

ENVIRONMENTAL IMPACT ASSESSMENT

For the Proposed Cemetery Development, at Burnt Ground, Hanover



Final Report



**Prepared for the National Environment
and Planning Agency**

June 2007



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**FINAL ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED CEMETERY DEVELOPMENT, BURNT
GROUND HANOVER, JAMAICA**

June 2007

Prepared by Environmental Management Consultants (Caribbean) Ltd. on contract to the National Environment and Planning Agency.

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EXECUTIVE SUMMARY

This Draft Environmental Impact Assessment is submitted in accordance with the Terms of Reference for the EIA (Appendix 1), which forms Annex 1 of the Contract for the services of the consultant to conduct an Environmental Impact Assessment (EIA) for the development of the cemetery at Burnt Ground, Hanover. It contains the substantive technical findings of the EIA preparation team as given in Appendix 2, and is submitted for stakeholder review and comment. In an effort to create increased cemetery capacity for urban dwellers within ~20 km of Montego Bay, Delapenha's Funeral Home sought to acquire and develop two parcels of land in the Burnt Ground area, at the corner between the road to Copse and the main road between Anchovy and Ramble. This site is located in the community of Burnt Ground, which is 11 km from the sea (at an average elevation of ~190 m above sea level). The proposed burial area is located 2 km southwest of the Shettlewood Spring. The closest point on Great River from the proposed cemetery site is located ~2.6 km west of the site.

Key environmental findings:

1. The ponds on property showed lower concentrations than the spring or Great River in respect of calcium, chloride, magnesium, sodium, and strontium. **This information confirms that the ponds can be used to monitor whether there is any leachate from the graves entering the pond, as cemetery plumes can be traced based on the presence of a salinity plume.**
2. There are at least five other cemeteries and family plots in similar or closer proximity to the Shettlewood Spring. Additionally, there is a pig farm, ponds, and orange orchard (using pesticides and fertilizers) within the general area. Sewage disposal in the area is mainly by soak-away.
3. The site is situated on terrain classified as undulating limestone terrain, and not characterized by pronounced sink-holes. Karstic terrain occurs in proximity to the site, but sink-holes appear to be generally blocked by clay overburdens.
4. Surface runoff is retained on the site by the nature of the low points except in the most severe climatic events where the southern (front) pond may overtop to neighbouring lands, and, a small area in the NW corner may allow drainage off-site, via the over-topping of the small divide here.
5. According to published geological maps the site is underlain by thick alluvium which may be overlying White Limestone (Bonny Gate Formation) dipping in this area at 12 degrees to the north-west. However, other data suggest that the site might be underlain by less pure limestones.
6. The site is affected by seismic activity which tends to be of magnitudes up to 4.2, which are not expected to yield intensities that would result in structural damage.
7. The soil on site is classified as the Chudleigh Clay Loam. This is moderately to rapidly draining acidic soil. This study concluded that: *"A very thick regolith layer comprising yellow-brown and red-yellow-brown cobbly, pebbly silty clays, loams and clayey silts and clays is present over the whole site, and overlies a weathered limestone of unknown petrology and weathering state, but is likely to contain cherty gravel (cobbles and pebbles). The soil layer is at least 8 m thick in the topographically high areas and of the order of 12 – 13 m thick in lower parts"*.
8. XRD investigation of the soil discovered the presence of minerals that are not expected to be typical weathering products of the White Limestone, which is reportedly more than 90% calcium carbonate, and in the case of the Bonny Gate Formation, may contain chert (silica). In addition, there was a notable absence of carbonate minerals. The minerals identified in the soils include quartz, nacrite, dickite, kaolinite and some illite, with other minor clays including some unexpected ones of a metamorphic origin (clinochlore), which may be more indicative of weathering of impure limestones.
9. The site is located in the catchment of the Great River. The Great River is a major water resource, with water from the Shettlewood spring is abstracted by the NWC and piped to several communities including Chester Castle, Ramble, Knockalva, Copse, Pearces Village, Shettlewood, Friendship, Lethe, Eden, Burnt Ground and Mount Peto. Shettlewood Spring System which is scheduled to undergo some improvements. The spring has the capacity to produce ~ 0.7 MGD and serves ~ 1,024 customers.
10. The main recharge area of the Shettlewood Spring is thought to be the Lilliput sub-basin, which is not connected to the BGS sub-basin by surface flows.

11. The proposed burial site was not flooded during the 150-year June 1979 storm event, supporting the conclusion of WRA that the site itself is not flood prone.
12. It was concluded that: *“the percolation patterns exhibit no unusual or unpredictable behaviour given the nature of the site’s colluvial soils; and all indicate a relatively uniform rate over the longer term within a narrow range”*.
13. The aquifer may be primarily recharged through discrete areas (perhaps outcrops) or pathways (perhaps dolines), and that much of the aquifer does not receive diffuse, regionally infiltrated rainwater. The presence of the thick colluvial soils generally in the district seems to support the idea that there is no widespread infiltration effect, and it is possible that this acts as a confining layer for the aquifer – thus causing elevated pressures. Accordingly, the cemetery site development is expected to have no impact in this matter.
14. There is no obvious direct connection of the site to the Shettlewood Spring, and no evidence to suggest that the groundwater gradient is towards the northeast. Surface flows in the area move to toward the south-east, and then westwards to the Great River. However, based on the limited available information (site elevation of 205 m, elevation of the spring at 150 m, regional water table at the site of ~25 m, and the distance of the spring of 2.1 km) it is speculated that the maximum regional water table (if it were to exist in this manner) has a hydraulic gradient of 0.0143.
15. The site itself shows no evidence of extensive underground conduit flows, and is affected by the presence of thick regolith. Adjacent limestone hills (road to Copse) show a dense unweathered limestone. Based on assumptions about the hydraulic conductivity at the site, and Darcian flow, it was calculated (Appendix 5) that the minimum travel time for the distance between the site and spring would be of the order of 140 years.
16. The pathway of any infiltrated water molecule at the site to the spring would be extremely tortuous and long. It will be longer than the 141 years above because it must move through the deep soils to the watertable. The dilution which would occur when factoring in concomitant infiltration and percolation over the 2100 m distance would be extremely large so as to render the likelihood of tracing such a molecule pathway nonsensical.
17. When asked whether they would accept the conclusions of the EIA if they were contrary to their present opinion, 64% (96 persons) of the 150 respondents indicated they would not. This is an important statistic because it indicates how open people are to finding out the results of the impartial scientific evaluation.

Predicted Impacts

Six direct environmental impacts are predicted to occur during the operational phase of the project. Five are considered negative impacts ranging, most of which are relatively small. The low level of community acceptability makes the effect level of land use change a relatively important negative impact that needs to be addressed. However, it must be kept in mind that this is private property, and the proposed development is predicted to function well within the national and international environmental laws, policies and criteria regulating such developments. The main positive environmental effect associated is also relatively important, and needs to be carefully evaluated in the decision-making process, as it has far reaching effects on the availability of burial spaces for residents of Montego Bay.

Impact	Type	Impact Level
1. Increased suspended solids in run-off	Negative	Negligible
2. Vermin or pest infestations	Negative	Minor
3. Increased traffic	Negative	Moderate
4. Soil, groundwater and spring contamination	Negative	Moderate
5. Land use change	Negative	Moderate
6. Additional burial capacity for urban dwellers.	Positive	Moderate

It is the finding of this study that the development proposal to locate a cemetery at Burnt Ground, Hanover is unlikely to produce any significant negative environmental impact, where such impact is defined as one that:

- Is located in proximity to any sensitive or protected areas and has been determined to impact negatively on these.
- Is extensive over space or time (scales must be appropriately defined)
- Is intensive in concentration (i.e. exceeding recommended criteria) or in relation to assimilative capacity (as appropriated to the affected receptor).
- Is not consistent with national plans for the general use of the area.
- Contributes to the endangerment of threatened species.
- Reduces the stocks of commercially important species.
- Permanently damages habitat quality or creates ecological barriers.
- Threatens cultural or heritage resources.
- Alters community lifestyles or requires long-term adjustments of local people in respect of traditional values and resource use.
- Represents a long-term nuisance or significant safety/public health risk to other users.

Based on the impacts identified above, the following mitigation measures are prescribed:

- Excavated or temporarily stockpiled soils must be properly managed to control mobilization by surface run-off or air. This should be done immediately upon excavation. If stockpiles are to be temporarily stored overnight, they should be covered and bunded
- Bare areas should be revegetated as soon as possible.
- Any food stored on property must be secured against pest infestation.
- In the event of major community objection to the project a programme of conflict resolution should be undertaken within 1 month of the permitting authority's final decision in respect of the application.
- Funerals should be scheduled for off-peak hours as far as possible.

Recommendations

- Approximately 2.9 ha are deemed suitable for interment, with spatial allotments of 2.88 m² per grave.
- A perimeter buffer zone should be imposed as suggested in Appendix 5.
- Cremated remains can be disposed of by scattering or shall burial provided that they are at least 2 m from any boundary and there is no potential for them to be transported offsite. Small drainage works, bunds, drains may be necessary.
- An impermeable earthen berm (>1 m high) should be constructed along the western boundary to prevent run-offs from the adjacent site (pig farm) entering the site. This will also reduce visibility of the burial area from western approaches.
- The cutting on the northern boundary should be remediated.
- Partially constructed vaults should be completed.
- The highest land on the site (near north-eastern boundary) is presently slated for burial. A retaining wall backfilled with free-draining adsorptive materials as recommended in Appendix 5 should be implemented.
- Graves should be properly managed to ensure that any settlement of the back-filled grave soils be continually topped-up and where possible the land should be re-shaped to shed surface runoff.
- Although it is recognized that use of concrete vaults may be cultural issue in Jamaica, it is not the optimal containment for interment. Given the nature of the soils and the climate, direct earth-contact interments are recommended. Filling the base with gravel and charcoal may be considered.

- A minimum compacted soil layer of 0.3 m (about 1 ft) should be made to fully cover between each interment. Minimum invert level for various numbers of interments should be: for one – 1.5 m (about 5 ft); for two – 2.3 m (about 7.5 ft) and for three – 3 m (about 10 ft).
- The figure below shows the area recommended for burial in yellow. It may be assumed that all other areas are to be excluded from burials. Based on the assessment of site conditions it is shown that the interment area can actually be expanded from the previous extent to the upper part of the proposed parking area on the western side of Lot 48 (north is vertical). Upon consideration of the whole estate which includes Lot 47, a section of Lot 47 was also found to be suitable for burial. These are shown in the figure below. The black dashed line represents the buffer zone, which is considerably relaxed on the northern and eastern side.



Environmental performance objectives for the cemetery should include:

1. Improvement of community relations.
2. Sound management of interment sites.
3. Control of buffer zones and perimeter integrity (fencing and access point security).
4. Maintenance of a visually pleasing aesthetic through effective solid waste containment and disposal, and continuous landscaping efforts. In this regard indigenous ornamental and shade trees should be used along with grass. Consideration should be given to earthen grave finishes with headstones or commemorative tree rather than concrete slabs as is commonly practiced.
5. Management of surface flows on site.
6. Sanitary handling and storage of food and beverages intended for human consumption.
7. Maintenance of a permanent record of the location of each grave site. Locations should be determined by GPS or triangulation survey.

PREAMBLE

This Final Environmental Impact Assessment is submitted in accordance with the Terms of Reference for the EIA (Appendix 1), which forms Annex 1 of the Contract for the services of the consultant to conduct an Environmental Impact Assessment (EIA) for the development of the cemetery at Burnt Ground, Hanover. It contains the substantive technical findings of the EIA preparation team as given in Appendix 2. This document has been revised further to stakeholder review and comment.

1 DESCRIPTION OF THE PROJECT

The aim of this section of the EIA is to provide comprehensive information about the proposed development, which can be used to assist in the assessment of the potential environmental impacts of the project.

1.1 PROJECT OVERVIEW

1.1.1 Justification

In Jamaica, burial capacity in cemeteries is required in areas where people do not have access to ancestral lands for traditional family burial plots. This is the case in the highly built up urban areas, such as Montego Bay. According to the Chief Executive Officer (CEO) of Delapenha's Funeral Home Ltd. (DFH), Mr. Dale Delapenha, cemetery capacity in the Greater Montego Bay area is becoming increasingly unavailable to DFH as the capacity in the existing cemeteries operated by the St. James Parish Council is very limited, and plans for increasing this capacity are delayed.

In addition, it is reported that the operator of the privately owned cemetery does not allow other funeral homes to use their facilities (Personal Communication, January 2007, Dale Delapenha). Consequently, more than 75% of all DFH business has been restricted to family plot burials outside of the urban area, despite the demand for cemetery burials in Montego Bay urban area.

In an effort to create increased cemetery capacity for urban dwellers within ~20 km of Montego Bay, DFH sought to acquire and develop two parcels of land in the Burnt Ground area, at the corner between the road to Copse and the main road between Anchovy and Ramble (Figure 1). Lot 48 comprises 3.3 ha. The front lot (Lot 47) comprises 3.4 ha, and contains a large pond.

1.1.2 Site Location

This site is located in the community of Burnt Ground, which ~ 13 km from Montego Bay (Figure 1), approximately 11 km from the sea (at an average elevation of ~190 m above sea level). The proposed burial area is located 2 km southwest of the Shettlewood Spring. The closest point on Great River from the proposed cemetery site is located ~2.6 km west of the site. Nearby communities include Burnt Ground, Shettlewood, Chester Castle, Ramble, Saddler's Hall and Haughton Grove.

1.1.3 Project Background

Delapenha's Funeral Home Ltd. (DFH) applied for an environmental permit to develop a cemetery at the Burnt Ground in October 5th 2004. The application involved development of the back one (Lot 48) for the purposes of burial. Aside from internal review at the National Environment and Planning Agency, the application was reviewed by various government advisory agencies, including the Water Resources Authority (WRA), the Environmental Health Unit (EHU) of the Ministry of Health, the National Land Agency, the Local Planning Authority and the National Works Agency. There was a consensus amongst these agencies that any environmental impacts could be effectively mitigated, an environmental permit was issued to the applicant on February 15th 2005 for a maximum capacity of 1215 vaults.

Further to the formal objections raised by the Ramble Community Development Committee (CDC) in July 2005, and instruction of the Honourable Minister of Land and Environment, Dean Peart, the permit was reviewed in November 2005. The WRA conducted a site visit on December 13th 2005 and submitted a Technical Note (January 9th 2006), which concluded: *"Based on site investigations and other in house data that were examined the proposed cemetery does not appear to be a threat to the water resources of the Burnt Ground area and the Shettlewood Spring in Hanover. It is important to note that the clay layer is very thick and its drainage capacity is slow which reduces the rate of infiltration in the subsurface and lessens the risk of contamination of the underlying aquifer."*

In March 2006 the Ramble CDC commissioned five boreholes to be drilled around the site (including one borehole immediately opposite), from which the depth to groundwater in this area was estimated to be ~ 14 m below ground level. This was in contrast to the WRA's estimate of 96 m, which was based on drilling in the Bonnygate bedrock done at Knockalva in 1971. WRA records for this well indicated that the well was abandoned after the water table had fallen even lower and the well was dry. However, WRA's findings in respect of the thickness of the soil (estimated to be 14 m thick on the site), which was one of WRA's main considerations in respect of the potential for groundwater contamination, were generally consistent with the findings of the CDC's March drilling exercises (12 m at Shettlewood Baptist Church and 9 m across the road from the cemetery).

Figure 1 Location of the Site



Based on a letter dated May 8th 2006 from the legal advisors of the Ramble CDC, it was suggested that an Environmental Impact Assessment (EIA) be done to fully investigate:

- a. *The dangers of leakage of contaminants from the vaults into the ground*
- b. *The probabilities that any contaminant which leaked would flow into the public water supply*
- c. *The toxic effects of formaldehyde and other embalming fluids upon the health of those who drink contaminated water*
- d. *All relevant environmental and safety considerations.*

On June 13th 2006, further to the May 8th communication on behalf of the Ramble CDC, the Honourable Dean Peart directed the applicant to cease any further development until the EIA was completed. The NRCA further issued a stop order on July 18th 2006, “*until a full Environmental Impact Assessment has been conducted and thereafter submitted for review by the Authority*”. A draft Terms of Reference (TOR) for the EIA was circulated amongst the government agencies in July 2006 and the Ramble CDC. The EIA consultant was contracted on January 2nd 2007.

1.2 SITE PLAN

Figure 2 shows the proposed site plan as permitted by NRCA, superimposed on the Google satellite image. The northern perimeter of the site is marked by a treed fence line, marking the old property boundary. The entire eastern boundary is marked by the fence on to a parochial road leading to the village of Copse. The western boundary is a fence shared with the adjacent pig farm and the southern boundary is marked by the main road between Ramble and Shettlewood, which is also a major thoroughfare for traffic travelling between Reading (Montego Bay) and the Ferris Cross.

1.3 DESIGN AND PLANNING SPECIFICATIONS

1.3.1 Criteria for Siting and Permitting the Cemetery at the Burnt Ground Location

The following criteria were taken into consideration by the developer in selecting the Burnt Ground site as a cemetery:

- The site is located within 30 minutes of Montego Bay, and would be an economic and logistically feasible alternative for urban interments.
- There is suitable acreage of gently sloping lands available at a reasonable cost.
- This site has soil that can be easily excavated with a back hoe to the required depth of 2 m.
- This soil is also quite stable in vertical section.

Figure 2 Site Plan

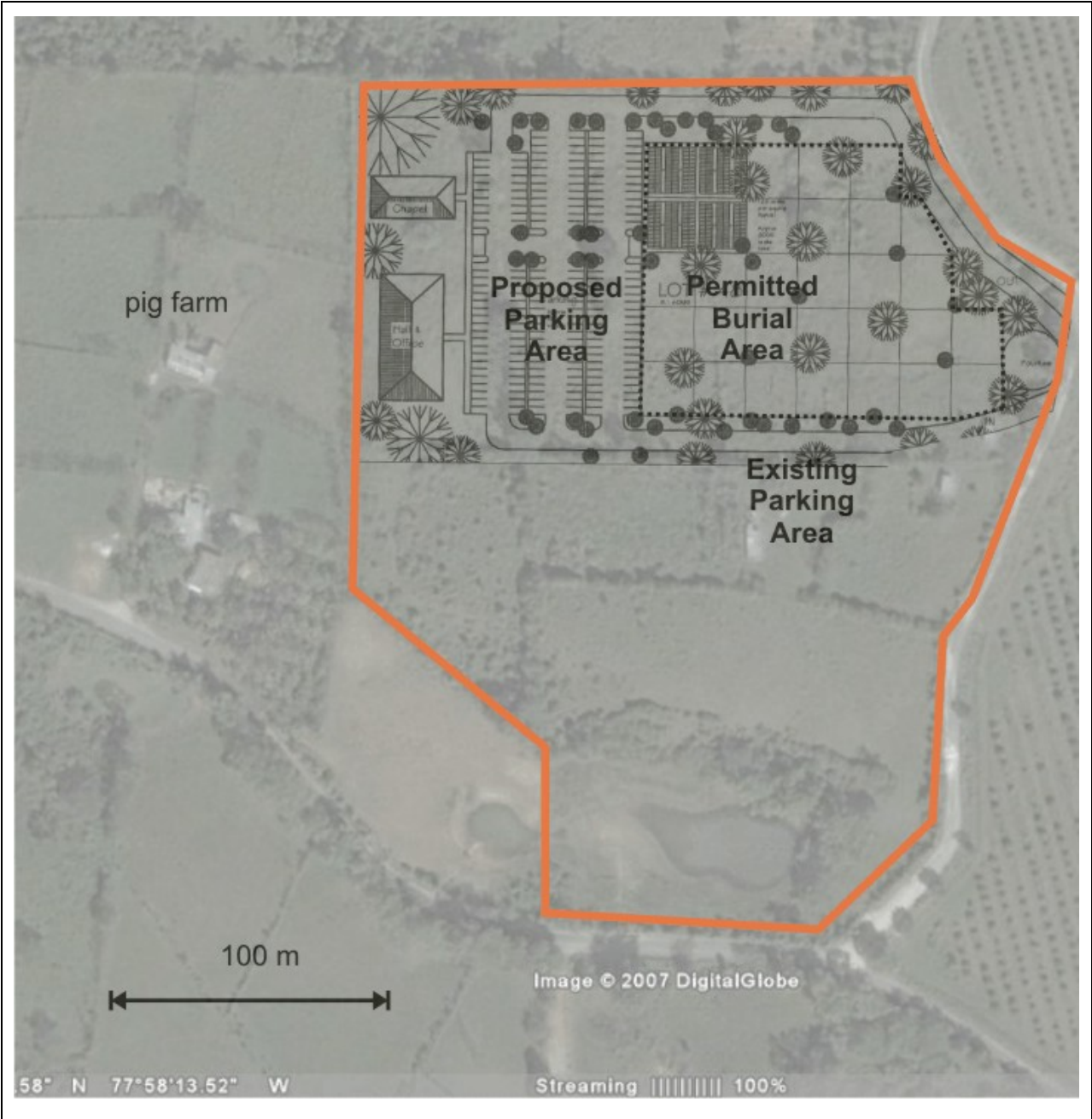


Diagram is oriented grid north.

Based on the WRA Technical Report, the following additional siting criteria were taken into consideration in making the decision to grant the permit:

- The soil was believed to be more than 9 m to bedrock based on WRA site investigations.
- The soil was thought to be clayey loam (Chudleigh Clay Loam) which was expected to have a suitable permeability. Further to this, the permit stipulated that leachate from graves would be further restricted by the inclusion of a 4" concrete layer at the base of the vaults.
- The groundwater table is thought to be >12 m below ground surface at the site.
- The water table at the Shettlewood Spring (~144 m above sea level) is thought to be higher than it was reported to be at Knockalva (~131 m above sea level); therefore it would be unlikely for flow to be from this area toward the spring. Streams in the area are not supported by baseflow, and therefore only flow during high rainfall periods.
- The site was believed not to be flood prone as it was not flooded in the 100-year event which produced flooding on the roads and at Haughton Grove in June 1979. The permit required sealing of the vaults at the top with concrete and covering with 0.5 m soil to prevent flooding of graves from surface flows. In addition, the area slated for burial grounds are located more than 30 m away from drainage features.
- This site is located more than 2000 m away from the Shettlewood Spring. This was considered to be a safe distance as the WHO recommends 250 m. Other research indicates that even in areas perceived to have high permeabilities; a safe distance can be ~415 m (Zhang, 2004).

1.3.2 Vaults

The permit issued by the NRCA allows a maximum of 1215 vaults to be constructed on Lot 47.

According to the permit, vault construction specifications included:

- Vault types: (a) single vaults: 0.8 m x 2.3 m x 1 m deep (b) double: 0.8 m x 2.3 m x 2 m deep (c) child's vault 0.8 m x 1.3 m x 1 m deep.
- Base of the vault to be completely sealed with a minimum of 4 inches of concrete.
- Strip footing foundation below the wall system reinforced with 5/8" steel rebars and covered with 6 prefabricated tiles (16" by 35" by 2/12" thick) and at least 24" of top soil and landscaping.

1.3.3 Project Footprint

1.3.3.1 Development Site

Table 1 below indicates the spatial allotments for various design elements of the project. Approximately 21% of the land area will be built up (impervious surface) as buildings, roads, parking area (including a 1 m buffer around the perimeter). Another 19% is proposed for use as the burial area, and the remainder (including the pond, earth drainage areas, tilefield) will be landscaped, accounting for 60% of the site left un-built.

Table 1 Design Footprint of the Proposed Development

Design Element	Footprint (m ²)	Status
Chapel (non-denominational)	228	Not built
Banquet hall, office and commissary	1,000	Not built
*SW Structure (see Figure 4b)	112	Constructed
**Parking lot and 800 m ² paved entrance area	3,800	Constructed
Perimeter (assuming 1 m buffer)	1,050	Constructed
Burial area	12,400	Incomplete
Landscaped area (including drainage and tile fields)	40,410	Incomplete
**Access road	4,000	Incomplete
TOTAL AREA	67,000	

*This has been erected in the south-western corner of the property to house sealed urns containing ash within the concrete vaults in the wall. It is roofed and has a concrete back wall. There are some temporary sheds erected in the vicinity of the parking lot.

**These numbers pertain to the “*as built*” scenario, and not the plan. There is a divergence from the plan in terms of the locations of the parking lot, paved entrance area and access road as they have actually been constructed. The original site plan proposed an area immediately west of the burial area for the main parking lot, and provided site access off the Copse minor road on the eastern boundary of the site. However, the developer later acquired the southern lot (Lot 47) and opted to construct the parking lot on the top of the small hill, and have the main entrance off the site from the main road between Anchovy and Ramble.

1.3.3.2 Offsite Linkages

The main linkages between the development and the wider environment include:

- There is approximately 1 km of perimeter fencing around the site with two main access points (a minor one on Copse road, and the major entrance to the facility on the Main Road). The main entrance has a guard facility. These two entrances are kept locked.

- Drainage: There is a site access road running along the boundary between Lot 47 and Lot 48 in an east-west direction. A drain is located on the north side of this road, to which all surface flows from Lot 48 are directed. This drain and all drainage from the site ultimately feed into the pond in Lot 47. This shallow pond is clay-lined, and does not drain freely. A culvert (spill way) designed to take overflow from the pond under the main road, and direct it along the main road towards the Great River (Figure 3c) has been constructed. Aside from this spillway, three other drain connections lead *into* the main pond from outside via the following culverts:
 - Culvert from the pond on the adjacent property (to the west) to the pond.
 - Culvert draining the surface of the main road to the pond (Figure 3a)
 - Culvert from Copse Road draining to pond (Figure 3b)
- Groundwater linkages are the subject of review in this EIA.
- There are free linkages to the outside environment in respect of airflows, and off-site dispersal of emissions generated on site. As there is no incinerator planned for the site, emissions are restricted mainly to fugitive dust and vehicular emissions.
- Socio-economic linkages: The head office and funeral parlour for the cemetery is based on Union Street, Montego Bay so there will be link with this area. Based on discussions with the director and the socio-economic survey, it is not anticipated that there will be a large proportion of patronage of the cemetery from the Hanover area. Consequently, it is expected that there will be increased vehicular traffic associated with burial processions coming from the Montego Bay area.
- In terms of visual linkages the burial area cannot be seen from the main road on an eastern approach (Figure 4a), because of the hill separating the entrance/pond area from the burial area. The parking lot is located on the topographic high, which is ~25 m above road level. On approach from the west, it is possible to see the burial area.

Figure 3 Drainage at the site



a/ Drain from main road to the site



b/ Drain from Copse road to the site



c/ Drain under main road.

Figure 4 Structure on the South-Western Corner of the Property



1.4 IMPACT-CAUSING ASPECTS

Table 2 examines primarily completion and operational (routine and accidental) aspects of the project as much of the land clearance, and construction (including sewage treatment plant) have been completed. No embalming, cremation, or open disposal of ash remains is proposed to be done at the site. Sealed urns containing ash will be sealed prior to transportation to the Burnt Ground site, where they will be stored in sealed concrete cells in a purpose-built covered structure.

Table 2 Impact Causing Aspects of the Proposed Development

Activities	Resource Demands	Waste Streams or Public Nuisances
Excavation of vaults	Backhoe	Soil and excavated material; this will be re-used to cover the vaults.
Completion of vaults & Construction of facilities	Land resource: 40% of the site to be developed of which 12% will be impervious. Concrete (cement, sand, steel, blocks) Labourers	Fugitive dust. Construction noise. Domestic wastes from workers.
Completion of drainage works		
Operations: Landscaping and maintenance. *the pond was deepened and naturally clay lined.	Water for irrigation. Plant material: indigenous trees, ornamentals etc. Fertilizer Grounds maintenance staff. Gate & Security staff.	Minor brush cuttings or vegetation debris.
Operations: Funeral Services & Facilities	Requirements of social functions (caters). Potable water supply (from NWC mains). Electricity (from JPSCo) estimated to be 1500 kwh per month.	Traffic along main road: this will vary with funeral. Minor emissions from vehicles. Negligible noise emissions during services and functions. Negligible solid waste from social functions.
Operations: Burials Opening of vaults and finishing of graves. Operations: Vaults (post-burial processes)	Soil to re-cover vaults. Whitewash Headstones. Use of concrete or earthen grave finishes. Subsidiary inputs for partial embalming process: product called Power 36, which contains 36% formaldehyde, lanolin, methyl alcohol and colouring.	The following wastes are expected to be generated per body (varies with age, size, state of decomposition at burial). <u>Effluents</u> Micro-organisms (variable with health) – 90% of the bacteria from a human corpse are anaerobes (WHO). More rapid die-off rates with acid soils and high temperatures. Decomposition fluids, expected to contain: <ul style="list-style-type: none"> ▪ 70-74% Water by weight ▪ Embalming fluids (variable)

Activities	Resource Demands	Waste Streams or Public Nuisances
<p>Operations: storage of urns containing ashes in sealed concrete cells in a covered concrete building. Operations: Sewage Treatment: septic tank and tile field (Capacity of 1.5 days flow)</p>	<p>Concrete (cement, aggregate, water). Urns. Space for storage within the building.</p>	<ul style="list-style-type: none"> ▪ Chemical elements (WHO 1998 estimate for a 70 kg man¹: 16 kg carbon, 1.8 nitrogen, 1.1 kg calcium, 0.5 kg phosphorus, 140 g potassium, 100 g sodium. 95 g chlorine, 19 g magnesium, 4.2 g iron. <p>These effluents leach into the soil or are contained in the vault, and may create salinity plume around the specific grave.</p> <p><u>Solid waste (mainly burial materials):</u></p> <ul style="list-style-type: none"> ▪ Wood, metal or plastic from coffin ▪ Paint chips from coffin ▪ Fabrics ▪ Organic sludge or wax
<p>Upset conditions: Heavy Rainfall Events</p>		<p>Increased surface flows to pond area from site, adjacent pond and road. This is expected to run-off across the road via culvert once pond has reached the level of 50 cm below road level (location of culvert). Run-off not expected to contain suspended solids as these would be retained in the pond.</p>
<p>Upset conditions: Earthquake Events</p>		<p>Potential for cracks in the structures: (1) Increased leakage from vaults (2) Cracks in the cells containing the sealed urns.</p>

¹ According to Ucisik. and Rushbrook, 1998, the composition of females varies between two thirds and three quarter that for males.

2 REGULATORY FRAMEWORK

The objective of this task is to provide an outline of the applicable policy and legislative requirements for the proposed development within the context of the local and national regulatory and institutional framework. Development activities must proceed in compliance with the governing legislations and policies on environmental conservation, safety and health, physical planning criteria, and building codes.

2.1 DEVELOPMENT CONTROL

2.1.1 Cemeteries

2.1.1.1 *Jamaican Legislation, Regulations and Policy*

The environmental Permit and License System (P&L), introduced in 1997, is a regulatory mechanism to ensure that all developments in Jamaica meet required standards in order to attenuate negative environmental impacts. The P&L System is administered by the **Natural Resources Conservation Authority (NRCA)**, through the Permit and License Secretariat. The NRCA was created and established under the Natural Resources Conservation Act (1991). This Act is the overriding legislation governing environmental management and sustainable development through the protection and responsible management of Jamaica's natural resources and the control of pollution. The NRCA Act and the Natural Resources Conservation (Permits and Licences) Regulations established a system of permits for certain prescribed activities as mandated by the Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order, 1996. The Order provides that the entire island of Jamaica is a prescribed area and lists specified categories of enterprise, construction and development that require a permit. Cemeteries and crematoriums require permits under this Order. The operation of a sewage treatment plant also requires a NRCA license.

The **National and Environment Planning Agency (NEPA)** has overall responsibility for controlling development of land and natural resources conservation. **NEPA** represents a merger between the National Resources Conservation Authority (NRCA), the Town Planning Department (TPD), and the Land Development and Utilization Commission (LDUC). **NEPA** has the NRCA Act as its core legislative mandate and now administers the Town and Country Planning Act. All development projects must have planning and building permissions (which considers planning constraints such as zonation, parking, availability of municipal services) from the Local Planning Authority and NEPA. The NRCA Act makes provision in Sections 9 and 10 for Environmental Impact Assessments (EIAs) to be conducted for projects falling within a schedule of prescribed activities (such as cemetery development projects), as a means of providing documentation to support an application for an environmental permit.

With increasing demands for new cemeteries throughout the island, the preparation of a policy/guideline document seeks to fill a void created by the lack of a national policy that addresses

the establishment of cemeteries throughout the island and is intended to assist the planning authorities in assessing applications for this use. A preliminary draft Cemetery Planning Policy/Guideline was prepared by the Planning and Development division of **NEPA** in January 2002. The issues addressed in the preliminary draft included siting and design, landscaping, use as open space, access/egress and parking, size and additional facilities.

Presently, Jamaica does not have a National Building Act or legal codes to guide and facilitate the approval of building applications. The Building Codes are currently being reviewed and developed by the Bureau of Standards. The technical document (code) being used to guide construction activity in Jamaica is a policy document. The Local Planning Authorities oversee building plans and approve them. There are no specific standards/codes in Jamaica to regulate construction of burial vaults. The recommended standards used in the permit include implementation of the mitigation measures relating to vault construction as proposed by the developer in their project application. Additionally the permit states that the vaults should be constructed using concrete blocks, steel bars, and should be completely sealed at the base with a minimum of 4 inch thickness of concrete.

The **Local Planning Authority/The Parish Council** is responsible for the general management, regulation, and control of cemeteries in Jamaica through the Cemetery Management and Regulation Act 1894. The Local Authority must issue the rights for burial and to build vaults. Provisions are made for the Local Government Minister/Parish Council to regulate operations within the cemetery and ensure the continued protection of public health. Permission to build is administered by the Local Planning Authority under the Parish Councils' Building Act, upon a review of the building plans for the developed site. The development not only includes vault construction for burial, but also a banquet hall and a non denominational chapel. The Burial within Town Limits

Act defines town limits in relation to burial and also provides a basis for the discontinuation of burial grounds in Jamaica. The Parish Council administers this Act.

2.1.1.2 International Standards and Guidelines

The World Health Organization (Ucisik and Rushbrook, 1998) has established a briefing document with some guidelines for siting of cemeteries. These include:

1. *Human or animal remains must not be buried within 250 m of any well, borehole or spring from which a potable water supply is drawn. This distance may be greater if the site has a steep hydrogeological gradient or the velocity of groundwater flow within an aquifer is rapid*
2. *The place of interment should be at least 30 m away from any other spring or watercourse and at least 10 m from any field or drain.*
3. *All burial pits on the site must maintain a minimum of one metre of subsoil below the*

bottom of the burial pit (i.e. the base of the burial must be at least one metre above solid rock).

4. *The base of all burial pits on the site must maintain a minimum of one metre clearance above the highest natural water table. (Any variability in the water table should be taken into account.)*
5. *Burial excavations should be backfilled as soon as the remains are interred, providing a minimum of one metre soil cover at the surface.*

2.1.2 Development Controls on Other Aspects of the Development

The National Works Agency (NWA) is responsible for reviewing the development proposal and approving any proposed road or drainage works, particularly as they tie in with pre-existing municipal roads and drainage systems. Legislative amendments to the Water Resources Act of 1995 have resulted in the repeal of the Flood Water Control Act 1958, which was regulated by the NWA. With the legislative amendments under way, the Water Resources Authority (WRA) will now have the mandate to regulate and manage flood water control. The NWA, however, maintains responsibility for approving and regulating drainage designs in terms of surveys, civil works and clearance. The physical planning team at the NWA will have to ensure that the surface drainage/storm water runoff generated from the project site and proposed development is effectively intercepted and disposed of (conforming to an approved drainage plan), and that the design of the entrance/exit point from the cemetery to the parochial road is safe.

The National Water Commission (NWC) has the responsibility for municipal water supply and sewage services. The water supply and sewage disposal plans have to be approved by the NWC. Recommendations from the WRA which is the main institution for managing water resources (in terms of supply, flood risk, water quality) must be made, upon review of the development proposals. The proposed development requires access to water and sanitation amenities that must be implemented by the NWC.

2.2 PHYSICAL PLANNING AND LAND USE CONTROLS

The Water Resources Development Master Plan as required under the Water Resources Authority Act (1995) has been developed to allow the proper management of water resources. It evaluates and recommends how Jamaica should use its water resources. A licensing system is in place to govern the allocation of such resources. The Water Resources Authority Act was promulgated to regulate and manage the abstraction and allocation of water resources, and preserve water quality through the establishment of the Water Resources Authority.

The National Physical Plan was developed to foster orderly development in the country. It focuses on physical planning, settlement, conservation, income generators (i.e. forestry and

fisheries, agriculture, mineral industries, tourism and manufacturing) and public utilities through the use of Development Orders. There are six Confirmed Parish Development Orders, four Confirmed Development Orders, six Confirmed Coastal Orders and thirteen Petroleum Filling Station Orders. Parish Development Orders are still required for Hanover, St. Catherine, Kingston and St. Andrew, St. Mary, Portland, St. Thomas and St. Elizabeth. The proposed development is located at Burnt Ground, Hanover, for which there is no Development Order.

2.3 ENVIRONMENTAL CONSERVATION/QUALITY

2.3.1 Water Resources

The **Water Resources Authority (WRA)** administers the Water Resources Act 1995, which regulates the allocation and preservation of water resources in Jamaica. WRA manages the water resources of Jamaica by issuing 5-year licenses for the abstraction of ground and surface waters. WRA also implements the Water Sector Policy Strategy/Action Plan (Ministry of Water, 1999), which addresses water resource management, urban water and sewerage, rural water and sanitation, urban drainage and irrigation. The WRA are normally asked to review cemetery development proposals and advise the NRCA accordingly.

Aside from stipulating that topsoil should be stored to prevent its dispersal, the permit established that the burial vaults should be concrete sealed to prevent grave leachate from entering the soil, and eventually the groundwater system. In addition, NRCA water quality standards (Table 3) may be used to monitor the environmental performance of permitted developments.

Table 3 Jamaican Water Quality Standards (Key Parameters)

Parameter	Freshwater	Sewage Effluent	Trade Effluent
Nitrates mg/L	0.10 - 7.5	10 (Nitrogen)	10
Phosphates mg/L	0.01 - 0.8	4	5
Biological Oxygen Demand mg/L	0.8 - 1.7	20	<30
Total Suspended Solids mg/L	-	20	<150
Faecal Coliform - MPN/100 ml	-	1000	100

2.3.2 Public Health

The **Public Health Act (1985)** makes provision for the establishment of the **Central Health Committee (appointed by the Minister chaired by the Chief Medical Officer)**. The Public Health Act under Section 7 makes provision for the local health boards (Parish Council) to regulate *inter alia* such areas as public sanitary conveniences, lodging houses and camps, swimming pools, restaurants, public nuisances, garbage and waste. This is done in conjunction with the Central Health Committee. The **Environmental Health Unit (EHU)** of the Ministry of

Health has responsibility for administering the act, including the review of designs for sewage treatment, and are normally asked to review the development proposals for cemeteries. The NRCA permit issued to the applicant stipulated that design of the sewage treatment system was subject to final approval from the EHU before implementation.

2.3.3 Solid Waste

The **National Solid Waste Management Authority** (NSWMA) is the public authority responsible for solid waste management in Jamaica, under the National Solid Waste Management Act, 2001. This includes provision for environmentally sound waste collection, transportation, re-use and recycling, and the establishment of a licensing system for operators of solid waste management facilities and collection systems. The permit issued to the applicant stipulated that the developer had the responsibility to dispose solid waste from the facility at an NSWMA approved disposal site.

2.3.4 Air Quality

The Clean Air Act (1964) is administered by the Central Health Committee, and regulates air emissions of any noxious or offensive gases and dust from a premise. This Act lists seven categories of dust and noxious gases, including air emissions from the following works: alumina, cement, lime, sulphur from petroleum processing, gypsum, and sugar factories. With the exception of cement that will be used in the construction phase of this development, the project does not include any of these activities in its construction or operational phase. The proposed development is expected to have bare soils periodically, and has the potential to generate fugitive dust. Consequently, the permit stipulated that fugitive dust was to be controlled by means of wetting. It also stipulated that fire was not to be used as a means of land clearance.

2.3.5 Noise

The proposed development is not expected to generate excessive noise levels and operations are expected to be limited to daylight hours. The main legislation for the control of noise in Jamaica is the **Noise Abatement Act (1997)**. Section 3 of this Act prohibits persons in private or public places from operating amplification devices in such a way that could cause a nuisance to persons in the vicinity. Under the Act, a person who wishes to operate sound equipment in a public area where there is a potential for disturbing residents of the area, is required to make a written application to the Superintendent of Police in charge of the division for permission to do so, no later than ten clear days before the date on which it is proposed to hold such activity. The NRCA environmental permit stipulated that noise from the site boundaries was not to exceed 70 dB at any time.

3 DESCRIPTION OF THE ENVIRONMENT

The purpose of this section is to describe sensitive environmental receptors in terms of pre-project status and trends (if the project is not implemented). This therefore provides a baseline against which future monitoring data can be compared to determine whether and how a project is actually impacting specific receptors. It also allows for evaluation of contributions to environmental degradation from other sources (or cumulative impacts), and the carrying capacity of the environment in respect of specific stresses. The most basic use of the data is terms objectively determining the effect level of impacts, using a classification system.

3.1 PHYSICAL ENVIRONMENT

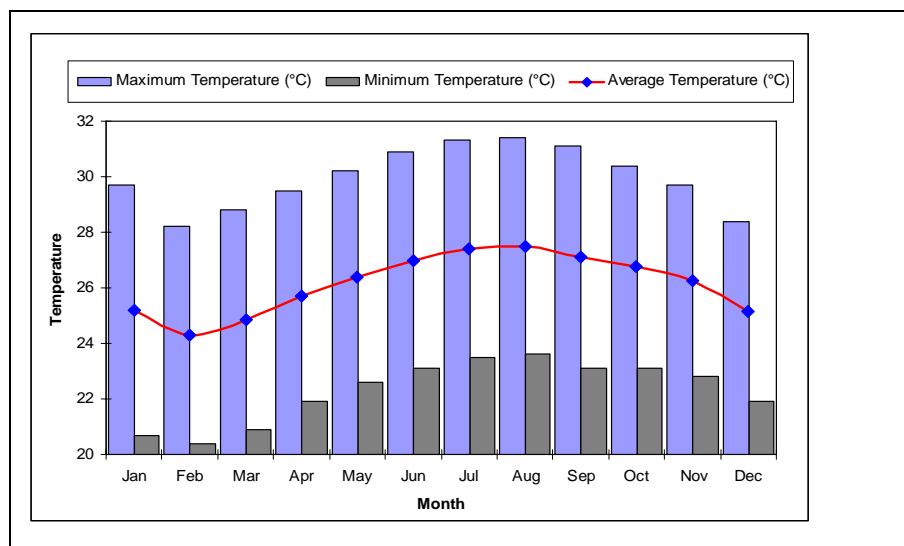
3.1.1 Climate

At latitude 18°N, Jamaica can be generally described as having a tropical maritime climate with dominant northeast trade winds. There is constant year round high temperatures and humidity with very little variation. The climate of the development site is very similar to that of the Sangster International Airport as it is located ~ 11 miles or ~18 kilometres to the southeast. The meteorological data for the Sangster International Airport is considered representative of the Burnt Ground area as it located within such close proximity.

3.1.1.1 Temperatures

Although there might be a slight variation in temperatures as Sangster's Airport (Figure 5) is close to sea level, and the site is located at 190 m above sea level (and therefore cooler), in general, the temperature variations will be similar in that the coolest months of the year occur in January and February, while the hottest months of the year are July, August and September.

Figure 5 Mean Temperatures for Sangster International Airport (sea level) (1951-1980)



(Source: National Meteorological Service of Jamaica)

Evaporation rates were estimated in the Water Resources Master Plan (1990) for the Great River Basin using available data from Smithfield (WRA, 1990). Evaporation rates varied between 93-96 mm (October to February) in the winter months, and 115 – 138 mm in the summer months. The total evaporative loss per year was estimated at ~1362 mm, which is ~75% of the total annual rainfall.

Relative humidity is higher during the morning hours, after which it declines rapidly in the afternoon. At 7:00 am, relative humidity varies between 82% and 89% and between 68% and 75% at 1:00 pm. For winter months, relative humidity is at its highest in the morning hours. For summer months, relative humidity is at its highest in the afternoon.

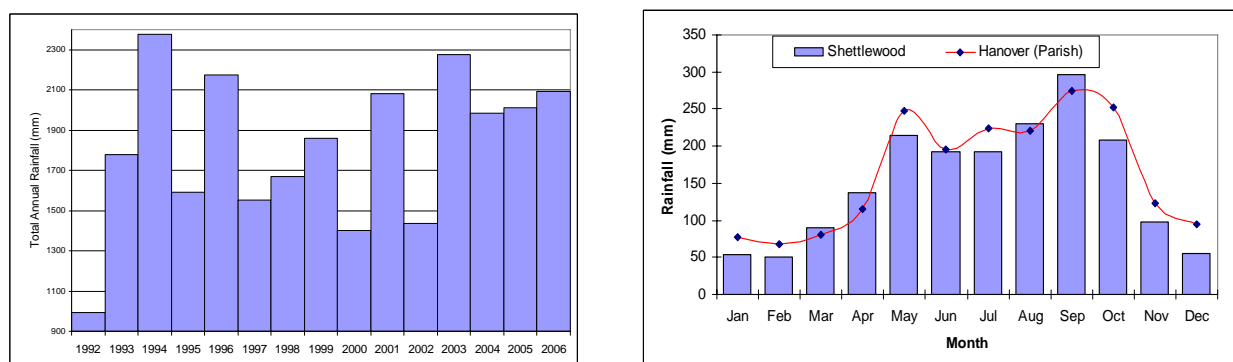
3.1.1.2 Rainfall

Figure 6a shows the total annual rainfall for Shettlewood (Met Office) for the 15-year period 1992 to 2006. The mean total annual rainfall for this period was ~1800 mm, with a maximum of 2375 mm (1994) and a minimum of 995 mm (1992). The last four years have experienced wetter than average rainfall conditions.

Rainfall in the area follows the typical annual distribution pattern of wet and dry seasons (Figure 6b). The wet season occurs between May and October (with a peak in September) where rainfall levels tend to exceed 150 mm per month. The dry season occurs between December and April with the driest months being December, January and February with 55, 53, and 51 mm of rainfall respectively.

In the available data set (1992-2006), monthly rainfall in excess of 150 mm has been recorded in every single month, including the dry season months, and there has also been 0 rainfall recorded for every month except June and August. The wettest month on record since 1992 is September 2004, when 540 mm of rain was recorded. Other months in this period experiencing more than 400 mm of rain include May 1994 (501 mm) and August 2002 (425 mm)

Figure 6 a/Total Annual Rainfall and b/Mean Precipitation for Shettlewood(1992-2006).

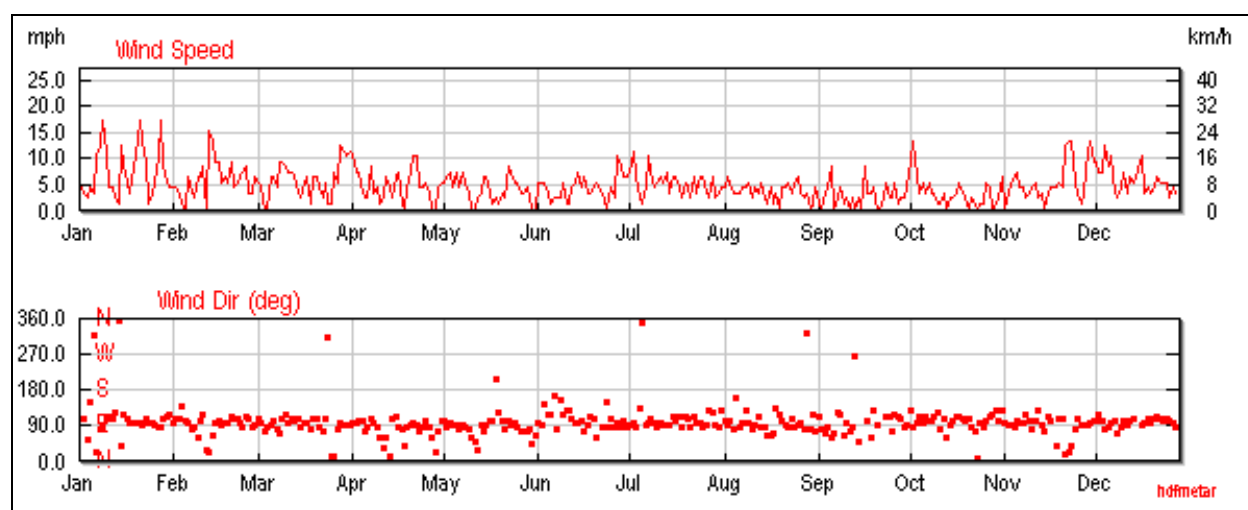


(Source: National Meteorological Service of Jamaica)

3.1.1.3 Winds

Winds in the area predominantly blow from the north and north-east (Figure 7). This is reflective of the effects of the northeast trades that tend to be strongest during the cooler months of the year. Higher wind speeds (>16 kph) occur between December and mid February, probably reflecting the fact that the trade winds are at also at their strongest during the cooler winter months and to a lesser extent, the effects of winter storm fronts from the north. July to mid-November generally marks a period of relatively calmer conditions.

Figure 7 Mean Wind Speed (mph/kph) and Direction (degrees) for Montego Bay (2006)



Source: wunderground.com

3.1.2 Air Quality

The proposed development is not expected to generate major air pollution and therefore no primary air survey was undertaken. The major existing source of emissions in proximity to the site is the main road between the communities of Montpelier and Knockalva, which is also a major thoroughfare between Ferris Cross and Reading. The main air pollutants in this area are associated with exhaust emissions and fugitive dust (from trucks and heavy construction equipment using this roadway). The levels of dustiness in the area is also dependent on prevailing weather conditions (wind and rainfall), and is predicted to be at its maximum levels during the dry winter months (December to March) when wind speeds are also at their peak.

3.1.3 Noise Levels

This project is not expected to result in a significant change to ambient levels of noise in the area, and no primary noise survey was undertaken. The main source of noise is from vehicular traffic using the main thoroughfare through the community, and the adjacent pig farm.

3.1.4 Water Quality

The purpose of this comprehensive assessment of water quality near to the site, downstream of the site and at the spring is to establish a baseline against which future monitoring can be compared. Figure 8 below shows the location points for the water and sediment stations. The DFH property is located at point one. Four water monitoring stations were established in addition to sampling of any water seepages found on site during drilling or trenching. Specifically, water samples were collected from (Figure 8):

1. The permanent pond located near the front entrance of the property. This pond receives inflows from three culverts: one that drains the surface of the main road, one that drains from the road to Copse, and one that drains from the adjacent property. There is an additional culvert which appears to be designed to take water from the pond under the road and out to an earth drain that empties to a sink hole located near to the Shettlewood Baptist Church.
2. Pit number 7. This was perched water over a clay lens that was encountered when the pit was dug. Sediments below the water were dry. This water level was not sustained.
3. The pond adjacent to the property, which is connected by way of a culvert: this pond is located at a slightly higher elevation than the pond on the property, and appears to drain to the pond, as does the main road. Run-off from a pig farm drains into this pond.
4. Great River (main road bridge at Montpelier): this site was chosen as most surface flows runs south-west towards the Great River above this point. The Great River is considered a sensitive environmental receptor as there is an NWC uptake, downstream of the bridge.
5. The Shettlewood Spring: this was chosen as stakeholders have raised concerns about the potential impact of the development on the main drinking water source. It is therefore important to establish a baseline of the water quality.

It was decided that the Jamaica Milk Products Well and the Cornwall Dairy-Montpelier #2 (originally proposed) should be dropped from the sampling programme as they were located too far away, and were located on the other side of the river from the locations of both the cemetery site and the Shettlewood Spring.

Water samples were collected on three occasions from these stations in triplicate (except for Pit 7 – only once). Samples were transported on ice to the laboratories. With the exception of the microbiology (Microlabs and Scientific Research Council) and BOD and Total Organic Carbon (ETAS), all tests were done at the Mines and Geology Laboratory.

Figure 8 Locations of Water and Sediment Sample Stations



NB: Stations 1 (Pond on Property) and 5 (Pit 7) were located on the site.

Parameters included:

1. The *in situ* parameters that are being recorded by a YSI meter included: Conductivity, pH and EH, Temperature, Alkalinity, Dissolved Oxygen (DO), Dissolved Carbon Dioxide
2. Microbiological screening tests (presence/absence) were done on first set of samples. Samples were screened for the presence of the 12 pathogens.
3. Heavy Metals: Manganese, Mercury, Cadmium, Lead, Iron, Copper, Zinc, Nickel and Chromium.
4. Nutrients: Nitrate/Nitrite, Ammonia-Nitrogen, Total Nitrogen, Total Phosphorus, Phosphate
5. Other Parameters: Faecal Coliform, Biological Oxygen Demand (BOD), Total Dissolved Salts (TDS), Total Suspended Solids (TSS), Total Organic Carbon (TOC), Sulphate, Potassium, Sodium, Magnesium, Bicarbonate, Carbonate, Chloride, Strontium, Silicon, Selenium, Arsenic, Boron, Fluorine.

It was decided that it was uneconomical to test for formaldehyde at this time, as the project is not yet implemented; formaldehyde is not expected to be found in the water samples at this time. However, the risk assessment addresses the potential this substance, if used at the cemetery, to impact on the water resources of the area.

3.1.4.1 Basic Parameters

The basic parameters that were measured in situ are given below in Table 4. These values represent the averages of three readings taken on three separate occasions, with the exception of Pit 7, which was a single event sample. The data (Appendix 3) shows very little variability in these parameters over the 3-week period.

Figure 9 Water Quality Stations

	
<p>Station 2 Pond on Property</p>	<p>Station 3 Pond adjacent to Property</p>
	
<p>Station 3/ Shettlewood Spring</p>	<p>Station 4/ Great River at the Bridge</p>
	
<p>Station 5/ Pit Seepage (Pit #7)</p>	

Table 4 Basic Water Parameters

	pH	Temperature °C	Dissolved Oxygen (DO) %
Pond on Property	8.8	25.7	5.6
Adjacent Pond	7.3	22.4	3.7
Shettlewood Spring	6.5	24.6	3.9
Great River at Bridge	6.8	23.5	7.3
Pit #7	4.2	24.9	2.6

pH is a measure of how acid or alkaline a water is, and ranges from 0 (acid) to 14 (caustic), with a mid-point reading 7, which indicates neutral water. Freshwaters normally range between 6.5 and 9.0 (Canadian Environmental Quality Guidelines, 2002), and fish cannot normally survive in water below 5 or above 11 (Helfrich, 2002). The perched water from Pit # 7 was very acidic, and probably reflects the pH of the soils in which the water was stored, which were found to be very acidic in this area.

Surprisingly the mean pH values obtained from samples taken from the ponds were relatively higher (8.8 and 7.3) than those obtained from the samples from the river and spring (6.8 and 6.5 respectively). However, the pH values in ponds are known to vary during the course of a day, varying with degree of photosynthesis (and therefore amount of aquatic plants in the water). The high pH in ponds occurs as a result of photosynthesis, which uses up the carbon dioxide, and thus increases the pH (Helfrich, 2002). Historic data available for the spring for 13 months between March 2000 and August 2004 indicated the pH of the spring does not vary by very much, only fluctuating between 6.8 and 7.4 over these 13 months. There was a tendency for slightly lower pH's to occur in drier months (January, March, August, and July).

Temperatures ranged between 22.4 (in the adjacent pond) and 25.7 degrees C (pond on property), with the readings being fairly consistent over the three weeks. The temperature in the spring and Great River were 24 degrees C. These water temperatures can be expected for February in Jamaica.

Dissolved oxygen (DO) is a measure of the percentage of oxygen available to support aquatic life in a water body, and is essential for aquatic faunas. The USEPA Water Quality Criteria (USEPA 1986) recommend a freshwater standard for warm water of 6 mg/l. DO ranged between 3.7 mg/l to 7.3 mg/l for all stations monitored. The Great River station had the highest level of oxygen as would be expected from moving water. The DO level in the pond was relatively high as well, and may be attributable to aerated inflows from the roads, as well as photosynthesis processes within the pond. The adjacent pond (which had less aquatic vegetation) and the Shettlewood spring had relatively lower levels, and Pit #7 had the lowest.

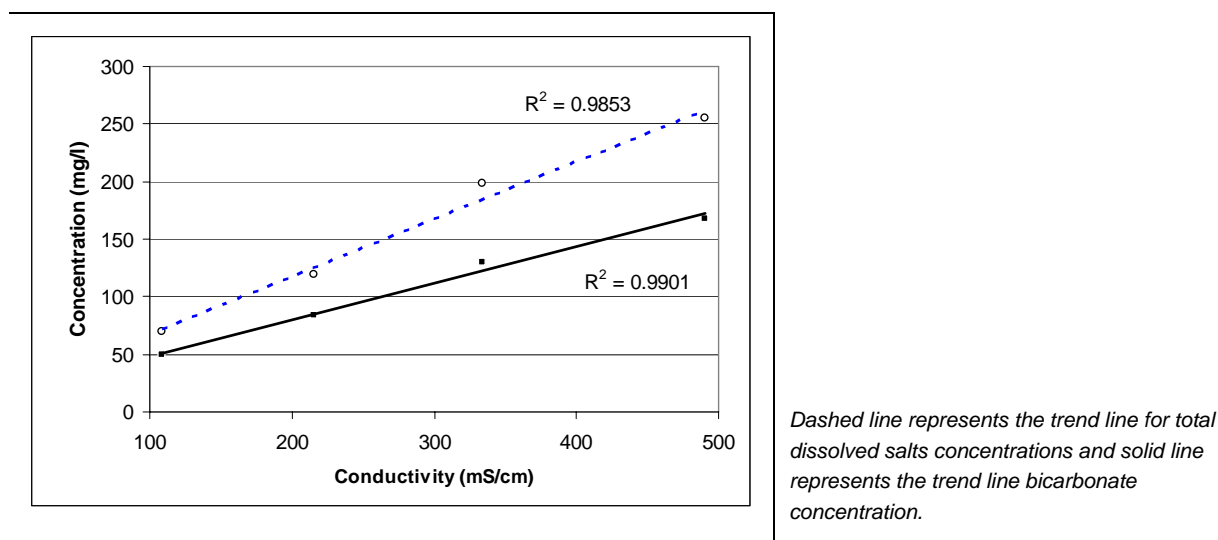
There was wider variation between stations in respect of **conductivity** (measured in micro-Seimens/cm), although there was little variation at each station over the three week period. Conductivity is a function of the dissolved salts present in the water. Conductivity ranged between 109 μ S/cm (pond on property) and 491 μ S/cm (Shettlewood Spring), and showed a high level of correlation with the mean concentrations of **Total Dissolved Solids (TDS)** and

Bicarbonate (both in mg/l) in the samples (Table 5 and Figure 10). The amounts of carbonate present in all samples were below detectable levels (which is consistent with historic data).

Table 5 Conductivity, Total Dissolved Solids and Bicarbonate.

	Conductivity $\mu\text{S/cm}$	TDS mg/l	Bicarbonate mg/l
Pond on Property	109	70.1	49
Adjacent Pond	215.3	118.9	84
Shettlewood Spring	490.7	255.7	168
Great River at Bridge	334.3	199	130

Figure 10 Correlation of Conductivity with TDS and Bicarbonate.



NB: Data from Pit # 7 (single sampling event) were not included in this analysis.

The high conductivity and bicarbonate/TDS levels in the spring are attributed to the fact that is derived from groundwater previously stored in limestone bedrock. Historic data from the WRA database (March 2000 to August 2004) for the Shettlewood spring indicated an average bicarbonate concentration of 257 mg/l and average TDS concentration of 247 mg/l. The measured values for both TDS at the spring falls within the range historically established (208 mg/l to 273 mg/l) However, the mean level of bicarbonate was slightly lower than the 174 mg/l to 309 mg/l historic data range. The Great River is also relatively high as it is fed by ground waters from several other sub-basins. The ponds, which are fed mainly by surface waters, are expected to have lower total dissolved salts and carbonates, and therefore lower conductivity.

3.1.4.2 Pathogens

Of the 12 pathogens for which the samples were screened, only four were found: *Clostridium difficile* (found only in Pit #7), *Alcaligenes sp.*, *Enterobacter spp.*, *Klebsiella pneumoniae*. The following were absent in all samples: *Staphylococcus*, *E. Coli*, *Salmonella*, *Shigella*, *Pseudomonas*, Yeast and Molds. Observations on the results include:

- *C. difficile* was only found in the Pit 7 sample. This is common bacteria that can cause diarrhoea and other conditions such as colitis, and is found in water contaminated by faecal contamination (Public Health Agency of Canada). This may have come from the adjacent pig farm or onsite.
- *Klebsiella* was found at the adjacent pond and in Great River on February 12th only. This bacterium is normally found in the intestines (and therefore may be indicative of faecal contamination). Again, its occurrence is likely to be associated with faecal material from pig and dairy cattle as well as soakaway systems.
- *Enterobacter spp.* was found in the Pond on property on the last two sample occasions and in the Great River samples on the first and last sample occasions. It is also associated with faecal contamination.
- *Alcaligenes* was the only pathogen found in samples from the spring. With the exception of Pit 7, it was also found at all other stations. It was only identified in samples on day 1 (all 4 permanent stations) and day 3 (spring and adjacent pond). This bacterium is found in the soil and aquatic environments.

It is important to understand that the presence of a specific pathogen at various sample locations on the same day does not purport a connection between these stations.

Total and Faecal Coliforms

The four permanent stations were tested for faecal coliforms (Table 6). Pit 7 was tested on the first day, and was not found to contain either total or faecal coliforms.

Table 6 Faecal Coliforms (MPN per 100 ml)

Stations	Location	Faecal Coliforms			Total Coliforms		
		2-Feb	12-Feb	19-Feb	2-Feb	12-Feb	19-Feb
1	Pond on Property	BDL	43	BDL	7	93	43
2	Adjacent Pond	43	93	4	1100	240	23
3	Shettlewood Spring	BDL	BDL	BDL	BDL	BDL	BDL
4	Great River Bridge	240	460	240	1100	1100	240

The Great River at the bridge was found to be the most polluted station, with levels exceeding the standard even for recreational use. The spring was found to be clear of total and faecal coliforms on the days sampled. The ponds were found to have some faecal contamination most probably due to the presence of the pig farm.

Historic information on the faecal coliform loading in the spring water was available through the Water Resources Authority (MF) for 14 months between October 1997 and July 1999. This was divided into dry months (including 7 samples taken between January to March and July-August) and the wet months (including 7 samples taken between April to June and September to November). During the wet months, faecal coliforms ranged from 35 MPN/100 ml to 700 MPN/100 ml. In the dry months, faecal coliforms ranged between 8 MPN/100 ml to 400 MPN/100 ml. The average faecal coliform load in the wet months was 250, which was significantly higher than the average dry season load of 100 MPN/100 ml. Based on this data, it is expected that the spring, as well as the other sites can be expected to have higher coliform loads during the wet season than in the dry season data presented here.

3.1.4.3 Heavy Metals

Of the nine heavy metals for which the samples were tested, the following were found to be below detectible levels in all samples: Cadmium, Chromium, Copper, Lead, Mercury, Nickel and Zinc. Neither manganese nor iron was found to be present in the spring samples. This can be expected as the area is predominantly rural, with no major industrial activities that would normally produce heavy metals in their effluents.

Manganese (with detection limit of 20 ug/l) was only found in on the second sample event in the onsite pond (20 ug/l) and in relatively high concentrations in the two samples taken in the adjacent pond and in Pit 7 (328 ug/l and 278 ug/l respectively). There are no criteria for manganese in freshwater, but the USEPA Water Quality Standards (1986 – Gold Book) recommends less than 50 ug/l for domestic water supplies. NOAA (1999) indicates a freshwater CMC (chronic mean concentration) criterion of 120 ppb (1 ppb – 1 ug/l).

Iron was found in all samples except those from the spring, and the concentrations found are given in Table 7 below. In concentrations above 0.1 mg/l, iron precipitates on exposure to air and can decrease the clarity of the water. As expected, the presence of iron was highest in the ponds, and the pit. The last sample taken in the Great River had elevated iron as well. Iron is likely to be naturally derived from the soils. Only the first sample taken from the adjacent pond approached the recommended criteria for freshwater aquatic life 1.0 mg/l (USEPA 1986), and exceeded the criterion for domestic water supplied (0.3 mg/l) set by the USEPA.

Table 7 Occurrence of Iron in the Sampled Waters (mg/l)

Stations	Location	2-Feb	12-Feb	19-Feb
1	Pond on Property	0.06	0.12	0.10
2	Adjacent Pond	0.91	0.07	0.04
3	Shettlewood Spring	BDL	BDL	BDL
4	Great River Bridge	0.04	0.05	0.12
5	Pit #7	0.12		

Detection Limit = .02 mg/l

3.1.4.4 Elements

Of the 12 other analytes for which the samples were tested, the following did not occur at any detectible levels: arsenic (DL = 0.01 mg/l), boron (DL= 0.5 mg/l), fluoride (0.05 mg/l), and silicon (1 mg/l). Table 8 summarizes the mean values obtained from the three separate sampling events at each station (see Appendix 3 for the raw data) for parameters that do not have any applicable water quality criteria. Selenium is treated separately as the USEPA has established criteria for this parameter.

In general, these waters can be characterized by their basic chemistry, with the two ponds having very similar levels, and the spring and the river being distinct waters.

Table 8 Mean Concentrations of Various Natural Elements in Water (mg/l)

Element	DL (mg/l)	Pond on Property	Adjacent Pond	Shettlewood Spring	Great River at Bridge	(NWC)*
Calcium	0.5	22.7	36.8	104.9	73.8	63-98
Chloride	1.0	9.1	7.4	14.2	12.2	4 – 7.6
Magnesium	0.05	1.2	1.0	3.8	6.1	1.4 - 9.7
Potassium	0.05	2.4	2.4	0.4	0.9	ND
Sodium	0.5	1.5	1.7	3.7	4.6	ND
Strontium	0.05	0.2	0.2	0.5	0.3	ND

ND: No Data. DL = Detection Limit * March 2000-August 2004 Historic data range for the spring only.

Mean calcium concentrations in the ponds were markedly lower than those found for the Great River and the Shettlewood Spring. The mean concentration (104 mg/l) found at the spring was marginally higher than the historic NWC maximum (98 mg/l).

Mean chloride concentrations for all stations ranged between 7.4 mg/l to 14.2 mg/l. As for calcium the two ponds showed significantly lower concentrations than the spring and the Great River. The mean chloride concentration found in the spring was ~2 times higher than the historic data provided by NWC. However, these concentrations are not considered harmful as normal stream water has ~7.8 mg/l and unpolluted groundwater can have up to 250 mg/l (Hitchon et al 1999). According to van Hoort (2006) fertilizers and manure can be an important diffuse source of chloride in groundwaters associated with arable lands.

Mean magnesium concentrations for all stations ranged between 1.0 mg/l to 6.1 mg/l. As for calcium the two ponds showed significantly lower concentrations than the spring and the Great River, with the latter having the highest concentration.

Mean potassium concentrations for all stations ranged between 0.4 mg/l (at the spring) to 2.4 mg/l at the 2 ponds.

Mean sodium concentrations for all stations ranged between 1.5 / 1.7 mg/l at the 2 ponds and 3.7 mg/l in the Great River

Mean strontium concentrations for all stations ranged between 0.2 mg/l at the two ponds and 0.5 (at the spring).

Selenium was found to be present in a very high concentration on the first sampling occasion at the Great River bridge station. This concentration (165 ug/l) was considerably higher than the 35 ug/l recommended by the USEPA for the protection of aquatic life in freshwater, or the 10 ug/l recommended for protection of human health (drinking water). NOAA recommends a maximum contaminant level of selenium of 50 ppb (50 ug/l). Subsequent measurements of selenium were within the USEPA criterion for aquatic life in freshwater.

Table 9 Concentrations of Selenium (ug/l)

Station	2-Feb	12-Feb	19-Feb
Pond on Property	BDL	22	31
Adjacent Pond	BDL	27	BDL
Shettlewood Spring	BDL	4	9
Great River at Bridge	165	BDL	25
Pit #7	BDL		

DL = 3 ug/l

3.1.4.5 Nutrients

Total Organic Nitrogen was found to be below the detectible level of 1 mg/l in all samples. Total Nitrogen was only found to be above the detectible level of 1.5 mg/l in the last sample taken from the pond on property and Pit 7. Ammonia was only found in the first sample taken from the adjacent pond, and was probably affected by the pig farm.

Table 10 Nitrate and Nitrite concentrations in the Sampled Waters (mg/l).

Stations	Location	Nitrate (DL: 0.5)			Nitrite (DL: 0.01)		
		2-Feb	12-Feb	19-Feb	2-Feb	12-Feb	19-Feb
1	Pond on Property	BDL	BDL	BDL	0.03	0.02	0.05
2	Adjacent Pond	0.8	BDL	BDL	0.02	0.02	0.12
3	Shettlewood Spring	1.1	1.2	0.8	0.02	BDL	BDL
4	Great River Bridge	0.8	BDL	0.7	0.05	BDL	BDL
5	Pit 7	1.6			0.01		

Nitrates were not found in the pond on the property and only in the first sample in the adjacent pond. It was however found in the pit (1.6 mg/l), spring (average of 1 mg/l) and in the Great River (less than 1 mg/l on two occasions). In general concentrations over 10 mg/l (USEPA criteria for domestic supplies) are of concern as they can lead to eutrophication. Historic data (March 2000 to October 2002) for the Shettlewood Spring indicate a nitrate load range from 1.4 mg/l to 5 mg/l, which was much higher than was recorded by this 2007 study. The historic data showed no significant differences in nitrate loading between wet and dry months.

Nitrites were only detected in very low quantities (between .01 and 0.1 mg/l). In general the ponds had higher concentrations.

Phosphate levels (Table 11) in the sampled waters ranged between 0.02 and 0.62 mg/l (at the spring on the first sampling occasion) compared to the historic data for the spring (0.07 mg/l to 0.5 mg/l). All concentrations found were below the NRCA freshwater standard of 0.8 mg/l.

Table 11 Total Phosphorus and Phosphate concentrations in Sampled Waters (mg/l)

Stations	Location	Phosphate DL = 0.02			Total Phosphorus DL = 0.02		
		2-Feb	12-Feb	19-Feb	2-Feb	12-Feb	19-Feb
1	Pond on Property	BDL	0.02	BDL	0.07	0.13	0.07
2	Adjacent Pond	0.1	0.02	BDL	0.87	0.06	0.02
3	Shettlewood Spring	0.62	0.06	0.06	1.33	0.32	0.15
4	Great River Bridge	BDL	0.02	BDL	0.88	0.05	0.10
5	Pit 7	0.13			0.31		

Phosphorus is a major nutrient in aquatic systems. This was found to be highest on the first sampling occasion at the spring (1.33 mg/l) and the adjacent pond and Great River (~0.9 mg/l).

Although sulphates can be an agrochemical (fertilizer) additive, they occur naturally in the environment and are usually around 11 mg/l in the stream water, and generally less than 250 mg/l in unpolluted ground waters. Very low sulphate levels were found in all samples (Table 12). The highest of these was the spring, which may be reflecting slightly elevated levels due to underground residence time.

Table 12 Sulphate (mg/l)

	2-Feb	12-Feb	19-Feb	Mean	Std Dev
Pond on Property	3.8	4.2	4.6	4.2	0.4
Adjacent Pond	9.6	6.2	8.0	7.9	1.7
Shettlewood Spring	16.0	BDL	BDL		
Great River at Bridge	5.7	1.6	4.3	3.9	2.1
Pit #7	4.6	--	--		

Historic data (March 2000 to August 2004) for the Shettlewood Spring indicate a sulphate load range from 0.62 mg/l to 4.4 mg/l. This was not consistent with this study which found sulphate on only one occasion at the spring, which was measured to be 16 mg/l. The historic data showed no significant differences in nitrate loading between wet and dry months.

3.1.4.6 BOD

BOD is a measure of the amount of oxygen required to decompose sewage and other organic matter present in a water sample. NRCA has established BOD criteria (0.8 to 1.7 mg/l) for freshwater. Table 13 shows the mean BOD concentration for the five stations.

The main observations of the data set are:

- the maximum recorded concentration of BOD was 6.2 mg/L, which was found at adjacent pond on the first day (pond receives a run-off contaminated with faecal material from the nearby pig pen);
- the two ponds exceeded the BOD standard on at least one sampling occasion;
- the Great River values were lower than the ponds, but were still considered high (above 1 mg/L on 2 of the 3 sampling occasions);
- the BOD concentration in the spring water was the lowest of the permanent stations, indicating the lowest sewage load in general; and
- the water in Pit 7 had a very low concentration of BOD, suggesting very little groundwater connection between the pig farm and the cemetery site, or even with either pond.

Table 13 BOD Concentrations (Wet and Dry Seasons)

Stations	Location	2-Feb	12-Feb	19-Feb	Average
1	Pond on Property	1.35	1.15	1.65	1.38
2	Adjacent Pond	6.2	1.35	1.6	3.05
3	Shettlewood Spring	0.55	BDL	0.50	0.53
4	Great River at Bridge	1.06	0.7	1.55	1.10
5	Pit #7	0.15			0.15

3.1.4.7 Total Organic Carbon (TOC)

TOC is a natural component of waters, which can be affected by organic pollution. Like BOD, it in the water can therefore be used as an indicator of organic contamination of natural waters. In general TOC (Table 14) for the two ponds and the spring were very similar (ranging between 3.7 and 7 ppm), and are probably representative of natural conditions.

The TOC levels in the Great River were found to be relatively low (generally being below 3 ppm). The single reading of Pit 7 also showed very low TOC. The two ponds had similar levels of organic contamination, ranging between 3.7 ppm and 7.0 ppm. The spring water had higher than expected levels of TOC (when compared to the Great River), but this could be as a result of the presence of abundant aquatic vegetation in the dam behind the point at which the spring water was sampled. As the spring was not sampled at the point at which it issued from the rock, and could be impacted by natural organic processes in the dam.

Table 14 TOC concentrations in sampled waters (ppm)

Stations	Location	2-Feb	12-Feb	19-Feb	Mean	Std Dev
1	Pond on Property	4.7	4.3	5.1	4.7	0.4
2	Adjacent Pond	7.0	3.7	4.8	5.2	1.7
3	Shettlewood Spring	4.4	4.9	3.8	4.4	0.6
4	Great River at Bridge	2.9	2.7	2.5	2.7	0.2
5	Pit #7	1.6				

3.1.4.8 Total Suspended Solids (TSS),

Total Suspended Solids (TSS) is an indicator of the amount of suspended solids in the water, which can affect the clarity of the water (Table 15). Pond waters can have very variable TSS values as they normally have muddy bottoms that can be re-suspended by heavy rainfall or animals. This was the case with the adjacent pond where the water had a high suspended load on the first day (445 mg/l). All of the permanent stations except the spring had a suspended load ranging between 2.7 mg/l and 17.7 mg/l, which would be normal for surface waters. The pit water had a slightly more elevated suspended load, and may have been contaminated by the activities of the bulldozer.

The spring water did not contain any suspended sediments at the times of sampling for this study. Historic data for the spring for 8 months (March 2000 to August 2004) indicate that the TSS values in the spring water ranges from 2 mg/l to 12 mg/l, with one exception recorded on April 16th 2003, when 33 mg/l was measured in a sample from the spring. Of the eight available months, three were wet months (September 2000, October 2002, and October 2004), and there was no difference in the range of TSS concentrations between wet and dry months. This is what would normally be expected from spring water, which is naturally filtered of impurities from filtration through limestone.

Table 15 TSS Concentrations (mg/l)

Stations	Location	2-Feb	12-Feb	19-Feb
1	Pond on Property	7	17.7	5.7
2	Adjacent Pond	445	16.7	7.3
3	Shettlewood Spring	BDL	BDL	BDL
4	Great River at Bridge	13.3	3.67	2.7
5	Pit #7	44.7		

3.1.5 Existing Sources of Water Contaminants

There are at least five other cemeteries and family plots in similar or closer proximity to the Shettlewood Spring. Additionally, there is a pig farm, ponds, and orange orchard (using pesticides and fertilizers) within the general area. Sewage disposal in the area is mainly by soak-away.

3.1.6 Landforms

3.1.6.1 Regional Terrain

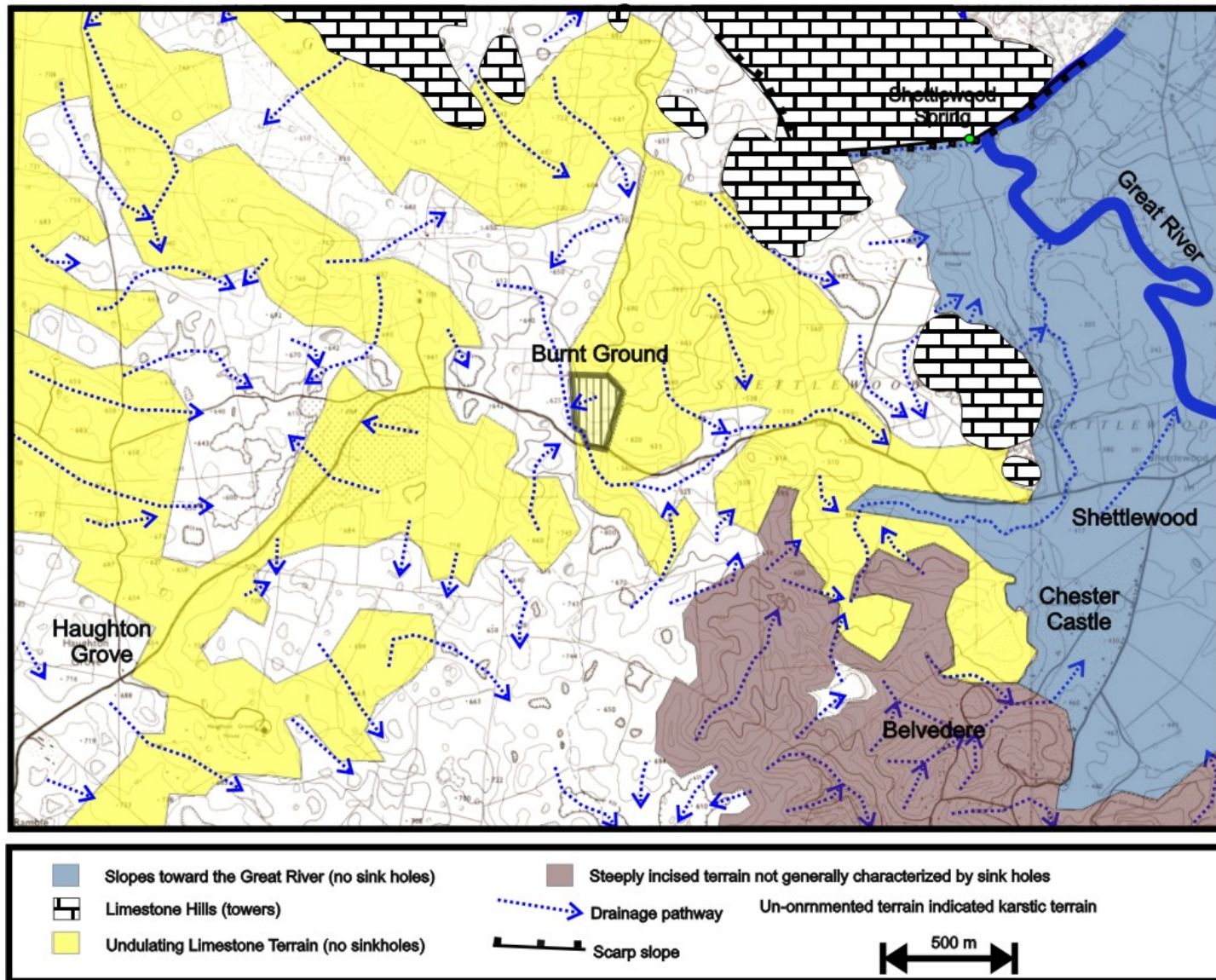
Figure 11 presents a simplified analysis of the terrain in the region of Burnt Ground, based on an interpretation of satellite imagery, field observations and an in depth analysis of the 1:12,500 Ordnance Survey Sheets.

Five basic types of terrain are identified, and described below.

1. Slopes oriented toward the Great River. In general this area lies below 150 meters in elevation, and occurs in proximity to the Great River. Much of the 100-year flood plain of the Great River is expected to fall within this area (n.b. flood plain mapping was outside the scope of this project).
2. Limestone Towers. There are a number of limestone hills that stand out in positive relief against the undulating lower topography. These appear to be orientated along the major NE-SW trending lineations. The Shettlewood Spring is associated with one of these limestone blocks (see Figure 11).
3. Undulating Limestone Terrain. A fair portion of the terrain consists of undulating limestone terrain that is not characterized by pronounced sink-holes. These areas also coincide with areas reported to have deeper soils. Most of the drainage pathways appear to drain from these areas toward the more karstic terrain. This terrain may indicate a lithological variation in the bedrock. The Burnt Ground Cemetery Site is located on this type of terrain. Drainage features are generally subdued in topography, and transmit water only during heavy rains. Small ponds may occur in the clay lined depressions such as the one found on the property.
4. Karstic Terrain: This is characterised by numerous enclosed karstic basins, some of which have become interconnected. In general, this terrain appears to be structurally controlled, following the general NE-SW trending lineations. The larger enclosed basins tend to pond water after heavy rains, the most notable of which occurred as a result of the June 1979 rains (Eyre, 1981). This suggests that the central shafts of the dolines are typically blocked with the impermeable clays.
5. Steeply incised hills. In the Belvedere area, the terrain is characterised by steeply incised hills that do not contain enclosed basins. This terrain may indicate a lithological variation in the bedrock.

The nearest cave reported by Fincham (1997) occurs at Copse Mountain (One Day Cave) at 230 m at metric grid reference 1469 1923.

Figure 11 Simplified Regional Terrain



3.1.6.2 Site Terrain

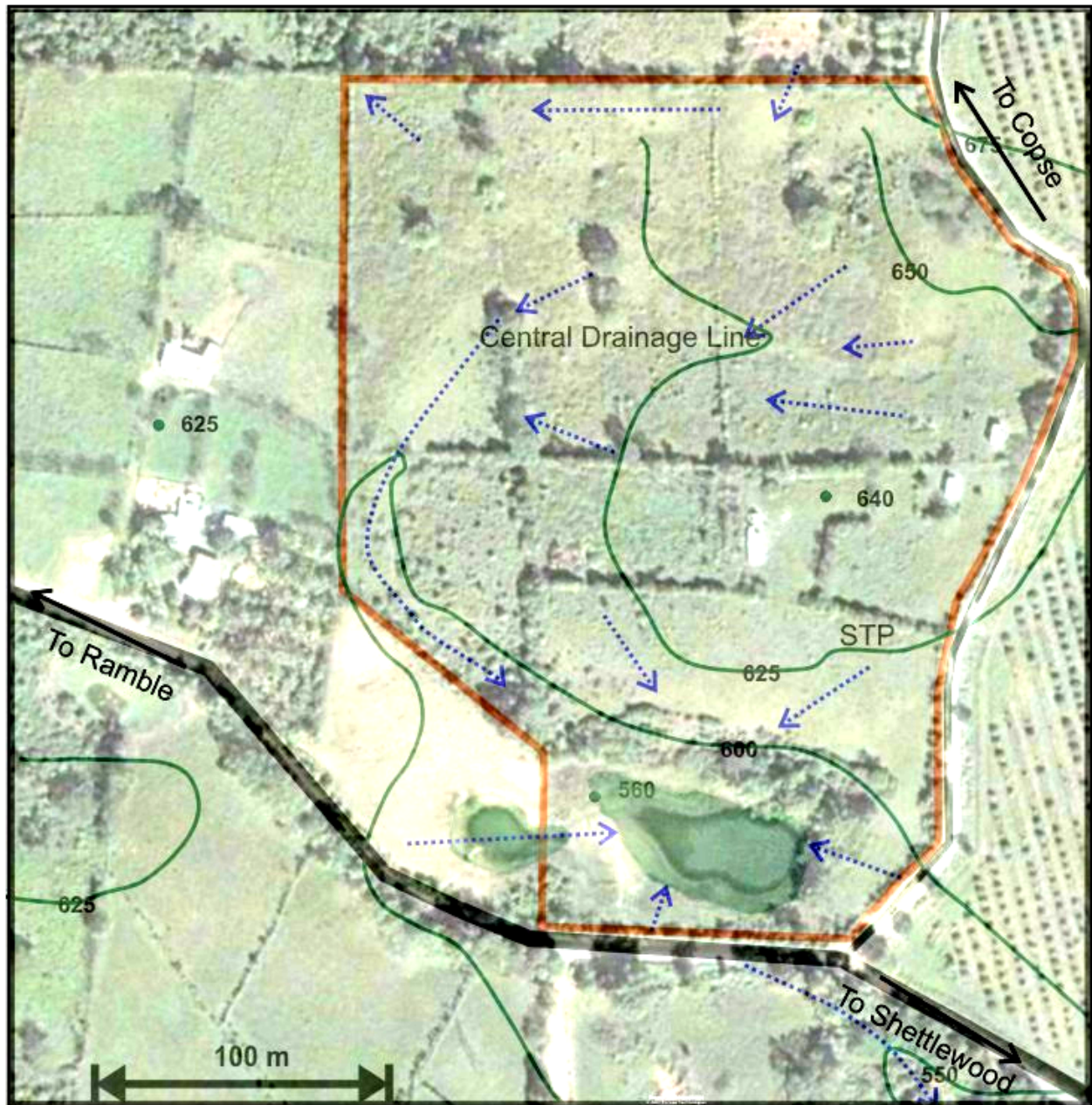
The geomorphology of the site is a little different to that of the nearby district, and that the landforms here appear to be developed on more erosion-resistant bedrock, which concomitantly is probably less fractured or porous than elsewhere. The site occupies the south-western flank of a small ridge comprised of limestone bedrock and deep regolith. The terrain dips steeply from the north-east corner generally to the southern boundary (Figure 12). About the middle of the site on the eastern boundary is an east-west orientated spur dipping to the west until it reaches a topographic low adjacent to the western boundary. This spur effectively divides the site in two: a northern part and a southern part. The spur also roughly corresponds with the property boundary between Lots 47 and 48, although part of the middle of the site and on the spur has been redeveloped as a car-park.

The northern part hosts a clearly defined “central drainage line”, which begins near the boundary and terminates in a doline adjacent to the western boundary. The southern part also hosts a doline but receives drainage from the west, north and east; the northern flank comprising steep slopes. This area represents the lowest-most topography of the site, and being adjacent to the Shettlewood – Houghton Grove road also provides the front site boundary and principal access. Much of the site here has been altered by road construction and redefinition of the sinkhole shape.

Above each of these low points the landform generally climbs modestly with typical side slopes of 7° - 9°, except in the vicinity of the central drainage line (Figure 12) and immediately north of the front sinkhole. The effect of the central spur is to separate the two low points and effectively create two sub-catchments for the site. A third, very minor one is located in the NW corner.

Surface runoff is retained on the site by the nature of the low points except in the most severe climatic events where the southern (front) pond may overtop to neighbouring lands, and, a small area in the NW corner may allow drainage off-site, via the over-topping of the small divide here.

Figure 12 Site Terrain and Drainage



The contours shown on Figure 12 are taken from the 1:12,500 OS map for the area. The topography is considerably different on site now as much of the previously permitted burial area has been graded, and other sections cut for roads. Filled thickness do not appear to be large and where found are hard to distinguish from the natural regolith because of its very mixed nature. Filled areas are not expected to significantly alter surface drainage or groundwater percolation.

3.1.7 Geology

3.1.7.1 Stratigraphy

The 1:250,000 map geology map of the area was used as it shows the extensive deposits of alluvial material (Qa) in this area as such. The relevant section of that map is excerpted below as Figure 13.

The oldest rocks in the area are fossiliferous Cretaceous rocks (limestones and shales) which outcrop in the southwestern and western part of the site in what is referred to as a Cretaceous Inlier. The younging direction of the strata from the inlier is generally toward the Great River.

The older rocks are overlain by the Yellow Limestone Group, which outcrop around the inlier and are mapped as the Chapelton Formation (Ech) in this area. The 1:50,000 Provisional Geology mapping (Sheet 3 – Mines and Geology Survey Division) shows the Yellow Limestone in this area undifferentiated impure limestones. MGD estimates the thickness of the Yellow Limestone in this area to be ~275 m.

The White Limestone Group outcrops extensively in this region. The base of the White Limestone (Troy Formation) is believed to be gradational from the shallow water Yellow limestones into deep water chert-bearing facies of the White Limestone Group (Bonny Gate and Montpelier formations). The Bonny Gate Formation outcrops extensively across the region around the site, forming the uplifted limestone hills described above. A typical section of lithology is shown in Figure 14, which is a photograph taken on the main road at Knockalva. This formation is a well-bedded pure limestone with chert nodules. Beds can be several metres thick and are separated by poorly cemented marly partings.

In the region of the cemetery site, the Provisional Sheet (#3) has bedding recording at a dip of 12 degrees to the north-west. This formation is estimated to be 457 m thick in this area.

The Montpelier Formation unconformably overlies the Bonny Gate Formation, and outcrops mainly to the north west of the site. Chert is found in the lower parts of the formation but are rarer in the upper parts of the formation. This unit is estimated to be more than 900 m thick.

The youngest sediments are those found on the site, which are classified as Qa, or Quaternary alluvium. These sediments are known to be several metres thick from boreholes drilled in the area. These deep soils cannot be easily explained as part of a weathering profile developed over the Bonny Gate Formation, which is supposed to be more than 90% pure calcium carbonate. In addition, non-carbonate pebbles are observed on the site, and minerals such as clinocllore (a metamorphic mineral) have been identified from XRD examination of soil samples collected from the site. Abundant chert fragments suggest that the soil is at least partly derived from colluvial material washing down from the surrounding limestone hills. This unit is discussed more fully below in Section 3.1.7 (Soils).

Figure 13 Excerpt of Geology of Jamaica, 1:250,000 map.

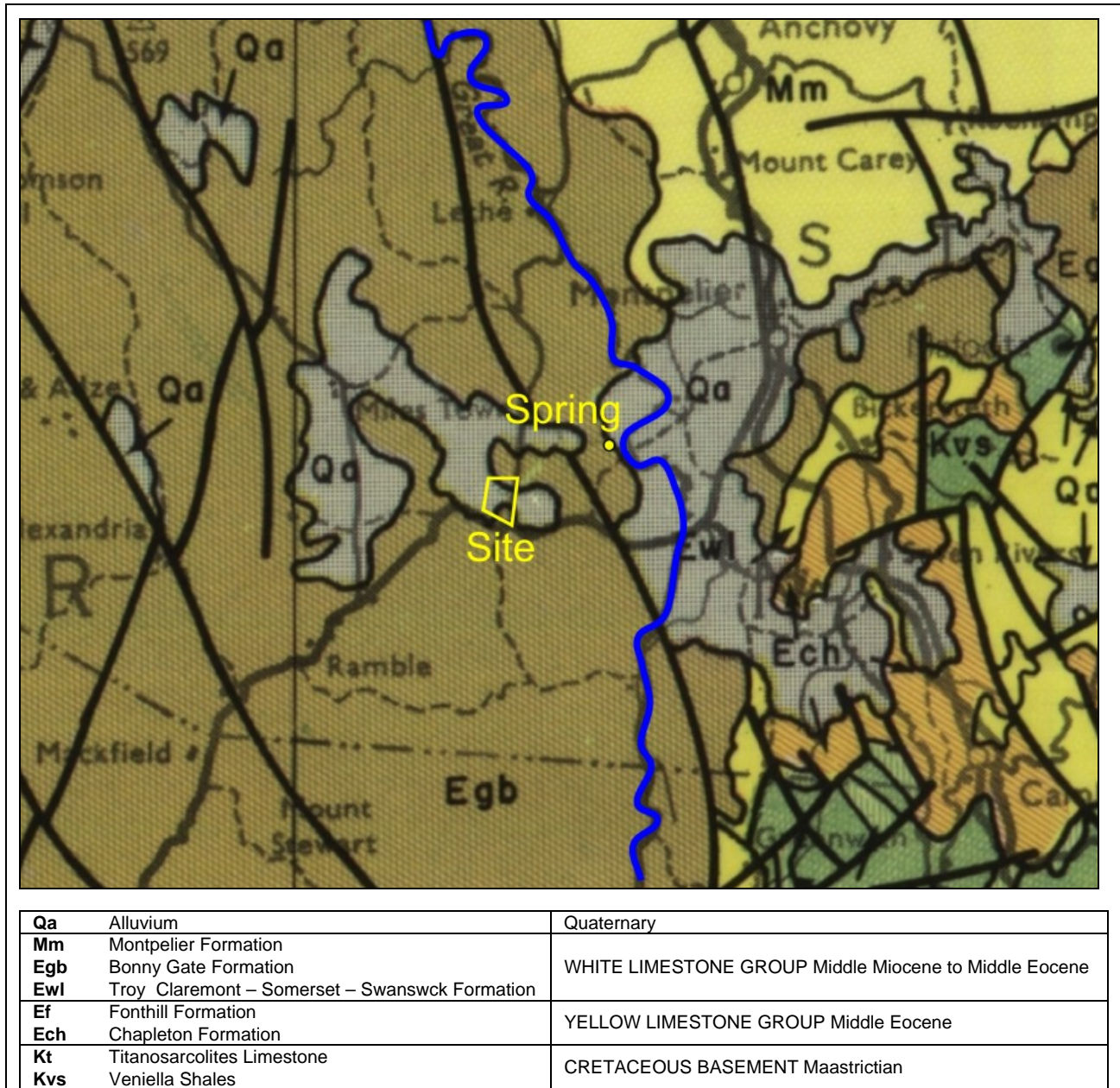
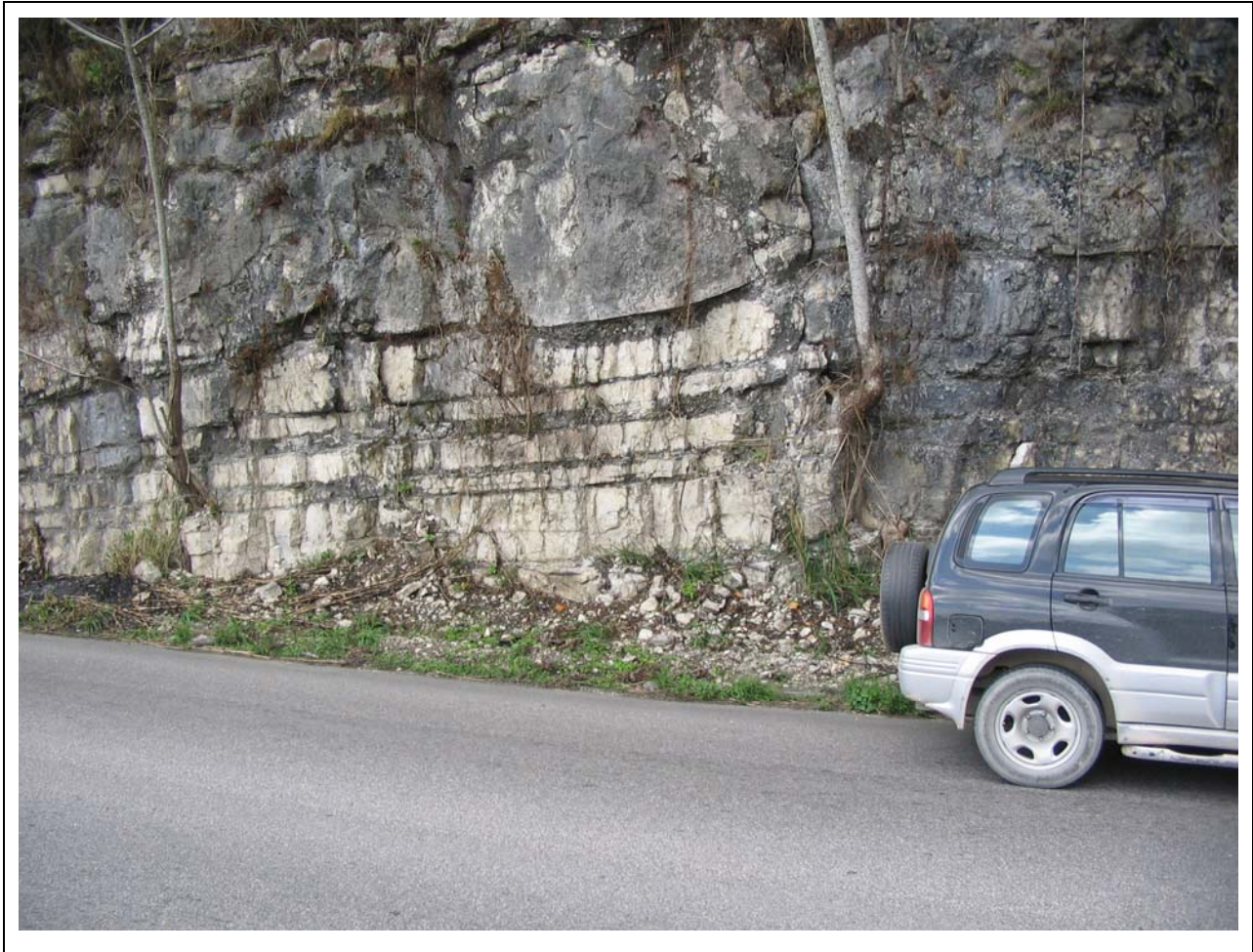
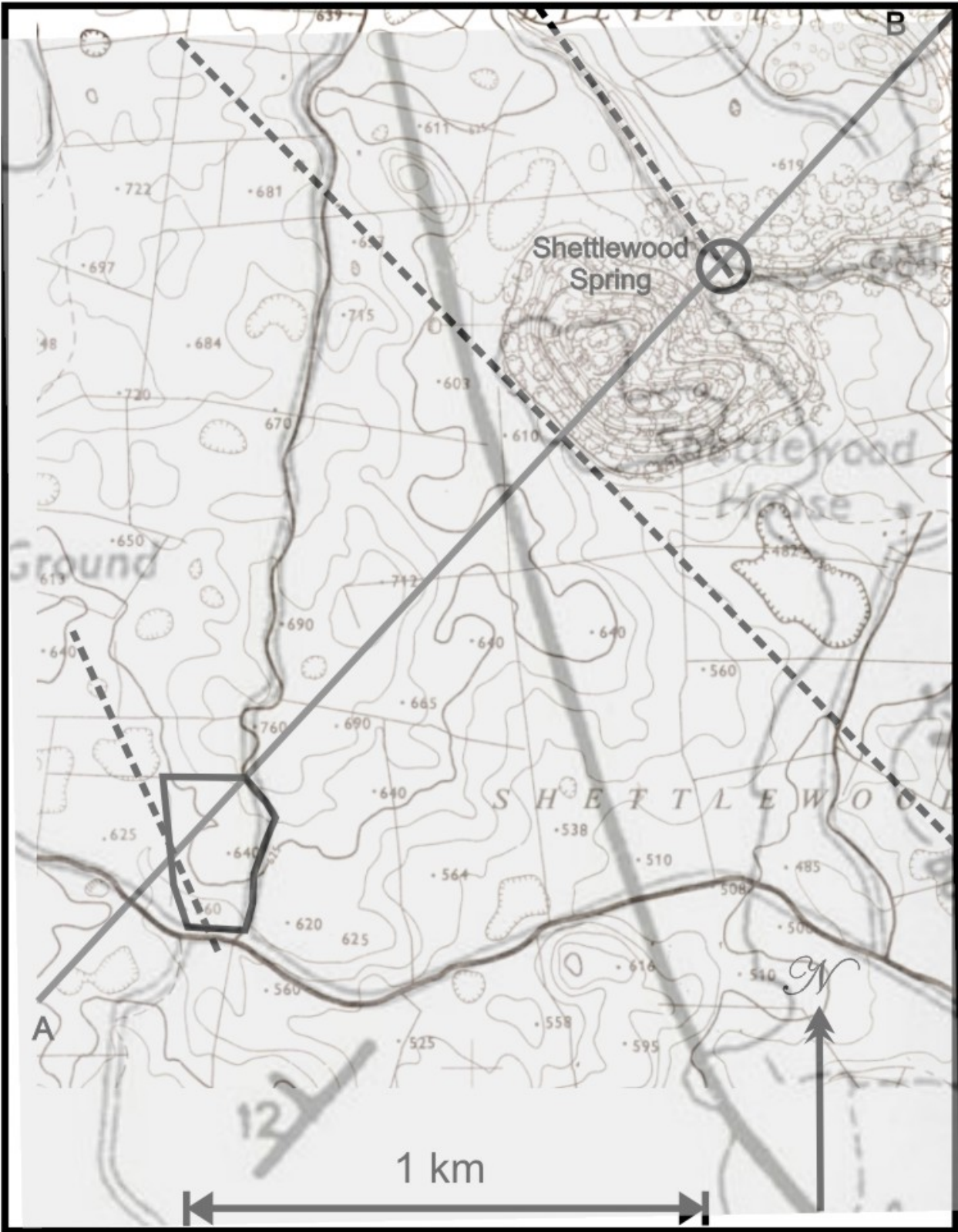


Figure 14 Outcrop of Bonny Gate Limestone (Knockalva)



There was insufficient geological information to produce a geological cross-section between the proposed burial site and the spring (Figures 15). This section line would be parallel to the strike of the beds (see Provisional Sheet #3, superimposed on Figure 15). Therefore the beds will appear to be horizontal in section, although they are reportedly dipping to the north-west at ~12 degrees. Provisional Sheet #3 places one fault through this section. However, this is reinterpreted based on available satellite imagery and the likely relationships between the faults and the topography. Two other unconfirmed faults are inferred from lineations and topography. It is likely that the gully occurring above the spring is in fact a fault scarp, along which water flows during rainfall events, and the spring is fault controlled.

Figure 15 Hydro-geological Map (Site to Spring)



It is suggested that the fault block to the east of the spring may have been downthrown so as to juxtapose the Bonny Gate Formation against the less permeable Montpelier Formation, resulting in the emission of the spring at that point, at an elevation of ~150 m.

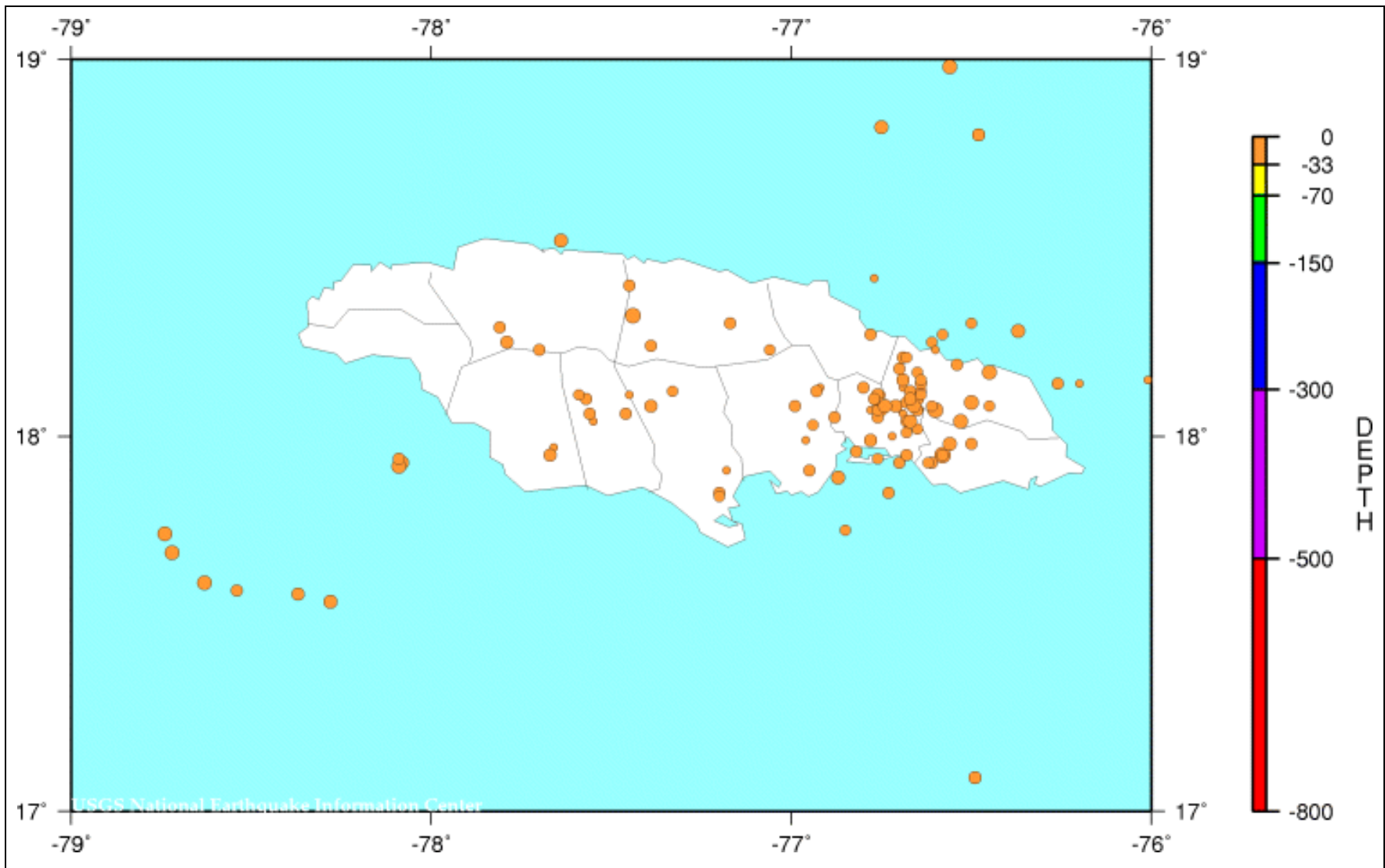
It is further suggested that the two fault blocks to the west of the spring were variably uplifted, so that much of the Bonny Gate Formation may no longer actually be present. Based on the thickness of the soils and their mineralogy, it is speculated that the base of the Bonny Gate Formation may be much closer to surface in the vicinity of the Orange Estate and cemetery than it is in the Haughton Grove-Ramble area.

3.1.7.2 Seismicity

Over the last 326 years, Jamaica has experienced 13 earthquakes with intensities greater than 7 (Wiggins-Grandison, 1996). Most of these (10 of 13) have affected the eastern part of the island more severely than the western section (Wiggins-Grandison, 1996). Figure 16 shows a map generated from a search at the USGS NEIC database for 1977 to 2005. All of these events are very shallow. The largest event to affect the area occurred in 1957 (magnitude 6.6 to 6.8). Reported intensity at Chester Castle and Montpelier was VI. According to community spoken history (Debbie Rowe-Lewis, February 18th 2007) it is reported that the Mount Ward Church in Haughton Grove was damaged by this earthquake, which also destroyed the school at that time.

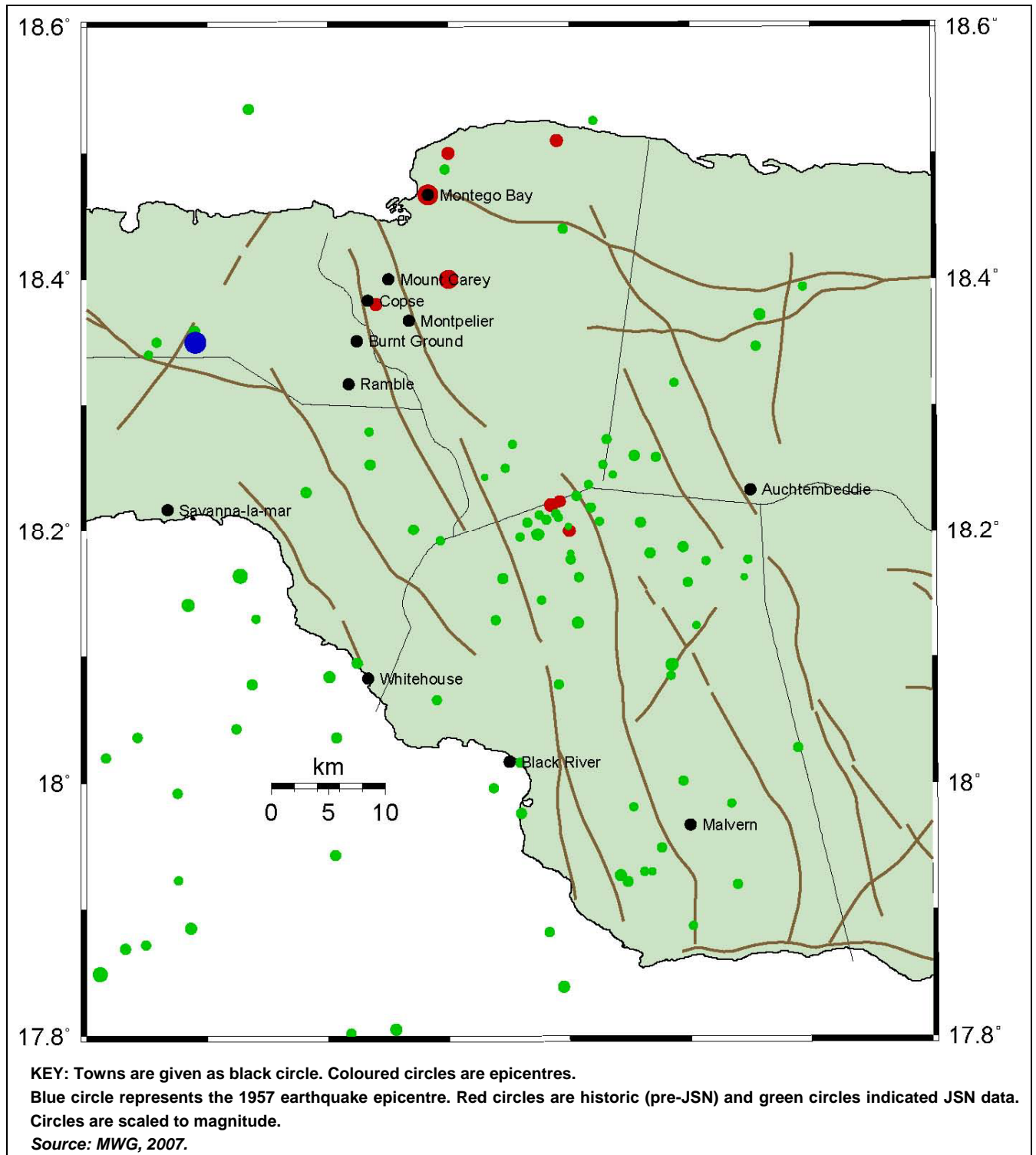
The report on seismic activity affecting the Burnt Ground area, as prepared by M. Wiggins-Grandison (Earthquake Unit, UWI) is included as Appendix 4. That analysis is based on instrumental records from the Jamaica Seismograph Network. Like all of Jamaica, the area is prone to earthquake activity. The site is located in the Montpelier-Newmarket Belt, which is defined by series of NW-SE trending faults. According to Dr. Wiggins-Grandison, earthquakes affecting the region are concentrated near Quick Step in Trelawney. Seismic activity (Figure 17) tends to be of magnitudes up to 4.2, which are not expected to yield intensities that would result in structural damage.

Figure 16 Earthquake Events Affecting Jamaica (1977 – 2005)



Source: [NEIC](http://neic.usgs.gov/neis/epic/epic_rect.html) (rectangular grid search): http://neic.usgs.gov/neis/epic/epic_rect.html

Figure 17 Seismic Activity around the Burnt Ground Area



3.1.8 Soils

The Ministry of Agriculture maps broadly (at a scale of 1:50,000) classify the soil on site as the Chudleigh Clay Loam. This is moderately to rapidly draining acidic soil. According to WRA (2006), it is likely that there are localized areas where the soil is less freely draining than typically expected for the Chudleigh Clay Loam, as evidenced by surface ponding that occurs in the enclosed depression on the site.

The Hydrology Risk Assessment (Appendix 5) included an investigation of the soils on the site by pitting and engineering boreholes (Appendix 6). Seven pits 6 m in width were excavated to ~3.6 m, and three boreholes were drilled in order to determine the thickness, continuity and general profile of the soils in the horizon likely to be effected by burials. Soil samples were collected by the consultant and analysed for various parameters (Appendix 7).

Further to his examination of these data it was concluded that: *“A very thick regolith layer comprising yellow-brown and red-yellow-brown cobbly, pebbly silty clays, loams and clayey silts and clays is present over the whole site, and overlays a weathered limestone of unknown petrology and weathering state, but is likely to contain cherty gravel (cobbles and pebbles). The soil layer is at least 8 m thick in the topographically high areas and of the order of 12 – 13 m thick in lower parts”.*

XRD investigation of the soil (Appendix 7) discovered the presence of minerals that are not expected to be typical weathering products of the White Limestone, which is reportedly more than 90% calcium carbonate, and in the case of the Bonny Gate Formation, may contain chert (silica). In addition, there was a notable absence of carbonate minerals. The minerals identified in the soils include quartz, nacrite, dickite, kaolinite and some illite, with other minor clays including some unexpected ones of a metamorphic origin (clinochlore), which may be more indicative of weathering of impure limestones. The presence of manganese throughout these soils is indicative of deposition from very slow-moving percolating waters at irregular times. The clay minerals found in these soils are not particularly swelling or sorptive, but the quantity of clay present makes the soil suitable for cemetery development (Appendix 5).

The material in the upper part of the soil is obviously transported colluvium containing abundant chert fragments derived from the Bonny Gate limestone (Figure 18). However, the boreholes suggest that the soil may contain coarser material at depth, although it is possible that that these coarser particles may be soil peds consisting of clay sized materials.

Figure 18 Typical Soil Profile

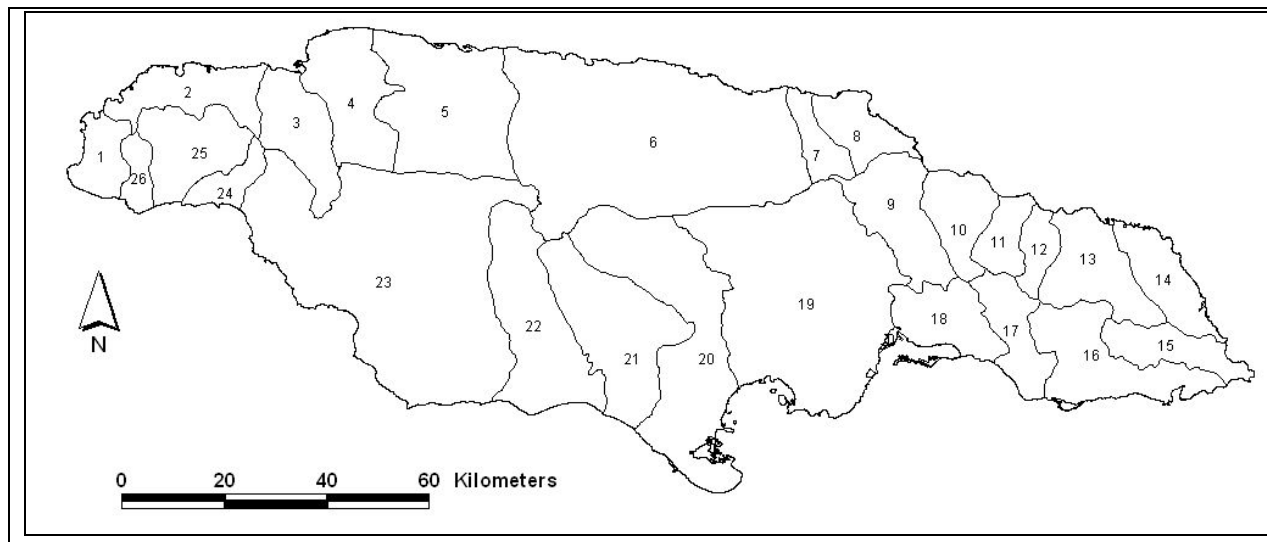


3.1.9 Hydrology

The site is located in the catchment of the Great River, which is WRA's Basin #3 as shown on Figure 19 below. This river system drains to the west of Montego Bay and is approximately 334 km² in area. The Great River is a major surface water resource. The NWC abstracts water directly from the river near to the Great River Bridge close to the border between St. James and Hanover. This station supplies the Greater Montego Bay area (Selicity, Flower Hill, Mango Walk, Salt Spring, Norwood, Paradise Acres, and Hendon) and to Hanover (Great River, Round Hill, Sandy Bay, Orchard Housing Scheme, Tryall, Barbican, Kennelworth, Tamarind Hill, and Guava Walk).

Additionally water from the Shettlewood spring is abstracted by the NWC and piped to several communities including Chester Castle, Ramble, Knockalva, Copse, Pearces Village, Shettlewood, Friendship, Lethe, Eden, Burnt Ground and Mount Peto. Shettlewood Spring System which is scheduled to undergo some improvements. The spring has the capacity to produce ~ 0.7 MGD and serves ~ 1,024 customers.

Figure 19 WRA's Watershed Management Units



The hydrological baseline herein described is intended to provide as much data as possible for the conduct of the risk assessment within budgetary constraints. It is not intended to be a comprehensive study of the regional groundwater system.

3.1.9.1 Surface Water

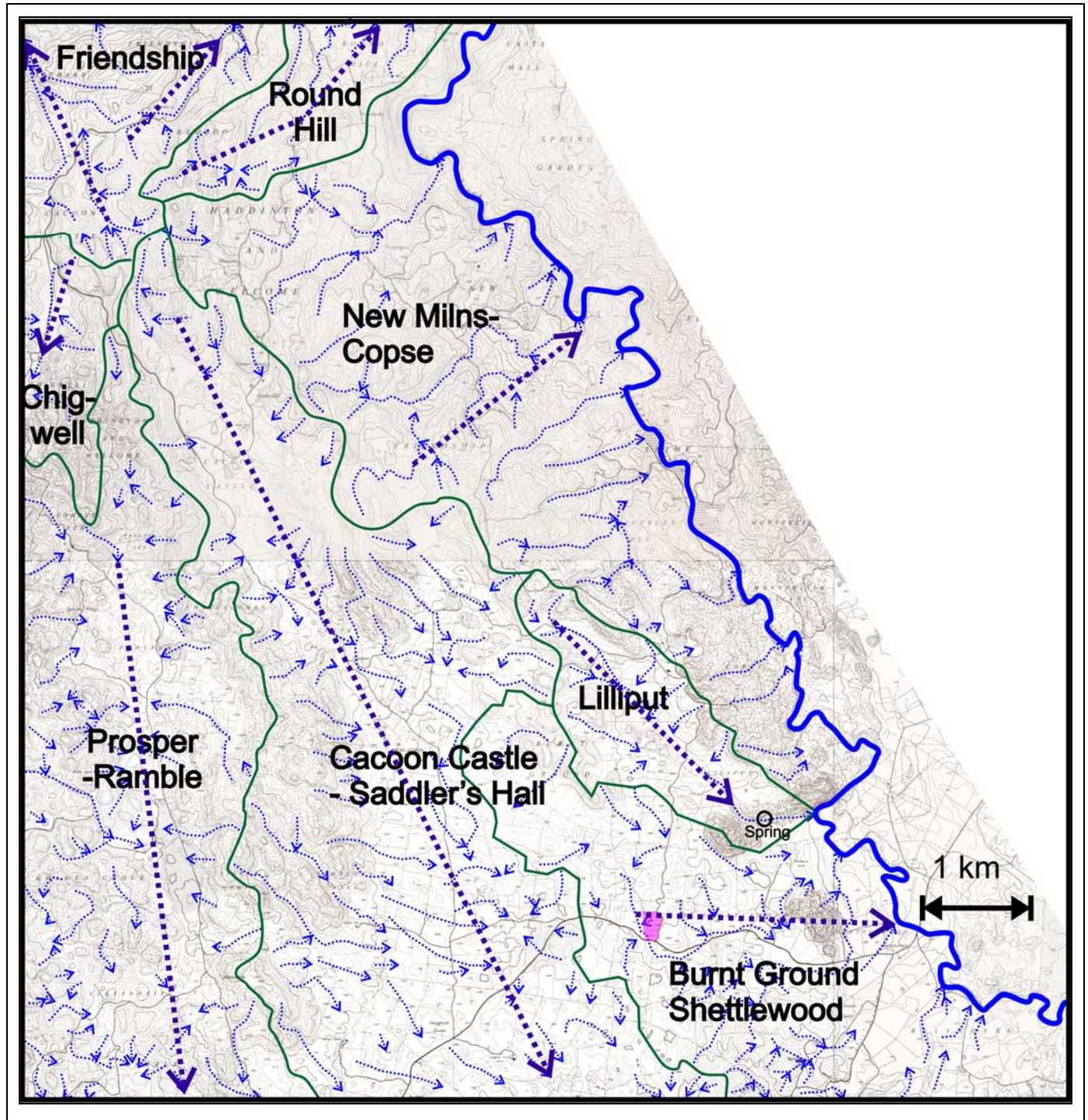
The physiography of the land can be expected to play an important role in the development of drainage. The major controls on the development of surface drainage include lithological variations, regional slopes, bedding, joint patterns and faulting. As these same factors are expected to influence groundwater flows very strongly as well, it is expected that the surface drainage pattern will reflect the underground water flows.

Figure 20 shows the regional surface hydrology based on the interpretation of the contours on the 1:12,500 Ordinance Survey map series. Surface drainage west of the Great River Basin is taken into account, and eight sub-basins are identified. The site is shown in pink shading.

These include:

- Two north draining sub-basins (Friendship and Round Hill).
- One east draining sub-basin (New Milns-Copse), the tributaries of which empty directly to the Great River.
- Chigwell (which drains to the south-west).

Figure 20 Regional Surface Hydrology



Solid blue line on right represents the Great River.
Dashed blue lines represent surface drainage pathways.
Darker blue dashed line indicate net flow directions.
Green lines represent basin divides.
Site shown in pink.

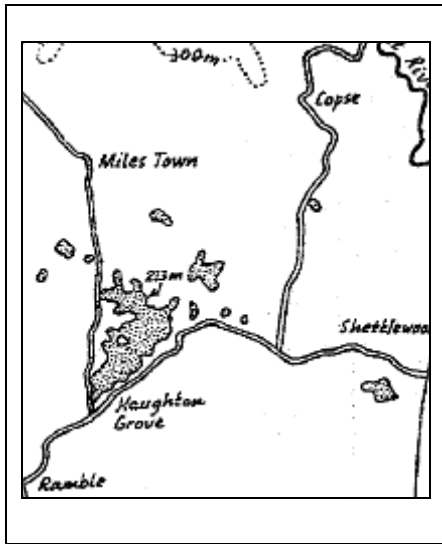
- Four sub-basins that drain to the south or south-west before eventually meeting the Great River include: a/ Prosper-Ramble (PR), b/ Cacoon Castle – Saddler’s Hall (CCSH), c/ Burnt Ground – Shettlewood (BGS). The upper catchment of this sub-basin drains towards the pond on the site, and the adjacent roads, and is shown in yellow in Figure 20. d/ Lilliput. This sub-basin is thought to be the main recharge basin for the Shettlewood spring, and does not receive surface flows from the adjacent BGS sub-basin. Although some of these sub-basins contain sink-holes, they also transmit considerable surface flows particularly during storm events. Sink-holes are typically considered to be indicative of well-developed underground drainage. However, the sinkholes observed in the area are clay-lined and pond water during storms. Most appear to retain ponded water over perched aquifers. These ponds are likely to be interconnected mainly by overflow rather than underground conduits. Underground flows within the basins are expected to follow the general surface flow trends.

3.1.9.2 Flooding

The WRA has reported that “*there is no history of flooding of the property and no other known flooding potential on the property as the remainder of the land is sloping and runs off to the pond*”. However, the community (through Mrs. Clarke, February 18th 2007) reported that the area experiences flooding, with the excess water from the pond on the property overflowing via a culvert under the road which empties to a drain running along the south side of the road. Mrs. Clarke and other members of the community reported that drain eventually empties into a large sinkhole located immediately west of the playing field near the Shettlewood Baptist Church. It was reported that the worst flood event in recent history occurred after the June 1979 flood rains.

This event was well documented by a special edition of the Journal of the Geological Society of Jamaica (1981). Approximately 443 mm of rain was recorded at Montpelier for June 12th 1979, and was calculated to be the equivalent of the 1 in 150 year event for the Mount Peto, Shettlewood and Cascade areas of Hanover (Blake, 1981). The 1 in 150 year event is an indicator of the rarity of the rainfall event. The term “*150-year storm event*” means that it is unlikely that there will be more than one storm of this magnitude in 150 years, or that there is less than a 0.007% chance that such a storm could occur in any given year. This storm event resulted in the formation of a lake at Haughton Grove. At least six other notable lakes formed during the June 1979 floods, including Newmarket, Exeter/Enfield, Townhead, Haddo, Cambridge, Chigwell. There is no evidence to suggest that these lakes were in any way interconnected.

Figure 21 Sketch of June 1979 Lake



According to Dr. Eyre's interpretation (Eyre 1981), more than one month after the rains fell, and a lake of ~ 107 ha persisted at Houghton Grove. His sketch map is given as Figure 18, which shows in stipple the location of that lake. The project site is located at the corner between the main road and the road to Copse. Dr. Eyre concluded that the Houghton Grove lake was "probably formed on a perched water table". The former lake area occurs in a shallow clay-lined enclosed karstic depression, which is likely to form a perched water table. The fact that the lake remained even after one month after the flood rains suggests that the area does not drain very well.

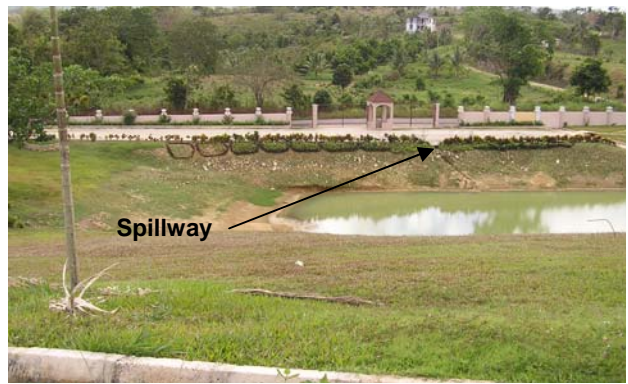
The proposed burial site was not flooded during the 150-year storm event, supporting the conclusion of WRA that the site itself is not flood prone. This is not to dispute the experience of the community that the area in general is prone to flooding.

Observations of the pond over the past rainy season indicate that the pond water could reach the spillway that drains to the main road (approximately 30 cm below road level) during the rainy season, and therefore drain off the property. Observations in the dry season support the view that the pond does not drain freely to the underlying bedrock.

Figure 22 Photos of the Pond on the Property



December 2nd 2006



March 12th 2007 – there is ~ 3 m difference in water level.

Based on site investigations, literature review and interpretation of map and satellite imagery, this study draws the following conclusions in respect of the flood potential:

- The areas indicated to be karstic terrain on Figure 11 above, may contain clay-lined karstic depressions, which would pond water during heavy rains. Although the secondary porosity of the underlying limestone bedrock may be well-developed, thick clay soils with low infiltration capacities preclude efficient draining of these areas.
- Flooding in the area also tends to occur along impervious surfaces such as roads and paved areas.
- The pond to the front of the property collects water from the surfaces within its catchment (See Figure 20). This shallow pond was deepened by the landowner to better accommodate storm flows from the roads and adjacent pond (Figure 23). A culvert that takes overflows from the pond to an earth drain across the main road. This drainage pathway leads directly to the Great River as shown on Figure 20. The depth of the excavated pond is estimated to be 5 m (up to spillway culvert), and its area is estimated to be 4000 m², giving an estimated storm water retention capacity of 20,000 m³.

Figure 23 Photos of the Pond on the Property



Photo taken on March 27th 2005, from the parking area looking south toward the pond, with the main road in the background.

Photo taken on March 26th 2005, showing the excavation of the pond.

3.1.9.3 Groundwater

Percolation: percolation tests (Appendix 5) were conducted on the site to better evaluate how water might make its way into the backfilled grave space from the surface, possibly interact with the interred remains, and then enter the undisturbed soils at below the grave. It was concluded that: *“the percolation patterns exhibit no unusual or unpredictable behaviour given the nature of the site’s colluvial soils; and all indicate a relatively uniform rate over the longer term within a narrow range”*.

Perched groundwater was encountered at 2.65 m to 3.0 m below the surface in Pit #7; below this level the soil was dry. This pit contained the most clayey soils, and was associated with the lowest drainage point on the central drainage line, and a clear change in the vegetation type. Drainage here appears to be severely retarded, with surface ponding occurring during heavy rainfall.

Regional Water Table: hydrographic analysis (Appendix 5) of the nearest wells (Jamaica Dairy products and the Cornwall Dairy) suggests that the piezometric surface in each well fluctuates between 6 to 9 m annually, and represents confined aquifer conditions. It is likely that the regional aquifers responded fairly to rainfall events. However, the extent to which these conclusions apply to the Burnt Ground area is uncertain. These wells are located on the northern side of the basin, and may have been drilled through a different part of the limestone succession than occurs at the site. Based on available data it is likely that the regional groundwater level is greater than 16 m below ground elevation in the area of the cemetery site.

The aquifer may be primarily recharged through discrete areas (perhaps outcrops) or pathways (perhaps dolines). Much of the aquifer does not receive diffuse, regionally infiltrated rainwater. The presence of the thick colluvial soils generally in the district seems to support the idea that there is no widespread infiltration effect, and it is possible that this acts as a confining layer for the aquifer – thus causing elevated pressures. Accordingly, the cemetery site development is expected to have no impact in this matter.”

Flow to the Shettlewood Spring: Structural analyses of the lineations in the topography suggest that there are two dominant trends NW-SE and NNE-SSW, with possibly two minor trends closer to E-W and N-S. The strikes of the faults in the west seem to suggest a significant lateral shear component. He further concluded that there may have been more than one stage of structural disruption which is likely to give rise to a complicated hydrostratigraphy. There is no obvious direct connection of the site to the Shettlewood Spring, and no evidence to suggest that the groundwater gradient is towards the northeast. Surface flows in the area move to toward the south-east, and then westwards to the Great River. However, based on the limited available information (site elevation of 205 m, elevation of the spring at 150 m, regional water table at the site of ~25 m, and the distance of the spring of 2.1 km) it is speculated that the maximum regional water table (if it were to exist in this manner) has a hydraulic gradient of 0.0143.

The site itself shows no evidence of extensive underground conduit flows, and is affected by the presence of thick regolith. Adjacent limestone hills (road to Copse) show a dense unweathered limestone. Based on assumptions about the hydraulic conductivity at the site, and Darcian flow, it was calculated (Appendix 5) that the minimum travel time for the distance between the site and spring would be of the order of 140 years. It must be emphasized that this is a simplistic model based on very general knowledge of the nature and hydraulics of the regional groundwater system.

The unlikely pathway of any infiltrated water molecule at the site to the Shettlewood spring would be extremely tortuous and long. It will be longer than the 141 years above because it must move through the deep soils to the watertable. The dilution which would occur when factoring in concomitant infiltration and percolation over the 2100 m distance would be extremely large so as to render the likelihood of tracing such a molecule pathway nonsensical.

3.2 SOCIO-ECONOMIC ENVIRONMENT

Socio-economic data to support the Environmental Impact Assessment (SIA) were collected through:

- Reconnaissance of the site and adjacent areas;
- Interviews with and socio-economic survey among local stakeholders;
- Telephone interviews with personnel of relevant government agencies and service providers;
- Analysis of National Population 2001 Census Data for the EDs shown in Figure 24 below;
- Documentary research of information from government institutions, such as, the National Environment and Planning Agency (NEPA), Ministry of Education, the Jamaica Tourist Board, the Social Development Commission and the Statistical Institute of Jamaica; and
- Review of Traffic Count data sets.

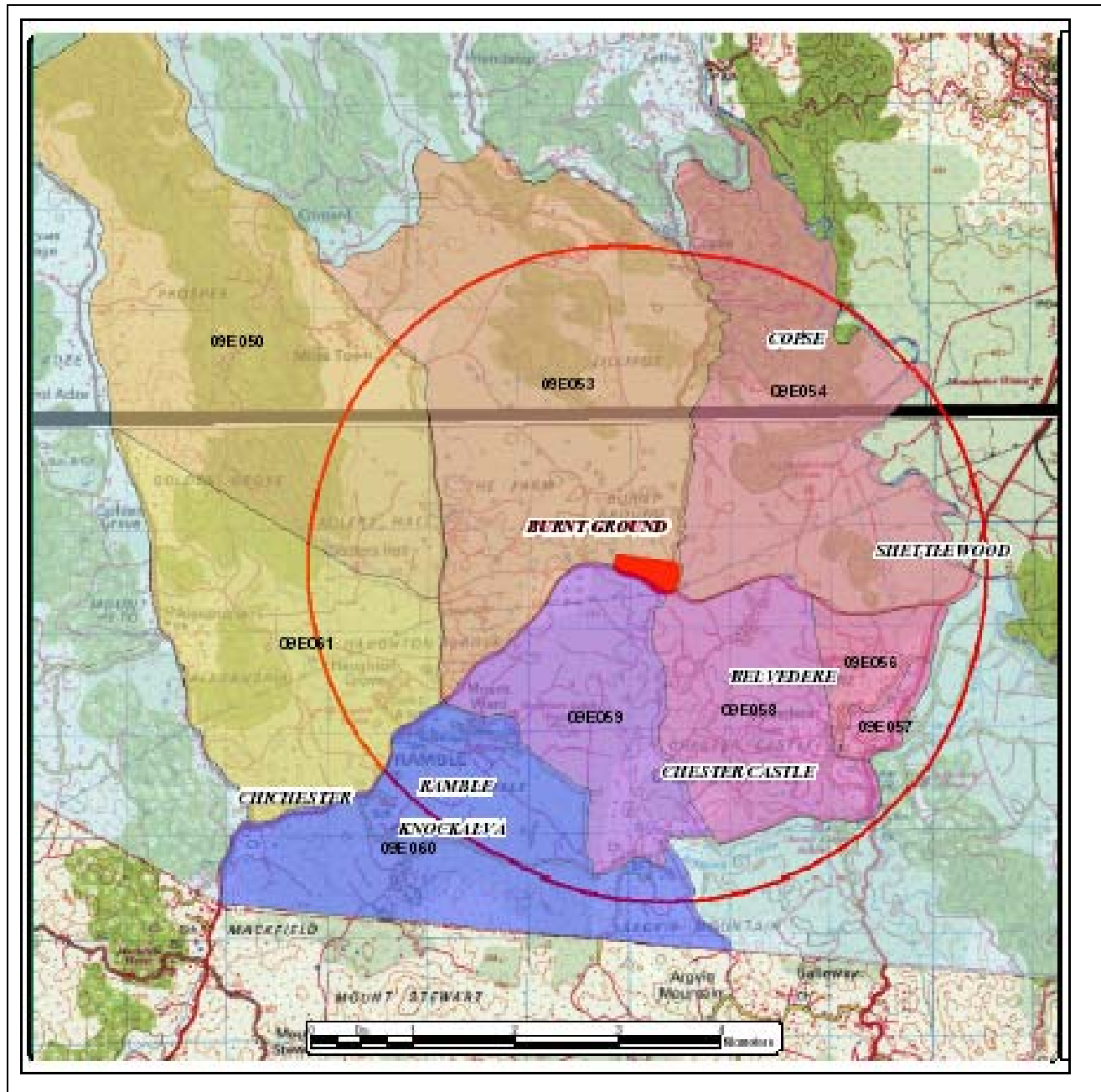
3.2.1 Demographic Profile

In the 2001 Population Census the enumerated population of Hanover stood at 67,037 in contrast to the 1991 population figure of 66,108. Between the two census periods (1991 and 2001) Lucea had a population increase of only 95 persons, increasing from 5,967 in 1991 to 6,062 in 2001 (Table 16). Over the period 1991-2001 the annual rate of population growth for Jamaica was 0.9 per cent, in contrast to the very low growth rates seen in Hanover and Lucea (0.14% and 0.16% respectively). Using this rate of growth, it may be projected that the population of Hanover may be close to 75,000 by the year 2015.

Table 16 Comparative population change 1991 – 2001

Location	1991	2001	Annual Growth Rate %
Hanover	66,108	67,040	0.14
Lucea	5,967	6,062	0.16
Ramble	2,034	2,024	-0.049
SIA area (includes Ramble)	4,714	4,739	0.052

Figure 24 Study Area for Socio-Economic Baseline



The very low growth rate may be due to out migration to other parishes for jobs or other opportunities. Between 1991 and 2001, 5,151 persons migrated from Hanover to other parishes, most migrated to St. James (1,848) and Westmoreland (1,266). During this same period, 4,344 person migrated to Hanover, the majority were from St. James (1,337) followed by Westmoreland (1,004). In 2004 the crude birth rate stood at 17.6 % and the crude death rate was 6.3 % (Ministry of Health, Annual Report, 2004). The national death rate is 6 per 1000 (Williams, PIOJ pers. Comm.), or 1,090 and 414 deaths in St, James and Hanover respectively.

The following are general observations of available demographic data:

- Approximately 55%² of the population was between 15 and 64 years;
- In 2002 the dependency ratio for Hanover was 82 people per 100 working population, which was better than the national average of 72;
- The ratio of men to women is roughly 1:1;
- The parish is largely rural (more than 90% of the population is classified as rural);
- At the end of 2002 the average unemployment rate was 24% in Hanover, in contrast to the national unemployment rate of 15%). This study (survey of nearby communities) found a local unemployment rate of 20%;
- Of those employed, a third earned less than 20,000 per month; and
- In 2001, the total number of households and dwelling units in Hanover was 20,283 and 19,867 respectively giving an average person per dwelling of 3.4.

3.2.2 Municipal Burial Capacity

There are fifteen (15) public cemeteries in St. James (see Appendix 8), four (4) of which are operated by the Council (Pye River, Barrett Town, Adelphi, Content). The Pye River Cemetery which is the largest (8 hectares/19.77 acres) has almost exceeded its capacity. The private cemetery at Sign, Orange, St. James was established in 2003 to meet the anticipated demand in the event that the Pye River Cemetery is closed in the short-term. Since the development of the Sign cemetery a few persons from the community were employed as watchmen or grave diggers, and there has been no significant impact on traffic flows during burial ceremonies as the site is secluded and far from residential or other developments and the volume of traffic along the road is usually high, especially those heading towards Montego Bay. During the construction (Phase II) of the development there was some opposition to its development by persons in the community, however, with time they have accepted it (Sgt. Dawkins, pers. comm, 2007).

There are eleven (11) cemeteries in Hanover which are owned by the Parish Council. These range in size from 1.5 acres to 7.5 acres (0.60 to 3.03 hectares). Reportedly five (5) are within or close to the area: Haughton Grove (with as many as 20 burials per year), Knockalva, Content, Burnt Ground and New Milns-Ramble). The cemeteries range in size from 1.5 acres to 2.5 acres (0.6 to 1 ha). These cemeteries have considerable capacity still (with the highest percentage used thus far being 30%). The only cemetery within the parish that has exceeded its capacity is the Sandy Bay Cemetery. The Lucea and Hopewell cemeteries are at 85% of their capacities (Appendix 9). In addition to the parish council cemeteries, burials are conducted at church yard cemeteries in the area (Mount Ward Church, St. Mary's Anglican Church and All Saints Anglican Church).

² Jamaica Survey of Living Conditions: Parish Report, 2002 (PIOJ, 2002)

3.2.3 Health

In Jamaica in 2002, the leading causes of death (ranked by deaths per 100,000 population) were cerebrovascular disease, heart disease, diabetes and homicides. Women were more disposed to die by cerebrovascular disease and diabetes while men were at a significantly higher risk from heart disease and homicides. Other than the traditional diseases, the HIV/AIDS pandemic and violence have had a negative impact on the death rate. Over the period 1982-2006 the total of 1,034 deaths from HIV/AIDS in St. James represented the second highest number of deaths by parish. In respect of violence-related deaths, Montego Bay experienced to highest number of homicides within the parish during 2005.

The Noel Holmes (NHH), Hanover and Cornwall Regional (CRH), St. James hospitals are two of four hospitals that fall within the Western Regional Health Authority (WRHA) serving Trelawny, St. James, Hanover and Westmoreland. Table 17 shows that in 2005 at the Noel Holmes (Hanover) Obstetrics, Diseases of the Circulatory System, Nutrition/Endocrine and Diseases of the Respiratory System were the leading categories of diseases by rate of discharge. On the other hand, at the CRH, the major diseases were similar except in the case of Accident and Injuries and Diseases of the Respiratory System. Infectious and parasitic diseases ranked the lowest at both hospitals.

Table 17 Rate of Discharges (2005)

Illness	NHH	CRH
Obstetrics	617	3591
Accidents and Injuries		1152
Diseases of the Circulatory System	151	1111
Nutrition / Endocrine	69	800
Diseases of the Respiratory System	42	759
Neuro- Psychiatric Conditions	37	
Diseases of the Digestive System	36	680
Neoplasm	27	753
Perinatal Conditions		577
Diseases of Genito-urinary System	26	573
Diseases of Skin and Subcutaneous Tissues	22	
Infectious and Parasitic Diseases	19	407

Source: Ministry of Health

Compared to other parishes, there is a very low incidence of gastroenteritis (Infectious diseases Parasitic Diseases) in Hanover (approximately 300) compared to St. James (approximately 1,500) in 2003.

3.2.4 Socio-Cultural Aspects

3.2.4.1 Beliefs & Burial Practices

Belief in traditional burial practices within the area is strong as 63.3% of the survey population indicated a preference for the use of family plots compared to 30% who preferred the use of cemeteries. The conventional wooden coffins (73%) are also preferred for burials compared to metal (17%) and concrete (10%). The traditional fear of ghosts does not exist and was not found to be one of the concerns in objecting to the development

3.2.4.2 Religion

As with most rural communities, churches play an integral role within the community providing a means of socialising and disseminating information. Based on observation and information ascertained from residents, there are approximately ten (10) churches of various denominations within the SIA, they include:

- 2 Baptist churches
- Catholic
- Seventh Day Adventist
- Revival
- Church of God of Prophecy
- Anglican
- Holiness
- Methodist
- Pentecostal
- United Bible Church

3.2.4.3 Governance and Community Leadership

The Member of Parliament for the constituency is Barrington Grey for the Jamaica Labour Party (JLP) and D.K. Duncan is the Caretaker candidate for the governing Peoples National Party (PNP). Burnt Ground lies in the Chester Castle Parish Council Division where the Parish Councillor is Mr. Albert Wong (JLP). In the study area like in all rural communities, leadership is usually also vested in community leaders or elders such as the Minister of Religion, the Teacher, Post Mistress, business persons, such as, the large property/estate owner, the grocery shop/supermarket operator and like persons of prominence in the community. The majority of respondents (83%) indicated that they vote.

3.2.5 Quality of Life Indicators

3.2.5.1 Housing

Home ownership within the parish was found be high in 2002, (STATIN, 2001), with 84% of dwellings being owned by the head of the household. This was consistent with the survey conducted for this EIA, which found that 86% of interviewed respondents (heads of households) owned their dwellings. Outer walls of 70% of all dwellings were wood, 19%, block and steel and 3%, nog (STATIN, 2005). The average size of most dwelling units within the parish (2001 national census) was in the range of 1-3 bedrooms.

3.2.5.2 Water Supply

In the study area 85% of the 1306 households reported (2001 Census) having access to public water supply, which is in contrast to the 46% of the total number of households in the parish that reported access to public water. Almost half of those (47%) with access to treated water had water piped either directly to their homes or to their yards, whilst the remainder had access to stand pipes. Only 6% reported using primarily catchments, rivers or springs (untreated water).

3.2.5.3 Sewage Disposal

The dominant (55%) means of sewage disposal for Hanover was pit latrine in 2001, compared to the national average of pit latrine usage of 10%. Numerically, this represented the 20,283 households in the parish including the 11,157 which used pit latrines, 27.7 % (3,093) of which were shared (STATIN, 2003). In the study area, 57% of 1257 households reported using pit latrines.

3.2.5.4 Solid Waste

Of the 150 persons surveyed, 81% reported burning their garbage as the main means of disposal. Six of the nine EDs had reports of garbage collection. Some dumping of garbage in open areas is also reported by a few (less than 6% in three of the EDs).

3.2.5.5 Proximity to Urban Centres

Urban centres are classified as regional centres, parish capitals, main towns and other towns. Lucea, the administrative capital, is the largest town in Hanover followed by Hopewell (4,759), Sandy Bay (2,817), Green Island 1,459, Dias (1,437) Cascade (866), and Negril (194) (STATIN, 2003). Other towns in the parish include March Town, Copse, Shettlewood, and Milns Town. However, in terms of the urban hierarchy, Montego Bay exerts the strongest influence on the area, being ~30 minutes away.

3.2.6 Ambient Levels of Traffic

The development is located along a Class B main road which links the area to the resort town of Montego Bay and is a primary arterial link with sections of Westmoreland and St. James (mostly Montego Bay). A traffic count was conducted by the National Works Agency (NWA) over the period Wednesday, 2007 January 24 to 30, at Burnt Ground, in the vicinity of the site (Appendix 10).

Table 18 Traffic Volumes (NWA January 2007)

	12-hour			24-hour		
	Northbound	Southbound	Difference	Northbound	Southbound	Difference
Weds	1,343	1,566	-223			
Thurs	1,655	1,731	-76	2,279	2,446	-167
Fri	1,691	1,661	30	2,406	2,551	-145
Sat	1,400	1,552	-152	2,095	2,526	-431
Sun	1,243	1,527	-284	1,861	2,305	-444
Mon	1,725	1,906	-181	2,302	2,638	-336

NWA found that over the period a total of 27,682 vehicles traversed the area, 89% of which, were Class 1 (mainly cars, SUV etc) while 5% were Class 3 (trucks, trailers etc).

The traffic volume data are presented in Table 18 below. Of greater interest to this project is the 12-hour data, which could be affected by funerals coming from Montego Bay. In general, southbound traffic (towards Westmoreland) exceeded northbound traffic (towards St. James). The lowest volumes were recorded on Sunday, and the highest were recorded on Friday.

NWA reported morning peak hours as occurring between 7:00 am and 11:00 am on week-days and between 10:00 and 12:00 am at the weekends. Afternoon peak hours varied from as early as 3:00 pm to as late as 9:00 pm, with the later peaks being on Friday and Saturday.

Traditionally, Sundays and Saturdays could be considered “funeral days” and during the traffic survey period, Sunday had the least 24-hr traffic count (4,166), followed by Saturday (2,952). However, the Sunday afternoon peak hour traffic (2.00 pm to 3.00 pm) occurred during the time period when most funerals are conducted but could be before the actual burials which tend to be later (up to 6.00 pm.) falling into the afternoon peak hour on Saturdays (5.00 pm to 6.00 pm). Impacting the use of main arterial roads is the issue of road safety and most accidents are said to occur along the Shettlewood, Ramble, Chichester and Chester Castle main roads in the area (personal communication with personnel at the Ramble Police Station).

3.2.7 Land Use

The area around the proposed site has been cultivated since the 18th Century. Consequently, much of the natural vegetation and habitats have been very disturbed. A land use map was produced (Figure 25) based on high resolution satellite imagery (Google), the 1:50,000 Ordinance Survey map for the area and field observations.

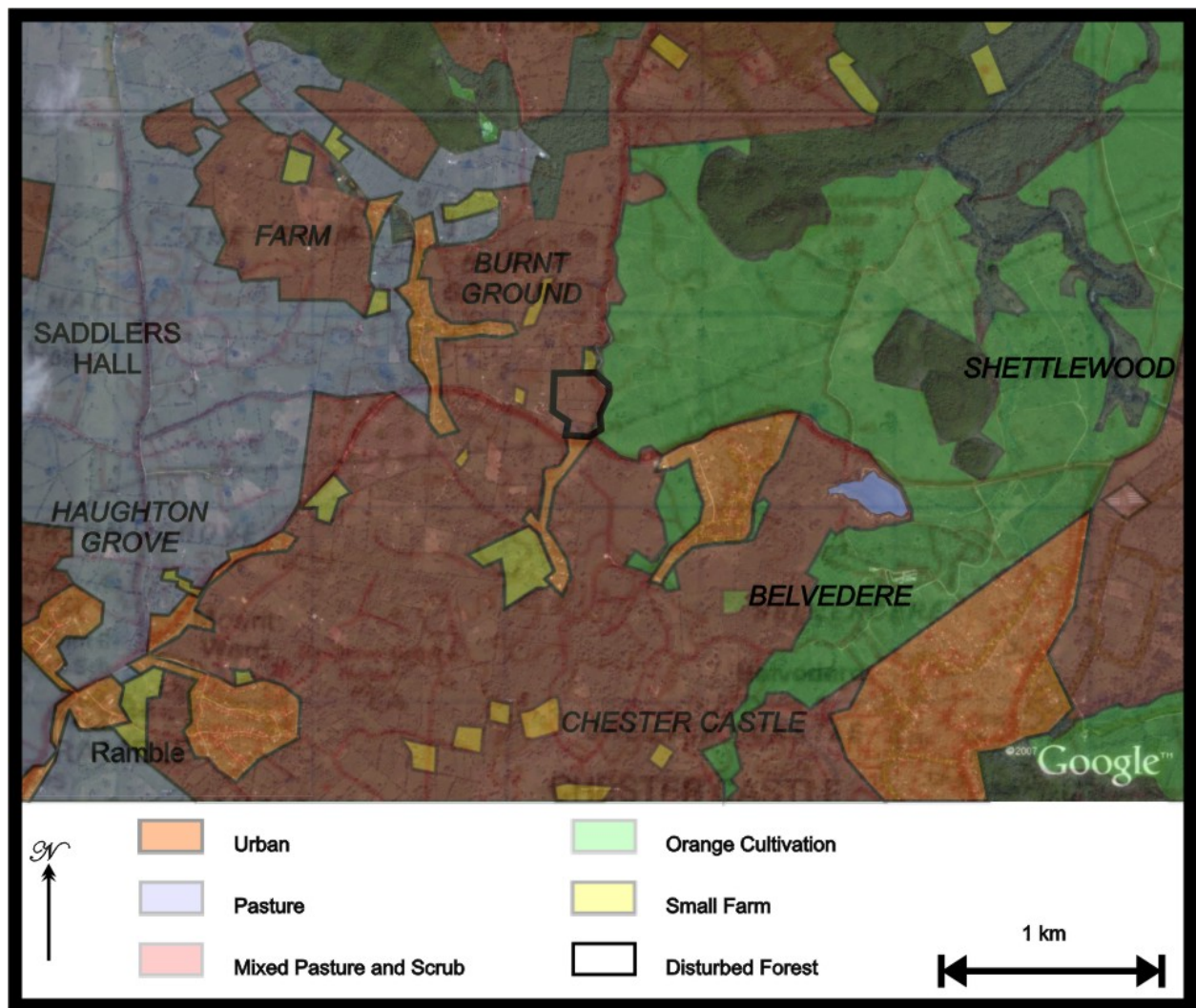
The area is predominantly agricultural, with the main land uses being mixed pasture/scrub, pasture (dairy cows mainly), orange cultivation, and small farms. One of the island's largest citrus orchards is located in this area. The property is owned by the Development Bank of Jamaica (BDJ) and occupies one thousand seven hundred and thirteen (1,713) acres (693.25 hectares).

For the 2002/2003 crop the property contributed 250,000 boxes of the four million boxes of oranges produced in Jamaica. The Montpelier Citrus Company (juice processing) is located in proximity to the orchard.

Other land uses include urban/residential and disturbed forest. The residential land uses tend to be located along the roads, whilst the disturbed forest areas are generally restricted to areas of steep slopes or along the river banks.

The site itself occurs in an area that is classified as mixed pasture and scrub. Adjacent land uses include pig and dairy farming on the western side and orange cultivation on the eastern side.

Figure 25 Regional Land Use



4 PUBLIC PARTICIPATION/CONSULTATION

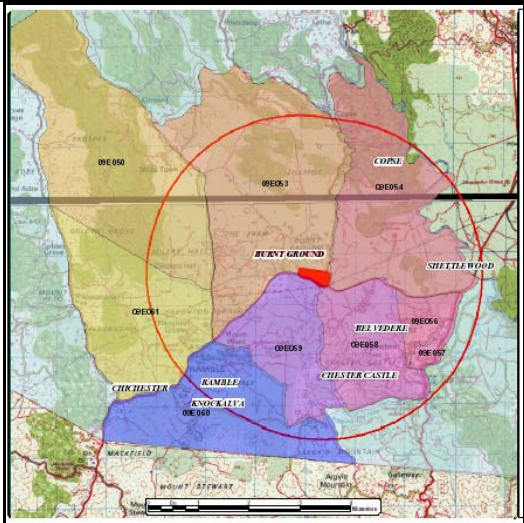
4.1 APPROACH AND METHODOLOGY

4.1.1 Questionnaire Survey

A survey of 150 house-holds within a 3-km radius of the site is scheduled for completion by February 23rd 2007. The survey instrument comprises thirty (30) questions. Twelve of the Draft Questionnaires were pre-tested in the communities of Chichester, Haughton Grove, Ramble, Burnt Ground, Mt. Peto and Mt. Ward on 2007 January 24. The finalized questionnaire is included as Appendix 10. A total of one hundred and fifty households (150) within a three kilometre (3 km) radius of the site will be surveyed. To sufficiently satisfy this requirement, the Enumeration District (EDs) in which the proposed development falls and also neighbouring EDs were ascertained. A total of nine (9) EDs were chosen and these are shown in below. The number of questionnaires administered in each ED was proportionate to the percentage population of that ED relative to the total population. Table 19 shows that the survey was administered to representative proportions of the total population in the impact area.

Table 19 Number of Questionnaires administered.

ED	ED Population	% Total Population	Equal Proportion of 150
E050	102	8%	12
ER053	137	10%	16
ER054	86	7%	10
ER056	179	14%	20
ER057	199	15%	23
ER058	167	13%	19
E059	91	7%	10
E060	224	17%	26
E061	121	9%	14
	1306	100%	150



4.1.1.1 Meetings and Discussions

Two public meetings were held thus far. This first meeting was scheduled for February 2nd 2007. The Work Plan (circulated to stakeholders) indicated that the first public meeting was scheduled to be held the week of January 29th, with venue and time to be advised. The venue and time were advertised in the Gleaner the day before, and in the communities on posters two days before the meeting. Although reasonably well attended, community representatives objected to the short notice, and refused to allow the presentations to be made.

Based on this experience and discussions with individuals, it was concluded that persons holding opposing perspectives to those of the community group were too intimidated to attend a public meeting. Consequently a true “public meeting” where all stakeholders were likely to attend could not be held. Alternatively, a focal group meeting was held on Sunday February 18th 2007. At this meeting various members of the Ramble Community Development Committee (CDC) gave presentations on the controversy, and the earthquake and flood history of the area. The community members also had an opportunity to state concerns they would like to see addressed in the EIA.

A third meeting is planned for Sunday April 22nd, the full Verbatim Report for which will be made available for public review.

4.1.1.2 EIA Document Availability

From Monday April 2nd 2007, the full EIA will have been available for public review at <http://www.eiacaribbean.com/cemetery>, and http://www.nepa.gov.jm/eias/Pages/curr_eia.asp (NEPA website). Hard copies will be circulated to various government agencies including WRA, NWA, EHU/MOH, ODPEM and the Hanover Parish Council. Additionally, copies will be sent to the Hanover Public Library in Lucea and the Ramble CDC for stakeholder review and comment. Stakeholders will have the opportunity to review the Draft EIA and submit their written comments on the draft to the EIA consultant before the EIA is finalized in May.

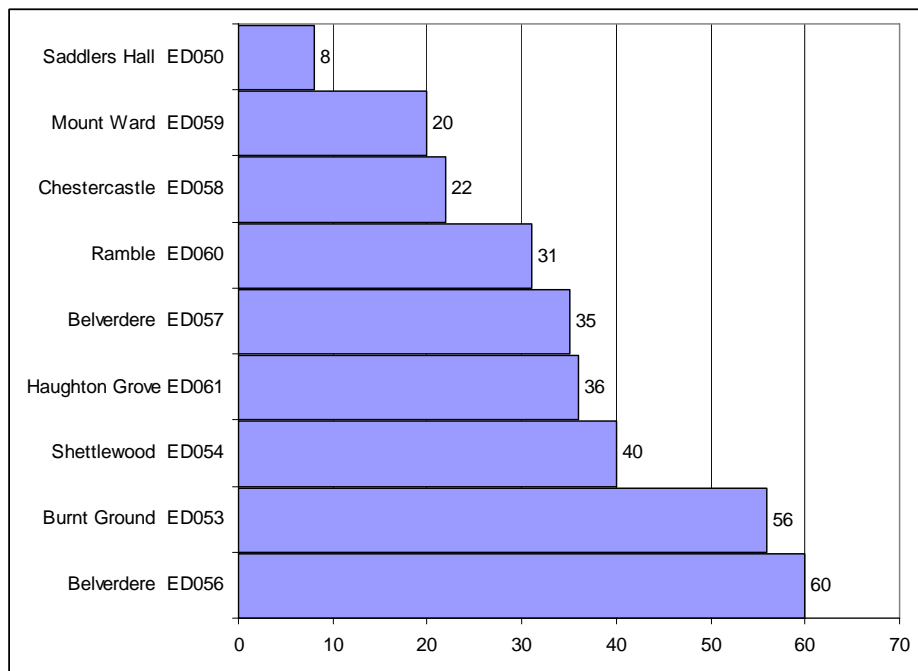
4.2 SUMMARY OF KEY ISSUES ARISING FROM STAKEHOLDER CONSULTATION PROCESS.

4.2.1 The EIA Process

At the February 18th Meeting it was indicated that there is a need to include wet season data to determine baseline water quality. Consequently, the EIA preparers have acquired and included historic wet season data from the NWC monitoring records for the Shettlewood Spring.

A concern was raised at the February 18th Meeting that persons administering the pilot survey were commenting on responses. This matter was raised with the social impact team, and the practice discontinued for the administration of the remainder of the survey.

When asked whether they would accept the conclusions of the EIA if they were contrary to their present opinion, 64% (96 persons) of the 150 respondents indicated they would not. This is an important statistic because it indicates how open people are to finding out the results of the impartial scientific evaluation. Figure 26 shows the willingness to accept the EIA broken down by community.

Figure 26 Willingness to Accept the EIA by Community

4.2.2 Environmental Aspects

4.2.2.1 The Risk of Water Pollution

There is a concern about the potential for cemetery related pollutants such formaldehyde to contaminate the Shettlewood spring. The majority of respondents (81%) felt that there will be a significant effect on the potable water supply and by extension on their health arising from the cemetery development. Another 13% felt there would be negative effects on public health. Strangely, only 15% of the respondents indicated they would like the EIA to determine whether the cemetery would actually affect the water supply. This concern has been addressed in the risk assessment study, with significant information being provided by the expert in respect to formaldehyde and the potential to impact on the spring. The issues of the possible effects of flooding and earthquakes on the risk of groundwater contamination have also been raised in several meetings and discussions with the community. These issues have been addressed both in the baseline sections of the EIA and in the risk assessment.

4.2.2.2 *Perceived Benefits of the Project*

Respondents were asked to indicate whether they thought there would be any potential positive impacts of the project, including improved job and business opportunities, new resources for the community and security, more visitors, and use of land. More than two thirds of the respondents from following communities felt there would be positive impacts: Belvedere, Shettlewood, Haughton Grove, Mount Ward and Ramble.

Table 20 Potential Benefits

		Jobs	Resources	Business	Land	None
56	Belvedere	75	10	0	0	15
54	Shettlewood	20	20	10	30	20
61	Haughton Grove	64	7	0	7	21
59	Mount Ward	50	10	0	10	30
60	Ramble	35	27	0	8	31
57	Belvedere	17	30	0	0	52
53	Burnt Ground	25	13	0	0	63
50	Saddlers Hall	8	28	0	0	64
58	Chester Caslte	17	0	0	0	83

4.2.2.3 *Level of Objection to the Development*

Persons were asked, to rank how opposed to the cemetery development they were on a scale of 1-10, with 1 being the least and 10 being the greatest. Surprisingly, only 58% indicated a value greater than 5. When asked to rank their level of concern about the development, 68% indicated a value greater than 5. Surprisingly, only 30% of the respondents objected to other existing cemeteries in the area. Half of those objecting cited the All Saints Anglican Church Cemetery.

5 ANALYSIS OF ALTERNATIVES

The purpose of this section of the EIA is to examine feasible alternatives to the project and highlight the benefits of the project that need to be considered against any potential environmental costs. It outlines in a balanced way, the wider societal benefits of the development proposal that could arise if the environmental permit is granted. Feasible land use options are compared in terms of lowest costs and most benefits criteria: environmental impacts, social acceptability, economics and design feasibility.

5.1 DESCRIPTION OF OPTIONS CONSIDERED FEASIBLE

5.1.1 Proposed Use (Cemetery)

This option includes the development of cemetery facilities (as described in Section 1) and the eventual population of 1,215 vaults. This is a permanent land use and is expected to become a permanent part of the physical landscape. There have been public outcries against the establishment of a cemetery at this site, arising from fears of ground and surface water contamination by burial related pollutants (formaldehyde) or the facility's sewage treatment plant, and the perceived risk to the Shettlewood Spring. The findings of this study do not support the perception that the cemetery poses a contamination risk to the groundwater and surface water resources in the area, or that there are any significant negative environmental impacts that cannot be cost-effectively mitigated.

5.1.2 No Action

If this option is selected, the development of the cemetery would not proceed. This alternative would allow the site to remain under pasture. Historically, the area appears to have been predominantly agricultural (orange orchards to the east and animal farming in most of the region). The main environmental impacts of this would be:

- There would be a loss of opportunity to provide additional urban burial spaces within a cemetery. There would still be a need in the near future to find environmentally sound sub-urban burial grounds for the city of Montego Bay.
- There would be lost opportunities in terms of potential increases in land values of surrounding lands, and earning opportunities arising from a sub-urban cemetery be located there (jobs, demands for local goods and services).
- There would be costs associated with fully restoring the site (removal concrete vaults, parking lot, access roads and sewage treatment plant already constructed).

5.1.3 Sub-Urban Residential Land Use

The development of a sub-urban housing project on the site is considered a relatively feasible option for this site. Such a development could offer medium to low density residential lots (~36 lots at 1/3 acre).

This option would utilize the development of the land thus far (landscaping, fencing and gate, sewage plant), and would represent productive land use. It would also bring earning opportunities (temporary construction jobs, and more permanent domestic jobs such as helpers and gardeners). Such a development would not be very compatible with the adjacent pig farm, but would definitely improve regional land values.

This would involve the following major environmental considerations.

- During the construction phase, there would be construction related environmental impacts: heavy vehicular traffic, nuisance noise and dust, domestic wastes from construction camps, transportation and storage of construction materials etc.
- There would be more sewage production (assuming a population of 150 persons) and the sewage treatment plant capacity would have to be increased to at least 2500 gallons per day, resulting in an even greater perceived threat to groundwater.
- Utilities demand: water, electricity, telephones, etc.
- Increased demand on municipal resources of the parish of Hanover for road maintenance, schools, health care and emergency services for persons working in the parish of St. James.
- The same level or increased amounts of impervious space will be created (depending on the average square footage of residences). This could lead to increased levels of run-off to the pond, and less capacity to receive run-offs from the roads.
- Commuter traffic: instead of 2 funeral processions per week, there could be at least 36 more vehicles commuting to Montego Bay on a daily basis, this will lead to associated impacts of increased congestion, noise, and vehicular emissions.

5.1.4 Animal Farm

Under this alternative, the site would be developed into a pig or dairy farm, and would be very consistent with the land use to the west of the site. Hypothetically, this would involve rearing and feeding of the animals and maintenance of pens. Although the traffic impacts will be considerably reduced, there would other environmental impacts such as:

- Nuisance odours and noise from the farm.
- Similar potential for perceived groundwater contamination from pathogens and nutrients related to animal faeces.

- Greater demands on water supply than the cemetery.
- No significant increase in land values.

5.1.5 Extension of Orange Cultivation

Under this alternative, the orange orchard to the east of the site will be extended to include the site. The environmental effects could include:

- Similar potential for perceived groundwater contamination from pathogens and nutrients related to animal faeces.
- Greater demands on water supply than the cemetery.
- No significant increase in land values.
- Traffic related to transportation of produce.
- Inputs of fertilizers and pesticides, which would also represent a perceived threat to ground and surface water resources.

5.2 COST-BENEFIT ANALYSIS

The five land use development options outlined above are compared in terms of most benefits and least costs using a range of factors or normative criteria given in Table 21 below. This approach tries to evaluate the economic, technical, social and environmental consequences of each option. These options are compared using a simple ranking system in relation to the normative criteria. A rank of number 1 indicates that the option is best suited to satisfying the normative criterion, and a rank of 5 indicates that the option is least suited to satisfying the normative criterion. The option scoring the lowest total score may be regarded as the most suited overall.

Table 21 Ranking of Most Benefits and Least Costs Criteria

		Cm	NA	RU	AF	OF
1	Highest economic yield land use	2	5	1	3	3
2	Most earning opportunities for communities	2	5	1	4	2
3	Best effects on land values in the area	1	5	1	4	4
4	Most preservation of green space	3	1	5	4	1
5	Best meets wider societal needs and economics	1	5	2	3	3
1	Least use toxic substances, pathogens and nutrients	4	1	3	2	5
2	Least change to land surface and drainage	3	1	5	2	3
3	Least traffic impacts	4	1	5	2	2
4	Least implementation costs	4	1	5	2	2
5	Least public outcry	5	1	3	3	2
	Total	29	26	31	29	27

Cm = Cemetery NA = No Action RU = Sub-Urban Residential Use AF = Animal Farm OF = Orange Farm

Based on these criteria, the “no action” alternative scored the lowest (26 points). However, no use is not necessarily the best use for the land, especially from the perspective of the landowner. To be able to implement this option, the government would have to purchase the lands, and compensate the landowner for his investment in his property thus far.

The next options would be putting the area under orchard farming (27 points) or animal farming (29 points), both of which are consistent with adjacent land uses. These would have the following implications:

- As the landowner has no expertise in this business, he would have to sell the land; and the orange or the pig farm would have to be willing to expand.
- There would still be environmental issues related to pesticide and fertilizer use or sewage contamination.

The next alternative to the cemetery would be the residential land use, which scored the highest, suggesting overall least satisfaction of the range of most benefits and least costs. The cemetery, although having the greatest level of public outcry, would have less environmental impact than a residential development, and would be most consistent with the landowner’s expertise and economic rationale.

6 POTENTIAL IMPACTS

6.1 IMPACT IDENTIFICATION

The purpose of this task is to identify the major environmental and public health issues of concern and indicate their relative importance to the design of the project and the intended activities. Both positive and negative project impacts are identified using the following methods:

1. Stakeholder consultation.
2. Technical inputs from environmental specialists on the EIA team, and technical reports already completed in connection with the site.
3. Review of the possible impact-causing aspects of the project.
4. Review of environmental assessments done for similar projects.
5. Regulatory criteria governing aspects of the environment likely to be impacted.
6. The sensitivity of valued environmental components (VECs) likely to be impacted by the project.
7. Review of the risks arising from the project and the range of environmental consequences that could arise under upset conditions.

6.2 METHOD OF IMPACT ASSESSMENT

Each identified impact will be assessed using the following criteria:

1. **Spatial Extent**: this refers to the magnitude of the adverse effect in terms of the geographic extent of influence arising from frequency and magnitude of the causative action. This allows higher assessment of impacts with a wider sphere of influence. This criterion was recommended for use in impact assessment by FEARO (1994), Hurley and Ellis (2004), DEAT (2002), UNEP (2002) and Rossouw (2003). To some extent this relates to the "Context" parameter of Canter and Canty (1993), which also included time scale. Where there are distance decay functions in terms of the intensity of the impact with respect to distance from the impact cause, this is identified under this section.
2. **Ecological Scale**: this considers the number of individuals (organisms, people etc.) from a valued population or the percentage of a habitat that stands to be impacted. This parameter can refer to indicator species or general receptor populations. To some extent, this parameter relates to the discussion of "intensity or severity/magnitude" advocated by UNEP (2002), DEAT (2002), Hurley and Ellis (2004) and further discussed in Rossouw's (2004) review of impact assessment criteria.

3. **Secondary Effects**: This parameter looks at the impact as a trigger mechanism for other effects, particularly those manifesting downstream of a pathway emanating from a project component. Latent effects that could occur in the future, such as bioaccumulation of heavy metals in the food chain, or effects on future generations are considered by this criterion. This criterion is herein suggested as a useful parameter for defining the effect level of an impact, and to some extent further relates to the UNEP (2002) parameter of “intensity or severity/magnitude”. It also precludes the need to characterise the primary impact as direct or indirect as only primary impacts are assessed in the tables, and secondary impacts summarized under this criterion. The rationale for assessment of primary impacts is that if these can be effectively managed, secondary effects will also be mitigated.

4. **Resilience of the Environmental Receptor/Valued Eco-system Component (VEC)**: This criterion examines ecological resilience/sensitivity (ability of a population to cope with effect). Existing stresses and variability of sensitivity (spatial or temporal) should be considered. Resilience/sensitivity can be determined by eco-toxicological response, dose/response relationships and exposure of the population given effect pathways. Degree of loss (risk) can also be factored in terms of quantifiable amounts. This criterion relates to the “timing” criteria recommended by UNEP (2002), and the “resilience” and “ecological context” parameters discussed in FEARO (1994) and Hurley and Ellis (2004).

5. **Environmental Persistence (Temporal scale)**: This addresses the length of time an impact (and residual effects) could be predicted to continue to impact the environment. This should take into consideration the frequency and duration of the cause of the impact, as well as environmental recovery factors. In general, persistent (long-term) or frequently adverse effects are regarded as more significant. This criterion relates to the “duration/frequency” parameter discussed by FEARO (1994), DEAT (2002), UNEP (2002), Hurley and Ellis (2004) and Rossouw (2004).

6. **Effect Reversibility**: This criterion evaluates the extent to which an effected receptor can be returned to its pre-project state (reversibility). This criterion was recommended for use in impact assessment by FEARO (1994), UNEP (2002), DEAT (2002), Hurley and Ellis (2004) and Rossouw (2004).

7. **Divergence from Baseline (Baseline change)**: this relates to any model or prediction of the extent of change that can be expected. This should compare predicted levels of change with normal fluctuations as well as trends in the parameter without the effect of

the project. This criterion is herein suggested as a useful quantitative parameter for defining the effect level of an impact. Activities external to the project to which the project's impacts would be cumulative are taken into account in the examination of the baseline, as well as divergence from the baseline that might be expected to arise from project implementation.

8. **Manageability**: This addresses the ease to which feasible measures can be implemented to prevent or reduce the environmental cost ("mitigatory potential" used by DEAT 2002). It should consider the economic cost of implementing these measures, and whether there are any moderating circumstances or benefits that need to be considered given the environmental cost and the extent to which appropriate and cost effective measures can be implemented to mitigate the effects. Rossouw (2003) discusses this criterion for impact assessment. The Federal Environmental Assessment Review Office of Canada (1994) also asserts that "*no final determination can be made about the significance of likely adverse environmental effects or related matters unless the implementation of any appropriate mitigation has been considered*".

9. **Uncertainty**: This allows for disclosure of the level of scientific confidence in the predicted outcomes, and the general reliability of the data and models used to predict impacts (DEAT 2002). Although the likelihood of occurrence (probability) may be used to describe the nature of impacts, (UNEP 2002, Haugh *et al. loc cit* DEAT 2002), it is not easily applied to an assessment of effect level. It does not follow that the environmental effects arising from its occurrence will be more significant if the impact or impact-causing aspect is more likely to occur. The level of uncertainty and frequency with respect to the predicted parameters of the impact (e.g., scale, ecological scale, etc.) is taken into account under the "uncertainty" and "persistence" criteria respectively.

10. **Acceptability to stakeholders**: This examines the willingness to make trade-offs or degree of objection, given potential benefits of the project. This also includes planning constraints and scientific criteria (maximum allowable limits), and associated regulatory controls. This criterion was discussed by UNEP (2002). Sippe (1999, *loc cit*, DEAT 2002) indicated that one of the common elements in significance determination was the acceptability of perceived changes to affected communities. Canter and Canty (1993) suggested the relative importance of institutional recognition (laws, rules, standards, plans and policies), public recognition (stakeholder experience and opinion) and technical recognition (scientific judgment).

The criteria given above are used in a simple rating scale, which further defines each of the criteria, according to the four basic effect levels commonly used in EIA practice (No Impact, Minor, Moderate and Significant). These are defined in Tables 22 and 23 and are consistently applied to each of the impacts identified.

Each impact is evaluated against each of the set criteria, with the assignment of a score (based as far as possible on the available scientific data presented in the EIA), and given a score between 0 and 5. The scores ranges from less than 1 (no impact to negligible), 1 to 1.9 (minor), 2 to 3.9 (low to high moderate), and more than 4 (low to high significant). Total score is averaged out of the scores in respect of the criteria to determine the overall averaged effect level for the impact. Where a criterion is not relevant, no score is assigned, and the average calculated only on the number of relevant and scored criteria.

6.3 DETAILED IMPACT ASSESSMENT TABLES

6.3.1 Perceived Impacts of the Site Development Phase

- Above ambient levels of noise during construction (use of back hoe) etc. was considered to have no real impact as there are no noise-sensitive receptors within 100 m of the site's perimeter. The levels of noise expected will be well within the normal range to which construction workers are exposed to routinely.
- Dispersal of fugitive dust during construction was considered not be have any real environmental impact as there are no dust sensitive receptors within 100 m of the site's perimeter. The levels of dust expected will be well within the normal range to which construction workers are exposed to routinely, and will be further controlled by wetting.
- The effect of decline in visual aesthetics during completion of the project is not regarded to have any real environmental impact as most of the burial area cannot be easily seen from the main road. Also, there are no adjacent dwellings.
- Solid wastes produced by workers during the construction period will be very small and will not require any special haulage arrangements. The site is already cleared of any significant vegetation so there will not be any vegetative solid waste.

Table 22 Pre-set Impact Assessment Criteria (Negative Impacts).

	0	1	2	3	4	5
CRITERIA	Negligible	Minor	Moderate		Significant	
Spatial Scale	Effects on immediate area around source	Isolated effects. Reduction in intensity or dilution/dispersal (distance decay) to acceptable levels within site boundaries.	Localized area close to borders or offsite dispersion pathways. Distance decay to acceptable levels within a "local" distance (i.e. cannot be considered regional).		Widespread/catastrophic: offsite regional/national or global effects. Consistent intensity within the impact area.	
Ecological Scale	<0.1 % impact	< 1% population or habitat area is directly exposed or displaced	1% to 10% population or habitat disturbed or displaced. >5% disturbance should be ranked as 3.		>10% population or habitat area is directly disturbed, displaced or destroyed. More than 55% disturbance should be ranked as 5.	
Secondary Effects	None	Few. One trophic level within one generation affected.	Many. Effects felt high on food chain (more than 1 trophic level) in one generation.		Many. Future generations affected. Entire food chain impacted.	
VEC Resilience	Receptors are resilient. Located far away from sensitive areas or species.	Impact does not occur at a time when receptors are vulnerable or there are other mitigating circumstances occurring Occurs close to a buffer zone for environmental sensitive area (ESA). Nuisance but no real loss of revenue or amenity.	(Species) morbidity or public health concern. Occurs at the start or end of a period when receptor is particularly vulnerable. Interferes with migration pathways or other critical routes. Is within a buffer zone for an ESA or may impact food or habitat of an environmental sensitive species (ESS). Temporary loss of revenue or amenity, resulting in temporary adjustments; traditional/informal land use is changed.		Receptors unable to cope. Mortality or trauma in populations. Impact occurs at the peak time when receptor is vulnerable. Creates ecological or economic barriers. ESA or ESS directly impacted Loss of revenue or amenity is sustained after remedial action is taken or socio-economic activities unable to resume. Heritage resources, community lifestyle/values impacted.	
Environmental Persistence	No persistence	Short-term: hours to days before recovery occurs with no observable residual effects.	Medium Term: weeks to months before signs of recovery can be expected		Long-term: Years or impacts on a biological population over a number of recruitment cycles. Permanent damage.	
Effect Reversibility	Can be returned to original state completely with removal of structural elements.		Can be returned to a productive state with removal or change of use of structural elements.		Cannot be easily or cost-effectively returned to previous state or be re-used for any other productive purpose.	

EIA for the Proposed Cemetery Development at Burnt Ground Hanover. June 2007

	0	1	2	3	4	5
CRITERIA	Negligible	Minor	Moderate		Significant	
Baseline change	Within normal range of fluctuation	Effects are barely measurable against baseline conditions – within 1 standard deviation of the mean.	Moderate deviation from baseline conditions. Within 2 standard deviation of the mean. Contributes moderately to cumulative effects from unrelated projects.		Major deviation from baseline conditions: > 2 standard deviations of the mean. Contributes significantly to cumulative effects from unrelated projects.	
Manageability	No mitigation necessary.	Very easily mitigated. Significant opportunities for environmental enhancement or benefits.	Cost-effectively mitigated. Long-term environmental benefit.		Requires major design modification or no mitigation possible. No opportunity for environmental enhancement or no perceptible environmental benefit.	
Scientific Uncertainties	>99% confidence in the validity of the prediction of the impact parameters. Site specific model output available. No data gaps or uncertainties. Data is reliable.		76-99% confidence in the validity of the predictions. (i.e. the effect might not occur as predicted). Numeric models extrapolate data set. Application of models developed in other areas with similar conditions.		<75% confidence in the validity of the predictions. Inadequate data available for numeric modelling. Predictions based on qualitative or anecdotal evidence. Worst-case scenarios apply.	
Acceptability	No issue.	Acceptable to affected community. Complies with legal thresholds and /or best practice or wise use of resource, physical plans and land use policies.	With mitigation is acceptable to stakeholders. Affected stakeholders willing to make trade off. Approaches legal thresholds, limits or criteria or maximum allowable levels.		Public outcry. Prohibitive legislation, plans or policies. Exceeds legal thresholds, limits or criteria or maximum allowable levels.	

Table 23 Pre-set Impact Assessment Criteria (Positive Impacts)

	0	1	2	3	4	5
CRITERIA	No impact	Minor	Moderate		Significant	
Scale:		Isolated effects within project site.	Localized area close to borders or offsite dispersion pathways.		Widespread: offsite regional effects	
Affected Numbers:		Less than 1% population or habitat affected.	1-10% population or habitat affected.		More than 10% population or habitat affected	
Secondary Effects		Few indirect positive effects.	Many indirect positive affects. One trophic level within one generation affected.		Many indirect positive affects. More than 1 generation affected. Several trophic levels involved.	
Resilience:		Receptors are not able to take full benefit or benefit indirectly. Minor advantage but no real increase in revenue or amenity. Impact does not occur at a time when receptors are able to accept.	Medium term increase of revenue or amenity. Impact occurs at the start or end of a period when receptor is able to benefit.		Receptors benefit directly. Revenue or amenity is sustained after in the long term. Benefits are accessible at best time for receptor.	
Persistence:		Lasting less than a few months before recovery occurs with no observable residual effects. Related to duration of event.	Lasting from a few months to two years before signs of recovery.		Impact persistent after 2 years. Impacts on a biological population over a number of recruitment cycles.	
Baseline change:		Effects are barely measurable against baseline conditions – within 1 standard deviation of the mean.	Moderate deviation from baseline conditions. Within 2 standard deviation of the mean.		Major deviation from baseline conditions: > 2 standard deviations of the mean.	
Scientific Uncertainties		<75% confidence in the validity of the predictions. Inadequate data available for numeric modelling. Predictions based on qualitative or anecdotal evidence. Worst-case scenarios have to be applied. Numerous conditions that are likely to occur that would affect impact of benefits.	76-99% confidence in the validity of the predictions. Numeric models extrapolate data set. A number of conditions that could off-set benefits.		>99% confidence in the validity of the prediction of the impact parameters. No data gaps or uncertainties. Data is reliable. Few conditions that could off-set benefits.	

6.3.1.1 Perceived Impacts of the Operational Phase

Positive Effects

- **Economic Opportunities:** Cemetery operations do not usually create a large number of jobs as it is not a labour intensive business. The development appears to have already staffed the development with a few grounds men. There may be opportunities for gardeners or suppliers of goods. Local businesses may get some additional patronage. Because of the relatively low volume of visitors into the area (assuming a maximum of 100 per week), it is not expected that this will be a real environmental impact.
- **Land Values:** Although the visual aesthetic of the cemetery would be apparent, it is difficult to assess the effect this will have on adjacent land values. According to Zhang (2004), cemeteries generate a high net return on land, and this would be expected to be higher than adjacent uses.

Negative Effects

- **Air Pollution:** As there will be no cremation on site or open air disposal of ash remains there is not likely to be an air pollution arising from disposal of human remains. The amount of fugitive dust expected to arise during grave preparation and completion is not expected to be significantly above ambient levels and the normal range for this type of activity. The proposed sealed storage of urns on the site is not expected to produce any environmental impact.
- **Surface Water Pollution:** Members of the community have indicated the perception that there might be run-offs from the site containing blood or body fluids from the embalming process, as well as effluents from sewage disposal on site. Neither of these is likely as no body preparation will be done on site. Bodies will be prepared at the funeral home, and transported to the site in a casket for the burial. In respect of sewage effluent, a septic system and tile field approved by the Environmental Health Unit of the Ministry of Health will be in operation.
- **Flooding:** None of the proposed project activities are predicted to increase the flood risk at the site. Excavation of the pond on the property and engineered drainage will allow for improved control of run-off and retention of storm flows.
- **Safety Hazard:** Excavation and heavy equipment may pose a safety risk to communities or animals. However, in this case it is unlikely as the entire perimeter of the property is completely fenced, and the site generally inaccessible to persons not entering through the front gate.

- Demands for resources, utilities and infrastructure: Project requirements for water, solid waste disposal, electricity, municipal social amenities and emergency services are not expected to be significant, and to compete with other users in the area.

6.3.2 Predicted Operational Impacts

6.3.2.1 Soil, Groundwater and Spring Contamination from Grave Leachate

A qualitative hydro-geological risk assessment was conducted by Dr. Boyd Dent and is included as Appendix 5. He conducted a first hand inspection of the soils on the property, the surrounding area (including the spring), meetings with the funeral director and visits to existing cemeteries to observe burial practices in Jamaica.

Aside from concluding that there is little basis for a ground water connection between the spring and the site (discussed in Section 3.1.9.3), the risk assessment also determined the 100-day travel distance of ground waters leaving the site. The 100-day parameter is an indicator developed by Dr. Dent (Dent 2002) as the time after which the risk from bacterial or viral infection which might have percolated into the soil or groundwater is insignificant.

Using worst-case assumptions (moisture content etc.) and data collected from the site in respect of soil depth, texture and permeability, his model predicted that in 100 days ground water from the site would travel a maximum of 8 m, and in one year, ground water from the site would travel 30 m. It would take 3.4 years for ground water from the site to travel 100 m. He specifically concluded: *“Soil water percolation at the site – generally - is considered to be well within acceptable criteria for sanitary flow – that is, a minimum 100 travel time days from a grave and before leaving the cemetery boundary or entering possible drainage pathways.”*

The risk assessment also specifically addressed the concern about formaldehyde. Formaldehyde is also considered to be ubiquitous in almost all living organisms e.g. as an intermediate metabolite, and also from processes of respiration and is common in surface water in small amounts. It is present in rainwater up to 1-2 mg/kg (i.e. about 1 ppm). In humans it is breathed-in daily in different amounts depending whether the person is mostly outdoors or indoors (higher amounts) and their level of exposure to fires, decaying vegetation, furnishings that give off the gas, and whether they smoke. Humans typically also ingest small amounts daily in their food. The body breaks down formaldehyde in the human to methanoic (formic) acid and then ultimately to carbon dioxide and water”.

Interviews with Delapenha and other funeral homes indicated that the common practice in Jamaica is not a full visceral embalming, but replacement of a portion of the blood with embalming fluids when the casket is to be open at the funeral. The human body contains ~5 litres of blood (~1.1 gallons). According to Mr. Delapenha, bodies to be buried at Burnt Ground will typically be embalmed using a fluid called “Power 36”, which contains 36% formalin solution. Approximately 0.6 to 0.85 l of this fluid (or 307 g of formaldehyde) is used per body. Using the

information about the soils at the site and these assumptions, the model predicted that for the depth 1 m beneath the grave the concentration of formaldehyde would be 400 mg/l. He extrapolated his distance model which showed a soil linear velocity for the site to be ~8 m in 100 days, to predict a maximum possible concentration of 0.001 mg/l after 100 days for formaldehyde from 100 bodies (maximum number assumed to be interred per year).

The amount of formaldehyde that might possibly leave the individual grave space is relatively low: its rapid attenuation in the site's soils will ensure that there is an extremely low risk of it reaching any water table; the amount of risk is likely to be unquantifiable above background values. The development of the site with attention to interments in permitted areas only, suitable buffer zones and other best-practice protocols, will virtually ensure that any formaldehyde possibly percolating in the soils, for example by shallow groundwater interflows, is likely to biodegrade before reaching the cemetery boundary.

It is important to note that these models do not take into consideration the retarding effects of concrete base or other concrete vaulting. Therefore the risk assessment extends to the scenarios in which there is some level of compromise of structural integrity arising from seismic activity.

CRITERIA	ASSESSMENT	Score
Scale:	Grave leachate is not expected to exceed 10 m of the burial site within 100 days. There may be a salinity plume associated with the cemetery, with localized loading of salts and nutrients.	1
Affected Numbers:	-	
Secondary Effects	Localized nutrient loading may have a positive effect on deep rooting site vegetation.	0
Resilience	-	
Persistence:	Most of the grave products will biodegrade over time.	3
Reversibility:	-	
Baseline change	The presence of grave products will alter (and be altered by) the immediate soil chemistry significantly.	4
Manageability	Based on the models, there is no need to mitigate this by sealing the base of the graves.	0
Uncertainty	Worst case scenarios have been modelled although primary data was also collected on the soils.	4
Acceptability:	There has been major public outcry against the cemetery. However, the proposed development is not likely to exceed any international criteria or guidelines for cemeteries, and is not inconsistent with adjacent land uses or physical plans.	4
Classification:	MODERATE	1.6

6.3.2.2 Increased suspended solids in run-off

This impact can arise during the operational phase mainly when vaults are excavated in preparation for a burial.

CRITERIA	ASSESSMENT	Score
Scale:	Approximately 2 cubic meters of soil will be excavated from the vault. Much of this material will be used to fill the grave after the burial, and cover the top. A small percentage of this material may be mobilized in the event of rain. However, it is expected that suspended solids from the burial area will not leave the site. The frequency of this is not expected to be greater than 2 per week, which may not necessarily coincide with rain days.	1
Affected Numbers:	-	0
Secondary Effects	-	0
Resilience	-	0
Persistence:	This effect will only occur during rains (hours)	1
Reversibility:	-	0
Baseline change	The TSS load is expected to be very variable. Dry season data suggested a high pond load of ~18 mg/l. Run-offs to the pond may elevate this during rains to levels above the normal range. However, fines are expected to settle out.	2
Manageability	It is expected that excavation will be done in a controlled manner, and that soil will be properly managed. Bare soils should be tended and revegetated or covered.	1
Uncertainty	The likelihood of mobilization of suspended solids to the pond will vary with the coincidence burials with rain.	3
Acceptability:	Generally acceptable with implementation of proper mitigation measures	
Classification:	NEGLIGIBLE	0.8

6.3.2.3 Vermin or Pest Infestations

The developers are proposing to operate a canteen/commissary and condolence hall on property. Therefore it is expected that there might be some storage of food on property, which might attract disease vectors such as rodents and roaches.

CRITERIA	ASSESSMENT	Score
Scale:	This is likely to be very small scale as there may not be more than 2 burials a week and condolence functions only last a few hours. Much of the food is expected to be catered and transported in.	1
Affected Numbers:	The nearest human domicile to the cemetery (based on Google satellite imagery) is the owner of the pig farm, whose house is located ~53 m from the cemetery fence. The nearest settlement is Burnt Ground, which is concentrated along the roads. Based on the scale of operations, less than 1% of the population is expected to be impacted. Few permanent grounds staff may come in contact with vectors.	1
Secondary Effects	Infestations of disease vectors can lead to public health issues if not properly managed.	1
Resilience	These pests are generally just nuisances, and are fairly common in these areas already.	1
Persistence:	This effect is only persistent if it is unmanaged.	2
Reversibility:	Completely	1
Baseline change	The adjacent property is likely to store grain for pigs and therefore it is not expected that there will be any far reaching change in the baseline.	1
Manageability	This effect is very manageable with proper food storage practices in place.	1
Uncertainty	-	0
Acceptability:	Generally acceptable if managed.	1
Classification:	MINOR	1

6.3.2.4 Change in Land Use

If the project is permitted, it is expected that there will be a change in the land use from mixed farming and scrub to cemetery (urban) usage.

CRITERIA	ASSESSMENT	Score
Scale:	Based on this assessment, the major off-site extent of this land use change will be that it is visible from a western approach.	2
Affected Numbers:	Thus far members of community have objected to the location of the cemetery at this site on the basis that they believe that the facility presents a high risk to the spring, particularly given their perception of flood and earthquake risk of the area. Although this study finds that these fears do not have a sound scientific basis, it was also found that most people (two thirds) are not likely to accept the findings of the study unless it supports their original position. This represents more than 55% of the population of the adjoining EDs.	5
Secondary Effects	The change in land use is likely to produce objections from the community. These can include dissatisfaction with the political and municipal leadership. The community members in the past have demonstrated that they are not given to such behaviour as vandalism or rioting. In fact they have taken the route of legal protest, and peaceful demonstrations.	3
Resilience	Despite the objections, there are no real public health hazards, loss of public amenity or major public nuisances being created by the change in land use. The population is therefore considered to be resilient.	1
Persistence:	Once the cemetery is implemented it is expected to be a very long term change of use.	5
Reversibility:	Due to cultural taboos, it is unlikely that structural elements will be removed.	5
Baseline change	There a number of cemeteries operating within very similar conditions to this site in this area including Parish Council Cemetery in Chester Castle which is 2.6 km from the spring, the All Saints Cemetery in Chester Castle (3.7 km from the spring) and St. Mary's Cemetery (3.2 km from the spring), Parish Council Cemetery at Houghton Grove (4.5 km from the spring) and Mt Ward Grave Yard (4.9 km from the spring).	2

Manageability	Visual intrusion can be managed by creating an earthen berm along the western boundary, which also serves to ensure that surface flows between the properties are not connected. According to the social survey, the vast majority of householders in this area (80%) are educated, having completed at least high school. They should therefore be expected to be reasonable in efforts to resolve this conflict. Facilitated conflict resolution may be necessary.	3
Uncertainty	Although there is a high certainty in respect of the level of the direct impact (change of land use), the secondary impacts are more difficult to assess. Predicting human behaviour beyond statistics and historic norms is difficult and at best speculative.	3
Acceptability:	Cemetery space is an important consideration in urban land use planning for the city of Montego Bay. The model has also predicted that it is unlikely that the development will deleteriously affect water quality or public health. The proposed site is not in conflict with any national physical plans for this area. However, as discussed above, there is the issue of the unwillingness of the community to accept this particular development.	5
Classification:	MODERATE	3.4

6.3.2.5 Increased Traffic along the Main Road between Reading and Shettlewood.

As it is the intent of the developer to offer cemetery plots to urban dwelling persons who do not have access to family burial plots, it may be expected that most funeral processions will be coming from Montego Bay. It is also the norm that burials during normal day light hours, and tend to be mainly on weekends.

CRITERIA	ASSESSMENT	Score
Scale:	An average funeral procession can have ~50 cars, although this may vary with the social standing of the person being buried, as well as the size of their family. The procession will impact on the main road between Montego Bay to Shettlewood, which is a regional scale effect.	4
Affected Numbers:	At most this is expected to impact on 100 cars (assuming a maximum of 2000 vehicles moving in both directions over a 12 hour period). This amounts to an inconvenience to less than 5% of daily road users.	2
Secondary Effects	Increased traffic can have the effect of increasing normal wear on the roads, as well as increasing cumulative vehicular emissions. It also increases the traffic hazards in populated	2

	areas through which the main road passes – such as Anchovy.	
Resilience	Most road users and communities are highly resilient to the effects of moderate increases in traffic. Increased traffic is not expected to coincide with week day rush hour traffic.	1
Persistence:	However, this journey is not expected to take more than 45 minutes unless there are upset conditions on the road.	1
Reversibility:	Completely.	
Baseline change	Very minor.	1
Manageability	All drivers working with the developer should observe standard road safety. Funerals should be scheduled for off-peak hours as far as possible.	0
Uncertainty	Varies with the size and number of funerals over time.	3
Acceptability:	Generally acceptable.	1
Classification:	MODERATE	1.4

6.3.2.6 Additional burial capacity for urban dwellers

Public burial capacity is a very finite commodity in urban areas, and even more so in Jamaica, where much of the land is hillside, flood prone, coastal or underlain by limestone aquifers. As the city of Montego Bay continues to grow, it can be expected that there will be an increasing demand for cemetery plots.

CRITERIA	ASSESSMENT	Score
Scale:	The largest cemetery (Pye River) is already close to its capacity. This will have a net effect on the total capacity available in the wider Montego Bay area.	4
Affected Numbers:	Uncertain. May be of the order of 1 to 10%.	2
Secondary Effects	The major secondary effect is associated with the type of burials being offered – which is different to the typical public cemetery, in that much more attention is being paid to the visual aesthetic of the grounds. More natural grassed graves (as opposed to arrays of concrete graves) with headstones only are being contemplated by the developer.	2
Resilience	Benefits will be accessible to receptors upon completion of the project.	5
Persistence:	The impact of this is expected to last between 12 to 15 years depending on various factors.	5
Baseline change	The proposed development will provide an additional 1215 burial spaces. The actual existing capacity is uncertain, but this is expected to improve availability above present levels.	2
Uncertainty		4
Classification:	MODERATE	3.4

6.4 CONCLUSIONS OF IMPACT SIGNIFICANCE

Six direct environmental impacts are predicted to occur during the operational phase of the project. These are given in Table 24. Five are considered negative impacts ranging, most of which are relatively small (scoring less than 2). The low level of community acceptability increases the effect level land use change as a negative impact, which needs to be addressed. However, it must be kept in mind that this is private property, and the proposed development is predicted to function well within the national and international environmental laws, policies and criteria regulating such developments. The main positive environmental effect associated is also relatively important, and needs to be carefully evaluated in the decision-making process, as it has far reaching effects on the availability of burial spaces for residents of Montego Bay.

Table 24 Summary of Predicted Direct Environmental Impacts

Impact	Type	Impact Level	Score
7. Increased suspended solids in run-off	Negative	Negligible	0.8
8. Vermin or pest infestations	Negative	Minor	1.0
9. Increased traffic	Negative	Moderate	1.4
10. Soil, groundwater and spring contamination	Negative	Moderate	1.6
11. Land use change	Negative	Moderate	3.4
12. Additional burial capacity for urban dwellers.	Positive	Moderate	3.4

It is the finding of this study that the development proposal to locate a cemetery at Burnt Ground, Hanover is unlikely to produce any significant negative environmental impact, where such impact is defined as one that:

- Is located in proximity to any sensitive or protected areas and has been determined to impact negatively on these.
- Is extensive over space or time (scales must be appropriately defined)
- Is intensive in concentration (i.e. exceeding recommended criteria) or in relation to assimilative capacity (as appropriated to the affected receptor).
- Is not consistent with national plans for the general use of the area.
- Contributes to the endangerment of threatened species.
- Reduces the stocks of commercially important species.
- Permanently damages habitat quality or creates ecological barriers.
- Threatens cultural or heritage resources.
- Alters community lifestyles or requires long-term adjustments of local people in respect of traditional values and resource use.
- Represents a long-term nuisance or significant safety/public health risk to other users.

7 ENVIRONMENTAL MANAGEMENT PLAN

7.1 MITIGATION SCHEDULE

Based on the impacts identified above, the following mitigation measures are prescribed:

- Excavated or temporarily stockpiled soils must be properly managed to control mobilization by surface run-off or air. This should be done immediately upon excavation. If stockpiles are to be temporarily stored overnight, they should be covered and bunded
- Bare areas should be revegetated as soon as possible.
- Any food stored on property must be secured against pest infestation.
- In the event of major community objection to the project a programme of conflict resolution should be undertaken within 1 month of the permitting authority's final decision in respect of the application.
- Funerals should be scheduled for off-peak hours as far as possible.

7.2 GENERAL RECOMMENDATIONS

Several important recommendations for enhancement of project design have been given by the Cemeteries Consultant (Dr. Boyd Dent), and are included in Appendix 5. They are summarised below:

- Approximately 2.9 ha are deemed suitable for interment, with spatial allotments of 2.88 m² per grave.
- A perimeter buffer zone should be imposed as suggested in Appendix 5 (see Figure 27 – black dashed line).
- Cremated remains can be disposed of by scattering or shallow burial provided that they are at least 2 m from any boundary and there is no potential for them to be transported offsite. Small drainage works, bunds, drains may be necessary.
- An impermeable earthen berm (>1 m high) should be constructed along the western boundary to prevent run-offs from the adjacent site (pig farm) entering the site. This will also reduce visibility of the burial area from western approaches.
- The cutting on the northern boundary should be remediated.
- Partially constructed vaults should be completed.
- The highest land on the site (near north-eastern boundary) is presently slated for burial. A retaining wall backfilled with free-draining adsorptive materials as recommended in Appendix 5 should be implemented.

- Appendix 5 indicates certain areas that should be specifically excluded from interments because of their association with site drainage. Areas that are suitable for burial are shown in yellow on Figure 27.

Figure 27 Recommended Extent of the Burial Area



- Graves should be properly managed to ensure that any settlement of the back-filled grave soils be continually topped-up and where possible the land should be re-shaped to shed surface runoff.

- Although it is recognized that use of concrete vaults may be cultural issue in Jamaica, it is not the optimal containment for interment. Given the nature of the soils and the climate, direct earth-contact interments are recommended. Filling the base with gravel and charcoal may be considered.
- A minimum compacted soil layer of 0.3 m (about 1 ft) should be made to fully cover between each interment. Minimum invert level for various numbers of interments should be: for one – 1.5 m (about 5 ft); for two – 2.3 m (about 7.5 ft) and for three – 3 m (about 10 ft).

7.3 MANAGEMENT PLAN

Environmental performance objectives for the cemetery should include:

1. Improvement of community relations.
2. Sound management of interment sites.
3. Control of buffer zones and perimeter integrity (fencing and access point security).
4. Maintenance of a visually pleasing aesthetic through effective solid waste containment and disposal, and continuous landscaping efforts. In this regard indigenous ornamental and shade trees should be used along with grass. Consideration should be given to earthen grave finishes with headstones or commemorative tree rather than concrete slabs as is commonly practiced.
5. Management of surface flows on site.
6. Sanitary handling and storage of food and beverages intended for human consumption.
7. Maintenance of a permanent record of the location of each grave site. Locations should be determined by GPS or triangulation survey.

7.4 MONITORING PLAN

7.4.1 General Considerations

It is recommended that the following be monitored:

- Report upon implementation of any stipulation conditions (that may relate to the foregoing recommendations) that may be attached to a final permit if such is issued.
- Annual reports of burial plot consumption and functioning of the sewage treatment plant to the NRCA.
- Monitoring of the water quality in the pond on property as stipulated below.

7.4.2 Water Quality Monitoring

The following regime should be implemented:

Monitoring Regime	Stipulation
Location	One station at a minimum depth of 1 m.
Frequency	Quarterly
Replicates per sampling events	Three
Parameters	<ul style="list-style-type: none"> • pH, conductivity and TDS • BOD, sulphate, total organic nitrogen, calcium phosphorus, potassium, sodium, chlorine and formaldehyde. • Screening (presence/absence) for <i>E. Coli</i>, <i>Pseudomonas aeruginosa</i>, <i>Clostridium perfringens</i>, and <i>Salmonella</i> spp.

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