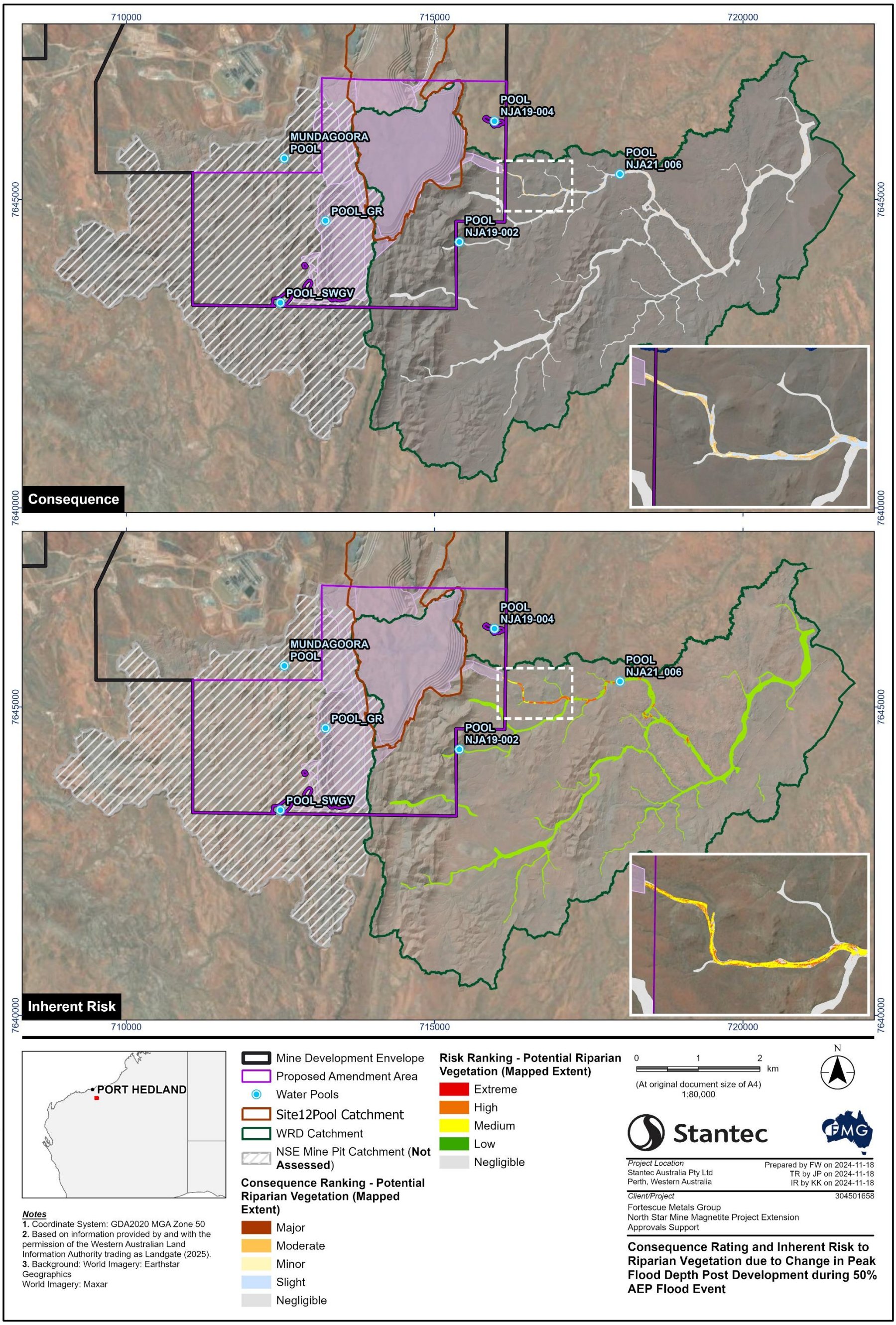

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Figure 3-7: Inherent Risk to areas with potential to support riparian vegetation due to change in peak flood depth (50% AEP), post-development scenario

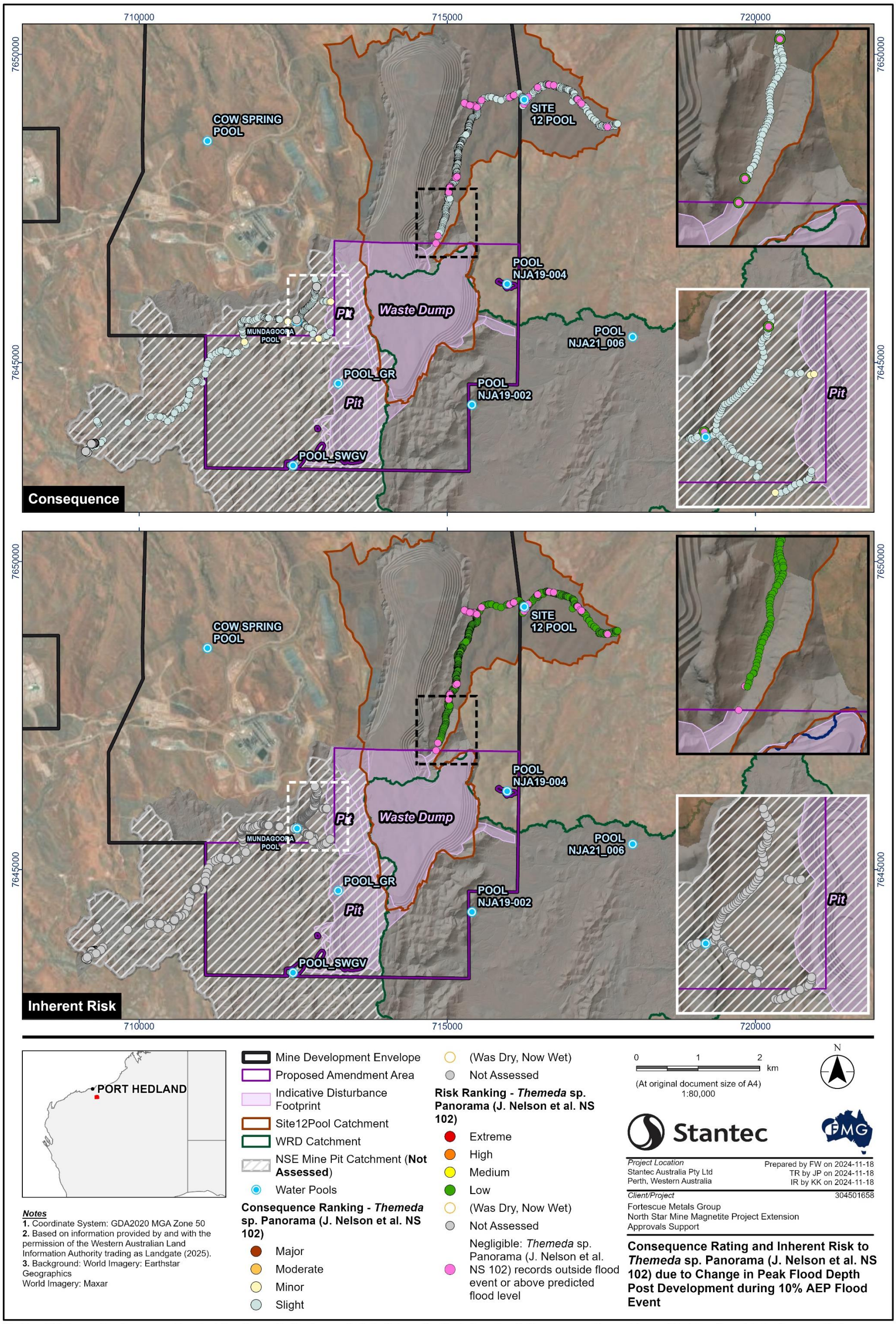

Figure 3-8: Inherent Risk to *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) due to change in peak flood depth (10% AEP), post-development scenario

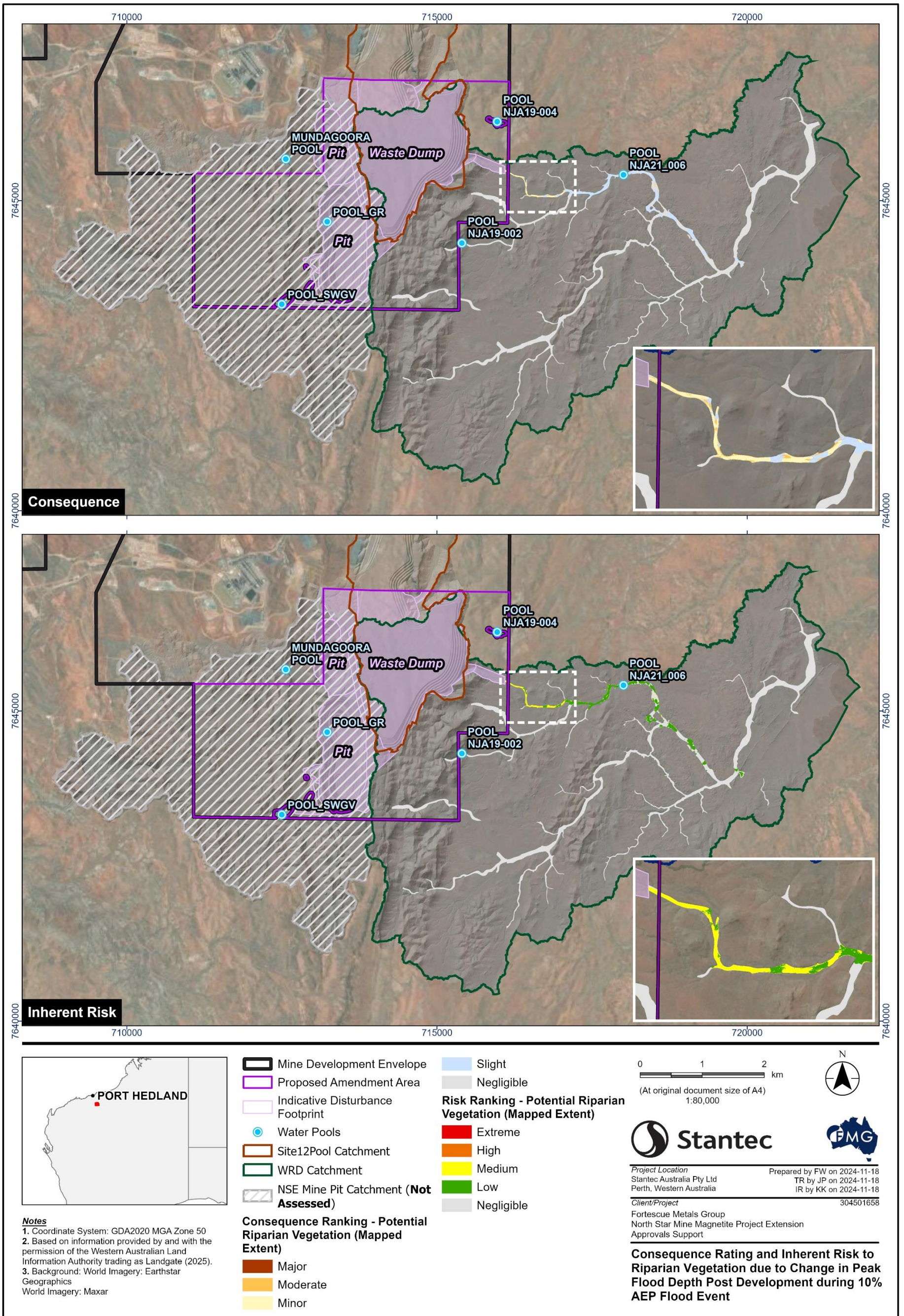

Figure 3-9: Inherent Risk to areas with potential to support riparian vegetation due to change in peak flood depth (10% AEP), post-development scenario.

4 Conclusion

This risk assessment presents inherent risk prior to the implementation of mitigation measures and controls. Overall combined areas of inherent risk assigned to riparian vegetation within the catchment areas as summarised in **Table 4-1** includes:

- **High** risk for 4.49 ha, **Medium** risk for 4.29 ha and **Negligible** risk for 120.93 ha of mapped potential riparian vegetation under the 50% AEP event;
- **Medium** risk for 3.68 ha, **Low** risk for 12.68 ha and **Negligible** risk for 113.33 ha of mapped potential riparian vegetation under the 10% AEP event; and
- **Medium** risk for 1.36 ha, **Low** risk for 26.28 and **Negligible** risk for 102.06 ha of mapped potential riparian vegetation under the 1% AEP event.

The 50% AEP and 10% AEP flood event are considered the most relevant modelled events applicable to this risk assessment based on higher frequency of occurrence. The 1% AEP scenario have been assessed to provide context of a rare and extreme event and inherent risk ratings applied are shown in Appendix A.

The Proposed Amendment will result in changes to surface hydrology within the NSE Mine Pit, Site 12 Pool and WRD Catchments. Surface hydrology in the NSE Mine Pit Catchment has been excluded from the risk assessment of potential impacts to potential riparian vegetation and significant flora species from changes in surface hydrology. Based on the literature review, changes in surface hydrology may impact on riparian vegetation along drainage lines due to its association with higher water availability within the root zone, compared to the surrounding landscape and *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1). *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) may be susceptible to waterlogging, which may occur when surface water flows are increased, and localised (or general) flooding occurs and is considered less likely to be significantly affected by reduced surface water flows. Although, reduced surface water flows over a longer time period may result in a decrease in plant vigour as energy stores in the root system are depleted.

Riparian vegetation has also been mapped throughout the NSE Mine Pit Catchment, however no inferences on risk can be made due to a lack of cumulative surface hydrology modelling.

Site 12 Pool, east of the WRD, in the Site 12 Pool Catchment is not believed to contain fringing riparian vegetation. No riparian vegetation was identified in the NSE Site 12 Pool catchment by Ecoscape (2023) and an extension of the vegetation mapping was not undertaken for this catchment.

Under the 50% AEP modelled event for the NSE WRD Catchment 4.49 ha or 3.5% of potential riparian vegetation (mapped extent within the catchment) was assigned as **High** risk. This area occurs within the area approximately 2 km immediately downstream of the WRD where surface flow will no longer be received post development, in areas where the potential riparian vegetation was once wet during baseline levels and is now dry in the post development scenario. Areas assigned as **Medium** risk total 4.29 ha and comprise a total of 3.3% of mapped potential riparian vegetation within the WRD catchment under the 50% AEP event. The **Medium** risk is assigned due to a slight consequence rating where **minimal Impact** to areas of potential riparian vegetation or loss of individuals is expected to occur. The majority (120.93 or 93.2% of mapped potential riparian vegetation) is considered to be at **Negligible** risk.

Under the modelled 10% AEP flood scenario, across the majority of the NSE WRD Catchment (113.33 ha, 87.4% of mapped potential riparian vegetation), the risk to riparian vegetation is expected to be **Negligible. Low** risk for areas mapped as riparian vegetation (12.68 ha or 9.8%), commences approximately 2 km downstream of the WRD. In this area, flood depths will only decrease in the order of 50 cm to 20 cm as floodwaters from other parts of the catchment and surface water from adjacent sub-catchments contribute to system flows during larger less frequent events. A medium risk was assigned to just 3.68 ha, 2.8% of mapped potential riparian vegetation within the WRD Catchment under the 10% AEP flood scenario.

The risk to riparian vegetation is further reduced during larger (less frequent) rainfall and flow events, with **Medium** risk for 1.36ha or 1.0% of potential riparian vegetation (mapped extent within the NSE WRD catchment) downstream of the NSE WRD Catchment, **Low** risk for 26.28ha or 20.3% of mapped potential riparian vegetation, and **Negligible** risk for 102.06 ha or 78.7% of mapped potential riparian vegetation under the 1% AEP event where the relative impacts to riparian are also reduced during larger (less frequent) rainfall and flow events.

For Pool NJA21-006 a **Medium** inherent risk from reduction in peak flood depth (-0.30m reduction in peak flood depth post development) is assigned for the 50% AEP scenario, **Low** (-0.34m reduction in peak flood depth post development) for the 10% AEP), and **Low** (-0.50m reduction in peak flood depth post development), for the 1% AEP scenario**.** Pool NJA19-002 is assigned a **Negligible** risk for all AEP scenarios as the change of peak flood depth is likely to fall within natural fluctuations. Pool NJA19-004 is outside the modelled extent.

In contrast to riparian vegetation, the significant flora species *Themeda* sp. Panorama (J. Nelson *et al*. NS 102) (P1) may be susceptible to waterlogging, where flooding depth increases for extended periods. However, assuming the landform is relatively well-drained, and surface water flows occur at low velocity, episodic increases in surface water flows are unlikely

to have a detrimental effect to populations of this species. In addition, there are no records of *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) south of the WRD within the WRD Catchment.

The 50% AEP results in a **Medium** risk to 396 locations of *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) within the modelled extent, where water levels increase in the order of 0.4m. This is due to a slight consequence level being assigned where **minimal impact** is expected to occur resulting in limited impact to plant health/no loss of individuals.

The 10% AEP event Worley (2024), results in a **Low** level of inherent risk assigned to 454 locations of *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1). The length of time that water persists in these locations is not known. The 1% AEP is the least applicable scenario for assessing risk to *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) due to the actual nature of the extreme flood event and the assigned inherent risk may not apply.

However, more broadly infrastructure development that may contribute to changes in the surface hydrological regime (mining pits or WRD landforms) are located near the catchment divide, limiting potential impacts to vegetation and flora. Impacts to potential riparian vegetation also typically reduce downstream and less evident during infrequent intensive rainfall and flow events in both catchments.

The areas that are assigned higher risk rankings are considered conservative and are based on inherent risk without consideration of the implementation of appropriate mitigation measures outlined in the Iron Bridge Surface Water Management Plan and given the high variability of the Pilbara environment, flora and vegetation are adapted to seasonal and interannual changes, within tolerance limits.

Table 4-1: Overall areas of inherent risk ratings applied for both catchments (NSE Mine Pit Catchment, Site 12 Pool Catchment and WRD Catchment)

Risk Rating	Potential Riparian Vegetation Area (ha)			Justification	Risk Rating	*Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) Records (no of individuals) [1]			Justification
Peak flood depth scenario	**50% AEP**	**10% AEP**	**1% AEP**		**Peak flood depth scenario**	**50% AEP[1]**	**10%AEP[2]**	**1% AEP[3]**	
High	4.49	0.00	0.00	***High*** *inherent Risk assigned within approximately 2 km immediately downstream of the WRD in areas where the potential riparian vegetation is subject to increased dryness and a reduction in flow rate in the post development scenario.*	High	0 (0)	0 (0)	0 (0)	*There are no records or individuals of Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) at **High** inherent risk from change in peak flood depth.
Medium	4.29	3.68	1.36	*Due to change in peak flood depth downstream of the WRD in areas where potential riparian vegetation is subject to increased dryness and reduced flow rate.*	Medium	396 (7,076)	0 (0)	0 (0)	*Due to the potential for waterlogging to occur within 2km north of the WRD (with a conservative approach taken due to a lack of scientific information). The length of time that water persists in these locations is not known. The following range of change in peak flood depth occurs for locations identified at* ***Medium*** *inherent risk:* • 50% (-0.43 to 0.43m) • 10% (0.3m to 0.99m) • 1% (0.6m to 2m).
Low	-	12.68	26.28	*Due to a minimal change in reduction in peak flood depth.*	Low	0 (0)	454 (8,371)	472 (8,820)	*Due to a minimal change in reduction in peak flood depth.*
Negligible	120.93	113.33	102.06	*Due to a negligible change in peak flood depth, or change occurring within range of natural fluctuations.*	Negligible	91 (4,349)	33 (3,054)	15 (2,605)	*These records of Themeda sp. Panorama (J. Nelson et al. NS 102) (P1) were either outside the flood event level or above the predicted flood level*
TOTAL	**129.70**					**487 (11,425)**			N/A

[1] 50% AEP- 13, [2] 10% AEP: 0, [3] 1% AEP: 0: number of locations that were dry at baseline and now wet (subject to potential water pooling).

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Appendix A Inherent Risk Assigned 1% AEP Event

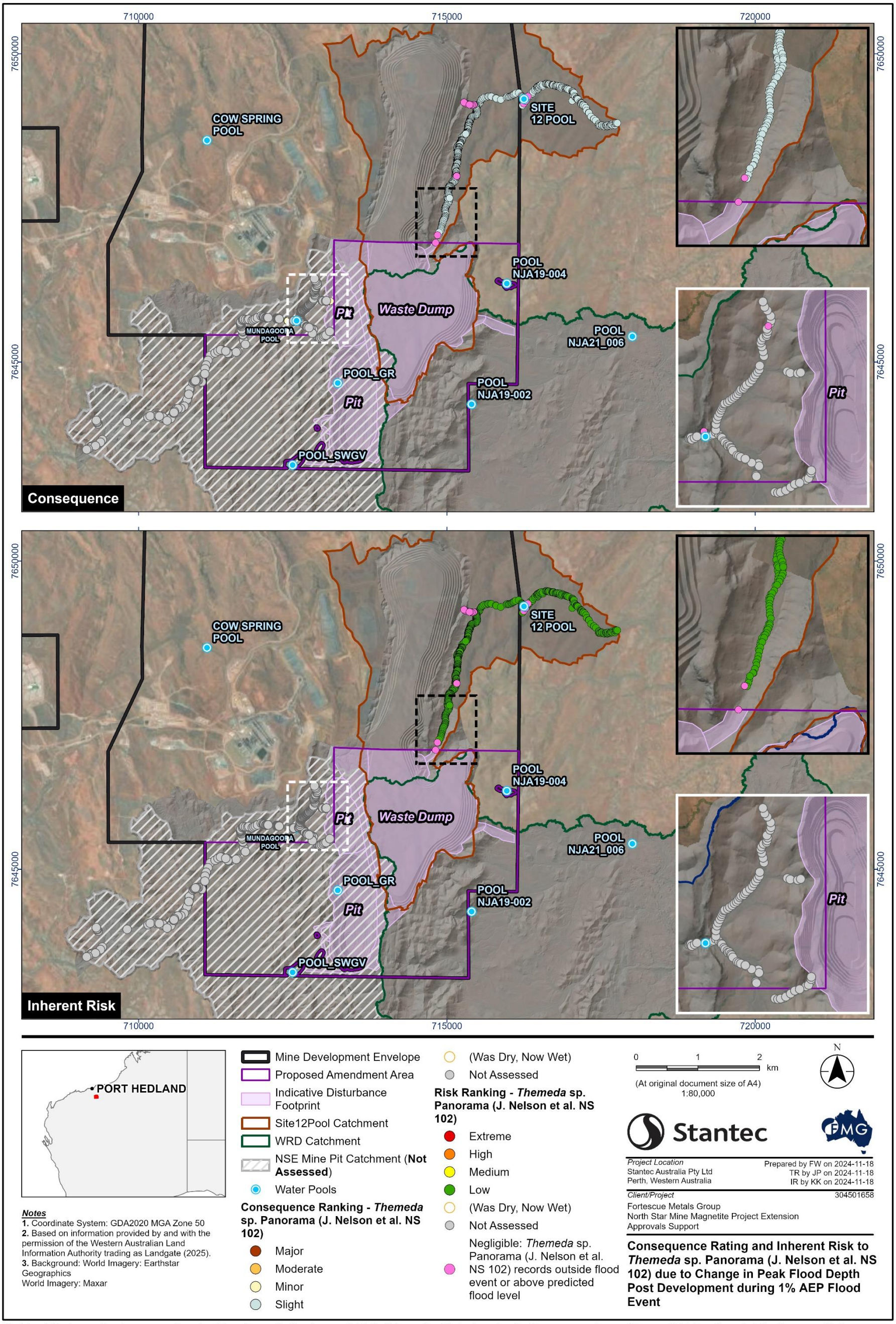

Figure A 1: Inherent Risk to *Themeda* sp. Panorama (J. Nelson et al. NS 102) (P1) due to change in peak flood depth (1% AEP), post-development scenario.

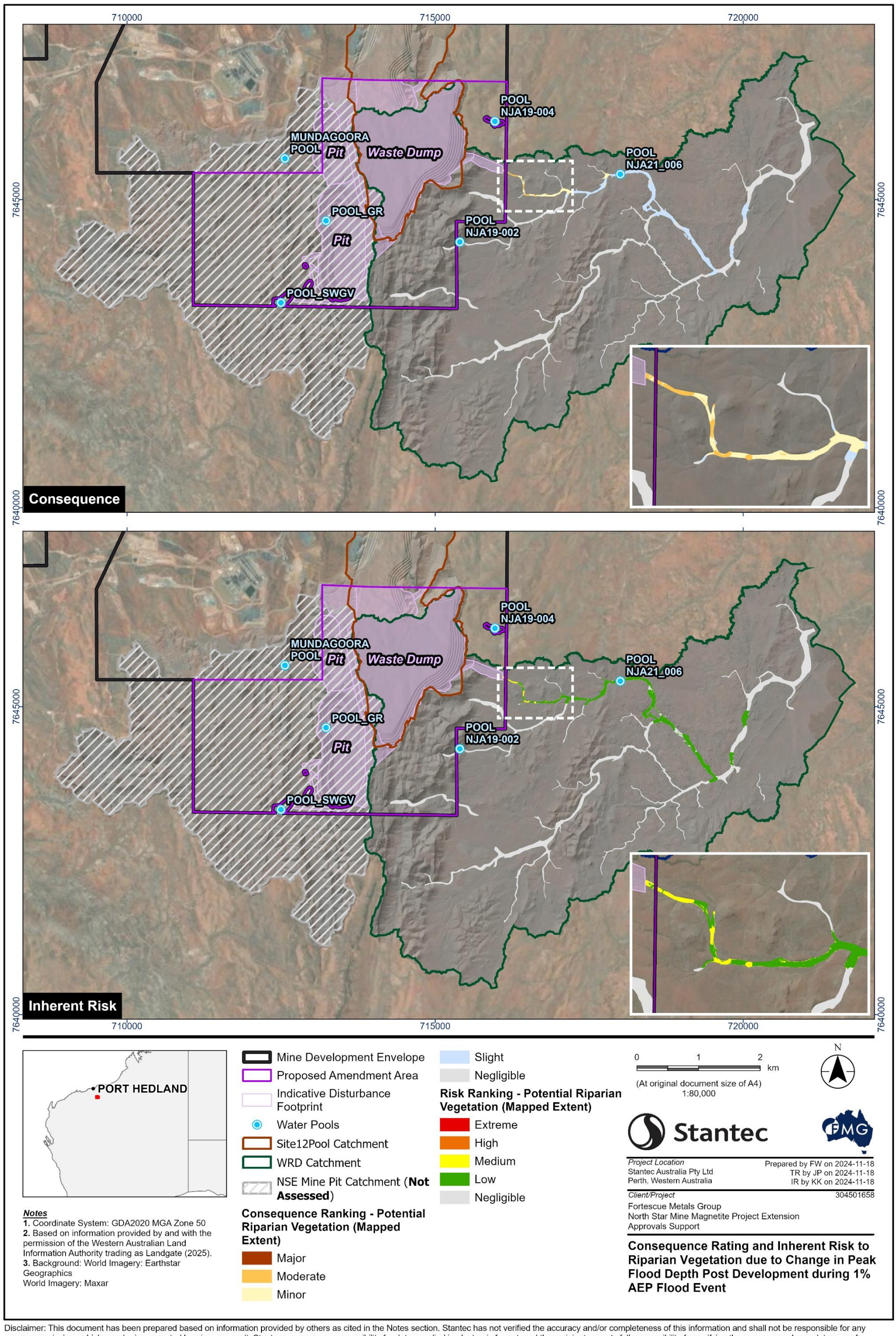

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Figure A 2: Inherent risk to areas with potential to support riparian vegetation due to change in peak flood depth (1% AEP), post-development scenario.

DESIGN WITH COMMUNITY IN MIND

Communities are fundamental. Whether around the corner or across the globe, they provide a foundation, a sense of place and of belonging. That's why at Stantec, we always design with community in mind.

We care about the communities we serve—because they're our communities too. This allows us to assess what's needed and connect our expertise, to appreciate nuances and envision what's never been considered, to bring together diverse perspectives so we can collaborate toward a shared success.

We're designers, engineers, scientists, and project managers, innovating together at the intersection of community, creativity, and client relationships. Balancing these priorities results in projects that advance the quality of life in communities across the globe.

Stantec trades on the TSX and the NYSE under the symbol STN.
Visit us at stantec.com or find us on social media.

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