

3.0 Description of Existing Operation

3.1 Site Location

The project is located approximately 650 km east of Darwin at the western end of the Gove Peninsula in the north-east corner of Arnhem Land. The site's regional location is shown on Figure 3.1.1.

The major components of the existing operation include the bauxite mine, the refinery, the port, and the residue disposal area (RDA). The locations of these key components are shown on Figures 3.1.1 and 3.1.2.

The workforce for the mine and the refinery lives in the township of Nhulunbuy which is located midway between the mine and the refinery. The town has a population of 3,800 and has developed into an important regional centre.

The township of Yirrkala is located about 15 km to the south-east of Nhulunbuy. In addition, there are other small settlements in the area including Galupa, Gunyanara, Galaru and Wallaby Beach. About 1,500 Aboriginal people (Yolngu) reside in the Gove area, including Yirrkala and the nearby Yolngu Homeland communities of which there are 22.

The majority of people travel to Nhulunbuy by air. The airport is located adjacent to the mine. Road access is via a 650 km unsealed road from Katherine which is only normally open during the dry season. Most heavy equipment and supplies are transported to the site by ship from Darwin.

The region has distinct wet and dry seasons with tropical cyclones occurring during the wet season. The coastal zone consists largely of sandy beaches and mangrove lined estuaries. The two principal inlets in Melville Bay, the Latram and Giddy Rivers, are feeding and breeding grounds for a number of intertidal and marine animals. A number of small islets surround the site including Strath Island, Granite Islands, and West Woody Island. The larger Bremer Island is located approximately 5 km to the north of Nhulunbuy.

3.2 Existing Leases

Table 3.2.1 summarises the various leases within which the current operations are located. It also shows the approximate area used or disturbed by the operations to date. The locations of these leases are shown on Figure 3.2.1.

Table 3.2.1
Existing Leases

Lease	Use	Lease Area (ha)	Used Area (ha)
SML 11 Part 1	Mine	20,018	3,508
SML 11 Part 2	Conveyor	282	282
SML 11 Part 3	Refinery	191	130
SPL 213	Bulk Cargo Wharf	13	13
SPL 215	Residue Disposal	90	17
SPL 217	General Cargo Wharf	14	14
SPL 249	Foreshore Protection	8	8
SPL 253	Water Discharge	0.1	0.1
SPL 277	Cooling Water Intake	0.7	0.7

Table 3.2.1
Existing Leases

Lease	Use	Lease Area (ha)	Used Area (ha)
SPL 403	Residue Disposal	1414	543
SPL 214	Nhulunbuy	660	660
SPL 250	Industrial Area	50	50
SPL 251	Conveyor Access	23	23

3.3 Overview of Existing Operation

Detailed exploration of the area began in 1965 and a joint venture agreement was signed in 1969. Alumina production commenced in 1972. Since then, over 147 million tonnes (Mt) of bauxite have been mined and 37 Mt of alumina have been produced and exported.

The refinery's current production of alumina is around 1.95 million tonnes per year (Mt/y). An optimisation program is currently being undertaken which will increase its production to 2.0 Mt/y by improving the efficiency of existing equipment and technology improvement programs.

The existing operations consist of the following main components:

- Mine;
- Refinery;
- Residue Disposal; and
- Port.

Bauxite is mined from a laterite deposit that is approximately 3.5 m deep and is overlain by up to 2 m of topsoil. The mine is located 19 km to the east of the refinery as shown in Figure 3.1.1. Bauxite is removed from just below the ground surface (after the topsoil has been removed) and it is carried by truck to a crushing plant where it is crushed and then transported by conveyor to the refinery.

At the refinery, which is located at the western end of the peninsula, some of the unprocessed bauxite is delivered to export ships but most of it is processed in the refinery. Some of the refinery's production is hydrated alumina but the majority of the production is calcined to produce alumina.

The major solid waste from the refinery is the residue left after the alumina is extracted from the bauxite. It is alkaline and is disposed of in purpose-built containment facilities. Until 1992, the residue was disposed of as low density slurry into clay-lined ponds. In recent years residue disposal has been improved considerably by adopting dry stacking methods that result in a more stable and easily rehabilitated residue. It also requires less land compared to low density disposal. The RDA is located approximately 5 km east of the refinery.

The port which supports the operation includes unloading facilities to receive bulk materials to supply the mine and refinery. The main imported components are fuel oil and caustic soda. The major materials exported from the port are bauxite and alumina. A minor quantity of hydrated alumina is also shipped from a separate cargo wharf where limestone is unloaded for use in the refinery.

Water supply for the operation is recovered from an aquifer located under the bauxite mine. Water is then pumped to the mine, the refinery, to Nhulunbuy, Yirrkala and other smaller communities in the area. Electricity is generated at

a power station located at the refinery which supplies the refinery, the mine, Nhulunbuy and the surrounding communities. The power station also generates steam which is used within the refinery process.

3.4 Mine

3.4.1 Location

The existing bauxite mine is located on the eastern side of the Gove Peninsula as shown on Figure 3.1.1. It occurs within Part 1 of Special Minerals Lease (SML) 11 (Figure 3.4.1). As shown in Table 3.2.1, the lease has a total area of 20,018 hectares (ha) of which approximately 3,508 ha have been disturbed. The area not yet disturbed but containing exploitable bauxite reserves and subject to future mining is 3,570 ha. The balance of the lease is currently not suitable for mining.

Mining commenced in 1971. The extent of the mined area is shown on Figure 3.4.1. The various categories of disturbance (as at December 2002) are summarised in Table 3.4.1

Table 3.4.1
Area of Mine Disturbance

Land Use	Area (ha)
Active mining	302
Cleared land ready for mining	736
Airport	94
Mine infrastructure	40
Rehabilitated land	2,504
Future mining areas	3,570
Balance of lease	12,980

3.4.2 Geology

The main rock types underlying this part of the Arnhem Bay/Gove region are the Giddy Granite and Bradshaw Granite, overlain by quartz/ferruginous sandstone, laterite, aluminous laterite, sand and residual soil.

The Bradshaw Granite, the oldest formation in the region, occurs extensively in north-east Arnhem Land. It underlies Gove Peninsula and is exposed in places in the form of rocky outcrops and rounded tors. Prominent outcrops occur on Drimmie Head, as Dimbuka Rocks, and in places on rocky islands within Melville Bay.

Mullaman Beds overlying the Bradshaw Granite in the central and western parts of Gove Peninsula is a sequence of sedimentary rocks up to 100 m in thickness. These sediments are of Lower Cretaceous age and consist of white and yellow sandy claystone, ferruginous sandstone, quartz sandstone and dolomitic siltstone. They are widespread throughout eastern Arnhem Land where they represent the erosional remnants of a once-continuous sheet. On Gove Peninsula they occur within a shallow basin-shaped structure, the limits of which approximately correspond to the limits of the bauxite-capped plateau.

The mine is located on an extensive plateau, 60-80 m above sea level, which occupies the central and eastern part of the peninsula. It is bounded in most places by escarpments, up to 20 m in height, which are less pronounced on the western side. The plateau is capped with laterite, some of which form the bauxite deposits.

The laterite profile beneath the plateau is given in Table 3.4.2 below.

Table 3.4.2
Laterite Profile

Description		Thickness (m)
Topsoil	Loose sand, gravelly in part, contains organic debris.	Up to 2
Zone Of Enrichment	Loose pisolitic laterite. Cemented pisolitic laterite. Tubular laterite, partly cemented. Nodular laterite, partly cemented. Pseudo-conglomeratic laterite, partly cemented.	Up to 3.5 Up to 3.0 Up to 2.0 Up to 1.8 Up to 3.0
Mottled Zone	Clay, mottled white and red, weakly cemented patches, may contain sandy zones.	Up to 3.0
Leached Or Pallid Zone	Clay, white, grading downwards into weathered parent rock.	Up to 5.0

3.4.3 Mining

The bauxite deposit is approximately 3.5 m deep and is overlain by up to 2 m of topsoil. Bauxite ore from this deposit is mined using conventional open-pit mining techniques.

First, the surface vegetation is cleared from the proposed mining area and topsoil and subsoil are removed and retained for rehabilitation. Bauxite ore is then ripped by large bulldozers and loaded by front-end loaders into 100 tonne capacity dump trucks for transport to the crushing plant.

On average, approximately 130 ha are mined each year with a similar area rehabilitated. Mining operations do not involve the use of explosives.

Mining operations are undertaken for 24 hours a day, 7 days per week. The current mining rate is approximately 6.5 million dry tonnes (Mdt) of bauxite per year. At this rate, there are sufficient reserves available within the existing leases for the next 39 years.

In the mid 1990s, mining commenced on the Rocky Bay deposit, a satellite ore body that is located south-east of Alcan Gove's existing operation (Figure 3.4.1). The Rocky Bay deposit is being developed as a joint venture between Yirrkala Business Enterprises Pty Ltd (YBE) and Alcan Gove. YBE is contracted to load and haul bauxite from Rocky Bay to a stockpile about 10 km distant, where it is then transported by mine dump trucks to the crushing plant.

The erosion and sediment control measures employed at the mine are described in Section 16.4.5.

3.4.4 Crushing and Screening

Bauxite ore is delivered from the mine in varying sizes from 4 mm particles up to 1 m³ rocks to a centrally located crushing and screening plant (Figure 3.4.1). At the plant, the ore is fed onto two separation screens. Material that is smaller than 100 mm falls through the screen and drops onto conveyor belts located below, and by-pass the primary crusher. All material larger than 100 mm is fed into the primary crusher where the ore is crushed. At this stage, approximately 60% of the bauxite ore is at final product size (i.e. 40 mm or less).

A screening plant is utilised to separate the final crushing product from the oversized material. The bauxite of final product size is screened out and fed directly to a surge bin. The oversized material is discharged to the secondary crusher for further crushing to the required 40 mm size.

The crushing and screening design capacity is 1,440 tonnes per hour (t/h).

Once the ore has reached the required size, it is transported to the refinery via the 19 km long overland conveyor system. The capacity of the conveyor is 1,270 t/h.

3.4.5 Rehabilitation

Mine rehabilitation involves the restoration of the natural environment in areas where mining has ceased. This program is conducted through close consultation with, and assistance from, the traditional landowners of the area.

Since mining commenced in 1971, 2,504 ha of the mined area have been rehabilitated. The remaining area is currently used for active mining, roads, crushing plant and facilities and will be rehabilitated progressively or upon closure.

The rehabilitation practices associated with the mining activities include the following:

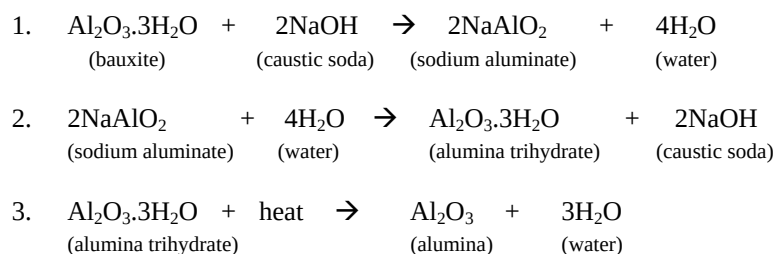
- Timber clearing well in advance of mining, allowing understorey plant species to propagate.
- Removal of topsoil and overburden from pre-mined areas which is immediately placed on the adjacent mine floor. The seed rich topsoil leads to the regeneration of ground cover and grasses.
- Deep ripping of mined-out areas along natural contours to promote drainage, aeration and root penetration.
- Annual collection of seeds from native shrubs and trees native to the mine lease. Seeds are sown with a single application of fertiliser immediately prior to the wet season.

Natural development of rehabilitated areas with care taken to avoid bushfires until the trees are well developed.

Further details of the mine's rehabilitation procedures are given in Section 19.3.1.

3.5 Refinery

The refinery uses the Bayer process to extract alumina from bauxite. This involves dissolving the alumina component of the bauxite ore in sodium hydroxide (caustic soda) liquor (equation 1 below), removing the undissolved component of the bauxite (residue) by settling and filtering, precipitating alumina trihydrate out of the caustic soda liquor (equation 2 below), and then calcining (heating) it to produce alumina (equation 3 below). An overview of the refinery process is illustrated in Figure 3.5.1. The key reactions are summarised in the following equations.



Each tonne of bauxite yields about 0.5 tonnes of alumina. The balance is residue.

A more detailed description of the existing refinery operations is given below. The layout of the existing refinery is given in Figures 3.5.2 and 3.5.3.

3.5.1 Bauxite Stockpiles

Bauxite ore conveyed from the mine is stockpiled at the eastern end of the refinery. Stockpiling is by an automated stacker conveyor. The bauxite is blended and reclaimed by rotating barrel reclaimers. Most of the bauxite is conveyed from the stockpile to the refinery (4.7 Mt/y) but some is conveyed directly to the wharf for export (1.4 Mt/y). The storage capacity of the stockpiles is 400,000 to 500,000 t.

The blending of bauxite is achieved by the combined function of stacking and reclaiming. During stacking, the bauxite is deposited in layers and reclaiming occurs from the cross-sectional face of the stockpile. By using this technique, uniform blended bauxite for the whole length of the stockpile is achieved.

3.5.2 Grinding and Digestion

Bauxite reclaimed from the stockpiles is mixed with caustic liquor and fed into three parallel rod and ball mills to produce a fine bauxite slurry. The grinding allows for better solid liquid contact during the digestion phase. The fine slurry is then pumped via storage relay tanks to the first on-line digester.

In the first digester, the mill slurry is combined with hot recycled caustic liquor. The slurry flows from the first to the last digester under pressure and, to ensure extraction of alumina from the bauxite, a reaction temperature of 145°C is maintained through the digestion process. Each digester is fitted with an agitator and high levels inside the vessels are maintained to ensure adequate residence time. This residence time is essential to reduce the liquor silica level, which precipitates out and becomes part of the residue together with the undigested component of the bauxite.

When the hot digestion slurry leaves the last digester it is a mixture of alumina in solution, undissolved bauxite solids and silica. It then proceeds through three flash tanks. As the pressure drops back to atmospheric across each flash tank, the subsequent reduction in boiling point causes vapour to “flash off” as process steam. The steam from flash cooling is reused to preheat the incoming slurry to the digesters thereby reducing thermal energy requirements.

3.5.3 Residue Separation, Filtration and Washing

The undigested bauxite components (residue) from the digestion process are separated from the alumina rich caustic liquor in a de-sanding gravity separation process to remove coarse sand residue and then in large settling tanks called thickeners to remove the fine mud residues.

Residue separation begins with the de-sanding of the digestion slurry. The de-sanding process has a number of functions including reducing the temperature of the slurry, removing and washing the sand, and collecting the resultant de-sanded slurry for transfer to the thickeners. Once the slurry is below boiling point, sand separation occurs through the use of a hydro-separator (a small thickener) or cyclones. This process results in the heavier and coarser sand being diverted to the under-flow while the fine mud slurry overflows to the thickener feed tank.

Liquor is removed from the sand by washing in stages using classifiers. The first classifier (hydro-separator) removes sand from caustic liquor and fine mud, the second and third classifiers (cyclones) wash the sand with condensate to remove most of the caustic. The de-sanded slurry from either the hydro-separator or cyclones is pumped to the thickeners. The washed residue sand is pumped to a dedicated sand handling plant where it is slurried with some of the recycled residue area water for pumping to the RDA.

In the thickeners area, de-sanded slurry is pumped into one of three thickeners with the addition of polymer. Polymer or flocculent is added to assist the thickener settling process, thereby reducing caustic losses. The undigested part of the bauxite ore is settled out as red mud and transferred to the washer area. The thickener overflow (liquor) still contains a very small portion of red mud. At this stage in the process, the liquor is referred to

as turbid liquor. The turbid liquor is then filtered to remove the remaining red mud. After the last red mud particles are removed by filtration, the liquor is known as pregnant liquor.

The washers area plays an important part in the operation. Its main function is to regain as much of the caustic present in the red mud as possible. Red mud from the thickeners is pumped into one of the two parallel washer trains, each containing six washers. To recover caustic soda, red mud is washed using recycled condensate in a counter-current washing process in the washers (large settling tanks). The caustic content of the red mud progressively reduces as it approaches the last washer, from where it is transferred to the deep washer area.

The deep washer area provides the final caustic washing step. The washer tanks in this area are designed to achieve a high under-flow density whereby most of the caustic liquor is removed from the mud. Liquor overflowing from the deep washers is pumped to each of the washer trains to enable mud washing in these tanks. The high density washed red mud is then pumped to the RDA.

3.5.4 Precipitation

The pregnant liquor from filtration is cooled in plate heat exchangers and then flows into the precipitators where it is seeded with hydrated alumina, commonly called hydrate. The seeding promotes agglomeration of fine alumina crystals in the precipitators. Agglomeration requires a high super-saturation of the pregnant liquor and the quantity and particle size of seed added is adjusted to control product quality. The amount of seed is varied to achieve the required solids concentration. The agglomeration process is essential to make a sandy or coarse grade alumina.

3.5.5 Classification and Filtration

Hydrate slurry from the precipitation area is pumped to the cyclone batteries for separation into product and coarse and fine seed. Separation is achieved by using product and seed hydro-cyclones. The hydro-cyclones use centrifugal force where the larger and heavier particles are forced to the outside of the cyclone and down the cone. The fine fraction is collected from the central area of the cyclone. The purpose of the cyclone operation is to produce a product and coarse seed underflow and a fine seed overflow.

There are four key streams from the product and seed hydro-cyclones. These are:

- The product cyclone underflow or product hydrate. Product from the underflow of the product cyclones is pumped to the product filters and the resultant filtrate is pumped to the hydrate thickener. The washed and partially dry product hydrate is then conveyed to the calcination area.
- The overflow from the product or seed hydro-cyclone. The overflow is pumped to the seed hydro-cyclones for further classification.
- The seed cyclone underflow, or coarse seed. The underflow is filtered in the hydrate filtration area and returned to the first growth precipitator to promote further agglomeration of fine alumina crystals.
- The overflow from the seed cyclone, or fine seed. The overflow from the seed cyclones is washed and conveyed to fine seed charge tanks where pregnant liquor is added and the slurry formed is pumped to the agglomeration precipitators.

3.5.6 Calcination and Alumina Storage

The filtered and washed hydrate received from the filtration area contains approximately 37% water by weight, of which 5% is adherent water and the remaining 32% is present as chemically combined water (water of crystallisation). The adherent moisture is easily evaporated at temperatures in excess of 100°C. However, the water

of crystallisation is more strongly bonded to the alumina by chemical bonding and high temperatures of up to 1,100°C are required to remove it.

The heat required to remove the water of crystallisation and thus converting the hydrate to alumina is provided in rotary kilns. Hydrate is delivered from the filtration area via conveyor to the storage bins for each of the four rotary kilns. Within the rotary kiln, the hydrate is initially subjected to a tumbling and cascading action by curved metal lifters. This section is designed for the maximum amount of drying and a large percentage of the heat content of the hot combustion gases is recovered. As the alumina proceeds further down the kiln, the very high temperature is attained by using refractory dams which increase the residence time of the material in the kiln.

The hot gas leaving the kiln is laden with alumina dust. Approximately 95% of this dust is removed in multiclones. Almost all the remaining dust is removed by two banks of electrostatic precipitators. The dust collected is returned into the kiln.

In addition to the four rotary kilns, the refinery also operates a stationary calciner which uses more efficient technology than the rotary kilns.

The calcined alumina from both the rotary kilns and the stationary calciner is transported to one of four storage silos to await shipment. The total alumina storage capacity is approximately 300,000 t. The alumina is conveyed from the storage silos to the port for export by ship.

3.5.7 Evaporation

The purpose of the evaporation area is to:

- Remove water from the spent liquor from filtration to produce a liquor suitable for re-use in the digestion plant; and
- Produce process condensate for product, seed and red mud hydrate washing.

The evaporation plant removes most of the water that enters the liquor circuit for the purpose of mud, sand and hydrate washing. The plant must also remove unwanted water or “parasitic” water that enters the circuit. Parasitic water includes rain and any water used for hosing. Water removed from the spent liquor is known as condensate and is distributed throughout the refinery for washing purposes.

The evaporation area is designed to gain full utilisation of the heat available in the steam by use of a 13 stage evaporation/heat recovery system. This heat is recovered by the use of the first 10 heat recovery (or flash) stages. After the tenth flash stage, further heat recovery is not economical and the remaining three stages condense the steam directly into seawater. Seawater is pumped continuously from Melville Bay for this cooling process and is then discharged back to the Bay.

3.5.8 Lime Plant

The purpose of the lime plant is to burn limestone, then slake it to produce milk of lime which is required in the refinery to;

- Produce tri-calcium aluminate which is used as a filter aid in security filtration; and
- Remove carbonate and organic impurities from the plant liquor.

The limestone is imported by ship via the cargo wharf, then trucked and stockpiled adjacent to the lime plant. The limestone is reclaimed from the stockpile and fed into an oil-fired lime kiln. The kiln operation is cyclic and kiln feeding is not a continuous operation.

The kiln consists of two identical shafts both filled with limestone. The limestone moves slowly downwards through the kiln through the influence of slowly stroking discharge tables at the bottom of each shaft. Only one shaft is heated at a time.

The burnt lime from the kiln is discharged onto a conveyor which feeds into an impact crusher. After crushing, it is transported by a bucket elevator and discharged into two 900 t capacity silos. Burnt lime is then fed from the silos to a slaker tank where it is mixed with hot condensate to form milk of lime. Unburnt stone and other refuse is removed by means of a classifier.

3.6 Residue Disposal

3.6.1 Residue Characterisation

The alumina refinery process produces two main residue streams. The major stream termed “red mud” is a fine-grained material (fine silt and clay sizes) consisting of components such as iron oxide, titanium dioxide, alumina, silica, and sodium aluminosilicate. However, it is alkaline because of remnant caustic soda from the refinery process. The minor stream, termed “residue sand”, is a coarse-grained material predominantly containing silica, alumina and caustic soda. The refinery also produces several contaminated water streams that can be either mixed with the main refinery residues during their disposal, mixed with the red mud during the washing process, or mixed with seawater to neutralise the contaminants prior to their release to the environment.

Options for future economic reuse of residue stored have been the subject of extensive study by the aluminium industry. To date no economic options for reuse or extraction of resources from the residue have been identified. Recently options for use of a limited portion of the residue to abate the environmental impacts of acid mine drainage have been identified. Alcan Gove will continue to work with the industry and government to further develop reuse options.

3.6.1.1 Chemical Properties

Residue is currently produced at a rate of approximately 3.0 Mt/y. It is alkaline due to retained caustic soda from the process and has a pH of 11 to 12.

The typical chemical composition of the residue is given in Table 3.6.1.

Table 3.6.1
Residue Chemical Composition

Component	% by Weight
Fe ₂ O ₃	43
SiO ₂	9
CaO	2
Al ₂ O ₃	20
TiO ₂	10
Na ₂ O	5
Miscellaneous	1
Loss on Ignition	10

As can be seen from Table 3.6.1, the bulk of the residue (99%) is composed of the oxides of only six elements plus water and carbon dioxide ignition losses. The remaining trace elements include vanadium, phosphorus and fluorine.

3.6.1.2 Physical Properties

Red mud disposal involves the transfer of the residue from the refinery to the RDA in the form of a slurry. At the RDA it is discharged into shallow drying bays formed on the mud surface by using a swamp dozer. This dozer is also used during the drying cycle of the red mud to increase the mud surface area exposed to natural drying to create a denser disposed mud bed. This is termed “mud farming”. Once drying has completed to the degree required, the dozer is used to reform a new drying bay to accept further red mud deposition.

The physical properties of the slurry and the settled residue are summarised in Table 3.6.2.

Table 3.6.2
Residue Physical Properties

Slurry Material	Property	Slurry Form	Settled Form
Red Mud	Specific gravity	3.3	3.3
	Slurry density	680 g/L	1.44 t/m ³
	Slurry % solids	44.8%	72%
Residue Sand	Specific gravity	3.3	3.3
	Slurry density	50 g/L	1.37 t/m ³
	Slurry % solids	5.0%	70%

3.6.2 Residue Management

Current residue management practice is to dispose of the red mud and sand in large purpose-built containment structures at the RDA. Most of the waste water streams are introduced into the red mud during the washing process where leachable constituents of caustic soda are washed from the red mud. The balance is discharged to the RDA with the mud.

The layout of the RDA is shown on Figure 3.6.1. As can be seen, Ponds 3, 3/4 and 4 are currently being used for mud farming. Pond 5 is currently storing both residue and waste water (see Section 3.6.3) while Pond 6 currently contains waste water only. Pond 7 is empty and is available as a backup storage area. Ponds 1 and 2 (Taylors Pond

and Northern Pond) were located on the northern side of the conveyor but have been decommissioned and revegetated.

The current Long Range Residue Disposal Plan indicates that there is adequate capacity for the continued operation of the existing RDA until 2025 based on current residue discharge rates and Gove bauxite reserves.

Details of the RDA revegetation program are given in Section 19.5

3.6.3 Waste Water Management

In addition to the residue, the RDA also contains water which includes waste water from the refinery which is pumped to the RDA with the slurried residue and rain water. Traditionally, the RDA has operated as a closed circuit with the waste water and rainfall accumulating in the RDA and being returned back to the refinery red mud washing process.

During the last five years, some of the waste water at the RDA has been mixed with seawater in a neutralisation process which enables the neutralised waste water to be discharged to the marine environment. This neutralisation occurs in a “labyrinth” facility located at the RDA (Figure 3.5.1). This has the advantage of reducing the build up of waste water inventory that occurs during the wet season. When the seawater is added to the waste water, it has the effect of flocculating the finer fractions and some of the dissolved minerals in the red mud thereby enabling them to settle in the labyrinth. The flocculation is largely driven by the presence of some of the hydrated alumina that can not be extracted in the refining process and remains in the discharged mud.

The precipitate formed by the reaction between the caustic soda and seawater is primarily a mixture of hydrotalcite and calcium carbonate and is stored in the RDA. In situations where there is a significant excess of calcium in the liquor, then hydrocalumite may also be present. These are all naturally occurring minerals. These reactions remove the alkaline caustic soda from the waste water and reduce the pH.

The current inventory of waste water is approximately 9 million cubic metres and is stored primarily in Ponds 5 and 6. The actual volume stored varies with rainfall. The inventory is reduced by evaporation, returning to the washing circuit at the refinery, and neutralisation in the labyrinth. Seawater for the labyrinth neutralisation process is pumped from Macassar Creek. The neutralised waste water from the labyrinth is pumped back to the refinery where it is discharged to Melville Bay via the refinery outfall.

3.6.4 Pond Design and Management

3.6.4.1 Pond Embankment Design

The pond embankments have been constructed from clay regolith excavated from within each pond area. During the construction of embankments, the near-surface gravels and laterite were partially removed in some areas of the pond floors in order to source clayey borrow materials. When granular strata were located beneath proposed embankments, a key (trench) was excavated and backfilled with clayey material. This trench was designed to reduce the potential for lateral seepage of waste water.

The earth fill of the embankments has been compacted to maintain low permeability through the cross section. A sand interceptor drain has been constructed within the embankments to collect any seepage that does occur and direct it to a toe drain. No seepage has been observed to date, but if it does occur action will be taken to either seal off the source and/or carry out test work on the seepage water quality to determine other treatment options.

The embankment downstream slopes vary from 1V:2.5H to 1V:4H. Their surface is protected against erosion by vegetation. The embankments have been geotechnically designed to ensure embankment stability. Nevertheless there is an ongoing program of embankment stability monitoring to ensure that engineering integrity of the embankments is maintained.

The criteria adopted for design of the ponds and the containment requirements were developed from a review of national and state guidelines together with guidelines from the Australian National Committee on Large Dams, and International Committee on Large Dams (LRRDP 2001 Vol 2 – Design Criteria).

3.6.4.2 Hydrological Design Criteria

The principal hydrological design criteria that apply to the ponds at the RDA are as follows:

- Annual Exceedence Probability (AEP) of flood to be totally contained - 0.5% (1 in 200 event)
- AEP of flood to be passed over spillways - Probable Maximum Flood
- Freeboard below the lowest point along the pond wall - 1 m

The water storage capacity of the RDA has been designed to have sufficient capacity to store runoff resulting from the 0.5% AEP (1 in 200 event). At Gove, the estimate 1 in 200 year wet year (October – September) rainfall is 2,516 mm.

The runoff resulting from the 0.5% AEP storm has been adopted as the required capacity of the RDA's drainage system (including leachate and security drains). Intensity-duration relationships for this exceedence probability has been used to determine the critical discharge rates to be contained by the drains.

3.6.4.3 Catchment Management

The existing RDA catchments and waste water transfer arrangements for each are summarised in Table 3.6.3.

Table 3.6.3
RDA Storage Catchments and Transfers

Storage Name	Rainfall Catchment	Inflows From	Transfers Out	Spillway Overflows to:
Water Treatment Facility Pond	Release Pond	Pond 3 and 3/4 overflows Pump transfer from Ponds 5 or 6 Refinery parasitic waters	Waste water pumped to Pond 5 Refinery Labyrinth	Melville Bay, via the Duck Pond Ck
Pond 3 and 3/4	Pond 3 and 3/4	Red mud leachate	See spillway	Release Pond
Pond 4	Pond 4	Red mud leachate	See spillway	Ponds 5 and 6
Pond 5	Ponds 4 and 5	Pond 4 overflow Leachate from residue sand and mud by-pass Pump transfer from Release Pond or Pond 6	Waste water pumped to Release Pond Refinery	Pond 6

Storage Name	Rainfall Catchment	Inflows From	Transfers Out	Spillway Overflows to:
Pond 6	Pond 6 plus overflow from Ponds 4 and 5	Pond 4 and 5 overflows	Waste water pumped to Refinery Release Pond	Pond 7
Pond 7	Pond 7 plus overflow from Ponds 4, 5, 6	Pond 6 overflow	See spillway	Melville Bay*

* Pond 7 is kept empty so that sufficient capacity is available to receive the overflow from Ponds 4, 5 and 6 without the need to discharge.

3.7 Port

The Alcan Gove port is situated on both sides of Dundas Point in Melville Bay (Figure 3.5.2). The bay area adjacent to these facilities is referred to as Gove Harbour. On the western side of Dundas Point there is the Bulk Cargo Wharf which consists of an alumina and bauxite export ship-loading terminal and a fuel and caustic soda tanker unloading terminal. On the eastern side of Dundas Point there is the General Cargo Wharf at which coastal vessels dock to unload bulk materials required for the refinery (eg limestone) and load hydrate for export. Perkins Wharf is situated further into Gove Harbour and is used mainly by the supply barges as well as two to three fishing charter vessels and occasional commercial fishing boats. Perkins Wharf is also used to unload sulfuric acid.

The alumina is discharged from the storage silo floors and fed to the alumina export conveyor by means of pneumatic conveyors. The distance from the silos to the ship loader is approximately 3 km. Three individual belt conveyors, the longest being 1.8 km, lead to the export wharf which is located 1 km from the shoreline. Alumina is loaded into export ships at an average rate of 1,200 tonnes per hour (t/h) via a telescopic chute.

Bauxite is also exported from the site. Export bauxite is reclaimed from the bauxite stockpiles and conveyed directly to the ship loader. Bauxite is also loaded into the export ships at an average rate of 1,200t/h via a telescopic chute.

Existing ship movements are given in Table 4.7.1.

3.8 Input Materials

The raw materials used in the refining process for 2002 are summarised in Table 3.8.1. This table includes the major raw materials, in addition to chemicals required in the process and fuel for power and steam generation. The figures quoted in this section are approximate only.

Table 3.8.1
Major Inputs – Existing Refinery

Material	Use	Consumption (t/y) ¹	Form	Source	Transport	Storage
Bauxite	Basic raw material	4,700,000	Bulk	Mine	Conveyor	Stockpile
Caustic Soda	Extraction of alumina from bauxite	210,000	Bulk	US, Saudi Arabia, Japan, Korea	Ship	Tank
Limestone	Used to remove impurities	87,000	Bulk	Japan	Ship	Stockpile

Table 3.8.1
Major Inputs – Existing Refinery

Material	Use	Consumption (t/y) ¹	Form	Source	Transport	Storage
Acids	Descaling and cleaning	1,100	Isotainers	Queensland	Ship	Tank
Flocculants and Reagents	Assist separation of solids from liquids, cleaning	1,500	Drums	Western Australia	Ship	Tank
Fuel Oil	Power station, calciners, lime kiln	480,000	Bulk	Kuwait	Ship	Tank
Diesel Oil	Fuel for vehicles and equipment	7,200	Bulk	Singapore	Ship	Tank
Unleaded Fuel	Vehicles	1,150	Bulk	Singapore	Ship	Tank
Seawater	Evaporation Cooling	5,100 m ³ /hr	Bulk	Melville Bay	Pipeline	None
	Neutralisation of waste water	180 m ³ /hr	Bulk	Macassar Ck	Pipeline	None
Fresh Water	Process solutions, washing, steam production, cooling, fire fighting, potable uses	650 m ³ /hr	Bulk	Mine borefield	Pipeline	Tank
Filter Cloth security disc	Product filtration	50 sets	Bulk	Australia	Ship	Warehouse
		12,900 each	Bulk	Australia	Ship	Warehouse
Grinding balls rods	Bauxite grinding	80	Bulk	Australia	Ship	Warehouse
		70	Bulk	Australia	Ship	Warehouse

¹ All units in tonnes per year unless otherwise noted.

3.8.1 Bauxite

Bauxite is the basic raw material for the refinery from which the alumina is extracted. It is mined from the bauxite mine approximately 19 km to the east of the refinery. It is delivered to stockpiles at the refinery by conveyor. Most of the bauxite is conveyed from the stockpile to the refinery for the production of alumina. However, some bauxite is conveyed directly to the wharf for export.

3.8.2 Caustic Soda

Caustic soda is used to extract the alumina from bauxite. Caustic soda is delivered by ship to the site. It is pumped ashore from the ships at the bulk unloading wharf at the port and piped to storage tanks at the harbour tank farm from where it is piped to smaller tanks in the refinery.

3.8.3 Lime

Lime is used in the refinery process as an aid to pregnant liquor filtration and for caustic regeneration. It is imported by ship from Japan. The limestone is unloaded by grab unloader at the Cargo Wharf at Dundas Point and transported by truck to an on-site limestone stockpile adjacent to the lime plant.

3.8.4 Acids

Sulfuric acid is used predominantly for cleaning and descaling. Acids are stored in the acid tank farm located adjacent to the evaporation plant.

3.8.5 Flocculants and Reagents

Flocculants assist in the fast and efficient separation of solids from liquids. They are used in several stages of the process for thickening and dewatering, with the majority of the flocculant being used in bauxite residue separation. Other reagents are used as drainage aids, anti-foaming, cleaning etc.

3.8.6 Fuel Oil

Fuel oil is used as the energy source in the steam power station, for calcination and the lime plant. The oil is imported by ship and stored in the harbour tank farm from where it is heated and transferred by pipe to smaller tanks adjacent to the power station.

3.8.7 Diesel

Diesel is used to fuel vehicles throughout Alcan operations and also in the emergency electricity generators. It is shipped and stored in a similar manner to the fuel oil.

3.8.8 Unleaded Fuel

Unleaded fuel is used on-site for a small number of vehicles.

3.8.9 Seawater

Seawater is pumped from Melville Bay for cooling in the evaporation plant. This is a once-through system with the seawater being discharged after use back to Melville Bay. Seawater is also pumped from Macassar Creek for neutralising the supernatant liquor in the labyrinth at the RDA.

3.8.10 Fresh Water

Fresh water is used as process make-up water, boiler feed and cooling water make-up. It is also used for washing and cleaning purposes as well as for potable uses. It is sourced from a borefield near the mine site and pumped to the refinery, mine and RDA.

3.8.11 Fabric Filters

Fabric filters are used in the mud separation and product filtering processes within the refinery.

3.8.12 Grinding Balls and Rods

The mills used to grind the bauxite consume grinding balls and grinding rods which require regular replenishment.

3.9 Output Products

3.9.1 Alumina

The main output product from the refinery is alumina which is in the form of a fine dry white powder. All of the alumina is exported by ship from the alumina loading wharf at Dundas Point.

A small quantity of hydrated alumina is also exported. This is alumina that has not been calcined and retains its water of crystallisation ($\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$). Approximately 60,000 t/y of hydrate are exported.

The balance of the refinery's product is calcined alumina. This is alumina that has passed through the calcination process which removes the water of crystallisation (Al_2O_3). The current export rate of alumina is 1.95 Mt/y.

3.9.2 Bauxite

Some of the bauxite that is mined is not used in the refinery for the production of alumina but is exported as ore for use in other refineries. Bauxite is currently exported at a rate of 1.8 Mt/y.

3.9.3 Electricity

The steam power station at the refinery generates electricity and steam for use in the refinery which has a demand of approximately 53 MW. It also generates electricity for use by the mine and the local communities at Nhulunbuy, Yirrkala and surrounding areas. Electricity is distributed throughout the community via an overhead distribution system. The demand for the mine is approximately 3.5 MW and for the community it is approximately 6.5 MW.

3.10 Workforce and Accommodation

Alcan Gove is an equal opportunity employer and currently employs 1,100 people at Gove. This includes wages employees, salaried staff, and several hundred contractors. The majority of employees are residents of Nhulunbuy while approximately 60 direct employees participate in fly-in fly-out arrangements.

A variety of shift arrangements operate. These include a continuous shift roster (day/night), a continuous day shift roster (7 am to 7 pm), the fly-in fly-out roster (8 days on and 8 days off), and several other shift arrangements.

The executive management organisation structure at Alcan Gove is shown in Figure 3.10.1.

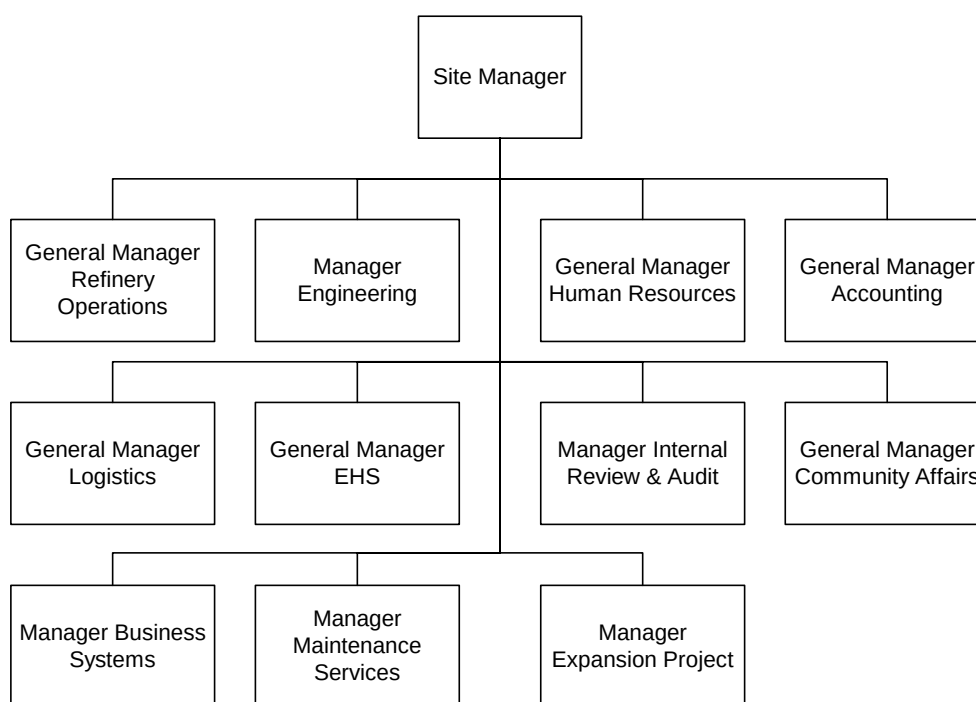
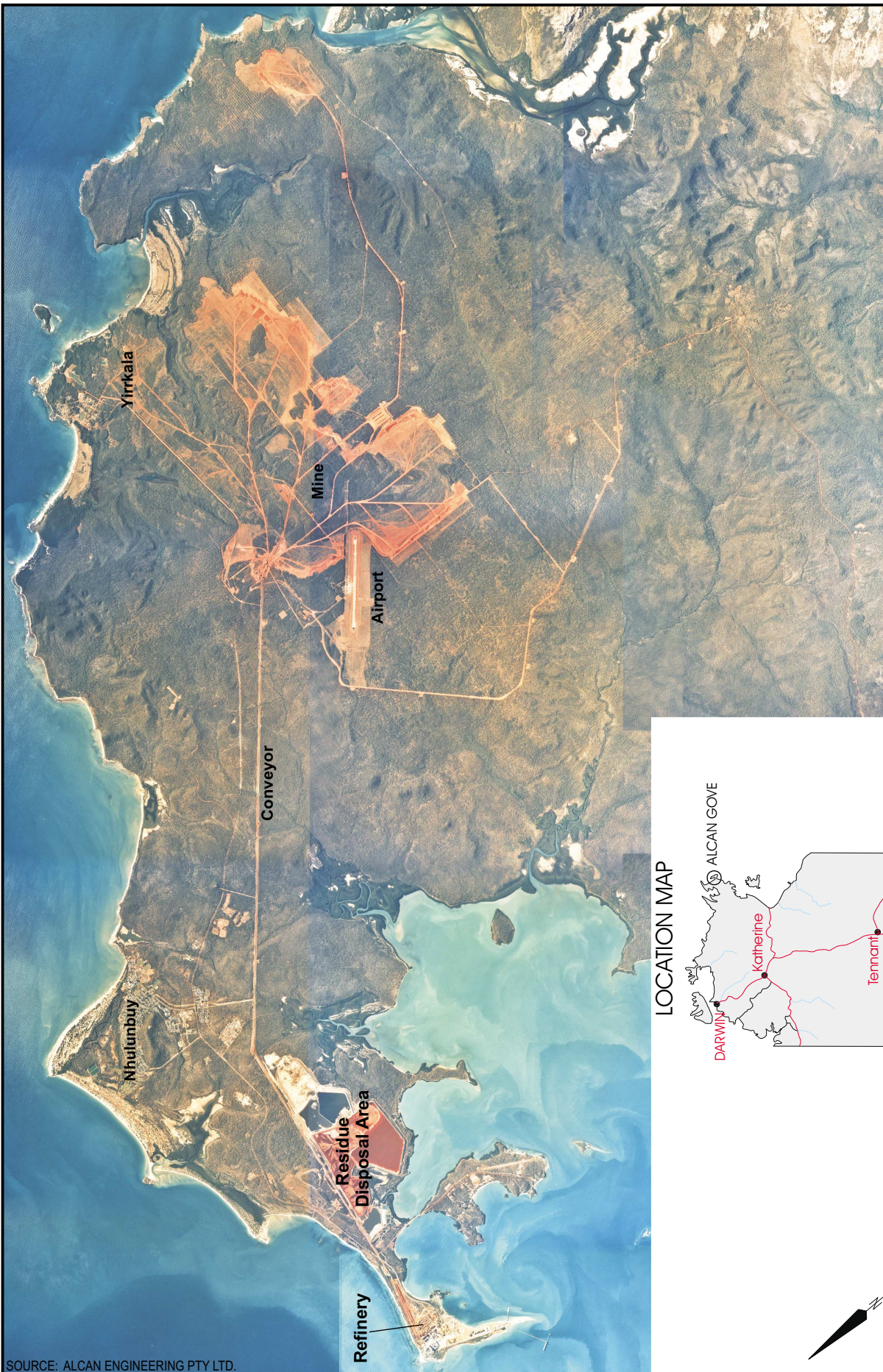


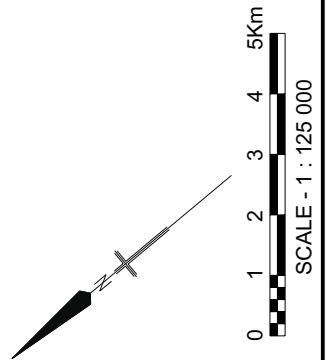
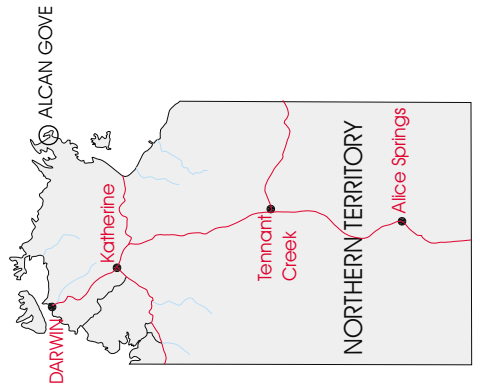
Figure 3.10.1
Alcan Gove Organisation Chart – Executive Management

There are 590 Alcan Gove owned detached houses in Nhulunbuy – around half of all the houses in the town. In addition to those houses, there are 130 town flats for employees and 260 hostel rooms also owned by Alcan Gove. Alcan Gove employees also use the privately owned accommodation village (200 apartments) on the eastern side of town.



SOURCE: ALCAN ENGINEERING PTY LTD.

LOCATION MAP



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REGIONAL LOCATION

Figure 3.1.1

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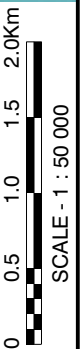
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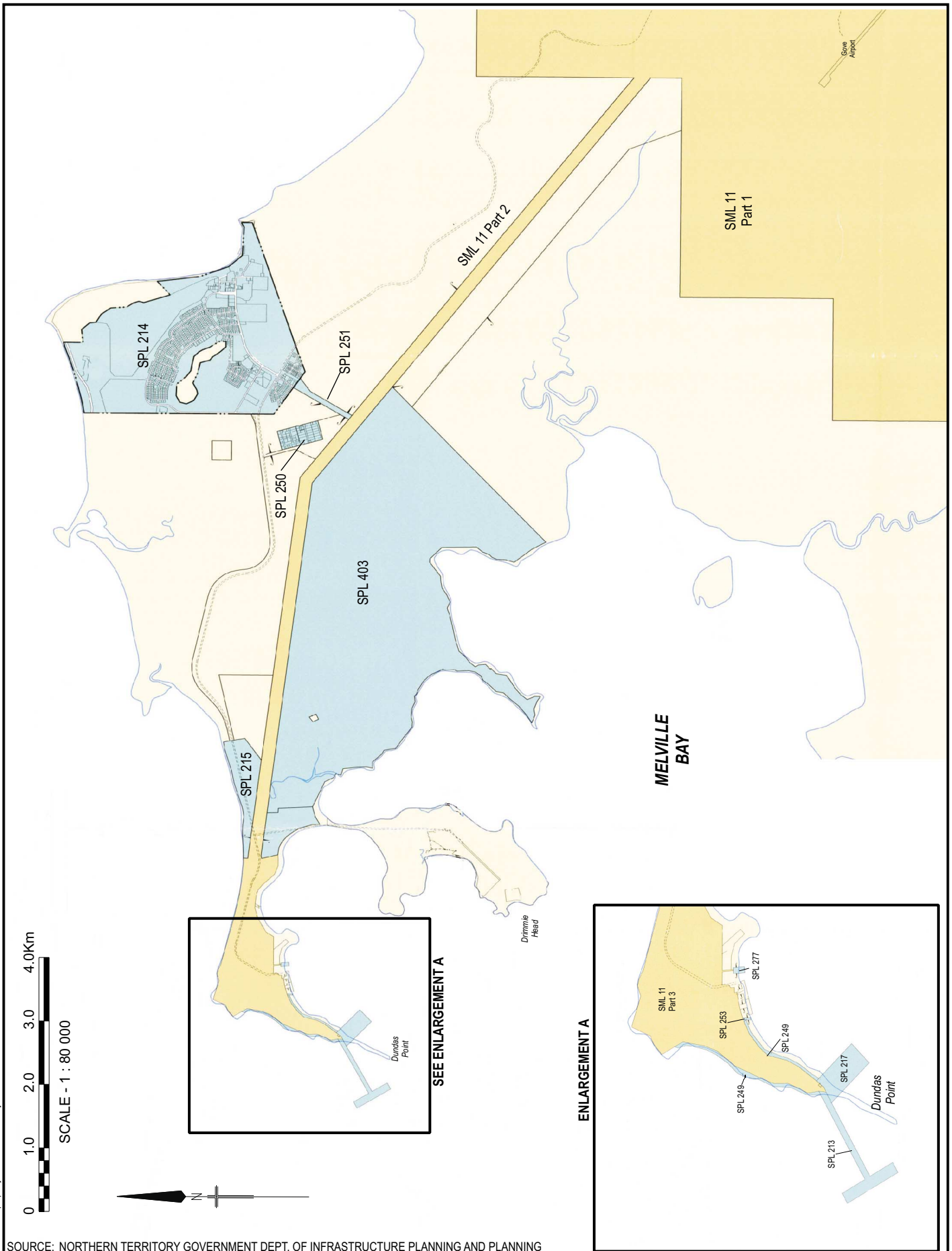
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**REFINERY AND RESIDUE
DISPOSAL AREA**

Figure **3.1.2**



SOURCE: NORTHERN TERRITORY GOVERNMENT DEPT. OF INFRASTRUCTURE PLANNING AND PLANNING



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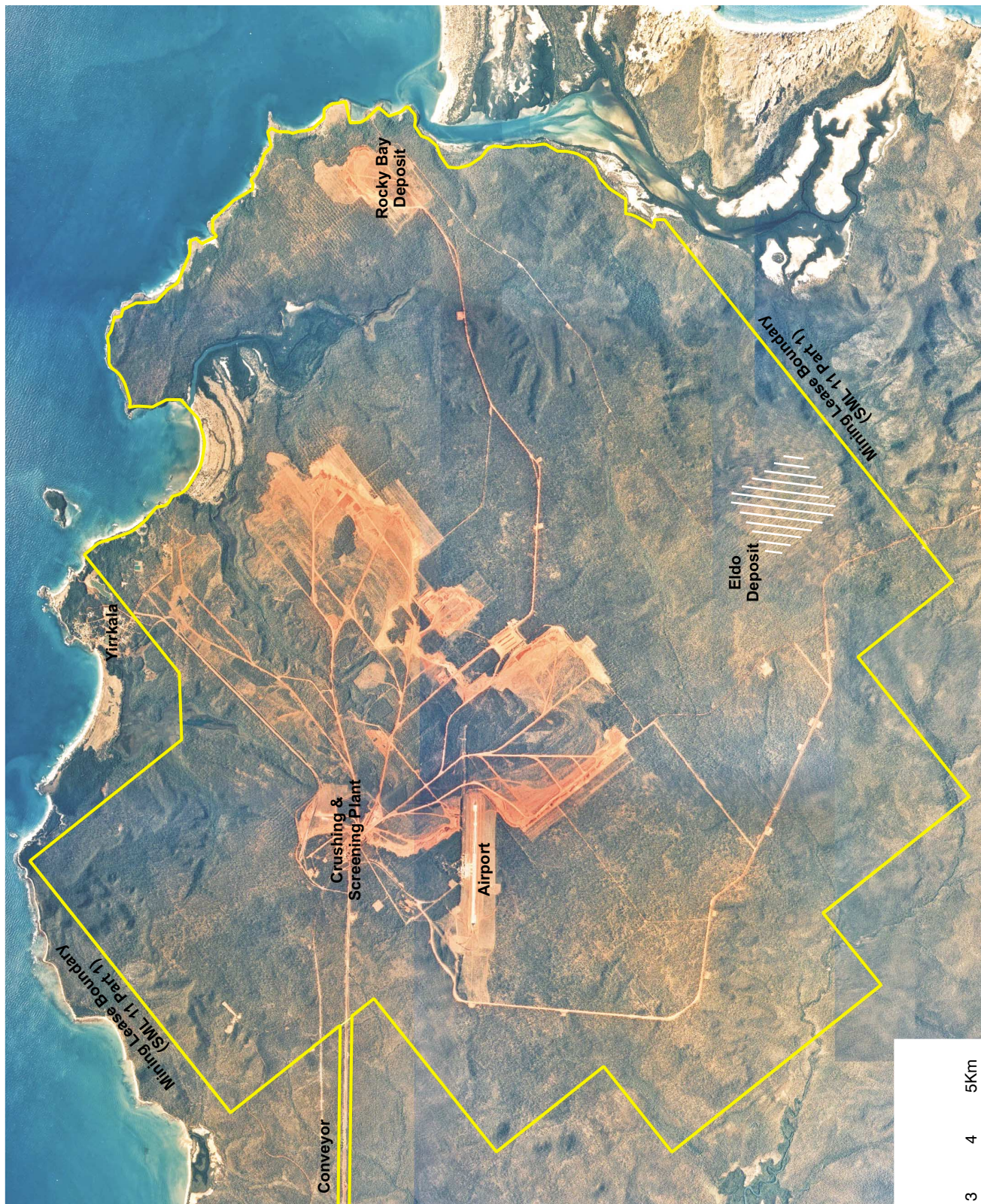
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LAND TENURE

Figure **3.2.1**



SOURCE: ALCAN ENGINEERING PTY LTD.



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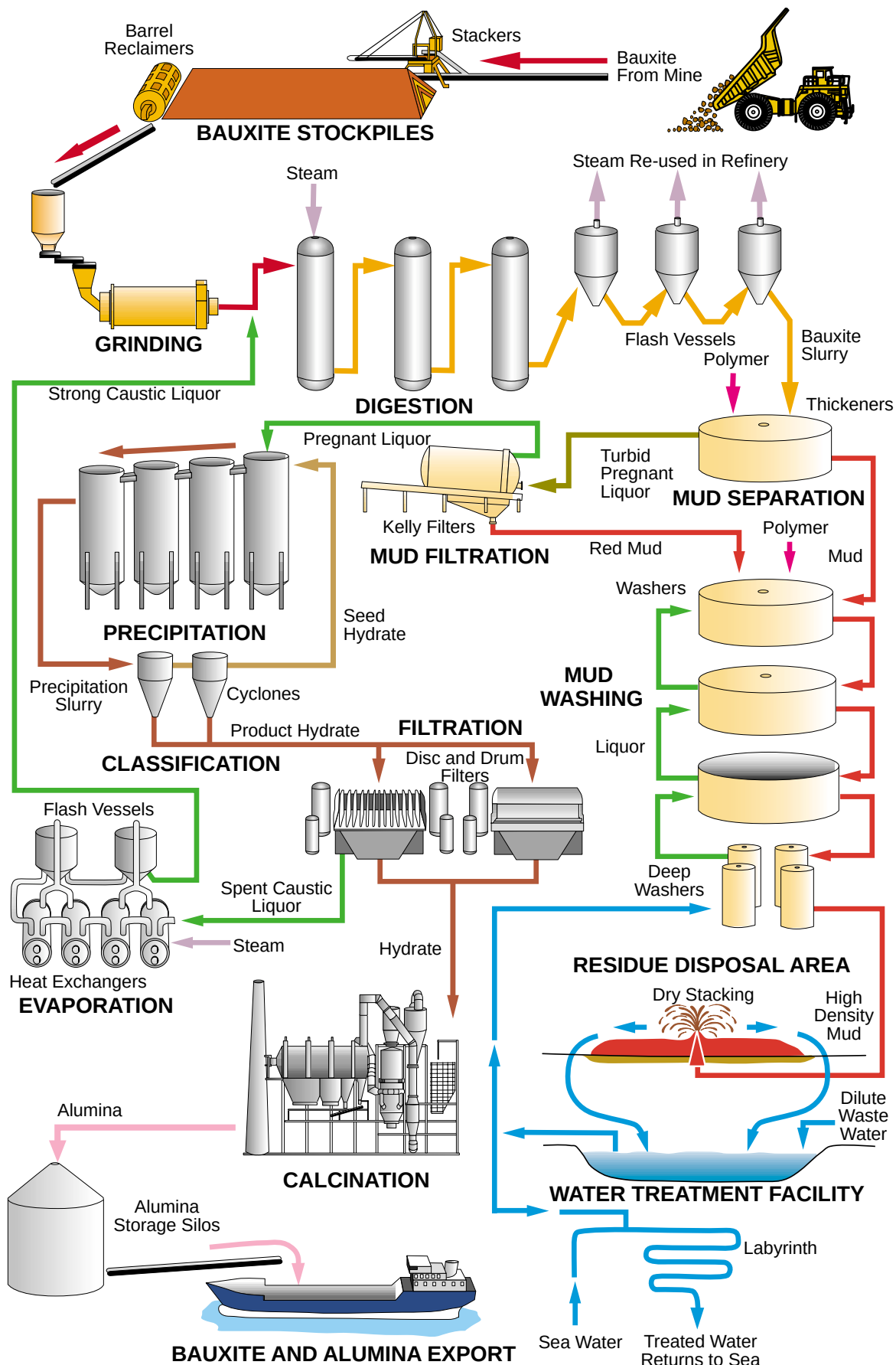
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MINE AREA

Figure **3.4.1**



SOURCE: ALCAN ENGINEERING PTY LTD



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EXISTING REFINERY PROCESS FLOW DIAGRAM

Figure 3.5.1

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EXISTING REFINERY

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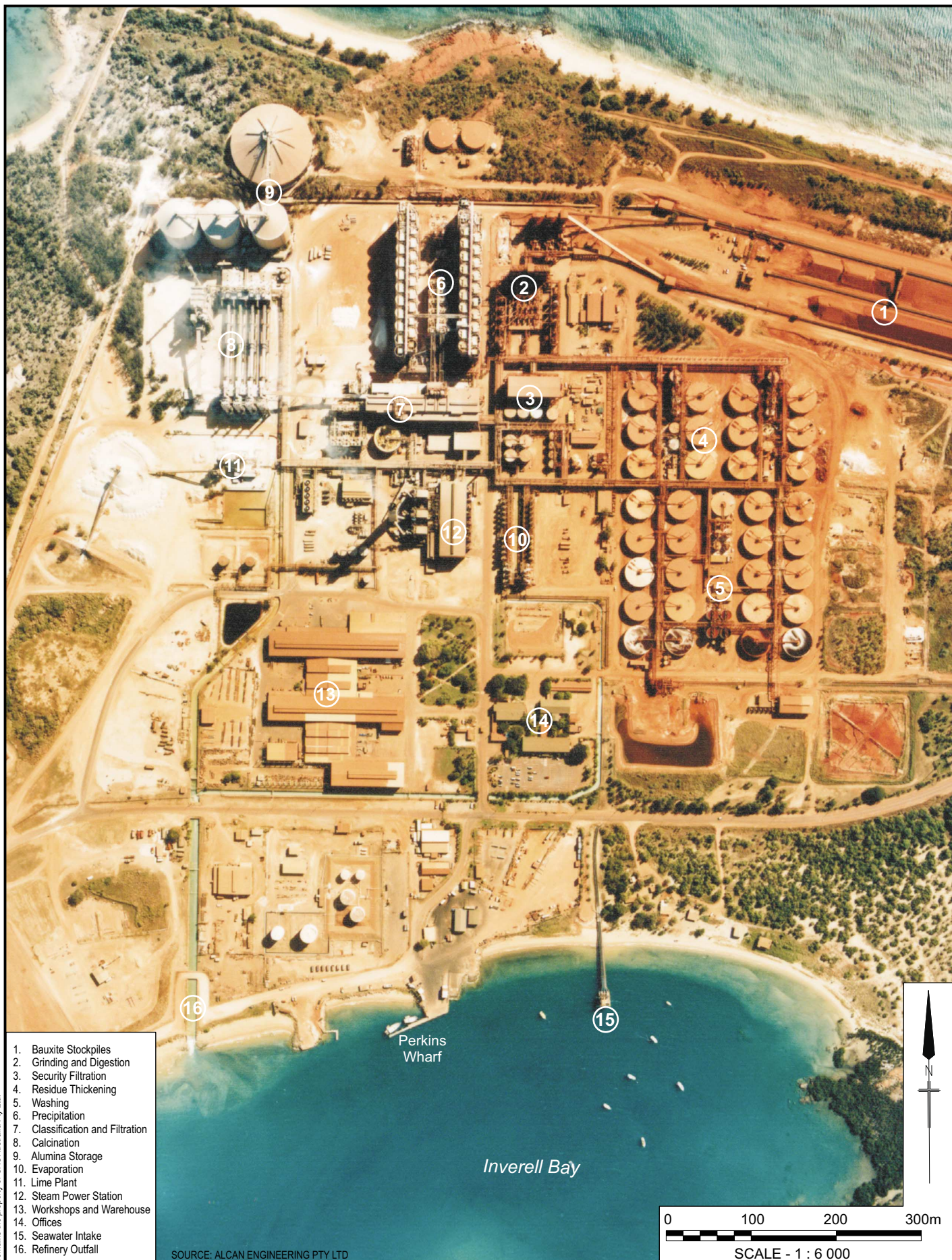
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Figure 3.5.2



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REFINERY LAYOUT

Figure **3.5.3**

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RESIDUE DISPOSAL AREA

Figure 3.6.1