PROJECT OF TANK-WELD LIMITED
Kingston, Jamaica

HYDROLOGY COMPONENT
Environmental Impact Assessment
LPG Pipeline, Storage & Filling Plant
Rio Bueno, Trelawny, Jamaica

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prepared for

ENVIRO PLANNERS LIMITED
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By

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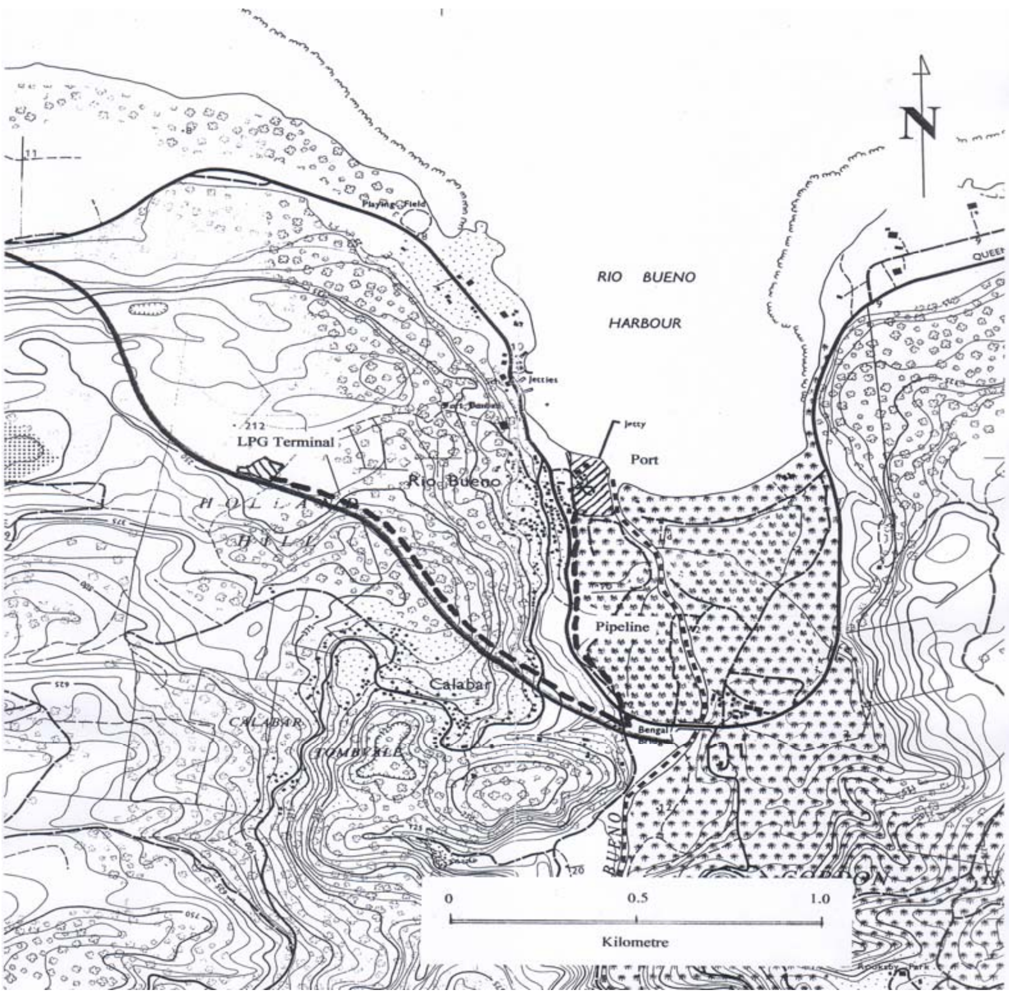
1. INTRODUCTION

1.1 Background

Tank-Weld proposes to construct a Liquid Petroleum Gas (LPG) Facility on a 1.07 hectare (2.64 acre) site at Holland Hill above the town of Rio Bueno, in the parish of Trelawny. The approximate location of the site is shown in **Figure 1-1**.

Figure 1-1: **LOCATION OF PROPOSED LPG FACILITIES IN RIO BUENO**



The main components of the proposed LPG facilities are as follows: -

- Port facilities in the Rio Bueno Harbour to receive the LPG from marine tankers, which is already being constructed and is outside the Terms of Reference of this assignment;

- A Product Storage and Loading Terminal at Holland Hill;

- A buried, 204mm (8inch) ID Product Receipt Pipeline linking the Port to the Product Storage and Loading Terminal;
- Water Storage Tank with a holding capacity of 200,000 imperial gallons, for purposes of fire-fighting, and
- A Sewage Treatment Facility incorporating a Bio-digester Septic Tank, Reed Beds, Chlorination chamber and disposal by re-use of the treated effluent for on-site irrigation.

The location of the port facilities, the Storage/Loading Terminal and the alignment of the transmission pipeline are also shown on **Figure 1-1**. The Water Storage Tank and Sewage Treatment Plant are to be sited within the boundary of the Storage/Loading Terminal.

Enviro Planners Ltd (EPL) has been contracted by Tank-Weld to prepare an Environmental Impact Assessment (EIA) of the LPG Pipeline and Storage/Loading facilities at Rio Bueno. Hydrology Consultants Limited (HydroConsult) has been sub-contracted by EPL to conduct the Hydrology Component of the EIA, the results of which are incorporated in this report.

1.2 Objectives and Scope

The Hydrology Component of the EIA has the following objectives and scope as defined/abstracted from the Terms of Reference for the project, approved by the National Environmental and Planning Agency (NEPA): -

Task #2: Description of the Environment/baseline Studies data Collection and Interpretation.

(i) Detailed description of the existing soil, geology, geomorphology, landscape, aesthetic values and hydrology, as it would relate to the stability and integrity of the pipeline and tank farm;

(ii) Special emphasis to be placed on storm water runoff, drainage patterns, aquifer characteristics, effects on groundwater and availability of potable water.

Task #3: Policy, Legislative and Regulatory Considerations.

(iii) The pertinent regulations and standards relating to surfacewater and groundwater availability and water quality, drainage and/or flooding;

Task #4: Identification and Assessment/Analysis of Potential Impacts

(iv) Identification of the nature, severity, size and extent of potential direct, indirect and cumulative impacts (for terrestrial and aquatic environments) during the pre-construction, construction and operational phases of the development as they relate to (but are not restricted by) the following: -

- Change in drainage patterns;
- Flooding potential;
- Pollution of potable, coastal, marine, surfacewater and groundwater;
- Landscape impacts of excavation and construction, and
- Loss of and damage to geological and palaeontological features

(v) Distinguish between significant positive and negative impacts, reversible and irreversible, direct and indirect, long term and immediate impacts, as well as avoidable impacts;

(vi) Characterisation of the extent and quality of the available data, explaining significant information deficiencies, assumptions and any uncertainties associated with the predictions of impacts.

Task #5: Drainage Assessment

(vii) An assessment of Storm water Drainage shall be conducted to include consideration of the drainage of the site during construction and during operation, and mitigation for sedimentation to the aquatic environment.

1.3 Approach and Methodology

Implementation of the terms of reference of this study involved execution of the following tasks: -

(i) Review of the Project Description to understand the nature and components of the structures and activities of the proposed development, as well as examination of the Terms of Reference with a view to identifying those aspects of the Terms of Reference that were to be addressed by the Hydrology Component of the EIA;

(ii) Collation of available maps, plans, reports and data of relevance to the project and their review by desk study to understand the hydrological framework and to guide field investigation of the development site and its environs;

(iii) Field reconnaissance of the development site and its environs to confirm the desk study interpretation and collect such additional data as was possible, including on-site discussions with the Project Engineer and

(iv) Analysis, interpretation and preparation of draft project report, which was reviewed by EPL before completion and issue of the final report.

The respective data sources are referenced and the analytical methodologies used described in the relevant sections of the report.

1.4 Acknowledgements

Hydrology Consultants Ltd is grateful for the cooperation and/or assistance in the implementation of this assignment provided by members of the organisations listed below: -

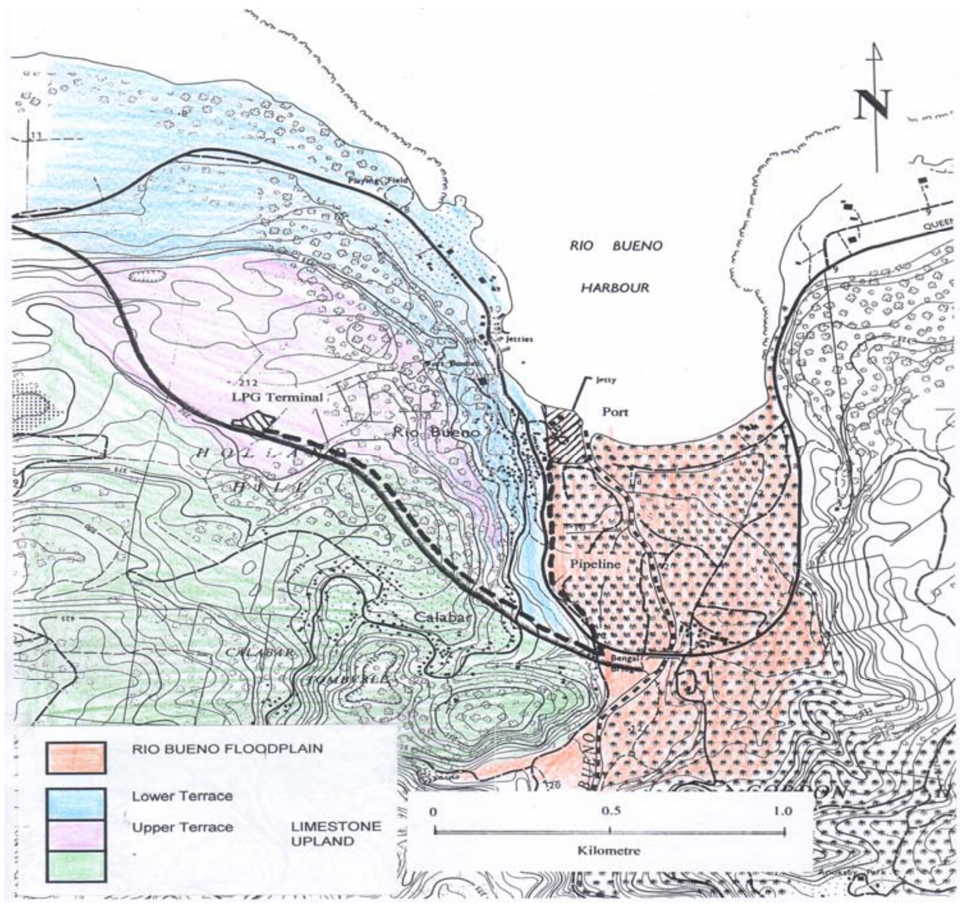
National Works Agency
Jamaica Meteorological Office
Water Resources Authority
Tankweld Construction Ltd
Industrial Gases Limited
Enviro Planners Ltd

2. HYDROLOGICAL FRAMEWORK

2.1 Geomorphology

The Rio Bueno project area consists of the swampy, coastal flood plain of the Rio Bueno and the adjoining limestone upland to the NW, including the Rio Bueno town and the area of Holland Hill, as shown in **Figure 2-1.**

Figure 2-1: **GEOMORPHOLOGICAL SUB-DIVISIONS OF THE RIO BUENO PROJECT AREA**



The valley occupied by the Rio Bueno flood plain forms a depression in coastal uplands that extends almost to the coastline. The 1:12,500 topographic sheet published by the Jamaica Survey Department indicated ground surface elevations generally less than 8m

(25 ft) amsl. The very steep valley walls suggest the influence of faulting, but this is not supported by the geological map of the area. The Rio Bueno port development is located at the north-western corner of the flood plain, on the left bank of the river.

To the west of the Rio Bueno flood plain, the ground surface rises steeply to an elevation of about 122m (400 ft) amsl in the Holland Hill area. This upland area is made up of two distinct terraces, which roughly parallels the coastline to the north, believed to be formed by raised reefs. The inland limit of the lower terrace is marked by a 15m (50 ft) high cliff line at an elevation of 38m (125 ft) and the upper terrace by a similar 15m (50 ft) high cliff line at 76m (250 ft). The upper terrace has a N-S width of about 0.6 km, gradually sloping north through that distance down to the cliff line at 38m (125 ft), whereas that of the lower terrace slopes through 0.3 km distance down to the coastline.

The proposed alignment of the Product Receipt Pipeline leads from the port, south along the western edge of the Rio Bueno flood plain to a juncture with the North Coast Highway and then sharply to the NW up-slope to Holland Hill paralleling the northern edge of the North Coast Highway. The LPG Storage/Loading Terminal is to be located on the upper terrace.

2.2 Hydro-stratigraphy

Two hydro-stratigraphic units are of direct relevance to the project – the Rio Bueno alluvium aquiclude and the Coastal aquiclude mapped by the Mines & Geology Division (1974) as Quaternary Alluvium and Coastal Group, respectively. The Product Receipt Pipeline is to be constructed within reclaimed coastal wetland developed on the alluvium aquifer as it traverses the Rio Bueno port and through Coastal aquiclude up to Holland Hill. The LPG Storage/Loading Terminal is to be constructed on Coastal aquiclude at Holland Hill. A hydro-stratigraphic map showing outcrops of these aquicludes, the alignment of the pipeline and the location of the LPG Storage/Loading Facility is set out in **Figure 2-2**. E-W and N-S aligned hydrogeological cross sections given as **Figure 2-3**, illustrate the stratigraphical and structural relations between the hydro-stratigraphic units.

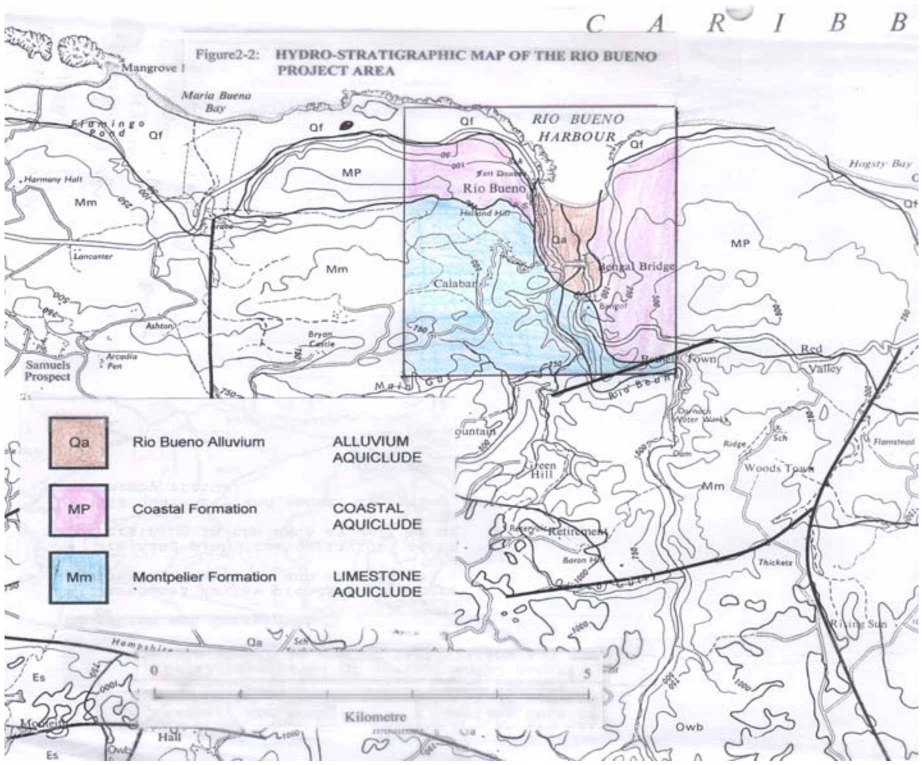
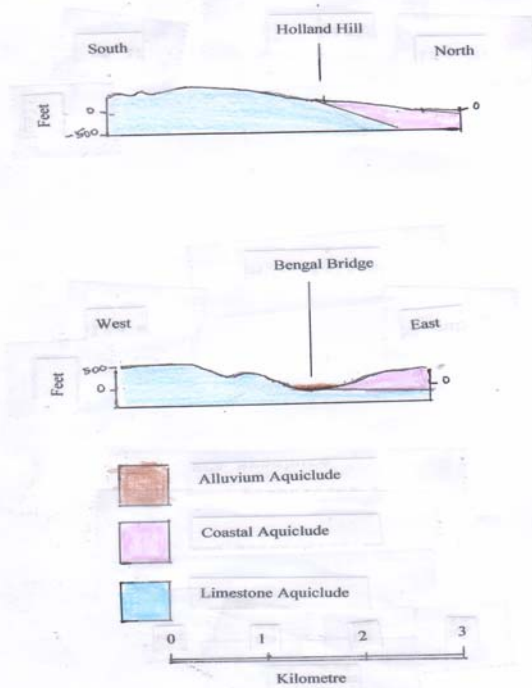


Figure2-2: HYDRO-STRATIGRAPHIC MAP OF THE RIO BUENO PROJECT AREA
C A R I B B
RIO BUENO HARBOUR
Maria Buena Bay
Mangrove
Flamingo Pond
Hogsty Bay
Rio Bueno
Calabar
Samuels Prospect
Red Valley
Woods Town
Green Hill
Retirement
Rising Sun
Qa
Rio Bueno Alluvium
ALLUVIUM AQUICLUDE
MP
Coastal Formation
COASTAL AQUICLUDE
Mm
Montpelier Formation
LIMESTONE AQUICLUDE
0
5
Kilometre

Figure 2-3: **HYDROGEOLOGICAL SECTIONS THROUGH THE RIO BUENO PROJECT AREA.**



(a) Rio Bueno Alluvium Aquiclude

The Rio Bueno alluvium aquiclude was deposited by the Rio Bueno River, forming a N-S aligned coastal flood plain occupying an area of about 0.8km^2 (1.25 x 0.63 km) at the mouth of the river.

The Rio Bueno alluvium is composed primarily of limestone sand and gravel in a matrix of terrestrial clays, with inter-bedded layers of peat. Its thickness has not been established, but coastal alluviums in St. Mary exceed 30m (100 ft) in thickness. The Rio Bueno alluvium is underlain by Coastal aquiclude at depth.

Although there is expected to be a perennial water table within the alluvium with elevations approximating the river stage, the Bengal Farm has not developed wells within the Rio Bueno alluvium to water their livestock (dairy and beef cattle), implying that it is a low permeability alluvium – hence its classification as an aquiclude i.e. a geological strata that does not support economic yield from springs and/or wells.

(b) Coastal Aquiclude

In the Rio Bueno area the Coastal aquiclude is composed primarily of limestone reef rubble and blocks of chalk deposited down slope of the Montpelier hinterland, in the late Miocene (Mines & Geology, 1974). Exposures in the recent road cuts along the North Coast Highway in the vicinity of Rio Bueno and as Holland Hill is approached, shows relatively thin and discontinuous bauxitic soils on the surface and minor karstification throughout the depth of the limestone exposure. The absence of karstification in the limestone is a clear indication of relatively low permeability and its classification as an aquiclude. The main water resources product from Coastal aquiclude is surface runoff.

There is no known spring or well located within Rio Bueno area to indicate the presence of a water table. If present, fresh groundwater would most likely occur as a thin lens floating on seawater at depth, with little if any potential to serve as a source for water supply.

2.3 Surfacewater Hydrology

The Rio Bueno (river) is a perennial stream which is the main surface drain of the Dry Harbour Mountains limestone aquifer. It rises as a large karstic resurgence known as the Dornock bluehole at a geological contact between limestone aquiclude and limestone aquifer, some 8kms inland, just north of Stewart Town. Its flow regime is characterised by relatively high dry season flows and low broad wet season peaks. The river has a reliable yield of 246,240m^3/d (54.2 migd) sustained entirely by groundwater discharge from the limestone aquifer. Contribution from the slopes of the Rio Bueno (river) is very small.

The raised reef terraces are drained by shallow, dry, limestone gullies that carry flow for a few hours after significant rainfall events.

2.4 Groundwater Hydrology

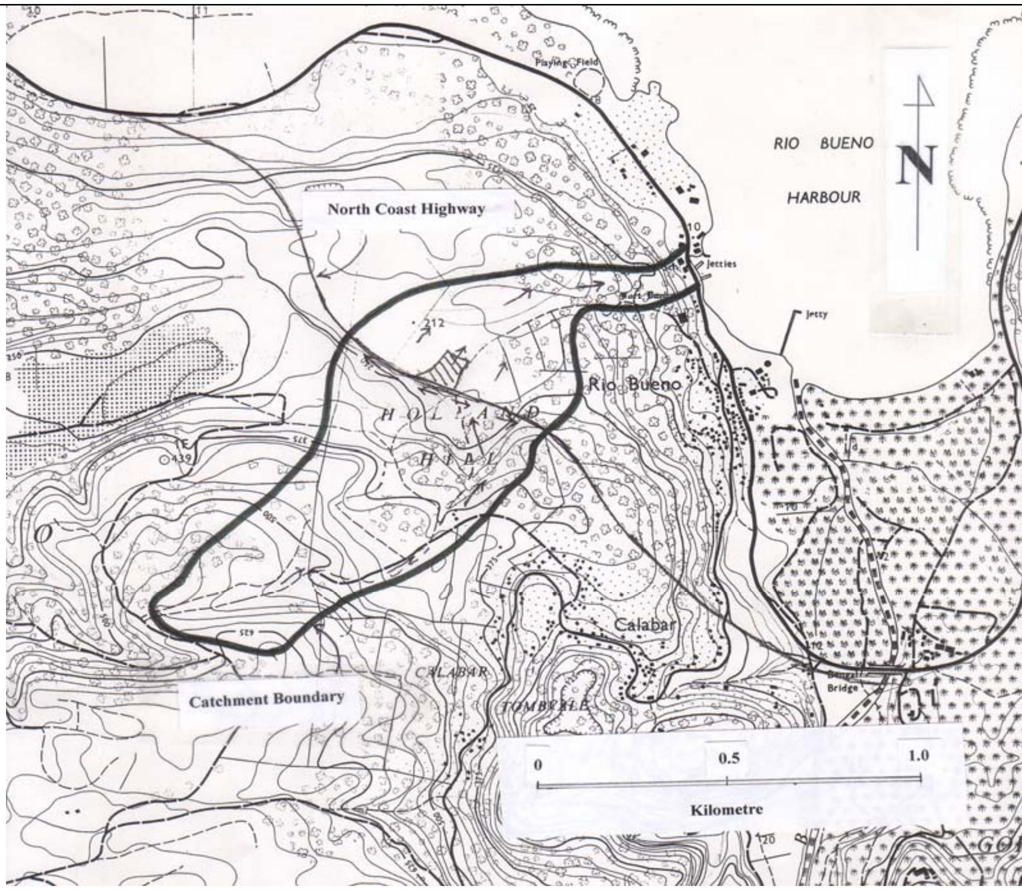
There are no significant fresh groundwater resources within the Rio Bueno area. A conclusion which is consistent with the hydraulic characterisation of the relevant geological formations as aquicludes, the absence of surface springs, submarine springs and/or wells.

3. SURFACE DRAINAGE

3.1 Catchment Area

The proposed LPG Storage/Loading Terminal is situated at Holland Hill within a 63.9ha (157.7ac) surface catchment shown in **Figure 3-1**. The boundaries of the catchment area were delineated using the topographic map of the area and its environs at a scale of 1:12,500 published by the Jamaica Survey Department.

Figure 3-1: **LOCATION OF THE HOLLAND HILL CATCHMENT TRELAWNY**



The catchment boundaries and flow paths determined from the review of the topography, were confirmed during field reconnaissance of the area carried out on 2008 March 14. The flow directions are indicated by arrows which point in the direction of flow and the approximate location of the LPG Storage/Loading Terminal shown as a hatched box also on **Figure 3-1**.

3.2 Drainage Patterns

Natural surface runoff generated on the catchment is conveyed by a seasonal gully which becomes active only in response to rainfall of sufficient magnitude to generate runoff. Flow is in a southwest to northeast direction and is discharged into the sea about 300m (1,000 ft) north of the town of Rio Bueno.

The natural drainage pattern of the catchment has been significantly (and permanently) altered by the recent construction of the Rio Bueno by-pass section of the North Coast Highway. The approximate alignment of the highway within the catchment is also shown in **Figure 3-1**. This elevated roadway has divided the catchment into two sub-areas. The area to the south of the highway is designated Area A and that located to its north - Area B.

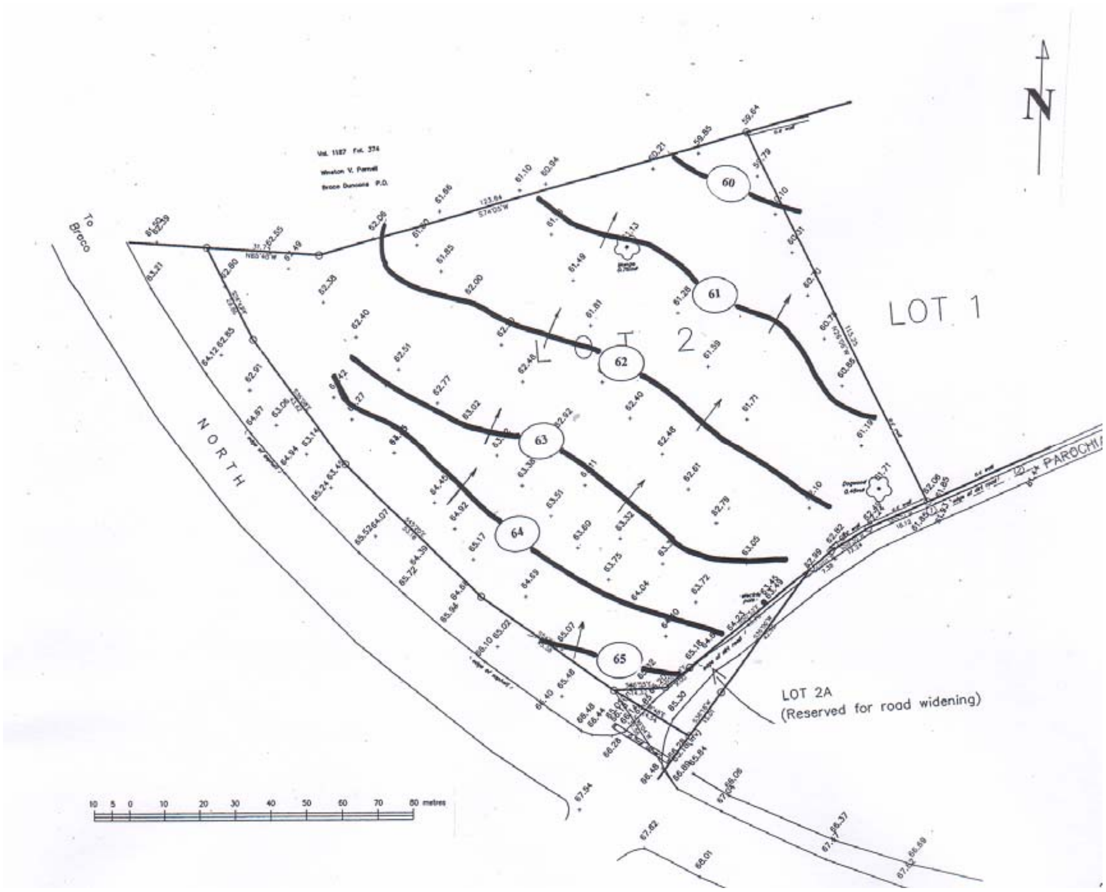
The North Coast Highway functions as a barrier to flow from Area A. Runoff is now discharged via an earthen road-side drain along the southern side of the highway. There is a topographic high within this drain near to the parochial road leading south, such that discharge via the road-side drain is to the southeast on the one hand and to the northwest on the other.

A similar drain is located on the northern side of the highway and disposes of flow generated on the highway pavement itself.

Note that peak runoff generated within Area A would affect the site of the LPG Storage/Loading Terminal only in the event that its magnitude exceeded the capacity of the southern road-side drain, over-topped the elevated pavement of the highway and also exceeded the carrying capacity of the northern road-side drain.

The drainage pattern within the site of the LPG Storage/Loading Terminal itself was determined using the spot elevation data generated by a survey plan of the site. The contours developed from these measurements together with the flow directions are shown in **Figure 3-2**. Note that flow from the site is to the northeast toward Lot #1 currently occupied by Tankweld Ltd. and not toward the northern road-side drain, located at the property's southern boundary. The topography suggested that surface runoff on the site will occur primarily as sheet flow given the absence of a defined surface channel.

Figure 3-2: **PATTERN OF SURFACE DRAINAGE FROM THE SITE OF THE LPG TERMINAL, HOLLAND HILL**



3.3 Determination of Peak Discharges.

(a) Computational Method

Peak runoff was estimated using the Rational Method. It is an empirical method applicable to small catchments with simple drainage patterns in which the time of concentration is less than the duration of the storm, causing the runoff. Peak runoff (Q_p) is given by the model given below: -

Q_p = CIA,

Where:

Q_p is peak discharge in cfs,

C is a dimensionless runoff coefficient between 0 and 1.0, dependent on the catchment characteristics;

I is rainfall intensity in inches/hour, and

A is the catchment area in acres.

(b) Data Requirements

The basic data requirements for input into the model and their determination are described below: -

(i) Runoff Coefficient

The values of C used in the computations were obtained from published literature (Chow 1964). Area A was adjudged to be most akin to woodland, with above average infiltration rate, and a coefficient of 0.1 assigned accordingly. Area B most closely approximated residential area having coefficients ranging from 0.30 to 0.50. The most conservative value of 0.50 was adopted for this area. A “C value” of 0.30 was adopted for the site of the LPG Terminal in its natural state. This is the maximum value assigned to unimproved areas. It was conservatively assumed that the entire site of the LPG Terminal would be covered with buildings or pavement when constructed, and a “C value” of 1.0 assigned for the computation of the post-project flows.

(ii) Rainfall Intensity

Rainfall depth for storms of 24-hour duration with return periods form 2 to 100 years obtained from the Jamaica Meteorological Office for rain gauges located in the parish of Trelawny are given in **Table 3-1**.

The rain gauge at Braco was the closest to Holland Hill and adjudged to be representative of that area.

Table 3-1: **24-HOUR FOR VARIOUS RETURN PERIODS AT BRACO, TRELAWNY**

Rainfall Depth	Return Period (year)					
	2	5	10	25	50	100
mm	101	146	186	237	274	312
inch	3.46	5.00	6.37	8.12	9.39	10.69

The Meteorological Office has also developed a series of 6 No. typical time distributions of the 24 hour rainfall. These are shown in **Table 3-2**. Distribution C which was recommended by the Flood Plain Mapping Project was adopted for these investigations. The highest rainfall intensity indicated by this distribution occurs between hours 6 to 7, was used in the computations.

Table 3-2: **TYPICAL TIME DISTRIBUTION FOR 24-HOUR RAINFALL IN JAMAICA**

Hour	Distribution A	Distribution B	Distribution C	Distribution D	Distribution E	Distribution F
0	0.000	0.000	0.000	0.000	0.000	0.000
1	0.066	0.040	0.023	0.006	0.000	0.000
2	0.130	0.080	0.060	0.042	0.010	0.003
3	0.203	0.110	0.100	0.078	0.033	0.010
4	0.233	0.180	0.143	0.113	0.086	0.032
5	0.353	0.263	0.230	0.186	0.123	0.053
6	0.700	0.263	0.230	0.186	0.123	0.070
7	0.803	0.553	0.376	0.333	0.273	0.180
8	0.843	0.576	0.406	0.350	0.310	0.233
9	0.850	0.603	0.466	0.410	0.366	0.240
10	0.850	0.640	0.546	0.500	0.456	0.280
11	0.870	0.673	0.603	0.630	0.486	0.320
12	0.976	0.796	0.630	0.630	0.500	0.366
13	0.996	0.836	0.696	0.633	0.516	0.396
14	1.000	0.890	0.766	0.663	0.516	0.416
15	1.000	0.923	0.813	0.706	0.583	0.476
16	1.000	0.946	0.830	0.733	0.643	0.513
17	1.000	0.973	0.850	0.773	0.680	0.543
18	1.000	0.986	0.910	0.836	0.733	0.560
19	1.000	0.986	0.946	0.876	0.796	0.603
20	1.000	0.993	0.973	0.900	0.830	0.663
21	1.000	0.996	0.983	0.950	0.916	0.860
22	1.000	1.000	0.993	0.980	0.970	0.880
23	1.000	1.000	1.000	0.993	0.990	0.913
24	1.000	1.000	1.000	1.000	1.000	1.000

(iii) Catchment Area

The areal extent of Area A, Area B and the project site were determined to be 105.5, 52.2 and 2.6 acres, respectively. Determinations were made using a planometer.

(c) Peak Discharge

The estimates of peak flows from using the data presented in Section 3.3(b) above produced the peak discharge values set out in **Table 3-3**. Note that the impact of the constructed project on runoff from Area B was of the order of 5% increase in peak discharge rate. This result is consistent with the relatively small size of the project site in relation to that of Area B.

Table 3-3: **COMPUTATION OF PEAK DISCHARGES FOR THE PROJECT (HOLLAND HILL) CATCHMENT**

Catchment Area	Scenario	Parameter	Unit	Return Period (year)		
				25	50	100
A	Pre-project	P_{24}	in	9.33	10.88	12.28
		i	in/hr	1.36	1.59	1.79
		A	acre	105.5	105.5	105.5
		C		0.1	0.1	0.1
		Q_p	cfs	14.4	16.8	18.9
B	Pre-project	P_{24}	in	9.33	10.88	12.28
		i	in/hr	1.36	1.59	1.79
		A	acre	52.2	52.2	52.2
		C		0.5	0.5	0.5
		Q_p	cfs	35.6	41.5	46.8
B	Post-project	P_{24}	in	9.33	10.88	12.28
		i	in/hr	1.36	1.59	1.79
		A	acre	52.2	52.2	52.2
		C*		0.52	0.52	0.52
		Q_p	cfs	37.3	43.5	49.1

C* = 0.52 area weighted runoff coefficient

3.4 Adequacy of Southern Road-side Drain

The flow patterns described in Section 3.2 indicated that surface runoff generated within the Area A was likely to impact on the plant site in the event that the highway drain did not have sufficient capacity and the highway was overtopped. The capacity of the drain to convey the peak flows was determined using Manning's equation for uniform flow. It is given as: -

$$Q= (1.49AR^{2/3}S^{1/2})/n \qquad (1)$$

where: Q is discharge in cfs,

A is flow area of the channel section in square feet,

R is the hydraulic radius,

S is the channel slope, and,

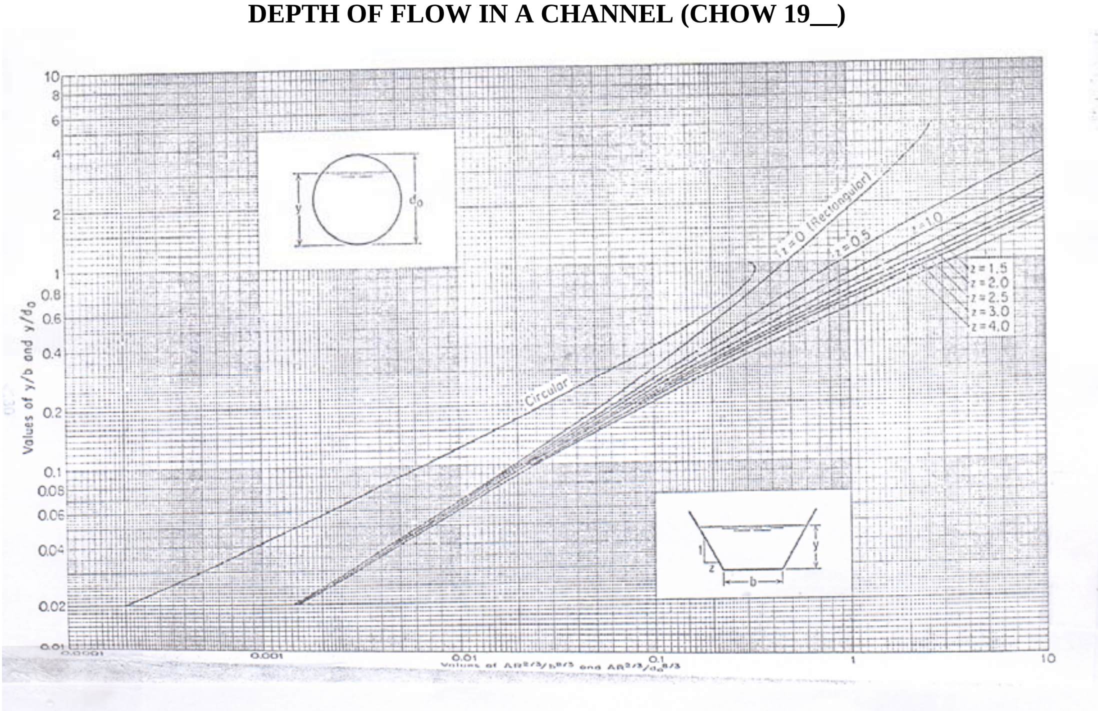
n is a roughness coefficient dependent on the channel properties.

Equation may be rearranged as

$$AR^{2/3} = nQ/1.49S^{1/2} \quad (2)$$

The expression $AR^{2/3}$ is known as the section factor for uniform flow computation. If the parameters on the right hand side of Equation 2 are known then the section factor can be determined. The relationship between the station factor and the depth of flow in a channel with a specified geometry is given in the nomogram presented as **Figure 3-3**.

Figure 3-3: **RELATIONSHIP BETWEEN THE STATION FACTOR AND THE DEPTH OF FLOW IN A CHANNEL (CHOW 19__)**



Determination of each of the parameters used to compute the station factor is discussed in turn below. A roughness coefficient (n) of 0.033 was adopted for this drain. It is the value assigned to straight excavated earth channels containing grass/weeds. The channel slope was estimated from survey measurements of the ground surface along the highway alignment, shown in **Figure 3-4** for ease of reference. A channel slope of 0.0209 was determined. Field measurement of the dimensions of the drain indicated that it is approximately trapezoidal in geometry with a bottom width of 3 feet and side slope of 1:1.5. The maximum allowable depth of flow within the drain i.e. without breaching the road surface is about 3.3 feet.

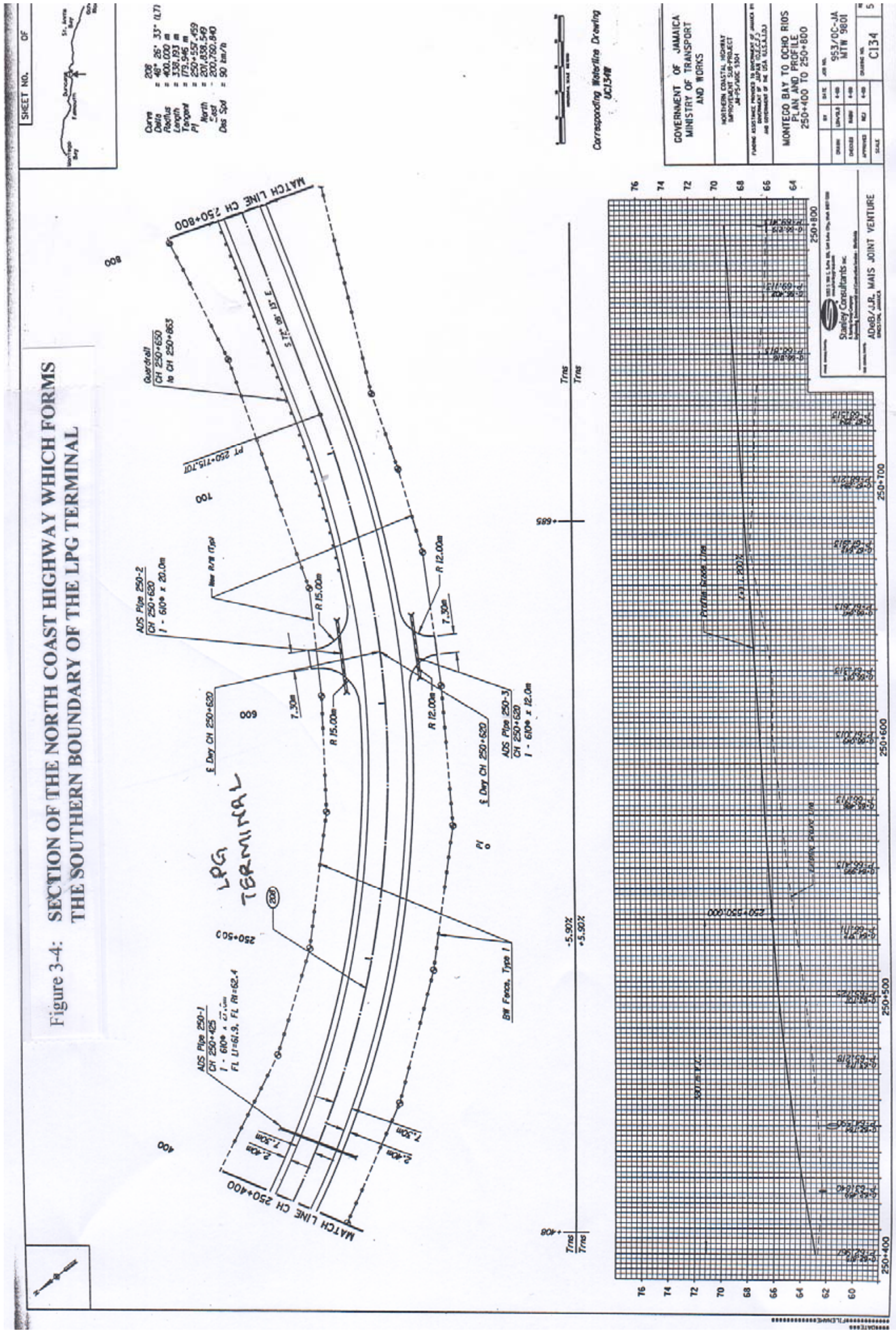


Figure 3-4: SECTION OF THE NORTH COAST HIGHWAY WHICH FORMS THE SOUTHERN BOUNDARY OF THE LPG TERMINAL

The flow depths calculated from the foregoing data for the peak discharges determined for the 25, 50 and 100 year storms are as set out in **Table 3-4** below. These data indicated that the roadside drain was of sufficient capacity to dispose of the peak flows generated in Area A.

Table 3-4: **FLOW DEPTHS IN THE SOUTHERN ROAD-SIDE DRAIN OF THE NORTH COAST HIGHWAY AT HOLLAND HILL**

Parameter	Return Period (year)		
	25	50	100
Dischage (cfs)	14.40	16.80	18.90
Station Factor	2.20	2.57	2.89
Flow depth (ft)	0.78	0.82	1.05

3.5 Flooding Potential

The potential for flooding of the site of the LPG Terminal was virtually eliminated by the construction of the North Coast Highway. Surface Runoff generated on the site is readily disposed of by sheet flow down slope over relatively even surface with no significant surface depressions to facilitate ponding and/or flooding.

However, there is anecdotal evidence that surface runoff from the site of the LPG Terminal contributes to flooding of Lot #1, presently used as a works yard by Tankweld Ltd. The capacity of the shallow depression at Lot #1 is readily exceeded and sheet flow continues down slope along the parochial road into and through the town of Rio Bueno to the sea. There was no evidence of major scouring or gullying resulting from pre-construction runoff.

The post-construction increase in surface runoff is expected to be less than 5%, an insignificant increase and one that could not justify mitigation measures, particularly in the context of there having been a major reduction in storm flows occasioned by the construction of the North Coast Highway.

4. DISPOSAL OF TREATED SEWAGE EFFLUENT

The sewage treatment facility proposed for the LPG Storage Loading Terminal involves the following components: -

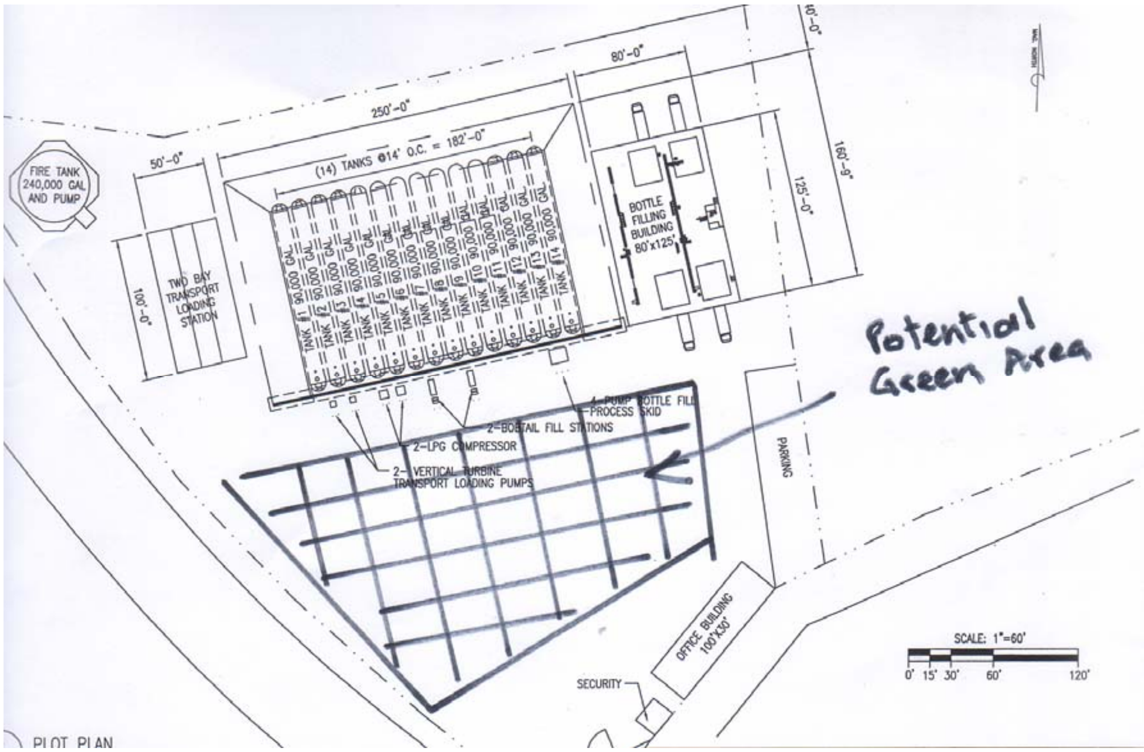
- Initial screening to remove relatively large debris;
- Bio-digester Septic Tank for anaerobic digestion of the sewage;
- Reed-bed and gravel filter for particulate and nutrient removal, and
- Re-use of the treated sewage effluent for on-site irrigation using buried pipes.

The sewage load was computed at $3.50m^3/d$ (770igpd), assuming unit water demand of $0.25m^3/d/capita$, times the 14 operational crew manning the Terminal. The per capita water consumption was conservatively assumed to be that used by the National Water Commission for urban households.

Assuming evapo-transpiration of an average 5mm/d from grass and shrub, then the unit irrigation water demand would be $0.01m^3/d/m^2$ ($0.2igpd/ft^2$). In this event, the $3.50m^3/d$ of treated sewage effluent can be expected to irrigate $350m^2$ (0.09ac) of green area. The potential area available for green area at the site of the LPG Storage/Loading Terminal exceeds $1,000m^2$ (0.25ac), an area which far exceeds the minimum requirement for irrigable land to dispose of the available treated sewage effluent generated by the sewage plant. The preliminary site plan for the Terminal showing potential green area is given as **Figure 4-1**.

For those rain days for which irrigation is not necessary, then the infiltrating rainwater would flush the treated sewage effluent from the soil and below the root zone, to percolate to the water table at depth, such as may exist within the Coastal Aquiclude. Given the relatively small quantities involved, the seasonal nature of such flushing and that there is no likely groundwater potential within the Coastal aquiclude, the issue of groundwater pollution does not arise.

Figure 4-1: **POTENTIAL GREEN AREA AT LPG TERMINAL**



5. WATER SUPPLY OPTION

Tank-Weld proposes to obtain the water it needs for fire-fighting from the National Water Commission who are in the process of installing a new pipeline, the alignment of which will take it conveniently pass the LPG Terminal site at Holland Hill on the northern side of the North Coast Highway. This source is expected to have the ability to provide an adequate and reliable supply to sustain the 908m^3 (200,000 imperial gallon) tank to be constructed at the LPG Terminal for fire-fighting purposes.

Alternatively, water for fire-fighting may be obtained from the Rio Bueno (river) at the old Bengal Bridge. A low flow frequency analysis included as Figure 5-1 indicated a reliable yield (i.e. the annual minimum 7-day flow with a 1 in 10 year return period) of

$2.85m^3/s$ ($246,240m^3/d$ or 54.2 migd), which can easily satisfy the fire-fighting demand of the LPG Terminal. In this event Tank-Weid would have full control over its primary fire-fighting water supply source and now have the added security of a standby facility as the NWC connection would be operated as a secondary (or reserve) water supply service. Such a decision must of necessity be informed by a cost/benefit analysis which weights the cost of using treated NWC domestic water against the capital and operational cost associated with taking un-treated fresh water from the Rio Bueno (river). Such an analysis is outside the scope of this assignment.

The Rio Bueno (river) source would require establishment of a surface diversion and pumping station say at the old Bengal Bridge and a transmission pipeline to the LPG Terminal. A licence to abstract the water from the river would be required from the Water Resources Authority at a minimal cost (now $15,000) and there would be no additional cost for the water itself, except for the capital and operational/maintenance cost of this alternative water supply system.

5. SUMMARY OF RESULTS

The examination of the hydrological considerations associated with the establishment and operation of an LPG Terminal at Holland Hill has concluded as follows: -

Surface Drainage

(i) The site of the proposed LPG Terminal is located within a 64 ha (158 ac) catchment composed of Coastal limestone aquiclude;

(ii) The North Coast Highway has permanently divided this catchment into two independent sub-catchments, that south of the highway (sub-catchment A) having an area of 42.7ha (105.5ac) with a drainage pattern characterised by channel flow, whereas the sub-catchment north of the highway (sub-catchment B) has an area of 21.1ha (52.2ac) which is characterised by sheet flow;

(iii) The southern road-side drain of the North Coast Highway was determined to have carrying capacity in excess of the surface runoff generated on sub-catchment A in a 100-year storm event, such that there would be no future flow from that sub-catchment to sub-catchment B; the northern road-side drain of the North Coast highway would readily dispose of the surface runoff generated on the highway pavement, whereas the significantly reduced surface runoff from sub-catchment B would continue to flood a natural, shallow, surface depression presently occupied by Tankweld construction Ltd, before flowing to the north-east into and through the roadside town of Rio Bueno;

(iv) The LPG Terminal which is located at the southern up-stream boundary of sub-catchment B would not be subject to flooding in a 100 year storm event;

(v) The post development surface runoff in sub-catchment B would be increased by 5% with the construction of the LPG terminal, which would be off-set against the permanent and larger 28% reduction in pre-construction flow occasioned by the construction of the North Coast Highway, a situation which makes mitigation measures against the increased post-construction flow, un-necessary;

Pollution of Surfacewater and/or Groundwater

(vi) There is no perennial or seasonal stream within the Holland Hill surfacewater catchment and no known groundwater potential in the Coastal Aquiclude underlying the LPG Terminal so there is no potential for the pollution of surfacewater and/or groundwater resources;

(vii) The potential size of the green area at the LPG Terminal far exceeds that required for the disposal of treated sewage effluent generated on-site;

Water Source for fire-fighting

(viii) The use of the Rio Bueno (river) as the primary water supply source for fire-fighting, with the NWC supply serving as a standby system should be examined.

End of Report

7. REFERENCES

CHOW, VEN TE (19__): Open Channel Hydraulics. Published by McGraw-Hill International Editions. Civil Engineering Series.

CHOW, VEN TE (1964): Handbook of Applied Hydrology – a compendium of water resources technology. Ven Te Chow – Editor in Chief. Published by McGraw-Hill Book Company.

MINES AND GEOLOGY DIVISION (1974): Geological Sheet 11 – Discovery Bay, Jamaica (Provisional). Published April 1974, Government of Jamaica.

SURVEY DEPARTMENT OF JAMAICA (1971): Topographic Sheet 61C, Scale 1:12,500. Ja. 200 Preliminary Edition. Government of Jamaica