11. ENVIRONMENTAL IMPACT ASSESSMENT - OTHER ENVIRONMENTAL FACTORS - PORT DEVELOPMENT ENVELOPE

Other relevant environmental factors for the Port Development Envelope comprise the following:

- Benthic Communities and Habitat.
- Marine Fauna.
- Terrestrial Environmental Quality.
- Human Health.
- Hydrological Processes.

Potential impacts for each factor are detailed in Sections 11.1 to 11.4.

Potential impacts to the Town of Broome and the Port of Broome were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Installation of mooring points or anchoring disturbing benthic communities	Impacts to benthic communities or habitats from anchoring or mooring will not occur, as vessels will use the existing Port of Broome wharf infrastructure.
Noise or light from construction and operational activities impacting birds or terrestrial fauna	No construction will be undertaken, and operational activities occur within the context of an existing operational port, so no additional significant light or noise emissions that will impact marine fauna will be generated.
Changes in hydrological regimes impacting Sawfish or Northern River Shark	Sawfish and Northern River Shark are found in proximity to the Derby Port Development Envelope, rather than the Broome Port.
Dust generation, product spillage, or radiation exposure affecting the terrestrial environment	Dust generation, product spillage and radiation exposure are not expected to occur at the Port of Broome as the products are packaged during transport and transfer to ocean-going vessels.
Disturbance of contaminated soils affecting the terrestrial environment	No construction will be undertaken, so no contaminated soils will be disturbed.
Radiation exposure or dust emissions affecting human health	Transport vehicles will bypass the Town of Broome, and be on a dedicated heavy vehicle road. The port is not located near to residential areas. Dust generation, product spillage and radiation exposure are not expected to occur at the Port of Broome as the products are packaged during transport and transfer to ocean-going vessels. Specific activity concentrations of products are below concentrations where transport and storage requires regulation.
Diesel particulate and gaseous vehicle emissions affecting human health	Transport vehicles will bypass the Town of Broome, and be on a dedicated heavy vehicle road. Any increases in particulate matter or gaseous emissions are unlikely to be measureable, and will occur outside of residential areas.
Hydrological processes	As products will be packaged, dust suppression during product storage and transfer will not be required. Water use at the Port of Broome is thus likely to be insignificant and could be met by existing water supply infrastructure at the Port.

Potential impacts to marine fauna from shipping in the Kimberley have been assessed as part of the overall shipping assessment for the Derby Port Development Envelope (Section 11.2.2.4).

11.1 BENTHIC COMMUNITIES AND HABITAT

The EPA's objective for benthic communities and habitat is "*to maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales*".

11.1.1 Key Statutory Requirements, Environmental Policy and Guidance

Benthic communities and habitats are protected under Commonwealth and State legislation, primarily governed by the following Acts:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).
- *Conservation and Land Management Act* 1984 (WA).
- *Environmental Protection Act 1986* (WA).
- *Fish Resources Management Act 1994* (WA).

In addition, the following policy and guidance statements were considered in the impact assessment for benthic communities and habitats:

- Environmental Assessment Guideline 3, *Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (*EPA 2009b).
- Wetlands Conservation Policy for Western Australia (DPaW 1997).
- The Wetlands Policy of the Commonwealth Government of Australia (Commonwealth Government of Australia 1997).

The ESD lists 'Guidance Statement for Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (GS 1) (EPA 2001)' and 'Environmental Assessment Guideline 7 (EAG 7) *Marine Dredging Proposals* (EPA 2011)', but neither are relevant to the proposal. GS 1 specifically addresses the protection of tropical arid zone mangroves, habitats and dependent habitats along the Pilbara coastline from Cape Keraudren at the southern end of Eighty Mile Beach to Exmouth Gulf. EAG7 is not relevant as the Thunderbird Mineral Sands Project (the project) does not include dredging.

11.1.2 Assessment of Potential Impact

Potential impact pathways for benthic communities and habitats include:

- **Installation of mooring points disturbing benthic communities and habitats** - direct physical disturbance within the Derby Port limits.
- **Anchoring disturbing benthic communities and habitats -** direct physical disturbance occurring near the entrance to King Sound at the pilot boarding point from ocean-going vessel dropping anchor.

The waters of King Sound are not known to support seagrasses, macroalgae, corals or any other visible benthic primary producer due to the high turbidity and large tidal movements of the waters as detailed in Section 4.3.13.2. Mangrove communities along the shoreline of King Sound are widely represented within the Derby region.

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Land clearing	Derby is an operational port and export activities at Derby will utilise existing port infrastructure. A Product Storage Facility will be constructed on previously cleared land where a similar storage facility was located and this will not require clearing of mangroves. As such, there will be no direct disturbance to mangrove communities and no direct impact on benthic primary producer habitat at Derby Port as a result of the project.
Dust coating leaves of plants, affecting plant health	A sparse collection of young mangrove plants occur in the intertidal zone beside the Product Storage Facility. The nearest well-developed mangals are located beyond the Derby Port Development Envelope. A dust modelling study was conducted for the project (Atmospheric Solutions 2016). This study showed that deposited dust within the Port Development Envelope was around 3.5 g/m^2/month. However, the dust modelling is known to be very conservative due to the use of a set of generic assumptions, and is likely to represent the worst-case scenario. In a study by Chevron (2012), it was found that rainfall was likely to be the main factor affecting the health of plants and that plant health did not differ significantly with distance from the dust source. No impact on benthic primary producer habitat at Derby Port is expected as a result of this stressor.
Dust or spillage of product in the marine environment	This impact could only occur indirectly through dust or spillage affecting marine water quality, which in turn affects BPPH. As this stressor has been assessed as part of Marine Environmental Quality (see Section 9.1.2.2) and assessed as 'Low', it is not necessary to assess it again. The mineral sands products are environmentally benign and no impact to benthic communities or habitats is expected as a result of this stressor.
Hydrocarbon spillage in the marine environment	This impact could only occur indirectly through hydrocarbon spillage affecting marine water quality, which in turn affects benthic communities or habitats. As this stressor has been assessed as part of Marine Environmental Quality (see 9.1.2.3) and assessed as 'Low', it is not necessary to assess it again. No impact to benthic communities or habitats is expected as a result of this stressor.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

The EPA's Environmental Assessment Guideline No. 3 – Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (EPA 2009b) has been considered. However, as this guidance relates to proposals that will result in irreversible loss of or serious damage to benthic primary producer habitats, it is not applicable to this Project.

11.1.2.1 Installation of Mooring Points Disturbing Benthic Communities and Habitat

For any benthic communities and habitat that may be present in the vicinity of the wharf mooring point or sea transfer point, there is potential for impact from the physical disturbance of the benthos during the installation of moorings. There is also potential for the minor operational impact of mooring lines dragging along the ocean floor in lower tides. Any impact associated with the installation and operation of moorings would be localised to the site of project disturbance. The wharf mooring zone and the sea transfer point are within the Port limits. The sites are located at the same sites previously used as mooring zones by Lennard Shelf Pty Ltd, and have been disturbed previously.

Any potential for indirect impact to any benthic communities and habitat through additional turbidity generated through installation of moorings has been addressed in Section 9.1.2.1.

Although it is possible that benthic invertebrate and burrowing organism habitat could be present in the area, there are no known seagrasses or corals within the port limits (Section 4.3.13.2). Any impacts to benthic habitats will be localised to the immediate vicinity of the moorings. Due to the low likelihood of significant benthic communities and habitat occurring in the vicinity of the wharf mooring zone and sea transfer point it is considered 'Unlikely' that the project will result in any discernible changes to the structure, diversity and distribution of benthic habitats and communities in King Sound. The potential residual impact from the installation and operation of mooring points to benthic habitats and communities, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Disturbance of benthic communities and habitat through installation of mooring points	Incidental	Unlikely	Low

11.1.2.2 Anchoring Disturbing Benthic Communities and Habitat

On average, an ocean-going vessel will visit King Sound less than once per week. It is necessary to take on board a pilot with local knowledge of the islands and topography of the Buccaneer Archipelago, the Sunday Straits, and King Sound. Therefore the ocean-going vessel will need to drop anchor at the pilot boarding point at the entrance to King Sound. The dropping of anchor will cause direct disturbance to any benthic communities and habitat present at this location.

The seafloor at the pilot boarding point is approximately 40 - 50 m deep. At this depth, the benthos would not be likely to support hard corals or seagrasses due to the lack of light penetration. It is possible that the seafloor in the area may support sparse distribution of sponges or habitat for burrowing invertebrates (see Section 4.3.13.2). However, disturbance will be localised to the pilot boarding point. This is the same pilot boarding point that was used by Lennard Shelf Pty Ltd, and is therefore likely to have been slightly disturbed previously.

Due to the likely absence of significant benthic communities and habitat in the vicinity of the pilot boarding point, it is considered 'Unlikely' that the project will result in any discernible changes to the structure, diversity or distribution of benthic habitats and communities in King Sound or adjacent waters. The potential residual impact from the anchoring of the vessel at the pilot boarding point to benthic habitats and communities, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Anchoring disturbing benthic communities and habitat	Incidental	Unlikely	Low

11.1.3 Management Measures

Management measures associated with physical disturbance of benthic communities and habitats are addressed below in Table 78. Management measures associated with indirect impact pathways for benthic communities and habitats have been addressed in Section 9.1.3.

Table 78: Proposed Management Measures for Benthic Communities and Habitat

Potential Impact Requiring Management	Measure
Installation of mooring points disturbing benthic communities and habitat	• Sheffield will either upgrade or replace existing moorings installed at transhipment vessel and ship loading points within Derby Port limits.

Potential Impact Requiring Management	Measure
Anchoring disturbing benthic communities and habitat	• Dropping anchor by ocean-going vessels outside King Sound to collect the pilot will be confined to the pilot boarding area approved by the relevant Port authority in order to minimise damage to benthic communities and habitats.

11.1.4 Predicted Outcome

Installation of new moorings may cause direct disturbance within the mooring zones, however this is unlikely to impact the overall function of any benthic communities or habitats within King Sound. Dropping of anchor by the ocean-going vessel at the pilot boarding point may cause localised damage to any benthic communities and habitats, but due to the low benthic light levels which are characteristic of deeper waters, it is considered that there will not be any change to the structure, function, diversity, distribution and viability of benthic communities and habitats.

Sheffield considers that the potential impacts of mooring point installation and anchoring on benthic communities and habitats will be able to be adequately managed such that the objective (Section 11.1) will be met, and that the residual impacts are therefore acceptable.

11.2 MARINE FAUNA

The EPA's objective for marine fauna is "*to maintain the diversity, geographic distribution and viability of fauna at the species and population levels*".

In May 2016, the (then) Department of the Environment (DoE) provided comment on the draft Environmental Scoping Document (ESD) prior to finalisation. It was specifically requested that the Public Environmental Review (PER) address potential impacts on five threatened marine species namely:

- *Megaptera novaeangliae* (Humpback Whale) - Vulnerable.
- *Glyphis garricki* (Northern River Shark) - Endangered.
- *Pristis clavata* (Dwarf sawfish) – Vulnerable.
- *Pristis pristis* (Largetooth Sawfish) – Vulnerable.
- *Pristis zijsron* (Green Sawfish) – Vulnerable.

The following presents an impact assessment of these and other marine species that are of conservation significance.

11.2.1 Key Statutory Requirements, Environmental Policy and Guidance

Marine fauna are protected under Commonwealth and State legislation, primarily governed by three Acts:

- *Wildlife Conservation Act 1950* (WA).
- *Environmental Protection Act 1986* (WA).
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

Sawfish species and Northern River Shark are also totally protected under the:

- *Fish Resources Management Act 1994* (WA).

In addition to State and Commonwealth legislation, the following policy, legislation and guidance statements were considered in the impact assessment for marine fauna:

- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983.*
- *Pollution of Waters by Oil and Noxious Substances Act 1987.*
- EPA Guidance Statement No. 33, Environmental Guidance for Planning and Development (EPA 2008).
- Marine Bioregional Plan for the North-West Marine Region (DSEWPC 2012b).
- Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life (DEWHA 2009).
- Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life: Review 2009-2014 (DoE 2014).
- Sawfish and River Sharks Multispecies Recovery Plan (DoE 2015a).
- Sawfish and River Sharks. Multispecies Issues Paper. Commonwealth of Australia. (DoE 2015b).
- International Convention for the Prevention of Pollution from Ships (MARPOL), 1973; Annex V, 2013.
- Environmental Assessment Guideline 5, Protecting Marine Turtles from Light Impacts (EPA 2010).

11.2.2 Assessment of Potential Impact

In considering the potential impacts to Humpback Whales, the Marine Bioregional Plan for the North-west Marine Region (DSEWPC 2012b) was taken into account. The issues of concern for Humpback Whales related to this project were specifically associated with vessel strike and vessel noise impacts.

The potential impacts to Sawfish species and the Northern River Shark in the North-west bioregion are discussed in the Sawfish and River Sharks Multispecies Issues Paper (DoE 2015b). The threats of potential concern to these species related to this project are changes to hydrological regimes (such as groundwater drawdown or impediments to surface water flows) and solid waste/marine debris (entanglement in wastes released to the marine environment).

Impacts to other marine fauna such as marine reptiles, dolphins and seabirds were also assessed using the Marine Bioregional Plan for the North-west Marine Region (DSEWPC 2012b).

In addition to marine fauna, several coastal/terrestrial species that are listed as threatened may occur in the Derby Port Development Envelope. Of these, 10 species are birds and two are terrestrial mammals (Section 4.3.10.2). As the potential impacts to marine fauna may also affect these species, they included in the assessment here.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

The sources of potential impact to marine fauna include the following activities:

- **Noise from construction and operational activities at Derby Port impacting birds or terrestrial fauna** – noise from construction/upgrade of export facilities and operation of export facilities causes impacts to birds or terrestrial fauna
- **Light from construction and operational activities at Derby Port impacting birds or terrestrial fauna** – light from construction/upgrade of export facilities and operation of export facilities causes impacts to birds or terrestrial fauna
- **Changes in hydrological regimes at the Mine Site Development Envelope impacting Sawfish species or Northern River Shark** – caused by excessive groundwater or surface water abstraction or construction of weirs.

- **Additional shipping and transhipment impacting marine fauna** – these could be direct or indirect through:
  - Vessel strike.
  - Noise.
  - Light.
  - Hydrocarbon spill.
  - Solid waste/marine debris.

11.2.2.1 Noise from Construction and Operational Activities at Derby Port Impacting Birds or Terrestrial Fauna

Although several marine fauna species are known to occur at Derby Port, the area is not considered important habitat for any species (see Section 4.3.14). Any noise disturbance caused by the construction of the Product Storage Facility and upgrade of export facilities is likely to be of a local and temporary nature. Additional pile driving is not required. The Derby Port Development Envelope is an already disturbed site in an existing industrial area. The storage facility to be constructed will utilise the same footprint as a previous shed by Lennard Shelf Pty Ltd.

Derby Port Development Envelope is not encroaching on any habitats of particular significance for migratory birds. Derby sewage ponds are listed as important habitat for the Little Curlew; however there will be no impact from the project on the Derby sewage ponds which are approximately six kilometres away from the Product Storage Facility.

As shown in Figure 42, the closest habitats of significance for migratory birds to any shipping corridors are the North-west and South-east Islands. These islands are approximately eight kilometres southwest of the pilot boarding point, where the ship will enter King Sound.

No discernible change to breeding patterns or behaviour is expected, however some short term disruption of marine fauna in the immediate vicinity of project infrastructure is considered 'Possible'. The potential residual impact of noise on marine fauna, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Noise from construction and operational activities at Derby Port impacting birds or terrestrial fauna	Incidental	Possible	Low

11.2.2.2 Light from Construction and Operational Activities at Derby Port Impacting Birds or Terrestrial Fauna

Derby Port is an existing and operating industrial facility and already has functioning lighting in place. There are large street lights several metres tall at regular intervals along the wharf itself with additional lights on the western shore of the wharf near the conveyor. The roads and footpaths around the export facility and storage facility are also well-lit with street lighting. Additional lighting will need to be installed to allow the 24 hour per day operation of the Product Storage Facility and export infrastructure. It is expected that the level of lighting installed will not significantly exceed lighting that was in place at the site previously for Lennard Shelf Pty Ltd.

Marine fauna such as turtles and migratory birds are sensitive to artificial lighting (EPA 2010). Nesting turtles can be discouraged from nesting on lit beaches, whilst turtle hatchlings can be disorientated by artificial lights. However, the habitats of the Derby Port Development Envelope are not suitable nesting habitats for turtles and although non-nesting turtles may occasionally pass near the wharf, the behaviour and breeding patterns of turtles are not at risk from artificial lighting at the Port.

Artificial lighting may similarly disorientate migratory seabirds and shorebirds that are active at night, causing collisions with infrastructure or starvation due to incorrect navigation. The North-west Marine Bioregional Plan lists species for which light pollution is of "potential concern" (DSEWPC 2012b). Of these species, there are 11 species that are known to occur or may occur around the Derby Port Development Envelope. One of these species is listed as threatened and migratory, the Curlew Sandpiper. This species is known to occur in the Port Development Envelope although it is not a breeding site (DoE 2016).

There are 10 other migratory and non-threatened species that may occur and may be affected by light pollution (DSEWPC 2012b). Of these species, only the Little Tern has potential breed near the Derby Port Development Envelope. A small percentage of Little Terns occurring in northwest Australia are part of the breeding population, with the majority being non-breeding migrants. Breeding pairs of the Roseate Tern and Lesser Frigate are known to occur on some on islands in the Buccaneer Archipelago (DoE 2016, Birdlife 2016).

Information from the EPA (2010) suggests best practice methods from implementing lighting. This guideline suggests keeping lighting off when not needed, mounting lights as low as possible and with the lowest intensity needed for the job, ensuring lighting is shielded to prevent light escaping outwards and upwards and use long wavelengths where possible. This guideline will be considered in any additional lighting installations.

Given that the Derby Port Development Envelope is an existing industrial area with existing lighting, the additional lighting is not likely to result in the loss of conservation significant fauna habitat; nor the loss of individuals of a conservation significant species. No discernible change to breeding patterns or behaviour is expected, however some short term disruption of marine fauna in the immediate vicinity of project infrastructure is considered 'Possible'. The potential residual impact of light on marine fauna, after the implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Light from construction and operational activities at Derby Port impacting birds or terrestrial fauna	Incidental	Possible	Low

11.2.2.3 Changes in Hydrological Regimes Impacting Sawfish or Northern River Shark

Sawfish species and the Northern River Shark are known to venture up rivers to brackish conditions. The Largetooth Sawfish is known to utilise completely freshwater habitats at certain life stages, and has been found as far inland as 400 km (DoE 2015b). Fraser River South has been identified as the only inland habitat associated with the proposal where juvenile Largetooth Sawfish are predicted to occur during the wet season. This watercourse is not considered potential habitat for other Sawfish species or the Northern River Shark (DoE 2015b).

In certain projects, the alteration of flow in rivers due to groundwater drawdown and the installation of weirs or impoundments can severely compromise the habitats and behaviour of Sawfish species. A reduction in the dry season flows of rivers could restrict the habitat availability for the Sawfish species and Northern River Shark (DoE 2015b).

The river channel extends to approximately 10.5 km from the Mine Site Development Envelope and will be crossed by Site Access Roads at the existing Mt Jowlaenga Road crossing and 1.7 km upstream of this point. The portion of the river within the Mine Site Development Envelope is at the uppermost reaches of the catchment. The river in this section is an ephemeral, poorly incised, shallow watercourse typical of upper catchments that carry low flow volumes infrequently after significant rainfall (Figure 26).

The only physical impact on the river channel will be the Site Access Road crossing which will be fitted with suitable culverts to allow wet season flows to pass. These culverts would also allow the movement of juvenile Sawfish, should they venture this far upstream in the wet season. The river channel at the point of crossing the Site Access Road is shown in Figure 26.

The catchment area of the Fraser River South upstream of the first visible channel is approximately 300 km^2. Any reductions in runoff from water capture in active mining areas will have negligible hydrologic impact. Maximum groundwater drawdown at the Fraser River South headwaters is predicted to be less than 2 m over the life of the project, which would result in minimal impact on wet season surface flows. Since this channel is naturally dry during the dry season, there will be no change to dry season flows.

Fraser River South is potential habitat for the Largetooth Sawfish in the wet season only. The closest section of the river is 10.5 km from the main mining operation and it will be crossed by the Site Access Road. The maximum drawdown in the catchment headwaters is expected to result in minimal impact to wet season surface flows. The project is expected to result in no discernible loss of conservation significant fauna habitat, loss of individuals, or interruption to breeding patterns or behaviour. Impact to Sawfish and Northern River Sharks is 'Unlikely'. The potential residual impact from changes in hydrological regimes to Sawfish and the Northern River Shark, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Changes in hydrological regimes impacting Sawfish or Northern River Shark	Incidental	Unlikely	Low

11.2.2.4 Additional Shipping or Transhipment Impacting Marine Fauna

Shipping is an existing and well-established industry in the Kimberley. In the year 2014/15, a total of 1,515 vessels were known to berth at the deep water Kimberley ports of Broome and Wyndham and the tidal port of Derby (see Table 32). The project will bring an additional 40 - 70 ocean-going vessels to the Kimberley each year. Taking the conservative higher number of 70 additional vessels per year, this represents a maximum increase in 4.6% per year of ships navigating the waters of the Kimberley.

Within the Derby Port limits, the vessel movements will be restricted to transhipment vessels towed by tug boats. Tug boats and transhipment vessels already regularly visit the area and travel at slow speeds. As Derby Port is already an existing port, and considering the number of recreational vessels which are not included in the data, the increase in transhipment vessel and tug movements is expected to present a limited additional impact. The method of transhipment will be very similar to that used by Lennard Shelf Pty Ltd which operated with no major incidents.

Vessel Strike from Additional Shipping Impacting Marine Fauna

Vessel strike or collision with marine fauna is a known cause of deaths or injuries to marine fauna such as Whales, Inshore Dolphins and Sea Turtles. Species at risk of vessel strike by project vessels would include Humpback Whales, Australian Humpback Dolphins, Indo-Pacific Bottlenose Dolphins, Snubfin Dolphins, Flatback Turtles, Green Turtles, Loggerhead Turtles, Olive-Ridley Turtles and Leatherback Turtles.

The areas considered of higher risk of vessel strike would be the areas outside the port limits where the water is less turbid and more wildlife is likely to occur. The slow-speed movements of transhipment vessels and tugs inside the port limits are less likely to result in vessel strike.

Humpback Whales migrate along the West Australian coast to calving grounds in the Kimberley. Surveys show that whales remain offshore, passing King Sound and aggregate at the Frost and Tasmanian Shoals and Camden Sound (Jenner *et al*. 2001). Ocean-going vessels entering King Sound to moor at the sea transfer point will pass through the migration path and potential calving grounds of the Humpback Whale. As Humpback Whales are not known to use the southern part of King Sound where transhipment vessel movements will occur, the only potential interaction with Humpback Whales is from the ocean-going vessels coming to and from the sea transfer point.

The ocean-going vessels are not expected to pass through any of the three zones where the highest concentrations of whales occur, which are the Lacepede Islands, the Frost and Tasmanian Shoals and Camden Sound (ellipses as shown on Figure 42). Given that Humpback Whales are only present in the area for four to five

months per year; this would mean a maximum of an additional 16 vessels would be crossing the whale migration path each year.

Inshore Dolphins are also considered at risk from vessel strike, with the risk increasing with speed of the vessel. Reports indicate that there have previously been collisions between Dolphins and boats in the northwest region. Vessel strike is also known to cause death or injury to Sea Turtles in Australia, although there are few quantifiable data specifically in the region. The species' poor hearing and vision can affect their ability to avoid boats (DSEWPC 2012d).

Several measures will be put in place to minimise harm to marine fauna. If crew of Sheffield operated vessels sight cetaceans or sea turtles, these will be reported to other vessels to ensure they are informed and can take precautions in the area. Captains of ocean-going vessels will be informed to take extra care during the Humpback Whale migration season (July to November), adjust vessel speeds and have crew on watch as needed. Sheffield operated vessels will reduce speed below 8 knots if whale sightings are within vessel movement areas. Any potential impacts to Humpback Whales will be managed through the Port Environmental Management Plan (EMP). Any wildlife strikes by Sheffield operated vessels will be reported through the Port EMP and adaptive management practices implemented if necessary.

Shipping in the Kimberley is an established industry and this project represents a small percentage increase in vessel movements. Vessels will need to cross the Humpback Whale migration path, and will also pass through areas where Dolphins and Turtles are likely to occur. It is 'Possible' that vessel strike could cause the death of an individual animal of a conservation significant species, although this would not impact on the population's ability to survive locally. The potential residual impact of vessel strike on Humpback Whales, Dolphins and Sea Turtles, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Vessel strike from additional shipping impacting marine fauna	Incidental	Possible	Low

Noise from Additional Shipping Impacting Marine Fauna

Noise related to shipping has been shown to have a damaging affect to some cetaceans. Noise impacts to Humpback Whales are considered of potential concern according to DSEWPC (2012) as the frequency of shipping noise directly overlaps with the frequency range of some baleen whales. Rolland *et al.* (2012) found that Right Whales (*Eubalaena glacialis*) in the USA exhibited increased stress with an increase in shipping noise in a high shipping traffic area. Similarly, noise may also impact Inshore Dolphins, including potentially limiting the detection of natural sounds, disturbing normal behaviours and masking communication including the whistles required for social interactions. Dolphins may exhibit vessel avoidance behaviour due to vessel noise. Noise impacts from shipping are also a potential concern for Sea Turtles (DSEWPC 2012d).

The increase in shipping movements from the project will be equivalent to less than one additional vessel per week during the whale migration, meaning that noise impacts will be intermittent. Other species that would be susceptible to noise impacts (i.e. Inshore Dolphins and Sea Turtles) are not found in the area of the sea transfer point in large numbers and the proposed route of the ocean-going vessel will not pass close to any habitats of particular significance for these species (see Figure 42).

The project only represents an addition of 2.6% to the vessel movements of the Kimberley (based on 2014/15 data). It is 'Possible' that noise from additional shipping could result in short term, intermittent disruption of marine fauna breeding and/or behavioural patterns that do not affect population health or survival. The potential residual impact of noise from additional shipping on marine fauna, after the implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Noise from additional shipping impacting marine fauna	Incidental	Possible	Low

Light from Additional Shipping Impacting Marine Fauna

When the ocean-going vessel is moored at the sea transfer point, it will need lighting at night. This is a DoT requirement and necessary for navigational safety. Lighting will also be required to allow 24 hour a day loading of the ocean-going vessel from the transhipment vessel.

Sea Turtles are sensitive to artificial lighting (EPA 2010). Nesting turtles can be discouraged from nesting on lit beaches, whilst turtle hatchlings are disorientated and can be attracted by artificial lights. The coastline nearest the sea transfer point at Point Torment is likely suitable nesting habitat for Flatback Turtles (R.I. Prince, pers. comm. cited in SWOT 2009). However, this is not considered a nesting habitat of particular significance.

As discussed above in Lighting – Derby Port, artificial lighting may similarly disorientate migratory seabirds and shorebirds that are active at night. The North-west Marine Bioregional Plan lists species for which light pollution is of "potential concern" (DSEWPC 2012b). Of these species, there are 11 species that are known to occur or may occur in the shipping or transhipment route or around the Derby Port Development Envelope. One of these species is listed as threatened and migratory, the Curlew Sandpiper. This species is known to occur in the shipping or transhipment route or around the Derby Port Development Envelope although it is not a breeding site (DoE 2016). The nearest breeding site of significance to the shipping or transhipment route is the North-west and South-east Islands, which are significant breeding sites for the Roseate Tern (Birdlife 2016). These islands are located approximately eight kilometres from the pilot boarding point, and light impacts to this site will be insignificant.

The chance of additional lighting causing disturbance to marine fauna is considered 'Unlikely'. The lighting associated with additional shipping is not likely to result in the loss of conservation significant fauna habitat; nor the loss of individuals of a conservation significant species. No discernible change to breeding patterns or behaviour of marine fauna is expected. The potential residual impact of light from additional shipping on marine fauna, after the implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Light from additional shipping impacting marine fauna	Incidental	Possible	Low

Hydrocarbon Spill from Additional Shipping Impacting Marine Fauna

In the event of a hydrocarbon spill, species potentially at particular risk would include Inshore Dolphins, seabirds and shorebirds and Sea Snakes (DSEWPC 2012b).

This impact could only occur indirectly through hydrocarbon spillage affecting marine water quality, which in turn affects marine fauna. This stressor has been assessed as part of Marine Environmental Quality (see Section 9.1.2.3) and given the management and mitigation measures addressed in that section, has been assessed as 'Low'.

It is 'Unlikely' that a hydrocarbon spill in King Sound or adjacent waters could result in the death of an individual animal of a conservation significant species. If it did occur, it would not be expected to impact on the population's ability to survive locally. The potential residual impact of a hydrocarbon spill from additional shipping on marine fauna, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Hydrocarbon spill from additional shipping impacting marine fauna	Incidental	Possible	Low

Solid Waste/Marine Debris from Additional Shipping Impacting Marine Fauna

Marine debris includes all non-biodegradable solid waste from commercial and recreational shipping, land-sourced garbage, discarded fishing gear and "ghost nets" – pieces of fishing nets floating in the sea. Historically, the commercial shipping industry has been responsible for the discharge of large amounts of solid waste which in turn becomes marine debris. Marine debris is a potential impact of concern to marine fauna, as they can ingest it or become entangled, resulting in death or injury. This process is listed as a "Key Threatening Process" in the *EPBC Act* (DEWHA 2009). Marine debris is of particular concern for the Sawfish species (DoE 2015a). Due to their barbed rostrum, these species are known become entangled in marine debris, causing death or injury.

According to International Convention and Commonwealth and State laws, it is illegal to dump garbage from ships into the sea except under very specific circumstances. Amendments to *the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V* came into force on 1 January 2013. This amendment reversed the presumption that dumping at sea was allowed, except in specific areas. MARPOL is administered in Australian waters through the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*. In Western Australia, the *Pollution of Waters by Oil and Noxious Substances Act 1987* also applies.

Solid waste facilities are provided at the Derby Port. All crew on the Sheffield transhipment vessel and tug boat teams will be made aware of the importance of preventing the escape of solid waste. All solid waste will be disposed of in appropriately covered receptacles at Derby Port and transferred to a licensed disposal facility. The Captain of the ocean-going vessel will be provided with information on the legal obligations of preventing the escape of solid waste. The management of solid waste and all debris will be covered in the Port EMP.

Solid waste and marine debris are considered 'Unlikely' to result in either the loss of individuals of a conservation significant species or the loss of conservation significant fauna habitat; or disruption to marine fauna breeding patterns or behaviour. The potential residual impact of solid waste/marine debris from additional shipping on marine fauna, after the implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Solid waste/marine debris from additional shipping impacting marine fauna	Incidental	Unlikely	Low

11.2.3 Management Measures

Management measures to reduce potential impacts to marine fauna are addressed in the Port EMP.
The ESD states that a Humpback Whale Management Plan should be produced if needed. As all potential impacts to Humpback Whales have been assessed as 'Low', it is not considered necessary to produce a stand-alone management plan for this factor. However, any potential impacts to Humpback Whales will be addressed in the Port EMP along with all other marine factors.

Key management measures related to marine fauna are detailed below in Table 79.

Table 79: Proposed Management Measures for Marine Fauna

Potential Impact Requiring Management	Measure
Lighting from Port and vessels	• Lighting design will consider minimisation of attraction of wildlife. • Operators of the ocean-going vessel will be made aware of potential lighting impacts to marine fauna and the advice of Environmental Assessment Guideline No. 5, Protecting Marine Turtles from Light Impacts (EPA 2010).
Inland Hydrological Change affecting Sawfish	• Culverts will be constructed at the channel of the Fraser River South where it crosses the Site Access Road to facilitate wet season surface water flows and allow the passage of juvenile Sawfish.
Vessel Strike	• If crew of Sheffield operated vessels sight cetaceans or sea turtles, these will be reported to other vessels to ensure they are informed and can take precautions in the area. • Captains of ocean-going vessels will be informed to take extra care during the Humpback Whale migration season (July to November), adjust vessel speeds and have crew on watch as needed. • Sheffield operated vessels will reduce speed below 8 knots if whale sightings are within vessel movement areas. • Any wildlife strikes by Sheffield operated vessels will be reported through an incident reporting system and adaptive management practices implemented if necessary.
Hydrocarbon Spill	• All Sheffield marine vessels will be maintained to high standards as required by DoT. Refuelling of marine vessels will be consistent with Port of Derby criteria. • Refuelling equipment will include emergency shutdown valves and be monitored at all times. • Used oil or oil-soaked absorbents will be securely stored and disposed of at a licensed facility. • Spills of oil, fuel or other hydrocarbons to water will be immediately reported to DoT. • A spill kit located at Derby Port will be maintained in working order. • An appropriately sized and stocked marine spill kit will be located on each Sheffield owned or operated tug boat to address small scale spillages.
Solid waste/marine debris	• Employees and contractors operating Sheffield transhipment vessel and tug boat teams will be made aware of the importance of preventing the escape of solid waste. • Solid waste will be disposed of in appropriately covered receptacles at Derby Port and transferred to a licensed disposal facility. • The Captain of the ocean-going vessel will be provided with information on the legal obligations of preventing the escape of solid waste.

11.2.4 Predicted Outcome

Derby Port is an existing facility and the transhipment and shipping routes have been used historically. The increase in shipping movements is minimal, representing an additional 2.6% per year (based on the year 2014/15). This minimal increase in vessel movements will result in negligible increases in noise and light emissions or solid waste impacts. Therefore, it is not anticipated that these minimal increases will result in any loss of conservation significant fauna habitat or individuals of a conservation significant species, or change to breeding patterns or behaviour of marine fauna.

Whilst hydrocarbon spills and vessel strikes could result in the death of an individual animal of conservation significance, it is unlikely that such an event would occur and it is not anticipated that this would affect the ability of the population of that species to survive in King Sound or the vicinity.

Sheffield considers that the potential impacts of the project on marine fauna will be able to be adequately managed such that the objective (Section 11.2) will be met, and that the residual impacts are therefore acceptable.

11.3 TERRESTRIAL ENVIRONMENTAL QUALITY

The EPA's objective in relation to terrestrial environmental quality is "*to maintain the quality of land and soils so that the environment values, both ecological and social, are protected*".

11.3.1 Key Statutory Requirements, Environmental Policy and Guidance

Key statutory requirements, environmental policy and guidance for Terrestrial Environmental Quality, in relation the Derby Port Development Envelope, are the same as for the Mine Site Development Envelope, see Section 10.3.1.

11.3.2 Assessment of Potential Impact

The bulk ilmenite and zircon concentrate products will be transported from the Mine Site to Derby Port for export via King Sound. Terrestrial environmental quality along the transport route and at the Derby Port has the potential to be impacted from transport, storage and export of product activities such as:

- **Dust generation or spillage of product affecting the terrestrial environment** – could occur at the Derby Port or transport route.
- **Radiation exposure affecting the terrestrial environment** – as a result of a spill.
- **Disturbance of contaminated or acid sulfate soils affecting the terrestrial environment** - during construction of the Product Storage Facility.

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Uncontrolled drainage from Product Storage Facility	Terrestrial pollution will not be caused through uncontrolled drainage. The Product Storage Facility will either be a fully enclosed, concrete floored facility or silos. Drainage within the shed will be directed to sumps. Materials collected in the sumps will be removed as needed and returned to the Mine Site for reprocessing. Shed doors will only open to allow entry and exit of road trains. Product to be stored is insoluble and considered environmentally benign.
Disturbance of contaminated soils or acid sulfate soils (ASS) affecting the terrestrial environment	Assessment of the soils and sediments within the lease area which may be disturbed in minor volumes by construction of a Product Storage Facility indicated no significant risk of ASS. As the site is already levelled, very minimal disturbance of soils is expected other than for installation of services and minor foundations works as required. No significant disturbance of marine sediment and hence opportunity for oxidation and metals/metalloids release is expected for the proposed development as the wharf is already constructed.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

11.3.2.1 Dust Generation or Product Spillage Affecting the Terrestrial Environment

The potential impact of dust on human receptors is addressed in 9.2.2.1.

The terrestrial environment may be affected by dust or deposition or a spillage of product along the transport route or at the Derby Port Development Envelope. Dust is likely to be generated during construction of the Product Storage Facility subject to site conditions at the time. During the operational phase, dust could be generated from transportation of product in road trains to the product export facility and potentially from export activities. Spillage could result from incorrect filling or tipping of road trains.

There will be an average of 10 return road train trips (20 road train movements) along the transportation route per 24 hour period during the operational phase of the project. Other than the Site Access Road, road trains accessing the Derby Port Development Envelope from the Mine Site will be travelling on sealed roads and dust generation is expected to be minimal. Bulk product will be transported in covered containers. Mineral sands products are naturally occurring and environmentally benign as they are insoluble and not readily prone to dust generation. In the event of any spilt material (e.g. truck rollover), this would represent a very low risk to the terrestrial environment. Material spilt would be collected and returned to site for re-processing and dust suppression measures would be applied during this clean-up and recovery as necessary.

Sensitive receptors in the terrestrial environment may include conservation significant flora, fauna, and soils. Long term exposure to excessive dust levels can affect flora and fauna health. There are no listed threatened species of flora located within the Derby Port Development Envelope or transportation route. There are eight species of listed threatened terrestrial fauna that may occur in the Derby Port Development Envelope. Six of these are birds and two are mammals. Due to a lack of unsuitable habitat, most of these are expected to be infrequent visitors. The causeway across the mudflats between the Port and Derby townsite was constructed from local rock and soil sourced from the Derby hinterland. All soil at the proposed storage facility area consists of fill material, primarily Pindan soil imported and placed in 1997 as part of construction works for the former lead and zinc concentrate storage facility. Although this soil fill shows some residual levels of lead and zinc from previous activities (MBS 2016c, Appendix 14), the dust generated by disturbance of this soil is not environmentally damaging.

Impacts from dust generation are likely to be limited to within 50 m of the generation point. Dust modelling has been conducted for the project in the section of road between Derby town and the Product Storage Facility. In the absence of specific detailed inputs for the model, the modelling has adopted standard emissions and is therefore likely to be an over-estimate. Average monthly dust deposition in Derby town will be 0.5 - 0.8 g/m^2/month and 3.5 - 4 g/m^2/month at the Port (Atmospheric Solutions 2016; Appendix 17). This level (equal to or below human amenity levels), is not considered significant for flora or fauna (or human) health.

Product dust escaping during storage and transfer of bulk mineral sands products will be minimal. The export products have limited potential for dust generation as they are granular in nature and do not contain fines and have high specific gravities. They are highly insoluble materials and do not contain leachable contaminants such as heavy metals, hydrocarbons or acids.

The Product Storage Facility to be constructed will be purpose designed and will be fully enclosed which will prevent product dust escaping. The facility will store up to 50,000 to 60,000 tonnes of mineral sands products, and will accommodate all unloading and storage activities. If a shed facility is constructed, road trains will drive through the warehouse and tip into a specific product drop area. A front end loader will feed a hopper/conveyor system which runs the length of the shed and feeds the transhipment vessel loading conveyor. The conveyer system is covered to minimise loss or spillage of product.

Minor dust generation within the Derby Port Development Envelope is not considered a risk to the terrestrial environment given the impact of previous activity on the site, nature of the material and the lack of sensitive environmental receptors within close proximity to dust generation points.

Although some dust generation or spillage of product may occur, it is considered 'Unlikely' that it will result in any loss of soil resources or environmental values, or cause land contamination. The potential residual impact of dust generation and deposition on terrestrial environmental quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Dust generation or product spillage affecting the terrestrial environment	Incidental	Unlikely	Low

11.3.2.2 Radiation Exposure Affecting the Terrestrial Environment

The radioactivity levels of naturally occurring radioactive materials (NORMs) in exported products is less than 10 Bq/g with the primary product by volume (ilmenite) having an activity of less than 1 Bq/g (SGS 2016; Appendix 21). Zircon concentrates have a somewhat higher activity of up to 9.10 Bq/g but will be bagged and represent only a small proportion of material exported (e.g. primary zircon 8,227 tpa in Stage II, approximately 1%).

In accordance with Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2005) and International Atomic Energy Agency Safety Guide RS-G-1.7 (IAEA 2004), materials containing NORMs are excluded from regulations and considered inherently safe if the specific activity concentrations are below 1 Bq/g. Concentrations of NORM up to 10 Bq/g are generally considered exempt in relation to transport restrictions due to the nature of the materials and form of radiation (alpha rather than gamma) primarily emitted (ARPANSA 2008). The potential impact to the terrestrial environment from naturally occurring radioactive materials is therefore extremely small and will not require special consideration and management. Background radiation levels in soil, sediments and airborne dust will be measured prior to construction commencing.

Minor spillages of low radioactivity ilmenite material would be of negligible impact to the terrestrial environment of Derby Port Development Envelope. In the unlikely event of a major spill, the product will be recovered and returned to the Mine Site for re-processing.

There is very minor potential for impact to the surface terrestrial environment from significant spillage without appropriate clean-up of the zircon products, in particular the primary zircon which may exceed environmental screening criteria of 10 µGy/h if left at surface in large amounts. Any such environmental effects would take years to decades and also be unlikely due to the limited area of any impact. Risk of general emissions are unlikely due to transport of zircon being in small quantities and packaged in bags and hence very unlikely to be release dust. If a bag is split or lost during transport, the product will be recovered and returned to the Mine Site for re-processing. Cleanup will be conducted in conjunction with validation testing of remaining surface soils to ensure levels of radiation have returned to background levels away from the spill location. Recovered material will either be returned to the Product Storage Facility or returned to the Mine Site for reprocessing or disposal.

Short term exposure of terrestrial flora and fauna within a very limited spatial area during this process to low levels of activity is not considered to be of significant impact. All products also have a specific gravity higher than 4.7 and are therefore not susceptible to dispersion as dust.

The products have very low to insignificant levels of natural radiation. It is considered 'Unlikely' that radiation will result in any loss of soil resources or environmental values or cause land contamination. The potential residual impact from radiation on terrestrial environmental quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the terrestrial environment	Incidental	Unlikely	Low

11.3.2.3 Disturbance of Contaminated Soils Affecting the Terrestrial Environment

The Product Storage Facility site has a history of contamination and was remediated in 2010/11 after which it was deemed to be remediated to a level that is appropriate for its intended land use (industrial/commercial) (MBS 2012). The site remains classified as 'Possibly Contaminated – Investigation Required' due to a lack of groundwater data from beneath the site (which is affected by tidal intrusion). A baseline contamination assessment of the Derby Port Development Envelope in 2016 (MBS 2016c; Appendix 14), found levels of potential contaminants to be below Environmental Investigation Levels and Health Investigation Levels values and soils and subsoil clays were not potentially ASS (Section 4.3.7).

The project is expected to result in no loss of soil or land resources or associated terrestrial environmental values as a result of construction of the Product Storage Facility. Impacts associated with ASS are assessed as 'Unlikely'. The potential residual impact from ASS on terrestrial environmental quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Disturbance of contaminated soils or acid sulfate soils affecting the terrestrial environment	Incidental	Unlikely	Low

11.3.3 Management Measures

Management measures implemented to minimise the potential impact on terrestrial environment quality have been identified in Table 80.

Table 80: Proposed Management Measures for Terrestrial Environmental Quality

Potential Impact Requiring Management	Measure
Dust generation or product spillage	• Bulk products will be transported in covered containers. • Bulk product will be stored in a purpose built Product Storage Facility. This will include a drive through enclosed unloading area to ensure product is contained within warehouse during unloading activities. • Product storage and loading onto the conveyor will be conducted within the shed. • Transfer of product to barges will be via covered conveyor.
Radiation exposure affecting terrestrial environment	• The RMP will define the requirements for periodic monitoring for both personal and environmental monitoring of radiation levels. This will include establishment prior to operations of background soil, sediment and airborne dust samples. • Products spills along the transport route or Derby Port will be subject to clean up such that residual levels of radiation are returned to established background levels. Material collected from any such spills or accidental release will be returned to the Mine Site for re-processing or disposal. • Background radiation levels in soil, sediments and airborne dust will be measured prior to construction commencing.

11.3.4 Predicted Outcome

The potential for impacts to terrestrial environmental quality as a result of transport, storage and export of product within the Derby Port Development Envelope is minimal. All transport of product is via covered road trains on

sealed roads. These unload in an enclosed facility and product is loaded onto a conveyor within a bunded area. The product itself is granular, has a high specific gravity, and is not prone to producing dust, although some minor generation of dust may occur throughout the life of the project. The product is naturally occurring with a low level of radiation and is environmentally benign.

Soils at the site are not potentially ASS and the project will not result in any significant disturbance to soils or marine sediment within the Derby Port Development Envelope. The project will not result in loss of soil resources or associated environmental values.

Sheffield considers that the potential impacts of dust, radiation, and contaminated soils on terrestrial environmental quality will be able to be adequately managed such that the environmental objective (Section 11.3) will be met, and that the residual impacts are therefore acceptable.

11.4 HUMAN HEALTH

The EPA's objective in relation to human health is "*to ensure that human health is not adversely affected*".

11.4.1 Key Statutory Requirements, Environmental Policy and Guidance

Key statutory requirements, environmental policy and guidance for Human Health, in relation to the Derby Port Development Envelope are the same as for the Mine Site Development Envelope (Refer to Section 10.5.1), with the addition of the following considered in undertaking this impact assessment:

- A Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities (DEC 2011).
- EPA Guidance Statement No. 3, Separation Distances between Industrial and Sensitive Land Uses (EPA 2005).
- Air Quality Modelling Guidance Notes. Perth, WA. (DEC 2006).
- *National Environment Protection Measure for Ambient Air Quality 1994* as Amended 2003 (NEPC 2003).

11.4.2 Assessment of Potential Impact

This section discusses the potential for impact on human health in relation to the transport and export of materials through Derby Port. Bulk product received by the Derby Port; including transports within the Port, unloading of product for storage, storage of the product within a facility, and loading of product from the storage facility onto ships; has the potential to impact upon human health through exposure to radiation or increased exposure to dust particulates. Diesel particulates and vehicle emissions from haulage through the town of Derby also have the potential to impact on human health.

Naturally occurring radioactive materials (NORMs) contain the elements thorium and uranium which are associated with the heavy minerals, and in particular with monazite. As demonstrated in the mine residues characterisation (MBS 2016; Appendix 20), the uranium and thorium in monazite is tightly bound and unavailable environmentally, but is still subject to radioactive decay and emissions proportional to the concentration of monazite. In accordance with Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2005) and International Atomic Energy Agency Safety Guide RS-G-1.7 (IAEA 2004), materials containing NORMs are excluded from regulations and considered inherently safe if the specific activity concentrations are below 1 Bq/g. Concentrations of NORM up to 10 Bq/g are generally considered exempt in relation to transport restrictions due to the nature of the materials and form of radiation (alpha rather than gamma) primarily emitted (ARPANSA 2008).
The highest activity material exported is zircon concentrate (9.10 Bq/g) and therefore subject to decision by the Radiation Council and DMP may be exempt from transport restrictions. A Radiation Management Plan (RMP) and

Radiation Transport Management Plan (RTMP) will be prepared which will outline the management measures for worker and public radiation exposures are managed in accordance with the legislation.

Potential exposures and impacts include:

- **Radiation exposure affecting the health of transport drivers** - by external gamma radiation, radon and dust inhalation resulting from product handling and proximity to product while driving.
- **Radiation exposure affecting the health of workers** - by external gamma radiation, radon and dust inhalation resulting from product handling (unloading from trucks, storage and loading for shipping).
- **Radiation exposure affecting the health of members of the public** - through direct proximity (gamma radiation) to the products, or exposure to increased particulates through product transport through the town of Derby, product unloading, and product loading onto ships.
- **Dust emissions affecting the health of workers or members of the public** from:
  - Port product handling activities (e.g. loading and unloading vessels).
  - Emissions from the Derby Port Product Storage Facility (e.g. unloading from trucks).
  - Emissions associated with truck movements at Derby Port and through Derby townsite.
- **Diesel particulate and gaseous vehicle emissions exposure affecting the health of members of the public** - generated by transport vehicles travelling through Derby

Impacts from general dusts/particulates for the amenity related measures of TSP and dust deposition were discussed and addressed in Section 9.2; impacts from fine airborne particulates and inhalation of radionuclides in dust are discussed below.

11.4.2.1 Radiation Exposure Affecting the Health of Port Facility Workers

Potential exposures for Port workers were estimated based on:

- Exposure to external gamma irradiation by general proximity to the NORM materials (assumed 1 m distance).
- Inhalation of dust containing radionuclides (and hence exposure to otherwise short lived alpha particles).
- Possible inhalation of radon gas and radon decay products.
- Exposure of port workers was estimated based on handling of all export products by the same workers through a single export facility. Subsequent changes to allow export through two ports will affect exposure calculations. Exposures for individuals working at only one of these locations will be less than this estimate.

A high estimate of potential radon concentration is approximately 9.8 Bq/m^3, which is within typical background concentrations of radon in Australian homes of about 10 Bq/m^3 (Radiation Professionals 2016, Appendix 21).

Exposures for Derby Port workers to dust were calculated based on a high estimate of continual inhalation of 3 mg/m^3 airborne dust loadings at average total activity of all products (1.77 Bq/g). This assessment is also considered conservative as such dust levels are considered high for occupational levels, unlikely to be continual, and the majority of material which may generate dust (ilmenite) has low activity of 0.59 Bq/g (Radiation Professionals 2016; Appendix 21). Standard dust suppression measures of wetting/misting, covered conveyors, PPE and enclosed cabins will minimise exposure to dust for Port workers. Estimated exposures for Derby Port workers (Radiation Professionals 2016; Appendix 21) are summarised in Table 81 in comparison to the occupational exposure limit of 20 mSv/year (Regulation 16.18 *Mines Safety and Inspection Regulations 1995*).

Table 81: Summary of Estimated Derby Port Facility Workers Radiation Exposure

Exposure Pathway	Unit	Calculated Dose	Guideline Value	Percentage Guideline
External Gamma	mSv/year	1.24	20	6.2 %
Dust Inhalation	mSv/year	0.38	20	1.9 %
Total Exposure	mSv/year	**1.62**	**20**	**8.1 %**

Although radiation exposure to Derby Port facility workers is considered 'Almost Certain' by means of general proximity to products and hence exposure to gamma radiation within the Derby Port Development Envelope, the total exposure is considered 'Incidental'. The potential residual impact of radiation on the health of Derby Port workers, after implementation of the RMP and RTMP, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the health of Derby Port facility workers	Incidental	Almost Certain	Medium

11.4.2.2 Radiation Exposure Affecting the Health of Transport Workers

Exposure to dust inhalation and radon inhalation for drivers in sealed cabins and not normally involved in loading operations is considered very low, and was not assessed.

Although radiation exposure to transport workers is considered 'Almost Certain' when transporting higher activity loads such zircon concentrate, the total exposure is considered 'Incidental'. The potential residual impact of radiation on the health of transport workers, after implementation of the RTMP, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the health of transport workers	Incidental	Almost Certain	Medium

11.4.2.3 Radiation Exposure Affecting the Health of Members of the Public

Potential exposures for members of the public may occur through external gamma irradiation if in sufficiently close proximity to the products, or by inhalation of potential radionuclides within the dust.

Radon inhalation is not considered significant due to its rapid decay and dispersion. An estimate of exposure to gamma irradiation was based on walking within 10 m of the stockpiled products for five minutes every day (Radiation Professionals 2016, Appendix 21). Dust inhalation estimates were based on the same conservative airborne dust loadings as for workers (3 mg/m^3), but for only five minutes per day (very close proximity to loading operations would be required for this).

Potential exposure for members of the public on this conservative basis are summarised in summarised in Table 82) in comparison to the public exposure guideline of 1 mSv/year (ARPANSA 2002). Assessment of potential exposure to members of the public during routine trucking by brief periods of close proximity to loaded trucks was also made and assessed as being of very low potential exposure (Radiation Professionals 2016, Appendix 21).

Table 82: Summary of Estimated Public Radiation Exposure

Exposure Pathway	Unit	Calculated Dose	Guideline Value	Percentage Guideline
External Gamma	mSv/year	0.002	1	0.2 %
Dust Inhalation	mSv/year	0.006	1	0.6 %
Total Exposure	**mSv/year**	**0.008**	**1**	**0.8 %**

Although radiation exposure to members of the public is considered 'Possible' within the Derby Port Development Envelope and transport route to the Port, the total exposure is considered 'Incidental'. The potential residual impact of radiation on the health of members of the public, after implementation of the RMP, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the health of members of the public	Incidental	Possible	Low

11.4.2.4 Dust Emissions Affecting the Health of Workers or Members of the Public

There is potential for an increase in airborne dust loadings from activities associated with the project, such as product transport and loading/unloading operations at the Derby Port.

Airborne dust particles less than 10 microns aerodynamic diameter (PM_{10}), and specifically those less than 2.5 microns ($PM_{2.5}$) are strongly linked to adverse human health effects such as cardiovascular disease and respiratory effects (NEPC 2014). There is potential for an increase in fine fraction (PM_{10} and $PM_{2.5}$) airborne particulate loadings from dust generation as a result of transport and loading/unloading operations at the Derby Port. Fine fraction airborne dust particulate matter as PM_{10} and $PM_{2.5}$ for the Derby Port Development Envelope were modelled by Atmospheric Solutions (2016) along the transport route (Loch Street) and Port area to examine the potential impact of fine fraction airborne particulate matter on Derby workers and residents' health.

Modelled ambient particulate levels and dust deposition for the Derby Port Development Envelope and the transport route are shown in Figure 52 to Figure 54. Both PM_{10} and $PM_{2.5}$ were modelled for a 24 hour period. Comparative ambient air quality targets for PM_{10} and $PM_{2.5}$ are 50 µg/m^3 and 25 µg/m^3 respectively (NEPC 2003).

Modelling showed that PM_{10} concentrations ranged from an ambient level of 20 µg/m^3 to a maximum of 22 µg/m^3 along the transport route and within the Derby townsite (Figure 52). A concentration of 50 µg/m^3 PM_{10} was modelled at the Port boundary, however there are no sensitive receptors/residents located in this area.

Modelled $PM_{2.5}$ concentrations ranged from the ambient level, 7 µg/m^3 to a maximum of 8 µg/m^3 along the transport route and within the Derby townsite (Figure 54). A concentration of 15 µg/m^3 $PM_{2.5}$ was modelled at the Port boundary, however there are no sensitive receptors located in this area.

Results of air emissions inferred from modelling are summarised in Table 83, with predicted particulate emissions for PM_{10} and $PM_{2.5}$ below the limits specified in the National Environment Protection Measure for Ambient Air Quality (NEPM AAQ).

Table 83: Modelled Fine Fraction Dust Emissions for Port and Transport Activities

Particulate	Unit of Measure	Guideline Limit	Modelled Maximum Project Level		
			Port Boundary	Transport Route	Derby Townsite
Ambient PM_{10}	µg/m³ (24 hr average, maximum level)	50[1]	50	22	22
Ambient $PM_{2.5}$	µg/m³ (24 hr average)	25[2]	15	8	8

[1] Unit as specified in the NEPM AAQ Limit for the particulate; [2] NEPM AAQ Advisory Standard.

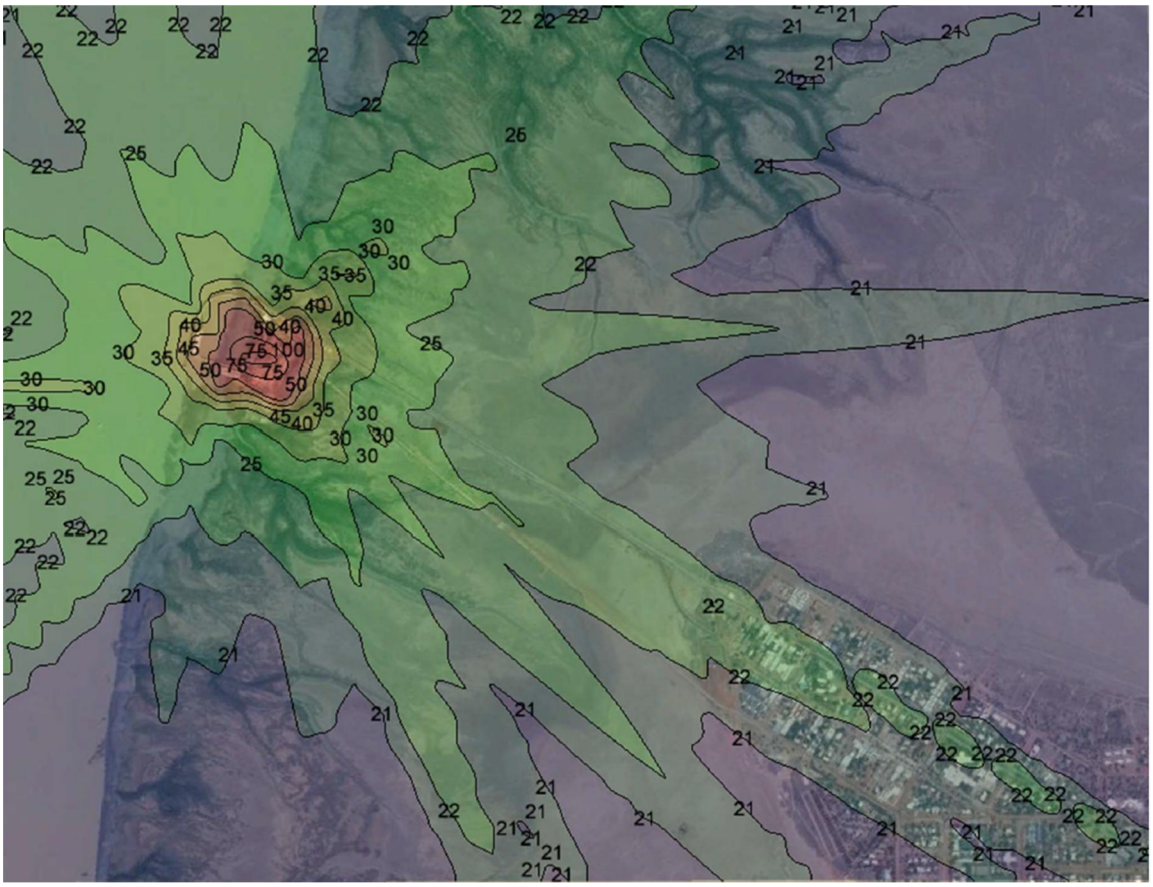

Figure 52: Modelled Ambient PM10 (24 hr average, maximum) Derby Port and Transport Route

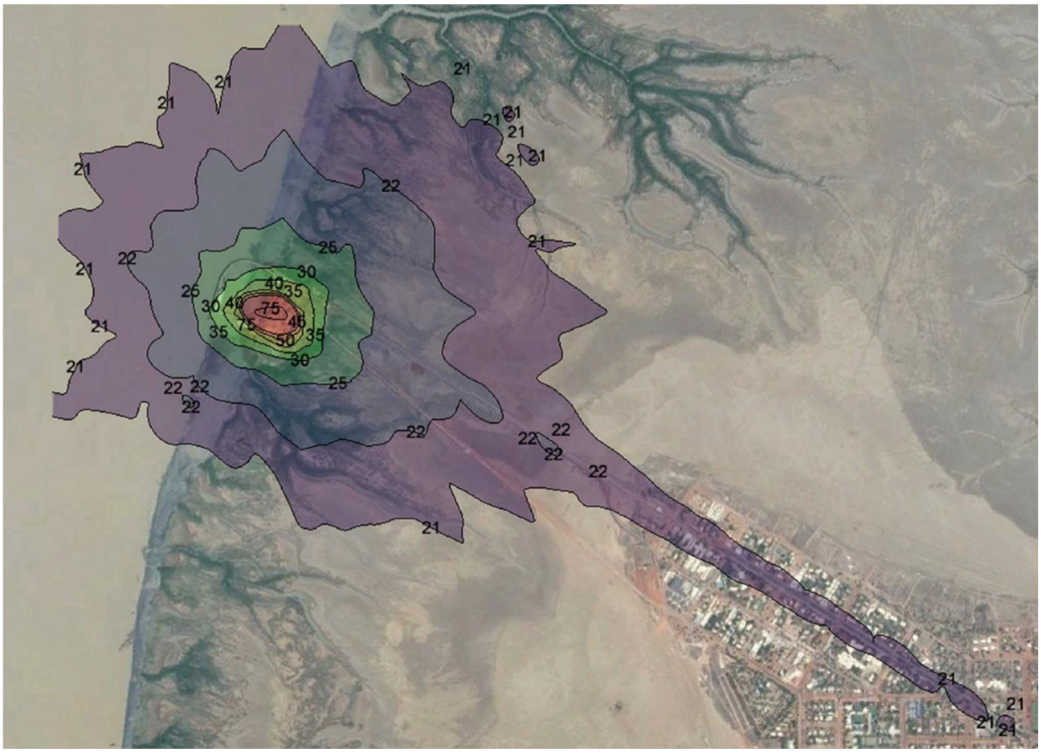

Figure 53: Modelled Ambient PM10 (24 hr average, 6th highest in order) Derby Port and Transport Route

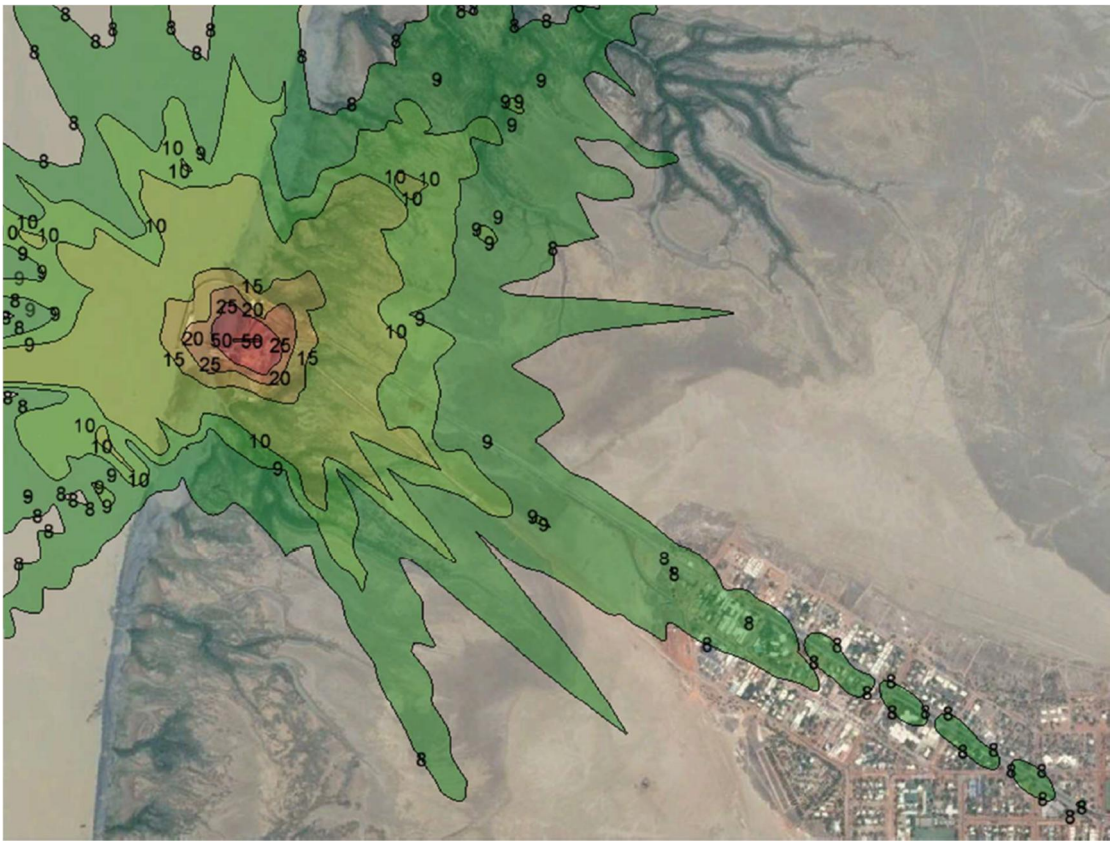

Figure 54: Modelled Ambient PM2.5 (24 hr average) Derby Port and Transport Route

Dust generation during construction of the Product Storage Facility is expected to be short-term and localised. As the site is already levelled, very minimal disturbance of soils is expected other than for installation of services and minor foundation works as required.

Dust emissions during storage and transfer of mineral sands products are expected to be incidental. The export products have limited potential for dust generation as they are granular, do not contain fines, and have high specific gravities. Mineral sands products will be unloaded and stored within the Product Storage Facility, which will be negatively pressured to further minimise dust emissions and also wetted/misted if required based on observations and results of monitoring. All mineral sands products are highly insoluble and do not contain leachable contaminants such as heavy metals or other environmental toxicants.

There will be an average of 20 road train movements (10 return trips) along the transport route per 24 hour period during the operational phase of the project. Other than the Site Access Road within the Mine Site Development Envelope, the transportation route is entirely on sealed roads using covered or bagged product transport, vastly decreasing the amount of dust generated when compared to unsealed roads. Products will be stored in a purpose-built facility with dust suppression including an enclosed unloading area to ensure products are contained within the facility during unloading activities. Transfer of bulk product to transhipment vessels (barges) for loading will be via a covered conveyor. Loading and handling of products at the Port and within the Product Storage Facility will be subject to positional environmental dust monitoring as part of an integrated environmental management plan (EMP) for the Port and Mine Site.

Based on the results of the modelling, product properties and management measures, bulk product transport and port activities, isolated and infrequent acute impacts may occur to the health of members of the public, but this is very 'Unlikely' to occur. However, it is 'Possible' that isolated and infrequent acute impacts may occur to the health of workers. The potential residual impact of dust emissions on the health of workers and members of the public, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Dust emissions affecting the health of workers	Incidental	Possible	Low
Dust emissions affecting health of members of the public	Minor	Unlikely	Low

11.4.2.5 Diesel Particulate and Gaseous Vehicle Emissions Exposure Affecting the Health of Members of the Public

Diesel particulate matter (DPM) was classified as a definite human carcinogen by the International Agency for Research on Cancer (IARC) in June 2012 (IARC 2012). Diesel particulate consists of very fine particles of elemental carbon which have the ability to absorb significant quantities of various semi-volatile hydrocarbons (many classified toxic and carcinogenic such as polyaromatic hydrocarbons [PAHs]) originating from unburnt fuel and lubricating oils during the combustion cycle. The very small particle size of DPM (typically less than 1 micron aerodynamic diameter) gives it the potential to reach deep into the lung. The classification of DPM as a definite carcinogen was the progression of studies over 30 years (AIOH 2013, IARC 2014), based primarily on occupational DPM exposure from older diesel engines (pre-2004), and adjusting for a latency (delay) period between exposure and cancer of 30 to 40 years.

During this period of time however, advances in diesel engine technology and introduction of emissions laws in Europe and the US have resulted in significant reductions in emitted levels of DPM and associated compounds such as PAHs. Percentage reductions in DPM measured in elemental carbon (99%) and PAHs (79%) in 2007 model engines versus 2004 technology engines indicate the degree to which these measures have been effective (IARC 2014) and hence reduced the risk of exposure leading to health effects. Estimates in Australia range from 80 to 90% reduction in DPM with modern diesel engines such as Euro V (DIRD 2016). Studies in California, one of the first jurisdictions to require diesel emissions controls on vehicles, have shown a threefold decrease in DPM to below 0.6 µg/m^3 ambient background concentrations despite a significant 80% increase in vehicle traffic since 1990 (Propper *et. al.* 2015). The currently recommended occupational health guideline for DPM in WA is 100

µg/m^3 (AIOH 2013). In addition, with changes in fuels the chemical emission profile is now significantly different to past DPM exposures upon which cancer epidemiology studies were based – namely reductions in carcinogens such as PAHs as well as general DPM. Health effects of gaseous vehicle emissions (CO, NO_x and SO_x) were previously discussed in Section 10.4.2 – it is noted that vehicle emissions and fuel standards have also led to significant reductions in emissions for these species.

Based on the additional 10 return trip truck movements per day along Loch Street (an approximate 2.4% increase on 2013/14 levels) for modern diesel trucks generally operating at optimum temperatures, any increases in DPM and gaseous vehicle emissions are not likely to be measurable. Isolated and infrequent acute impacts to the health of members of the public is considered 'Unlikely'. The potential residual impact of diesel particulate and gaseous vehicle emissions on the health of members of the public, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Diesel particulate and gaseous vehicle emissions exposure affecting the health of members of the public	Minor	Unlikely	Low

11.4.3 Management Measures

A summary of key measures to address potential impacts on human health from radiation is shown in Table 84. Further detail regarding the assessment and management measures for the protection of human health are detailed in Appendix 21 (Radiation Professionals, 2016).

No further management measures are considered necessary.

Table 84: Proposed Management Measures for Human Health (Derby Port and Transport Route)

Potential Impact Requiring Management	Measure
Radiation exposure affecting the health of Derby Port employees or members of the public	• Provision and maintenance of equipment and facilities for controlling radiation sources, including housekeeping, dust suppression and surface contamination control to maintain a duty of care to employees and the public • The facility will be registered under the RSA with the Radiological Council and DMP and Sheffield will appoint a Radiation Safety Officer (RSO) to implement a Radiation Management Plan (RMP) on behalf of Sheffield. • A radiation monitoring program will be implemented at the Port in consultation with the Radiological Council and DMP which will define the requirements of monitoring for both personal (and environmental radiation levels. This may include background, operational and post-closure radiation monitoring for personal exposure of Port workers as well as soil, sediment and air samples.
Radiation exposure affecting the health of transport workers or members of the public	• The product transport activities from the Mine Site to Derby Port will be registered with the Radiological Council and Sheffield will appoint a Radiation Safety Officer (RSO) to implement a Radiation Transport Management Plan (RTMP). • Personal dose monitoring for transport workers (in particular drivers) will be undertaken in accordance with a radiation transport management plan (RTMP) endorsed by the Radiological Council.

Potential Impact Requiring Management	Measure
	• Radiation monitoring of transport trucks leaving the Mine Site and Port facility for external radiation levels using hand held gamma radiation and alpha radiation wipe tests will be conducted in accordance with the RTMP. • Products spills along the transport route or Derby Port will be cleaned up such that residual levels of radiation are returned to established background levels. Material collected from any such spills or accidental release will be returned to the Mine Site for re-processing or disposal.
Dust emissions affecting the health of workers or members of the public.	• Bulk Product will be transported in sealed containers. • Bulk product will be stored in a purpose built Product Storage Facility with enclosed drive through unloading area to minimise dust emissions and then loaded onto transhipment vessels using a closed conveyor and/or sealed bags. • Dust monitoring will be conducted in accordance with DMP CONTAM and DER requirements.
Diesel particulates and gaseous vehicle emissions affecting the health of members of the public	• Road trains used for the project will employ modern Euro V (post 2009) diesel engines which are maintained according to a regular maintenance schedule.

11.4.4 Predicted Outcome

Radiation can be effectively managed under the *Mines Safety and Inspection Act 1995* and *Radiation Safety Act 1975* jointly by DMP and Radiological Council of WA.

The predicted dose to Derby Port workers was estimated to be a maximum of 1.62 mSv/year which is well below the dose rate limit for radiation workers of 20 mSv/year. The predicted dose to transport works was conservatively estimated to be less than 0.5 mSv/year which is below the public limit of 1 mSv/year. The predicted dose to a member of the public was conservatively estimated to be 0.008 mSv/year which is well below the public limit of 1 mSv/year.

All activities for transport and handling of product at the Derby Port Facility associated with the project will be undertaken in accordance with the *Radiation Safety Act 1975* and *Radiation Safety (Transport of Radioactive Substances) Regulations 2012*. The facility will be registered under the RSA and the proponent will engage a Radiation Safety Officer on the implementation of a RMP and a RTMP, to implement periodic personal and environmental monitoring of radiation levels for formal reporting to the Radiological Council and DMP. Implementation of these arrangements will ensure that any potential radiation doses to workers, the public and the environment will be monitored, controlled and minimised to ensure that all legal requirements are met and that radiation doses are below regulatory limits.

Sheffield considers that the potential impacts of radiation, DPM, and gaseous vehicle emissions to human health will be able to be adequately managed such that the objective (Section 11.4) will be met, and that the residual impacts are therefore acceptable.

11.5 HYDROLOGICAL PROCESSES

The EPA's objective in relation to hydrological processes is "*to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*".

11.5.1 Key Statutory Requirements, Environmental Policy and Guidance

Relevant statutory requirements, environmental policies and guidance for hydrological processes at the port are similar to those of the Mine Site Development Envelope, as detailed in Section 8.3.1.

11.5.2 Assessment of Potential Impacts

King Sound is subject to extremely high tides as detailed under Section 4.3.11.2. The port area has been constructed using imported fill and has been raised above the high tide level. The proposed Product Export Facility will not change or impact current hydrological processes at the port. Key infrastructure, notably the storage shed, will be constructed above the highest recorded tide level and will not be prone to flooding.

No groundwater will be abstracted for operation of the export facility and all water needs will be met by the town water scheme using existing infrastructure. No hydrological impacts are therefore expected within the Port Development Envelope.

11.5.3 Management Measures

No management measures are required for hydrological processes at the port.

11.5.4 Predicted Outcome

As the project will not impact existing hydrological processes within the Port Development Envelope, Sheffield considers that the EPA objective for hydrological processes will be met.