ENVIRONMENTAL IMPACT ASSESSMENT
FOR 2.8 MILLION METRIC TONNE PER YEAR EFFICIENCY UPGRADE AT JAMALCO

JAMALCO,
A PLANT WITHIN A PARK

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EXECUTIVE SUMMARY

1 Executive Summary

1.1 Introduction

An Environmental Impact Assessment (EIA) was carried out by a highly experienced interdisciplinary team of professionals on the proposed brownsite efficiency upgrade of the Government of Jamaica-Alcoa owned Jamalco bauxite-alumina production facilities from its current 1.25 million metric tonnes/year production to 2.80 millom metric tonnes/year (mty).

Alcoa has been operating in Jamaica since 1963, firstly as a bauxite mining, drying and shipping operation and later as an alumina producer, following construction and commissioning of a refinery at Halse Hall, Clarendon in 1970. The start-up capacity of the refinery was 500,000 mty. The plant was built for expansion. Through a series of incremental expansions, the facility has improved production capacity to the current capacity of 1,250,000 mty. The Company has established an environmental, social and economic baseline of over forty years of operations in Jamaica.

Bauxite for supply to the upgraded plant will be mined from Clarendon, South and North Manchester. The last named being a new area for mining.

Cutting edge, state-d-art, technologies developed over the last thirty four years of alumina production will be used in the efficiency upgrade. This will enable the facility to achieve this level of production without doubling of its physical size. Since the plant was built for expansion, essentially, the upgrade will take place within the existing battery limits of the refinery.

A new Residue Disposal Area (RDA # 5) will be constructed for bauxite residue management. The technology for bauxite residue management will be changed to the more efficient, solar drying, thickened residue disposal technology, commonly known as "dry stacking". This stores more bauxite residue per unit area, hence conserving on land space. A special thickener required for this purpose is already in place.

Relatively minor modifications will take place at the port involving: reinforcement of the dolphins, elevation of the shiploader, maintenance dredging to increase depth by 4.5 to 5.5 ft. A parallel railway line will be constructed at the port to allow for staging of more rail cars during off-loading. A temporary, private, parallel access path along the alignment of the railroad, from the port to the refinery to facilitate the transportation of heavy equipment from the port to the plant during construction is being considered. This would alleviate potential impacts on the public roadways.

Upgrading of the facilities represents an investment of US$ 690,000,000.00; the largest single investment in Jamaica's history. Of this US$ 300,000,000.00 will be spent in Jamaica for purchasing goods and services which will register to the National Accounts.

On completion of construction and start-up of operations, an additional

US$ 77,000,000.00, in new income, will be earned annually by Jamaica.

During the twenty four month construction period approximately 2,500 persons will be employed. About one hundred permanent jobs will be created during operations.

In collaboration with HEART/NTA, Jamalco has already started a major human resource development programme, in an effort to improve the skills base of the area and possibly supply skilled tradesmen for the upgrade project.

Jamalco has had to compete intensively with other bauxite rich locations, worldwide within the Alcoa system, to qualify for consideration for upgrading of this plant. This involved significantly improved efficiencies and effectiveness in corporate management, business management and environmental, health and safety management.

Various alternatives were identified and analyzed in conducting the studies. After rationalization and optimization the most suitable alternative was justified and selected.

Consequent on its 40 year baseline of operations in Jamaica there will be no new or unfamiliar environmental impacts or risks. Furthermore the Company has, as a matter of policy and its internal values, consistently improved its technologies and methodologies for environmental, health and safety management.

1.2 Terms of Reference

The EIA was done against Terms of Reference (TOR) approved by the National Environment and Planning Agency (NEPA) (see Section 14).

1.3 Regulatory Framework

The regulatory framework for the project included international and national policies, legislation, regulations and standards as well as Alcoa International policies and values. The project was designed and the EIA conducted to insure project compliance with the regulatory framework.

1.4 Environmental Setting & Baseline

The environmental setting and baseline for the proposed efficiency upgrade included studies, analyses and assessments on: geomorphology, geology, water resources, terrestrial and marine ecology, land use and aesthetics, socio-economics, community consultations, archaeological and historical heritage resources, air quality and weather, noise and vibration, natural hazard vulnerability and risk assessment, among others.

The EIA also addressed the following issues:

- Solid and hazardous waste management practice/landfill.
- Wastewater management

- Occupational health and safety
- Human health risk of proposed actions
- Analysis of Alternatives
- Impact identification
- Impact mitigation
- Strategic elements in relation to other developments planned for the region

Closure plans for construction phase and structural integrity testing.

1.5 Regional Location

The parishes of Clarendon and Manchester comprise the general regions of the project, while the project specific sites are provided below.

1.6 Site Specific Locations

The specific sites for the proposed project are as follows:

- Mining: - Clarendon, South & North Manchester
- Alumina Refinery & Residue Disposal Area: - Halse Hall, Clarendon
- Alumina Port: - Rocky Point
- Transportation Corridors:- Mines to Alumina Refinery and Alumina Refinery to Rocky Point Port.

In addition, other developments planned for the area of the study were noted and their strategic importance taken into account along with those of the proposed efficiency upgrade.

1.7 Approach & Methodology

Various creative, innovative and standard methodologies and approaches were used involving literature and qualitative and quantitative field studies for each aspect of the EIA.

1.8 Project description

The proposed project will be constructed over a period of 24 months and will involve changes in: mining location, the refinery, bauxite residue disposal technology, the port and transportation corridors.

1.9 Potential impacts identified

The potential impacts identified were both negative and beneficial. No new or unfamiliar major negative impacts or risks were identified. Those negative impacts identified could all be mitigated using traditional and new technologies.

The potential environmental impacts identified for the pre-construction, construction and operating phases of the proposed project included:

1.9.1 Negative

- fugitive airborne, particulate emissions at the mines, plant, port and transportation corridors.
- gaseous atmospheric emissions from fuel combustion for co-generation of steam and electrical energy at the refinery as well as alumina hydrate calcination. Fuel combustion in mobile and stationery equipment.
- loss of biodiversity, at the port and mines
- change in drainage regime at the mines

- contamination of ground water resources
- improper collection and handling and disposal of wastes
- improper wastewater management
- noise and vibration during construction and operations
- aesthetics and transient change land use
- archaeological and historical heritage resource impacts

1.9.2 Positive

- improved macro and micro economic performance nationally, throughinvestment, increased revenue and job creation.

1.10 Impact Mitigation

The proposed efficiency upgrade, being a brownsite project with an operating and environmental baseline of forty years, there are no new or unfamiliar negative impacts or risks. All the impacts will be effectively mitigated using traditional and state of the art methods.

1.11 Impact Maximization

The potential beneficial impacts are particularly significant to Jamaica's economic stability, growth and development. There are various potential opportunities for maximization of these benefits.

1.12 Conclusion

The proposed brownsite efficiency upgrade of Jamalco's bauxite mining and alumina refining operations in Jamaica is planned to take place against a background of a forty year baseline of operations and in a highly competitive global bauxite alumina industry, both within the Alcoa international system and externally in the world's aluminium industry in general.

Jamalco has had to significantly improve its efficiencies to make Jamaica an attractive location to qualify for consideration as a candidate site for this efficiency upgrade.

Over the forty year period which the company has operated in Jamaica there has been marked improvement in alumina production and environmental technology and management.

The potential impacts identified will be mitigated using proven technologies, most of which have been effectively applied in the past. No new or unfamiliar environmental impacts or risks have been identified with the proposed efficiency upgrade.

The proposed project which represents the largest single investment in Jamaica's history bears the potential for enormous macro and micro economic as well as social benefits to Jamaica.

1.12.1 Recommendations

Jamalco and the Government of Jamaica should make every effort to maximize the potential benefits which could come to Jamaica as a result of this project.

Because the potential impacts of the project can be mitigated and the beneficial impacts are substantial, we recommend that this project be permitted for implementation.

POLICY, LEGISLATION AND REGULATIONS

2 Policy, Legislation and Regulations

2.1 POLICY, LEGAL & ADMINISTRATIVE FRAMEWORK

This section provides a background on Alcoa's (Jamalco) Environmental Policy and International & National Policies, Legislation and Regulations applicable to the proposed upgrade and expansion of the Jamalco facility (Plant, Port and Mines).

2.1.1 ALCOA'S POLICIES, PRINCIPLES AND GUIDELINES

2.1.1.1 Alcoa's Environmental Policy

The Jamalco facility, under the management of Alcoa, strives to meet or exceed all environmental policies and regulations locally and within its corporate structure. As such, the facility is operated under strict guidance and guidelines to insure compliance at all levels of operation. The following information is derived from the existing Jamalco Environmental Policy Document.

It is Alcoa's policy to operate world-wide in a manner which protects the environment and the health of our employees and of the citizens of the communities where we have an impact.

- ✓ We will comply with all applicable environmental laws, regulations and permits, and will employ more restrictive internal standards where necessary to conform with the above policy.

- ✓ We will anticipate environmental issues and take appropriate actions which may precede laws or regulations.

- ✓ We will work with government and others at all levels to develop responsible and effective environmental laws, regulations and standards.

- ✓ All Alcoans are expected to understand, promote and assist in the implementation of this policy.

2.1.1.2 Alcoa's Environmental Principles

In support of Alcoa's Environmental Policy, the following principles have been developed to provide additional direction on specific issues. The implementation plan, which follows, provides details on how the Policy and Principles will be carried out.

- ✓ *We will support Sustainable Development*
- ✓ Alcoa will incorporate sustainable development into our operations by integrating environmental considerations into all relevant business decisions. We will achieve cleaner production through programs of waste minimization and pollution prevention with specific and measurable reduction targets.
- ✓ *We will practice responsible use of natural resources*
- ✓ Alcoa will utilize the best available information to plan and execute all projects that involve extraction of raw materials, or which may restrict the use of natural resources or impact ecosystems.
- ✓ *We will utilize techniques accepted as best practices on a worldwide basis for resource extraction, resource use, waste management, and rehabilitation of ecosystems disturbed by our activities.*
- ✓ *We will use energy wisely*
- ✓ Alcoa will strive to maximize efficient energy use, conserving non-renewable resources.
- ✓ *We will practice sound environmental management*
- ✓ Alcoa will integrate environmental management fully with business and operating management to ensure that long-term and short-term environmental issues are considered together with market and economic aspects when decisions are made about new and existing facilities, processes, products, services, acquisitions and divestitures.

- ✓ *We will provide training and information*

- ✓ Alcoa will sponsor training in the environmental area. We will also provide employees, suppliers, customers and neighbors with information needed to understand and help us achieve the goals of our environmental policy.

- ✓ *We will audit our operations and report findings*

- ✓ Alcoa will audit each of its operations on a regular basis to identify strengths and weaknesses of the location's environmental management process and to identify actions that need to be taken to prevent environmental problems or correct environmental deficiencies. Appropriate management, including the Alcoa Board of Directors, will be informed of the audit findings.

- ✓ *We will sponsor activities to improve the science of environmental protection.*

- ✓ Alcoa will sponsor and conduct research and development (including application of emerging technologies) to improve our ability to predict, assess, measure, reduce, and manage environmental impacts of our operations. We are committed to continuous improvement in all aspects of our environmental performance.

- ✓ *We will develop and adhere to high standards.*

- ✓ Alcoa will develop and implement worldwide environmental standards and best practices with emphasis on areas that are unique to our business.

- ✓ *We will report on our activities*

- ✓ Alcoa will communicate promptly and openly with individuals and communities regarding the environmental aspects and impacts of our operations, as well as with concerned parties who request such information. Alcoa will also provide an annual Environmental Health and Safety report that describes our programs, plans and performance. The report will be made available to shareholders and the public.

2.1.1.3 Alcoa's Bauxite Mine Rehabilitation Standards & Guidelines

The following guidelines are adapted from Bauxite Mine Rehabilitation Standards & Guidelines (1994). These are standard practices to which the client is committed to maintaining at the proposed bauxite railhead, storage areas, mining sites and transportation corridors in southern Manchester and Clarendon.

- During land clearing, utilization of existing resources on the site must be maximized. These may include timber, buildings and produce.
- If the existing vegetation can assist in the rehabilitation process it should be harvested and redistributed in a timely manner on the areas being rehabilitated.
- Burning as a means to remove vegetation should be used as a last resort and should be considered only after harvesting, habitat and burying options have been considered.
- Land area cleared should be the minimum for efficient mining (pits and infrastructure) and rehabilitation.
- Topsoil and remaining vegetation debris must be harvested from the entire area to be mined and either stored where it can be recovered or utilized immediately on other areas being rehabilitated.
- Whenever topsoil is stored it should be done so for the least possible time to minimize the loss of biological activity and nutrients.
- If there are potentially toxic substances in the overburden and mine waste, they should be handled in such a way as to minimize the impact on the rehabilitation and the surrounding areas.
- In some circumstances, in addition to topsoil, subsoil horizons and/or a portion of the overburden may need to be harvested and re-spread on the rehabilitated areas in order to successfully establish the desired vegetation. Topsoil and subsoil/overburden should be re-spread as separate strata and not mixed together.

- Clearing of additional vegetation for storage of topsoil and/or overburden should be minimized.

- Finished slope angles in reshaping will depend on aesthetics, final land use, soil characteristics and safety. Reshaped terrain should conform to the natural landscape.

- All slopes must be stable. If erosion is likely to occur then erosion control works should be put in place

- Compression resulting from the mining, reshaping and soil placement process must be relieved (e.g. by ripping, plowing and sub-soiling etc.) where rehabilitation plans require water infiltration and plant root penetration. During this operation care must be taken to ensure that unfavorable sub-soil materials are not brought to the surface and excessive topsoil burial does not occur.

- soil nutrient and pH levels must be adjusted where this is necessary to achieve rehabilitation objectives

- Where regeneration of native vegetation is the objective, nutrient and pH levels should closely match pre-existing conditions. Soil conditioners should be considered to ameliorate adverse conditions.

- Topsoil must be replaced as the final soil profile. The thickness and area to which the topsoil is returned must provide the maximum value to the end use of the rehabilitated area.

- The topsoil should be evenly spread over the area.

- Where native vegetation is to be re-established, only propagules of the indigenous plant species should be used. Preferably, these should be collected from the areas being cleared or other local provenances.

- Revegetation strategies should be based on a high level of understanding of local climatic conditions and ecological processes. Re-established plant communities should eventually duplicate the natural ecological processes and functions of the original vegetation.

- Fauna return should be encouraged by natural means through the creation of suitable habitat rather than by physical re-introduction. Keystone species may need to be transferred where they are absent or inadequately represented in surrounding areas.

- Artificial barriers such as perimeter roads and fences, which inhibit flora or fauna recolonization, should be removed as soon as practical.

Implementation of these policies, principles and guidelines within Alcoa, begins with the CEO who is ultimately responsible for assuring conformance with Alcoa's Environmental Policy Worldwide. The technical guidance and support will be provided by the environmental staff and other support groups.

At Jamalco, local implementation of these policies, principles and guidelines is the responsibility of the location manager, business unit managers, staff support groups, operating managers, sponsoring managers, environmental affairs staff, government affairs staff, Alcoa personnel and other staff groups.

2.2 Local Policies, Legislation and Regulations

2.2.1 Policy, Legislation, Regulations & Standards

The following represents descriptions of applicable legislative requirements with which activities of this proposed upgrade must comply:

- Agenda 21
- Natural Resources Conservation Authority (NRCA) Act, 1991
- Wildlife Protection Act, 1945
- Watershed Protection Act, 1963
- Mining Act, 1975
- Minerals (Vesting) Act, 1947
- Bauxite and Alumina (Special Provisions) Act, 1978
- Bauxite and Alumina Encouragement Act, 1950
- Town & Country Planning Act, 1987
- Forestry Act, 1937
- Water Resources Act/Underground Water Control Act, 1959
- Jamaica National Heritage Trust Act, 1985
- Beach Control Act, 1956
- Public Health Act, 1985
- Disaster Preparedness & Emergency Management Act, 1993

- National Solid Waste Management Authority Act, 2001
- Occupational Safety & Health Act, 2003 (DRAFT)
- Clarendon Parish Provisional Development Order, 1982
- Manchester Parish Provisional Development Order, 1974

2.2.1.1 AGENDA 21

In June 1992, Jamaica participated in the United Nations Conference for Environment and Development (UNCED). One of the main outputs of the conference was a plan of global action, titled Agenda 21, which is a “comprehensive blueprint for the global actions to affect the transition to sustainable development” (Maurice Strong). Jamaica is a signatory to this convention. Twenty seven (27) environmental principles were outlined in the Agenda 21 document. Those relevant to this project, which Jamaica is obligated to follow are outlined below:

The proposed project is governed by national policies and regulations but the country also subscribes to international environmental policies. Jamaica is signatory to one such convention which came out of the conference on the Environment and Development, held at Rio de Janeiro in June 1992.

The United Nations hosted the EARTH SUMMIT '92 and from this conference twenty - seven (27) environmental principles were outlined. Not all of these principles are applicable to the project but those deemed relevant and appropriate are outlined below.

Principle 1: Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 2: States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own environment and developmental policies, and the responsibilities to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdictions.

Principle 3: The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 6: The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

Principle 10: Environmental issues are best handled with the participation of all concerned citizens, at the relevant level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in the decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle 17: Environmental impact assessments, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to the decision of a competent national authority.

2.2.1.2 Natural Resources Conservation Authority Act, 1991

The Act is the overriding legislation governing environmental management in the country. It also designates National Parks, Marine Parks, Protected Areas and regulates the control of pollution as well as the way land is used in protected areas.

This Act requires among other things, that all new projects or expansion of existing projects which fall within a prescribed description or category must be subjected to an Environmental Impact Assessment (EIA).

The regulations require that eight (8) copies of the EIA Study Report must be submitted to the Authority for review. There is a preliminary review period of ten days to determine whether additional information is needed. After the initial review the process can take up to ninety days for approval. If on review and evaluation of the EIA the required criteria are met, a permit is granted.

Specifically, the relevant section(s) under the Act which addresses the proposed mining activities are:

s.10: (1) Subject to the provisions of this section, the Authority may by notice in writing require an applicant for a permit of the person responsible for undertaking in a prescribed area, any enterprise, construction or development of a prescribed description or category-

(a) to furnish the Authority such documents or information as the Authority thinks fit; or

(b) where it is of the opinion that activities of such enterprise, construction or development are having or are likely to have an adverse effect on the environment, to submit to the Authority in respect of the enterprise, construction or development, an EIA containing such information as may be prescribed, and the applicant or, as the case may be, the person responsible shall comply with the requirement.

s.12: Licenses for the discharge of effluents etc.

s.17: Information on pollution control facility

s.18: Enforcement of Controls – threat to public health or natural resources

s.32-33: Ministerial Orders to protect the environment

s.38: Regulations

2.2.1.3 Wildlife Protection Act, 1945

This act involves the declaration of game sanctuaries and reserves, game wardens, control of fishing in rivers, protection of specified rare or endemic species. The Act also provides for the protection of animals and makes it an offence to harm or kill a species which is protected. It stipulates that, having in one's possession "whole or any part of a protected animal living or dead is illegal.

This Act has to be considered for the proposed project, ecological assessments will determine if rare or endangered species will be impacted.

2.2.1.4 Watershed Protection Act, 1963

This Act governs the activities operating within the island's watersheds, as well as, protects these areas. The watersheds which are designated under this Act include Rio Minho, Cane River and Rio Nuevo watersheds areas.

Determinations will be made to identify any potential impacts that this project may have on the various watershed areas and will propose mitigative actions where impacts are identified.

2.2.1.5 Mining Act, 1975

The Mining Act regulates the activities of the mining sector including the various intricacies involved in the granting of licenses, prospecting rights and regulations, compensation payments and the utilization of special lands under a mining lease.

This Act is of special importance to the proposed mining activities and would be administered by the Jamaica Bauxite Institute (JBI).

2.2.1.6 Minerals (Vesting) Act, 1947

The Minerals (Vesting) Act, through the Minister, has the power to declare that all minerals being in, on or under any land or water, whether territorial waters, rivers, or inland sea, are vested in and are subject to the control of the Crown. As such this Act governs the extent to which royalties are payable to landowners.

2.2.1.7 Bauxite and Alumina (Special Provisions) Act, 1978

This Act makes provision for the power of the Minister (s) to declare on behalf of the Government to confirm agreements and arrangements between Government and Bauxite Producers, the power to declare persons "Bauxite Producers" and the power to transfer or vest lands of Bauxite Producers. The Act identifies exemptions from approval consents, Transfer Tax, Stamp Duty and Fees of land being owned by a Bauxite Producer for the production of bauxite.

It also gives the Minister power to ensure that orders or regulations are consistent with agreements made and finally it enforces that Income Tax shall be payable against production levees and to be paid in United States currency.

2.2.1.8 Bauxite and Alumina Encouragement Act, 1950

This Act authorizes a company to produce bauxite and alumina. It also identifies the power of the Minister on behalf of the Government, to approve the expansion of the alumina industry in Jamaica. In addition, the Act identifies exemption of customs duty for articles/materials used in the production of bauxite, as well as, specific circumstances for payments of General Consumption Tax and conditions for exemption from excise and customs duty. Special provisions are also made for exemptions from Income Tax.

2.2.1.9 Town & Country Planning Act, 1987

This Act governs the development and use of land. Under this law the Town Planning Department is the agency responsible for the review of any plans involving industrial development. The law allows for specific conditions to be stipulated and imposed on any approved plans. This planning decision is based upon several factors, these include;

- the location of the development
- the nature of the industrial process to be carried out
- the land use and zoning
- the effect of the proposal on amenities, traffic, etc.

This Act is applicable to the proposed plant and port upgrades and mining activities.

2.2.1.10 Forestry Act, 1937

This Act provides for the management and the declaration of Forest Reserves on Crown Lands and regulates activities in Forest Reserves. This Act will be reviewed to determine if the upgrade activities (particularly mining) will impact on Forest Reserves and to what extent.

2.2.1.11 Water Resources Act; the Underground Water Control Act, 1959

The Underground Water Control Act of 1959 is the legal instrument and is enforced by the Water Resources Authority (WRA). The Water Resources Act is expected to provide for the management, protection, controlled allocation and use of water resources of Jamaica. Thus the water quality control for both surface and ground water are regulated by this Act.

If the proposed facility intends to utilize any existing ground water, permission would be needed, in the form of an issued license for this activity. Under this Act exploratory activities such as the boring/drilling of wells for the purpose of searching for underground water without the written consent would be a violation.

In addition, any activity which negatively influences the quality of existing water, whether ground or surface, would be relevant to this Act.

The proposed project will impact on:

- Ground water resources as it proposes, to increase ground water extraction rates.

2.2.1.12 Jamaica National Heritage Trust Act, 1985

The Act is administered by the Jamaica National Heritage Trust, formerly the Jamaica National Trust. This Act provides for the protection of important areas, including the numerous monuments, forts, statues, buildings of historic and architectural importance in Jamaica.

In the Parish of Clarendon, several historic sites and buildings have been identified within the general area of this project, these include:

- Halse Hall Great House and Tombs
- God's Well (near Milk River)
- Ruins of a Dam (Raymonds near Dawkins Pen)
- Milk River Bath
- Braziletto Mountain Conservation Area
- Portland Bight Protected Area and National Park

In the Parish of Manchester, several historic sites and buildings have been identified within the general area of this project, these include:

- Hibernia (North Manchester)
- Moravian Monuments and grave sites (North Manchester)
- God's Well (South Manchester)
- Derry (National Monument)
- Numerous historic buildings

During this project, an Archaeological and Heritage Retrieval Plan will be implemented to protect any historical or archaeologically significant item encountered.

2.2.1.13 The Beach Control Act (1956)

The Beach Control Act provides for the regulation of activities within twenty-five (25) metres of the shoreline. It includes control of the construction of sheds and huts on beaches, and prohibits the use of public beaches for fishing activities. The Act is administered by NEPA, and also makes provisions for the creation of Marine Protected Areas. The sections of the Act relevant to the project are:

Section 7: **(1)** Notwithstanding anything to the contrary in this Act, the Minister may, upon the recommendation of the Authority, make an order declaring:

(a) any part of the foreshore and the floor of the sea defined in the Order together with the water lying on such part of the floor of the sea to be a protected area for the purpose of this Act; and

(b) such activities as may be specified in the Order to be prohibited activities in the area defined in the Order, being any or all of the following activities:

(i) fishing by any means specified in the Order;

(ii) the use of boats other than boats propelled by wind or oars where such boats are used for purposes other than for the doing of anything which may be lawfully done under the Harbours Act, the Marine Board Act, the Wrecks and Salvage Law, the Pilotage Act or the Exclusive Economic Zone Act;

(iii) the disposal of rubbish or any other waste material;

(iv) water-skiing;

(v) the dredging or disturbance in any way of the floor of the sea.

Section 9: **(1)** Subject to the provision of Section 8 (this does not apply to docks wharves pier etc. constructed prior to June 1, 1956), no person shall erect, construct or maintain any dock, wharf, pier or jetty on the foreshore or the floor of the sea, or any structure, apparatus or equipment pertaining to any dock, wharf, pier or jetty and encroaching on the foreshore or the floor of the sea, except under the Authority of a license granted by the Minister on behalf of the Crown.

This Act will be relevant during works prescribed for the Port area of the project.

2.2.1.14 The Public Health Act (1974)

This Act controls and monitors pollution from point sources. Any breaches of this Act would be sent through the Central Health Committee which takes action through the Ministry of Health, Environmental Control Division (E.C.D.). The ECD has no direct legislative jurisdiction, but works through the Public Heath Act to monitor and control pollution from point sources. Action against any breaches of this Act would be administered by the Central Health Committee. The functions of the department include:

- The monitoring of waste water quality, including regular water quality analysis, using water standards published by NEPA;
- Monitoring of occupational health as it relates to industrial hygiene of potentially hazardous working environments;
- Monitoring of air pollutants through its laboratory facilities.

In addition, there are various sections of this legislative instrument which governs and protects the health of the public. Relevant sections under the Public Health Act of 1985, are Sections 7.- (1) *A Local Board may from time to time, and shall if directed by the Minister to do so, make regulations relating to (o) nuisances* and 14.- (1) *The Minister may make regulations generally for carrying out the provisions and purposes of this Act, and in particular, subject to section 7, but without prejudice to the generality of the foregoing, may make regulations in relation to (d) air, soil and water pollution.*

Aspects of the project related to odour have been considered since odour is a part of the Air Emissions regulations to be promulgated in 2004.

2.2.1.15 Disaster Preparedness and Emergency Management Act, 1993

The principal objectives of the Act is to advance disaster preparedness and emergency management measures in Jamaica by facilitating and coordinating the development and implementation of integrated disaster management systems. Jamalco has established procedures and guidance documents in place in terms of disaster preparedness and emergency management.

2.2.1.16 National Solid Waste Management Authority Act, 2001

The National Solid Waste Management Authority (NSWMA) under this Act has the responsibility to manage and regulate the solid waste sector. It includes requirements for licences for operators and owners of solid waste disposal facilities (in addition to permit requirements of NEPA).

2.2.1.17 Occupational Safety & Health Act, 2003 (DRAFT)

This Act oversees the prevention of injury and illness resulting from conditions at the workplace, the protection of the safety and health of workers and the promotion of safe and healthy workplaces.

Sampling of sections from the Draft Act that are relevant to this project, include:

4. (1) This Act applies to all branches of economic activity and to all owners, employers and workers in all such branches.

5. (1) The owner of every industrial establishment or mine which carries on business on or after the appointed day shall, subject to subsection (8), apply to the Director in the prescribed form to be registered under this Act.

18. (1) Provides a description of the duties of employers, outlining the need for quality work areas and work environments, procedures and guidelines that will result in safe and healthy workplaces.

19. (1) discusses the duties of employers at construction sites in terms of employee safety and health during work activities.

25. (1) an employer shall make or cause to be made and shall maintain an inventory of all hazardous chemicals and hazardous physical agents that are present in the workplace.

26. (1) this section provides guidelines and procedures for employers to follow in terms of identification of hazardous chemicals. This includes labeling and identification protocols.

30. (1) Basically, this section of the Act requires an employer to provide training of its employees with a potential for exposure to hazardous chemicals or physical agents.

It is expected that this Draft Act will be Gazetted in the near future. As such, it is important that Jamalco have an understanding and appreciation for its contents.

2.2.1.18 Clarendon Parish Provisional Development Order, 1982

This document provides the development plan for the Parish of Clarendon. It clarifies the role and responsibility of the local planning authority and provides guidance on how development of the parish should proceed. All activities in this proposed upgrade of the Jamalco operations that requires local planning authority approval will be properly identified and the appropriate permits and licenses will be secured.

2.2.1.19 Manchester Parish Provisional Development Order, 1974

This document provides the development plan for the Parish of Clarendon. It clarifies the role and responsibility of the local planning authority and provides guidance on how development of the parish should proceed. All activities in this proposed upgrade of the Jamalco operations that requires local planning authority approval will be properly identified and the appropriate permits and licenses will be secured.

In terms of mining, the Order indicates that there are "widespread and substantial deposits of bauxite occur at various places within the Parish and it is intended that these should not in any way be rendered incapable of extraction as a result of urbanization".

Special note: The Jamaica Bauxite Institute (JBI) is the regulatory agency monitoring the bauxite industry, and as such their policies will extend to any development on bauxite owned lands.

2.2.2 Summary of the Legislation and Responsible Agencies

Table 1: NATIONAL LEGISLATION AND RESPONSIBLE AGENCIES

LEGISLATION	INSTITUTION RESPONSIBLE
NRCA Act, 1991	Natural Resources Conservation Authority
Wildlife Protection Act, 1945	Natural Resources Conservation Authority
Watershed Protection Act, 1963	Natural Resources Conservation
Mining Act, 1975	Ministry of Agriculture & Mining Jamaica Bauxite Institute Mines and Geology Division
Minerals (Vesting) Act, 1947	Ministry of Agriculture & Mining Jamaica Bauxite Institute Mines and Geology Division
Bauxite & Alumina (Special Provisions) Act, 1978	Ministry of Agriculture & Mining Jamaica Bauxite Institute Mines and Geology Division
Bauxite & Alumina Encouragement Act, 1950	Ministry of Agriculture & Mining Jamaica Bauxite Institute Mines and Geology Division
Town & Country Planning Act, 1987	Town Planning Department
Forestry Act, 1937	Forestry Department
The Water Resources Act/UWC Act, 1959	Water Resources Authority
Ja. National Heritage Trust Act, 1985	Jamaica National Heritage Trust
Beach Control Act, 1956	Natural Resources Conservation Authority
Public Health Act, 1985	Ministry of Health/Environmental Control Division
Disaster Preparation & Emergency Management Act, 1993	Office of Disaster Preparedness and Emergency Management
National Solid Waste Management Authority Act, 2001	National Solid Waste Management Authority
Clarendon Parish Provisional Development Order, 1982	Town Planning Department
Manchester Parish Provisional Development Order, 1974	Town Planning Department

DESCRIPTION OF THE ENVIRONMENT

3 Description of the Environment

3.1 Land Use and Aesthetics

3.1.1 LAND USE

3.1.1.1 Introduction

The upgrading of JAMALCO's operations will include the mines, the plant, the port, transportation corridors and environs. The parishes directly affected by the upgrade are Manchester and Clarendon – an area identified in the National Physical Plan 1978 – 1998 as Region D, the Manchester-Clarendon Region. (Figure 1)

The specific areas that are likely to be exposed to socio-economic and physical impact will be the areas approximately 4 to 6 km north of the main road traversing the region and south of the said main road to the Manchester/Clarendon Coast and the Caribbean Sea. There will be even more intensive and extensive impact on the parish of Manchester, the parish which has been extensively zoned and leased for bauxite mining operations.

3.1.1.2 Historical

3.1.1.2.1 Clarendon

Clarendon was a major sugar production parish during the establishment of plantation settlements by the British Plantocracy between 1660 and 1683. The parish also thrived on the sale of dry goods, confectionery and baked products. May Pen was one of the series of settlements and became a prime location being midway on the main road between Kingston and Mandeville, with a major railway station, a link in the national transportation and communication system.

The town's central location played a contributory role as the main collecting and marketing centre for a major agricultural hintherland extending beyond the parish boundary, to other urban areas, e.g. Old Harbour, Old Harbour Bay and Spanish Town.

Figure 1: PLANNING REGIONS

May Pen which derived its name from the May's property, owned by the wife of Reverend May, then Rector of the Kingston parish Church, was boosted by the economic enhancement of the Aloca alumina refinery at Halse Hall in 1963. In 1969, the first alumina refinery was constructed at this plant causing a rapid increase in population between 1970 and 1982. Features of cultural and historic interest are the 360 year old Halse Hall Great House, St. Peter's Anglican Church 1675, Costal defences established and maintained for decades, including the U.S. Naval base at Little Goat Island 1942-49.

The most well known and popular historical feature is the Milk River Bath Hotel and Spa, the Free Village with its historic and religious artefacts at Hayes; the Pusey Hill ruin; the aqueduct on Old Milk River canal; Anglican and Methodist Churches at Alley and Mitchell Town; industrial estates at Alley, Bog, Salt River and Monymusk.

3.1.1.2.2 Manchester

Manchester was demarcated in 1814 from a sub-division of Clarendon and St. Elizabeth hence its location between both parishes. Its name is derived from the then Governor of Jamaica, the Duke of Manchester.

Mandeville, its main town and now a regional centre since 1970. Mandeville was selected in 1816 as the "parish capital" deriving its name from the eldest son of the then Governor of Jamaica.

The pattern of urban settlement is scattered in small communities and isolated dwellings except for the urban centres of Christiana/Spaldings, Mile Gully, Williamsfield, Porus, Newport, Cross Keys, Victoria Town, and Milk River.

Several sites of historic interest are located along the main road to Cross Keys, dwelling houses and church/cemetery at New Broughton, ruins of dwellings at Wigton, New Forest and Mount Forest, the Rowes corner Jewish Cemetery, churches at Grove Town and Smithfield, the Court House in Mandeville and Roxborough the birthplace of National Hero – Rt. Excellent Norman Washington Manley as also the Albion and Marlborough great houses.

3.1.1.3 Topography

The topography of Clarendon is characterised by the diverse nature of the coastal fringe and offshore islands and cays. The national and marine park and protected area of the Brazilletto Mountains, Portland Ridge, Peake Bay, Portland Bight and the plains in the Southern areas with elevations from 0-150 meters, the Mocho Mountains at elevations of 150-300 meters, extending to the limestone uplands in the north around main ridges, and the Bull Head Mountain. The topography of Manchester is undulating with escarpments and highlands of which the most prominent are the Carpenters Mountains, Mile Gully Mountains, May Day and Don Figuerero Mountains.

3.1.1.4 Area and Land Cover

Clarendon contains an area of 1142.8 sq.km and Manchester an area of 791.6 sq.km.

Land cover in Clarendon is characterised by a scattering of villages and major urban centres, vast areas of sugar cane, wetlands, dry forests and scrub, industrial estates, aquaculture, mixed cultivation including bananas, citrus, subsistence crops by small farmers which includes yams, congo peas, sweet potatoes, etc.; the decline of the sugar industry has left large areas abandoned and taken over by scrub vegetation. Uncultivated areas due to salinity include much of the coastal side of the plains. Tidal flats are largely inaccessible. There are also the dry forests of the Brazilletto mountains and the Portland Ridge, where Taino petroglyphs and some Taino burial caves are to be found.

Manchester also accommodates a scattering of villages and other urban settlements. Mixed cultivation is confined to the northern regions. Bauxite deposits have impacted on the levels of mixed cultivation. Large areas in the valleys are now used as pasture lands, some areas are in woodland and ruinate providing poor grazing for small herds of cattle and goats.

Citrus is cultivated in some areas as are mixed crops such as corn, coffee, Irish potatoes, pimento. Upland areas are cultivated in ackee, breadfruit, mango, cocoa, etc.

The South coastal areas are rich in ethnographic, historic and pre-historic heritage sites and caves, along with areas of outstanding natural beauty and a variety of marine species.

The Northern area comprises forests and forest reserves, within conservation areas.

3.1.1.5 Land Capability

Agricultural land capability in Clarendon varies between classes II, III, IV and VI, and in Manchester between classes I, II, III and V. The following table identifies the suitability of each class. (Figure 2)

Figure 2: AGRICULTURAL LAND CAPABILITY

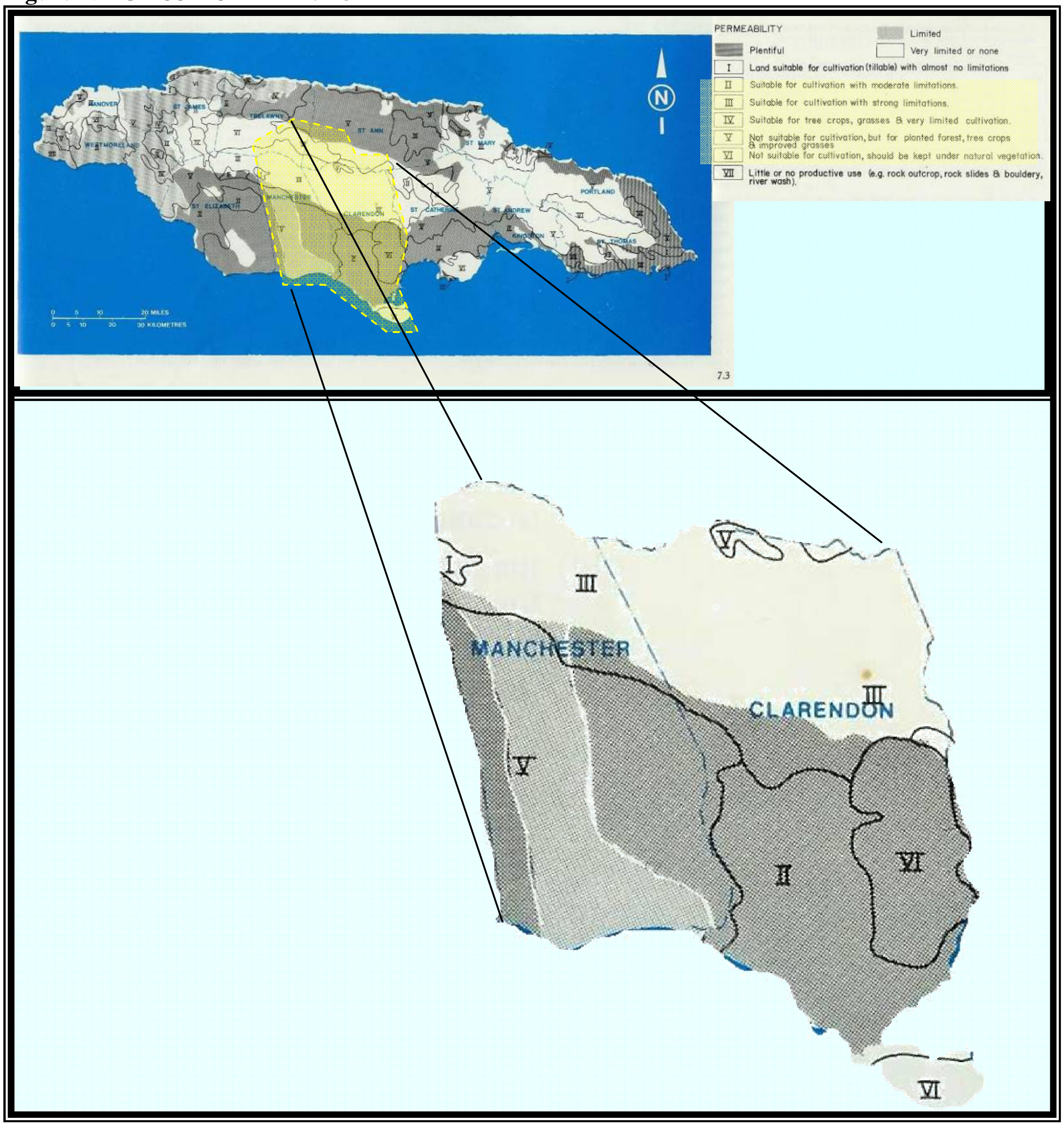


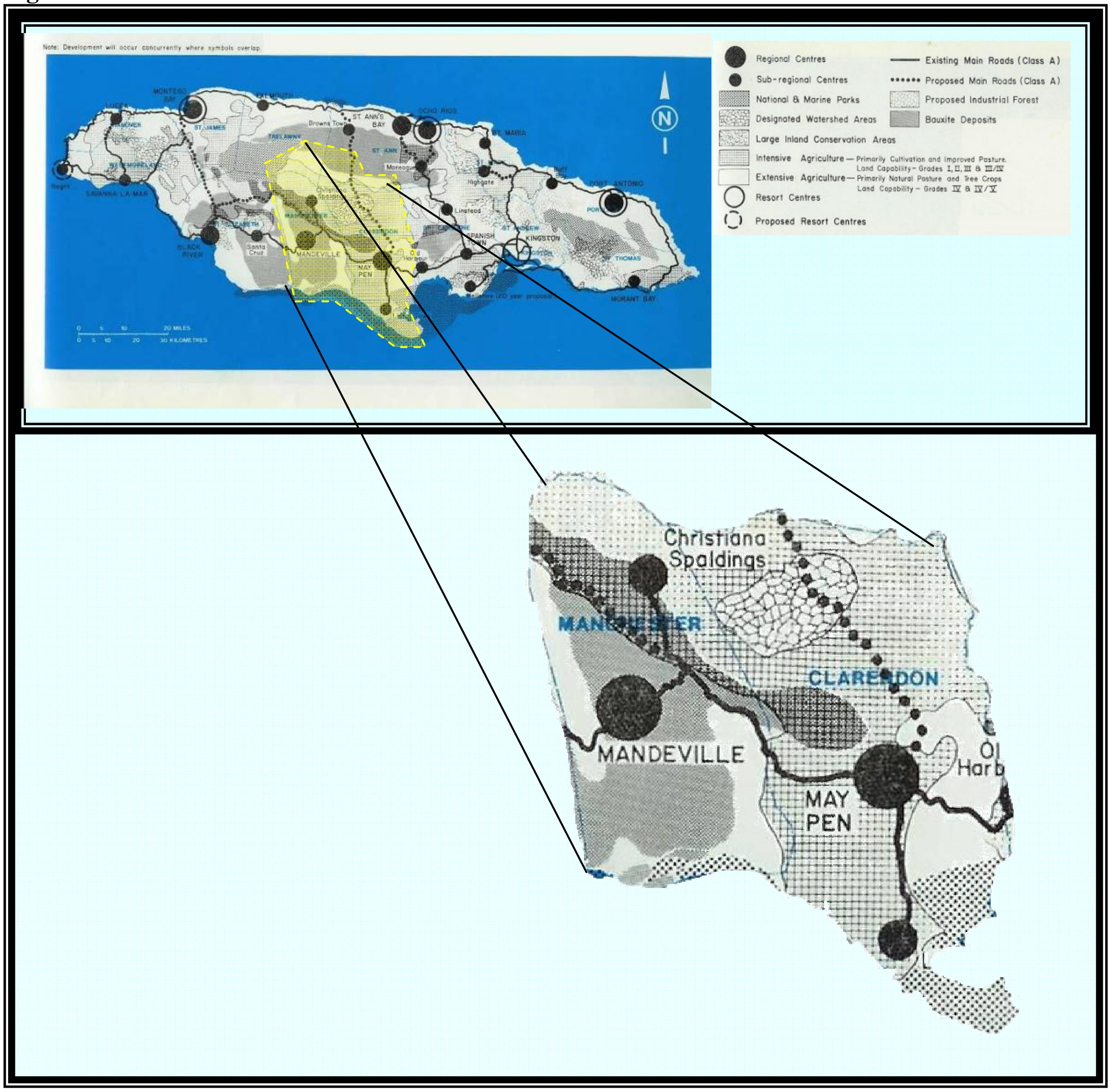
Table 2: AGRICULTURAL LAND CAPABILITY

LAND CLASS	CAPABILITY	PERMEABILITY
I	Suitable for cultivation (tillable) with almost no limitations.	Plentiful
II	Suitable for cultivation with moderate limitation	Plentiful
III	Suitable for cultivation with strong limitations	Very limited or none
V	Not suitable for cultivation, but for planted forest, tree crops and improved grasses	Limited
VI	Not suitable for cultivation – should be kept under natural vegetation.	Plentiful

3.1.1.6 Development Strategy

The long term land management and development strategy is to allow for available resources to be used in a manner that ensures maximum economic benefits without contravening the general principles of conservation. In this regard there are definitions of growth centres for urbanization and conservation. Land uses include agriculture, national & marine parks, watershed areas, industrial forests, resort centres and bauxite deposits. (Figure 3)

Figure 3: DEVELOPMENT STRATEGY



Physical, social and economic growth and development over the last 30 years, have been influenced by the bauxite/alumina industry through Alcoa, Alpart, and other foreign interests largely enhanced by Alcan of Canada. Mandeville, the parish capital, has become a strong financial and commercial location as also an important administrative centre which continues to experience growth.

Residential and commercial uses are developed in urban areas designated as villages, district centres, sub-regional centres and regional centres. The latter three are classified in the National Physical Plan 1978-1998. (Figure 4).

In addition, there are scatterings of linear and star shaped villages along roadways and road intersections throughout the Manchester/Clarendon region, which have not been classified as growth points, though they continue to sprawl, leap frog and become conurbations.

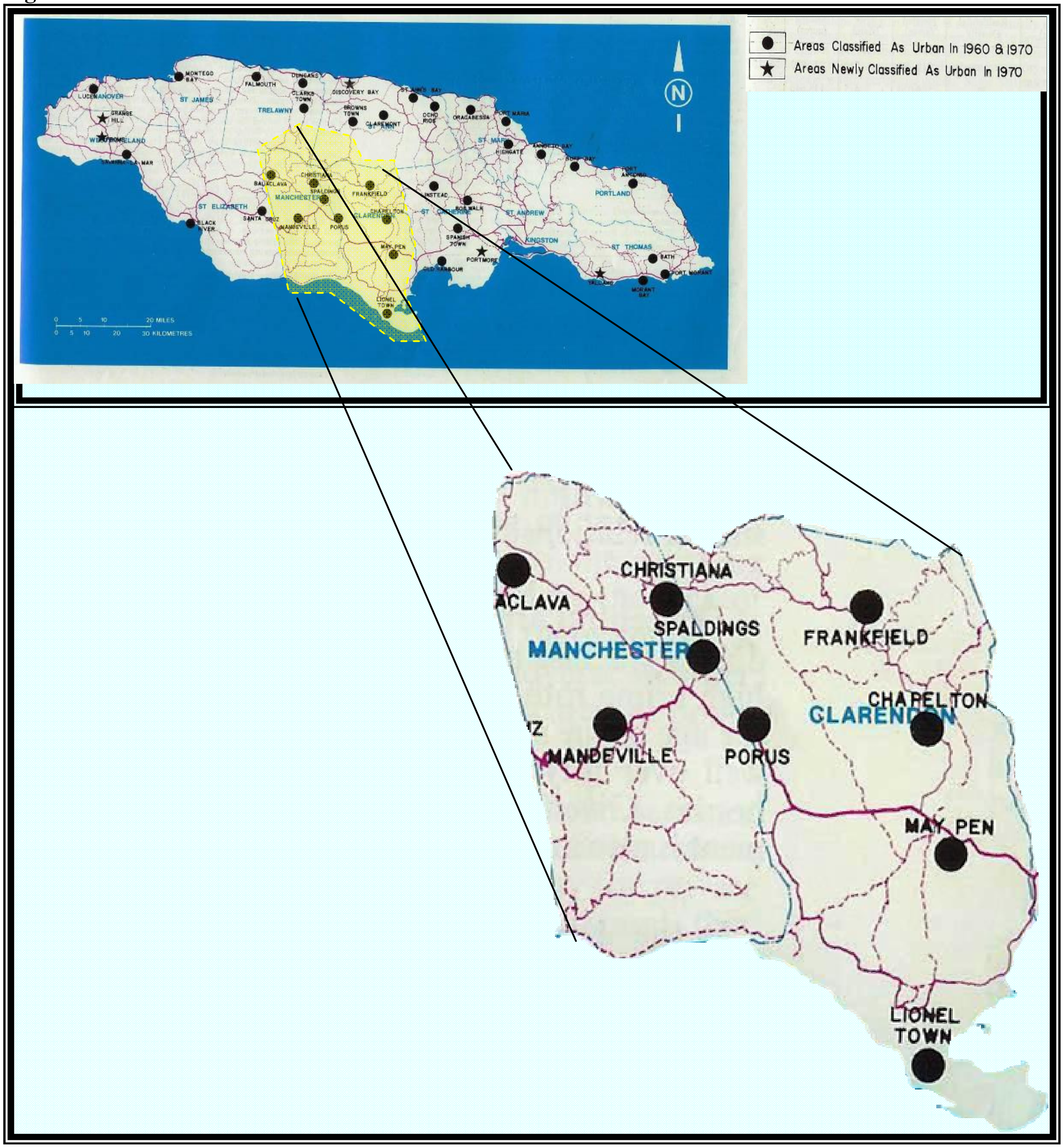
3.1.1.7 Industrial

Light industrial land use is confined to the hierarchy of rural/urban settlements and linear occupancy along district, sub-arterial and arterial roads. Heavy and special industrial plants include bauxite and alumina storage and shipment at Port Esquivel and plants at Halse Hall (Jamalco) and Kirkvine (Windalco).

Sugar factories are in New Yarmouth, Monymusk and Sevens

Transportation and access routes, e.g. all classes of roads and railway lines link all urban centres and also penetrate agricultural areas, national parks and conservation areas.

Figure 4: AREAS CLASSIFIED AS URBAN



URBAN SETTLEMENT DEVELOPMENT

Table 3: URBAN SETTLEMENT DEVELPMENT

CLARENDON – HEIRARCY OF GROWTH CENTRES		
District Centres	**Sub-Regional Centres**	**Regional Centres**
James Hill	Lionel Town	May Pen
Kellits		
Hayes		
Chapelton		
Kemps Hill		
Osbourne Store		
Mocho		
Rock River		
Chapelton		
Frankfield		
Alston		
MANCHESTER – HEIRARCHY OF GROWTH CENTRES		
Mile Gully	Christiana/Spaldings	Mandeville
Williamsfield		
Porus		
New Port		
Cross Keys		
Victoria Town		

3.1.1.8 Parish Council/Land use Zoning

The Region (Manchester/Clarendon) is covered by Development Orders and subsequently falls under the aegis of the Town and Country Planning Act. Thus any form of development requires an application to the relevant Local Planning Authority (Parish Council) for permission to carry out building, engineering and mining operations or change in the use of land or buildings.

There are no specific demarcated zones for land use, but there are general statements of intended uses, supporting requirements and standards.

3.1.2 Aesthetics

There are several areas of outstanding natural beauty, visual and recreational amenity, and therapy. There are also areas of which aesthetically appealing and spiritually inspiring. The view from the Brazilletto mountains over the protected Peake Bay and West Harbour wetlands and the sea is outstanding The Milk River Bath is world renown for its therapeutic quality, views from Spur Tree over the slopes toward the Alligator Pond and Canoe Valley coastal areas are magnificent; the Canoe Valley wetlands support considerable marine life and is itself outstandingly beautiful.

A wide variety of micro climates exits throughout both parishes, ranging from cool climatic conditions in Mandeville and Spur Tree – Manchester, to high temperatures on the Clarendon plains and dry limestone forests in the Portland Bight and Brazilletto Mountains.

The areas under study are adequately provided with transportation infrastructure – roads, railway and seaports, power transmission and social infrastructure – hospitals, police stations, post offices, some government offices, schools, etc.

3.1.3 Potential Uses

Both parishes are designated as watershed areas. Vast areas are designated as national parks and protected areas. Some are likely to be zoned for specific classification of industrial uses and buffer zones to avoid conflict and potential nuisances between industrial and residential users.

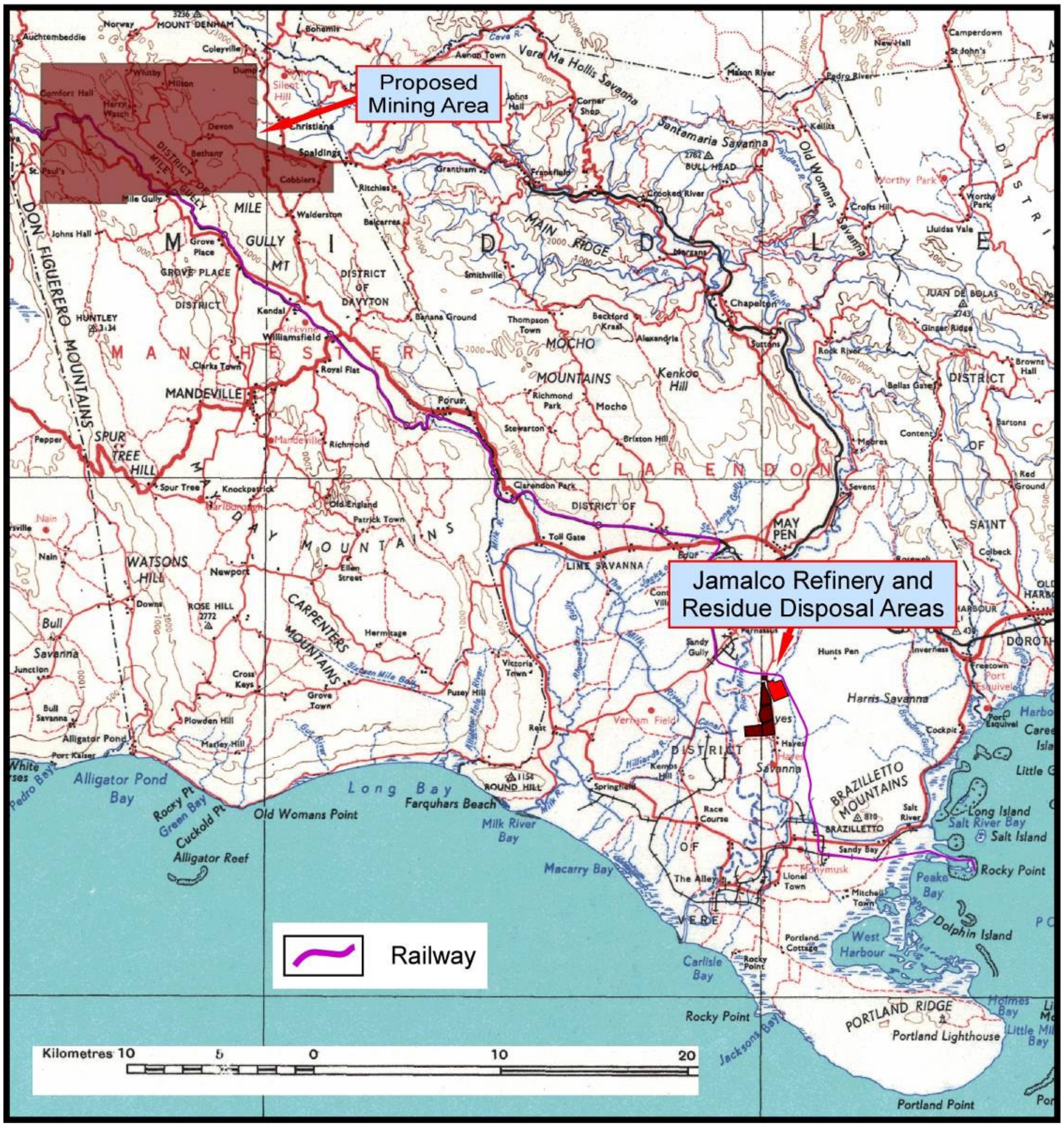
Most of the potential land uses in Manchester consists of future mining areas, existing mining areas and mined out lands for rehabilitation, forests and grassland.

The region will also accommodate a l km wide route for Highway 2000. The route will traverse the approximate central area of the Region – Manchester/Clarendon from the border of St. Catherine/Clarendon to the border of Clarendon/Manchester.

The disused Vernamfield Aerodrome is slated for development as a warehousing and cargo import/export centre and will be zoned for industrial use.

3.2 Geotechnical Analysis and Soil

Figure 5: LOCALITY MAP OF THE PROPOSED PROJECT SITE



3.2.1 TERMS OF REFERENCE

The following represents the terms of reference for this section:

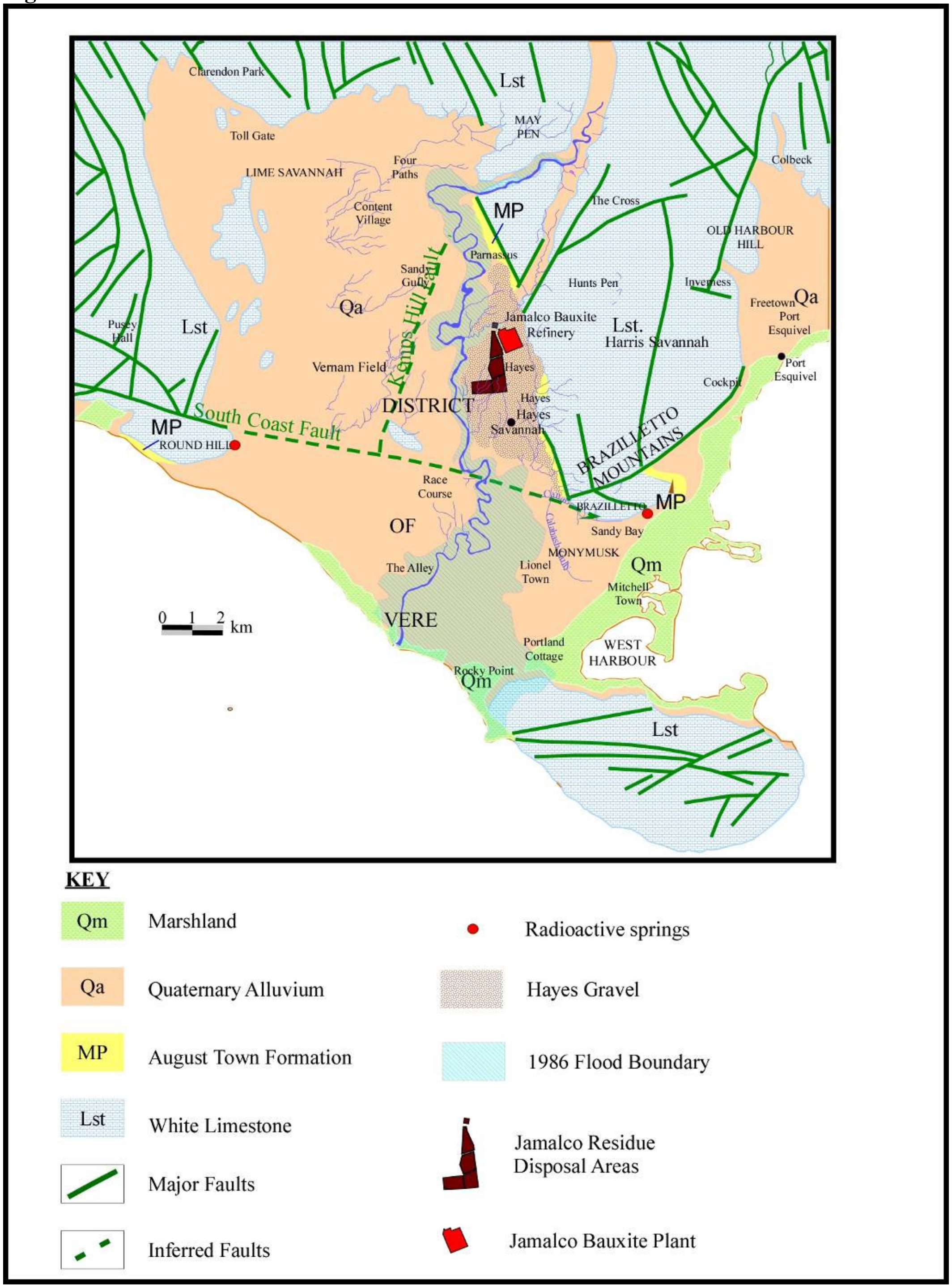
- Geotechnical Analysis and Soils Assessment in the proposed mining expansion area in North Manchester, and the proposed Residual Disposal Area (RDA) expansion and the existing refinery at Hayes.
- Include mineral resources, flood plain boundaries, erosion and the existing refinery.
- Identify issues relevant to flood control in these areas.
- Identify special or unique features in the study area.
- Determine local and regional tectonic and seismic activity, identify fault lines.

3.2.2 EXPANSION OF JAMALCO REFINERY AND RESIDUE DISPOSAL AREA, HAYES, CLARENDON

3.2.2.1 GEOLOGY

The area under consideration is in the district of Halse Hall, in southern Clarendon. It can be located on the 1:50,000 topographic Sheet 17 (metric edition) at co-ordinates 245385 (Figure 6). Geomorphologically, the area lies on the gently sloping alluvial fan of the Rio Minho. The apex of the fan, at May Pen, lies at an altitude of about 70 m asl, although the present river bed is incised into the fan, being at about 50 m asl at May Pen. From May Pen the river flows over a straight line distance of about 20 km to the sea. In the vicinity of Hayes, at the confluence with Webbers Gully, the river bed lies at an altitude of 38 m asl, while the plant and RDAs at Hayes, east of the river, lie on an old, dissected terrace remnant at elevations of 45 to 50 m asl with flat to gently undulating topography. The terrace remnant forms a high spot between Webbers Gully, which borders the site on the north and northwest before entering the Rio Minho, and Cannons Gully which extends along the eastern side of the site, draining to the south at Bog and separating the site from the limestone plateau of Harris Savanna.

Figure 6: GEOLOGY MAP OF SOUTHERN CLARENDON



South of Hayes the alluvial fan flattens out to form what have been called the Vere Plains (Figure 6). Elevations over this area are low and the water table is relatively high, so that settlements such as Lionel Town and Alley are frequently flooded.

The rocks of the area consist of two main units. The various unconsolidated alluvial sediments, part of the Rio Minho fan complex, rest on limestone bedrock with a highly irregular surface.

3.2.2.1.1 The Alluvial Fan Complex

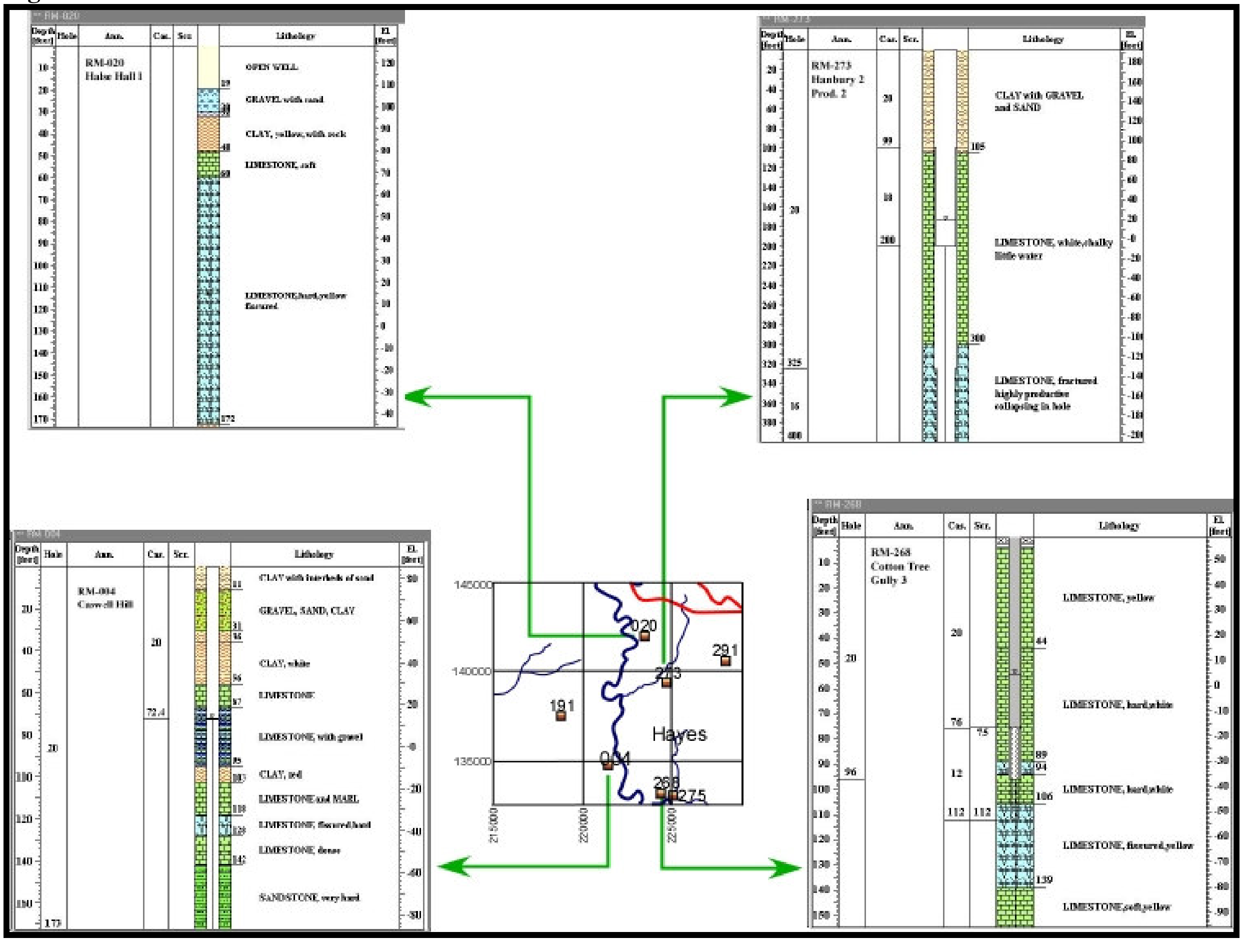
The alluvial fan contains a wide range of more or less unconsolidated siliciclastic sediments. The top of the original fan, which has been extensively dissected, is preserved only in the neighbourhood of Halse Hall and Hayes (Figure 6). The sediments underlying the plant and RDAs make up this remnant and have been called the Hayes Gravels. The gravels range in particle size from pebbles and cobbles to silt and range in thickness from zero to 5-6 m in the north to 14-15 m in the south of the plant area (Figure 7). Clay is rare and the gravels are well-drained. Within the rest of the eastern part of the fan the sediments are very variable, although generally finer grained than the Hayes gravels, and with alluvial clay lenses.

Figure 7: Hayes Gravel at Site of Proposed Residue Disposal Pond[i]

3.2.2.1.2 The Limestone Bedrock

The sediments of the Hayes Gravels are separated from the limestone bedrock by an irregularly developed layer of clay (Figure 8), at least in part being a weathered palaeosol developed on the limestone surface.

Figure 8: WELL LOGS THROUGH THE HAYES GRAVELS



The limestone has been divided by the Mines and Geology Division into the lower, relatively pure Newport Limestone (Mn on Geological Sheet 16) and the upper, less pure August Town Formation (MP). The Newport limestone consists of moderately well-bedded, compact limestones, containing frequent rubbly layers, while the August Town Formation consists of impure limestones with irregularly interbedded marly and clayey layers. These rocks are exposed along the eastern side of the alluvial fan, less than a kilometre east of the plant site.

3.2.2.2 GEOTECHNICAL CHARACTERISTICS

3.2.2.2.1 The Alluvial Fan Complex

Table 4 below, adapted from an earlier report (Conrad Douglas & Associates) indicates the characteristics of materials that should be expected in the Hayes Gravels. In summary the gravels should be pervious to very pervious with good to excellent shear strength, of negligible compressibility and good to excellent workability as a construction material, as utilized in the construction of the RDA dykes (Figure 9) Alluvial materials sourced from other places in the Rio Minho fan should also be well suited for construction after washing and grading.

Table 4: PROPERTIES OF VARIOUS SOIL GROUPS (ADAPTED FROM CONRAD DOUGLAS & ASSOCIATES EIA)

Typical Names of Soil Groups	**Group Symbols**	**Important Properties**			
		Permeability when Compacted	Shearing Strength when Compacted and Saturated	Compressibility when Compacted and Saturated	Workability as a Construction Material
Well-graded gravels, gravel sand mixtures, little or no fines.	G.W.	Pervious	Excellent	Negligible	Excellent
Poorly graded gravels, sand mixtures, little or no fines.	G.P.	Very pervious	Good	Negligible	Good
Silty Gravels, poorly graded gravel-sand-silt mixtures.	G.M.	Semi-pervious to impervious	Good	Negligible	
Clayey gravels, poorly graded gravel-sand-clay mixtures.	G.L.	Impervious	Good to fair	Very low	Good
Well-graded sands, gravelly sands, little or no fines.	S.W.	Pervious	Excellent	Negligible	Excellent
Poorly graded sands, gravelly sands, little or no fines	S.P.	Pervious	Good	Very Low	Fair
Silty sands, poorly graded sand-clay mixtures	S.M.	Semi-pervious to pervious	Good	Low	Fair

Figure 9: PHOTO OF AN RDA DYKE

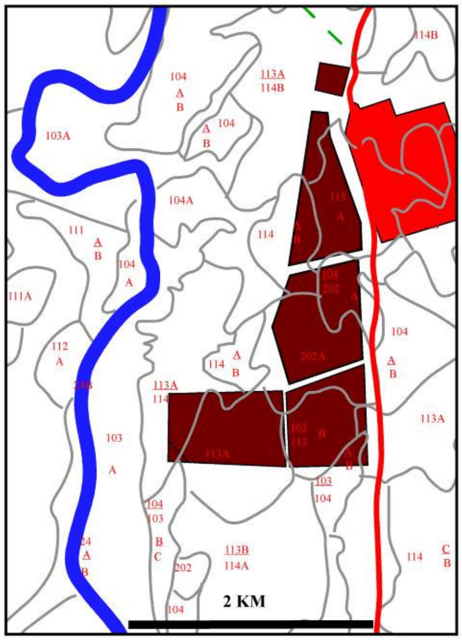
The limestone bedrock of the area may be thickly stratified and massive, but contains frequent zones of less competent, rubbly and marly limestone. There may be a case-hardened layer up to several metres thick, over the softer limestone, where it has been indurated from weathering. The rubbly zones are frequently the result of brecciation associated with faults. Solution features consist of joints widened by solution and there may be cave development. Most large features in the limestones of southern Clarendon and St. Catherine consist of vertical shafts with widening laterally into extensive cave complexes in some areas, such as Portland Ridge (Fincham, 1997).

In summary the bearing capacity of the limestone bedrock is good, although for large structures the presence or otherwise of caverns or fissures at shallow depth should be ascertained.

3.2.2.3 SOILS

The soils of the Hayes region are intimately associated with the alluvial deposits of the Rio Minho Fan Complex. Figure 10 indicates the distribution of the different soils of the area. In Figure 10 the classification follows that used by the Ministry of Agriculture, the symbol group representing the soil type and steepness of slopes.

Figure 10: SOILS MAP OF HAYES, CLARENDON



SOIL TYPES

24	Agualta Sandy Loam
103	Agualta Loam
104	Agualta Clay
111	New Yarmouth Loam
112	New Yarmouth Clay Loam
113	Halse Hall Clay
114	Halse Hall Clay (Red Phase)
202	Rhymsbury Clay

SLOPE CATEGORIES

A	0 - 2 Degrees (0% - 5%)
B	2 - 5 Degrees (5% - 11%)
C	5 - 10 Degrees (11% - 22%)

3.2.2.4 MINERAL RESOURCES

The only mineral resources of note are the limestone forming the Harris Savanna plateau, which has been used as a source of marl and crushed stone from the disused quarry near Halse Hall, and the sand and gravel extraction industry in the bed and flood plain of the Rio Grande. The Hayes Gravels contain small pebbles and occasional larger cobbles of the semiprecious stone jasper (Porter et al. 1982; Porter, 1990). Rarely fragments of silicified wood may be collected.

3.2.3 PROPOSED MINING EXPANSION AREAS, MANCHESTER

3.2.3.1 GEOLOGY

Figure 11 shows the location of the proposed mining area in North Manchester Parish. This area straddles the Mile Gully and Christiana development areas delineated by the Manchester Parish Development Committee.

Figure 11: PROPOSED MINING AREA IN MILE GULLY AND CHRISTIANA DEVELOPMENT AREAS.[ii]

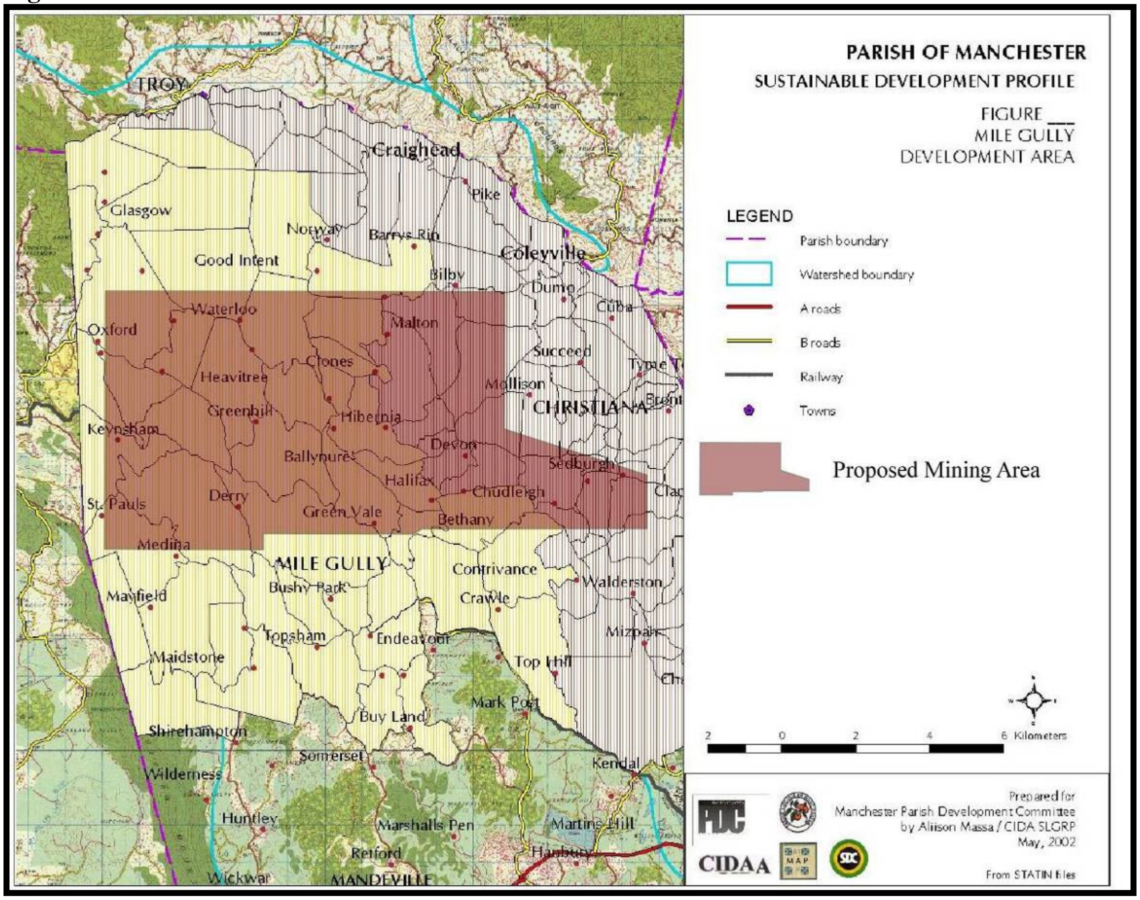
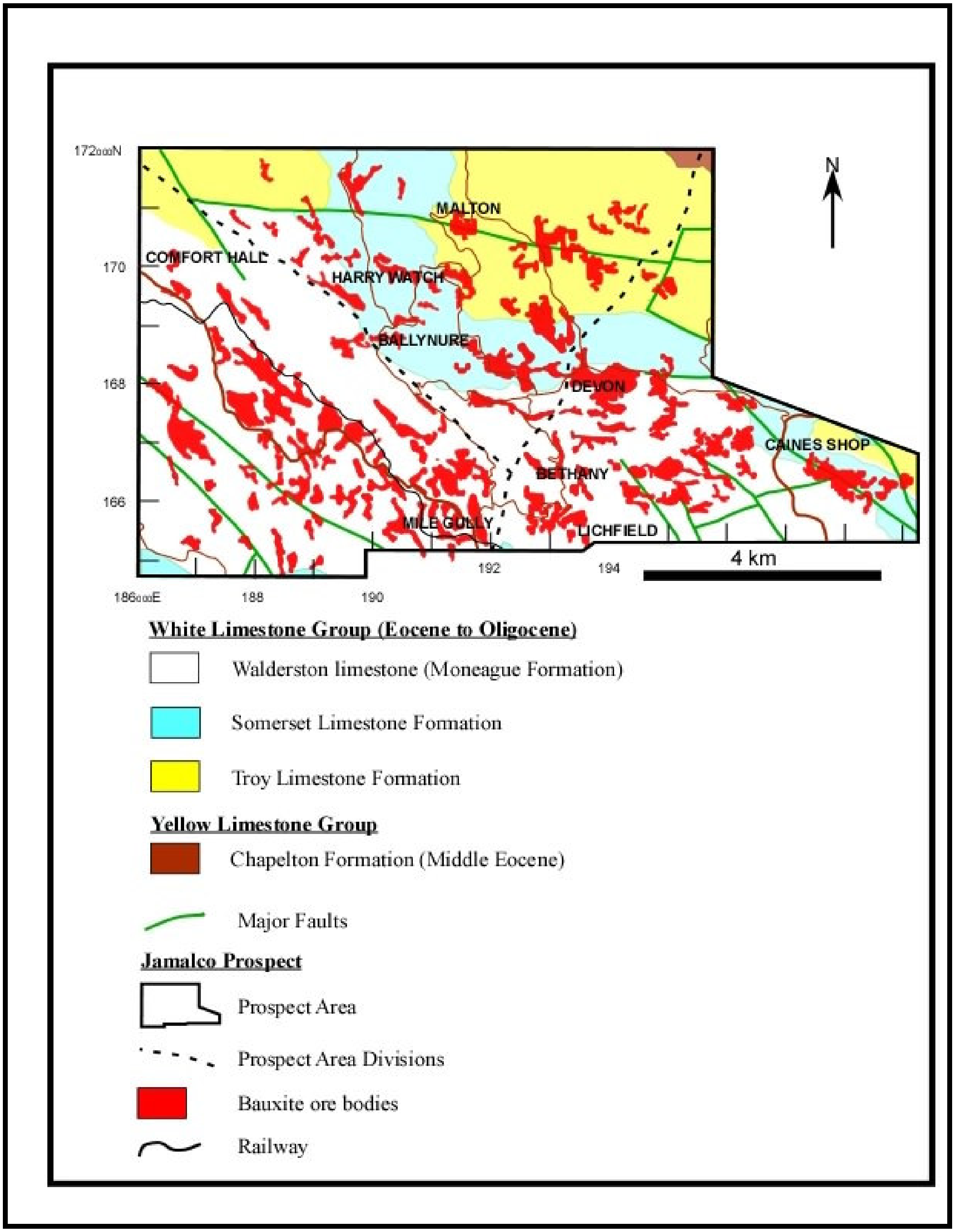


Figure 12 shows the geology and surface extent of bauxite ore bodies. Rocks in this region are represented by strata belonging to the Yellow and White Limestone Groups

Figure 12: GEOLOGY MAP OF THE JAMALCO PROSPECT AREA, MANCHESTER



3.2.3.1.1 Yellow Limestone Group

The Yellow Limestone Group outcrops in the extreme northeast corner of the region (Figure 12). It consists of cream to tan coloured impure bioclastic limestones and marly limestones.

3.2.3.1.2 White Limestone Group

Divided informally into three lithostratigraphic units:

3.2.3.1.2.1 Troy-Claremont Formation (middle Eocene age)

Recently renamed Troy Formation by Mitchell (in press), this unit consists of well-bedded, variously coloured micritic limestones, poorly fossiliferous and variably dolomitic. The main outcrops of this unit in the proposed mining area are in the northern, higher region, underlying about a quarter of the prospect area.

3.2.3.1.2.2 Somerset Formation (Late Eocene age)

The type locality of this formation is south of the area of interest. It consists of well-lithified bioclastic limestones containing a distinctive fauna of larger foraminifera. Rocks belonging to this formation occupy about a quarter of the proposed mining area, mainly in the higher, northern part of the region.

3.2.3.1.2.3 Moneague Formation (Oligocene to middle Miocene age)

On the official Geological Sheets 9 and 12 (1974), covering the region of interest, this formation is separated into two units, the Walderston –Browns Town Limestone and the Newport Limestone. These have been grouped into a single Moneague Formation by Mitchell (in press). The type locality of the Walderston limestone, as originally defined by Hose and Versey (1956) occurs at the edge of the area of interest, at its southeast. Here the rocks are variably bedded, occasionally nodular or ‘rubbly’. Rocks resembling the much more fossiliferous and bioclastic component, originally named the Browns Town limestone by Hose and Versey (1956), appear to be absent from the area. Rocks of Walderston type underlie a little over half of the proposed mining area, mainly in the lower lying Mile Gully region.

The Newport limestone consists of moderately well-bedded, compact limestones, that are frequently difficult or impossible to distinguish from the Walderston limestones in the field, hence its inclusion with that unit in the Moneague Formation. The Newport strata overlie the Walderston limestone and a distinction may be made on the basis of the relative age of the two units, the Newport being Miocene while the Walderston is Oligocene. No rocks assignable to the Newport limestone have been mapped in the area of interest.

3.2.3.1.3 Superficial Deposits and Ore Bodies

The bauxite overlies and in general occupies depressions in the underlying limestone bedrock (Figure 13). They are typical karstic deposits (Hill & Ostojic, 1982). In parts of northern Manchester these deposits are more extensive and may be considered as blanket deposits (Lyew-Ayee & Stewart, 1982).

Figure 13: LOOKING NORTH OVER ORE BODY N 18° 09.139 W 77° 33.987

3.2.3.2 GEOTECHNICAL CHARACTERISTICS

3.2.3.2.1 Troy Formation

These rocks are normally medium to thick bedded, well-lithified, hard, competent limestones, forming much of the high plateaux of the study area. Primary porosity is very low, but secondary porosity is high. This may be vuggy, due to partial or complete dolomitization of parts of the formation, or as conduits, resulting from the presence of extensive joints and fissures, widened into caves and sinkholes through the development of a mature karst. This means that surface flow of water is absent; all rainfall descending quickly to the water table, which in this region is well below the ground surface, except where the base of the formation overlies the less permeable impure limestone and marl of the Chapelton Formation, as in the extreme northeast corner of the area. The cave systems frequently follow the joints and the zones of fractured rocks associated with faults. However, comparatively few caves have been recorded from this area (Fincham, 1997).

3.2.3.2.2 Somerset Formation

The Somerset Formation is similar in its geotechnical characteristics to the Troy Formation, being generally hard and competent, although rarely dolomitized. It is used extensively as an aggregate, as for example, from the large quarry at Somerset itself, south of the study area.

3.2.3.2.3 Walderston (Moneague) limestone

The Walderston limestone is lighter in colour than the underlying Eocene units of the White Limestone Group. It may be thickly bedded and massive, but contains zones of less competent, rubbly and marly limestone, as at the quarry near Ballynure. There is usually a case-hardened layer up to several metres thick, over the softer limestone, where it has been indurated from weathering. The rubbly zones are frequently the result of brecciation associated with faults.

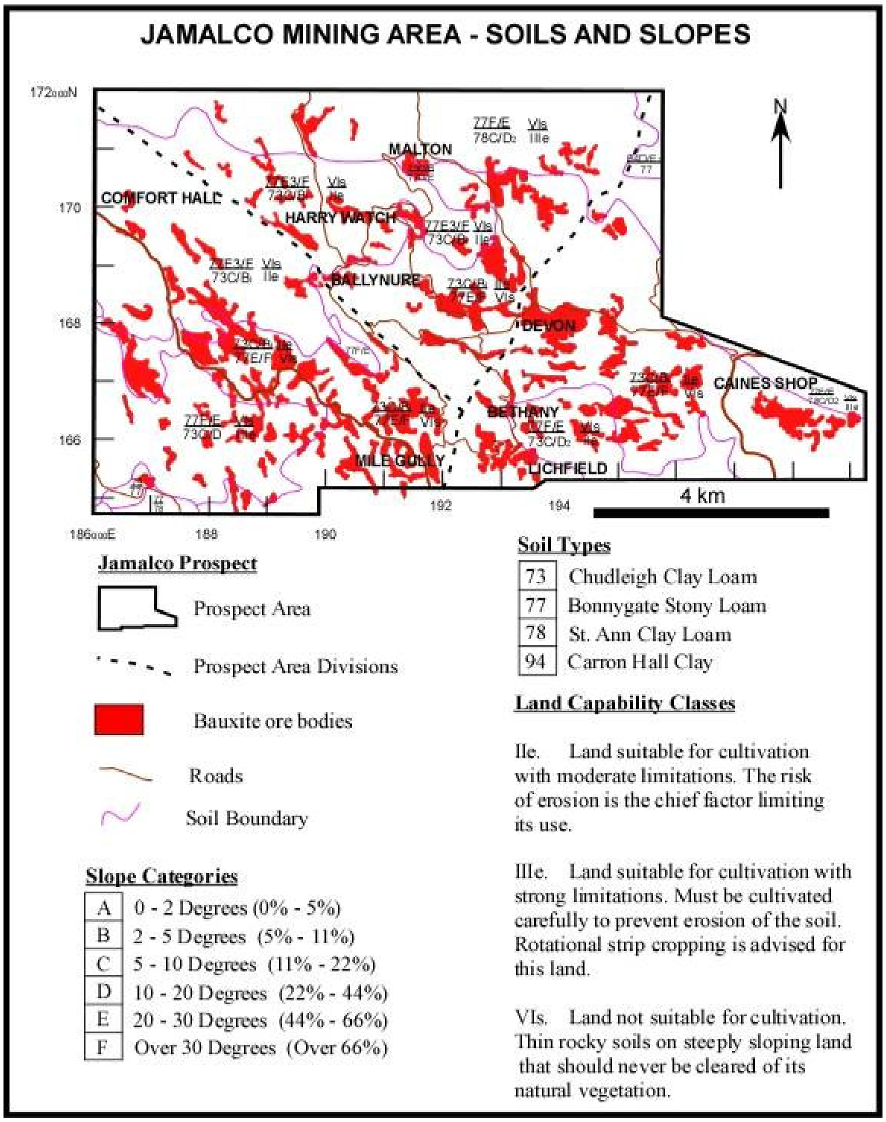
In summary the bearing capacity of the limestone bedrock is good, but some care should be exercised to locate near-surface caves and softer beds below case-hardened surfaces before building large structures. In addition differential settlement may be a problem, as superficial soils vary greatly in thickness, ranging from a few centimetres to the tens of metres associated with bauxite ore bodies (Figure 14).

Figure 14: LOOKING EAST AT ORE BODY 90 N 18° 09.991 W 77° 35.119

3.2.3.3 SOILS

The limestone plateau is covered by a varying thickness of very permeable bauxite soils. In the study area four main soil types have been identified, all associated with limestone bedrock (Stark, 1964). In general the steeply sloping areas with very shallow soils (Bonnygate Stony Loam) have been severely eroded where cultivation or human settlement has taken place. In more gently sloping areas overlying thicker bauxitic soils (red St. Ann Clay Loam or brown Chudleigh Clay Loam), erosion is a relatively minor problem. In Figure 15 the classification follows that used by the Ministry of Agriculture, the first symbol group representing the soil type and steepness of slopes and the second group relating the soil to land capability.

Figure 15: SOIL AND SLOPE MAP OF THE JAMALCO MINING PROSPECT AREA IN MANCHESTER.



3.2.3.4 MINERAL RESOURCES

Apart from bauxite there are no mineral occurrences in the region other than the limestone. Several quarries have been opened for aggregate production in and around the proposed mining area.

3.3 Air Quality and Weather

3.3.1 Air Quality

3.3.1.1 Air Quality Management Program

Jamalco has developed and maintained an Air Emissions Management Program to ensure compliance with the Natural Resources Conservation Authority (NRCA) ambient air quality standards, pending air quality regulations, Alcoa Air Emissions standards as well as to conform with ISO 14001 requirements and the company's EHS policy.

The Clarendon Alumina Works (CAW) facility which is the major source for atmospheric emissions, is approximately 165 feet above mean sea level (msl) and is surrounded by a mix of undeveloped and residential land uses. The terrain elevations rise up to over 400 feet above msl at approximately 2000 feet to the east of the refinery.

3.3.1.1.1 Meteorological Features

The facility operates an on-site meteorological tower, which is located at the center of the refinery. Hourly surface observations are monitored which includes:

- Wind speed
- Wind direction
- Air temperature
- Barometric Pressure
- Ground temperature
- Precipitation and,
- Standard deviation of the Wind direction.

Analysis of data derived from the onsite tower indicates that predominantly there is a strong occurrence of light winds from the northeast, which is typical for areas within this tropical latitude. See wind rose, which shows a joint frequency distribution based on the wind speed and direction for each hour of the year.

3.3.1.1.2 Stack Emission Sources

Currently there are three (3) calciner units, which are vented through one (1) stack via three highly efficient (all in excess of 99.5%) electrostatic precipitators (ESPs). The calciner stack is the tallest stack at the facility at a height of 275 feet.

Two calciner units will be added to the expanded facility and these will be vented through a new stack of similar dimensions to the existing stack.

The calciners and attendant stack are located in the Calcination Department, which is located on the southeastern side of the refinery.

There are four (4) industrial boilers, which operate under normal operating conditions. Boiler #'s 3 and 4 vent through the eastern stack whilst boiler #'s 5 and 6 vent through the western stack. There is also boiler #6A (emergency boiler), which is currently out of commission, which is tied into the western stack. Two additional boilers are planned for the expanded facility and will similarly emit combustion gases through an additional 250 feet stack to be erected at the Power House.

The Power House is located in the south central part of the refinery.

The facility also operates a biomedical waste incinerator, which is used to incinerate medical waste at the CAW facility as well as oxalate cloth. Combustion gases are vented through a seventeen feet (17ft) stack. The biomedical waste incinerator is used on an as needed – basis.

The Rugby Lime plant located in the northern part of the facility operates the other stack emission source within the property boundary.

Jamalco formerly operates a lime kiln with attendant stack but this has been out of operation for a number of years.

#6 Bunker C fuel oil is burnt in the calciners, boilers and at the limekiln, whilst liquid petroleum gasoline and diesel oil are burnt at the medical waste incinerator.

Diesel oil is used to preheat the calciners.

3.3.1.1.3 Air Emissions

The primary emissions that are released from the CAW refinery include Particulates, NOx, SO_2, CO, neglible quantities of VOCs and trace levels of metal.

3.3.1.1.3.1 Particulates

Emissions of particulates are released from the calciners, boilers and medical waste incinerator. In addition, particulates are intermittently released as a result of mining activities, windblown dust associated with bulk material handling, transportation and stocking of raw material (bauxite), intermediate product (hydrate) and the alumina product itself.

Particulate emissions have also been associated with the Residue Disposal Area (RDAs) should the surface of these lakes become dry.

Proven particulate control and dust suppression strategies have been employed at Jamalco facilities, which have significantly minimized particulate and fugitive dust emissions.

These include but not limited to the use of hooded conveyors, sprinkler systems, cyclones, bag houses and ESPs.

The location has implemented a number of fugitive emission control measures inclusive of the following:

- Controlling fugitive particulate emissions from storage piles through enclosures, covers or stabilization, minimizing the slope of the upwind face of piles where practicable. Confining as much pile activity as possible to the down wind side of piles.
- Limiting the size of loads to minimize loss of material to wind and spillage.
- Planting special wind breaks at critical points.

- Prompt removal of soil and other dust -forming debris from paved roads and scraping and compaction of unpaved roads to stabilize the road surface as often as necessary to minimize re-entrainment of fugitive particulate matter from the road surface.

- Vegetating areas with grass.

- To the extent practicable restricting vehicular travel to established paved roads.

- Watering of unpaved roads and other unpaved open spaces as often as necessary to minimize re-entrainment of fugitive particulate matter from these surfaces. Drip irrigation is also practiced at the refinery.

- Maintaining good house keeping practices to minimize the accumulation of materials, which could become fugitive.

The major source of fugitive dust at Jamalco is from open areas (uncovered with grass or unpaved).

3.3.1.1.3.2 NOx Emissions

NOx emissions are determined at the facility through periodic site wide stack emission tests. The company has moved to the implementation of low NOx burners, as was the case when Boiler # 6 was added during the 1.25 Million metric tonnes upgrade.

Progressively low NOx burners will be added at the facility when existing boilers are retrofitted, these along with improved operational adjustments will result in the reduction of NOx emissions.

3.3.1.1.3.3 SO_2 and CO Emissions

Sulphur dioxide and carbon monoxide emissions are also determined from stack emissions tests. Jamalco has consistently operated its facilities well within the stipulated regulated limits for sulphur content in fuel oil.

The company remains committed to operating within the sulphur content limits of 2.2% and 3% respectively, which are specified for new and existing sources.

Carbon monoxide emissions result from the incomplete combustion of fuel oil, this type of gaseous emission should therefore reduce as the Jamalco facility improves its efficiency.

3.3.1.1.3.4 Trace Metals

Trace Metals such as mercury are introduced into the Bayer process as a direct result of being present in the bauxite. Alcoa is in the process of understanding mercury mass balance, and in this regard tests are being carried out at various plants. Jamalco will continue to benefit from these novel researches and accordingly will implement mercury removal systems to reduce emissions to the atmosphere, although this is not yet a regulatory requirement in Jamaica.

3.3.1.1.3.5 Ambient Air Quality Monitoring

Jamalco operates two ambient air-monitoring stations located in the New Bowens and Corn Piece communities. These stations are capable of monitoring SO2, NOx, COx and Ozone. ***Data derived from these stations have consistently shown levels well below the Jamaican Ambient Air Quality standards.***

Monthly monitoring reports are submitted to the regulatory agencies through the Jamaica Bauxite Institute (JBI), which have responsibility to conduct environmental monitoring of the Bauxite & Alumina Industry.

Calibration checks are conducted on the monitors on a scheduled basis and are done within applicable test methods and manufacturers specifications.

Jamalco also maintains a stringent TSP monitoring program. There are seven (7) permanent TSP monitoring stations; these are located in communities around the refinery, at the RDAs, Breadnut Valley and at the Rock Point Port facility.

3.4 Weather

3.4.1 Regional Setting/Sphere of Influence

3.4.1.1 Proposed Mining Area

The proposed mining area is located in Northern Manchester in a general area extending from Medina in the southwest, to Cobbler in the southeast, following the Spaldings-Christiana main road to the Devon area then extending to Coleyville in the northeast and across to Waterloo and Comfort Hall in the northwest as indicated on Figure 73: SEPL 530 BOUNDARY

Major settlements in the sphere of influence of the proposed mining area include:

- Medina
- Hibernia
- Bethany
- Malton
- Derry
- Mile Gully
- Ballynure
- Comfort Hall
- Whitby
- Contrivance
- Chudleigh
- Devon
- Waterloo
- Coleville
- Harry Watch

This area comprises settlements of varying sizes and population, however, the bauxite deposits are distributed randomly throughout these communities and in many cases are void of human encroachment. The sphere of influence of the proposed mining activities is not anticipated to extend outside of the prescribed mining area.

3.4.1.2 Refinery Area

Jamalco's refinery which is proposed for upgrade is located in Halse Hall, Clarendon between the New Bowens settlement to the north, Cornpiece to the south, the Braziletto Mountains to the east and its red mud lakes to the west. The plant has been in its present location since 1972 and is the largest industrial facility in the general area.

Major settlements in the area of the plant include:

- Cornpiece
- Kemps Hill
- Savannah
- Hayes Newtown
- New Bowens
- Race Course
- Hayes
- Rocky Point
- Raymonds
- Lionel Town
- Halse Hall
- Alley

3.4.1.3 Rocky Point Port

Jamalco's Rocky Point Port was established over 40 years ago primarily to store and transship bauxite mined in northern Clarendon to refineries overseas. The actual port structures are located on at the end of a mangrove peninsula in Colon Bay along the northeastern side of the Portland Bight Protected Area. It is intended that only minor changes will be made to the port facilities during the upgrade of the Jamalco operations.

Major settlements in the area of the port, include:

- Salt River
- Rocky Point
- Portland Cottage
- Mitchell Town
- Lionel town
- Cockpit

3.4.1.4 Mining Area Climate

Mean annual average rainfall is 2,032 mm (80 inches) per year. The historical pattern has light rains in May, a summer dry season marked by brief but torrential thunderstorms, a main rainy season from September to November and a marked dry season from November to April. However, both annual totals and daily rainfall patterns are highly variable. The stationary weather system over central Jamaica in June and July 2002 produced two-thirds of the parish's annual rainfall in 15 days.

Annual rainfall gradients decrease from north to south and west to east. The northern mountains have the highest volumes, often in the form of heavy fog. In the center, Mandeville averages over 80 inches while amounts are lower in sheltered parts, such as Grove Place.

3.4.1.5 Refinery and Port Climate

South Clarendon has a dry climate. With poor surface drainage and extremely permeable soils, the area is heavily dependent on catchment of rainfall and often suffers from drought.

3.4.2 Rainfall

Rainfall totals for the southern Clarendon region are low when compared to that of the northern Manchester regions. Over the period 1983 – 2003 the area averaged 988.1 mm (38.9 inches) of rainfall with a monthly average of 83.1 mm (3.27 inches). The area experiences its wettest period during the months of May-June (90 – 163 mm) and August-November (89 – 154 mm).

This generally low rainfall is responsible for the aggressive and well maintained irrigation regime employed at the Jamalco refinery to manage the real potential for fugitive dust emissions.

Table 5: ANNUAL RAINFALL - INCHES. JAMALCO REFINERY

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR'S TOTAL	MONTHLY AVERAGE
1983	0.44	6.68	0.40		2.54	6.48	0.06	6.36	1.42	5.29	2.01	0.16	31.84	2.89
1984	0.52	2.17	5.39	0.58	5.37	3.62	2.13	1.76	5.88	3.86	1.75	0.07	33.10	2.76
1985	0.14	-	-	-	-	-	-	2.45	1.86	8.62	7.74	1.12	21.93	1.83
1986	1.95	0.78	1.05	3.53	-	22.56	1.36	0.52	3.36	8.87	2.01	0.78	46.77	3.90
1987	1.86	0.28	0.16	6.90	6.48	1.31	1.70	3.04	1.46	17.38	5.52	3.10	49.19	4.10
1988	0.10	0.63	1.63	2.20	5.62	1.59	1.65	8.70	8.81	1.24	6.53	1.81	40.51	3.38
1989	2.99	1.60	3.01	0.74	4.64	1.40	0.21	1.61	7.15	0.98	1.22	0.36	25.91	2.16
1990	2.04	0.79	1.78	2.51	1.43	2.11	2.26	0.60	1.33	6.59	7.68	1.80	30.92	2.58
1991	0.39	0.26	1.58	1.46	7.52	0.37	1.66	1.67	2.36	2.24	3.37	0.37	23.25	1.94
1992	0.21	2.22	0.38	1.61	9.11	2.95	0.47	2.14	4.36	2.82	1.24	0.22	27.73	2.31
1993	3.60	3.54	4.62	7.89	27.45	0.75	1.82	0.75	4.76	0.68	3.59	7.27	66.72	5.56
1994	1.74	0.07	2.62	3.29	4.10	0.00	1.70	4.10	3.22	0.58	13.85	0.70	35.97	3.00
1995	2.75	0.80	2.31	5.09	6.19	3.05	1.13	13.08	8.32	17.70	0.87	1.83	63.12	5.26
1996	1.40	0.17	0.90	0.94	0.60	0.92	2.17	4.40	6.12	6.83	7.22	0.03	31.70	2.64
1997	1.03	0.89	1.26	1.36	0.85	7.88	0.33	0.64	5.70	6.47	3.14	2.15	31.70	2.64
1998	0.74	1.54	8.55	2.53	0.67	1.14	4.96	4.15	11.36	5.71	2.21	4.66	48.22	4.02
1999	0.87	3.10	6.93	0.93	2.43	3.67	2.96	1.75	13.63	11.73	8.87	1.99	58.86	4.91
2000	0.77	1.75	1.65	3.47	1.28	0.85	2.47	2.00	9.28	3.80	1.05	6.19	34.56	2.88
2001	1.75	0.35	0.49	1.48	6.14	0.09	1.73	0.55	2.31	5.30	8.55	5.78	34.52	2.88
2002	3.27	1.81	2.39	3.80	20.05	6.68	0.34	0.47	22.48	6.04	0.94	1.60	69.87	5.82
2003	1.31	0.91	1.97	3.00	14.72	3.46	1.08	12.64	2.28	3.30	1.46	1.11	47.24	3.94
2004	1.07	0.16	0.24	0.16	1.07								2.70	0.54

Review of temperature data collected at the Jamalco refinery meteorological station at the refinery for a period 1999 -2003, indicates that the maximum temperatures range from 34.5 deg. Celcius to 31 deg. Celcius and that the low temperatures range from 24 deg. Celcius to 18.9 degrees. The intense and prolonged heat of this typically xerophytic environment combined with the low rainfall results in a dry and sometimes dusty environment, if no controls are in place.

Jamalco has a sprinkling and irrigation regime for exposed areas of the plant, which includes landscaping and irrigation of open spaces.

Table 6: TEMPERATURE - JAMALCO REFINERY

MONTHS	1999		2000		2001		2002		2003	
	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.
JANUARY	31.6	21.1	31.1	19.7	31.0	23.0	31.5	20.5	31.5	21.0
FEBRUARY	31.1	19.9	31.5	18.9	31.7	23.0	32.2	20.0	32.0	21.1
MARCH	31.5	20.8	31.8	19.1	31.4	20.2	32.7	19.9	32.3	21.4
APRIL	31.8	21.4	32.1	20.9	32.2	21.1	32.9	20.7	32.9	22.1
MAY	32.6	23.0	32.2	22.3	32.6	21.8	31.8	21.6	32.4	22.1
JUNE	32.6	23.6	32.6	22.7	33.3	22.7	32.2	22.3	32.1	22.9
JULY	33.4	23.5	33.8	22.7	33.5	23.5	32.9	23.0	33.4	23.1
AUGUST	33.8	24.0	33.7	23.2	33.8	23.5	34.4	23.3	34.0	23.0
SEPTEMBER	33.3	23.0	33.4	23.0	34.5	23.0	33.3	22.8	34.0	22.8
OCTOBER	31.9	21.7	33.9	22.5	33.3	22.4	33.4	22.7	34.0	229.0
NOVEMBER	32.2	21.8	33.5	21.9	31.2	21.2	33.3	23.1	32.8	22.6
DECEMBER	31.4	20.5	31.3	22.6	32.2	20.4	32.5	21.7	32.1	21.1

3.5 Water Resources

3.5.1 Hydrogeology

3.5.1.1 Hydrostratigraphy

The Clarendon Alumina Works (CAW) consisting of the bauxite/alumina plant and the Residue Disposal Areas (RDAs) owned by Jamalco is located within the parish of Clarendon on the south central coast of the island (Figure 16). The parishes of Clarendon and Manchester together form the Rio Minho Hydrologic Basin that consists of the Rio Minho, the Milk River and the Gut-Alligator Hole Watershed Management Units (Figure 17)

Figure 16: BASIN LOCATION

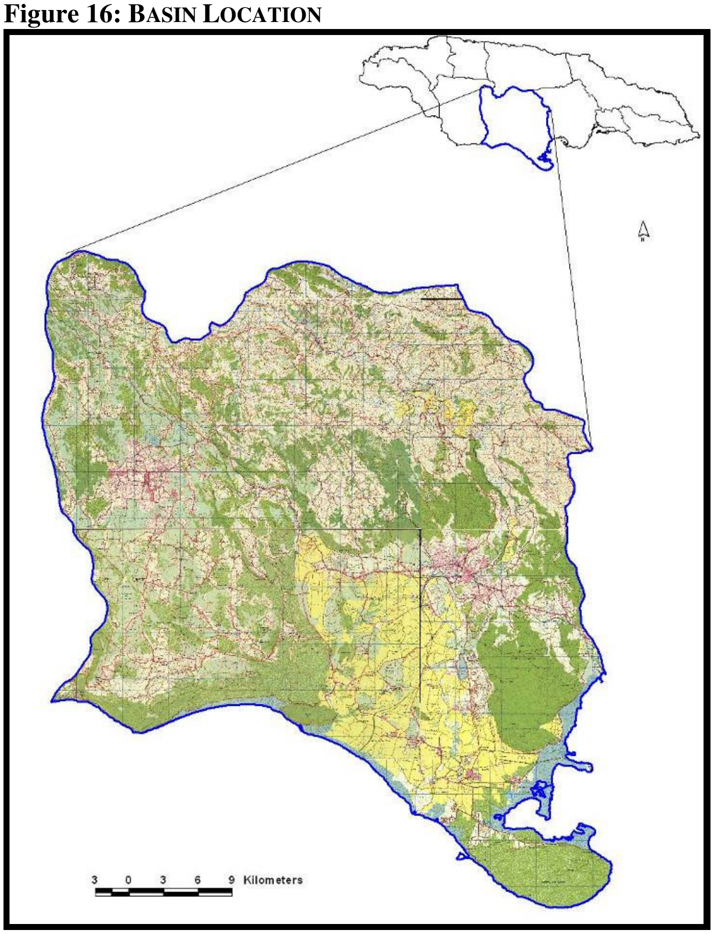
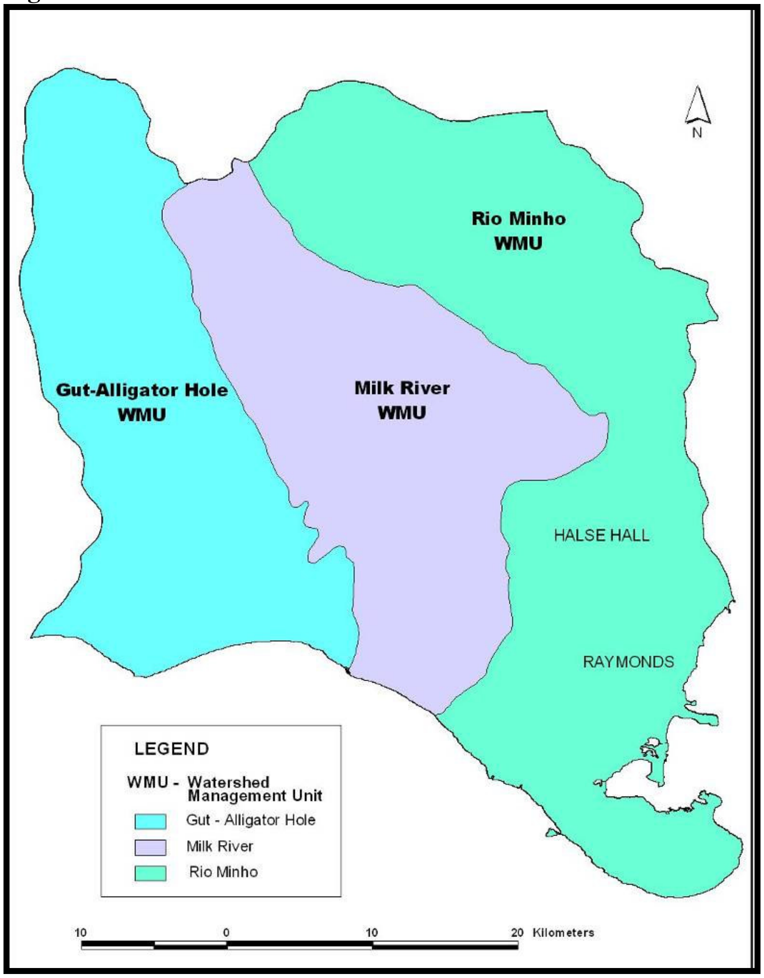


Figure 17: BASIN WATERSHED MANAGEMENT UNITS



The Rio Minho Hydrologic Basin extends over an area of 1,705 km^2 (Map 1). The Basin is subdivided into 3 sub-basins and 3 hydrostratigraphic units (Figure 18). Table 7 below summarizes the area for each catchment.

Figure 18: HYDROSTRATIGRAPHY MAP OF PROJECT AREAS

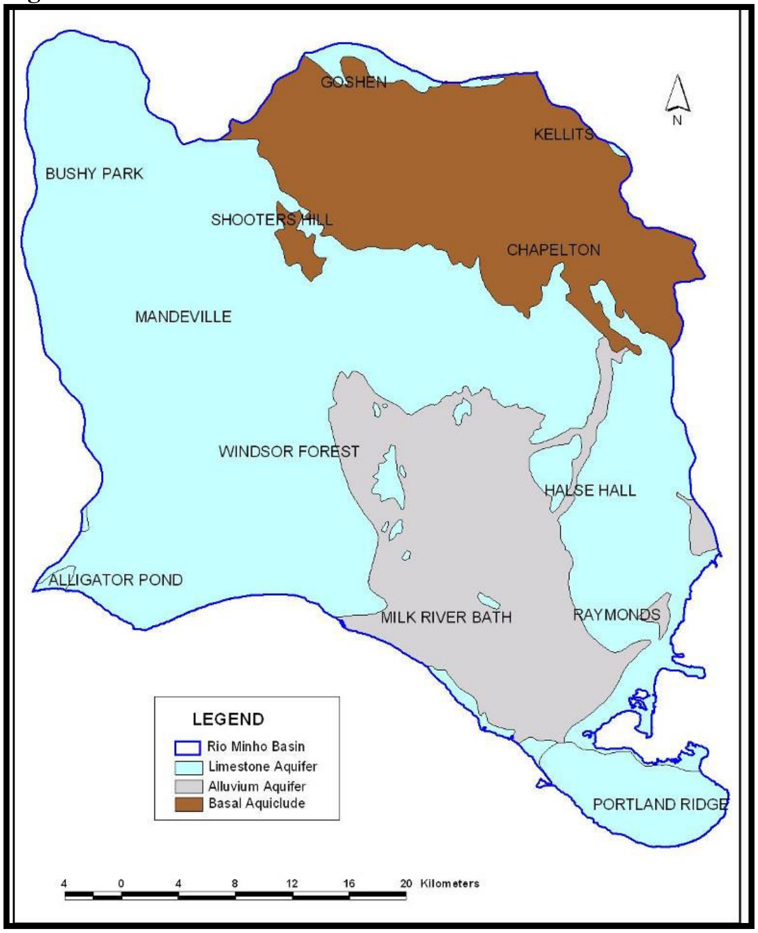


Table 7: Areas OF THE HYDROSTRATIGRAPHY UNITS OF THE SUB-DIVISIONS OF THE RIO MINHO HYDROLOGIC BASIN

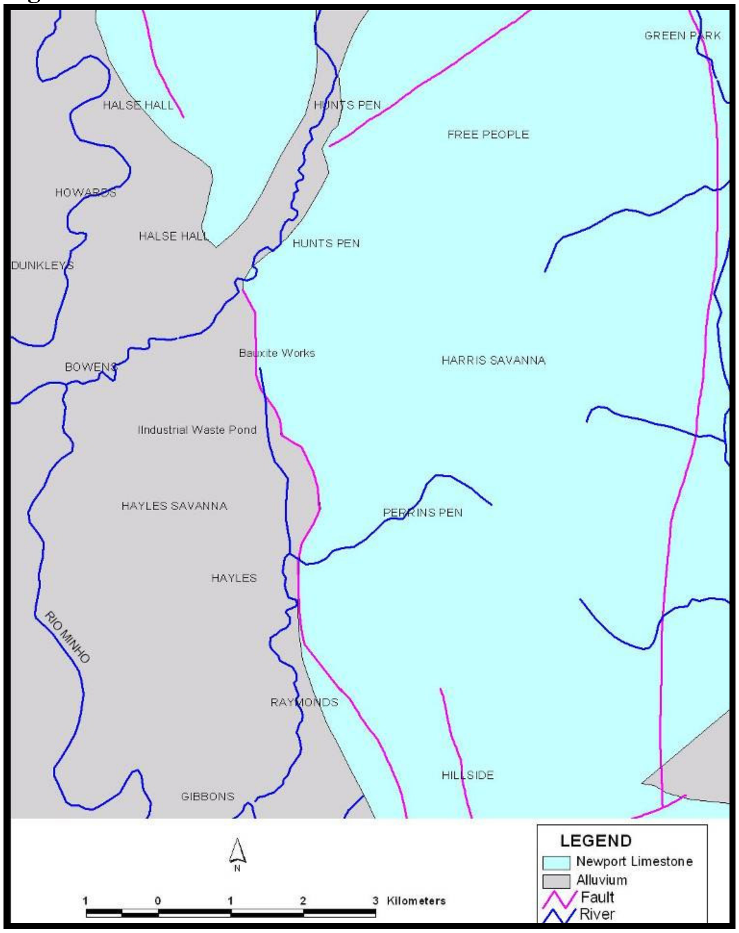
Sub-basins	Hydrostratigraphic Units (km^2)			Total	Percent
	Basement Aquiclude	**Limestone Aquifer**	**Alluvium Aquifer (Aquiclude)**		
Upper Rio Cobre	362	31	NIL	393	23
Clarendon Plains	6	528	415	949	56
Manchester Highlands	NIL	358	(5)	363	21
Total	368	917	420	1,705	----
Percent	22	54	24	----	100

3.5.1.2 Hydrogeologic Characteristics

The CAW is located within the Clarendon Plains subdivision (Rio Minho Watershed Management Unit) atop the limestone aquifer (Figure 19) The limestone formation is a member of the White Limestone Group of Tertiary Age (7-28 million years). The alluvium of Pleistocene Age (2 million years) has been deposited atop the limestone (Figure 20).

Figure 19: LOCATION OF CAW

Figure 20: GEOLOGY OF AREA



The White Limestone acts as a single hydrogeological unit. The main member the Newport Formation covers most of the Rio Minho basin to a considerable depth. It outcrops in the hills of the Brazilletto Mountains and underlie the alluvium of the plains, where it is the principal source of groundwater. The exact thickness of the limestone is not known but the UNDP/FAO water resources project estimated that in the southern area of the basin the thickness exceeds 1,200 metres as proven by an exploratory oil well drilled at Portland Point.

The primary limestone formation under the CAW is the Newport Limestone Formation. This formation extends throughout the Rio Minho Basin and is the major aquifer that provides water to the wells that support irrigation, domestic and industrial water in the parish. The Newport is essentially a micrite and in its lowest horizon is characterized by an abundance of corals. The majority of the monitor wells drilled by Jamalco penetrated the middle to lower horizons of the Newport Limestone as marked by the abundance of fossils such as gastropods, corals and bivalves.

The limestone aquifer is very permeable and of high transmissivity. The Dry River 5R well yielded 8722 m^3/day with a drawdown in the water table of 0.27 metre. The specific capacity, an indication of the wells performance, was 32,304 m^3/day per metre of drawdown. The transmissivity of the limestone was calculated from the pumping test information as 15,200 m^2/d (15,200 m^3/day/m).

The high permeability is demonstrated by the loss of circulation (drill water) during the drilling, the drop of the drill string as cavities were encountered and the high yield/low drawdown of the monitor wells when tested using a compressor as a pumping unit. The wells drilled in the vicinity of the CAW encountered the water bearing horizons at 13 to 16 metres below sea level. The saturated thickness of the limestone in the area is estimated to be in excess of 150 metres as proven by the Vernamfield well drilled into the same central depression atop which the CAW is located. At the final drill depth of the monitor wells there was evidence of high secondary permeability and the saturated thickness was in excess of 110 metres.

The alluvium atop the limestone consists mostly of sands, gravels and clays. The alluvium also fills the fault-incised channels in the underlying limestone. One such channel approximates the course of the Rio Minho. The alluvium thickens southwards from Bowens. The coarser sediments are concentrated within the buried channel and along the course of the Rio Minho. Monitor Well 5 located on the banks of the Rio Minho west of the RDA proved a thickness of 17 metres of coarse sand and gravel with clay between 15 to 17 metres. Examination of the lithologic logs from the monitor wells drilled around the CAW indicates a basal layer of clay separating the alluvium from the underlying limestone. The Alcoa No. 1 borehole located at E4655 N3618 encountered 10 metres of white sticky clay atop the limestone. The alluvium in the vicinity of the CAW is dry and no water was encountered during the drilling of the monitor wells. The alluvium is unsaturated and functions as an aquiclude (Geomatrix Jamaica Ltd. 1995).

3.5.1.3 Structure

The area around the CAW is a large limestone depression criss-crossed by several faults The lateral and vertical movements along these faults are responsible for the variation in lithology encountered during the drilling of the monitor and production wells i.e. lower, middle or upper Newport Limestone Formation. Faults that cross the area and trend northeast to southwest and northwest to southeast truncate at the boundary of the alluvium. The faults are buried beneath the alluvium but if extrapolated would meet north of the Webbers Gully at New Bowens settlement. One fault trending northwest to southeast passes east of the bauxite/alumina plant and has incised a deep channel within the limestone. The thickened alluvium encountered in Hanbury No 2R well and Monitor Well 3 mark this fault zone. This fault reappears at Raymonds to the south of Hayes Township where it abuts onto the South Coastal Fault (Figure 20).

The UNDP/FAO Water Resources Assessment of the Rio Minho-Milk River Basin, Annex II-Water Resources Appraisal divides the basin into 3 units and treats each unit as being separate. The boundary between Units B and C was said to be a groundwater divide at the western edge of the Brazilletto Mountains until it intersects the South Coastal Fault, which for all purposes is the southern boundary of the limestone aquifer. While there is no evidence for the groundwater divide the fault that is located east of the plant could be the eastern boundary of Unit B.

Cross sections drawn in a north-south and east-west direction across the Halse Hall area show the following:

- The erosional (wavy) surface of the limestone
- The variation in thickness of the alluvium
- The basal clay layer at the limestone/alluvium boundary; and
- The water table in the limestone aquifer.

The cross sections are shown as Figure 21 and Figure 22

Figure 21: Cross-section – East-West Direction across the Halse Hall Area

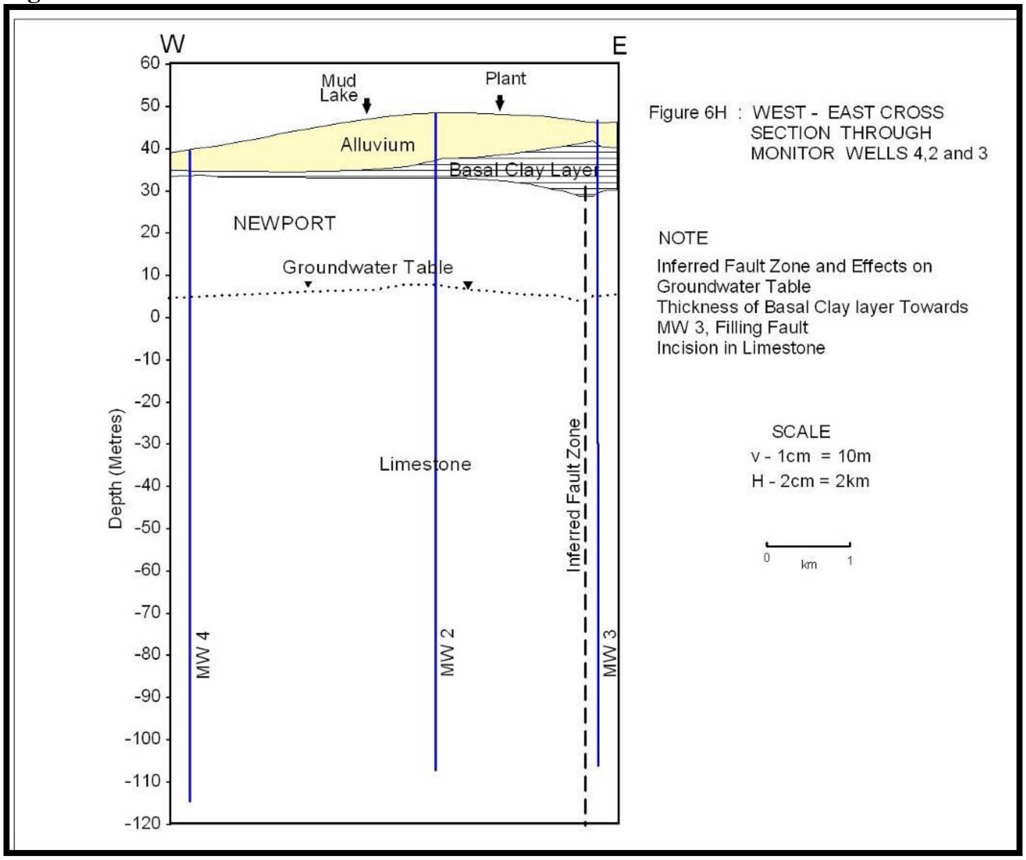
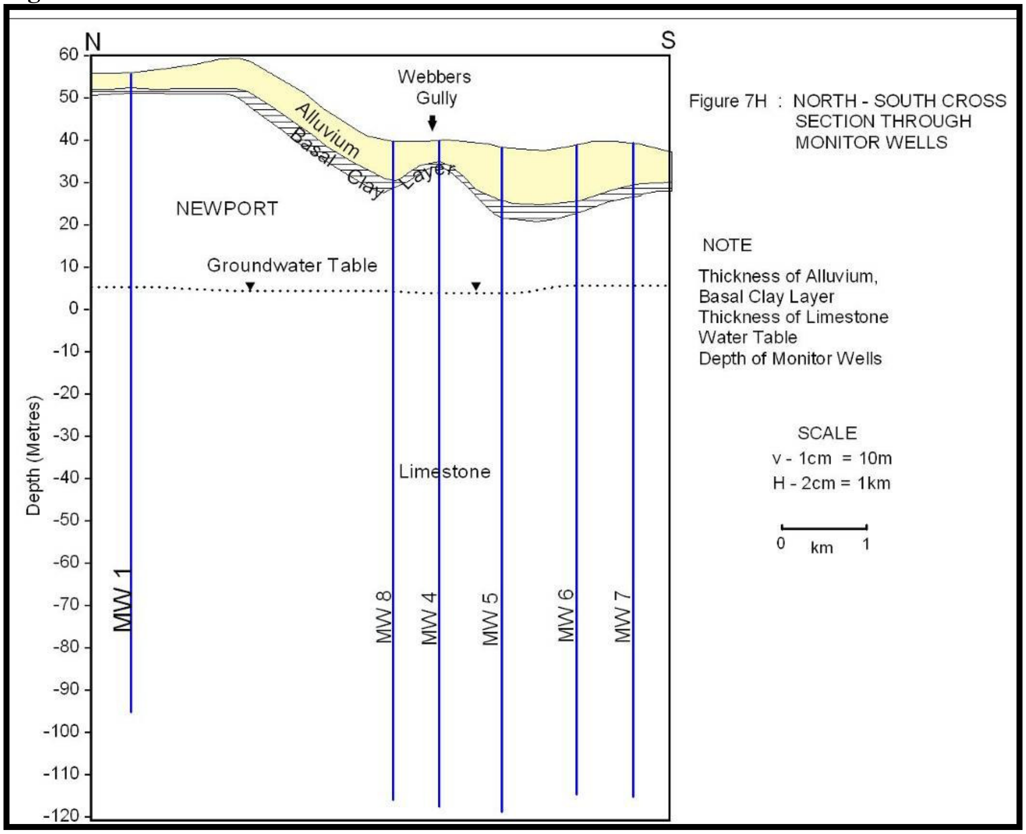


Figure 22: Cross-section – North-South Direction across the Halse Hall Area



3.5.1.4 Topography and Drainage

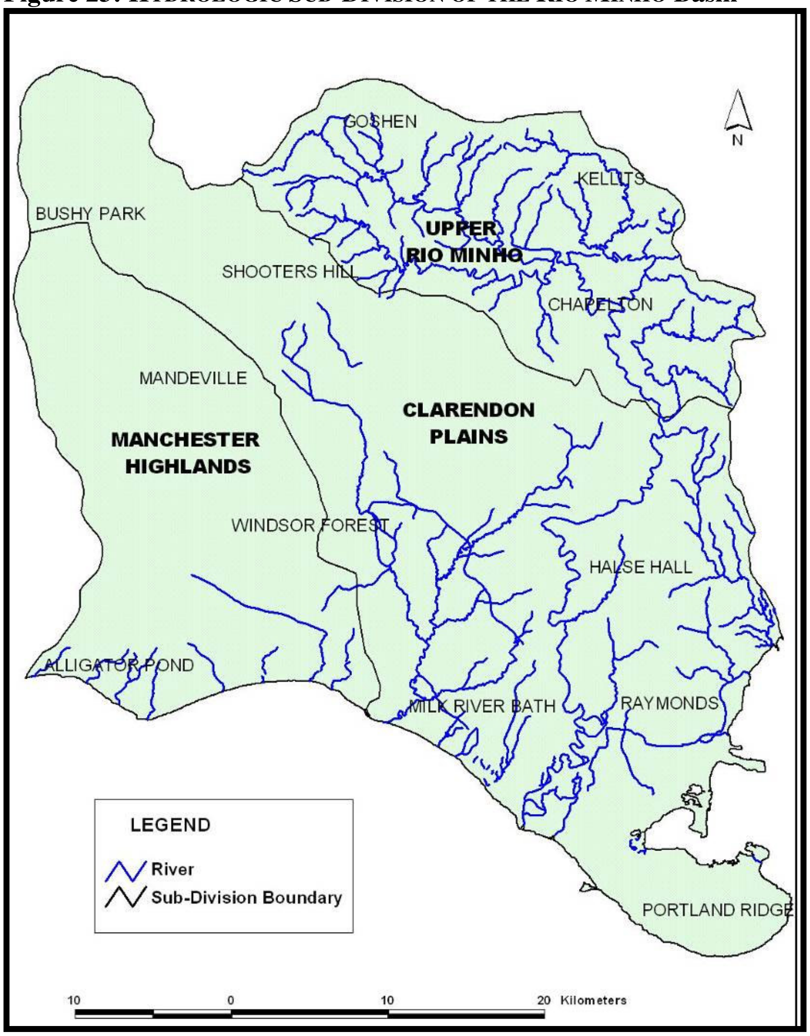
Topographically the area is of low relief with gentle rolling hills on the Harris Savanna. The Brazilletto Mountains form the high ground rising to 250 metres above mean sea level to the east of the bauxite/alumina plant. The Rio Minho flows in a north-south direction west of the RDAs and is the major surface water drainage system. The Webbers Gully, a tributary of the Rio Minho, drains the area north of the Plant. The Webbers Gully is seasonal and carries storm water from the northeast section of the basin into the Rio Minho. During high rainfall events when the Rio Minho is in spate its stage is higher than that of the Webbers Gully with the result that the gully cannot enter the river and will overtop its banks with resultant flooding. The Webbers Gully was straightened to facilitate the construction of the No. 1 RDA (mud lake) and the Clear Lake. The Webbers Gully flows between the northern dike of the No. 1 RDA and the southern edge of the Clear Lake. Monitor well 8 is located just south of the Webbers Gully before it joins the Rio Minho.

3.5.2 Hydrology

3.5.2.1 Surface Water Hydrology

The hydrologic sub-divisions of the Rio Minho basin is shown as Figure 23.

Figure 23: HYDROLOGIC SUB-DIVISION OF THE RIO MINHO Basin



The Rio Minho and the Webbers Gully are the main constituents of the surface water hydrologic system in the Halse Hall area.

The Rio Minho, located west of the RDAs, flows in a north-south direction. The Webbers Gully, a tributary of the Rio Minho, drains the area between New Bowens and the plant site. The alluvium filled Webbers Gully joins the Rio Minho Valley through Palmers Cross at the Barrel Hole sink west of Chateau, May Pen. It joins the Rio Minho at Old Bowens flowing north of Monitor well 8.

The Rio Minho and the Webbers Gully are seasonal in flow. The Rio Minho is seasonal between May Pen and Alley. The river loses its flow-an average of 20 million cubic metres per year (MCM/yr)-just north of May Pen to the limestone aquifer. At Alley the river becomes perennial and is sustained by wet season surface water throughflow from the Upper Rio Minho sub-basin (111 MCM/yr) and perennial inflow of irrigation return water (22 MCM/yr), totaling 133 MCM/yr average discharge to the sea. There is no significant contribution to the Rio Minho throughout its passage across the Clarendon Plains sub-basin to the sea.

Ponding of water occurs along the course of both surface water systems. The ponding indicates the effectiveness of the basal clay layer in preventing vertical movement of water through the alluvium to the limestone aquifer. However along the Webbers Gully in the vicinity of the clear lake there are outcroppings of limestone. Surface flow as well as any contaminant can enter the limestone aquifer through these surface exposures of limestone.

3.5.2.2 Ground Water Hydrology

Ground water is water that is stored within the saturated section of the limestone formation. The natural level of the water i.e. the water table, marks the upper section of this zone of saturation. Rainfall is the sole source of recharge to the ground water system but artificial, intentional or unintentional, inflows can also contribute and may affect ground water type and quality. The impact will depend on several factors and may include.

- Hydrostratigraphy
- Permeability
- Water levels
- Flow direction

As stated above in section 3.5.1.1 the two main hydrostratigraphic units within the project area are the limestone aquifer and the alluvium aquifer/aquiclude. The alluvium is unsaturated and does not function as an aquifer. It can for all purposes be classified as an aquiclude.

A hydrostratigraphic unit is a geologic formation (or series of formations), which demonstrates a distinct hydrologic character. An aquifer is a geologic formation or group of formations that readily and perennially yields water to a spring or well. An aquiclude is the opposite of an aquifer.

The alluvium overlies and confines the limestone aquifer within the project area. The full penetration of the alluvium during the well drilling operations proved its lack of water. The limestone aquifer was partially penetrated to a thickness of 135 metres out of a reported thickness of 1350 metres-10% only. Yet this was the deepest drilling to have been done in the area. The confinement of the aquifer was evident in the drilling of the monitor wells where artesian rises in the water level of up to 14 metres were noted (Geomatrix 1995).

Ground water is ponded within the karstic Clarendon Plains limestone aquifer by clayey alluviums on the downfaulted southern block of the South Coastal Fault. Along its southeastern boundary alluviums and underlying coastal aquicludes act as a barrier to direct outflow to the sea. Note the change (increase) in the elevation of the water table just behind the fault as shown in Figure 24.

The alluvium south of the South Coastal Fault is an aquifer and is tapped by the Sugar Company of Jamaica using tube wells to provide irrigation and domestic water to its operations at Monymusk. The thickness of the alluvium in this area was determined in 1978 using a gravity survey (Bouguer Anomaly) to be a maximum of 650 metres (Wadge, Brooks and Royall 1983).

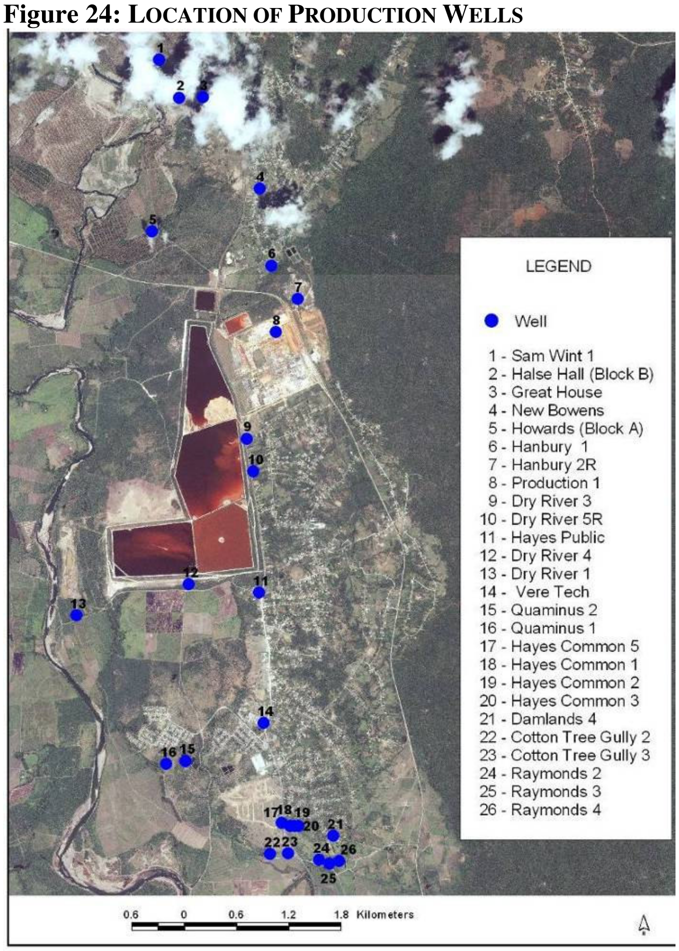
3.5.3 Water Resources

3.5.3.1 Well Locations and Yields

The seasonal character of the main rivers in the Basin combined with the high agricultural demand account for the heavy reliance on ground water. Wells tapping the limestone aquifer produce water for agricultural, domestic and industrial uses. At present over 80% of the water supplied in the basin is from ground water.

Located east of the Rio Minho River within the Clarendon Plains sub-division and to the north (from Halse Hall Great House) and south (to Raymonds) of the CAW are 26 production wells tapping the limestone aquifer. A list of these wells, the owners, their use and licensed/historical yield is given in Table 8 below. The locations of these wells are shown in Figure 24.

Figure 24: LOCATION OF PRODUCTION WELLS



The greater numbers of the wells is located south of the CAW, are all owned by SCOJ, are all used for irrigation and are centered on the Hayes Common-Raymonds area. The location of these wells is along the South Coastal fault that is open to the sea at the western and eastern ends. The high permeability associated with the fault and the ponding of groundwater behind the fault influenced the locations. The wells located along the fault are high producers.

Of these 26 wells the Sugar Company owns 14 that are used for irrigation purposes; the National Water Commission owns 2 for Public Water Supply; the Ministry of Education owns 1 for agricultural uses and Jamalco owns 9 for private domestic, agricultural and industrial uses. The wells owned by Jamalco and used for agricultural purposes are leased to a farming entity.

The total licensed abstraction for the wells owned by Jamalco total 83,830 cubic metres per day (m3/d); that for the National Water Commission totals 10,130 m3/d; that for the Ministry of Education (Vere Technical well) totals 1,690 m3/d and the historical abstraction for the Sugar Company of Jamaica (SCOJ) totals 131,112 m3/d. One well, Quaminus 2, is shared between the NWC and the SCOJ. The NWC purchases water from this well to meet the demands of the Hayes New Town.

The total licensed or historical entitlement of abstraction from the area around the CAW is 226,762 m^3/day.

Table 8: LIST OF PRODUCTION WELLS EAST OF THE RIO MINHO AND WITHIN THE VICINITY OF THE CAW

Name of Well	Name of Owner	Water Use	Yield (m^3/day)
Great House	Jamalco	Private Domestic	250
Sam Wint	Jamalco	Agriculture	7,560
Halse Hall (Block B)	Jamalco	Agriculture	11,160
Howrads (Block A)	Jamalco	Agriculture	10,880
Dry River 3	Jamalco	Industrial	9,815
Dry River 5R	Jamalco	Industrial	9,815
Hanbury 1	Jamalco	Industrial	8,184
Hanbury 2R	Jamalco	Industrial	10,902

Table 8: LIST OF PRODUCTION WELLS EAST OF THE RIO MINHO AND WITHIN THE VICINITY OF THE CAW - continued

Name of Well	Name of Owner	Water Use	Yield (m^3/day)
Production 1	Jamalco	Industrial	15,264
New Bowens	National water Commission	Public Supply	3,272
Hayes Public	National water Commission	Public Supply	6,858
Vere Technical	Ministry of Education	Agricultural/Domestic	1,690
Hayes Common 1	Sugar Company of Jamaica	Irrigation	11,088
Hayes Common 2	Sugar Company of Jamaica	Irrigation	13,944
Hayes Common 3	Sugar Company of Jamaica	Irrigation	10,224
Hayes Common 5	Sugar Company of Jamaica	Irrigation	11,088
Quaminus 1	Sugar Company of Jamaica	Irrigation	15,936
Quaminus 2*	Sugar Company of Jamaica	Irrigation	8,184
Cotton Tree Gully 2	Sugar Company of Jamaica	Irrigation	9,168
Cotton Tree Gully 3	Sugar Company of Jamaica	Irrigation	9,096
Damlands 4	Sugar Company of Jamaica	Irrigation	2,760
Raymonds 2	Sugar Company of Jamaica	Irrigation	6,072
Raymonds 3	Sugar Company of Jamaica	Irrigation	9,168
Raymonds 4	Sugar Company of Jamaica	Irrigation	10,200
Dry River 1	Sugar Company of Jamaica	Irrigation	9,168
Dry River 4	Sugar Company of Jamaica	Irrigation	5,016

*- well shared between SCOJ and NWC.

In addition to the 26 production wells there are two disused production wells, Dry River 2 and Dry River 6, as well as twelve (12) monitor wells located around the CAW. Of the 12 monitor wells one has been destroyed (Monitor Well 7) and one has become inaccessible due to expansion of the plant.

The 12 monitor wells were drilled in 2 phases. Phase 1 saw 8 wells being completed in 1994 with a further 4 wells in phase 2 being completed in 1997. The locations of the monitor wells are shown as Figure 25.

Figure 25: LOCATION OF THE MONITOR WELLS

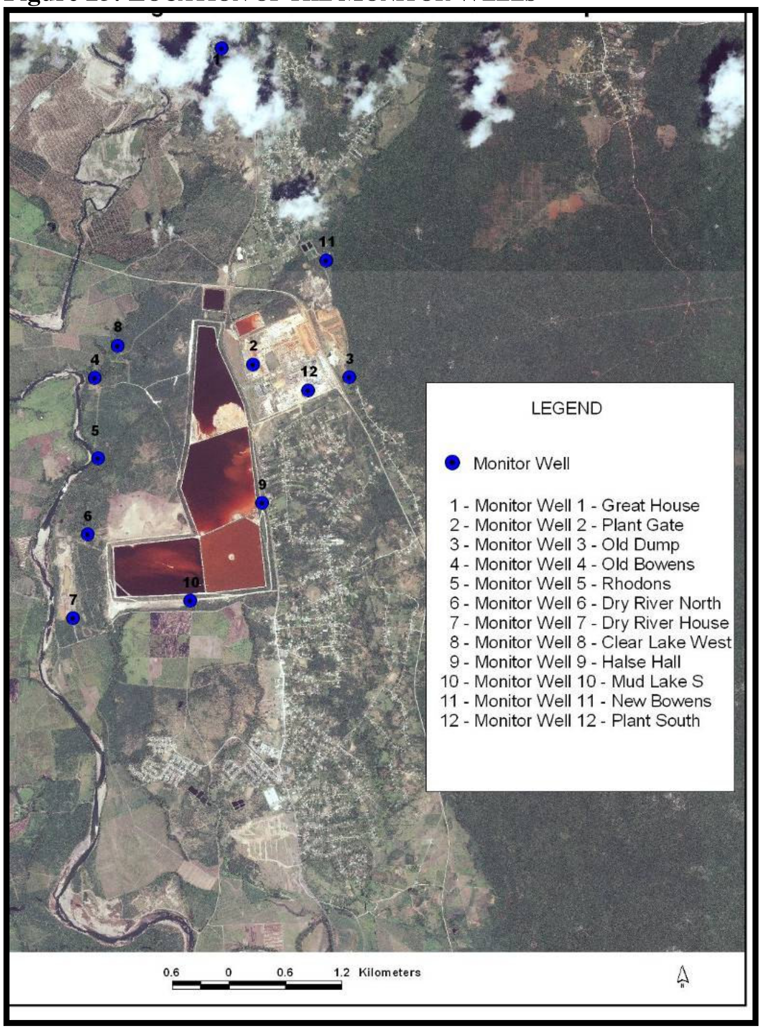


Table 9: CONSTRUCTION DETAILS OF MONITOR WELLS-JAMALCO-CAW

Monitor Well		Drill Hole		Casing/Screen					Filter Pack				Seal	Cement Grout
No.	**Name**	**Dia. (cm)**	**Depth (m)**	**Type**	**Dia. (cm)**	**From (m)**	**To (m)**	**Length (m)**	**Type**	**From (m)**	**To (m)**	**Thickness (m)**		
1	Great House	10.16	152.4	Blank Screen Bank	5 5 5	+0.3 146.3 149.3	146.3 149.3 152.4	146.6 3.0 3.1	MS FS MS	-1.5 141.7 143.2	141.7 143.2 152.4	140.2 1.5 9.2	141.7	1.5 0 to 1.5
2	Plant Gate	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 140.2 143.2	141.7 143.2 155.4	140.2 3.0 12.2	141.7	1.5 0 to 1.5
3	Old Dump	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 144.8 146.3	144.8 146.3 155.4	143.3 1.5 9.1	144.8	1.5 0 to 1.5
4	Old Bowens	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 144.8 146.3	144.8 146.3 155.4	143.3 1.5 9.1	144.8	1.5 0 to 1.5
5	Rhodons	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 144.8 146.3	144.8 146.3 155.4	143.3 1.5 9.1	144.8	1.5 0 to 1.5
6	Dry River North	10.16	152.4	Blank Screen Bank	5 5 5	+0.3 146.3 149.3	146.3 149.3 152.4	146.6 3.0 3.1	MS FS MS	-1.5 143.3 144.8	143.3 144.8 152.4	141.8 1.5 7.6	143.3	1.5 0 to 1.5
7	Dry River House	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 143.3 144.8	143.3 148.8 155.4	143.3 1.5 10.6	143.3	1.5 0 to 1.5
8	Clear Lake West	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 143.3 146.3	143.3 146.3 155.4	141.8 3.0 9.1	143.3	1.5 0 to 1.5
9	Halse Hall	10.16	155.4	Blank Screen Bank	5 5 5	+0.6 128.0 131.0	128.0 131.0 134.0	128.6 3.0 3.0	MS FS MS	-1.5 127.5 134.0	127.5 134.0 155.4	126.0 6.9 21.0	126.5	1.5 0 to 1.5
10	Mud Lake South	10.16	155.4	Blank Screen Bank	5 5 5	+0.8 146.3 149.3	146.3 149.3 152.3	147.1 3.0 3.0	MS FS MS	-1.5 140.0 152.4	140.0 152.4 155.4	138.5 12.4 3.0	140.0	1.5 0 to 1.5
11	New Bowens	10.16	155.4	Blank Screen Bank	5 5 5	+0.8 149.4 152.4	149.4 152.4 155.4	150.2 3.0 3.0	MS FS MS	-1.5 122.0 154.0	122.0 154.0 155.4	120.5 32.0 1.4	121.5	1.5 0 to 1.5
12	Plant Site South	10.16	152.4	Blank Screen Bank	5 5 5	+0.4 137.2 140.2	137.2 140.2 143.2	137.6 3.0 3.0	MS FS MS	-1.5 91.5 143.2	91.5 143.2 155.4	90.0 51.7 12.2	90	1.5 0 to 1.5

MS-Medium Sand FS-Fine Sand

Each well was drilled to a depth of 155.4 metres and completed with 5 cm diameter PVC casing and screen. The annular space of each well was packed with gravel and coarse sand. The screened area, which was close to the bottom of the well, was packed off using bentonite as a seal. Development was carried out using a compressor as the pumping unit. Water samples were collected every 30 metres to develop a water quality profile with depth. The locations of the monitor wells are shown on Figure 22

Details on the construction of the monitor wells are given in Table 9 above.

3.5.3.2 Groundwater Levels

Groundwater level (elevation of water table above sea level) is monitored monthly by Jamalco staff at each of the 10 accessible monitor wells. The groundwater table fluctuates seasonally with recharge and abstraction/discharge. When recharge exceeds abstraction/recharge the storage increases and the water table rises. When abstraction/discharge exceeds recharge water is taken from storage and the water table elevation will decline. In the dry season the water table elevation in the area around the CAW varies from 2.40 to 4.10 metres above sea level with the highest level being recorded at Monitor Well 1 to the north.

The year 2003 was one of high water table elevations as the recharge from the extreme rainfall events in May/June and September of 2002 increased storage within the limestone aquifer. Water table elevations around the CAW remained higher than 6 metres above sea level for all of 2003. In fact at two wells, monitor wells 1 and 12, the water table elevation was higher than 7 metres above sea level. This has gradually declined and in April of 2004 the water table elevations varied from a high of 5.34 (in the north of the area) to a low of 4.51 (west of the RDAs) metres above sea level. There has not been a decline in the groundwater table since the measurements began in 1998.

The water table elevation upon completion of the monitor wells and that on April 1, 2004 is compared in

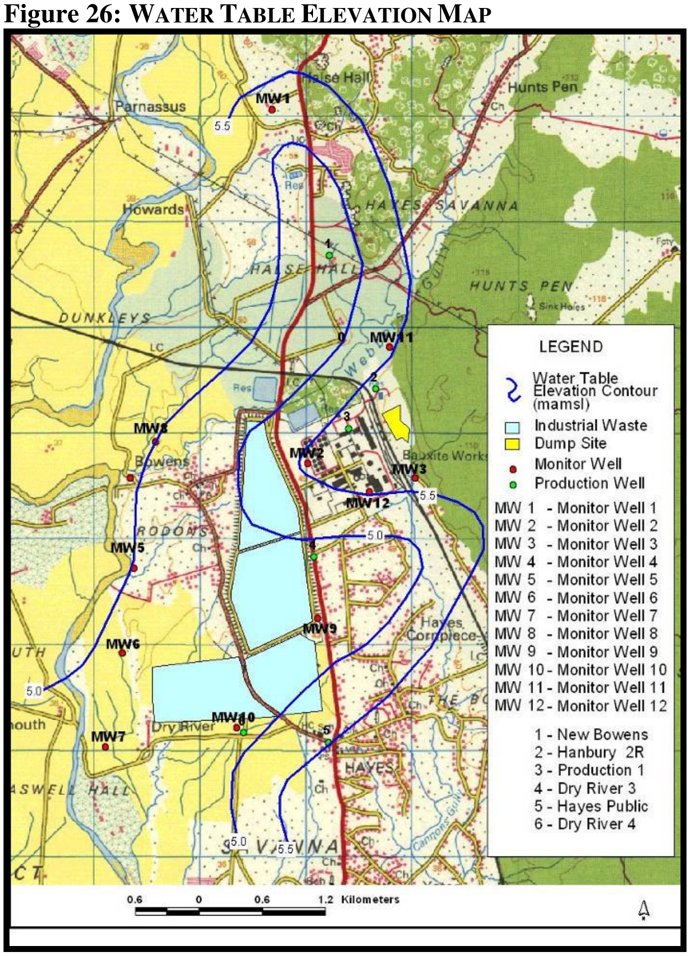
Table **10** below.

Table 10: COMPARISON OF WATER TABLE ELEVATIONS FOR THE MONITOR WELLS

Name of Well	Water Table Elevation (M asl)		Remarks
	Upon Completion	April 2004	
Monitor Well 1	3.35	5.20	MW 1-8 completed
Monitor Well 2	4.63	5.63	In 1994
Monitor Well 3	4.23	5.23	
Monitor Well 4	4.37	4.95	
Monitor Well 5	3.85	4.97	
Monitor Well 6	3.79	4.51	
Monitor Well 8	3.84	4.97	
Monitor Well 9	3.91	4.80	MW 9-12 completed
Monitor Well 10	3.87	4.81	In 1997
Monitor Well 11	3.79	5.34	
Monitor Well 12	3.87	7.38*	*June 2004

The water table elevation map for April 2004 is shown as Figure 26. The groundwater table elevation shows a high of just over 6 metres above sea level. The direction of flow is from the high to the low elevation and is from north to south through the CAW.

Figure 26: WATER TABLE ELEVATION MAP



3.5.3.3 Discharge

Knowledge of the discharge to the sea via the limestone south of the South Coastal Fault is not known. There is no evidence to show that there is a discharge along this reach to the sea. The actual discharge into the sea may be some distance offshore where the White Limestone is exposed to the seabed. It is possible that outflow may be restricted to those periods of high water table and marine discharge in normal conditions may be small.

The principal discharge from the aquifer is by abstraction from pumped wells. In Table 8 a list of the pumped wells is given with the licensed or historical abstraction rates.

The total committed water for abstraction from the area around the CAW was 226,762 m3/day (10.30 x 108 imperial gallons per day). There has never been a period when all the wells have been abstracting at their maximum and the 226,762 m3/day was being abstracted. This area of the limestone aquifer has the greatest abstraction in the basin and is concentrated in particular to the area south of the CAW that includes the Hayes Common-Raymonds area. Many of the wells suffer from saltwater contamination either from penetration of the fresh water-seawater interface along the South Coastal Fault, the movement of saltwater (influenced by the pumping) along the fault that is open to the sea at both the western and eastern ends or the recirculation of return saline irrigation water.

3.5.3.4 Reservoir Volume

The effective ness of an aquifer to supply water on a reliable basis is determined by the volume of the reservoir rock capable of holding the water. The effective volume of the reservoir is that amount of water that the rock will yield.

The thickness of the permeable section of the aquifer in the northern area of the basin is not known. However this is determined by the depth to the impermeable basement rocks (Yellow Limestone or Volcanic rocks) and the aquifer is thin where these rocks are near to the surface. In the area around the CAW the impermeable sediments are covered by the great thickness of the White Limestone (Newport Formation) and they do not affect the depth to which water can penetrate. The depth of solution in the limestone is limited by the lowest base level in effect during the history of solution development. The degree of karstification has a direct bearing on the capacity of the limestone to store and transport water. In the area beneath the CAW the level of karstification and high permeability in the limestone was found to be over 100 metres deep and has been proven to be over 150 metres deep within the central depression.

The reservoir volume is assumed to be equivalent to the saturated thickness of the reservoir. Assuming a saturated thickness of at least 100 metres and an area of the aquifer bounded by the South Coastal Fault to the south, by the Rio Minho to the west, by the fault between the plant and the Brazilletto Mountains to the east and by an imaginary east-west line drawn north of the Great House and Sam Wint wells with an approximate area of 34.5 square kilometres, the volume of the reservoir would be 345 million cubic metres of water (a value of 10% is used for the calculation of the reservoir volume).

The groundwater table elevations are relatively flat in the central area of the basin and around the CAW. They are controlled by several factors, which will include the storativity and the transmissivity of the aquifer. The dry season water table elevation varies from 2.5 metres above sea level to a high of 5 metres above sea level, which gives an average water table elevation of approximately 3.75 metres above sea level within the study area. The total water that could be abstracted is 12.94 MCM.

3.5.4 Water Quality

3.5.4.1 Ambient Water Quality

The groundwater resources of the Clarendon Plains and the area around the CAW are associated with the limestone aquifer, which occurs throughout the area and fills the central depression. Except where contaminated by industrial and municipal effluents or seawater, the quality of the groundwater is adequate for all standard uses. Physical, chemical and bacteriological quality is generally as follows:

- pH 7.2
- Conductivity 450 to 700 uS
- TDS 250 to 450 mg/l
- Coliform 5 MPN/100 ml.

Total Dissolved Solids (TDS) tends to be slightly high for use in industrial boilers without softening, but the bacteriological quality requires minimum treatment for use as a municipal/ public or private water supply. However where contamination has occurred the quality would vary depending on the nature of the contaminant.

The typical background quality of the groundwater in the limestone aquifer is shown in Table 11 below.

Table 11: TYPICAL BACKGROUND QUALITY OF GROUNDWATER IN THE LIMESTONE AQUIFER-CLARENDON.

Constituents	Units	Concentrations
pH		7.2
Turbidity	NTU	<1.0
Colour	HU	<5
Specific Conductivity	uS	550
Calcium	mg/l	<75
Magnesium	mg/l	10
Sodium	mg/l	12
Potassium	mg/l	1.0
Iron	mg/l	0.01
Chloride	mg/l	10
Sulphate	mg/l	8
Nitrate	mg/l	4
Carbonate	mg/l	0.0
Bicarbonate	mg/l	260
Total Hardness	mg/l	270
Total Alkalinity	mg/l	260
Total Dissolved Solids	mg/l	350
Bacteriological	MPN/100 ml	<5
Na:Cl ratio		<1.5

3.5.4.2 Groundwater Chemical Types

All groundwater can be classified into types according to the dominance of various anions and cations in the water. The major types are:

1. Calcium/Magnesium bicarbonate
2. Sodium bicarbonate
3. Calcium chloride
4. Sodium chloride

Natural groundwater, which is uncontaminated, has as the dominant cation, calcium or magnesium, dependent on the source rock through and over which the water flows. The dominant anion is bicarbonate and together with the dominant cation, the chemical water type becomes calcium or magnesium bicarbonate water. The changes from the naturally occurring calcium bicarbonate type water to the sodium chloride type water is an indication of contamination of the groundwater and the replacement of the calcium by sodium and the bicarbonate by chloride.

Around the CAW the major groundwater chemical type is the calcium bicarbonate type with sodium chloride type to the south around Hayes Common-Raymonds and at depth within the limestone aquifer.

3.5.4.3 Sources of Groundwater Contamination

The assessment of any change in groundwater quality and type must include an evaluation of the possible sources of contamination and the impact each can have on water quality.

Around the CAW there are three main possible sources of contamination of groundwater. These are:

1. The intrusion of saltwater (saline intrusion) into the karstic aquifer as a result of the **over pumping** resulting in high chloride and sodium concentrations.

2. **Industrialization**, specifically the bauxite/alumina operations at Halse Hall consisting of the plant and the RDAs.

3. **Municipal** impacts from the improper disposal of liquid and solid wastes.

3.5.4.3.1 Saltwater Intrusion

The limestone formation responds as a Ghyben-Herzberg aquifer. The Ghyben-Herzberg Principle specifies that the occurrence of saline groundwater in a coastal aquifer, similar to that of the Rio Minho Hydrologic basin within which the CAW is located, is dependent on the head of fresh water above sea level. A ratio if 1:40 i.e. one metre of fresh groundwater above sea level to 40 metres of fresh groundwater below sea level before entering the freshwater/saline water interface. This has been proven by Botbol in the adjoining Rio Cobre Hydrologic basin a karstic limestone area. Around the CAW with water levels 6 metres above sea level there should be 240 metres of freshwater below sea level before the fresh/salt water interface is encountered.

Within the area of the CAW the potential for saline intrusion by way of upconing from the Ghyben–Herzberg Zone is provided by the below sea level pumping depressions associated with the well fields around the Hayes Common-Raymonds area. The saline water can also be brought to the upper level of the aquifer by way of the faults, which act as preferred paths of flow due to the increased permeability along the fault zones. In addition the wells south of the CAW are all located along the South Coastal Fault Zone, which is open to the sea at both its eastern and western ends.

3.5.4.3.2 Industrialization-Bauxite/Alumina Operations

The bauxite/alumina industry produces an alkaline waste known commonly as “red mud”. This bauxite residue is a thick fluid suspension with a water content between 65 – 75% depending on the technology and method of management used, high concentrations of sodium and hydroxide ions; iron oxides and organic substances which originate from the bauxite and which on decomposition and reaction with caustic soda, impart an unpleasant smell to the water. The pollutants present in the bauxite residue are in sufficient quantities to make the groundwater unfit for domestic and agricultural uses, in the event the bauxite residue is not effectively contained within the storage areas. Effective containment is achieved through the use of sealants such as clay.

The CAW was constructed in the early 1970's. The plant is located on the Clarendon Plains an important agricultural region where over 90% of the irrigation water and 100% of the public water supply is derived from groundwater using wells tapping the limestone aquifer. The bauxite residue is a potential agent for degrading this water quality with potentially significant social and economic consequences.

The bauxite residue is disposed of into Residue Disposal Areas (RDA). RDA 1 was commissioned into use on March 6, 1972. RDA 2 and RDA 3 were constructed in 1980 and 1990 respectively. RDA 4 was constructed in 2000 and the dike was raised by an additional 20 feet in 2004. The RDAs have all been sealed with clay in the base and the sides. Supernatant (caustic enriched) liquor and plant runoff are collected and stored in RDAs (clear and storm lakes) from where it is recycled into the plant. Total volume of mud in storage exceeds 15 million tonnes.

3.5.4.4 Contamination Criteria

The monitoring programmes established by Jamalco in conjunction with the Government of Jamaica regulating agencies are intended to detect above average concentrations of the chemical constituents that can contaminate the groundwater. The inclusion of the aesthetic indices such as colour, taste and odour also assist in the determination of the level of contamination of groundwater.

Five indices are specifically used to detect contamination from the bauxite/alumina operations. These are:

1 Sodium to chloride concentration ratio exceeding the maximum ratio encountered in uncontaminated groundwater in Jamaica of 1.5 (White and Rose 1975).

2 High sodium content. This alone is not a precise indicator as sodium chloride waters are found in the limestone aquifer as a result of saline intrusion. However in this form of contamination high sodium concentrations are associated with high chloride concentrations. This is not the case in the event of a caustic contamination.

3 Sodium to calcium concentration ratio in excess of the ratios generally encountered in uncontaminated groundwater of 1.0

4 High pH values in excess of 8.5 units, the limit set by the USEPA and the WHO for drinking water and the maximum encountered in groundwater in Jamaica.

5 The presence of suspended solids, red discoloration, poor smell and unpleasant taste.

In addition high conductivity, TDS and alkalinity concentrations aree used to determine the source of the contamination.

3.5.4.4.1 Water Quality Monitoring

Jamalco has conducted water quality monitoring around the CAW since 1989. The programmes have been intensified over the years to generate information on the impact of the bauxite/alumina operations on the groundwater quality of the limestone aquifer. Initially the programme consisted of monthly sampling and analysis of existing production wells within and around the CAW. The drilling of the monitoring wells has led to the expansion of the monitoring programmes and the level of the analysis done. The monitoring and analysis has led to an increased database on which to base the evaluation of the impacts of the bauxite/alumina operations on groundwater quality. To date the following have been completed and for which data is available:

1 Analysis on a monthly basis of production wells between January 1998 to the present for the parameters- pH, conductivity, chloride, sulphate, sodium, magnesium carbonate, calcium carbonate, and hardness. The sodium:chloride ratio was calculated from the results. The sampling points included-Production wells 1 and 2, Hayes Common wells 1,2 and 3, Dry River 2 and 5 wells, Hayes Public well, Quaminus 2 well, Halse Hall well (Greenvale), Woodside well, Breadnut Valley well, Rocky Point (Morelands) well, Rocky Point drinking water (trucked water) and Webbers Gully.

2 The completion of the first 8 monitor wells in 1994 led to the expansion of the programme and provided monitor points that were not affected by pumping and tapped groundwater deep within the aquifer.

3 The completion of the next 4 monitor wells in 1997 further expanded the programme.

4 During the drilling of the monitor wells water samples were collected every 30 metres depth below the water table to ensure that a water quality profile of the monitor well could be developed. Each monitor well yielded 4 sets of samples. The parameters analyzed are shown in Table 12 below.

5 Since 1998 Jamalco has contracted a consultant to carry out quarterly sampling and analysis of all the wells as an independent assessment of the impacts of the bauxite/alumina operations on water quality. The samples are analyzed by a USEPA and NELAP certified laboratory in the USA. The sample points and the parameters analyzed are shown in Table 13. Jamalco at the same time continues its independent sampling and analysis of the same monitor points.

6 In 2000 Jamalco instituted a twice-yearly sampling of all the sources of water to its facilities to assess the quality of water being used for domestic purposes. The sampling points and the parameters analyzed are shown in TABLE 14 below.

The data collected has been analyzed and to date no significant contamination of groundwater has been detected.

Table 12: PARAMETERS ANALYZED FOR EACH WATER SAMPLE, MW1 TO 12.

Group of Parameters	Constituents
Metals	Aluminium: Arsenic: Barium: Cadmium: Calcium: Chromium: Iron: Lead: Magnesium: Manganese: Mercury: Selenium: Silver: Sodium.
Inorganics	Cyanide (Total): Chloride: Carbonates: Bicarbonates: Nitrate: Sulphate: Hexavalent Chromium.
Physical/chemical	Turbidity: pH: Specific Conductance
Organics	Phenol: Polychlorinated Biphenyls (PCB): Naphthalene
VOAs (Volatile Organic Aromatic Compounds)	Acetone: Benzene: toluene: Carbon Tetrachloride: Vinyl Chloride: Chloroform: Chlorobenzene: 1,1-Dichloroethane: Methyl Ethyl Ketone (2-Butane)
TPH (Total Petroleum Hydrocarbons)	Hydrocarbons-Petroleum

Table 13: LIST OF WELLS AND PARAMETERS-MONTHLY SAMPLING PROGRAMME JAMALCO

Sampling Point	Well Depth (m)	Use of Water	Parameters
Monitor Well 1	155.4	Monitoring	Lab:- Sodium
Monitor Well 2	155.4	Monitoring	Calcium,
Monitor Well 3	155.4	Monitoring	Magnesium
Monitor Well 4	155.4	Monitoring	Chloride
Monitor Well 5	155.4	Monitoring	Sulphate
Monitor Well 6	155.4	Monitoring	Nitrate
Monitor Well 8	155.4	Monitoring	TDS
Monitor Well 9	135.0	Monitoring	Alkalinity
Monitor Well 10	152.4	Monitoring	
Monitor Well 11	155.4	Monitoring	Field:- pH
New Bowens	70.1	Public Supply	Temp.
Dry River 3	76.2	Industrial	Cond.
Dry River 4	55.8	Irrigation	
Hayes Public	67.0	Public Supply	Water Levels
Production 1	86.3	Industrial	Na:Cl ratio
Production 2	122.0	Industrial	calculated

Duplicate samples are collected and a comparison made of the analytical results between the Jamalco Laboratory and the USEPA Laboratory in the USA that analyses the samples. The comparison indicates that on the whole the results compare favourably. However at times the difference in the chloride concentration has been very large. This probably due to the fact that the samples are analyzed beyond the maximum holding time and the samples were not preserved in the field.

TABLE 14: LIST OF FACILITIES, SOURCES, SAMPLE SITES AND PARAMETERS ANALYZED

Facility/Location	Source/Supply	Sample Site	Parameters
Clarendon Alumina Works [CAW]	Production Well 1	At Well Head	**Metals:** Aluminium; Arsenic: Cadmium: Calcium: Copper: Iron: Lead: Magnesium; Manganese: Mercury: Selenium: Sodium: Zinc **Non-metals:** Chloride; Cyanide: Fluoride; Nitrate: Sulphate: TDS: pH; Temp.: **Bacteria:** Coliform -T and F **Pesticides:** gamma-BHC: Aldrin: Dieldrin: 4,4'-DDT: Technical Chlordane: Methoxychlor. **Organics:** 1,1-Dichloroethane: Chloroform: Benzene: 1,2-Dichloroethane: 2,4,6-Trichlorophenol: Pentachlorophenol: Hexachloroethane: Benzo(a)Pyrene.
	Production Well 2	At Well Head	
	Dry River Well 3	At Well Head	
	Groundwater from PW 1/PW 2 after Treatment	Drinking Fountain in Building 1	
Halse Hall Great House	Great House Well	At Well Head	
	Great House Well after Treatment	At Great House Kitchen Tap	
Breadnut Valley	Breadnut Valley Well	At Well Head	
	Breadnut Valley Well after Treatment	Drinking Fountain in Plant Office	
Woodside Lands Office	NWC Supply from Kraal Well 1	Drinking Fountain in Main Office	
Rocky Point Port	Trucked Water	Domestic Tank Tap	
Waterloo Road Office	NWC Supply from Hermitage Dam	Tap in Office Kitchen/Pantry	

3.5.4.4.2 Analytical Results

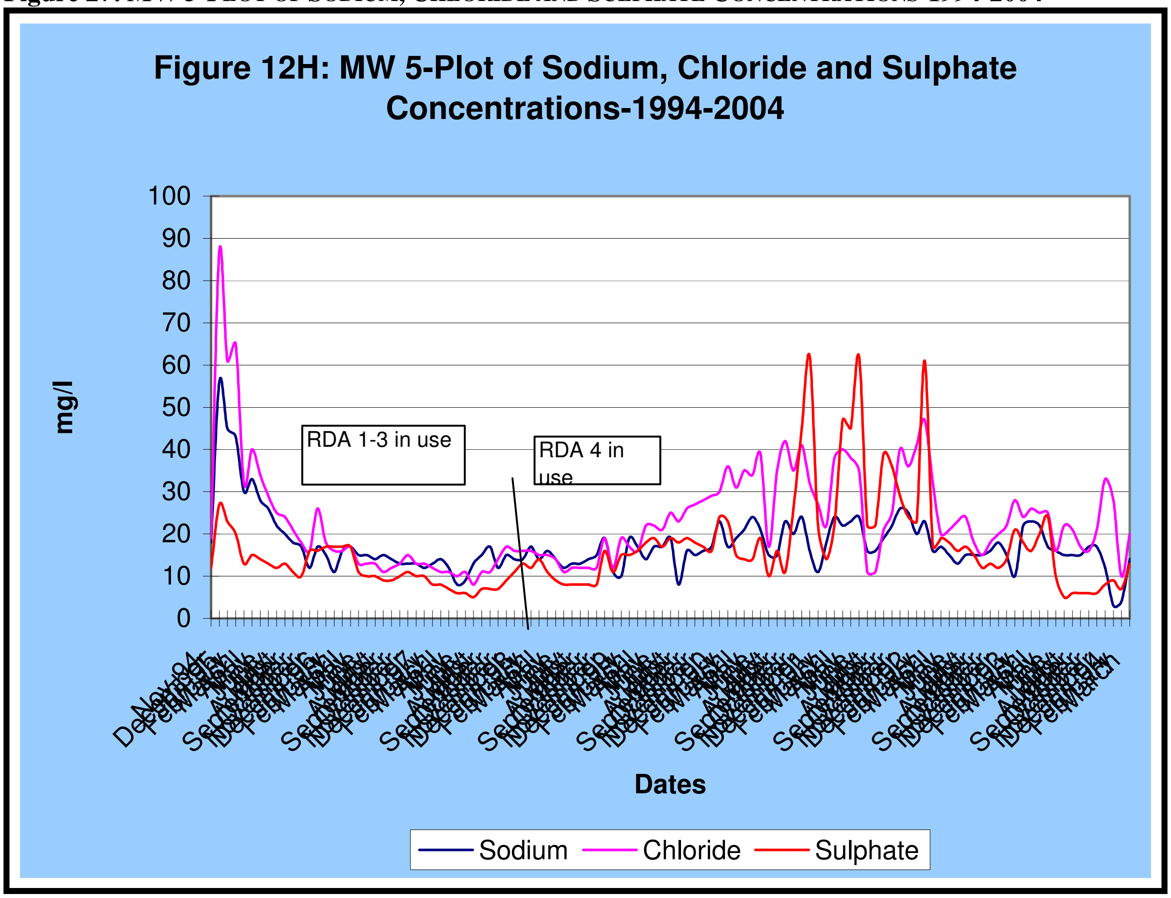
a) Borehole Profile

The samples collected from each borehole at 30 metre intervals during drilling indicate that no contamination resulting from the bauxite/alumina operations was detected in any of the wells. In several wells the sodium concentration was higher than normal but so was the chloride concentration. The Na:Cl ratios were at all times less than 1. It is noteworthy that neither Arsenic, Cadmium, Mercury, Selenium nor Silver was detected at any depth within any of the wells. Phenol was the only organic compound detected at one level in 5 of the wells and all at very low concentrations. No Volatile Aromatic Compound was detected at any concentration that exceeded the guideline values. No TPH was detected that would be a cause for concern.

b) Monthly Sampling and Analysis

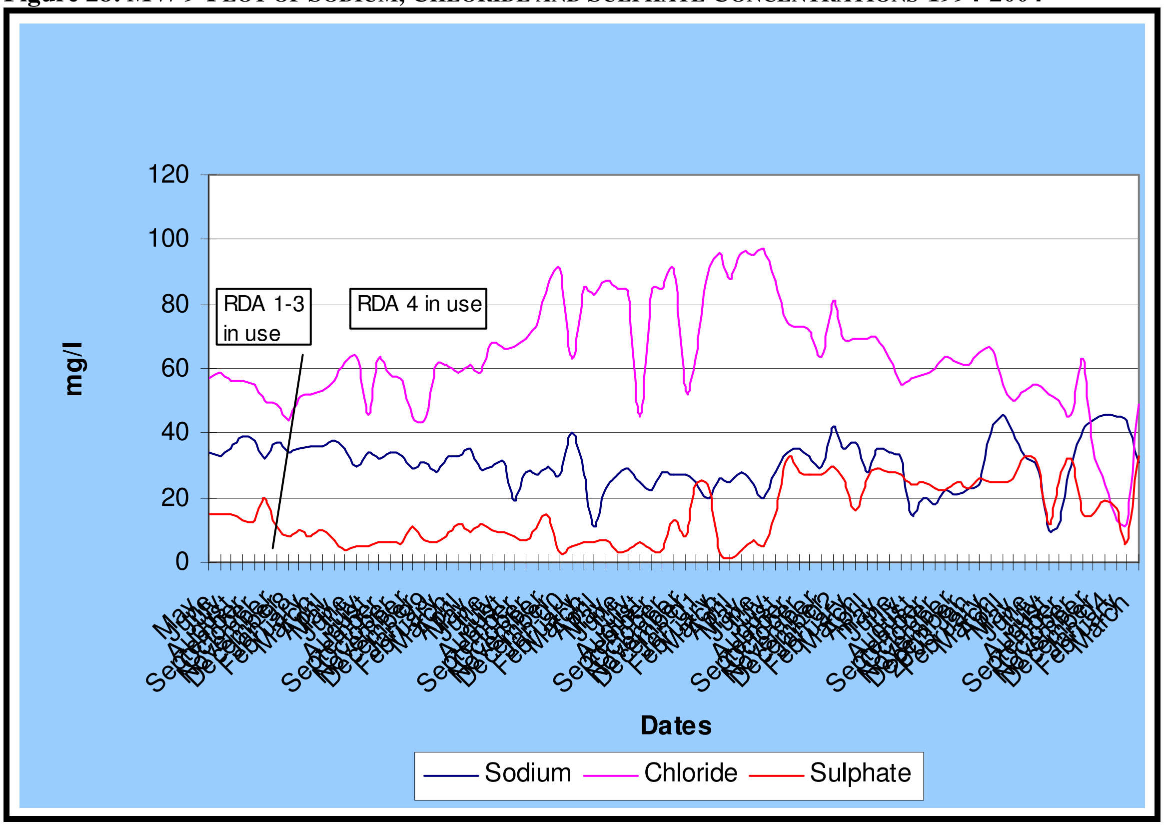
The results for the monthly sampling and analysis programme are shown plotted for four of the monitoring points-3 monitor wells and 1 production well. The points are MW 5 to the west of the RDAs; MW 9 to the east of the RDAs; MW 10 to the south of the RDAs and Hayes Public well located to the south of the RDAs and between MW 9 and MW 10. The Hayes Public well was selected, as this well is the source of the water supply for the Hayes community and has been the discussion of many community meetings as to its quality and suitability for domestic uses. The plots of the sodium, chloride and sulphate concentrations are shown as figures Figure 27 to Figure 31.

Figure 27: MW 5-Plot of Sodium, Chloride and Sulphate Concentrations-1994-2004



At MW 5, to the west of the RDAs, the data plot Figure 27 shows no significant increase in the sodium concentration over time. There is a close correlation between the chloride and sodium concentrations. In all cases the Na:Cl ratio would be less than 1. The assessment took into consideration the impact of each RDA as it was commissioned into service. As can be seen there was an increase in the chloride and sodium concentration after RDA was brought on stream. However, this is not due to leakage from the RDA but to the below average recharge coupled with increased pumping.

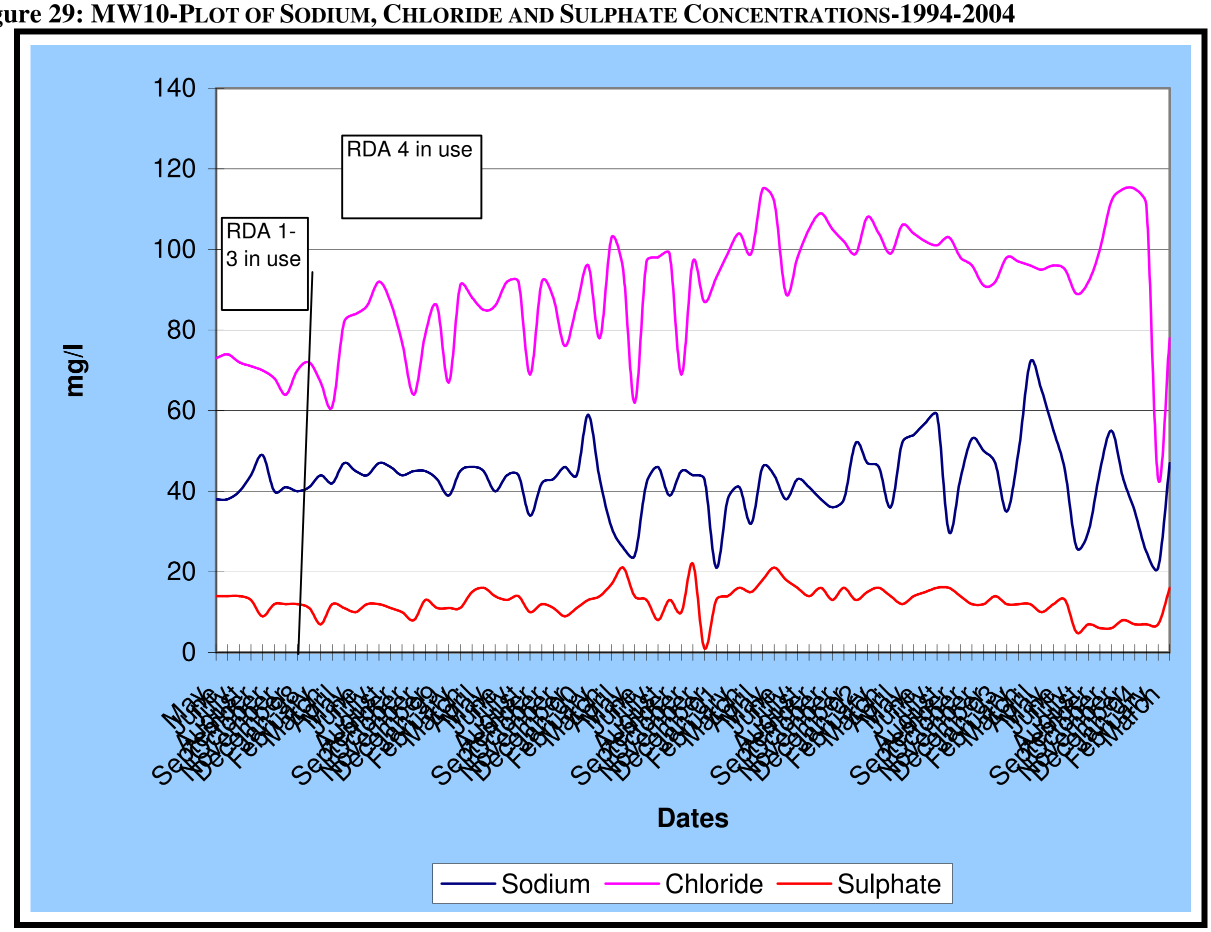
Figure 28: MW 9-PLOT OF SODIUM, CHLORIDE AND SULPHATE CONCENTRATIONS-1994-2004



At MW 9, to the east of the RDAs, the plot Figure 28 while showing a varying concentration for sodium does not show a trend toward an increasing concentration. The chloride shows an increasing upward trend in concentration up to June 2001 where after there is a decline in the concentration. This increased chloride concentration is probably due to the less than average rainfall/recharge between 1999 to 2000 and the increased pumping to meet water demand. Here also the high chloride concentration compared to the lower sodium concentration would ensure that the Na:Cl ratio is less than 1.

The commissioning of RDA 4 did not lead to any increase in sodium concentration. The increase in chloride concentration is not attributable to the RDA but to recharge and pumping conditions and would most probably represent increased salinity of the groundwater during that period. An increase in the sulphate concentration after June 2001 was noted. This led to the concentration moving from less than 20 mg/l to between 20 to 30 mg/l. The reason for this is not known but the concentration is still far below the WHO guideline value of 400 mg/l.

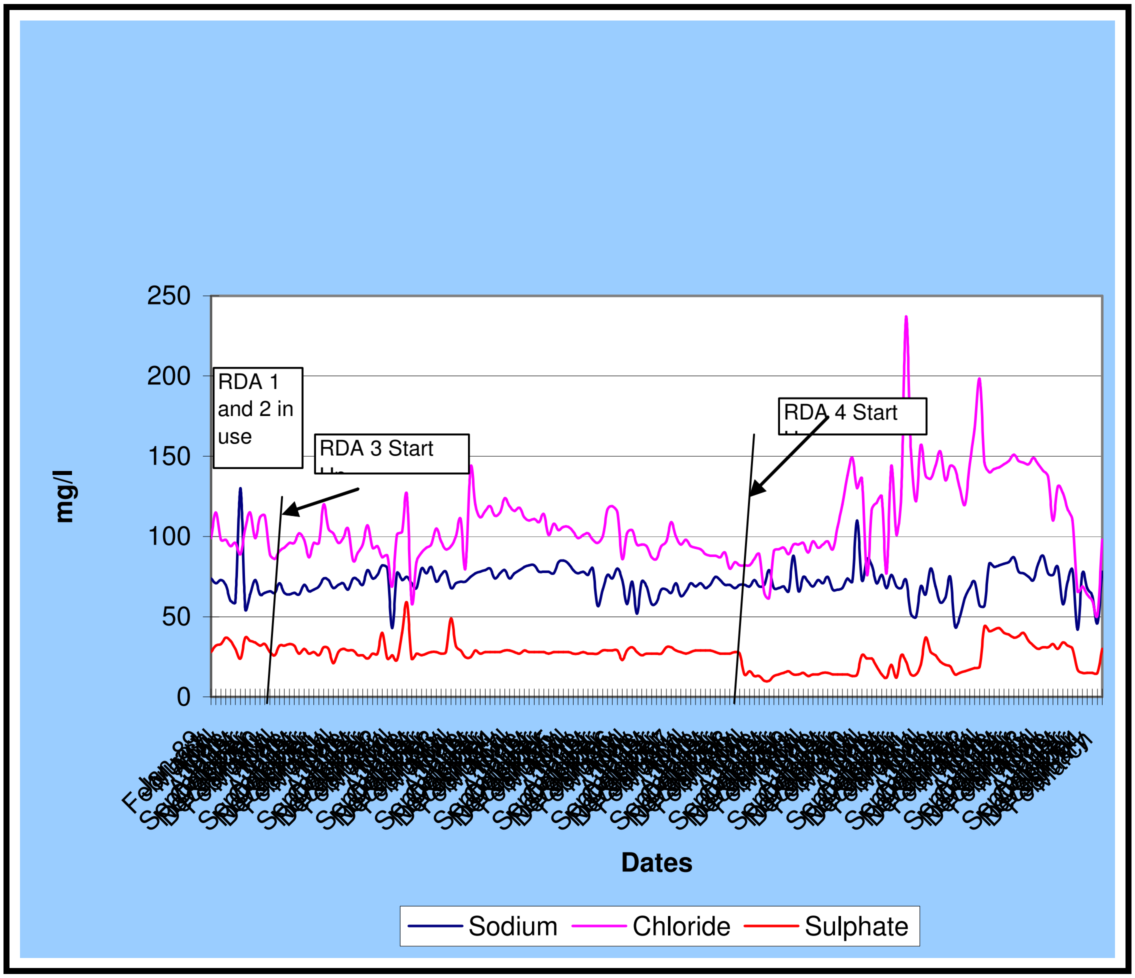
Figure 29: MW10-PLOT OF SODIUM, CHLORIDE AND SULPHATE CONCENTRATIONS-1994-2004



At MW 10, to the south of the RDAs, the plot (Figure 29) there is a trend to an increase in chloride concentration. This well is located close to the Dry River 4 irrigation well that has reported chloride concentrations of up to 150 mg/l. There has not been a trend towards an increase in the sodium and sulphate concentrations.

The use of RDA 4 after 1998 has not resulted in an increase in the sodium concentration. As is the pattern with the other wells an increase in the chloride concentration was noted. However this is more related to salinity changes within the aquifer. There was no overall change in the sulphate concentration.

Figure 30:HAYES PUBLIC WELL PLOT OF SODIUM, CHLORIDE AND SULPHATE CONCENTRATIONS 1989-2004



At the Hayes Public well, also south of the RDAs, the plot Figure 30 shows a very constant concentration of sodium and chloride up to the year 2000. The chloride concentration has shown an increase since 2000 that again may be due to the below average recharge and increased pumping. The start up of RDA 3 and RDA 4 as shown on the graph did not in any way affect the concentrations of sodium and sulphate. This well is the most southern of the monitor points and is the closest to the South

Coastal Fault and the wells at Hayes Common that show high chloride concentrations exceeding 350 mg/l at times. The Na:Cl ratio here would also be less than 1.

The controversy of the possible contamination of the Hayes Public well has led to many meetings between Jamalco and the Hayes community. The monthly sampling does not show any caustic contamination at the Hayes well. Further investigation was recommended and on April 1, 2004 a sample was collected and analyzed for heavy metals. The results are presented below in Table 15.

As can be seen only one parameter exceeds the World Health Organization (WHO) guideline value for drinking water. That parameter is Aluminium and the concentration was reported at 0.22 mg/l while the guideline value is 0.20 mg/l. Aluminium has no toxicological effect on the human body. The concentration of Copper was reported at 0.011 mg/l with a guideline value of 1.0 mg/l. Barium was reported at 0.055 mg/l. There is no guideline value for Barium. All the other thirteen parameters had concentrations less than the Laboratory Reporting Limit (LRL).

The conclusion reached is that the water quality at the Hayes Public well meets the drinking water guidelines and is suitable for use as a domestic water supply. The bauxite/alumina operations have not impacted on the water quality in the limestone aquifer to affect that being abstracted at the Hayes Public well.

Table 15: ANALYTICAL RESULTS OF HEAVY METALS FOR HAYES PUBLIC WELL (NWC) – APRIL 2004

Parameter	Concentration (mg/l)	Lab Reporting Limit (LRL) (mg/l)	WHO Guideline Limit for Drinking Water (mg/l)	Remarks
Aluminium	0.22	0.10	0.20	Exceeds Guideline-No toxicological Effect.
Antimony	<0.50	0.50	0.002	
Arsenic	<0.50	0.50	0.05	
Barium	0.055	0.010	None	
Beryllium	<0.0050	0.0050	None	
Cadmium	<0.010	0.010	0.005	

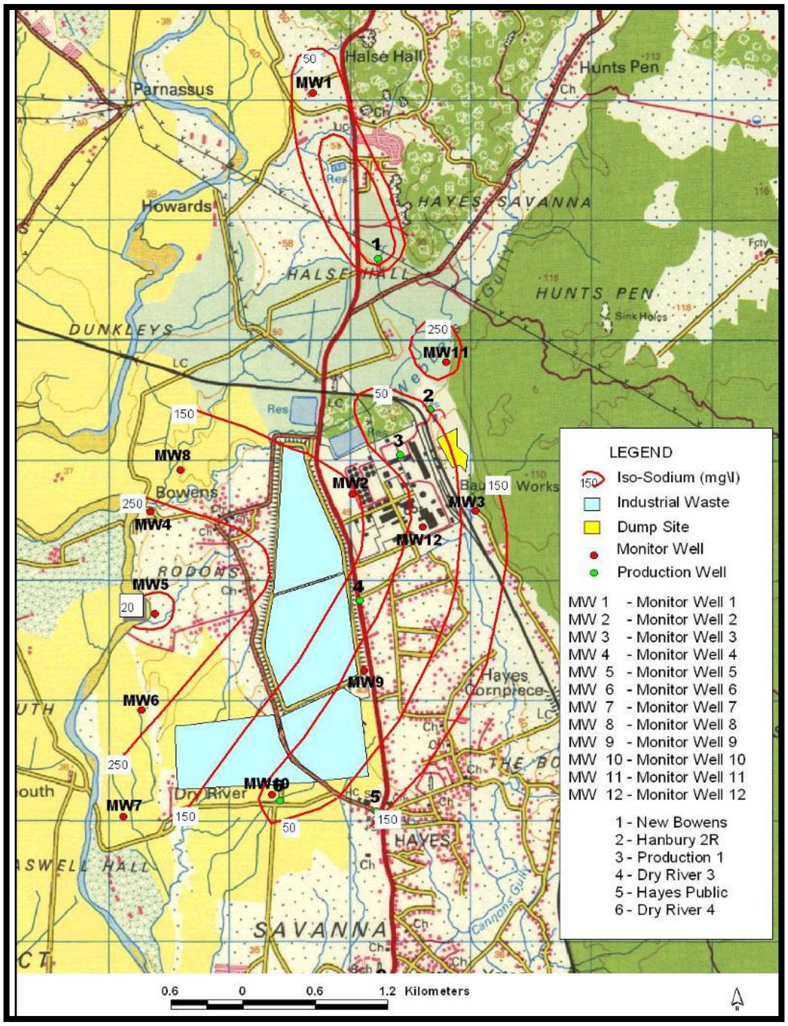
Table 15: ANALYTICAL RESULTS OF HEAVY METALS FOR HAYES PUBLIC WELL (NWC) – APRIL 2004 - ***continued***

Parameter	**Concentration (mg/l)**	**Lab Reporting Limit (LRL) (mg/l)**	**WHO Guideline Limit for Drinking Water (mg/l)**	**Remarks**
Chromium	<0.020	0.020	0.05	
Copper	0.011	0.010	1.0	
Iron	<0.10	0.10	0.3	
Lead	<0.10	0.10	0.05	
Manganese	<0.010	0.010	0.1	
Mercury	<0.00020	0.00020	0.001	
Nickel	<0.020	0.020	None	
Selenium	<0.50	0.50	0.01	
Thallium	<0.50	0.50	0.006	
Zinc	<0.020	0.020	5.0	

The analytical results for the quarterly sampling done in April 2004 are included as Table 16 and Table 17 The sodium concentration reported for monitor well 1 and shown in Table 16 incorrect and is not in keeping with previous historical results reported. This high sodium concentration and the lower chloride concentration yields a Na:Cl ratio of 2.73 which would indicate caustic contamination. However this well is located north and upgradient of the CAW. It is outside the zone of contamination from the bauxite/alumina works and saline intrusion. The duplicate sample analyzed by Jamalco reported a sodium concentration of 8 mg/l and chloride concentration of 12 mg/l with the Na:Cl ratio at 0.67 which is more in keeping with the historical results reported since 1994.

The iso-sodium plot for April 2004 is shown as Figure 31. Sodium concentration varies from 50 mg/l to over 250 mg/l west of the RDAs. The contours of the highest sodium concentrations (250 mg/l) match those areas where saline intrusion is met at depth in the wells-MW 6 and 8.

Figure 31: ISO-SODIUM PLOT - APRIL 2004



c) Facilities Sampling

The sampling of sources of water being supplied to Jamalco's facilities across Clarendon and the Kingston Office is executed twice per year-once in the dry season and once in the wet season. The objective of the sampling programme is to determine the quality of water supplied for use within the facility and to determine the impact of the bauxite/alumina operations on water quality. As shown in Table 14 the facilities are supplied with water from both Jamalco's own wells and from the National Water Commission's public supply. The analysis is for specific parameters and covers metals, non-metals, pesticides, PCBs and volatile organics. The results for January 2004, the last sample period, are presented as Table 18 to Table 21. The results indicate that the bauxite/alumina operations, the disused solid waste dump at Mineral

Heights and the sewage disposal methods in the May Pan area have not impacted on the water quality in the limestone aquifer.

Table 16: SUMMARY OF ANALYTICAL RESULTS AND FIELD DATA – APRIL 2004

PARAMETER	MONITORING WELL RESULTS (mg/l)											WHO DW Guideline (mg/l)	US EPA DW Standard (mg/l)	Typical Limestone Aquifer *WQ (mg/l)
	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-8	MW-9	MW-10	MW-11	MW-12			
LAB RESULTS														
CALCIUM	72	74	NO	78	66	110	80	63	60	170	N	75		75
MAGNESIUM	33	41		53	12	44	46	37	37	22	O	150		10
SODIUM	71	180	S	250	17	280	170	31	47	290		200	200	12
CHLORIDE	26	350	A	430	20	470	360	49	78	410	S	250	250	10
NA/CL RATIO	2.73	0.51	M	0.58	0.85	0.60	0.47	0.63	0.60	0.71	A	-	-	<1.5
ALKALINITY	260	250	P	250	210	310	260	280	270	510	M	-	-	260
**NITRATE	0.24	0.13	L	<0.050	0.073	1.00	0.17	0.069	0.12	0.18	P	10 (as N)	10 (as N)	4
SULFATE	19	23	E	60	13	58	38	33	16	63	L	400	250	8
TDS	340	850	HOLE	1100	290	1300	880	390	430	1300	E	-	500	350
Field Data														
TEMP. (*C)	29.2	29.8	Blocked	33.1	31.7	30.6	31.0	28.9	28.8	25.1		-	-	
pH	7.46	7.71	At 144'	7.51	7.53	7.29	7.48	7.52	7.53	7.44		6.5-8.5	6.5-8.5	7.2
COND. (uS)	569	1430		1930	500	2050	1460	681	742	2150		-	-	550
DTW (m)	51.46	43.71	42.43	35.54	32.93	32.26	34.95	38.10	33.38	47.91				
DOW (m)	152.4	155.4	155.4	155.4	155.4	152.4	155.4	135.00	152.4	155.4	143.2			
TOW ELEV. (m)	56.66	49.34	47.66	40.49	37.90	36.77	39.92	42.90	38.19	53.25	50.24			
WATER(m)(amsl)	5.20	5.63	5.23	4.95	4.97	4.51	4.97	4.80	4.81	5.34				
ODOUR/OTHER										**Very Turbid**				

***Shaded Values = exceedances   *WQ – Water Quality.   NS – Not Sampled.   **Nitrate – As N includes Nitrite if present.   ND – Not Detected   NP – Well Not Pumping**

Table 17: SUMMARY OF ANALYTICAL RESULTS AND FIELD DATA – APRIL 2004

PARAMETER	**MONITORING WELL RESULTS (mg/l)**											**WHO DW Guidelines (mg/l)**	**US EPA DW Standards (mg/l)**	**Typical Limestone Aquifer WQ(mg/l)**
	PW-1	**PW-2**	**HP**	**NB**	**DR-3**	**DR-4**								
LAB RESULTS														
CALCIUM	88	88	98	77	P	100						75		75
MAGNESIUM	14	16	20	11	U	23						150		10
SODIUM	42	43	78	22	M	87						200	200	12
CHLORIDE	52	70	98	31	P	140						250	250	10
NA/CL RATIO	0.81	0.61	0.80	0.71		0.62						-	-	<1.5
ALKALINITY	270	260	310	240	O	330						-	-	260
**NITRATE	2.2	2.1	1.5	1.9	U	1.3						10 (as N)	10 (as N)	4
SULFATE	15	15	30	5.4	T	34						400	250	8
TDS	410	380	560	320		610						-	500	350
Field Data														
TEMP. (*C)	24.6	25.4	26.1	24.5		25.8						-	-	
pH	7.74	7.71	7.44	7.63		7.53						6.5-8.5	6.5-8.5	7.2
COND. (uS)	659	700	900	481		969						-	-	550
DTW (m)	ND	ND	ND	ND	ND	ND								
DOW (m)	86.3	122	67.0	70.1	76.2	55.8								
TOW ELEV. (m)														
WATER(m)(amsl)														

***Shaded Values = exceedances *WQ – Water Quality. NS – Not Sampled. **Nitrate – As N includes Nitrite if present. ND – Not Detected NP – Well Not Pumping.**

Table 18: ANALYTICAL RESULTS-METALS-JANUARY 2004

PARAMETERS	MONITORING POINTS RESULTS (mg/l)											LRL* (mg/l)	WHO DW Stds (mg/l)	US EPA DW Stds. (mg/l)
	Production Well 1	Production Well 2	Buildg 1 Ftn.	Plant Stores Ftn	Great House Well	Great House Tap	WS Tap	BV-Well	BV-Tap	RP Tap	WR Tap			
METALS														
Aluminium	0.24	0.23	0.22	0.23	0.21	No	0.20	0.26	0.24	0.20	0.29	0.1	0.2	None
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.05	0.03
Cadmium	<0.0005	<0.0005	0.00072	<0.0005	<0.0005	Data	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	0.005	0.005
Calcium	91	91	90	89	85		80	97	97	78	43	0.5	75	None
Copper	<0.002	0.0041	0.57	0.0064	<0.002	Sample	0.0097	0.0094	0.16	0.0066	<0.002	0.005	1.0	1.3
Iron	0.047	0.014	0.063	0.014	0.010		0.034	0.18	0.020	0.036	0.012	0.1	0.3	0.3
Lead	<0.005	<0.005	<0.005	<0.005	<0.005	Bottle	<0.005	<0.005	<0.005	<0.005	<0.005	0.002	0.05	0
Magnesium	15	15	15	15	12		9.3	1.4	1.4	15	10	0.1	150	None
Manganese	< 0.005	<0.005	<0.005	0.018	<0.005	Broke	<0.005	<0.005	<0.005	<0.005	0.008	0.005	0.1	0.05
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002	0.001	0.002
Selenium	0.006	<0.005	<0.005	<0.005	<0.005	Spilt	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.01	0.05
Sodium	48	48	48	48	21		7.2	5.8	5.6	48	10	0.5	200	200
Zinc	0.099	<0.020	0.13	2.2	<0.020	Sample	2.1	0.038	0.026	<0.020	<0.020	0.02	5.0	5.0

NOTES
Production Well 1-At well head ***LRL-Laboratory Reporting**
Limit
Production Well 2-At well head
Plant Stores-At Drinking Water Fountain
Buildg 1 Ftn - Building 1 Drinking Water Fountain.
Great House Well - At Well Head.
Great House Tap – Kitchen Tap.
WS Tap - Woodside Drinking Water Fountain (NWC Supply).
BV Well – Breadnut Valley Well – At Well Head.
BV Tap – Breadnut Valley Drinking Water Fountain.
RP Tap – Rocky Point Port Drinking Water Tank-At Tap (Trucked Water).

Table 19: ANALYTICAL RESULTS-NON-METALS AND BACTERIOLOGICAL-JANUARY 2004

PARAMETERS	MONITORING POINTS RESULTS (mg/l)											LRL* (mg/l)	WHO DW Stds. (mg/l)	US EPA DW Stds. (mg/l)
	Production well 1	Production well 2	Buildg 1 Ftn	Plant Stores Ftn	Great House Well	Great House Tap	WS Tap	BV-Well	BV-Tap	RP Tap	WR Tap			
NON-METALS														
Chloride	56	58	58	57	27	27	10	13	12	61	10	1	250	250
Cyanide	0.0033	<0.001	<0.001	<0.001	0.0014	<0.001	0.0012	0.0011	0.0026	0.003	0.0048	0.001	0.1	0.1
Fluoride	0.16	0.13	0.13	<0.10	<0.10	0.14	0.14	<0.10	<0.10	0.12	0.10	0.1	1.5	4
Nitrate*	2.4	2.6	2.7	2.2	2.4	2.4	1.7	1.5	1.5	2.4	0.23	0.05	10	10
Sulphate	22	23	21	22	6.9	6.5	3.5	2.4	2.5	23	39	2	400	250
Total Dissolved Solids (TDS)	430	430	420	430	310	320	270	270	260	390	210	10	1000	500
PH	7.44	7.57	7.77	7.42	7.58	7.78	7.44	7.44	7.45	7.77	8.01	NA	6.5-8.5	6.5-8.5
Temperature	24	24.5	10.5	13.4	25.3	26.1	29.3	30.1	18.8	28.6	25.4	NA	None	None
BACTERIOLOGICAL (MPN/100ml)														
Total Coli form	< 3	< 3	<3	<3	< 3	<3	<3	<3	< 3	<3	< 3	NA	0	0
Faecal Coliform	< 3	< 3	< 3	<3	< 3	<3	<3	< 3	< 3	< 3	< 3	NA	0	0

NOTES
Production Well 1-At well head.
Production Well 2-At well head .
Plant Stores-At Drinking Water Fountain
Buildg 1 Ftn - Building 1 Drinking Water Fountain.
Great House Well - At Well Head.
Great House Tap –Kitchen Tap.
WS Tap - Woodside Drinking Water Fountain (NWC Supply).
BV Well – Breadnut Valley Well – At Well Head.
BV Tap – Breadnut Valley Drinking Water Fountain.
RP Tap – Rocky Point Port Drinking Water Tank-At Tap (Trucked Water).
WR Tap – Waterloo Road Office Kitchen Tap (NWC Supply).

***LRL-Laboratory Reporting Limit**

***Nitrate-Nitrogen**

Table 20: ANALYTICAL RESULTS-PESTICIDES/PCBS-JANUARY 2004

PARAMETERS	MONITORING POINTS RESULTS (ppb)											LRL* (ppb)	WHO DW Stds (ppb)	US EPA DW Stds. (ppb)
	Production well 1	Production well 2	Buildg 1 Ftn	Plant Stores Ftn	Great House Well	Great House Tap	WS Tap	BV-Well	BV-Tap	RP Tap	WR Tap			
PESTICIDES/ PCBs														
gamma-BHC [Lindane]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	3	0.2
Aldrin	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.03	NF
Dieldrin	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.03	NF
4, 4'-DDT	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.3	1	NF
Technical Chlordane	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	0.3	2
Methoxychlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	30	40

*LRL-Laboratory Reporting Limit NF-None Found

Table 21: ANALYTICAL RESULTS-ORGANICS-JANUARY 2004

PARAMETERS	MONITORING POINTS RESULTS (ppb)											LRL* (ppb)	WHO DW Stds. (ppb)	US EPA DW Stds. (ppb)
	Production well 1	Production well 2	Buildg 1 Ftn	Plant Stores Ftn	Great House Well	Great House Tap	WS Tap	BV-Well	BV-Tap	RP Tap	WR Tap			
ORGANICS														
1, 1-Dichloroethane*	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	NF	5
Chloroform*	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	30	100
Benzene*	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	NF	5
1, 2-Dichloroethane*	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	10	NF
2,4,6-Trichlorophenol+	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	10	NF
Pentachlorophenol+	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	50	10	30
Hexachloroethane+	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	NF	NF
Benzo(a)Pyrene+	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	0.01	NF

***Volatile Organic Compounds---+Base Neutral/Acid Compounds:**

NR-Not Reported ***LRL-Laboratory Reporting Limit** **NF-None Found**

3.5.5 Expansion of Plant-Impact on Water Resources

3.5.5.1 Introduction

Among the aims of the efficiency upgrade of the Jamalco bauxite/alumina is to increase the production of alumina. The proposal is for production to be increased from the existing 1.25 million tonnes per year to 2.8 million tonnes per year. Along with this increase in production the following will also increase:

1) Production of bauxite residue which at the current industry rate is on a 1.2:1 ratio with the production of alumina.

2) The proposed RDA # 5 to store the increased bauxite residue

3) Runoff from plant site as more permeable ground is covered by tanks and pavement

4) Wastewater generation including sewage

5) Solid waste from the expanded dining facilities to cater for the increased staff as well as from offices and operational departments.

6) Water use to meet the increased production and the domestic demands from an expanded staff

There is a potentially increased risk to the groundwater resources of the Rio Minho Hydrologic basin with the efficiency upgrade of the plant and the increased production of bauxite residue, liquid and solid wastes, runoff and withdrawal of groundwater.

3.5.5.2 Risks

3.5.5.2.1 Risk from Increased Bauxite Residue Production.

The RDA area to be used for the storage of the bauxite residue is bounded on the west by the Rio Minho, to the east by the dikes of RDA 1 and 2, to the south by the dike of RDA 4 and to the north by the fence between the Old Bowens Road and the recently installed mud thickener. The area is located on a terrace of alluvium deposited by the Rio Minho. The monitoring wells to the west of the proposed RDA site are MW 4, 5 and 6. The lithologic logs for each of these boreholes indicate a thinning of the alluvium to the north.

At MW 4, the most northern of the 3 monitor, wells the alluvium is 6.1 metes thick while at MW 5 and 6 to the south the alluvium is 15.2 metres thick in each borehole. In all 3 boreholes the alluvium consisted of intercalated sand, silt and clay.

The present site preparation has however indicated that there is a limestone high in the northwestern corner and the limestone is exposed at the surface. The highs and lows of the limestone (wavy erosional surface) are shown in the cross sections Figure 21 and Figure 22

The area was classified by the Water Resources Authority as having a high pollution vulnerability because of the karstified nature of the limestone aquifer and the low attenuation capacity of the overlying alluvium. The appearance of the limestone at the surface will significantly increase the risk of contamination of the aquifer. The area therefore needs to be completely sealed, and this is the traditional practice of the project proponents.

The proposed method of disposal is a thickened mud with stacking and drying. Effluent to the clear lake will have to be collected to ensure that this fraction of the effluent that could contaminate the groundwater is removed from the drying areas thus reducing the risk to water resources.

The water quality monitoring programme and the analysis of the data generated has shown that the existing RDAs have not had any significant impact on the quality of water within the aquifer (Section 3.5.4). The sealing and drainage systems utilized in the construction of these RDAs have been such that no significant leakage has occurred to contaminate groundwater.

3.5.5.2.2 Risk from Increased Plant Runoff

The expansion of the plant will mean construction of tanks, bunds around tanks, paved parking and working areas and consolidated driving surfaces. The increase in impermeable area will lead to an increase in the rainfall runoff. The plant at present has a storm water drainage system that collects runoff and transfers it to the storm lake from where it is reused within the plant.

The size of this storm water system will have to be verified for capacity to transport the additional runoff generated. This is critical in light of the variability in climate and weather now being experienced across the Caribbean.

3.5.5.2.3 Risk from Solid and Liquid Wastes

The upgrading of the plant will lead to an increased workforce. This will lead to an increase in the volume of liquid and solid waste generated. The capability of the Sewage Treatment Plant (STP) to adequately handle the waste generated will be most crucial to reducing the risks to water quality and health. The present system is designed to serve 1200 persons. Owing to improvements in efficiency, the permanent workforce is now at 600 persons. Hence the capacity of the waste water treatment system has practicable doubled.

The assessment of water quality is discussed in section 3.5.4 and indicates low nitrate concentrations in the groundwater (Table 16 and Table 18) as well as low bacteria (Table 18: ANALYTICAL RESULTS-METALS-JANUARY 2004). The STP should adequately treat the sewage to minimize the risk of contamination with increasing nitrate and bacterial concentration.

The increased solid waste that will be generated will vary from organic material from canteens, paper waste from offices, ink cartridges from computers and processing waste material that could impact on water quality if disposed of in an inadequately prepared area. The disposal area would have to be prepared against flooding and through flow of water from rainfall runoff. The floodwaters and the through flow could pick up contaminants and transport these to surface water systems and unto groundwater as recharge.

The dumpsite to the east of the plant is located atop a most permeable fault zone. To date the water quality for the monitor wells located along this zone-MW 3 and 11-have not shown any negative impact of their location close to the dumpsite (Table H10). Any future dumpsite would have to be permitted by the National Environment and Planning Agency after investigations to determine suitability in terms of its risk to groundwater quality among others.

3.5.5.2.4 Risk from Increased Withdrawal of Groundwater

The increase in alumina production will require additional water for the process. While no water demand has been given for the expansion it is expected that the requirement would be approximately twice the present usage. Since there is no surface water available in the area the additional water would have to come from the limestone aquifer. This increased withdrawal would be attained through the drilling and equipping of new wells tapping the limestone aquifer.

The impact of additional withdrawal of groundwater could be placed into three scenarios. The first is the depletion of storage with the resultant impact on the existing wells not being able to meet their licensed capacity; the second is the over pumping of the aquifer creating a pumping depression with below sea level pumping leading to increased salinity of the groundwater, and the third is the modification of flow around the CAW due to an increased radius of influence, and the possible contamination of groundwater from waste disposal systems.

There are three (3) most important questions to consider:

1) Is additional groundwater withdrawal necessary?

2) Is there enough water resources available to allow the additional withdrawal?

3) Can the area around the CAW accommodate more wells without affecting existing wells and water quality?

3.5.5.2.4.1 Present Abstraction

The CAW uses water from a number of wells that tap the limestone aquifer. These wells inclued-Production Well 1; Production Well 2 (Hanbury 2R) and Dry River 3. In early 2004 a new well Dry River 5R, to replace the abandoned and sealed Dry River 5 well located in the middle of the proposed bauxite residue disposal area, was drilled and equipped. This well is to be used for the purpose of wetting down of the mud when it becomes dry and could be a dust nuisance. The volumes of water abstracted from the wells and supplied to the plant for the period 1988 to 2004 is shown in Table 22 below.

There is no information on the volume of water reused within the system and taken from the clear and storm lakes.

Table 22: ANNUAL ABSTRACTION FROM WELLS SUPPLYING CAW-1988 TO 2004

Year	No. Of Wells	Total Abstraction (MCM)	Daily Average Abstraction (m^3/day)	Remarks
1988	2	2.14	5863	
1989	2	3.60	9863	
1990	2	3.94	10,795	
1991	2	4.89	13,397	
1992	2	5.23	14,329	
1993	2	3.00	8,219	
1994	2	No data	No data	
1995	2	0.57	3677	Data for 5 months
1996	2	1.33	3644	1 well down for 9 months
1997	2	2.05	5616	
1998	2	1.25	3425	
1999	2	1.60	4383	
2000	2	2.19	6000	
2001	2	1.32	3952	For 11 months
2002	3	1.84	5509	For 11 months
2003	3	1.49	4082	
2004	3	0.24	4000	For 2 months

MCM-million cubic metres. m^3/day-cubic metres per day.

The data indicates that average daily abstraction varied from a low 3425m^3/day in 1998 to a high of 14,329 m^3/day in 1992. The years 1989 to 1993 were the years with the highest usage of water at the CAW. No data was available for 1994. Since 1995 there has been a decline in the volume of water used within the CAW. The average daily abstraction/supply between 1995 and 2003 varied from a low of 3425 m3/day in 1998 to a high of 6000 m3/day in 2000. This has indicated some improvement in the efficiency of water use.

The single largest abstraction from Production well 1 was in January 1993 when the total abstraction was 0.56 MCM or 18,072 m^3/day. The largest abstraction from Production well 2 was reported for January 1992 at 0.33 MCM or 10,688 m^3/d.

If the water use were to be doubled then the **average daily use** on the high side would be approximately 30,000 m^3/day and on the low side 7,000 m^3/day.

3.5.5.2.4.2 Licensed Volumes versus Maximum Abstraction

Jamalco has been allocated water from the limestone aquifer by the Water Resources Authority through a system of licensing. Table 23 below compares the maximum abstraction against the licences allocated to Jamalco for each well.

Table 23: COMPARISON OF MAXIMUM ABSTRACTION FROM WELLS TO CAW VERSUS LICENSED

Name of Well	Licensed Volume (m^3/day)	Maximum Abstraction (m^3/day)	Difference Surplus (Deficit)	Remarks
Production 1	15,264	18,072	(2,808)	Max-1993
Production 2	10,902	10,688	214	Max-1992
Dry River 3	9,815	6,056	3,759	
Dry River 5R	9,815	0.0	9,815	Just equipped
Hanbury 1	8,184	0.0	8,184	Not in use-standby well
Total	53,980	34,816	19,164	

The comparison indicates that the licensed volumes exceed the maximum abstractions between 1988 and 2004 the period of the record. In fact there is a surplus of 19,164 m^3/day. The Dry River 5R well has recently been equipped and the Hanbury 1 well is maintained as a standby and is not pumped. If the more recent abstractions, which are lower than the maximum, were used in the comparison then the surplus would be much higher. Adding the water returned to the plant from the clear and/or storm lakes will further increase the surplus of water for processing.

In addition the use of the wells now leased for agricultural purposes viz. Howards (Block A); Halse Hall (Block B) and Sam Wint 1 will allow for an additional 29,600 m^3/day of water to be available for processing. There would be the need to put in place the transmission line to move the water from these wells to the plant. This is an engineering task that can be easily and successfully implemented.

Based on this analysis there seems to be no need for any additional withdrawal from the limestone aquifer to meet the increase demand for water and therefore the risk to the aquifer from increased withdrawal of water will be eliminated.

3.5.5.2.4.3 Water Availability

If there is a need for additional water, are the resources available? The water resources assessment of the Rio Miho basin shows that the reliable yield assessed is 439 MCM/yr while the present production from the aquifer is approximately 335 MCM/yr. This leaves 104 MCM/yr for allocation and further development.

The licensed volume for the 26 wells within the defined area around the CAW is 226,762 m^3/day. This is 18.8 % of the total safe yield of the basin and 24.7 % of the estimated total production in the basin.

If the assumption is made that the expansion of the plant will require additional water (twice the present abstraction/use) and, using the high end of the historical abstraction of 30,000 m^3/day as the volume that will be required, the total additional annual demand will be 11 MCM. On the macro-scale (in terms of the basin) this would seem to be available from the unused resources that could be allocated.

However the assessment of water resources executed for the National Water Resources Development Master Plan (WRDMP) in 1990 was based on the data available at that time. Several assessments of aquifers and sub-basins competed since 1990 have yielded estimates of availability of resources much lower than that of 1990. The inventories of demand and availability are now being done for the upgrade of the WRDMP and it is hoped that these new assessments will become available by the end of 2004. If the new assessments indicate that there is lower resource availability then it may not be possible to obtain the additional resources.

The priority in the allocation of water resources is guided by Section 31 of the Water Resources Act 1995 which allows the Water Resources Authority to reserve water to satisfy the requirements of public water. In an area where there is a shortage of water the requirement of public domestic water supplies must first be satisfied before any other allocation is made. The satisfaction of industrial demand would have to be done once all domestic demands have been fulfilled. In addition, if after the allocation is made to meet a demand other than that of the public for water, a problem of availability develops then the Authority can recommend a reduction in the licensed volumes granted to ensure that public demand is maintained.

3.5.5.2.4.4 Wellfield Design

While the water may be available, the ability to harness the resources safely without compromising quality and the yields of other wells tapping the same aquifer is most crucial. The design of the Wellfield to minimize the interference effects between wells and reduce the overall drawdown of the groundwater table is a major factor. The high salinity levels recorded around the Hayes Common-Raymonds area is due to the interference effects between wells and the resulting increased drawdown. The density of the Hayes Common-Raymonds Wellfield is shown in Figure 21.

Around the CAW the space for new wells is limited to that small area west of the RDAs between Webbers Gully to the north, the Rio Minho to the west and the southern fence at Dry River. To the east of the RDAs there is the Dry River 3, Dry River 5R and Hayes Public wells all in a north south line. Where as:

- The Dry River 4 well is to the south of the RDAs.
- Production wells 1 and 2, Hanbury 1 and New Bowens (NWC) are all within the vicinity (east and north) of the plant site.
- The Howards, Halse Hall, Sam Wint and Great House wells are all to the northwest.

The locations of any new wells will be selected to ensure that:

1 Well yields are high with minimal drawdown (High specific capacity)

2 Water quality is high and will remain so i.e. no changes from the pumping of these wells

3 There is no interference with existing wells

4 Transmission distance is kept to a minimum

5 Wells are not at a risk of flooding

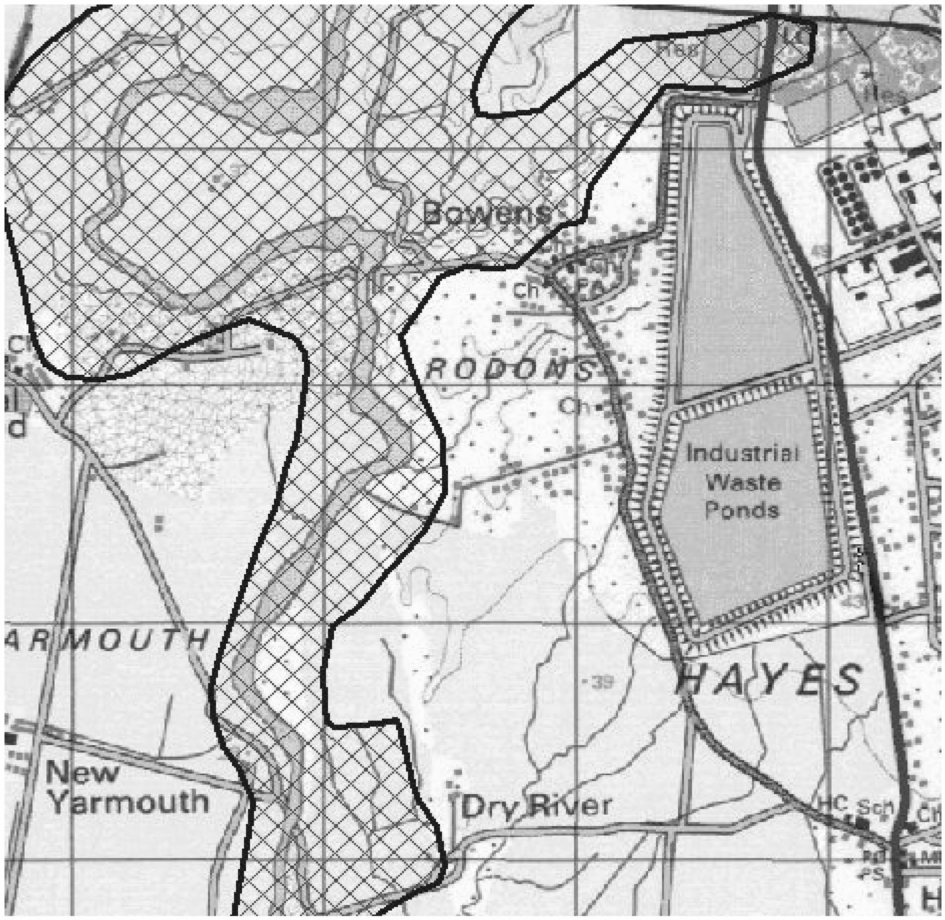
The risk to the aquifer and of course existing systems will be low if the above items are used as guidelines in the well site selection and evaluation process.

3.5.6 Flood Risk

The Rio Minho over geologic time deposited the alluvium atop the limestone formation. As the river meandered across the plains there was erosion and deposition of alluvial material to shape the present landforms. At Halse Hall the CAW and the RDAs are located on one of two terraces formed by the river. The first terrace is the highest and the present and proposed RDAs are located atop these terraces. The second terrace is the lower of the two and was recently mined by Jamalco for material to raise the dike on RDA 4. This terrace is normally flooded when the Rio Minho is in spate. However there is a need to assess the flood boundaries for different rainfall events; to determine within which boundary the RDAs are and will be located and to determine if the present and future RDAs are at risk from flooding and a total washout. The flood plain mapping and modeling that is required to enable such a determination is beyond the scope of this assessment.

In 1986 the rainfall event that led to the wide scale flooding of Southern Clarendon was reportedly a 100-year event. The mapped flood boundaries for the area around the CAW are shown on Figure 32 below. The mapping was done after the event and once the flooding had receded hence there may be some inaccuracy in the boundaries.

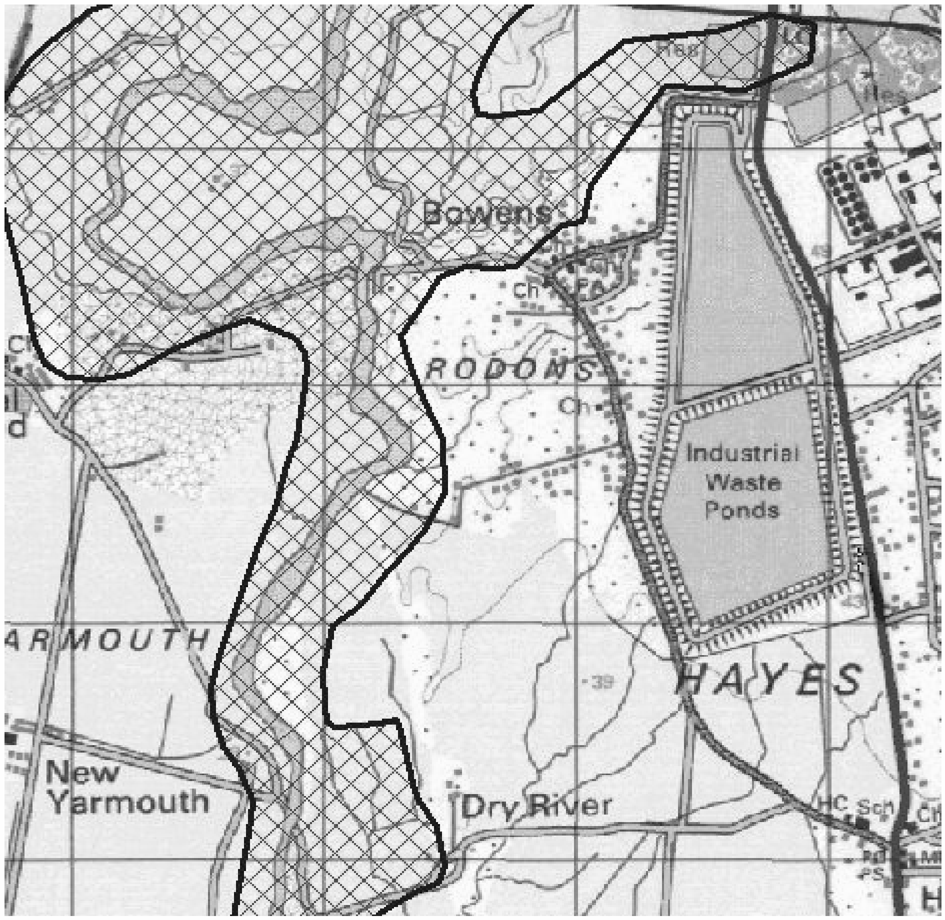
Figure 32: Flood Boundaries around the CAW for the 1986 Flood Events



As can be seen, the flood boundaries for the Webbers Gully extends across the clear lake and up into New Bowens. The Rio Minho flood boundaries follow the contour of the terraces. It is not known if the flood level was above the second terrace. RDAs 3 and 4 were not yet constructed at the time of flooding. No damage was reported to RDAs 1 and 2.

The impact of climate and weather variability could yield a higher flood event where the flood boundaries for a lesser or similar rainfall event could be higher and would cause damage to the RDAs.

Figure 32: FLOOD BOUNDARIES AROUND THE CAW FOR THE 1986 FLOOD EVENTS



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The impact of climate and weather variability could yield a higher flood event where the flood boundaries for a lesser or similar rainfall event could be higher and would cause damage to the RDAs.

Flooding of the RDAs would have a significant and possible catastrophic impact on the water quality within the basin. The surface water system would be the first to become contaminated followed by the groundwater system as the contaminated surface water recharges the aquifers-limestone and alluvium. The plant would have to cease operations, as the loss of the RDAs would mean that there would be no bauxite residue storage area.

The mapping of the flood boundaries would allow for the design of structures to prevent the floodwaters from reaching the RDAs. One possible structure could consist of embankments of river material protected by gabions to prevent erosion of the embankments as was done in Webbers Gully after the straightening of the gully. Non-structural methods to prevent flooding could also be implemented. These could include the regular cleaning of the river to remove material deposited and so maintain the gradient and freeboard of the river.

It should be noted that the location of the monitor wells, particularly MW 5 and 6, were selected to prevent flooding and compromise of the monitoring system as well as loss of the monitoring point.

It is therefore recommended that Jamalco employ the services of a Hydrologist with experience in modeling and use of the HEC-RAS software to determine the flood levels for various events. The mitigation effect of different structural and non-structural methods to reduce the impact of the flooding could also be modeled to determine the most optimal solution.

3.5.7 Early Warning/Monitoring System

The ability to determine at a very early stage any impact that the bauxite/alumina operations has on the groundwater around the CAW will be necessary and critical to reducing the risk to groundwater quality. While the existing monitor wells were located, designed and constructed to allow for this determination, over time it has been noted that improvements can be made. However at the time of the location of the monitor wells there was not as much information on the hydrogeology of the area as there is now. The drilling, monitoring and interpretation of the analytical data has led to a greater understanding of the hydrogeology and the water resources around the CAW. The loss of two monitor wells however, has left gaps within the system that need to be closed.

The monitor wells as designed, in the absence of any data at that time, monitors water quality from one zone only and that zone is deep within the aquifer. The screens were placed at depths based on the theory that the denser caustic effluent would sink to the base of the water column or the aquifer bottom. However because of the depth of the monitor wells, a few enter the mixing zone above the freshwater/seawater interface and there is no detection of high sodium concentration without the corresponding high chloride concentration; no detection of pH above 8.5 units and no detection of high alkalinity.

An assessment of the system to date would show that it has performed well and has provided new information to enable a more informed understanding of the water resources of the area. However improvements to the system can and should be made.

It is recommended that the following be implemented to upgrade the monitoring system and analytical systems to ensure that impacts of bauxite/alumina operations on water quality can be easily and quickly detected to allow mitigative action to be taken.

1 Replace monitor wells 7 and 12 to close two gaps.

2 Based on the expansion of the CAW locate and construct new monitor wells to enable improved coverage around the CAW.

3 Install multi-level piezometers to enable determination of zone contributing contaminant, if any, to the well

4 Dedicated sampling pumps to be installed in each well to prevent cross contamination

5 Analyze for heavy metals (suite of 16) for each well at least once per year. Analyses to be done overseas at USEPA and NELAP certified laboratory.

6 Jamalco to improve sampling procedures and upgrade laboratory to ensure QA/QC of analyses

7 Priority to be given in laboratory to analyses of samples to ensure completion within the maximum holding time.

3.5.8 Conclusions

The expansion of the CAW could increase the risk to water resources of the following;

1 Water quality degradation-resulting from possible leakage from the expanded Refuse Disposal Areas (RDAs) and increased withdrawal of groundwater from the limestone aquifer to meet the increased demand for water. The former could lead to contamination by caustic effluent while the latter could lead to increased salinization of groundwater as a result of over pumping and the movement inland of seawater.

2 Dewatering of the aquifer and the sustainability of aquifer yield

3 Flooding of areas from increased plant runoff

4 Damage to the RDAs caused by flooding of the areas from the Rio Minho River as a result of significant rainfall events in the upper watershed.

The risk to water quality from caustic effluent can be eliminated if the construction of the RDAs is executed in accordance with engineering standards, as have the previous RDAs (Mud Lake 1-4). As shown through the information generated by the monitoring programmes executed by Jamalco and by the consultant on behalf of Jamalco have shown no significant change in water quality with time and previously expanded operations. The concentrations of certain parameters indicate the expanse of the seawater intrusion within the limestone aquifer due to over development for agriculture in the pre-1961 period when there was no management of water resources in the basin.

The assessment of water resources also indicates that meeting the increased demand may not result in an increase in withdrawal from the aquifer. Improved water use efficiency and the bringing into the industrial process wells formerly used for agricultural purposes, can assist in meeting the water demand. If there is to be increased withdrawal there is sufficient resources to meet the demand. The main concern would be the location of the wells to minimize interference effects and reduce drawdown while maintaining water quality.

The risk of flooding from plant runoff can be removed by improving the plant storm water collection and storage systems. The operation of these systems must be such that the maximum freeboard is available in the systems before the rainy season to allow retention of runoff and so prevent flooding and possible contamination of water resources.

The risk to the RDAs from the floodwaters of the Rio Minho after a significant rainfall event is high and a most critical risk. The flood boundaries for the Rio Minho in the vicinity of the CAW should be derived and where necessary structures put in place to prevent erosion of the RDAs and contamination of water resources. Protection for the anti-flooding structures should also be placed where necessary.

It is not expected that the increased staffing and resultant increase in sewage and solid waste would be a significant risk to water quality. Existing disposal systems for solid and liquid wastes are in operation and work very effectively. No contamination from solid or liquid wastes has been detected through the monitoring programmes. Sewage treatment capacity will exceed the requirements for the post-upgrade complement of staff. Temporary arrangements with chemical toilets will be made during the construction phase.

The ability of the monitoring network to detect at an early stage the impacts on water resources from the expansion of the CAW will be very critical. The areal coverage of the network (covering all the gaps); the effectiveness of the network (is it providing the data and information to assess the impacts if any); the frequency of monitoring and the parameters monitored need to be assessed and action implemented to deal with any shortcomings. Recommendations for improvement are set out in section 3.5.7 above.

3.6 Wildlife and Vegetation

3.6.1 Introduction

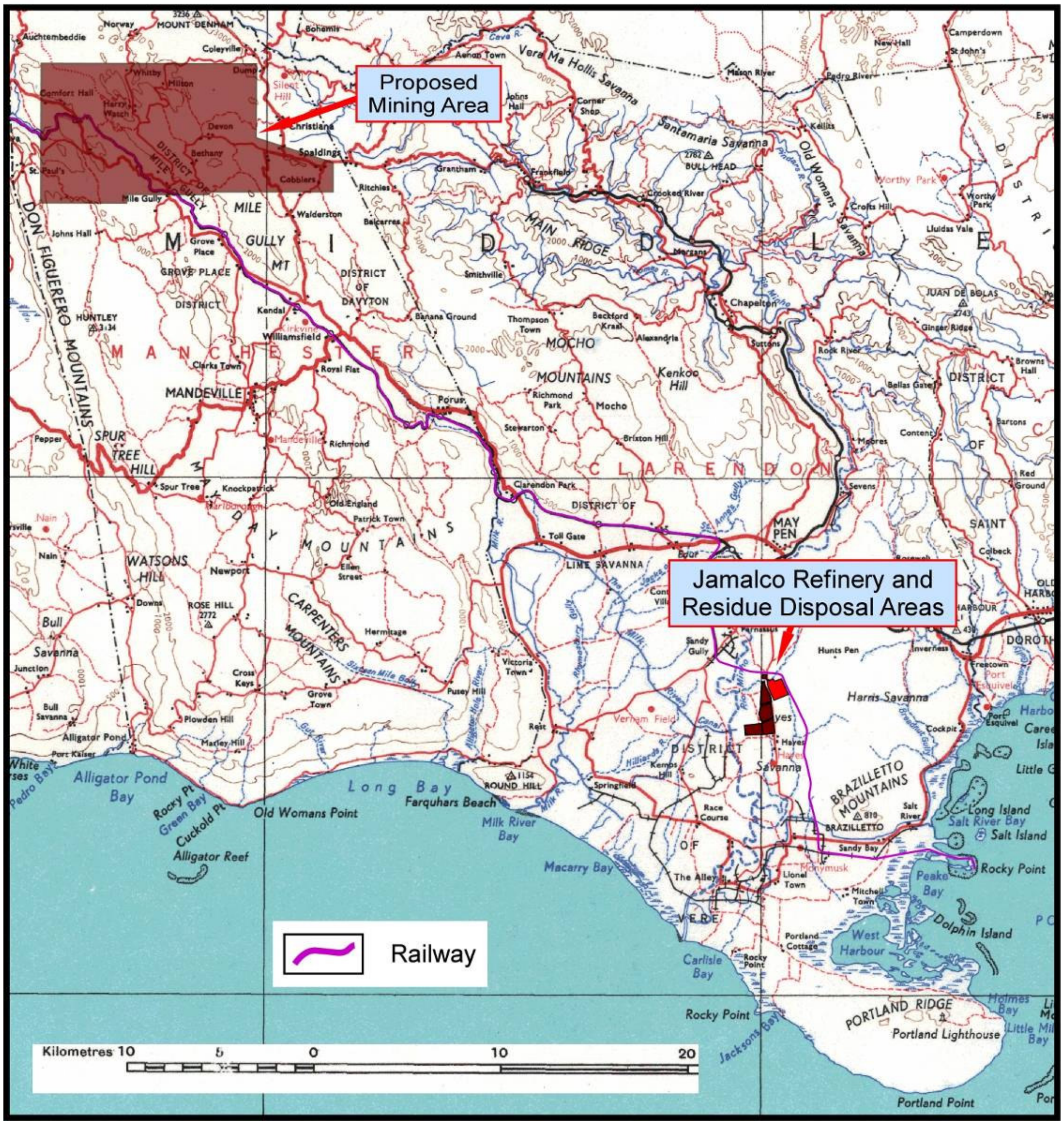
In support of the efficiency upgrade of the Jamalco refinery at Halse Hall in Clarendon, expansion of mining in an area situated in North Manchester is proposed. The spatial relation between the proposed mining area, existing alumina refinery and residue disposal site, the port and the transportation corridors between the various operating nodes are shown in Figure 33.

Bauxitic soils are infertile and do not support mature vegetation that could typically be found on other soil types and under the influence of the prevailing climatic conditions. Tree species, are found on the limestone outcrops with mainly grasses and small shrubs in areas overlying the bauxite in the depressions Bauxite mining operations are normally confined to the depressions interspersed with these hillocks and this is reflected in the profile of mined areas.

The proposed mode of transport of bauxite ore from the new mining site to the plant is by rail. The rail line is an existing one owned by the Jamaica Railway Corporation, which has been out of operation for some time now and therefore will require refurbishing. Rail transport is the mode currently used to move material from the existing mines of the Manchester plateau from a rail head at St Jago to the Alumina Plant. Transport of material between the refinery and the port, Rocky Point in Clarendon is also by rail.

There will be increases in the volume of bauxite moved from mine to plant and in the amount of alumina moved from plant to port. As mentioned in the project description, there will be increase in the flow of materials between the port and the plant. The proposed improvements in the ports facilities will not impact the terrestrial ecosystem.

Figure 33: Locality of the Proposed Project Site



3.6.2 Terms of Reference

In keeping with the agreed terms of reference, this section covers:

- The forestry and wetlands, estuaries and coastal zones, flora and fauna and endangered or endemic species that may be impacted by this project.

- It presents the species diversity and ecological relationships among them, identifies special or protected areas and the potential impacts on these and,

- Records the extent and potential impact of the upgraded facilities and mining

3.6.3 Methodology

The ecological assessment was conducted primarily through qualitative methods supported by literature research. The literature review was based on a series of relatively current studies which employed the use of quantitative methods for several areas in the sphere of influence of the project sites. Methods employed included the following:

- Aerial photography and land use classification mapping to identify plant species distribution and classification.
- Ground- truthing to confirm land use classification and vegetation type and distribution
- Plant collection and plant identification through the aid of a recognized taxonomist and herbarium
- Literature research of information related to the geographical influence of the proposed project to generate species inventories .
- Animal identification through field guides, photography, vocalization, tracks, fecal deposits, burrows among others.

3.6.4 Ecological Context

The vegetation types noted in the study area range from wet limestone forests to coastal vegetation, featuring extensive areas of mangroves and dry xerophytic vegetation.

This gradation of vegetation types is influenced by elevation, temperature, degree of rainfall and soil types. The coastal areas are exposed to harsher conditions due to water unavailability in saline areas, where plants require special adaptations to manage physiological drought to more inland areas where cooler temperatures and frequent rainfall have influenced the evolution of hydrophillic species.

3.6.4.1 National Biological diversity – International and National levels

A diversity in habitats has clearly led to Jamaica being rated fifth highest in endemic plants of any island, worldwide. Based on information through the National Strategy and Action Plan on Biological Diversity in Jamaica- 2003, of the 3,304 known vascular species to occur in the country at least 28% are endemic.

Table 24-FLORA DIVERSITY[iii]

Terrestrial flora	# of indigenous species	# of endemic species	% endemicity
Bromeliads	60	22	36.7
Orchids	230	60	26
Ferns	579	67	11.5
Cacti	20	10	50
Palms	10	7	70
Grasses	~200	1	0.5

Faunal species similarly have high levels of endemicity with land birds showing 45% and amphibians and reptiles showing a 100% and 76% , respectively

Table 25- FAUNA DIVERSITY[iii]

Terrestrial fauna	# of indigenous species	# of endemic species	% endemicity
Land snails	514	505	98.2
Grapsid crabs	9	9	100
Jumping spiders	26	20	76.9
Fireflies	48	45	93.8
Butterflies	133	20	15
Ants	59	6	10.3
Amphibians	22	22	100
Reptiles	43	33	76.7
Shore & Seabirds	39	1	2.6
Land birds	67	30	44.8
Bats	21	2	9.5
Other mammals	2	2	100

In order to protect this diversity, the Government, through the Forestry Department, has entered into an arrangement with Jamalco, guided by a 'no-net-loss' policy where the two organizations will work to compensate for the loss of forest cover due to mining operations. This will see the establishment of new forests on selected reclaimed bauxite mined out areas as well as the protection and preservation of existing forests. The full text of the MOU is presented in APPENDIX III

3.6.5 Findings

3.6.5.1 Description of Vegetation types

At least four distinct vegetation types were identified in the project area covering the study area;

- Wet limestone vegetation (various degrees of disturbance)
- Agricultural and pastureland
- Thorn scrub
- Coastal vegetation and associated mangal forest

3.6.5.1.1 Wet limestone forest (Ruinate)

The vegetation found in the areas of Mile Gully, Christiana, Colleville etc was composed primarily of Wet Limestone Forest vegetation interspersed with hillside cultivation and pastureland.

In forested areas trees were thin boled (basal diameter ranged from 6 to 72 cm) and branched high off the ground, perhaps a result of competition for light. The canopy was shallow but continuous. The understorey was quite open with low light penetration and primarily had saplings of the larger species. Epiphytes and climbers were well represented.

Leaf litter was high and, based on the leaf structure decomposition rates appeared slow. Soil was shallow and dark in colour indicating high organic matter. The substrate was fragmented limestone rock. Fungi, particularly Bracket fungi were common here and seem to be responsible for decomposition of plant material.

Figure 34: TYPICAL VEGETATION RECORDED IN THE PROPOSED MINING AREA - WET LIMESTONE RUINATE

For convenience, two ecological zones were demarcated in the mining area: "Wet Limestone Ruinate" at the higher elevations and "Wet Limestone Lower Region". A listing of the species, typical of these two areas is presented in Table 26 and Table 27 respectively.

Table 26: WET LIMESTONE (RUINATE)

Family	Scientific Name	Common Name	Habit	Status	Area Located
Anacardiaceae	*Mangifera indica*	Mango	Tree up to 15m	Common cultivated	Pasture, ruinate
Araliaceae	*Dendropanax arboreus*	Angelica Tree	Tree 3-16m	Common in damp	Natural vegetation
Asteraceae	*Eupatorium odoratums*	Jack-in-the bush	Erect or scrambling	Common weed	Pasture, Ruinate
Bignoniaceae	*Spathodia campanulata*	African Tulip tree	Tree up to 16m	Common	Orchard
Bombaceae	*Ceiba pentandra*	Silk Cotton Tree	Tree 10-40m	Occasional, perhaps	Ruinate Forest
Boraginaceae	*Bourreria sp.*	***	Shrub	Common	Ruinate

Table 26: WET LIMESTONE (RUINATE) - *CONTINUED*

Bromiliaceae	*Tillandsia sp.*	Bromeliad	Epiphyte	Common	Orchard, Ruinate (on
Caesalpiniaceae	*Haemotoxylum campechianum*	Logwood	Gnarled Tree up to	Common	Ruinate
Caesalpiniaceae	*Cassia sp.*	***	Shrub	Common	Ruinate, Pasture
Compositae	*Bidens cynapiifolia*	Spanish Needle	Herb, 15-20cm	Common	Pasture, Ruinate
Lauraceae	*Nectandra antillana*	Long-leafed Sweetwood	Tree to 15m or more	Common	Pasture
Malvaceae	*Hibiscus elatus*	Blue Mahoe	Tree up to 25m	Common, often	Pasture
Mimosaceae	*Samanea saman*	Guango	Tree up to 20m	Common	Ruinate, Orchard
Moraceae	*Castilla elastica*	Central American	Tree up to 20m	Common	Ruinate, Orchard
Myrtaceae	*Psidium guajava*	Guava	Cultivated Tree or	Common on site	Orchard
Nyctaginaceae	*Pisonia aculeata*	Cockspur	Shrub up to 6m	Common	Ruinate
Papaveraceae	*Bocconia frutescens*	John Crow Bush	Shrub 2-3m; Tree 5m	Frequent in woodlands	Ruinate
Papilionaceae	*Gliricidia sepium*	Quick stick	Tree up to 6m	Common	Orchard
Poaceae	*Axonopus compressus*	Carpet Grass	Perennial grass	Common weed	Orchard, Pasture
Rutaceae	*Citrus sp. (C. □aradise & C..*	Ugli	Cultivated Tree	Occasional on site	Orchard
Rutaceae	*Citrusauranthum*	Sour Orange	Cultivated Tree	Common on site	Orchard
Rutaceae	*Citrus sinensis*	Sweet Orange	Cultivated Tree	Common on site	Orchard
Rutaceae	*Citrus reticulata*	Tangerine	Cultivated Tree	Occasional on site	Orchard
Rutaceae	*Citrus sp. (Citrus sinensis & Citrus*	Ortanique	Cultivated Tree	Occasional on site	Orchard
Sapindaceae	*Cupania glabra*	Wild Ackee	Tree up to 12m	Widely scattered	Forest
Sapindaceae	*Matayba apetala*	Coby Wood	Tree 5-10m	Widely distributed	Forest

Table 26: WET LIMESTONE (RUINATE) - *CONTINUED*

Urticaceae	*Pilea sp.*	***	Shrub	Common	Forest
Verbenaceae	*Lantana camara*	White Sage	Climbing aromatic	Common in pasture	Pasture
Species present - 27					

Families represented -22
Endemics –none

Table 27: WET LIME STONE LOWER REGION

FAMILY	SPECIES	COMMON NAMES	STATUS	HABIT
Agavaceae	*Agaves sobolifera*	Maypole	Common	Shrubby plant
Anacardiaceae	*Mangifera indica*	Mango	Common	Tree up to
Bignoniaceae	*Enallagma latifolia*	Gourd tree	Common	Tree up to 5m
Boraginaceae	*Ehretia tinifolia*	Bastard Cherry	Common	Tree 6 - 15m
Bromeliaceae	*Tillandsia sp.*	Bromeliads	Common	Epiphyte
Burseraceae	*Bursera simaruba*	Red birch	Common	Tree up to 25m
Cactaceae	*Hylocercus triangularis*	Cactus, climbing	Endemic-common	Climber/creeper*
Caesapiniaceae	*Haemotoxylum campechianum*	Logwood	Common	Tree up to 10m
Caesapiniaceae	*Delonix regia*	Poinciana	Common	Tree, 5 -15m
Euphorbiaceae	*Ricinus communis*	Castor Oil Plant	Common	Short-lived shrub/small tree
Gramineae	*Bambusa vulgaris*	Bamboo	Common	Arborescent up to 10m
Mimosaceae	*Albizia lebbeck*	Woman's tongue	Common	Tree up to 20m
Mimosaceae	*Samanea saman*	Guango	Common	Tree up to 16m
Moraceae	*Cecropia peltata*	Trumpet tree	Common	Tree up to 20m
Musaceae	*Musa sp.*	Banana	Common	Tree
Palmae	*Thrinax parviflora*	Bull Thatch	Endemic-common	Tree
Rhamnaceae	*Ziziphus mauritiana*	Byrie/Coolie plum	Common	Tree up to 15m
Sapindaceae	*Melicoccus bijugatus*	Guinep	Common	Tree deciduous 6 - 18m

Species -18
Families represented -16
Endemics-2

Twenty- two families representing twenty seven species of higher plants were found in the "Wet Limestone Ruinate" zone. Emerging tree species noted included African Tulip, Silk Cotton, Angelica and Guango. None of these are considered rare or endangered species and none are endemic. The general area is characterized by the appearance of cultivated agricultural tree species interspersed with the non – agricultural tree species. Among the crop species were fruit trees such as Orange, Mango and Guava. A few epiphytic specimens were noted.

Figure 35: EPIPHYTIC SPECIMEN ON LARGE TREE SPECIES

The vegetation in the Lower Region of the mining area is typical of that to be expected in drier areas and could be indicative of more freely draining soils. Of the sixteen families found, two are common endemics, Bull Thatch and Climbing Cactus. Eighteen species were identified. Anthropogenic intrusion is evidenced by the presence of species such as banana (*Musa sp*), Bastard Cherry (*Erhritia tinnifolia*) and Coolie Plum (*Ziziphus mauritiana*).

Summary

Elevation and human influence impacted on the species composition in these areas. Within the more remote and higher elevations at least twenty-seven species were recorded. However, no endemics were recorded. In the lower elevations , at least eighteen species were recorded with two endemics noted.

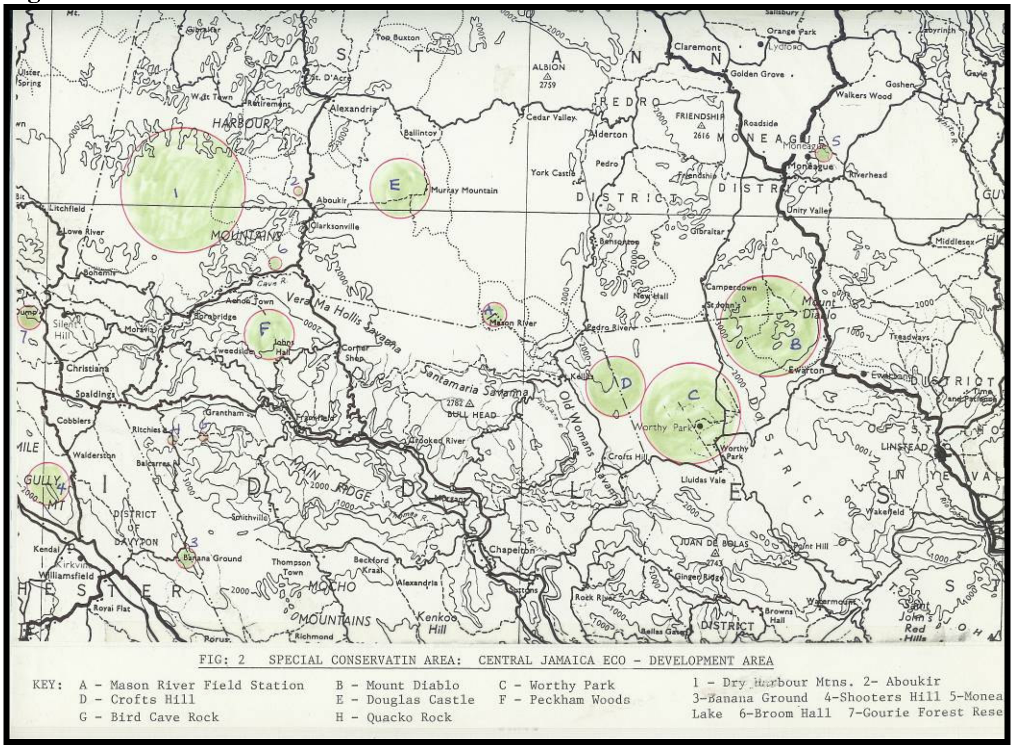
3.6.5.1.2 Agricultural Crop Species

Anthropogenic influences were particularly strong in the areas of Mile Gully, Devon, and Bethany. Extensive farm plots in the area primarily featured yam *(Diosocea sp),* but other crops included corn (*Zea Mays*), sweet potato (*Ipomoea batatas*) and cassava (*Manihot esculenta*). In areas visited these farming areas in combination with buildings and recreational areas, to a great extent, replaced the natural vegetation of the valley floor .

3.6.5.2 Other Important Ecological Areas

In close proximity to the proposed mining area are two areas of ecological importance; Bird Cage Rock and Quaco Rock. Earlier studies revealed a high level of endemicity of species within these two areas. Bird Cave Rock showed potentially 14 plant families existing in the area accounting for 46 species. Of this number at least13 were endemic. For Quaco Rock, 31 families were noted accounting for 62 species. Endemicity was at 62.9%. These areas speak to the potential for high biodiversity levels in the general area but indicate more exceptional habitats rather than representative ones. Care needs to be exercised to mitigate indirect impacts from bauxite mining as well as anthropogenic intrusion through relocation of human settlements.

Figure 36- LOCATION OF IMPORTANT ECOLOGICAL AREAS



3.6.5.3 Railway Route Mine to Plant

Transport of ore from the mining area to the plant will traverse a number of communities and several ecological zones moving from the wetter limestone forest type vegetation to thorn scrub on the plains. A recent study by Conrad Douglas and Associates (1997) provides details on the vegetation typical of some of these communities. For ease of reference, the relevant sections of this study dealing with “The Biological Environment” are presented below.

a) Wet Limestone forest

The wet limestone forest typically has a uniform canopy of 15 - 18m (50 - 60 ft) but emergent trees may be as high as 30 m. Canopy depth is not wide being formed by thin boled trees (0.30.6m) with wide spreading crowns. Naturalized species included Red Birch, made conspicuous by its red, flaky bark and the Trumpet tree.

The subcanopy has an average height of 12 m (40 ft) and is very dense. The shrub and field layers were sparser and merge in some areas. The herb or ground layer is not well represented due to the influences of substrate and/or availability of sunlight (shading from taller species).

The moist, cool micro-conditions favour climbers such as ariods and epiphytes such as *Tillandsia.* Only the latter was observed but the hanging roots of the former added to the thickness of the sub canopy layer.

Topographic variations exerts a major influence on physiognomyl of the vegetation. In the valley regions accumulation of soils, leaf litter contributions and percolation can induce changes, supporting larger and more robust individuals and may have a higher concentration of epiphytic plants.

<u>b)Dry limestone Forest</u>

This type was obvious in the hills immediately west of the proposed railhead site, and effectively starts at the boundary between plains and the rocky limestone of the contiguous hills. Physiognomy was essentially reflective of typical dry limestone forests. However at the lower elevations (along access roads and paths) the presence of uncharacteristic species such as wild cerasee *(Momordica charantia)* confirmed interference by human activity.

Canopy height of the vegetation was estimated to be between 5 - 15m (15 - 45 ft). Plants were very thin boled, with branched rooting systems to gain anchorage on the rocky substrate. Leaf litter was evident but in the early stages of decomposition. Termite mounds were also noted. Termites act as an important nutrient recycler by digesting cellulose of dead or fallen trees.

Stratification was not distinct in forming upper, middle or lower canopies. Though the canopy was continuous, it was not deep. The dominant species was *Thrinax parviflora* (Bull thatch) which grew in obvious clusters. *Simaruba bursei* (Red Birch) was the dominant emergent tree, prominent for its burnt red, flaky bark. Its prevalence is probably due to fire resistance and unsuitability for lumber or charcoal. Specimens of *Agave soblifera* (Maypole) with their bright yellow inflorescence were also readily identifiable.

Climbing, scrambling and epipihytic plants were represented by climbing cacti and the common orchid, *Broughtonia sanguinea.* No rare or endemic species were identified.

Increasing altitude (cooler conditions), and increasing distance west on the Manchester Plateau (higher rainfall), result in an increase in species wl1ich prefer wetter environments such as mosses and bromeliads.

Field observations confirm that plant diversity was lower in the environs of the railhead than was observed in the hillslopes above Harmons Valley, and was not stratified and as complex as the hillside vegetation.

At the proposed railhead and storage area species diversity was low with two species dominating the area, a stoloniferous grass resembling Carpet grass and Wild poponax. The grass provided 100% coverage, leaving bare areas only in places with obvious disturbances

One coal kiln was observed in the environs of the railhead indicating that local forest species were being harvested for charcoal production. Others were reported.

c)Thorn savannha

The vegetation here is generally exposed to dry and hot conditions and it spanned from the railhead! storage area through the entire length or pathway of the proposed railway.

Succulent plant parts, mircrophyllous leafs, compound leaves and thick cuticles were all adaptations to the dry hot environment which are geared towards reducing excessive water loss.

Wild poponax had an even distribution with specimens having an average height of 3 m (9ft). The plants were highly branched with deep canopies, accounting for an estimated 60% of the plants height. However, the plants did not form a continuous canopy. A herb or sub-canopy was not represented in the savanna area.

At Spring Plain (Leg I) the species composition comprised almost pure stands of Logwood. This community may be the result of previous economic cultivation of the species (use in the production of dyes). Other conspicuous tree species included

Poinciana and Guango.

Historically introduced pasture grasses are found in the area. These include include Guinea grass *(Panicum maximum)* and species from the genus *Andropogon.*

d) Aquatic (Riverine) vegetation

At least three water ways cut through or run close to the proposed railway corridor, the Milk River, Baldwin gully and the Rhymesbury gully. These waterways contribute significantly to changes in the otherwise xerophytic vegetation of the Thorn savannha. Species, which prefer wetter conditions, thrive in proximity to these waterways.

There is considerably more biodiversity in the environs of these waterways. Observed communities included Cotton tree, Guinep, Mangoes, Gourd tree, Bamboo, Water grass and Guango.

The Baldwin Gully had the most developed vegetation with a closed canopy over the water, creating a dim and cool environment. Canopy height was an estimated 10m with vegetation forming a narrow belt about 16 m wide along the gully.

3.6.5.4 Residue Disposal Area

A new Residue Disposal Area (RDA), adjoining the existing RDA 4 will be constructed. The Rio Minho runs nearby.

Figure 37: TYPICAL STANDS OF WILD POPONAX FOUND ON AND AROUND RDA

The ecology of this site and the areas along the railway leading to the alumina plant reflects plant species exposed to dry and hot conditions which may be generally described as Thorny scrub. Many of the water conservation measures employed by species in the coastal areas, described below, were noted here. The dominant species was Wild poponax (*Acacia tortusa*) which had an even distribution. Specimens were found to be of an average height of 3 m (9ft). The plants were highly branched with deep canopies, accounting for an estimated 60% of the plants height. However, the plants did not form a continuous canopy. A herb or sub-canopy was not represented in the scrub area. However, Seymour grass (*Andropogon pertusus*) was quite common. The species list is presented in Table 28 below.

Table 28: Thorn Scrub

Family Name	Scientific Name	Common Name	Status/Rank	Habit
Amaranthaceae	*Achyranthes indicia*	Devil's horse whip	Widespread	Annual herb
amaranthaceae	*Gomphrena decumbens*	None	Common	Herb
Anacardiaceae	*Mangifera indicia*	Mango	Cultivated/Naturalized	Tree (5-10m)
Anacardiaceae	*Anacardium occidantale*	Cashew	Cultivated	Tree (4-8m)
Asclepiadaceae	*Calotropis procera*	Dumb cotton	Widespread	Shrub/Tree (4-6m)
Boraginaceae	*Ehertia tinifolia*	Bastard cherry	Fairly common	Tree (6-15m)
Cactaceae	*Harrisia gracilis*	Torchwood dildo	Common	Shrubby cactus (2-6m)
Caesalpiniaceae	*Haemotoxylum campechianum*	Logwood	Common/Naturalized	Tree (10m)
Commelinaceae	*Commelina diffusa*	Water grass	Widespread	Weed
Compositae	*Eupatorium spp*	None		Usually a Shrub
Euphobiaceae	*Jatropha gossypiifolia*	Belly-ache Bush/Cassada Marble	Common	Shrub (60-120cm)
Fabaceae	*Crotalaria retusa*	Rattle weed	Common	Shrubby herb (1m)
Malvaceae	*Sida acuta*	Broom weed	Common	Under shrub
Mimosaceae	*Leucaena leucocephala*	Lead Tree	Widespread	Shrub/Tree (3-6m)
Mimosaceae	*Mimosa pudica*	Shame-a-Lady/Shame weed	Widespread	Weed (30-100cm)
Mimosaceae	*Samanea saman*	Guan go	Common/Naturalized	Tree (16m)
Mimosaceae	*Acacia tortusa*	Wild poponax	Common	Shrub/Tree (3-5m)
Nyctaginaceae	*Pisonia aculeate*	Cockspur/Wait-a-bit/Fingrigo	Same	Shrub (6m)
Orcidaceae	*Broughtonia sanguine a*	Orchid	Common	Epiphyte
Poaceae	*Andropogon pertusus*	Seymour grass	Widespread	Grass, stoloniferious
Poaceae	*Axon opus compressus*	Carpet grass	Widespread	Grass, stoloiferous
Sapindaceae	*Blighia sapida*	Ackee	Same	Tree (8-15m)
	None	Callaloo	Cultivated	Shrub

The Rio Minho River runs through a section of the study area. Vegetation flanking the river showed a marked difference to that found on the plains. The height, diversity and density of the plant species were much greater and the proximity to water resources is undoubtedly a contributing factor. Aquatic and hydrophilic plants represented the only variation from xerophytic vegetation and naturally their distribution was limited to the waterbodies and waterways traversing the Thorn Scrub. Tree species found in close proximity to the river included Guango, Ackee and Mango. Other noticeable plants found close to the water edge included reeds (*Typha domingensis*) and water grass (*Commelina diffusa*).

General trends observed in the vegetation found in proximity to the RDA were as follows:

- Vegetation height of Wild Poponax increased with distance from the access road with an average height of 2.6m (8.5ft)
- Areas of bare ground were mainly as a result of pathways

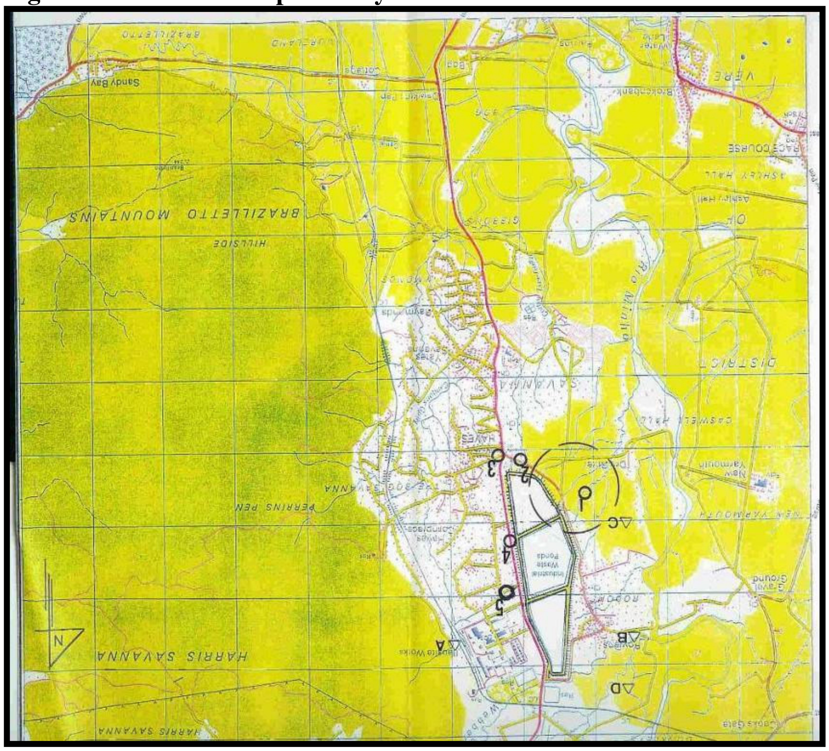
Sugarcane fields to the south of the RDA could come within the sphere of influence during the construction phase of the RDA. See

Figure 38 below.

Summary

Sixteen plant families were recorded accounting for twenty-four species. One endemic species was noted, *B.sanguinea*, a common orchid.

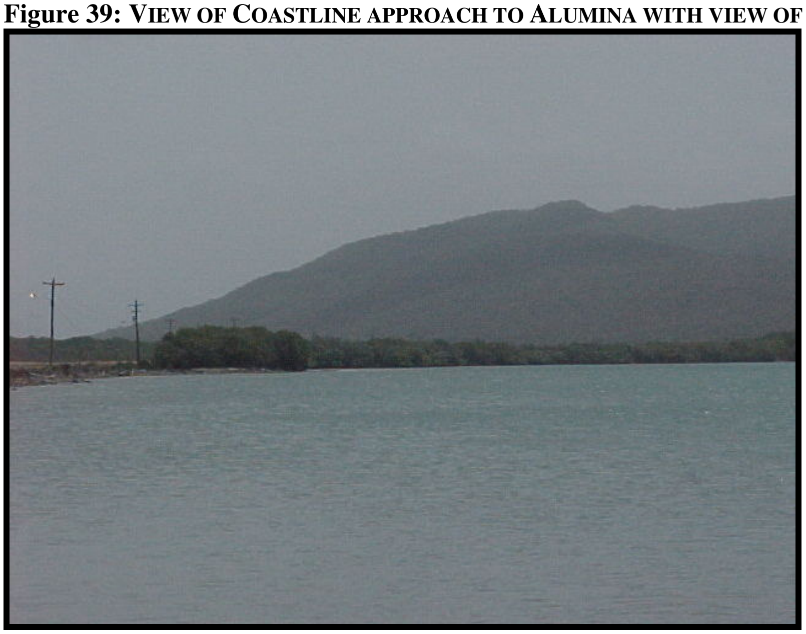
Figure 38- RDA and its proximity to the Rio Minho



3.6.5.5 Coastal vegetation

The movement of material between the plant and port will be via the existing rail system. Any considered or planned upgrades to the rail or port will not impact the terrestrial ecology.

Figure 39: VIEW OF COASTLINE APPROACH TO ALUMINA WITH VIEW OF BRAZILETTO MOUNTAINS



The vegetation in proximity to the Rocky Point Port is coastal type, which indicates that vegetation in this area is subject to water stress due to salinity of the surrounding areas, as well as increased levels of transpiration due to high winds. Accordingly, the plants that have colonized the study area demonstrate classic adaptations to survive this harsh environment.

Figure 40: **VIEW OF VEGETATION ALONG RAILWAY**

Figure 41: **BURNT VEGETATION ALONG THE RAILWAY**

In general the following adaptations were noted;

- Small, thick and/or shiny leaves to reduce transpiration loss.
- Succulent parts for increase water storage.
- Presence of salt glands for excreting excess salts e.g. mangroves.
- Presence of spines, prickles and hairs to reduce herbivory [1].
- Modified root systems to avoid oxygen deprivation e.g. pnuematophores[2] of Black Mangrove.

Stratification in this community was not complex and primarily consisted of a tree layer. Generally, plants were thin-boled with open and thin-depth canopies , although mature stands of Red Mangroves *(Rhizophora mangle*) showed diameter at breast height (dbh)of 10 inches and above.

Ground cover was for the most part absent, except in open areas where species such as Seaside Purslane (*Sesuvium portulacastrum*) and Jamaican Samphire (*Batis maritima*) dominated.

Mangroves were among the species recorded and accounted for the majority of the vegetation cover of the area. Button mangrove (*Conocarpus erectus var erectus*), Red Mangrove *(Rhizophora mangle*) and Black Mangrove (*Avicennia germinans*) were among the dominant species along with Seaside Mahoe (*Thespecia populnea*).

[1] Herbivory-consumption of plant/plant parts by animals

[2] Pnuematophores- roots with straight, erect, blunt branches

Figure 42: BLACK MANGROVES SHOWING DISTINCT PNUEMATOPHORES

Figure 43: LARGE SPECIMEN OF RED MANGROVE - NOTE DAMAGE FROM HUMAN INTERVENTION

Distribution of the various species was not calculated but various environmental factors did influence plant distribution. Water levels and/or proximity to the sea dictated mangrove distribution with Button mangrove restricted to high areas without water, where Black and Red mangrove were common. Human influence was noted through cutting of mangroves particularly large specimens of Red Mangrove.

Summary

Of the species identified all were noted as common and naturally occurring in their distribution . None of the observed species were listed as endemic[3] or rare species. See Table 29 below.

Table 29: COASTAL SPECIES

FAMILY	SCIENTIFIC NAME	COMMON NAME	HABIT	STATUS
Aizoceace	*Sesuvium portulacastrum*	Seaside purslane	Perennial, with succulent stem and leaves	Common, widespread distribution
Asclepediadaceae	*Calotropis procera*	Dumb Cotton	Shrub or small tree 3-5 m high	Locally commom
Asteraceae	*Eupatorium odoratums*	Jack-in-the bush	Erect or scrambling shrub; 2-3m	Common weed
Avicenniaceae	*Avicennia germinans*	Black mangrove	Shrub or tree 3-10 m high	Common in saline and brackish communities
Bataceae	*Batis maritima*	Jamaican samphire	Low growing succulent	Common in coastal areas and on cays
Cactaceae	*Stenocereus hystrix*	Dildo/Dildo Pear	Columnar type cactus 4-5m high	Locally abyndant in coastal areas
Capparaceae	*Capparis ferruginea*	Mustard shrub	Shrub or tree ranging from 1-8m	Common in coastal areas and on cays
Combretaceae	*Conocarpus erectus var erectus*	Button mangrove	Shrub or small tree	Common and

[3] Endemic- found only in one area or location

			3-5 m high	widespread

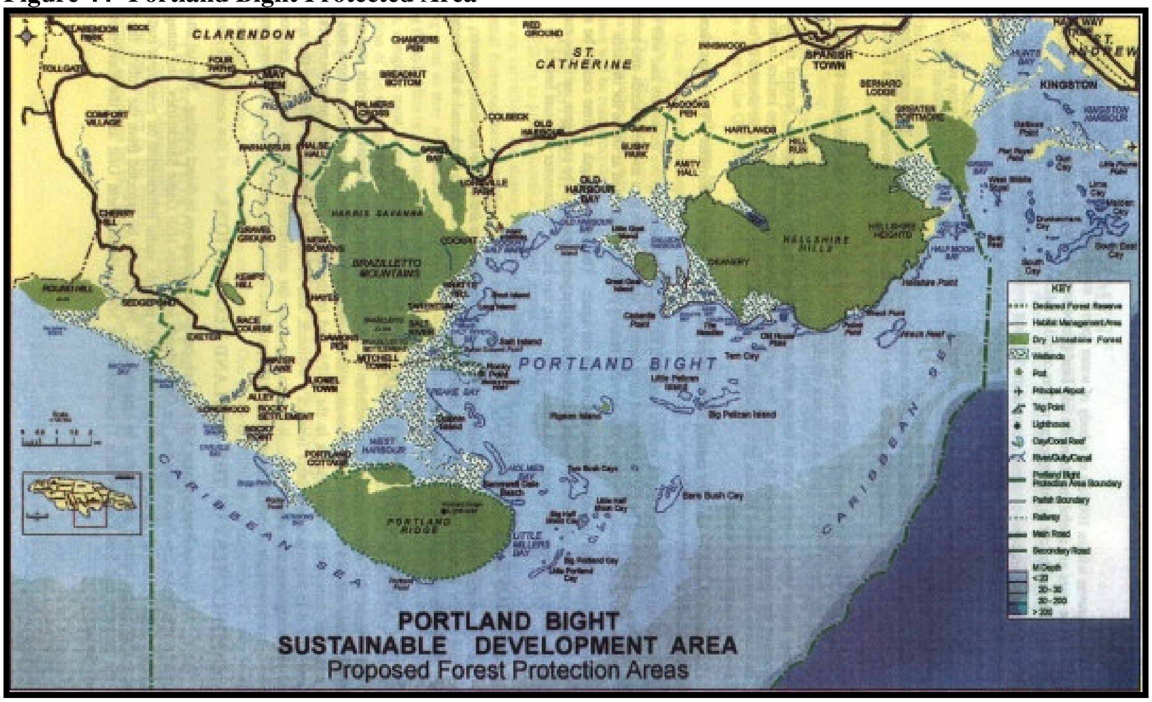
Table 29: Coastal Species - *continued*

Graminaceae	*Sporobulus virginicus*	none	Grass	Abundant and gregarious, sometimes forming continuos swards
Malvaceae	*Thespecia populnea*	Seaside Mahoe	Shrub or tree with spreading branches average 3-6 m in height but may attain heights of up to 20 m	Common in littoral situations , widespread throughout the tropics
Mimosaceae	*Acacia tortusa*	Wild Poponax	Shrub or tree with spreading branches average 3-5 m in height	Locally very common

3.6.5.6 Protected areas

The port is located within the Portland Bight area which is a designated protected area under the NRCA Act 1991 and under the management of non-governmental organization, Caribbean Coastal Area Management. Please see Figure 44 below

Figure 44- Portland Bight Protected Area[iv]



The increased activities willl have no further impacts on the terrestrial ecosystem.

3.6.5.7 Faunal studies

3.6.5.7.1 General Faunal Description

The primary focus of the faunal studies was on the avifauna in the area and for the other species noted such as insects, reptiles and amphibians. Not all observed species were identified.

Analysis of avifauna species was conducted in relation to habitat types as outlined above in the vegetation analysis.

At least 18 bird species were observed with 15 of these identified. Of this number, 73.33% (11) were residents, 13.33% (2) were migratory and 6.66% (1) introduced. It is likely, however, that one of the unidentified birds was migratory.

According to the Gosse Bird Club of Jamaica, all the birds identified are given a status of one (1), indicating ‘Common in suitable habitat’. The number of sightings also indicated that many of the identified birds were common in the area. There were no endemic, rare or endangered species noted in the area. However, a number of species, particular grass quits and warblers were seen collecting nesting material.

Literature sources confirmed that major nesting periods are between January and May.

3.6.5.7.2 Thorn scrub

The vegetation types identified in the study area have the potential to support a number of bird species, providing habitats particularly for columbids, and passerines. The vegetation types have also been known to support a large number of migrant warblers in the winter season.

Generally, bird counts conducted over the study period did not confirm a large number of bird species and only one migrant was identified in the total of fifteen (15) species identified.

3.6.5.7.3 Wet limestone (Ruinate) areas

Of the species identified the following feeding categories were represented;

Frugivores (fruit and seed eaters) - 28.6% (6)

Insectivores (predominantly insect eaters) - 14.3%(3)

Omnivores (a combination of the above two feeding groups) - 23.8% (5)

Scavengers (carrion feeders) - 4.8 %(1)

There were trends in the locations at which these feeding types were sighted. The majorities were found in the mining area, which showed more organized and developed vegetation types, 76.2% of the birds species were identified.

3.6.5.7.4 Estuaries and rivers

Of the species identified the following feeding categories were represented in the railway route.

Frugivores (fruit and seed eaters) - 19.1% (4)

Omnivores (a combination of the above two feeding groups) - 19.1% (4)

Carnivores (meat eaters) - 4.8 % (1)

Shore feeder/Wader (feeds on mollusks, annelids etc.) - 4.8% (1)

38.1% of the total number of birds identified was observed along the proposed railway area, which consisted of dry scrub. Of the 38.1% total, 14.3% of the birds were in altered habitats due to the effects of rivers or streams. These wetter areas showing similar type vegetation structures as that of the mining area.

Only 14.3% of the bird species was shared between the mining area and railway route and included the columbids.

The figures strongly suggest that the habitats provide mainly for fruiting, seeding structures and insects, these food types being maximized by the omnivores. The second largest group was the frugivores. It is apparent that the mining area provides these habitats to a greater extent based on the number of species recorded there.

Please see Table 30 and Table 31

Table 30: LIMESTONE

FAMILY	SCIENTIFIC NAMES	COMMON NAMES	FEEDING HABIT
Accipitridae	Buteo jamaicensis	Red-tailed Hawk	Carnivore
Ardeidae	Bubulcus ibis	Cattle Egret	Omnivore
Coerebinae	Coereba flaveola**	Bananaquit	Frigivore
Cucilidae	Crotophaga ani	Smooth-billed Ani	Omnivore
Columbidae	Columbina passerina	Common Ground Dove	Frugivore
Columbidae	Zenaida asiatica	White-winged Dove	Frugivore
Columbidae	Columba leucocephala	White-crowned Pigeon	Frugivore
Columbidae	Zenaida aurita	Zenaida Dove	Frugivore

Table 30: LIMESTONE - *continued*

Emberizinae	Tiaris olivacea	Yellow-faced Grassquit	Frugivore
Mimidae	Mimus polyglottos	Northern Mockingbird	Omnivore
Parulinae	Dendroica pharetra**	Arrow-headed Warbler	Insectivore

Parulinae	Dendroica caerulescens	Black-throated Blue Warbler	Insectivore
Parulinae	Setophaga ruticilla	American Redstart	Insectivore
Picidae	Melanerpes radiolatus**	Jamaican Woodpecker	Omnivore
Psittacidae	Aratinga nana**	Olive-throated Parakeet	Frugivore
Thraupinae	Euphonia jamaica**	Jamaican Euphonia	Frugivore
Todidae	Todus todus**	Jamaican Tody	Insectivore
Trochilidae	Anthracothorax mango**	Jamaican Mango	Nectarivore
Trochilidae	Trochilus polytmus polytmus**	Red-billed Streamertail	Nectarivore
Turdidae	Turdus aurantius**	White-chinned Thrush	Omnivore
Tyrannidae	Myiarchus barbirostris**	Sad Flycatcher	Insectivore
Tyrannidae	Myiarchus stolidus	Stolid Flycatcher	Insectivore
Tyrannidae	Tyrannus caudifasciatus	Loggerhead Kingbird	Omnivore
Tyrannidae	Tyrannus dominicensis	Gray Kingbird	Omnivore

Families -15
Species -24
Endemics ** -10 (41.7%)

Table 31: Coastal and Thorn Scrub

FAMILY NAMES	SCIENTIFIC NAMES	COMMON NAMES	STATUS/ RANK	FEEDING HABIT
Apodidae	*Tachornis phoeicobia*	Antillean Palm Swift	R1	Insectivore
Apodidae	*Streptoprocne zonaris*	White-Collard swift	R1	Insectivore
Ardeidae	*Bubulcus ibis*	Cattle Egret	R1	Omnivore
Cathartidae	*Cathartes aura*	Turkey Buzzard	R1	Scavenger
Charadriidae	*Charadrius vociferous*	Killdeer	R1	Omnivore
Columbidae	*Columbina passerine*	Ground Dove	R1	Frugivore
Columbidae	*Zenaida aurita*	Mourning Dove	R1	Frugivore
Cucilidae	*Crotophaga ani*	Smooth-billed Ani	R1	Omnivore
Emberizinae	*Tiaras olivacea*	Yellow-faced Grass quit	R1	Frugivore
Falconidae	*Falco sparverius*	American Kestrel	R1	Carnivore
Mimidae	*Mimus polyglottos*	Northern Mockingbird	R1	Omnivore
Scolopacidae	*Actitis macularia*	Spotted sandpiper	W1	Omnivore
Sturnidae	*Sturnus vulgaris*	European Starling	I1	Frugivore
Trochilidae	*Mellisuga minima*	Vervain	R1	Nectarivore
Tyrannidae	*Tyrannous dominicensis*	Gray Kingbird	S1	Insectivore

Families -13
Species - 15
Endemics -none

3.6.5.8 Other fauna

Insects were fairly well represented, with butterflies and bees being the most obvious of the group. Lepidoptera (butterflies etc,) were represented with at least 5 different species noted . More importantly is the ecological functions of these insects where they act as pollinators.. Other insect's species included ants, beetles, stinkbugs, wasps and honeybees.

3.6.5.8.1 Amphibians and reptiles

Reptiles and amphibian were not noted during surveys however literature reviews indicated the likely occurrence of certain species in the study area. Please refer to the list below, which a list of potential amphibians and reptiles in study area.

<u>Serpentes</u>

- ✓ *Arrhyton funereum*- **e**
- ✓ *callillaemum*- **e**
- ✓ *Typhlops jamaicensis*- **e**

CROCODYLIA

- ✓ *Crocodylus acutus* – **indigenous (Protected under both local and international law)**

SPHAERODACTYLUS

- ✓ *Sphaerodactylus argus* –**not e**

<u>Celestus</u>

- ✓ *Celetes duquesneyi*- **e**
- ✓ *c. d crusculus*- **two subspecies – e**
- ✓ *c. barbouri*

<u>Anolis</u>

- ✓ *Anolis valencienni*- **e**
- ✓ *sagrei*- **not e**
- ✓ ***OPALINUS*- E MAYBE EXTINCT**
- ✓ *lineatopus*-**e**
- ✓ *GRAHAMI* **-E INTRODUCED TO OTHER ISLANDS**
- ✓ *garmani*- **e intr to other is**

<u>Sauria</u>

- ✓ *Ameiva dorsalis*

<u>Testudines</u>

- ✓ *Trachemys terrapen* – **not e**

Amphibia

- ✓ **Anura**
  - o *Osteopilus brunneus*-**e**
  - o *Hyla wilderi*-**e**
  - o *Hyla marianae*- **e**
  - o *Bufo marinus* - introduced
- ✓ *Eleutherodactylus planirostris planirostris* - **not e**
- ✓ *E. pantoni pantone*
- ✓ *E.junori*-**e**
- ✓ E.jamaicensis – **e**
- ✓ *E.grabhami*- ***e***
- ✓ *E gossei gossei*-***es***
- ✓ *E. gossei oligaulax*-***es***
- ✓ *E. cundalli*-***e***
- ✓ *E. cavernicola*-***e***
- ✓ E. calyptahyla crucialis **–e**

At least four species of *Arrhyton sp* of which three are endemic. The snakes feed on other reptiles and amphibians such as *Anolis spp, Eleutherodactylus* adults and eggs as well as *Sphaerodactylus spp*. Of the *Sphaerodactylus spp* one, not endemic, has a range extending to the study area.

In addition, at least six *Anolis spp* are suspected to occupy the area. Of these six species at least five are endemics with one species thought to be extinct.. Our largest reptile *C.acutus* has also been reported in the Portland Bight area.

Of the amphibians at least 15 species are thought to have the potential to occur in the study area and of these fifteen , twelve are endemic. Furthermore, nine of those species are *Eleutherodactylus spp.*

3.6.5.8.2 Butterflies

As with amphibians and reptiles, this group was not surveyed and unfortunately literature did not yield concrete data on species distribution. Information from the Begs report

2000, which focused on faunal studies in Southern Manchester, indicated the likely occurrence of certain species. The report identified seven families accounting for 41 species. Of which nine are endemic species or subspecies.

3.6.5.8.3 Other invertebrates

The Begs report - 2000 also identified species such as moths and, microlepidoptera. Please refer to the species list below:

e = endemic

- ✓ **MOTHS**
  - **Family Arctiidae**
    - Ammalo helops Cramer
    - Calidota strigosa Walker
    - Eunomia rubripunctata Butler **- e**
    - Cosmosoma achemon F
    - Cosmosoma auge L.
    - Cosmosoma fenestrata Drury
    - Horama grotei L. **- e**
    - Empyreuma anassa Forbes **- e**
    - Phoenicoprocta jamaicensis Schaus**-e**
    - Composia credula F. Rare.
    - Correbidia sp. Rare.
  - **Family Hyponomeutidae**
    - Atteva auria
  - **Family Pyralidae**
    - Diaphina hyalinata L.
    - Epipagis huronalis Guinie
    - Anania florella Cramer

    No of unidentified spp. = 66
  - **Family Sphingidae**
    - Enyo biosduvali Oberthur
    - Erinnyis alope Drury
  - **Family Geometridae**
    - Nepheloleuca foridata Grote

    No. of Unidentified = 51
  - **Family Noctuidae**
    - Ascalapha odorata L. (Black Witch)
    - Melipotis sp1
    - Melipotis sp2
    - Melipotis sp3
    - Sylectra ericata Cramer
    - Leucania juncicola Guenee
    - Thysania xenobia Cramer

        - Cinccia sp

        No of Unidentified >50
    - **Family Lasiocampidae**
        - Unidentified species: 1
    - **MICROLEPIDOPTERA**
        - No. of Unidentified species: >100

    Total no. of moth species: >300

- ✓ **ODONATA**

  (Dragonflies and Damselflies)
    - **Family Aeshnidae**
        - Coryphaeschana adnexa
    - **Family Libellulidae**
        - Erythemis simplicollis
        - Erythemis plebeja
        - Tramea abdomiinalis Tramea insulris
        - Tramea binotata
        - Erythrodiplax aunrata
        - Erythrodiplax bernice
        - Dthemis rufinervis
        - Macrothemis celeno
        - Lepthemis vesiculosa
        - Anax junius
        - Micrathytyria didyma
        - Pantala flavescens
  - **Zygoptera** (Damsel flies)
        - Undentified species: 1

  Total no. of Odonata species = 15

- ✓ **MANTODEA** (Praying mantis)
    - Stagmomatis domingensis

- ✓ **ISOPTERA** (Termites)
    - Nasutitermes nigricepes
    - Procyptotermes cornicepes

- ✓ **ORTHOPTERA** (Grasshopers & Crickets)
    - **Family Gryllidae**
        - Halpithus sp.
    - **Family Acrididae**
        - Orphullela punctata
        - Neoconocephalus affinis
        - Stilpnochlora laurifolium

- ✓ **DERMAPTERA** (Earwigs)
  - Euborellia annulipes
  - Cabidora rip aria

- ✓ **HOMOPTERA** (Plant bugs)
  - **Family Membracidae**
    - Tyolzygnus fasciatus
  - **Family Cidadidellidae**
    - Poeciloscata laticepes

- ✓ **HEMIPTERA** (True bugs)
  - **Family Gerridae**
    - Gerris sp.
  - **Family Pentatomidae** (Stink bugs) Loxa viridis
    - Nezara viridula
    - Proxy victor
    - Euschistatus bifibulous
    - Alcaeorrhyndicus grandis
    - Proscys victor
  - **Family Cydinidae**
    - T ominotus communis
  - **Family Rudiviidae**
    - Unidentified sp.
  - **Family Porrhocoridae** (Stainers)
    - Dysdercus jamaicensis
    - Oncopertus sanderchatus
    - Oncopertus pictus

- ✓ **NEUROPTERA** (Lace wings & ant lions)
  - **Family Chrysopidae**
    - Chrysopa bicornea
  - **Family Myrmelontidae**
    - Hesperoleon sp.

- ✓ **COLEOPTERA**

- ✓ **DIPTERA** (Flies)
  - **Family Tipulidae**
    - Limonira spp.

- **Family Syrphidae** (Flower flies)
  - Ornidia obesa *(F)*
  - Copestylum inatoma
  - Copestylum tamaulipanaum
  - Pseudodorus clavatus
  - Toxomerus pulchallus
- **Family Bombylidae** (Bee flies)
  - Paecillathrax lucifer *(F.)*
- **Family Stratyomyidae** (Soldier flies)
  - Hermatia illuscells
- **Family Assilidae**
  - Leptogaster jamaicensis
  - Cerotainia jamaicensis
  - Ommatis alexanderi Farr
- **Family Tephritidae**
  - Anastrepha sp. (fruit fly)

- **Family Stphylinidae**
  - Carpelimus petomus
  - Carpelimus sp.
- **Family Tenebrionidae**
  - Tarpela metabilis
- **Family Scolytidae**
  - Xyleborus spp.
- **Family Cincindellide**
  - Cicindela carthagena jamaicana
- **Family Scarabeeidae**
  - Paragymentis lanius
  - Ligyrus fossor
  - Macraspis tetradactyla
  - Strategus sp.
  - Oniticellus cubiensis
  - Phanaeus vindex
- **Family Chrysomelidae**
  - Coptocyia jamakana
  - Metriona flavolineata
  - Diabrotica bivittata
  - Disonycha laevigate
  - Homophoeta albicellis

  - Cerotoma ruficornis
- **Family Coccinellidae**
  - Chalieorus cacti
  - Cyc1oneda sauguinea

- **Family Cerambycidae**
  - Eburia postica
  - Oreodera sp.
  - Chlorida festiva
  - Elaphidon spinicorne
  - Neoptychodes trilineta
  - Neoc1ytus longipes
  - Neoc1ytus sp.
- **Family Dyticidae**
  - 1 sp.
- No. Unidentified beetles: 23

✓ **HYMENOPTERA**

- **Family Scolidae**
  - Compsomeris dorsata
  - Campsomeris attrata
- **Family Ichneumonidae**
  - Icheumonus sp.
- **Family Apidae**
  - Euglossa jamaicensis
  - Centris sp.
  - Apis mellifera
  - Exomolapsis sp.
- **Family Megachilidae**
  - Megachile concina
  - Megachile poyei
- **Family Sphecidae**
  - Sceliphron asimile
  - Zeta abdominalae
  - Pachydynerus nasidens
- **Family Vespidae**
  - Polistes crinitus
  - Polistes hunteri
  - Polistes major
  - **Family Chalcidae**
  - Spilochalsis sp.
  - **Family Formicidae**
  - Paratrechina longicornis
  - Crematogaster sp.
  - Pheidole sp.
  - Camponutus sp.
  - Trachymymex jamaicensis **- e**

✓ **COLLEMBOLA**

- Unidentified species: 1

✓ Other unidentified insects species: > 250

- **Total no. of insect species collected: >350**

- **SPIDERS**
  - Peucetia sp. Argiope aurunita
  - Micrathena spp.
  - Phalaugium sp.

- **MILLIPEDES**
  - Julida
  - 2 spp

- **SCORPIONES**

- **PSEUDO SCORPIONS**
  - Unidentified species: 1

- **IXODES**
  - Boophilous microplus

- **ISOPODA**
  - Unidentified species: 2

- **EARTH WORMS**
  - *Pheretima sp.*
  - *Proto scolex sp.'"*

- **SNAILS**
  - *Thelidomus aspreera*
  - *Sagda jayana*
  - *Sagda anodon*
  - *Sagda torrefactor*
  - *Plectocycoltus jamaicensis*
  - *Lucidella granulosa*
  - *Lucidella anroela*
  - *Lucidella sp.*
  - *Urocoptis aspera*
  - *Urocoptis brevis*
  - *Urocoptis sp*
  - *Orthalicus undatus*
  - *Eutrochatella*
  - *Pleurodonte autalucena*
  - *Tudora jayana*
  - *Tudora tectilabris*
  - *Tudora banksiana*
  - *Tudora sp*
  - *Dentelaria sp.*

3.6.5.9 Ecological Relationships

- **Soil fertility and Trees.** It is well established that the presence of trees contribute significantly to soil amelioration. Trees provide a number of functions; physically, they prevent soil erosion by protecting and the soil from direct rainfall through interception with their canopies, and they improve soil stability through their root systems. Chemically, they improve soil quality by additions of organic matter (leaf litter, decomposing branches and root exudates) and through leaching from stem and leaves.

  The species *Samanea saman* (Guango) may play a greater role in this regard. The plant is a nitrogen fixing tree, and large specimens are frequent in several areas

- **Plant dispersal and Pollination.** Several of the plant species have specialized relationships with birds to ensure pollination and seed dispersal. One such case occurs with bromeliads being pollinated by *Trochilus polytmus polytmus* (Red-billed streamertail) and the *Cecropia peltata* (Trumpet tree) whose seeds are dispersed by birds.

- **Habitats** Several plant species provide valuable habitats for animals species. In general provide feeding and nesting grounds for bird species. In addition to creating microhabitats , suchs as bromeliads and other epiphytes . These plants in turn support the breeding species as tree frogs and crabs.

3.6.5.10 Biodiversity levels

In summary a general survey of the project locations, the mining area, along the raiway routes, the plant and port site, reveal no rare or endangered plant species. A comparison of species diversity in study areas, with the potential species likely to occur in a more extensive study against the national levels

Jamalco has commissioned a more extensive study of the proposed mining area. The reslts of which will be used to inform decisions regarding the protection of any valuable species that may be identified

The committement of the company to the preservation and conservation of Jamaica's biodiversity is underscored by the alliance established with the Forestry Department

Figure 45: COMPARISON OF BIODIVERSITY LEVELS

	Observed species	**Endemics**	**Potential species from literature**	**Endemics**	**National levels**	**Endemics**
Plants	60	2	47	Not indicated by study	3,304	167
Birds	39	10	144	19	106	31
Bats	0	N/a	9	1	21	2
Butterflies	5	unknown	41	9	133	20
Amphibians	0	N/s	14	12	22	22
Reptiles	0	N/a	16	11	43	33
Snails	2	unknown	19	Not indicated	514	505

Note- numbers include bird migratory species

Listing from Quaco rock and Bird Cave rock omitted

3.6.6 Conclusions & Recommendations

3.6.6.1 Conclusions

The proposed project although wide in its geographical scope will not impact greatly on the ecology of the area , with one exception , the mining lactivities which will involve the clearing of vegetation to facilitate the removal of the bauxite ore.. In respect of the other elements of the project the impact willl be minimal:

- The expansions to the Port will be contained within the existing boundaries
- The railway and transport system is already in existence and its operation will pose not threat to vegetation cover
- Species noted in the study area are relatively common . Key species such as those noted in Hellshire, Bird Rock and Quaco cave are out of the zone of influence of the project.

3.6.6.2 Recommendations

The area of concern will be the proposed mining areas, where vegetation will have to be removed to facilitate mining. In such cases the following steps show be taken,

- Land clearance should be kept to a minimum to reduce unnecessary habitat loss
- Care should be exercise to minimize anthropologic influences on nearby areas of significant biological value.
- Where possible important plant species should be removed. The involvement of such groups as the Jamaica Orchid society to do a sweep of the area before clearance should be considered. The same should apply to smaller animals such as tree frogs or snakes. Local NGO's could be mobilized to aid with this rescue effort.
- Jamalco should organize a response team through NGO input to deal with any animals that maybe disturbed during actual mining.

- Jamalco should have a monitoring programme to record any animal species that may be killed during mining. This information would be useful in supporting national conservation databases.

- Indigenous species should be utilized in their rehabilitation programme to promote re-establishment of similar vegetation types, in keeping with Jamalco's policies and the MOU with the Forestry Department.

The operations in the are essentially represent that of a brown site efficiency upgrade. Hence none of the potential impacts in the area will be new. The activities from the efficiency upgrade will result only in an intensification of these activities. However, in the case of the SEML, proposed for mining in Northern Manchester, in spite of the observations made in this period short period of time during which this EIA was conducted, it is strongly recommended that Jamalco conducts a more intensive study over a period of at least 12 months to capture the seasonal variations in vegetation tyupe, fauna and habitat types and their ecological relationship prior to the commencement of mining.

Such a study is already underway and is about three months in progress. Undoubtedly, Jamalco has taken this initiative to inform policy directives and actions in keeping with the environmental values of creative conservation. This, among other things encourages inducement of the natural biota which existed prior to mining to naturally recolonize the area through habitat formation and other actions.

Results of this study will be available long before mining operations begin in North Manchester.

MARINE ASSESSMENT

3.7 Marine Assessment

3.7.1 INTRODUCTION

As part of the proposed efficiency upgrade of the Jamalco operations, consideration is being given to modify aspects of the Rocky Point Port operations to accommodate anticipated changes in alumina shipment.

In order to provide information, which could be used to support the development and implementation of plans for the expansion of the port, a marine assessment of the environment in proximity to the port facility was conducted.

3.7.1.1 Regional Setting

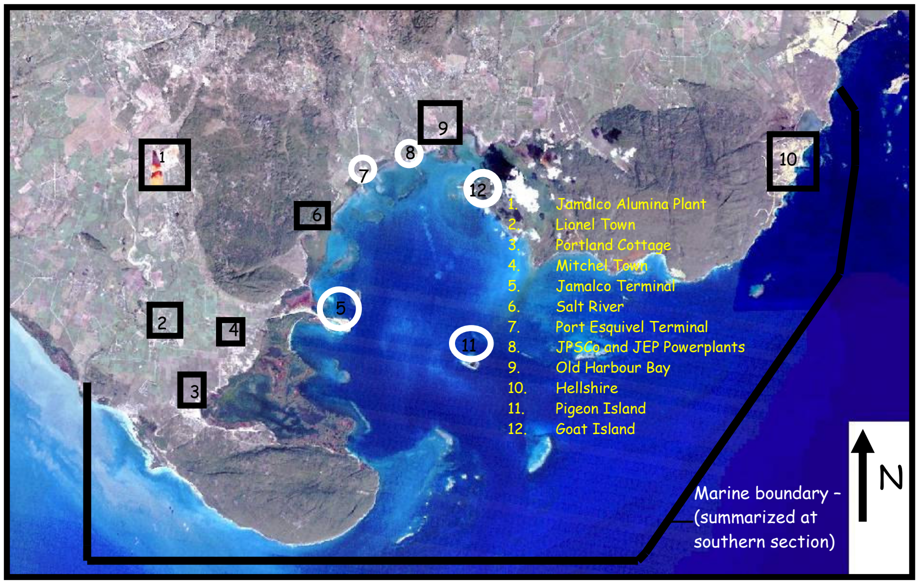
The JAMALCO Marine Terminal was established over 40 years ago on a Mangrove inhabited peninsula at Colon Bay in the northeastern side of Portland Bight in the Parish of Clarendon. The Marine Terminal facilitates the export of Alumina from the JAMALCO Halse Hall refinery and the import of raw materials and goods (e.g. fuel, caustic soda) required for the operation. The port accommodates vessels at the terminal by way of a T-shaped piled pier and mooring dolphins (See Figure 46).

Figure 46: ROCKY POINT PORT

The facility is one of two Marine terminals in the Bight, WINDALCO's Port Esquivel facility being the other. The terminal also shares marine accesses with two power generation facilities, namely the Jamaica Public Service Company Ltd's Old Harbour Bay Power Station and the Jamaica Energy Partners Power Barge. Finally, a number of communities ring the Portland Bight area, including Mitchel Town, Portland Cottage, Salt River, Tarentum, Longville, Kelly's Pen and Old Harbour Bay.

The JAMALCO Terminal falls within the Portland Bight Protected Area, which extends from the Hellshire Hills area to the east, to the Rio Minho River estuary in the west. The Natural Resources Conservation Authority (NRCA) declared the protected area on April 22, 1999. The NRCA ultimately delegated responsibility for the protected area to two management entities. The Caribbean Coastal Area Management Foundation which oversees the management of the areas extending from Old Harbour Bay, west and south to the Portland Cottage area and including the cays and marine environment contained within. The Urban Development Corporation will oversee the management of the Hellshire Hills area and the Goat Island region[v] (See Figure 47).

Figure 47: ENVIRONMENT CONTAINED WITHIN THE PORTLAND BIGHT PROTECTED AREA– LANDSAT TM IMAGE

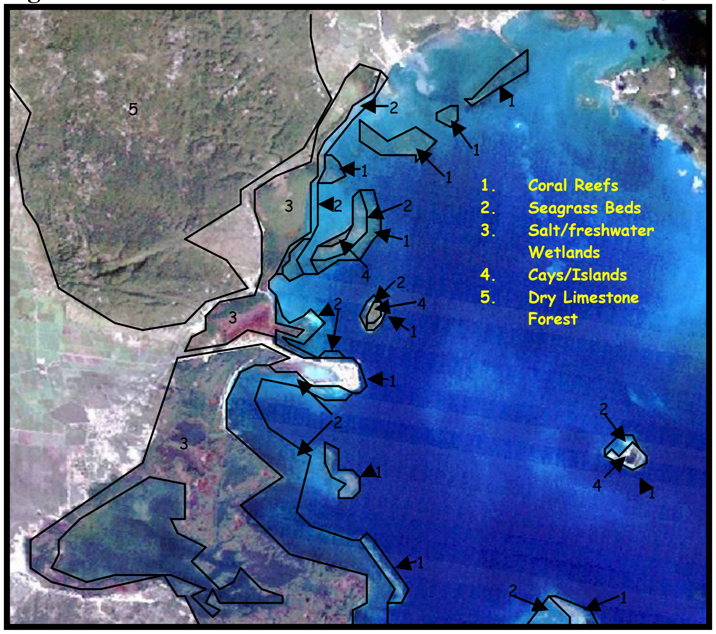


The declaration was initiated, owing in part to the presence of rich coastal and marine resources within the area. Some of the largest Mangrove wetlands and fresh water marshes in the island exist within and adjoin the borders of the Portland Bight [vi]. Also integrally associated with wetlands are Seagrass Beds and Coral Reefs, which support a diverse array of fish, crustaceans and other forms of marine organisms[vii].

Several studies have been initiated in the past, which have shed light on the extent and value of natural resources within the Portland Bight Protected area. The most extensive to date has been an environmental baseline study, which was commissioned by the Jamaica Public Service Company Ltd in 1997-98 for a Coal/Oil fired power plant, which was proposed for the Salt River area[viii].

Extensive land-use, climatic, terrestrial, marine and socio-economic research was conducted to support the preparation of the baseline study. Figure 48 represents a spatial representation of the marine resources within the study area, and as projected over the Protected Area using aerial interpretation techniques.

Figure 48: COASTAL AND MARINE RESOURCES ADJOINING JAMALCO TERMINAL.



In addition to the Baseline Study, another applicable source of information was an assessment of the marine resources immediately adjoining the Marine Terminal, which was commissioned by JAMALCO in 1996[ix]. This report concluded that:

"The general area around the dock and pier was alive with a reasonable reef community showcasing multiple species of fish, coral and other expected species. The patch reef system within the project area does not appear to be very different from that found elsewhere in the area"

"Staghorn coral populations are significant with a lot of new growth evident"

"the seagrass community is very extensive and appears to be healthy, the large numbers of sightings of sea urchins within the project area is also a good indication of the feed palatability of the grass"

"the presence of healthy sponges growing directly on the pilings is an indication that the marine community is not at present suffering from any substantial negative effects as a consequence of pier activity"

"Water current activities are directly related to the wind patterns that prevail in that area. The overriding pattern seems to be towards Burial Point and Colon Bay".

Information and diagrams presented within this report were used to prepare a marine resource diagram of the Terminal and its immediate environs, similar in representation to that of Figure 48 (See Figure 49).

Figure 49: MARINE RESOURCES AT JAMALCO MARINE TERMINAL, IMAGE SOURCE .SURVEY DEPT

3.7.1.2 Study Area Demarcation:

The area defined for the oceanographic and benthic assessment was selected with proximity to the existing facilities being the primary consideration. However, the selection bore relevance to another consideration, which was that the area in proximity to the existing structures of the marine terminal appeared to be representative of the general benthic conditions existing along the Peninsula at which the terminal is situated, as outlined by the 1996 JAMALCO study. Thus, determinations made for the marine environment immediately adjoining the terminal could be extended by extrapolation to bordering areas. Conversely, previously existing information for the area was used to make generalizations about the study site, which could then be verified in the field.

3.7.2 MARINE ASSESSMENT METHOD DESCRIPTION:

3.7.2.1 Aerial Photo Interpretation:

The marine assessment was initiated using photogrammetric techniques to remotely identify and determine the spatial distribution of marine seafloor characteristics, which can be discerned with these methods (by definition, Photogrammetry is the science of using aerial photographs and other remote sensing imagery to obtain measurements of natural and human-made features on the earth [x]). These characteristics relate to colour, 3-dimensional form and texture patterns, which can be used by a suitably trained and experienced remote sensing technician to identify the various types of bottom substrates and marine benthic features (organisms attached permanently to the seafloor) existing within Jamaica's waters. Vertical aerial coverage of the area for the year 1991 was accessed through the Survey Department and examined for the interpretation process.

This distinction was also used to establish the level of field information, capture method and detail that will be required at the ground truthing stage. This is illustrated by the fact that aerial photo interpretation revealed the presence of both hard and soft seafloor substrates within the study area. Since hard substrates are often more likely to possess attached marine organisms, a more refined search method would be required to examine this area.

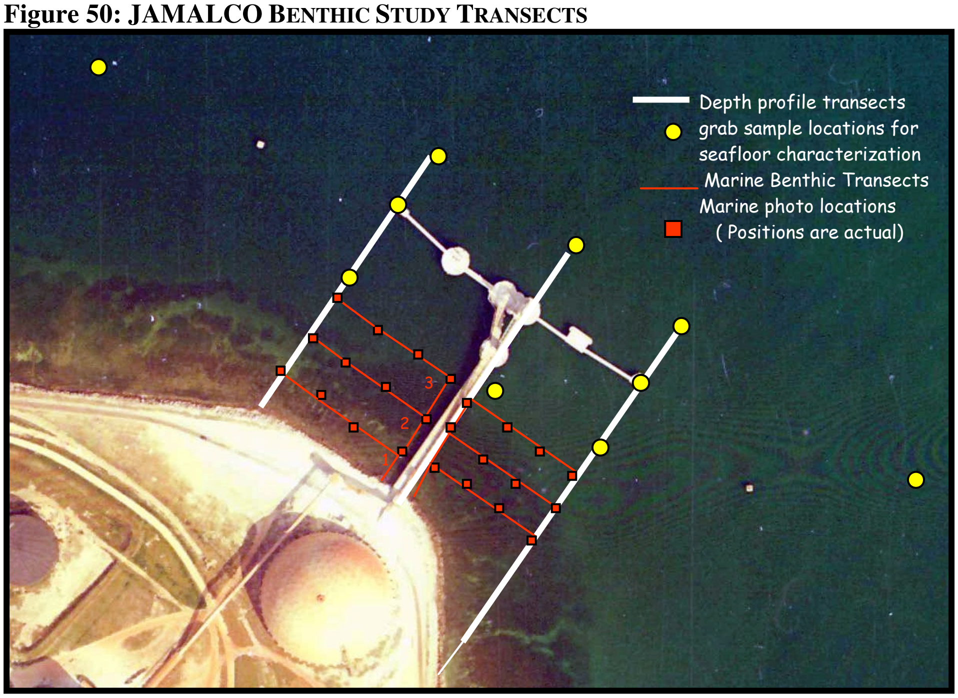
3.7.2.2 Ground Verification

After the process of aerial assessments was completed, ground truthing was conducted to verify interpretations made during aerial photo assessments. In addition, verification was conducted to provide information on the status of natural resources that may exist within the immediate study area. This would allow for an expanded understanding of the environment that exists outside of the study area through extrapolation.

For the area interpreted as being of a hard seafloor substrate, ground truthing was conducted along transects, which were deployed on the seafloor, as defined by aerial photo interpretation of substrates existing within the study area. Deployment included twenty-four 20 meter long visual transects traversing the area surrounding and including the pier and adjoining shoreline. Transects were defined with a 20 meter surveyors tape measure. A 'comb tooth' transect layout pattern was used for the purpose of the survey. One linear grouping of three 20 meter transects was run along the alignment of the pier, perpendicular to the depth profile of the area. This grouping of transects served to identify any substrate type or character changes, which may be governed by depth. Once a particular seafloor substrate or character was identified, linear groupings of 20 meter transects were run parallel to depths at the point where they intersected the main transect. In this case, three linear groupings of three 20 meter transects were deployed. Observations made along these transects would serve to confirm the lateral continuity of any substrate or character changes observed with depth changes.

Three 100 meter visual transects were used to confirm the seafloor composition within the area designated as being of a soft bottom characteristic (See Figure 50). This type of census method was chosen, since it was deemed to be unlikely that extensive marine biological resources would be found in these areas.

Figure 50: JAMALCO BENTHIC STUDY TRANSECTS



Visual transects were conducted by two divers with slates, laminated pictures of marine resources, a 1 meter PVC quadrat and a Nikonos 5 underwater still camera to facilitate information gathering. All benthic species, fish and other mobile species observed within a 1 meter strip along each of the transects were identified and estimates of their sizes and numbers made. All underwater photographs obtained at the site were taken with a vertical orientation. From these photographs, an estimate of the percentage area of seafloor covered by various marine features within the image was determined by overlaying the image with transparent graph paper and counting the number of graph squares corresponding with the feature. This area was then extrapolated for the survey area.

Finally, the contour of the seafloor, was determined by cross section using a linear scale estimated from the 1991 aerial photo scale reference and using depths read from depth gauges during the visual survey and soundings taken during grab sampling.

3.7.2.3 Oceanographic Assessment Methods:

The oceanographic process examined during the study was sea current movement. This was examined in order to determine the means by which the marine environment within the study area could be influenced by agents transported to, from and through the system.

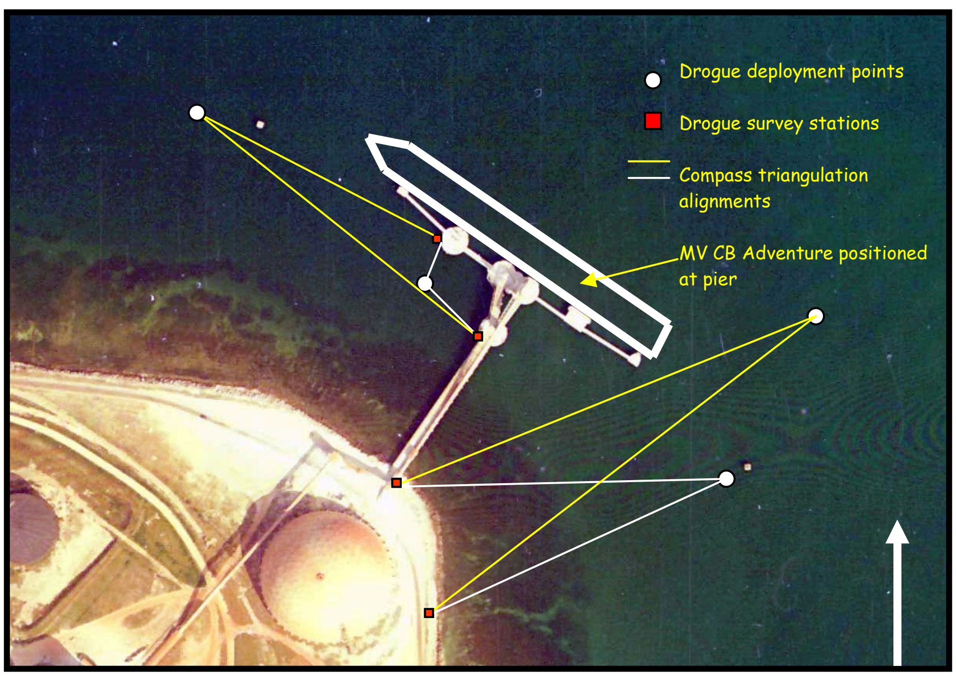
Three approaches were adopted for the evaluation of the study's target oceanographic processes. Firstly, wave crest movement and patterns exhibited by the movement of turbid water within the study area, as shown on aerial photographs, were examined. This was done to obtain general water movement trends for the time at which the images were taken, usually before 9:00 am. Again, the 1991 aerial coverage of the area proved useful for this purpose. Secondly, average day and night time wind directions and speeds for the area were obtained from communications with technical officers at the Meteorological Service.

This weather information was important in the evaluation of sea current movement, since one of the driving forces behind sea current movement is wind movement[xi]. Thirdly, actual sea current speed and direction, within the borders of the Marine Terminal structures were determined through the use of two drogues.

Each drogue was constructed by interlocking two-1 meter square plates to form a vane, which was suspended from a white fish pot marker float [4]. The float would suspend the vane in the water column while the vane would present a surface upon which currents would exert a force, resulting in lateral displacement.

For the determination of surface currents, the vane was suspended one meter below the float. For deeper current movement study, the vane was suspended 5 meters below the float. Both drogues were tracked from positions on the Marine Terminal Pier using bearings obtained from hand held Silva compasses, with bearings being taken every 5 minutes for total time period of 15 minutes (See Figure 51). Drogues were initially deployed at the locations outlined on Figure 51, tracked for 15 minutes and then moved to other locations in order to obtain a general appreciation of current movements over the entire study area. Once bearings were obtained, these were plotted onto the 1991 aerial image of the site to show movement direction and speed.

Figure 51: JAMALCO CURRENT STUDY STATIONS



[4] As designed for 1996 Jamalco Rocky Point Study

3.7.2.4 Limitations

The most significant limitation experienced during the study period was sea state. The Meteorological Services Division's weather reports advised that a series of high-pressure ridges had prevailed over the central Caribbean for several days leading up to, and during the time of the survey. As a result of this, south easterly winds in excess of 20 knots blew constantly over the Portland Bight area during both day and night periods generating 2 meter seas within the study area and reducing underwater visibility at all locations within the study area to less than a meter.

The prevailing sea state also prevented the surveying of the seafloor within 30 meters of the shoreline adjoining the pier. This was due to the presence of high swells and breaking waves, which prevented safe diving and snorkeling in this area.

In addition to the sea state, on the morning of the survey, an Alumina bulk carrier vessel, the MV CB Adventure was maneuvered into position at the terminal for the on loading of Alumina. The presence of the vessel above the proposed 100 meter visual transect paths made the conducting of diving operations in these areas impossible, since the Port's security protocols forbid the conducting of diving operations under the vessel. In any case, such a diving operation could not have been conducted safely, since it would have meant diving under the ship.

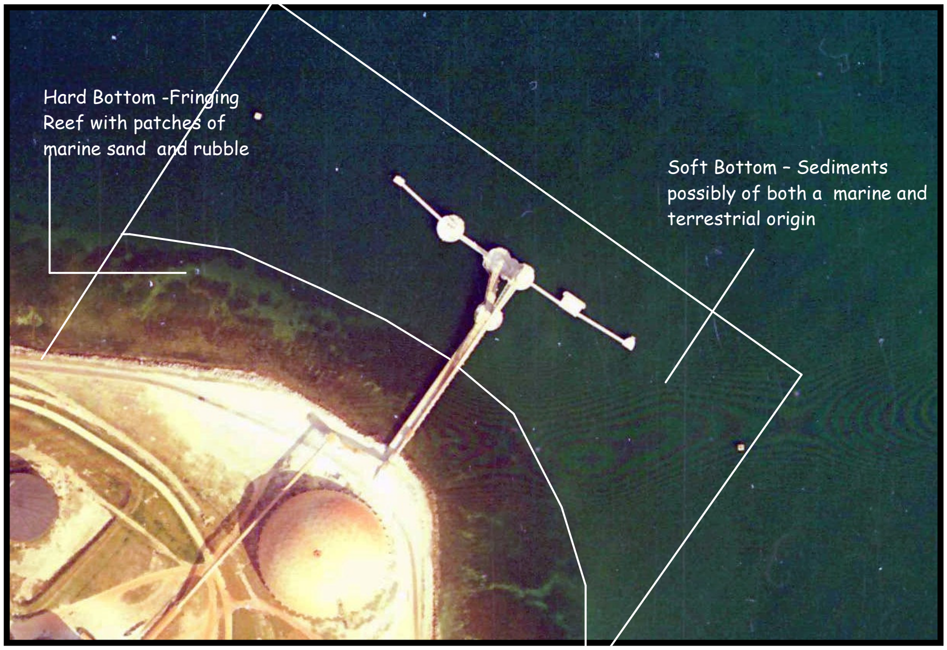
Therefore, information on the seafloor along these transects was determined using a clamshell grab sampler to allow the viewing of any seafloor sediments that may have been present at the location.

3.7.3 OBSERVATIONS

3.7.3.1 Aerial Photo Analysis – Marine Observations:

The form, colour and texture patterns observed during aerial photo analysis lead to the conclusion that there were both hard and soft substrate areas within the study area. The spatial distribution of these substrates defined an area characteristic of a fringing coral reef. By deduction (due to locations adjoining the fringing reef) and colour, the soft substrate area was inferred to be composed of sediments of a marine origin. Figure 52 outlines the spatial separation between hard and soft substrate areas deduced to be within the study area.

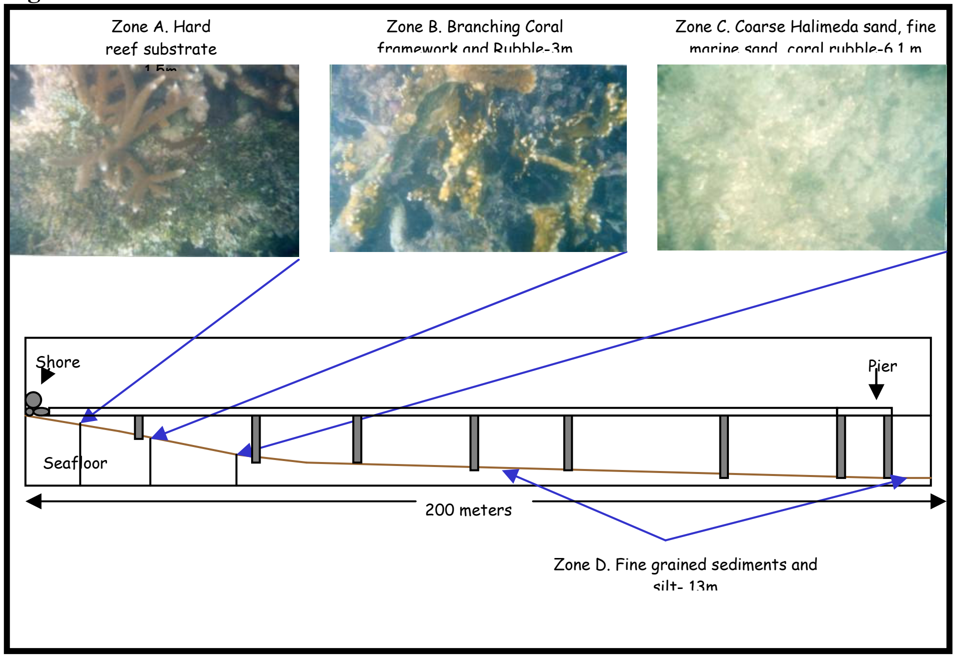
Figure 52: SEAFLOOR SUBSTRATE CHARACTER DEDUCED FROM AIR PHOTO STUDY



3.7.3.2 Diver-assisted Visual Observations – Substrate Zonations:

Figure 53 outlines a cross section summary of the observations made along the main transect within the hard substrate zone and the three-grab sample transects conducted beyond. The area identified as being of a hard bottom character was confirmed during the visual surveys as being a fringing reef.

Figure 53: BOTTOM PROFILE AND SUBSTRATE CHARACTER



The reef area had been determined by aerial photo interpretation to be approximately 70 meters in width and this was also confirmed through measurements made with surveyors tapes deployed underwater along transects 1-3 (Figure 51). Within the fringing reef area, three zones were identified. These are described as follows:

Zone A:

This zone extended from the shoreline to about 30 meters seaward and to a depth of 1.5 meters, as defined by transect 1 (See Figure 50 and Figure 53). A hard coralline substrate of low rugosity dominated the area (rugosity being defined as the level of complexity that a reef has, for example, the extent to which a reef area has holes, crevasses and overhangs within its substrate[xii]). The coral framework had apparently experienced extensive physical impact from wave action, since only the dead coral skeleton bases remained. There was, however, new growth of both branching and massive corals in this zone.

Zone B:

This zone extended from the seaward limit of Zone A for about 20 meters and to a depth of 3 meters, as defined by transect 2. Branching coral rubble overlaying hard, dead

Elkhorn reef was the dominant substrate at this location (See Figure 50 and Figure 53). This zone had high rugosity.

Zone C:

This zone extended from the seaward limit of zone B for about 20 meters and to a depth of 6.1 meters, as defined by transect 3 (See Figure 50 and Figure 53). The dominant bottom substrate type found here was a combination of coarse marine sand, silt and branching coral rubble.

Zone D

This zone extended seaward of Zone C and beyond the seaward end of the grab sample transect, which was terminated at a distance of approximately 200 meters from shore. Water depth at this point was approximately 14 meters, as estimated from grab sampler soundings (See Figure 53).

At this location, the seafloor was dominated by soft sediments, assumed to be of a combination of marine and terrestrial origin, owing to its cream and gray colour and proximity to areas from which riverine discharges occur.

Zone E.

The pilings of the pier demonstrated significant importance as a substrate upon which marine life could and indeed, had colonized. Though it was not defined as a naturally occurring substrate zonation in the area, it was nevertheless examined (See Figure 53).

3.7.3.3 Diver-assisted Visual Observations- Marine Species:

Zones A, B and E had the greatest variety of attached, mobile and free swimming organisms associated with them and were thus regarded as the most important life-bearing areas within the study area. Table 32, Table 33, and Table 34 list the species observed in each zone, both visually while in the field and identified from underwater photographs taken during the survey.

Zone A:

The dominant benthic invertebrate species observed were corals, Milleporids and Mat Zooanthids, all of which were visually perceived to be equally represented. Coral species diameters observed within this zone were generally equal to or greater than 20 cm, with Staghorn coral dominating. It was apparent that the Staghorn growths occurring within the area had occurred due to the dispersal of previous growth by wave action. This was deduced, since most of the Staghorn coral growth observed was not cemented to the seafloor and could easily be picked up by the divers conducting the survey.

Halimeda sp. and turf algae predominated as marine plant species within this zone.

Where mobile organisms were concerned, reef fish were the most obvious with three varieties being observed. Total numbers of fish individuals observed were low, being less than 10, with the exception of Doctor Fish, a school of which was observed numbering in excess of 20 individuals. Fish sizes were generally less than or equal to 10 cm in length.

Sea urchins concluded the list of observations, being the most abundant mobile bottom dwelling organism observed. Two species were observed and their numerical abundance was estimated at an individual per 1 m^2 of seafloor.

Table 32: SPECIES LIST - ZONE A

MARINE PLANTS	
Common Name	**Scientific Name**
	Halimeda sp.
Turf Algae	
Y-branched Algae	(*Dictyota* sp.)
Green grape Algae	(*Caulerpa sertularoides*)
BENTHIC INVERTEBRATES	
Corals	
Common Name	**Scientific Name**
Brain Coral	(*Diploria* sp.)
Staghorn Coral	(*Acropora cervicornis*)
Startlet Coral	(*Siderastrea* sp.)
Mustard Hill Coral	(*Porites asteroids*)
Zooanthids	
Common Name	**Scientific Name**
Mat Zooanthid	(*Zoanthus* sp.)
Octocorals	
Common Name	**Scientific Name**
Fire Coral	(*Millepora* sp.)
MOBILE INVERTEBRATES	
Common Name	**Scientific Name**
Rock Boring Urchin	(*Echinometra lucunter*)
Reef Urchin	(*Echinometra vividis*)
FISH	
Common Name	**Scientific Name**
Caesar Grunt	(*Haemulon carbonarium*)
Damsel Fish varieties – Dusky, Yellow tail, Bi-colour	(*Stegastes* sp.)
Doctor Fish	(*Acanthurus chirurgus*)

Zone B:

The dominant sessile invertebrate species observed were sponges, which encrusted a percentage of the coral rubble found within this zone. Corals and Milleporids followed in importance.

Coral species diameters observed within this zone were generally equal to or greater than 20 cm, with both Elkhorn coral and Fire Coral types dominating. It is useful to note that at least 2 “unusually large” examples of Brain Coral (> 1 meter diameter) were observed in this zone.

Halimeda sp. and turf algae again predominated as marine plant species within this zone.

There was a noticeable increase in fish diversity in zone B as compared with zone A. In addition, the overall sizes for fish species observed in zone B, appeared to be larger than similar species, which were also observed in zone A. Fish sizes, on a whole, were generally greater than or equal to 10 cm in length.

Sea urchins were the most abundant mobile bottom dwelling organism observed, as was the case for zone A. The same two species were observed, however, their numbers were perceived to be greater, with an estimate of 3 individuals per 1 m^2 of seafloor being made. Two Spiny Lobsters were observed under a dead coral head within this zone, further hinting at the greater level of diversity observed in this zone.

Table 33: SPECIES LIST - ZONE B

BENTHIC INVERTEBRATES	
Corals	
Common Name	**Scientific Name**
Brain Coral	(*Diploria* sp.)
Staghorn Coral	(*Acropora cervicornis*)
Startlet Coral	(*Siderastrea* sp.)
Mustard Hill Coral	(*Porites asteroids*)
Elkhorn Coral	(*Acropora palmata*)
Corallimorphs	
Common Name	**Scientific Name**
Florida Corallimorph	(*Ricordea florida*)
Anemones	
Common Name	**Scientific Name**
Sun Anemone	(*Stichodactyla helianthus*)
Sponges – rope and encrusting varieties	
Common Name	**Scientific Name**
Brown Variable Sponge	(*Anthosigmella varians*)
Variable Boring Sponge	(*Siphonodictyon coralliphagum*)
Yellow Calcareous Sponge	(*Clathrina canariensis*)
Scattered Pore Rope Sponge	(*Aplysina fulva*)
Octocorals	
Common Name	**Scientific Name**
Fire Coral	(*Millepora* sp.)
Soft Coral	(*Pseudoplexaura* sp.)
Segmented Worms	
Common Name	**Scientific Name**
Magnificent Feather Duster *magnifica*)	(*Sabellastarte*
Christmas Tree Worm	(*Spirobranchus giganteus*)
MOBILE INVERTEBRATES	
Common Name	**Scientific Name**
Rock Boring Urchin	(*Echinometra lucunter*)
Reef Urchin	(*Echinometra vividis*)
Spiny Lobster	(*Panulirus argus*)
Variegated Urchin	(*Lytechinus variegates*)
FISH	
Common Name	**Scientific Name**
Caesar Grunt	(*Haemulon carbonarium*)
Damsel Fish varieties – Dusky, Yellow tail, Bi-colour	(*Stegastes* sp.)
Doctor Fish (*Acanthurus chirurgus*)	
Long Jaw Squirrel Fish	(*Holocentrus ascensionis*)
Sergeant major	(*Abudefduf saxatilis*)
Striped Parrot Fish	(*Scarus croicensis*)
Bar Jack	(*Caranx rubber*)
Pork Fish	(*Anisotremus virginicus*)
Schoolmaster Snapper	(*Lutjanus apodus*)
Indigo hamlet	(*Hypoplectrus indigo*)

Zone E

The dominant sessile invertebrate species observed were sponges on the upper to mid water sections of the pier's support pilings and octocorals on the lower portion near to the seafloor. *Caulerpa sp*. predominated as marine plant species within zone E, but its distribution was confined to the sections of the pilings, which were periodically exposed by waves and tides. Where mobile organisms were concerned, reef fish were the most obvious. Fish sizes were generally greater than or equal to 10 cm in length. The types of fish observed, however, were mainly migratory schooling fish, as opposed to types that tend to remain in one general reef area.

What was peculiar about this location was that, while there was hard substrate directly under the pier, there was very little marine growth within its alignment. Indeed, the area under the pier had a very uniform contour and low rugosity. It was also relatively free of rubble and was at least 2 meters lower in depth than the adjoining reef areas outside of its alignment. These observations were reminiscent of an area that had been excavated.

Table 34: SPECIES LIST - ZONE E

MARINE PLANTS	
	Caulerpa verticillata
	Halimeda sp.
BENTHIC INVERTEBRATES	
Corals	
Brain Coral	(*Diploria* sp.)
Staghorn Coral	(*Acropora cervicornis*)
Hydroids	
Stinging Hydroid	(Sertularella speciosa)
Sponges – rope and encrusting varieties	
Pink and Red Encrusting sponge	(*Spirastrella coccinea*)
Red sieve Encrusting Sponge	(*Phorbas amaranthus*)
Scattered Pore Rope Sponge	(*Aplysina fulva*)
Octocorals	
	Carijoa sp.
	Gorgonia sp.
	Pseudoplexaura sp.
MOBILE INVERTEBRATES	
Variegated Urchin	(*Lytechinus variegates*)
FISH	
Doctor Fish	(*Acanthurus chirurgus*)
Bar Jack	(*Caranx rubber*)
Pork Fish	(*Anisotremus virginicus*)
Schoolmaster Snapper	(*Lutjanus apodus*)

3.7.3.4 Percentage Cover Reef Resources:

Within the study area, estimates of seafloor surface area covered by algal and coral indicators of reef health, as determined from area analysis made of underwater photos taken, and visual estimates made in the field, indicate coverage of approximately 20% for Coral and 70% for algae in zone A, with the remaining 10% being dominated by Zooanthids. For zone B, percentage cover was 10% for coral, 60% for algae and 30% sponges. For zone E, virtually all of the pier's shallow water supporting pilings (corresponding with the distances for zones A to C) was occupied with sponges.

3.7.3.5 Oceanography - Aerial Photo and Drogue Tracking Observations

The 1991 aerial photos of the study area and knowledge of the prevailing wind were useful in the determination of the manner in which sea currents moved in the vicinity of the Terminal. The 1991 photos were taken in the early morning, when land-derived winds from the North were dominating.

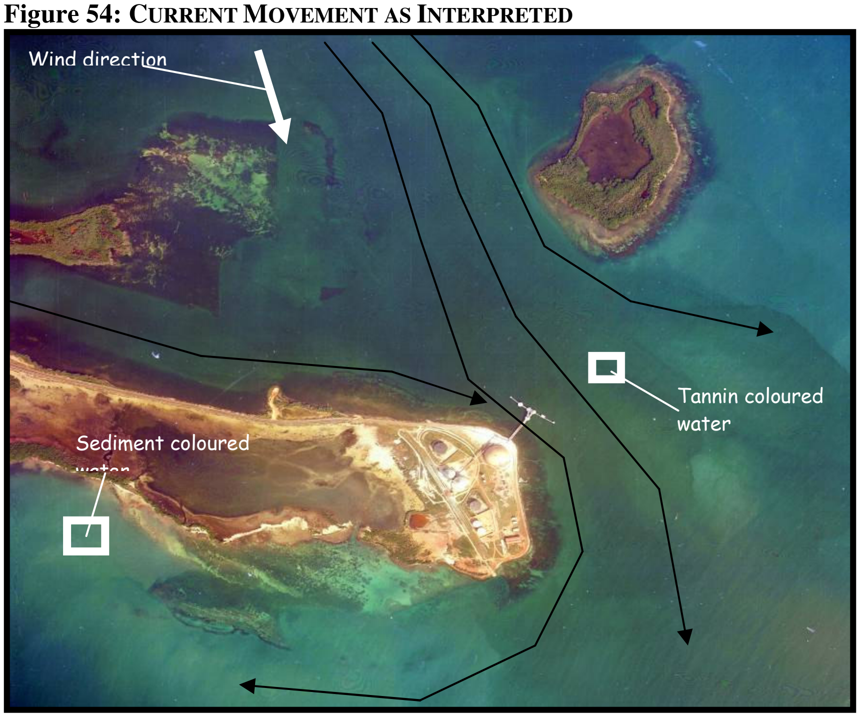
It was therefore expected that currents would be influenced by the direction in which these winds were blowing[xiii]. Two physical characters illustrated on the aerial photos were used for the purpose of confirming the influence of wind on the currents in the study area. The 1991 photos showed discharges of fresh water from wetland sources adjoining the area.

These discharges were dark brown in colour, a reflection of the presence of Tannins (phenol compounds formed from the breakdown of Mangrove vegetation[xiv]). Such coloured discharges would float on top of seawater (fresh water being less dense) and could be used to interpret surface water movement.

The photos also showed water turbidity, caused by the disturbance of seafloor sediments. This turbidity would also be moved by the currents and, like the tannin-bearing discharges, would show water movement. However, this water movement would be reflective of a greater representation of the water column. In short, tannin-bearing water would illustrate surface water movement while otherwise turbid waters would illustrate midwater and bottom current movement.

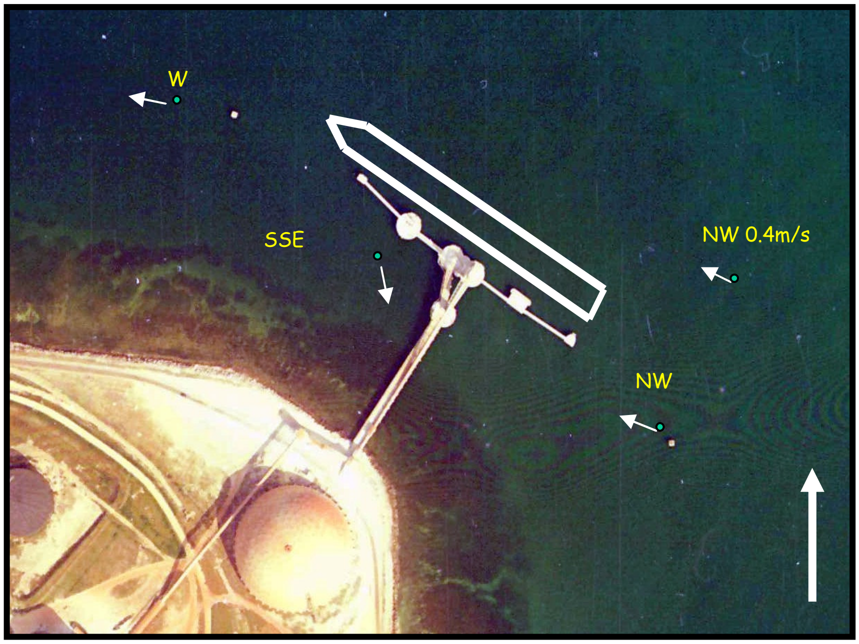
Figure 54 suggests that both water movement indicators were being influenced by the prevailing wind at the time. Contributing to the direction of movement would be the effect that the seafloor has on currents, through a process called wave refraction (The process by which a wave approaching the shore changes direction due to slowing of those parts of the wave that enter shallow water first[xv]).

Figure 54: CURRENT MOVEMENT AS INTERPRETED



Drogue measurements for both surface and deep-water currents conducted at the study site revealed movement in a direction consistent with that of the wind. Wind direction at the time of the study, however, was from the Southeast. Surface and deep-water currents were tracked moving in a west northwesterly direction, with surface currents moving at 0.4 m/s and deep-water currents moving at 0.1 m/s (See Figure 55).

Figure 55: CURRENT SPEED AND DIRECTION AS MEASURED BY DROGUES –IMAGE SOURCE SURVEY DEPT.



This direction of movement was consistent with anticipated daytime wind directions from experience. One drogue location did reveal surface movements in an opposite direction (south southeasterly at 0.08 m/s). This was interpreted to be as a result of the ship moored at the pier acting as a refracting agent for the current, causing it to bend around the bow of the vessel. There was no questioning this observation, since small boat operations in support of divers diving close to the western side of the pier was hampered by the boat consistently drifting towards the pilings.

3.7.4 CONCLUSIONS:

3.7.4.1 Reef Resources Status:

In the early 1970's, Jamaica's north coast reefs had an average live coral cover of 52%. Algae cover at the time was approximately 4%. Reef health was good at this time and this coral to algae relationship was accepted as a high standard for coral reef health. Similar studies conducted at the north coast in the 1990's revealed a significant change in the relationship, with live coral cover dropping to 5% while algae cover increased to 95%[xvi]. Factors such as land-based eutrophication of marine waters (contamination with nutrients), over fishing and tropical storm events have contributed to this drastic change[xvii].

The percentage cover results observed for the study area are indicative of a reef undergoing coral stress. The main sources of stress at this location appear to be turbidity (as indicated by the poor prevailing visibility and the proportions of sponges observed), wave/current action, causing physical reef damage and introducing turbidity causing agents, and finally, eutrophication (as indicated by the percentage cover of algae estimated).

Having declared that the reef was stressed, it was encouraging to observe the new coral growths in zones A and B of the survey area. It is anticipated that, by association and extension, that was a condition of regrowth that extended to the entire fringing reef system.

3.7.4.2 Oceanography:

Surface and deep water current movement was determined to be a factor of wind movement and, by deduction, there would be a reversal in the movement of currents past the Terminal depending on time of day, with a southerly current movement being experienced in the morning as influenced by land winds and a northwesterly current as influenced by sea winds. Obstructions in the path of the currents, passing the Terminal, such as a ship moored at the pier, could also influence current direction.

3.7.4.3 Comparison with 1996 Study

The observations made during the present study concurred with those made for the 1996 study where the general state of the adjoining reef and current movements were concerned. The current study also concluded, like the 1996 representation, that the Terminal was not apparently causing any substantial negative impacts on the marine community in the area. It was apparent that the construction of the section of the pier running through the fringing reef might have had a significant negative impact on the reef at the time.

3.7.4.4 Implications for Future Development of the Terminal

Any construction works, which will have components that will extend beyond the shoreline and onto the seafloor within zones A to C (as defined on Figure 53) will certainly have negative impacts on the fringing reef adjoining the terminal. Considerations would have to be made where the mitigation of impacts related to actual contact with, or the sedimentation of this reef area are concerned. However, as observed, the coral reef system has regenerative capacity.

3.8 Archaeological and Historical Resources

3.8.1 Summary [xviii]

3.8.1.1 Manchester

Manchester was separated from the adjoining parishes of St. Elizabeth, Clarendon and Vere in 1814, and was named after the Duke of Manchester, who was the Governor of the island at the time. The chief town, Mandeville, was named after his eldest son.

The parish is more noted for its agricultural than historic associations. Tourists frequently visit Mandeville from the United States and Canada. The courthouse is said to have cost upwards of £20,000. In the in the Parish churchyard is the tombstone of Sir William Scarlett, Chief Justice of the island from 1821 to 1832.

3.8.1.2 Clarendon

The parish of Clarendon was named in honour of the celebrated Lord Chancellor of England & Wales. The parish of Vere, now merged in it, was named after Vere, daughter of Sir Edward Herbert, Attorney General to Charles I, and first wife of Sir Thomas Lynch, who, with her two sons, died on her passage from England to Jamaica in 1683.

Carlisle Bay, the scene of the principal military engagement with a foreign foe which has taken place in Jamaica during the British occupation, is on the south-west coast of the old parish of Vere.

3.8.1.3 National Monuments[xix]

3.8.1.3.1 Clarendon

3.8.1.3.1.1 Buildings and Monuments of Architectural and Historic Interest

There are various buildings and monuments of architectural and historic interest in the parish of Clarendon. Some of these are listed below.

- Halse Hall Great House (Figure 57)
- Churches, Cemeteries, Tombs'
- St. Peter's Church, Alley
- Clock Tower
- May Pen Clock Tower (Figure 58)

3.8.1.3.1.2 Natural Site

- Milk River Spa

3.8.1.3.2 Manchester[xix]

3.8.1.3.2.1 Buildings of Architectural and Historic Interests

- Marlborough Great House, Spur Tree (Figure 60)
- Marshall's Pen Great House (Figure 61)
- Williamsfield Railway Station
- Roxborough Castle Plantation- Birthplace of National Hero Rt Excellent Norman Manley (Figure 59)

3.8.1.3.2.2 Public Buildings

- Mandeville Court House

3.8.1.4 Protected Natural heritage Sites

3.8.1.4.1 Clarendon

3.8.1.4.1.1 Natural Sites

- Mason River Botanical Station

Figure 56: LOCATION OF SELECTED HERITAGE SITES

3.8.2 Expounded Overview

3.8.2.1 Clarendon's Heritage Sites[xx]

3.8.2.1.1 Arawaks

In Clarendon, they lived in Portland Ridge (the part of the parish that juts out into the sea) as well as in the Braziletto Mountains and on Round Hill. There was also a village on the banks of the Rio Minho near Parnassus Estate and the others were on the banks of the Milk River.

3.8.2.1.2 Halse Hall Great House

Halse Hall Great House, believed to be built on the site of a house that stood on the Site of Buena Vista, was acquired by Thomas Halse who came to Jamaica with Venables. Henry de la Beche, one of its many owners was the founder of the Geological Survey of Great Britain. He made detailed Geological notes of the places he visited in Jamaica. In 1969 the estate was acquired by ALCOA, the house renovated by them. It is now the property of the National Trust.

3.8.2.1.3 St. Peter's Church Alley

St. Peter's Church, Alley, the 3rd oldest Anglican Church. Built in 1671, it became the Parish church for Vere in 1673 it was extensively damaged by the 1692 earthquake and had to be almost totally rebuilt in 1975.

3.8.2.1.4 Historic Sites and Buildings[xxi,xxii]

3.8.2.1.4.1 Halse Hall Great House:

Figure 57: HALSE HALL GREAT HOUSE[xxiii]

This is one of Jamaica's historic Houses. This architectural masterpiece is now owned and used by Jamalco. The lands on which the house was erected were given to an English officer, Major Thomas Halse in 1655 and were passed from him to Francis Sadler Halse who played a leading role in the Maroon Wars. It became a more imposing and beautiful two- storey structure in an era of security and prosperity during the late 1740s.

An elaborate arrangement of stone steps ascended to the new entrance, which was flanked by columns and capped with a fanlight. The peaked portico was added later to conform to a popular architectural style; a new wing which harmonizes well with the Great House architecture.

3.8.2.1.4.2 The Alley Church

This was built with brick and stone quoins in 1671. The Alley Church was originally a square building. The eastern end was erected and consecrated in 1872. The Alley Church is the oldest Anglican Church in the Island.

3.8.2.1.4.3 Morgan's Valley and Estate

Sir Henry Morgan, a privateer, buccaneer and former Governor of Jamaica, owned Morgan's Valley and Estate. He lived there while he was Governor of Jamaica.

3.8.2.1.4.4 May Pen Clock Tower:

Figure 58: MAY PEN CLOCK TOWER[xxiii]

May Pen Square is over 80 years old. It was constructed in honor of Dr. Samuel Glaister Bell, a renowned doctor of the parish who lost his life while crossing the Rio Minho after visiting a patient.[xxiii] . The May Pen Clock Tower is made of stone. It is approximately twenty- four (24) feet in height, eight feet (8) in width, and eight feet in length. The exact date of its erection has not been ascertained, but it appears to have been constructed after World War II.

There is an inscription on the west side of the Tower and reads as follows:

The Great War 1914-1918: Message to the Government of Jamaica

From the Secretary of State for the Colonies 16th November 1918.

Now that the war has been brought to a victorious conclusion, I desire

On behalf of His Majesty's Government, to express to the people of Jamaica and her dependencies, the mother country's high appreciation

Of the military efforts they have made, their cheerful acceptance of compulsory service in the common cause, and their

Struggle in spite of

The difficulties in which visitations of nature have

Involved them at home.

I recall with gratitude the share of men of Jamaica in

Our final victory in Palestine

3.8.2.1.4.5 St Gabriel's Anglican Church

Once called Lime Savannah Chapel, was the "daughter" Church of St. Paul's in Chapelton. When the Church of the White Cross fell into disuse, St. Gabriel's took its place.

3.8.2.1.4.6 St. Paul's Church- Chapleton

When the present parish of Clarendon was divided into the parishes of Clarendon and Vere, the Cross church was then the parish church of Clarendon. St. Paul's was built as a chapel of Ease to the Cross Church, and was the first place of worship erected in Upper Clarendon. It was originally known as "the Chapel". It took the name from the church, being called "Chapel Town," and in the course of time shortened to its present form, Chapleton.

Of special note is the area covered by the Special Exclusive Mining Lease (SEML) in northern Manchester. The candidate human settlements located in the SEML and villages which could be directly impacted by bauxite mining are as follows:

- Derry
- Green Vale

- Halifax
- Bethany
- Chudleigh
- Sedburgh
- Malton
- Greenhill
- Waterloo
- Heavitree
- Medina
- Keynsham
- Clones
- Hibernia
- Ballynure
- St. Paul's and
- Devon

3.8.2.2 Manchester's Heritage Sites[xxiv]

Here the two most prominent landmarks are the Georgia style Courthouse and the parish church. Both were built in the 1820's.

The police station Christiana dates from 1896

3.8.2.2.1 Manchester Parish Church

This is an Anglican Church which was opened in 1820. The chancel and timber clerestory and tower were added later. For many years this was the only church in the parish. During the slave rebellion of 1823 the organ loft was used as a jail. Members of the parish council used to have their meetings in the Vestry before the Parish Council Chamber was built.

3.8.2.2.2 Mandeville Hotel

This building is located on Hotel Street. It was originally the barracks for English troops when Mandeville was a garrison. Many of these troops died in a yellow fever outbreak and were buried in the eastern part of the parish Churchyard. After the troops left in the 1890's, the building was used as a hotel. This was first called the Waverly and later; Brooks hotel under a Miss Jane Brooks and finally the Mandeville hotel. The hotel is now owned and operated by the McIntyre family.

3.8.2.2.3 Mandeville Jail & Workhouse

They were among the first buildings erected in the parish. The police station is now housed there.

3.8.2.2.4 Mandeville Courthouse

Located in one side of Mandeville Square, the Mandeville Courthouse is a good example of indigenous architecture. Built of limestone blocks cut by enslaved people, it was completed around 1820 and was one of the four original public buildings in the town. The first school in the parish was held on the ground floor of this building.

3.8.2.2.5 Roxborough

Figure 59: ROXBOROUGH CASTLE PLANTATION[xxiii]

Birthplace of National Hero, the late Rt Excellent Norman Manley. During the late Nineteenth Century, Thomas Albert Samuel Manley, father of Norman Manley, purchased part of the property. On the 4th of July 1893 Norman Manley was born on the property .He lived there until 1903 when his father died .The house was destroyed by fire in 1968. Currently only the foundation remains. The Manley family left Roxborough to live in Porus at the turn of the century, they moved to their Belmont property at Guanaboa Vale. In the last decade however, their bodies were exhumed from Porus and re-buried there. This property was originally part of an estate recorded as "Roxboro Castle". The Jamaica National Heritage Trust proposes to restore the building.

3.8.2.3 Churches

3.8.2.3.1 The Bethany Church

This offers a majestic view of the Don Figueroa Mountains and Mile Gully Valley. It is located in the SEML and could be impacted on by mining.

3.8.2.3.2 The Mizpah Moravian Church

The Mizpah Church which dates from 1866 is also set on a hill. Its name as well as that of the surrounding community was given by its first priest, Theodore Sondermann. Mizpah means: "the Lord watches over us". Sondermann left for Europe with the church uncompleted, though he hoped to return. He died in Europe, however and it was left to Swiss missionaries and Surveyor Heinrich Walder to complete the church. It is probably due to this that the church resembles an alpine chalet.

3.8.2.3.3 Marshall's Pen and Marlborough

Traveling though Mile Gully towards Balaclava, one can see the remains of what was once a handsome church even in its state of disrepair the old beauty can be seen.

Figure 60: MARLBOROUGH GREAT HOUSE, SPUR TREE[xxiii]

Certain cemeteries, some associated with churches represent significant historical heritage resources. Some of these include for example:

Clarendon

The principal tombs in Vere Church

3.8.2.4 Great Houses of Manchester

3.8.2.4.1 Marshall's Pen Great House:

Figure 61: MARSHALL'S PEN GREAT HOUSE[xxiii]

This is set on a large 300-acre farm, with a colourful bird sanctuary and hiking trails.

The design of Marshall's Pen Great House features Spanish walls and louver windows. It is a sturdy square building with a gabled red roof. There have been many additions to the main building but these have not compromised its integrity.

The outbuildings are made out of cut stone and one of them boasts an outstanding chimney. The coffee storage house has been converted into a quiet cottage. A modern upper floor has been added and a walkway constructed across the barbecue, which still stands providing evidence that the property was engaged in the production of coffee.

To the east of the barbecue is the former coffee mill, and the central port of the old wheel is still in position. The coffee factory has been converted into a guest house, the upper floor having been converted into bedrooms for visitors who go there for "ecotours", in particular, bird watching.

Marshall's Pen Estate dates back some two hundred years to the first Provost General of Jamaica. It was originally a cattle property, hence its name. In 1755, the property was purchased by the Earl of Balcarres who was then Governor of Jamaica. In 1853, the property was purchased from the Earl of Balcarres by the Muirheads . It stopped producing coffee about 1838when coffee came under stiff competition from Brazilian coffee. It was then sold to the Suttons in 1939. The property is presently owned by Robert Sutton and his wife Ann.

Marshall's Pen is also rich in archaeological significance as it was once a Taino site.

3.8.2.4.2 Kendal Great House

This is now owned by a church group. It is available for conferences and camps.

3.8.2.4.3 Plinlimon Great House

Plinlimon Great House is owned by Alumina Partners of Jamaica. It has been converted into a community centre by the company and donated to the community of Pear Tree, South Manchester.

The Plinlimon House overlooks what used to be the major highway from Kingston to Westmoreland. It has, almost intact, many of the features which made it an outstanding building scores of years ago.

3.8.2.4.4 The Albion Great House

Located on the property of the same name, is only recognizable by the walls, which are still standing, and the gate pillars, which can be seen at the entrance to the large yard. Huge cut stones still held in place by mortar comprising white lime and red earth, speak eloquently of the grandeur of bygone days. Under a massive old cotton tree, numerous mounds of stones hint at the presence of a burial ground for enslaved people.

3.8.2.4.5 Bloomfield Great House

Bloomfield Great House is situated on a property formerly known as the Bloomfield Estate. It precedes the formation of the parish of Manchester. In fact, the Mandeville Square now stands on land donated by four estates one of which was donated by Bloomfield.

The property passed through many phases of development being operated in the past as coffee plantation, a citrus plantation, cattle rearing farm and a dairy. The property was even at one time leased to Willing Mullings who used the Great House to operate a small hotel for a number of years. In 1925, the property was purchased by Guy Winchester Harris, who effected a number of changes to the building which housed the hotel. The property was sold in 1962 to Richard Harris who operated a dairy. The majority of the land was again sold in 1966. In 1972, Guy Barrington Grant purchased the property on which the Great House now stands. Today, the property is operated as a Restaurant and Gift Shop.

3.9 Noise Levels and Vibration

3.9.1 Mining

During mining operations, it is anticipated that the potential for noise impact will come primarily from the utilization of heavy equipment and blasting (where necessary). Because of the location of Jamaica's bauxite deposits atop limestone deposits, it is usually easy to access the ore by simply removing the overburden.

Noise will be generated by heavy equipment and machinery, however, the identification of bauxite deposits in the proposed mining area in North Manchester makes it difficult to predict the closeness of residents to mining activities. What is known is that Jamalco has a noise management policy that has governed its mining operations in Jamaica for many years which will continue to be implemented.

Monitoring of nearby residences and communities will be undertaken as necessary to collect both baseline noise level data and measurements to ensure that the residential limit of 70 db(A) is not exceeded. All complaints related to noise will be addressed as Jamalco is committed to complying with the regulations.

3.9.2 Refinery

Since the refinery is an active facility, it was possible to commission an audiometric survey to assess the baseline noise and vibration levels of its Halse Hall operations and the potential noise impact on the adjoining residential communities of Cornpiece and New Bowens.

3.9.3 Audiometric Survey

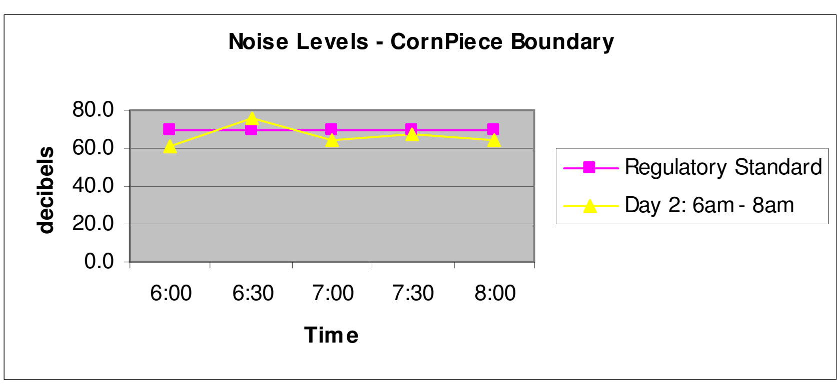
The audiometric survey was conducted at the property boundaries adjacent to the residential communities of Cornpiece and New Bowens to determine baseline noise levels during normal operation of the refinery. These locations were selected as they represented the closet points on the refinery boundaries to residential communities which would be major receptors.

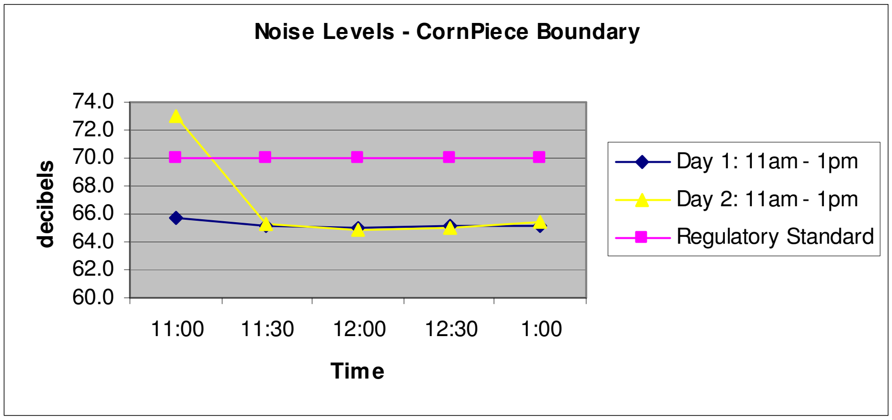
The refinery is bounded on the north by the community of New Bowens, on the east by the Brazilletto Mountain range, Cornpiece to the south and the Hayes main road and red mud lakes to the west. The more conservative residential noise standard of 70 decibels was used to determine if noise from the facility would impact on residents of the nearby communities.

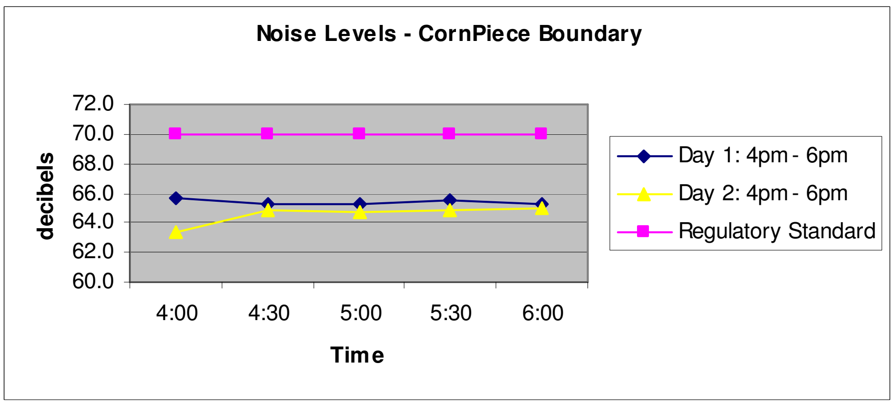
The audiometric survey was conducted using handheld digital audiometers, calibrated each day of the survey. Noise levels were measured over a two (2) day period at two (2) hour intervals, from:

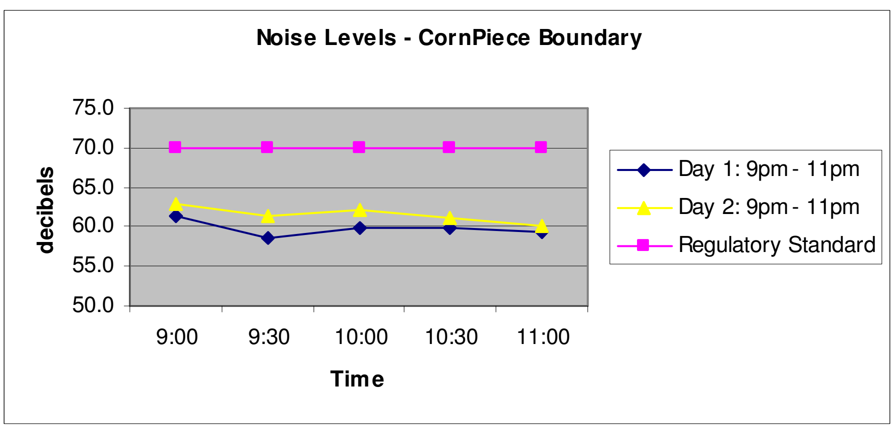
From	To
6:00 am	8:00 am
11:00 am	1:00 pm
4:00 pm	6:00 pm
9:00 pm	11:00 pm

These intervals were selected because they coincided with shift changes and active periods at the facility. This is a very conservative approach as any noise from the plant measured at the property boundary would further dissipate as it approaches the closest residence in the community. Samples collected at the facility boundary with the Cornpiece community are graphed in relation to the regulatory standard and are presented below:



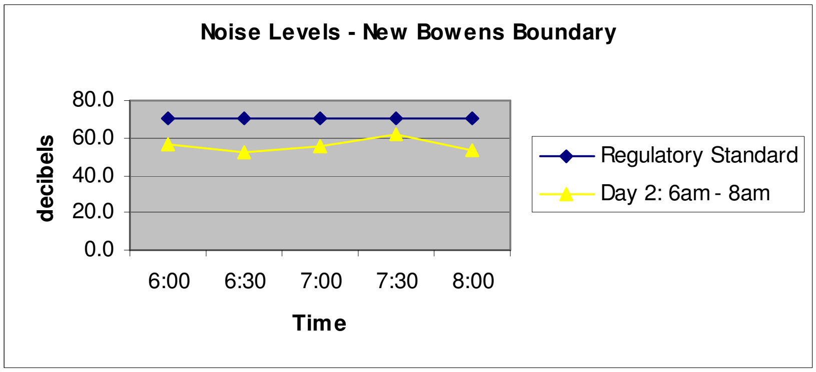


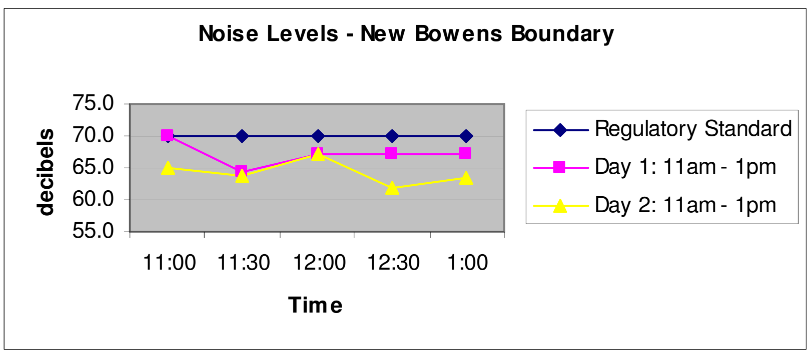


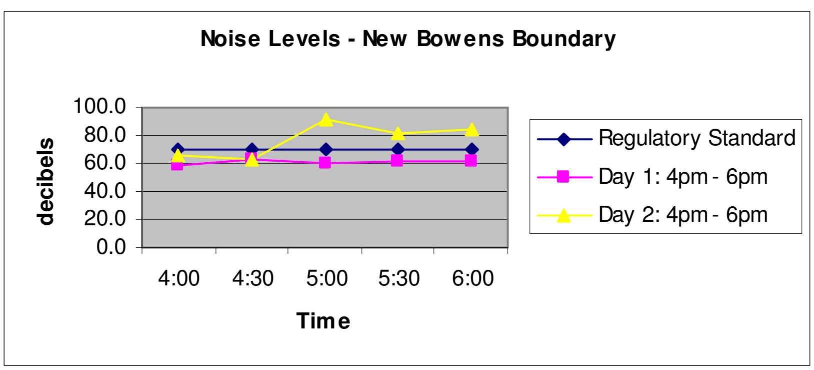


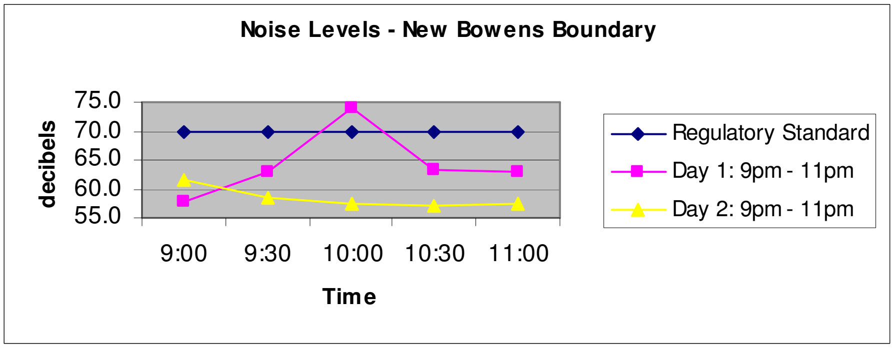
The northern boundary of the community of Cornpiece is located just outside the southern gates of the refinery. The results of the audiometric survey indicate that along the facility boundary with the Cornpiece community, the noise levels are consistently between 58 db and 66 db. Two readings recorded above the residential standard were taken specifically as heavy equipment (crane) was passing by the sampling area. Data recorded as the train passed by did not exceed the residential standard.

Simultaneously, data was collected at the northern facility boundary closest to the community of New Bowens. Data collected is presented graphically below:









The closest residents of the community of New Bowens is located less than ½ mile to the north of the Jamalco refinery boundary. The northern facility boundary is located next to an access road to the facility where there is intermittent truck traffic from the Hayes main road into the plant. The movement of trucks during the assessment was recorded to specifically ascertain the momentary impact. The results from the noise survey at the northern boundary indicates that generally the facility maintains a noise level between 52 db and 70 db, however, as trucks move along the property boundary noise levels increase momentarily (measured as high as 91 db). Due to the distance of the New Bowens community from the plant it is unlikely that these momentary increases in noise will carry to the closest residences at or above the 70 db residential standard.

Generally, the data shows that noise during normal operation of the refinery is presently not a major issue and while there may be increases during construction, it is not anticipated that these increases will have a negative impact on residents if measured in the communities.

3.9.3.1 Port

The Rocky Point Port is located on a remote peninsula in Colon Bay. The loading and offloading of vessels is not a noise intensive activity, the greatest noise potential is the train which transports alumina to the port and other commodities from the port to plant. However, there are no residences within 2 km of the port. It is not anticipated that the upgrade will have a major negative impact on noise levels at the port.

3.9.4 Vibration Analysis

Vibration analysis studies previously conducted to determine the impacts of vibration on the surrounding communities inclusive of the northern rail corridor, the plant and the southern rail corridor to the port, have proven to be inadequate.

To derive truly conclusive scientific data a detailed program of investigation should be developed and implemented on an objective basis using scientifically approved criteria and techniques.

Sufficient vibration data should be generated which would be subjected to rigorous statistical analysis over all operational conditions. This should also take into account other factors in the environmental baseline which may contribute to the introduction of errors and inaccuracies in these observations.

Based on consultation with residents of the community, where concerns were raised about existing impact from vibration, the consultant recommends that Jamalco include periodic vibration measurements in its monitoring programme.

Baseline data should be collected prior to commissioning of the efficiency upgrade so that changes caused by the upgrade (if they were to occur) could be measured against that baseline. In addition, these measurements should be taken along the rail corridor as well as within communities which may be impacted.

3.10 Natural Hazard Vulnerability

3.10.1 Natural Hazard Vulnerability - Clarendon

3.10.1.1 Flooding

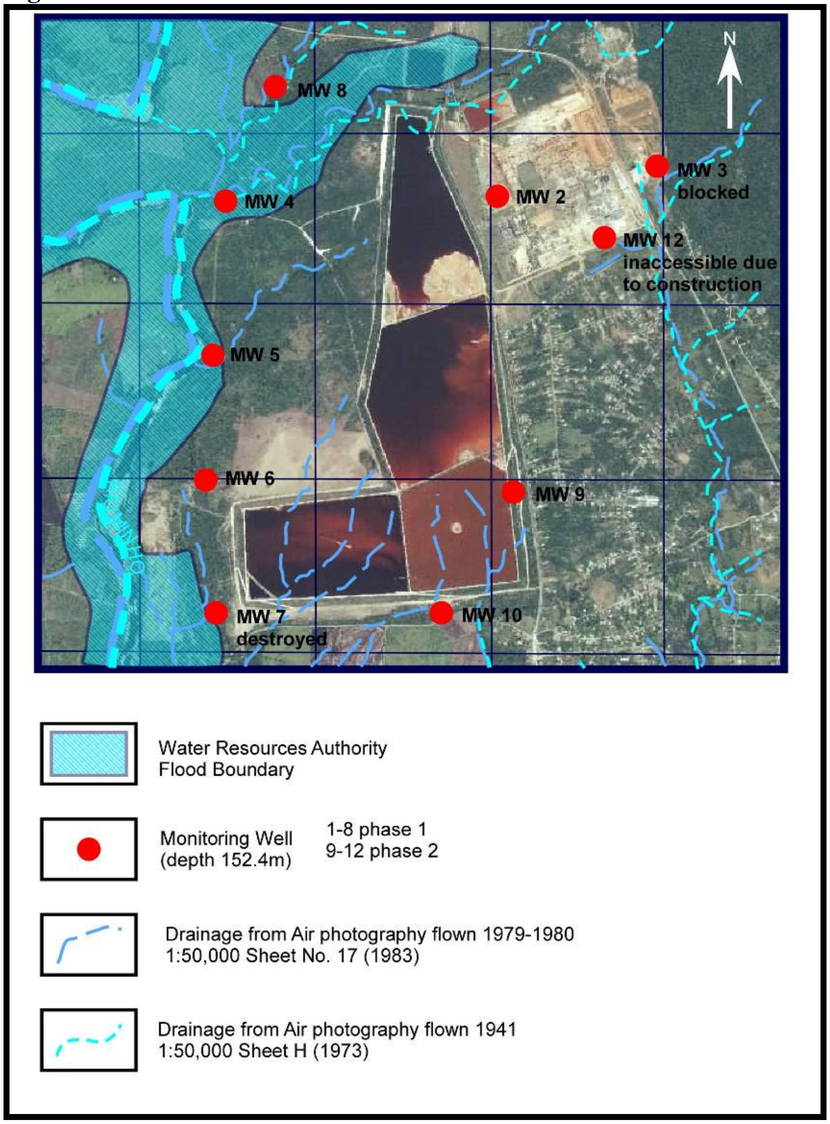
Specific records of flooding in the Rio Minho floodplain date back to 1886, reported in the Tri-Weekly Gleaner, June 19, 1886 (Rowe, 2004, in preparation), when heavy rains in June of that year led to what was believed to be the worst flooding on record for that river. The river was 40 ft (12.2 m) deep at the May Pen bridge, some 4 ft higher than the previous record, and did immense damage to roads and property. Affected localities included Halse Hall and Parnassus and Caswell Hill.

The worst flood event of the 20th century occurred in 1986, when rainfall within the Rio Minho catchment caused the river to overflow its banks to cover wide areas of the Rio Minho Alluvial Fan. The approximate extent of this flood event is inserted on Figure 6. According to the Water Resources Authority, this event had an estimated return period of 100 years.

The most notable feature of the flood water extent is that north of Kemps Hill the flooding was confined to a relatively narrow floodplain, whereas south of Kemps Hill the flood waters spread out over a wide area. This is a reflection of the fact that the river is incised into the upper part of the fan, while in the southern, Vere Plains part, it is not. It is suggested that this may be a function of continuing movements along the South Coast Fault.

With respect to the plant and RDA area (Figure 62), the risk from flooding is low, due to the fact that these are constructed on the high terrace of the well-drained, relatively thin Hayes Gravels. During the June 1986 flood event the only part of the plant that was flooded was the low-lying storm lake at the northern end of the RDAs.

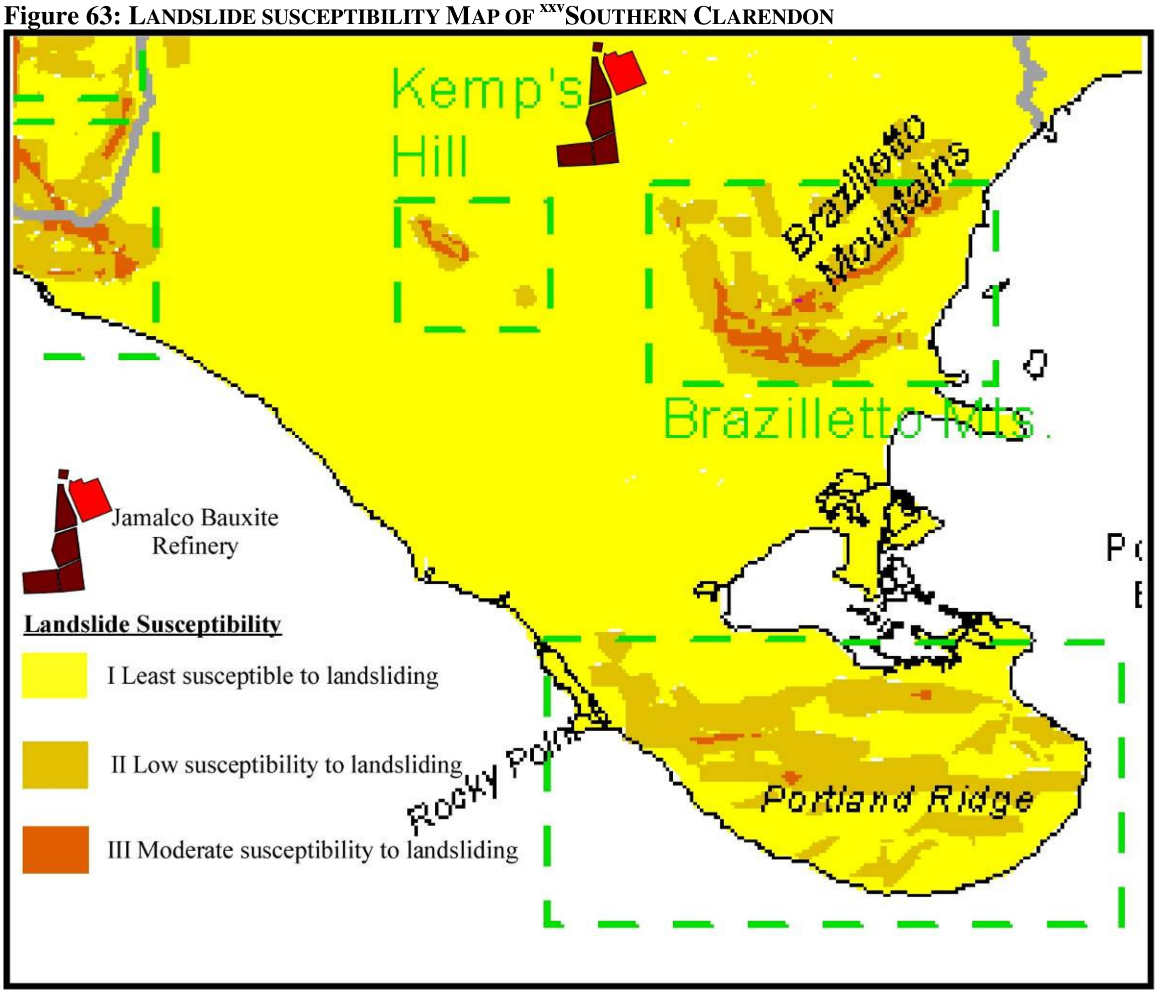
Figure 62: 1986 FLOOD BOUNDARY AND MONITORING WELLS AT CLARENDON ALUMINA WORKS



3.10.1.2 Landslides

There appear to be no historical records of landslides in the district. While no detailed assessment of the landslide susceptibility has been carried out in southern Clarendon to date, the landslide susceptibility map of southern Clarendon (Figure 63) indicates low susceptibility levels at Hayes. This can be attributed to the flat lying nature of the topography, the presence of fairly easily drained alluvial soils, and the relative dry climate.

Figure 63: LANDSLIDE SUSCEPTIBILITY MAP OF [xxv]SOUTHERN CLARENDON



The design and construction of the dykes impounding the present RDAs appear to be sound, with no reports of slumping or collapse. The slopes of the dykes are subject to erosion from rainfall, taking the form of vertical runnels. The attempts to control or reduce this erosion through the planting of grass, appears to be successful where the grass has caught. On the east-facing slopes the grass cover is well-developed (Figure 64). On other slopes the cover is still incomplete.

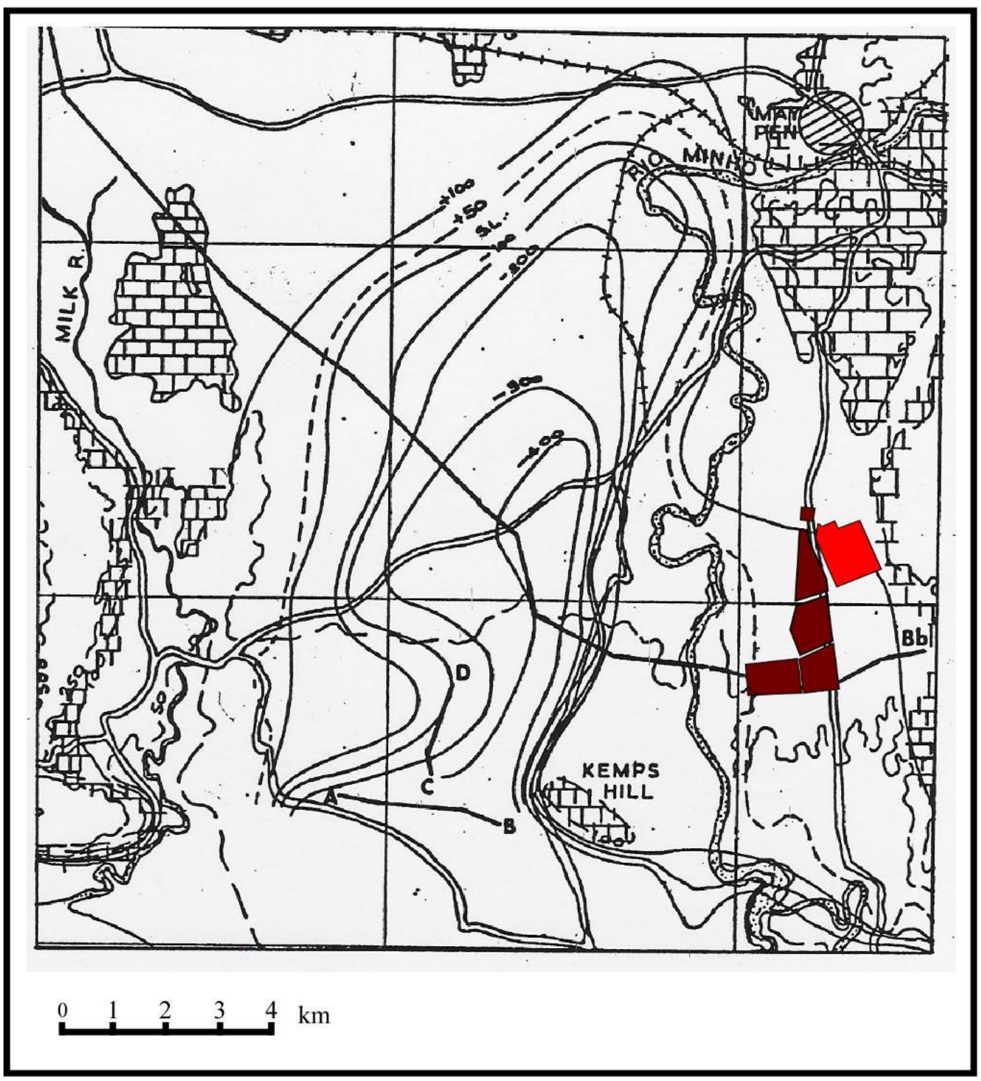
Figure 64: GRASS COVERING SLOPE OF DYKE OF RESIDUE DISPOSAL AREA.

3.10.1.3 TECTONICS AND FAULTING

3.10.1.3.1 Tectonic History

The tectonic history of the Clarendon Plains includes block faulting in the surrounding limestone uplands, producing the half graben in the limestone bedrock underlying the plains (Figure 65). This fault activity probably continued during the earlier stages of the formation of the alluvial fan complex. It is likely that the southern Clarendon Plains are experiencing gradual subsidence in recent times.

Figure 65: CONTOUR MAP SHOWING LIMESTONE ELEVATIONS UNDER PLAIN (ELEVATIONS IN FEET ABOVE SEA LEVEL).[xxvi]



3.10.1.3.2 Location of Faults

The distribution of faults on Figure 6 is derived from Geological Sheet #16, May Pen (1974), the earlier 1:250 000 scale geological map of Jamaica (1958) and Charlesworth (1980). The Rio Minho alluvial plain appears largely unaffected by faulting, but as these are superficial deposits it is unlikely that any faults can be identified by surface mapping. Two sets of faults have been mapped within the limestone. One set has a general ENE-WSW trend, while the other set trends roughly N-S. The effects of this faulting and the age relationship with the alluvial plain are uncertain. However, the variability in depth to bedrock (Figure 65) suggests the presence of N-S trending faults in the bedrock which have controlled the thickness of alluvial sediments (e.g. the Kemps Hill fault, Figure 6; Charlesworth, 1980). These faults may even extend up into the lower part of the alluvial cover, although there is no direct evidence for this. The ENE-WSW trending set is truncated by the alluvium, indicating that the faulting pre-dates the deposition of at least the more recent alluvial material. These faults probably are also continuous beneath the alluvial cover.

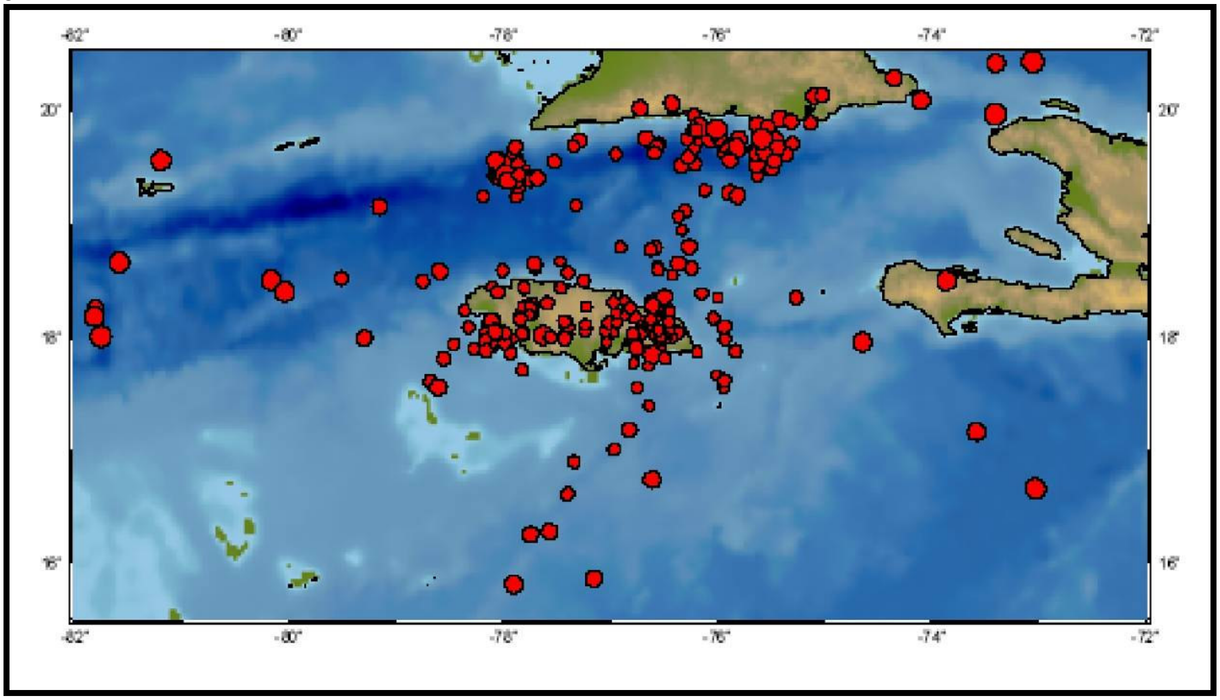
The southern part of the alluvial plain, south of Kemps Hill, contains thicker alluvial deposits and this difference in thickness appears to be controlled by the E-W trending South Coast Fault, a well defined feature which extends from Great Pedro Bay in St. Elizabeth a distance of approximately 60 km, through the Brazilletto Mountains in southern Clarendon and beyond (Figure 6). That this fault is still active is strongly suggested by the existence of the radioactive mineral springs that occur at Salt River and Milk River (Zans et al., 1963).

3.10.1.4 Seismic Activity

3.10.1.4.1 Regional

Jamaica lies in the seismically active northern plate boundary zone of the Caribbean Plate (Draper et al., 1994 and Figure 66). High magnitude earthquakes originating from as far away as the south coast of Cuba may be felt in Jamaica. For example the Cabo Cruz earthquake of magnitude 6.9 which occurred in May 1992 was felt with intensity 4 in Kingston, Jamaica. The 1993 earthquake of magnitude 5.4 which originated in Jamaica was felt in Cuba with intensities of 3-4. No damage was reported in either case from the distant country (pers. comm. M. Grandison).

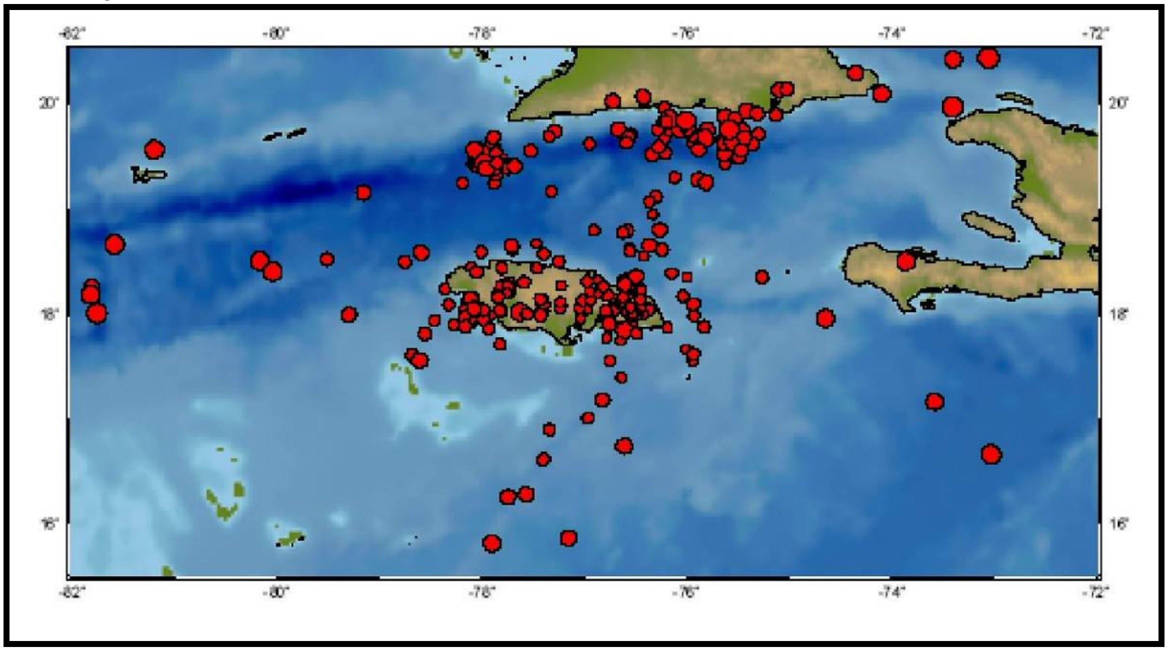
Figure 66: EPICENTRES OF EARTHQUAKES OCCURRING BETWEEN 1998 AND 2001 IN THE VICINITY OF JAMAICA[xxvii]



3.10.1.4.2 Local

Figure 67 is a map of Jamaica showing the epicentres for earthquakes that occurred in the period 1998-2001. No local earthquakes of these magnitudes occurred in the vicinity of Hayes, although there is one located on the trace of the buried South Coast Fault.

Figure 67: EPICENTRES OF EARTHQUAKES OCCURRING BETWEEN 1998 AND 2001 LOCATED IN AND AROUND JAMAICA[xxviii]



An investigation of the historical records carried out for an earlier EIA for the Hayes plant and RDAs (Conrad Douglas and Assoc.) of seismic activity in this area has shown that the adverse effects of earthquakes have been experienced there:

"The well-documented 1692 Port Royal earthquake had disastrous effects in the Lower Vere Plains, with modified Mercalli intensities of MM(X) being experienced in Alley and Salt River, both of which lie at about a 10 km radius from the study area.

The following quote from a newspaper clipping written by the local Rector illustrates: "all brick and stone building were thrown down and water spewed out of the chasms opened in the ground by the earthquake so that even dry gullies ran water". The St. Peter's Anglican Church in Alley built in 1671 was destroyed beyond repair. However, the Halse Hall Great House, where alluvial thicknesses are comparatively low, survived the 1692 earthquake, as well as subsequent ones."

The Great House (now the property of JAMALCO) is situated about 6 km to the north of the JAMALCO alumina plant, and perhaps, more significantly, lies on the well-drained Hayes gravels, well above the water table.

"Subsequent damaging earthquakes are, most notably, those of 1907 and 1957. The 1907 earthquake appears to have caused some damage in the Vere Plains. Intensities of MM(VII) were reported in Alley with incidence of damage to chimneys and buildings (Tomblin & Robson, 1977). The 1957 earthquake had intensities of MM(IV) to MM(V) in the Lower Vere Plains (Robinson *et al.,* 1959). In each 50-year period, starting with 1991 and counting backward for four 50-year cycles, at least one damaging earthquake, of MM(VI) or higher, has occurred in the area. Shepherd (1971) reported that Lower Vere had a frequency of 5-9 damaging earthquakes per century on average.

Compared to the rest of Jamaica, the study area is not in a very active zone. However, the Vere Plain is largely built up of alluvial clays, sand and gravel, and in the presence of ground water, this material will be susceptible to liquefaction in an earthquake of high enough intensity. Thus, the height of the water table will be an important factor in determining the area's earthquake risk.

3.10.1.5 Conclusion

- The geotechnical characteristics of both the limestone bedrock and the overlying Hayes gravel are suitable for continued expansion of plant facilities and additional RDAs.

- The risk of flooding is minor, except for the area immediately north of the present RDAs.

- The plant and RDA areas are unlikely to experience landslides.

- The present design of the dykes impounding the RDAs appears to result in stable structures. The planting of grass on the dyke slopes to combat erosion is successful where the vegetation has caught, notably on east-facing slopes.

- Seismic activity is low in the immediate vicinity of the plant, but more distant, high magnitude events are likely on a multidecadal scale. These should not pose a problem through liquefaction.

3.10.2 Natural Hazard Vulnerability - Manchester

3.10.2.1 Flooding

Although flooding has occurred in the limestone regions of Manchester Parish in times of unusually heavy and/or prolonged rainfall (e.g. at Porus, Harmons and Content in 2002), there are no historical records of flooding in the proposed mining area. There is no surface drainage.

3.10.2.2 Landslides

There appear to be no historical records of landslides in the district. However, the near vertical slopes on some limestone hills bounded by faults or with mature karst topography makes such slopes susceptible to rock falls. Also, on steep slopes where cultivation has resulted in soil erosion there is the potential for the accumulation of screes, which could become unstable.

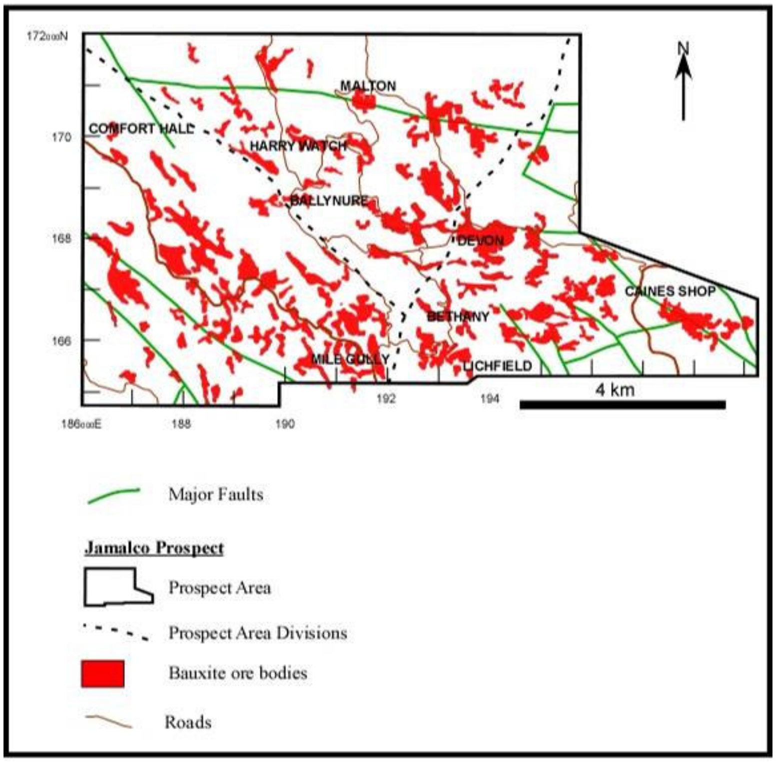
3.10.2.3 Tectonics and Faulting

3.10.2.3.1 Tectonic History

The highlands of northern Manchester are in the structural form of a syncline of which the axis is centred more or less along the depression of Mile Gully. This structure is named the Kendal-Porus Trough (Zans and others, 1963). This suggests that the relief of the area, following the structure, is relatively young geologically. Uplift of Jamaica above the sea occurred in this region within the last 10 to 25 million years (Hill &Ostojic, 1982), perhaps significantly less.

3.10.2.3.2 Location of Faults

Figure 68: FAULT MAP OF JAMALCO OF THE JAMALCO MINING PROSPECT AREA IN MANCHESTER.



The distribution of major faults on Figure 68 is derived from Geological Sheets 9 and 12 of the Mines and Geology Division (1974). Major fault trends are northwest – southeast, the same as the axis of the Kendal-Porus Trough.

3.10.2.4 Seismic Activity

3.10.2.4.1 Regional

The likely importance of high magnitude earthquakes, originating from as far away as the south coast of Cuba has been discussed in the previous section on regional seismicity.

3.10.2.4.2 Local

Local earthquakes occur but are unlikely to affect mining operations.

3.10.2.5 CONCLUSIONS

- The type of limestone does not directly affect the nature of the bauxite deposits. Other factors, such as height above water table, elevation and position on fault blocks may also play a part in ultimate quality of the bauxite.
- There appear to be no impediments from a geological standpoint, to mining bauxite in the proposed area of northern Manchester Parish.
- The mining operation is not likely to encounter problems any different from those experienced in the present mining areas.
- A more complete appraisal will require detailed geological and orebody mapping to determine slopes of mined out orebody faces, extent of brecciated zones in the limestone, etc.

PROJECT DESCRIPTION

4 Project Description

4.1 Background

Established in 1963 as a bauxite mining and shipping operation, Alcoa Minerals of Jamaica, a subsidiary of Alcoa International, operated bauxite mines at Teak Pen at Woodside then later to Mocho Clarendon and transported the bauxite by rail to Rocky Point Clarendon where it was dried, temporarily stored in a dome and shipped to the United States of America for further processing

In 1970 Alcoa commissioned, a 500,000 ton per year alumina refinery located in Halse Hall, Clarendon, with one of its most outstanding features being a sealed tailings impoundment pond (residue disposal area) which became the standard and hallmark for bauxite residue management and disposal in Jamaica.

The refinery operated continuously until 1985 when it was temporarily closed due to low demand for alumina on the world market. However, it re-opened firstly, as Clarendon Alumina Production (CAP) under lease from Alcoa, and finally in partnership with the Government of Jamaica (GOJ) as JAMALCO. Since that time the refinery has undergone successive incremental increases in capacity leading to its present production capacity of 1.25 million tonnes per year.

Alcoa and Jamalco have established a 40 year baseline of operation in bauxite mining, alumina production and shipping in Jamaica and in this regard has been a responsible corporate citizen operating within local and international guidelines, policies, legislation, regulations as well as their own stringent internal environmental, health and safety guidelines and standards.

4.2 The Bayer Process

Jamalco proposes to continue using the conventional Bayer process invented by Austrian Karl Joseph Bayer in 1888 and patented by him in the same year. This process is essentially an extractive hydro-metallurgical process that belongs to the alkaline series of extractive processes and involves the use of caustic soda at elevated temperature to extract the hydrated aluminum hydrates from bauxite to generate alumina and sodium aluminate solution and water. This is followed by decomposition or precipitation of the alumina hydrate solution in precipitators to produce alumina tri-hydrate in the form of the American sandy alumina. The tri-hydrate is then washed and finally passed to calciners where water of free moisture of crystallization is driven off at high temperatures. Calcined alumina is stored in silos from which it is unloaded into rail cars and transported to the port, Rocky Point, from where it is shipped to alumina smelters overseas.

Caustic soda is recovered, concentrated in evaporators and reused in the process of digestion or extraction. The process is a cyclic, closed loop system where there is minimal loss or waste of material. At the same time there is concentration or accumulation of alumina and other values.

The bauxite residue, which is insoluble in caustic soda, plus other materials found in the process such as calcium compounds and phosphates are then transported in the form of a residue slurry to a bauxite residue impoundment lake known as a residue disposal area (RDA). In this area, the supernatant liquor is collected and pumped back to the plant using bottom drain techniques for recycling or reuse.

Of the materials and chemicals used in the bauxite/alumina process, only bauxite and alumina are specific to the Bayer process. All other chemicals and materials that are found in the process are found in many other industries in Jamaica and the world.

The mining operations as well as the refinery are operated continuously on a three shift, 24 hour basis. The plant is stopped only for major scheduled maintenance. The major processes are supported by various ancillary services, including co-generation of electricity for the production of steam used for heating the plant processes. Electricity is generated through power houses based on fossil fuels, in this case, bunker-c oil.

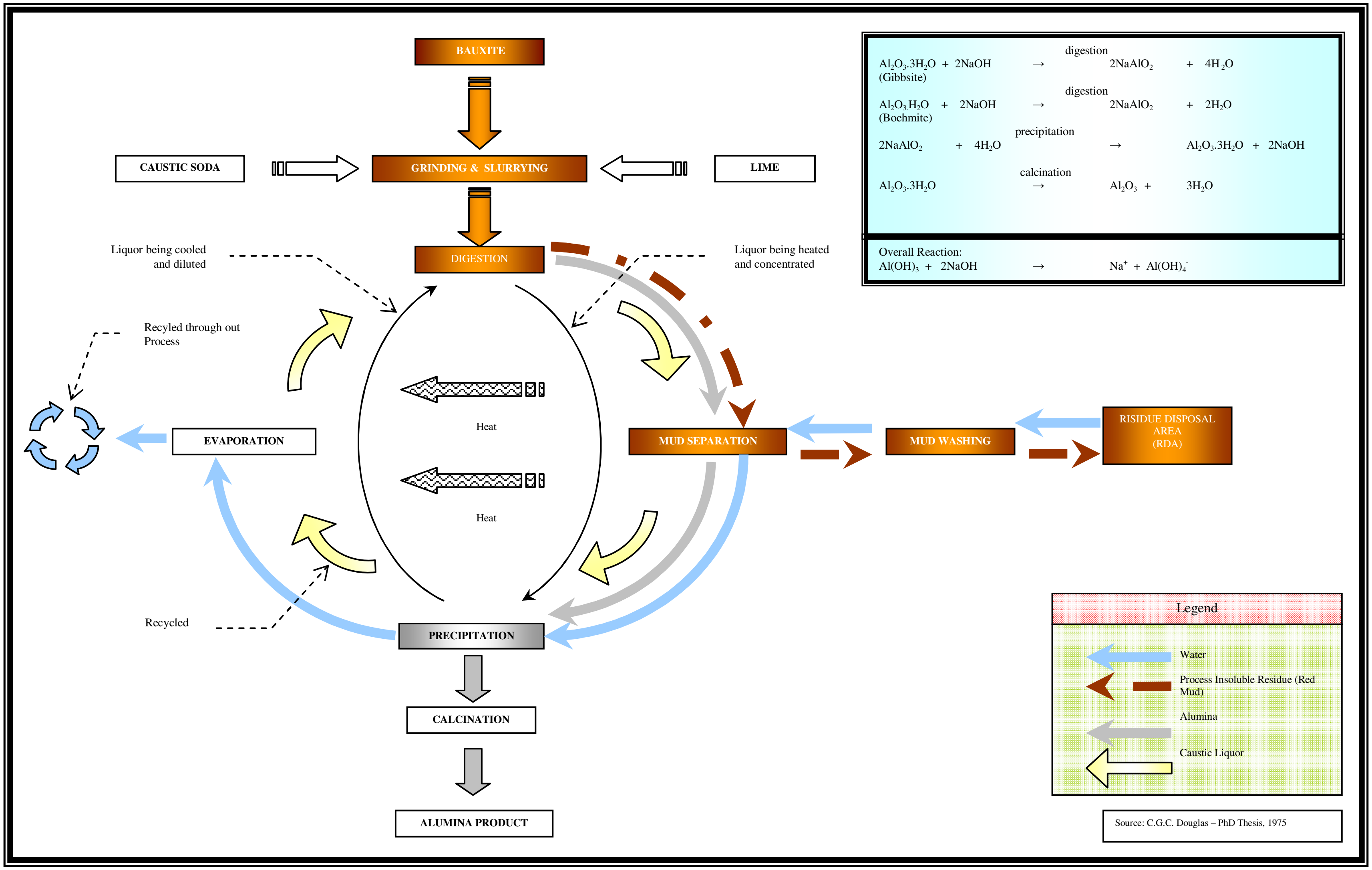
Additionally, there are service activities in support of the major processes. This includes water supply and treatment for the facility including the power plant, transportation services for movement of products, primarily by rail.

The process is designed and operated so that particulates and other emissions are kept under control and within regulatory limits through the use of cyclones, bag buses, and electrostatic precipitators, with the particulates collected recycled within the plant to increase efficiency and lessen environmental impacts.

The overall Bayer process is illustrated graphically in the flow sheet included as Figure 69 which shows the major unit operations of the process from mining, to grinding and alumina calcination, pre–digestion, pre-desilication, to bauxite storage, digestion, mud separation, mud washing and residue tailings disposal and storage. In order to meet the proposed increased capacity of the upgraded refinery, a new residue disposal area will be constructed using “Thickened Tailing Disposal” technology as an integral part of the system. Figure 69 also shows precipitation, evaporation, recycling of the caustic aluminate liquor for digestion, hydrate washing of the precipitated alumina, followed by calcination, storage, transportation by rail to the port and shipping from the port in 56,000 tonne vessels to various smelters.

At the port, the existing loading mechanism will be upgraded to accommodate these larger capacity vessels; these will have built-in efficiencies to minimize potential environmental impact through spillage.

Figure 69: BAYER PROCESS SCHEMATIC[xxix]



4.3 The Proposal

The proponent of the project, JAMALCO proposes to improve the efficiency of the plant by upgrading its capacity by an additional 1.55 million tonnes per year to bring it to a total annual output of alumina of 2.8 million tonnes per year. This upgrade of the facility will involve minor changes to the port as illustrated in Table 35, additional equipment at the plant refinery as shown in Table 36 and changes to the mine areas (new areas of mining and existing mining areas) as indicated in Table 38.

Table 35: PROPOSED UPGRADE CHANGES - PORT

Item	Change
Dolphin	Reinforcement to accommodate larger vessels.
Ship Loader	Increase height by 5 - 10 feet.
Rail Line	Lay additional rail line to facilitate the maneuvering of a string of alumina cars.
Storage Capacity	No change.
Maintenance Dredging	To increase depth at port by 4.5 to 5 feet.
Heavy Equipment	Will be delivered at port during construction and transported to plant for installation.

Table 36: PROPOSED UPGRADE CHANGES -REFINERY

Process Area	Expansion Equipment	Quantity
Bauxite Grinding	Mills	3
	Storage Mills	4
	Tanks	3
Bauxite Slurry Storage Tank	Storage Tanks	2
	Heat Exchangers	8
Digestion	Digester units(1.1M Tonnes/ yr)	1
	Tanks	35
	Heat Exchangers	39
Clarification	Clarifiers	16
	Filters	10
	Other Tanks	3
	Heat Exchanger	1

Table 37: PROPOSED UPGRADE CHANGES –REFINERY - CONTINUED

Precipitation	Tanks	56
	Filters	8
	Heat Exchangers	6
Calcination	Calciners	2
	Tanks	2
	Bins	1
	Stack	1
Power House	Boilers	2
	Turbine	1
	Stack	1
Other Tanks Plant Wide		23
Sewage		no increase
Residue Area		1

Table 38: PROPOSED CHANGES UPGRADE - MINES

Item	**Action**
Location	South and North Manchester
Distribution of Mining Activity	2/3 of time in South Manchester (Present Location). 1/3 of time in north Manchester
Mode of Transportation	Rail and possibly by conveyor system.
Bauxite Quantity	9M Tonnes/yr

4.3.1 Major Material Consumption

Major material consumption will increase consistent with the upgrade. Table 39 below, provides a listing of materials detailing current quantities and anticipated quantities based on the upgrade.

Table 39: PRESENT AND CURRENT QUANTITIES OF MATERIALS FOR UPGRADE

Item	Present Quantity	Proposed Quantity	Difference
Bauxite	2,682,397TPY	9 MT/year	6,317,603 TPY
Caustic Soda	98,980 TPY	197,960 TPY	Double
Lime	244 TPD	730 TPD	486 TPD
Fuel Oil	306,667 TPY	613,333 TPY	Double
Water Demand	9200 m^3/Day	18400 m^3/Day	Double
Alumina Shipped	1.25 MT/year	2.8 MT/year	1.55 MT/year
Vessel Size	37,000 tonnes	56,000 tonnes	19,000 tonnes

This proposed upgrade represents the single largest investment in Jamaica's history representing an estimated US$690 million, of which approximately US$300 million will be retained in the Jamaican economy. At full operations, the upgrade will result in Jamaica earning an additional US$44M per year in taxes and royalties, and US$30M spent in the economy on goods and services. This will have a stabilizing effect on the exchange rate, inflation and should reduce the trade deficit of the country significantly.

As a result of technological improvements between 1972 and the present, this proposed capacity upgrade, will also result in improvements in Jamalco's ability to provide environmental controls, management and monitoring. The doubling of capacity will not result in the doubling of environmental impacts.

Jamalco maintains constant contact with local communities through Community Councils that are made up of individuals taking on leadership roles. A Fact Sheet detailing the basics of the project has been prepared and consultative meetings have been held with these community leadership groups. These consultative meetings are designed to provide members of surrounding communities, with information on the proposed development and to listen to the concerns of the people in face-to-face meetings. Concerns gleaned from these meetings have been addressed in this EIA document and in some cases dialogue is continuing with these groups to find solutions to issues and concerns.

4.3.2 Project Schedule

Preliminary designs are being completed for the project. It is anticipated that upon approval of the EIA and the granting of a permit, Jamalco will be able to complete detailed designs, procure equipment and complete construction of the upgraded facility in approximately 24 months. This time-frame may change based on regulatory approvals, internal decisions or issues beyond the control of Jamalco.

4.3.3 Project Location

The mining, handling, processing and shipping of bauxite and alumina are all part of an integrated system with five (5) primary nodes, these are:

I. <u>The Mines:</u> Presently located in South Manchester and Clarendon. Existing bauxite mines that supply the Jamalco refinery are located in the region of the Manchester Plateau in South Manchester and the mountains of Northern Clarendon. New sources of bauxite will be developed in North Manchester in areas zoned for that purpose.

Figure 70: MINING ACTIVITY

II. <u>The Northern Transportation Corridor:</u> This includes all roadways, haul roads and means of conveyance including the railroad tracks that will facilitate the movement of bauxite from the mining areas to the refinery for processing. This is a long corridor and for the upgrade, sections of railroad tracks that were abandoned by the Jamaica Railroad Corporation (JRC) are being considered for refurbishing and may be incorporated into the corridor. The northern transportation corridor will extend through most of the parish of Manchester, to the refinery in Halse Hall, Clarendon.

III. <u>The Refinery:</u> Jamalco's alumina refinery is located in Halse Hall Clarendon along the Hayes main road between the districts of New Bowens and Hayes-Cornpiece. The refinery consists of bauxite handling and processing equipment, which includes the residue disposal areas for bauxite residue.

Figure 71: REFINERY

IV. The Southern Transportation Corridor: This represents primarily the railroad connection between the refinery and the port at Rocky Point in Clarendon. This corridor extends through residential communities close to the plant and continues through sugar cane farmlands and limestone forests as it makes its way south to Rocky Point.

V. The Port: The Rocky Point Port is located to the southeast of the plant on a peninsula separating Salt River Bay to the north and Peake Bay to the south. The port is reached via a secondary road and is supplied with alumina by rail for shipment overseas.

Figure 72: PORT

4.3.4 BAUXITE MINING

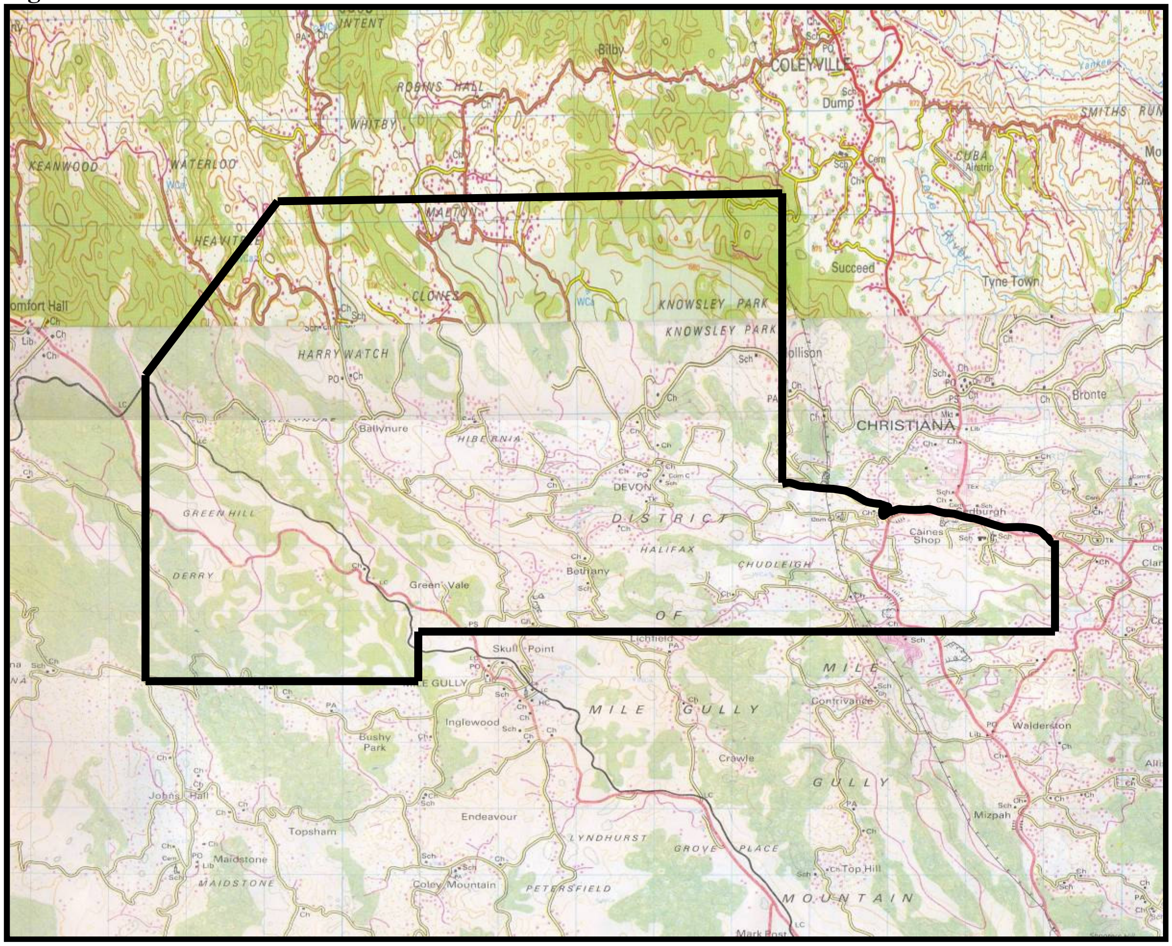
4.3.4.1 Natural Heritage Resources

The Company's activities take a particular interest in preserving existing and potential historical sites within the development area. The operations are guided by and must comply with Alcoa's World Alumina strict Environment, Health and Safety Standards. The requirements of the Jamaica Heritage Trust will be adhered to.

4.3.4.2 Bauxite Resource Area

New bauxite mining areas will be developed in North Manchester to supplement existing mines in South Manchester and Clarendon. The planned development area is bounded by coordinates listed in the duly approved Special Exclusive Prospecting Licence No. SEPL 530. The description of the Licence approximately defines an area of 74 km^2 in the Waterloo, Devon and Chudleigh areas of the Parish of Manchester. The Licence has been staked with a metal corner beacon situated at the approximate false coordinate intersection of 170 000m North and 186 000m East on sheets 7 and 11 of the 1:50,000 (metric edition) topographical map Jamaica. (See Figure 73: SEPL 530 BOUNDARY)

Figure 73: SEPL 530 BOUNDARY



This EIA is bounded by the SEPL boundary definition and this also forms the legal boundary in which the company can carry out mining related activities in order to supply bauxite to Clarendon Alumina Works (CAW).

4.3.4.3 Ore Transportation Systems

The development of the North Manchester resource area initially considers the rehabilitation (and where necessary the improvement) of the existing government rail line that traverses the area. The final decisions on this methodology have not been taken the company is presently in the mode of verifying the available bauxite resource.

There are two options presently being considered for connecting into the existing company owned rail lines and they are:

a. Transporting the ore to Logan's Junction in Clarendon and then switching it to the rail line coming from the Jacob's Hut Junction

b. Construction of a new connecting line from the Clarendon Park curve to connect to the newly built railhead at St. Jago.

4.3.4.4 Haul-roads

Jamalco has transitioned away from the construction of large haul-roads to support 100 Ton trucks, and today has developed an effective model where highway trucks will be used on smaller roads to transport the bauxite. This approach was developed in the old mining area of Mocho and significant knowledge has been gained during the time of the company's operations in that community. This is a direct result of Alcoa's core values, which are designed to provide environmental and economic benefit to the communities. Some of the improved opportunities are:

1) Road conditions have significantly improved when compared to those which existed before mining activities began. The improvements have also resulted in the reduction and in some instances the elimination of dusting issues.

2) Improved road signs

3) Opportunity of residents to earn a livelihood from the trucking activities

4) Reduced trucking hours.

5) In areas where the existing road is not adequate, the company has worked, and will continue to work in tandem with the Manchester Parish Council in improving the road condition.

4.3.4.5 Land Acquisition and Resettlement

The Company has developed a comprehensive Land Acquisition and Resettlement program over the thirty years of operation on the island. The program continues to benefit from improved methodology and strategy in clearing mining lands while creating as minimal an impact on the existing social structure of the affected communities. In developing the North Manchester Resource areas the company's present thinking is to utilize available government owned lands as the first areas that would be mined. This presents two important opportunities to the future development of the area:

1. Minimal social disturbance as government lands are sparsely populated and in most cases free of any settlement(s).

2. Provision of suitable lands (after rehabilitation and certification) for resettlement of residents from other potential mining areas.

The company approaches this process with an open mind and as such, feels that residents must also have the option to exercise their right to choose where they would like to be resettled. For a more comprehensive overview of Jamalco's Land Acquisition and Resettlement methods please refer to the Jamalco publication "You and Jamalco" (© Jamalco 2000 – included as APPENDIX II). This represents an easy and simple guide for residents to understand the issues that will impact on their lives and what are their available options.

The company feels that the utilization of suitable available lands in the proposed mining areas for resettlement will minimize the negative issues of community dislocation.

4.3.5 Bauxite Mining and Load Station

Current Mine Plan concepts have targeted the initial mining on government lands. There are no established grade control plans, as the company is still engaged in completing exploration activities throughout the SEPL. Additionally, there exists a possibility that the ore from North Manchester will be blended with ore from the Harmons Valley and South Manchester Plateau resource areas in order to maintain the required feed to the CAW refinery.

4.3.5.1 Load Station

The final decision on the size and location of the new load station to support transportation of the North Manchester Bauxite has not been made to date.

The final decision on this facility is dependent on the completion of exploration activities. Critical to the selection of this area is the identification of the critical mass of reserves.

4.3.5.1.1 Staffing for the Load Station

Modeled on the recently completed Mocho operations, it is anticipated that the new load station will have a staffing complement of 30 individuals comprising both employees and contractors

4.3.5.1.2 Waste Oil Management at Load Station

The facility will have a fully approved containment and management facility for oils and lubricants. Existing Alcoa EHS safe handling procedures will be implemented at the facility

4.3.5.2 Sewage Treatment

While no final decision has been taken on the size of the sewage treatment plant to be installed at the facility, the company will install an adequate treatment plant and implement approved operating and monitoring procedures to ensure that local and corporate standards are met or improved upon. During construction activities, portable, mobile chemical toilets will be utilized to satisfy the needs of workers. These toilets will be supplied, handled and disposed by a company licensed and permitted to do so.

4.3.5.3 Run-off treatment and sedimentation control.

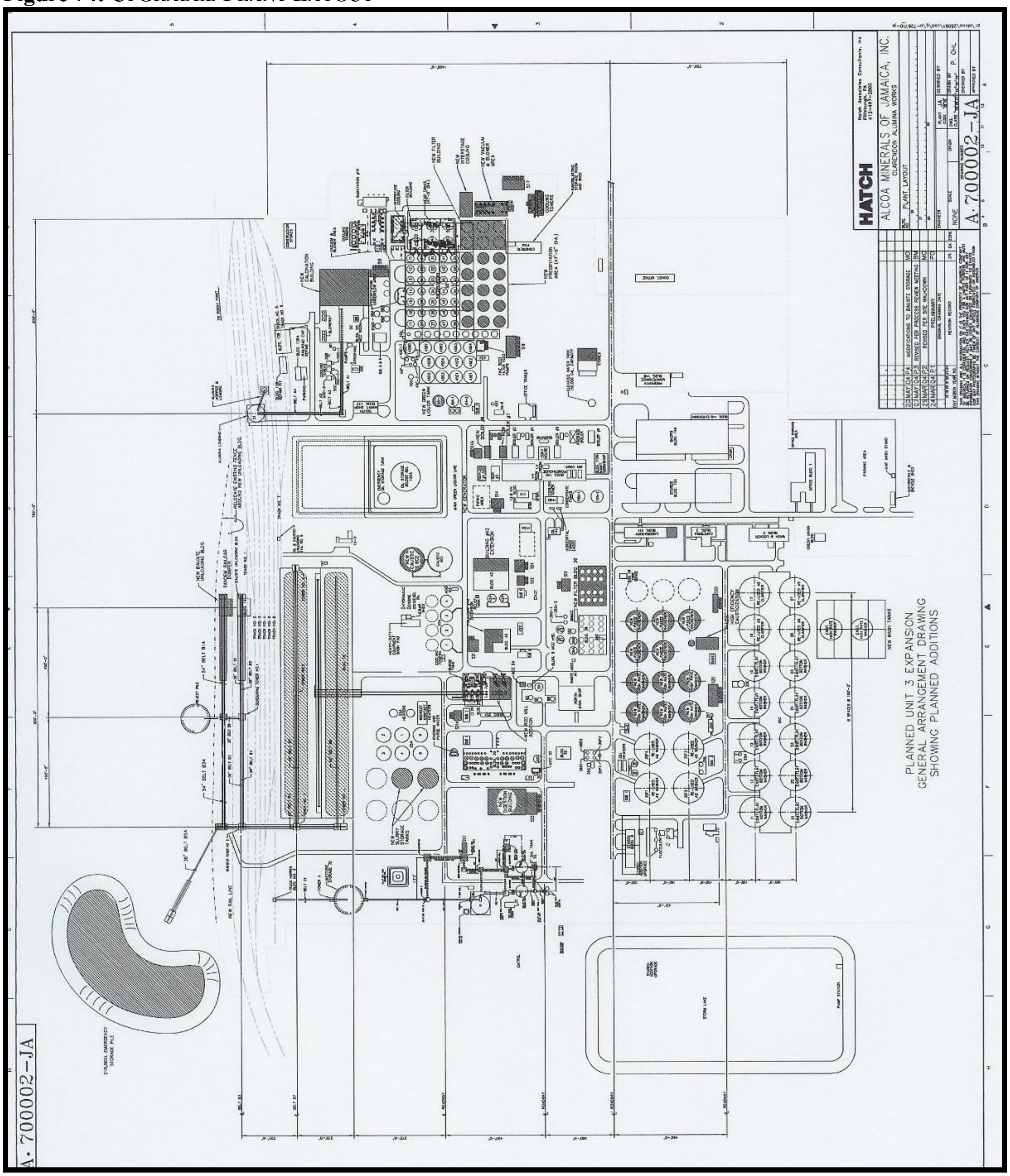
Engineering designs will adequately address the control of sediments and runoff water. Since this is area and condition specific, designs will be completed as each area is developed.

4.3.6 Restoration and Rehabilitation.

4.3.6.1 Refinery and Efficiency Upgrade

Production capacity at the Jamalco refinery located in Halse Hall is proposed to be increased from the current 1.25 MTY to 2.8 MTY. While this more than doubles the current production capacity of the facility, it does not represent a doubling of the physical footprint of the plant. Through technological advancement and improvements in efficiency, the facility will be able to accomplish this increase with miniscule advance outside of its existing plant boundaries. Figure 74: UPGRADED PLANT LAYOUT, shows the relationship between existing plant components and those proposed for the upgrade. Major features of the proposed upgrade at the refinery are presented in tabular form Table 36

Figure 74: UPGRADED PLANT LAYOUT



4.3.6.2 Solid Waste Management

Current solid waste management practices at the plant will be maintained. The plant has an existing landfill that will have suitable capacity for the foreseeable future. If and/or when the need arise, Jamalco will make the necessary preparations including design and permitting to either expand the existing facility or develop a new landfill site.

4.3.7 PORT UPGRADE

The existing Rocky Point Port will be upgraded during this project. It is anticipated that upgrade work at the port will be minimal. It is not anticipated that any new tankage will be needed at the facility for storage of fuel oil or caustic soda. Additional alumina storage capacity will be gained through the use of additional rail cars as proposed in Table 35 along with other changes also included in Table 35 above.

Rather than increasing the frequency of shipping or the quantity of alumina stored, Jamalco proposes to utilize larger ships. The facility currently ships alumina from the port in 37,000 tonne vessels and proposes to upgrade to vessels capable of holding 56,000 tonnes. This will require the modifications described in the table above.

4.3.7.1 Solid Waste Management

There is no anticipated increase in solid waste generation during the operational phase of the port upgrade. There is a possibility that during construction activities, due to the increased shipment of materials and equipment, more solid waste will be generated. As needed Jamalco will increase the numbers of garbage skips at the port and also the frequency of collection to match any increase that may arise. As currently obtains, solid waste at the port will be taken to the land fill at the refinery for disposal

4.3.8 UTILITY IMPROVEMENTS

The upgrade of the Jamalco system will require the increase and/or improvement of several service and utility components. These include:

1. Energy Supply

2. Water Supply

3. Sewage Treatment – construction phase and new mines

4. Residue Disposal Area

4.3.8.1 Energy Supply

Jamalco presently utilizes fuel oil to operate its existing powerhouse boilers. These boilers consume fuel to produce steam which is used for heating purposes in the refinery as well as to drive the turbines to generate electricity (co-generation) to provide electrical power to meet the demand of the refinery complex. Excess energy, above the refinery demand, is supplied to the national grid. Jamalco has a keen interest in seeing the early implementation of a Government of Jamaica (GOJ) led project to make liquefied natural gas (LNG) available for power generation. Jamalco has been party to discussions regarding the availability of LNG as a source of fuel in the near future. LNG will represent a more environmentally friendly and cheaper source of energy for the facility.

As part of the upgrade of the Jamalco refinery, it is anticipated that two (2) new boilers each at 400,000 lb/hour at 1200 psi, will be needed along with one new 35 MW steam turbine and an additional stack. Low pressure steam from the turbine will go to the refinery. Although total energy requirement will increase, the efficiency of the new boilers will result in a unit (specific efficiency) net saving of resources and fuel consumption (e.g. less barrels of oil consumed per tonne of alumina produced). The overall energy usage will be 9.2 GJ/tonne of Alumina, which is better than the current usage of 12.61 GJ/Tonne

4.3.8.2 Sewage Treatment

4.3.8.2.1 Mine

Existing mining locations are equipped with sewage treatment systems or arrangements. At the proposed new mining location in North Manchester, a sewage treatment system is proposed, which will adequately handle the expected population of workers. Since the actual location has not been selected at this time, Jamalco will commit to installing an adequate sewage treatment system, including approved operating and monitoring procedures in keeping with the requirements of the Environmental Control Division of the Ministry of Health, as well as other local and corporate standards.

4.3.8.2.2 Plant

There is an existing sewage treatment system at the existing plant facility. This sewage treatment system consisting of extended aeration, contact stabilization and chlorination components, was designed to adequately handle waste generated by a workforce of approximately 1300, while Jamalco now maintains a workforce of approximately 600 persons. It is not anticipated that a new or upgraded system will be required for the operational phase of the upgrade. However, during the construction phase of the project when 2,500 workers are expected at the facility, Jamalco proposes to utilize numerous, temporary, chemical toilets that will be delivered, maintained and disposed of by a company licensed facility for this activity. Jamalco will audit the operations of the licensed facility to ensure that it meets the regulatory and corporate requirements.

4.3.8.2.3 Port

Presently, sewage generated by the small staff at the port is held in a septic system and withdrawn as necessary by a licensed waste hauler for appropriate disposal at a licensed facility. There is no indication at this time that there will be any increase in staff at the port, therefore, this practice which works very well will be continued.

4.3.8.2.4 Water Supply

The major issues related to increased water supply for the upgraded operations are addressed in detail in the Water Resources Section of this report (Section 3.5, page 83). Basically, water supply to the plant will be doubled. However, a portion of this increased volume can be achieved from reserves in existing permits (that are not being extracted at this time).

4.3.8.3 Residue Disposal Area

Jamalco pioneered and maintains sealed residue disposal areas (RDA's) at its facility. These disposal areas are sealed with a thick clay liner that is compacted to effectively contain bauxite residue from the refinery. Recently, the facility has upgraded its existing RDA's, elevating the dike walls by 20 feet to increase capacity. With the upgrade of the refinery, an increase in the volume of bauxite residue produced will be realized (1.2:1 ratio of bauxite residue to alumina produced). In order to continue with their responsible and progressive approach to bauxite residue management, Jamalco is proposing the addition of a new bauxite residue residue disposal area (RDA) and desire to introduce the space saving and efficient "Thickened Tailing Disposal" technology.

4.3.8.3.1 Thickened Tailings Disposal Technology

Jamalco presently has four active residue disposal areas (RDAs) covering 214 hectares. RDA 1 was commissioned in 1972, RDA 2 in 1980, RDA 3 in 1990, and RDA 4 was commissioned in 1997. RDAs 1 and 2 were constructed as simple clay lined impoundments. The construction of RDAs 3 and 4 included based drainage system to improve the rate of consolidation of the residue and to reduce the hydrostatic pressure on the clay seal at the base of the deposits.

Thickened Tailings Disposal (TTD) is proposed for the next residue disposal area RDA#5. It offers the advantages of a stable mass during the life of the facility, a higher storage density per unit of area than wet disposal methods, and high shear strength and bearing capacity. The latter greatly facilitates early rehabilitation after closure, as well as access to the area for feedpipe installations and/or modifications during the operating life of the disposal area. In addition this disposal method offers relatively high storage volumes and will eliminate the need to construct large dikes.

The proposal for Thickened Tailings Disposal involves thickening or densifying the residue feed stream to a relatively high consistency and discharging it from elevated positions. The discharged residue will form mounds or ridges sustained by self-draining stable slopes of between 3 and 5 percent. A specialised thickener will be used to raise the solids content of the feed stream from the present ten (10) percent to between thirty one (31) percent and thirty four (34) percent solids, by weight. The residue will achieve a final compaction of at least fifty-five (55) percent solids by a combination of self-weight consolidation and solar drying.

Mud is continually applied in this manner around the perimeter of the dykes, from one point to the next, ultimately returning to the starting point where the process began. The process is then repeated. Depending on the size of the area, this may take 10 – 14 days at which time the mud at the original point of application becomes dried through solar energy. A fresh layer of mud is then applied to this area and the process is repeated. In the event of rainfall, run-off water flows down the slope i.e., on top of the mud. The water is collected in a special sump. This alkaline water is recycled to the plant.

Bauxite residue stacking has been proven to work efficiently in several countries, primarily in Germany, where it was developed and subsequently in Jamaica at the Windalco Ewarton facility where it has been in operation since the early 1980s. Jamalco will adopt this technology to significantly reduce the area required to store bauxite residue for an extended period of time while utilizing a similar area to that presently being used for previous RDAs.

The location of the RDA is one of net evaporation, therefore solar drying will proceed effectively and efficiently through the process of evaporation. An important feature of dry mud stacking is to ensure that the surface of the mud is never completely dry. If this is so, then it is possible that under extremely windy conditions, the mud particles may become airborne and disperse into adjoining communities.

This Environmental Impact Assessment (EIA) follows the detailed Terms of Reference discussed and approved by NEPA. The Terms of Reference for the project is included in Section 14 of this report. The Terms of Reference essentially covers the following:

- Legislative & Regulatory Considerations
- Land Use and Aesthetics
- Geotechnical Analysis and Soil
- Air Quality and Weather
- Water Resources
- Wild Life, Vegetation and Marine Assessment

- Archaeological/Historic Resources
- Socio- Economics
- Noise Levels
- Solid and Hazardous Waste Management Practice/Landfill
- Occupational Safety and Health Issues
- Risk Assessment
- Human Health Risks of Proposed Actions
- Natural Hazard Vulnerability
- Analysis of Alternative
- Closure Plans for Construction Phase
- Structural Integrity Testing

(See Section 14 for the detailed Terms of Reference)

As directed by NEPA, the EIA report is presented in the following format under the approved Terms of Reference

1. Executive Summary
2. Policy, Legal and Administrative Framework
3. Description of the Environment
4. Description of the Proposed Project in Detail
5. Significant Environmental Impacts

6. Socio-Economic Analysis of Project Impacts
7. Identification and Analysis of Alternatives
8. Mitigation Action
9. Environmental Management and Training
10. Monitoring Programme
11. Public Involvement
12. List of References
13. Appendices

ENVIRONMENTAL IMPACTS

5 Environmental Impacts

5.1 Fugitive Emissions

5.1.1 Mining

The small particle size of Jamaican bauxite makes it susceptible to becoming airborne as it dries out. Bauxite as it is extracted from the deposits has a moisture content of approximately 20 – 25%. This naturally suppresses fugitive dust formation. Potential fugitive dust problems may occur after bauxite is mined and becomes dry during the following conditions, especially when it is windy:

- Vehicular traffic
- Spillage on roadways
- Stockpiles (overburden and bauxite)
- Bauxite blending

5.1.2 Transportation of Ore to Plant

Bauxite ore is transported from mine to plant in open cars via rail. The moisture content of the bauxite (between 20 - 25%) does not usually allow it to be dispersed even in relatively strong wind. Unless the bauxite is allowed to dry out appreciably, this is not a source of impact.

5.1.3 Refinery

At the refinery, fugitive dust may be generated from the bauxite stockpile, if allowed to dry, alumina loading onto rail cars and on rare occasions from bauxite in rail cars for temporary storage. The surfaces of the RDAs are maintained at moist so the generation of fugitive dust from them is not a problem. The loading of alumina into rail cars for transport to the port has the potential for impacting on the built and natural environments through accidental releases. Generation of fugitive dust at the refinery is usually episodic and all efforts are made under Jamalco's existing dust management regime to minimize these instances.

5.1.4 Transportation of Alumina from Refinery to Port

There is the potential for fugitive emissions of alumina during transport to the port. In some instances, small amounts of alumina will spill on top of the rail car after loading. As the train slowly leaves the plant and moves towards the port, this small amount of alumina may become airborne and result in emissions.

5.1.5 Port

At the port, alumina is loaded from rail cars into storage silos followed by loading onto ships for transport to smelters overseas. During all transfer activities, the potential exists for fugitive dust emissions. It is a function of Alcoa's principles, local rules and regulations, employee training and monitoring that insure that fugitive emissions are kept to a minimum and eliminated where possible.

5.1.6 Construction Activities

During construction activities, the potential exists for fugitive emissions from earth movement and clearing, vehicular traffic on dirt roads or spillage of soils during transport.

5.2 Air Quality

5.2.1 Mining

Primary air quality impacts associated with mining activities are related to heavy equipment emissions and the potential for particulates from dried bauxite.

5.2.2 Refinery

While the Jamalco refinery may be the largest source of air emissions in the general area, it is by know means the only contributing source. Other sources of air emissions in the area include:

- Monymusk Sugar Factory
- New Yarmouth Sugar Factory
- Jamaica Public Service Company (power generation)
- Jamaica Energy Partners (power generation)
- Sugar cane field burning
- Coal burning
- Motor vehicles

5.3 Noise

5.3.1 Mining

During mining activities, there will be a potential for noise from several sources. These include:

- Heavy equipment
- Bauxite processing (blending & stockpiling) and conveying.

It will be important for Jamalco to monitor and mitigate issues relevant to noise impacts in respect of Occupational Health & Safety (OHS) and as it relates to residents of the area.

5.3.2 Refinery

The Jamalco refinery has operated within the local standards and regulations for industrial noise levels. In areas of the operation that have a potential to exceed these levels, signs are posted and safety equipment provided. Main sources of noise at the refinery include the powerhouse and associated turbines, blowers and pump motors throughout the facility. In terms of the upgrade, there may be the potential for noise being generated during construction activities and as heavy equipment moves around the refinery.

An audiometric survey was conducted at the plant boundaries to establish a baseline for the area and to assess the potential for noise impacts on the adjoining communities. This assessment is included elsewhere in this report.

5.3.3 Transportation by Rail and Truck

The locomotive and rail cars which transport bauxite from the mines to the plant and alumina from the refinery to the port have the potential to cause a noise impact on the communities through which they must travel daily. Noise generated in rail travel tends to be most pronounced in turns where the wheels tend to give off a high pitched noise. The plant relies primarily on rail transportation and limits the use of truck through the communities as much as possible. However, when used, trucks also have a potential for noise impacts from engine noises to the unnecessary use of horns.

5.3.4 Port

It is not envisioned that noise impacts will be increased significantly at the Rocky Point Port as a result of this project. At present, there are no major noise related issues at that location.

5.4 Loss of Biodiversity

5.4.1 Mining

The loss of biodiversity represents a major potential impact during the transient change in land use occasioned by mining operations, particularly in gaining access to the bauxite deposits.

However, bauxite deposits do not support high levels of diverse vegetation because of its infertility. Vegetation is usually limited to grass and small shrubs. Indeed this formed the basis for discovery of bauxite in Jamaica and provides the principal indicator for aerial prospecting and identification of bauxite resources. It is the limestone hillocks which principally support vegetation and hence biodiversity.

Jamalco has significant experience in rehabilitation and revitalization of mined out areas and has developed and continues to conduct research and development work on its science & technology. The company has demonstrably managed this impact with marked effectiveness.

There will be unavoidable displacement of species and loss of habitat during land clearing and mining operations.

5.4.2 Refinery

There will be no significant impact associated with biodiversity during activities at the refinery. The efficiency upgrade of the refinery is a brownsite area activity essentially within the existing battery limits of the plant and impacts no new areas.

5.4.3 Port

There is proposed reinforcement of the dolphins and maintenance dredging at the port to facilitate the upgrade. This should have a minor impact on marine resources in the area as the areas being considered have previously been impacted and no new impacts are envisioned. It is noteworthy that corals, which are also subject to natural impacts such as siltation and bleaching, have shown regenerative growth.

5.5 Water Supply

5.5.1 Mining

Due to the elevations and location of the north Manchester bauxite deposits being considered for mining, it is not envisioned that the new mines will have a major impact on subsurface water supplies. Drainage regimes will be impacted. However, as the deposits to be mined are identified, geotechnical and hydrology assessments will be conducted to gain more knowledge of the areas.

Potable and irrigation water supply are used at the mines for employee facilities and dust suppression. It is not envisioned that there will be major impacts on water supplies to communities because of mining activities or usage. Where necessary water will be trucked in and stored for use as needed.

5.5.2 Refinery

The refinery, particularly the RDAs have a significant potential for impacting on the groundwater resources of the area. The majority of potable water utilized at the Jamalco facility and those communities around that have piped water comes from wells located in the vicinity of the plant. The methods and type of construction of the new RDA take into consideration the potential for groundwater impacts.

It is proposed that the plant will need to double the quantity of water it currently extracts from wells in the area. This new demand may have a potential impact on the aquifer and local resources and has been assessed (see hydrology section of this report).

5.5.3 Port

There will be no new water supply related impacts at the Rocky Point Port.

5.6 Waste Management

5.6.1 Mining

There will be various types of waste materials that may be generated at the mines that must be properly managed. Waste streams include, hazardous waste (chemicals, lubricants), vegetative matter (land clearing waste), and garbage. Potential impacts stem from the collection, handling and disposal of these waste materials.

5.6.2 Refinery

The refinery has existing programmes and protocols in place to deal with all types of waste generated there. All waste generated during the construction and commissioning of the upgraded facility will be handled based on these established protocols. The refinery has a landfill facility which includes a sealed area for disposal of certain hazardous materials. All identified waste management impacts can be successfully mitigated.

5.6.3 Port

No new waste management impacts are anticipated at the Rocky Point Port.

5.7 Sewage

5.7.1 Mining

Sewage generated at the mines will be managed using Jamalco's time tested approaches. A sewage treatment system will be designed and constructed at the main mine area based on the number of employees. Portable chemical toilets will be used as needed; these will be managed and disposed by a licensed company. Potential impacts include spillage and accidental releases.

5.7.2 Refinery

The refinery has a working sewage treatment facility that was designed to service a plant staff of 1200 employees, at present the staff complement is 600. After the proposed upgrade is completed a maximum of 100 new employees are anticipated. Consequent on reduced wastewater generation, about 50% below design capacity, the existing plant will be able to effectively manage this increased loading. No new impacts are envisioned.

During construction, their will be an anticipated 2,500 temporary employees at peak construction. Portable chemical toilets will be utilized to meet the demands of this increased capacity. These toilets will be sourced from a reputable licensed company, who will treat and dispose of the contents.

5.7.3 Port

During work at the port it is anticipated that there may be an increase in sewage generated by the construction workforce. Portable chemical toilets will be used at this location also. Potential impacts include accidental spillage onto land or into the sea.

5.8 Vibration

5.8.1 Mining

Vibration in and around the mining area will be a potential impact of heavy equipment (bulldozers, excavators, trucks) movement and the use of bauxite screening equipment. Depending on the proximity of the mining activity to residents and structures, this impact may be major or minor.

5.8.2 Rail Corridors

The use of additional train cars or more frequent trips have the potential to increase vibration impact potential along the rail corridor. In the past residents have complained of impacts from the trains, such as vibration, and cracking of walls and floors. These impacts have the potential to be major requires inspection prior to the upgrade and regular monitoring and assessment during construction and operations.

5.8.3 Refinery and Port

No new vibration related impacts are anticipated at the refinery or port facilities.

5.9 Labour

5.9.1 Mining

The proposed new mining activities if implemented will employ an estimated 60 new employees. Many of which will come from the areas being mined. In addition, consideration is being given to the utilization of smaller over-the-road trucks (rather than large 100 tonne trucks) sub-contracted from the surrounding areas to move bauxite from mines to mine stockpile. This would provide additional employment and revenues to people of the area. Hence would be a beneficial social and economic impact with a built in mitigation component in respect of both the natural and man made environments.

5.9.2 Refinery

It is expected that the upgrade activities at the refinery will employ an additional 2,500 temporary employees during the 24 month construction period. After upgrading it is anticipated that approximately 100 new permanent positions will be created at the plant. Many of these employees will be recruited from the area. In collaboration with HEART/NTA, Jamalco has embarked on a training programme that will prepare a significant portion of that workforce for jobs through skills upgrade and hands-on training. This is a major positive impact for the community.

5.9.3 Port

No significant increase in permanent labour is anticipated at the port. There will be a minor increase in temporary employment if the proposed upgrade is implemented.

5.10 Aesthetics

5.10.1 Mining

Aesthetics in the mining areas will be impacted. The removal of vegetation and soils will cause a distinct change in the appearance of the land and land use. This is a major reversible impact, which is addressed in rehabilitation and revitalization of the area when mining is completed.

5.10.2 Refinery and Port

No new aesthetic impacts are anticipated at either the refinery or the port since no significantly different changes are proposed for either facility. All changes will be substantially within the battery limits of the respective areas.

5.11 Archaeological and Historical Heritage

5.11.1 Mine

There is the potential for negative impacts during mining activities on archaeological and historical heritage resources in the new proposed mining area. Since the actual bauxite deposits have not been fully assessed at this time, specific guidelines must be developed to handle any specific issues that may arise involving contact or disturbance of archaeological or historical resources.

5.11.2 Refinery and Port

No new impacts are anticipated at the refinery or port.

5.12 STRATEGIC ELEMENTS OF THE EIA

5.12.1 Macro Economic Level

The following major strategic benefits will accrue to the country's national benefit:

- Largest single invest in Jamaica's history of US$690M

- Jamalco has had to improve its competitiveness significantly through marked efficiency gains in corporate, business and environmental health and safety management, to move its operations from within the last quintile of Alcoa worldwide network, to the pride of place which it now enjoys within the first quintile of the network of alumina refineries. Competition in other Alcoa locations worldwide was intensive for this expansion opportunity

- Of the US$690M to be invested on this upgrade, US$300M will be retained in Jamaica for the purchase of goods and services, hence registering a major positive benefit to the national accounts and generating a suite of spin-off benefits island wide in industrial and commercial activities, indirectly resulting in additional job creation.

- The investment inflow will have the effect of stabilizing the exchange rate, reducing inflation and reducing interest rates. These factors could in themselves induce a raft of investments in the countries economy.

- The country will have additional alumina for export resulting in more foreign exchange earnings and revenue inflows while at the same time reducing its trade deficit.

- During operations an additional US$77M in new income per year will be earned by the country

- During construction phase approximately 2,500 temporary jobs will be created.

- During operational phase approx 100 permanent jobs will be created
- Increased demand for a variety of goods and services to support the increased employment
- Reactivation of portions of the decommissioned Jamaica Railway Corporation rail lines to facilitate movement of bauxite from mines to plant.
- A major skills training programme will be undertaken by Jamalco in collaboration with Heart/NTA to provide training for prospective employees during the upgrade
- Highway 2000 will facilitate the safer and more efficient transportation of goods and services

5.12.2 Planned Developments

The efficiency upgrade recognizes other important developments planned for the area, included among them are:

Development of the Vernamfield aerodrome and commercial center
Housing development in Inverness Newtown to accommodate approximately 150,000 residents inclusive of support services

These proposed developments have greater elements of complimentarity rather than elements of potential conflicts to the Jamalco upgrade.

SOCIO-ECONOMIC ANALYSIS OF PROJECT IMPACTS

6 Socio-Economic Analysis of Project Impacts

6.1 Summary

6.1.1 Introduction

This report presents the findings of a survey conducted among residents within the radius of influence of the project, in Southern Clarendon and Northern Manchester between May and June 2004.

6.1.2 Objective

The objective of the survey was to determine the level of knowledge of the population of the existing and proposed operations, to ascertain their views on the impact of the operations as well as to what they perceived as solutions to existing problems.

6.1.3 Methodology

The survey was based on a 5 per cent sample of households from the enumeration districts in the study area (as defined by the Statistical Institute of Jamaica) for the 2001 Population Census. The households for administration of the questionnaire were selected at random by the interviewer, within the enumeration districts. The respondent in all instances was the household head.

The information collected through the questionnaire included the following:

1. Personal Characteristics

    - Age and Gender
    - Number of Years Lived in the Community

2. Opinions on the community
    - Factors most preferred
    - Factors least preferred
    - Benefits of large scale development to the community
3. Awareness and Opinions on Existing Bauxite Operations
    - Perceived negative impacts
    - Perceived positive impacts

    Knowledge of and Views on Upgrade Plans as they relate to:
    - Economic Value of the Community
    - Pollution specifically
    - The Local Environment generally
    - The Individual
    - Job Opportunities
4. Water Availability
    - Source of drinking water
    - Perception of water safety

5. Miscellaneous

    - Awareness of community activities by Jamalco
    - Working experience in bauxite industry
    - Receipt of compensation for pollution problems

In most instances the questions allowed for multiple responses. The responses were coded and the data captured. SPSS used to produce tabulations, which form the basis of the analysis presented in this report. The findings as they relate to the two main areas of the parishes indicated are summarized below. The details of the specific findings related to the communities are presented Section 6.2 and Section 6.3 of this report.

6.1.4 The Survey Population

A total of 278 respondents were covered in the survey, 141 women and 137 men.All but 3 persons reported their age. One man was less than 20 years old and 43 persons were 60 years and over. The majority of the sample (83 per cent), therefore ranged between 20 and 59 years..There was a degree of stability as it relates to residence as the majority of residents (63.8 per cent) have lived in the communities for more than twenty years.

6.1.5 Main Findings

6.1.5.1 Opinions on the Community

- Issues related to “quality of life and people” were viewed as the best things about the communities; the reasons people liked their communities. More than two thirds (69.7 per cent) of the Clarendon respondents like their community because it is quiet. Just over a half (53 per cent) gave “friendly people” as the reason while more than a third (36.8 per cent) offered as a reason “no crime and violence”. Ten per cent of respondents said they like the community because of the clean environment

- The factors, which were reported by most Clarendon respondents as the reason for not liking their community, were unemployment and lack of utilities. Unemployment was given as the reason by 48.4 per cent of respondents and lack of utilities by 43.3 per cent.

- More than 8 out of 10 (82.7 per cent) of Clarendon respondents viewed "large scale development as beneficial to the community. Job opportunities and the potential for development of skills were seen as the primary reasons for this view.

- Respondents who did not agree with the statement saw large-scale development as impacting negatively on the environment as well as reducing the peacefulness of the area.

6.1.5.2 Awareness and Opinions on Existing Bauxite Operations

- The majority of respondents (92.4 per cent) in the Clarendon study area are aware of the existence of bauxite or alumina processing plant operations in the area

- Of these (63.1 per cent) said they personally experience negative impacts

- Dust, soot or gaseous emissions, odour and damage to property are the three factors identified by most of the respondents as the negative impacts. Forty two per cent identified dust etc while odour and property damage were both identified by 26 per cent.

- Six out of ten (61.4 per cent) of the respondents agreed that the bauxite facility has had negative impacts on the people in the community. The reason given by the majority of the respondents is that "the area smells like caustic soda more often than not". Just fewer than 30 per cent (29.6) gave this response. More than one fifth of respondents offered, "plants are harder to grow (27.1 per cent) and "the area has widespread corrosion" (22.7 per cent) as, reasons.

- More than two thirds (67.9 per cent) of respondents agreed that the bauxite facility has had positive impacts on the people in the community. Issues related to individual benefits, "job opportunities" and "educational and social benefits" were the reasons given by the majority of the respondents: 58.1 per cent and 21.3 per cent respectively.

6.1.5.3 Knowledge and Views on Upgrade Plans

- Almost nine out of ten (86.6 per cent) of the Clarendon respondents were aware of the upgrade plans.

- Almost as many persons felt that the proposed upgrade would affect them personally (42.9 per cent) as felt that it would not affect them (42.2 per cent). Approximately 12 per cent were not sure while the remaining 3 per cent did not respond.

- While 64.3 per cent of respondents were of the view that the upgrade would have a positive impact on economic value of the community a higher 77.3 per cent saw the effect on job opportunities as positive. An almost equal proportion of respondents were of the view that there would be no change in relation to job opportunities (9.4 per cent) or on the economic value (9.7 per cent) of the community.

- Approximately two fifths (40.8 per cent) of respondents were of the view that the proposed upgrade will impact negatively on pollution, 31 per cent saw a positive impact while 13 per cent saw no change. More than 10 per cent (11.6 per cent) said they did not know what the impact on pollution would be.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. The prospects of job opportunities emerged as the main impact seen by the respondents. More than two thirds (68.6 per cent) of responses identified this as the main impact. About a quarter (24.9 per cent) of the respondents indicated 'better community relations' as the main impact. More dust circulating, (38.3 per cent) more air pollution and noise (28.5

per cent) and more occurrences of diseases that affect breathing (12.3 per cent) reflected the negative effects. Increased population was given as a response by 30 per cent of respondents.

- As reasons for the particular answers given, 65.1 per cent stated that more jobs would be available. Presumably in relation to the circulation of dust and the existence of more pollution and noise, 38 per cent of respondents felt that 'the present bauxite and mining and processing facilities have caused this already so it can only get worse' and 'this is something common to all bauxite operations'. Approximately 32.4 per cent of respondents were of the opinion that the upgrade will add new equipment that will be cleaner to operate, the majority of these being the respondents who saw the increase in job opportunities as having the main impact on the community.

6.1.5.4 Availability of Water

- The majority (44.2 per cent) of respondents had water piped indoor available to them, while 41.7 per cent had water piped outdoor. The public standpipe and rain water were sources for 8.3 per cent and 3.2 per cent respectively.

- The National Water Commission was the original supplier for 86.3 per cent of respondents. Six per cent of respondents did not know who the original supplier was.

- Slightly more persons are of the view that the water is not safe to drink (45.5 per cent) than those who feel that the water is safe (44.4 per cent). The proportion that does not know or are not sure is 8.3 per cent.

- The main reason given for belief that the water was not safe by 72 per cent of the respondents who stated this view was that the water was affected by bauxite mining and other sources. Ninety five per cent of the respondents, who felt that the water was safe to drink, felt this way because the National Commission tested the water frequently and that the water looked and or smelt clean.

6.2 Southern Clarendon

6.2.1 The Communities

While the selection of the areas for interviewing were based on the enumeration districts as defined by STATIN, the communities as presented in this report were defined in the field by the interviewer and the respondent. Accordingly it is possible for a number of communities to cross Ed boundaries. The list of communities identified appears through Figure 75 to Figure 77 below.

Figure 75: ENUMERATION DISTRICTS SURVEYED IN SOUTHERN CLARENDON - MAP 1 OF 3

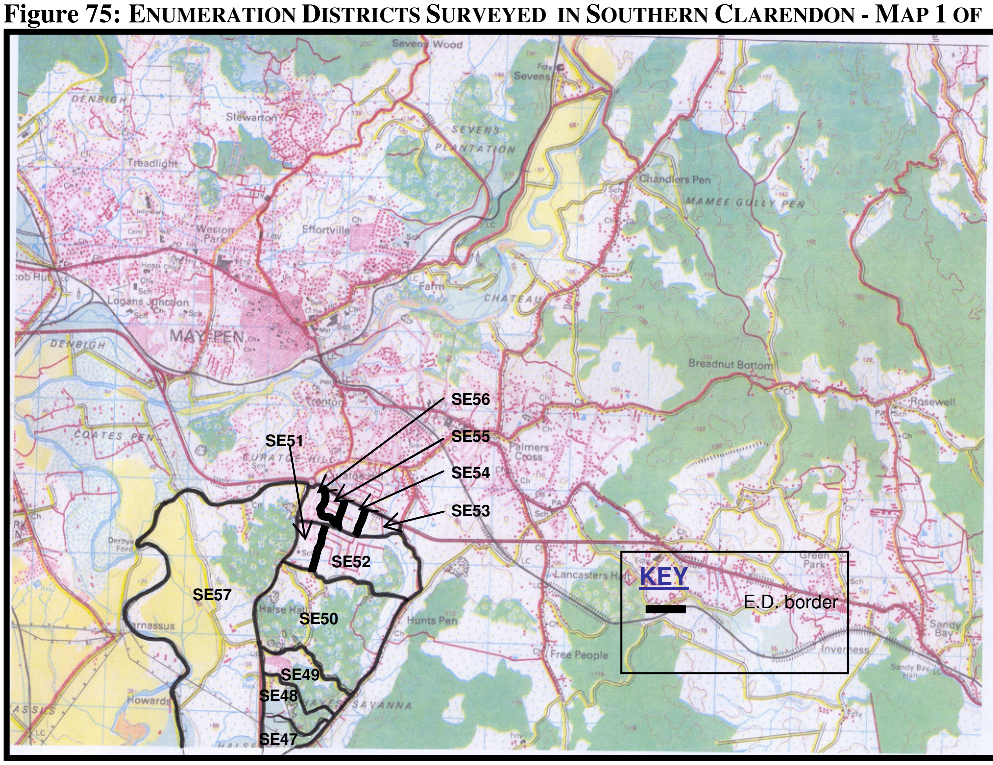


Figure 76: ENUMERATION DISTRCTS SURVEYED IN SOUTHERN CLARENDON - MAP 2 OF 3

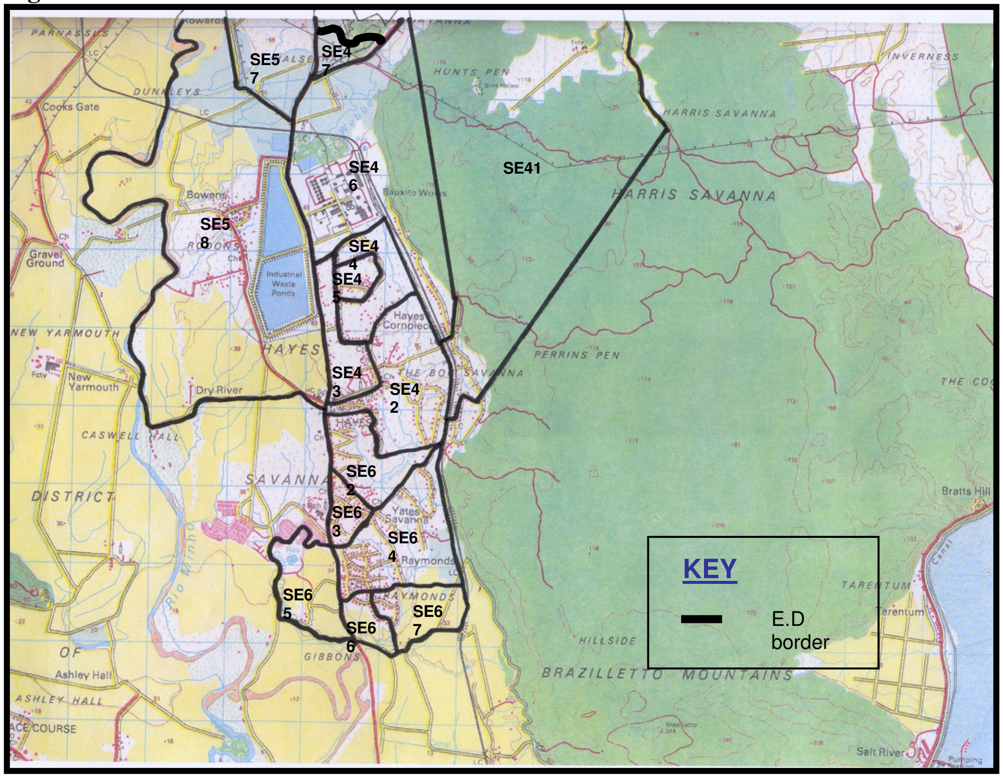
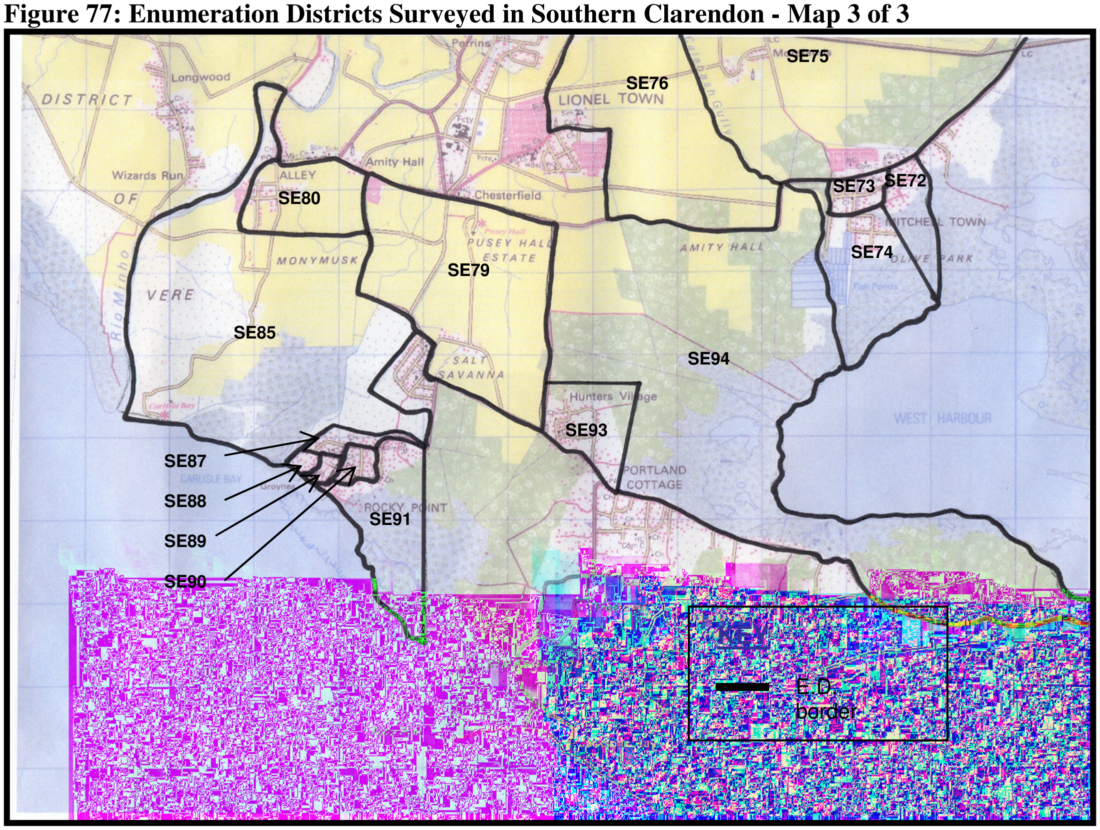


Figure 77: Enumeration Districts Surveyed in Southern Clarendon - Map 3 of 3



6.2.2 Demographic and Social Profile

The total population identified for this area in the 2001 census was 24,100. Females were predominant, comprising 50.5 per cent of the total. The women were slightly older than the men with an average age of 27.5 years compared to 27 years for men. In relation to educational attainment approximately 65 per cent of the population 15 years and older had attained a secondary level education, while 7 per cent had attained tertiary level.

There were 5,567 housing units in the area, 90 per cent of which were of the separate-detached type. The main material used in the construction of the housing units was concrete. Average household size was 3.5. While approximately 55 per cent of units were owned, 42.4 per cent were occupied under lease and rent free arrangements.

Eighty-two per cent of the approximately 6100 households had access to piped water. Of this, 9 per cent was receiving the water from a private source. Less tan a half (48 per cent) of households had access to water closets as toilet facilities.

6.2.3 Finding of the Study for the Communities

Due to the small size of the community samples, the analysis will be presented on the basis of the absolute numbers and not on percentages.

6.2.3.1 Mineral Heights

6.2.3.1.1 The Survey Population

A total of 17 respondents were covered in the survey, 10 men and 7 women ranging between 20 and 59 years old. The majority of persons (10) have lived in the community between 11-20 years. Two persons have been residents for more than 20 years.

6.2.3.1.2 Main Findings

6.2.3.1.2.1 Opinions on the Community

- Twelve persons reported that they liked the community because of the friendly people and because it was quiet and 4 persons liked it because of the clean environment.

- Crime and Violence (5) Unemployment (4) and poor roads (3) were the main reasons given for not liking the community.

- Fifteen of the 17 residents interviewed viewed "large scale development as beneficial to the community". Job opportunities and the potential for development of skills were seen as the primary reasons for this view

6.2.3.1.2.2 Awareness and Opinions on Existing Bauxite Operations

- Sixteen (16) persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 12 of them said that they had not experienced any negative impacts from the operations.

- The 4 who reported that the operations had impacted negatively on them identified dust, soot and gaseous emissions and odour as the factors affecting them.

- Four persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (2); the area has widespread corrosion (1); and you get sick more often (1).

- All 17 respondents agreed that the bauxite facility has had positive impacts on the people in the community because of the job opportunities (16); educational and social benefits (2); and improved community relations (1).

6.2.3.1.2.3 Knowledge and Views on Upgrade Plans

- Fifteen of the 17 persons were aware of the upgrade plans, 10 thought the impact on the economic value of the community would be positive and 14 saw the impact on job opportunities as positive.

- With regard to the impact on pollution, 9 persons saw it as negative, 5 as positive, 1 saw no change and 2 did not know.

- While 11 persons felt the upgrade will *not* affect them personally, 3 felt it would and 3 were not sure. One person did not respond.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. The prospects of job opportunities emerged as the main impact seen by 10 of the respondents. More dust circulating in the area (5); loss of income (2); more air pollution and noise (1); less air pollution and noise (1); and more diseases affecting breathing (1); were the other reasons given.

- As reasons for the particular answers given 11 stated that more jobs would be available. Presumably in relation to the circulation of dust and the existence of more pollution and noise, 3 respondents felt that the present bauxite and mining and processing facilities have caused this already so it can only get worse and this is something common to all bauxite operations (1). One respondent was of the opinion that the upgrade will add new equipment that will be cleaner to operate.

6.2.3.1.2.4 Availability of Water

- All 17 respondents had water piped indoor available to them with The National Water Commission as the original supplier

- Fourteen (14) persons were of the view that the water is safe to drink because it is tested frequently by the NWC (13) and it looks and smells clean (1).

6.2.3.1.2.5 Awareness and Solutions

- Only 4 of the 17 respondents stated that they had ever voiced an opinion on the pollution problem.
- Eight (8) persons said that they were satisfied with efforts to deal with the health problems in the community.
- No one had ever received compensation
- Four (4) persons reported that they or members of their household had worked in the bauxite industry.
- Six (6) of the 17 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- While 7 persons said they did not know or were unsure of what should be done about the pollution problem, 5 responses suggested that the bauxite emissions should be controlled/ reduced and the air filtered, while 2 responses recommended a plant upgrade.
- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (2); build/expand clinic (1); and compensation for residents/discomfort allowance (1); upgrade plant (2).
- Eleven (11) persons did not know or did not respond.

6.2.3.2 Bowens

6.2.3.2.1 THE SURVEY POPULATION

A total of 16 respondents were covered in the survey, 7 men and 9 women. Fourteen persons were between the ages of 20 and 59 years and 2 men were 60 years and over. The majority of persons (11) have lived in the community for more than 10 years, with 5, more than 20 years.

6.2.3.2.2 MAIN FINDINGS

6.2.3.2.2.1 Opinions on the Community

- Eight persons reported that they liked the community because it is quiet, 4 because of the friendly people and 3 because of the availability of farmland.

- Unemployment (6), poor roads (4) and the dirty environment (2) were the main reasons given for not liking the community.

- Ten of the 16 residents interviewed saw "large scale development as beneficial to the community". Job opportunities (8) were seen as the primary reason for this view.

6.2.3.2.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 16 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 14 of them said that they had experienced negative impacts from the operations.

- Odour (6), dust, soot and gaseous emissions (6) and damage to property (5) were the main factors identified.

- All but two persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (8); you get sick more often (3); and plants are harder to grow (2).

- Twelve of the 16 respondents agreed that the bauxite facility has had positive impacts on the people in the community because of the job opportunities (7) and the environmental conditions (4).

6.2.3.2.2.3 Knowledge and Views on Upgrade Plans

- Fifteen of the 16 persons were aware of the upgrade plans, 5 thought there would be no change in the economic value of the community impact on the economic value of the community, while there were as many responses (4) for a positive impact as for a negative impact. In relation to job opportunities, while 7 persons saw a positive effect, 5 persons saw no change, 2 saw a negative effect and 2 did not know.

- With regard to the impact on pollution, 10 persons saw it as positive, 5 as negative, and 1 did not know.

- While 14 persons felt the upgrade will affect them personally, 2 felt it would not.

- The responses to the question on the main impact overall of the proposed upgrade suggested negative factors. More dust circulating in the area (8) and more air pollution and noise (6) were the main reasons given.

- As reasons for the particular answers given there were 13 responses stating that the present bauxite and mining and processing facilities have caused this already so it can only get worse.

6.2.3.2.2.4 Availability of Water

- Fourteen respondents had water piped indoor available to them and 2 had outdoor pipe. The National Water Commission was the original supplier

- Only 1 person was of the view that the water is safe to drink. Nine said it was not safe and 5 were not sure. Seven persons gave the reason for doubting the safety as ‘bauxite mining affects the water’.

6.2.3.2.2.5 Awareness and Solutions

- Thirteen of the 16 persons said they had voiced their opinion on the health and pollution problems in the community

- Thirteen (13) persons said that they were not satisfied with efforts to deal with the health problems in the community.
- Six of the 16 respondents had received compensation in the past.
- Three (3) persons reported that they or members of their household had worked in the bauxite industry.
- Six (6) of the 16 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Regarding advice on solutions to the pollution problem, 5 persons suggested a relocation of the plant and 4 recommended control and reduction of bauxite emissions.
- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (5); build/expand clinic (2); and compensation for residents/discomfort allowance (4).

6.2.3.3 Raymonds

6.2.3.3.1 THE SURVEY POPULATION

A total of 17 respondents were covered in the survey, 8 men and 9 women. All except one man ranged in age between 20 and 59 years old. The majority of persons (9) have lived in the community between 11-20 years and 7 persons have been residents for more than 20 years.

6.2.3.3.2 MAIN FINDINGS

6.2.3.3.2.1 Opinions on the Community

- Twelve persons reported that they liked the community because of the friendly people and because it was quiet and 4 persons liked it because of the availability of farmland.

- Poor roads (6); unemployment (5); crime and violence (3); the dirty environment (2); and unfriendly people (1); were the main reasons given for not liking the community.

- Ten of the 17 residents interviewed saw "large scale development as beneficial to the community". Job opportunities (8) were the primary reason for this view. One person indicated the opportunity for skills development and one person although seeing the benefits of large-scale development, thought that it would affect environmental quality, negatively.

6.2.3.3.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 17 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and all of them said that they had experienced negative impacts from the operations.

- Dust, soot and gaseous emissions (10); damage to property (5); and odour (2) were the main factors identified.

- All 17 also agreed that the bauxite operations have had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (12); the area has widespread corrosion (1); you get sick more often (3); and plants are harder to grow (1).

- While 11 respondents agreed that the bauxite facility has had positive impacts on the people in the community, 6 said it did not. Job opportunities (8) and environmental conditions (3) were cited as the reasons.

6.2.3.3.2.3 Knowledge and Views on Upgrade Plans

- Fifteen of the 17 persons were aware of the upgrade plans. Ten persons thought the impact on the economic value of the community would be positive and 14 saw the impact on job opportunities as positive.

- With regard to the impact on pollution, 12 persons saw it as positive, 5 as negative.

- Most persons (16) felt the upgrade will affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. Most responses (8) related to 'more dust circulating in the area' while 7 responses indicated t job opportunities as the main impact. Loss of income (1) more air pollution and noise (6) were the other reasons given.

- As reasons for the particular answers given 10 stated that the present bauxite and mining and processing facilities have caused this already so it can only get worse. There were 7 responses stating that more jobs would be available.

6.2.3.3.2.4 Availability of Water

- The majority of respondents (14) received water from outdoor pipes. Only 2 had indoor pipes and 1 used a public standpipe. The National Water Commission was identified as the original supplier.

- Fourteen (14) persons were of the view that the water *was not* safe and 3 were not sure. The reason given by the 14 persons was that bauxite mining affects drinking water.

6.2.3.3.2.5 Awareness and Solutions

- All but one person indicated that they had voiced their opinion regarding health and pollution problems.

- Sixteen (16) of the 17 persons said that they were not satisfied with efforts to deal with the health problems in the community.

- Ten (10) persons had received compensation in the past.

- Four (4) persons reported that they or members of their household had worked in the bauxite industry.

- Only 3 of the 17 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Thirteen (13) persons suggested an upgrade of the bauxite plant as a solution to the pollution problem. Two (2) responses suggested that the bauxite emissions should be controlled/reduced and the air filtered.

- In relation to the health problems, the main responses were as follows; provide free/partially-funded healthcare (6); relocate JAMALCO farther away (5); and compensation for residents/discomfort allowance (2).

6.2.3.4 Savanna

6.2.3.4.1 THE SURVEY POPULATION

A total of 15 respondents were covered in the survey, 8 men and 7women. Twelve persons were between the ages of 20 and 59 years and 3 men were 60 years and over. The majority of persons (9) have lived in the community for more than 20 years. Six persons have been resident between 11 and twenty years.

6.2.3.4.2 MAIN FINDINGS

6.2.3.4.2.1 Opinions on the Community

- Six persons reported that they liked the community because it is quiet, 4 because of the friendly people and 3 because of the availability of farmland.

- Unemployment (9) and poor roads (5) were the main reasons given for not liking the community.

- Ten of the 15 residents interviewed saw "large scale development as beneficial to the community". Job opportunities (7) were seen as the primary reason for this view.

6.2.3.4.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 15 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and all of them said that they had experienced negative impacts from the operations.

- Odour (5); dust, soot and gaseous emissions (5) and damage to property (5) were the factors identified.

- Fourteen persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (7); and you get sick more often (3) ; the area has widespread corrosion (2) and plants are harder to grow.

- Thirteen of the fifteen respondents agreed that the bauxite facility has had positive impacts on the people in the community because of the job opportunities (5); environmental conditions (5); improved community relations (2) and educational and social benefits (1).

6.2.3.4.2.3 Knowledge and Views on Upgrade Plans

- Fourteen of the 15 persons were aware of the upgrade plans but not all thought the impact on the economic value of the community would be positive. While 6 persons thought the impact would be positive, 5 expressed the view that it would be negative, 1 thought there would be no change and 2 did not know. Ten of the respondents felt however that the impact on job opportunities would be positive.

- With regard to the impact on pollution, 10 persons saw it as positive and 5 as negative.

- Most persons (14) felt the upgrade will affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested more negative than positive factors. More dust circulating in the area (8) and more diseases affecting breathing (5) were the main reasons given. There were 4 responses for more job opportunities.

- As reasons for the particular answers given 12 respondents felt that the present bauxite and mining and processing facilities have caused this already so it can only get worse and this is something common to all bauxite operations (2).

6.2.3.4.2.4 Availability of Water

- Most persons (11) used outdoor pipes, and 4 had water piped indoors. The National Water Commission was the original supplier

- The respondents were equally divided on the question of the water safety; six persons were of the view that the water is safe to drink, 5 felt it was not safe and 4 were not sure. The water is tested frequently by the NWC (5) and it looks and smells clean (1); while bauxite mining affects the drinking water (4) were the responses regarding reasons for the opinions.

6.2.3.4.2.5 Awareness and Solutions

- Ten of the 15 persons said that they had voiced their opinion about the pollution and health problems in the past.
- All 15 respondents said that they were not satisfied with efforts to deal with the health problems in the community.
- Fourteen persons had received compensation in the past.
- Five (5) persons reported that they or members of their household had worked in the bauxite industry.
- Only 4 of the 15 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Suggestions regarding the solutions to the problem of pollution were as follows: relocate the plant (6); upgrade the plant and control/reduce bauxite air emissions.
- In relation to the health problems, the main responses was provide free/partially-funded healthcare (6).

6.2.3.5 Hayes Cornpiece

6.2.3.5.1 THE SURVEY POPULATION

A total of 30 respondents were covered in the survey, 15 men and 15 women. The majority of persons (25) were between the ages of 20 and 49 years and 23 persons have lived in the community for more than 20 years.

6.2.3.5.2 MAIN FINDINGS

6.2.3.5.2.1 Opinions on the Community

- Friendly people (11), quiet (5) and availability of farmland (4) were given as the main reasons for liking the community.
- Poor roads (14); unemployment (14); and the dirty environment (6) were the main reasons given for not liking the community.
- Twenty four of the 30 residents interviewed saw "large scale development as beneficial to the community". Job opportunities (20) were seen as the primary reason for this view.

6.2.3.5.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 30 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and all of them said that they had experienced negative impacts from the operations.
- Dust, soot and gaseous emissions (25); noise (12) and odour (9) and damage to property (8) were the main factors identified.
- All persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (22); too much noise (9); you get sick more often (9); plants are harder to grow (9) and area has widespread corrosion (6);

- The majority of respondents (21) agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities (15); educational and social benefits (5).

6.2.3.5.2.3 Knowledge and Views on Upgrade Plans

- The majority of respondents (27) were aware of the upgrade plans. Seventeen (17) thought there would be positive effects on the economic value of the community. In relation to job opportunities, while 20 persons saw a positive effect, while 5 persons saw no change.

- With regard to the impact on pollution, 15 persons saw it as negative while 12 persons saw it as positive.

- Twenty eight (28) persons felt the upgrade will affect them personally, 2 felt it would not.

- The responses to the question on the main impact overall of the proposed upgrade suggested negative factors. More dust circulating in the area (19) and more air pollution and noise (6) were the main negative reasons given while 8 responses indicated more jobs.

- As reasons for the particular answers given there were 23 responses stating that the present bauxite and mining and processing facilities have caused this already so it can only get worse.

6.2.3.5.2.4 Availability of Water

- The majority of respondents (20) had outdoor piped water available to them, 7 had indoor pipe with The National Water Commission being the original supplier

- Only 8 persons were of the view that the water is safe to drink. Nineteen said it was not safe because bauxite mining affects the water.

6.2.3.5.2.5 Awareness and Solutions

- Twenty three of the 30 persons said they had voiced their opinion on the health and pollution problems in the community

- All 30 persons said that they were not satisfied with efforts to deal with the health problems in the community.

- Twenty two (22) of the 30 respondents had received compensation in the past.

- Twenty one (21) persons reported that they or members of their household had worked in the bauxite industry.

- Twenty respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Regarding advice on solutions to the pollution problem, 14 persons suggested a relocation of the residents and 6 recommended the relocation of the plant.

- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (14) and compensation for residents/discomfort allowance (5).

6.2.3.6 Hayes Newtown

6.2.3.6.1 THE SURVEY POPULATION

A total of 4 respondents were covered in the survey, 1 man and 3 women all between the ages of 20 and 59 years. All 4 had lived in the community for between 11 and 20 years.

6.2.3.6.2 MAIN FINDINGS

6.2.3.6.2.1 Opinions on the Community

- No one reason stood out as the main one for liking the community as each person had a different response; friendly people, availability of farmland, quiet and no crime and violence.
- Unemployment (3), poor roads (1) and more development needed (2) were given as reasons for not liking the community.
- The 4 respondents were divided equally on the issue of the benefits of large-scale development as 2 said it was beneficial while said it was not. The potential for skills development and the negative effect on the environment were given as the reasons for the respective answers.

6.2.3.6.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 4 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and all of them said that they had experienced negative impacts from the operations.
- Odour (3) was the main factor identified.
- All agreed that the bauxite facility has had negative impacts on the people in the community, because the area had widespread corrosion.
- The 4 persons also agreed that the bauxite facility has had positive impacts on the people in the community and interestingly identified environmental conditions as the reason.

6.2.3.6.2.3 Knowledge and Views on Upgrade Plans

- All 4 persons were aware of the upgrade plans and were not very positive about the impact on the economic value of the community. Two thought this would be negative and 2 thought there would be no change. In relation to job opportunities 3 persons thought there would be no change.

- All 4 persons did however see a positive effect on pollution.

- The 4 persons felt the upgrade will affect them personally as more dust would be circulating in the area. This was because this was common to all bauxite operations.

6.2.3.6.2.4 Availability of Water

- All 4 respondents had water piped indoor available to them .The National Water Commission was the original supplier

- No one was of the view that the water is safe to drink because bauxite mining affects drinking water.

6.2.3.6.2.5 Awareness and Solutions

- All 4 persons said they had voiced their opinion on the health and pollution problems in the community and all said that they were not satisfied with efforts to deal with the health problems in the community.

- Two of the 4 respondents had received compensation in the past.

- Two (2) persons reported that they or members of their household had worked in the bauxite industry.

- Two of the 4 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Regarding advice on solutions to the pollution problem, 1 person suggested an upgrade of the plant and 1 recommended control and reduction of bauxite emissions.

- In relation to the health problems there were 3 responses recommending a relocation of people and 2 suggesting community meetings.

6.2.3.7 Lionel Town

6.2.3.7.1 THE SURVEY POPULATION

A total of 21 respondents were covered in the survey, 10 men and 11 women. The majority of persons (15) were between the ages of 20 and 49 years; and 13 persons have lived in the community for more than 20 years.

6.2.3.7.2 MAIN FINDINGS

6.2.3.7.2.1 Opinions on the Community

- Friendly people (13), quiet (8) and clean environment (6) were given as the main reasons for liking the community.
- Poor roads (21) and unemployment (18) were the main reasons given for not liking the community.
- All but 1 of the 21 residents interviewed saw "large scale development as beneficial to the community" because of the job opportunities.

6.2.3.7.2.2 Awareness and Opinions on Existing Bauxite Operations

- Twenty of the 30 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area but only 6 of them said that they had experienced negative impacts from the operations.
- Dust, soot and gaseous emissions (3); odour (2); and damage to property (2) were the main factors identified.
- Nine of the 21 persons felt that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (2); plants are harder to grow (2) and the area has widespread corrosion (2).
- While 11 persons felt that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities, 10 persons felt that there was no positive impact.

6.2.3.7.2.3 Knowledge and Views on Upgrade Plans

- The majority of respondents (18) were aware of the upgrade plans and thought there would be positive effects on the economic value of the community. In relation to job opportunities, 20 persons saw a positive effect.

- With regard to the impact on pollution, 4 persons saw it as positive, 9 persons saw it as negative and 8 said they did not know.

- Only 3 persons felt the upgrade will affect them personally. Thirteen felt it would not and 5 were not sure.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive factors. More job opportunities (20) arising from the fact that more jobs would be available was seen as the main impact.

6.2.3.7.2.4 Availability of Water

- The majority of respondents (11) had indoor piped water available to them and 9 had outdoor pipes. Nineteen (19) residents stated that The National Water Commission was the original supplier while 1 did not know.

- Only 5 persons were of the view that the water is safe to drink, because it looks and or smells clean. Fourteen said it was not safe with 8 responses indicating that the water is affected by bauxite mining and other sources.

6.2.3.7.2.5 Awareness and Solutions

- Only 5 of the 21 persons said they had voiced their opinion on the health and pollution problems in the community

- Only 6 persons said that they were not satisfied with efforts to deal with the health problems in the community.

- No one had received any compensation for pollution problems in the past.

- Only 1 person reported having worked in the bauxite industry.

- Only 4 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Regarding advice on solutions to the pollution problem, 8 persons suggested controlling/ reducing bauxite emissions while 7 said they did not know what to do.

- In relation to the health problems, the responses were as follows; build/expand clinic/ upgrade hospital (4); provide free/partially funded healthcare (3) and compensation for residents/discomfort allowance (3).

6.2.3.8 Mitchell Town

6.2.3.8.1 THE SURVEY POPULATION

A total of 37 respondents were covered in the survey, 16 men and 21 women. Twenty two of these persons were between the ages of 20 and 49 years; and 32 persons have lived in the community for more than 20 years.

6.2.3.8.2 MAIN FINDINGS

6.2.3.8.2.1 Opinions on the Community

- Quiet (29) and friendly people were given as the main reasons for liking the community.

- Poor roads (36); unemployment (28); lack of utilities (13) and the dirty environment (6) were the main reasons given for not liking the community.

- The overwhelming majority of the 37 residents interviewed (36) saw "large scale development as beneficial to the community". Job opportunities (36) and skill development potential (14) were seen as the primary reasons for this view.

6.2.3.8.2.2 Awareness and Opinions on Existing Bauxite Operations

- All but 1 of the 37 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area. There was an almost equal division between the numbers who reported that they had experienced negative impacts (18) and those who had not (19).

- Dust, soot and gaseous emissions (15); odour (8) and damage to property (6) were the main factors identified.

- Seventeen of the 37 respondents felt that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area has widespread corrosion (8); the area smells like caustic soda more often than not (6); plants are harder to grow (5).

- The majority of respondents (32) agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities (29); educational and social benefits (17) and improved community relations.

6.2.3.8.2.3 Knowledge and Views on Upgrade Plans

- The majority of respondents (33) were aware of the upgrade plans. Thirty two (32) thought there would be positive effects on the economic value of the community and 34 responses stated that there would be a positive effect on job opportunities.

- With regard to the impact on pollution, there were 18 responses for a negative impact and 9 for a positive impact.

- Twenty one (21) persons felt the upgrade will not affect them personally, 7 felt it would.

- The responses to the question on the main impact overall of the proposed upgrade suggested negative factors. The responses to the question on the main impact overall of the proposed upgrade suggested positive factors. There were 37 responses indicating that more jobs would become available.

- There were 5 responses anticipating an increase in population in the community.

- More dust circulating in the area (11) and more air pollution and noise (10) were the main negative reasons given.

6.2.3.8.2.4 Availability of Water

- Twelve (12) respondents had indoor piped water available to them, 14 had outdoor pipes and 7 used standpipes. The National Water Commission was identified as the original supplier by 15 respondents.

- More than a half (21) of the 37 persons were of the view that the water is *not* safe to drink. Ten said it was not safe because other sources affect the water and 10 did not respond. The 16 indicating that the water was safe had as the reason the fact that the water was tested frequently by the NWC and that it looked and or smelt clean.

6.2.3.8.2.5 Awareness and Solutions

- Only 8 of the 36 persons said they had voiced their opinion on the health and pollution problems in the community

- Sixteen persons said that they were satisfied with efforts to deal with the health problems in the community while 19 said that they were not satisfied.

- No one had ever received compensation for pollution problems.

- Twenty five (25) persons reported that they or members of their household had worked in the bauxite industry.

- All but 1 respondent indicated an awareness of programs or activities initiated by JAMALCO.

- Regarding advice on solutions to the pollution problem, 13 persons suggested controlling/ reducing bauxite emissions while 13 persons did not know.

- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (5).

- Eleven respondents said that they were willing to offer assistance in solving the problem.

6.2.3.9 Rocky Point

6.2.3.9.1 THE SURVEY POPULATION

A total of 26 respondents were covered in the survey, 16 men and 10 women. The majority of persons (17) were between the ages of 20 and 49 years and 17 persons have lived in the community for more than 20 years.

6.2.3.9.2 MAIN FINDINGS

6.2.3.9.2.1 Opinions on the Community

- There were 25 responses indicating friendly people and 23 to the quietness of the area as the main reasons for liking the community. Fifteen responses identified ‘no crime and violence’.

- Poor roads (20); unemployment (22) and lack of utilities (7) were the main reasons given for not liking the community.

- Twenty four of the 26 residents interviewed saw “large scale development as beneficial to the community”. Job opportunities (23) and the offers of skill development (16) were seen as the primary reason for this view.

6.2.3.9.2.2 Awareness and Opinions on Existing Bauxite Operations

- Twenty four of the 26 respondents said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 9 of them said that they had experienced negative impacts from the operations.

- Dust, soot and gaseous emissions (4); odour (6) and damage to property (3) were the main factors identified.

- Eleven agreed that the bauxite facility has had negative impacts on the people in the community. The main reason given was that plants are harder to grow (8).

- Just over a half of the respondents (14) agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities (13); improved community relations (5) and educational and social benefits (3).

6.2.3.9.2.3 Knowledge and Views on Upgrade Plans

- The majority of respondents (21) were aware of the upgrade plans. There were 21 responses indicating that there would be positive effects on the economic value of the community. In relation to job opportunities, while 20 persons saw a positive effect, while 4 persons saw no change.

- With regard to the impact on pollution, 8 responses saw it as negative, 5 saw it as positive and 8 indicated no change.

- Only 6 of the 26 persons felt the upgrade will affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive factors. There were 24 responses indicating that more jobs would become available.

- There were 10 responses anticipating an increase in population in the community.

6.2.3.9.2.4 Availability of Water

- The majority of respondents (15) had indoor piped water available to them and 9 had outdoor pipes. Nineteen (19) residents stated that The National Water Commission was the original supplier while 4 did not know.

- Only 8 persons were of the view that the water is safe to drink but there were 18 responses indicating that the water is frequently tested by the NWC and the water looks and or smells clean. There were 13 responses indicating that the water was not safe but the reasons for this were not clear as there were only 6 responses indicating that the water is affected by bauxite mining or other sources.

6.2.3.9.2.5 Awareness and Solutions

- Seven persons said they had voiced their opinion on the health and pollution problems in the community

- Only 4 persons said that they were satisfied with efforts to deal with the health problems in the community.

- No one interviewed had ever received compensation for any pollution problems.

- Ten (10) persons reported that they or members of their household had worked in the bauxite industry.

- Only 5 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Regarding advice on solutions to the pollution problem, 5 persons suggested controlling/ reducing bauxite emissions while 8 said they did not know what to do.

- In relation to the health problems, the highest number of responses (11) was for build/expand clinic/upgrade hospital.

6.2.3.10 Alley

6.2.3.10.1 THE SURVEY POPULATION

A total of 16 respondents were covered in the survey, 8 men and 8 women. One man was under 20 years old and eleven persons were between the ages of 20 and 49 years. The majority of persons (9) have lived in the community for between 11 and 20 years.

6.2.3.10.2 MAIN FINDINGS

6.2.3.10.2.1 Opinions on the Community

- Twelve persons reported that they liked the community because it is quiet, 7 because there is no crime and violence and 5 because of the friendly people.
- Unemployment (16) and poor roads (4) were the main reasons given for not liking the community.
- Fifteen of the 16 residents interviewed saw "large scale development as beneficial to the community". Job opportunities were seen as the primary reason for this view.

6.2.3.10.2.2 Awareness and Opinions on Existing Bauxite Operations

- Nine persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 3 of them said that they had experienced negative impacts from the operations.
- Odour, dust, soot and gaseous emissions and damage to property were the factors identified.
- Four persons indicated that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not; you get sick more often and plants are harder to grow.

- Six respondents felt that the bauxite facility has had positive impacts on the people in the community because of the job opportunities (5) and the improved community relations (1).

6.2.3.10.2.3 Knowledge and Views on Upgrade Plans

- All 16 persons were aware of the upgrade plans but not all thought the impact on the economic value of the community would be positive. While 7 persons thought the impact would be positive, 5 expressed the view that it would be negative, 3 thought there would be no change and 1 did not know. Thirteen of the respondents felt however that the impact on job opportunities would be positive.

- With regard to the impact on pollution, 8 persons saw it as negative.

- Most persons (13) felt the upgrade will *not* affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested more positive than negative factors. There were 13 responses for job opportunities, compared to ‘more dust circulating in the area’ (4).

- As reasons for the particular answers given 10 respondents felt that more jobs will become available.

6.2.3.10.2.4 Availability of Water

- Most persons (11) used outdoor pipes, and 5 had water piped indoors. The National Water Commission was the original supplier

- All but 1 respondent, who was not sure, said the water was safe to drink. The water is tested frequently by the NWC (14) and it looks and smells clean (1), were the responses regarding reasons for the opinions.

6.2.3.10.2.5 Awareness and Solutions

- Only 1 person reported ever voicing an opinion on the pollution problem.
- Only 3 of the 16 persons said that they were satisfied with efforts to deal with the health problems in the community.
- No one reported having received compensation in the past.
- Only 2 persons reported that they or members of their household had worked in the bauxite industry.
- None of the 16 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Suggestions on solutions to the pollution problem range from, there is nothing that can be done (4), don't know (3) to control/reduce bauxite emissions (3).
- While 4 persons said that nothing can be done about the pollution problem, and 3 said 'don't know' 3 responses suggested that the bauxite emissions should be controlled/ reduced and/ or the air filtered.
- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (7); build/expand clinic (5).

6.2.3.11 Brokenbank/Water Lane

6.2.3.11.1 THE SURVEY POPULATION

A total of 6 respondents were covered in the survey, 2 men and 4 women. A half of the persons were between 50 and 59 years and 4 persons have lived in the community for more than 20 years.

6.2.3.11.2 MAIN FINDINGS

6.2.3.11.2.1 Opinions on the Community

- Five persons reported that they liked the community because there is no crime and violence and 2 because of the friendly people.

- Unemployment (4) and poor roads (4) were the main reasons given for not liking the community.

- Four of the 6 residents interviewed saw "large scale development as beneficial to the community". Job opportunities and the offer of skill development were seen as the primary reasons for this view.

6.2.3.11.2.2 Awareness and Opinions on Existing Bauxite Operations

- Four of the 6 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area. Only 1 person had experienced negative impacts from the operations, due to the odour.

- One person agreed that the bauxite facility has had negative impacts on the people in the community. The reason given was that, the area smells like caustic soda more often than not.

- Three respondents agreed that the bauxite facility has had positive impacts on the people in the community because of the job opportunities

6.2.3.11.2.3 Knowledge and Views on Upgrade Plans

- All 6 persons were aware of the upgrade plans but not all thought the impact on the economic value of the community would be positive. While 2 persons thought the impact would be positive, 4 expressed the view that it would be negative. All of the respondents felt however that the impact on job opportunities would be positive.

- With regard to the impact on pollution, 2 persons saw it as negative and 1 as positive and the remaining 3 did not know.

- Most persons (5) felt the upgrade will not affect them personally.

- The responses to the question on the main impact overall was that more jobs would be available

6.2.3.11.2.4 Availability of Water

- Four (4) persons used outdoor pipes, and 2 had water piped indoors. The National Water Commission was the original supplier

- While 5 persons were of the view that the water is safe to drink, 1 was not sure. The water is tested frequently by the NWC (4) and it looks and smells clean (1), were the responses regarding reasons for the opinions.

6.2.3.11.2.5 Awareness and Solutions

- Two (2) of the 6 persons reported that they had voiced an opinion on the pollution problem

- No one was satisfied with efforts to deal with the health problems in the community.

- No one had received compensation for pollution in the past.

- All reported that no or member of their household had worked in the bauxite industry.

- Only 1 of the 6 respondents indicated an awareness of programmes or activities initiated by JAMALCO.

- Regarding suggestions for dealing with the pollution problem, there was 1 response each for the following; there is nothing that can be done, health inspectors should visit the plant and citizens should be notified when the burning of cane was to take place.

- In relation to the health problems, the main responses were as follows; provide free/partially-funded healthcare (2).

6.2.3.12 Cockpit

6.2.3.12.1 THE SURVEY POPULATION

A total of 17 respondents were covered in the survey, 11 men and 6women. Eleven persons were between the ages of 20 and 59 years and 4 were 60 years and over. The majority of persons (10) have lived in the community for more than 20 years.

6.2.3.12.2 MAIN FINDINGS

6.2.3.12.2.1 Opinions on the Community

- Eight persons reported that they liked the community because of the friendly people and 6 because it is quiet.
- Poor roads (16); Unemployment (11) and lack of utilities were the main reasons given for not liking the community.
- Sixteen of the 17 residents interviewed saw "large scale development as beneficial to the community". Job opportunities (16) were seen as the primary reason for this view.

6.2.3.12.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 17 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 9 of them said that they had experienced negative impacts from the operations.
- Odour (5); and dust, soot and gaseous emissions (5); were the factors identified as causing the problems.
- Nine persons agreed that the bauxite facility has had negative impacts on the people in the community. The main reason given was that, the area has widespread corrosion (8).
- Ten of the 17 respondents agreed that the bauxite facility has had positive impacts on the people in the community because of the job opportunities (7).

6.2.3.12.2.3 Knowledge and Views on Upgrade Plans

- The majority of respondents (10) were aware of the upgrade plans and all thought the impact on the economic value of the community and job opportunities would be positive.
- The impact on pollution was however seen as negative.
- Most persons (12) felt the upgrade will not affect them personally.
- The responses to the question on the main impact overall of the proposed upgrade suggested more positive than negative factors. All saw the availability of more jobs as the main impact.

6.2.3.12.2.4 Availability of Water

- Most persons (12) used public standpipes and 5 had access to outdoor pipes. The National Water Commission was identified as the original supplier by 3 of the 5 persons. Two indicated that they did not know who the original supplier was.
- All but 1 respondent felt that the water was safe to drink. The water looks and smells clean (11) and is tested frequently by the NWC (4) were the responses regarding reasons for the opinions.

6.2.3.12.2.5 Awareness and Solutions

- Eleven (11) of the 17 respondents reported that they had voiced an opinion on the pollution problem.
- Only 1 person said that they were satisfied with efforts to deal with the health problems in the community.
- One person had received compensation for the pollution problem in the past
- Four (4) persons reported that they or members of their household had worked in the bauxite industry.

- Two (2) of the 17 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Regarding suggestions for dealing with the pollution problem, there were 9 responses for control/reduce bauxite emissions.

- In relation to the health problems, there were also 9 responses for provide free/partially funded healthcare.

6.2.3.13 New Gayle

6.2.3.13.1 THE SURVEY POPULATION

A total of 5 respondents were covered in the survey, 4 men and 1woman. Two persons were under 40 years old. All had been resident in the community for more than 5 years, with 2 residents for more than 20 years.

6.2.3.13.2 MAIN FINDINGS

6.2.3.13.2.1 Opinions on the Community

- All 5 persons reported that they liked the community because it was quiet and there was no crime and violence.
- Poor roads (5); unemployment (5) and lack of utilities (2) were the main reasons given for not liking the community.
- While 2 of the 5 residents interviewed saw large-scale development as beneficial to the community, because of the job opportunities, 3 did not, mainly because of the negative impact on the environment.

6.2.3.13.2.2 Awareness and Opinions on Existing Bauxite Operations

- Three (3) of the 5 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and they had experienced negative impacts from the operations.
- Damage to property and damage to plants and trees were the reasons cited.
- Two persons agreed that the bauxite facility has had negative impacts on the people in the community. The main reason given was that plants are harder to grow.
- Only 1 person saw a positive impact but the reason was not identified.

6.2.3.13.2.3 Knowledge and Views on Upgrade Plans

- All 5 respondents were aware of the upgrade plans but while 4 thought the impact on the economic value of the community would be negative 3 felt that the impact on job opportunities would be positive.
- The impact on pollution was however seen as negative.
- While 2 persons felt the upgrade will affect them personally, 2 did not.
- The responses to the question on the main impact overall of the proposed upgrade suggested more positive than negative factors. All saw the availability of more jobs as the main impact.

6.2.3.13.2.4 Availability of Water

- Most persons (4) had access to outdoor pipes. The National Water Commission was identified as the original supplier by 3 of the 5 persons.
- All but 1 respondent felt that the water was safe to drink because it was tested frequently by the NWC.

6.2.3.13.2.5 Awareness and Solutions

- No one reported that they had voiced an opinion on the pollution problem.
- Only 1 person was satisfied with efforts to deal with the health problems in the community.
- No one had received compensation for the pollution problem in the past
- No one reported having worked in the bauxite industry.
- No one indicated an awareness of programs or activities initiated by JAMALCO.
- Regarding suggestions for dealing with the pollution and health problems there were no clear views.

6.2.3.14 Old Gayle

6.2.3.14.1 The Survey Population

A total of 5 respondents were covered in the survey, 4 men and 1woman. All persons were 40 years old or more. Four persons had been resident in the community for more than 20 years.

6.2.3.14.2 MAIN FINDINGS

6.2.3.14.2.1 Opinions on the Community

- Four persons reported that they liked the community because it was quiet and 1 because there is no crime and violence.
- Poor roads (4) and unemployment (4) were the main reasons given for not liking the community.
- While 2 of the 5 residents interviewed saw large scale development as beneficial to the community, because of the job opportunities, 3 did not, mainly because of the negative impact on the environment.

6.2.3.14.2.2 Awareness and Opinions on Existing Bauxite Operations

- Four (4) of the 5 respondents said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 2 of them said that they had experienced negative impacts from the operations.
- Dust, soot and gaseous emissions and damage to property were the factors identified as causing the problems.
- Two persons agreed that the bauxite facility has had negative impacts on the people in the community. The main reason given was that plants are harder to grow.
- Two respondents agreed that the bauxite facility has had positive impacts on the people in the community because of the job opportunities.

6.2.3.14.2.3 Knowledge and Views on Upgrade Plans

- All 5 respondents were aware of the upgrade plans but all thought the impact on the economic value of the community would be negative while the impact on job opportunities would be positive.

- The impact on pollution was however seen as negative.

- All persons felt the upgrade will not affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested more positive than negative factors. All saw the availability of more jobs as the main impact.

6.2.3.14.2.4 Availability of Water

- Most persons (4) had access to outdoor pipes. The National Water Commission was identified as the original supplier by 3 of the 5 persons. Two indicated that they did not know who the original supplier was.

- All respondents felt that the water was safe to drink because it is tested frequently by the NWC.

6.2.3.14.2.5 Awareness and Solutions

- None of the 5 respondents reported that they had voiced an opinion on the pollution problem.

- No one said that they were satisfied with efforts to deal with the health problems in the community.

- No one had received compensation for the pollution problem in the past

- One (1) person reported having worked in the bauxite industry.

- None of the respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Regarding suggestions for dealing with the pollution problem, there were 2 responses for ceasing the burning of cane.
- In relation to the health problems, the responses were for provide free/partially-funded healthcare.

6.2.3.15 Portland Cottage

6.2.3.15.1 THE SURVEY POPULATION

A total of 17 respondents were covered in the survey, 6 men and 11women. More than a half of the sample (10) was between the ages of 20 and 49 years. The majority of persons (15) have lived in the community for more than 20 years.

6.2.3.15.2 MAIN FINDINGS

6.2.3.15.2.1 Opinions on the Community

- Fourteen persons reported that they liked the community because of the friendly people, and 11 because it is quiet.
- Unemployment (17) poor roads (16) and lack of utilities (10) were the main reasons given for not liking the community.
- Thirteen of the 17 residents interviewed saw large scale development as beneficial to the community because of the job opportunities (14) and prospects for skill development (12).

6.2.3.15.2.2 Awareness and Opinions on Existing Bauxite Operations

- Sixteen of the 17 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 11 of them said that they had experienced negative impacts from the operations.
- Odour, dust, soot and gaseous emissions and damage to property were the factors identified.
- Eleven persons indicated that the bauxite facility has had negative impacts on the people in the community. The main reason given was that the area has widespread corrosion.
- Eleven respondents felt that the bauxite facility has had positive impacts on the people in the community because of improved community relations (8); the job opportunities (6) and educational and social benefits (6)

6.2.3.15.2.3 Knowledge and Views on Upgrade Plans

- The majority of the 16 respondents (11) were aware of the upgrade plans and there were 13 responses indicating a positive impact on the economic value of the community and on job opportunities.

- With regard to the impact on pollution, 9 persons felt there would be no change, 5 were of the view that it would be positive and 3 felt it would be negative.

- The respondents were almost equally divided regarding the possible effects on them personally. Seven (7) felt that it would not affect them personally, 6 felt that it would and 4 were not sure.

- The responses to the question on the main impact overall of the proposed upgrade suggested more positive than negative factors. There were 11 responses for job opportunities, compared to 8 responses for more dust circulating in the area and more air pollution and noise.

6.2.3.15.2.4 Availability of Water

- Most persons (12) had water piped indoors while 5 used outdoor pipes. The National Water Commission was the original supplier

- Most respondents (12) did not think that the water was safe to drink because the water is affected by sources other than the bauxite mining. The water is tested frequently by the NWC (4) and it looks and smells clean (1), were the responses regarding reasons for the view that it is safe to drink by those who think so.

6.2.3.15.2.5 Awareness and Solutions

- Four (4) persons reported that they had ever voiced an opinion on the pollution problem

- Only 1 person reported being satisfied with efforts to deal with the health problems in the community.

- No one reported having received compensation in the past.

- Four (4) persons reported that they or members of their household had worked in the bauxite industry.

- Two (2) of the 17 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Suggestions on solutions to the pollution problem focused on control/reduce bauxite emissions.

- In relation to the health problems, the response generally was to provide free/partially funded healthcare.

6.2.3.16 Race Course

6.2.3.16.1 THE SURVEY POPULATION

A total of 7 respondents were covered in the survey, 4 men and 3 women. Four persons were under 50 years old and 3 were 60 years and over. While 4 persons have lived in the community for more than 20 years, 1 of the remaining 3 had been resident for between 0 and 5 years.

6.2.3.16.2 MAIN FINDINGS

6.2.3.16.2.1.1 Opinions on the Community

- All 7 persons reported that they liked the community because of the friendly people 4 because it is quiet and 3 because of the clean environment.

- Unemployment (7) was the main reasons given for not liking the community. There were 4 responses indicating that more development was needed.

- All 7 residents interviewed saw "large scale development as beneficial to the community". Job opportunities were seen as the primary reason for this view.

6.2.3.16.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 7 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and they all said that they had experienced negative impacts from the operations.

- Odour (7), and dust, soot and gaseous emissions (5) were the factors identified as causing the problems.

- Six persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were; you get sick more often (5); the area has widespread corrosion (4) and the area smells like caustic soda (4);

- Five of the 7 respondents agreed that the bauxite facility has had positive impacts on the people in the community because of job opportunities (5); improved community relations (4) and educational and social benefits (4).

6.2.3.16.2.3 Knowledge and Views on Upgrade Plans

- All 7 persons interviewed were aware of the upgrade plans and 6 of the 7 thought the impact on the economic value of the community and job opportunities would be positive.

- As regards the impact on pollution 1 person saw it as negative, while 4 saw no change.

- Most persons (4) felt the upgrade will not affect them personally.

- The response to the question on the main impact overall of the proposed upgrade was mixed. While there were 5 responses indicating more jobs, 5 responses saw more air pollution and noise and 4 responses suggested more dust circulating in the area.

6.2.3.16.2.4 Availability of Water

- Six of the 7 persons had indoor pipes. The National Water Commission was identified as the original supplier.

- Four (4) respondents felt that the water was not safe to drink because the water is affected by sources other than the bauxite mining. The water is tested frequently by the NWC (2) and it looks and smells clean (1), were the responses regarding reasons for the view that it is safe to drink by those who think so.

6.2.3.16.2.5 Awareness and Solutions

- None of the 7 respondents reported that they had voiced an opinion on the pollution problem.
- Two (2) persons said that they were satisfied with efforts to deal with the health problems in the community.
- No one had received compensation for the pollution problem in the past
- Three (3) persons reported that they or members of their household had worked in the bauxite industry.
- None of the respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Regarding suggestions for dealing with the pollution problem, there were 3 responses for control/reduce bauxite emissions.
- In relation to the health problems, the provision of free/partially funded healthcare was proposed.

6.2.3.17 Salt River

6.2.3.17.1 THE SURVEY POPULATION

A total of 7 respondents were covered in the survey, 3 men and 4 women. Three persons were under 50 years old. While 4 persons have lived in the community for more than 20 years, 2 of the remaining 3 had been resident for between 0 and 5 years.

6.2.3.17.2 MAIN FINDINGS

6.2.3.17.2.1.1 Opinions on the Community

- All 7 persons reported that they liked the community because it is quiet.
- Unemployment (4) and lack of utilities (3) were the main reasons given for not liking the community.
- Six (6) of the 7 residents interviewed saw "large scale development as beneficial to the community". Job opportunities were seen as the primary reason for this view.

6.2.3.17.2.2 Awareness and Opinions on Existing Bauxite Operations

- Six (6) persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 2 of them said that they had experienced negative impacts from the operations.
- Dust, soot and gaseous emissions were the factors identified as causing the problems.
- The majority of persons (6) did not think that the bauxite operations impacted negatively on the people in the community.
- They thought that the bauxite facility has had positive impacts on the people in the community mainly because of the educational and social benefits.

6.2.3.17.2.3 Knowledge and Views on Upgrade Plans

- The majority of respondents (6) were aware of the upgrade plans and all thought the impact on the economic value of the community and job opportunities would be positive.

- The impact on pollution was however seen as negative.

- The respondents were divided on the issue of how the upgrade would affect them. Three (3) felt it would, 2 felt it would not and 2 said there would be no change

- The responses to the question on the main impact overall of the proposed upgrade suggested more positive than negative factors. All saw the availability of more jobs as the main impact.

6.2.3.17.2.4 Availability of Water

- No one had access to any piped water and rainwater was the main source.

- Four (4) of the 7 respondents felt that the water was safe to drink as it looks and smells clean.

6.2.3.17.2.5 Awareness and Solutions

- Only 1 of the 5 respondents reported that they had voiced an opinion on the pollution problem.
- No one said that they were satisfied with efforts to deal with the health problems in the community.
- No one had received compensation for the pollution problem in the past
- Four (4) persons reported that they or members of their household had worked in the bauxite industry.
- Four (4) of the 7 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Regarding suggestions for dealing with the pollution problem, there were 4 responses indicating that they did not know what to do. There were 2 responses for control/reduce bauxite emissions.
- In relation to the health problems, there was 1 response each for provide free/partially funded healthcare and build/expand clinic.

6.2.3.18 Kemps Hill

6.2.3.18.1 THE SURVEY POPULATION

A total of 14 respondents were covered in the survey, 4 men and 10 women. More than half of the sample (9) was between the ages of 20 and 49 years. The majority of persons (9) have lived in the community for between 11 and 20 years.

6.2.3.18.2 MAIN FINDINGS

6.2.3.18.2.1 Opinions on the Community

- The community is liked because of friendly people (13), it is quiet (12) and there is no crime and violence (11).
- Unemployment (14) was the main reasons given for not liking the community.
- All residents interviewed saw “large scale development as beneficial to the community”. Job opportunities were seen as the primary reason for this view.

6.2.3.18.2.2 Awareness and Opinions on Existing Bauxite Operations

- All persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 13 of them said that they had experienced negative impacts from the operations.
- Odour, dust, soot and gaseous emissions and damage to property were the factors identified.
- All 14 persons indicated that the bauxite facility has had negative impacts on the people in the community. The main reasons given were that, the area has widespread corrosion (14) the area smells like caustic soda (10)
- Ten respondents felt that the bauxite facility has had positive impacts on the people in the community mainly because of the improved community relations (9); educational and social benefits (9) and job opportunities (7) and.

6.2.3.18.2.3 Knowledge and Views on Upgrade Plans

- Eleven of the 14 respondents were aware of the upgrade plans and 13 felt that the impact on the economic value of the community would be positive. Thirteen of the respondents felt however that the impact on job opportunities would be positive and 12 gave the opinion that the impact on job opportunities would also be positive.

- With regard to the impact on pollution, a half of the persons saw no change.

- Six (6) persons felt the upgrade will affect them personally, 4 thought it would not and 4 saw no change.

- The responses to the question on the main impact overall of the proposed upgrade suggested both positive than negative factors. There were 12 responses for job opportunities and 5 for better community relations, but there were 10 each indicating more dust circulating in the area and more pollution and noise. There were 11 responses which indicated that the upgrade will mean new equipment for cleaning.

6.2.3.18.2.4 Availability of Water

- Most persons (11) used indoor pipes, and 3 had piped water outdoors. The National Water Commission was the original supplier

- The majority, 8, of the 14 respondents said the water was safe to drink. The water is tested frequently by the NWC and it looks and smells clean, were the responses regarding reasons for the opinions.

6.2.3.18.2.5 Awareness and Solutions

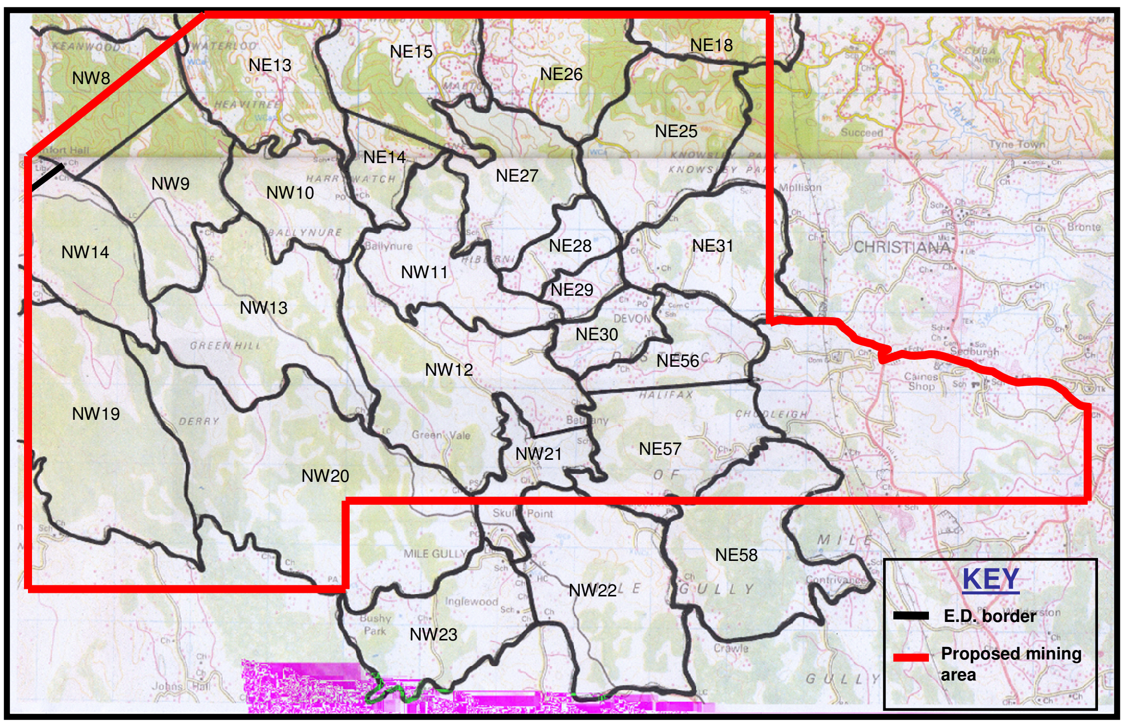
- Only 4 persons reported ever voicing an opinion on the pollution problem.
- Only 1 of the 14 persons said that they were satisfied with efforts to deal with the health problems in the community.
- No one reported having received compensation in the past
- Only 3 persons reported that they or members of their household had worked in the bauxite industry.
- None of the 14 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Eight (8) persons said they did not know what could be done about the pollution problem, and 4 responses suggested that the bauxite emissions should be controlled/ reduced and /or the air filtered.
- In relation to the health problems, the responses were as follows; build/expand clinic (8); provide free/partially funded healthcare (5).

6.3 Northern Manchester

6.3.1 The Communities

While the selection of the areas for interviewing were based on the enumeration districts as defined by STATIN, the communities as presented in this report were defined in the field by the interviewer and the respondent. Accordingly it is possible for a number of communities to cross Ed boundaries. The list of communities identified appears as Figure 78 below.

Figure 78: Enumeration Districts Surveyed for Northern Manchestr



6.3.2 Demographic and Social Profile

The total population identified for this area in the 2001 census was 13,000. Males were predominant, comprising 52.4 per cent of the total. The women were on average older than the men with an average age of 30.7 years compared to 29.2 years for men. In relation to educational attainment approximately 52 per cent of the population 15 years and older had attained a secondary level education, while 4 per cent had attained tertiary level.

There were 3,147 housing units in the area, 90 per cent of which were of the separate-detached type. The main material used in the construction of the housing units was concrete. Average household size was 3.5. While approximately 67 per cent of units were owned, 31 per cent was occupied under lease and rent free arrangements.

The main source of water for 62 per cent of the approximately 3,400 households, was the private catchments. The pit toilet was the main type utilized by about 70 per cent of households.

6.3.3 FINDINGS OF THE STUDY FOR COMMUNITIES

Due to the small size of the community samples, the analysis will be presented on the basis of the absolute numbers and not on percentages.

6.3.3.1 Mile Gully

6.3.3.1.1 THE SURVEY POPULATION

A total of 37 respondents were covered in the survey, 21 men and 16 women .The majority of persons (22) ranged between 20 and 49 years. The majority of persons (25) have lived in the community for more than 20 years.

6.3.3.1.2 MAIN FINDINGS

6.3.3.1.2.1 Opinions on the Community

- Thirty four persons reported that they liked the community because it was quiet, there were 27 responses each for friendly people and no crime and violence.

- Unemployment (38) and lack of utilities (28) were the main reasons given for not liking the community.

- Thirty four of the 37 residents interviewed saw “large scale development as beneficial to the community”. Job opportunities and the potential for development of skills were seen as the primary reasons for this view.

6.3.3.1.2.2 Awareness and Opinions on Existing Bauxite Operations

- Thirty three (33) persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 19 of them said that they had not experienced any negative impacts from the operations.

- The 14 who reported that the operations had impacted negatively on them identified dust, soot and gaseous emissions and odour as the factors affecting them.

- Twelve persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area has widespread corrosion (9); and the area smells of caustic soda (5).

- Twenty nine of the 33 respondents agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities (26).

6.3.3.1.2.3 Knowledge and Views on Upgrade Plans

- Twenty seven of the 37 persons interviewed were aware of the upgrade plans, 23 thought the impact on the economic value of the community would be positive and 26 saw the impact on job opportunities as positive.

- With regard to the impact on pollution, 8 persons saw it as positive, 7 saw no change and 5 did not know.

- While 14 persons felt the upgrade will *not* affect them personally, 8 felt it would and 5 were not sure.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. The prospects of job opportunities emerged as the main impact with 23 responses identifying this with ‘better community relations’ having 19 responses. The main negative impact was seen as ‘more air pollution and noise’ (8).

- As reasons for the particular answers given 16 stated that more jobs would be available. Five (5) respondents were of the opinion that the upgrade will add new equipment that will be cleaner to operate.

6.3.3.1.2.4 Availability of Water

- The majority (28) of respondents have access to rainwater through the use of tank or drum. Eight respondents had water piped indoor available to them with The National Water Commission as the original supplier to 4. The remaining 4 stated that they were responsible for the provision of the water originally.

- On the issue of water safety, there were 24 respondents indicating that the water was safe to drink. This was so because the water looks and or smells clean as indicated by 22 responses. There were 16 responses stating that the tanks are kept properly covered and or bleach is added to the water. The main reason for the doubts about water safety was related to the lack of piped water in the community.

6.3.3.1.2.5 Awareness and Solutions

- Only 9 of the 37 respondents stated that they had ever voiced an opinion on the pollution problem.

- Most persons (23) said they were not satisfied with efforts to deal with the health problems in the community.

- No one had ever received compensation for pollution

- Twenty (20) persons reported that they or members of their household had worked in the bauxite industry.

- Only 5 of the 37 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- As much as 25 responses indicated no knowledge or some uncertainty of what should be done about the pollution problem or did not respond and 3 said there is nothing that can be done. Two (2) responses suggested that the bauxite emissions should be controlled/ reduced and the air filtered.

- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (17); build/expand clinic (10).

- Eleven (11) persons did not know or did not respond.

6.3.3.2 Chudleigh/Lichfield

6.3.3.2.1 THE SURVEY POPULATION

A total of 11 respondents were covered in the survey, 4 men and 7 women, with 7 persons being 40 years and over. Nine persons have lived in the community for more than 20 years.

6.3.3.2.2 MAIN FINDINGS

6.3.3.2.2.1 Opinions on the Community

- Friendly people, the 'quietness' of the community and the absence of crime and violence were identified as the main reasons for liking the community.
- Unemployment and the dirty environment were the main reasons given for not liking the community.
- Ten (10) of the 11 residents interviewed saw "large scale development as beneficial to the community". Job opportunities and the potential for development of skills were seen as the primary reasons for this view

6.3.3.2.2.2 Awareness and Opinions on Existing Bauxite Operations

- Four (4) persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 3 of them said that they had experienced negative impacts from the operations.
- The 3 who reported that the operations had impacted negatively on them identified dust, soot and gaseous emissions and odour as the factors affecting them.
- Three (3) persons agreed that the bauxite facility has had negative impacts on the people in the community because of widespread corrosion and the smell of caustic soda.
- Four (4) of the 11 respondents agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities.

6.3.3.2.2.3 Knowledge and Views on Upgrade Plans

- Only 4 of the persons interviewed were aware of the upgrade plans. All thought the impact on the economic value of the community and on job opportunities would be positive.

- With regard to the impact on pollution, only 1 person saw it as positive, 2 saw it as negative,2 saw no change and 4 did not know.

- Two (2) persons felt the upgrade will affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. The prospects of job opportunities (2) and more dust in the area (2) were seen as the consequences of the upgrade.

6.3.3.2.2.4 Availability of Water

- Rainwater through the use of tanks and drums was the main source of drinking water for the community. Only 1 person had access to indoor pipes and 1 had access to outdoor pipes. The National Water Commission was the original supplier for 1 and the other person was responsible for the provision of the facility originally.

- On the issue of water safety, all 11 respondents indicated that the water was safe to drink. This was so because the water looks and or smells clean and the National Water Commission tested frequently.

6.3.3.2.2.5 Awareness and Solutions

- Only 2 of the 11 respondents stated that they had voiced an opinion on the pollution problem.
- Four (4) persons said they were satisfied with efforts to deal with the health problems in the community.
- One (1) person had received compensation for pollution
- Two (2) persons reported having worked in the bauxite industry.
- Only 2 of the 11 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Ten (10) responses indicated no knowledge or some uncertainty of what should be done about the pollution problem or did not respond.
- In relation to the health problems, the responses were as follows; provide free/partially-funded healthcare (4).

6.3.3.3 Comfort Hall

6.3.3.3.1 THE SURVEY POPULATION

A total of 8 respondents were covered in the survey, 3 men and 5 women. Six persons were under 50 years. All persons had been residents of the community for more than 10 years.

6.3.3.3.2 MAIN FINDINGS

6.3.3.3.2.1 Opinions on the Community

- Six persons reported that they liked the community because it was quiet.
- Unemployment and poor roads were the main reasons given for not liking the community.
- Only 2 of the 8 persons interviewed saw "large scale development as beneficial to the community". Job opportunities and the potential for development of skills were seen as the primary reasons for this view.

6.3.3.3.2.2 Awareness and Opinions on Existing Bauxite Operations

- Three (3) of the eight said that they were aware of the existence of bauxite or alumina processing plant operations in the area and none of them reported any impacts, negative or positive, on themselves or the community.

6.3.3.3.2.3 Knowledge and Views on Upgrade Plans

- Although none of the 8 persons interviewed was aware of the upgrade plans they thought the impact would be largely positive, there were 3 responses indicating a positive impact on the economic value of the community and 7 for positive impacts relating to job opportunities.
- With regard to the impact on pollution, 3 persons saw it as positive, 2 saw as negative and 3 did not know.
- Only 1 person felt there would be personal effects from the upgrade.

- The responses to the question on the main impact overall put the prospects of more jobs primary.

6.3.3.3.2.4 Availability of Water

- Three (3) of the respondents had access to water by way of indoor pipes. The others used rainwater (2), outdoor pipes (1) and public standpipe (1). The National Water Commission was the original supplier of the piped water.

- All 8 persons thought the water was safe for drinking because it was tested frequently by the NWC and it looked and smelt clean.

6.3.3.3.2.5 Awareness and Solutions

- There were 2 persons who said that they had voiced some opinion on the topic of pollution.

- Three (3) of the 8 persons expressed satisfaction with what is being done in relation to health problems in the community.

- No one had ever received compensation for pollution

- Two (2) persons reported that they or members of their household had worked in the bauxite industry.

- Only 1 of the 8 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Generally there was no knowledge of what should be done about any pollution problem but there were 5 responses suggesting that a possible solution to health problems would be to build/expand clinic.

6.3.3.4 Contrivance

6.3.3.4.1 THE SURVEY POPULATION

A total of 4 respondents were covered in the survey, 3 men and 1woman ranging in ages between 20 and 59 years. All 4 persons had lived in the community for more than 10 years.

6.3.3.4.2 MAIN FINDINGS

6.3.3.4.2.1 Opinions on the Community

- Friendly people and the 'quietness' of the community were identified as the main reasons for liking the community.
- Poor roads, unemployment and a lack of utilities were the main reasons given for not liking the community.
- All 4 residents interviewed saw "large scale development as beneficial to the community". Job opportunities and the potential for development of skills were seen as the primary reasons for this view

6.3.3.4.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 4 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and they reported that they had experienced negative impacts from the operations.
- Dust, soot and gaseous emissions and damage to property were identified as the factors affecting them.
- Three (3) persons agreed that the bauxite facility has had negative impacts on the people in the community because of widespread corrosion and the smell of caustic soda.
- The 4 respondents agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities.

6.3.3.4.2.3 Knowledge and Views on Upgrade Plans

- Three (3) of the 4 persons interviewed were aware of the upgrade plans. All thought the impact on the economic value of the community and on job opportunities would be positive.

- With regard to the impact on pollution, 2 persons saw it as negative while 1 saw no change.

- Only 1 person felt there would be personal effects from the upgrade.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. The prospects of job opportunities (2) and more dust in the area (2) were seen as the consequences of the upgrade.

6.3.3.4.2.4 Availability of Water

- Rainwater through the use of tanks and drums was the main source of drinking water for the community. No one reported access to piped water.

- As regards water safety, 2 respondents indicated that the water was safe to drink while 2 said it was not It was seen as safe because it looks and smells clean. It is seen as not safe because it is not treated properly (1) and bauxite mining affects water (1).

6.3.3.4.2.5 Awareness and Solutions

- Three (3) of the 4 respondents stated that they had voiced an opinion on the pollution problem.
- All 4 persons said they were not satisfied with efforts to deal with the health problems in the community.
- One (1) person had received compensation for pollution
- One (1) person reported having worked in the bauxite industry.
- No one indicated an awareness of programs or activities initiated by JAMALCO.
- While there were 2 responses indicating no knowledge or some uncertainty of what should be done about the pollution problem, 2 suggested providing medical assistance and conducting more surveys to determine problems and solutions.
- In relation to the health problems, the responses were as follows; provide free/partially-funded healthcare (2); build/expand clinic (2).

6.3.3.5 Halifax

6.3.3.5.1 THE SURVEY POPULATION

A total of 5 respondents were covered in the survey, 2 men and 3 women Three persons were 40 years and older. Four persons have lived in the community for more than 20 years.

6.3.3.5.2 MAIN FINDINGS

6.3.3.5.2.1 Opinions on the Community

- A quiet area with friendly people was the reasons the residents gave for liking the community.
- Unemployment and poor roads were the reasons for not liking it.
- Only 1 resident saw "large scale development as beneficial to the community". Job opportunities were seen as the primary reasons for this view

6.3.3.5.2.2 Awareness and Opinions on Existing Bauxite Operations

- None of the 5 persons was aware of the existence of bauxite or alumina processing plant operations in the area and as a result none reported any impacts, negative or positive, on themselves or the community.

6.3.3.5.2.3 Knowledge and Views on Upgrade Plans

- Two (2) of the 5 persons interviewed were aware of the upgrade plans, but only 1 thought the impact on the economic value of the community and on job opportunities would be positive. The others did not know.
- With regard to the impact on pollution, only 1 person saw it as positive and 1 saw it as negative.
- The 2 persons were not sure if the upgrade would affect them personally but they were of the opinion that more job opportunities would result from the upgrade activity.

6.3.3.5.2.4 Availability of Water

- Three (3) of the 5 obtained water from the public standpipe and 2 used rainwater.

- As regards water safety, there were 2 respondents indicating that the water was safe to drink. This was so, they felt, because the water looks and or smells clean as indicated by 9 responses.

6.3.3.5.2.5 Awareness and Solutions

- No one had ever voiced an opinion on the subject of pollution.

- Four (4) persons said they were satisfied with efforts to deal with the health problems in the community.

- No one had ever received compensation for pollution

- No one person reported having worked in the bauxite industry.

- No one indicated an awareness of programs or activities initiated by JAMALCO.

- Not being aware of the pollution and health issues usually related to bauxite operations the residents of Halifax had no ready solutions.

6.3.3.6 Malton

6.3.3.6.1 THE SURVEY POPULATION

A total of 14 respondents were covered in the survey, 11 men and 3 women. One (1) woman was under 20 years and 3 were 60 years and older. Thirteen persons have lived in the community for more than 20 years.

6.3.3.6.2 MAIN FINDINGS

6.3.3.6.2.1 Opinions on the Community

- There were 14 responses stating the ‘quietness’ of the community as the main reason for liking it and 12 stating ‘friendly people.
- Unemployment (13) and lack of utilities (10) were the main reasons given for not liking the community.
- Eleven of the 14 residents interviewed saw “large scale development as beneficial to the community”. Job opportunities and the potential for development of skills were seen as the primary reasons for this view

6.3.3.6.2.2 Awareness and Opinions on Existing Bauxite Operations

- Nine (9) persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and all 9 of them said that they had not experienced any negative impacts from the operations.
- Only 2 persons agreed that the bauxite facility has had negative impacts on the people in the community. They gave no reasons for their opinion
- Seven (7) of the 9 respondents agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the educational and social benefits.

6.3.3.6.2.3 Knowledge and Views on Upgrade Plans

- Nine (9) of the 14 persons interviewed were aware of the upgrade plans. All thought the impact on the economic value of the community and on job opportunities would be positive.

- With regard to the impact on pollution, only 1 person saw it as positive, 2 saw it as negative,2 saw no change and 4 did not know.

- Five (5) persons felt the upgrade will affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. The prospects of job opportunities emerged as the main impact with 9 responses. More dust circulating in the area (6) and contamination of water supplies (4) represented the negative responses.

- As reasons for the particular answers given, 5 stated that more jobs would be available and 2 said ‘the present mining causes this (dust), so it can only get worse.

6.3.3.6.2.4 Availability of Water

- All 14 respondents have access to rainwater through the use of tank or drum.

- On the issue of water safety, there were 12 respondents indicating that the water was safe to drink. This was so because the water looks and or smells clean as indicated by 9 responses.

6.3.3.6.2.5 Awareness and Solutions

- Five (5) of the 14 respondents stated that they had voiced an opinion on the pollution problem.
- Only 3 persons said they were satisfied with efforts to deal with the health problems in the community.
- No one had ever received compensation for pollution
- Only 1 person reported having worked in the bauxite industry.
- Only 1 of the 14 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Nine (9) responses indicated no knowledge or some uncertainty of what should be done about the pollution problem or did not respond, and 3 said there is nothing that can be done. Four (4) responses stated that pollution was not a problem in that area.
- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (5); build/expand clinic (5).

6.3.3.7 Grove Place

6.3.3.7.1 THE SURVEY POPULATION

A total of 14 respondents were covered in the survey, 9 men and 5 women. Eight persons were under 40 years. A half of the respondents have lived in their community for more than 20 years.

6.3.3.7.2 MAIN FINDINGS

6.3.3.7.2.1 Opinions on the Community

- The 14 persons reported that they liked the community because it was quiet and there were 9 responses for' friendly people'.
- Unemployment (15) and lack of utilities (8) were the main reasons given for not liking the community.
- Twelve of the 14 residents interviewed saw "large scale development as beneficial to the community". Job opportunities and the potential for development of skills were seen as the primary reasons for this view.

6.3.3.7.2.2 Awareness and Opinions on Existing Bauxite Operations

- Eleven (11) persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 7 of them said that they had experienced negative impacts from the operations.
- The 7 who reported that the operations had impacted negatively on them identified dust and damage to property as the factors affecting them.
- As many persons (5) said that there have been negative impacts on the community as said that there was none. The reasons given were that, the area has widespread corrosion, the area smells of caustic soda and people often get sick.
- Ten of the 14 respondents agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities and improved community relations.

6.3.3.7.2.3 Knowledge and Views on Upgrade Plans

- Six of the 14 persons interviewed were aware of the upgrade plans, and all 6 saw the impact on the economic value of the community and on job opportunities as positive.

- With regard to the impact on pollution, 1 persons saw it as positive, 1 saw it as negative, 1 saw no change and 2 did not know.

- Only 1 person felt that the upgrade would have personal effects.

- While the responses to the question on the main impact overall of the proposed upgrade, suggested the availability of job opportunities, ‘more dust circulating in the area’ an ‘contamination of water supplies’, were also identified as likely impacts.

6.3.3.7.2.4 Availability of Water

- Rainwater through the use of tanks and drums was the main source of drinking water for the community. No one reported access to piped water.

- As regards water safety, 8 respondents indicated that the water was safe to drink while 4 said it was not and 2 were not sure. It is seen as safe because it is tested frequently by the NWC and it looks and smells clean. It is seen as not safe because and bauxite mining affects water (1).

6.3.3.7.2.5 Awareness and Solutions

- Only 5 of the 14 respondents stated that they had ever voiced an opinion on the pollution problem.
- Most persons (10) said they were not satisfied with efforts to deal with the health problems in the community.
- Three (3) persons had received compensation for pollution.
- Nine (9) persons reported that they or members of their household had worked in the bauxite industry.
- Only 1 of the 14 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- As much as 9 responses indicated no knowledge or some uncertainty of what should be done about the pollution problem or did not respond. Two (2) responses suggested that the bauxite emissions should be controlled/ reduced and the air filtered.
- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (4); build/expand clinic (4).

6.3.3.8 Greenvale

6.3.3.8.1 THE SURVEY POPULATION

A total of 14 respondents were covered in the survey, 9 men and 5 women. Nine persons were under 50 years. A half of the respondents have lived in their community for more than 20 years.

6.3.3.8.2 MAIN FINDINGS

6.3.3.8.2.1 Opinions on the Community

- Ten persons reported that they liked the community because it was quiet; there were 7 responses each for friendly people and a clean environment.
- Unemployment (10) and lack of utilities (8) were the main reasons given for not liking the community.
- Twelve of the 14 residents interviewed saw "large scale development as beneficial to the community". Job opportunities and the potential for development of skills were seen as the primary reasons for this view

6.3.3.8.2.2 Awareness and Opinions on Existing Bauxite Operations

- Ten (10) persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 6 of them said that they had not experienced any negative impacts from the operations.
- The 4 who reported that the operations had impacted negatively on them identified damage to property and dust as the factors affecting them.
- Three (3) persons expressed the view that the bauxite facility has had negative impacts on the people in the community. Widespread corrosion and the smell of caustic soda were the impacts identified.
- Eight (8) of the 14 respondents agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities and the improved community relations.

6.3.3.8.2.3 Knowledge and Views on Upgrade Plans

- Six of the 14 persons interviewed were aware of the upgrade plans, and all 6 saw the impact on the economic value of the community and on job opportunities as positive.

- With regard to the impact on pollution, 3 persons saw it as positive, 1 saw it as negative and 1did not know.

- While 3 of the 6 persons felt the upgrade would affect them personally, felt it would not.

- The responses to the question on the main impact overall of the proposed upgrade reported the prospects of job opportunities and better community relations to be the main outcomes.

6.3.3.8.2.4 Availability of Water

- Rainwater through the use of tanks and drums was the main source of drinking water for the community. Only 1 person reported access to piped water for which the National Water Commission was the original supplier.

- As regards water safety, 4 respondents indicated that the water was safe to drink while 6 said it was not and 4 were not sure. It is seen as not safe because bauxite mining and other sources affect the water (3) and because it is not piped water (2). It is seen as safe because it is tested frequently by the NWC, it looks and smells clean and the tanks are kept covered.

6.3.3.8.2.5 Awareness and Solutions

- Only 4 of the 14 respondents stated that they had ever voiced an opinion on the pollution problem.
- Only 3 of the 14 persons said they were not satisfied with efforts to deal with the health problems in the community.
- No one had ever received compensation for pollution
- Six (6) persons reported that they or members of their household had worked in the bauxite industry.
- Only 4 of the 14 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- All 14 respondents indicated no knowledge or some uncertainty of what should be done about the pollution problem or did not respond.
- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (2); build/expand clinic (9).

6.3.3.9 Ballynure

6.3.3.9.1 THE SURVEY POPULATION

A total of 17 respondents were covered in the survey, 13 men and 4 women . Nine of the 17 were between the ages of 20 and 39 years and 15 persons had lived in the community for more than 10 years.

6.3.3.9.2 MAIN FINDINGS

6.3.3.9.2.1 Opinions on the Community

- Friendly people, a clean environment and availability of farmland were identified as the main reasons for liking the community.
- Poor roads and a lack of utilities were the main reasons given for not liking the community.
- Fourteen of the 17 residents interviewed saw "large scale development as beneficial to the community". Job opportunities and the potential for development of skills were seen as the primary reasons for this view

6.3.3.9.2.2 Awareness and Opinions on Existing Bauxite Operations

- Eleven (11) persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area but only 2 reported that they had experienced negative impacts from the operations.
- Dust, soot and gaseous emissions and damage to property were identified as the factors affecting them.
- Only 1 person felt that the bauxite facility has had negative impacts on the people in the community because 'you get sick more often'.
- The other respondents agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities.

6.3.3.9.2.3 Knowledge and Views on Upgrade Plans

- Eleven (11) of the 17 persons interviewed were aware of the upgrade plans. All thought the impact on the economic value of the community and on job opportunities would be positive.

- With regard to the impact on pollution only 1 person said it would be positive. Among the others, 3 persons saw it as negative, 2 saw no change. And 5 did not know.

- Five (5) persons felt the upgrade would affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. There were increased population (9); job opportunities (7); better community relations (7); and more air pollution and noise (4) were seen as the consequences of the upgrade.

6.3.3.9.2.4 Availability of Water

- Rainwater through the use of tanks and drums was the main source of drinking water for the community. Only 1 person reported access to piped water which had been provided through private arrangements.

- As regards water safety, 10 respondents indicated that the water was safe to drink while 6 said it was not. It is seen as safe mainly because it looks and smells clean and to a lesser extent because the tanks are kept closed and clean. It is seen as not safe because bauxite mining and other sources affect water.

6.3.3.9.2.5 Awareness and Solutions

- Only 4 of the 17 respondents stated that they had voiced an opinion on the pollution problem.
- Seven (7) of the 17 persons said they were not satisfied with efforts to deal with the health problems in the community.
- One (1) person had received compensation for pollution
- Three (3) persons reported having worked in the bauxite industry.
- Two (2) persons indicated an awareness of programs or activities initiated by JAMALCO.
- While there were 13 responses indicating no knowledge or some uncertainty of what should be done about the pollution problem, 2 suggested providing a better water supply system and the covering of tanks in the area.
- In relation to the health problems, the responses were as follows; provide free/partially-funded healthcare (5); build/expand clinic (3).

6.3.3.10 Devon

6.3.3.10.1 THE SURVEY POPULATION

The survey covered 3 male respondents between the ages of 20 and 49 years. older and had all lived in the community for more than 20 years, who have been residents of the community for more than 6 years.

6.3.3.10.2 MAIN FINDINGS

6.3.3.10.2.1 Opinions on the Community

- A quiet area with friendly people and available farmland were the reasons the residents gave for liking the community.
- Poor roads was reported as the reason for not liking it.
- Only 1 resident saw “large scale development as beneficial to the community”. The offers of skill development were seen as the primary reasons for this view

6.3.3.10.2.2 Awareness and Opinions on Existing Bauxite Operations

- Two (2) of the 3 persons were aware of the existence of bauxite or alumina processing plant operations in the area but none reported any positive or negative impacts, on themselves or the community.

6.3.3.10.2.3 Knowledge and Views on Upgrade Plans

- None of the 3 persons interviewed was aware of the upgrade plans and how it could impact on of the community.

6.3.3.10.2.4 Availability of Water

- Two (2) of the 3 respondents obtained water from the public standpipe and 1 used rainwater.
- As regards water safety, there were 2 respondents indicating that the water was safe to drink. This was so, they felt, because the water looks and or smells clean.

6.3.3.10.2.5 Awareness and Solutions

- One person reported ever voicing an opinion on the subject of pollution.
- One (1) person expressed satisfaction with efforts to deal with the health problems in the community.
- No one had ever received compensation for pollution
- One (1) person reported having worked in the bauxite industry.
- No one indicated an awareness of programs or activities initiated by JAMALCO.
- For solutions to the pollution problem the Devon respondents suggested that the bauxite emissions should be controlled/reduced and the air filtered. The suggested solution to the health problems was ‘provide free/partially funded healthcare’.

6.3.3.11 Race Course/Oxford Land Settlement

6.3.3.11.1 THE SURVEY POPULATION

A total of 5 respondents were covered in the survey, 4 men and 1 women ranging between 20 and 59 years. Four persons have lived in the community for more than 20 years.

6.3.3.12 MAIN FINDINGS

6.3.3.12.1.1 Opinions on the Community

- A quiet area with friendly people and available farmlands were the reasons the residents gave for liking the community.
- Poor roads was the main reason given for not liking the community.
- The residents were equally divided on the impact of large scale development. Two saw it as positive and 2 as negative. The fifth person did not respond.. Job opportunities were seen as the primary reasons for the positive view. No clear reason was given for the opposite view.

6.3.3.12.1.2 Awareness and Opinions on Existing Bauxite Operations

- None of the 5 persons was aware of the existence of bauxite or alumina processing plant operations in the area and as a result none reported any impacts, negative or positive, on themselves or the community.

6.3.3.12.1.3 Knowledge and Views on Upgrade Plans

- Two (2) of the 5 persons interviewed were aware of the upgrade plans, and they thought the impact on the economic value of the community and on job opportunities would be positive.

- With regard to the impact on pollution, 1 person saw it as positive and 1 saw it as negative.

- One of the 2 persons said there would be effects from the upgrade while the other respondent was not sure. They were of the opinion however that more job opportunities would result from the upgrade activity.

6.3.3.12.1.4 Availability of Water

- Two (3) of the 5 persons had access to indoor piped water, originally supplied by the National Water Commission and the rest used rainwater.

- As regards water safety, all 5 respondents indicated that the water was safe to drink. This was so, they felt, because the water looks and or smells clean and was frequently tested by the National Water Commission.

6.3.3.12.1.5 Awareness and Solutions

- No one had ever voiced an opinion on the subject of pollution.

- Three (3) persons said they were satisfied with efforts to deal with the health problems in the community and there was no response from the others.

- No one had ever received compensation for pollution

- No one person reported having worked in the bauxite industry.

- One person indicated an awareness of programs or activities initiated by JAMALCO.

- Not being aware of the pollution issues usually related to bauxite operations the residents of Race Course/Oxford Land Settlement had no ready solutions. For health problems they did suggest as solutions: compensation for residents (1); provide free/partially-funded healthcare (1); build/expand clinic (1).

6.3.3.13 Ticky Ticky

6.3.3.13.1 THE SURVEY POPULATION

A total of 3 respondents were covered in the survey, 1 man and 2 women They were all 40 years and older and had all lived in the community for more than 20 years.

6.3.3.13.2 MAIN FINDINGS

6.3.3.13.2.1 Opinions on the Community

- A quiet area with friendly people was the reason the residents gave for liking the community.
- Unemployment and lack of utilities were the reasons for not liking it.
- Only 1 resident saw "large scale development as beneficial to the community". Job opportunities and the offers of skill development were seen as the primary reasons for this view.

6.3.3.13.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 3 persons were aware of the existence of bauxite or alumina processing plant operations in the area but none reported any negative impacts, on themselves or the community. On the other hand, they saw positive effects in the form of job opportunities.

6.3.3.13.2.3 Knowledge and Views on Upgrade Plans

- Only 1 of the 3 persons interviewed was aware of the upgrade plans, and thought the impact on the economic value of the community and on job opportunities would be positive.
- With regard to the impact on pollution, the 1 person did not know.
- The 1 person was not sure if the upgrade would affect him/her personally but they was of the opinion that more job opportunities would result from the upgrade activity.

6.3.3.13.2.4 Availability of Water

- Two (2) of the 3 respondents had access to water piped indoors and 1 used rainwater from a tank or drum. The piped water was supplied originally through private arrangements by the respondent.

- As regards water safety, there were 2 respondents indicating that the water was safe to drink. This was so, they felt, because the water looks and or smells clean and the tanks are covered and cleaned..

6.3.3.13.2.5 Awareness and Solutions

- No one had ever voiced an opinion on the subject of pollution.

- Two (2) persons said they were satisfied with efforts to deal with the health problems in the community.

- No one had ever received compensation for pollution

- No one person reported having worked in the bauxite industry.

- One (1) person indicated an awareness of programs or activities initiated by JAMALCO.

- Not being aware of the pollution issues usually related to bauxite operations the residents of Ticky Ticky had no ready solutions. With regard to problems of health, there were 2 responses for: provide free/partially funded healthcare.

IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

7 Identification and Analysis of Alternatives

7.1 Analysis of Alternatives

7.1.1 No Action Alternative

With the "No Action" Alternative, the situation remains the same. The plant maintains its present footprint and mining operations continue in Clarendon and South Manchester for an extended period of time, and the port would not be upgraded. However, Jamaica misses the opportunity for a major investment of US$690M (the single largest investment in its history) of which US$300M would go towards purchasing Jamaican goods and services and additional income to the country of US$77M per year, the loss of approximately 100 permanent jobs and approximately 2,500 temporary jobs during construction. In addition, Jamaica would lose the opportunity to maintain inflation at a low level, lower interest rates, strive toward greater development of local businesses, education and upgrade of the workforce.

7.1.2 Plant Alternatives

7.1.2.1 Commission another Plant

Impractical, the existing plant is built for expansion, space already existing to accommodate new equipment. The capital expenditure, space allocation, identification of resources (water supply, bauxite ore, red mud disposal) and the regulatory requirements would make this alternative practically impossible.

7.1.2.2 Move Plant and expanded facility to new location

Impractical, the plant already located in center of critical mass in respect of bauxite, linkages, port and red mud disposal areas. When these plants were built in the 1960s, the types of environmental requirements, zoning regulations and regulatory standards that exist today were not in existence and the permitting process of a plant of this type would be very difficult at this time.

Permit the Proposed Application

Practical alternative, funds have been

7.1.2.3 Substitute New Equipment in the Existing Process

Impractical, best practice being used at present, the effort and cost required to substitute process equipment may exceed the cost and practicability of the proposed project.

7.1.3 Residue Disposal Alternatives

7.1.3.1 Use Alternative Technology for Residue Disposal

This can be done and will be done as dry-stacking technology has been proposed as part of this project. Dry-stacking technology will significantly increase the life span of the new residue disposal area since it requires a smaller storage area and offers greater residue storage per unit area.

7.1.3.2 Continued Use of Sealed Impoundments

Sealed impoundments have been used successfully by Jamalco for over 40 years. Engineered impoundments consisting of compacted clay or synthetic liners can be used. The only limiting factor has traditionally been the hydrostatic head which in the case of RDAs 3 & 4 has been significantly improved through the use of under drain technology. Groundwater assessments and analyses to date have not associated groundwater problems with impacts of the sealed impoundments. A combination of thickened tailings disposal "dry stacking" in a sealed impoundment may be the ideal alternative. This is the proposed method for residue disposal in RDA#5. Some of the advantages of thickened tailings disposal are as follows:

- Increased caustic soda recovery
- Faster consolidation of the solid phase resulting in faster attainment of workable load bearing capacity
- Reduced unit land area

7.1.3.3 At Sea using Pipelines or Barges

Impractical, Jamaica relies on the quality and beauty of its coastal resources to risk the potential damage that this alternative would entail. The potential for environmental and socio-economic damage is significant and should not be risked.

7.1.3.4 Unsealed Red Mud Lakes

This practice has been used in Jamaica in the past, however, it would be a step back for Jamalco and is therefore impractical. The deposition of red mud in unsealed lakes can lead to significant environmental problems, primarily with groundwater and surface water resources through seepage. Jamalco has never utilized this mode of residue disposal as it designs its plants to be zero discharge operations.

7.1.3.5 Disposal in Surface Waterways (Rivers and Streams)

The Jamalco refinery is located just to the east of the Rio Minho River Basin and there is a possibility that this surface waterway could be used as a disposal point for red mud. This is not a good alternative, as the dependence on the river for irrigation and in some cases domestic water coupled with the potentially devastating environmental impact makes it impractical.

7.1.3.6 Shoreline Land Reclamation

This involves creation of an impoundment dike adjoining the shore, but with its footprints in the marine environment. Bauxite residue is stored in the shoreward area behind the dike. This is unacceptable since it results in significant loss of marine resources.

7.1.4 Mining Alternatives

7.1.4.1 Mine Bauxite from areas other than those proposed

Impractical, mining areas are determined by location of bauxite deposits suitable for processing in the plant. Additionally, several of the areas are government lands, zoned and reserved just for this purpose.

7.1.5 Port Alternatives

7.1.5.1 Share Port Facilities

Make arrangements with neighbouring port to share their facilities for shipping additional alumina overseas (share Port Esquivel with Windalco) rather than dredge to new depth to allow larger ships. Jamalco has an existing port that is underutilized and the proposed upgrade does not include any serious environmental impact

7.1.5.2 Increase Berths at Rocky Point Port

Increase number of berths at the existing port to accommodate more ships rather than larger ships.

This would be a capital intensive project and the existing structures at Rocky Point can be easily and cost effectively upgraded to meet the needs of the upgraded facility.

7.1.6 Transportation Alternatives

7.1.6.1 Use Conveyors to Transport Ore to Rail

Possible alternative, will involve major land acquisition, environmental and socio-economic concerns. This alternative would reduce or eliminate the number of trucks that may be necessary to move bauxite ore from mine to staging area. This would also exclude members of the community from realizing benefits from the upgrade, since transportation by trucks usually involves small independent contractors sourced locally.

7.1.6.2 Extend Rail Lines to Mines

Possible alternative, that would involve similar concerns as the alternative above, but would include issues related to noise and vibration. In some areas, this alternative could result in the revitalization of formerly abandoned Jamaica Railway Corporation rail lines.

7.1.6.3 Transport Alumina to Port via Trucks

Impractical alternative, the rail line infrastructure is already in place and functional. Existing roadways in the area are of relatively poor quality and would require extensive upgrade, or that new roads be built. The issues related to dust, spillages, traffic and noise associated with this alternative make it impractical when compared to rail transport.

7.1.6.4 Transport Construction Equipment from Port via Rail

Possible alternative, however, equipment that is heavier or bulkier than allowable or transportable by rail would still be an issue. Jamalco's existing rail system could be used with additional offloading/loading equipment installed at the Port. Lower cost alternative depending on whether or not items can be transported by rail.

7.1.6.5 Transport Construction Equipment from Port via Existing Roadway

Possible alternative, however, severe limitations in terms of heavy or bulky items. Existing roadway options include Highway 2000 and the Salt River-Dawkins Pen road. In some cases, roads would have to be widened, reinforced and utilities temporarily relocated or disconnected. Traffic disruption would be significant. This alternative would represent a significant cost to Jamalco in terms of road repair, upgrade and the provision of utility service for various communities while electricity and phone lines were temporarily relocated.

7.1.6.6 Transport Construction Equipment from Port via Temporary Access Path

Possible alternative, a new temporary path could be constructed parallel to the rail lines from port to the plant. This would greatly minimize the disruptions to utilities and traffic flow which is almost guaranteed with all other alternatives. While this may seem to be an expensive alternative, the potential problems associated with most other transportation alternatives must be considered. Cost is uncertain at this time due to the depth of detail that is involved.

The preferred or selected alternative is to implement the efficiency upgrade:

1. By increasing the production capacity of the plant to 2.80 mty

2. Upgrade the Rocky Point Port

3. Win and process the bauxite resources available in South and North Manchester for use as feedstock in the plant

4. Upgrade the transportation corridors between mina and plant and plant and port to facilitate material transportation

5. Permit the construction of RDA#5 using thickened tailings technology for bauxite residue storage

By so doing, the environmental resources will be effectively conserved through the mitigation and management of potential environmental impacts. This will also secure the substantial macro and micro economic and social benefits for Jamaica.

MITIGATION ACTION

8 Mitigation Actions

8.1 Fugitive Emissions

8.1.1 Mining

Alcoa has over 40 years of experience mining bauxite in Jamaica. During this time, they have developed protocols specifically to address issues such as control of fugitive emissions. At a minimum, fugitive emissions at the mine areas will be controlled through sprinkling, cleaning up of spilled bauxite and maintenance of moisture content in the ore.

This is not an expensive mitigation item since all this equipment and knowledge presently exists within the company.

8.1.2 Transportation of Ore to Plant

No mitigation necessary since the bauxite ore maintains moisture content of between 20 - 25% and will not easily disperse. This has not been a problem at Jamalco.

8.1.3 Refinery

At times, sections of the stockpile may become dry enough to allow for dispersion in the wind. Jamalco takes this very seriously and works hard at keeping the stockpile from drying out at any time. This is an ongoing process. No better method of mitigation will be required with the upgrade other than taking into consideration that the stockpile will be larger and protocols, etc. should reflect that. This mitigation will not incur additional costs to Jamalco.

The loading of alumina into railcars will be continuously monitored. In the event of spillage, steps will be taken to collect the spilled product before it becomes airbourne. Unfortunately, even with the best of care, episodic incidents will occur and Jamalco has Spill Prevention and Mitigation Plans in place to deal with these.

<u>Transportation of Alumna from Refinery to Port</u>

If any quantity of alumina is observed spilled on top of a rail car, all attempts will be made to recover the alumina before it becomes airbourne. Alumina is the final product from the refinery and Jamalco sells it on the world market. Jamalco does not want to see its product lost in the wind, so all efforts will be made to minimize or eliminate this potential impact.

8.1.4 Port

The proposed upgrade of the port facilities include newer, larger, more advanced ship loading equipment. This will allow for greater control during ship loading. Other transfer points will be reviewed; however, losses are minimal at other areas. There will be a significant cost to upgrade the ship loading equipment, however, these costs are part of the facility upgrade and have been considered by Jamalco.

8.1.5 Construction Activities

During construction activities any fugitive emissions that is anticipated, will be mitigated. Especially at the refinery, all existing protocols and standard operating procedures will be observed.

8.2 Air Quality

8.2.1 Mining

Proper servicing and maintenance of heavy duty diesel equipment should alleviate most impacts, these types of equipment naturally emit some degree of partially combusted fuel into the atmosphere, which is a minor impact.

8.2.2 Refinery

Jamalco conducts air quality testing at all of its major sources on a regular basis. Additionally, there are air quality monitors set up in surrounding communities and other receptor points to measure the presence of impacts and in some cases to quantify the impact if it exists.

Along with this, Jamalco has from time-to-time commissioned predictive modeling assessments of its air emission sources to better understand potential receptor areas and the potential impacts under different operational scenarios. If the modeling is deemed reliable, then recommendations presented are considered for implementation. The issue of cumulative impact must also be assessed since it is acknowledged that other sources are in the area that contribute to air quality issues.

Jamalco has developed and maintains an Air Emissions Management Program to ensure compliance with local and Alcoa's internal ambient air quality standards. Additionally, physical methods of treatment or impact reduction are included in the facility, these include:

- Electrostatic precipitators (99.5% efficiency)
- Cyclones
- Bag houses
- Hooded conveyors

Meteorological data including wind speed, wind direction, air temperature, barometric pressure, ground temperature, precipitation are collected and ambient air-monitoring stations are located in both the Cornpiece and New Bowens communities. The monitoring stations monitor SO_2, NOx, Cox and Ozone. All these methods will be continued with the upgrade and new approaches are being sought to supplement these efforts.

8.3 Noise

8.3.1 Mining

Jamalco will monitor noise levels of its mining operations. If the noise impact on residents of any community exceeds the prescribed residential standard of 70 decibels, then steps will be taken to reduce the noise impact or eliminate it (depending on the source). Jamalco has all required equipment and personnel in-house to provide this mitigation measure.

8.3.2 Refinery

Jamalco conducts noise assessments of its refinery operations as needed to establish baselines or develop guidelines for employee health and safety. In a recent audiometric survey conducted at the facility, it was found that noise levels at the facility boundaries with neighbouring communities was well within the conservative residential standards for noise. During construction, there may be times when noise levels increase in an episodic manner, but for the most part noise should not be a major issue.

The Jamalco refinery has operated within the local standards and regulations for industrial noise levels. In areas of the operation that have a potential to exceed these levels, signs are posted and safety equipment provided.

8.3.3 Transportation by Rail and Truck

Enforcement of train speeds, particularly while cornering will help to resolve the issue of high pitched noises from the wheels. In many cases, the perceived "noise" as the train goes by is a combination of the associated sounds and the rumble or vibration which accompanies it. Based on findings of the vibration assessment conducted at the facility and contact with residents, Jamalco will establish baseline conditions in homes and structures along the train lines that have reported impacts.

8.3.4 Port

It is not envisioned that noise impacts will be increased significantly at the Rocky Point Port as a result of this project. At present, there are no major noise related issues at that location.

8.4 Loss of Biodiversity

8.4.1 Mining

Jamalco has a very proactive and successful program of mine rehabilitation. Jamalco has signed a memorandum of understanding with the Forestry Department to develop revegetation and habitat creation through technologies involving creative conservation. The fundamental philosophy and strategies underpinning the actions which have already been initiated and extended into a program, is to create habitats that will induce the flora and fauna characteristics of the area to recolonize the rehabilitate mined out areas.

The rehabilitation process involves reclamation which is the mechanical reshaping of the land and restoration and re-vegetation which involve the establishment of grasses and crops and the covering of the land area. Reclamation is the engineering component of the rehabilitation process while restoration is the agronomic component.

- The following guidelines are adapted from Bauxite Mine Rehabilitation Standards & Guidelines (1994). These are standard practices which Jamalco is committed to maintaining at the bauxite railhead,storage areas,mining sites,and transportation corridors in southern Manchester,Clarendon and northern Manchester.

- During land clearing, utilization of existing resources on the site must be maximized. These may include timber,buildings and produce.

- If the existing vegetation can assist in the rehabilitation process it should be harvested and redistributed in a timely manner on the areas being rehabilitated.

- Burning as a means to remove vegetation should be used as a last resort and should be considered only after harvesting ,habitat and burial options have been considered.

- Land area cleared should be the minimum for efficient mining (pits and infrastructure) and rehabilitation.

- Topsoil and remaining vegetation debris must be harvested from the entire area to be mined and either stored where it can be recovered or utilized immediately on other areas being rehabilitated.

- Whenever topsoil is stored it should be done so for the least possible time to minimize the loss of biological activity and nutrients.

- If there are potentially toxic substances in the overburden and mine wasts,they should be handled in such a way as to minimize the impact on the rehabilitation and surrounding areas.

- In some circumstances,in addition to topsoil,subsoil horizons and/or a portion of the overburden may need to be harvested and respread on the rehabilitated areas in order to successfully establish the desired vegetation. Topsoil and subsoil/overburden should be respread as separate atrata and not mixed together.

- Clearing of additional vegetation for storage of topsoil and/or overburden should be minimized.

- Finished slope angles in reshaping will depend on aesthetics, final land use, soil characteristics and safety.Reshaped terrain should conform to the natural landscape.

- All slopes must be stable. If erosion is likely to occur then erosion control works should be put in place.

- Compression resulting from the mining , reshaping ,and soil placement process must be relieved (e.g. by ripping, ploughing and subsoiling etc.)where rehabilitation plans require water infiltration and plant root penetration.During ths operation care must be taken to ensure that unfavourable sub-soil materials are not brought to the surface and excessive topsoil burial does not occur.

- Soil nutrient and pH levels must be adjusted where this is necessary to achieve rehabilitation objectives.

- Where regeneration of native vegetation is the objective, nutrient and pH levels should closely match pre-existing conditions. Soil conditioners should be considered to ameliorate adverse conditions.

- Topsoil must be replaced as the final soil profile.The thickness and area to which the topsoil is returned must provide the maximum value to the end use of the rehabilitated area.

- The topsoil should be evenly spread over the area.

- Where native vegetation is to be re-established, only propagules of the indigenous plant species should be used.Preferrably these should be collected from the areas being cleared or other local provenances.

- Revegetation strategies should be based on a high level of understanding of local climatic conditions and ecological processes.Re-established plant communities should eventually duplicate the natural ecological processes and functions of the original vegetation.

- Fauna return should be encouraged by natural means through the creation of suitable habitat rather than by physical re-introduction.Keystone species may need to be transferred where they are absent or inadequately represented insurrounding areas.

- Artificial barriers such as perimeter roads and fences, which inhibit flora or fauna recolonization should be removed as soon as practical.

- At Jamalco, local implementation of these policies, principles and guidelines is the responsibility of the location manager,business unit managers,staff support groups,operating managers,sponsoring managers, environmental affairs staff,government affairs staff,Alcoa personnel and other staff groups.

8.4.1.1 MEMORANDUM OF UNDERSTANDING between JAMALCO and FORESTRY DEPARTMENT OF JAMAICA

The purpose of this memorandum is to establish the framework for collaboration between the parties to carry out the successful reclamation and rehabilitation of certain mined-out lands via the reforestation and / or afforestation of these lands.

It seeks to address the concern of the Forestry department that the reduction and degradation of forests as a result of bauxite operations should be guided by the No-Net-Loss Policy which would result in the compensation for the loss of forest cover from one site via the reforestation of another area of equivalent proportion.

The MOU (APPENDIX III) became effective on 29 August 2002 and has a tenure of 5 years.

The parties will review the Reforestation strategy after two years to determine whether the objectives are being met and whether the strategy needs to be reassessed.

Trees that have been selected for use in the programme are as follows:

- **ORNAMENTAL/ LUMBER TREES**
    - Cedar
    - Ficus
    - Acacia
    - Wild Tamarind
    - Blue Mahoe
    - Mahagony
    - Bitterwood
    - Bitter Damson

    - Spanish Elm

- **FRUIT TREES**
    - Mango
    - Orange
    - Avocado
    - Breadfruit
    - Ackee

Section 8.4.1.3 of this report gives a photographic presentation of bauxite orebodies in various stages of development:

- Figure 79 shows active mining in progress
- Figure 80 shows a picture of a mined-out orebody
- Figure 81 shows an exhausted orebody being reshaped in preparation for final restoration.
- Figure 82, Figure 83, and Figure 84 show different end uses of completely rehabilitated land namely housing ,recreational activity and farming.

8.4.1.2 EMERGENCY RESPONSE

Jamalco has an excellent well documented procedure for handling natural disasters such as hurricanes, fires, earthquakes and the like. This includes an Early Warning System for responding to process emergencies and a 72 hour shut down procedure if this becomes necessary.

8.4.1.3 Photo-Inventory

Figure 79: ACTIVE MINING IN PROGRESS

Figure 80: 'MINED-OUT' ORE BODY

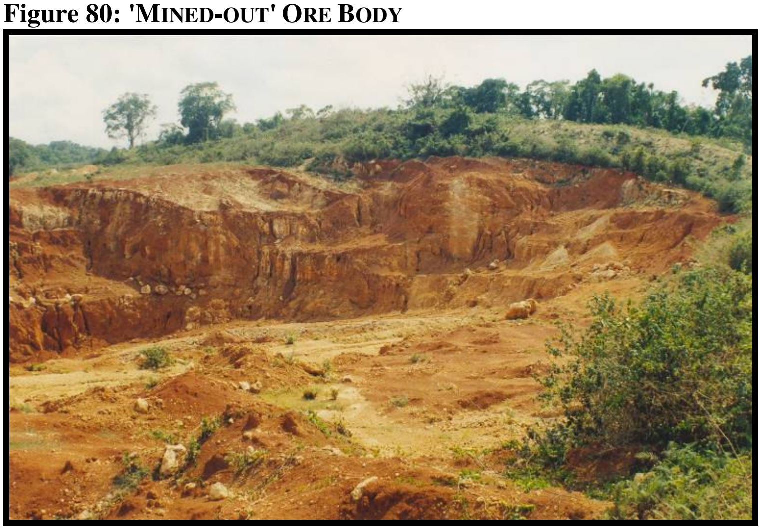


Figure 81: MINED-OUT OREBODY SHOWING COMMENCEMENT OF RECLAMATION

Figure 82: REHABILITATED 'MINED-OUT' OREBODY BEING USED FOR A PLAYING FIELD AND PASTURE

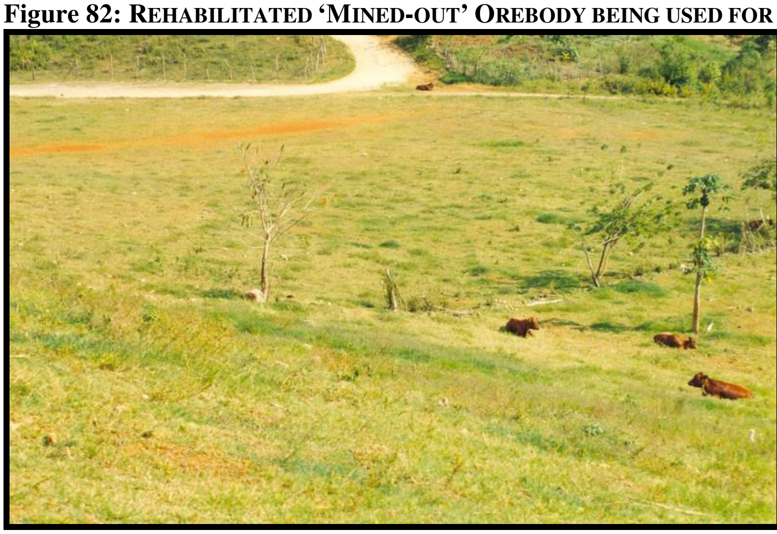


Figure 83: REHABILITATED 'MINED-OUT' AREA RETURNED TO PASTURE

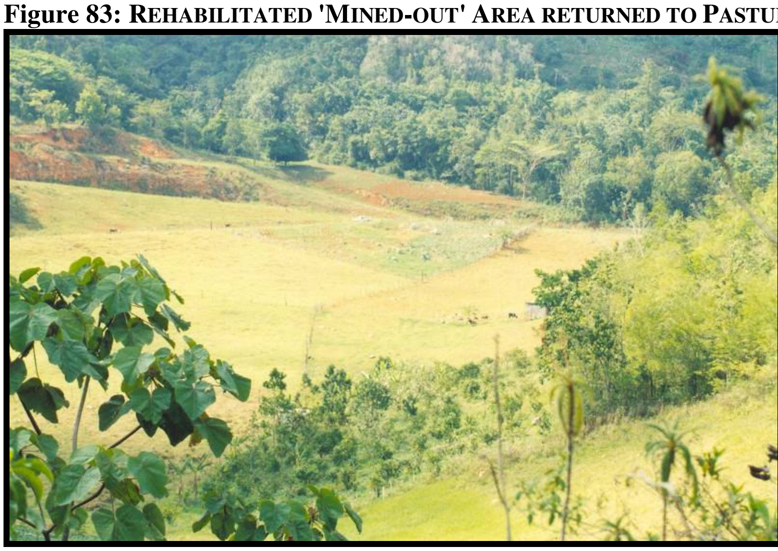


Figure 84: REHABILITATED LAND RESORED TO HOUSING AND FARMING

8.4.2 Refinery

There will be no significant impact associated with biodiversity during activities at the refinery.

8.4.3 Port

No new impacts are envisioned at the port.

8.5 Water Supply

8.5.1 Mining

It is not envisioned that the new mines will have a major impact on subsurface water supplies. However, as the deposits to be mined are identified, geotechnical and hydrology assessments will be conducted to gain more knowledge of the areas.

8.5.2 Refinery

Jamalco's existing RDAs are constructed as sealed impoundments with compacted clay liners. The proposed RDA#5 will be constructed in a similar manner and will offer the same level of protection to groundwater reserves as the others do. There has never been a major RDA failure at Jamalco.

Based on findings of the hydrogeology assessment, Jamalco should be able to meet the increased demand for water without having to drill new wells into the aquifer. The facility has additional capacity that it can withdraw under existing permits.

These mitigation items are either figured into the cost of the upgrade or are already in place and require no further capitalization.

8.5.3 Port

There will be no new water supply related impacts at the Rocky Point Port.

8.6 Waste Management

8.6.1 Mining

Defined waste collection areas with proper labeling and instructions will be located at the mining offices for collection of waste materials. Jamalco will utilize its existing waste collection protocols and will continue to manage and dispose of all grades of waste in keeping with its current protocols. Proper training and direction will be provided to all employees in waste handling and management at the site.

8.6.2 Refinery

The refinery has existing programmes and protocols in place to deal with all types of waste generated there. All waste generated during the construction and commissioning of the upgraded facility will be handled based on these established protocols. The refinery has a landfill facility which includes a sealed area for disposal of certain hazardous materials. All identified waste management impacts can be successfully mitigated.

8.6.3 Port

No new waste management impacts are anticipated at the Rocky Point Port.

8.6.4 Closure Plans for Construction

Throughout the 24 month construction program a system will be put in place for good housekeeping. This will involve continuous collection and environmentally sound disposal of construction debris in their existing approved landfill located at the refinery.

Where possible and practical, Jamalco will practice waste segregation and recycling of materials to minimize the amount of waste that is placed in the facility’s landfill, incinerated or disposed elsewhere.

These involve specific routine daily standard practices which all contractors and employees will be required to comply with.

On completion of construction, detailed inspections will be made on all machinery and equip installed. All extraneous substance and waste will be collected, classified and disposed. On satisfactory completion of these activities, the plant will be subjected to a further series of tests leading to the point of commission and start-up.

8.7 Sewage

8.7.1 Mining

Sewage generated at the mines will be managed using Jamalco's time tested approaches. A sewage treatment system will be designed and constructed at the main mine area based on the number of employees. Portable chemical toilets will be used as needed; these will be managed and disposed by a licensed company.

8.7.2 Refinery

The refinery has a working sewage treatment facility that was designed to service a plant staff of 1200 employees, at present the staff complement is 600. After the proposed upgrade is completed a maximum of 100 new employees are anticipated. Consequent on reduced wastewater generation, about 50% below design capacity, the existing plant will be able to effectively manage this increased loading.

During construction, their will be an anticipated 2,500 temporary employees at peak construction. Portable chemical toilets will be utilized to meet the demands of this increased capacity. These toilets will be sourced from a reputable licensed company, who will treat and dispose of the contents.

8.7.3 Port

During work at the port it is anticipated that there may be an increase in sewage generated by the construction workforce. Portable chemical toilets will be used at this location also. Potential impacts include accidental spillage onto land or into the sea.

8.8 Vibration

8.8.1 Mining

If excessive vibration is pre-empted, assessments are done prior to and during the activities to verify levels.

8.8.2 Rail Corridors

We anticipate that because of potential increased frequency (or longer trains) of bauxite from mine to plant and alumina from plant to port by rail, vibration may increase. Consequently, Jamalco will extend its vibration monitoring programme to include baseline data collection and monitoring on an as needed basis along the rail corridors and in nearby communities to determine if impacts exist.

8.8.3 Refinery and Port

No new vibration related impacts are anticipated at the refinery or port facilities.

8.9 Labour

8.9.1 Mining

Increased employment will be welcomed in the communities. No mitigation required.

8.9.2 Refinery

Increased short term (2 years) employment of approximately 2,500 persons and permanent employment of approximately 100 will be of great benefit to the surrounding communities. No mitigation required.

8.9.3 Port

No significant increase in permanent labour is anticipated at the port. There will be a minor increase in temporary employment if the proposed upgrade is implemented.

8.10 Aesthetics

8.10.1 Mining

Aesthetics in the mining areas will be restored through Jamalco's rehabilitation and revitalization program and their MOU with the Forestry Department. Jamalco has demonstrated their commitment to this through the rehabilitation works completed in the Mocho area of Clarendon following mining in that area. This will be continued in the proposed new mining area.

8.10.2 Refinery and Port

No new aesthetic impacts are anticipated at either the refinery or the port. No mitigation required.

8.11 Archaeological and Historical Heritage

8.11.1 Mines

For any archaeological or historical heritage item that may be impacted during mining activities, the Jamaica National Heritage Trust (JNHT) approved guidelines for managing archaeological and historical heritage items discovered during such activities will be utilized by Jamalco. It includes specific methods of operation including necessary contacts and procedures to follow.

ENVIRONMENTAL MANAGEMENT AND TRAINING

9 Environmental Management and Training

9.1 Environmental Management

Jamalco is an ISO 14001 and ISO 9000 certified facility. Jamalco's ISO 14001 certification was issued by Det Norske Veritas (DNV) in November of 2002 and remains valid until November 2005. The associated Environmental Management System (EMS) is accredited by ANSI RAB.

The EMS covers Jamalco's operations and includes activities associated with the railway transportation system, the bauxite alumina refinery, plant waste storage and disposal sites and the port at Rocky Point.

In keeping with the mandates of its ISO 9000 quality certification, Jamalco abides by their Quality Policy, which states:

Jamalco is committed to being "The Alumina Supplier of Choice"

- "Jamalco will relentlessly pursue continual improvement in everything we do to:
- Consistently provide product that meets customer and other applicable requirements for quality
- Enhance customer satisfaction by consistently meeting and exceeding their expectations
- Be cost effective and remains competitive in the global market
- Operate in a safe and environmentally responsible manner"
- Excellence Through Quality

Jamalco has a highly qualified technical, administrative and support staff within its Environmental Management Department, many trained to the tertiary level. All employees within the Department report to the Manager, Environmental, Health & Safety, a senior manager in the company who in turn reports directly to the Managing Director.

All aspects of Jamalco's operations have an environmental management, health and safety component. Environmental Standard Operating Procedures, guidelines and instruction have been developed by Jamalco to govern operations in all areas. As a result, all technical and support staff have a responsibility to insure that they operate in a safe and responsible manner regardless of the task being undertaken.

Many aspects of environmental management at the facilities are monitored through the use of checklists, periodic reporting and internal audits. These provide timely indications as to the effectiveness of the procedures and provide indications as to the need for changes where applicable. The monitoring and checks also inform process operations and controls.

9.1.1 Training

Jamalco has a commitment to the improvement and advancement of all its employees. A major component of this commitment is the provision and facilitation of training for employees at all levels.

Specific to environmental management, Jamalco provides training in the following areas, which are designed to keep relevant employees and contractors informed and ensures competence in performing their duties. The training program achieves the following:

- Conformance with Jamalco's EH&S policy
- Identifies significant actual and potential impacts of their work
- Defines associated benefits of improved personal performance
- Identifies the roles and responsibilities in achieving conformance with the EMS
- Relays proper environmental operating procedures for managing environmental related aspects of their duties

- Reinforces Jamalco's policy that only properly trained and experienced individuals are allowed to work unsupervised

MONITORING PROGRAMME

10 Monitoring Programme

10.1 Environmental Monitoring Programme

In keeping with its Environmental Health and Safety policies as well as the legislation and regulations of the Government of Jamaica, Jamalco has an extensive Environmental Monitoring Programme which is carried out on all aspects of its operations.

In respect of Section 17 of the NRCA Act of 1991 the company is required to and submits the results of its Monitoring Programme to NEPA on a quarterly basis.

Among the parameters reported to NEPA are:

- raw materials used
- water quality
- effluent quality
- hazardous materials used
- water consumption
- fuel specifications
- materials and chemicals consumption. This category includes:
    - solvents
    - flocculants
    - oils and lubricants
    - acids

- refrigerants

Jamalco also provides monthly monitoring and reporting to the Jamaica Bauxite Institute (JBI). In addition to the above named, ongoing monitoring activities, Jamalco will implement a monitoring programme during this brownsite efficiency upgrade, which will cover the pre-construction, construction and operations phases of the efficiency upgrade at the mines, the refinery the port and the transportation corridors.

These will be based on the potential impacts identified in the impact identification and impact mitigation actions documented in those sections of this report.

The objective is to insure that all potential impacts and the appropriate mitigation actions are taken.

Monitoring will be done at regular intervals as follows:

1. The conditions of the sites and transportation corridors will again be inspected and recorded two weeks before construction start-up
2. At start-up of construction all activities will be monitored every two weeks for the first three months.
3. Monitoring will take every month from month four to month six.
4. Monitoring will take place quarterly until completion of construction i.e. from month seven to twenty four.
5. Monitoring will be on a monthly basis for three months during commissioning and start-up.

Monitoring reports will be prepared and submitted to NEPA for each monitoring interval for 1 to 5 above.

10.2 Structural Integrity Testing

All materials used in the construction of the upgraded Refinery as well as modifications at the Mines and Port will be of the best available quality.

In addition to effective material selection, which will bear the certification and warranties of material suppliers, materials used in construction such as steel and concrete will be subjected to internationally recognized standard tests such as those approved by the ASTM and ISO.

Testing will involve both destructive and non-destructive methods. For example in the case of concrete, cube tests will be done extensively on each pour.

Non-destructive testing will be used to determine the structural integrity of the materials of construction of major machinery and equipment. These are standard procedures, which form an integral part of equipment suppliers' warranties and guarantees.

Destructive, non-destructive testing as well as regular inspection and periodic maintenance is ongoing. These are deeply entrenched aspects of Jamalco's operation and these must comply with Alcoa's stringent engineering standards. These principles and activities are of such importance to Alcoa that Jamalco has an entire Reliability Department and Reliability Manager dedicated to these activities, which implements an ongoing comprehensive maintenance program.

The entire production capacity is dependent on the safe operating integrity and availability of machinery and equipment. The structural integrity of all the company's assets is of critical importance.

In addition to Jamalco's own internal standards, for insurance purposes the facility is subjected to independent due diligence inspections and audits from various agencies such as Factory Mutual from the USA.

It is important to note that the most recent 250,000 tonne upgrade at the facility was subject to this process of inspection and testing and certified accordingly.

ENVIRONMENTAL WASTE AND OCCUPATIONAL HEALTH AND SAFETY

11 Environmental Waste and Occupational Health and Safety

11.1 Risk Assessment and Human Health Risk

Four main categories of risk have been identified, which must be avoided or minimized in the efficiency upgrade for all aspects of the project. These are:

1. Natural Hazards
2. Manmade Hazards
3. Accidents
4. Structural Failure

The associated risks are described below and actions suggested for avoidance, minimization, prevention and solution are illustrated in the table below:

Table 40: RISKS AND THEIR PREVENTATIVE ACTIONS

Category	Risk	Source	Prevention	Solution
Natural Hazards	Hurricane	Nature	None	Implement 72 hour shutdown procedure; coordinate with ODPEM
	Earthquake	Nature	None	Plant and facilities designed to withstand earthquakes greater than 7.0 on the Richter Scale
	Flood	Rainfall		Proper design, construction and maintenance
	Lightning	Nature	None	Lightning arrestors
Manmade Hazards	Fire	Various (electrical, mechanical, accidental)	Proper maintenance and monitoring	Employ state of the art fire fighting systems to control and extinguish
	Explosion	Various (explosive environment, human error)	Proper maintenance, instrumentation and fail-safe systems	Continual training, audits, testing and monitoring
	Equipment Failure	Various	Proper maintenance, instrumentation and fail-safe systems	Continual training, inspection, audits, testing and monitoring

Table 40: RISKS AND THEIR PREVENTATIVE ACTIONS

Category	Risk	Source	Prevention	Solution
Accidents	Electrocution	Electrical contact	Training, education	Lock-out, tag-out procedures
	Contravening Safety Procedures	Ignorance, negligence	Training, supervision and audits	Educative discipline
	Falls	Structures	Training, education, with updates	Provision and use of proper equipment
	Suffocation	Confined/poorly ventilated Space	Training, following standard procedures	Adequate ventilation, buddy system, signage
	Spills	Vessels, pipeline	Implementation of Jamalco's spill management procedures	Implementation of Jamalco's spill management procedures
Structural Failure	Dike Failure	RDAs	Proper design and engineering	Inspection, corrective actions
	Impoundment Liner	RDAs	Proper design and engineering	Inspection, corrective actions

11.2 Occupational Health and Safety

11.2.1 JAMALCO'S OH&S POLICY

Jamalco's OH&S policy is based on the worldwide policy used by Alcoa at all their operations and as such is often more stringent in many respects than local OH&S requirements. All activities must be conducted in a safe manner with proper regard for the health of all concerned. No worker will be required to work in any area and to do any activity without adequate provisions being made to ensure that the health and safety of that worker is not compromised.

Jamalco has an organized, documented set of Standard Operating Procedures which govern employees actions as they perform tasks at the facility. These procedures provide definitions of unfamiliar terms, outlines required safety equipment necessary to undertake the activity, provides direction and instruction on proper handling and management of associated waste streams and record keeping guidelines. This approach to worker safety is universal within Alcoa and Jamalco.

11.2.2 DRAFT OCCUPATIONAL HEALTH AND SAFETY ACT 2003

The Occupational Health and Safety Act, 2003, which is in Draft form makes provision for a safe and healthy working environment for all working persons and to provide for matters incidental thereto or connected therewith.

The objects of the Act are as follows:

a. the prevention of injury and illness resulting from conditions at the workplace.

b. the protection of the safety and health of workers.

c. the promotion of safe and healthy workplaces.

As a good corporate citizen, Jamalco is committed to conducting its mining operation in a manner that complies with the requirements of this Act.

Some specific elements of these requirements are as follows:

- A joint committee of worker and management personnel shall be established at every workplace where twenty or more workers are regularly employed.
- An employer shall place in a conspicuous place in the workplace, a list containing the names and work locations of the members of the joint committee.
- Where fewer than twenty workers are regularly employed, the employer shall cause a safety and health representative to be selected.
- An employer shall make or cause to be made and maintain an inventory of all hazardous chemicals and hazardous physical agents that are present in the workplace.
- The employee shall make available to the workers the inventory of hazardous materials and pertinent Material Safety Data Sheets.
- Any worker who is likely to be exposed to hazardous chemical or physical agents must be provided with appropriate training and instruction.
- A worker has the right to refuse work if he has reasonable grounds for believing that his safety or health is endangered.

11.2.3 Solid and Hazardous Waste Management

The management of hazardous waste resulting from any aspect of the Mining Enterprise will be done in accordance with the Mining Regulations, 1991 of the Government of Jamaica as well as the applicable standards for Jamalco and the standards for Alcoa Operations worldwide. These include handling, segregation, storage and disposal considerations. If there are potentially toxic substances in the overburden and mine waste, they will be handled in such a way as to minimize the impact on rehabilitation and the surrounding areas.

The mining of bauxite and the processing of bauxite ore into alumina generates a wide variety of waste streams that must be properly handled and managed. Jamalco has very well defined procedures for the management of all waste streams generated at all its facilities.

Since the proposal for upgrade of the facility is one of “Brownsite” upgrade and no new or unfamiliar activities are proposed, the same time tested, high quality approach to waste collection, handling and management will be utilized. The following is an overview of how waste is managed at Jamalco presently and how it will continue to be managed after the upgrade.

11.2.3.1 Solid Waste Management

Solid waste generated at Jamalco includes, among other items:

- Used filters
- Empty drums
- Aerosol cans
- Garbage
- Boiler ash
- Demolition waste
- Medical waste
- Absorbents
- Office refuse
- Lime reject
- Waste Rags
- Sand

For each waste stream identified, there exists complete listing of tasks necessary for the collection, handling and management of that waste. The procedures identify sources of that particular waste stream, accumulation or storage locations and provides instruction on proper labeling, proper storage and individual responsibilities. The procedures are specific for all locations (plant, port, mines) and are comprehensive in its approach.

11.2.3.2 Hazardous Waste Management

Jamalco has strict requirements for the handling of hazardous waste materials. All waste streams considered hazardous waste are identified and listed by department and activity. As with all other waste streams at the facility, very specific tasks, procedures and instructions are provided.

Jamalco utilizes satellite accumulation of its hazardous waste streams which are established based on international guidelines. These include:

- Waste collection containers must be located at or near the point of generation
- Waste containers must be in the control of the generator
- The collection station will be well marked and identified as “Satellite Collection Station”.
- The station shall be located in a secure and protected area. All waste must be labeled.
- Containers must be compatible with the waste being stored
- Container lids and bungs must be closed at all times
- Weekly inspections
- Container management

Examples of hazardous waste at JAMALCO include:

- PCB Waste

- Lead waste
- Spent solvents
- Sand blast residue
- Mercury Contaminated

11.2.3.3 Landfill Management Program

Jamalco owns and operates a landfill facility located in the northeast section of the refinery. This landfill is subject to the National Environment and Planning Agency's Landfill Permit and License System and is operated within the local regulations and internal standards.

Jamalco has a complete list of items acceptable for disposal at the landfill site including special wastes such as regulated asbestos containing materials (RACM) which are deposited into an area within the landfill site that has been specially designed and sealed to accept these types of waste.

Specific internal rules and regulations govern the operation of the facility. Instructions on what type of waste is acceptable, mode of transportation, packaging, landfill maintenance, etc. are all specified in associated documentation. The landfill undergoes monthly inspections and specific forms designed for that purpose are used throughout the inspection process.

PUBLIC INVOLVEMENT

12 Public Involvement

12.1 Introduction

Jamalco has an established record of consultation and cooperation with the communities, settlements and residents who are stakeholders in the area. This process of ongoing contact through meetings and activities provides Jamalco with an opportunity to understand and work with the communities expectations of the community.

During communication with the community, Jamalco provides information to the residents on ongoing activities and initiatives and coordinates mutually accepted solutions to address areas of concern. Jamalco intends on continuing this level of communication and dialogue with the communities throughout the entire upgrade process primarily through the five (5) Community Council groups with which they meet on a regular basis. These groups are:

- Port Community Council
- Refinery Community Council
- Railroad Community Council
- Pleasant Valley Community Council
- Havanna Heights Community council

These community groups are comprise influential citizens, area leaders, community activists and individuals who have the best interest of the communities at heart.

12.2 Community Contributions

Over the years, Jamalco has played a major role as a good corporate citizen in the community. The company has been involved in the daily life and development of these communities in many ways, these include:

12.2.1 Education

- Established computer labs in six (6) High Schools, three (3) Primary Schools and Five (5) Basic Schools
- Cafeteria and bathroom expansion – Vere Technical High School
- Nutrition Programme – Daily supply of milk to 26 Basic Schools
- New bathrooms – Hayes
- Construction of a block of classrooms (Alcoa Block) including a Physics Lab
- Refurbished Vocational Department and upgraded electrical work in all classrooms – Lennon High School
- Back-to-school assistance for tertiary and high school students – annually
- Summer employment – students in tertiary institutions
- Support for the University of the West Indies – Labs, UWICED, distribute over 15,000 books annually for the past 14 years
- Skills training – sponsor students for HEART/NTA programmes and 4H clubs
- Developing skills training centre with HEART/NTA at Jamalco's Breadnut Valley facility

12.2.2 Health

- Supply of medical supplies for clinics and hospitals – Islandwide
- Wellness programme – hypertension and diabetes checks – Mitchell Town, Hayes and Mocho
- Support – University Hospital Sickle Cell Unit, Kidney Unit, Cardiac Emergency Unit and Burn Unit

12.2.3 Infrastructure Upgrade

- Pave roads - Cornpiece
- Street lights improvements - Cornpiece
- Clean and construct new drains on a regular basis to alleviate flooding
- Constructed new Postal Agency – Mitchell Town
- Constructed new Post Office – Hayes
- Constructed Police Station – Hayes
- Expanded Health Center – Mitchell Town
- Constructed Community Center – Hayes
- Provided water supply system – Top Hill, Hayes

12.2.4 Sports

- Sponsor – Jamalco Community Netball Team
- Sponsor – Clarendon Netball League
- Sponsor – Various football teams

12.3 Community Consultation on Efficiency Upgrade

Jamalco has consulted with members of the community on the proposed upgrade of the facility through their regular Community Council meetings and one specially arranged meeting. At the regular Community Council meetings, general information of the proposed upgrade was presented to the community representatives by Jamalco personnel. At the specially arranged meeting, the entire focus was on the upgrade project and details of the proposed upgrade were presented by the consultants conducting the EIA (Conrad Douglas & Associates Limited).

The meeting was attended by approximately 25 residents of surrounding communities. At this meeting, the details of the upgrade were presented by the consultant and any concerns or issues raised were noted and where possible, responses were provided.

Among the concerns raised were:

- Noise and vibration
- Atmospheric pollution
- Matters concerning transportation corridors
- Upgrade of community facilities
- Water Quality
- Employment

These concerns will be assessed for validation and engineering designs and management procedures, in keeping with Jamalco's ISO 14001 Certification will be used to address these concerns.

APPENDICES

13 Appendices

APPENDIX I: SURVEY INSTRUMENT

Socio-Economic Survey for the Expansion of JAMALCO's Plant Operations, Port Facilities, and Mining Operations

Community Name	______________________	Community Code	☐☐☐☐☐

SECTION 1
PERSONAL CHARACTERISTICS

1) Gender
    1. Male
    2. Female

2) Age Range
    1. Under 20
    2. 20 – 39
    3. 40 – 49
    4. 50 – 59
    5. 60 – over
    6. Not Stated/No Response

3) How many years have you been living in the community?
    1. 0 – 5 Years
    2. 6 – 10 Years
    3. 11 – 20 Years
    4. more than 20 Years
    5. Not Stated/No Response

SECTION 2
OPINIONS ON THE COMMUNITY

4) What do you like most about the community? ***ASK & WAIT FOR RESPONSE***
    1. Friendly people
    2. Clean environment:
    3. Availability of farmland
    4. Quiet
    5. No crime & violence

6. Other, (specify)________________________________
7. Not Stated/No Response

5) What don't you like about the community? ***ASK & WAIT FOR RESPONSE***
    1. Poor roads
    2. Lack of Utilities
    3. Crime & violence
    4. Unemployment
    5. Dirty environment
    6. Other, (specify)________________________________
    7. Not Stated/No Response
6) "Large scale development is beneficial to this community " (e.g. construction activities, plant upgrades, mining operations, housing) Do you agree?
    1. Yes
    2. No
    3. Not Stated/No Response (Go to Q 8)

7) Why do you think so?
    1. Job opportunities
    2. It will reduce the peacefulness of the area
    3. Offers skills development
    4. Improves utilities
    5. It will affect environmental quality in a negative way
    6. Other (specify)
    7. Not Stated/No Response

SECTION 3
AWARENESS & OPINIONS ON EXISTING BAUXITE FACILITIES

8) Are you aware that there is bauxite mining or alumina processing plant operations in your area?
    1. Yes
    2. No (Go to Q 14)
    3. Not Stated/No Response

9) Are you experiencing any negative impacts from the bauxite operation or facility mentioned above?
    1. Yes
    2. No (Go to Q 11)
    3. Not Stated/No Response

10) If **YES ASK**: What is this negative impact?
    1. Odour
    2. Traffic
    3. Dust, soot or gaseous emission

4. Noise
5. Damage to your property
6. Not Stated/No Response
7. Other, (specify)______________________

11) Would you say that the bauxite mining or processing facility has had negative impacts on the people in this community?
    1. Yes
    2. No (Go to Q 13)
    3. Not Stated/No Response

12) If **YES, ASK** - WHY WOULD YOU SAY THAT?
    1. The area has widespread corrosion
    2. The area smells like caustic soda more often than not
    3. You get sick more often
    4. Plants are harder to grow
    5. Too much noise
    6. Other (specify)
    7. Not Stated/No Response

13) Would you say that the existing bauxite mining and alumina processing facility have had a positive impact on this community?
    1. Yes
    2. No

14) What positive impacts do you think the bauxite mining and alumina processing facility has had on the community?

1. Improved community relations
2. Job opportunities
3. Educational and social benefits
4. Amenities – roads, lights, water supply
5. Environmental conditions
6. None of the above
7. Other (specify)_____________________________
8. Not Stated/No Response

SECTION 4
KNOWLEDGE AND VIEWS ON UPGRADE PLANS

15) Are you aware that JAMALCO proposes to upgrade their existing bauxite mining operations and processing plant facilities in the near future?
    1. Yes
    2. No
    3. Not Stated/No Response

16) What effect do you think the proposed upgrade of JAMALCO's bauxite mining operations and processing plant facilities in or near your area will have on the following:

Economic value of the community
1. Positive
2. Negative
3. No Change
4. Don't Know
5. Not Stated/No Response

Job Opportunities
1. Positive
2. Negative
3. No Change
4. Don't Know
5. Not Stated/No Response

Pollution
1. Positive
2. Negative
3. No Change
4. Don't Know
5. Not Stated/No Response

17) Do you think the proposed upgrade will affect you personally?

1. Yes
2. No
3. Don't Know/Not Sure
4. Not Stated/No Response

18) What do you think are the main impacts that the upgrade would have on the local environment?
1. More jobs
2. Loss of income
3. More dust circulating in the area
4. Less air pollution and noise
5. More air pollution and noise
6. Contamination of Water supplies
7. Better community relations
8. Improved water supply and other amenities
9. More occurrences of diseases that affect breathing
10. More crime in the community
11. Increased population
12. Don't know/Not Sure
13. Other (specify)

14. Not Stated/No Response

19) Why do you think so?

1. The present mining and processing facilities have caused this already. So it can only get worse.
2. The upgrade will add new equipment that will be cleaner to operate
3. More jobs will be available
4. This is something common to all bauxite operations
5. The upgrade will cause more people to pass through the community. So it gives more opportunity for crime
6. This is something that someone told me
7. Don’t Know/Not Sure
8. Other (specify)
9. Not Stated/No Response

SECTION 5
AVAILABILITY OF WATER

20) What is your main source of drinking water?

1. Indoor tap/pipe
2. Outdoor private tap/pipe
3. Public standpipe
4. Spring, pond, river
5. Rainwater (tank or drum)
6. Trucked water (NWC)
7. Other (specify)
8. Not Stated/No Response

21) If you have piped running water in or around your household, who supplied it originally?

1. National Water Commission
2. JAMALCO
3. Other (specify)
4. Don’t Know
5. Not Stated/No Response

22) “In this community, I think that we have access to safe water to drink” Do you agree?

1. Yes
2. No
3. Don’t Know/Not Sure
4. Not Stated/No Response

23)Why do you think so?

1. bauxite mining or processing operations affect the drinking

water
2. Sources (not bauxite mining or alumina processing related) affect the drinking water quality
3. The water is tested frequently by the N.W.C.
4. The water looks and/or smells clean
5. Other, please specify
6. Not Stated/No Response

24) Have you or anyone in your household, received compensation for any pollution problems?

1. Yes
2. No
3. Don't Know
4. Not Stated/No Response

25) Have you or any member of your household ever worked for a bauxite company or in the bauxite industry?

1. Yes
2. No
3. Don't Know/Unsure
4. Not Stated/No Response

26) Are you aware of any programs or activities initiated by Jamalco in your community?

1. Yes
2. No
3. Don't Know/Unsure
4. Not Stated/No Response

THANK YOU
END OF INTERVIEW

Name of Interviewer:
Date of Interview:

APPENDIX II

APPENDIX II: 'JAMALCO AND YOU' Q & A BOOKLET

Your Guide To Resettlement

JAMALCO is a bauxite mining and alumina refining joint venture association between ALCOA Minerals of Jamaica and the Government of Jamaica. Our operations which began in 1976 are concentrated mainly in the parish of Clarendon.

Like other companies with a mining lease, JAMALCO has the right by law to mine all bauxite that is found within the boundaries of the lease. In order to do this, it is sometimes necessary to relocate people. The Company ensures, however, that if individuals or communities have to be relocated, this is done as smoothly as possible.

At JAMALCO, we have been playing our part in helping to build and sustain communities through our resettlement programme. The Company also strives to ensure that persons who are relocated enjoy an improved standard of living.

Now that you are about to be resettled, JAMALCO is committed to working with you to help you to feel at ease as you go through the process. Here, we seek to answer your questions, by providing detailed information that will make resettlement easier.

Our mission is to help you to find peace of mind as you take this important step. Our people are dedicated to working tirelessly to find the right resettlement option for you.

1

THE COMPANY'S POLICY

Q **Does JAMALCO have the right to mine bauxite wherever it is found?**

A Yes. The law of Jamaica says wherever bauxite is found, mining should be done. JAMALCO therefore has the right to acquire all the land that is needed for mining, building haulroads to the ore deposits, relocating public roads within the area and resettling land owners.

Q **How does JAMALCO acquire land?**

A The Company can acquire land using any combination of four methods.

DIRECT PURCHASE OPTION

I. This creates an opportunity for the land owner to be paid in cash for his/her property, existing buildings, structures and crops. An independent valuator values the property and this forms the basis for negotiations. The agreed price is then paid to the vendor.

LAND EXCHANGE

II. In this method, land is offered in exchange for the land that will be acquired by JAMALCO. The amount of land given in exchange, is determined by the amount and quality of land that the vendor had. For example, one (1) acre of arable land in the mining area is given for one (1) acre of arable land in the resettlement area OR half an acre of arable land in the resettlement area can be exchanged for one (1) acre of non-arable or rocky land in the mining area.

2

RESETTLEMENT

III. This method is used where the land owner is resettled in another community or developed sub-division.

SURFACE LEASE OR NON-TRANSFER OF TITLE

IV. This method is used where JAMALCO does not purchase the property but is given access to the land for the purpose of mining the bauxite found there. In this method, JAMALCO mines and restores the property to the level where it is certified by the Ministry of Mining. The land owner is compensated for loss of use of his property and crops during the period that JAMALCO had possession of the property.

Q **What is the Company's approach to resettlement?**

A JAMALCO has a mining lease that gives the Company the right to mine all bauxite that is found within the boundaries of the lease. Some of this land is owned by government, while a large portion of the land on which bauxite is found is often privately owned. Whenever we decide to mine in an area, we must purchase the property tha is privately owned. Many discussions are then held between Company representatives and the residents of the community. JAMALCO works with the Jamaica Bauxite Institute (JBI) and the Ministry of Mining to value the properties of land owners. We also make sure that the community is involved in the change process.

Q **If my property is surrounded by bauxite and JAMALCO wants to buy it but I do not want to sell, is there any action that the Government or the Company can take?**

A Under the law, if you own land that is required for mining and you refuse to sell, Government has the right to value the property, acquire the land, and lodge the money with the court. Fourteen (14) days notice is then given to you, after which the Company moves on to the property. However, this method of operation is a last resort for JAMALCO. We prefer to meet and to negotiate with you concerning purchasing the land and arriving at a settlement that benefits both you and the Company.

Q **Where does JAMALCO get the land on which people are resettled?**

A JAMALCO acquires large pieces of land for resettling land owners. We then sub-divide these pieces of land and put in the necessary

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infrastructure such as water, electricity and roads.

HELPING YOU TO MAKE THE MOVE

Q **If I occupy leased land and JAMALCO targets this land for mining, do I have to continue to pay the lease?**

A Yes. If the land is leased property, you must continue to pay the lease until you have been served notice terminating the lease.

Q **If I am to be relocated, do I have a choice about where I will be resettled?**

A JAMALCO tries to give everyone a choice when they are about to be resettled. We identify land that will allow people to return to as normal a life as possible. You can choose, however, to sell your property to the Company, take the money and purchase land wherever you wish. The Company will then re-build your house on the property of your choice.

Q **Can entire districts be removed?**

A Sometimes it becomes necessary to re-locate whole districts. JAMALCO informs residents in good time so that proper arrangements can be made for their resettlement. We also ensure that all social facilities (e.g. schools and churches) are replaced.

Q If twelve families, for example, live in a small community, will all the members be relocated to the same area?

A Yes , but only if they wish for this to be done. Family members, however, generally have the option to go wherever they choose as long as the land selected is of equal value and the new area is not targeted by the Company for mining.

SOLVING THE TITLE PROBLEM

Q What happens if I want to sell but I do not have a title for the land that JAMALCO wants to buy?

A JAMALCO will assist you to use whatever documents you may have providing that you are the owner of the land to get a registered title for the land.

Q If I do not have a title, what other papers can I use to show proof of ownership and help to secure the title?

A Some of the documents you may use to prove

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ownership, include tax receipts, land receipts, deeds of gift and wills to assist you to get a title

Q What happens if there are various family members living on the land who have a claim but no title?

A If family members can prove their claim, JAMALCO will assist them to use whatever documents are available to get a registered title for the land. This is done with the help of our lawyers and the Titles Office but each case will be handled separately.

Q Who pays the lawyer?

A While it is the land owner's responsibility to have a registered title, JAMALCO, as a public service, will assist in paying the lawyer where there are cases of need.

Q When I am resettled, will I get a title for the land?

A Yes. As a land owner, when you are re-located, JAMALCO works with the Titles Office to provide a registered title for the new piece of land on which you are resettled.

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Q What if I live in a community where some persons are being resettled but I am not because my land is not required for mining?

A JAMALCO acquires only those lands that are required for mining. If your land is not required and you will not be affected by the mining activities you will not be resettled.

Q If I have to be resettled, what will happen to the graves of my loved ones?

A When graves are found on land that the Company acquires, they are removed and re-located to a cemetery in the presence of loved ones and under the supervision of the Ministry of Health. The laws of Jamaica are discouraging the burial of the dead on private property, however, and people are being asked to bury their dead in cemeteries. At JAMALCO, we make it our policy to show respect for the dead.

GIVING YOU THE HOME ADVANTAGE

Q What happens if I had a house on land that was bought by the Company?

A JAMALCO will build a house for you on the land on which you are to be resettled.

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Q What type of building will JAMALCO put on the new land?

A JAMALCO generally replaces the old building with a new structure. We build all new structures of concrete with at least one indoor bathroom and a kitchen.

Q If I lived in a board house, what type of new structure will the Company build for me?

A JAMALCO will build a concrete structure of similar size with enclosed kitchen and bathroom for you, after the Company's land agent measures your existing house to get the total value.

Q What if my house is built on leased land, how will I be compensated?

A Your house will be valued and you will be compensated according to its value.

Q What if my house is unfinished , how will I be compensated?

A At JAMALCO, our objective is to give each house owner a finished building. We will value the existing structure and apply this value to the structure that you eventually receive . If you

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also own the land, you may choose to put a part of the value of the land towards completing your new house.

Q **If I have both a large house and a small house on the same property, can both be combined?**

A Yes. The houses will be measured and the square footage of each determined. If you wish, both will then be combined to make one house.

Q **Can the square footage of an outbuilding be transferred to my house?**

A No. However, the value of the building can be used to increase the square footage of your new house.

Q **What if I am a shopkeeper and I am to be resettled, what will happen to my shop?**

A The Company will replace your shop in the area of your choice.

Q **Will I be compensated for other structures such as fowl coops and pig pens?**

A Yes. These will be valued by the Company's

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land agents and you will be paid for the structures.

Q **What will happen to those persons who own livestock?**

A JAMALCO will make every effort to relocate people to areas where they can continue to raise their livestock.

Q **If I had crops on the land, will I be compensated for them?**

A Yes. Our land agent counts each tree, assesses the economic value of the crops and compensates you accordingly. The assessment is done using rates established by the Jamaica Bauxite Institute and the Ministry of Agriculture. In the case of cash crops, you will be allowed up to six months to reap your crops.

Q **What if I have established tree crops such as ackee, or citrus? How will I be compensated?**

A If these crops are found on land bought by JAMALCO, they will be valued and you will be compensated for the amount that you would have earned from the crops. The Company will also provide similar tree crops for

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the land on which you are to be resettled and assist you to care for them for approximately three years until they are fully established.

Q **If I owned a water tank, will it be replaced by the Company?**

A Yes. Depending on the site chosen for your resettlement, JAMALCO will re-build a tank of equal capacity.

AFTER MINING, WHAT NEXT?

Q **After the Company completes its mining activities in an area, what happens to the land in that area?**

A After JAMALCO completes its mining operations in an area, the land is re-filled, reshaped and restored and people may return to occupy the land.

Q **Can former residents return to live on mined out land that has been reclaimed?**

A Yes, but certain conditions apply. Once land is sold, it becomes the property of the Company. People who previously lived on the land, however, can make special arrangements with the Company to purchase the land for resettlement.

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If you have other questions, or require further information, please do not hesitate to call or write to us. At JAMALCO, we provide quality service to improve the quality of life for all.

We welcome your questions and comments at:

JAMALCO
Clarendon Alumina Works
Halse Hall, Clarendon
Tel: (876) 986-2561-4
(876) 986-2028
(876) 986-2575

or

JAMALCO Lands Department
Woodside, May Pen, Clarendon
Tel: (876) 902-3233
Fax: (876) 902-3234

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Handing over the keys "Home Sweet Home "

Completed house ready for occupation

Pepper farming on resettled land

Jamalco

Better Communities. Better Lives.

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APPENDIX III

APPENDIX III: REFORESTATION PLAN IN JAMAICA – MEMORANDUM OF UNDERSTANDING BETWEEN MINISTRY OF AGRICULTURE- FORESTRY DEPARTMENT AND ALCOA.

CLARENDON, JAMAICA -- Alcoa and Jamaica's Forestry Department have signed an agreement to work together to rehabilitate reclaimed mined-out lands through reforestation on the island. The five-year accord includes developing a public education program, planting of suitable trees, and a research program aimed at enhancing the development and reforestation of the lands.

JAMALCO and the Forestry Department in the Ministry of Agriculture (GOJ)have signed a memorandum of Understanding (MOU), to establish a framework for collaboration for the successful rehabilitation of reclaimed mined-out lands through reforestation of these areas.

This five year accord, signed recently by Jerome Maxwell, JAMALCO'S Managing Director and Marilyn Headley, Conservator of Forests, at the Halse Hall Great House in Clarendon, will see the Forestry Department and JAMALCO partnering to effect this restoration of adequate plant cover.

Guided by the 'no-net-loss' policy, the two organizations will work to compensate for the loss of forest cover due to mining operations. This move will see the establishment of new forests on selected reclaimed bauxite mined out areas as well as the protection and preservation of existing forests.

Under the MOU, the Forestry Department will utilize its skills for the establishment and management of forests, along with a forest research program aimed at enhancing the development and reforestation of the lands.

According to Miss Headley, this is in keeping with the Forestry Department's mandate outlined in the Forest Act of 1996 and which includes privately owned properties such as the JAMALCO lands.

At the signing, Mr. Maxwell, described the MOU as "timely and reflective of JAMALCO's environment protection policies and Alcoa's worldwide 'One Million Trees' project."

Specific areas of cooperation agreed on in the MOU include the development of a public education program for farmers and students to improve understanding of the contribution of forests to local and national well-being and economic development. Provisions have also been made for other areas of collaboration to be explored.

The agreement also specifically mandates the planting of suitable ornamental and lumber tree species such as cedar, ficus, acacia, wild tamarind, blue mahoe, mahogany, bitter wood, bitter damson, and spanish elm along with fruit trees such as mango, orange, avocado, breadfruit and ackee.

Appendix IV – Forest Reserves of Jamaica

Forest Reserves of Jamaica
· conservation of naturally existing forests
· as a source of forest products
· for the conservation of soil and water resources
· to provide parks and other recreational facilities for public use
· as a habitat for the protection and conservation of endemic flora and fauna
· the forest reserve areas shown in the Gazette are estimates, based on descriptive, not surveyed, boundaries

A programme of surveying forest reserve boundaries is underway and survey data are being digitised which will produce more accurate maps. In the years since the Forestry Department was established in 1937, the government has set aside a significant portion of its land for forest
reserves. They now amount to over 111,000 hectares or over 10 percent of the country's total area. These protected areas provide us with a be cared for so that their benefits can be enjoyed by future generations. The 1996 Forest Act provides for the creation and protection of forest reserves for the following purposes:

Most of the country's forest reserves are located in areas of rugged terrain such as the John Crow Mountains, Blue Mountains and Cockpit Country as well as the dry, hilly uplands in the south, west and north-west portions of the country. Despite their remoteness, serious encroachment has taken place. The 1998 analysis of forest cover and land use in Jamaica, carried out by the Forestry Department, shows that more than 20 percent of land within forest reserves has been impacted by human activity such as conversion to agricultural and/or residental use, mostly without Forestry Department permission.

Under the Forest Act, the Minister may declare to be forest reserves any Crown land, or private land if the owner requests such a declaration.
Further, the Minister may order or declare any land not in a forest reserve to be a forest management area, including private land if he is satisfied that the use of the land should be controlled for the protection of the national interest. Crown lands may be declared a protected area if required for a number of purposes specified in the Forest Act, including flood and landslide .Further, the Minister may order or declare any land not in a forest reserve to be a forest management area, including private land if he is
satisfied that the use of the land should be controlled for the protection of the national interest.
Crown lands may be declared a protected area if required for a number of purposes specified in the Forest Act, including flood and landslide

protection, soil preservation, erosion, maintenance of water supply and protection of amenities, flora and fauna. On protected areas cultivation, grazing, burning and clearing of vegetation is prohibited or strictly regulated.
The forest reserve areas listed in the following table are garnered from The Jamaican Gazette. The records show that the area of forest reserves and Crown lands managed by the Forestry Department is 109,514 hectares, of which 98,962 hectares are forest reserves and 10,552
hectares are Crown lands. These figures from the Gazette show a variation from those compiled by the Forestry Department in its recent assessment of forest cover and land use. The reasons for the difference are:
· the forest reserve areas compiled by the Forestry Department during its assessment were digitised from 1:250 000 maps and not from
actual surveyed forest reserve boundaries.

Parish Remarks

Forest Reserves of Jamaica by Parish
Forest Reserve/
Crown Land Name
Area (ha) Reference in the

Manchester Denham Farm 20.00 27-09-1956 486 Part of Devon Land Settlement
Gourie 141.65 Crown
Hudson's Bottom 226.63 Crown
John Anderson 121.40 Crown
New Forest 160.78 01-12-1950 432 Part of New Forest Land Settlement
Oxford 133.55 Crown
Ramble 48.18 01-12-1950 435
St. Jago A 163.90 09-10-1969 654 Plan A, Vol 1030 Fol 433
St. Jago B 66.00 09-10-1969 654 Plan B, Vol 1030 Fol 433
Virginia 13.03 01-12-1950 434 Part of Virginia Land Settlement
Total Manchester 472 623

Clarendon Bull Head 220.06 01-12-1950 417
Kellets-Camperdown 1497.79 01-12-1950 417
Kellits Stream A 8.30 01-12-1950 425 Block A (Miller's Spring)
Kellits Stream B 1.62 01-12-1950 425 Block B (Mosquito River)
Peace River 116.70 25-06-1959 423
Peak Bay A 302.72 01-12-1950 433 Block A
Peak Bay B 152.57 01-12-1950 433 Block B
Peak Bay C 60.70 01-12-1950 433 Block C
Peckham 70.89 01-12-1950 426 Prev. 06-09-1945 (part of Peckham Land Sett.)
Pennants A 169.19 01-12-1950 437 Block A (part of Pennants Land Sett.)
Pennants B 59.40 01-12-1950 438 Block B (part of Pennants Land Sett.)

Pennants (Douces) A 26.42 01-12-1950 438 Block A (part of Pennants Land Sett.)
Pennants (Douces) B 3.07 01-12-1950 438 Block B (part of Pennants Land Sett.)
Pennants (Douces) C 2.55 01-12-1950 438 Block C (part of Pennants Land Sett.)
Portland Ridge 5612.30 Crown Vol 403 Fol 40
Teak Pen A 532.99 01-12-1950 439 Block A (part of Teak Pen Land Sett.)
Teak Pen B 149.74 01-12-1950 440 Block B (part of Teak Pen Land Sett.)
Total Clarendon 3375 5612

St. Catherine Dawson Mountain 1 55.04 Crown Lot 101, Mount Dawson Land Settlement
Dawson Mountain 2 75.86 Crown Lot 104, Mount Dawson Land Settlement
Harkers Hall 6.82 01-12-1950 425 Prev. 06-09-1945 (Harkers Hall Land Sett.)
Healthshire Hills 4856.40 01-12-1950 422
Treadways 26.39 01-12-1950 422 Part of Treadways Land Settlement
Troja 18.86 21-07-1955 362 Lot 41, Troja Land Settlement
Twickenham Park 2.06 Crown
Little Goat Island 6.00 30-06-1960 278 2.4 km south of the mainland
Great Goat Island 188.00 30-06-1960 278 2.0 km south of the mainland
Total St. Catherine 5102 133

TERMS OF REFERENCE

14 Terms of Reference

14.1 SCOPE OF WORK

Environmental Impact Assessment for Jamalco Facility and Operations Upgrade To 2.8 Million Tonnes Annually.

Assess and define the physiographical features of the study area to determine geological sphere of influence of the project. Gather base line data for all new areas that Jamalco wiJI disturb and also for neighboring properties. Conduct detailed Air dispersion modelling for all air emissions sources in the proposed upgraded areas for both pre and post expansion emissions. Detailed ground water dispersion study will also be conducted to determine the potential impacts on the aquifer system in the Vere area.

These modeling and studies will be guided by accepted local and international standards,

A focused marine assessment will be conducted at the Rocky Point!&t Facilities withina 2.5 km radius of the Alumina handling operations.

Recommendations will be made regarding corrective actions and/or mitigation measures and monitoring programs suggested where negative potentials are identified.

The proposed EIA will give a full and detailed assessment of impacts in the following resources prior to construction, during construction and the operational phases of the project:-

1) Legislative & Regulatory Considerations

Outline the pertinent regulations and standards governing environmental quality, safety and health, protection of sensitive areas, protection of endangered species, siting and land use control at the national and local levels. The examination of the legislation shall include at minimum, legislation such as the NRCA Act, the Housing Act, Public Health Act (nuisance regulations), Clean Air Act, National Solid Waste

Management Act and the Draft Occupational Health & Safety Bill, Water Resources Act, the Town and Country Planning Act, Building Codes and Standards, Development Orders and Plans and the appropriate international convention, protocol or treaty where applicable.

2) Land Use and Aesthetics

- Land use: Residential, commercial, industrial, etc.
- Land capacity or potential
- Parish Council Zoning

3) Geotechnical Analysis and Soil

- Features - mineral resources - fault line - flood plain boundaries erosion and run off rate.
- Flood Control.
- Identify unique or special features in the study area.
- Determine local and regional tectonic or seismic activity.

4) Air Quality and Weather

- Air emission dispersion modeling in the environs of the refinery.
- Particulate, vehicle emission, $S0_2$, opacity, wind speed and direction, precipitation and relative humidity, ambient temperatures inclusive of the plant, mining areas, port and residue disposal areas.
- Sphere of influence of dust generated by future mining and transportation activities and identify potential receptors, which may be impacted by dust fallout.
- Stack emission and ambient air quality standards will be included. Fuel types and composition will be included. Detail the particular grid location of potential receptors that may be impacted by dust fallout.

5) Water Resources

- Determine if the aquifer system can sustain for 40 years and beyond twice the current refinery abstraction rate. If not, recommend alternatives. Identify any licenses which may be required from WRA or others for abstraction of water from the aquifer. Mitigation measures will be addressed.

- Ground water modelling study around the area of the refinery and Residue Disposal Areas (RDA).

- Surface and ground water quality, potable water quality natural drainage, sediment control, water shed areas.

- Milk River and Canoe Valley water resources in South Manchester.

- Fish farming activities on neighboring properties.

- Assessment of rainfall events.

6) Wild Life and Vegetation

- Forestry and wetlands, estuaries and coastal zones, flora and fauna, endangered or endemic species.

- Species diversity and ecological relationships. Identify special or protected areas (eg. Portland Bight Protected Area) and potential impacts.

- Record the extent and the potential impact of the expanded facilities and mining on biodiversity.

7) Marine Assessment

- Identify extent of alumina spillage into sea.

- Determine chemical effects of alumina, and all other chemicals handled or stored at the port if they are spilled into the physical environment. Review of past environmental incidents will be thorough.

- Review and comment on Emergency Response procedures for the port facility.

- Determine effect of alumina spillage on the marine water quality. Compile detailed species inventory, biodiversity and assess the general health of the Port's marine ecosystem.

- Identify any adverse effect on the marine environment.

- Emphasis will be placed on existing operations, their possible impacts, examination of new proposals and incorporation of mitigation of existing and potential impacts on the marine water quality and environment.

- The marine assessment will follow acceptable guidelines from NEPAs Coastal Zone Management Branch.

8) Archaeological/Historic Resources

- Possible effects on Milk River and other historic resources in southern Manchester and Clarendon.

- Develop contingency retrieval plan should any archaeological artefacts be unearthed during the excavation and mining phases of the project.

9) Socio- Economics

- Anticipate and predict the likely impacts of the proposed activities on the day-to-day quality of life of the people and communities. Communities, culture, livelihood, commercial, industrial and agricultural activities.
- Social Amenities
- Economic impact of proposed project.
- Community attitudes towards the proposed project.
- Population dynamics and sociological profiles.

10) Noise Levels

- Internal, External and Vibrations
- Determine baseline noise levels prior to construction.
- Propose mitigative actions for potential noise pollution.
- Noise and vibration potentials due to construction operation and upgraded

11) Solid and Hazardous Waste Management Practice/Landfill

- Sewage and domestic garbage disposal.
- Construction activities waste handling and disposal.
- Increased rate of storage of bauxite residue and other currently generated refinery wastes. Identify additional storage space and determine impacts due to increased rate of storage of bauxite residue. Detail expected volumes of bauxite residue and other generated refinery wastes. Include methods to reduce solid waste.
- Detail management and final closure plans for post-construction and waste disposal areas (residue areas for the mud as well as landfill areas for solid waste).

- Outline amounts and types of hazardous waste including appropriate management strategies.

- Outline proposed interfaces with existing response mechanisms for example the National Hazardous Material Response Team.

12) Occupational Safety and Health Issues

- Assessment of occupational and health safety issues as it pertains to oils & lubricants, other chemicals, noise and dust exposure levels and the use of protective devices.

- Review the Draft Occupational Health & Safety Bill.

- Propose a detailed mitigation action plan for potential health & safety issues (other than the use of protective devices). An assessment of issues of health & safety of the communities will be addressed.

13) Risk Assessment

The potential effects of activities on humans. Water quality, air quality, residue disposal areas, tanks and pressure vessels.

14) Human Health Risks of Proposed Actions

- Solid and Hazardous Waste Management

- Potential Air Quality Management Issues

- Odour Issues.

15) Natural Hazard Vulnerability

- Floods, Hurricanes, Earthquakes (natural hazard impact assessment). Include in project description.

- Detail hazards influenced by climatic change and those specific to the project. Include hazard maps.

- Review historical analysis of floods, hurricane and earthquakes that have affected the project areas

- Evaluate project hazards and hazards influenced by climatic change

- Disaster management evacuation procedures, emergency response procedures

16) Analysis of Alternative

- Examine alternative methods of transportation, process technologies and residue disposal methods.

- Site location analysis, including grid location (alternate site grid location). Other areas being considered for expansion works.

- No action alternatives

- Cost benefit analyses and justification for preferred alternatives.

- Water Resources

17) Closure Plans for Construction Phase

18) Structural Integrity Testing

TEAM MEMBERS

15 Team Members

15.1 Project Team

Dr. Conrad Douglas

Mr. Paul Thompson

Dr. Art Reid

Mr. Easton Douglas

Prof. Edward Robinson

Mr. Orlando Robinson

Mrs. Valerie Nam

Mr. Burklyn Rhoden

Mr. Noel Watson

Epsilon Associates Inc.

Geomatrix Ltd.

Ms. Dahlia Bean

University of the West Indies – Sociology Department

Mr. Vance Johnson

Mr. Valton Simpson

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