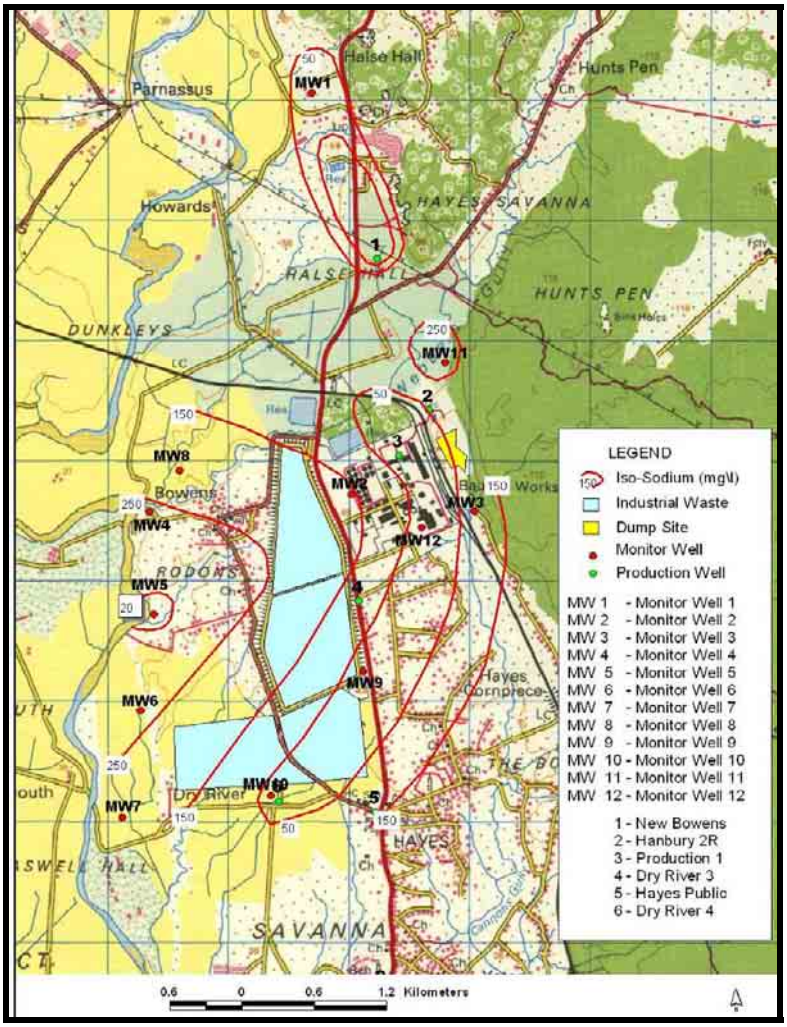
FIGURE 3-19: Iso-Sodium Plot - April 2004



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 3-10 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 3-14 to Table 3-17. 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 3-12: 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**

TABLE 3-13: 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 3-14: 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 3-15: 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 3-16: 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 3-17: 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**

3.4 AIR QUALITY AND WEATHER

3.4.1 AIR QUALITY

3.4.1.1 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 refinery which is the major source for atmospheric emissions is approximately 165 feet above mean sea level (amsl) and is surrounded by a mix of undeveloped and residential land uses. The terrain elevations rise up to over 400 feet amsl at approximately 2000 feet to the east of the refinery. The RDAs are not significant sources of air emissions.

3.4.1.1.1 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.

3.4.1.1.2 AIR EMISSIONS

The primary emissions that are released from the REFINERY refinery include particulates, NO_x, SO_2, CO, neglible quantities of VOCs and trace levels of metal.

3.4.1.1.2.1 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).

3.4.1.1.2.2 NOx Emissions

NOx emissions are not anticipated to be an issue during the implementation of the RDA project.

3.4.1.1.2.3 SO_2 and CO Emissions

Sulphur dioxide and carbon monoxide emissions are not anticipated to be an issue during the implementation of the RDA project.

3.4.1.1.2.4 Trace Metals

Trace Metals such as mercury are not anticipated to be an issue during the implementation of the RDA project.

3.4.1.1.2.5 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 SO_2, 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 Rocky Point Port facility.

3.5 WEATHER

3.5.1 REGIONAL SETTING/SPHERE OF INFLUENCE

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

3.5.2 RDA REGIONAL 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.

3.5.3 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 3-18: ANNUAL RAINFALL - INCHES. JAMALCO REFINERY

YEAR	Month												YEAR'S TOTAL	MONTHLY AVERAGE
	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.		
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. Celsius to 31 deg. Celsius and that the low temperatures range from 24 deg. Celsius 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 3-19: 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

3.6 WILDLIFE AND VEGETATION

3.6.1 INTRODUCTION

The proposed construction of the RDA will occupy an estimated 100 hectares of land adjacent to RDA 4. The previous four lakes cover an estimated area of 210 hectares (519 acres). The areas in proximity to the walls of the RDAs and the lands behind them that extend to the river, support a vegetation type typical of a scrubland/ thorn savannah. In most areas, the physiognomy of the plant communities are very similar. Whilst in others the structure of the vegetation has been modified by specific events or activities such as old excavations, grazing, tree felling for charcoal burning or post making, and even flood events. The area, although in proximity to the Rio Minho, appears to be dry. This is evident with the existing plant community that demonstrates xerophytic adaptations such as thick land shiny cuticles, small leaves or succulent parts.

The map and table below shows sample locations and coordinates at Hayes.

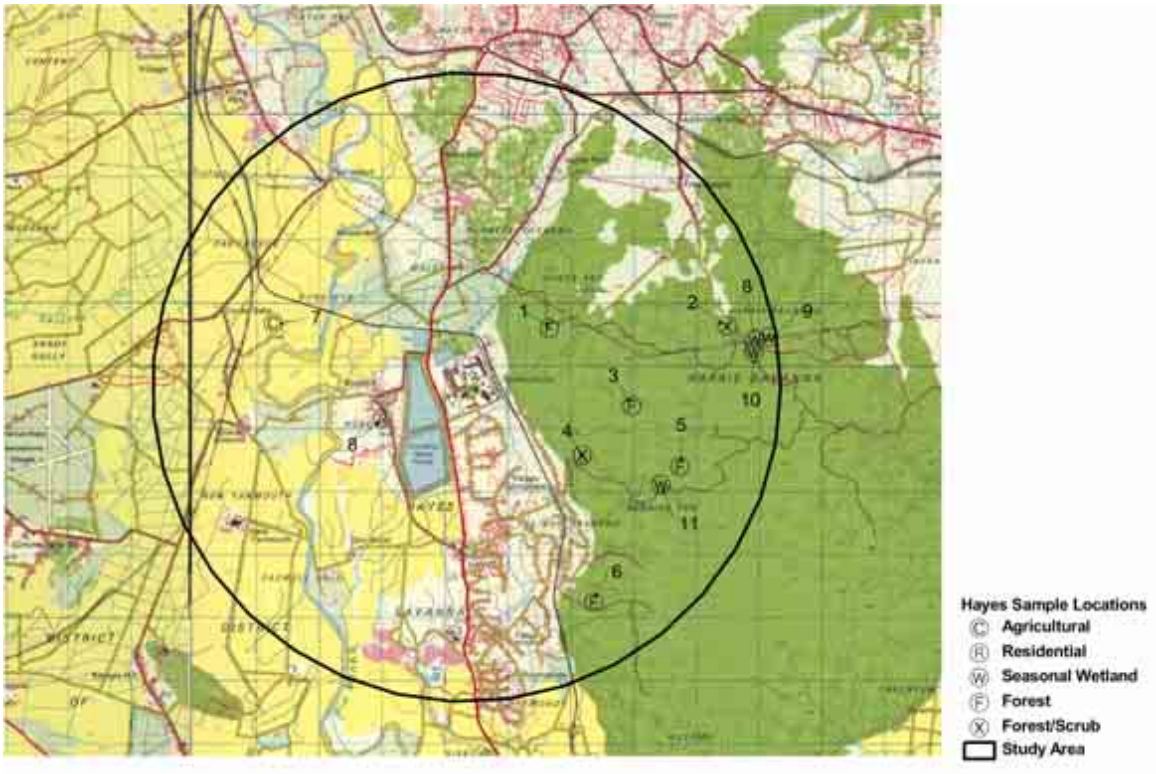


FIGURE 3-20: : MAP SHOWING SAMPLE LOCATIONS AT HAYES, CLARENDON

TABLE 3-20: COORDINATES OF SAMPLE SITES AT HAYES, CLARENDON (COORDINATES CORRESPOND TO 1:50,000 METRIC MAP)

ID HAYES	TYPE	X	Y
1	Woodland	225,665	139,600
2	Woodland/Scrub	228,497	139,634
3	Woodland	226,978	138,356
4	Woodland/Scrub	226,193	137,584
5	Woodland	227,740	137,401
6	Woodland	226,373	135,248
7	Agricultural	221,270	139,679
8	Seasonal Wetland	228,934	139,417
8	Residential	223,016	138,160
9	Seasonal Wetland	229,160	139,452
10	Seasonal Wetland	228,916	139,208
11	Seasonal Wetland	227,432	137,113

3.6.2 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, faecal deposits, burrows among others.

3.6.3 ECOLOGICAL CONTEXT

3.6.4 NATIONAL BIOLOGICAL DIVERSITY – INTERNATIONAL AND NATIONAL LEVELS

Jamaica is 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 3-21-Flora diversity[i]

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 3-22- Fauna diversity[i]

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 IV

3.6.5 FINDINGS

3.6.5.1 SAMPLE LOCATIONS

The following locations were selected as representative of the different ecosystem identified during the reconnaissance. The selected sample sites are indicated on the accompanying maps.

3.6.5.1.1 HAYES FACTORY PERIMETER

The circular perimeter of 5 km radius around the Hayes factory is subdivided into a western agricultural and eastern woodland area, the latter forming a part of Harris Savanna. Residential areas mainly stretch along the main road that runs southwards from Curatoe Hill trough Hayes and towards Lionel Town. To the east of the road, the bed of Rio Minho meanders southward.

Growing on top of flat though often rugged limestone, the woodland consists of a mosaic of secondary scrub dominated by exotic plants and degraded dry limestone forest of varying quality. Secondary scrubs are most common in the most northern section of the area and along drive roads. The least disturbed dry forest is found away from drive roads and footpaths. Shallow depressions filled with alluvial deposits intersect the limestone. These soil-rich areas are mostly clear-cut and covered with grassy plants. Prone to flooding, they contain a series of seasonal wetlands that support a unique flora.

The agricultural and residential areas are located on the Clarendon alluvial plain. They have lost their natural vegetation in the distant past and are dominated by exotic plants. The major crop species is sugar cane.

Location 1 and 2 - Strongly disturbed limestone forest with only few tall trees, mainly Red Birch. Dense and rather scrubby, but with many native species typical of mature forest.

Locations 2 and 4 - Mixture of strongly disturbed limestone forest dominated by native species and secondary scrub dominated by exotics.

Locations 3 and 5 - Located within a section of least disturbed forest. A variety of tree species grow to considerable height. Some patches close to undisturbed forest.

Location 7 - Agricultural area dominated by sugar cane and pastures.

Location 8 - Residential area dominated by exotic fruit trees and ornamental species.

3.6.5.2 DESCRIPTION OF VEGETATION TYPES

The vegetation was generally what is expected in highly disturbed areas.

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. An 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 4-3-23: Thorn Scrub below.

TABLE 4-3-23: 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)

Family Name	Scientific Name	Common Name	Status/Rank	Habit
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) (Figure x)
- 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.

PLATE 3-2: TYPICAL STANDS OF WILD POPONAX FOUND ON AND AROUND RDAS

Summary

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

3.6.5.3 FAUNAL STUDIES

3.6.5.3.1 4.6.6.3 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. Analysis of avifauna species was conducted in relation to habitat types as outlined above in the vegetation analysis.

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.

TABLE 3-24: 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 Grassquit	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

3.6.5.4 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.

3.6.5.4.1 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.

Serpentes

- ✓ *Arrhyton funereum* - endemic
- ✓ *A. callillaemum* - endemic
- ✓ *Typhlops jamaicensis* - endemic

SPHAERODACTYLUS

- ✓ *Sphaerodactylus argus* – not endemic

Celestus

- ✓ *Celetes duquesneyi* - endemic
- ✓ *C. d crusculus* - two subspecies – endemic
- ✓ *C. barbouri*

Anolis

- ✓ *Anolis valencienni* - endemic
- ✓ *A. sagrei*

***A OPALINUS* - ENDEMIC MAYBE EXTINCT**

- ✓ *A. lineatopus* - endemic

***A. GRAHAMI* - ENDEMIC INTRODUCED TO OTHER ISLANDS**

- ✓ *A. garman i*- endemic introduced to other islands

Sauria

- ✓ *Ameiva dorsalis*

Testudines

- ✓ *Trachemys terrapen*

Amphibia

- ✓ **Anura**
  - o *Osteopilus brunneus* - endemic
  - o *Hyla wilderi* - endemic
  - o *Hyla marianae* - endemic
  - o *Bufo marinus* - introduced
- ✓ *Eleutherodactylus planirostris planirostris*
- ✓ *E. pantoni pantone*
- ✓ *E.junori* - endemic
- ✓ *E.jamaicensis* - endemic
- ✓ *E.grabhami* **-** endemic
- ✓ *E gossei gossei* - endemic
- ✓ *E. gossei oligaulax* - endemic
- ✓ *E. cundalli* - endemic
- ✓ *E. cavernicola* - endemic
- ✓ *E. calyptahyla crucialis* **-** endemic

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.*

3.6.5.4.2 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.

3.7 ARCHAEOLOGICAL AND HISTORICAL RESOURCES

3.7.1 SUMMARY [ii]

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.

3.7.2 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
- Churches, Cemeteries, Tombs'
- St. Peter's Church, Alley
- Clock Tower
- May Pen Clock Tower

3.7.3 NATURAL SITE

- Milk River Spa

3.7.4 PROTECTED NATURAL HERITAGE SITES

3.7.4.1.1 NATURAL SITE

- Mason River Botanical Station

3.7.4.1.2 OTHER HERITAGE SITES[iii]

3.7.4.1.2.1 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.

3.7.4.1.2.2 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 in 1655 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.

3.7.4.1.2.3 St. Peter's Church Alley

St. Peter's Church Alley, is the 3rd oldest Anglican Church in Jamaica. 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

3.7.4.1.2.4 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.

3.7.4.1.2.5 May Pen Clock Tower:

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. 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.

3.7.4.1.2.6 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.

3.7.4.1.2.7 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.

3.8 NOISE LEVELS AND VIBRATION

3.8.1 BASELINE NOISE LEVELS

Noise levels are measured on a reasonably regular basis at the existing RDAs. Recently, these measurements have been taken in support of the Step-in-dyke being constructed in RDA 1. Recent data from the RDAs taken during active operation of heavy equipment (track excavators, loaders, bulldozers and trucks) follows.

The audiometric survey was conducted using a Metrosonic audio dosimeter. The survey points were triangulated around RDA 1 (See Plate 3-3 below), along the RDA #1 perimeter wall. The audiometer was operated continuously throughout the duration of the survey, with instantaneous readings for the Sound Pressure Levels (SPL) being recorded at one minute intervals, or at a moment of significant activity,1 over a period of fifteen (15) minutes each.

Table 3-25, Table 3-26, and Table 3-27 show the instantaneous measurements for the SPL levels which were recorded from the audiometer at the three survey points indicated in Plate 3-3 below.

[1] Significant activity is to be defined as, any activity which affects the audiometer's SPL measurement such that it deviates from the instantaneous 'background' effecting activity.

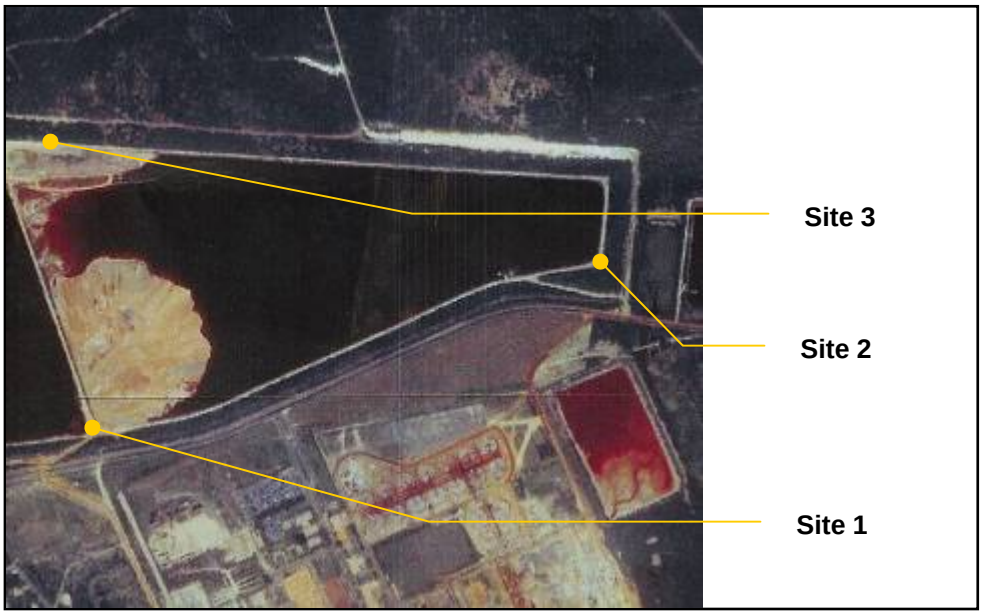


PLATE 3-3: AUDIOMETRIC SURVEY SITES AROUND RDA # 1[2]

3.8.1.1 SOUND PRESSURE LEVEL (SPL) ANALYSIS

3.8.1.1.1 SITE 1

The average SPL value at site 1 was calculated as 62.6 db. There were only two occasions when the 70.0db limit was exceeded; however, only on one of the two exceedances was due to the operation of heavy the equipment, whereas the other was due to inherent background activity such as wind. It should be noted that the occasion which generated the highest SPL value was the instantaneous and continual inherent background activity, which is beyond the control of Jamalco.

[2] Please note that the aerial picture does not represent the RDA's present state. It is only to be used as a guide to indicate the audio metric survey points

TABLE 3-25: SITE 1 SPL VALUES

Time/ mins	SPL/ db	Effecting Activty
0	61.6	Background (2)
0-1	70.7	Caterpiller Grader
1	62.6	Background (2)
2	73.2	Background (2)
3	66.2	Truck Traveling along Highway
4	59.1	Background (2)
4-5	66.7	Truck Carrying Reject Material
5	63.4	Background (2)
6	61.5	Background (2)
7	59.2	Background (2)
8	59.3	Background (2)
9	62.9	Background (2)
10	61.1	Background (2)
11	66.4	Passing Truck
12	61.6	Background (2)
13	53.6	Lull in Wind
14	60.0	Background (2)
15	58.2	Background (2)
Average	**62.6**	

Table Notes

- Time ranges displayed as x-y are to be perceived as any time measurement between x and y
- The "Effecting Activity" labeled as "Background (1)" is defined as perpetuating noise from continuous wind movement across the microphone.
- Information in blue font represent "Significant Activity" and information in red font represent exceedances above the 70db limit

3.8.1.1.2 SITE 2

In the absence of significant construction activity, the contributing agent to the variation of the SPL values would be the random activity which occurs in the background. The terrain at Site 2 is such that there is a thick growth of epiphytes along the outer area of the dyke's perimeter wall. This growth was observed to act as buffer to the prevailing winds, resulting in the diminished effects of the prevailing wind on the SPL levels measured by the audiometer at Site 2. The effect of the diminished wind activity at Site 2 is reflected in the average SPL values observed at Site 2 and Site 3. (See Table 3-26 and Table 3-27 below)

TABLE 3-26: SPL VALUES FOR SITE 2

Time/ mins	SPL/ db	Effecting Activity
0	66.9	Background (2)
1	73.2	Passing Trucks on Highway
1-2	53.2	Lull in Wind
2	60.1	Background (2)
3	54.4	Lull in Wind
4	53.8	Lull in Wind
4-5	65	Horn of Bauxite Rail
5	65.7	Background (2)
6	65.4	Background (2)
7	56.5	Background (2)
8	63.5	Background (2)
9	54.6	Background (2)
10	60.0	Passing Vehicle on Highway
11	55.6	Background (2)
12	57.6	Background (2)
13	60.4	Background (2)
14	67.0	Background (2)
15	57.1	Background (2)
Average	**60.6**	

Table Notes

- Time ranges displayed as x-y are to be perceived as any time measurement between x and y
- The "Effecting Activity" labeled as "Background (2)" is defined as perpetuating noise from continuous wind movement across the microphone.
- Information in blue font represent "Significant Activity" and information in red font represent exceedances above the 70db limit

3.8.1.1.3 SITE 3

The terrain at Site 3 is an open flat area with no buffer or vegetation alongside the perimeter of the original RDA #1 wall. Therefore, the wind passes over the land unhindered.

A comparison between SPLs for Site 1, Site 2, and Site 3 reveal that Site 3 consistently has higher SPLs either Site 1 or Site 2. This is due to the accessibility and/or the vulnerability to the area to the prevailing wind for the reason described above. It should be noted that the influence of the wind activity is especially evident in the average SPL value recorded at Site 3, which is only 1 db below the defined standard of 70db.

Therefore, one may conclude that the SPL levels at the site are greatly influenced by the naturally occurring wind activity, and may elevate SPL values above the 70db limit. The likely occurrence of such events is beyond the control of Jamalco.

TABLE 3-27: SPL VALUES FOR SITE 3

Time/ mins	SPL/ db	Effecting Activty
0	73.4	Background (2)
1	69.3	Background (2)
2	57.9	Background (2)
3	71.1	Background (2)
4	66.6	Background (2)
5	64.4	Background (2)
6	70.2	Background (2)
7	61.5	Background (2)
8	79.7	Background (2)
9	75.6	Background (2)
10	69.7	Background (2)
11	66.4	Background (2)
12	61.0	Background (2)
13	66.4	Background (2)
14	74.1	Background (2)
15	77.0	Background (2)
Average	**69.0**	

Table Notes

- Time ranges displayed as x-y are to be perceived as any time measurement between x and y
- The "Effecting Activity" labeled as "Background (2)" is defined as perpetuating noise from continuous wind movement across the microphone.
- Information in blue font represent "Significant Activity" and information in red font represent exceedances above the 70db limit\

were determined by identifying communities that might be impacted during the various phases of this project. The communities' were identified through field surveys and aerial photographs.

The selected areas were monitored using a digital audiometer (Quest Electronics Model 2700, Impulse Sound Level meter) with a wind screen. The instrument was calibrated using a supplied calibrator prior to being used.

A total of x locations were identified and monitored to determine baseline noise levels. The selected sites monitored are:

Location 1:

Location 2:

Location 3:

Location 4:

3.8.2 AUDIOMETRIC SURVEY

Survey results…… TO FOLLOW

3.8.3 VIBRATION ANALYSIS

The proposed impact of vibration associated with the proposed earthworks are not expected to carry into the bordering communities of Hayes and Hayes Cornpiece. Any vibration associated with the potential blasting exercises will be monitored along with the usage of the explosives to effectively minimise the possibility of adverse effects.

3.9 NATURAL HAZARD VULNERABILITY

3.9.1 NATURAL HAZARD VULNERABILITY

3.9.1.1 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 3-21. 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 part, Vere Plains, 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 7), 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.

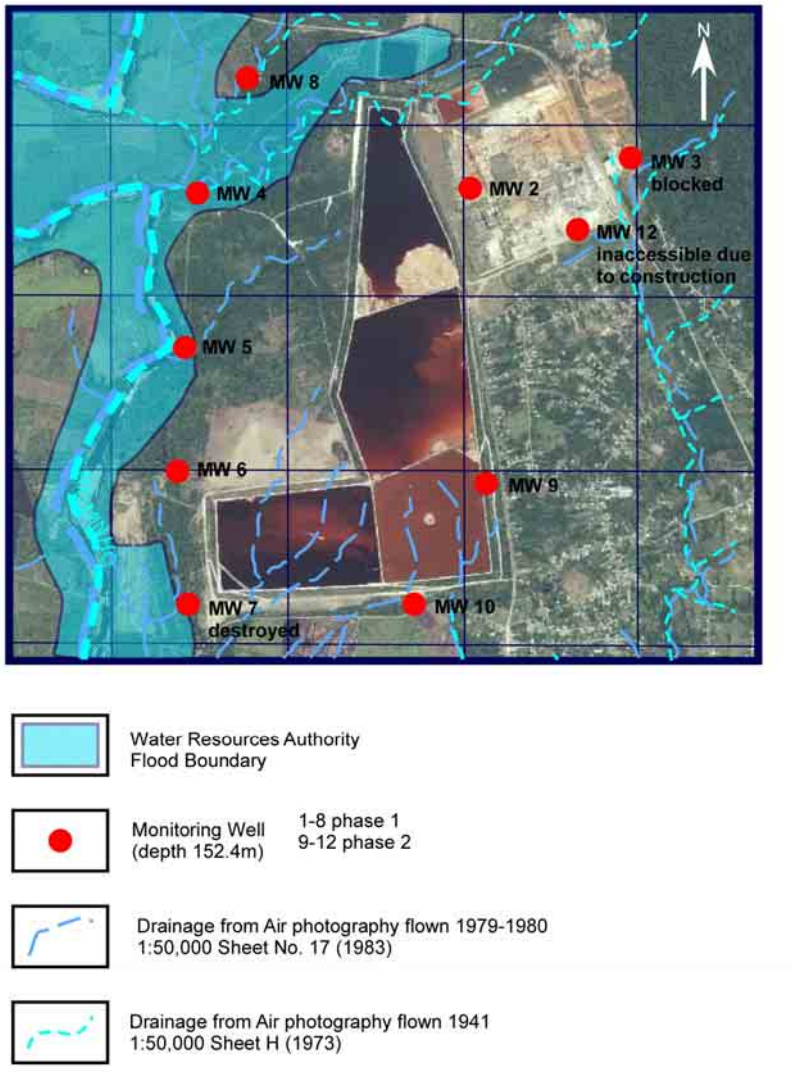


FIGURE 3-21: 1986 FLOOD BOUNDARY AND MONITORING WELLS AT THE REFINERY.

Using data from the Trout Hall rainfall station in the Upper Rio Minho Basin an analysis of the maximum 24hr rainfall depths for the 10, 25, 50, and 100yr return period floods was undertaken by the Water Resources of Jamaica (WRA) (Table 3-28). Data from the Trout Hall rainfall station was used because it is generally located in the Upper Rio Minho Watershed and it best represents the rainfall distribution over the watershed.

TABLE 3-28: 24HR RAINFALL BASED ON DATA FROM THE TROUT HALL RAINFALL STATION[3]

Storm Duration	1950 – 1986 Data (Trout Hall) (mm)			
	10yr	25yr	50yr	100yr
1min	17.9	21.7	28.5	30.4
15min	37.3	45.1	59.3	63.2
1hr	71.8	86.8	114.0	121.5
2hr	97.6	119.4	162.5	177.8
3hr	107.2	131.5	180.5	198.8
6hr	123.4	151.9	211.0	234.2
12hr	143.0	176.6	247.8	277.7
24hr	**175.0**	**217.0**	**308.0**	**347.0**

The profiles for the 10 – 100yr floods used by WRA were developed using the Steady flow analysis and one-dimensional flow methodology. Input data utilised information such as cross-sections of river channels. There are eight hydraulic structures on the Webbers Gully that could affect flow, none on the Rio Minho in the vicinity of the proposed development. Eight (8) parallel and identical circular culverts, each with a diameter of 3.96m serve as conveyance capacity at two locations on the Webbers Gully, located at the Alcoa train line and at the main road from Hayes to May Pen. The starting water surface elevations for the simulation of flood levels for Webbers Gully are presented in Table 3-29.

TABLE 3-29: STARTING WATER SURFACE ELEVATIONS AT THE WEBBERS GULLY/RIO MINHO RIVER JUNCTION[4]

Return Period (yr)	Peak Flow (m3/s)	Water Surface Elevation (m) a.m.s.l.
	Webbers Gully	Rio Minho River
10	86	33.35
25	111	34.66
50	129	35.51
100	145	36.17

Using a Hydrologic Engineering Center River Analysis Systems (HEC-RAS) modelling software developed by the US Corps of Engineers and the following scenarios, revealed:

[3] Part of Rio Minho River/Webbers Gully Floodplain Mapping Project, Prepared by Water Resources Authority, June 2005
[4] Part of Rio Minho River/Webbers Gully Floodplain Mapping Project, Prepared by Water Resources Authority, June 2005

1. Scenario 1: the culverts are free of debris and any other obstruction that may restrict flow,
2. Scenario 2: the capacity of the culverts was approximately 50% blocked by debris, and
3. Scenario 3: the capacity of the culverts was nearly 100% blocked by debris

Flood plain Maps (Figure 1-1, Figure 3-23, and Figure 3-24) show the outcome of the above scenarios.

The Alley Bridge, which is approximately 2km downstream of the proposed site, had no effect on flood levels even with the bridge opening completely blocked. The WRA found that there was no significant inundation on either side of the Webbers Gully by any flood events modelled. There was general overtopping of the left bank of the Webbers Gully in all three scenarios by the flood events along the reach extending from the train line to the main road. However, there was only significant overtopping of the right bank if the culverts are blocked. Flood duration for the 50 and 100yr events along the Webbers Gully are expected to last for approximately 3 to 4 hours when culverts are clear.

ODPLAIN MAP - CLARENDON
ne - Rio Minho River)
ne & Main Road Modeled Free of Debris)

TH T-YEAR FLOODS
Maximum 24hr Rainfall (mm)
217
269
308
347

Datum: JAD2001
Coordinate System: WGS 1984
Projection: Lambert Conformal Conic
Central Meridian: -77
Latitude of Origin: 18
Standard Parallel 1: 18
Standart Parallel 2: 18
False Easting: 750000
False Northing: 650000

Scale 1:3,500

0.05 0 0.05 0.1 0.15 Kilometers

Topographic Base Map: KOMO1 Satellite Image (2001)

LOCATION MAP

WEBBERS GULLY FLOODPLAIN MAPPING PROJECT

Prepared by: L. Barrett — Engineer/Hydrologist

Assisted by: H. Thomas — Dir. Resource Management
A. Hiduk — Water Resources Engineer
E. Douglas — Senior Assistant Hydrologist
H. Roper — Assistant Hydrologist

CLIENT: ALCOA MINERALS JAMAICA, INC. (JAMALCO)
KIER/CCC

PART OF WEBBERS GULLY AND RIO MINHO RIVER FLOODPLAIN MAPPING

Water Resources Authority
Hope Gardens
P.O. Box 91
Kingston 7
Jamaica

Date: June 2005

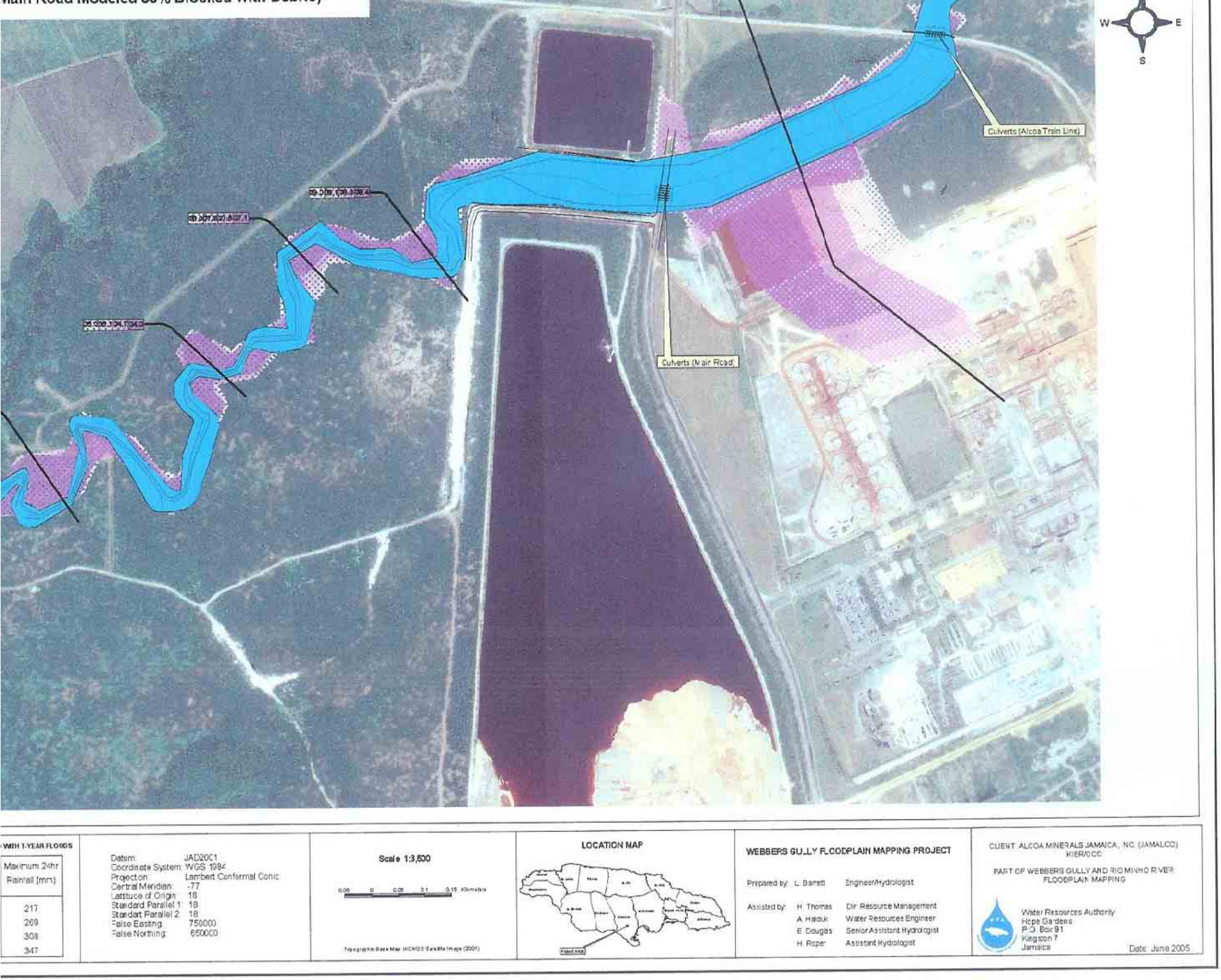


FIGURE 3-23: OUTCOME OF SCENARIO 2

AR FLOODS

n 24hr	
(mm)	

Datum: JAD2001
Coordinate System: WGS 1984
Projection: Lambert Conformal Conic
Central Meridian: -77
Lattitude of Origin: 18
Standard Parallel 1: 18
Standard Parallel 2: 18
False Easting: 750000
False Northing: 650000

Scale 1:3,600

0.05 0 0.05 0.1 0.15 Kilometers

Topographic Base Map: IKONOS Satellite Image (2001)

LOCATION MAP

WEBBERS GULLY FLOODPLAIN MAPPING PROJECT

Prepared by: L. Barrett — Engineer/Hydrologist

Assisted by: H. Thomas — Dir. Resource Management
A. Haduk — Water Resources Engineer
E. Douglas — Senior Assistant Hydrologist
H. Roper — Assistant Hydrologist

CLENT: ALCOA MINERALS JAMAICA, INC. (JAMALCO)
KIER/CCC

PART OF WEBBERS GULLY AND RIO MINHO RIVER FLOODPLAIN MAPPING

Water Resources Authority
Hope Gardens
P.O. Box 91
Kingston 7
Jamaica

Date: June 2005

3.9.1.2 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 3-25) 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.

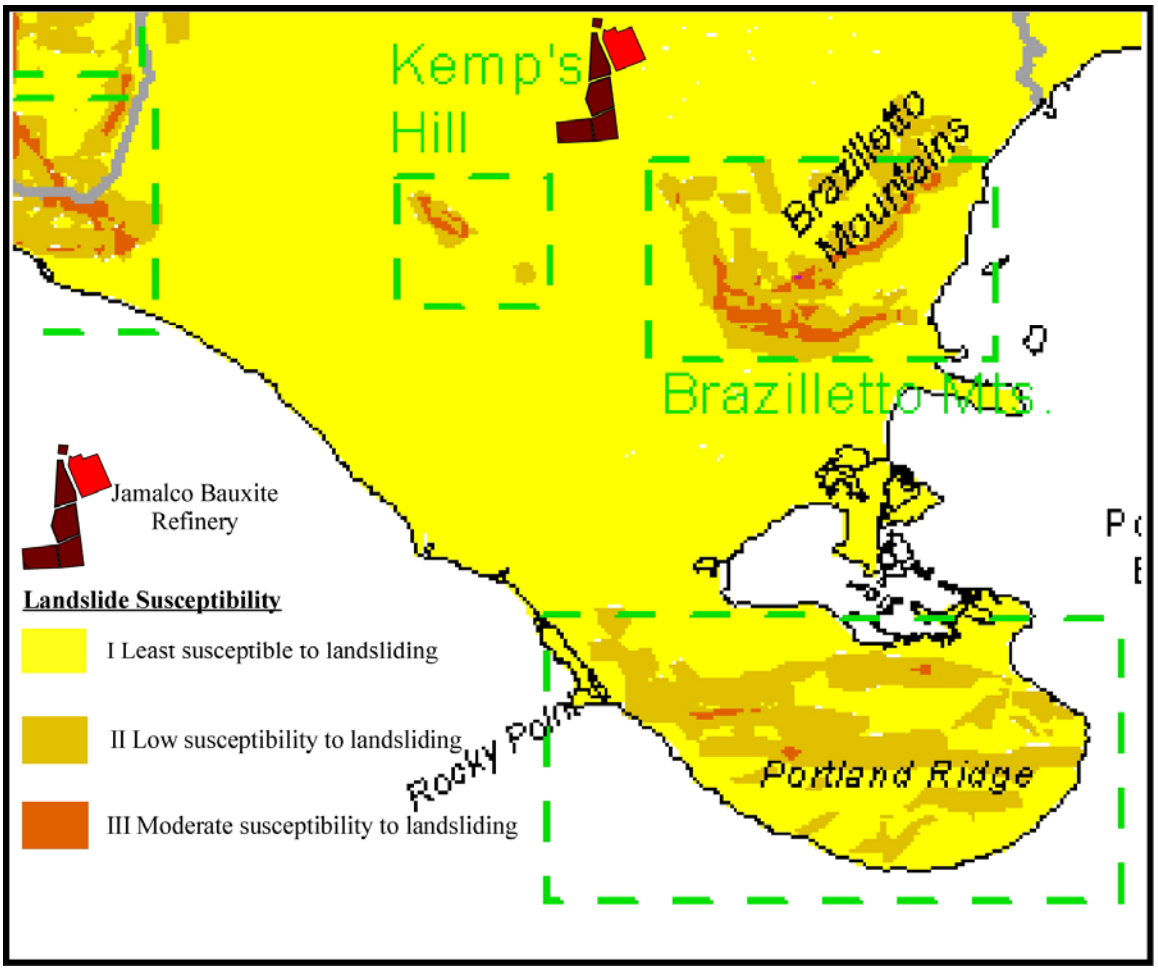


FIGURE 3-25: LANDSLIDE SUSCEPTIBILITY MAP OF SOUTHERN CLARENDON (SOURCE: SOUTH COAST DEVELOPMENT PROJECT.)

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 appear to be successful where the grass has caught. On the east-facing slopes the grass cover is well-developed (Figure 3-26), but on other slopes the cover is still incomplete.

FIGURE 3-26: GRASS COVERING SLOPE OF DYKE OF RESIDUE DISPOSAL AREA.

3.9.1.3 TECTONICS AND FAULTING

3.9.1.3.1 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 3-27). 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.

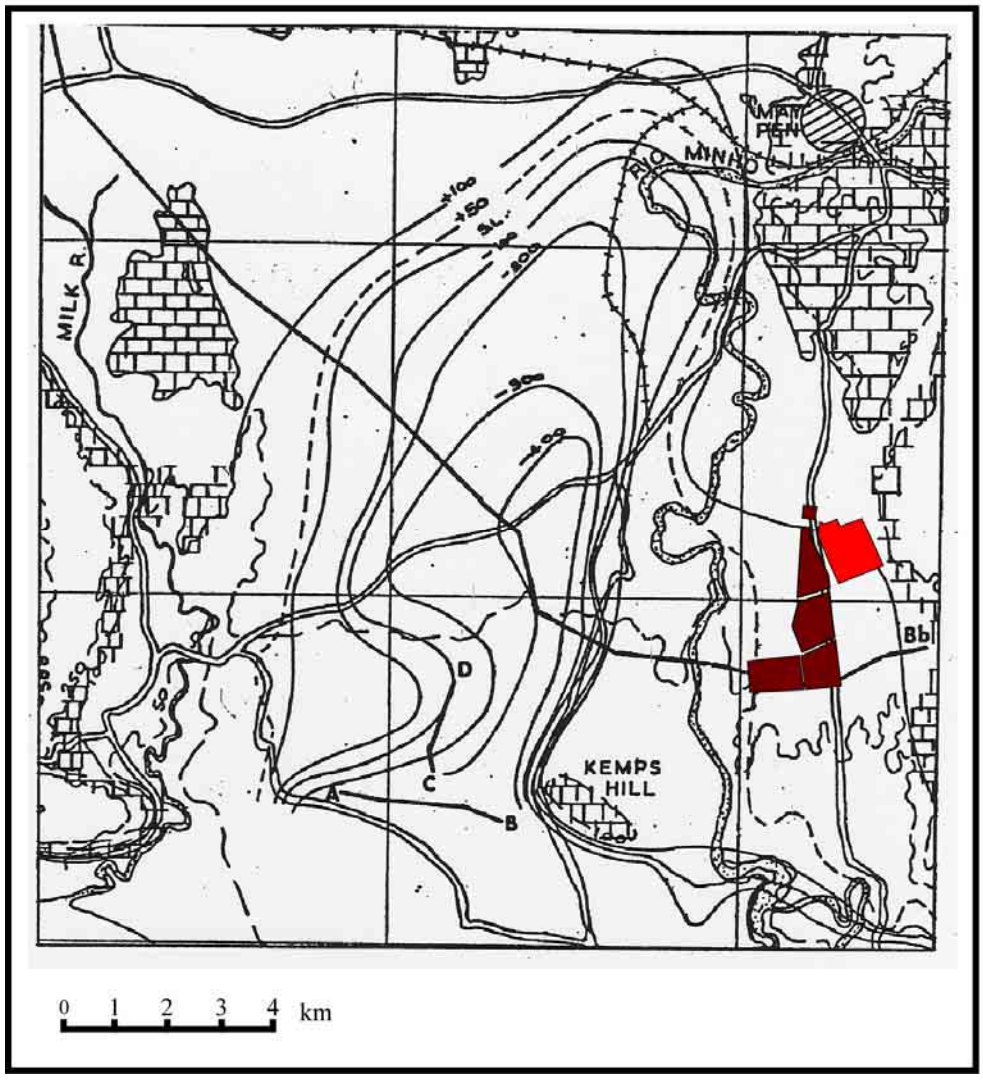


FIGURE 3-27: CONTOUR MAP SHOWING LIMESTONE ELEVATIONS UNDER PLAIN (ELEVATIONS IN FEET ABOVE SEA LEVEL). (SOURCE: CHARLESWORTH, 1980).

3.9.1.3.2 LOCATION OF FAULTS

The distribution of faults on Figure 2 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 3-27) 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 3-27; 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. 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).

3.9.1.4 SEISMIC ACTIVITY

3.9.1.4.1 LOCAL

Figure 3-28 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.

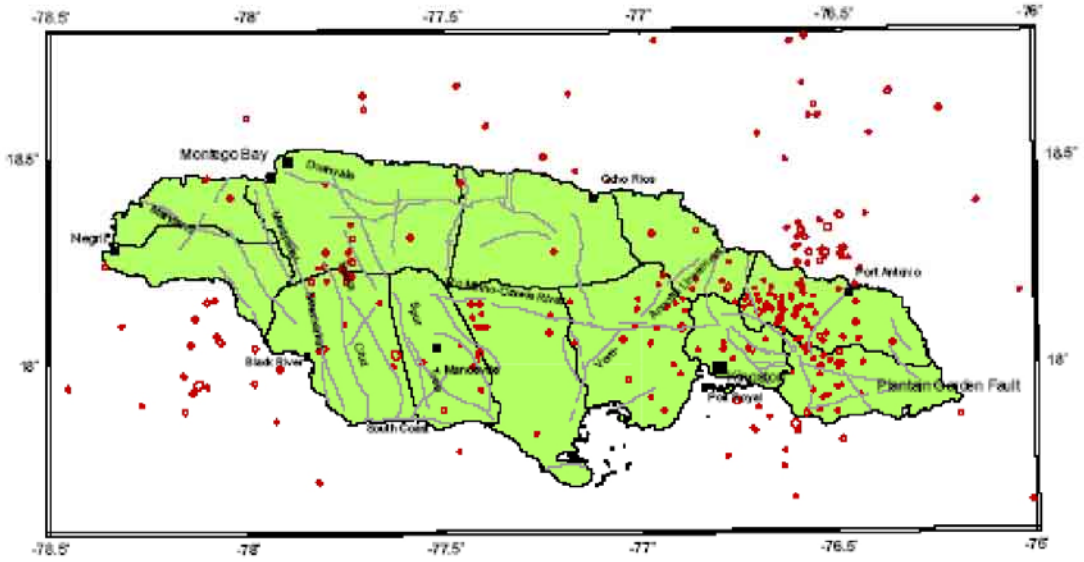


FIGURE 3-28: EPICENTRES OF EARTHQUAKES OCCURRING BETWEEN 1998 AND 2001 LOCATED IN AND AROUND JAMAICA. (SOURCE: THE EARTHQUAKE UNIT).

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 (Appendix D) 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.

3.9.1.5 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.