13.1 Background

Alcan Gove's operations interact with the local marine environment (marine water, seabed, flora and fauna) principally via the refinery outfall discharge. The other area of potential influence on the marine environment is through shipping operations and the associated transfer of products and raw materials.

This section assesses the current and potential impacts of the proposed expansion on marine water quality and sediment, and outlines how these potential impacts will be mitigated. The related potential impacts on marine biology and mitigation measures are discussed in Section 14.

13.2 Monitoring/Investigation Program

The description given in this EIS of marine water and sediment quality of the shallow nearshore waters surrounding the operations is drawn from the various Alcan Gove monitoring programs discussed below.

13.2.1 Routine Monitoring Program

Routine water quality monitoring is undertaken by Alcan Gove at sites around the Gove Peninsula shoreline.

The program includes monitoring of discharges to the marine environment and of receiving waters at a number of locations including reference (low impact) sites (eg. Dundas Point and the seawater intake) and impact sites (eg. the refinery outfall and Northern Beach). Since 1993, all data obtained has been entered on the Alcan Gove environmental database (ENVSYS).

Alcan Gove reports annually to the Northern Territory Government on the results of its monitoring program as a condition of its waste discharge licence issued under the *Water Act 1992*. The sampling program for the licence monitoring sites is summarised in Table 13.2.1. The locations of the sampling sites are given in Figures 11.2.1 and 11.2.2.

Table 13.2.1
Waste Discharge Licence Sampling Program

Parameter	S004 Seawater Intake	S001 Refinery Outfall	S1006 Macassar Creek	S010 Northern Beach	S006 Stockpile Creek	S034 Light Fuel Tank Farm	S1001 Duck Pond Weir
Temperature	monthly	daily	monthly	n/s	n/s	n/s	n/s
pH	"	"	"	monthly	monthly	monthly	monthly
Conductivity	"	"	"	"	"	"	"
Turbidity	"	"	"	"	"	"	"
Alkalinity	"	"	"	"	"	"	"
Phosphorus	"	monthly	"	"	"	"	"
Nitrogen	"	"	"	"	"	"	"
Aluminium	"	"	"	"	"	"	"
Arsenic	"	"	"	"	"	"	"
Vanadium	"	"	"	"	"	"	"
Flow Rate	n/s	daily	n/s	n/s	n/s	n/s	n/s

n/s not surveyed

13.2.2 Additional Monitoring Programs

In addition to the routine monitoring program, Alcan Gove has commissioned a number of other investigative programs, in some cases incorporating follow-up surveys, focussing on water and sediment quality in areas where an impact may have already occurred or may occur in the future. More general surveys of the physical and chemical characteristics of marine sediment have also been undertaken in conjunction with the habitat surveys for this EIS.

Relevant investigations are outlined below.

13.2.2.1 Refinery Outfall

In 1991, a marine water and sediment survey was undertaken in Gove Harbour and at a number of reference sites to identify the potential impacts of the refinery outfall discharge on marine water and sediment quality adjacent to the refinery outfall (McConchie and Saenger, 1993).

Follow-up sediment surveys were undertaken in 2000 (URS, 2001a) and 2002 (URS 2003b) to assess the effect on benthic biota. A survey of the discharge plume water quality characteristics was undertaken in 2001 (URS, 2001f).

13.2.2.2 Groundwater Seepage (Northern Beach)

A survey of intertidal sediments and biota at and adjacent to the site of groundwater flow at the beach to the north of the refinery (Northern Beach) was undertaken in 1995 (LDM, 1995). A follow-up survey was undertaken in 2000 (URS, 2001c). Sediment samples were collected during these surveys to determine whether the sediments were affected in any way by discharges from the refinery and whether these changes in sediment characteristics had the potential to affect marine life. In both surveys, no effect on marine life in the area was detected.

13.2.2.3 Drimmie Arm

In April 1999, as a result of extremely heavy rainfall, a bund wall was breached to allow the controlled release of stored water from a water treatment storage pond at the Residue Disposal Area (RDA) into Drimmie Arm (Section 11.3.2.5). Water and sediment surveys of the affected area were undertaken immediately following the release to determine the area of effect of the discharge (LDM, 2000). A follow-up survey was undertaken in 2000 (URS, 2001e) to ascertain whether any residual effects of the release could be detected in sediments or biota. This survey found:

- No exceedance of water quality guidelines (ANZECC, 1992) in Drimmie Arm;
- Arsenic, gallium and vanadium were undetectable in the water while their concentrations had declined in the sediments;
- Partial recolonisation of the sediments by worms and crabs;
- No traces of precipitate on the leaves, trunks or aerial roots of the mangroves at any site; and
- No evidence of stress features of large-scale defoliation of mangroves at any sites inspected.

The survey report concluded that metal concentrations in the sediments would continue to decline with re-suspension of the precipitate, and that there would continue to be a slow recovery of benthic organisms in the northern end of Drimmie Arm.

13.2.2.4 Background Marine Sediment Quality Survey

A survey of the seabed sediments in Gove Harbour was undertaken in 2002 (URS, 2003b). The parameters analysed included metals, hydrocarbons, particle size and total organic carbon.

13.3 Standards

13.3.1 Water Quality

The Northern Territory Government has declared that the "beneficial uses" of the waters of Southern Melville Bay be "Protection of Aquatic Ecosystems, Recreation and Aesthetics". There are no current established water quality criteria for Melville Bay. The beneficial use declaration provides a general guide to the expectations for the water quality in Melville Bay.

Melville Bay in the vicinity of the RDA and the refinery can be described as a slightly to moderately disturbed ecosystem. The ANZECC (2000) water quality guidelines have identified that water and sediment quality in these ecosystems should be managed to protect at least 95% of all marine species. Guidelines are also provided for various levels of recreational use (eg. primary and secondary contact) and for the protection of aesthetic values. In order to achieve the required level of species protection, the ANZECC guidelines have established default water quality trigger values. If water quality concentrations exceed the trigger values, the guidelines recommend that the issue be investigated. For the purposes of this EIS, the ANZECC default trigger values have been used to help define the potential area of impact from the refinery discharge. In line with ANZECC requirements, Alcan Gove will finalise locally applicable trigger values by December 2004.

13.3.2 Sediments

Interim sediment quality guidelines for Australian marine sediments are also presented in ANZECC (2000). 'Low' and 'high' trigger concentrations are proposed for a range of metal contaminants. The low trigger value is defined as the concentration below which there is a low risk of adverse biological effects and for which continued monitoring (in low risk situations) or further ecosystem-specific investigations (in high risk situations) may be required. High trigger levels are concentrations at which toxic effects on organisms are probable if all of the contaminant is in a biologically available form. The biological availability of contaminants is dependent on a range of chemical and biological factors that can occur in undisturbed and modified environments. The ANZECC (2000) guidelines use the total concentration of a contaminant which is a conservative means of eliminating metals that are not of concern and identifying those that may warrant an investigation. The trigger values have been developed for broad application throughout Australian waters and do not take account of natural variations from one location to another. An exceedance of a trigger level is therefore not an automatic indication of an environmental impact.

13.4 Current Marine Water Quality

13.4.1 Region

Regional water and sediment quality in nearshore waters is influenced by seasonal runoff. The influence of terrestrial inputs on the nearshore marine environment is determined by geology and land use in the catchment. The volume of the discharge, coastal morphology and nearshore circulation patterns largely determine the area affected by the inputs.

There are few anthropogenic inputs to the marine environment (Munksgaard & Parry 2002). Uses of Melville Bay include:

- Shipping related to the Acan Gove refinery;
- Commercial cargo operations;
- Gove Yacht Club;
- Recreational fishing and boating; and
- Traditional fishing and food gathering.

13.4.2 Gove Harbour Water Quality

For the purposes of this review, water quality data from the Alcan Gove environmental database for the five-year period 1998 to 2002 (inclusive) was reviewed.

Background water quality for Gove Harbour has been derived from data from the monitoring sites located at the Seawater Intake (Site S004) and Dundas Point (Site S036) (Figure 11.2.1). These are located on either side of the refinery outfall. Both sites however show indications of being influenced by the outfall, as indicated by elevation in temperature and some metal concentrations and hence do not represent “true” background values. Because of this, median rather than 80^{th} percentile of ‘background’ values have been used for temperature and suspended solids and 95^{th} percentiles for metals and organic compounds.

The seasonal variability in water quality at the discharge site (Refinery Outfall) and the two Gove Harbour background sites (Seawater Intake and Dundas Point) has been reviewed for the period 1998 to 2002. For the purpose of this review, the year has been divided into a wet season extending from December to March and a dry season from April to November. The short transition seasons that immediately precede and follow the wet season have been included in the dry season period. The key water quality parameters at each of the background sites and at the refinery outfall are presented in Table 13.4.1.

Table 13.4.1
Dry and Wet Season Values for Key Water Quality Parameters

Parameter	Dundas Point (Background)		Seawater Intake (Background)		Refinery Outfall (Discharge)	
	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Temperature (^oC)	n/d	n/d	29	31	44	46
TSS (mg/L)	24	14	15	30	98	89
Aluminium (µg/L)	16	9.3	33	27	53	101
Arsenic (µg/L)	5	5	5.4	5.2	20	6.1
Vanadium (µg/L)	6.6	4.3	17	8.1	104	92

The effect of the refinery discharge on the water quality of Gove Harbour has been modelled. The results of the modelling are discussed in Section 13.7.1.4.

13.4.3 Drimmie Arm Water Quality

Runoff from the Northern and Taylor's Pond areas flows via the Duck Pond into Drimmie Arm. This discharge is intermittent flowing only after rain events primarily during the wet season.

A survey of Drimmie Arm undertaken in April-May 2000 (URS 2001e) indicated the following:

- No exceedance of the relevant water quality guidelines (ANZECC, 1992); and
- Arsenic, gallium and vanadium were undetectable in the water.

13.4.4 Northern Beach Water Quality

As discussed in Section 12.1.1, a groundwater discharge occurs at Northern Beach. This discharge, which is naturally dark-coloured from the organic materials in the ground, has also been shown by the monitoring program to contain water with pH above background levels. Studies have been undertaken to investigate the likely environmental impact of this discharge. These investigations indicated that, apart from a temporary affect of the natural discolouration on water clarity over a small area, there was no measurable environmental impact occurring at Northern Beach as a result of the groundwater discharge (URS, 2001c).

13.5 Existing Marine Sediment Quality

Sediment conditions are less affected by short-term variability than is water quality, allowing data from one-off surveys to be used to establish background conditions. For this purpose, data have been obtained not only from southern Melville Bay, but a number of comparable sites across the north coast of Australia (Munksgaard & Parry 2002, McConchie and Saenger 1993). This has allowed background concentrations for a number of sediment quality parameters to be developed and compared with local site values and the sediment trigger values presented in the ANZECC (2000) Guidelines for Fresh and Marine Water Quality.

13.5.1 Gove Harbour Sediment Quality

The natural sediments of Gove Harbour range from medium to coarse-grained, cream-coloured, quartz, feldspar and carbonate sands on the beaches and shallow subtidal zones, grading to grey silts and clays with a mild odour of hydrogen sulphide in the deeper parts of the basin.

In a survey undertaken in July 2002 (URS, 2003b), of the 56 sites sampled, the only site to return a metal concentration above an ANZECC trigger value was a site some 200 m south of the outfall. The concentration of arsenic at this site was 44 mg/kg, compared to the ANZECC low and high trigger values of 20 mg/kg and 70 mg/kg, respectively. The highest concentrations of aluminium and gallium occur at sites within a 400 m radius of the refinery outfall.

Within a 700 m radius of the refinery outfall, the seafloor is typically blanketed by a layer of flocculant generated by the interaction between the outfall discharge and the receiving seawater (Section 11.3.1.2). The flocculant is sulphidic and highly reducing, has concentrations of aluminium and gallium above background and a mineralogy characterised by hydrocalumite. Trace element analyses indicate that the flocculant has low potential for metal toxicity, but the unconsolidated and anoxic nature of the flocculant layer prevents the establishment of benthic macrofauna. The impacts on the marine biota are discussed in Section 14.

13.5.2 Drimmie Arm Sediment Quality

As discussed in Section 11.3.2.5, as a result of extremely heavy rainfall in April 1999, a bund wall was breached to allow the controlled release of stored water from a water treatment storage pond at the RDA into Drimmie Arm. A survey of the marine sediments undertaken immediately following the release was conducted to determine the nature and area of effect of the discharge (LDM, 2000). This survey found that the release had caused a deposition of precipitate containing elevated levels of aluminium, arsenic, gallium and vanadium on the sediments in the north end of Drimmie Arm and in Duck Pond Creek. A follow-up survey in April-May 2000 (URS 2001e) found that the concentrations of arsenic, gallium and vanadium in the sediments had declined. It was concluded that metal concentrations in the sediments would continue to decline with resuspension and redeposition of the precipitate.

13.5.3 Northern Beach Sediment Quality

As discussed in Section 13.4.4, there is a discharge of groundwater at Northern Beach. This has resulted in the formation, over a few square meters of the low tidal beach zone, of a crust of stained sand weakly-cemented by calcium, aluminium and iron salts. There is no evidence of any impact on the sediments over a wider area.

13.6 Refinery Expansion

The proposed expansion will result in some changes to activities that could potentially impact marine water quality and marine sediments. These include:

- A small increase in discharge volume at the refinery outfall;
- A change in the composition of the discharge at the refinery outfall;
- An increase (25%) in the number of ships using the port (including an increase in the volume of ballast water discharged); and
- A change in the risk of material spillage at the port.

13.6.1 Refinery Outfall

As discussed in Section 11.8.2, the waste water inventory reduction project will result in changes to the chemical and physical characteristics and volume of the refinery discharge. The system will neutralise waste water enabling it to be discharged to the marine environment thus reducing the waste water inventory at the RDA. There will be no increase in the discharge of cooling water from the evaporation process for the expanded refinery because the Stage 3 evaporation plant will use a fresh water, closed circuit cooling system. The current discharge conditions for Stage 1 and 2 evaporation will be unchanged.

The quality of the stormwater discharge is expected to improve following implementation of the upgraded bunding and containment strategy.

The effect of the above changes on the water quality at the refinery outfall has been modelled based on water chemistry and projected flow rates. The projected outfall quality for key water quality parameters is given in Table 13.6.1.

Table 13.6.1
Projected Outfall Discharge Quality for Key Parameters

Period	Outfall Discharge (m^3/hr)	Temperature (^oC) (Median)	Vanadium (μg/L) (95%ile)	TSS (mg/L) (Median)
Current Refinery	6,000	45	184	81
Third Stage Expansion	6,340	43	120	79

The impact of this discharge is discussed in Section 13.7.1.

13.6.2 Shipping

The most significant changes to the existing shipping regime will be the elimination of bauxite exports, an increase in the alumina exports, an increase in caustic soda and lime imports, and a 95% reduction in fuel oil imports once gas is available. Details of these changes are summarised in Section 4.7.

13.7 Impact Assessment

13.7.1 Refinery Outfall Discharge

13.7.1.1 Overview

The impact of the discharge of the refinery outfall has been assessed using a suite of marine models which takes into account:

- the existing and future discharge quantity and quality;
- current, wind and wave conditions; and
- buoyancy and dispersion characteristics of the discharge constituents.

The models predict contaminant concentrations in the marine environment and these have been compared with the ANZECC (2000) trigger levels to identify the potential impact of the refinery discharge.

The modelling was undertaken by Global Environmental Modelling Systems (2003).

13.7.1.2 Model Descriptions

Current Circulation Model

GCOM3D is a state-of-the-art three-dimensional numerical ocean model to predict ocean currents on or near the continental shelf and in harbours and estuaries. It simulates the physical oceanography driven by winds and tides. This model has been set up over southern Melville Bay and the northern beaches of Gove Peninsula and has incorporated relevant data on bathymetry, tides, and winds.

The model was verified by comparing measured and predicted tide levels over a 10-day tidal cycle. Agreement between the measured and predicted levels confirmed the reliability of the model.

Wave Model

Wave energy in the study region was modelled with the SWAN shallow water wave model. SWAN is a third generation spectral model developed by the DELFT University in the Netherlands. Due to the need to allow for a reasonable fetch for generation of waves the SWAN model was setup on a larger grid than was used for current modelling. The output of SWAN in shallow water was used to derive turbulence parameters for input to the plume dispersion calculations.

Dispersion Model

Dispersion modelling was undertaken using PLUME3D which is a high-resolution 3D model that derives wind and 3D ocean current data from GCOM3D and simulates the behaviour of discharge plumes under defined release conditions (quantity, rate etc.). The model reports mass and concentration levels on the water surface, on shorelines, in the sediments or through the water column as required.

13.7.1.3 Modelling Methodology

Table 13.6.1 provides the water quality of the refinery discharge from both the existing and the expanded refinery. These data have been used in the marine models to enable the impacts of the discharge from the expanded refinery to be determined.

The following three key discharge quality parameters have been modelled:

- Temperature – to assess the effects of the increased temperature from the evaporation cooling water.
- Total Suspended Solids (TSS) – to assess the effects of the flocculant which forms from the neutralisation of caustic contamination with seawater.
- Vanadium – to assess the effects of metal contamination. Vanadium was selected as most of the other metal constituents in the refinery discharge (eg. arsenic, chromium, iron, lead, nickel) are at concentrations that are less than the ANZECC (2000) trigger levels.

The modelling methodology used required the following steps:

- Running GCOM3D driven by tides and winds for the 24 months of 2001 and 2002 to predict currents in Gove Harbour and Melville Bay;
- Running PLUME3D for two years to simulate the thermal behaviour of the plume discharged from both the existing and expanded refinery;
- Running PLUME3D for two years to simulate the behaviour of vanadium discharged from both the existing and the expanded refinery; and
- Running SEDTRAK for two years to simulate the behaviour of suspended solids discharged from both the existing and the expanded refinery.

13.7.1.4 Model Results

The model results have been used to define the extent of what has been termed the “mixing zone”. The mixing zone has been defined as the area in Gove Harbour surrounding the refinery outfall in which the ANZECC (2000) trigger levels are exceeded. The location at which the concentration of the contaminant in the discharge has dispersed so that its concentration equals that of the trigger value defines the edge of the mixing zone. A different mixing zone will apply for each contaminant in the discharge.

The size of the mixing zone will vary according to tide, current and wind conditions. The model has predicted the extent that the mixing zone will vary according to these variables by showing the location of the mixing zone boundary for various percentage exceedences over the two-year modelling period. For example, the 1% exceedence boundary shows the location beyond which concentrations from the discharge will exceed the trigger values for a total of 7.3 days (1%) over the two-year modelling period. For 99% of the time, concentrations beyond the boundary will be less than the trigger values.

The results of the modelling are shown on Figures 13.7.1, 13.7.2 and 13.7.3. They indicate the 1%, 5% and 10% exceedence boundaries for temperature, vanadium and TSS respectively.

The key result of the modelling is that there is little difference between the impacts caused by the discharges from the existing and expanded refinery. The results indicate:

- For temperature, the mixing zone for the expanded refinery will be slightly reduced due to the lower discharge temperature;
- For vanadium, the mixing zone for the expanded refinery will reduce due to the decreased concentration in the discharge; and
- For TSS, there will negligible change in the size of the mixing zone.

Metals present in the discharge do not have any significant effects because most occur at concentrations below the guideline trigger levels. All are discharged at concentrations less than that of vanadium and hence the mixing zones for the other metals will be smaller than that for vanadium. Some metals do not have recommended trigger levels for marine environments (eg. aluminium) because they are either not considered a potential toxicant or insufficient work has been undertaken to determine their significance as a toxicant. Alcan Gove will manage discharges to minimise the release of metals no matter what their toxicity rating.

Alcan Gove is committed to achieving a zero mixing zone for its discharge to meet the intent of the ANZECC guidelines. As part of its continuous improvement program, further investigations will be undertaken with the ultimate objective of reducing the mixing zone to zero. This will be achieved when the concentrations of contaminants in the refinery outfall do not exceed the Alcan Gove trigger values.

As the modelling shows very small change in water quality impact from the expanded refinery, there will also be no significant change to the marine biological impacts as discussed in Section 14.

13.7.2 Changed Shipping Movements

13.7.2.1 Ballast Water

As shown in Table 13.7.1, the proposed expansion will increase the average annual number of vessels discharging ballast water from 87 to 125 and the total volume of ballast water discharged each year from 830,000 t to 950,000 t.

Table 13.7.1
Ballast Water Discharged at Gove

Current Refinery	Hydrate	Alumina	Bauxite	Total
Number of Shipments/Year	3	56	29	87
Estimated Total Ballast Water Discharged (tonnes)	11,00	490,000	330,000	830,0000
Expanded Refinery	**Hydrate**	**Alumina**	**Bauxite**	**Total**
Number of Shipments/Year	4	107	0	125
Estimated Total Ballast Water Discharged (tonnes)	15,000	940,000	0	950,000

The increase in the total volume of ballast water discharged is relatively small (15%) and is not expected to have a significant effect on water quality at Gove. The current good practices in managing ballast water will be maintained with the expanded refinery.

The change in risk of pest species being introduced from the ballast water is discussed in Section 14.5.1.

13.7.2.2 Oil Spill Risk

Once a gas supply is secured there will be a significant reduction in the number of fuel oil import shipments from the current eight to only one. This represent a reduction in fuel oil imports from 480,000 t/y to 34,000 t/y.

If the natural gas supply is delayed, fuel oil shipments will increase by approximately 75%. This would result in an increase of six further shipments increasing the number of annual shipments to 14, with the total imports rising to 850,000 t/y. There would be a commensurate increase in the risk of a major spill associated with the increased number of shipments. An additional 150,000 t/y of heavy fuel oil will also transit Melville Bay in the form of fuel for the ships that transport the materials to and from the port.

Management strategies for the changed spill risk as a result of the expansion are discussed in Section 13.7.2.4.

13.7.2.3 Other Shipping Risks

The will be a minor change to other environmental risks from shipping operations as a result of the proposed expansion. The majority of materials imported or shipped through Gove are relatively inert (eg. bauxite, alumina, limestone) and would not have a significant effect on water quality if spilt. The impact of such a spill would be the blanketing of a small area of seafloor causing temporary localised smothering of benthic flora and fauna and changes to sediment structure and composition.

As a result of the proposed expansion there will be an increase in both alumina and limestone shipments and consequently a potential increase in the risk of a spill of these substances. Bauxite will no longer be exported and hence the risks from this source will be eliminated.

Improvements to reduce dust and spillage from the current shiploading facilities will be undertaken in 2004 and 2005 as part of the continuous improvement initiatives to be implemented through the current strategic plan for Alcan Gove operations.

There will also be an increase in the importation of caustic soda from 9 to 18 shipments per year. Caustic soda is highly reactive but readily neutralised in seawater. A spill would cause a temporary increase in pH in the water in the immediate vicinity of the spill, the size of which would depend on the amount spilt. It may also result in the formation of a cloud of suspended solids that would disperse in the tidal currents around the port. The mass of solids in this plume would be much less than for a spill of a similar volume of process liquor because of the absence of aluminium which is an important element in the precipitation process. The caustic soda would neutralise naturally and the suspended solids would gradually disperse under tidal action. No management intervention would be required other than the establishment of a temporary boating exclusion zone around the spill site.

13.7.2.4 Spill Risk Management

The risk of shipping incidents, including accidental discharge of fuel or products will continue to be managed through GOVE PLAN, which is the existing emergency response plan for the port. GOVE PLAN is currently being updated to reflect the latest information available on the marine environment, marine protection requirements, the changes to risk associated with the proposed increased shipping movements, and changes to quantities of the materials being shipped. However, in general terms, the existing spill management and containment strategy is appropriate for the changed shipping regime associated with the expansion.

Alcan Gove has recently upgraded its tug fleet to significantly improve its ship handling capabilities. This will provide additional safety in vessel handling and further reduce the risk of a shipping accident while improving response capabilities should an accident occur.

13.8 Management

A strategic environmental management plan outlining strategies for the management and monitoring of marine water and sediment quality is presented in Section 25.

Existing Refinery

Expanded Refinery

1% Exceedance Time
5% Exceedance Time
10% Exceedance Time

SOURCE: Global Environmental Modelling Systems Pty Ltd, December 203

ALCAN

URS

ALCAN GOVE REFINERY EXPANSION
ENVIRONMENTAL IMPACT STUDY

MARINE DISCHARGE TEMPERATURE

Project No. 12373-021-559	Date 16-01-04		Figure 13.7.1
CAD File No. -g-068.CDR	Rev. A	A4	

Existing Refinery

Expanded Refinery

1% Exceedance Time
5% Exceedance Time
10% Exceedance Time

SOURCE: Global Environmental Modelling Systems Pty Ltd, December 203

ALCAN

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ALCAN GOVE REFINERY EXPANSION
ENVIRONMENTAL IMPACT STUDY

MARINE DISCHARGE
VANADIUM

Project No. 12373-021-559	Date 16-01-04		Figure 13.7.2
CAD File No. -g-069.CDR	Rev. A	A4	

Existing Refinery

Expanded Refinery

1% Exceedance Time
5% Exceedance Time
10% Exceedance Time

SOURCE: Global Environmental Modelling Systems Pty Ltd, December 203

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ALCAN GOVE REFINERY EXPANSION
ENVIRONMENTAL IMPACT STUDY

MARINE DISCHARGE
TOTAL SUSPENDED SOLIDS

Project No. **12373-021-559**	Date 16-01-04		
CAD File No. -g-070.CDR	Rev. A	A4	Figure **13.7.3**