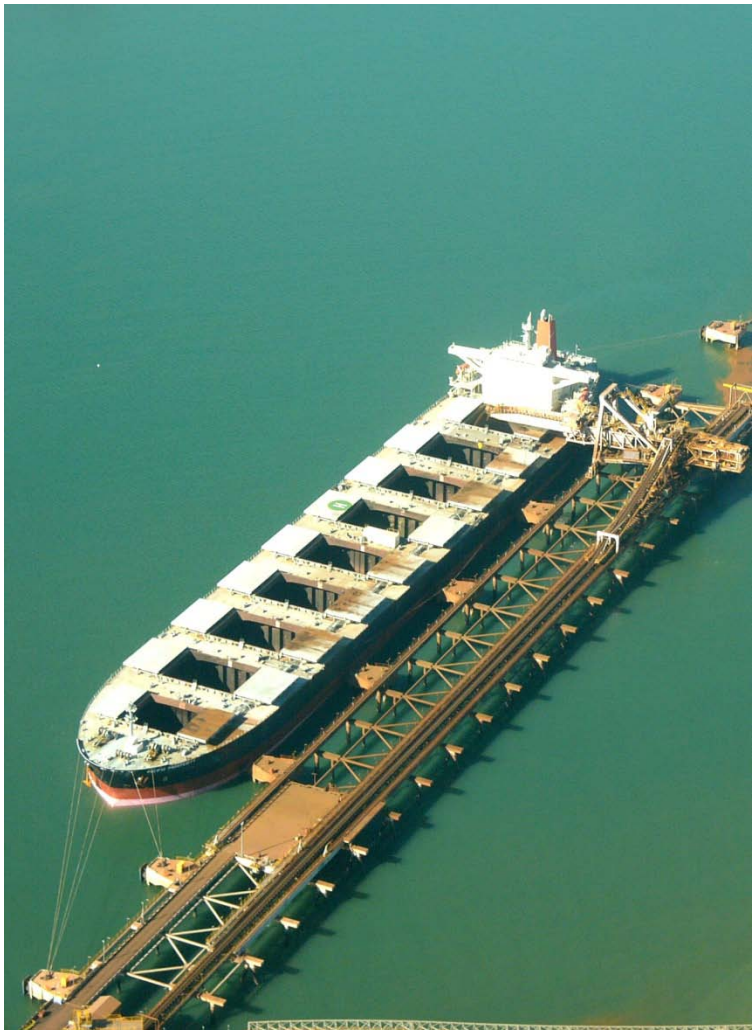
Outer Harbour Development: Subterranean Fauna Risk Assessment



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Report 2008/41

Outer Harbour Development: Subterranean Fauna Risk Assessment

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[1] SKM, [2] BHPBIO

Executive Summary

This report provides a desktop review of the risks to subterranean fauna associated with the Port Hedland Outer Harbour Development. Impacts of construction were evaluated for six elements of the development: stockyards, car dumpers, conveyor tunnels, infrastructure corridor to Finucane Island, transfer pad on Finucane Island, and railway lines. The review is based on a description of the Port Hedland Outer Harbour Development supplied by SKM.

There are two types of subterranean fauna. Stygofauna are aquatic and live in groundwater whereas troglofauna are air-breathing and live in deep subterranean spaces above the watertable. Risks to each group were considered separately. Evaluation of risks focussed on elements within the development where potentially significant impacts (principally de-watering or excavation) will occur and where subterranean fauna are likely to be present. Less likely, and probably less significant, impacts of groundwater and soil pollution were also considered.

Results of previous regional stygofauna survey showed almost 50 species of stygofauna occur within 100 km of Port Hedland, suggesting that stygofauna are present within the development. De-watering, and thus potentially adverse impacts on any stygofauna present, will occur at the new stockyards, car dumpers and conveyor tunnels. However, groundwater in the vicinity of those elements mostly has salinities of 10-60 g L^{-1} Total Dissolved Solids (TDS). There are almost no records of Pilbara stygofauna at such high salinities and, therefore, it is highly unlikely any stygofauna occur within the area of the stockyards, car dumpers and conveyor tunnels.

De-watering will not be required during construction of the proposed infrastructure corridor, transfer pad or rail lines and any stygofauna present in these areas are unlikely to be impacted by development. Construction of the Western Spur rail option will utilise water from shallow bores nearby, which if located within sands or alluvium, may possibly result in very localised loss of fauna. Extracting small water volumes only from shallow bores will prevent any risk to species survival.

Groundwater pollution caused by spillages of hydrocarbons, waste or hazardous materials can potentially result in reduced health of any stygofauna communities present under, or downstream of, project facilities. However, adoption of adequate threat management, including spill management plans, should prevent any significant impacts on stygofauna.

Troglofauna are considered unlikely to occur in significant numbers within 5 m of the surface because they require high humidity and relatively constant environmental conditions. Furthermore, at shallow depths they are likely to be outcompeted by surface animals. Given that the depth to groundwater under the stockyards, car dumpers and conveyor tunnels is only 3-4 m, occasionally much less after heavy rain, and that watertables are even shallower close to the coast where the infrastructure corridor and transfer pad lie, troglofauna are unlikely to be present under any component of the development other than rail lines. Existing knowledge of patterns of troglofauna occurrence suggest that few, if any, species will be present around rail lines. The spatial scale of any impact from rail construction will be very small because excavation will mostly be less than 1 m, which is above the zone occupied by

troglofauna. Thus, the development is not considered to pose a risk to troglofauna. Given that troglofauna are unlikely to occur within the Outer Harbour Development, potential loss of troglofauna through soil pollution is very unlikely to occur, especially if spillages of hydrocarbons, waste or hazardous materials are managed.

Desktop study has shown there is very low probability of either stygofauna or troglofauna being impacted upon by de-watering, groundwater abstraction, soil excavation or soil leveling for the Port Hedland Outer Harbour Development. The afore-mentioned activities, together with soil and groundwater pollution, are considered to be the only potential impacts to subterranean fauna. Pollution can be mitigated through management. No significant pollution is expected and best practice management should prevent pollution threat to any subterranean fauna.

It is considered that desktop review has provided a reliable assessment of risk to subterranean fauna from the Port Hedland Outer Harbour Project. Given the very low risk to subterranean fauna, no further fieldwork or subterranean fauna survey is recommended.

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1.0 Introduction

The Port Hedland Outer Harbour Development involves the development of infrastructure off Finucane Island at Port Hedland by BHP Billiton Iron Ore (BHPBIO). The purpose is to increase the capacity to ship iron ore through the harbour to meet forecast growth in global iron ore demand. The expanded infrastructure consists principally of stockyards for temporary storage of iron ore, associated railways, car dumpers and tunnels to bring ore into the stockyards located near Boodarie (Figure 1.1), and a conveyor system to transport ore to Finucane Island for loading via a jetty or wharf.

This report provides a desktop review of the risks to subterranean fauna associated with the development. The components of the project evaluated were construction of the stockyards, car dumpers, conveyor tunnels, infrastructure corridor (including conveyor system), transfer pad on Finucane Island and new rail lines.

Objectives of the review were:

1. Collate and review existing subterranean fauna information
2. Collate and review existing hydrogeological information that is relevant to the occurrence of subterranean fauna
3. Identify the potential occurrence of subterranean fauna communities within the development area based on biological and habitat information
4. Provide species lists of potentially occurring subterranean fauna and highlight those of conservation significance
5. Consider likely direct and indirect impacts to subterranean fauna from planned development
6. Recommend management, and further work if necessary, where a high risk of impact on subterranean fauna is identified.

No maps of subterranean fauna occurrence and suitable habitat are provided with this report because of a low probability of subterranean fauna occurrence and the substantial small-scale variability that is likely in the distribution of any species that do occur. Distributions are expected to be variable because of large spatial and temporal variation in groundwater salinity, which is likely one of the major factors controlling stygofauna distribution (e.g. Masciopinto et al. 2006).

2.0 Description of relevant aspects of project

The terrestrial section of the Outer Harbour Development will be located to the west of Port Hedland, with the main node of infrastructure being located to the south of Finucane Island (Figure 1.1.). Proposed infrastructure and associated activities are listed below:

1. Rail loop and rail options. There are four rail options being considered. Three rail options (Options 1, 2 and 3A) extend south from a rail loop located immediately adjacent to the stockyards. The Goldsworthy rail option extends east from a rail loop also located immediately adjacent to the stockyards. Iron ore will be transported by rail from various mine sites within the Pilbara to the car dumpers, at which point the iron ore will be off-loaded. Proposed excavations associated with rail construction are unlikely to be greater than 1m depth, except where deeper excavations (3-4m) are required in the southern extent of the project area to cut through hills. No dewatering is anticipated to be required (Table 2.1). Construction of the proposed Goldsworthy Rail and all Outer Harbour Development infrastructure will utilize water from the

Town of Port Hedland water scheme. Construction of the rail options south of Boodarie will require groundwater from nearby shallow bores.

2. Stockyards. The proposed stockyards are located at Boodarie to the north of the former HBI site. Iron ore transported by rail from mine sites across the Pilbara will be stockpiled prior to being transported by a conveyor system to Finucane Island. Excavations less than 2m depth are proposed during construction (Table 2.1). Dewatering will not be required. Water for construction and dust suppression will be obtained through the Town of Port Hedland Water Supply scheme.
3. Car dumpers. Construction of four car dumpers is proposed. These will be located adjacent to the stockyards and will be connected to it via a series of conveyor tunnels. Iron ore transported by rail from mine sites will be emptied using a car dumper, which tips each car as the train passes slowly through the facility. Excavation to an approximate depth of 25m is planned for the construction of the car dumpers. Dewatering will be required as part of the construction process (Table 2.1).
4. Conveyor tunnels. Four conveyor tunnels are proposed, one leading from each car dumper to the stockyards. Iron ore emptied from the cars will be transported to stockpiles in the stockyards via the conveyor tunnels. Proposed excavations are planned to range from approximately 25m deep in the vicinity of the car dumper to ground level at the stockyards. Dewatering will be required during construction of the conveyor tunnels. Construction or operation of this planned infrastructure does not pose any risk in terms of groundwater or soil pollution.
5. Infrastructure corridor (including conveyor system). This links the stockyards to the transfer pad on Finucane Island and iron ore from the stockyards will be transported via the conveyor system. Proposed excavations are unlikely to be greater than 1m depth, except in isolated hilly sections where proposed excavations of approximately 3m depth may be required. Dewatering is not expected as part of construction (Table 2.1).
6. Transfer pad. This is located on Finucane Island, where there is a change in alignment of the conveyor as it comes from the stockyards and travels out along the proposed jetty. Proposed excavations are generally unlikely to be greater than 1m depth, with exception of the northern side of Finuncane Island where dunes are present and excavations of approximately 5m depth may be required. Dewatering will not to be required across most of the excavated area because groundwater will not be intercepted.

The activities associated with development that are most likely to have impacts on any subterranean fauna present are de-watering, groundwater abstraction and soil excavation. Significant soil and groundwater pollution may also detrimentally affect subterranean fauna. Possible sources of soil or groundwater pollution include:

- leakage of polluted dust suppression water from stockpiles;
- fuel and oil leaks from storage facilities and machinery;
- washdown of plant equipment;
- discharge from site ablution facilities, and
- spillage of maintenance chemical such as hydraulic fluids, paints and thinners.

Table 2.1 summarises the activities associated with construction of Outer Harbour Development infrastructure that could potentially affect subterranean fauna.

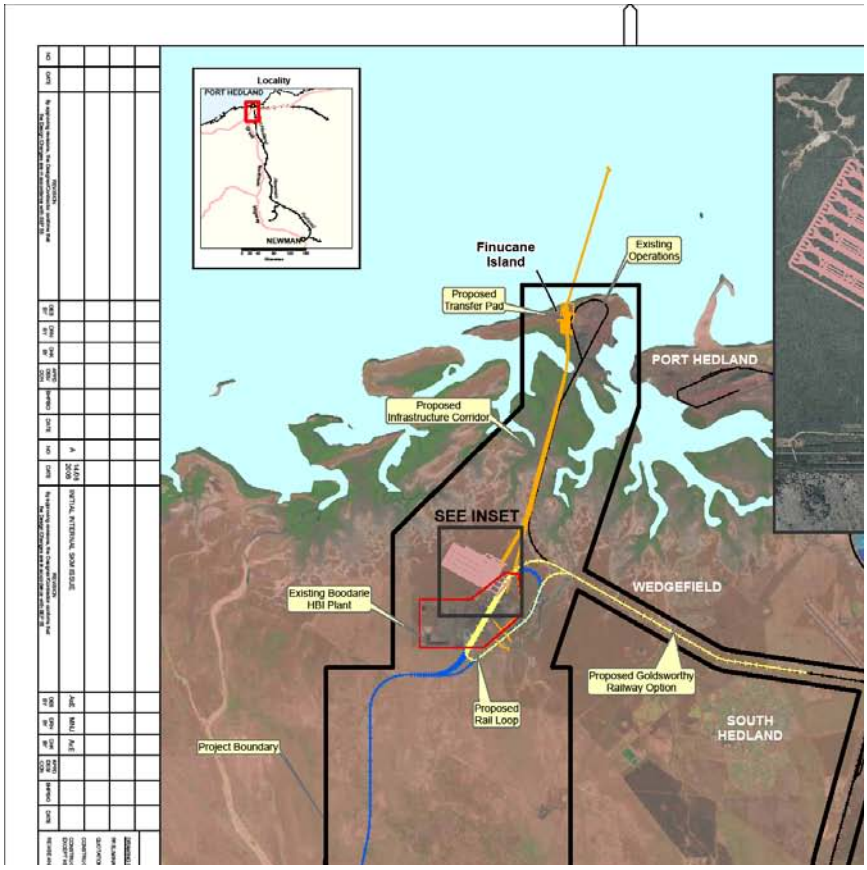

Figure 1.1 (also Appendix A)**. Location of major infrastructure associated with the Port Hedland Outer Harbour Development.** Map provided by SKM

Table 2.1. Summary of disturbance caused by different elements of Outer Harbour Development

	Groundwater drawdown (m below ground level)	Excavation depth (m below ground level)
Rail		
Options 1, 2, 3A	unlikely	localized 4-5 m
Goldsworthy	unlikely	1 m
Stockyards	unlikely	<2 m
Car dumpers	up to 25 m	25 m
Conveyer tunnels	up to 25 m	25 m
Infrastructure corridor	unlikely	1 m, localized 3 m
Transfer pad	localized dewatering	<5 m

3.0 Methods

This desktop review is based on the description of the Port Hedland Outer Harbour Development in Section 2.0.

3.1 Hydrogeology

Information on geology of the site was taken from the HBI plant CER (BHP 1994) and a recent review of various aspects of the geology and hydrologyof the Port Hedland Outer Harbour Development (SKM 2008a).

Information of groundwater levels and salinity within the development area was obtained from the former Boodarie HBI plant CER, annual environmental monitoring for the plant (BI 2006; Ecowise Environmental unpubl. data) and studies at Finucane Island (Coffey 2007; SKM 2008b). Information about groundwater levels and salinity on the plain around Port Hedland was obtained from water quality data collected during previous biological surveys (Halse et al. in prep.).

3.2 Subterranean fauna

Subterranean fauna is a term used to describe animals that spend all, or most of, their life cycle underground and possess morphological adaptations to an underground existence. Most commonly, these are loss of eyes and skin pigmentation although some subterranean species retain eyes.

There are two kinds of subterranean animals: stygofauna and troglofauna. Stygofauna are aquatic and occur in groundwater. Troglofauna are air-breathing and occur in underground cavities and small fissures above the water table. Nearly all subterranean fauna are invertebrates, although both stygofaunal fish and troglofaunal reptiles have been recorded in Western Australia.

Available information on stygofauna, from a recent Pilbara-wide biological survey (Halse et al. in prep.), were collated. Inferences about the habitats occupied by stygofauna and troglofauna were based on a range of scientific publications (cited as appropriate) and results of the Pilbara survey.

3.3 Risk to subterranean fauna

The assessment of risk to subterranean fauna from the proposed development was based on the species of subterranean fauna likely to be present, their likely habitat requirements and environmental tolerances, and the likely changes to subterranean fauna habitat resulting from development. Information about stygofauna occurrence in the sub-region was obtained from a recent Pilbara-wide

biological survey (Halse et al. in prep.), whereas all information on troglofauna was inferred because of lack of survey data in the public domain.

The changes to subterranean habitats in the proposed development that are considered likely to affect subterranean fauna are de-watering and soil excavation. Pollution also has the potential to affect subterranean fauna although the eastern part of Finucane Island has already experienced contamination with hydrocarbons and metals, particularly manganese and chromium (Coffey 2007; SKM 2008b).

Considerable weight was given to geology and the likelihood of voids and other underground spaces for animals to inhabit when considering whether subterranean species were likely to occur within the development. Groundwater salinity in relation to known tolerances of Pilbara stygofauna species (Halse et al. unpubl.; see also Eberhard et al. 2008) was also an important aspect of risk assessment.

The recent conclusion of the Environmental Protection Authority (EPA) that troglofauna are unlikely to occur on the eastern side of Exmouth Gulf because of the shallow depth to groundwater and saline environment (EPA 2008) provided context for the importance of issues when evaluating the likelihood of occurrence of troglofauna in the development area.

4.0 Results

4.1 Physical description

The project envelope for the Port Hedland Outer Harbour Development covers a study area of 361 km^2 extending inland from the coast at Port Hedland. It lies within the broad, flat coastal plain, up to 20 km wide, that runs the length of the Pilbara coast. All significant development activity other than railway construction will be restricted to the northern part of the development area between Finucane Island and BHPBIO's former HBI plant in the Boodarie industrial area.

Finucane Island is a small island that encloses the bay into which South West Creek discharges when it flows after cyclonic rain. It is substantially modified, with the eastern part mostly covered by harbour-related infrastructure but the northern side has retained comparatively undisturbed dunes (Figure 4.1). The mainland opposite Finucane Island, where the infrastructure corridor is proposed, has extensive intertidal and supratidal mudflats. The latter support samphire and there are mangroves along the margin of the intertidal flats in more sheltered areas. Inland of the mudflats, where the rail loops, stockyards and car dumpers will be located the area is predominantly sandplain covered by open grassland (Figure 4.2).

4.2 Climate

The climate of Port Hedland is warm to hot and semi-arid, with mean maximum temperatures of 35°C in January and 26°C in July. Maximum temperatures in summer are usually moderated by a humid sea breeze. Most rain results from cyclones and monsoonal depressions. Average annual rainfall is about 330 mm (http://www.bom.gov.au/climate/averages/tables/cw_004002.shtml) but this is highly variable between years because most rainfall is cyclonic.

4.3 Geology

Most of the development area, which lies within the Turner River catchment consists of silty red brown sand, with patches of clayey sand and bands of high level sand (Figure 4.3). River courses themselves

Figure 4.1. Finucane Island loading facilities in the right hand side of photo, dunes above. Note the mangroves on Finucane Island in the foreground

Figure 4.2. Environment around the HBI plant at Boodarie. The stockyards are planned to be located north (to the left and towards viewer) of the now demolished plant. The route to be used approximately by the conveyor to Finucane Island is visible

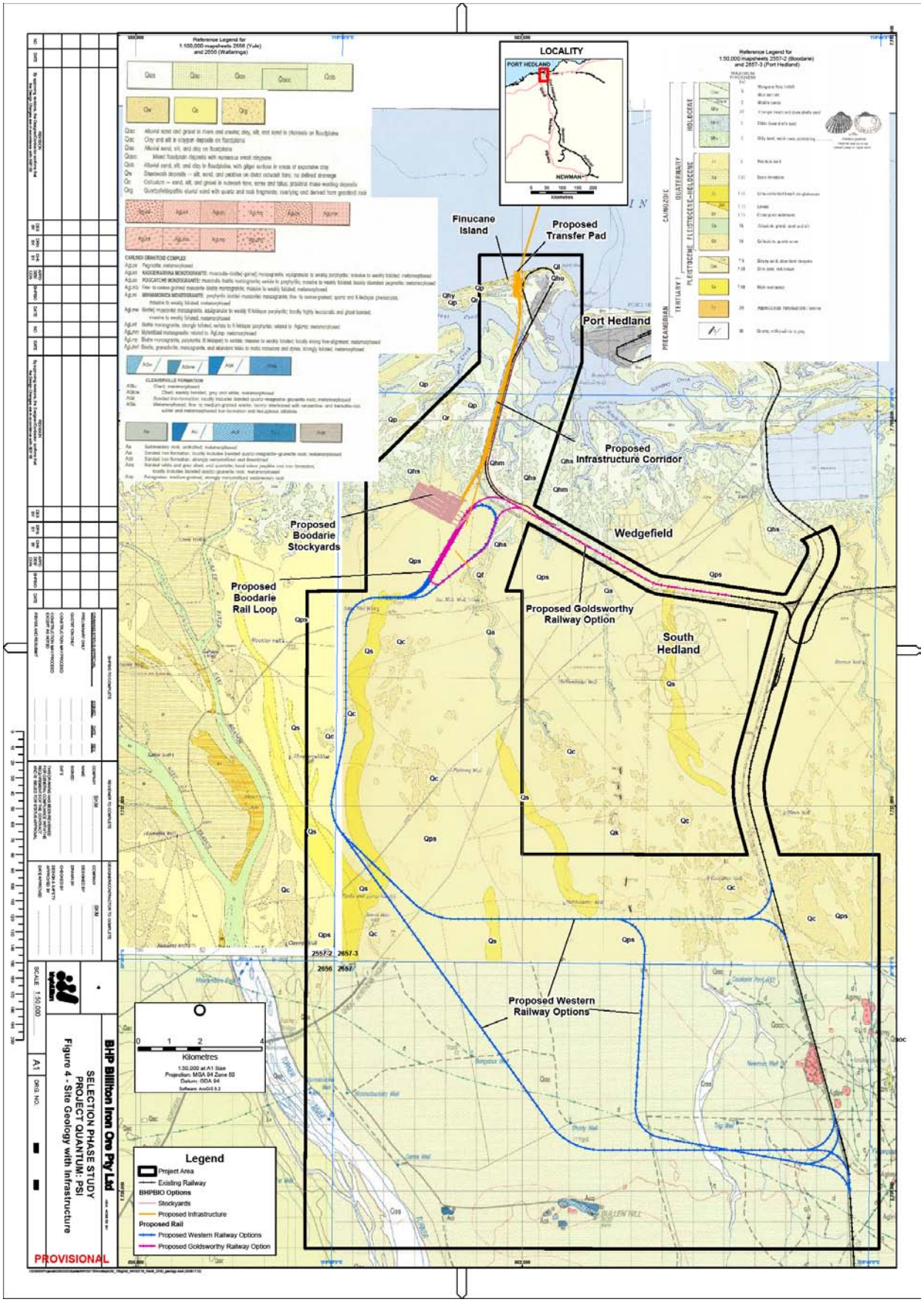

Figure 4.3 (see also Appendix B). **Geology of the Outer Harbour Development**. Supplied by SKM

contain alluvium. Towards the coast there is a band of silty sand grading into mangrove areas and mudflats, with patches of dune limestone emerging from the mudflats (Geoscience Australia 1981). On the northern side of the adjacent Finucane Island, there is a ridge of dune limestone and lime cemented beach conglomerate. South of this ridge, the island consists of mudflats and mangrove areas.

4.3.1 Subterranean fauna habitat

The lithologies underlying different elements of the Outer Harbour Development are summarized in Table 4.1. In terms of providing physical space for subterranean fauna habitat, areas with alluvium, dune limestone and lime cemented beach conglomerate are likely to contain large enough interstitial spaces and voids to support most types of subterranean fauna (Gibert et al. 1994; Wilkens et al. 2000). Silty sand and clayey sand are likely to support smaller subterranean species, such as stygal micro- and meiofauna (animals not easily visible to the naked eyes), together with species capable of burrowing. Burrowing species are likely to be surface animals rather than troglofauna or stygofauna.

The habitat review suggests all elements of the Outer Harbour Development occur in habitats that are likely to have the physical structure to support at least some subterranean fauna.

4.4 Groundwater

4.4.1 Depth

Modelling of groundwater flow in the Outer Harbour Development shows overall movement north towards the coast (Figure 4.4).

Groundwater conditions within the area proposed for construction of the stockyards, car dumpers and conveyor tunnels were described in the former Boodarie HBI plant CER (BHP 1994). It can be inferred from the CER and subsequent monitoring of bores north of the plant (Figure 4.5), that groundwater depth under the new stockyards and associated infrastructure is mostly 3-4 m below ground level (Table 4.2), although Figure 4.4 suggests it is only 1-2 m. Depth to groundwater below the railway is variable according to location but increases with distance from the coast.

Depth to groundwater on Finucane Island varies from about 7 m in the centre of the island to 1 m in the south-east. There is evidence of limited groundwater mounding in the eastern part of the island (around the wharf area) associated with leakage from wet processing of iron ore (SKM 2008b).

4.4.2 Chemistry

Monitoring around the HBI plant suggests salinities are mostly 10-60 g L^{-1} Total Dissolved Solids (TDS), which is similar to the figure of 13-52 g L^{-1} TDS given for groundwater under the plant by BHP (1994). However, there is considerable spatial and temporal variability in salinity (Table 4.2, Figure 4.6). Recorded salinities during about 10 years of monitoring at bore 456 in the south-west part of HBI plant were 0.8-1.6 g L^{-1} TDS, while bore 421 on the north-east corner of the former residue storage pond had salinities of 20-30 g L^{-1} TDS until 1999 when groundwater level rose and salinities dropped to 1-3 g L^{-1} TDS and then fresh conditions persisted despite groundwater level returning to previous levels (Ecowise Environmental unpublished data converted from mS). Even fresher water was present (and persisted) in some bores, such as 101, after rain in autumn and winter of 2001 (Figure 4.6).

Groundwater under Finucane Island appears to be less saline than in the plant area with salinities (based on conductivity readings) of about 4-28 g L^{-1}. It is considered likely, however, that a lens of fresher water forms seasonally over the more saline 'regional' groundwater (SKM 2008) and the lower salinity recordings were probably collected from this layer.

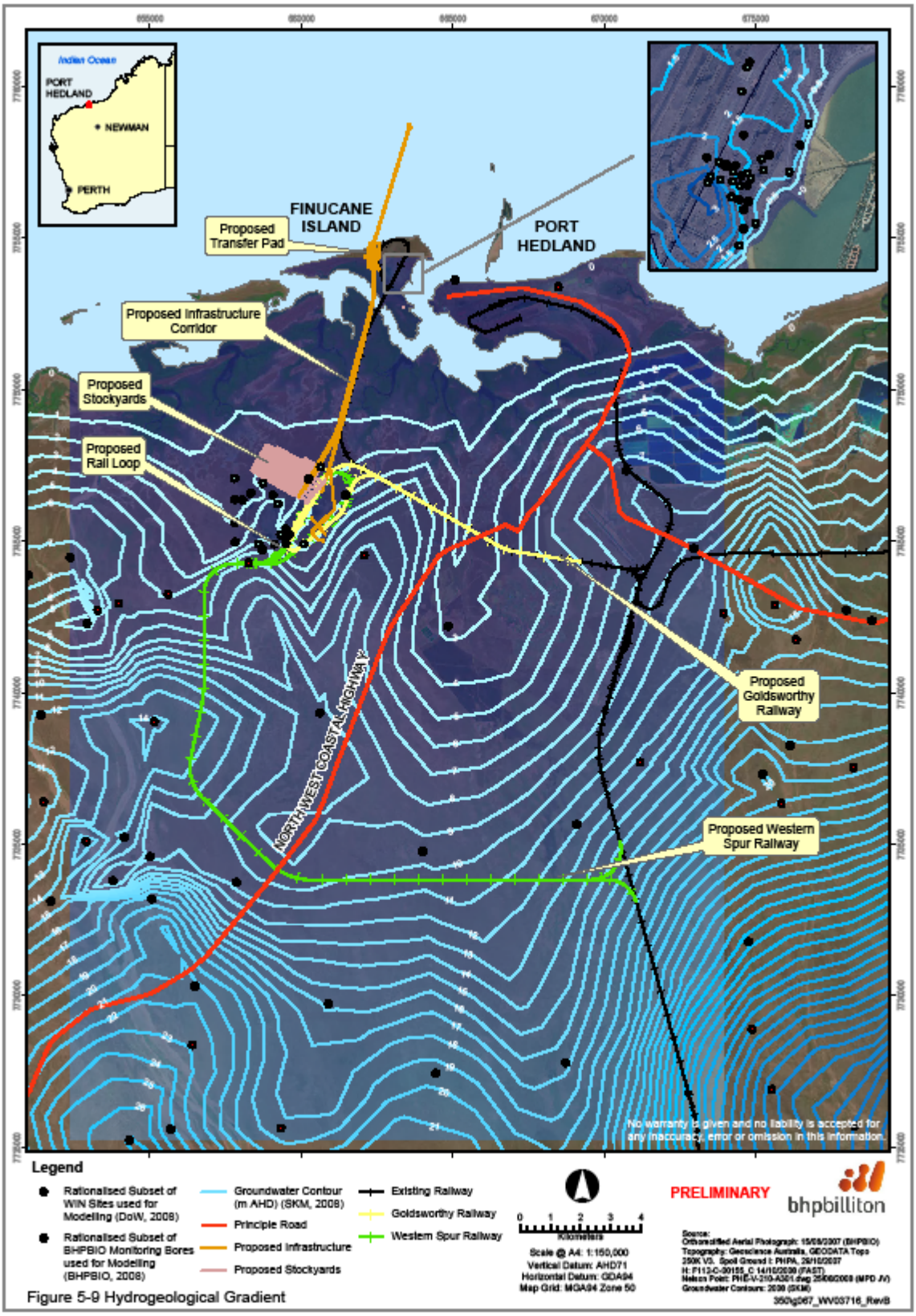

Figure 5-9 Hydrogeological Gradient

Figure 4.4. Modelled groundwater contours and flow within the Outer Harbour Development

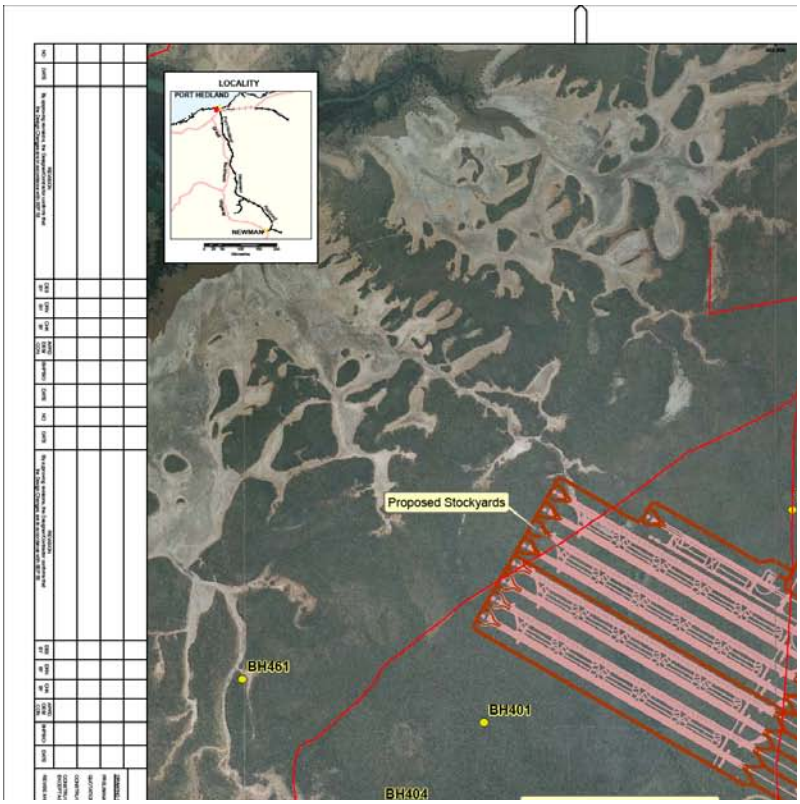

Figure 4.5. Groundwater bores monitored at former Boodarie HBI plant

Table 4.1 Geologies present in different parts of the Outer Harbour Development. Data provided by BHPBIO

Development element	Geologies
Rail loop	
Options 1, 2, 3A	Silty sand, clayey sand, high level sand
Goldsworthy	Silty sand, clayey sand, high level sand, mudflat and mangrove, alluvium
Stockyards	Silty sand
Car dumpers	Silty sand
Conveyor tunnels	Silty sand
Infrastructure corridor	Mudflat and mangrove, silty sand
Transfer pad	Lime cemented beach conglomerate, dune limestone, mudflat

When data on groundwater salinities were examined for bores located elsewhere on the coastal plain, there was little evidence of saline water and, therefore, it is expected that salinities under southern parts of the railway line will be low (Table 4.2). It is likely that high salinities close to the coast in the development area are a product of the shallow water table and relatively high clay content of soils. Marine influences probably also have a role but not all groundwater close to the sea is saline (e.g. bores 261-263, Table 4.2).

Existing information suggests there is pollution of groundwater and soil at the eastern end of Finucane Island as a result of port and stockpiling activities. Potentially significant groundwater pollution was identified by ITE (2005), particularly with petroleum derivitives and manganese. An investigation by Coffey (2007) suggested diesel was the likely source of exceedances of total petroleum hydrocarbon (TPH) and polycyclic aromatic hydrocarbon (PAH). A subsequent investigation by SKM (2008b) did not detect any metal levels about guideline values, although the risk of manganese and chromium leaching out of stockpiles into groundwater and the marine environment was identified.

Table 4.2. Groundwater depth and salinity on the coastal plain. Bores BH101-460 around HBI plant, data from BI (2006) and Ecowise Environmental (unpublished); bores PSS024-263 and POL091 on coastal plain around Port Hedland (see Figure 4.7), data from Halse et al. (unpublished) and Bennelongia (unpublished)

Development area/HBI plant bores				Coastal plain sub-region stygofauna bores			
Bore	Depth (m)	TDS (g L^{-1})	Geology	Bore	Depth (m)	TDS (g L^{-1})	Geology
North of HBI plant				PSS024	5	0.5	alluvium
BH101	0.6-1.7	30-60[1]	clayey sand	PSS025	7.2	0.55	alluvium
BH104	0.9-3.7	21-56[2]	clayey sand	PSS027	11.5	0.5	colluvium
BH401	1.6-3.4	26-34	silty sand	PSS132	7.1	0.05	alluvium
BH422	1.4-4.4	10-55[3]	clayey sand	PSS133	6.8	0.07	alluvium
BH460	1.7-4.2	44-56	clayey sand	PSS134	10	0.23	alluvium
Fresher sites				PSS261	2.4	0.63	conglomerate[5]
BH421	1.3-4.9	1.1-22	silty sand	PSS262	6.3	0.74	conglomerate[5]
BH450	2.7-5.5	5-18[4]	clayey sand	PSS263	2.5	2.8	conglomerate[5]
BH456	2.7-4.6	0.4-1.6	silty sand	POL091	3.8	7.2	alluvium
				POL100	5.7	7.2	alluvium

[1] Value of 0.03 g L^{-1} recorded in February 2001; [2] outlying upper value 80 g L^{-1}; [3] fresher period in 1997 and values 30 g L^{-1} only in 1998-99; [4] 0.04 g L^{-1} in April 1999; [5] lime cemented beach conglomerate

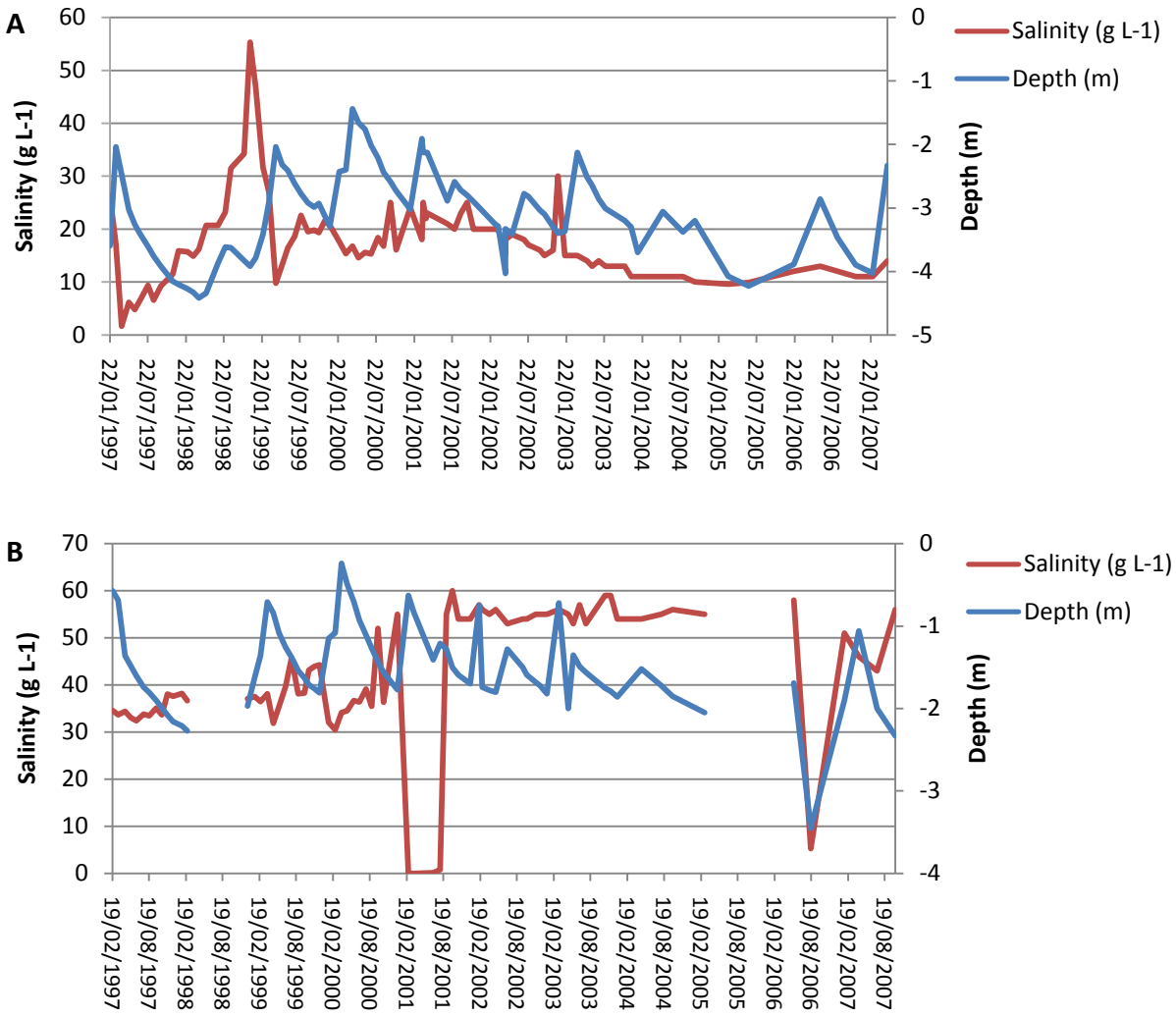

Figure 4.6. Temporal variation in depth and salinity of groundwater. Bores from the vicinity of the former HBI plant, monitored from 1997 to early 2008. A, Bore BH422; B, Bore BH101 (see Figure 4.5 for locations)

4.5 Anchialine habitat

Karstic anchialine systems constitute very important habitat for stygofauna (Humphreys 2000). These systems are based on the Ghyben-Herzberg relationship, where a lens of fresh water overlying sea water is able to displace the sea water to considerable depth, thus creating significant fresh water habitat in a marine environment. Anchialine systems occur on the Exmouth Peninsula, where the habitat and stygofaunal community are informally listed as a Threatened Ecological Community and several of the component species are listed as rare under the *Wildlife Conservation Act* 1950. Anchialine systems can potentially occur in many coastal limestones but the high salinities and absence of fresh groundwater at the former HBI plant suggest there is no suitable freshwater lens to form anchialine conditions in much of the area planned for the Outer Harbour Development.

It has been suggested that a freshwater layer overlays more saline groundwater at Finucane Island (SKM 2008b). It is likely this is principally a seasonal phenomenon supplemented by some groundwater mounding associated with wet processing of iron ore and leakage from tailings ponds (Coffey 2007). It is

unlikely to form an anchialine habitat of the type used by stygofauna (e.g. Iliffe et al. 1984), which requires more permanence to enable animals to complete many life cycles in a stable environment.

4.6 Subterranean fauna

4.6.1 Known records in the local area

The recent stygofauna survey of the Pilbara region, completed as part of the Department of Environment and Conservation's Pilbara Biological Survey, has provided broadscale information about stygofauna occurrence on the coastal plain around Port Hedland and in the hinterland of the Turner River catchment (Halse et al. in prep.) (Figure 4.7). Within 100 km of the Outer Harbour Development, 41 stygofauna species have been recorded from 16 bores in the catchment and 37 stygofauna species have been recorded on the coastal side of the North West Coastal Highway (Table 4.3). On the basis of the relatively rich stygofauna community in the local area, the Outer Harbour Development area would be expected to contain stygofauna.

There are no troglofauna trapping data in the public domain from areas closer to Port Hedland than the Ord Ranges.

4.6.2 Potential occurrence of stygofauna fauna based on habitat assessment

Stygofauna are expected to occur within the Port Hedland Outer Harbour Development, based on sampling records from the Port Hedland sub-region and the geology of the development area, although the high salinities in many of the monitored bores must preclude the occurrence of stygofauna (see below). The species listed in Table 4.3 were found in alluvium, silty sand, clayey sand and related habitats (and to a lesser extent lime cemented beach conglomerate and associated habitats), which are prospective for stygofauna (Halse et al. in prep.).

Proposed infrastructure that will require de-watering during construction include the car dumpers, conveyor tunnels and stockyards. These are located in alluvium and silty sand and clayey sand. It is highly unlikely, however, that any stygofauna species is restricted to the areas to be de-watered. Firstly, this is because of the predominance of widespread species in the coastal plain stygofauna community. Only 2 of the 37 species recorded on the coastal plain are known from a single river catchment (*Areacandona yuleae* and Tubificidae sp. WA24, Table 4.3) and the distributions of these two species may widen with additional sampling. Secondly, the small size of the stockyards and associated infrastructure relative to the scale at which there is significant spatial heterogeneity in silty and clayey sands and alluvium make it unlikely that even a stygofauna species restricted to a particular feature within alluvium or sands would have a range as small as a de-watering area (the stockyards, car dumpers, conveyor tunnels envelope is less than 20 ha).

There will be no significant de-watering on Finucane Island. It is also unlikely that any stygofaunal species are restricted to it because of small size and the dynamism of coastal structures in the Pilbara (Turalski et al. 1996). Although the lime cemented beach conglomerate and dune limestone on Finucane Island may potentially contain stygofauna habitat, the marine conditions on this low lying and geologically recent island make it unlikely that restricted freshwater species occur. Marine species are usually widely distributed compared with freshwater subterranean species. Sampling of lime cemented beach conglomerate west of Port Hedland at bores PSS261-263 revealed a typical fauna of the Pilbara coastal plain consisting of between two and 10 species at a bore. All species were widespread.

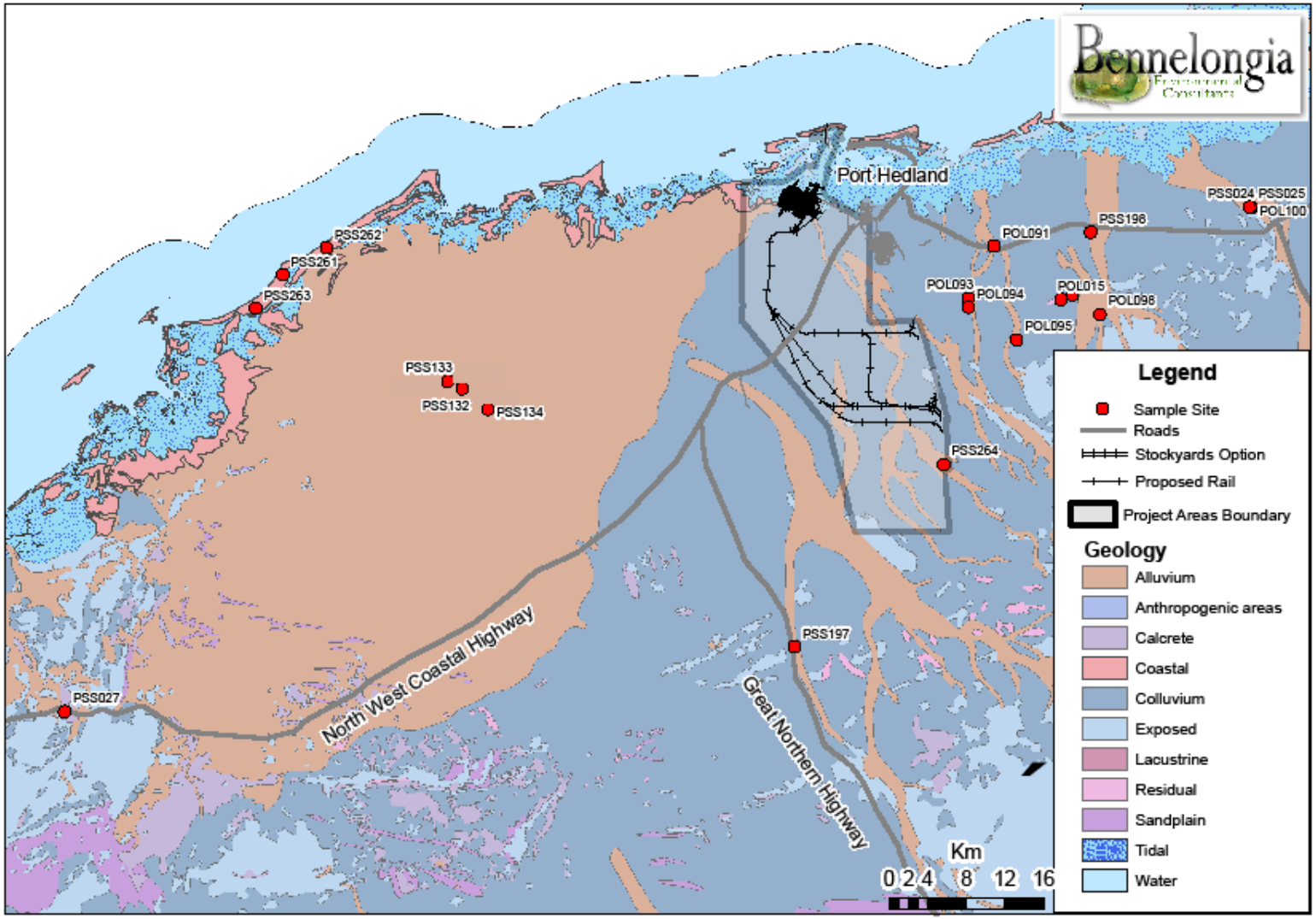

Figure 4.7. Location of bores within 100 km of Port Hedland. Bores on the coastal side of the North West Coastal Highway or within the Turner River catchment are shown. Habitat marked as alluvium is mostly silty sand and clayey sand, colluviums is mostly sand according to the classifications used in Figure 4.3

Table 4.3. Stygofauna within 100 km of Port Hedland in 16 bores within the Turner catchment and in 11 bores north of North West Coast Highway. Available information on distribution and abundance (number of records in the Pilbara Biological Survey) of species is summarized. Bore locations shown in Figure 4.7.

Taxa	Turner catchment	North of Highway	Distribution	Abund.
Nematodes				
Nematoda sp.	1	1	N/A	
Worms				
Aeolosoma sp. 1 (PSS)		1	Pilbara	45
Aeolosoma sp. 2 (PSS)		1	Pilbara	5
Dero nivea		1	cosmopolitan	34
Monopylephorus n. sp. WA29 (ex *Pristina* WA3) (PSS)	1	1	Pilbara	30
Insulodrilus lacustris s.l. Pilbara type 1 (PSS)	1	1	NW Pilbara	3
Insulodrilus lacustris s.l. Pilbara type 2/3 (PSS)	1	1	NW Pilbara	5
Astacopsidrilus sp. WA31	1	1	Pilbara	6
Phreodrilid with dissimilar ventral chaetae	1	1	Pilbara	190
Phreodrilid with similar ventral chaetae	1	1	Pilbara	70
Tubificidae stygo type 1 (imm *Ainudrilus* WA25/26?) (PSS)		1	Pilbara	12
Tubificidae sp. WA24 (PSS)	1	1	Yule River	1
Snails				
Ancylidae sp.		1	? N Pilbara	2
Planorbidae sp.		1	Pilbara coast	46
Gastropoda sp.		1	N/A	
Mites				
Acariformes sp.	1	1	N/A	
Seed shrimps				
Cypretta seurati		1	Pilbara	76
Gomphodella sp. 2 (PSS)	1		Turner River	1
Areacandona iuno	1		P Hedland Coast	8
Areacandona jessicae	1	1	P Hedland Coast	9
Areacandona krypte	1	1	P Hedland Coast	2
Areacandona yuleae	1	1	Yule River	3
Humphreyscandona fovea[1]	1	1	Robe/Fortescue	25
Humphreyscandona waldockae	1		W Pilbara	5
Leicacandona mookae	1		Yule River	1
Copepods				
Stygoridgewayia westaustraliensis ms Tang et al.	1		NWA coast	23
Diacyclops cockingi	1	1	Pilbara	40
Diacyclops einslei	1		W Pilbara	12
Diacyclops humphreysi humphreysi	1	1	WA	209
Diacyclops scanloni	1		Pilbara	38
Diacyclops sobeprolatus	1	1	Pilbara	81
Halicyclops (Rochacyclops) calm	1		W Pilbara	45
Mesocyclops brooksi	1		southern Australia	150
Microcyclops varicans	1		cosmopolitan	200
Elaphoidella humphreysi	1	1	W Pilbara	66
Parastenocaris jane	1		Pilbara	50
Parastenocaris sp.	1	1	N/A	

Taxa	Turner catchment	North of Highway	Distribution	Abund.
Stygonitocrella bispinosa	1		Pilbara	31
Stygonitocrella trispinosa	1		W Pilbara	38
Stygonitocrella unispinosa	1	1	Pilbara	41
Syncarids				
Chilibathynella sp.	1	1	Pilbara	6
Hexabathynella A (PSS)		1	N Pilbara	3
Hexabathynella B (PSS)		1	N Pilbara	3
Parabathynellidae sp.	1	1	N/A	
Slaters				
Microcerberidae sp.	1	1	N/A	
Scuds				
Nedsia nr *douglasi*	1		Barrow Island	1
Nedsia sp.	1	1	W Pilbara	186
Melitidae sp. 1 (PSS)	1	1	W Pilbara	41
Paramelitidae sp. 2 (PSS)	1		Pilbara	80
	41	37		

[1] Probably an identification error (see Distribution)

4.6.3 Salinity tolerance of stygofauna

Examination of the salinities at which Pilbara stygofauna have been recorded suggest that it is highly unlikely any species will be found at the new stockyards, car dumpers and conveyor tunnels or the infrastructure corridor because groundwater salinities are too high most of the time for the occurrence of Pilbara stygofauna. In the recent Pilbara-wide stygofauna survey, only seven out of nearly 4000 records of stygofauna were in water with a salinity exceeding 10 g L^{-1} and all were under 11 g L^{-1} TDS (Figure 4.8). Water at the stockyards, car dumpers and conveyor tunnels was mostly 10-60 g L^{-1} TDS.

Stygofauna are likely to occur, however, in fresher water to the south in the broad vicinity of the stockyards and under all railway options.

4.6.4 Potential occurrence of troglofauna based on habitat assessment

Troglofauna studies are still at an early stage of development in Western Australia and the habitats used by these animals are still being documented. It is known that troglofauna occur in mineralized outcrops and ranges throughout the Pilbara, including coastal areas (Biota 2006; Subterranean Ecology 2007; Bennelongia 2008a) and they are also occur in calcretes (e.g. Edward and Harvey 2008). Troglofauna have very rarely been collected when sampling has extended away from mineralized areas into colluvium and it has been suggested sands and gravels are unfavourable habitat in the Pilbara (Biota 2006), although there are also difficulties trapping in such habitat and troglofaunal groups such as symphylans (millipede-like animals) have been collected in low abundance from sandy or alluvial habitat in the South-West (Biota 2005).

Relatively little attention has been paid to depth requirements of troglofauna but trapping by Biota Environmental Sciences showed catches for some troglofaunal groups are greatest below 10 m depth (Figure 4.9). Trapping experience suggests few troglofauna occur at depths less than 5 m below the surface. There are several theoretical reasons to expect few troglofauna at shallow depths, unless perhaps in unusual cave situations:

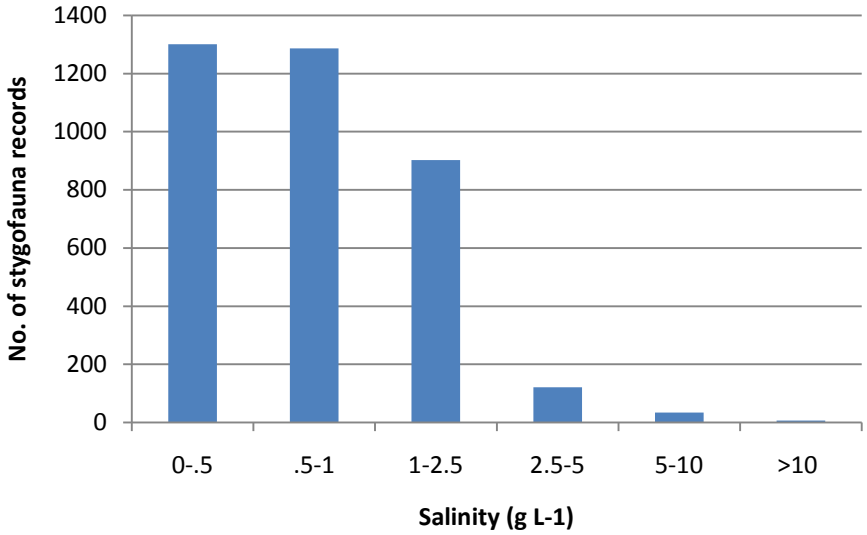

Figure 4.8. Occurrence of stygofauna in relation to salinity in the Pilbara. Data based on preliminary analysis of sampling across the whole Pilbara (Halse et al. in prep)

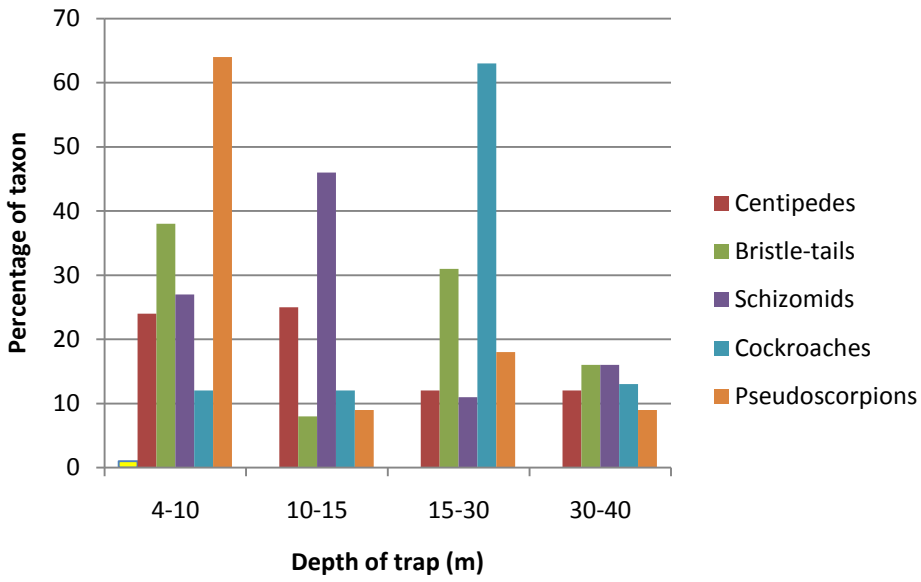

Figure 4.9. Percentage of troglofaunal animals trapped at different depths below ground. Data for various higher taxonomic groups from the Robe Valley. Conditions reduced efficiency of traps at 30-40 m depth and these yields are likely underestimated. Some centipedes excluded from dataset because they were not considered to be troglofauna so that centipede total <100 %. Other taxa exclusively troglofaunal. Extracted and re-graphed from Biota (2006)

- Troglofauna are likely to be outcompeted at shallow depths by foraging surface species that have energy resources from the upper surface layers to enable them to be more vigorous than troglofauna (Gibert & Deharveng 2002)
- Troglofauna require a near- saturated atmosphere. During the dry season plant roots dry out the vadose zone, which forces troglofauna to move away from the surface towards the watertable where conditions remain saturated. The saturated zone is likely to be very thin when the watertable is near the surface and daytime temperatures are about 35°C
- When the watertable occasionally approaches the surface, as happens around the stockyards and infrastructure corridor (Table 4.1, SKM 2008a), any troglofauna present will be displaced by rising water.

On the basis of the information provided above, it is considered very unlikely that any troglofauna occur at the new stockyards, car dumpers, conveyor tunnels or infrastructure corridor. The shallow the depth to groundwater is likely to make habitat unsuitable. Furthermore, no troglofauna have been caught from similar coastal plain habitat in past studies (albeit little trapping has occurred). Finucane Island appears even less likely to provide troglofauna habitat because of substantial inundation, erosion and flooding during cyclones and the shallow depth to water under the island.

In relation to the Port Hedland Outer Harbour Development, it is noteworthy that the EPA recently considered that, on balance, there was a low risk of troglofauna occurring on the eastern side of Exmouth Gulf because the thickness of rock above seawater was less than 8 m, it contained no air-filled chambers or voids and the underlying groundwater was of seawater concentration (EPA 2008). Conditions in the northern part of the Port Hedland Outer Harbour Development represent even shallower, equally or more saline habitats and are likely to be even less prospective for troglofauna.

There is insufficient information available to conclude that troglofauna do not occur under the rail lines to the south. However, silty sands and other types of alluvium and colluviums are not recognized as high quality troglofauna habitat (e.g. Biota 2006).

5.0 Subterranean fauna risk assessment

The Port Hedland Outer Harbour Development appears very unlikely to threaten the survival of any subterranean fauna species.

5.1 Stygofauna

Based on survey records and geology, stygofauna are likely to occur within the southern part of the development area. They are unlikely to occur between the former Boodarie HBI plant and Finucane Island because salinities of the groundwater in the areas mostly exceed the maximum values at which Pilbara stygofauna have been recorded. The effect of existing pollution at Finucane Island is difficult to assess but it is localized at the eastern end of the island and probably unlikely to have a major effect on any stygofauna species present.

Survey data from the adjacent coastal plain suggest most species in the southern portion of the development area will have relatively large ranges, usually covering several river catchments. Even if species that are restricted to a single catchment occur, the homogeneous geology of the coastal plain makes it very unlikely any species could be restricted to a small area. There are no geological barriers or significant features in the development area that might constrain a species range.

Potential development impacts on stygofauna are de-watering, water abstraction and groundwater pollution. Temporary de-watering will occur to construct the car dumpers and conveyor tunnels (to depth of about 25 m) and stockyards (to about 5 m). Water for dust suppression is not expected to be abstracted from the development area but water for some rail construction is likely to be abstracted from shallow bores. The volumes of water required, however, are highly unlikely to result in significant aquifer drawdown. Improved management practice with regards to contamination will be employed at the stockyards, transfer pad and other infrastructure (sections 2.0 and 3.3) and groundwater pollution is expected to be minimal.

This desktop review strongly suggests that stygofauna are absent from the stockyards, car dumpers and conveyor tunnels area, which is the only location where significant groundwater drawdown and, therefore groundwater habitat change, is likely as a result of the development. The development is considered unlikely to affect stygofauna.

5.2 Troglofauna

Based on geological evidence and current knowledge of distribution and habitat requirements, troglofauna are unlikely to occur between the former Boodarie HBI plant and Finucane Island because of the shallow depth to watertable. In addition, sandy/clayey soils are sub-optimal habitat. Troglofauna are considered unlikely to occur in lime cemented beach conglomerate and dune limestone on Finucane Island because of the small size of the island, its low elevation and exposure to cyclonic events, and the lack of a strongly developed karstic system. A depauperate troglofauna community may occur in the southern part of the development area.

Troglofauna are regarded as typically having small ranges (Biota 2006) but these small ranges are usually associated with a geological feature. If troglofauna species occur in sandy soils in the southern part of the development area, they are unlikely to be highly restricted. Such soils (usually referred to as alluvium and colluvium, although different terminology is employed here) are very extensive habitats in the sub-region (see Figure 4.7). Troglofauna species with ranges that extend more than 100 km have recently been recorded in the Pilbara (Bennelongia 2008b) and it is becoming clear that troglofauna may be regionally widespread in habitats with high connectivity.

Potential impacts on troglofauna are soil excavation and pollution. Excavation itself is unlikely to impact on troglofauna unless deeper than about 5 m, although there may be some indirect effect of shallow excavation on troglofauna from altered re-charge patterns of water, energy and nutrients to deeper subterranean habitats. Deep excavation will occur for the car dumpers and conveyor tunnels (depth of 25 m) and shallow excavation for the stockyards (5 m), conveyor system and transfer pad (1 m) and rail lines (up to 1 m and deeper when cutting through hills).

This desktop review suggests troglofauna are absent from all areas of excavation with the possible exception of rail lines in the southern portion of the development area. Existing, albeit inadequate data, suggest that few, if any, troglofauna will occur in this area of sandy soils. Species that do occur are unlikely to be restricted to a small area because of the lack of geological barriers or significant features in the development area to constrain species ranges. It should also be recognized that the scale of any impact from rail construction will be very small, occurring only when cuttings in low ‘hills’ are required. The southern development area is relatively flat. Therefore, the development is unlikely to affect troglofauna.

6.0 Conclusions and recommendations

This desktop review has shown there is very low probability of either stygofauna or troglofauna occurring in the areas of de-watering or deeper soil excavation for the Port Hedland Outer Harbour Development.

A depauperate troglofauna community may occur in the southern development area, where shallow excavation will occur for rail construction, although existing data on troglofauna distribution does not show them to be present in sands of the Pilbara coastal plain. The shallow excavation envisaged for rail construction will not extend to depths where troglofauna would be expected to occur.

Stygofauna are likely to occur throughout the southern part of the development area but, other than possible abstraction of groundwater for rail construction, no impact of the project on groundwater habitats is expected in this area. Groundwater abstraction for rail construction will result in minimal groundwater drawdown if several shallow bores are used.

Stygofauna are unlikely to occur between the former Boodarie HBI plant and Finucane Island because salinities of the groundwater in this area mostly exceed the maximum values at which Pilbara stygofauna have been recorded. Therefore, the de-watering that will be associated with infrastructure construction is unlikely to affect stygofauna.

On the basis of the evidence available, the Port Hedland Outer Harbour Development is unlikely to cause any species of subterranean fauna to be at risk of extinction.

It is considered that this desktop review has provided a reliable assessment of risk to subterranean fauna from the Port Hedland Outer Harbour Project. No further fieldwork or survey of subterranean fauna is recommended.

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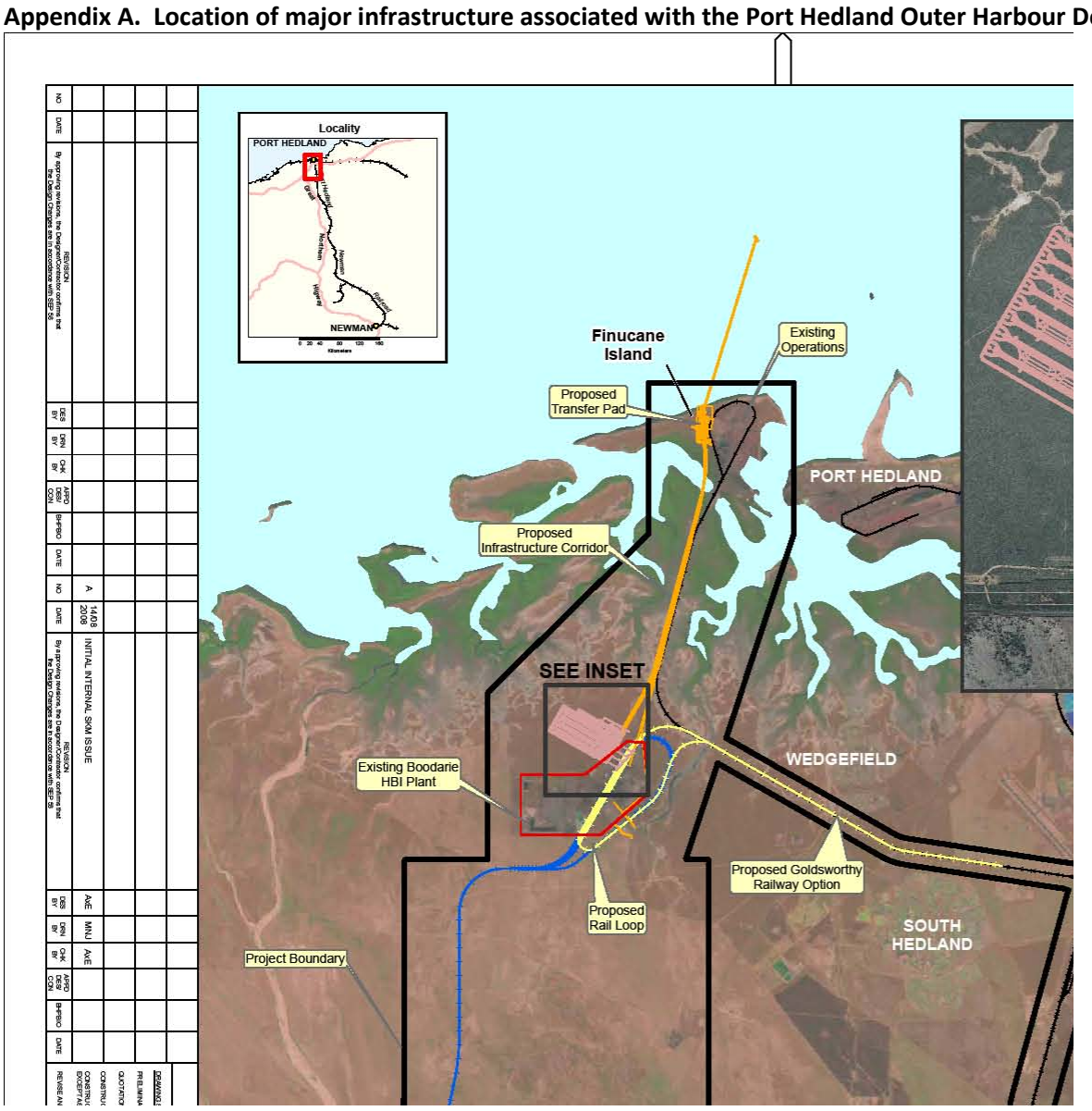
Appendices

Appendix A. Location of major infrastructure associated with the Port Hedland Outer Harbour Development. Map provided by SKM



Appendix B. Location of major infrastructure associated with the Port Hedland Outer Harbour Development. Map provided by SKM