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Appendix C East Arm Wharf Drainage Strategy

East Arm Wharf Drainage Strategy: Issues, Options and Guideline Recommendations.

Northern Territory Government Department of Construction and Infrastructure

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Executive Summary

The East Arm Wharf (EAW) is a major facility in the Port of Darwin, providing services for large vessels including import and export of cargo, export of bulk minerals, liquids and livestock and cruise ships.

In April 2010 the Department of Natural Resources, Environment, The Arts and Sport (NRETAS) issued a Pollution Abatement Notice to the Darwin Port Corporation (DPC) following a visible stormwater plume in the marine environment from a drain on the wharf. The Australian Institute for Marine Science conducted sampling of waters and sediment around the EAW for NRETAS at the time of the plume. These tests found elevated concentrations of some contaminants, particularly of copper in stormwater from the EAW entering the marine environment.

The DPC, in cooperation with the Department of Construction and Infrastructure, has therefore commissioned the development of a Drainage Strategy for the EAW, aiming to improve the management of stormwater and reduce the likelihood of contaminants entering stormwater and the potential risk of harm to the environment in line with the General Environmental Duty specified in Section 12(1) of the *Waste Management and Pollution Control Act 1998*.

Options considered in this Drainage Strategy address outcome based criteria, opportunities and constraints at the industrial wharf, existing data, and activities and controls in place at the EAW. This Strategy then considers further management and engineering options to address minimisation, management, monitoring and response actions in relation to improving stormwater management, and provides recommendation marine water quality monitoring with regard to ANZECC guideline values. Recommended actions are included for both short and longer term.

In conjunction with this Drainage Strategy, the DPC has commenced marine water quality monitoring around the wharf and other investigations to help inform its decisions and assess the existing environment and success of actions taken immediately following the plume. In addition, the DPC has developed an Environment Management Plan for the EAW.

Following review and confirmation of feasibility of options provided within this Drainage Strategy, further work required includes development of designs for implementation of further engineered stormwater controls at the EAW.

1. Introduction

1.1 Issue

The Darwin Port Corporation, part of the Northern Territory Government, manages land within the Port of Darwin, including the East Arm Wharf, under a Board of Directors that was established pursuant to the *Darwin Port Corporation Act 2005*. The East Arm Wharf (EAW) is a major facility for the Darwin Harbour, providing services including berthing for ships carrying bulk dry minerals as well as livestock, bulk liquids and general cargo. The East Arm Wharf Facilities Masterplan 2030 is a plan to guide future development and upgrades to existing facilities at the EAW to accommodate anticipated trade and vessel demands. The current facility has direct road and rail access to the EAW with ship loading and conveyor systems for loading the bulk dry materials onto ships.

Following a rainfall event that resulted in a visible plume in the Darwin Harbour extending from a stormwater outfall at the wharf approximately 80 m to sea, the Northern Territory Government Department of Natural Resources, Environment, The Arts and Sport (NRETAS) issued the Darwin Port Corporation (DPC) with two separate pollution abatement notices (PANs) pursuant to Section 77 of the *Waste Management and Pollution Control Act 1998* (the WMPC Act):

- PAN No 2010/2: requires DPC to take immediate steps to ensure that loading of copper concentrate does not cause harm in breach of section 83(4) or 83 (5) or in non-compliance with section 12(1)

- PAN EN2010/3: requires DPC to take all reasonable measures to ensure that runoff discharged into Darwin Harbour does not contain contaminants at levels that exceed the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (ANZECC Guidelines).

An investigation of water and sediment quality at the East Arm Wharf was undertaken in April 2010 by the Australian Institute for Marine Science (AIMS) for NRETAS, the results for which are provided in the report prepared by Dr David Parry of AIMS dated June 2010.

This Drainage Strategy includes options and recommendations for short and longer term management and engineering measures for the EAW in order to address the issues raised by these PANs and improve stormwater management at the EAW in general.

An annotated google imagery photograph of the East Arm Wharf that covers approximately 50 ha is provided in Figure 1. Pond F is currently being used as a settlement pond for diverted stormwater runoff from the minerals loading area.

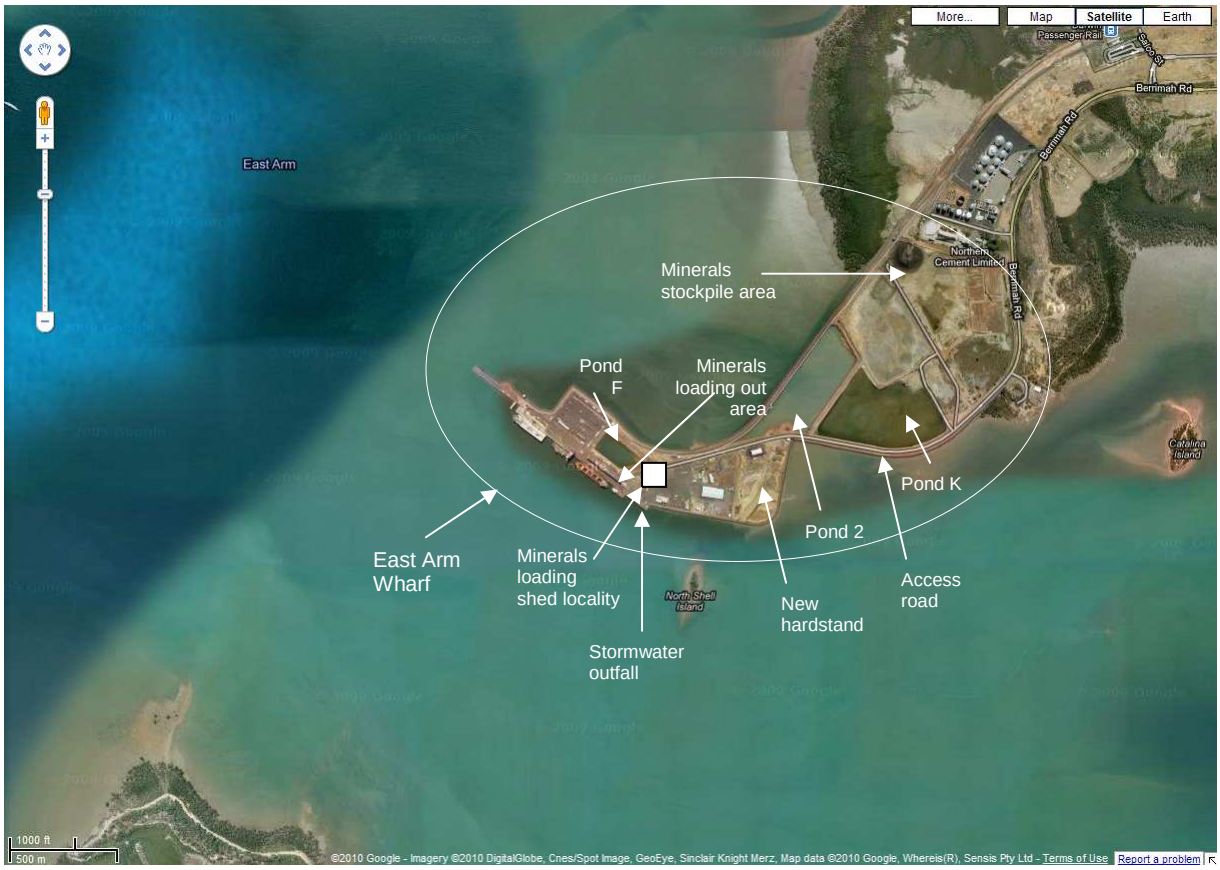

Figure 1 East Arm Wharf locality, Berrimah NT

1.2 Regulatory context

There are no provisions for licensing of stormwater discharges under the WMPC Act and NRETAS advise that they do not intend to regulate stormwater via any such authorisation, although future amendments to the *Water Act 1992* will provide mechanisms that would provide for such licensing (Mr Ewan Gunn (NRETAS), pers. comm., 13 December 2010).

Therefore it is considered that the broad duty prescribed under Section 12(1) of the WMPC Act provides the key guiding legislative requirements. Section 12(1) is the requirement to comply with the General Environmental Duty, being that a person conducting an activity or performing an action that is *likely to cause pollution resulting in environmental harm* must take all *reasonable and practicable* measures to *prevent or minimise the pollution or environmental harm*.

Pollution is defined by the WMPC Act and relates to emission of contaminants. Contaminants as defined by the Act includes Listed Waste (defined by Schedule 2 of the *Waste Management and Pollution Control (Administration) Regulations*) *1998*. Iron and Manganese are not defined as Listed Waste however copper, cobalt and zinc as identified in PAN EN2010/3 are Listed compounds.

Of these Listed compounds identified in the PANs, the most relevant activity at the EAW is related to transfer of copper concentrate to ships.

Other potential sources of particulates in stormwater from key activities at the EAW that are not Listed contaminants linked to definitions in the WMPC Act, but which however have been considered in relation to stormwater management, include loading of iron ore, manganese and livestock. There are

no specific activities conducted by DPC at the EAW that relate to handling of zinc or cobalt compounds, however these metals have also been considered pursuant to PAN EN2010/3.

NRETAS does not have any specific stormwater Code of Practice approved under Section 13 of the WMPC Act that can be used as demonstration of compliance with the General Environmental Duty, nor any legislated limits for stormwater discharges.

However, advice from NRETAS, including the requirements specified in the PANs, refers to ANZECC Guidelines as providing the relevant guidelines for contaminants in stormwater. The legislation for this non-licensable activity provides that compliance with the General Duty is related to the test of reasonable and practicable measures to reduce the potential for harm and ensuring that no harm is caused.

For context of determining reasonable and practicable measures, the Act designates that regard should be given to the:

- nature of harm
- sensitivity of the environment
- current technical information and likelihood of success
- financial implications.

The offences specified under Section 83 referred to in the PANs are 83(4) Material Environmental Harm and 83(5) Environmental Nuisance are listed in Appendix A.

Refer to Appendix A for relevant sections of the WMPC Act and definitions.

1.3 Guideline values

There are no defined criteria for water quality for the waters of Darwin Harbour, however a Water Quality Protection Plan is in the process of being developed for the region. As part of this process, evaluation of Beneficial Uses defined under the *Water Act 1992* is being undertaken for the development of Water Quality Objectives for Darwin Harbour (Aquatic Health Unit, 2010). The Water Quality Objectives are aimed at protecting human health and the health of the aquatic ecosystems and are intended to be used in regions where the water quality is relatively homogeneous and are not for heavily urbanised areas (Aquatic Health Unit, 2010). Darwin Harbour is highly valued by the community and the outcome of public consultation on beneficial uses was that the community preferred to retain existing uses and ranked the environment as the highest value (Aquatic Health Unit, 2010).

The EAW activities do not fall into the class of land uses that are designated as those which may be suitable for using default environmental values. In accordance with the ANZECC guidelines, guideline values have been suggested by the Aquatic Health Unit for Darwin Harbour for slightly to moderately disturbed environments as per the 95% species protection guideline values for marine waters, and >90% protection in relation to sediment quality, with highly disturbed systems with values suggested between 80% and 90% species protection guideline levels (Aquatic Health Unit, 2010). The Aquatic Health Unit (2010) notes, in accordance with the accepted use of ANZECC guidelines, that these values are to be used only as triggers for further investigation rather than a ‘failure’ (Aquatic Health Unit, 2010).

1.4 Approach

This EAW Drainage Strategy proposes improved management practices and engineering solutions for managing stormwater quality which aim to minimise the risk of causing pollution of water from discharge of a contaminant that results in harm or nuisance as defined by the WMPC Act. As the climate on Darwin has very high rainfall with most falling during intense rain periods between

December and March, management of stormwater is a challenging task (Environment Protection Agency 2006), such that containment of all stormwater is not feasible, additionally given space limitations presented at the EAW. Thus a risk based approach is proposed in order to reduce the potential for contaminants in stormwater to enter the marine environment and thus reduce the potential to cause harm.

The risk based approach as described by the NRETAS Aquatic Health Unit (2010) has been used as a basis for the proposed monitoring and assessment of stormwater management measures at the EAW (Figure 2). A monitoring plan will need to be devised for the EAW and an outline of the suggested approach is provided in Section 5.3.

It is proposed that the ANZECC 95 % protection guideline values for marine water quality be used to assess marine water quality trends in relation to management of stormwater runoff at the EAW.

The proposed ANZECC guideline values are applicable to the marine environment in the vicinity of the EAW, although stormwater quality should also be monitored periodically to provide further information on the success of management measures and as a reference for assessment of marine water quality monitoring results.

If statistical assessment of sampling conducted in the marine environment at the EAW shows a trend of exceedance of guideline values, further investigation will be required to determine further stormwater management measures that may be required to minimise the risk of particulates including constituents entering the marine environment through stormwater runoff.

In addition to ANZECC guideline values in relation to monitoring marine water quality in relation to stormwater runoff from the EAW, the Draft Stormwater Management Strategy for the Darwin Harbour Catchment (2006) has also been considered for the EAW Drainage Strategy. The approach of this Drainage Strategy for the EAW to address a range of improved stormwater management practices supports Objective 2 of the Draft Stormwater Management Strategy for the Darwin Harbour Catchment to *maintain or improve water quality through improved practice*' (Environment Protection Agency, 2006). The 2006 Draft Strategy for Darwin Harbour states that Objective 2 will be achieved through implementation of best practice guidelines or Codes of Practice as designated under Action 6 of the implementation plan, however none have been released to date (Environment Protection Agency, p 16, 2006). Therefore this Drainage Strategy for the EAW will address aspects influencing stormwater at the EAW as its own 'catchment' and minimises potential impacts on marine water quality, and can be generally aligned with the objectives and actions listed within the Draft Strategy for Darwin Harbour.

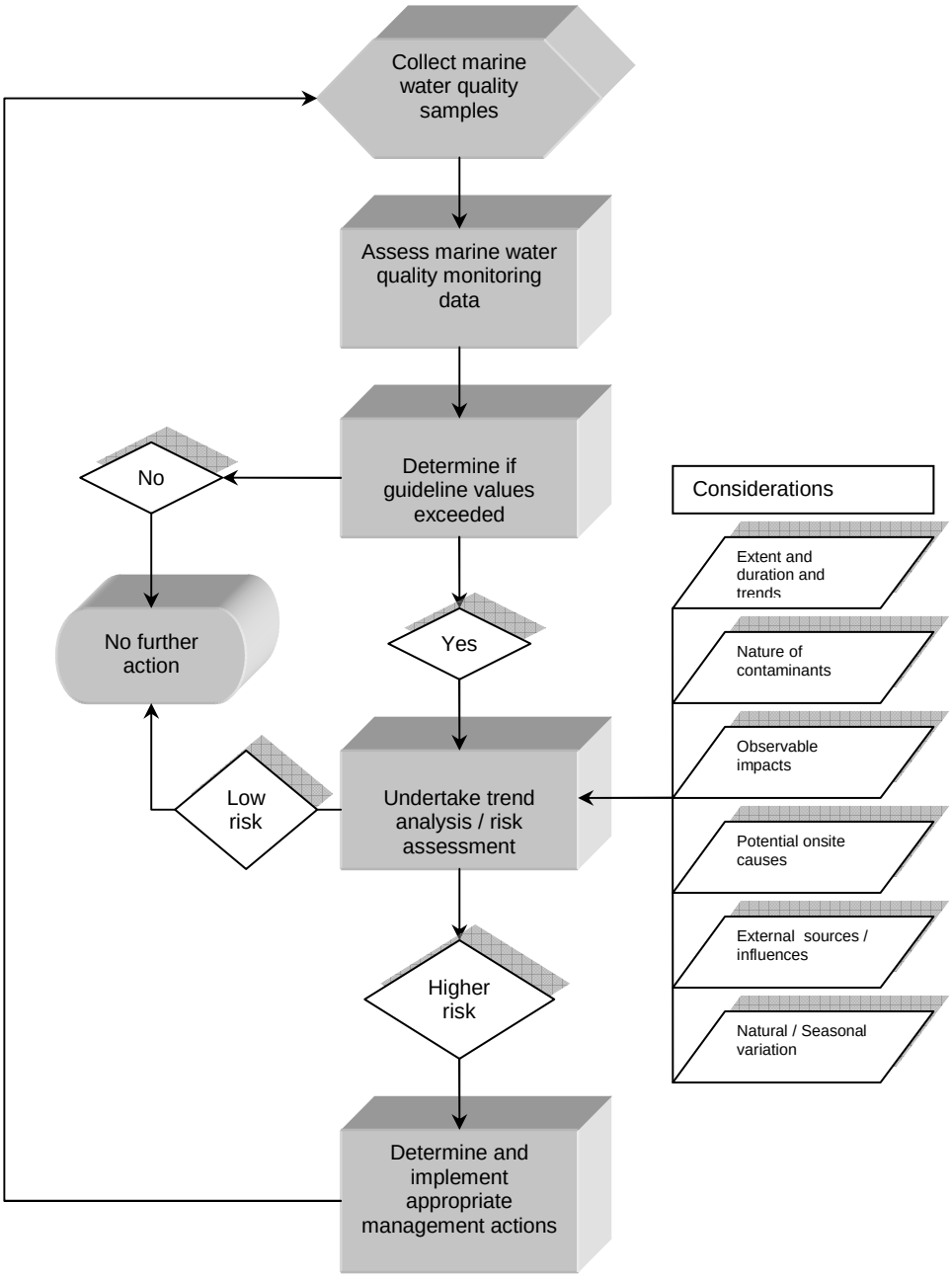

Figure 2 Risk based approach to assessing marine water quality at the East Arm Wharf

1.5 Stakeholders

The parties with specific interest in relation to stormwater management at the East Arm Wharf include:

- NT government
    - DPC
    - DCI

    - NRETAS

- East Arm Wharf Industry Activities and Users (Coffey Environments 2010)
    - Australian Customs and Border Protection Service (Customs) and Australian Quarantine and Inspection Service (AQIS) areas, waste collection and incineration and washbay
    - Berth and area cleaning
    - Bulk liquids and dangerous goods storage and loading (including petroleum, biocides at Baker Hughes transit shed and drilling muds)
    - Containers and general cargo loading operations eg for cement clilnker and cars
    - Cruise and naval vessels
    - Dry bulk imports and exports operators
    - Freight rail operator
    - Livestock export operator
    - Marine pollution (MARPOL[1]) response and oil / water storage tanks
    - Mining companies exporting ore and concentrate
    - Offshore oil and gas support vessels
    - Offshore supply and rig tender service vessel operators
    - Provedores
    - Sewage removal operations and storage tanks
    - Sewage treatment plant
    - Ship repair
    - Stevedores
- Community
- Environment

A description of activities at the EAW is provided in the EAW Environment Management Plan released in December 2010[2].

[1] MARPOL activities address requirements of the International Convention for the Prevention of Pollution from Ships (1973/78) to manage oil, noxious bulk liquids, packaged harmful substances, sewage, solid waste, and air pollution.

2. Considerations

2.1 Key criteria for acceptable outcome

The Strategy considers stormwater management options for the East Arm Wharf Drainage Strategy that aim to achieve compliance with the WMPC Act.

The proposed stormwater management options have been considered in line with regulatory and administrative approaches by the NT government in the context of:

- compliance with the General Environmental Duty which requires reasonable and practicable measures (considering sensitivity of the environment, current technical information and likelihood of success and financial implications)
- use of marine waters for an industrial wharf conducting large scale ship loading activities
- the likelihood and nature of harm that may occur at that location
- use of ANZECC marine water quality guidelines for evaluation and trend analysis of marine water quality monitoring results to determine any required further investigation, rather than automatic failure; this is in accordance with the suggested approach by the Aquatic Health Unit and application of ANZECC guidelines.

The options must be technically possible.

The options must be economically feasible.

2.2 Constraints and limitations

2.2.1 Physical and operational

The industrial activities at the EAW are expanding and contribute to the growth of the Northern Territory's prosperity. This expansion however limits the opportunities to use large valuable areas of land as stormwater detention ponds at the EAW. The operational needs of the valuable industrial activities and services provided at the EAW need to be balanced with requirements for stormwater management that will provide an acceptable level of environmental protection.

Options are further restricted by the fact that the EAW is only one to one and a half metres above sea level, with some areas subject to tidal influences. In particular this limits options for the construction of deeper ponds (to compensate for lateral space restrictions) and the shallow grading presents challenges for gravity fed detention.

When ships are in port, loading occurs on a 24 hr basis and although street sweeping measures are in place, any rain during loading may limit the success of this management option if any dust emissions occur at the time. Other measures to reduce dust and reduce the likelihood of residues washing into stormwater that are in place at the EAW but which could be improved include use of sprinklers for dust attenuation. Further options will be considered, however costs may be a limiting factor. For example, complete containment of all stockpiling and loading activities to cover the entire operation is likely to be very cost prohibitive and impractical. Actions to further reduce dust emissions and remove surface residues will however be considered.

2.2.2 Technical

Available technology to treat stormwater, such as the oil and gross pollutant traps, are effective for many contaminants however are not capable of removing the very fine clay particles and colour

associated with some of the minerals handled at the EAW (Appendix F). Filtration technologies that can remove colour will be considered however are costly and limited by treatment capacity and thus are unlikely to be able to treat the scale or rate required in the Darwin climate.

2.2.3 Environmental

There is limited long term monitoring data available to consider in relation to background water quality, particularly for metals. However available studies may be used to benchmark against the data obtained from sampling by AIMS following the observable plume discharge in April 2010, and to gauge the potential improvements that may result from options presented in this Strategy.

2.2.4 Social

Expectations by the community for protection of environmental values need to be balanced in the context of a working wharf. Recreational use is not to be encouraged in close vicinity of the EAW for safety due to large shipping movements and consideration of establishing formal exclusion zones for this purpose should be considered. Therefore criteria for aesthetics and recreational use of the waters surrounding the EAW are considered as indicative only but are considered more applicable for waters outside of the current informal 100 m exclusion zone.

2.2.5 Economic

Options for improved stormwater management need to be evaluated for protection of the environment but also must be economically achievable. Short, medium and long term budget planning therefore will be required in order to ensure requisite funding is available from Treasury to achieve the proposed improvement measures.

3. Existing Environment

3.1 Infrastructure and management

3.1.1 Environment management system and plan

DPC have developed for their business, an Environment Management System (EMS) of policies and procedures developed using ISO 14001:2004- *Environmental management systems - Requirements with guidance for use*, with an accompanying Environment Management Plan (EMP) developed specifically for the EAW developed by Coffey Environment for DPC in December 2010[2]. The EMP addresses environment and safety issues for the EAW.

3.1.2 Stormwater management

The stormwater drain to the marine environment that was investigated in April 2010 has been blocked off at the marine outlet and runoff diverted to Pond F (Figure 3). This is intended to capture low flows and thus likely to prevent the majority of sediment particulates entering the marine environment. During high storm intensity runoff events it is necessary to open the marine outlet of the drain or risk overland flow carrying the excess water.

A street sweeper operates full time whilst loading operations are undertaken, which is usually 24 hours a day for several days whilst ships are at berth. This assists in reducing the potential stormwater sediment load from dust fallout onto the paved areas. However as the loading operations occur over several days, it may not be possible to remove all dust from the surface prior to or during rainfall events. Frequent cleaning using a street sweeper is said to be a time-proven and cost effective method that, along with preventative measures can limit the levels of contamination in stormwater (US EPA 1993). Other methods such as use of vegetation as a buffer, assists in removal of particulates and nutrients but would have limited opportunity for application at the EAW.

Figure 3 Pond F at EAW looking southward

[2] Information on the DPC EMS and the EAW EMP available via DPC website: http://www.darwinport.nt.gov.au/environment-and-safety

Access roads used by trucks transporting ore do not currently have kerb and guttering (Figure 4).

Figure 4 Top: EAW access road looking westward; Bottom: Looking westward towards access road from new hardstand area

3.1.3 Dust management

Dust suppression sprays are in place at the iron ore and manganese stockpile area as well as along the conveyer/loader. However there is a limit to its use as ships cannot take minerals with large amounts of water as the minerals processing requires low moisture content.

There is a wheel wash in place at the exit form the bulk ore stockpile area prior to entry to the access road.

Copper ore is transported in closed kibbles eliminating dust issues for this product.

3.1.4 Chemical storage

Chemicals and bulk fuels are stored undercover. Bunding and spill kits are in place at the facility.

3.1.5 Exclusion zones

The 'International Ship and Port Facility Security Code' (ISPS) has been in force in Australia since 1 July 2004. This Code is implemented pursuant to the Commonwealth *Maritime Transport and Offshore Facilities Security Act 2003*. A security exclusion zone may exist at a port if it handles security regulated ships.

Safety exclusion zones are managed by the Australian Maritime Safety Authority and/or the relevant jurisdiction. DPC have an informal safety exclusion zone around the EAW for safety purposes and small recreational craft should not be used in the vicinity of large shipping. It is understood that DPC is considering formalising this safety exclusion zone (eg 100m).

3.2 Marine environment

There is no ongoing monitoring of the Darwin Harbour to provide background water quality monitoring data for metals and other contaminants other than as related to sewage discharges. The existing marine environment has however been considered with regard to existing monitoring information provided by DCI/DPC as well as other studies that provide useful information.

3.2.1 Sources of pollutants

The potential emission of pollutants from activities at the EAW should aim to be minimised as far as practicable and also be viewed in the context of Darwin Harbour as a whole. Key sources of pollutants including heavy metals, nutrients and suspended solids occur from both diffuse and point sources. Diffuse source pollution includes runoff from urbanised, industrial and at a lower level, rural and undisturbed areas as shown by sediment load visible in aerial photography (Figure 6). Point sources also contribute, including through licensed discharges (eg sewage treatment plants).

The main potential sources of pollutants in stormwater runoff at the EAW include:

- storage, transport and loading of bulk minerals (iron ore, manganese and copper)
- storage and loading of bulk liquids including petroleum
- storage of dangerous goods, chemicals and drilling mud
- refuelling activities
- livestock loading
- waste management activities

- sewage management
- sedimentation and erosion from unsealed areas.

The main concern raised by the PANs issued by NRETAS is the emission of mineral residues in stormwater runoff.

The site visit of the EAW on 13 December 2010 indicated the presence of mineral residues on the hard surface as indicated by the discolouration, particularly around the loading shed (Figure 5), the runoff from which is now diverted to Pond F with the outfall having been blocked-off.

Figure 5 EAW area west of loading shed looking southward

Existing information

It should be noted that there is a general increase in metal loads when runoff entering Darwin Harbour from undisturbed or rural areas is compared to that from urbanised areas with lead, zinc and chromium having the greatest increase in concentration for metals (*Skinner et al*., 2009). Increases in contaminant loads calculated for developed areas that did not include the EAW activities compared to undeveloped areas ranged for example (according to Skinnner *et al.,* 2009; Water Monitoring Branch, 2005), from:

- x 5 to 9 for Arsenic
- x19 to 20 for Copper
- x 70 to 90 for Lead
- x 4 for Manganese
- x 13 to x 70 for Zinc.

Sources of potential contaminants in stormwater runoff from roadways in general can include the following:

Constituent	Source examples
Cadmium	Tyre wear (and insecticides where applicable)
Chromium	Moving engine parts, brake lining wear
Copper	Brake lining wear, moving engine parts, bearing and bushing wear (fungicides and insecticides where applicable)
Particulates	Pavement wear, vehicles, atmosphere
Iron	Rust, steel structures, moving engine parts
Lead	Tyre wear, vehicle exhaust
Manganese	Moving engine parts
Nickel	Diesel and petrol, oils, brake lining wear, asphalt paving
Nitrogen, Phosphorus	Atmosphere (and fertiliser where applicable)
Petroleum	Spills, leaks, motor lubricants, antifreeze and hydraulic fluids, asphalt surface leaching
Zinc	Tyre wear, oil, grease

Table 1 Typical sources of contaminants in stormwater runoff from roads

Source: US EPA (1993a) cited in US EPA (1993b).

This indicates that in general, urbanisation around Darwin Harbour increases loads of metals in runoff discharged to the marine environment with the major contaminant of concern entering Darwin Harbour said to be phosphorus from sewage treatment plants (Water Monitoring Branch, 2005). High sediment loads also enter the marine environment increasing turbidity and potential contaminants as illustrated in Figure 6. Thus monitoring near the EAW needs to be assessed in the context of natural or 'normal' variations in pollutant loads entering the Harbour, whilst minimising the potential to cause harm by reducing as far as practicable, additional pollutants in stormwater from the EAW.

Figure 6 Visible sediment load entering the Darwin Harbour from diffuse sources near the East Arm Wharf
Source: NTG Dept Lands and Planning

3.2.2 Marine water quality

A summary of marine water and sediment quality information for Darwin Harbour is tabulated in Appendix D.

Arsenic was measured by AIMS during April 2010 in runoff in the stormwater drain at the EAW and in the marine environment. The results for samples taken from the drain itself were below the freshwater 95th percentile limit in the ANZECC Guidelines (13 µg/L) and just above the ANZECC 99th freshwater percentile guideline value (0.8 µg/L) ranging between 0.84 µg/L and 1.61 µg/L, with similarly low levels in the marine environment. These results are within the range of results reported for marine water quality in other studies (refer Appendix D). There is no marine water quality limit identified for Arsenic and the monitoring results for marine water quality were below the guideline value specified for recreational use of 50 µg/L.

Thus arsenic is not likely to be a pollutant of concern due to activities at the EAW, but is present in marine waters, likely as a result of bedrock weathering (Warren 2001 In Fortune 2006).

Cobalt was identified in PAN EN2010/3 but is not a bulk mineral handled at the EAW. One sample taken from within the stormwater drain was slightly elevated at 4.6 µg/L for which the source is unknown, as cobalt is not specifically handled at the EAW. Cobalt is a naturally occurring element in the environment and is used to produce alloys for aircraft engines, magnets, grinding and cutting tools along with uses in the medical industry and colour for glass ceramics and paints (ATSDR, [Online] updated 2010). There are no freshwater guideline values identified in ANZECC guidelines. This one elevated result from the drain itself is below the ANZECC 90% marine water quality guideline value (14 µg/L) but above the 95% marine water quality guideline value (1 µg/L).

However all sample results of the marine environment at the EAW indicate that cobalt is not likely to be a contaminant of concern, with marine water quality results ranging from below laboratory detection limits of <0.02 µg/L to 0.116 µg/L, which is below the ANZECC 95% guideline value of 1 µg/L.

Copper is one of the bulk minerals handled at the EAW and was identified in PAN EN2010/3. It can be present in stormwater also from wear of brake linings, bushings and bearings and in general from moving engine parts (US EPA 1993). Copper is also an essential trace element required by most aquatic organisms and is readily taken up, but can be toxic if the rate of uptake exceeds the ability for the organism to regulate it (ANZECC 2000). Copper measured in the stormwater drain itself was elevated (0.34 µg/L to 1470 µg/L), indicating that there is a potential for this contaminant to enter the marine environment from activities at the wharf. This was evident in results from four samples for marine water quality that were taken during the copper loadout in April 2010 (13.5, 45.1, 1.79 and 4.45 µg/L). Two results exceed the ANZECC 95% marine water quality guideline value for copper of 1.3 µg/L and two exceed the 80% guideline value of 8 µg/L.

However exceedences were short lived as by four days after the loadout, all samples indicated that concentrations of copper were less than the 95% marine water quality guideline value (which is based on toxicity to the mollusc *Mytilus edulis*) and within the range of previously reported results for copper in Darwin Harbour.

Iron is a bulk mineral handled at the EAW but was not specified in PAN EN2010/3 issued by NRETAS and is not a listed waste. Iron concentrations were measured by AIMS during April 2010 in runoff in the stormwater drain at the EAW and in the marine environment. Results from samples taken from the drain itself ranged from 35.8 µg/L to 519 µg/L. Samples taken from the marine environment monitoring ranged from <2 µg/L up to 260 µg/L, the latter being post loadout. Pre loadout and during loadout levels (<2 to 98.3 µg/L) were within ranges reported in previous studies (28-148 µg/L).

There is no guideline value for iron identified in ANZECC for freshwater or marine waters. The elevated reading post loadout is below the ‘interim indicative’ or ‘low reliability’ value from Canada of 300 µg/L used as the Recreational use guideline value.

Thus although iron appears to be present in runoff from the EAW, this did not result in any detection above guideline levels in the marine environment. The turbidity created by the clay and possibly iron however should be considered and measures put in place to reduce the potential for sediment runoff. The turbidity and visible colouration are also aesthetic issues, however the area is used for industrial purposes and recreational uses should not be encouraged for safety reasons.

Manganese is one of the bulk minerals handled at the EAW but is not identified by PAN EN2010/3 and is not a listed waste. It can also be present in stormwater runoff from roadways due to moving engine parts (US EPA 1993). Manganese is a common element in the earth’s crust that has low toxicity and is essential trace element for life that can be bioconcentrated up to four orders of magnitude (ANZECC 2000). The ANZECC guidelines do not specify a value for manganese and only have a low reliability value provided in the background information of 80 µg/L, which is specified as interim and indicative only. All results for Manganese in marine waters measured during the loadout sampling conducted in April 2010 are well below this value. Two of 12 results taken from samples sourced from the stormwater drain itself exceeded this interim value (at 163 and 981 µg/L) but were well below the 99% freshwater guideline value of 1200 µg/L.

Thus, manganese residue is evident in runoff from activities at the EAW indicating further measures may be required to reduce the potential for harm, however manganese was not present at levels likely to cause harm to the marine environment in samples taken in April 2010 and were within previously reported ranges for manganese in marine waters of Darwin Harbour.

Zinc was identified by NRETAS in PAN EN2010/3 but is not a bulk mineral handled at the EAW. Zinc is a common element in urban runoff and can also result from natural weathering processes. Sources can include tyre wear, oil and grease (USEPA 1993). It is an essential trace element for life and occurs naturally in most waters (ANZECC 2000). The uptake and toxicity of zinc decreases with increased salinity, with acute toxicity of zinc to animals in saline conditions ranging between 190 µg/L and 320 000 µg/L (ANZECC 2000). Plants are reported to be affected between 19 µg/L and 10,100 µg/L (USEPA sourced quoted in ANZECC 2000).

The ANZECC 95 % marine water quality guideline value is set at 15 µg/L. Two of 12 samples taken from the stormwater drain itself exceeded this value (at 62.1 µg/L and 35.0 µg/L), but all marine water quality samples were below this limit and within previously reported ranges for marine water quality in Darwin Harbour, with most being non-detectable. Thus zinc is not likely to be a specific contaminant of concern in relation to activities at the EAW.

Copper is the main chemical that was elevated above suggested guideline values in sample DCU04 in two of three water column samples (top and middle), and sample DCU03 in one of three water column samples (bottom). However, the results of water quality monitoring after 4 days indicated levels returning to below guideline values and remaining so at the sampling conducted in May 2010.

Background information provided in Volume 2 section 8 of the ANZECC guidelines reported that acute toxicity of copper to saltwater animals (ie that which would be relevant to short term elevated metals) ranged from 5.8 µg/L for blue mullet to 600 µg/L for green crab (USEPA 1986 in ANZECC 2000). Two of 18 unfiltered samples during the loadout (25 April 2010) exceeded 5.8 µg/L by two to ten times (13.5 µg/L and 45.1 µg/L), however the extent and duration of the plume was limited as evidenced by samples taken four days later.

Aesthetics and recreational guideline values were not triggered although aesthetically (colour) was likely to exceed ANZECC guidelines (although this was not measured). It should be noted that visible turbidity changes are also identifiable in large sediment loads that commonly enter the Darwin Harbour both from disturbed and undisturbed areas as shown in Figure 6.

Regardless of these points, further reasonable and practicable measures to minimise the potential risk of any such future discharge to cause harm are recommended as part of meeting the General Environmental Duty specified in Section 12 of the WMPC Act.

Other chemical substances that may be of concern at the EAW in relation to marine water quality include:

- Tributyl tin, copper and Irgarol[3] from antifoulant paints
- Hydrocarbons from fuel
- Nutrients in sewage and waste from livestock
- General solid and quarantine waste from ships and wharf activities.

3.2.3 Sediment quality

A report by Fortune (2006) indicates that Arsenic in sediments in Darwin Harbour does not vary significantly between sites and that it is naturally elevated, with all three reference sites having levels

[3] 2-(tert-Butylamino)-4-(cyclopropylamino)-6-(methylthio)-s-triazine (http://www.chemblink.com/products/28159-98-0.htm)

above the ANZECC Interim Sediment Quality Guideline (ISQG)-Low guideline value of 20 mg/kg. This is likely to be a result of natural weathering of bedrock (URS 2004; Warren 2001 In Fortune 2006) and urban runoff (Fortune 2006). Fortune (2006) reports levels of arsenic in excess of 100mg/kg in reference areas (not including the East Arm Wharf) with no known anthropogenic sources. A 95th percentile limit for arsenic in sediments quoted from Warren 2001 in Fortune 2006 is 104 mg/kg for ports and marinas in Darwin Harbour.

The investigation by AIMS in April 2010 showed arsenic in sediment below the 104 mg/kg and below the ISQG-High limit in the ANZECC Guidelines (70 mg/kg), with some exceedences of the ISQG-Low (20 mg/kg). Based on these previous studies, this is not above naturally occurring levels in the harbour.

Of remaining heavy metals assessed, copper showed an exceedanceof the ANZECC Guidelines. Surface sediments sampled during April 2010 by AIMS showed ten samples exceeding the ISQG-Low value of 65 mg/kg. One of these (399 mg/kg) also exceeded the ISQG-High value of 270 mg/kg for copper. All other results were below the ISQG-Low value. All samples showed potentially bioavailable copper being below the ISQG-Low copper except one (95.5 mg/kg) which is below the ISQG-High ANZECC value of 270 mg/kg.

All other metals assessed were below relevant ANZECC Guideline levels.

This indicates that copper is the main concern in relation to sediment quality related to activities at the wharf. Additional measures are recommended to minimise the potential for sediment runoff containing copper entering the marine environment.

3.2.4 Flora and fauna:

The East Arm Wharf extends beyond the mangrove lined coastal areas of Darwin Harbour (refer Figure 7). These areas are most likely to be valuable habitat for marine species including fish, water birds and invertebrates. As the East Arm Wharf is built as an extension from natural land has a level of separation from likely breeding, nursery and feeding areas for threatened animals, such as the mangrove wetland areas. Further information is provided in the EAW EMP.

The Olive Ridley Turtle although known to breed in the area according to the EPBC search, would be unlikely to come to shore in the immediate vicinity of the Wharf as sea turtles breed on sandy beaches.

Aside from vessel movements and habitat destruction or disturbance, bioaccumulation of metals is considered likely to be the main risk to these Threatened species as it relates to stormwater discharges to the marine environment, as they may ingest either sediment (seagrass feeders such as turtles and dugongs) or consume other fish (such as sawfish). The sediment and water quality in the immediate vicinity of the wharf would be the key factor therefore in assessing risk to flora and fauna.

A search using the Environment Protection Biodiversity Conservation Protected Matters Search Tool (Online) found the following Threatened species (aquatic) or habitat for the species as potentially occurring in the East Arm Wharf marine environment or having habitat suitable (refer to Appendix E for full report):

Reptiles:

- Loggerhead Turtle (*Caretta caretta*) - Endangered
- Green Turtle (*Chelonia mydas*) - Vulnerable
- Leatherback Turtle, Leathery Turtle (*Dermochelys coriacea*) - Endangered
- Hawksbill Turtle (*Eretmochelys imbricata*) - Vulnerable

- Olive Ridley Turtle, Pacific Ridley Turtle (*Lepidochelys olivacea*) - Endangered. Breeding known to occur within area.
- Flatback Turtle (*Natator depressus*) – Vulnerable. Breeding known to occur within area

Rays and Sharks:

- Dwarf Sawfish Queensland Sawfish (*Pristis clavata*) - Vulnerable
- Freshwater Sawfish (*Pristis microdon*) - Vulnerable
- Green Sawfish, Dindagubba, Narrowsnout Sawfish (*Pristis zijsron*) - Vulnerable
- Whale Shark (*Rhincodon typus*) - Vulnerable

Mammals:

- Humpback Whale (*Megaptera novaeangliae*) - Vulnerable

Marine and migratory species listed as potentially occurring but which do not have a threatened species status are listed in Appendix E. The EAW EMP states that 415 species of fish, sharks and rays from 95 families, and an estimated 3,000+ marine invertebrate species are found within the Darwin Harbour. The Australian snubfin dolphin (formerly the Irrawaddy dolphin) (*Orcaella heinsohni*), Indo-Pacific humpback dolphin (*Sousa chinensis*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) as well as the dugong (*Dugong dugon*) and saltwater crocodile (*Crocodylus porosus*), are also said to be common within the Darwin Harbour region (Coffey Environments 2010). These larger animals are likely to be affected more directly by vessel movements in the Darwin Harbour and at the wharf, as well as pollutants and habitat destruction.

Copper appears to be the main heavy metal of concern, however acute toxicity to animals (ie that might occur with short term exposure to copper concentrations) as reported in Volume 2 of the ANZECC Guidelines, was between 5.8 µg/L to 600 µg/L based on USEPA data.

Marine crustaceans, corals and sea anemones are said to have acute toxic effects at 10 µg/L. Crabs and amphipods are reported in ANZECC to have acute effects at concentrations in sea water of 100 µg/L to 1000 µg/L and chronic effects at 10 µg/L to 300 µg/L. The most sensitive species identified as having acute toxic effects are the doughboy scallop and the Pacific Oyster, at 3 µg/L as well as algae at 5 µg/L to 100 µg/L. Gastropods and fish area reported in ANZECC to be relatively tolerant of copper with acute toxicity at 800 µg/L to 6000 µg/L[4].

One marine water quality bottom sample (13.5 µg/L) and two top samples (45.1 µg/L; 4.45 µg/L) that were analysed during the copper loadout in April 2010 had results above these lowest acute toxic values reported in ANZECC. One of the remaining 33 samples exceeded the 95% marine water quality guideline value for copper of 1.3 µg/L (1.79 µg/L).

All samples had results that were less than 1.3 µg/L (which is based on toxicity to the mollusc *Mytilus edulis*), four days after the loadout.

Ten sediment samples exceeded the ISQG-Low value and one exceeded the ISQG-High value.

It is unlikely that acute harm resulted from the discharge in April, however, further measures are recommended to reduce the potential future risk of harm occurring and to reduce the risk of accumulation in sediments.

[4] ANZECC refers to various specific scientific studies as for this source data

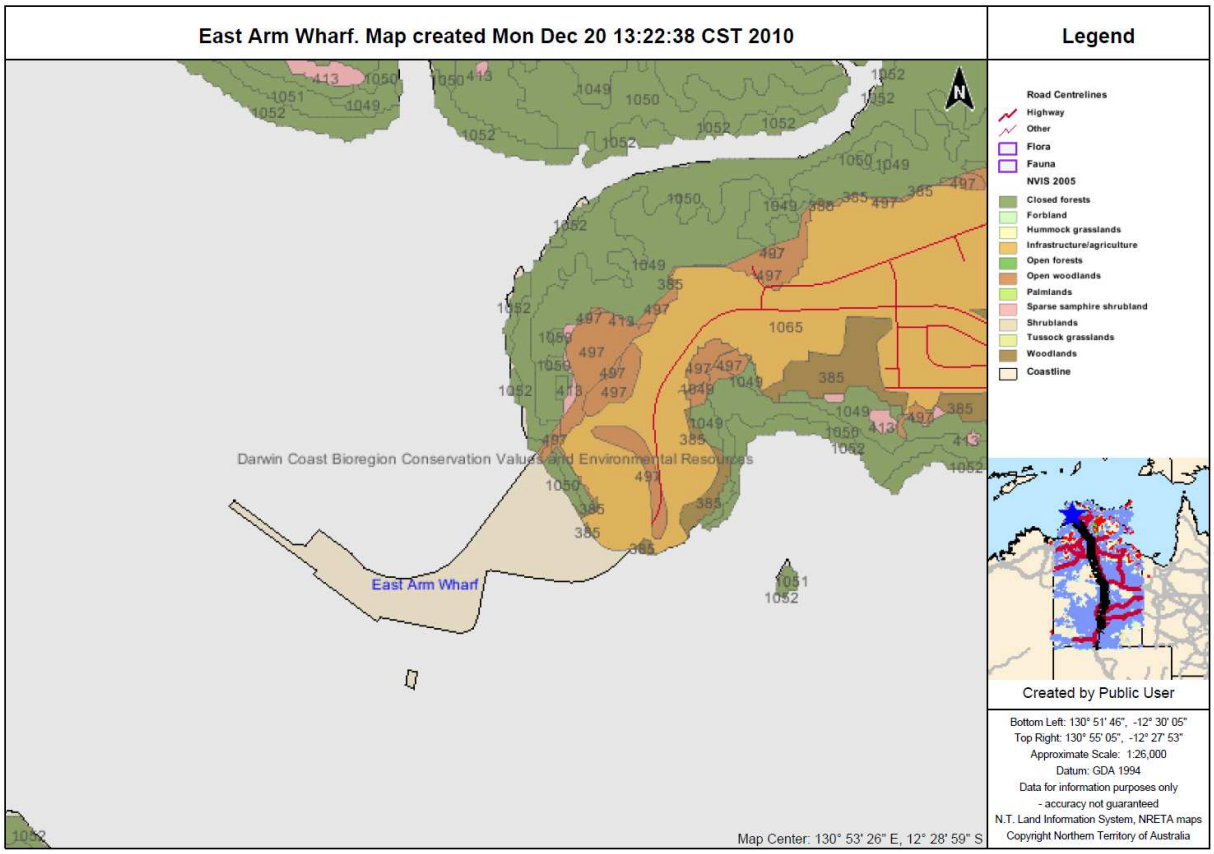

Figure 7 Vegetation near the East Arm Wharf
(source: NRETA maps)

4. Management Strategy – Options and Risk Assessment

A number of options presented below have been considered for the development of the drainage strategy.

The broad options have then been further developed into a desktop risk assessment (Section 4.2 and Appendix B), specifically to address risk to the marine environment from activities conducted at the EAW. Other site risks such as and relevant management procedures are addressed by the EMS and EMP. Risk is determined by identifying potential hazards or aspects and the potential impacts they may have on the environment. The related likelihood of an impact occurring and the consequence of that impact then form the risk level. Actions to reduce the risk are then suggested for further consideration. Appropriate actions should be implemented on a priority basis with targets or goals, responsibilities and timeframes identified to achieve those improvements as part of meeting the General Environmental Duty.

The recommended guidelines for the Drainage Strategy and suggested short, medium and long term actions for consideration and implementation are included in Section 5.

4.1 Options assessment

Table 2 Management Strategy Options Assessment

	Option	Advantages	Disadvantages	Recommendation
1.	**Do Nothing / Business as usual**	No additional costs Continued wharf operations	Likely to risk potential harm to the environment Likely to be unacceptable to regulator Likely to be unacceptable to the community Likely to attract further negative media	Disregard this option
2.	**Cease dry bulk storage and loading operations**	No further risk of harm from bulk minerals and other wharf shipping activities	Large economic impact to NT and industry Loss of major industry sector Large loss of jobs Major community objection Likely to attract further negative media	Disregard this option

	Option	Advantages	Disadvantages	Recommendation
3.	**Discharge under licence – mixing zone**	Assurance of compliance criteria Controlled discharge Continued wharf operations Possible to be more accepted by community	Likely to be unacceptable to regulator: advice that potential to licence in future but will not be likely regulatory method as advised by NRETAS Additional costs Prescriptive resolution Possible to attract negative community interest Possible to attract negative media interest	Disregard this option for the short to medium term – review if legislation and regulatory approach shifts
4.	**Engineering Solution: eg Diversion, Treatment and containment of first flush storm events** **SPEL Stormceptor or similar**	Reduces level of consequence if impact occurs Controlled stormwater management Diversion will treat first flush flows[5] Reduced risk of causing environmental harm Likely to be supported by regulator Likely to be supported by community Likely to receive positive media	Additional costs Some measures may take significant time Reactive or control rather than preventative mechanism	Prioritise for short, medium and long term, Implement appropriate budgetary planning Implement economically feasible options

[5] It is not reasonable or practicable to contain all stormwater at the site due to the naturally very high and intense rainfall periods experienced in the Darwin climate and limitations such as space and fall at the EAW

	Option	Advantages	Disadvantages	Recommendation
5.	**Preventative Solution – eg Cover stockpiles, use of dust suppressant on roads, stockpiles and conveyor, cover conveyor, street sweeping**	Reduces likelihood of hazard occurring Reduced risk of causing environmental harm Likely to be supported by regulator Likely to be supported by community Likely to receive positive media	Additional costs Additional procedures and resourcing Does not reduce consequence if impact occurs	Prioritise for short, medium and long term, Implement appropriate budgetary planning, procedures and training Implement economically feasible options Review and continually improve procedures
6.	**Monitoring Solution – Implement stormwater and marine water quality monitoring programme with results to be made publically available**	Direct access to data Improved understanding and knowledge of potential environmental harm Improved knowledge of success of risk management measures Likely to be supported by regulator Likely to be supported by community Likely to receive positive media	Additional costs Additional procedures and resourcing	Prioritise for implementation in short to medium term, Implement appropriate budgetary planning Review and continually improve programme

Recommendation: Implement combination of Options 4, 5 and 6 to ensure that engineering controls, preventative management measures and monitoring form a comprehensive Stormwater Drainage Strategy for the EAW to meet the General Environmental Duty to prevent or minimise as far as reasonable and practicable, the potential for causing harm to the environment.

4.2 Aspects, impacts and risks assessment

A desktop risk assessment has been conducted following meetings with DPC, DCI and NRETAS and a site inspection of the EAW. The details are provided in Appendix B in the form of an 'aspects and impacts' risk register and assessment. The risks assessed are those specifically related to marine water quality due to activities at the wharf. Other aspects are addressed by the site EMP.

Key risk areas identified include the storage, transport and loading of mineral ores (Figure 8), along with storage of chemicals and fuel and refuelling activities. In line with advice from NRETAS, risk of impacts to the marine environment due to stock loading activities at the wharf have also been considered.

Current risk controls are those as advised by DPC/DCI, with suggested risk management measures provided for consideration to reduce the risk (either by reducing the likelihood or consequence, or both). These risk management measures will need to be costed and a determination of what measures are desirable to ensure that all reasonable and practicable measures are implemented to reduce the risk of causing harm to the environment. The recommended actions should be considered for roll out to all future development at the EAW including the Marine Supply Base and Defence Hardstand and Boat Ramp.

These actions are presented in the following section that provides EAW Drainage Strategy Guidelines developed from the Issues and Options assessment and includes suggested priority and timeframes for implementation.

Potential sources of pollutants that may pose a risk to marine water quality include:

- storage, transport and loading of bulk minerals (iron ore, manganese and copper)
- storage and loading of bulk liquids including petroleum
- storage of dangerous goods, chemicals and drilling mud
- refuelling activities
- livestock loading
- quarantine and waste management activities
- sewage management
- sedimentation and erosion from unsealed areas.

Figure 8 Bulk Minerals Loading Conveyor at the EAW

5. Guidelines for EAW

5.1 Guideline values

The most relevant values within the ANZECC guidelines are recommended to be used to evaluate marine water quality trends and determine appropriate responses (refer to Appendix C).

The considerations in assessment of marine water quality against guideline values include:

- That the East Arm is a working industrial wharf extending past the near shore estuarine/mangrove environment
- That no recreational activities should occur within 100 m of the wharf for safety reasons
- The potential mineral constituents from the activities at the wharf in addition to those specified by NRETAS

It is considered that the shipping activity itself is likely to be causing disturbance to species and habitat at the near shore such that sensitive species are unlikely to be utilising this area for breeding and feeding. This could justify alternative acceptable guideline values for water and sediment quality, however the aim is to use the 95% marine water quality values as a benchmark for analysis.

The recommended guideline values include water quality and sediment quality guidelines for response. Water quality guideline levels are based on the lower of available values for:

- Marine water quality (as ecological protection) - using 95% protection guideline values for near shore (within 100 m) and to assess background levels further offshore (>100 m).
- Fish taint (in the case of taking of fish for consumption), noting that there is a 100 m recommended safety zone that discourages recreational fishing as a use close to the wharf for safety reasons.
- Recreational contact (in the case of secondary contact) again noting that the safety exclusion zone that would prohibit recreational access as a use close to the wharf.

Thus any exceedance of guideline values at <100 m from the wharf should be assessed against background measures at >100m (accounting for any external influences such as climatic events) and to determine any trends as part of the risk assessment.

Sediment Quality guideline levels have been based on:

- ISQG – High (for 0 to <100 m from the wharf)
- ISQG – Low (for >100 m from the wharf)

There are no aquaculture operations within close proximity of East Arm Wharf itself and thus these guideline values have not been considered.

The results of monitoring need to be assessed in relation to results from the background marine water quality and stormwater quality at East Arm Wharf, as well as in the context of potential external influences and any available background readings for the Harbour.

If guideline values are exceeded, a trend analysis and risk assessment should be undertaken to assess the environmental quality at East Arm Wharf. The risk assessment needs to take into account issues such as the frequency, duration, nature and extent of any observable plume, the concentrations of any elevated monitoring results from waters sampled and the bioavailability of metals.

ANZECC guidelines (2000) suggest the following in relation to protection of the aesthetic value for water quality:

- The natural visual clarity should not be reduced by more than 20%.
- The natural hue of the water should not be changed by more than 10 points on the Munsell Scale.
- The natural reflectance of the water should not be changed by more than 50%.

5.2 Recommended Actions

The options and risk assessment as detailed in Section 4 and Appendix B has been used to develop recommended actions as guidance for Darwin Port Corporation's East Arm Wharf Drainage Strategy. These include both engineering and management measures to reduce the potential for stormwater runoff to contain contaminants and reduce the likelihood of causing harm to the marine environment. This approach is aligned with the 'Guiding Principles' stated within the Draft Stormwater Management Strategy for the Darwin Harbour Catchment to implement both structural and non-structural controls (Environment Protection Agency, 2006).

Table 3 Recommended Short Term Actions to Address Potential Marine Water Quality Pollution[6]

Objective	Risk Assessment Reference	Management Actions	Timeframe	Comments
Prevent / Minimise				
1.	a)	Covering of trucks	As quickly as practically possible	Will need to consider impacts on dumping
2.	b)	Covering train wagons	As quickly as practically possible	Will need to consider impacts on dumping
3.	d), m), p), u), cc)	High pressure cleaning of wharf area, area immediately surrounding loading shed, wheel wash and conveyor to remove sediments from hard surfaces on a regular frequency or as required	Within 2 months	
4.	r), w), ff)	Increase use of suppression sprays in adverse wind conditions	Immediately	
5.	bb)	Ensure appropriate use and maintenance of wheel wash	Immediately	
6.	ee)	Control maximum height of stockpiles to below 5 m to help reduce wind exposure	Within 3 months	

[6] Note: some procedures are included and further detailed in the existing EMP for the EAW

Objective	Risk Assessment Reference	Management Actions	Timeframe	Comments
7.	vv)	Implement stormwater diversion from exposed hardstand areas to reduce sediment	Before next wet season	Temporary works already in place
8.		Ensure oil spill response equipment, planning and procedures are implemented and maintained appropriately.	Within 2 months	
9.	kk)	Require EAW users to ensure all hazardous chemical and liquids are stored in bunded areas undercover	Within 6 months	
Respond				
10.	i), z)	Ensure all EAW users have spill kits and spill response procedures and training including for dangerous goods (If not already in place)	Within 2 months	
11.	pp)	Additional cleaning procedures to remove waste from stock loading and truck parking areas	As quickly as practically possible	
Monitor				
12.	ss)	Develop, implement and review/improve marine, sediment and stormwater quality monitoring programme	Within 6 months	

		Engineering Actions		Comments
Control				
13.	e), n). q), dd)	Block stormwater drain for low flows and Redirect and pump low flow runoff to settlement Pond F	Immediately	Completed
14.	aa)	Increase capacity of wheel wash	Within 3 months	
Treat				
15.	nn), rr)	Install triple interceptor trap/s at non-critical outlets	As quickly as practically possible	

Table 4 Recommended Medium Term Actions to Address Potential Marine Water Quality Pollution

	Risk Assessment Reference	Management Actions	Timeframe	Comments
Prevent / Minimise				
1.	f)	Alter transport route to more central locality along wharf	Within 12 months	
Respond				
2.	zz)	Include all clean up, monitoring and response procedures in EMP	Within 12 months	
Monitor				
3.	ss)	Continue to implement and review/improve marine, sediment and stormwater quality monitoring programme	Ongoing for 12 months	

		Engineering Actions		Comment
Control				
4.	k), x)	Curtaining of shed & loading area	Within 12 months	
5.	s)	Curtaining of conveyor (if possible / practical)	Within 12 months	
6.	o)	Seal, kerb and gutter all surfaces on wharf including roads, loading and new hardstand areas	Within 18 months	
7.	jj)	Seal existing ponds	Within 18 months	
Treat				
8.	hh)	Divert all runoff to settlement ponds	Within 18 months	

Table 5 Recommended Long Term Actions to Address Potential Marine Water Quality Pollution

	Risk Assessment Reference	Management Actions	Timeframe	Comments
Prevent / Minimise				
9.	c)	Cease use of trucks in longer term	Within 5 years	
Respond				
10.	zz)	Review risks and response procedures and update EMP accordingly	Within 24 months	
Monitor				
11.	ss)	Review monitoring programme	After 12 months	

		Engineering Actions		Comments
Control				
	t)	Complete containment of conveyor	Within 5 years	
12.	g), q), n) v)	Seal Kerb and Gutter all surfaces and direct runoff to permanent settlement ponds	Within 3 years	
13.	yy)	Rehabilitate / vegetate land not to be sealed, to reduce sedimentation runoff	Within 3 years	
14.	h), ii), qq)	Construct permanent settlements ponds to contain first flush storm events for stockpile, transport and wharf areas	Within 3 years	
15.	l)	Complete enclosure of loading facility with negative pressurisation and air extraction through filter system in longer term (OHS considerations also required)	Within 3 years	
Treat				
16.	pp), xx)	Install oil and sediment traps at non critical outlets	Within 3 years	

5.3 Monitoring and response advice

Measures to minimise the potential for contaminants in stormwater runoff and thus accumulation in sediments, should be considered to reduce and mitigate the potential for harm to the marine environment. In order to determine the effectiveness of the engineering and management measures proposed, it is recommended that a marine and stormwater quality monitoring programme be developed and implemented.

It is unusual for metals to remain elevated in seawater in an open system such as Darwin Harbour as they quickly bind to sediments and must be chemically available (bioavailable) to present a toxicity hazard (Argue, J (Ed.) 2004); thus periodic sediment quality monitoring could also be undertaken as previous testing has indicated that copper levels may be elevated in sediments close to the wharf, although most results are below ANZECC guideline values. In addition, sediment monitoring is valuable to include as part of the overall understanding of potential impacts of activities at the EAW. Changes to the chemistry of sediments could change the availability by mobilising contaminants that were previously bound to sediments this becoming potentially toxic once more (Argue, J (Ed.) 2004), natural thus influences such as climatic events may re-suspend particles and need to be taken into account when assessing both sediment and marine water quality.

Sampling Parameters:

Marine water quality should include the standard suite of water quality parameters including heavy metals, hydrocarbons and nutrients (refer to Appendix C) using a suitable standard methodology based on the ANZECC guidelines.

Water quality indicators such as turbidity and total suspended solids (TSS) may be included however care should be taken when assessing these as these can be typically very high in the Darwin Harbour particularly in the wet season as shown in Figure 6 (refer to Appendix C). It is noted that the Water Quality Objective (WQO) suggested in the Darwin-Palmerston Report Cards (Drewry *et al*. 2010) for TSS is <10 mg/L; however there is no WQO for turbidity.

Any monitoring of sediments can be undertaken using grab samples tested and assessed in accordance with the *National Assessment Guidelines for Dredging 2009*.

Frequency:

This monitoring should occur over a range of climatic conditions for example, on a minimum monthly basis or preferably fortnightly if resources permit. This should continue for one year with additional event based monitoring where there is either:

- A greater than 1 in 0.3 year storm event (up to a maximum of 3 times per year)
- An observable plume (as relevant)
- An incident risking emission of contaminants to the environment (eg loader breakdown causing spillage)

Duration:

The monitoring programme should be undertaken initially for one year (including wet and dry seasons) with the results compared to previous sampling. A discussion and review of the future monitoring requirements should then be undertaken to determine whether there are actual or potential risks occurring and also to assess whether there are any amendments to the monitoring programme are required.

Location and sample design:

Monitoring is suggested to be undertaken at a minimum of two locations adjacent to stormwater outfalls at two distances from the EAW (one at less than 100m and the other at 100 to 500m from the

East Arm Wharf. The standard suite of water quality parameters should be measured including heavy metals. The two locations should be sampled, taking three replicate samples at three different depths within the water column (near top, middle and near bottom). This will provide a total of 36 samples. The sample locations should be recorded on a GPS system so that the same locations can be re-sampled during future monitoring rounds.

A schematic is provided in Figure 9 to illustrate the suggested sample design (not to scale).

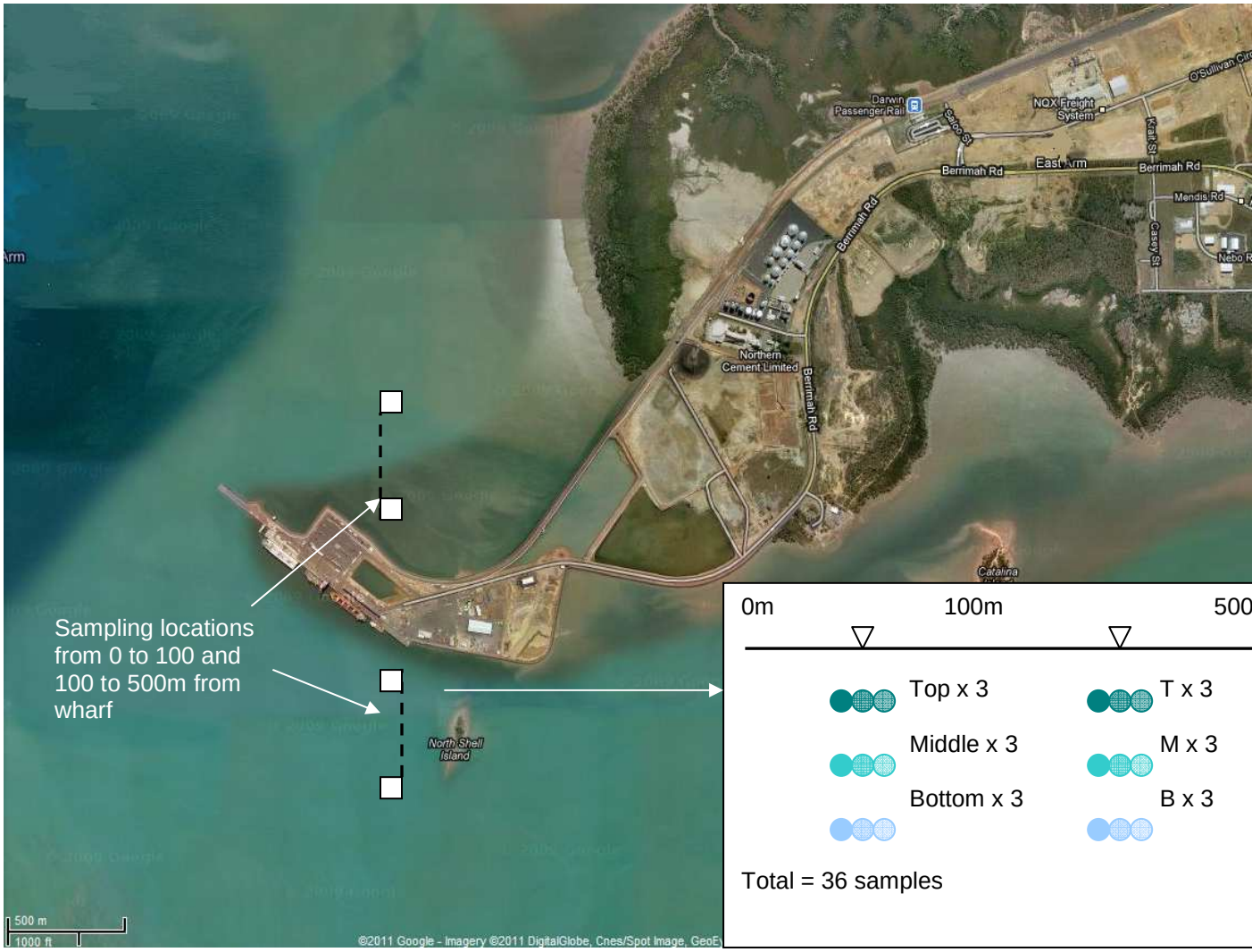

Figure 9 Schematic of suggested marine water quality sampling design at East Arm Wharf
(Source: Google Maps; accessed 13 January 2011).

In addition, it is suggested that samples be taken directly from any stormwater runoff outfalls for comparison/correlation with any elevated chemical substances detected in the marine environment.

Assessment and response:

Where concentrations of chemical substances are elevated and/or above the recommended ANZECC guideline values in the near shore environment, actions should be put into place such as:

- Assess against the background data (samples taken at 100 m to 500 m and any other available background data including relevant external influences such as weather events)

- Assess against previous data to determine any trends
- Review of management procedures to ensure current stormwater management procedures are followed
- Ensure all engineering controls are functioning appropriately
- Determine whether further investigation/sampling should be undertaken to confirm exceedance and/or ascertain background levels and potential sources from stormwater drains/outlets
- Determine if any actions are required to mitigate any potential impact
- Desk top risk assessment based on the steps above
- Contact NRETAS if any incident occurred that resulted in spills to the marine environment or visible plumes from stormwater outfalls
- Determine any required amendments to procedures to minimise the risk of recurrence if an unacceptable stormwater discharge resulted occurred.

Figure 2 provides an overview of this risk based approach to sampling and assessment.

Reporting:

Results of monitoring should be interpreted in a report that assesses trends, assesses onsite and offsite influences, assesses the level of success of management measures and proposes any relevant improvements to management of activities and stormwater at the EAW as well as to the monitoring programme.

6. Recommended Strategy

A number of actions can be implemented over both the short and longer term at the EAW to reduce and minimise the potential risk of contaminants in stormwater causing harm to the marine environment. These include reasonable and practicable management and engineering actions to meet the General Environmental Duty, which also align with the Objectives and Guiding Principles of the Draft Stormwater Strategy for Darwin Harbour (Environment Protection Agency 2006).

Costing of all options will be required in order to identify the feasibility and budget planning over time. Some actions proposed may not be feasible depending on funding availability. For example, complete enclosure of the conveyor system and complete kerb and guttering of all hard surfaces will be a costly exercise.

Priority for sealing surfaces and diversion of stormwater to ponds to contain the first flush flows should be given to areas of higher risk such as the loading facility and bulk minerals storage areas. Complete enclosure of the conveyor may be unfeasible, thus consideration to prioritise other actions to minimise the risk of fallout from this area including curtaining of the shed, increased use of dust suppression and high pressure cleaning of surfaces around the shed and conveyor to remove excess residues should be implemented. A review of the level of success of these actions can then inform future assessment of the need for further measures.

7. Next Steps

In accordance with the actions outlined in this strategy, the next steps will include:

- Developing concept engineering designs for:
    - Sealing, kerbing and guttering surfaces at the EAW including access roads, wharf area and minerals storage area.
    - Containment ponds.
    - Additional treatment (ie. additional to settlement ponds) including triple interceptor traps at key locations .
- Reviewing and updating the current monitoring at East Arm Wharf as required.
- Continuing the monitoring programme for a minimum of 12 months.
- Updating the EMP as required.
- Reviewing success of management actions in relation to visual inspections and results of marine water quality and sediment quality monitoring as relevant.

Limitations

This desk top assessment has been based on available information from others and the accuracy of those documents and data cannot be verified by the author.

Regulatory and compliance conclusions reached are opinions of the author based on knowledge, discussions and research of relevant legislation however can not be specifically relied upon as the opinion of the regulator. Any such confirmation would need to be provided in writing by the regulator. It is understood however that no specific approval of any actions, strategy or monitoring programme will be provided by the regulator as stormwater management is not a regulated activity.

Glossary

AIMS	Australian Institute of Marine Science
ANZECC	Australian and New Zealand Environment and Conservation Council
As	Arsenic
Cd	Cadmium
Co	Cobalt
Cu	Copper
DCI	Department of Construction and Infrastructure, Northern Territory
DPC	Darwin Port Corporation
EAW	East Arm Wharf
EMP	Environment Management Plan
EMS	Environment Management System
Fe	Iron
Ha	hectares
Hg	Mercury
ISO	International Organization for Standardization
ISQG	Interim Sediment Quality Guideline
m	metres
mg/kg	milligrams per kilogram
Mn	Manganese
Ni	Nickel
NT	Northern Territory
NTU	Nephelometric Turbidity Unit
NRETAS	Department of Natural resources, Environment, The Arts and Sport, Northern Territory
PAN	Pollution Abatement Notice
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
Pers. comm.	personal communication
PCB	Polychlorinated biphenyl

pH	Scale of measurement for acidity or alkalinity, 'power/percentage/potential of Hydrogen'
U	Uranium
µg/L	micrograms per litre
USEPA	United States Environmental Protection Agency
WMB	Water Monitoring Branch
WMPC Act	*Waste Management and Pollution Control Act 1998*
Zn	Zinc
%	percent
$k	thousand dollars
$M	millions dollars

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Appendices

Appendix A – Selected relevant sections and definitions within the WMPC Act

Waste Management and Pollution Control Act 1998 (NT)

Definitions:

environment means land, air, water, organisms and ecosystems and includes:

(a) the well-being of humans;

(b) structures made or modified by humans;

(c) the amenity values of an area; and

(d) economic, cultural and social conditions.

environmental harm means:

(a) any harm to or adverse effect on the environment; or

(b) any potential harm (including the risk of harm and future harm) to or potential adverse effect on the environment,

of any degree or duration and includes environmental nuisance.

material environmental harm means environmental harm that:

(a) is not trivial or negligible in nature;

(b) consists of an environmental nuisance of a high impact or on a wide scale;

(c) results, or is likely to result, in not more than $50,000 or the prescribed amount (whichever is greater) being spent in taking appropriate action to prevent or minimise the environmental harm or rehabilitate the environment; or

(d) results in actual or potential loss or damage to the value of not more than $50,000 or the prescribed amount (whichever is greater).

environmental nuisance means:

(a) an adverse effect on the amenity of an area that:

(i) is caused by noise, smoke, dust, fumes or odour; and

(ii) unreasonably interferes with or is likely to unreasonably interfere with the enjoyment of the area by persons who occupy a place within the area or are otherwise lawfully in the area; or

(b) an unsightly or offensive condition caused by contaminants or waste.

contaminant means a solid, liquid or gas or any combination of such substances and includes:

(a) noise, odour, heat and electromagnetic radiation;

(b) a prescribed substance or prescribed class of substances; and

(c) a substance having a prescribed property or prescribed class of properties.

pollute means:

(a) emit, discharge, deposit, or disturb, directly or indirectly, a contaminant or waste; or

(b) cause, permit, or fail to prevent, directly or indirectly, the emission, discharge, deposition, disturbance or escape of a contaminant or waste.

pollution means:

(a) a contaminant or waste that is emitted, discharged, deposited or disturbed or that escapes; or

(b) a contaminant or waste, effect or phenomenon, that is present in the environment as a consequence of an emission, discharge, deposition, escape or disturbance of a contaminant or waste.

waste means:

(a) a solid, a liquid or a gas; or

(b) a mixture of such substances,

that is or are left over, surplus or an unwanted by-product from any activity (whether or not the substance is of value) and includes a prescribed substance or class of substances.

Sections of the WMPC Act referred to in PANs

12 General environmental duty

(1) A person who:

(a) conducts an activity that causes or is likely to cause pollution resulting in environmental harm or that generates or is likely to generate waste; or

(b) performs an action that causes or is likely to cause pollution resulting in environmental harm or that generates or is likely to generate waste,

must take all measures that are reasonable and practicable to:

(c) prevent or minimise the pollution or environmental harm; and

(d) reduce the amount of the waste.

(2) Without limiting the generality of subsection (1), in determining which measures are reasonable and practicable for the purposes of subsection (1), a person is to have regard to:

(a) the nature of the environmental harm and the sensitivity of the environment into which a contaminant or waste is placed or may be placed;

(b) current technical information reasonably available to the person in relation to the activity and the likelihood that a measure proposed in the information would minimise the pollution, environmental harm or waste that the activity or action may cause; and

(c) the financial implications of implementing or carrying out the measures.

(3) A failure to comply with subsection (1) does not of itself constitute an offence, but where a person has failed to comply with the subsection a pollution abatement notice may be issued to him or her.

83 General environmental offences

(4) A person must not pollute the environment, where:

(a) material environmental harm results; and

(b) he or she knows, or ought reasonably be expected to know, that serious environmental harm or material environmental harm will or might result from the pollution.

Penalty: environmental offence level 3.

(5) A person must not cause an environmental nuisance.

Penalty: environmental offence level 4.

Other relevant sections of the WMPC Act for context

84 Defences to general environmental offence

(1) It is a defence to a prosecution for an offence against section 83 (other than subsection (5) or (7)), if it is proved that the alleged offence did not result from a failure on the defendant's part to exercise reasonable diligence.

86 Application of Environmental Offences And Penalties Act

Where in this Act the penalty is specified at the foot of a provision to be an environmental offence level 1, 2, 3 or 4, an offence against the provision is designated to be an environmental offence level 1, 2, 3 or 4, respectively, within the meaning of the Environmental Offences and Penalties Act.

87 General penalty and continuing offences

(1) A person who is found guilty of committing an offence against this Act for which no other penalty is prescribed is liable to the penalty that would be payable if the offence were designated to be an environmental offence level 4 within the meaning of the Environmental Offences and Penalties Act.

88 Regulatory offences

An offence against section 14(1), 30, 39(2), 43(1), 51, 58(2), 61(5), 63(2), 67, 76(c), 80(2), 83(5) or (7) or 112 is a regulatory offence.

96 Averments and evidence

(1) In a prosecution for an offence against this Act an averment in a complaint, information or indictment that:

(a) at a specified time, a particular person:

(i) was the owner or occupier of land specified in the complaint, information or indictment;

(ii) was a person to whom an instrument of an administrative character relates; or

(iii) was an employer, employee, or agent of, a specified person;

(b) a specified substance was a contaminant or a waste; or

(c) results referred to in the complaint were results of an analysis carried out by or under the direction of a person specified in the complaint, information or indictment,

is prima facie evidence of the matter so averred.

(2) An authorised officer may give evidence, without the need to call further opinion evidence, that the authorised person formed the opinion based on his or her own senses that:

(a) noise, smoke, dust, fumes or odour was emitted from a place occupied by the defendant, or was so emitted and travelled to a place occupied by a person or where a person lawfully was; and

(b) the level, nature or extent of the noise, smoke, dust, fumes or odour within the place to which it travelled was an unreasonable interference with the person's enjoyment of the place.

(3) Where an authorised officer gives evidence referred to in subsection (2) in relation to a matter, the evidence is prima facie evidence of the matter.

Appendix B – Aspects and Impacts Register and Risk Review

Table 6 Risk Matrix – Likelihood of Hazard

Level	Likelihood	Description	Frequency
A	Almost certain	The event is likely to occur in most circumstances based on operations	Daily or weekly
B	Likely	The event will probably occur in most circumstances or history of occurrence	Monthly
C	Possible	The event may likely occur at some time	Twice per year
D	Unlikely	The event could occur at some time but no history	Once per 5-20 years
E	Rare	The event should only occur in exceptional circumstances	Once per 20 year or more

Table 7 Risk Matrix – Consequence of Hazard

Consequence Level	Descriptor	Description
1	Catastrophic	High level major impact to one or more environmental compartments with long lasting or irreversible effects that requires long term monitoring and recovery programs Immediate widespread concern, incident reported Huge financial loss (>$5M) Causing serious environment harm in non compliance with legislation Ongoing exceedanceof guideline values and high risk

Consequence Level	Descriptor	Description
2	Major	Major long term (>5 years) impact to one or more environmental compartments that requires response procedures and monitoring to determine recovery with long lasting adverse effects on some components of the environment, potentially irreversible Concern to wider community, likely to be reported. Harm to beneficial uses. Major financial loss (>$1M - $5M) Causing material environmental harm in non-compliance with legislation Exceed guideline values and high risk of harm
3	Moderate	Moderate / medium impact to one or more environmental compartments that requires procedures and monitoring to rectify but with no long lasting effects (6 to 24 months), reversible / recovery likely in short to medium term Concern to local community. Risk to beneficial uses. High financial loss (>$100K - $1M) Potentially causing material environmental harm or causing nuisance in non-compliance with legislation or not meeting General environmental Duty Exceed guideline values but low risk of causing harm or impact on beneficial uses
4	Minor	Low impact on one or more localised / restricted environmental compartment/area that requires procedural response to rectify. Reversible/recoverable Some concern to immediately adjacent residents/occupants Moderate financial loss ($20K - $100K) Risk of environmental nuisance and not meeting General Environmental Duty or specified policy/Strategy/Objectives Short term or minor exceedance of guideline values (<1 week) negligible risk of harm
5	Insignificant / Negligible	Low level impact on isolated impact on environmental compartments Low acceptable financial loss ($0 to $20K) No legislation. Generally in line with Policy / Strategy. Meeting general environmental Duty. Elevated levels but no exceedanceof guideline values

Table 8 Risk of Harm Matrix and Indicative Levels of Priority

Likelihood →

Consequence ↑

Risk	A	B	C	D	E
1	A1 – 10	B1 – 9	C1 – 8	D1 – 7	E1 – 6
2	A2 – 9	B2 – 8	C2 – 7	D2 – 6	E2 – 5
3	A3 – 8	B3 – 7	C3 – 6	D3 – 5	E3 – 4
4	A4 – 7	B4 – 6	C4 – 5	D4 – 4	E4 – 3
5	A5 – 6	B5 – 5	C5 – 4	D5 – 3	E5 – 2

Risk rating	Priority	Shading	Description
H: 8 to 10	High risk		Specific control and monitoring measures to be identified and implemented in short term. Measures and risk level to be reviewed and improvements made as further information becomes available and as technology and economics permit.
M: 5 to 7	Medium risk		Specific controls and monitoring measures to be implemented in medium term. Measures to be reviewed and improved as further information becomes available indicating medium risk remains and as technology and economics permit.
L: 2 to 4	Low risk		Standard controls or monitoring to be implemented in medium to long term. Review in line with general site processes.

Dangerous Goods

The EMP for EAW identified a number of chemical substances and dangerous goods in various locations within the East Arm Wharf precinct. Those that may pose a potential risk to marine water quality are listed in Table 9.

Table 9 Potential sources of pollution as identified by chemical substances stored, used or handled at the EAW

	Locality	Substances
1.	East Arm Stockpile Area:	Manganese ore, iron ore, fuel and oil
2.	East Arm Wharf Precinct	Copper concentrate, manganese ore, iron ore, oil and motor spirits, acids, phosphates, chlorine, explosive and flammable liquids, paint, lubricants and degreasers, contaminated soils
3.	Transit shed	Biocides
4.	Bulk liquids wharf	Fuel, oil, acid
5.	Workshop	Fuel, oil
6.	Sewerage treatment facility	Sewage, effluent
7.	Mud ponds	Contaminated dredge material
8.	Quarantine area	Quarantine waste
9.	Waste oil area	Oil
10.	Copper concentrate storage shed	Copper concentrate

Table 10 Risk Assessment

	Aspects/ Hazards	Potential Impacts[7]	Existing Measures	Risk Rating	Further Mitigation Measures & Options	Residual Risk
1	Transporting Iron ore and Manganese to Loader	Fugitive mineral dust emissions from vehicles adversely impacting air quality and causing fallout on wharf	Nil	A4: 7 - Medium	a) Covering of trucks in short term b) Use covered trains c) Cease use of trucks in longer term	C4: 5 - Low
		Mineral dust fallout on wharf surface entering marine environment via stormwater runoff	Street sweeper when loading ships in port	A3: 8 - High	d) High pressure cleaning of wharf area to remove sediments from hard surfaces as required e) Direct low flow runoff to settlement Pond F f) Alter transport route to more central locality along wharf g) Seal, kerb and gutter road surfaces h) Construct permanent settlements ponds to contain first flush capacity for stockpile, transport and wharf areas	C4: 5 - Low
		Vehicle incident causing spill with risk of minerals entering marine environment via stormwater runoff	Road traffic controls and safety & communications procedures	B3: 7 - Medium	i) Spill kits and spill response procedures and training j) Cease use of trucks in longer term	E4: 3 - Low
2	Load Iron ore and Manganese into hopper	Mineral dust plume from air displacement causing emissions adversely impacting air quality and causing fallout	Loading under open ended covered shed	A4: 7 - Medium	k) Curtaining of loading area l) Complete enclosure of loading facility with negative pressurisation and air extraction through filter system in longer term (OHS considerations also required)	C4: 5 Low E4: 3 Low

[7] Scope of Impacts considered are related to those risks potentially impacting marine water quality only, ie rather than risks such as greenhouse gas emissions, fire or to OH&S.

	Aspects/ Hazards	Potential Impacts[7]	Existing Measures	Risk Rating	Further Mitigation Measures & Options	Residual Risk
		Mineral dust fallout impacting marine environment via stormwater runoff	Street sweeper when loading ships in port	A3: 8 - High	m) High pressure cleaning of area immediately surrounding loading shed to remove sediments from hard surfaces at as required n) Direct runoff to settlement pond F o) Seal, kerb and gutter all surfaces on wharf *Construct permanent settlement pond/s with capacity to contain first flush from 1 in 0.3 year storm event*	C3: 6 - Moderate
4	Load Iron ore and Manganese to ships via conveyor	Minerals dust fallout on wharf surface entering marine environment via stormwater runoff	Street sweeper when loading ships in port	A3: 8 - High	p) High pressure cleaning of area immediately surrounding conveyor to remove sediments from hard surfaces q) Direct runoff to settlement pond/s *Seal, kerb and gutter all surfaces on wharf* *Construct permanent settlement pond/s with capacity to contain first flush from 1 in 0.3 year storm event*	C3: 6 - Moderate
		Fugitive minerals dust emissions adversely impacting air quality and causing fallout to marine environment	Dust suppression sprays	A3: 8 - High	r) Increase use of suppression sprays in adverse wind conditions s) Curtaining of conveyor t) Complete enclosure of conveyor	C3: 6 - Moderate E3: 5 Low
5	Transporting Copper concentrate to loader/conveyor	Mineral dust fallout entering marine environment via stormwater runoff	Covered trains Street sweeper when loading ships in port	B3: 7 - Moderate	u) High pressure cleaning of area immediately surrounding loading shed to remove sediments from hard surfaces v) Direct runoff to settlement pond/s *Seal, curb and gutter all surfaces on wharf* *Construct permanent settlement pond/s with capacity to contain first flush from 1 in 0.3 year storm event*	C4: 5 - Low

	Aspects/ Hazards	Potential Impacts[7]	Existing Measures	Risk Rating	Further Mitigation Measures & Options	Residual Risk
		Fugitive mineral dust emissions adversely impacting air quality and causing fallout on wharf	Use of covered trains directed into shed	B4: 6 - Moderate	w) Increase use of suppression sprays in adverse wind conditions x) Curtaining of shed y) Complete enclosure of shed	C4: 5 - Low E3: 5 Low
		Vehicle incident causing spill with risk of minerals entering marine environment via stormwater runoff	Rail traffic controls and safety & communications procedures	C3: 6 - Moderate	z) Emergency response, Spill kits and spill response procedures and training	D3: 5 - Low
3	Vehicle dragout of minerals from around loading area	Minerals washed into marine environment via stormwater runoff	Wheel wash at loading facility Street sweeper when loading ships in port	B3: 7 - Moderate	aa) Increase capacity of wheel wash bb) Ensure appropriate use and maintenance of wheel wash cc) High pressure cleaning of area immediately surrounding wheel wash to remove sediments from hard surfaces dd) Direct runoff to settlement pond/s *Seal, curb and gutter all surfaces on wharf* *Construct permanent settlement pond/s with capacity to contain first flush from 1 in 0.3 year storm event*	D4: 4 - Low
6	Stockpiling ore	Fugitive mineral dust emissions adversely impacting air quality and causing fallout on wharf and roadways	Dust suppression sprays Bunding Diversion of runoff to settlement ponds	A4: 7 - Moderate	ee) Control maximum height of stockpiles to below 5 m ff) increase use of dust suppression sprays in adverse wind conditions gg) Removable covers for stockpiles hh) Sealed, graded and curbed/guttered storage areas to divert all runoff to settlement ponds	C4: 4 - Low
7	Insufficient and porous stormwater detention ponds	Overflow/seepage of potentially contaminated runoff to marine environment	Diversion of low flows to Pond F Existing ponds for stockpile runoff	B3: 7 - Moderate	ii) Construct permanent pond with sufficient capacity to contain first flush of 1 in 0.3 year storm events jj) Seal existing ponds	D3: 5 - Low

	Aspects/ Hazards	Potential Impacts[7]	Existing Measures	Risk Rating	Further Mitigation Measures & Options	Residual Risk
8	Storing chemicals, dangerous goods and Drilling muds	Chemical spillage risking emission to marine environment including via stormwater runoff	Various – Bunding, indicators, Automatic warning/cutoff, Spill/emergency response procedures/equipment/training	C2: 7 - Moderate	kk) Add any that are not in place	D2: 6 - Moderate
9	Storing fuel	Fuel tank rupture risking emission to marine environment	Various – Bunding, indicators, Automatic warning/cutoff, Spill/emergency response procedures/equipment/training	C2: 7 - Moderate	ll) Add any that are not in place	D2: 6 - Moderate
10	Refuelling activities	Fuel spillage risking emission to marine environment including via stormwater runoff	Various – filling only within rollover bunded area, Automatic cutoff, Spill/emergency response procedures/equipment/training	C2: 7 - Moderate	mm) Add any that are not in place nn) Install SPEL Oil interceptors	D2: 6 - Moderate
11	Sewage management	Sewage spills from vehicles or pipeline rupture	Procedures	D3: 5 - Low	oo) Bunding	D4: 4 - Low
		Sewage discharges at unacceptable concentrations		C3: 6 - Moderate	pp) Obtain licensing from NRETAS qq) Upgrade treatment plant to improve discharge quality	D3: 5 - Low
12	Waste management including Quarantine waste	Litter or spillages	Procedures	C4: 4 - Low	rr) Containment ss) Response	D4: 4 - Low
13	Loading stock to ships	Manure/nutrients entering marine environment including via stormwater runoff	Street sweeper when loading ships in port	A4: 7 - Moderate	tt) Additional surface cleaning procedures implemented as required	C4: 4 - Low

	Aspects/ Hazards	Potential Impacts[7]	Existing Measures	Risk Rating	Further Mitigation Measures & Options	Residual Risk
14	Stormwater discharges from wharf precinct in higher flow periods	Runoff potentially containing sediment and contamination risking harm to environment	Nil	A2: 9 - High	uu) Implement permanent sealed stormwater controls as described above including sealed, kerbed and guttered surfaces with diversion to storage and settlement facilities and new hardstand area for 1 in 0.3 yr storm events vv) Install stormwater treatment technology – settlement ponds as above plus SPELceptor ww) Develop, implement and review/improve marine and stormwater quality monitoring programme xx) Rehabilitate / vegetate land not sealed	C4: 5 - Low
15	Planning and Procedures	Out of date procedures and training	EMS and EMP	C3: 6 - Moderate	yy) Update EIS and EMP regularly and ensure training up to date	D3: 5 - Low

Appendix C – Guideline Values

Table 11 Recommended Guideline Values

'nv' = no value determined in ANZECC Guidelines. '-' = no value for relevant use.

	Guideline Value 0-100 m		Guideline Value 100 m+		ANZECC Source	
	Water Quality (µg/L)	Sediment quality (mg/kg)	Water Quality (µg/L)	Sediment quality (mg/kg)	Water Quality Guideline	Sediment Quality Guideline Interim Sediment Quality Guideline (ISQG)
Arsenic	-	70 (95th percentile 104 max)	<50	20[8]	Recreational purposes (<30 if any aquaculture likely to be proposed in this zone). No value for 0-100m as no recreational use.	0-100 m: ISQG-High[9] 100 m +: ISQG-Low Max: 95% upper limit (Warren 2001 In Fortune 2006).
Cobalt	1 *Note: there were no results for cobalt in references reviewed*	nv *Note: there were no results in references reviewed*	0.005	nv	Marine water quality guideline values 0-100 m: 95% 100 m+: 99%	*N/A*

[8] Exceedanceof this guideline value should not be seen as impact as studies have shown that arsenic is elevated in undisturbed tidal creeks across the harbour (NRETAS 2008)
[9] ANZECC Guideline states that ISQG-Low and –High refer to effects range–low and –median according to referenced study paper Long *et.al*. (1995).

Copper	1.3	270	0.3	65	Marine water quality guideline values 0-100 m: 95% 100 m +: 99%	 0-100 m: ISQG-High 100+ m: ISQG-Low
Iron	- R*eference sites for Fe ranged from 28 to 148 µg/L*	nv *Reference sites for Fe ranged from 14700 to 42136 mg/kg*	300	nv	Recreational purposes and 'interim indicative' figure from Canada *(<10 if any aquaculture likely to be proposed in this zone)* No guideline for 0-100 as no recreational use.	*N/A*
Manganese	- *Reference sites for Mn ranged from 1 to 8 µg/L*	nv R*eference sites for Mn ranged from 124.4 to 467.9 mg/kg*	100	nv	Recreational purposes (<10 if any aquaculture likely to be proposed in this zone) No guideline for 0-100m as no recreational use.	*N/A*
Tributyltin	0.006	70*	0.004	5*	Marine water quality guideline values 0-100 m: 95% 100m+: 99%	*measured in µg Sn/kg dry weight 0-100 m: ISQG-High[10] 100+ m: ISQG-Low

[10] ANZECC Guideline states that ISQG-Low and –High refer to effects range–low and –median according to referenced study paper Long *et.al*. (1995). 'High' should not be exceeded.

Zinc	15	410	7	200	Marine water quality guideline values 0-100 m: 95% 100+ m: 99%	 0-100 m: ISQG-High[11] 100+ m: ISQG-Low

Additional water quality parameters	0 to 100 m from wharf		100 m+ from wharf		ANZECC Source (0 to 100 m ; 100 m+)
	Marine water	Sediment	Marine water	Sediment	
pH	5 to 9	-	8.2	-	Recreational (Table 5.2.2); Marine Offshore pH (Aquatic ecosystems for Tropical Australia (Table 3.3.4) *Darwin Palmerston Report Card 2009 Water Quality Objective (DPRC WQO) = 8.2 to 8.4*
PAH	70 µg/L	-	50 µg/L	-	Napthalene 95; 99% marine water quality guideline value
Benzene	700 µg/L	-	500 µg/L 10 µg/L	-	Marine water quality 95; 99% (value for slightly to moderately disturbed ecosystems); Recreational contact
TPH	no noticeable film	-	5 µg/L	-	Primary Industries fish taint guideline value
PCB	-	23 µg/kg dry wt in sediment Low	*< 2 µg/L*	-	100+ m: ISQG-Low *Primary Industries – saltwater aquaculture*

[11] ANZECC Guideline states that ISQG-Low and –High refer to effects range–low and –median according to referenced study paper Long *et.al*. (1995).

	0 to 100 m from wharf		100 m+ from wharf		
Turbidity (NTU)	-	-	-	-	No ANZECC marine water quality guideline value (light attenuation recommended instead but no value for NT); *No DPRC WQO. 'Current condition' said to be 2.4*
Dissolved Oxygen (%)	> 80%	-	> 90%	-	Recreational ; Aquatic ecosystems for Tropical Australia (Offshore marine) (Table 3.3.4) *Note: DPRC WQO is 83 to 89%*
Faecal coliforms	-	-	< 1000 per 100mL[12] or 230 enterococci / 100mL ;	-	Secondary recreational contact *Compare to background monitoring by NRETAS, provided no STP outfalls in this zone*
Chlorophyll - *a*	0.7-1.4 µg/L	-	0.5-0.9 µg/L	-	Aquatic ecosystems for Tropical Australia (Offshore marine) (Table 3.3.4) *Note: DPRC WQO < 4 µg/L*
Total Suspended solids	-	-	-	-	*DPRC WQO* is < 10 mg/L and 'current condition' at 2 mg/L *ANZECC Aquaculture values < 10 mg/L (< 75 mg/L brackish waters)*
Ammonia	910	-	500	-	Marine water quality 95% species protection guideline value *DPRC WQO < 20 and ' current condition' as measured by 2001-2007 data is 5 µg/L*

[12] Median value from minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 4000 faecal coliform organisms/100 mL or maximum number in any one sample: 450–700 enterococci organisms/100 mL).

	0 to 100 m from wharf		100 m+ from wharf		
Colour	-	-	clarity reduction <20%; change in natural hue of <10 points on the Munsell Scale; change in natural reflectance less than 50%.	-	Recreational
Nitrate	-	--	< 10,000 µg/L	-	Recreational
Total Phosphorus	15 µg/L	-	10 µg/L	-	Marine guideline values for Tropical Australia (Table 3.3.4) *DPRC WQO < 30 µg/L and < 10 µg/L for filterable reactive (current cond'n = 15 µg/L and 4 µg/L)*
Total Nitrogen	100 µg/L	-	100 µg/L	-	Marine guideline values for Tropical Australia (Table 3.3.4) *DPRC WQO <300 and 'current condition' is 1250 µg/L <300*

Appendix D – Existing Water Quality and Sediment Quality data for Darwin Harbour

*Includes sample site off East Arm. Shaded = Bulk Minerals handled at EAW.

Exceeds 95% Marine Water Quality Guideline

Exceeds 80% Marine Water Quality Guideline

Table 12 Summary of Marine Water Quality Studies reviewed

		*Range of results (average Dry - D; average Wet - W) for Darwin Harbour main body [13]		Range of results - dissolved plus particulate (average)	AIMS 2006	Darwin Palmerston Report Cards 2009	Icthys sites near East Arm	AIMS [14] (pre loadout)	AIMS during loadout; excl ref sites ie DHCU03 & 04 only	AIMS post loadout; excl ref sites ie DHCU03 & 04 only	ANZECC Guideline [15]	*Range of all results*
Analyte	**Units**	**WMB 2005 (1994-95 data)**	**WMB 2005 (2001-03 data)**	**Padovan 2003 (1997, 1999, 2002 data)**	**Duggan 2006 2002-04 data)**	**Drewry et al. 2010 (2001-2007 data)**	**URS 2009**	**23 Apr 2010**	**25 Apr 2010**	**29 Apr 2010**	**95%; 80% Marine guideline unless otherwise specified**	
Aluminium	µg/L	-	**44 - 356** (99D; 141W)	**44 - 356** (148)	-	-	-	-	-	-	-	***44 - 356***

[13] WMB = Water Monitoring Branch (2005)
[14] AIMS = Australian Institute of Marine Science (2010)
[15] ANZECC = Australian and New Zealand Environment and Conservation Council (2000)

		*Range of results (average Dry - D; average Wet - W) for Darwin Harbour main body [13]		Range of results - dissolved plus particulate (average)	AIMS 2006	Darwin Palmerston Report Cards 2009	Icthys sites near East Arm	AIMS [14] (pre loadout)	AIMS during loadout; excl ref sites ie DHCU03 & 04 only	AIMS post loadout; excl ref sites ie DHCU03 & 04 only	ANZECC Guideline [15]	*Range of all results*
Arsenic	µg/L	**0.5 - 1.6** (0.8D; 1.3W)	**0.8 - 1.5** (1.3D; 1.2W)	**0.7 - 2** (1.4)	-	-	-	**1.22 - 1.39**	**1.25 - 1.60**	**1.17 - 1.59**	**50 (Recreational)**	***0.5 - 2.0***
Cadmium	µg/L	**0.012 – 0.027** (0.021 D; 0.021W)	**0.005 – 0.015** (0.01D ; 0.01W)	**0.02 – 0.05** (0.02)	-	-	-	**<0.03**	**<0.03**	**<0.02**	**5.5 ; 36**	***<0.03***
Chromium	µg/L	-	**<5**	**<5**	-	-	-	-	-	-	4.4 ; 85	***<5***
Cobalt	µg/L	-	-	-	-	-	-	**<0.02 - 0.062**	**0.021 - 0.067**	**<0.02 - 0.116**	**1 ; 150**	***<0.02 - 0.116***
Copper	µg/L	**0.23 - 3.32** (0.645 D; 0.673W)	**0.169 - 0.604** (0.28D ; 0.35W)	**0.3 - 1.4** (0.3)	-	-	-	**0.23 - 0.75**	**0.34 - 45.1**	**0.44 - 1.26**	**1.3 ; 8**	***0.169 - 45.1***
Iron	µg/L	-	**28 - 148** (57D; 87W)	**28 - 138** (67)	-	-	-	**<2 - 98.9**	**<2 - 92.3**	**<2 - 260**	**300 (Recreational)**	***<2 - 260***

		***Range of results (**average Dry - D; average Wet - W**) for Darwin Harbour main body** [13]		**Range of results - dissolved plus particulate** (average)	**AIMS 2006**	**Darwin Palmerston Report Cards 2009**	**Icthys sites near East Arm**	**AIMS** [14] **(pre loadout)**	**AIMS during loadout; excl ref sites ie DHCU03 & 04 only**	**AIMS post loadout; excl ref sites ie DHCU03 & 04 only**	**ANZECC Guideline** [15]	***Range of all results***
Lead	µg/L	**0.068 - 0.733** (140D; 296W)	**0.034 - 0.0107** (0.034D; 0.064W)	**0.04 - 0.6** (0.25)	-	-	-	**<0.02 - 0.052**	**<0.02 - 0.085**	**<0.03 - 0.195**	**4.4 ; 12**	***0.0107 - 0.733***
Manganese	µg/L	-	**1 - 8** (2D; 4W)	**1.3 - 6.1** (3)	-	-	-	**0.50 - 4.28**	**0.9 - 3.96**	**0.47 - 8.51**	**100 (Recreational)**	***0.47 - 8.51***
Nickel	µg/L	-	**0.18 - 0.357** (0.236D; 0.285W)	**0.22 - 0.36** (0.28)	-	-	-	**<0.5 - 0.89**	**<0.5**	**0.16 - 0.35**	**70 ; 560**	***0.18 - 0.89***
Uranium	µg/L	-	**-**	**-**	-	-	-	**2.75 - 2.86**	**2.72 - 2.87**	**2.74 - 2.87**	**-**	***2.72 - 2.87***
Zinc	µg/L	**0.31 - 4.95** (0.1634D; 1.411W)	**0.099 - 1.630** (0.241D; 0.447W)	**0.5 - 4** (1.9)	-	-	-	**<0.5**	**<0.5 - 2.92**	**<0.4 - 0.83**	**15 ; 43**	***0.099 - 4.95***

		***Range of results (**average Dry - D; average Wet - W**) for Darwin Harbour main body** [13]		**Range of results - dissolved plus particulate (**average**)**	**AIMS 2006**	**Darwin Palmerston Report Cards 2009**	**Icthys sites near East Arm**	**AIMS** [14] **(pre loadout)**	**AIMS during loadout; excl ref sites ie DHCU03 & 04 only**	**AIMS post loadout; excl ref sites ie DHCU03 & 04 only**	**ANZECC Guideline** [15]	***Range of all results***
Chlorophyll-*a*	µg/L	**0.3 - 2.7** (1.36D; 1.24W)	**0.25 - 3.00** (0.59D; 1.43W)	-	-	**WQO = <4;** 'Current' = 2	-	-	-	-	-	***0.3 - 3.0***
DO	mg/L	***5.25 - 5.84*** *(5.61D; 5.57W)*	***4.02 - 6.55*** *(5.78D; 5.72W)*	-	-	**WQO = 80 to 100%;** 'Current' = 83 - 89%	**74.4 - 103.0** % (93%)	-	-	-	-	***74.4 - 103.0%***
Euphotic depth	m	**5.3 - 18.8** (11.5D; 10W)	**6.0 - 22.6** (15.7D; 10.7W)	-	-	-	-	-	-	-	-	***5.3 - 22.6***
TN	mg/L	**0.13 – 2.0** (0.4D4; 0.55W)	**0.05 - 0.37** (1.07D; 0.15W)	-	-	**WQO = 0.3;** 'Current' = 1.25	-	-	-	-	-	***0.05 - 2.0***

		*Range of results (average Dry - D; average Wet - W) for Darwin Harbour main body [13]		Range of results - dissolved plus particulate (average)	AIMS 2006	Darwin Palmerston Report Cards 2009	Icthys sites near East Arm	AIMS [14] (pre loadout)	AIMS during loadout; excl ref sites ie DHCU03 & 04 only	AIMS post loadout; excl ref sites ie DHCU03 & 04 only	ANZECC Guideline [15]	*Range of all results*
TP	mg/L	**0.009 - 0.017** (0.014 D; 0.013W)	**0.01 - 0.04** (0.01D; 0.01W)	-	-	**WQO = <0.03;** 'Current' = 0.015	-	-	-	-	-	***0.009 - 0.04***
TSS	mg/L	**-**	**-**	-	-	**WQO <10;** 'Current' = 2	**1.6 - 54**	**1.5 - 5.4**	**<0.2 - 12.5**	**<0.2 - 11.2**	**-** [16]	***<0.2 - 54***
Turbidity	NTU	**1.5 - 20** (2.5D; 5.6W)	**1.0 - 7.0** (1.9D; 3.1W)	-	0.93 - 93.4 (2002/03) 2.3 - 197.6 (2004)	**No WQO;** 'Current' = 2.4	**0.0 - 73.6** (6.9)	-	-	-	**Clarity not reduced by >20%**	***0.0 - 197.6***

[16] ANZECC Guidelines for Primary Industry suggest values for aquaculture: <10 mg/L, or <75 mg/L for brackish waters;, however aquaculture does not currently occur in this vicinity

Table 13 Summary of Marine Sediment Quality studies reviewed

ISQG = Interim Sediment Quality Guidelines (ANZECC, 2000)

Exceeds ISQG – Low

Exceeds ISQG – High

	Fortune 2006							Welch *et al.* 2008					Padovan 2003 [17]	AIMS 2010		ANZECC 2000	
	East Pt-Lee Pt	Fannie Bay	Darwin City	East Arm	Middle Arm	West Arm	Central Harbour	Middle Arm	Reichardt East	Reichardt West	West Arm East	West Arm West	Fannie Bay and Darwin city	East Arm Wharf		ISQG - Low	ISQG - High
	Total concentration mg/kg (Mean)							Total concentration mg/kg (Mean)					Total mg/kg (Mean)	Ttl conc. mg/kg (Min to Max)	Pot'lly Bioavail mg/kg (Min to Max)	mg/kg	mg/kg
As				27.8	41.2	30.6	60.2	12.2	12.2	10.5	15.8	17.6	25	7.7 to 59.7	<0.4 to 4.03	**20**	**70**
Cd	1	0.9	<0.8	0.8	0.8	0.8	2.3	0.04	0.03	0.05	0.03	0.03	2	<0.02 to 0.15	<0.03 to 0.18	**2**	**10**
Cr	-	-	-	-	-	-	-	39.4	47.2	46.1	46.7	36.1	-	-	-	**80**	**370**
Co	-	-	-	-	-	-	-	-	-	-	-	-	-	3.46 to 10.8	0.45 to 4.15	**-**	**-**
Cu	3.9	4.2	7.3	6	5.8	6.4	5.2	5.6	8.12	9.06	5.67	4.78	5	2.91 to 399	0.34 to 95.5	**65**	**270**

[17] Cited in Padovan 2003, from Parry and Munksgaard 1997.

	Fortune 2006							Welch *et al.* 2008					Padovan 2003 [17]	AIMS 2010		ANZECC 2000	
Fe	14,700	17,226.7	21,786.7	33,544.8	33,238.1	30,987.5	42,135.7	-	-	-	-	-	24,400	17,500 to 45,200	53.6 to 8,620	**-**	**-**
Pb	10.6	11.2	19.8	12.7	16.3	14.6	22.6	12	13.4	17.7	9.71	9.31	18	4.79 to 18.5	<0.02 to 10.5	**50**	**220**
Ni	7.5	8.5	12	11.9	12.4	12	13.7	9.7	11.1	9.87	11.3	9.59	10	2.74 to 21.7	0.35 to 3.26	**21**	**52**
Mn	467.9	272.2	243	256.3	346.4	124.4	279.8	-	-	-	-	-	270	176 to 1110	108 to 820	**-**	**-**
Hg	0.035	0.036	0.036	0.031	0.039	<0.025	<0.025	-	-	-	-	-	0.03	-	-	**0.15**	**1**
U	-	-	-	-	-	-	-	-	-	-	-	-	-	0.83 to 2.07	0.05 to 1.15	**-**	**-**
Zn	24.1	25.1	63.5	35.9	26.2	31.3	25.9	23.8	30.3	37.7	27.2	20.8	29	5.86 to 98.3	0.67 to 47.5	**200**	**410**

Appendix E – EPBC Protected Matters Search Results

Appendix F – Treatment Systems

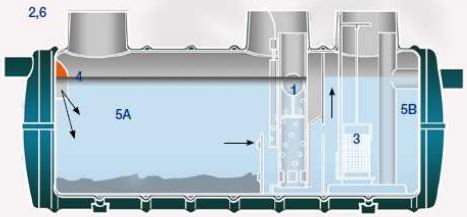
SPEL Environmental Stormceptors (sourced from http://www.spelproducts.com.au/selection-criteria.php)

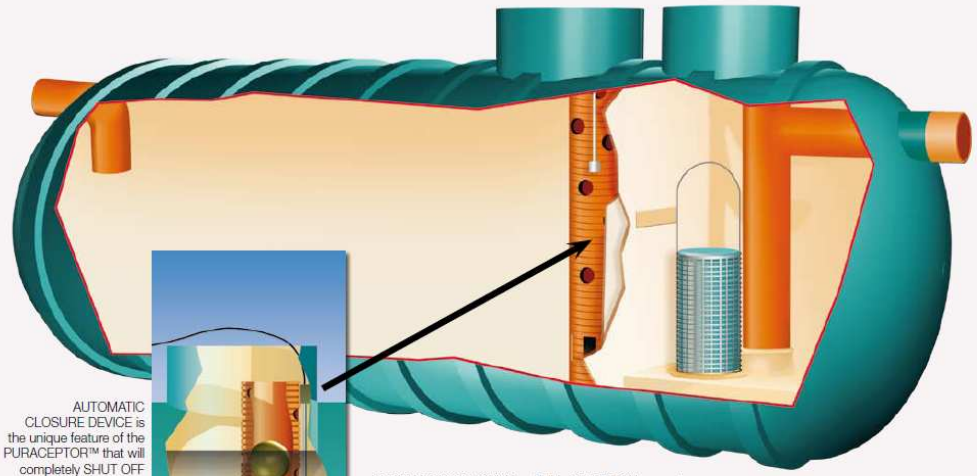
SPEL PURACEPTOR™ CLASS 1

Oil containment

High Risk

Oil spills & transformer oil ruptures





AUTOMATIC CLOSURE DEVICE is the unique feature of the PURACEPTOR™ that will completely SHUT OFF the separator in the event of a major oil spill. Not dependent on electricity to operate.

SPEL PURACEPTOR™ is a FULL RETENTION separator that treats all flows and is sized to contain more than the anticipated maximum oil spillage enabling it to be fully operational at all times.

It has two chambers, a coalescer and is fitted with an automatic closure device specifically designed to treat and contain major oil spills thereby making it suitable for high risk applications.

It achieves a water discharge quality of 5mg light liquids per litre complying to European Standard BS EN 858.1. 2006. Treatable flow rates range from 2LPS to 200LPS. Pipe sizes range from 100mm to 450mm (larger sizes on request).

APPLICATIONS

- *POWER STATIONS*
- *SUBSTATIONS & SWITCHYARDS*
- *MINING & HEAVY VEHICLE*
- *WINDFARMS*
- *WASTE TRANSFER DEPOTS*
- *RE-FUELLING AREAS*
- *SERVICE STATIONS*
- *ASPHALT PLANTS*

Careful and proper planning by corporate Australia and government bodies is essential when designing and implementing systems that are effective in protecting our environment.The proven and independently accredited SPEL PURACEPTOR™ (complies to European Standard BS EN 858.1 2006) is an Australian made stormwater treatment and oil containment device that can contain and prevent light liquid pollutants from discharging into our waterways.

1 **AUTOMATIC CLOSURE DEVICE**
The AUTOMATIC CLOSURE DEVICE (A.C.D.) is a precisely engineered device comprising a water-bouyant ball that is sensitive to any change in the water density as a consequence of light liquids build up, thereby automatically activating a process of depressing the A.C.D. to SHUT OFF the separator, preventing pollutants from discharging to drains and waterways.

2 **FULL RETENTION**
All liquid is treated. There is no by-pass operation.

3 **COALESCER EQUIPPED**
Provides a coalescing process for the separation of smaller globular of light liquid pollutants to reduce the light liquid content in the outlet to **5mg/litre or less.**

4 **INLET DIP PIPE - FLAME TRAP**
For minimum turbulence and to prevent fire and inflammable vapours passing through to the drainage system.

5 **TWO CHAMBER**
A non-turbulant flow through two horizontal treatment chambers, utilising the underflow principle to retain light liquids in all flow conditions.

A. CONTAINMENT CHAMBER: Where Total Suspended Solids (TSS) silt, sediments, sludge and gross pollutants are trapped and settle on the chamber floor and where light liquids are contained.

B. COALESCER CHAMBER: Where light liquids separation is enhanced reducing it to **5mg/litre** or less prior to discharge.

6 **GRAVITY OPERATED**
Will function in the event of power failure and fits into existing pipe drainage systems or new sites.

7 **MAINTENANCE**
Easy and safe with no entering of the tank required.
For further details, refer maintenance page 12.

SPEL PURACEPTORS™ are readily transportable to all sites and can be handled with ease.

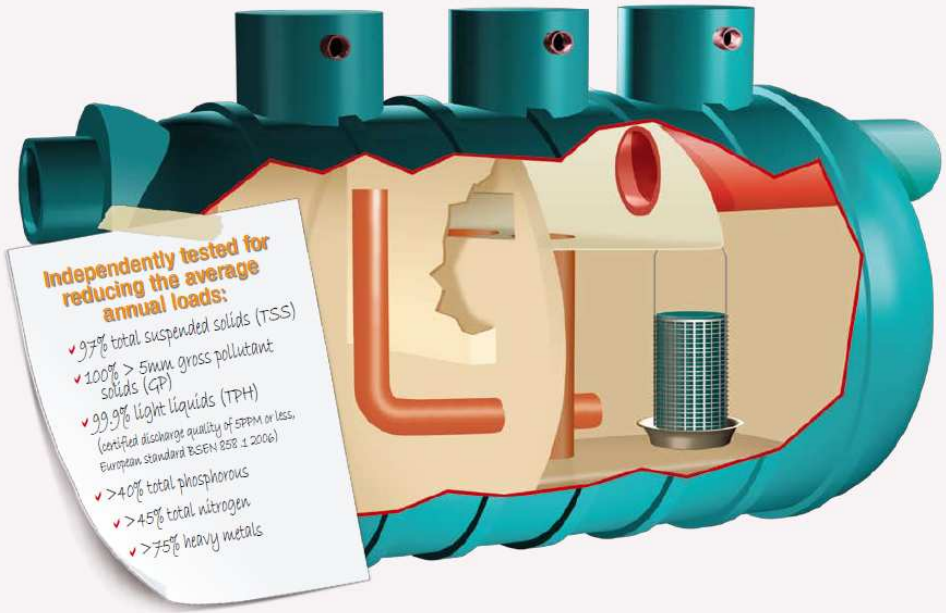
Cranbourne Switchyard, VIC
Refer job profiles, inside back cover.

Asphalt Producer
Refer job profiles, inside back cover.

SPEL STORMCEPTOR™ CLASS 1&2

The distinct advantage in water treatment

Medium Risk



SPEL STORMCEPTOR™ CLASS 1* is a horizontally configured two chamber stormwater quality improvement device (SQID) equipped with a gravity enhancing coalescer unit.

The design, facilitated by a retention period of approximately 6 minutes generates quiescent conditions within the secondary chamber, efficiently promoting the separation of total suspended solids (TSS), light liquids and pollutants.

Treatable flow rates range from 0.1LPS to 400LPS (max. flow rate to 4,000 LPS) and can fit pipe sizes from 160mm to 1500mm.

* **STORMCEPTOR™ CLASS 2** model with no coalescer is available for medium to low-risk applications.

1. BY PASS

NORMAL CONDITIONS: DIAGRAM A

Low flow or first flush is through the separation chamber, where the quiescent conditions and the coalescer enhancement allow the pollutants to separate out efficiently. Clean water flows from the separation chamber to the by-pass chamber and thence to the outlet.

HIGH FLOW CONDITIONS: DIAGRAM B

During a storm the level in the primary chamber rises and the storm water passes upwards from the cleanest zone over the weir via the storm cover duct into the by-pass chamber and to the outlet.

The design keeps the turbulence within the separation chamber to a minimum which avoids agitating the pollutants held.

2. COALESCER

Provides a coalescing process for the separation of smaller globules of light liquids to reduce the light liquid content in the outlet to **5mg/litre or less.**

3. HYDRAULIC DWELL TIME

Designed to contain enough volume to retain the inflow for a period of approximately 6 minutes.

4. INLET DIP PIPE - FLAME TRAP

For a minimum turbulence and to prevent inflammable vapours passing through the drainage system.

5. TWO CHAMBER

A non-turbulent flow through two horizontal treatment chambers - PRIMARY CHAMBER (4A) and SEPARATION CHAMBER (4B) utilising the underflow principle to retain suspended solids and light liquids in all flow conditions.

6. MAINTENANCE

Easy and safe with no entering of the tank required. For further details, refer maintenance page 12.

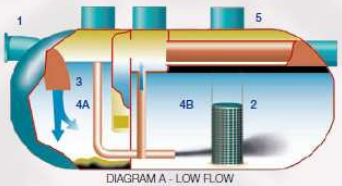


DIAGRAM A - LOW FLOW

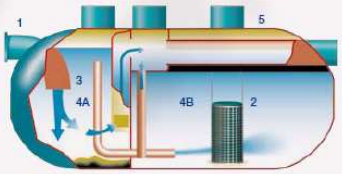


DIAGRAM B - HIGH FLOW


An industrial bitumen works. Launceston TAS.


SPEL STORMCEPTOR™ treating stormwater from various carparks and streets in PERTH CBD - Perth City Council.

APPLICATIONS

- *CAR PARKS & SHOPPING CENTRES*
- *COUNCIL DEPOTS*
- *INDUSTRIAL ESTATES*
- *MINING: HEAVY VEHICLE MAINTENANCE & STORAGE AREAS*
- *TRANSPORT DEPOTS & LOADING BAYS*
- *TUNNELS*
- *HIGHWAYS & TRANSPORT CORRIDORS*
- *RECYCLING YARDS*
- *AIRPORT APRONS & TARMACS*


SCOPES CREEK, PENRITH CITY COUNCIL, NSW. - Wood lot in the background is irrigated by the treated water by the STORMCEPTOR™.


Ford Broadmeadows, VIC, utilized SPEL STORMCEPTOR™ to intercept run-off from their entire site.


Port loading terminal, Gladstone QLD.