15.0 Terrestrial Biology

15.1 Introduction

The section describes the results of the investigations undertaken into the terrestrial flora and fauna on the site. It also provides information on biting insects. Details of the marine biology in the study area are given in Section 14.

15.2 Flora

15.2.1 Study Objectives

The objectives of the flora study were to:

- Review existing terrestrial vegetation data for the local area and region;
- Provide baseline data on vegetation communities occurring in the study area;
- Identify the occurrence or expected occurrence of significant plant species (significance is in terms of rarity, habitat value and importance to indigenous people);
- Describe weed species in the study area, especially 'declared' weeds;
- Assess the value of any areas that may be disturbed by the proposed expansion for vegetation conservation; and
- Determine impact of existing and expanded operations on the surrounding vegetation and develop appropriate management strategies.

15.2.2 Data Sources

In order to identify the range of species and communities that may inhabit the region and area, reviews of existing data from the Northern Territory Herbarium and the Commonwealth Department of Environment and Heritage (DEH) databases for the area $12^0$09' to $12^0$15'S; and $136^0$40' to $136^0$50'E were conducted. The database records include records of specimens collected from the area (NT Herbarium), and records and species predicted to occur in the area based on habitats (DEH).

Existing data on flora of the Gove region were compiled through acquisition of the following key references:

- A 1995 survey of the fauna of the Cape Arnhem area, which is approximately 30 km south-east of Gove peninsula. This report also contains a vegetative description of habitats present (Gambold et al, 1995);
- Information provided in the 1974 Red Mud Ponds EIS (Dames & Moore, 1974); and
- A 2001 assessment of the conservation status of the *Vegetation of the Australian Tropical Savanna* (Fox et al., 2001).

Threatened, significant or otherwise noteworthy flora[1] identified from the NT Herbarium and DEH databases are summarised in Appendix E1. From this list, an assessment of potential presence was made based on habitat preferences of those species compared with those habitats present on the site. Species identified as being potentially present in the project area were targeted during the field assessment.

Preliminary interpretation (including assessment of historical disturbance patterns) and mapping of the vegetation communities of the project area was conducted prior to the commencement of fieldwork in June 2003. Mapping techniques included vegetation community definition from aerial photography for the area flown May 1999 and July 2001. The preliminary mapping was subsequently ground-truthed and reviewed during the field surveys.

15.2.3 Sampling Conditions

Fieldwork was conducted during the dry season over a five-day period from 2–6 of June 2003. The survey involved a botanical survey and assessment of representative sites within each of the vegetation units delineated in the mapped area. During the sampling period, the weather was fine and hot with no recent rainfall. The survey was conducted under Parks and Wildlife Commission of the Northern Territory permit number 15641.

15.2.4 Floristics, Structure and Community Assessment

Several duplicate sites were surveyed in each vegetation type to allow for statistical comparison of samples if required to confirm the delineation of mapping units. A total of 17 sample plots were surveyed.

Sample plots were subjected to two different types of treatment, namely primary assessment plots (20 m x 20 m plots) at 13 sites and secondary (frameless 20 m x 20 m approx) assessment plots at two sites. In addition, meander searches were undertaken through two sites. The survey sites are denoted by P for primary sites, S for secondary and M for meander sites.

The locations of the sampling locations are shown in Figures 15.2.1 and 15.2.2.

15.2.4.1 Primary Plots

Fieldwork within primary sample plots included plant collection, structural analysis and species diversity characterisation of all flora present. Quantitative data recorded included the number of individuals per species (canopy, sub-canopy, shrub layer) allowing stem density measurements to be derived; diameter of canopy and sub-canopy trees at breast height; crown separation ratio (CSR) of the canopy, sub canopy and shrub stratum; and percentage foliage cover (PFC) of the ground stratum. The locations of the data collection sites were recorded by use of a GPS. Evidence of previous disturbance, fire history, incidence of exotic species and general notes were also compiled for each sample plot. There were 13 primary sample plots within the project area mainly within areas of integral remnant vegetation cover.

[1] Threatened species relate to species identified by Northern Territory (*Territory Parks and Wildlife Conservation Act* 2000) and Commonwealth (*Environment Protection & Biodiversity Conservation Act 1999)* legislation as critically endangered, endangered or vulnerable. Significant species are species that carry other legislation status or those that occur at the extent of their natural geographic range.

15.2.4.2 Secondary Plots

Fieldwork within secondary sample sites involved a semi-quantitative reconnaissance of structural and floristic characteristics focusing on the description of the dominant species within each stratum of the community surveyed within two frameless plots. Within these plots an assessment of abundance and projective foliage cover was also made. Notes were made on the degree of disturbance at each sample location.

15.2.4.3 Area Searches

Following assessment of each primary plot and selected secondary plots, an area of approximately 1.5 ha surrounding each plot was searched for 10 minutes utilising the random meander technique (Cropper, 1993) to identify additional (less abundant/dominant) species not recorded in the plots. Care was taken to avoid sampling in different vegetation types to those of the plots.

15.2.4.4 Meander Searches

The random meander technique of Cropper (1993) was used to assess disturbed sites and communities that might contain threatened and significant species identified by database searches. Approximately 15 minutes was expended at each of the four sites surveyed in an area of approximately 1.5 ha per site. Prior to surveying sites where threatened and significant species could potentially be found, a list of characteristic details of such species (eg. morphological characteristic, habit and habitat) was developed to assist in field identification.

15.2.4.5 Incidental Observation

Additional species not previously recorded by the above techniques were identified and/or sampled. Records were made on the vegetation association these species were growing in.

15.2.4.6 Specimen Identification

Where available, fruiting and/or flowering specimens were taken to assist with identification. Where possible, plant species were identified in the field, pressed and dried. For those species not field identified, positive identifications of plant specimens were subsequently made under laboratory conditions.

15.2.4.7 Vegetation Community Determination

Classification of vegetation type at each plot follows the established format of Walker & Hopkins (1990). This survey method provides a rapid assessment based on the structural features of each community, primarily using growth form, density and height descriptors in the classification.

Height estimates of each vegetation layer were made together with records of dominant or emergent taxa. The Crown Separation Ratio (CSR) used to determine the density of each stratum layer, was visually estimated. The CSR represents the ratio of crown width to crown separation. This procedure was used for each of the recognised upper layers in a community. Foliage Projection Cover (FPC) was used for the ground layer. Conversion of field data to a standardised forest type such as "woodland" with indications of height and dominant taxa was then undertaken using tables provided by Walker & Hopkins (1990).

Vegetation communities were sorted and described on the basis of land systems described by Fox *et al* (2001).

15.2.5 Regional Context

15.2.5.1 Vegetation Communities

Bioregionalisation

Gove Peninsula is located in the Arnhem Coastal Bioregion of north-eastern Arnhem Land identified in the Interim Biogeographic Regionalisation of Australia, (Environment Australia, 2000). Bioregions or biogeographic regions (Stanton and Morgan, 1977) are broad landscape patterns that reflect the interactions of ecosystems (flora and fauna) with major structural geologies, soils, landform and climate (Thackway and Cresswell, 1995; Sattler and Williams, 1999; Fox *et al*., 2001).

The Arnhem Coastal Bioregion comprises a coastal strip extending from just east of Cobourg Peninsula to just north of the mouth of the Rose River in south-eastern Arnhem Land, and including many offshore islands, most notably Groote Eylandt (and its satellites), the English Company and Wessel group, and the Crocodile Islands (Woinarski, 2002a).

Dominant Bioregional Vegetation Types

The Arnhem Coastal Bioregion lies within the Australian Tropical Savanna landscape which is a grassy landscape that occupies the northern (tropical) quarter of the continent. Savanna vegetation is the result of a marked seasonal pattern of tropical monsoon rains in the summer followed by a distinctly dry period in the winter (Fox et al, 2001). It occupies a distinct part of the tropical landscape between rainforests and arid areas. In areas where the summer rains occur over a longer period of the year, the vegetation tends to be dominated by rainforest and where the seasonal dry period is longer, arid vegetation dominates (Fox *et al*., 2001). Another influence on the structure and floristics of this landscape is fire.

Although the region is recognised for its broad open woodland (savanna) landscape (after Specht, 1970; Walker & Hopkins, 1990), other structural formations occur. Within the Arnhem Coastal Bioregion, four broad Tropical Savanna mapping communities that occupy greater than 5% of the bioregional area have been identified at a scale of 1:2,500,000. These are:

- *Eucalyptus miniata* Darwin woollybutt and *Eucalyptus tetrodonta* Darwin stringybark +/- *Corymbia nesophila* Melville Island bloodwood open-forest with *Sorghum* spp. sorghum tussock grass;
- *Eucalyptus tectifica* Darwin box and/or *Corymbia* spp. woodland with *Sorghum* spp. I.e. Sorghum and *Sehima nervosum* white grass, tussock grasses;
- *Eucalyptus tetrodonta* Darwin stringybark and *Eucalyptus miniata* Darwin woollybutt +/- *Corymbia bleeseri* rusty-barked bloodwood with *Sorghum* spp. tall-grasses; and
- *Corymbia dichromophloia* variable -barked bloodwood, *Eucalyptus miniata* Darwin woollybutt +/- *Eucalyptus tetrodonta* Darwin stringybark open-woodland with *Triodia bitextura* curly spinifex and *Sorghum* spp. grasses.

Since non-indigenous settlement began, greater than 90% of the areal extent of each of these communities still remain. (Fox et al., 2001).

Gove Peninsula

Tertiary laterite, the dominant geology of the Gove Peninsula, has given rise to the extensive lateritic bauxite deposits. Soils are typically red earthy sands and lateritic gravels. Inland from the coast, the most common

vegetation type on the Gove Peninsula is the open forest dominated by *Eucalyptus miniata* Darwin woollybutt and *Eucalyptus tetrodonta* Darwin stringybark (Yunupinu et al 1995, Gambold et al 1995, Woinarski 2002a).

The *Eucalyptus miniata* Darwin woollybutt and *Eucalyptus tetrodonta* Darwin stringybark Open Forests contain a variety of trees, shrubs, herbs and grasses and are floristically diverse. The influence of the local climatic factors is manifested in this vegetation type by a more shrubby understorey and lower biomass of annual and perennial grasses when compared with the more arid western top end (Yunupinu et al 1995). Other important vegetation types are *Eucalyptus tetrodonta* Darwin stringybark Woodlands, *Melaleuca* spp. Woodlands and grasslands that occur on coastal floodplains, seasonally inundated creeklines and billabongs and spring swamps, coastal monsoon vine thicket, and intertidal communities of mangrove forests (mangals) and chenopod/salt flats.

Species richness is generally considered moderate (Wooranski, 2002).

Historic Die Back Events

In the early 1990s, it was observed that some *Eucalyptus tetradonta* Darwin Stringybark on the Gove Peninsula (there were also some outbreaks in areas to the west) were undergoing a decline in vigour when leaves browned, died off and fell. From this point the trees either died or recovered. Similar events have occurred from time to time in the past (1992) and the vegetation communities have generally recovered. Investigations were undertaken by Curtain University (Davison, 2001) investigating possible plant pathogens (eg. the root fungus *Phytophthora*) or contaminants (Spain and Tibbet, in progress). Both studies could not definitively isolate the cause of the event, but airborne pollution from the refinery power station and soil borne pathogens were ruled out as possible causes.

RDA Effects

Since the ponds at the RDA occupy much of the hinterland catchment adjacent to Macassar Creek, they have reduced the freshwater input from the catchment to the landward sections of the tidal flats in the vicinity of the western side of Pond 5. This has resulted in increased groundwater salinities in the area. A rise in the water table in response to the filling of the ponds may also contribute to increasing salinities in the area. In response to these effects, there have been some changes to the local vegetation communities.

A preliminary investigation of vegetation decline in the area undertaken in 1992 (Dames & Moore, 1992) suggested that changes in the local hydrology had resulted in the encroachment of seawater into areas where vegetation, not normally tolerant to seawater (e.g. terrestrial trees such as Eucalypts, Melaleucas, Acacias, Livistonias) was growing. The displacement of freshwater by more saline water was considered to be the major contributor to the impacts on terrestrial trees.

The area was again surveyed in 1999 (LDM, 2000) and it appears that the *Melaleuca viridifolia/Pandanus* woodland had been replaced by a heath of mangrove fern (*Acrostichum speciosum*). This reflects increased salinities and/or alteration to groundwater and soil conditions (e.g. waterlogging) due to the proximity of the area to the RDA.

The effect of the RDA on the mangroves in the area is discussed in Section 12.2.4.2.

15.2.5.2 Vegetation Species

A search of the NT Herbarium for the area $12^0$09’ to $12^0$15’S; and $136^0$40’ to $136^0$50’E (which covers the entire lease area), revealed the presence of 188 taxa (7 identified to genera level, 181 identified to species level) representing 133 genera and 56 families (Appendix E1). In the Northern Territory, any species that carries a listing of extinct in the wild, critically endangered, endangered or vulnerable under the *Territory Parks and Wildlife*

Conservation Act 2000 is considered threatened and is classified as 'protected' wildlife. None of the species recorded by the herbarium are protected wildlife as defined by the Act.

Arenga palm *(Arenga australasica*), a species listed as Vulnerable under the Commonwealth's *Environment Protection and Biodiversity Conservation Act*, was identified by an interactive map search on DEH's *Matters of National Environmental Significance* database. This species is not threatened in the Northern Territory.

Woinarski (2002a) identifies four endemic *Acacia* and *Eucalyptus* species occur in the Arnhem Coast Bioregion being; *Acacia dunlopii, Eucalyptus* sp. (Maningrida K.Hill 3984), *Acacia* sp. (Gove D2219-2) and *Eucalyptus* sp. (Gan Gan K.Hill 3945). There are no reliable data on abundance, condition or trends, but the Acacia species may be affected detrimentally by altered fire regimes.

15.2.6 Flora Survey

15.2.6.1 Vegetation Communities

One disturbed and ten natural vegetation communities were described and mapped for the project area on the basis of aerial photograph interpretation and field survey results (Figures 15.2.1 and 15.2.2). These communities and their corresponding sampling sites are summarised in Table 15.2.1. Summary descriptions of each community are given in Appendix E2 together with a list of species identified during the survey.

Table 15.2.1
Vegetation Communities Surveyed

Landform	Community	Sites Sampled
1. Marine Deposits	1a. Mangroves	Nil – included in marine survey (Section 14.3.2.2)
	1b. Saline Flats	Nil – included in marine survey (Section 14.3.2.2)
2. Quaternary Coastal Dunes	2a. Foredunes	Nil – incidental observations and random searches (not within current or proposed future area of project activity)
	2b. Coastal Monsoon Vine Thicket	P5, P9
	2c. Mixed Eucalypt Coastal Woodland	P10, P12, P14
3. Cainozocic Sand Deposits	3ai. *Eucalyptus tetrodonta* Darwin stringybark Open Forest on sands	P1, P4, P8
	3aii. *Eucalyptus tetrodonta* Darwin stringybark Open Forest on Lateritic gravels	P7, P11
	3aiii. *Eucalyptus tetradonta* Darwin stringbark Woodland	S15
	3bi. *Melaleuca viridiflora* broad leaved stringbark / *Pandanus spirilis* spring pandanus Open (Savanna) Woodland with a grassy understorey	P2, P3, P6
	3bii. *Melaleuca* spp. *I pandanus spirilis* spring pandanus Woodland to Open Forest	S13
4. Disturbed Land		M16, M17

15.2.6.2 Vegetation Species

Surveyed Species

The survey identified the presence of 231 taxa representing 175 genera and 77 families (Appendix E2). Of these 26 were exotic species not native to Australia. Families represented by more than 4 species included Poaceae (31), Euphorbiaceae (17), Myrtaceae (15), Fabaceae (14), Mimosaceae (9), Malvaceae (7), Cyperaceae (6), Proteaceae (6), Convolvulaceae (5), Moraceae (5), Sterculiaceae (5), Verbenaceae (5), Asteraceae (4), Caesalpinaceae (4), Combretaceae (4), Dillenaceae (4), Rhizophoraceae (4), Rutaceae (4) and Sapindaceae (4). Genera represented by 3 or more species included *Acacia* (8), *Euphorbia* (5), *Eucalyptus* (5), *Cyperus* (4), *Melaleuca* (4), *Terminalia* (3), *Hibbertia* (3), *Stylosanthes* (3), *Corymbia* (3), *Grevillea* (3) and *Brachychiton* (3). Families with the most exotic weed taxa were Poaceae (5), Fabaceae (5), Euphorbiaceae (4), Asteraceae (2), Convolvulaceae (2) and Malvaceae (2). The most 'weedy' genera were *Euphorbia* (4), *Stylosanthes* (3) and *Sida* (2).

Endemic and Threatened Species

None of the species identified by the survey are threatened species under either Northern Territory or Commonwealth legislation. Nor are they endemic species identified by Woinarski (2002a). The arenga palm, a Commonwealth threatened species identified by a search of the Environment Australia database, is a species that inhabits Closed Monsoon Rainforest or jungle (Yunupinu, 1995). No Closed Monsoon Rainforest exists within the survey area and therefore this species is not found and not expected to occur within the project area.

Species of Cultural Significance

Many of the species encountered during the survey are of significance to the local Rirratjingu people. These range from use of parts of the plants for food, medicine, firewood, tools and weapon construction. Several also have spiritual significance. Riiatjinu use of plant species was documented by Yunupinu (1995) titled *Rirratjingu Ethnobotany: Aboriginal Plant Use from Yirrkala, Arnhem Land, Australia.* Plant use information, Rirratjingu names and scientific names for those species described by Yunupinu (1995) and identified during the survey are listed in Appendix E3. Note that the listed Rirratjingu names are approximations using anglicised characters and reference should be made to Yunupinu (1995) when interpreting the data contained in Appendix E3.

The Dhimurru Land Management Aboriginal Corporation (Dhimurru) is preparing a database of local flora and fauna species that are of significance to the local Aboriginal people. The database includes for each species a photograph and/or description (in both English and Yolngu Matha), habitat information, and details on its significance or use. Alcan Gove is supporting this initiative.

15.2.6.3 Conservation Significance

Project Areas

Vegetation present within the refinery consists of small disjunct copses of regrowth, landscaping and experimental rehabilitation. They are considered to have the lowest conservation value within the area surveyed.

Outside the refinery, the narrow fringe of coastal vine thicket is habitat for specialised, though not especially significant, vine thicket species and so is of moderate value. The thickets that have public access in the study area (such as those in the vicinity of the Yacht Club and Wallaby Beach) have significant anthropogenic disturbance from four-wheel drive vehicles and dumped rubbish including car bodies and general household refuse. Thickets

along the coast adjacent to the RDA are less disturbed with the level of disturbance decreasing with distance from the residue ponds. Overall, because of their small size and generally disturbed condition, the thickets have a low conservation significance.

The woodland and open forest habitats exhibit less disturbance than the coastal vine thickets though they are regularly burnt. They have a potentially high diversity of species, however most of these species are widely distributed. These habitats are common in the coastal Northern Territory. Much of the land around the RDA is regularly burnt, some areas are subjected to changes in hydrology around the edge of some ponds, and others are fragmented by numerous vehicle tracks. These tracks are sites from which environmental weeds germinate, establish and are then spread by animals, vehicles and humans into areas of more intact vegetation. The conservation significance of the vegetation around the RDA is therefore considered to be low to moderate with the level of significance increasing with distance from the ponds.

The vegetation at the construction workforce accommodation site is a regrowth open forest community in the middle stages of regeneration and is typical of this type of open forest habitat which generally regenerates over 30 to 50 years. Its conservation significance is therefore low.

Indigenous Protection Areas

As discussed in Section 20.6.3.1, the Dhimurru Land Management Aboriginal Corporation (Dhimurru) has prepared an Indigenous Protected Area Management Plan to identify areas determined to be significant by Aboriginal people. The creation of an Indigenous Protection Area (IPA) is a means of achieving collaborative conservation of Aboriginal land involving government conservation agencies (Environment Australia, Parks and Wildlife Commission NT) and other organisations such as the Northern Land Council. Two of the management units in the IPA in the vicinity of the Alcan Gove operations are:

- Northern Beaches; and
- Yarrapay.

The Northern Beaches area includes coastal lands between Wopurrwuy (Melville Bay) and Yirrkala. It has high environmental and cultural values for the Yolngu people and for marine conservation. The Yarrapay area includes coastal land between Garrirri (Rocky Bay) and Barinura (Little Bondi Beach). This management unit has high cultural and environmental values for the Yolngu people and for terrestrial and marine conservation.

The natural heritage values of these two IPA management units are linked to the existing ecosystems and habitats. They both have high plant diversity and faunal representation, including some species not recorded in other parts of the Northern Territory. This is reflected in their relatively intact natural values.

Neither of these area will be affected by the expansion project.

15.2.6.4 Regional Connectivity

None of the vegetation communities that can be considered integral vegetation (identified by vegetation communities 1-3) and therefore possessing some conservation value will be affected by the development. Therefore loss of regional connectivity will not be an issue with the project.

15.2.6.5 Bioregional Vegetation Considerations

Wooranski (2002) notes that the Arnhem Coastal Bioregion is generally in good condition, but this is being eroded by continuing increases in the number of feral animals (especially *Sus scrofa* pigs, but also *Bubalus bubalis* buffalo and *Bos* spp. cattle), weeds, and broad-scale changes in fire regime.

In addition, some riparian areas, swamps and rainforest patches across the bioregion are suffering ongoing decline from a mixture of factors including feral animals, weeds and changed fire regimes.

15.2.7 Project Effects

15.2.7.1 Vegetation Removal

Construction of the expanded refinery will require the removal of a total of 1.9 ha of vegetation from within the perimeter of the refinery consisting of revegetation (0.5 ha) and regrowth (1.4 ha). The locations of the haul roads and laydown areas to be cleared for the refinery construction are shown on Figure 15.2.1. None of this vegetation is of conservation or cultural significance and no threatened species will be affected.

The Banyan (*Ficus virens)* is a tree of cultural significance to the Rirratjingu people who know it as Rripipi or Dawumaka or Dawu. The fruit of the tree is eaten, the bark of the prop roots is used to make string bags, and when men prepare for sacred ceremonies they sit under the tree and sing. The name Rripipi also refers to the place where the spirit people live. One *Ficus virens* that is considered to be of cultural significance is located within the refinery. This tree will not be disturbed by the expansion and it will continue to be protected.

The planned construction accommodation facilities will be developed in an area of regrowth on a site formerly used for construction workforce accommodation during the refinery's initial construction. Whilst the buildings in this area were removed, the concrete slabs and road bases were left in tact. Over the past 30 years or so natural revegetation of the site has occurred, however the presence of these building materials has limited the extent of the regrowth. The site has limited ecological value.

15.2.7.2 Weeds, Pests and Fire

To avoid the introduction of plant pests or pathogens with construction materials, customs inspections of equipment or plant arriving from overseas destinations will be compulsory and pest eradication measures will be undertaken as directed, if required. Although this is normally undertaken by customs officials, Alcan Gove personnel will also monitor incoming vessels and equipment for non-compliance.

The introduction of earthmoving equipment to the area has the potential to introduce new and declared weeds listed in the *Weeds Management Act 2001*(*eg Echium plantagineum* Paterson's curse (Class A), *Parthenium hysterophorus* parthenium (Class A), *Acanthospermum hispidum* star burr (Class B), *Alternanthera pungens* khaki weed (Class B), *Argemone ochroleuca* Mexican poppy (Class B), *Jatropha gossypifolia* bellyache bush (Class B), *Stachytarpheta* spp. snakevines (Class B) and *Mimosa* spp. sensitive plants (Class B)). It could also facilitate the further spread of existing weeds (*eg. Senna alata* (Class B), *Ipomoea pes-tigridis, Merremia aegyptia* white convolvulus creeper, *Crotalaria goreensis, Macroptilium atropupureum,* sirato, *Stylosanthes* spp., *Hyptis suaveolens* Hyptis, *Sida* spp. (Class B), *Passiflora foeteda* wild passionfruit, *Cenchrus ciliaris* buffel grass. *Chloris gayana* Rhodes grass, *Pennisetum polystachion* mission grass (Clas B), *Themeda quadrivalvis* grader grass (Class B) and *Stachytarpheta australis* snakevine (Class B)).

The risk of spreading weeds will be minimised by:

- Washing down all vehicles and earthmoving equipment entering the work area;
- Monitoring the washdown area, wastewater collection point and construction sites for weed establishment; and
- Implementing weed eradication programs as required.

Existing fire regimes in the surrounding vegetation communities will not be affected by the construction activities.

The yellow crazy fire ant *Anoplolepis gracilipes* has been identified from the Gove Peninsula and has recently been identified at the mine site. In other parts of the world this pest has effected changes to the floristics of an area by disrupting normal plant/animal interactions resulting in a reduction of biodiversity. The management strategies in place to control this pest are discussed in Section 15.3.5.7.

15.2.7.3 Rehabilitation of Disturbed Areas

Disturbed sites will be landscaped and revegetated once construction is complete. Endemic and native species will be used. The revegetation methods to be used will be similar to those currently used at the mine for the rehabilitation of disturbed areas. Details of these are given in Section 19.3.1.

In the regional context, Alcan Gove provides logistical and technical support to a variety of landcare projects including projects undertaken by Yirrkala Dhambul Landcare and Conservation Volunteers Australia. Alcan Gove also contributes to the development of the regional landcare management strategy which also includes representatives from Dhimurru.

15.2.7.4 Dust

Alumina dust from the conveyor, silos, transfer points and calciners drifts westward across the refinery and settles in a small area of Mixed Eucalypt Coastal Woodland/Open Forest along the site's western boundary. Vegetation in this area is covered by alumina which also covers the ground in this area. A visual inspection during the survey did not indicate any obvious sign of stress to the vegetation. However, without ongoing monitoring of this area it is not possible to determine if there has been any subtle long-term deleterious effects on the structure and floristics of the area. As the refinery expansion will result in an improved dust control measures (Section 8.5.3), existing effects will not increase and dust generation is expected to reduce.

15.2.7.5 Mist from Cooling Towers

There is some evidence of vegetation impact in the form of crown dieback in the immediate vicinity of the existing cooling towers located on the hill in the north-west corner of the refinery site. This effect could be caused by low levels of caustic in the cooling tower mist. The affected vegetation is largely composed of regrowth and landscape plantings and has minimal conservation value. Much of this vegetation will be removed during the construction of the haul road that will be located in this area.

As part of the expansion, an additional cooling tower will be located in this area with the potential to increase the level of cooling tower mist effects on the adjacent vegetation. In order to reduce the risk of additional vegetation effects, the new cooling tower will be fitted with mist eliminators that are designed to minimise the amount of mist emitted. The effectives of the eliminators will be determined by monitoring the health of the surrounding vegetation during the first two years following commissioning of the new cooling tower.

15.2.7.6 Sulfur Dioxide Emissions

Existing Situation

During the EIS vegetation survey, an investigation was undertaken to detect the presence of any vegetation displaying sulfur dioxide (SO_2) damage arising from refinery emissions.

Experiments performed by O'Connor et al. (1974) on native species from southern Australia indicated a range of SO_2 sensitivities that could be relevant for species found in the Northern Territory. The most sensitive species included several *Acacia* and *Eucalyptus* species, and some *Banksia* and *Melaleuca* species.

Signs of leaf tip scorch, leaf bleaching and spotting, and discolouration of leaf margins were searched for during the survey. None were observed.

Gove has a markedly seasonal rainfall environment, which results in vigorous plant growth during the wet season and a dying back of some species and quiescence in others during the dry season. Because vegetation is generally more susceptible to injury by SO_2 during periods of active growth, the exposure conditions during the wet season are likely to be of greater relevance than are dry season conditions.

An SO_2 emissions air quality report commissioned to assess the current likely impact on vegetation of the Gove Peninsula (Doley, 2003) is given in Appendix E4. It concluded that SO_2 injury was very unlikely to occur to plant species growing in the vicinity of the refinery. This was based on the measured ground level concentrations of SO_2 and associated predictions of 1-hour maximum ground level concentrations in the surrounding area, together with the results of the vegetation impact survey. As shown in Appendix E4, modelling has shown that both short term and long term SO_2 concentrations were below threshold damage levels identified for short term exposure by O'Connor et al. (1974) and long term exposure (various authors).

Effects of Expansion

The planned expansion of the refinery includes conversion of the energy supply from fuel oil to natural gas. Should the gas supply be delayed, fuel oil will continue to be used but a fuel switching strategy will be implemented so that low sulfur fuel oil will be used when the wind is blowing towards populated areas. As can be seen from Table 8.7.1, this strategy will result in a reduction in the ground level concentrations of SO_2 at all of the nominated receptor locations. All of these receptors (except for West Melville Bay) are located to the east of the refinery. This is also the direction where the majority of the vegetation potentially affected by refinery emissions is located. As there is no observable SO_2 damage to vegetation from the existing SO_2 ground level concentrations and as they predicted to reduce with the expanded refinery, the expansion is unlikely to result in any vegetation damage from SO_2 emissions.

15.2.8 Management

The following commitments have been made to manage environmental risks to flora:

- All vegetation to be removed will be chipped and used as mulch in landscaping or pit burnt.
- Mist eliminators will be incorporated into the design of the new cooling towers to be located at the north-west of the refinery.
- All construction areas (and downstream areas) will be regularly surveyed for weed infestation during the construction phase. If weeds are identified they will be removed and the weed management strategies will be reviewed.

- Regular monitoring of vegetation health within the study area will be undertaken during and after construction. The objectives of this monitoring will be to augment the current vegetation information for the area, to assess the level of impact from the construction and/or operational activities, and to monitor the effectiveness of the management strategies outlined in the draft vegetation management plan (Section 25). The effectiveness of the monitoring program will be reviewed after two years of the expanded operations commencing.
- Quarantine inspections for all vessels entering Australian waters from overseas is the responsibility of the Australian Quarantine Inspectorate Service (AQIS), and although this is normally undertaken by customs officials, Alcan personnel will also monitor incoming vessels and equipment to ensure compliance with Australian quarantine requirements.
- Owing to the potential for declared and environmental weeds to be introduced or spread throughout the work area, Alcan Gove already has a quarantine system in place to ensure that all vehicles and other machinery transported to Gove are clear of plant material and soils before being placed on the barge for transport to Gove. These measures will continue to be applied for the construction phase of the expansion and beyond. Where weed species are known to occur or new infestations occur, control programs will be put in place to prevent transfer to the construction sites. Weeds of concern include the declared weeds identified above.

Strategies for the management and monitoring of flora effects are given in the draft management plan in Section 25.

15.3 Fauna

15.3.1 Study Objectives

The objectives of the fauna study were to:

- Review existing terrestrial fauna data for the local area and region;
- Provide baseline data on fauna and habitats occurring within and near the study area with reference to existing information and results from field surveys;
- Identify the occurrence or expected occurrence of any significant wildlife species, or any sites or habitats of significance to wildlife (including significance to indigenous people);
- Describe feral animal species in the study area;
- Assess the significance of the study area for wildlife, both in a local and regional context; and
- Assess the impact of current and future operations on wildlife and develop appropriate management strategies.

15.3.2 Data Sources

Existing data on fauna of the Gove region were compiled through acquisition of a number of key references. These included the following:

- A 1995 survey of the fauna of the Cape Arnhem area, which is approximately 30 km south-east of Gove peninsula. Aside from field survey results, this report also contains a compilation of historical fauna records for the east Arnhem region (Gambold et al, 1995).
- A search of the Parks and Wildlife Commission of the NT (PWCNT) “NT Fauna Database”, which lists all records, including historical records, for the area. The search was bounded by the following coordinates: $12^0$09’ to $12^0$15’S and $136^0$40’ to $136^0$50’E. These coordinates cover the entire lease area.

- Results of bird surveys conducted in the Gove area by Christopher Brady over two years between 1998 and 2000, as part of a PhD research project into mining rehabilitation (Brady, pers. comm.).
- Recent data on seabirds, shorebirds and mangrove birds (URS, 2003a), as well as recent PWCNT seabird and shorebird surveys (Chatto, 2001 and 2003).
- Information provided in the 1974 Red Mud Ponds EIS (Dames & Moore, 1974).

15.3.3 Field Survey Methods

A dry season survey was undertaken within the study area between 26 May and 1 June 2003 (under Parks and Wildlife Commission of the Northern Territory Permit Number 15641 and Animal Ethics Clearance No. A01013). Four survey sites were systematically sampled, while general observations from other areas were also compiled. Standard biological survey techniques were used during field surveys, including a number of live capture/release trapping techniques, standard and general observational and habitat searches, as well as methods to indirectly detect the presence of terrestrial fauna. The survey focussed on terrestrial vertebrate taxa, with incidental observations aimed at identification of any significant terrestrial invertebrate species. Fish species observed within the Wallaby Beach sewage treatment ponds and other nearby ponds within the residue disposal area (RDA) were identified where possible, but no collections were made.

Details of the survey methodology are given in Appendix E5.

15.3.4 Site Selection and Habitats

The fauna survey was designed to sample the major habitat types present within the refinery and residue disposal areas. Terrestrial habitats within the study area were defined with reference to topography, vegetation communities and soils. The distribution of fauna may also depend on other factors, such as the availability of open water, fire history and availability of microhabitat and other resources. These factors were considered when assessing the fauna habitats present.

Four survey sites were chosen (Figure 15.2.1 and 15.2.2) which represent the four most prominent habitats within the study area. These habitats are:

- Coastal Monsoon Vine Thicket (Site F1);
- Mixed Woodland (Site F2);
- *Melaleuca* dominated Freshwater Swamp (Site F3); and
- *Eucalyptus tetradonta* dominated Open Forest (Site F4).

The construction workforce accommodation site is a regrowth site that now consists of *Eucalyptus tetradonta* dominated open forest area and is of limited habitat value. Additional habitats occurring in the area were sampled incidentally. These include mangroves, saline swamps and flats, and beach habitats.

Detailed habitat parameters were recorded at each sample site and are provided in Appendix E5.

15.3.5 Survey Results

15.3.5.1 Sampling Results

A total of 93 native and 3 introduced terrestrial vertebrate species were recorded during field surveys in the study area, including 7 amphibian, 13 reptile, 63 bird and 13 mammal species (Appendix E6). The Elliot trapping and pit trapping program resulted in the capture of one frog, six lizard and one small mammal species (Appendix E7). One bat species was caught by mist net and four species were recorded by electronic bat detection.

15.3.5.2 Amphibians

Seven native amphibian species were observed within the study area, including representatives of two families (Myobatrachidae; Hylidae) (Appendix E6). Amphibian species were generally associated with wetter microhabitats within the areas sampled, especially in the area of the Wallaby Beach sewage treatment ponds, freshwater swamps and around human habitation. The most abundant species recorded were green tree frog (*Litoria caerulea*) and Roth's tree frog (*Litoria rothi*), both of which were found in natural habitats and around buildings. One species, marbled frog (*Limnodynastes convexiusculus*), was pit trapped in the freshwater swamp habitat (site F3) (Appendix E7). All species have been previously reported in the region. It is likely that wet season surveys would record additional amphibian species within the study area.

A total of 13 amphibian species are known from the Gove region (Appendix E8). All but one of the additional species (wood frog *Rana daemeli*) could be expected to occur on the lease areas. The wood frog is known from only a few permanent stream locations in the Gove region (Gambold et al., 1995) and suitable habitat for this species is not present on the study area.

15.3.5.3 Reptiles

Thirteen reptile species were identified during the survey, including representatives of seven families (Appendix E6). The reptile taxa identified included two gecko (*Gekkonidae*), two agamid (*Agamidae*), one monitor (*Varanidae*), five skink (*Skinkidae*), one python (*Boidae*) and one elapid snake (*Elapidae*) species. Pitfall traps captured four skink species, one gecko and one agamid species. The majority of the reptiles identified within the study area were encountered during active searches of habitats during the day, during spotlight survey, and incidentally during the course of the trapping and bird census surveys.

The richest site for reptiles was the coastal monsoon vine thicket and adjacent dune habitats (site F1), with five species. The most widespread species, found in all habitats, was the skink *Carlia munda*. Two snake species were observed in open forest within the RDA, the olive python (*Liasis olivaceus*) and western brown snake (*Pseudonaja nuchalis*).

Estuarine crocodiles (*Crocodylus porosus*) were observed at several locations along the beaches within the study area, and especially within the Wallaby Beach sewage treatment ponds, where four individuals were seen. Small skinks and geckoes were common throughout the area, and larger lizards, including the frilled lizard (*Chlamydosaurus kingii*) and northern sand monitor (*Varanus panoptes*) were present in open forest within the RDA.

A total of 75 reptile species (including marine species) have been recorded from the Gove region, including 27 recorded in the NT Fauna Atlas from the Gove Peninsula (Appendix E8). Many of these additional species could be expected within the study area. The field survey recorded two species not listed from Gove previously. The introduced Asian house gecko (*Hemidactylus frenatus*) is a common species seen around buildings and in mangrove

verges within the study area, while the northern sand monitor (*Varanus panoptes*) was observed on two occasions in sandy open forest areas within the RDA.

All six Australian species of marine turtle are known to occur in the Gove region (Appendix E8), although the green turtle (*Chelonia mydas*) is reportedly the most common nesting species (Gambold et al., 1995). One marine turtle nest (inactive) was found during the current survey, on a beach dune to the west of the refinery at site F2.

15.3.5.4 Birds

Sixty three bird species were observed within the study area during the survey period (Appendix E6). Of these, 32 species were recorded during the timed census counts at the 4 main study sites, while the other species were observed opportunistically throughout the study area.

Widely distributed species recorded on three or more sites included bar-shouldered dove (*Geopelia humeralis*), sulphur-crested cockatoo (*Cacatua galerita*), rainbow bee-eater (*Merops ornatus*), and Torresian crow (*Corvus orru*). The most abundant species recorded in counts were peaceful dove (*Geopelia striata*), sulphur-crested cockatoo, and white-throated honeyeater (*Melithreptus albogularis*) at site F4, and dusky honeyeater (*Myzomela obscura*) at site F3.

Birds were generally sparse in the vine thicket habitat at site F1, although this habitat contained several species which were restricted to it, or found elsewhere only in adjacent mangroves. These species were orange-footed scrubfowl (*Megapodius reinwardt*), mangrove gerigone (*Gerigone levigaster*), helmeted friarbird (*Philemon buceroides*), northern fantail (*Rhipidura rufiventris*) and yellow oriole (*Oriolus flavocinctus*).

The mixed woodland habitat adjacent to site F2 was very poor for birds, with only six species recorded. The freshwater swamp habitat at site F3 had the highest number of species recorded in the census counts, with 20. In addition, many of these species were abundant, such as white-throated honeyeater, dusky honeyeater, and peaceful dove. Sixteen species were recorded in the open forest habitat at site F4 during census counts. Species seen only at that site included grey butcherbird (*Cracticus torquatus*), yellow-throated miner (*Manorina flavigula*) and red backed fairy-wren (*Malurus melanocephalus*).

Few waterbirds were observed using the Wallaby Beach sewage treatment ponds, but this area may be attractive for waterbirds from time to time. Only the Radjah Shelduck (*Tadorna radjah*) was observed during the survey. Other waders observed along the beaches included eastern reef heron (*Egretta sacra*), great egret (*Ardea alba*), terek sandpiper (*Xenus cinereus*) and beach stone-curlew (*Esacus neglectus*). However at the time of the survey in mid dry season, numbers were low and migratory waders were not present (see Section 15.3.6.3).

Eight species of raptor were observed in the area included the osprey (*Pandion haliatus*), white-bellied sea-eagle (*Haliaeetus leucogaster*) and brahminy kite (*Haliastur indus*). The brown goshawk (*Accipiter fasciatus*) was recorded from mixed woodland at site F2. An active osprey nest was observed on a tower near the conveyor overpass of the main road.

Two nocturnal bird species, the tawny frogmouth (*Podargus strigoides*) and southern boobook owl (*Ninox boobook*) were recorded during spotlighting within the study area.

All of the bird species observed in the current survey have been previously recorded in the Gove region (Appendix E8). Regional bird records total 229 species, including 157 recorded in the NT Fauna Atlas from Gove Peninsula, 39 seabird and shorebird species recorded by URS (2003a) and 81 species recorded from open forest habitats in the mine area (C. Brady, pers comm.).

15.3.5.5 Mammals

Thirteen mammal species were identified during the survey, including ten native species, two introduced species and the dingo (*Canis lupus dingo*) (Appendix E6).

Mammals were generally uncommon in the study area, and only two individuals of one species were caught by Elliot and pit trapping. This species was the grassland melomys (*Melomys burtoni*), which was trapped in the freshwater swamp habitat at site F3. Northern brown bandicoots (*Isoodon macrourus*) were present mainly along the coastal fringes, including the vine thicket habitat and mangrove margins at site F1, where tracks and diggings were observed. This species was reported to suffer from road kills along the Melville Bay Road. Agile wallabies (*Macropus* agilis) were also present in these areas in low numbers.

Large numbers of flying foxes were present in the study area and around the town of Nhulunbuy during the survey, although no camps were located. The vast majority of those observed were little red flying foxes (*Pteropus scapulatus*), with only a few black flying foxes (*Pteropus alecto*). One northern blossom bat (*Macroglossus minimus*) was mist netted at the freshwater swamp site F3, while at least four species of microchiropteran bats were recorded by Anabat sampling. The exact identity of two of these species cannot be determined by the recordings. The most common call type within the study area has been assigned to either the hoary wattled bat (*Chalinolobus nigrogriseus*) or the little broad-nosed bat (*Scotorepens greyi*). Calls from Top End populations of these two taxa cannot be confidently separated (Milne, 2002). A number of additional calls characteristic of long-eared bats (*Nyctophilus sp*.) could not be identified to species level and may represent one or more additional bat species within the study area. Bats were most abundant around the sewage treatment ponds area of the RDA.

Regional mammal records total 44 species, including 9 recorded in the NT Fauna Atlas from Gove Peninsula (Appendix E8).

15.3.5.6 Other Fauna Groups

Invertebrate fauna groups were not sampled during the current survey. However, due to the known occurrence of an Endangered butterfly (Gove crow butterfly *Euploea alcathoe enastri*) in the Gove area, attention was paid to any "crow" butterflies observed. However, only one species, the two-brand crow (*Euploea sylvester*) was seen in the study area.

There are no natural freshwater waterbodies in the study area. However, several fish species were observed to have colonised the sewage treatment ponds and some of the less caustic RDA ponds. The following species were identified in these areas:

- Ox-eye Herring *(Megalops cyprinoides)*
- Mullet *(Family Mugilidae)*
- Bream *(Acanthopagrus sp.)*
- Snapper *(Lutjanus sp.)*
- Glassfish *(Ambassis sp.)*
- Goby *(Family Gobidae)*

All of these species are estuarine fishes which have colonised the ponds from the adjacent mangrove systems.

15.3.5.7 Introduced Species

General

Pigs *(Sus scrofa)*, buffalo (*Bubalus bubalis)* and cattle (*Bos* spp.) have been identified by Wooranski (2002) as major threats to the natural ecosystems of the Gove Peninsula. Feral buffaloes (*Bubalus bubalis*) were evident in all areas, even in close proximity to the refinery and the RDA. Individual buffaloes were observed in mangrove margins within the RDA and at the sewage treatment ponds. Buffaloes are heavy hoofed animals that can cause habitat degradation in sensitive environments, especially coastal plains and swamps. However, their impact on the habitats of the lease area is not severe because of the sandy nature of the soils and the low numbers of animals present. The proposed expansion is unlikely to modify existing distribution and abundance of feral animals on the peninsula.

Feral cats (*Felis catus*) occur throughout the area in low numbers. Feral pigs, cattle and horses are all reported to occur in low numbers around Gove, but none of these species were recorded during the survey. The introduced rock dove, or feral pigeon (*Columba livida*), is reported to be present in Nhulunbuy (Gambold et al, 1995), but was not observed during the survey. As mentioned in section 15.3.5.3, the introduced Asian house gecko was found to be common in all habitation areas and in mangrove margins on the Gove Peninsula during the survey.

Yellow Crazy Ant

The yellow crazy ant (*Anoplolepis gracilipes*) is a significant invertebrate pest and has recently been identified at the mine site and other parts of the Gove Peninsula. The ant is a highly invasive, swarming colonial species that can form multi-queened 'super colonies'. It has become established in many tropical and subtropical areas throughout the world. It was first recorded on the Australian mainland, in East Arnhem Land, in May 1990. Surveys in 1999 found yellow crazy ants were spread over five river drainage systems in East Arnhem Land (including the Gove Peninsula), covering an area of about 2,500 km^2 (DEH, 2003).

Owing to its aggressive swarming behaviour, poisonous sting, non-specific omnivorous diet, and ability to forage both terrestrially and arborealy, it has the ability to seriously impact upon faunal biodiversity, particularly in areas of high infestation.

Permanently wet, spring-fed forest patches, especially the monsoon vine thickets of northern Australia, provide favourable habitat for the yellow crazy ant. These vegetation communities are habitat to several nationally and regionally threatened animals, including the naturally rare and patchily distributed Gove crow butterfly *Euploea alcathoe enastri*.

Yellow crazy ants are spread by the movement of cargo and soil and these are the primary vectors by which it colonises areas remote from existing infestations.

Owing to the potential for significant ecological change and the social and economic impacts the spread of the pest could cause, Alcan Gove, in conjunction with inputs from Dhimurru and the Northern Land Council, will undertake a pilot quarantine and eradication study at the mine site. If successful, the techniques developed will be applied to other outbreaks on the Gove Peninsula/East Arnhem Land. Control techniques to be tested include contact sprays, dusts and toxic baits all of which have been successfully used to control the ant both on Christmas Island, where it is a major pest, and in Cairns where there was a small outbreak that was successfully eradicated in 2002.

Cane Toad

The cane toad was introduced into Queensland in the 1930s as a biological control for the cane beetle that was affecting cane production. However the cane toad was never effective at the task and it rapidly spread invading

natural ecosystems in much of Queensland, northern New South Wales, and more recently, the Northern Territory. It has spread rapidly as a result of its ability to exploit a wide range of habitats from saline through to arid areas, the female's ability to lay up to 20,000 eggs twice a year, and the fact that all life stages are poisonous. Because of its poisonous nature, the ramifications to the ecology of wetland areas in northern Australia such as Kakadu and the Gulf of Carpentaria are thought to be significant once the cane toad establishes.

Presently the cane toad is not in the Gove Peninsula, but it is anticipated that it will have naturally moved into the area in the next few years. However the movement of humans and goods from infested areas has the potential to spread them and speed up the colonisation of new areas. Additionally land use practices that create corridors also facilitate their spread.

A Northern Territory Parliamentary Committee has recently prepared a report on cane toads to the Northern Territory Legislative Council. It has made recommendations to arrest the toad's westward spread. Alcan Gove will adopt relevant recommendations from this report where appropriate. This will include imposing strict controls and quarantine inspections on all vehicles and equipment brought to the site as part of the expansion project. Additionally, in advance of the potential establishment of cane toads in the area, an audit of the refinery site will be conducted to identify potential breeding sites.

15.3.6 Significant Fauna Species and Habitats

15.3.6.1 Overview

The majority of the fauna species recorded or expected within the study area are widespread in either tropical northern Australia or other areas of the Australian mainland, while a small number of species are restricted to the region or have disjunct populations in northern Australia.

The conservation significance of species occurring in the Gove region was assessed with reference to the *Territory Parks and Wildlife Conservation Act 2000* and the Commonwealth *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act). Under these items of legislation, threatened species may be classified as Critically Endangered, Endangered, Vulnerable or "near-threatened". These classifications are derived from the internationally recognised IUCN "Red Data" lists, however the classifications of species at a national and state level are not necessarily consistent, reflecting their national or regional (Territory) importance.

In addition to the threatened species, the EPBC Act 1999 also includes a list of migratory species. These species are those which are listed under the following international agreements to which Australia is a signatory nation:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Convention on the Conservation of Migratory Species of Wild Animals - (Bonn Convention).

Under the EPBC Act (1999), Australia has an international obligation to protect significant populations and significant sites for these species.

15.3.6.2 Threatened Species

Within the wider Gove region, a total of 25 fauna species (including marine turtles) are listed as threatened under NT or Commonwealth legislation (Appendix E9). These include one amphibian, two marine turtles, eight birds, nine mammals and one invertebrate species under the Northern Territory legislation. Commonwealth legislation lists six marine turtles, three birds and two mammals.

Amphibians

One amphibian, the wood frog, is listed under NT legislation as Vulnerable. This species, which is widespread in New Guinea and far northern Queensland, was first recorded in the Gove area in 1990, and is not known elsewhere in the NT. It is known from only four sites in eastern Arnhem Land, in riverine areas where there is dense vegetation, typically rainforest (Woinarski, 2002b). The lack of such habitat within the study area means that it is unlikely that this species would be present.

Reptiles

The only listed threatened reptiles recorded for the Gove region are the six species of marine turtles (Appendix E9). Of these, both NT and Commonwealth legislation list the loggerhead turtle (*Caretta caretta*) as Endangered, while the Olive Ridley (*Lepidochelys olivacea*) is also listed as Endangered under Commonwealth legislation. All other species are regarded as Vulnerable. Further discussion of marine turtles is given in Section 14.

Birds

The only Endangered bird species recorded in the Gove region is the Gouldian finch (*Erythrura gouldiae*). The Gove area is not a noted habitat for this species, although there is a recent (1991) record for the Cape Arnhem area (Gambold et al, 1995). It is considered unlikely that this species currently occurs on the Gove Peninsula. One Vulnerable bird species, the red goshawk (*Erythrotriorchis radiatus*) has been reported from the region, with historical (1948) records from the Gove Peninsula (NT Fauna Atlas). There have been no recent records of this species in the region, but the possibility of it occurring in the area cannot be discounted.

Five other threatened bird species occurring in the Gove region have been classified in the lowest category of "near threatened" under NT legislation (Appendix E9). Of these species, only the bush stone curlew (*Burhinus grallarius*) is considered likely to occur within the study area.

Mammals

Of the eight terrestrial mammal species classified as threatened (Appendix E9), two are of particular interest. The golden bandicoot (*Isoodon aurantus*) (Endangered – NT; Vulnerable – Commonwealth) is known in eastern Arnhem Land from three specimens collected at Yirrkala in 1939. It is now considered extinct in the region apart from a population on one of the Wessel Islands (Woinarski, 2001).

The northern hopping mouse (*Notomys aquilo*) is regarded as Vulnerable at both Territory and Commonwealth levels. This species is known only from eastern Arnhem Land and Groote Eylandt. Recent survey work in the Cape Arnhem area suggest that this species is locally common in the region in areas of extensive coastal sand dune habitat (Gambold et al., 1995; Woinarski et al., 1999; Nanakiya Mununggiritj, pers. comm.). Searches of coastal dune habitat within the study area failed to locate any tracks of this species, and it was not trapped in the area (although it is reported to be difficult to trap). Suitable habitat for this species does occur within the study area, but it is very minor in extent, heavily disturbed and may suffer from dingo and feral cat predation.

Invertebrates

One Endangered (NT) species of invertebrate occurs in the Gove region, the Gove crow butterfly (*Euploea alcathoe enastri*). This is a large black butterfly with white dots on the wing tips. It is known from four locations in the Gove region, one of which is near Yirrkala. At all locations, the habitat has been reported as tall monsoon forest associated

with groundwater seepage. The larval food plants may include a local milkweed (*Tylophora benthamii*). Cited threats to this species include increased fire threat to monsoon patches, spread of mission grass (*Pennisetum polystachion*), and infestations by the yellow crazy ant (*Anoplolepis gracilipes*) (Wilson, 2002).

Gove crow butterflies were not observed in the coastal vine thickets surveyed in the current study, although the similar two-brand crow (*Euploea sylvester*) was commonly seen. Given the lack of tall, wet monsoon forest, it is doubtful that this species is present in the study area.

15.3.6.3 Migratory Species

Migratory species occurring in the Gove region (as defined by the EPBC Act 1999) include estuarine crocodile, 6 species of marine turtle, 43 bird species and two marine mammals (Appendix E9). The migratory bird species can be further classified into seabirds (10 species), shorebirds/waders (24 species) and land birds (9 species) (Appendix E9).

The Gove area is not considered to be a significant area for migratory birds. There are some important sites in the region such as Bremer Island and Higginson Inlet, however these are remote from the refinery and are not affected by its operations.

Habitats important for migratory species in the area are chiefly marine, and include beaches and mudflats (waders), open water bays and rocky islands (seabirds), and seagrass beds and beaches (dugongs and turtles). The migratory land birds include raptors, aerial species, flycatchers and fantails. The latter two groups are chiefly associated with closed forest habitats, such as vine thicket and mangroves.

15.3.6.4 Significant Sites or Habitats

Terrestrial habitats occurring within the study area are considered to be generally of low conservation value because they are small in area, disjunct and disturbed. The narrow fringe of coastal vine thicket present in several areas of the site is habitat for some more specialised species, but the quality and extent of this habitat is poor. Beach dune habitats in the area may hold populations of the Vulnerable northern hopping mouse, but investigations so far have not located the animal there. The open forest habitats have a potentially high diversity of species, but most of these species are widely distributed as this is a very common habitat in the coastal Northern Territory. The proposed construction workforce accommodation site is typical of this type of open forest habitat, which has regenerated over approximately 30 years.

15.3.7 Impact Assessment

15.3.7.1 Habitat Quality

Existing fauna habitats within the refinery and residue disposal areas include *Eucalyptus tetradonta* dominated open forest, *Melaleuca* dominated freshwater swamp, coastal monsoon vine thicket, mixed woodland on beach dunes, mangroves and other littoral habitats. These habitats are very restricted in size, and are degraded by various human activities and feral animals. The 5 ha site at Nhulunbuy which is proposed as the construction workforce accommodation village consists of regrowth open forest habitats typical of those found commonly in the region. No significant sites for fauna are known in any of these areas.

The proposed expansion project will not result in the loss or degradation of wildlife habitats within the refinery or residue disposal areas, since most of the project components will occupy previously cleared areas within the lease. The area to be cleared for the workforce construction accommodation site in Nhulunbuy consists of regrowth

habitat. Existing impacts on the fauna living in these areas will likely continue following the proposed expansion, but no additional impacts are expected.

15.3.7.2 Noise

Existing refinery noise levels in the small patches of mixed forest on the coastal dunes along the refinery's western boundary are probably sufficient to cause some fauna species, such as birds, to avoid use of the area. Results of bird surveys conducted in this area showed it to be the least diverse of four sites sampled. As discussed in Section 10.5, no significant noise increases are expected as a result of the refinery's expansion and hence no additional noise impacts on fauna in this area are likely.

15.3.7.3 Dust

Alumina dust from the conveyor, silos, transfer points and calciners drifts westward across the refinery and settles in the small mixed forest patch along the western boundary. Vegetation in this area is affected by fine white dust which also covers the ground in this area. Trapping for small mammals and reptiles at this site produced no results, and only one ground dwelling lizard was observed there. As this area already has poor habitat value and has few fauna species, any additional impacts from the refinery's expansion will be minimal.

15.3.7.4 Road Casualties

Road-killed animals were reported occasionally along the Melville Bay Road, especially where the road is near vine thickets. Species reported to have been killed include northern brown bandicoot and agile wallaby. The proposed expansion will not result in any significant increase in traffic along this road except during the construction phase when traffic will increase by an average of approximately 130 trips per day. However, as the incidence of existing fauna road fatalities is reported to be low, no significant increase in road-kills is expected during the 30 month construction phase. During the operations phase, there is unlikely to be any change from the current situation.

15.3.7.5 Habitat Fragmentation

The existing refinery and red mud ponds cover substantial areas of the western end of Gove Peninsula. The remaining natural areas within the lease have been fragmented by the developments, such that only the narrow coastal strips, and an area of open forest south of the RDA, now remains. Perimeter fencing and tracks, especially along the northern beachfront has fragmented the narrow vine thicket habitat through this area. In general, the fragmented habitat reduces fauna diversity by preventing local movements of some species, and by reducing the integrity of already small vine forest patches. No additional habitat fragmentation will occur as a result of the refinery's expansion.

15.3.7.6 Feral Animals

The refinery expansion will not affect the distribution and abundance of existing populations of feral animals within the study area. Feral cats occur in the area and these animals have an impact on the abundance of small mammals and birds. As the construction workforce will be prohibited from bringing pets on site, the refinery's expansion will not have any significant impact on the existing feral cat population.

Owing to the wide variety of national and international locations from which plant and equipment for the expansion project may be transported, there is potential for exotic animal pests to be introduced or spread to the refinery site. This risk will be controlled by a regime of inspection, quarantine and worker education and these strategies are outlined in the draft fauna management plan (Section 25).

The existing pilot program to control the yellow crazy ant will be continued. If successful, the techniques developed will be applied to other outbreaks on the Gove Peninsula/East Arnhem Land.

The recommendations from the report of the Northern Territory Parliamentary Committee on cane toads will be adopted where appropriate. This will include imposing strict controls and quarantine inspections on all vehicles and equipment brought to the site as part of the expansion project. Additionally, in advance of the potential establishment of cane toads in the area, an audit of the refinery site will be conducted to identify potential breeding sites.

15.3.8 Management

The following commitments have been made to manage environmental risks particularly those associated with the introduction/spread of animal pests:

- Regular monitoring of fauna habitats within the study area will be undertaken during and after construction. The objectives of this monitoring will be to augment the current information of fauna species in the area (including seasonal variations), to assess the level of impact from the construction and/or operational activities, and to monitor the effectiveness of the management strategies outlined in the strategic fauna management plan (Section 25). The effectiveness of the monitoring program will be reviewed within two years of the expanded operations commencing.
- Quarantine inspections for all vessels entering Australian waters from overseas is the responsibility of the AQIS, and although this is normally undertaken by customs officials, Alcan Gove personnel will also monitor incoming vessels and equipment for non-compliance with Australians quarantine requirements and conduct inspection for potential pests. If pests are detected, AQIS will be notified for cargos originating from international waters and the Department of Primary Industries and the PWCNT will be notified for cargoes originating from within Australia.
- The mine site, roads and other corridors will be surveyed for yellow crazy ants and any nests identified will be quarantined and treated. Vehicles and equipment leaving the site will be inspected for residue soils/active ants. If present, ants will be treated and the excess soil will be washed from the vehicles.
- The existing pilot program to control the yellow crazy ant will be continued. If successful, the techniques developed will be applied to other outbreaks on the Gove Peninsula/East Arnhem Land.
- An audit of the refinery will be conducted to identify potential shelter, feeding and breeding habitats for cane toads. Appropriate action will be undertaken to reduce the suitability of the areas.
- An education program aimed at raising awareness and identification of cane toads, yellow crazy ants and other exotic fauna will be conducted with the refinery's construction and operational workforce.
- The construction workforce will be prohibited from bringing pets onto the site.

Strategies for the management and monitoring of fauna effects are given in the draft management plan in Section 25.

15.4 Biting Insects

15.4.1 Previous Studies in the Nhulunbuy Area

Mosquitos and biting midges can reach sufficiently large numbers in various localities on the Gove Peninsula to be considered serious pests. While mosquitos and midges can show considerable host preference for a particular species, others are more indiscriminate taking blood meals from a variety of hosts. The bites themselves can be

painful and annoying with humans and animals suffering varying degrees of reaction. Some people become sensitive to further bites and suffer further reaction from additional bites. This can lead to restlessness, loss of sleep, and even secondary infections and scaring if bites are scratched.

Of greater concern is the potential spread of disease including several viruses (Ross River, Barmah Forest, Kunjin, Murray Valley Encephalitis, Japanese Encephalitis) and pathogens (eg. malaria) (Booth et al., 1988; Whelan, 1988, 2002; LGAQ, 2002). Often it is non-human animal sources that are reservoirs for disease within the environment and it is the mosquitos that are indiscriminate feeders that are responsible for the spread of disease from animal to human hosts early on in the case of an infectious outbreak. However, in Australia, biting midges do not carry any pathogens that cause human disease.

The Medical Entomology Branch (MEB) of the Territory Health Services in conjunction with the Nhulunbuy Corporation conducts weekly adult mosquito trapping at Nhulunbuy and also at Wallaby Beach. Mosquito trapping in the area has been performed over the past 11 years. The Gove District Hospital undertakes this trapping and collected samples are sent to the MEB for identification, comment and control (Wilson, 2002).

The MEB has also conducted four field inspections and prepared three reports (Wheelan & Hayes, 1992; Montgomery & Love, 1995; Wilson, 2000), with another currently being prepared. From a human health perspective, three of the most problematic mosquito disease vectors namely *Culex annulirostris* (*Cu. annulirostris*) Common Banded Mosquito, *Anopheles farauti* (*An. farauti*) Australia Malaria Mosquito and *Ochlerotatus vigilax* (*Oc. vigilax*) Saltmarsh Mosquito have been identified breeding on the Gove Peninsula (Table 15.4.1). Others mosquito species have been identified from trapping and larval surveys. However these have been in much reduced numbers and, while they are potential disease vectors, they are generally considered of lower disease risk.

Owing to the significant quantity of data available for the Gove area, a specific biting insect survey has been deemed to be unnecessary. The results of the previous surveys are summarised in Table 15.4.1.

Table 15.4.1
Characteristics of the Primary Problematic Mosquito Species on Gove Peninsula

Mosquito Species	Preferred Breeding SIte s	Concern or Risk	Recorded Breeding Location on Gove Peninsula	Comment
Anopheles farauti	Freshwater preferred, though does breed in brackish water; temporary and permanent pools, streams and along edges of wetlands. Will also use artificial containers.	Potential Australian Malaria vector.	Buffalo Creek, Nhulunbuy; saltmarsh to the west of Dimbuka Rocks, south of RDA pond 3 (headwaters of Macassar Creek).	Seasonally high numbers are prevalent. Presence of the mosquito and large cosmopolitan, transient population in Nhulunbuy is a significant risk for reintroduction of Malaria into the Northern Territory.
Culex annulirostris	Less ephemeral freshwater wetlands and surface depressions associated with vegetation. Breeding can be prolific in low lying areas that hold water for a few weeks following heavy rain.	Vector for Ross River, Barmah Forest, Japanese Encephalitis Murray Valley Encephalitis, Kunjin and Heart Worm in dogs.	Nhulunbuy Sewage Treatment Ponds.	Mount Saunders STP was previously identified as a breeding site, however this facility has been closed and the pond filled in. Major vector for Ross River and Barmah Forest in coastal NT.
Ochlerotatus vigilax	Coastal saltmarsh flats and brackish artificial and natural temporary pools flooded following heavy rains or during high tide	Ross River, Barmah Forest, Heartworm.	Wallaby Beach – Crocodile Creek and reclaimed red mud ponds on Special Lease 270; Buffalo	Historically the security pond at the RDA was a significant breeding site, but this has diminished owing to the upgrade of the facility to a retention pond thus diminishing

Mosquito Species	Preferred Breeding SIte	Concern or Risk	Recorded Breeding Location on Gove Peninsula	Comment
	events. Eggs layed on moist or drying muds and on the bases of saltmarsh plants.		Creek, Western Mud Flats including the tidal flats east of Woody Creek.	breeding potential (Wilson, 2000); high numbers trapped seasonally at Wallaby Beach. Major vector for Ross River and Barmah Forest in coastal NT.

Data from Wilson, 2000; Montgomery & Love, 1995; Whelan & Hayes, 1992; LGAQ 2002.

15.4.2 Mosquito Breeding at Gove Peninsula

Cu. annulorstris is a major pest and vector for the epidemic polyarthritic diseases Barmah Forest Virus and Ross River Virus, Japanese Encephalitis, Murray Valley Encephalitis and Kunjin. Additionally it is a major vector for the spread of heartworm in dogs. The Common Banded Mosquito breeds in lightly brackish freshwater wetlands particularly those with significant emergent and fringing wetland vegetation. In Gove it has previously been identified that the Nhulunbuy and Mt. Saunders sewage ponds, Nhulunbuy Lagoon and the depression east of the Drimmie Heads causeway (Whelan & Hayes, 1992; Montgomery & Love, 1995).

An. farauti is a potential vector for the spread of malaria and was the major vector for the disease in the Northern Territory until 1962 when the disease was eradicated from the population. Whilst *An. farauti* is the major potential vector, all human communities exposed to *Anopheles* spp. mosquitos are vulnerable to malaria. *An. farauti* breeds in brackish waters and has been identified breeding in Buffalo Creek, Freshwater Creek, and in tidal wetland 100 m west of Dimbuka Rocks (Booth et al., 1988; Wilson, 2000).

The Saltmarh Mosquito *Oc. vigilax* is a major pest and vector for the polyarthritic diseases Barmah Forest Virus and Ross River Virus and is a major vector for the spread of heartworm in dogs. *Oc. vigilax* has extensive breeding habitat within the area including Wallaby Beach, Crocodile Creek, Buffalo Creek, Rainbow Cliff Creek and the Western Mud Flats and the tidal flats of East Woody Creek (Whelan & Hayes, 1992; Montgomery & Love, 1995; Wilson, 2000).

15.4.3 Mosquito Breeding Issues Relating to the Alcan Operations

Historically several aspects of the refinery's operations have been identified as potentially facilitating the establishment of suitable mosquito breeding habitat. These have included the residue disposal ponds, Wallaby Beach sewage ponds, the duck ponds and the water treatment facility pond. Larval surveys by Montgomery & Love (1995) and Wilson (2000) indicated that these ponds were not significant breeding sites. The water treatment facility pond was previously identified by Whelan & Hayes (1992) as a significant site for *Oc. vigilax* breeding, primarily as a result of fringing semi-aquatic vegetation. However this vegetation has since been removed through chemical control (herbiciding) thus removing breeding sites.

Larval sampling within the headwaters of Macassar Creek identified the presence of significant numbers of *Cu. annulirostris* (Montgomery & Love, 1995; Wilson, 2000) a freshwater breeding species.

Montgomery & Love (1995) identified the revegetated Taylor's Pond and Northern Pond area as a significant *Oc. vigilax* breeding site after significant rainfalls. As the landform in this area is essentially a level plateau, ponding of water can occur within low lying parts of the finished surface particularly areas where the topsoil had eroded away. Following ponding, the pooled water can provide a suitable breeding habitat for *Oc. vigilax*. However since then, works have been undertaken by Alcan Gove to reduce these breeding sites. These works have included removal of vegetation from the drains, provision of rubble to reduce open ponded water, and some filling of localised depressions.

15.4.4 Impact Assessment

15.4.4.1 RDA

As part of the refinery expansion, process liquor will be neutralised at the refinery before being pumped to the RDA. This process will enable the inventory of stored water in the RDA to be reduced as its quality will be improved, thus enabling it to be discharged to the marine environment. This will result in the conversion of the existing highly alkaline freshwater system at the RDA to a slightly alkaline saline system with significantly less stored water.

The existing RDA consists of active cells or ponds into which the refinery residue is stacked. Excess water runs off the residue stack, as does stormwater, and is stored in the ponds from where it either evaporates, is pumped back to the refinery for reuse, or is pumped to the waste water treatment facility pond for neutralisation and discharge. The ponds in which this water is stored are all deep and steep sided without any emergent aquatic vegetation or fringing terrestrial vegetation. Although water within the circuit is fresh, potential breeding sites for freshwater mosquitos, particularly *Cu. Annulirostris,* are low owing to the hostile environment (high alkalinity and absence of aquatic plants).

Although the proposed waste water treatment process will eventually result in a change of water quality in the RDA from fresh to saline conditions, it is not expected that the RDA will become a breeding area for the saltmarsh mosquito (*Oc. Vigilax*) either during normal operations or following heavy rainfall events. Breeding is unlikely as ongoing residue disposal practices will ensure that water is not allowed to pool, areas will be regularly disturbed by the ongoing disposal operations, the water although of a salinity potentially favourable to *Oc. vigilax* will have a moderate alkalinity, and there will continue to be a general absence of fringing vegetation. The pH of waters in which larval and pupal forms develop is less important than other environmental factors such as temperature and salinity (Lee et al., 1984). Notwithstanding, the pH tolerances of *Oc. vigilax* in tropical waters have been given as pH 5.2-8.4 (Lee et al., 1984 cited Laird 1956). Given that the pH at the RDA will be of the order of 8.5, conditions for mosquitos will be generally unsuitable and significant breeding events are considered unlikely. Notwithstanding this, Alcan Gove will review the potential for mosquito breeding within the RDA annually with the Nhulunbuy Corporation and the Medical Entomology Branch.

To minimise the risk of the RDA becoming a breeding site, encroaching emergent and semi-aquatic vegetation will be eradicated if it establishes. Vegetation will be controlled by mechanical removal or chemical (herbicide) control. Larval monitoring and adult trapping will be implemented during the wet season if problematic and, where necessary, appropriate control measures will be implemented in consultation with MEB and the Nhulunbuy Corporation. The existing larval control activities and adult fogging of the area west of Dimbuka Rocks by the Nhulunbuy Corporation will continue. Adequate health and safety conditions are incorporated into the contract that Alcan Gove has with the Nhulunbuy Corporation for this task.

15.4.4.2 Refinery Stormwater Management

Existing stormwater management procedures within the refinery have not resulted in the development of any significant mosquito breeding sites.

Stormwater management and water discharge facilities at the refinery include two stormwater runoff ponds and the refinery discharge channel. The two refinery stormwater ponds are both steep sided. The western pond has vertical concrete lined banks and the southern pond is clay lined with a batter of 1:2. Neither emergent vegetation nor bankside vegetation is present. The discharge channel has vertical concrete walls with high temperature water which is continually flowing. All are hostile environments for mosquito larvae.

A sedimentation pond is located at the bauxite stockpile area. This drains to Stockpile Creek which discharges into Melville Bay. No concerns have been raised in the past over the potential for mosquito breeding in this area. The channel of the creek and pond are shallow with some aquatic plant development although extensive fringing vegetation is generally absent. Of all the water bodies on the site, this has the most potential as a mosquito breeding site. However the Nhulunbuy Corporation has investigated breeding within the creek in the past and no significant breeding was detected (T. O'Riley *pers comm.,* 2 September 2003).

The refinery expansion will not result in any significant changes to the existing stormwater ponds or the discharge channel. However, additional water quality control ponds may be developed in future. These will be deep and steep sided and no fringing aquatic vegetation will be allowed to become established. As with the existing stormwater ponds, these ponds are not expected to be a mosquito breeding site.

During construction, care will be taken to ensure that earthworks will not result in areas for water to pond. If any such areas do occur, they will be filled as soon as they are identified and contoured to prevent further ponding. Similarly management plans will ensure that all rubbish that could become a breeding site following rain will be removed form the site.

15.4.4.3 Construction Camp and Borrow Pits

Consideration of mosquito management has been based on Whelan (1988). All borrow pits under the control of Alcan will be graded regularly to prevent ponding of water for significant periods following rain. Borrow pits will not be sited within the intertidal zone and care will be taken to ensure that they are not developed in areas where there is a risk of intersecting the groundwater table. All overburden will be deposited in an area that will not impede natural drainage and will be shaped to prevent ponding.

The proposed construction workforce accommodation facility, although within the catchment of the Town Lagoon, a known mosquito breeding area, is more than 1.6 km from it[2]. Its development is unlikely to result in additional stormwater flows or dry season flow. Stormwater runoff will be managed by diverting it into natural drainage lines to ensure that additional breeding sites are not created. Additional control measures to be incorporated include:

- Where sub-surface drainage is not used all drainage channels/spoon drains will be kept as shallow as possible to prevent ponding;
- Rock bars will be placed in the channels to trap sediment to prevent the development of downstream, offsite impediments to stream flow and sites where emergent plants could establish;
- The drainage line will be developed to facilitate easy access and monitored and maintained regularly to remove silt and prevent water ponding;
- All landscaping (if developed) will be watered by an automatic, timed system to prevent any potential run-off;
- Natural drainage lines will not be impeded by fill unless piping is installed; and
- Regular inspection and cleanup of potential breeding receptacles (rubbish, tyres, drums etc.).

Sewage from the construction accommodation facilities will be diverted to the existing sewer system for treatment at the Nhulunbuy Sewage Treatment Plant. Nhulunbuy Corporation already co-ordinates larval and adult monitoring of the treatment plant in conjunction with the Gove District Hospital and the Medical Entomology Branch, and it undertakes management of the ponds to minimise mosquito breeding sites (eg. aquatic and semi-aquatic plant removal) and undertakes regular mosquito control.

[2] The Mount Saunders Primary Effluent Pond a confirmed breeding site for *Cu. annulorostris* has since been decommissioned, filled in and rehabilitated (T. O;Riley *pers comm.,* 2 September 2003).

15.4.4.4 Worker Education and Personal Protection

A cosmopolitan, temporary construction workforce has the potential to not only be unaware of potential health risks associated with mosquito borne arbovirus transmission, but to be vectors for arboviruses themselves either bringing disease to Nulunbuy or transporting it to their own or other communities. Therefore education of all construction contractors working on the project will be a priority.

Significant mosquito periods are the late dry and early wet seasons for the saltmarsh mosquito and wet and post-wet when lagoons and wetlands are full for other species. Workers will be instructed to be especially vigilant during these periods through the use of long sleaved shirts and trousers, avoidance of going outside at sundown, and the regular use of insect repellent with a high DEET. Insect repellent will be provided at work sites. All construction accommodation facilities will be screened and air conditioned and external street lighting will be fitted with yellow bulbs to discourage mosquitos. Insectocution devices may also be installed in area where large numbers may congregate.

15.4.5 Management Plan

Strategies for the management and monitoring of mosquitos are given in the draft management plan given in Section 25.

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ALCAN GOVE REFINERY EXPANSION
ENVIRONMENTAL IMAPCT STUDY

VEGETATION COMMUNITIES
REFINERY AREA

Project No.	12373-021-559	Date :	29-01-04
MapInfo File No.	12373-021-g-026e.wor	Revision:	E
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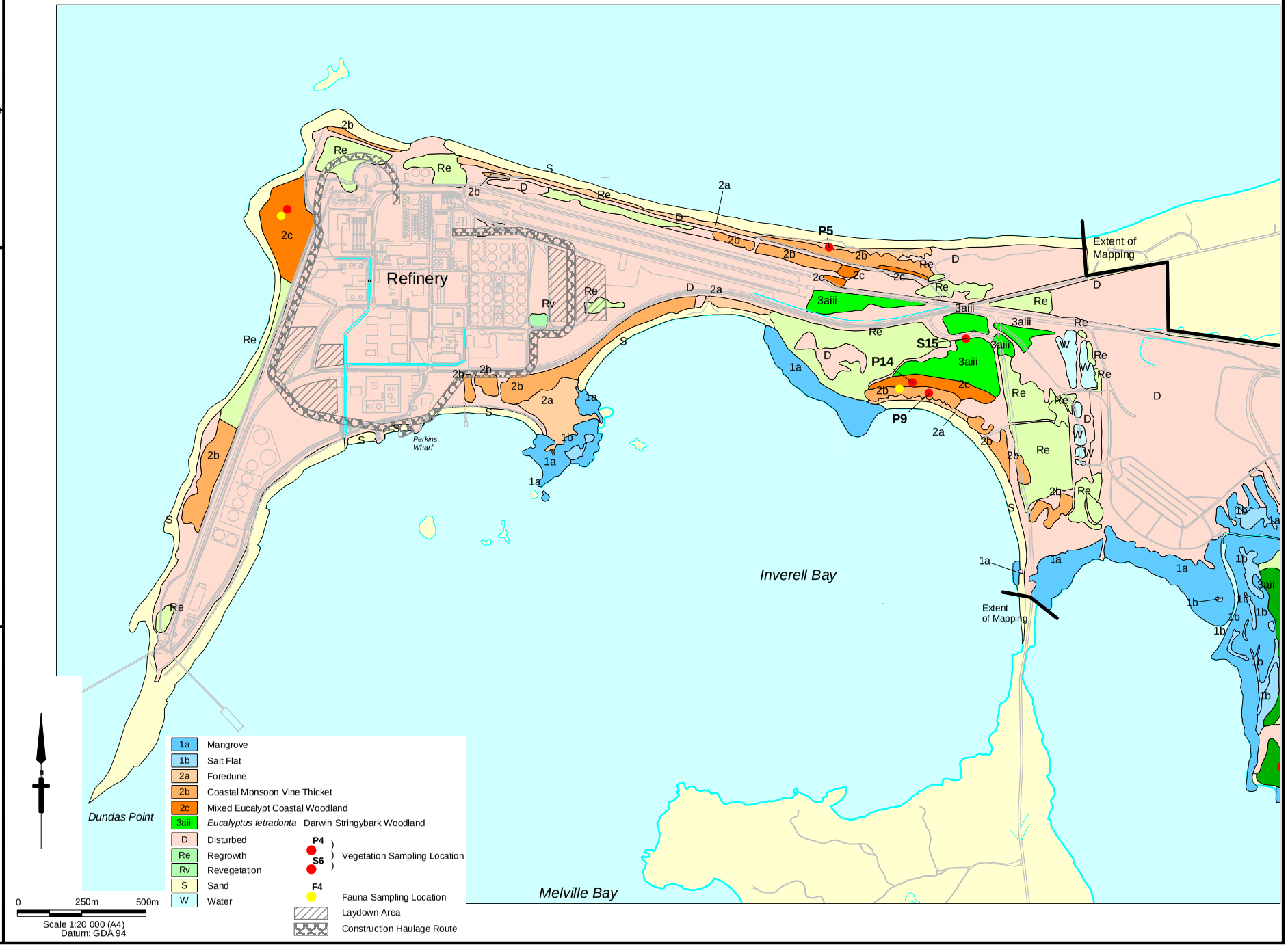
Figure: **15.2.1**



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VEGETATION COMMUNITIES
RESIDUE DISPOSAL AREA

Figure: **15.2.2**