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INDUSTRIAL POLLUTION MANAGEMENT IN THE SUGAR CANE INDUSTRY

SI/BZE/92/801

BELIZE

Technical report: Industrial pollution management in the sugar cane, rum, distillery and other industries in Belize*

Prepared for the Government of Belize
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Patrick J. Newell, consultant in agro-industry pollution control

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Vienna

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* This document has not been edited.

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TABLE OF CONTENTS

ABSTRACT

This project is concerned with the provision of advice and technical assistance to the Belize Government on the establishment of an industrial pollution control monitoring programme for the sugar, rum, brewery and other industries.

The report contains characterizations of these liquid waste streams, with particular emphasis on the effluents discharging into the New River. It also contains a proposal for the establishment of an industrial pollution control monitoring programme with a suggested layout for a national questionnaire for all industries.

The work involved in this report was carried out in the period 1/3/93 - 30/4/93 and consisted of on site meetings, investigations and sampling visits, laboratory analysis of the collected samples, correlation of the data and presentation of the results in report format.

Training of three Government appointed personnel in the techniques of site investigation, sampling, analytical procedures, results interpretation and reporting was also included in the duties carried out during this Consultancy .

Based on the findings of this study. It is recommended that a national pollution control and monitoring programme be implemented at the very earliest opportunity. Using the new Environmental Protection Act 1992, an effluent discharge licensing system should be enacted. Water quality standards similar to WHO, EEC or EPA should be adopted and the discharge licenses should be based on these standards.

At present, most of the Belizean waters are relatively unpolluted, with the exception of the New River. In order to maintain this position and reclaim the polluted stretches, it is important that a national environmental plan be implemented at the earliest opportunity.

INTRODUCTION

Background

Following a request by the Belize Government to the United Nations Industrial Development Organization, Vienna, for assistance in the establishment of an industrial pollution control monitoring programme, Patrick J. Newell B.E., Ph.D., C. Eng., Oaklands, Headford, Co. Galway Ireland was appointed as Consultant to the Department of the Environment, Belize for a period of 2 months, from March - April, 1993. The job description for the project is reproduced in Annex 1.

Objectives

The main objects of this study concerned:

* The characterization of the industrial waste being discharged into the New River.

* Assistance with the establishment of an industrial pollution monitoring programme.

* The provision of information and training to three government employees on sampling techniques, analytical procedures and treatment systems for the specific industrial waste concerned.

After preliminary discussion with Belize Government officials, the scope of these objectives was broadened, to include other industries in other areas of the country. The additional industries included; breweries, fish farming and the citrus industry.

The following report contains a characterization of the main industrial effluents in Belize together with proposals for the treatment of these wastes. Three government officials assisted with the sampling and analysis of the effluents. A portable laboratory facility, complete with chemicals, was provided by the Consultant. In the absence of this facility, it would have been difficult to achieve the objectives. On completion of this appointment, these testing facilities within the Department of the Environment will no longer exist. In order, for the Pollution Control Monitoring Programme to continue and develop, it is very important that a suitable testing facility be established within the D.O.E. and that it be staffed by qualified operators. (See Annex IV and V for recommendations).

Additional Information

Two previous studies had been carried out on the New River area. The first of these was carried out in April 1977 (Balfour & Sons) and the second study was carried out by various Departments from the Belize Government in March 1992 (Report unpublished). Cross reference to the water quality data contained in these studies was made during this Consultancy, in order to confirm and verify the data obtained in the present study. Copies of these reports can be obtained from the Department of the Environment at Belmopan.

I - PRELIMINARY SURVEYS

General

In order to establish a basis for a suitable Industrial Pollution Control Policy for the Sugar, Rum , Brewery and other Industries, it was first necessary to assess the existing national situation.

Sugar Industry

The two Sugar factories in Belize are situated in the North East, of the country or on the banks of the New River. The larger factory, Belize Sugar Industries (BSI) is located at Tower Hill, Orange Walk approximately 20 miles from the mouth of the New River. The second factory, Petrojam Ltd. is located at Libertad, Corozal, approximately 5 miles from the mouth of the New River. It is estimated that 950,000 tonnes of sugar cane is processed each year with approximately 66% going to Belize Sugar Industries and 34% going to Petrojam Ltd. B.S.I. process the sugar cane to give crystalline sugar and molasses, while Petrojam Ltd. only produce molasses. However, the ability to produce crystalline sugar still exists at Petrojam Ltd. The sugar and molasses is transported by river from these factories to Belize City. This is a route which takes the barges down the New River and then along the coast, between the reef and mainland, as far as Belize City. Most of this produce is then exported. Some of the sugar is retained for domestic use, while a small portion of the molasses is retained to produce Belize Rum.

Both of these factories produce substantial quantities of effluent.

Rum Industry

There are two distilleries in the country; Cuello Distillery located outside Orange Walk and Traveller's Distillery located on the Industrial Estate in Belmopan.

The Cuello distillery produces 7,740 gallons of rum per year. This is a relatively small distillery by international standards. At the time of inspection the distillery was not operating. When operational the distillery produces two main effluent streams:

(a) liquid waste from its bottle washing operation and
(b) liquid & solid wastes from the residue after distillation.

Stream (a) consists of water to which a dilute solution of sodium hydroxide has been added while stream (b) contains all the fermentation residue after the alcohol has been distilled. It is estimated that 172,000 gallons/year of liquid is generated in this stream (b). This is generated in four batches; 52,000, 48,000, 36,000 and 36,000 gallons. The maximum batch discharge, therefore, is 52,000 gallons.

There is no on-site treatment for either of these wastes streams. The owners of the distillery advise that the streams are discharged into a lagoon which is linked into the New River. They also advise that the concentrate solids fraction of the waste in stream (b) is used for agricultural purposes. No direct evidence of pollution from this source was detected during the survey of the New River. However, it is very probable that stream (b) contains a very high level of organic matter. Even with a COD of 10,000 mg/l, the batch discharge of 52,000 gallons would approximate to the discharge of domestic effluent from a city with a population of 26,230 inhabitants.

The liquid waste in stream (a) does not contain a high COD value. The main pollutant in this stream is the dilute sodium hydroxide used in the bottle washing process. This stream, therefore, requires neutralization. It is suggested that a balancing system be installed so that an evenly distributed flow can be generated. After suitable analysis of this effluent, a treatment system can be designed to meet the required effluent discharge standards.

A more formal approach to the discharge of these effluents should be adopted by the Government of Belize (DOE). This can be achieved by compulsory monitoring and regular reporting of the results by the companies, with occasional spot checks by Staff from the Department of the Environment. Acceptable discharge limits can then be established which will protect the quality of the receiving water body, while maximizing the self purification capabilities of the receiving water streams.

Brewery Industry

Two breweries were investigated. These were the Belikin and Crown Breweries both in Ladyville, Belize City.

The waste streams from these breweries are similar to the streams from the Rum Industry. In the case of the Belikin Brewery (the larger of the two) the wastes are discharged via a drain into a lagoon which feeds into the Belize River. This company is constructing a new brewery and has already laid both water supply (4" rising main) and waste water disposal (12") lines. While the foundations for this new brewery have already been installed, no plans have yet been prepared for an effluent treatment system.

The preparation and submission of these plans and specifications to the Department of the Environment for prior approval before construction should be a priority so that adequate effluent discharge standards can be specified by the D.O.E. No deterioration in water quality should be allowed in the Belize River, as it is already being used as a major ecotourism asset. It is also used as the main water supply source for Belize City but the intake is much further upstream than Ladyville.

It is also important that details of this new effluent treatment plant be supplied and agreed with the D.O.E. as it is intended to instal a diary plant on this same site, with the new effluent works being used to treat the effluent from all on-site sources.

In view of this proposal, it is strongly recommended that a formal effluent treatment system with primary, aerobic secondary and tertiary (if necessary) treatment be installed. The company advise that the solids from its fermentation process are used for agricultural purposes. This should be checked and verified, particularly in view of the probable increase in production capacity.

The Crown Brewery in Ladyville is a smaller operation. The liquid wastes from this operation are treated in an anaerobic settling tank (septic tank) with the settled liquid being pumped through a subsoil field drainage system. The settled solids are removed by vacuum tanker after a period of digestion. These solids are then transported to the city dump.

As the treated water is discharged into the ground and since the ground water table is high in this location it might be advisable to monitor an observation well in close proximity to the percolation area.

The information from this source, combined with a complete inventory of the brewery wastes, should allow the D.O.E. to assess the suitability of this system.

Fish Farming Industry

There is a very large Shrimp farming-harvesting operation at Ladyville on the Northern Highway, approximately 10 miles from Belize City. This is a relatively new enterprise which has only been in operation for a few years. 1,800 acres of sea water lagoons have been constructed. The shrimp are grown in the lagoons and are harvested and packed for export in a processing plant which is located within the complex. Liquid waste from the processing plant is treated in two oxidation ponds operating

in series. These oxidation ponds, appear to be adequate for the applied loads but there is no operational date or effluent inventory for these ponds.

A suitable monitoring procedure should be established with the data being forwarded on a routine basis to the D.O.E. The discharge from these oxidation ponds goes into a creek which discharges directly into the sea, approx. 1 mile downstream.

At harvesting time the main lagoons are emptied. This sea water is pumped directly into the sea. The quality of this water is not known. As a matter of urgency, the quality should be monitored, with particular emphasis being placed on: organic content, levels of pesticides, fungicides, algacides, bacteriological quality relating to the spread of fish disease and total volumes discharged. With this information available, the D.O.E. should establish suitable criteria for the safe discharge of this waste water into the sea.

Citrus Industry

There are two factories in the Stann Creek District which process the citrus crop. The juice and oil is removed from the crop and the residual solids remain for disposal. These solids are dumped in excavated holding areas, where natural fermentation and degradation occurs. During this process some of the material is released into a liquid phase. This residual liquid is a very strong pollutant.

During the period of the study a substantial fish kill occurred, due to the seepage of some of this material into the adjacent fresh water stream. While a detailed assessment of the wastes from the Citrus Industry, is outside the brief for this study, an outline proposal for the economic treatment of this waste is contained in ANNEX VI.

As part of a National Industrial Pollution Control Monitoring programme, a full effluent inventory for each of the Citrus processing factories should be obtained. Discharge standards should then be set by the D.O.E., in a manner similar to that which is being proposed herein for other industries. The stream which passes through the Pomona and Stann Creek Valley area is an extremely oligotrophic water body which has very low alkalinity and hardness values. Even the discharge of very small quantities of effluent into this water body will cause severe pollution problems. It seems very likely that this water body will not be a suitable discharge sink for any effluent stream, particularly during the dry season.

Conclusion

After the initial Preliminary surveys, it was recognized that the major sources of industrial water pollution in Belize are those generated by the Sugar and Citrus Processing Industries. While the other industries also contribute certain levels of pollution, their total pollution load and subsequent effects are only minor when compared with the two main industries. As an in depth investigation of the Citrus Industry effluent streams was outside the brief of this Consultancy, this report is confined to dealing with problems associated with the Sugar Industry and its effects on river water quality in the New River. However, its findings, conclusions and recommendations may be extended, in principle, to address other industrial wastes.

II - SUGAR FACTORY SURVEYS

General

Approximately 950,000 tons of sugar cane are grown per crop year in Belize. This crop harvest is divided between the two sugar factories, with

(a) Belize Sugar Industries, Tower Hill processing 634,000 tons and
(b) Petrojam Ltd, Libertad processing 316,000 tons.

The processing procedure is similar in both plants. This procedure can be generally divided into five steps

* Juice Extraction
* Juice Filtration and Clarification
* Juice Concentration
* Crystallization
* Centrifugation

Waste streams and products are produced in each step. A simplified flow diagram for raw sugar cane processing is given in Figure 1.

During juice extraction concentrated waste water is produced from wash water and cooling water for the bearings in the heavy machinery.

At the filtration and clarification stages filter cake solids are produced.

The concentration procedure involves increasing the solids content from 16% to 65%. This is achieved through boiling and and vacuum evaporation. A very large quantity of condenser cooling water is used in this process. This accounts for most of the liquid waste water produced by the factories.

With increasing concentration and purification of the liquid mass, crystallization of the sucrose molecules occurs. These crystals are further separated in the final centrifugation stage.

Sources of Pollution

(a) Air Pollution

It is estimated that 147,250 tons of bagasse is produced from the processing of the 950,000 tons of sugar cane. This bagasse is used to fuel the boilers which produced the heat and steam required for heat and power in the total plant. Only 59.3% of the bagasse is required for heat and power, the remaining 40.7% is burned in incinerators as a means of disposal.

These boilers and incinerators produce flue gases and air pollution. There are no scrubbers, cyclones or precipitators in these stacks, which results in substantial air pollution.

(b) Waste Solids

Bagasse, the solid residue remaining after the sugar cane juice has been extracted is used to produce heat and power. This results in approximately 3% remaining as ash waste. The ash is removed from the burners using a water stream and is settled in a separate ash settling pond. The settled solids are excavated and used as agricultural fertilizers or as a land fill. The settled water is discharged directly back into the river.

Mud solids are generated in the filtration process. These muds contain both organic and inert solids. This material is dumped on site and remains as an unstabilized source capable of causing serious water pollution during the rainy season.

(c) Water Pollution

Water Pollution from sugar cane processing is the most serious source of pollution in the whole process and is the central focus of attention for most Regulatory Bodies. The largest volume of waste water is produced in the condenser cooling water stream. The volume utilized in this process is so great, that standard biological or chemical water treatment systems could not be economically employed to treat any substantial organic contamination of this stream. Hence the focus of attention must be the prevention of contamination of this stream.

Fortunately, through the proper design and operation of the condenser-vacuum pans, it is possible to prevent any contamination. Some of the older condenser vessels may need modification to prevent the over spill of the boiling sugar liquid during periods of full load.

The remaining major source of pollution in this stream is the absorbed heat which is entrapped during the process. Some effort must be made in both factories to reduce the level of thermal pollution from this stream.

The next major specific waste water flow comes from the periodic cleaning and wash down of the heat exchanges and other vessels. Sodium hydroxide and hydrochloric acid are used in this cleaning process. These wastes, which are discharged in batch flows and in relatively large volumes contain substantial quantities of both chemical and

organic pollutants. A proper blending and disposal regime must be instigated for this waste stream.

Other sources of waste water include; floor washings, bearing cooling water, spillages, boiler blow down, domestic wastes, waste from the factory laboratory which may contain lead and other chemicals, etc. These source constitute the main continuous flow of organically contaminated waste water. The COD of this stream is typically 8,000 mg/l and it also contains; waste oil, fats, grease, detergents, etc.

All these waste water streams, with the exception of the properly protected condenser stream, require formal primary, secondary and possibly tertiary treatment before they can be safely discharged into the receiving water body.

Belize Sugar Industries, Tower Hill, Orange Walk. Drainage and effluent characterization

There are four separate waste water systems in this factory:

(i) Main condenser water
(ii) Contaminated waste stream
(iii) Ash pit drainage
(iv) Drainage from around the molasses tasks.

The main characteristics of these effluent streams are shown in Table 1. The general factory site layout is shown in Figure 2.

(i) Main Condenser Water

This stream contains by far the biggest flow. This flow is estimated at 18,000 gallons/min. (117,677 m3/day) which is the maximum flow rate for the supply pumps. This water is taken directly from the New River and returned to the New River approximately 100 meters downstream.

The Management at B.S.I. claim that since the new separation entrainment channels had been installed in the vacuum vessels, no organic pollution of this stream can occur. It is evident from the data in Table 1 that some organic contamination of this stream is still occurring. The Chemical Oxygen Demand (COD) on the 18/3/93 was 44 mg/l, while the upstream value in the New River at the Toll Bridge site was only 18 mg/l. This increase represents a total organic load of 3 tonnes/day which is approximately equivalent the domestic waste from a city with a population of 33,000 inhabitants. On the 29/3/93 there would appear to be no additional organic contamination in this stream. In the 'Balfour and Sons' Report, April, 1977, the Biochemical Oxygen Demand (BOD) in the Condenser stream was estimated at 77.5 mg/l (approximately equivalent to a COD value of 117 mg/l).

Based on this very limited spot checking of this effluent stream, it would appear that some improvement has taken place. However, the elevated value measured on the 18/3/93 is a cause for concern and warrants further investigation. The data presented in Table 2 shows COD values of 298 - 316 mg/l in this stream during March 1992. It is not clear from the Data in Table 2 whether these figures represent the combined flow of condenser water and discharge from the effluent treatment lagoons, as both waste streams join in the channel before gaining access to the New River.

Based on the data available, it is strongly recommended that a proportional flow automatic sampling device be installed in this stream and that daily analysis for COD, Ph, temperature and dissolved oxygen (DO) be carried out. This data should be

forwarded on a regular weekly basis to the D.O.E. as part of a National Inventory on Industrial Pollution within Belize. After a suitable data base, with independent cross checking of random spot samples, has been established, meaningful discharge standards can be laid down by the D.O.E.

The other major source of pollution in this stream is temperature. Readings of 37 Deg. C and 40 Deg. C were recorded on the 18th and 29th March, 1993 (Table 1). Readings of 25.4 Deg. C and 37.6 Deg. C were recorded on the 16th and 17th March, 1992 (Table 4). The management of BSI advised that turbulence was introduced into the discharge channel, in an attempt to reduce the temperature, but it appears that this is inadequate or ineffective. Table 6 shows some of the recorded hydrological flow data for the New River at Tower Hill in 1990. If the dry weather flow, recorded on the 13/7/90 (117,936 m3/day) occurs while the B.S.I. factory is in operation, then the daily factory water intake, 117,677 m3, will approximate to the total river flow. In such a situation, it is obvious that the river temperature will be elevated, far above the maximum recommended value of 2 Deg. C. It is, therefore, very important that a proper cooling system be installed in this stream, so that even in the low flow, dry weather season, the ambient temperature of this river is not elevated more than 2 Deg. C. Towards this end, it is important that an ambient temperature inventory for the New River be established upstream of any possible effects from the discharge source (the toll bridge site would appear to be a suitable location) and downstream after plume dispersion in the river.

The immediate recommendations for this stream are:

* Obtain representative continuous analytical data to establish a base line inventory.

* Reduce the discharge temperature, so that the ambient river temperature is not increased by more than 2 Deg. C, even under dry weather flow conditions.

* Obtain continuous base line data on the ambient temperature in the new river at the Toll Bridge and Orange Walk Bridge sites.

* Install an automatic proportional flow sampling system on the waste stream at the point of discharge into the new river.

* Forward the analytical results for BOD, COD, SS, pH, temperature, DO, Nitrate, Phosphate and Sulphate data to the D.O.E. on a regular weekly basis.

(ii) Contaminated waste stream

This stream contains all the effluent from factory wash-down, floor washings, spillages, bearing cooling waters contained heavy oils, boiler blow -down water, caustic and acid washings, etc.

The measured composition of this stream on the 18/3/93 is shown in Table 1 and in Tables 2 - 5 for dates in March, 1992. There is a wide variation in COD concentration in this waste stream. The measured flow rate (spot check) on the 18/3/93 was 387 m3/day. At the measured COD value of 8.700 mg/l, this represents an organic load of 3.4 tonnes/day. This COD load does not include for the heavy oil which has been removed in a surface skimming unit. The pH analyses for this effluent stream have not managed to detect the caustic or acid discharges which occur during cleaning of the heat exchangers. This waste stream is sent for treatment in a mechanically aerated lagoon system.

The immediate recommendations for this stream are:

* Obtain representative continuous analytical data to establish a base line inventory.

* Obtain continuous hydraulic flow data.

* Install a better oil removal system, such as a properly designed automatic dissolved air floatation unit.

* Install adequate storage buffering capacity for the caustic and acid flows, so that these can be continuously blended with the constant waste flow. It is almost impossible to operate a waste treatment facility which is subject to large sudden shock loads of caustic or acid. If the waste treatment facility is upgraded to an activated sludge plant, it may be possible to utilize one of the existing settling lagoons as a balancing tank.

* Install an automatic proportional flow sampling system on the waste stream at the point of discharge into the New River.

* Forward the analytical results for BOD, COD, SS, pH, temperature, DO, Nitrate, Phosphate and Sulphate to the D.O.E. on a regular weekly basis.

(iii) Ash pit drainage

The ash from the burners is removed by washing with water. This waste flow is passed through a settling pond where the inert solids are removed under gravity. The settled liquid is then returned directly into the New River, upstream of the main water

intake. If this water has only been used for ash removal then its organic content should be very low. However, a spot sample taken on the 15/3/93 gave a COD reading of 200 mg/l while the sample taken on the 18/3/93 (Table 1) gave a reading of 42 mg/l.

The Factory Management were unable to give an explanation for this occurrence. At the time of the inspection the settlement pond seemed to be almost full with solids. It is probable that short circuiting was occurring. The temperature of the discharging liquid was more than 37 Deg. C, which would also indicate that the retention time was very short. Equipment or facilities to carry out solids analysis were not available at the time of this Consultancy. The flow through the ash settling pond is an intermittent process.

The immediate recommendations for this stream are:

* Obtain representative continuous analytical data to establish a base line inventory.

* Obtain continuous hydraulic flow data.

* Install a more controllable solids settlement system, with regular solids discharge, which is automatically controlled by suitable density probes.

* Identify and remove any source of organic pollution.

* Install a cooling system, if detention time is too short to dissipate the entrained heat.

* Install an automatic proportional flow sampling system on the waste stream at the point of discharge into the New River.

* Forward the analytical results for COD, BOD, SS, pH, temperature, DO, nitrate, phosphate and sulphate to the D.O.E on a regular weekly basis.

(iv) Drainage from the molasses tanks

While no discharge occurred from this area during the Consultancy, the potential for serious pollution, from this area exists. If it is assumed that raw sugar cane produces 10% by weight processed sugar and that 0.31 tons of molasses is produced for each ton of sugar manufactured, then 19,530 tons of molasses is produced by B.S.I. each year. Molasses contains at least 200,000 mg/l COD. Any accidental spillage, even a small amount would have a very serious environmental impact. The spillage of only one cubic metre would result in a pollution load equivalent to the daily domestic effluent discharge from a population of 2,200 inhabitants.

The concentrate molasses is stored in large tanks, adjacent to the river bank and is discharged into river barges for transport to Belize.

Apart from accidental spillages, at loading, any leak from the storage tanks would be an environmental disaster. Proper bunding is advised. These storage tanks are cleaned on a irregular basis. Any cleaning water should be directed into the waste water treatment system.

The immediate recommendations for this stream are:

* Install adequate bunding around all storage tanks (including oil storage tanks).
* Direct the entrapped flow into a storage area or into the waste water treatment plant (if the viscosity of the molasses will allow it to flow in an open channel).

* Instigate an early warning system so that the D.O.E. will be notified immediately, if any spillage occurs.

Waste Water Treatment Facilities at B.S.I., Tower Hill.

General

Apart from the facility described for ash pit drainage, the main treatment works apply to the contaminated waste stream described at (ii) above. This stream has an estimated flow rate of 387 m3/day. A general layout for the treatment works is shown in Figure 2.

Present process.

The present process involves:

(a) Oil skimming
(b) Aeration
(c) Final settlements in two settling lagoons.

(a) Oil skimming

This is a manual process whereby oil is retained by use of a baffle board in the flow channel. The oil is then manually skimmed and deposited into storage barrels which are subsequently dumped in a corner of the factory site together with the separated solids generated in the filtration/clarification process.

(b) Aeration Pond

The waste liquid is fed forward into a lagoon. There are six surface aerators in this lagoon. At the time of inspection only five of these aerators were working.

The data presented in Tables 1 - 5 and Figures 3 - 6 give a general indication of the treatment efficiencies achieved in this aeration system. This data represents spot samples taken over short periods. Sudden fluctuations due to shock caustic, acid or organic loads are not shown.
It is obvious from this data that there is a wide variation in organic loading. The pH, temperature and DO values are all reasonably standard (caustic and acid streams excluded). The D.O. value in the aeration lagoon during the 1992 monitoring period, approximated to 1 mg/l but there was zero D.O. in the 1993 sample. The pH was adjusted to approximately neutral values in the aeration pond. This may have been due to the addition of chemical nutrients and lime.

If total treatment efficiency is assessed, including settlement in the settling lagoons, then an average COD remove efficiency of 76% is achieved with the 1st settlement lagoon, but only a 32% efficiency with the 2nd settlement lagoon. The efficiency for the 1993 data is much better with 91% and 96% removal in the 1st and 2nd settlement lagoons respectively.

The 1993 data is somewhat misleading, due to the fact that the lagoons were not being discharged into the stream at the time of sampling. The samples where taken from the surface of the lagoons and do not account for any organic solids which might be entrained in the flowing liquid. The 1992 data is probably a better representation of the plant operation.

(c) Final settlement

Two lagoons are used for final settlement. These lagoons are used both in series and parallel. Discharge to the main channel from the lagoon is made at irregular intervals when the surface COD reading is acceptable and when the water level in the receiving channel is lower that the invert level of the outlet from the lagoons.

The New River is subject to tidal effects, even as far up stream as Tower Hill. At times of high tide the water level in the river may be higher than the invert level of the outlet valves from the discharge lagoons.

Conclusions

The intermittent discharge from the settling lagoons is not a suitable mechanism for the proper operation of an effluent

treatment plant. There is no facility for the removal of settled solids from any of the lagoons or from the aeration pond. There is no buffering storage capacity for the concentrate caustic and acid washes when these are produced in the factory. The dissolved oxygen level in the aeration pond is well below the recommended minimum value of 1-2 mg/l for an aeration plant. Excess oil is gaining access to the aeration pond and the lagoons.

Recommendations

* Install adequate storage capacity to accommodate the caustic and acid wastes, so that these waste streams can be consistently blended with the main concentrate effluent stream.

* Install an automated dissolved air floatation unit, which will treat the effluent before it goes to the aeration pond.

* Find an alternative, environmentally friendly disposal mechanism for the oil and solids collected from this dissolved air floatation unit.

* Install an inter-connecting pipe net-work system with pumps, between the aeration pond and the 1st settlement lagoon so that these facilities can be used in tandem, as an activated sludge plant. (The 2nd settlement lagoon might be used for storage of the caustic and acid wastes).

* Combine the settled biological solids from the secondary settlement lagoon with the solids from the dissolved air floatation plant and the filter cake from the factory. Dispose of these solids in an environmentally friendly manner. Some of the energy from the excess bagasse might be used in a suitable drying (incineration) process.

* Invest in suitable monitoring equipment to access the operation of the proposed treatment system.

* Educate sufficient members of staff at B.S.I. to operate this effluent treatment system.

* Install an automatic proportional flow sampling system on the waste outlet before discharge into the main flow channel.

* Forward the analytical results for COD, SS, pH, Temperature, DO, Nitrate, Phosphate, Sulphate and oil to the D.O.E. on a regular basis.

Petrojam Ltd., Libertad, Orange Walk.
Drainage and effluent characterization.

General

The effluents from this factory are similar to those described for B.S.I. However, there is no waste treatment facility at this factory and all waste streams are combined, with one outfall into the New River. An analysis of the composition of this effluent stream is given in Table 7.

It must be clearly noted that the data obtained in the case of Petrojam relates to the total flow which is estimated at 81,870 m3/day. The estimated total organic load in this flow is 22.1 - 25.4 tonnes/day which is equivalent to the waste from a city with a population of 283,000 inhabitants. The temperature was measured at 36 - 37 Deg. C. There was also considerable oil pollution in the New River at the point of discharge. The DO in the New River downstream as far as the mouth of this river, approximated to zero. At times of high tides in the river, the pollution extends upstream for at least a distance of a half mile.

The Petrojam Ltd. factory, while not being as large as B.S.I. and while it only produces concentrate molasses, is causing far more substantial pollution in the New River than the B.S.I. factory. It is an older factory than B.S.I. and production processes may not be as efficient, resulting in sugar losses into the main condenser stream.

The proximity of this factory to the mouth of the New River, approximately five miles and the lack of any substantial settlement downstream, has probably prevented large scale publicity being associated with this very serious pollution problem.

In discussions with the Management it was indicated that the Company does not own sufficient land to install an effluent treatment system, similar to B.S.I. However, the pollution problem is so serious that some additional land must be acquired so as to install a suitable effluent system, even if this requires intervention by the Belize Government.

Recommendations

* Carry out a complete inventory of all waste streams in the factory.

* Instigate in house modifications to reduce and separate these waste streams.

* Remove all organic contamination from the condenser stream.

* Install a cooling system on the condenser stream.

* Install an effluent treatment system as described in the recommendations for B.S.I.

* Carry out the recommendations listed for the other waste streams at B.S.I.

III - NEW RIVER SURVEY

General

A number of surveys of the New River from Lamanai to the point of discharge into Corozal bay were carried out during this Consultancy. The data from these surveys is presented in Tables 8 - 17 and Figures 8 - 17. The main objectives of these surveys was to assess the pollution loads being dumped into the New River and the effect of this pollution on the water quality within this water body.

The water was analyzed for; dissolved oxygen (DO). Chemical Oxygen Demand (COD), temperature, sulphate, phosphorus, nitrate, ammonia, iron, hardness and alkalinity. It is clearly evident from all the data that there is a major deterioration in water quality from the Lamanai Lagoon to the point of discharge into Corozal Bay.

Two major sources of pollution were identified. These sources were at the outfalls from B.S.I. Sugar Cane Factory at Tower Hill and Petrojam Ltd. Sugar Cane Factory at Libertad.

Results

a) Dissolved Oxygen

Table 8 and Figure 8 give the data relating to dissolve oxygen. The DO fell from a supersaturation value at Lamanai of 10.5 mg/l (saturation value of 9.0 mg/l at 20 Deg. C) to 0.25 mg/l at the mouth of the river. There is a gradual decline from Lamanai to the Toll Bridge. This decline is normal and is consistent with a deep, slow flowing river in a tropical/subtropical climate. The sudden fall after the outfall from B.S.I. is indicative of excessive organic pollution.

The dissolved oxygen level has recovered considerably by the time it reaches Orange Walk and continues to recover all the way down to Caledonia and Santa Cruz. Again there is a sudden deterioration around the outfall from Petrojam Limited. The river does not recover from this until it reaches the sea at Corozal Bay, a distance of approximately 5 miles. Because the New River is a deep, slow flowing river, it is very subject to tidal fluctuations which can caused stagnant or reverse flow conditions for a considerable length upstream. This is the reason that the pollution effects from the Petrojam Factory, can be noticed even at one mile upstream.

(b) Chemical Oxygen Demand (COD)

The changes is COD values, Table 9 and Figure 9 are not as noticeable as the DO readings, although it is this organic matter which causes the DO deficits. There is, however, a very noticeable change in COD values after the outfall from the Petrojam factory. The very high reading at the mouth of the river may have been due to the spot sampling method used. From Libertad down to the mouth of the river there is an hydrogen sulphide odour with gas bubbles rising from the river bed. Sometimes these bubbles cause mud clouds to rise to the top of the water, resulting in localized high solids contents and organic readings. Because of the laminar flow pattern in this river and a depth estimated at 20' - 30', it is very probable that a layering effect occurs. An attempted was made to measure this layering effect, but because of the extension lead for the probe was only 9', it was not possible to measure below this level. The temperature reading did show a decreasing value with increasing depth. All the spot samples were taken at approximately 6" below the surface. If the layering theory is applicable, it is probable that the effluent plumes in the river extend long distances beyond the actual outfall and mixing with the general water body may take a long time. This aspect should be borne in mind when discharge limits are being set for industries along this river basin.

(c) Temperature

It is obvious from the data presented in Table 10 and Figure 10 that the temperature variation is closely associated with the ambient air temperature. Even at a depth of 9', there is less than 1 Deg. C between the temperature at the top and at 9' down. However, from the data plotted in Figure 10, it is obvious that there is an increase of 1 - 2 Deg. C above the ambient value, down streams of both factories outfalls.

While the hydrological flow data for the New River was not available for the period of this Consultancy, it is known that the flow was much greater than the minimum flow recorded on the 13 July 1993, Table 6. As discharge limits should relate to the minimum dry weather flow, it is very important that the temperature of the condenser flow streams be reduced, so that the limits described in Chapter IV are achieved. On 29 March 1993, a temperature of 40 Deg C., in a flow of 117,677 m3/day, was recorded for the condenser waste stream at B.S.I. (Table 1.)

(d) Sulphate

There is no noticeable alteration in sulphate readings as a consequence of the two factories discharges (Table 11 and Figure 11). There appears to be a decreasing trend in the sulphate values along the river. This may due to the decreasing DO levels which results in an increase in hydrogen sulphide readings. Hydrogen sulphide levels were not monitored, but there was a very distinct hydrogen sulphide odour in the river from the Petrojam outfall, as far as the mouth of the river at Corozal Bay. Sulphate is converted to Hydrogen sulphide in the absence of dissolved oxygen. It should be noted that hydrogen sulphide is a very toxic gas. While the sulphate levels are generally not excessive (Table 18 and 20,) they are far greater than the zero levels recorded in the Stann Creek area at the Citrus Company of Belize outfall in Pomona. (See ANNEX VI)

(e) Phosphorus

In general the background phosphate levels are quite low. (Table 12 and Figure 12). This means that eutrophication is well controlled in this water body. There is no noticeable change in Phosphate levels at the B.S.I. outfall. However, there is a very substantial increase in phosphate levels at the Petrojam Ltd outfall, particularly on 29th March 1993. There is no apparent reason for this sudden increase and since a similar occurrence does not happen at the B.S.I. outfall, this matter should be investigated. It is possible that a molasses spillage around the 29th March could have caused this increase. These relatively high levels of phosphate in the river, discharging into Corozal Bay, may if allowed to continue, result in substantial eutrophication of both the final section of this river and the bay itself. Tertiary treatment methods for phosphate removal are not difficult to implement.

(f) Nitrate

Similar to the phosphate readings above, the nitrate values are acceptable. (Table 13 and Figure 14). However, similar to phosphate, the readings for 29th March 1993, at the Petrojam outfall are very high and need further investigation. High levels of nitrates combined with high phosphate values will result in eutrophication . The removal of nitrate is an expensive process and would not be an economical preposition for volumes of flow involved.

(g) Ammonia

The readings for ammonia are presented in Table 14 and Figure 14. Once again, the data shows a similar pattern to

the phosphate and the nitrate values described above. The elevated values for the 29th March 1993 correspond with the elevated nitrate values for this same date. As ammonia represents an unoxidized fraction of the total nitrogen content, it is logical that the ammonia values should follow the nitrate pattern. Ammonia is a toxic element and it desirable to maintain levels below 0.02 mg/l in fresh water. However, the toxicity effect is dependent on pH, temperature and other water quality parameters. Values of 2.53 - 4.5 mg/l are extremely high and need to be controlled. Very low dissolved oxygen levels will lead to the reduction of nitrate to ammonia. This may be a contributory factor at the Petrojam Ltd outfall.

(h) Iron

In general the iron readings are quite low. (Table 15 and Figure 15). The values for the sample point at 1/2 m down steam from Petrojam are relatively high. This should be investigated, together with the phosphate, nitrate and ammonia levels around this same stretch of river. The high levels of these parameters may be due to a molasses spillage, as molasses contains high levels of these compounds.

The anaerobic conditions present in the stretch of New River from the Petrojam Ltd outfall to Corazal bay, will tend to reduce the level of free iron due to the chemical attraction between iron and hydrogen sulphide.

(i) Hardness

The general level of hardness in the New River is very high. (Table 16 and Figure 16). This indicates that the water drainage into this river comes from a limestone basin. This high hardness value helps the river to deal with the heavy organic loads which are being discharged into these waters. If the New River had a hardness value of 12 mg/l CaC03 similar to the stream at Stann Creek, then it would not be able to receive any degree of organic contamination, as the pH would drop, resulting in acidic conditions.

(j) Alkalinity

Table 17 and Figure 17 show that the alkalinity readings for this river are similar to the hardness values described above. The alkalinity level in this river is high. This is a factor which helps the river to deal with the high organic loads being discharged into its waters.

Discussion

It is very obvious from this data that both Sugar factories are causing substantial pollution in the New River. The degree of pollution caused by the B.S.I. factory is not as great as that caused by Petrojam Limited. This finding is consistent with the data obtained in the factory surveys (Chapter II). The river is effectively dead from the Petrojam outfall until it reaches the sea. As sampling did not coincide with the caustic or acid washes, the effects of these discharges have not been monitored. It has been reported, that on occasions, a distinct change in water colour takes place during these washing cycles, which severely affects the fish life. Such an occurrence happened on the week-end of the 17th April, 1993, at B.S.I. which resulted in a sustained fish kill for a period of 5 days.

When the river was sampled on the 29 March 1993, there was gross oil pollution in the Petrojam outfall area. Apart from being a major source of pollution, it is most unsightly and does not add to the image of Belize as an ecotourism destination.

From the data obtained in the factory survey, the river surveys and the hydrological data for the New River, Table 6. It is obvious that this river is incapable of assimilating large organic loads. The river is deep, slow flowing, non turbulent with an ambient temperature range up to almost 30 Deg C. It has a natural ambient background organic load at the Toll Bridge site of up to 18 mg/l COD (the apparatus to measure BOD was not available at the time of the surveys). The river is now being promoted as part of a natural ecotourism promotional effort, which because of its size and navigability, is ideally suited to this task.

In view of these facts, it is very important that pollution discharges into this river should be regulated and controlled with discharge and quality standards being set which approximate to recognized International Standards as described in Chapter IV

IV - INDUSTRIAL POLLUTION CONTROL MONITORING PROGRAMME

General

The Belize Government has recently introduced the Environmental Protection Act, 1992. This act deals with the prevention and control of environmental pollution and sets out the rules and regulations governing effluent discharges in Belize. In order to implement this Act, the Government of Belize is anxious to establish guideline standards for the control of industrial effluents. These standards should be broadly based on WHO, EPA and EEC standards.

In most countries, discharge limits are set on an individual basis, i.e., a license is issued to each discharger which limits the type, quality and quantity of pollution which the industry is allowed to discharge into the environment. The limits are based on information supplied by the Industry in an inventory which lists the complete characteristics of the waste streams and specifies the location of the streams on a suitable site map. A sample application form is shown in Annex VIII.

These limits also take into account the assimilative capacity, if any, of the receiving water body. Hence it is also desirable to establish a national classification of all relevant water bodies in the country. This classification can be based on many factors such as organic content, salinity, nutrient status, bacteriological quality, trace organics, acidification, solids content, radio activity, etc. However, this type of classification is very expensive and requires a lot of monitoring. A more general guide to national water quality is achieved by using some type of biotic index. This involves creating a list of biological indicators, which normally occur in these waters and which have different levels of tolerance to various pollutants. There are several examples of this type of quality assessment which are broadly referred to as a biotic index.

The establishment of such an index should be the goal of the Belize Government. Recommendations for such a system are contained in Technical Report No 34 WMO/TD-No. 522, 1991.

Water Quality Objectives

The determination of quality parameters and of water quality objectives for all beneficial uses of the national water bodies is a very complex process. However, in arriving at water quality objectives all beneficial uses should be taken into

account and the quality objectives must be designed to meet the most stringent beneficial use requirements. This use will normally be one associated with fisheries or human consumption.

Where the national water quality is already inferior to the recommended values, no additional pollution loads should be applied and efforts should be made to identify and correct the cause of the existing pollution.

There are basic physical, chemical and biological differences between marine, estuarine, river and lake waters and even in a single watercourse, ecological conditions may vary widely within short distances. It is very difficult for global national water quality standards to meet the needs of all individual aquatic ecosystems and such standards should therefore be applied with considered judgement of local conditions and in consultation with local Fishery Authorities and other local Water Authorities.

However, the data shown in Tables 18 and 20 should be looked upon as the minimal standards to be maintained, while aiming for superior standards.

EEC Water Quality Standards

The mandatory minimal water quality objectives for surface waters intended as sources for drinking water within the EEC are listed in Table 18. The mandatory quality requirements for bathing waters within the EEC are listed in Table 19, while the water quality objectives for spawning and salmonoid freshwaters, estuaries and other coastal waters are listed in Table 20. These values list the minimal quality objectives. Member States may set more stringent limits for certain of these parameters. The EEC also identify certain of the above parameters to which it ascribes more stringent 'desirable limits'.

Effluent Discharges

General

Tables 18, 19 and 20 indicate the maximum allowable concentrations for certain chemical parameters in different water bodies, depending on the use of these water bodies. If an effluent discharges into a water body, the resultant mixture should meet these minimum requirements. These Tables do not list any recommendations for organic loads or alterations in; dissolved oxygen levels, nutrients enrichment (eutrophication), suspended solids or temperature.

In defining the discharge limits for these parameters reference must be made to the existing status of the water body and its

assimilative capabilities, including such physical characteristics as; dilution factor, reaeration capabilities, flow patterns, seasonal variations and other hydrological influences.

In deciding what portion of the assimilative capacity of a receiving water may be allocated to an individual discharge, it is essential to consider other existing and possible future discharges.

(a) Organic loads

Most of the recommendations for organic loads relate to the work of the 'Royal Commission' in 1912. The reports from this Commission are mostly concerned with domestic effluents but over the years these recommendations and findings have been extended to include other organic wastes.

In these Reports, it is recommended that the Biochemical Oxygen Demand (BOD) of an effluent should be such that on admixture with the receiving water, the BOD value of this receiving water will not be increased by more than 1 mg/l. In no circumstances should the BOD value of the effluent be such that the BOD of the receiving water will be increased to a value greater than 5 mg/l. In the case of discharges from large urban areas, the Commission recommended that an effluent with a BOD of 20 mg/l or less and a suspended solids (SS) content of 30 mg/l or less would be acceptable, provided that there is a minimum dilution factor in the receiving water body of 1 in 8, at all times of the year.

It is a cumbersome and expensive procedure to carry out BOD analysis on a routine regular basis for a large number of samples. Hence, Chemical Oxygen Demand (COD) data is used as an alternative, where ever possible. For each individual effluent, the relationship between BOD and COD should be established at the outset. COD data can then be substituted for BOD data. It is very important that accurate BOD data be obtained initially so that a true picture of the organic pollution in the water body can be obtained.

(b) Dissolved Oxygen

The kinetics of BOD and dissolved oxygen are described in many publications and will not be repeated here (Balfour & Sons, 1977). For protection of the aesthetic quality of waters, it is only necessary to have sufficient dissolved oxygen to prevent the occurrence of septic or anaerobic conditions. However, in order to protect fish and other aquatic life more stringent standards are required. In addition, salmonoid and certain other fish species bury their fertilized eggs in bottom gravels. In order to ensure an adequate supply of oxygen in the

interstices of the gravel for the developing fish of these species, even more stringent standards are required. The following standards refer to water quality outside the mixing zone. (The mixing zone should not be so long and intense as to reduce the DO level across the full river section by more than 50%).

(i) Non salmonoid waters.

1) General DO levels to be not less than 70% of the saturation value in 50% of the samples.

2) DO level to be not less than 4 mg/l in 95% of the samples

3) No sample to have been less than 3 mg/l DO.

4) BOD not to exceed 5 mg/l.

(ii) Salmonoid and spawning waters

1) General DO levels to be not less than 90% of the saturation value in 50% of the samples.

2) DO level to be not less than 6 mg/l in 95% of the samples.

3) No sample to have less than 4 mg/l DO.

4) BOD not to exceed 4 mg/l.

(iii) Estuaries and other coastal waters.

1) General DO levels to be not less than 70% of the saturation value in 50% of the samples.

2) DO level to be not less than 5 mg/l in 95% of the samples.

3) No sample to have less than 4 mg/l DO.

4) BOD not to exceed 4 mg/l.

(c) Nitrates

Nitrates are important nutrients in eutrophication. They are abundant in nature and are easily leached from soil or fixed from the air as nitrogen. It is not practical, therefore, to recommend a nitrate concentration for eutrophication control in fresh water.

Problems similar to eutrophication, however, can occur in estuaries and even at sea. Phosphate is rarely the limiting nutrient in marine waters, usually it is nitrate, or, out of reach of land, silicate. Particular attention should be paid to the discharge of nitrogenous effluents near estuarine mud-flats which may cause problems of weed growth and decay. In order to prevent eutrophication in estuaries and coastal waters, a value of 1 mg/l nitrate is recommended as a suitable quality objective for these waters. Since concentrations of nitrate or nitrite, sufficient to cause toxic effects on fish life can rarely occur in natural waters, no recommendations for these parameters are being made for the protection of aquatic life.

High nitrate concentrations pose a potential health risk to infants under 3 months of age. The mandatory limit for drinking water is 50 mg/l.

(d) Ammonia

When ammonia dissolves in water a chemical equilibrium is established which contains un-ionized ammonia (NH3), ionized ammonia (NH4) and hydroxide ions (OH). Total ammonia refers to the sum of the un-ionized and ionized forms (NH3 + NH4). The harmful effects of ammonia in water are attributed to the un-ionized (NH3) fraction, which increases with rising pH and temperature. The toxicity of ammonia in fresh water is, therefore, dependent on the concentration of total ammonia, pH value and temperature.

To avoid adverse effects on aquatic life, a water quality objective of 0.02 mg/l of un-ionized ammonia (NH3) is recommended for freshwater.

The NH3 concentration is also dependent on ionic strength, decreasing with increasing salinity in dilute saline solutions. Since data on the effect of ammonia on marine species is limited, no water quality objective is recommended for coastal waters.

(e) Phosphorus

Limitation of phosphorus in effluent discharges is generally associated with control of nutrient enrichment or eutrophication of still water bodies, particularly lakes.

The physical and ecological characteristics of lakes are so variable that it is not possible to suggest a single or even a range of values for phosphate concentration which would assure control of eutrophication in any particular case.

However, the Vollenweider method of controlling the annual phosphate loading of lakes provides a useful approach to

eutrophication control. Vollenweider relates total phosphorus (P) loadings, in grams per square metre of surface area per year, to the ratio mean lake depth in metres divided by the hydraulic detention time in years. The loadings suggested by Vollenweider, and presented in the following Table, range from oligotrophic or permissible loadings to eutrophic or critical loadings. If phosphorus loadings are not allowed to reach the eutrophic level and are limited as nearly as possible to the oligotrophic levels, positive results can be expected.

LOADING VALUES FOR PHOSPHATES AS TOTAL PHOSPHORUS (P) IN LAKES
VOLLENWEIDER, 1973

Mean depth/ Hydraulic detention time (metres/year)	Oligotrophic or Permissible Loading (grams/metre2/year)	Eutrophic or Critical Loading (grams/metre2/year)
0.5	0.07	0.14
1.0	0.10	0.20
2.5	0.16	0.32
5.0	0.22	0.45
7.5	0.27	0.55
10.0	0.32	0.63
25.0	0.50	1.00
50.0	0.71	1.41
75.0	0.87	1.73
100.0	1.00	2.00

(f) Oil and Grease

Since oil and grease do not constitute definite chemical categories, but include thousands of organic compounds with varying properties, it is not possible to set numerical values as water quality objectives. They may be volatile or non-volatile, soluble or insoluble, biodegradable or persistent, and may be lethal or sub-lethal in their effects on aquatic life. Bioaccumulation of even minute concentrations of petroleum products may result in tainting of fish life or danger to human health. The following descriptive water quality objectives are recommended.

Oils and grease should not be present in qualities such as to:

1) form visible films on the surface of waters,

2) form coatings on the beds of watercourses, benthic biota or food sources,

3) cause deleterious effects on aquatic life,

4) impart a detectable taste or odour to edible aquatic species,

(g) Suspended Solids

Suspended and settleable solids and turbidity measurements are important parameters in water quality management. They are particularly important in the context of public and industrial water supplies. High turbidity makes water unattractive for recreational purposes, especially water contact sports. The effects of suspended solids on fish can be summarized as follows;

(i) Direct effect resulting in fish kills, reduced growth or reduced resistance to disease.

(ii) Prevention of the successful development of fish eggs and larvae by blanketing the bottom of water bodies.

(iii) Interference with natural movement and migration of fish.

(iv) Reduction of available food supplies by blanketing benthic populations and by a decrease in primary food production caused by reduced light penetration.

The present state of knowledge does not allow firm water quality criteria to be set for all waters in this context. However, the following guidelines are recommended.

(1) Artificial increase in turbidity should not be allowed to reduce the dept of light penetration by more than 10% outside the mixing zone.

(2) In the absence of adequate seasonal records of light penetration, total suspended solids should not exceed 30 mg/l in its effluent.

(3) Scum and other floating or suspended solids should not be present in the receiving water in unsightly or deleterious amounts.

(4) Deposition of solids shall not be much as to affect bottom feeding flora and fauna, or spawning or shellfish beds, or to form putrescible or otherwise objectionable sludge deposits.

(h) Temperature

Temperature is one of the most important factors regulating the composition, variety and activity of living species in an aquatic environment. It is also an important physical parameter which can effect many of the beneficial uses of water. Changes in

ambient water temperature have effects which are notable for their complexity and diversity and which are not sufficiently well understood to enable comprehensive thermal standards to be set for all waters or effluents.

Increased temperatures in polluted waters can cause aesthetic deterioration and danger to aquatic life by increased oxygen absorption caused by accelerating the biodegradation of organic matter both in the water column and in benthic deposits. This effect is magnified by the fact that the solubility of oxygen in water decreases with rising temperature.

Natural diurnal and seasonal changes in the temperatures of water bodies caused by climatic conditions determine the community structure and diversity of species, and are necessary to regulate certain life functions. For instance, the reproductive cycle is recognized as being most sensitive to temperature variation and is often induced by low winter temperature. In addition, a slight increase above naturally occurring temperatures, in early Spring can lead to advanced spawning with the result that young fish are hatched before their normal food source is available.

Uniform elevation of temperature over the year is less serious than brief fluctuations in temperature, particularly if these coincide with reproductive functions in the life cycle. Nevertheless it is important that thermal increase be minimized during all seasons of the year. In Summer the maxima are particularly important since they can cause critical conditions for brief periods which may result in death, emigration or other sublethal effects. These Summer thermal maxima should, if possible, be established for each water body and no increase on these maxima by artificial means should be allowed.

As a general guide, it is recommended that effluent discharged into a water body should not elevate its ambient temperature by more than 1 Deg. C at any time throughout the year.

(i) Toxic Pollutants

In an ideal situation the basis for establishing the safe concentration of a toxic pollutant would be to select the species in the receiving water most sensitive to the particular pollutant and to subject this species to long-term bioassays with various concentrations of pollutants, in conditions as closely as possible resembling those in the receiving water. In view of the cost involved in such long-term testing the "safe" level is normally estimated firstly by determining the concentration of pollutant which is lethal to 50% of the test species in 96 hours. This concentration is known as the 96 hour LC50 value. An "application factor" or safety factor is then used to calculate a concentration of pollutant which will protect all life stages of

the test organism and of all other organisms in the receiving water. The application factor is generally assigned on the basis of scientific knowledge of the relation between safe levels and lethal levels.

Where this approach is not possible reference should be made to an appropriate list of water quality objectives such as that given in Table 20. The particular objectives listed apply to two important categories of water, namely fresh waters which support salmonoid fish or spawning areas, and estuaries and other coastal waters. The objectives are based on laboratory experiments into the lethal and sub-lethal effects of the substances listed. Because of differences in water chemistry between the laboratory and the field, quality objectives for toxic substances may not be valid in all localities. For example, there may be situations where naturally occurring levels exceed those listed in Table 20. In such cases the natural level should be regarded as the water quality objective. It should be emphasized that water quality objectives are to be applied at the boundary of mixing zones and not to the water body as a whole.

(j) Other Quality Characteristics

Recommended water quality objectives for other characteristics such as pH and sulphate are also given in Table 20.

V - CONCLUSIONS

* There is still substantial industrial effluent pollution of the New River by the Sugar Cane factories.

* An improvement has taken place at the B.S.I. factory in Tower Hill, since the last major survey was carried out in April 1977 (Balfour & Sons) but this factory is still causing substantial contamination of the river.

* There is no effluent treatment facility at the Petrojam factory in Libertad.

* Effluent treatment systems need to be installed and/or improved at both sugar factories.

* A suitable effluent treatment system needs to be installed at the Belikin Brewery site in Ladyville.

* Suitable monitoring and assessment procedures need to be installed on the waste streams from the two distilleries, the Crown Brewery at Ladyville and other smaller industries which have a waste water discharge.

* A suitable effluent treatment system needs to be installed for the citrus industry effluents in the Stann Creek area.

* A systematic monitoring and assessment procedure for assessing all waste discharges (air, water, solids, etc.) in Belize needs to be implemented.

* Base line quality standards for all water bodies in Belize, needs to be established.

* There is no national policy for regulating industrial discharges. Such a policy needs to be established.

RECOMMENDATIONS

* Establish a suitable water quality testing laboratory within the D.O.E.

* Train or employ suitably qualified staff.

* Advise the large polluting industries to employ and train suitably qualified staff to operate and monitor appropriate effluent treatment systems.

* Establish a legal framework for the introduction of an effluent discharge licensing system.

* Carry out a national inventory of all industries in Belize in order to implement an effluent discharge licensing system.

* Establish a 'Biotic Index' for all waters in Belize.

* Create a standard proposal form which can be circulated to all the industries for data logging of the water quality results for proportional flow, composite samples and the regular routine reporting of this water quality data to the D.O.E. The data from these reports can be used to establish a national water quality inventory as well as being a means of regulatory monitoring of these industries. Independent verification of this data can be achieved by random sampling of the sources by D.O.E. staff.

* The effluent license procedure should include for the levying of charges by the D.O.E. to cover the cost of this monitoring and assessment role.

* There should be a regular annual or bi-annual review of all these effluent discharge licenses.

* Introduce regulations governing the safe disposal of all non-stabilized solids.

* Introduce air pollution regulations for all major industries, particularly the Sugar industries.

* Implement the necessary legal frame work required within the Environmental Protection Act, 1992 so that polluters can be brought to Court and fined.

ANNEX I

JOB DESCRIPTION

POST TITLE:	Consultant on Sugar Agro-Industry Pollution Control
DURATION:	2 months
STARTING DATE:	1 March 1993
DUTY STATION:	Belize Capital and travel within the country
PURPOSE OF PROJECT:	To strengthen the institutional capacity of the Government of Belize in industrial control, mainly within the sugar and rum industries.
DUTIES:	Using internationally accepted industrial pollution standards, eg WHO, EPA, EEC, the consultant is expected to determine what is required for the establishment of an Industrial Pollution Control Monitoring Programme for the Sugar and Rum Industries of Belize. The consultant will be responsible for carrying out the following activities:

- Do a complete study of the industrial processes to determine volume of liquid and solid wastes generated.

- Do a complete analysis of the chemical and physical characteristics of the wastes, comparing it with the standard products observed in the countries where the industry is already controlled.

- Based on the characteristics of the wastes generated and on the industrial pollution control standards being applied internationally, to define the requirements for establishing an industrial pollution control and monitoring system for the sugar and rum industries in the country.

- Define the minimum physical infrastructure and human resources required to implement the proposed industrial

pollution control and monitoring system.

- Provide technical information and required explanation on the establishment of an industrial pollution control and monitoring system to three Government officials appointed as technical counterpart to the Consultant.

- The consultant is also expected to prepare a detailed report pointing out all the conclusions of his/her assignment and recommendations to the Government of Belize.

QUALIFICATIONS: Technical background in chemical/food engineering with experience in pollution control and monitoring within the sugar and alcohol industry.

LANGUAGE: English.

I BACKGROUND INFORMATION:

The sugar industry has been the base of the Belizean agricultural economy for several decades. In the past, it has provided more than 20% of the Gross Domestic Product, GDP 50% of the export earnings and 70% of agricultural exports. The sugar industry experienced strong declines in output during the 1980's but remained the most important foreign exchange earner.

Presently, 950,000 tons of cane are ground per crop year. 147,250 tons of bagasse is produced per crop year. 59.2% of the bagasse is burnt in boilers as fuel. 40.8% is burnt in an incinerator and 3% of the total bagasse remains an ash product, solid waste.

During the course of the crop year, while the cane is being ground, approximately 2,520 gallons of liquid waste per hour is generated at the plant. This waste water comes mainly from cleaning at the plant. This liquid waste has a very high organic load and a high content of waste oils that comes from the machines. Presently, this waste is being treated inefficiently at one facility and none at all at the other before it is discharged into the receiving environment, in this case, the New River.

In addition to the above, a Rum Distillery located upstream from the same river is discharging untreated waste water into the river; as a result, contributing to the pollution problem of the New River.

Incidents of fish and turtle kills have been reported as a result of these industries discharging raw untreated liquid waste into the New River. Presently, the Government of Belize has no department directly involved in industrial pollution control. There is a desperate need for the establishment of an industrial pollution control and monitoring programme.

In this respect the Government of Belize has sought assistance from UNIDO in providing expertise for the establishment of an industrial pollution control and monitoring programme. This industrial pollution control and monitoring programme will address specifically the New River pollution problems.

II THE PROJECT

a) Project Objectives

To provide the Government of Belize with advice on the establishment of an industrial pollution control monitoring programme for the sugar, rum, brewery and other industries.

b) Outputs

1) A report containing complete characterization of the liquid waste streams into the New River.

2) A plan for the establishment of an Industrial Pollution Control Monitoring Program.

3) Three government employees familiar with techniques necessary to analyze and monitor liquid waste streams.

c) Activities

The activities will be carried out as follows:

To reach Output (a)

1 Do a complete analysis of the industrial processes to determine volume of liquid waste generated.

2 Do a complete analysis of the quality of the liquid waste.

3 Prepare the technical reports that describe the present pollution problem and the recommendation of possible solutions.

To reach Output (b)

1 Using internationally accepted industrial pollution standards,

eg WHO, EPA, EEC, to determine what is required for the establishment of an Industrial Pollution Control Monitoring Program for the Sugar and Rum Industries of Belize.

2 Determine what monitoring equipment will be needed for such a programme.

To reach Output (c)

1 Provide technical information and required explanation on the establishment of an industrial pollution control monitoring system to 3 government employees including the following:

- sampling procedures
- analytical procedures
- application of monitoring equipment
- characterization of waste
  - quantity
  - strength
- treatment of liquid waste

d) Inputs

(i) Government Inputs

The Government of Belize will provide the following inputs:

- Counterparts to the Consultant to carry out all the necessary activities to accomplish the assistance to the government.
- Access to laboratory equipment for characterization of the liquid streams.
- Secretarial services and office.
- Audio/visual aids (overhead projector, slide projector, etc) Reproduction facilities, teaching facilities.
- Arrangements (planning) of local factory visits.
- All the wages, salaries and allowances of the local personnel on project training and/or associated with the project activities.
- All sundry expenses concerning the execution of the project directly related to the activities of the international staff

of project.

(ii) UNIDO Inputs

UNIDO will provide two months of consultancy services needed to undertake the exercises.

	M/M	US$
Consultancy costs in industrial pollution control	2	22,000
Sundries and report preparation cost		1,000
GRAND TOTAL	2	23,000

III REPORTING AND EVALUATION REQUIREMENTS, EXPECTED FOLLOW-UP

a) Evaluation Plans:

A terminal self evaluation exercise may be required for this project in accordance with the requirements of UNIDO internal evaluation system on the completion of the project.

b) Envisaged Follow-up

None.

ANNEX II

SENIOR COUNTERPART STAFF

1 Dr Victor Gonzalez
Permanent Secretary
Ministry of Tourism & the Environment
Belmopan
Belize
Central America

2 Mr Ismael Fabro
Chief Environmental Officer
19 Mayflower Street
Belmopan
Belize
Central America

3 Mr Evaristo Avella
Environmental Technician
19 Mayflower Street
Belmopan
Belize
Central America

4 Mr Jose Mendoza
Environmental Technician
19 Mayflower Street
Belmopan
Belize
Central American

ANNEX III

LIST OF PEOPLE MET

1 Honourable Glen Godfrey
Minister
Ministry of Tourism & the Environment
Belmopan
Belize
Central America

2 Dr Victor Gonzalez
Permanent Secretary
Ministry of Tourism & the Environment
East Block
Belmopan
Belize
Central America

3 Mr Ismael Fabro
Chief Environmental Officer
19 Mayflower Street
Belmopan
Belize
Central America

4 Mr Weizman Pat
Assistant Secretary
Ministry of Tourism & the Environment
East Block
Belmopan
Belize
Central America

5 Mr Evaristo Avella
Environmental Technician
19 Mayflower Street
Belmopan
Belize
Central America

6 Mr Jose Mendoza
Environmental Technician
19 Mayflower Street
Belmopan
Belize
Central America

7 Mr Moises Cal
Ministry of Economic Development
Belmopan
Belize
Central America

8 Mr Frank Panton
Chief Hydrologist
Hydrology Department
PO Box 717
Belize City
Belize
Central America

9 Mr Paulo Rosado
Manager
PETROJAM LTD
PO Box 86
Corozal Town
Corozal District
Belize
Central America

10 Mr Narciso Avila
Manager
Belize Sugar Industries
Tower Hill
Orange Walk District
Belize
Central America

ANNEX IV

PROPOSED TRAINING PROGRAMME

It is suggested that two of the counterpart staff be sent for further formal training in Water Quality Management and assessment techniques. This training should be carried out a third level college culminating in a degree or diploma qualification.

This training is necessary in order that the two members of staff should have a formal training in both the theoretical and practical aspects of Water Quality and Pollution Control. This qualification will be useful when dealing with the legal status of effluent discharge licenses and statutory pollution controls.

There are also short courses available in water quality testing procedures from, among others, Hach Company, PO Box 389, Loveland, Colorado 80539, USA. These courses give technical training in analytical procedures for water quality assessment.

At present there are only two government officials available to carry out the necessary monitoring and assessment programs. If a national program is to be implemented and continuous monitoring carried out, additional staff will be required, together with a suitably well equipped laboratory.

ANNEX V

LIST OF RECOMMENDED EQUIPMENT

1 Hach Dr/2000 Spectrophotometer, complete kit DREL/2000

Catalogue No 45250-05

1 Spectrophotometer DR/2000
2 Digital titrator
3 Operation manual
4 Portable pH meter with pH probe and 20' extension lead
5 Portable conductivity/TDS meter with probe and 20' extension lead
6 Battery recharger
7 Carrying cases for the equipment
8 Chemicals and reagents for
- a Nitrate nitrogen
- b Ammonia nitrogen
- c Phosphorus
- d Hardness - (Digital titration method)
- e Calcium - (Digital titration method)
- f Magnesium - (Digital titration method)
- g Iron
- h Sulphate
- i Dissolved oxygen
- j Alkalinity - (Digital titration method)

Estimated cost = US $18,500

2 Hach dissolved oxygen meter

Model No 16046-00 with 20' extension cable and probe, complete with battery charger and manual.

Estimated cost = US $4,800

3 Hach COD reactor

Model 45600-00 complete with

a) Safety shield model No 23810-00 and 25 vials

b) 0 - 15,000 mg/l range Model No 24159-25

c) 0 - 1,500 mg/l range Model No 21259-25

Estimated cost = US $1,100

4 Hach Manometric BOD apparatus

a) Model No 2173-01

c) Regulator 2597-00 - 115V

d) Buffer 14861-98

Estimated cost = US $1,900

5 Portable membrane filtration Apparatus (Millipore, USA)

a) including 50 litre incubator

Estimated cost = US $2,100

(Alternative: Hach microbiological detection kit)

6 Electronic balance - 4,000g x 0.01

Estimated cost = US $1,050

7 Drying oven - Gallenkamp OVB 300 - 230 W

Estimated cost = US $450

8 Muffle furnace - type FML 11/25 carbolite, Bamford, Sheffield S30 2AV, England

Estimated cost = US $1,800

9 Autoclave - 500 x 500 x 500

Estimated cost = US $4,500

10 Glassware and measuring cylinders

Estimated cost = US $1,500

11 Chemicals and equipment

Estimated cost = US $1,500

ANNEX VI

COMPANY VISITS AND REPORTS

REPORT ON FISH KILL AT BIG CREEK, MELINDA

On Tuesday, March 23rd personnel from the Department of the Environment (DOE) and Forestry Department (FD) conducted an investigation on fish kill in Big creek near Melinda in the Stann Creek district.

Thousands of orange waste are hauled by trucks and dumped in several piles in an environmentally undesirable manner near the old Mullins River Road. This improper disposal of such waste is causing several environmental problems.

The Citrus Company of Belize (CCB) is solely responsible for this practice. It was obvious that as the oranges rot their waste water secretion into open drains located near the road. These drains are connected to a main water resource for the area, this is the Big Creek. The water in the drains was brownish in color. It was also noticeable that the vegetation near the drains was dyeing, probably due to too much organic material from the oranges. The smell from the rotten oranges was very noxious to the senses. According to one of the personnel from Forestry Department in Melinda, the smell of the oranges is seriously affecting his family and nearby residents. The bad smell of the oranges is particularly noxious when the day is hot and the wind is calm.

It seems that after CCB received word that the Forestry Department was complaining about the situation, they immediately sent a tractor to cover the entrance of a drain. They did this so that it would seem that the waste was not running into the creek. One of the workers from CCB said that the entrance had been blocked for a long time. It was clear however, that the soil was fresh. A tractor was seen near the drain grading an area. According to the same CCB worker, the tractor was grading the area to build a settling pond.

We then drove down to where the drain empties into Big Creek. At the time the creek was flowing very slowly. The color of the creek was brownish, apparently due to orange sediments that were seen at the bottom of the creek. Several dead fish could clearly be seen at the creek bottom.

The team then proceeded to another area of Big Creek. This area is by a bridge on the Coastal Road. In this area the creek was not flowing. The color of the water was also brown. Hundreds of dead fish could be seen floating in the creek. Many fish had already sunk to the bottom of the creek.

Dr. Patrick Newell, a Waste Water Expert working as a technical assistant for the DOE, took several samples of the water. Dr. Newell took several water samples: from the drains; where the drain empties into the creek; the area where the dead fish could be seen; and far above the creek where there appeared to be no problem. Above the creek the water was crystal clear and running with many fish visible.

The personnel from Forestry said that many people, especially people who have farmlands, use the creek as a main source for water. They also said that the problem of fish kills usually happens during the dry seasons when the river is low and not flowing.

The worker from CCB who was accompanying us said that to reduce this problem they will build a settling pond to dump the waste oranges. He continued saying that even during the wet season there will be no problem because the overflow of the pond will be clean. This is so he said, because the sediments of the oranges will have already settled to the bottom of the pond.

The DOE took several photographs of the area, especially of the piles of oranges, the drains, the creek and the dead fish. These photos will be used by DOE to document the problem in Big Creek. Also, the water samples that were taken are being analyze to find out the exact cause of the fish kill.

A preliminary analysis of the samples indicated that there is a noticeable deterioration in the quality of the water at Big Creek, downstream of the drain from the CCB dump. The Chemical Oxygen Demand (COD) of the effluent in the drain is estimated at 45,825 mg/l. Domestic sewage would only have a COD of 300-400 mg/l. The pollution potential from this effluent is very clear: even a small discharge would cause a major fish kill.

The Department Of Environment (DOE) is concerned about the health of Belizean waters and hereby informs CCB that this practice is both damaging to the environment and illegal.

Please note that Part III of the Environmental Protection Act (EPA) entitled, *'Prevention and Control of Environmental Pollution"* discredits any form of pollution. Paragraph 10, section 1, states that:

> ***Any person or undertaking exploiting the land, water resources, seas or other natural resources shall ensure the protection of the environment against unnecessary damage or from pollution by harmful substances.***

Furthermore, paragraph 11, section 1, states:

> *No person shall emit, import, discharge, deposit, dispose of, or dump any waste that might directly or indirectly pollute water resources or damage or destroy marine life.*

Also, paragraph 11, section 2, states that :

> *Any person who contravenes subsection 1 above, shall be guilty of an offence and shall be liable on summary conviction to a fine not less than five thousand dollars and not exceeding twenty five thousand dollars or to imprisonment for a period not exceeding two years or to both, and to a further fine not exceeding one thousand dollars a day for every day that the offence is continued after a notice by the duly designated officer requiring him to cease that act specified therein has been served upon him.*

Again, Part IV of the EPA cited *'Prohibition On Dumping'* states that:

> *No person shall dump or dispose of or deposit any garbage, refuse, toxic substances or hazardous wastes in any place that might directly or indirectly damage or destroy flora or fauna, or pollute water resources or the environment. (paragraph 13 subsection 1).*

Furthermore, subsection 2 of paragraph 13 states that:

> *Any person who contravenes subsection (1) shall be guilty of an offence and shall be liable on summary conviction to a fine not exceeding five thousand dollars or to imprisonment for a term not exceeding two years, or to both such fine and imprisonment.*

Attached is a copy of the Environmental Protection Act, No. 22 of 1992 for your reference.

RECOMMENDATIONS:

The DOE hereby takes the opportunity to express its concerns about the environmental implications that have resulted from the above mentioned company, with consideration for what is in the best interest of Belize and Belizeans natural resources.

It is a fact that the waste oranges dumped by CCB have caused the pollution and grievous harm to Big Creek and the death of hundreds of fish and vegetation in that area.

With this in mind the following recommendations are strongly suggested:

1. **An investigation should be undertaken to determine proper waste treatment system.**

-- The area in which the CCB dump is presently located is a low lying plain and subject to flooding during the rainy season. Even if the dump area is completely cleaned and sealed , with reliance on evaporation for effluent disposal, it would not be acceptable as severe contamination can occur in the rainy season. An immediate investigation should be undertaken to determine a proper waste treatment system which is environmentally sensitive and in line with the ecotourism image of Belize. Again, the proposed design for loading rates should be submitted to DOE for approval prior to any work that is being carried out.

2. A settling/stabilization/evaporation pond is recommended only as an immediate interim measure because this will minimize the direct drainage of the waste into the creek. This will not lead to a long-term solution.

-- CCB should find a new site for the disposal of their waste and for the settling pond.
-- the site for the settling pond should be far from human habitation.
-- The site should be far from any ecological or sensitive area, see attached for examples of sensitive areas.
-- Coastal areas - at least 1/2 km from high tide line.
-- The site for waste disposal should be checked to verify permeability so that no contaminants percolate into the ground water, creeks, river, etc.
-- Waste disposal areas should be planned down wind of villages and townships.
-- The pattern of filling a disposal site should be well planned so as to prevent unsightly build-up of waste material. The appropriately pre-treated solid wastes should be disposed of according to the approved plan.
-- At this point, given the severity of the situation, all plans should be designed in consultation with DOE.
-- Intensive programmes of tree planting on disposal areas should be undertaken.

3. The long-term objective should be that the citrus industry should develop a waste management plan to reduce, or even eliminate at source the production of any nuisance, pollution or waste and to help save raw materials, natural resources and energy. This can be done by:

- recycling the valuable part of wastes whose production cannot be avoided (recycling them into the production process, transforming them into a different product, or designing a system for exchange of wastes between producers and

prospective users).

- Some examples of ways in which the orange waste might be recycled are:

+ Composting
+ Biogas - this is strongly recommended because orange wastes are fermentable and are capable of producing biogas.

As pollution of water bodies is a serious offence we require CCB's immediate attention to this very serious matter.

Patrick J. Newell, BE PhD CEng EurIng MIEI MIWEM

Consulting Engineers

OAKLANDS, HEADFORD, CO. GALWAY

Phone (093) 35641 / 35467 & (088) 551878
Fax (093) 35641

Your Ref:

Our Ref:
(Please quote in all correspondence)

Mr. Henry Canton,
Manager,
Citrus Company of Belize,
Pomona,
Stann Creek District,
Belize.

Re: Waste from Citrus Factory at Pomona.

Dear Mr. Canton,

Further to our recent meeting on the 31st March, I have prepared an outline of a suggested treatment system for the waste solids. Based on an assumed annual production of 35,000 tonnes solids waste per year and a 365 day operation, the daily load is estimated at approximately 100 tonnes. If it is assumed that the voids ratio for this material is 50%, then the total daily volume will be 200m3.

The proposed treatment system consists of:

(1) Macerator
(2) Acidification 1st stage anaerobic digester
(3) In-line solids separator
(4) Chemical adjustment
(5) Upflow fixed film anaerobic digester.

Assuming a liquid production volume of 50% from the 100 tonnes per day solids, the volume to be treated in stage (5) will be 50m3/day. This liquid will have a COD of approx. 45,825 mg/l, based on the analysis carried out on the liquid in the existing channels. At an assumed loading rate of 10kg COD/m3, the digester volume required for phase (5) will be 230 m3. (50,660 gallons). If it is assumed that a 20 day retention is sufficient for the acidification stage, i.e. stage (1), then the volume required for this stage will be 4,000 m3 (881,000 gallons). Various construction options can be investigated for this first phase. Stage (5) digester can be either steel or concrete.

Based on the above assumptions, it is estimated that approx. 220 kW (heat energy equivalent) continuous energy can be recovered from the waste. It is probable that this energy could be recovered as 147 Kw heat energy and 74 Kw electrical energy.

The stabilized solids from phase (1) will need to be de-watered and if possible incinerated to yield additional heat.

The above design outline is based on an existing operating digestion unit (dairy plant) and the above assumed data. In order to confirm the suitability of this proposed design, a complete analysis of the waste should be carried out.

I trust that the above information is satisfactory for your present purposes and if I can be of further assistance, please contact me at The Department of the Environment, Mayflower Street, Belmopan, phone 08-22816/22542, fax. 08-22862 or the above address.

Yours sincerely,

Patrick J. Newell.

REPORT ON WATER QUALITY AT THE OUTFALL FROM PETROJAM SUGARCANE FACTORY AT LIBERTAD

On the 18th and 29th of March, 1993 two site visits by personnel from the Department of The Environment were made to the stretch of the New River from Tower Hill Toll Bridge to one mile down stream of the outfall from the Petrojam Factory at Libertad. On both occasions substantial pollution of the river water around the outfall from the Petrojam Factory was noticed. This pollution was very extensive and was very bad on the 29th March with oil floating on top of the river water, extensive gassing by the river sediments, floating islands of mud, strong H2S odor and many other indicators. This pollution extends almost one mile upstream and approximately one mile downstream of the outfall.

Analyses of the water quality was carried out by Dr. Patrick J. Newell, UNIDO Consultant to the Department of the Environment. A copy of these results is enclosed.

It is very clear from these results that the Petrojam Factory is causing extreme pollution of the New River. Assuming a total waste water flow of 81,870 m3/d (18 million gallons/day) the total organic load going into the river is estimated at 22.1 - 25.4 tonnes of COD/day. This is equivalent to the waste from a city with a population of 263,800. Additional pollution is being caused by waste oil which comes from the machinery in the factory. This oil can be seen floating on the surface of the water and attached to the banks of the river and the plants in this area. On the 29th March the dissolved oxygen in the stretch of the New River from one mile upstream to one mile downstream of the outfall was approximately zero. This means that no fish could live in this section of river for the duration of the contamination. Additional severe pollution is being caused when the caustic and acid washes from the cleaning of the equipment in the factory is being carried out. This leads to variations in the Ph and has resulted in fish kills in the past. The elevated temperature of the waste stream is also causing stress in the New River and some form of cooling tower should be installed.

A preliminary analysis of the samples indicated that there is a noticeable deterioration in the quality of the water at Libertad, downstream and upstream of the drain from Petrojam. The Chemical Oxygen Demand (COD) of the effluent in the drain is estimated at 22.1 - 25.4 tonnes/day. This is equivalent to the waste from a city with a population of 263,800. The pollution potential from this effluent is very clear.

The Department of Environment (DOE) is concerned about the health of Belizean waters and hereby informs Petrojam that this practice is both damaging to the environment and illegal.

Please note that Part III of the Environmental Protection Act (EPA) entitled, *"Prevention and Control of Environmental Pollution"* discredits any form of pollution. Paragraph 10, Section 1, states that:

Any person or undertaking exploiting the land, water resources, seas or other natural resources shall ensure the protection of the environment against unnecessary damage or from pollution by harmful substances.

Furthermore, paragraph II, section I states:

No person shall emit, import, discharge, deposit, dispose of or dump any waste that might directly or indirectly pollute water resources or damage or destroy marine life.

Also, paragraph II section 2 states that:

Any person who contravenes subsection 1 above, shall be guilty of an offence and shall be liable on summary conviction to a fine not less than five thousand dollars and not exceeding twenty five thousand dollars or to imprisonment for a period not exceeding two years or to both; and to a further fine not exceeding one thousand dollars a day for every day that the offence is continued after a notice by the duly designated officer requiring him to cease that act specified therein has been served upon him.

Again, Part IV of the EPA cited *'Prohibition on Dumping'* states that:

No person shall dump or dispose of or deposit any garbage, refuse, toxic substance or hazardous wastes in any place that might directly or indirectly damage or destroy flora or fauna, or pollute water resources or the environment. (paragraph 13 subsection 1).

Furthermore, subsection 2 of paragraph 13 states that:

Any person who contravenes subsection (1) shall be guilty of an offence and shall be liable on summary conviction to a fine not exceeding two years, or to both such fine and imprisonment.

Attached is a copy of the **Environmental Protection Act, No. 22 of 1992** for your reference.

RECOMMENDATIONS;

1. An immediate investigation of the sources of pollution in the Petrojam Factory should be undertaken so that the sources can be identified and quantified.

2. A plan should then be formulated to reduce the pollution loads from these sources both in quantity and organic content.

3. A treatment system should be devised to provide adequate treatment for the remaining effluents. (Because of the volume of water involved as condenser water for the vacuum pans, it is considered imperative that no organic matter should be allowed to gain access to this stream. It would be uneconomical to provide effluent treatment facilities for such a large volume of water, approx. 81,600 m3/day or 17.97 million gallons/day.)

4. Cooling Towers should be installed to reduced the temperature of this condenser water.

5. The isolated contaminated streams should be treated in a conventional aerobic oxidation pond system with primary and secondary sedimentation.

6. The waste oil should be contained, separate from any of the waste water streams.

7. A dissolved air flotation unit should be installed to provide primary treatment for the contaminated waste stream.

8. Discharge of caustic and acid washes should be contained and continuously blended with the waste stream over the full operating cycle of the factory.

9. A proper solids and organic sludge disposal system should be instigated which will not contaminate surface or ground water, either in the dry or rainy seasons. This disposal regime should include for the ash from the furnaces.

10. The molasses storage tanks and other storage vessels should all be bunded and any washdown or leakage should be fed into the waste stream for treatment.

11. Air pollution from the stacks should also be reduced by the installation of cyclones, precipitators, etc.

Before any of these works are carried out details and plans of the proposed treatment systems should be submitted to and agreed with the Department of the Environment.

As pollution of water bodies is a serious offence, Petrojam is required to immediately attend to this very serious matter.

MEETING WITH PETROJAM Ltd., 7/4/93

(Meeting attended by Mr. Paulo Rosado, Manager, Petrojam Ltd, Mr. Evaristo Avella, Department of Tourism and The Environment and Dr. Patrick J. Newell, UNIDO Consultant)

The results and findings of the water analysis for the waste streams and New River area adjacent to the Petrojam factory were presented and discussed with the Management.

The Company expressed a willingness to carry out works which will reduce the pollution load going into the river. Their major problem, at present, is the lack of any suitable site in which they can locate a effluent treatment system. They are seeking the assistance of the Government of Belize in obtaining additional lands, adjacent to the factory, which will accommodate the necessary treatment tanks/ponds. It is estimated that at least 4 hectares will be required for a suitable treatment system.

In the meantime, it was suggested to Petrojam Ltd. that they should undertake an extensive investigation of the effluent streams in the factory so that the pollution loads and discharge quantities can be quantified. This investigation should be instigated immediately and the results forwarded to The Department of Tourism and Environment within an agreed time schedule. It would be very beneficial if Petrojam Ltd. invested in the necessary laboratory equipment and personnel training, so that these investigations could be carried out ion site. These testing facilities will be required when an effluent treatment system is finally installed.

After characterization of the wastes have been completed, a suitable waste treatment can be designed and installed. Such a system should be based on the recommendations listed in the previous Report forwarded to Petrojam Ltd. from the Ministry of Tourism and the Environment.

It is recommended that a time scale for these works should be agreed between the Department and Petrojam Ltd.

REPORT ON BELIZE RIVER AT LADYVILLE, MARCH 1993

Surface samples of the water in the Belize River were taken by personnel from The Department of Environment and The Fisheries Department on the 25th March, 1993. The analysis of these samples is shown in the attached Table.

It is evident from this data that the Belize River is a eutrophic river at the sample locations. The dissolved oxygen levels are well below the saturation value of 8.1 mg/l (Temp. 27 Deg. C), even at 4pm on a sunny day. Even allowing for salinity the saturation value would still be greater than 7.7 mg/l.

The water is a relatively hard water with a high level of alkalinity. This will allow the water body to absorb a certain level of organic matter without a noticeable change in Ph. When organic matter enters a water body, the native bacteria convert this material into new bacterial cells and organic acids. If sufficient buffering, in the form of alkalinity, is not available, then the Ph will drop and cause severe stress to the fish and animal populations in the water. The water in the Belize River is in complete contrast to the water in the river feeding into Big Creek, Stann Creek District, which has an alkalinity of 12 mg/l CaCO3. This Big Creek river has no capacity to absorb even very low levels of organic pollution.

The addition of organic material to a water body will also cause an increase in the demand for dissolved oxygen. In the case of the Belize River, the dissolved oxygen is already well below the normal saturation level for a fresh water at an equivalent temperature. The addition of any additional organic material to this river must be viewed with concern and the capacity of the river to absorb this organic material must be thoroughly investigated.

The existing COD values are quite good, but it should be noted that the samples were all taken from the surface. More concentrate organic loads may be present at greater depths. The DO readings would seem to indicate a relatively large organic load in the main water body.

The sulphate level, while being quite high, is consistent with water samples taken from the New River. These levels may be attributable to the formations in the catchment area or may be an indication of past contamination of the river, upstream of the sampling points.

The nitrate, ammonia, phosphorus and iron readings show the water to have a good quality.

In general, any proposed discharge of effluent into this river should be thoroughly investigated and maximum removal of organic matter and suspended solids should be applied. As a very minimum standard, any discharge should have a BOD level less than 20 mg/l and a suspended solids level less than 30 mg/l with a dilution factor greater than 1:8.

ANALYSES OF THE BELIZE RIVER AT LADYVILLE, MARCH 1993

TITLE/DATE	Ladyville 25/3/93 Canal (C)	Ladyville 25/3/93 Upstream C	Ladyville 25/3/93 New Pipe line	Ladyville 25/3/93 B. R. L.
T Deg. C	25.3	27.5	27.5	28
Ph	7.6	7.7	7.5	7.5
Nitrate -N (mg/l)	0.3	0.4	0.7	0.6
Ammonia-N (mg/l)	0.17	0.07	0.09	0.09
Phosphorus (mg/l)	0.4	0.3	0.1	0.02
Hardness (mg/l)	339	369	362	366
Iron (mg/l)	0.26	0.01	0.02	0.02
Sulphate (mg/l)	155	195	175	165
Alkalinity (mg/l)CaC03	155	168	177	172
COD (mg/l)	8	6	5	6
DO (mg/l)	3.9	3.6	5	4.9

* Canal (C) :- Canal from old power plant at Ladyville.
Upstream of C :- Centre of Belize River, upstream of canal outlet.
New pipeline :- Centre of Belize River, opposite the location for the new pipe line to the Belikin Brewery.
B.R.L. :- Centre of Belize River, opposite the Belize River Lodge.

Dissolved oxygen saturation value at 27 Deg. C. and 0.0 chlorides, 760mm atmospheric pressure is 8.1 mg/l

REPORT ON WATER QUALITY AT OUTFALL FROM BELIZE SUGAR INDUSTRIES, NEW RIVER, TOWER HILL.

On the 18th and 29th March, 1993 two site visits by personnel from the Departments of Environment and Fisheries were made to the stretch of the New River from Tower Hill Toll Bridge to one mile down stream of the Petrojam factory at Libertad. Samples of water were taken from various locations along this stretch. Samples were also taken at the main outfalls from the Belize Sugar Company cane-sugar factory at Tower Hill and from the strong effluent stream leading into the treatment lagoons. The lagoons were also sampled.

Analyses of the water quality of each of these samples was carried out by Dr. Patrick J. Newell, UNIDO Consultant to the Department of the Environment. A copy of these results is enclosed.

These results indicate that a number of items need attention:

(1) The main flow of water, the condenser water from the vacuum pans, is being discharged into the river with an elevated temperature (40 Deg. C on the 29/3). Because of the very large volume contained in this stream, estimated at 18,000 gallons/minute (117,677 m3/day), the total temperature effect is very significant. The total river flow on the 13th July, 1991 at Tower Hill Bridge was gauged at 117,936 m3/day. Department of Hydrology, Belize. Even at a conservative estimate, the ambient temperature may be raised by 10 Deg. C. The flow at the time of sampling was not measured. An elevated temperature in the river is detrimental to fish and animal life and should not be allowed. An increase of 1 - 2 Deg. C. would be the maximum acceptable level. The actual minimum dry weather flow is the critical flow in the river and all discharges must be related to this minimum flow.

In view of the relatively high volume of flow used in the main condenser stream, a cooling tower system should be installed. Balfour & Sons, 1977 estimate the flow in this waste stream to be 172,800 m3/day which is even greater than the total river flow gauged on the 13th July, 1991 by the Department of Hydrology.

(2) The elevated temperature also affects the dissolved oxygen saturation value for the river water. Increasing temperature reduces the saturation value. An increase from 20 - 30 Deg. C changes the dissolved oxygen saturation value from 9.2 mg/l to 7.6 mg/l, i.e., a fall of 1.6 mg/l. This factor also increases the stress on the native fish and flora in

this river and leaves less dissolved oxygen available for organic degradation.

(3) On the 18th March, the dissolved oxygen level at Tower Hill Bridge was 6.8 mg/l and at Orange Walk was 4.0 mg/l. On the 29th March, the dissolved oxygen at Tower Hill Bridge was 4.7 mg/l and at San Jose Palmer was 0.2 mg/l. The level had recovered to 3.5 mg/l at Orange Walk on the same date. The measurement of 0.0 - 0.4 mg/l at San Jose Palmar is totally unacceptable.

(4) The measured organic content of the main condenser/ vacuum pan stream varied from 18 - 44 mg/l COD. On both dates, there was no discharge from the lagoons into this main stream. Even with a COD value of 44 mg/l the total increased daily load of untreated organic effluent into the New River is estimated at 3 tonnes/day. This is equivalent the discharge of domestic effluent from a population of 33,000 people. In the Balfour & Sons Report (April, 1977) the measured BOD strength in the condenser steam was 77.5 mg/l. This is considerably higher than the COD of 44 mg/l observed during this testing period even though there was no waste being discharged from the lagoons during the sampling period. It is probable that larger organic discharges occur at times of over-load in the condensers and during back wash and cleaning in the factory. An automatic proportional sampling system should be installed on this stream, in order to obtain more accurate composite samples and a better characterization of the effluent.

(5) The concentrate effluent stream contains waste oil and a high organic load. This waste oil is partially removed by manually skimming the surface of the stream. The oil is placed in containers which are then dumped in another corner of the factory compound. The collected oil should be fed to the furnace and burned with the excess bagasse. The present situation is only changing the location of the oil disposal and is not dealing with the problem. The oil separation system should be improved and automated. A fully automated dissolved air flotation unit should be installed. This will also help to reduce the organic load to the aeration lagoons. This waste oil is particularly noxious and should not be dumped in an area which could lead to seepage and/or washout during the rainy season.

(6) The waste stream going to the aeration lagoons contains 8,700 mg/l COD and has an estimated flow rate of 387 m3/day. The total organic load is estimated at 3.4 tonnes COD/day. This stream also receives the concentrate caustic and acid washes during the de-scaling operations. As described in (5) above it also contains considerable amounts of waste oil. The caustic and acid washes are first collected in a steel holding tank. The discharge from this holding tank should be a continuous flow which is balanced over the complete factory cycle. The present situation where these wastes are discharged over short periods, prevents the aeration lagoons from operating properly. The dissolved oxygen in all the lagoons was 0.0 mg/l. There was no discharge from these aeration lagoons during the two site visits. On the 29th March, the surface water level in the receiving stream was higher than the invert level of the outfall. This is an engineering/structural feature which should be rectified.

(7) It is very clear from the data on the lagoons that these lagoons are not operating properly. The first lagoon, even with 6 surface aerators still had 0.0 mg/l dissolved oxygen. A proper operating procedure should be initiated where the organic load is balanced with the oxygen supply and mixed liquor suspended solids (MLSS) and where the proper nutrient balance is maintained. The 2nd lagoon should be used as a settling tank with solids recycle to the main aeration chamber. The 3rd lagoon could be used for settled organic solids stabilization or as an additional settling tank if required. The outlet for the treated and settled liquid should be raised so that a continuous discharge flow can be maintained over the 24 hour period. This will prevent sudden shock loads.

(8) Apart from the two waste streams described above there is also a waste stream from the ash pit. There is a substantial flow from this stream and again the temperature is elevated above ambient. This stream also contains a very high level of sulphate. This stream passes through a settlement lagoon where the ash solids are removed. However, if this settlement lagoon is not emptied on a very regular and systematic basis, the ash solids will gain direct access into the river and cause added contamination through an increase in the suspended solids concentration. Suspended solids were not measured during this study.

GENERAL

The Department of Environment (DOE) is concerned about the health of Belizean waters and hereby informs B.S.I. that it is very concerned about the quality of water in The New River, especially around the outfalls from the Sugar Factory.

Please note that Part III of the Environmental Protection Act (EPA) entitled, "*Prevention and Control of Environmental Pollution*" discredits any form of pollution. Paragraph 10, Section 1, states that:

Any person or undertaking exploiting the land, water resources, seas or other natural resources shall ensure the protection of the environment against unnecessary damage or from pollution by harmful substances.

Furthermore, paragraph II, section I states:

No person shall emit, import, discharge, deposit, dispose of or dump any waste that might directly or indirectly pollute water resources or damage or destroy marine life.

Also, paragraph II section 2 states that:

Any person who contravenes subsection 1 above, shall be guilty of an offence and shall be liable on summary conviction to a fine not less than five thousand dollars and not exceeding twenty five thousand dollars or to imprisonment for a period not exceeding two years or to both; and to a further fine not exceeding one thousand dollars a day for every day that the offence is continued after a notice by the duly designated officer requiring him to cease that act specified therein has been served upon him.

Again, Part IV of the EPA cited '*Prohibition on Dumping*' states that:

No person shall dump or dispose of or deposit any garbage, refuse, toxic substance or hazardous wastes in any place that might directly or indirectly damage or destroy flora or fauna, or pollute water resources or the environment. (paragraph 13 subsection 1).

Furthermore, subsection 2 of paragraph 13 states that:

Any person who contravenes subsection (1) shall be guilty of an offence and shall be liable on summary conviction to a fine not exceeding two years, or to both such fine and imprisonment.

Attached is a copy of the **Environmental Protection Act, No. 22 of 1992 for your reference.**

RECOMMENDATIONS

A) Remove waste oil from main effluent steam and incinerate with excess bagasse.

B) Instal a dissolved air flotation unit for the concentrate effluent stream before it enters into the aeration lagoons.

C) Instal proper balancing equipment for the caustic and acid wash waste water, so that these wastes can be continuously blended with the main stream over a full operating cycle. Buffering may be required if these stream alter the Ph of the main flow.

D) Install and maintain proper aerobic sludge in the aerated 1st lagoon. Carry out proper monitoring of the dissolved oxygen, Ph, mixed liquor suspended solids, BOD/COD loading and removal efficiency, etc. in this lagoon.

E) Install proper sludge recycle and removal systems in the 2nd and 3rd lagoons and monitor the final discharge from these lagoons.

F) Raise the invert level of the outlets from these lagoons, so that they are always above the highest level of the New River. The tidal effects in this river can be noticed even at Orange Walk.

G) The discharge from these lagoons should be continuous over the full day and an automatic proportional sampler should be installed to collect representative samples.

H) A better control system should be installed in the condenser - vacuum pan system so that direct contamination of this large waste stream by accidental discharges of the sugar syrup can be avoided. Under no circumstances should any of the caustic or acid wash waste water be added to this stream.

I) A cooling system should be installed on this very large waste stream so that the temperature of discharge into the river is never more than 2 Deg. C. higher than the ambient river water temperature.

J) An automatic proportional sampler should be installed on this stream so that an accurate assessment of the quality of this stream will be obtained.

K) A proper ash settlement/removal system should be installed so that no suspended solids can gain access into the river. The temperature of the waste flow from this stream should not be more than 2 Deg. C. above the ambient river

temperature. There should be no organic matter in this effluent stream.

L) Waste solids, including ash should not be dumped on site but should be placed in a properly controlled and protected dump or spread on land with the agreement of the Department of the Environment.

M) Daily analysis should be carried out on all composite samples and on all waste streams discharged to the river. The results of these analyses should be forwarded to the Department of the Environment on a monthly or agreed routine basis. Independent testing by the Department of the Environment should also be carried out on a regular basis.

N) The situation in relation to air pollution from the stacks must also be addressed. There is a lot of fly ash in the air around the general factory area.

O) The holding tanks for the molasses and oil hold tanks should all be bunded with channels from these tanks back into the main concentrate effluent stream. All wash water from these tanks must be returned to the effluent stream for treatment.

P) The treated effluent from the lagoons, the main condenser - vacuum pan stream, ash pit stream, etc. must comply with specific discharge standards which will be based on the effluent characteristics of each stream. These standards will be specific to each stream.

Q) There is also a question relating to the level of lead in the waste stream. Substantial quantities of lead compounds are used in the laboratory analysis of the sugar compounds. The waste from these tests appear in the effluent streams.

MEETING WITH BELIZE SUGAR INDUSTRIES, TOWER HILL, 7/4/93

(Meeting was attended by Mr. Narcesio Avila, Manager, Belize Sugar Industries, Tower Hill, Orange Walk, Belize, Mr. Evaristo Avella and Dr. Patrick J. Newell, UNIDO Consultant)

The results and findings of the water analysis for the waste streams and New River area adjacent to the Tower Hill factory were presented and discussed with the Management.

The Company advised that they had installed a cascade system in the main condenser water channel in an attempt to reduce the temperature of this effluent stream. However, this does not seem to be very effective and a better cooling tower system should be installed.

The Company keep daily records of the pollution loads going into the treatment ponds and the loads within these ponds. Effluent is discharged from the final ponds when it reaches a pre-determined standard. It would be much more satisfactory if a continuous discharge was made with effluent which complied with pre-set standards and flow rates. The Company also maintain records of the dissolved oxygen levels within the lagoons. (The loading data for the lagoons does not seem to correspond with the spot samples taken by the Department of Tourism and The Environment, 18/3/93 and 29/3/93 and the data collected in March, 1992. The Company seem to be under estimating the loads)

The Company advised that entrainment channels had been installed in the vacuum-condenser vessels and that it was no longer possible for excess juice to contaminate the main waste flow from these condensers. They could not account for the elevated COD levels found in this main effluent stream. It was suggested that the COD at the intake was high on the same day. No sample of the intake was taken for analysis. Even if the intake COD level is high, then this high COD value must be coming from pollution produced by the factory and introduced into the New River from another waste stream, possibly from the lagoon discharge.

The Company advise that they already have a proportional sampler on the main condenser waste stream, but they did not present any data on the quality of this stream. It is important that daily samples are collected and analyzed and that a similar analysis is carried out on the intake for this stream.

The recommendations in relation to the improvements for the lagoon treatment system and the waste oil was discussed. The Company stated that they would study the proposals and revert with their response as soon as possible.

The Company indicated that the question relating to the caustic and acid washes was difficult as a large quantity of waste is produced at this time. The intermediate steel tank only has a capacity of a few hours and would not be adequate to hold the total flow for a full factory cycle. It was suggested that the 3rd lagoon might be used to store this waste over a full cycle, so that a uniform blending of this waste flow into the aeration lagoon could be achieved. This procedure would only be suitable if a proper activated sludge process is operated and maintained in the aeration lagoon and secondary settling lagoon.

The situation concerning the ash pits would be investigated and improved so that adequate impounding capacity would be maintained at all times.

The Company stated that they would investigate the possibility of obtaining a suitable land area for disposal of the ash solids and the filter-cake solids, so that these solids do not become an environmental hazard.

The Company advise that they have changed the chemicals being used in the laboratory, so that waste lead will no longer occur in the effluent stream.

There was no commitment from the Company in relation to the air pollution from the stacks

MEETING WITH CUELLO DISTILLERY, ORANGE WALK

This involved a brief visit to the distillery and an inspection of process and waste streams generated. This is a relatively small distillery which is located in a very rural district. It is part of a small complex which includes, the distillery, a soap manufacturing unit, an automobile service facility and a large intensive farming operation.

The volume of liquid waste generated in the Distillery is relatively small and is mostly composed of the caustic washings from bottle washing operation. This effluent is discharged by an open drain into a lagoon at some distance from the distillery. This lagoon discharges into the New River, upstream from Orange Walk. There was no discharge at the time of the visit and no alcohol was being fermented or distilled.

It is recommended that the Company be requested to provide an Effluent Waste Stream profile together with a detailed site layout showing the exact position of all drains and lagoons. Information on the disposal of all solids and fermentation wastes should also be provided. It was advised that these wastes were used in the intensive farming operation.

Based on the information supplied in this Effluent Profile and from independent testing of the waste streams, the Department of Tourism and The Environment should prepare an Effluent Discharge License for this Company.

MEETING WITH BELIKIN BREWERY, LADYVILLE, BELIZE.

This Company produces most of the beer consumed in Belize. Production of the beer is carried out on a batch process and no beer was being produced at the time of the factory visit. The only operation in progress was bottle washing and filling.

Similar to the Cuello Distillery above, the bottles are washed with a dilute caustic wash. This waste wash water is then discharged via an open drain into a lagoon. This lagoon discharges into the Belize River, near Ladyville.

At present, the Company are constructing a new Brewery and they advised that they are getting a new effluent treatment plant designed. We requested information, details and plans on this effluent plant, but these had not been supplied before the end of this Consultancy. The Company have built and partially equipped a new laboratory.

ANNEX VII

EXTENDED TABLES AND CHARTS

TABLE 1 - ANALYSIS OF THE NEW RIVER AT BELIZE SUGAR INDUSTRIES, TOWER HILL, MARCH 1993

TITLE/DATE	Tower 18/3	Hill 29/3	T.B. 18/3	S.J.P 18/3	O.W. 18/3	S.E 18/3	Cal. 18/3	Feed 18/3	1st L 18/3	2nd L 18/3	3rd L 18/3	2nd O 18/3
T Deg. C	37	40	23	29	29	28	28	35	25	28	29	33
Ph	7.43	6.0	7.6	7.51	7.46	7.46	7.62	5.27	7.6	7.15	7.12	7.48
Nitrate -N (mg/l)	1.0	0.6	0.4	0.3	0.6	0.7	0.7	2.1	30.5	1.8	0.0	0.2
Ammonia-N (mg/l)	0.47	0.36	0.31	0.59	0.37	0.54	0.34	16.0	11.25	14.0	12.5	0.49
Phosphorus (mg/l)	0.3	1.1	0.6	0.4	0.7	0.8	0.8	69	132.5	20.5	25.7	3.7
Hardness (mg/l)	350	375	330	277	354	362	282	1067	825	840	910	435
Iron (mg/l)	0.03	0.03	0.02	0.02	0.02	0.01	0.0		3.75	0.13	0.21	0.04
Sulphate (mg/l)	160	160	195	150	210	210	170	63	0.0	0.0	0.0	195
Alkalinity (mg/l)CaC03	127	136	135	140	138	205	137		632	1146	1176	247
COD (mg/l)	44	18	18	14	14	15	18	8700	4950	820	310	42
DO (mg/l)	4.9	0.2	6.8	5.3	4.0	5.7	6.9	0.0	0.0	0.0	0.0	3.0

* T.B. :- Toll Bridge at Tower Hill; S.J.P. :- San Jose Palmer; O.W. :- Orange Walk; S.E. :- San Estevan; Cal :- Caledonia; Feed :- Concentrate waste stream with oil; 1st L ;- 1st Lagoon at B.S.I.; 2nd L :- 2nd Lagoon at B.S.I.; 3rd L :- 3rd Lagoon at BSI 2nd O;- 2nd outfall at B.S.I. outfall from the ash pit.

TABLE 2 - COD (mg/l)
Tower Hill Sugar Factory, March 1992

	Location	16/3/92	17/3/92	18/3/92	19/3/92	20/3/92	21/3/92
1	Aeration Pond In.	7778	9126	7155	5911	6222	3837
2	Aeration Pond Out	6118	8296	7155	4978	5496	3630
3	Outlet 1st Lagoon	1970	1348	1659	1556	1763	1244
4	Outlet 2nd Lagoon	4667	4044	4978	4148	4667	4977
5	Main Drain	316	298				

*Data supplied by the NATIONAL HYDROLOGICAL SERVICE, Belize

TABLE 3 - pH
Tower Hill Sugar Factory, March 1992

	Location	16/3/92	17/3/92	18/3/92	19/3/92	20/3/92	21/3/92
1	Aeration Pond In.	4.78	4.86	5.00	5.10	5.29	5.40
2	Aeration Pond Out	4.77	4.85	5.00	5.10	5.30	5.36
3	Outlet 1st Lagoon	7.16	7.23	7.33	7.80	7.34	7.40
4	Outlet 2nd Lagoon	5.70	5.40	5.32	5.40	5.39	5.38
5	Main Drain	7.63	7.72				

*Data supplied by the NATIONAL HYDROLOGICAL SERVICE, Belize

TABLE 4 - Temperature (Deg. C)
Tower Hill Sugar Factory, March 1992

	Location	16/3/92	17/3/92	18/3/92	19/3/92	20/3/92	21/3/92
1	Aeration Pond In.	26.3	26.2	26.0	29.0	26.4	27.6
2	Aeration Pond Out	26.0	26.1	26.2	28.8	26.5	27.5
3	Outlet 1st Lagoon	27.2	27.0	26.5	28.8	26.3	27.5
4	Outlet 2nd Lagoon	26.8	26.6	26.5	28.8	26.4	27.8
5	Main Drain	25.4	37.4				

*Data supplied by the NATIONAL HYDROLOGICAL SERVICE, Belize

TABLE 5 - Dissolved Oxygen (mg/l)
Tower Hill Sugar Factory, March 1992

	Location	16/3/92	17/3/92	18/3/92	19/3/92	20/3/92	21/3/92
1	Aeration Pond In.	1.4	1.2	0.9	0.5	0.8	0.8
2	Aeration Pond Out	1.1	1.3	0.9	1.0	0.7	0.9
3	Outlet 1st Lagoon	0.8	0.5	0.8	0.7	0.5	0.4
4	Outlet 2nd Lagoon	0.7	0.9	0.5	0.9	0.6	1.0
5	Main Drain	3.9	2.7				

*Data supplied by the NATIONAL HYDROLOGICAL SERVICE, Belize

TABLE 6 - FLOW DATA FOR THE NEW RIVER, 1990 - 1991

Location	Date	Discharge (m3/day)
Tower Hill	1/5/90	344,477
Tower Hill	7/5/90	314,755
Tower Hill	14/5/90	305,597
Tower Hill	28/5/90	787,536
Tower Hill	5/6/90	527,645
Tower Hill	11/6/90	407,894
Tower Hill	13/7/90	117,936
Libertad	20/7/91	204,595

*Data supplied by the NATIONAL HYDROLOGICAL SERVICE, Belize

TABLE 7 - ANALYSIS OF THE NEW RIVER AT LIBERTAD, MARCH 1993

TITLE/DATE	Petro 18/3	jam 29/3	S.C. 18/3	1/2m up 18/3	1/2m d 18/3	1/2m d 29/3	1m d 29/3
T Deg. C	37	36	28	29	30	31	30
pH	7.07	7.0	7.58	7.29	6.84	7.1	8.1
Nitrate -N (mg/l)	0.0	69	0.6	0.5	0.8	10.8	8.0
Ammonia-N (mg/l)	0.93	1.77	0.24	0.32	0.87	2.53	4.5
Phosphorus (mg/l)	7.6	11.1	0.6	1.1	4.9	11.3	11.5
Hardness (mg/l)	287	473	299	395	345	350	440
Iron (mg/l)	0.44	0.75	0.0	0.01	0.09	0.36	0.02
Sulphate (mg/l)	150	130	160	135	165	125	70
Alkalinity (mg/l)CaC03	140	51	127	170	123	44	202
COD (mg/l)	270	310	15	20	22	357	251
DO (mg/l)	2.0	2.0	6.7	4.7	0.02	0.0	0.0

* S.C. :- Santa Cruz; 1/2m up :- 1/2 mile upstream of outfall; 1/2m d :- 1/2 mile downstream of outfall; 1m d :- 1 mile downstream of outfall.

TABLE 8 - DISSOLVED OXYGEN (mg/l)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon				10.5	
2	Centre Lamanai Lagoon				9.4	
3	Outlet Lamanai Lagoon				10.35	
4	Toll Bridge	6.8	4.6	4.8	7.5	
5	San Jose Palmar	5.3	0.0	0.1		
6	Orange Walk	4.0	3.8	3.0		
7	San Estevan	5.7	4.8	4.0		
8	Caledonia	6.9	4.7	4.0		
9	Santa Cruz	6.7	4.1	3.3		
10	1/2 mile up from Libertad	4.7	0.4	0.0		
11	1/2 mile down from Libertad	0.02	0.2	0.0		0.25
12	1 mile down from Libertad		0.0	0.0		
13	Mouth of New River					0.25

TABLE 9 - COD (mg/l)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon					
2	Centre Lamanai Lagoon					
3	Outlet Lamanai Lagoon				0.0	
4	Toll Bridge	18.0			3.0	
5	San Jose Palmar	14.0				
6	Orange Walk	14.0				
7	San Estevan	15.0				
8	Caledonia	18.0				
9	Santa Cruz	15.0				
10	1/2 mile up from Libertad	20.0				
11	1/2 mile down from Libertad	22.0	357			21.0
12	1 mile down from Libertad		251			
13	Mouth of New River					1233.0

TABLE 10 - TEMPERATURE (Deg. C.)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon				19.5	
2	Centre Lamanai Lagoon				19.5	
3	Outlet Lamanai Lagoon				19.8	
4	Toll Bridge	23.0	30.0	29.0	19.8	
5	San Jose Palmar	29.0	32.0	31.0		
6	Orange Walk	29.0	30.0	30.0		30.0
7	San Estevan	28.0	29.0	29.5		29.0
8	Caledonia	28.0	29.0	28.0		29.0
9	Santa Cruz	28.0	28.0	27.5		28.3
10	1/2 mile up from Libertad	29.0	30.0	28.0		
11	1/2 mile down from Libertad	30.0	32.0	30.0		28.5
12	1 mile down from Libertad		31.0	29.0		
13	Mouth of New River					27.5

TABLE 11 - SULPHATE (SO4 mg/l)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon				380	
2	Centre Lamanai Lagoon				200	
3	Outlet Lamanai Lagoon				190	
4	Toll Bridge	195			205	
5	San Jose Palmar	150				
6	Orange Walk	210				
7	San Estevan	210				
8	Caledonia	170				
9	Santa Cruz	160				
10	1/2 mile up from Libertad	135				
11	1/2 mile down from Libertad	165	125			245
12	1 mile down from Libertad		70			
13	Mouth of New River					230

TABLE 12 - PHOSPHORUS (PO4 mg/l)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon				0.4	
2	Centre Lamanai Lagoon				0.8	
3	Outlet Lamanai Lagoon				0.8	
4	Toll Bridge	0.6			1.0	
5	San Jose Palmar	0.4				
6	Orange Walk	0.7				
7	San Estevan	0.8				
8	Caledonia	0.8				
9	Santa Cruz	0.6				
10	1/2 mile up from Libertad	1.1				
11	1/2 mile down from Libertad	4.9	11.3			1.6
12	1 mile down from Libertad		11.5			
13	Mouth of New River					1.5

TABLE 13 - NITRATE (NO3 - N mg/l)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon				0.7	
2	Centre Lamanai Lagoon				0.6	
3	Outlet Lamanai Lagoon				0.5	
4	Toll Bridge	0.4			0.4	
5	San Jose Palmar	0.3				
6	Orange Walk	0.6				
7	San Estevan	0.7				
8	Caledonia	0.7				
9	Santa Cruz	0.6				
10	1/2 mile up from Libertad	0.5				
11	1/2 mile down from Libertad	0.8	10.8			0.5
12	1 mile down from Libertad		8.0			
13	Mouth of New River					0.2

TABLE 14 - AMMONIA (NH3 - N mg/l)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon				0.14	
2	Centre Lamanai Lagoon				0.19	
3	Outlet Lamanai Lagoon				0.04	
4	Toll Bridge	0.31			0.05	
5	San Jose Palmar	0.59				
6	Orange Walk	0.37				
7	San Estevan	0.54				
8	Caledonia	0.34				
9	Santa Cruz	0.24				
10	1/2 mile up from Libertad	0.32				
11	1/2 mile down from Libertad	0.87	2.53			0.16
12	1 mile down from Libertad		4.5			
13	Mouth of New River					0.61

TABLE 15 - IRON (Fe mg/l)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon				0.01	
2	Centre Lamanai Lagoon				0.02	
3	Outlet Lamanai Lagoon				0.04	
4	Toll Bridge	0.02			0.0	
5	San Jose Palmar	0.02				
6	Orange Walk	0.02				
7	San Estevan	0.01				
8	Caledonia	0.0				
9	Santa Cruz	0.0				
10	1/2 mile up from Libertad	0.01				
11	1/2 mile down from Libertad	0.09	0.36			1.23
12	1 mile down from Libertad		0.02			
13	Mouth of New River					0.02

TABLE 16 - HARDNESS (CaCO3 mg/l)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon				490	
2	Centre Lamanai Lagoon				355	
3	Outlet Lamanai Lagoon				315	
4	Toll Bridge	330			380	
5	San Jose Palmar	277				
6	Orange Walk	354				
7	San Estevan	362				
8	Caledonia	282				
9	Santa Cruz	299				
10	1/2 mile up from Libertad	395				
11	1/2 mile down from Libertad	345	350			480
12	1 mile down from Libertad		440			
13	Mouth of New River					1200

TABLE 17 - ALKALINITY ($CaCO_3$ mg/l)
New River, March - April, 1993

	Site Location	18/3/93	29/3/93 (top)	29/3/93 (3mdeep)	6/4/93	13/4/93
1	Top Lamanai Lagoon				134	
2	Centre Lamanai Lagoon				130	
3	Outlet Lamanai Lagoon				151	
4	Toll Bridge	135			150	
5	San Jose Palmar	140				
6	Orange Walk	138				
7	San Estevan	205				
8	Caledonia	137				
9	Santa Cruz	127				
10	1/2 mile up from Libertad	170				
11	1/2 mile down from Libertad	123	44			170
12	1 mile down from Libertad		202			
13	Mouth of New River					187

TABLE 18 - Minimum Quality Requirements for Surface Waters to be used as Sources for Drinking Water within the EEC (Directive 75/440/EEC

Parameter	Units	A1	A2	A3
Colour after filtration	mg/l Pt scale	20	100	200
Temperature	Deg. C	25	25	25
Nitrates	mg/l (NO3)	50	50	50
Fluorides	mg/l (F)	1.5	-	-
Dissolved Iron	mg/l (Fe)	0.3	2.0	-
Copper	mg/l (Cu)	0.05	-	-
Zinc	mg/l (Zn)	3	5	5
Arsenic	mg/l (As)	0.05	0.05	0.1
Cadmium	mg/l (Cd)	0.005	0.005	0.005
Chromium (Total)	mg/l (Cr)	0.05	0.05	0.05
Lead	mg/l (Pb)	0.05	0.05	0.05
Selenium	mg/l (Se)	0.01	0.01	0.01
Mercury	mg/l (Hg)	0.001	0.001	0.001
Barium	mg/l (Ba)	0.1	1.0	1.0
Cyanide	mg/l (CN)	0.05	0.05	0.05
Sulphates	mg/l (SO4)	250	250	250
Phenols	mg/l (C6H5OH)	0.001	0.005	0.1
Dissolved or Emulsified Hydrocarbons	mg/l	0.05	0.2	1.0
Polycyclic Aromatic Hydrocarbons	mg/l	0.0002	0.0002	0.001
Total pesticides	mg/l	0.001	0.0025	0.005
Ammonia	mg/l (NH4)	-	1.5	4.0

* A1, A2, A3; These correspond respectively to increasing degrees of water treatment required to make them potable.

TABLE 19 - Quality Requirements for Bathing Waters

Parameters	G	I	Minimum Sampling frequency
Total coliforms /100 mls	500	10,000	2 weeks
Faecal Coliforms /100 mls	100	2,000	2 weeks
Faecal Streptococci /100 mls	100	-	(2)
Salmonella /1000 mls	-	0	(2)
Entero viruses PFU/10 litres	-	0	(2)
pH	-	6 - 9	(2)
Colour	-	No change	(1)
Mineral oils (mg/l)	-	No visible film or odour	2 weeks
Surface active substances reacting with methylene blue (mg/l lauryl sulphate)	-	No lasting foam	2 weeks
Phenols (mg/l C6H5OH)	-	No odour	2 weeks
Transparency (m)	2	1	2 weeks
Dissolved oxygen (% saturation O2)	80 - 120	-	(2)
Tarry residues & floating materials	0	-	2 weeks
Ammonia (mg/l NH4)			(3)
Nitrogen Kjeldhal (mg/l N)			(3)
Pesticides (mg/l)			(2)
Heavy Metals (mg/l)			(2)
Cyanides (mg/l Cn)			(2)
Nitrates & Phosphates (mg/l)			(2)

G = Guide I = Mandatory * EEC Directive 76/160/EEC

(1) If sampling from the previous year indicates a water of better quality and if no obvious source of contamination has occurred, sampling frequency may be reduced by a factor of 2

(2) Concentrations to be checked by competent authorities when an inspection shows that these substance may be present or that the water quality has deteriorated.

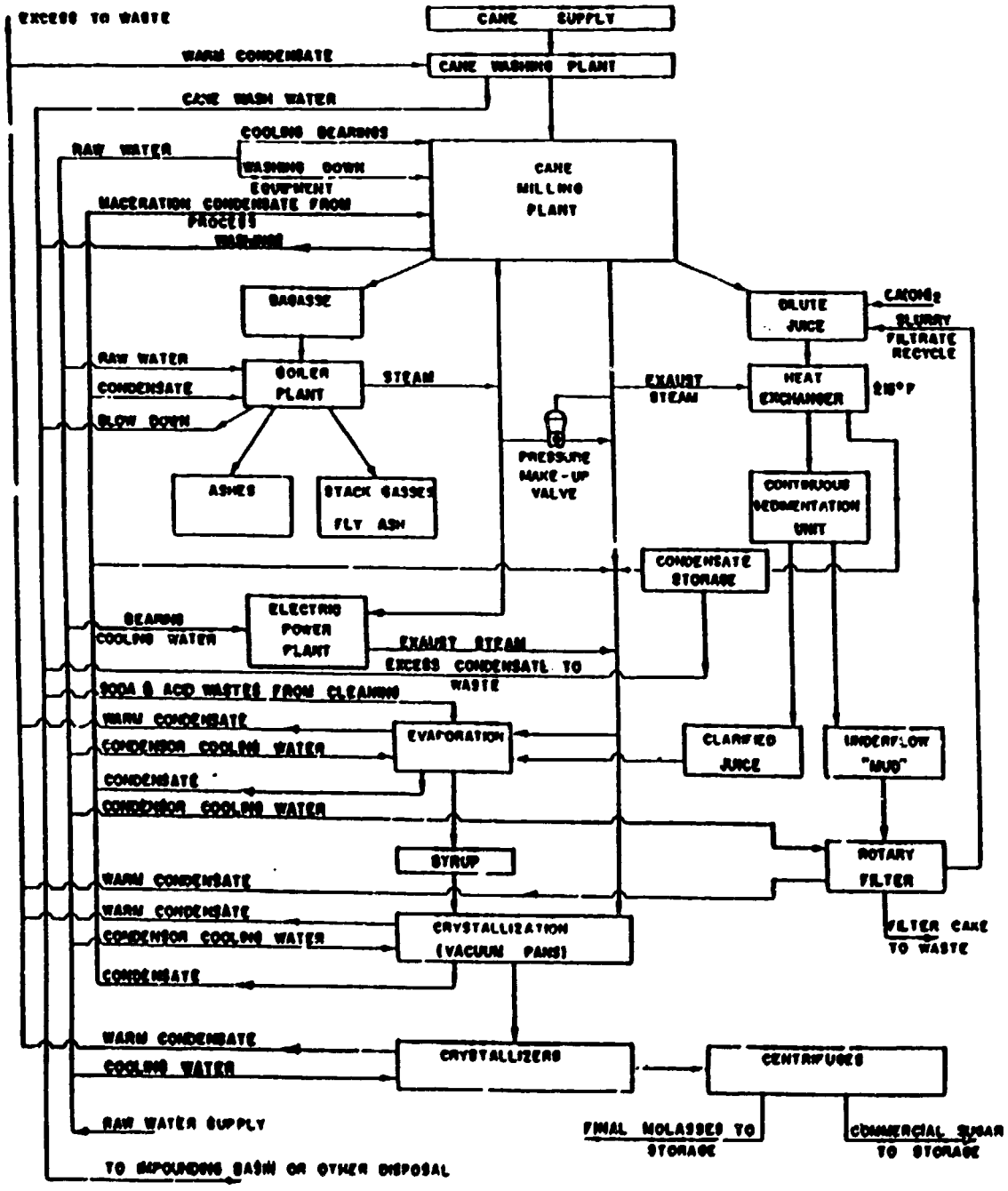
(3) These parameters should be checked where there is a tendency towards eutrophication.

TABLE 20 - Water Quality Requirements for Salmonoid and Spawn Freshwaters, Estuaries and other Coastal waters

Parameter	Units	Salmonid & Spawning Freshwaters	Estuaries & Coastal Waters
Cadium	ug/l (Cd)	5	10
Chloride	ug/l (Total residual Chlorine)	5	10
Chromium	ug/l (Cr)	50	100
*Copper	ug/l (Cu)	25	50
Cyanide	ug/l (CN)	10	10
Fluoride	ug/l (F)	1.5	-
Lead	ug/l (Pb)	50	100
Manganese	ug/l (Mn)	-	100
Mercury	ug/l (Hg)	0.05	0.10
Nickel	ug/l (Ni)	500	500
Nitrate	mg/l (NO3)	50	1.0
pH		6 - 9 (No change greater than 0.5 units from natural)	6.5 - 8.5 (No change greater than 0.2 units f natural)
Phenol	ug/l (C6H6O)	1.0	1.0
Silver	ug/l (Ag)	10	10
Sulphate	mg/l (SO4)	250	-
Sulphide	ug/l (Undissolved H2S)	2.0	2.0
*Zinc	ug/l (Zn)	100	100

* The recommended values for these parameters apply to waters with a hardness greater than 50 mg/l as CaCO3.
The above recommended values apply at the boundary of the mixing zone.
The values for chromium, copper and zinc may not provide sufficient public health protection in the case of edible shellfish. Special quality requirements apply to these activities.
(Table taken from Memorandum no. 1, Water Quality Guidelines, D.O.E., Dublin, Ireland. 1990)

A SIMPLIFIED FLOW DIAGRAM FOR RAW CANE SUGAR MANUFACTURE



A simplified flow diagram for raw cane sugar manufacture.

Figure 1

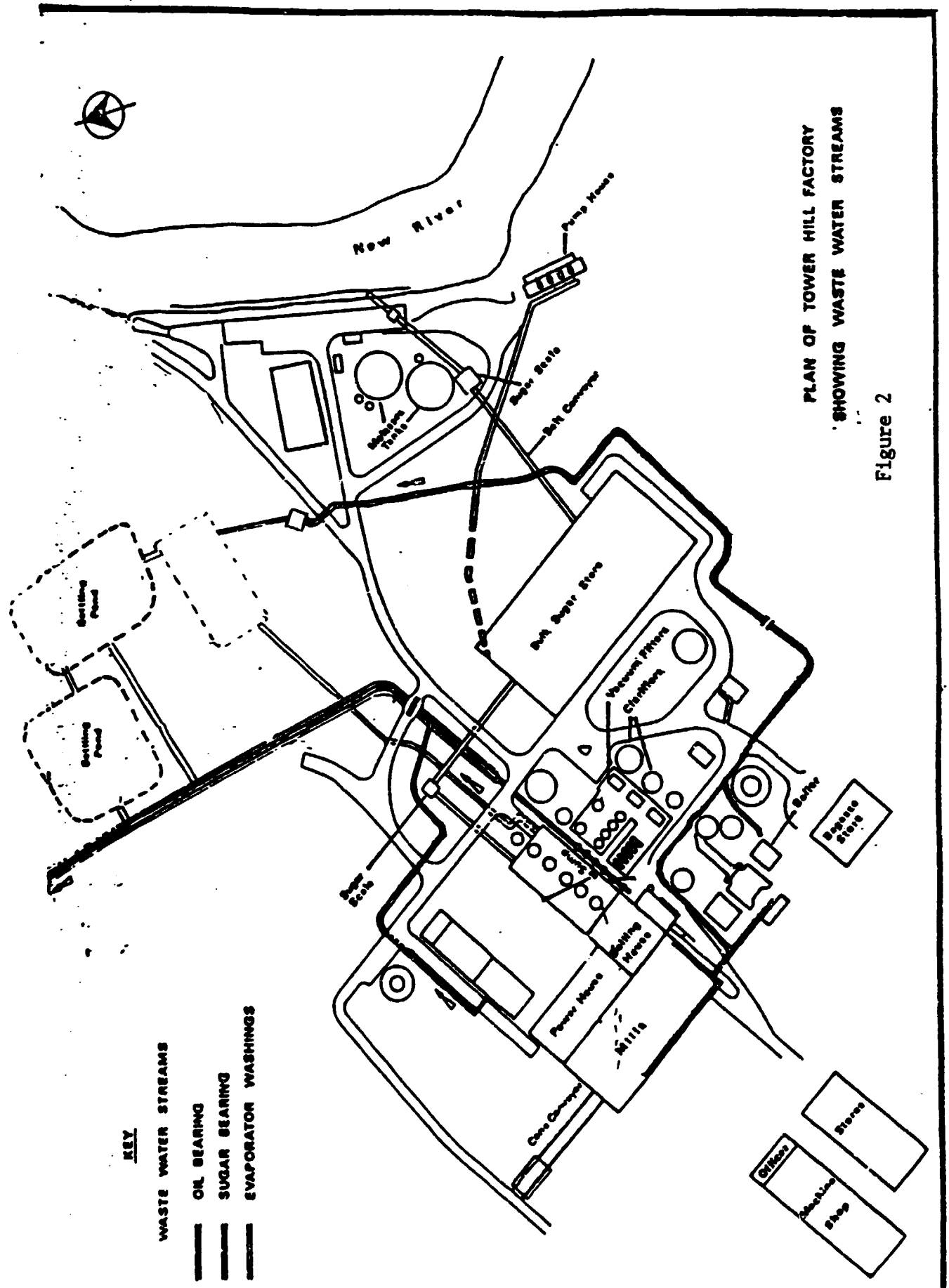
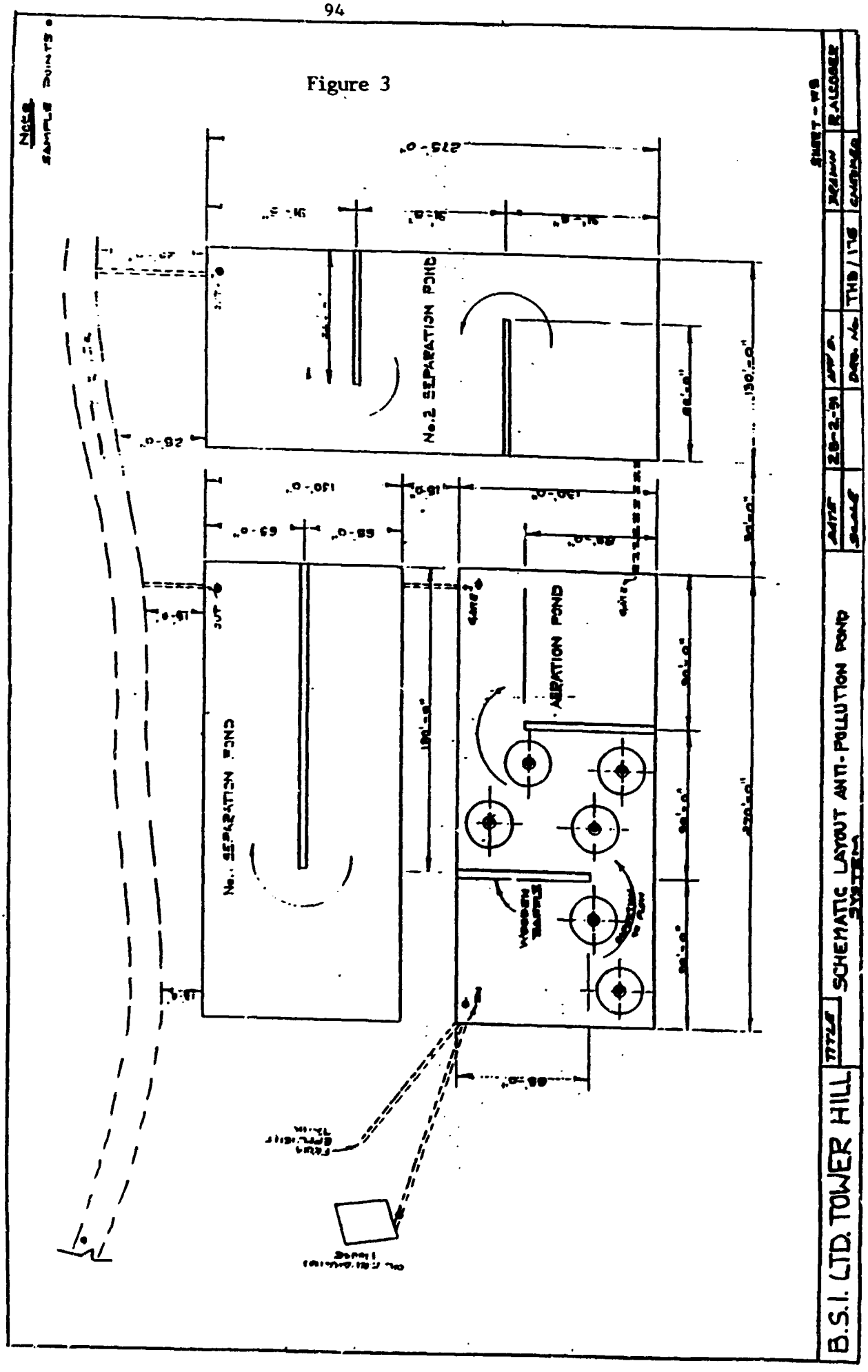

PLAN OF TOWER HILL FACTORY
SHOWING WASTE WATER STREAMS
KEY
WASTE WATER STREAMS
OIL BEARING
SUGAR BEARING
EVAPORATOR WASHINGS
New River
Pump House
Sugar Scale
Belt Conveyor
Settling Pond
Settling Pond
Belt Sugar Store
Vacuum Filters
Clarifiers
Boiler
Bagasse Store
Sugar Scale
Melting House
Power House
Mills
Cane Conveyor
Offices
Machine Shop
Stores

Figure 2

Figure 3


B.S.I. LTD. TOWER HILL
SCHEMATIC LAYOUT ANTI-POLLUTION POND
No.2 SEPARATION POND
No.1 SEPARATION POND
AERATION POND
R.ALGAR
THB/176

COD (mg/l)
Tower Hill Sugar Factory

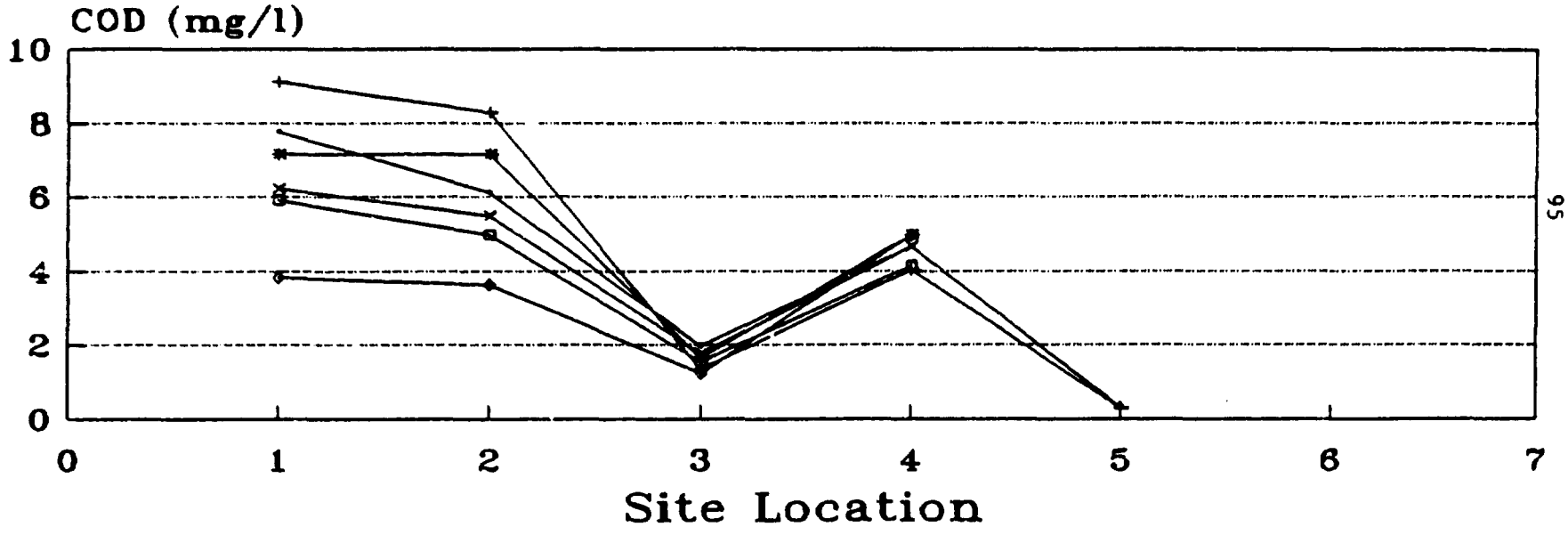


Figure 4

See Table 2 for Site Location Index

pH
Tower Hill Sugar Factory

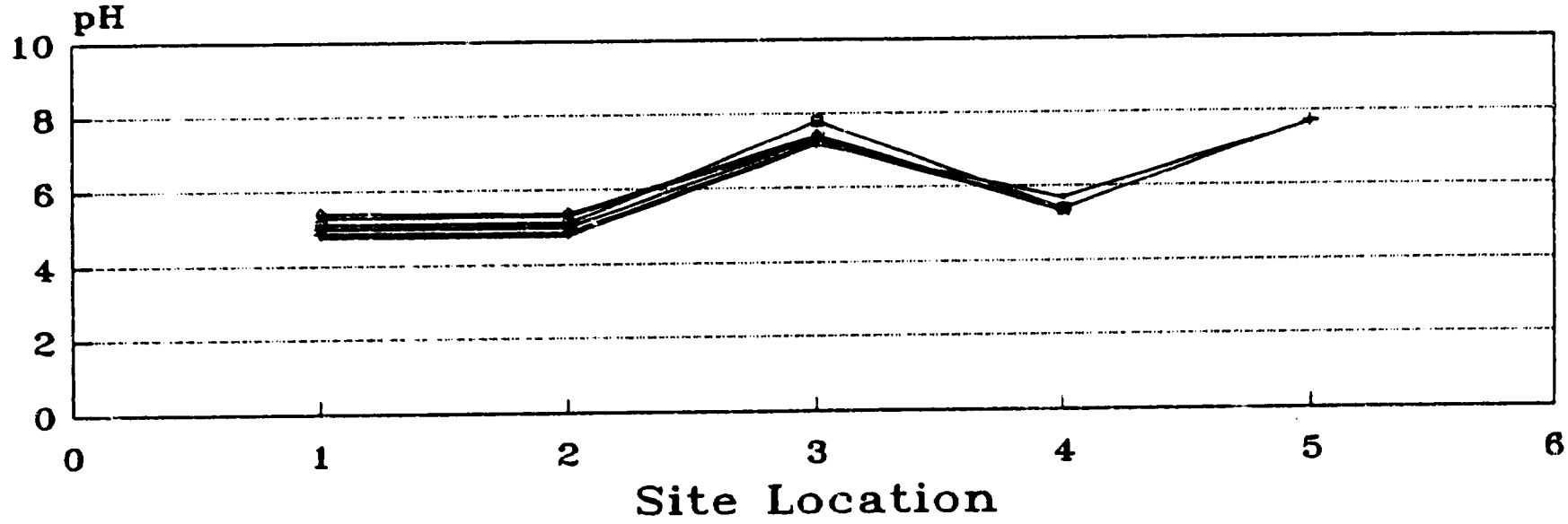


Figure 5

16/3/92 17/3/92 18/3/92
19/3/92 20/3/92 21/3/92

See Table 3 for Site Location Index

TEMPERATURE (Deg. C)

Tower Hill Sugar Factory

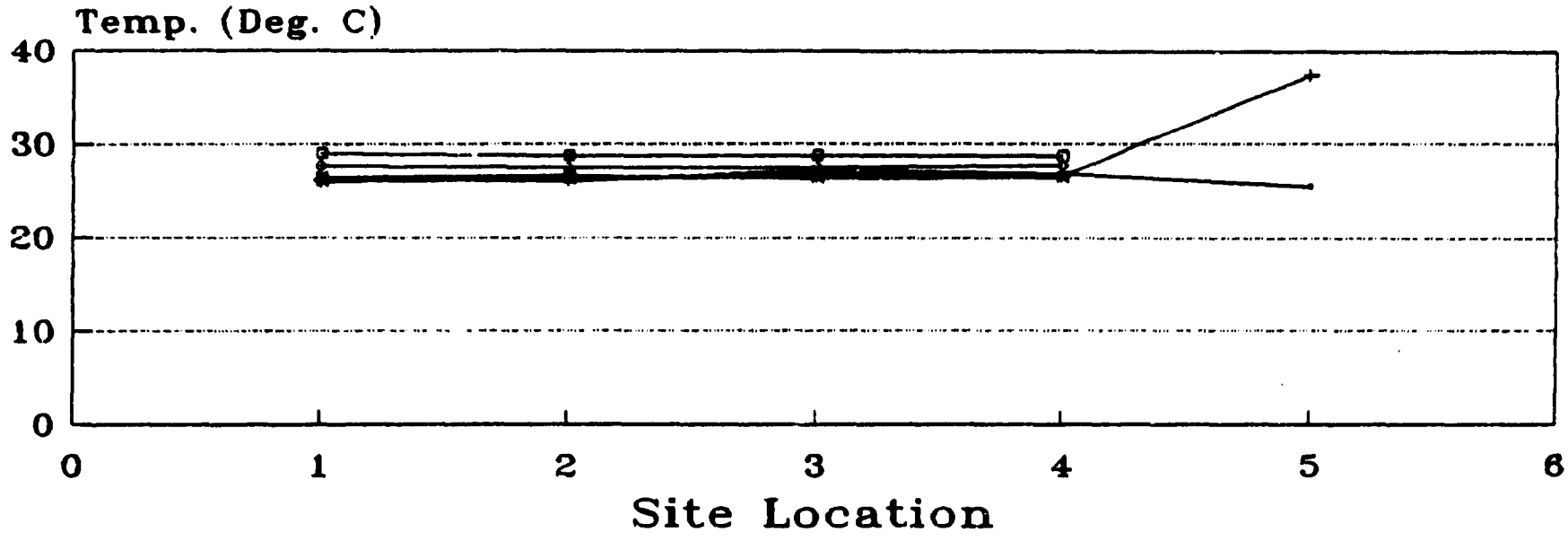


Figure 6

16/3/92 17/3/92 18/3/92

19/3/92 20/3/92 21/3/92

See Table 4 for Site Location Index

DISSOLVED OXYGEN (mg/l)

Tower Hill Sugar Factory

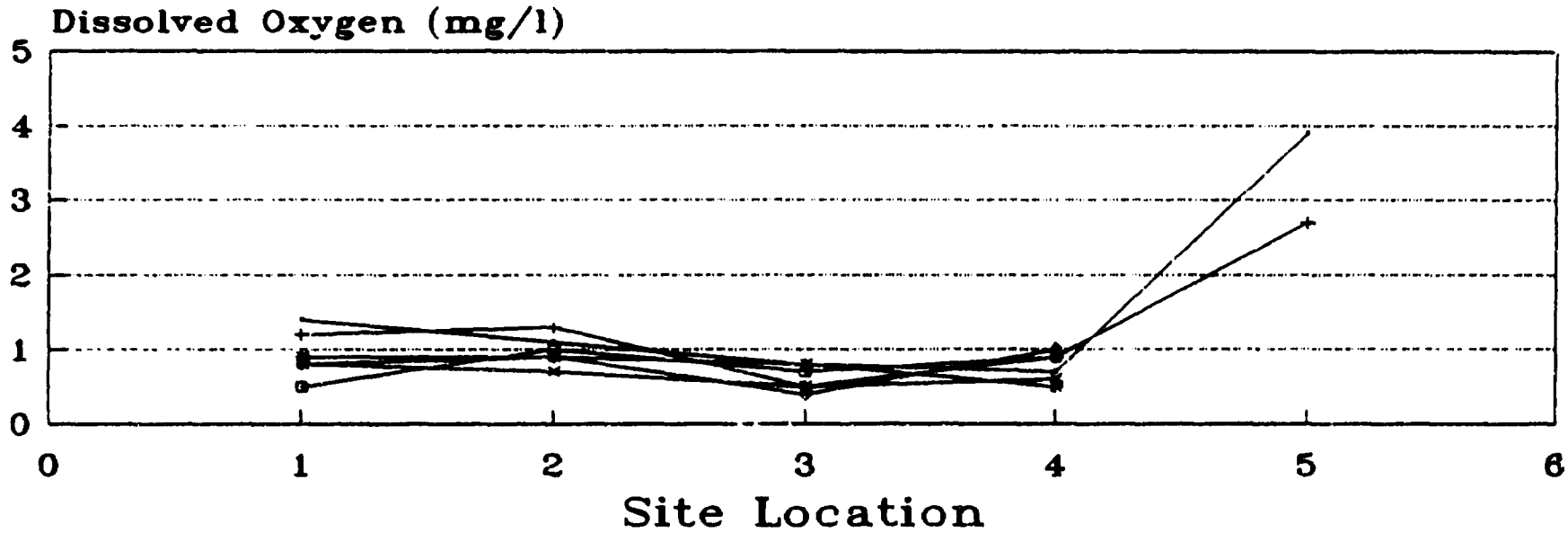


Figure 7

See Table 5 for Site Location Index

DISSOLVED OXYGEN (mg/l)

New River, March – April, 1993

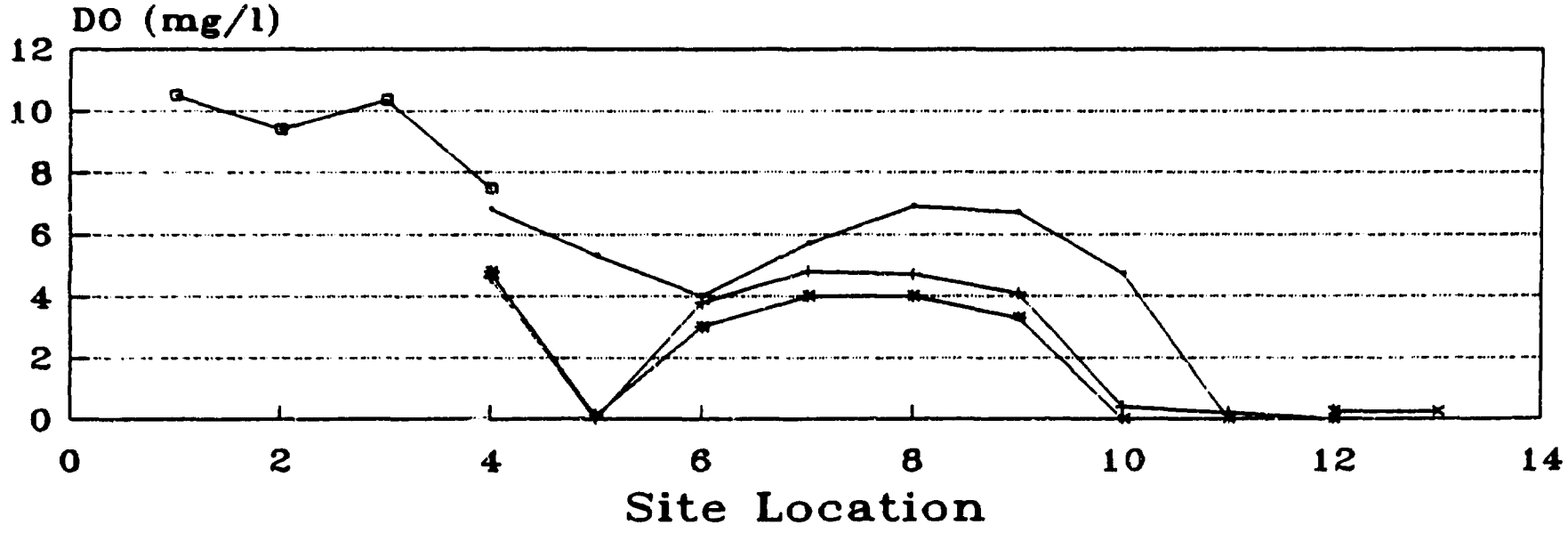


Figure 8

18/3/93
29/3/93 (top)
29/3/93 (3 m deep)
6/4/93
13/4/93

See Table 8 for Site Location Index

COD (mg/l)

New River, March - April, 1993

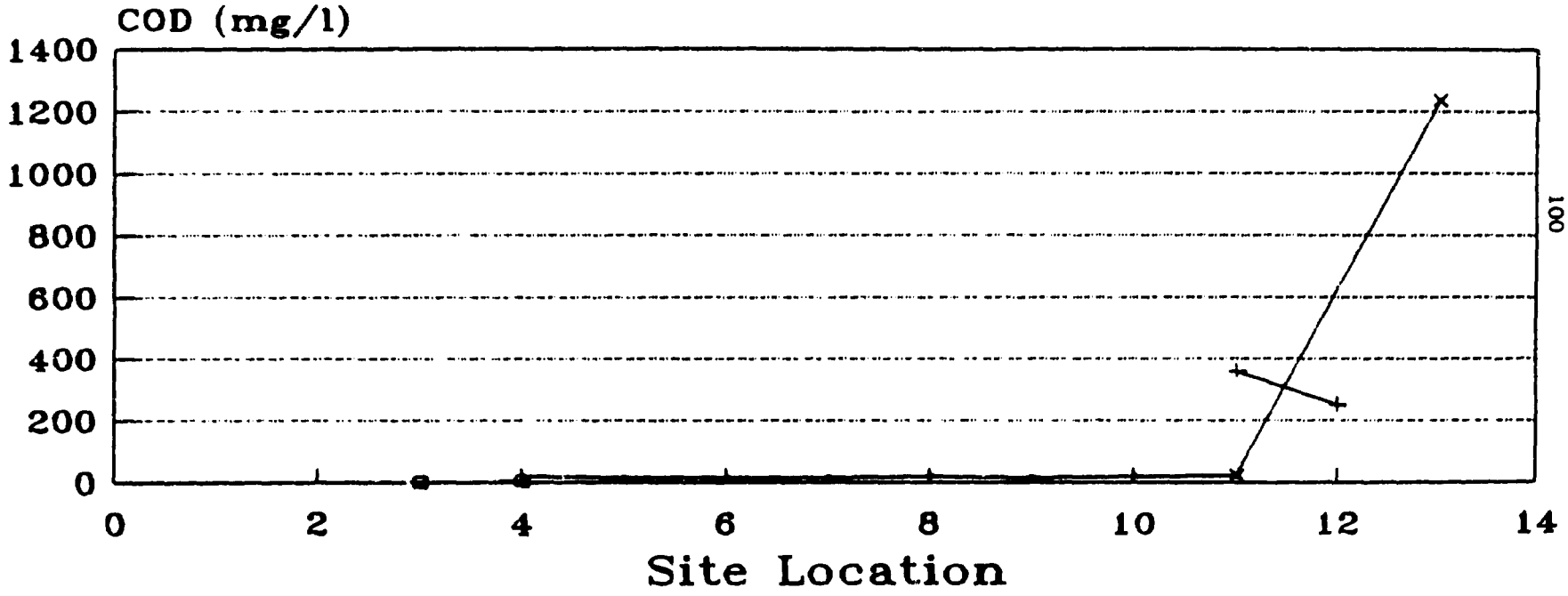


Figure 9

18/3/93 29/3/93 (top) 6/4/93 13/4/93

See Table 9 for Site Location Index

TEMPERATURE (Deg. C)
New River, March – April, 1993

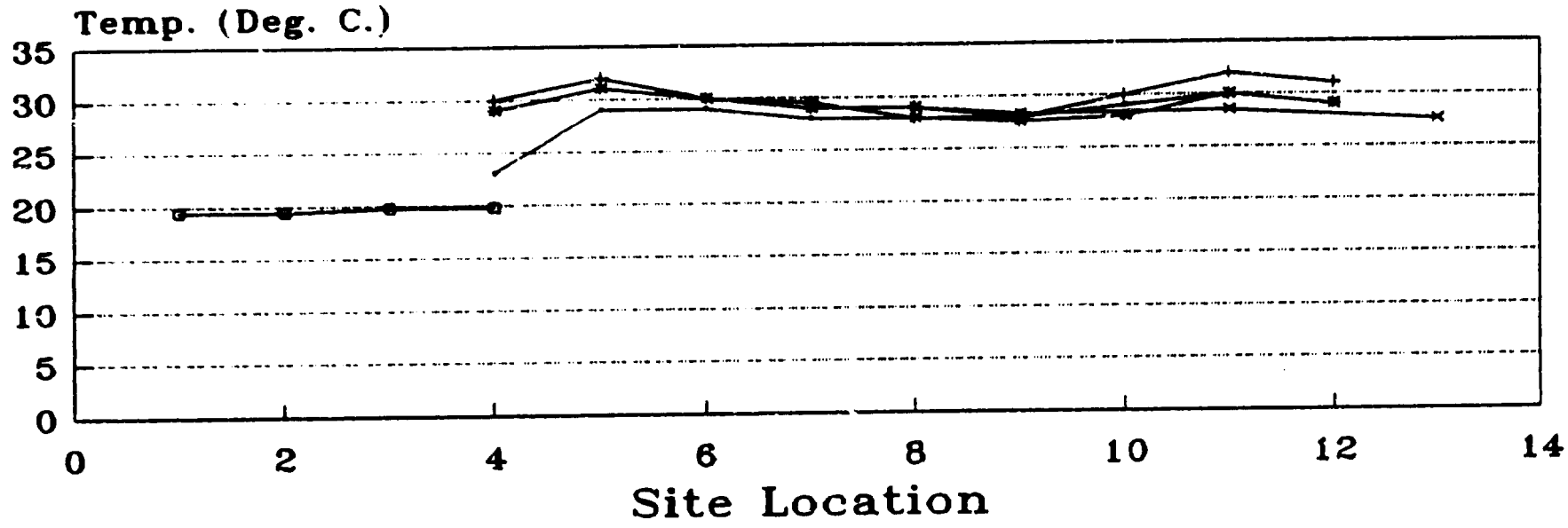


Figure 10

See Table 10 for Site Location Index

SULPHATE (SO4 mg/l)
New River, March – April, 1993

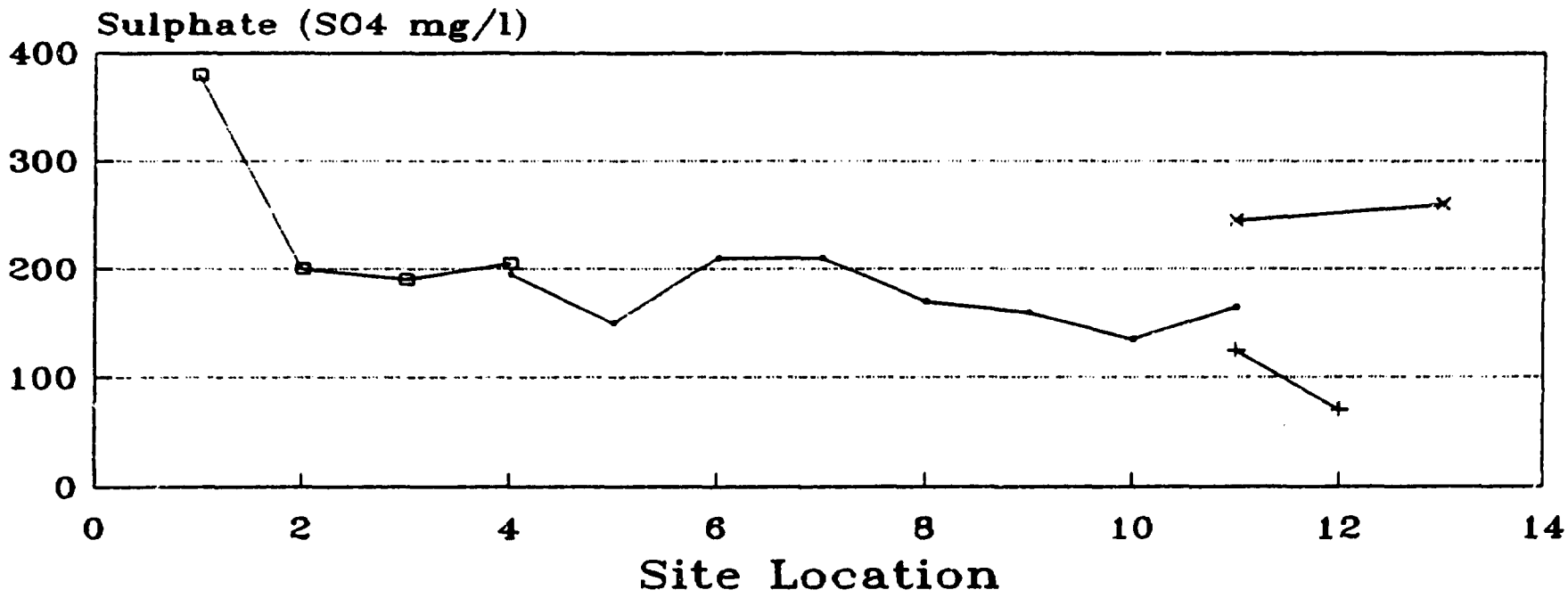


Figure 11

18/3/93 29/3/93 (top) 6/4/93 13/4/93

See Table 11 for Site Location Index

PHOSPHORUS (PO4 mg/l)

New River, March – April, 1993

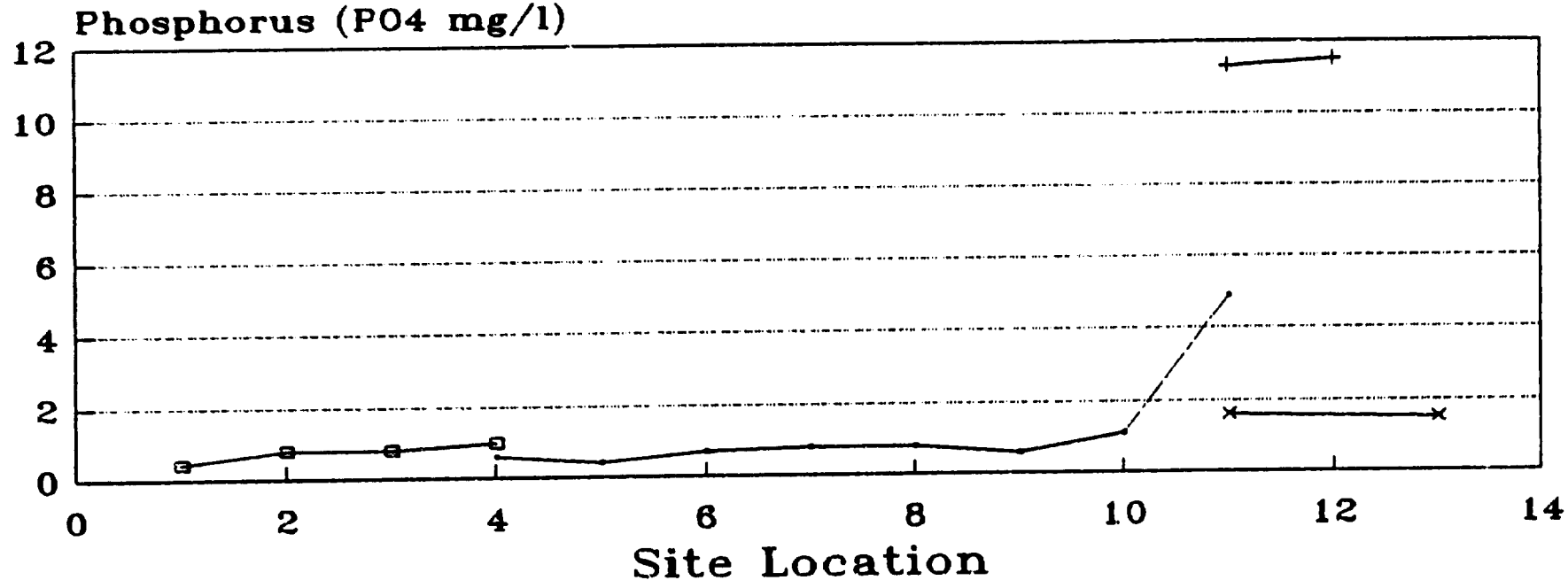


Figure 12

18/3/93 29/3/93 (top) 6/4/93 13/4/93

See Table 12 for Site Location Index

NITRATE (NO3 – N mg/l)
New River, March – April, 1993

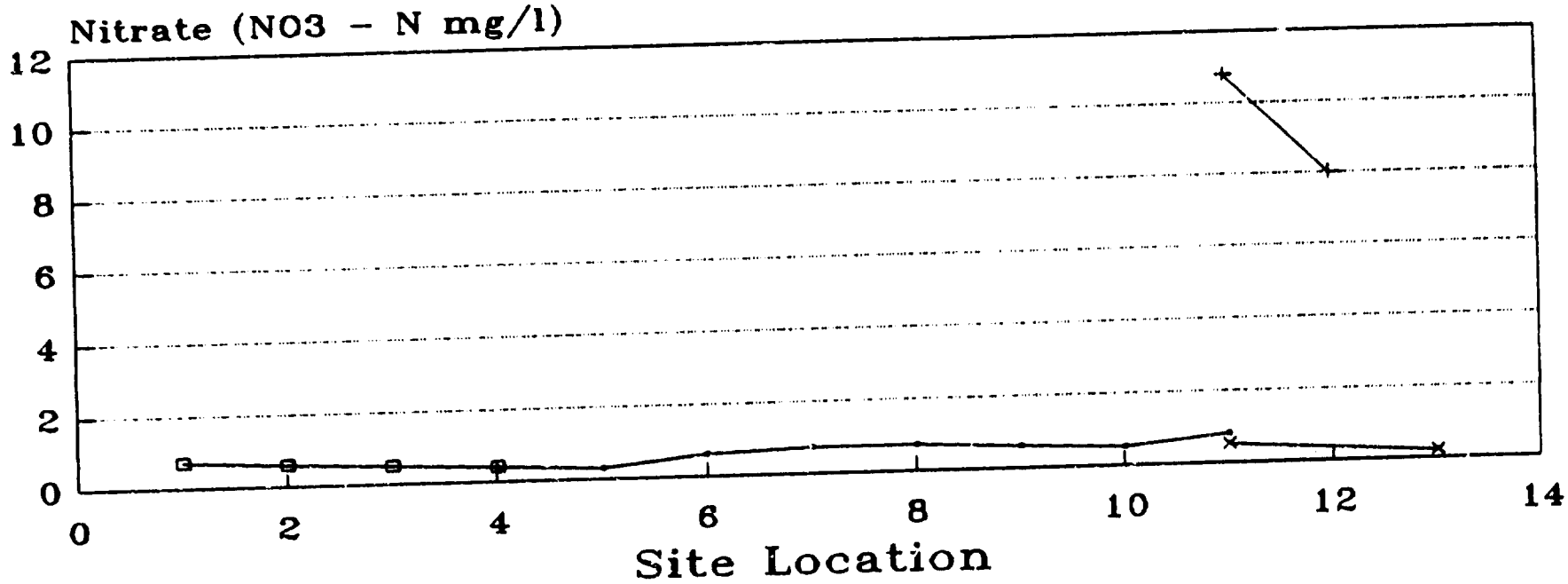


Figure 13

See Table 13 for Site Location Index.

AMMONIA (NH3 mg/l)
New river, March - April, 1993

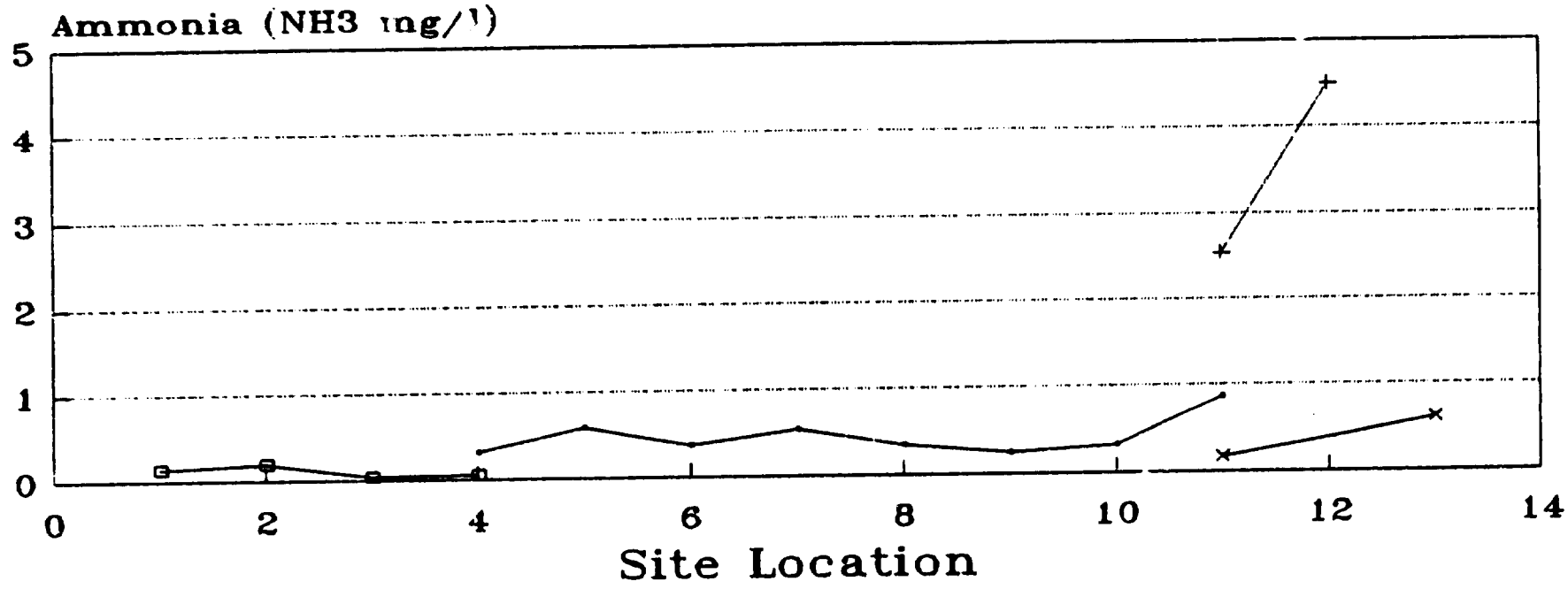


Figure 14

18/3/93 29/3/93 (top) 6/4/93 13/4/935

See Table 14 for Site Location Index

IRON (Fe mg/l)
New River, March - April, 1993

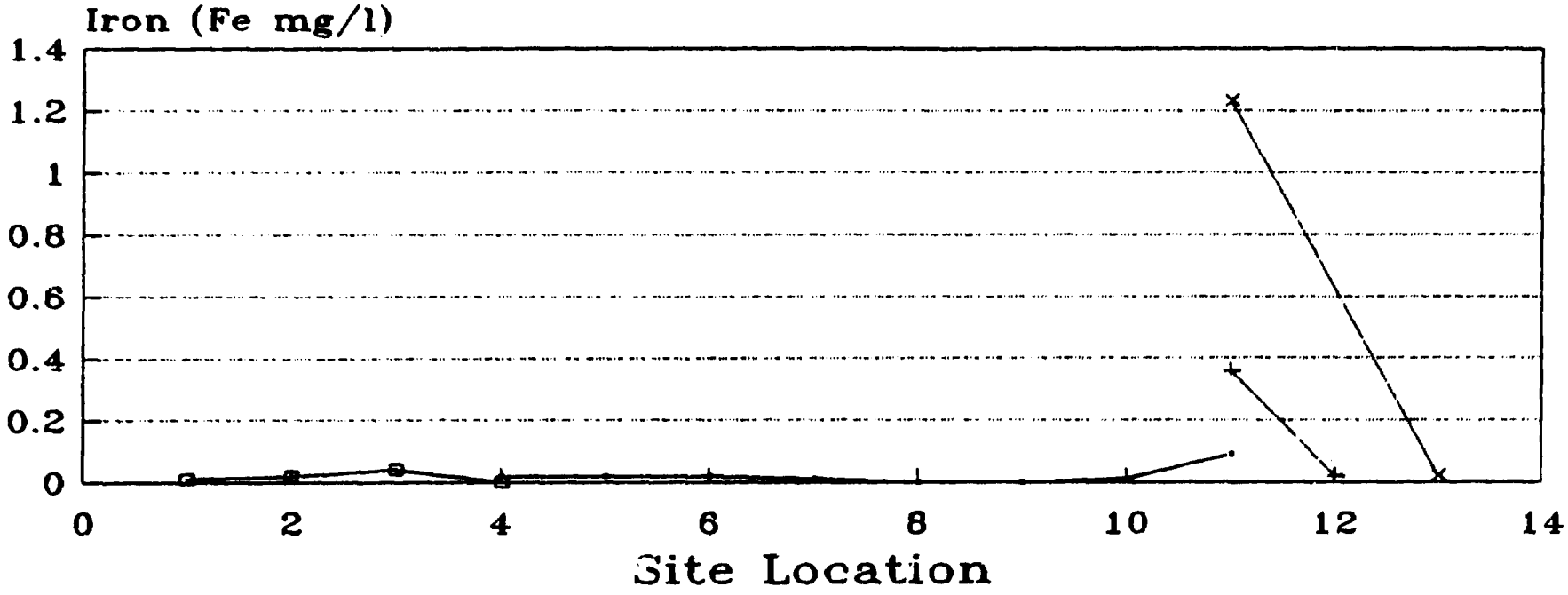


Figure 15

18/3/93 29/3/93 (top) 6/4/93 13/4/93

See Table 15 for Site Location Index

HARDNESS (CaCO3 mg/L)
New River, March - April, 1993

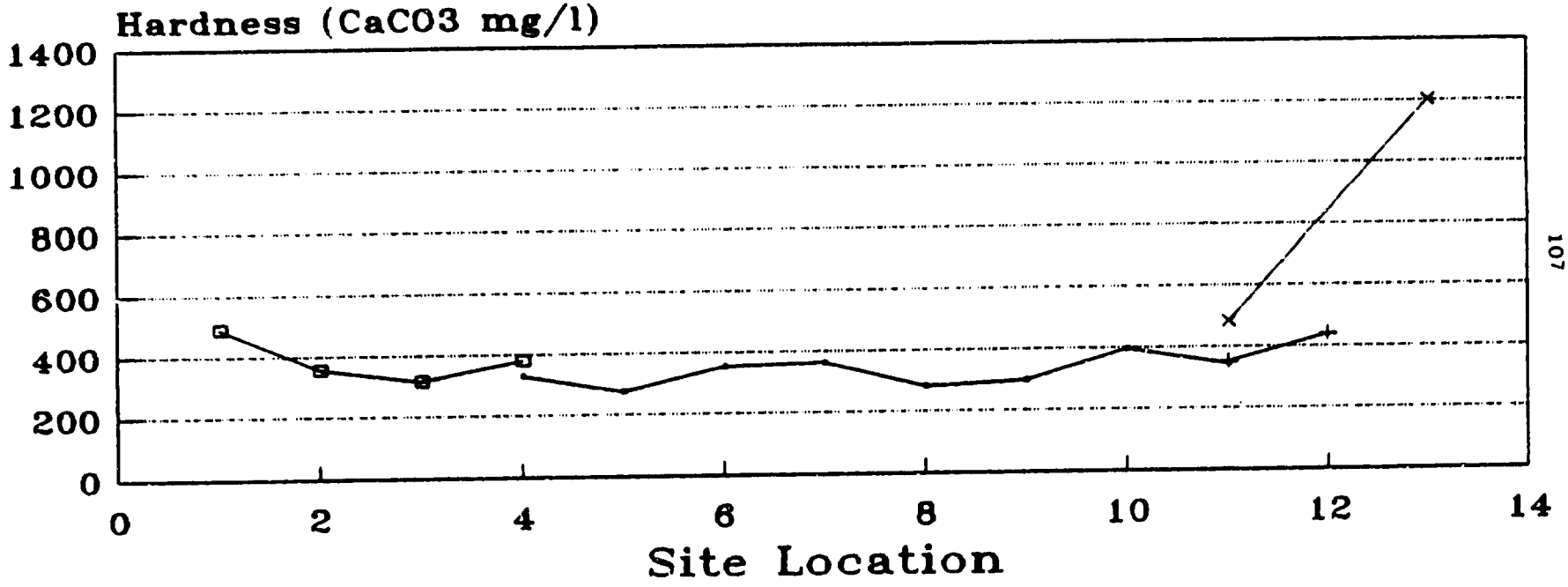


Figure 16

See Table 16 for Site Location Index

ALKALINITY (CaCO3 mg/l)
New River, March – April, 1993

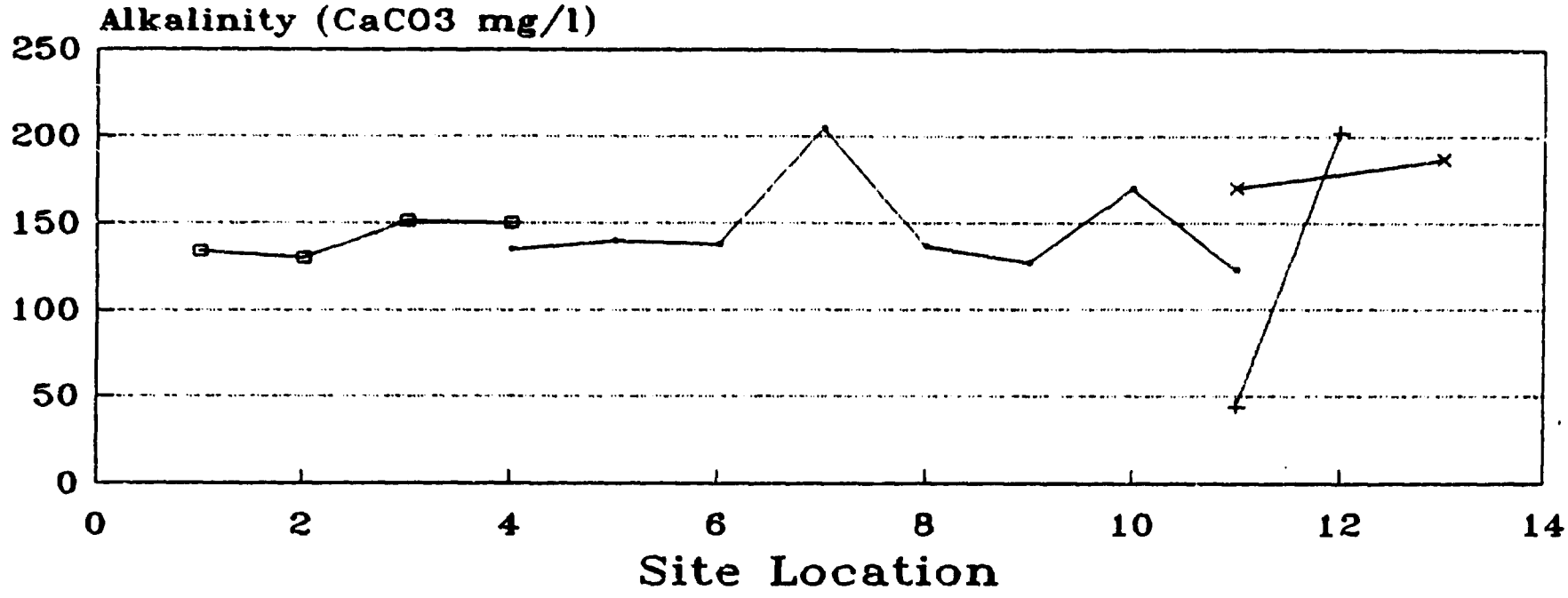


Figure 17

18/3/93 29/3/93 (top) 6/4/93 13/4/93

See Table 17 for Site Location Index

ANNEX VIII
DEPARTMENT OF THE ENVIRONMENT, BELIZE.
Application for a license to discharge trade effluent to Waters.

1. Name of Applicant:

   Address:

2. If Discharger is a Registered Company state:
   (a) Registered name of Company
   (b) Address of Registered Office

   (c) Name of Company Secretary

3. Name and address of premises from which the discharge is/will be made:

4. General description of process or activities giving rise to the discharge

5. Location and site plan showing the pcints of discharge to the waters:

6. Details of size and type of discharge outlets:

7. Is the discharge and existing discharge:

8. If the drainage is existing, state the date on which the discharge commenced:

9. Give details of any other discharges from the premises:

10. State reference number and date of planning permission (if applicable):

11. State source of water supply:

12. Give details of provisions made for sampling and measurement of effluent flows:

13. Give details of any special arrangements to prevent accidental discharges:

14. Trade Effluent: Volume of effluent to be discharged:
    (a) Normal per day:
    (b) Maximum in any one day:
    (c) Maximum rate per hour:
    (d) The period or periods of the day in which the discharge is to take place:
    (e) Any seasonal or other variations (including any arising from plant malfunction), total volume to be discharged:

15. Particulars of any effluent treatment:

16. Characteristics of the Trade Effluent:
Complete for all applicable characteristics, giving concentration ranges where applicable. The following list is meant to be indicative only - such other physical, chemical or other characteristics as are pertinent to the effluent in question should be specified.

Characteristics:	Prior to Treatment:	As Discharged:
Temperature (Deg. C)		
pH		
B.O.D.		
C.O.D.		
Colour		
Suspended Solids		
Settleable Solids		
Dissolved Solids		
Ammonia (as N)		
Nitrates (as N)		
Phosphorus (as P)		
Sulphates (as SO4)		
Chlorides (as Cl)		
Fluorides		
Phenols (as C6H5OH)		
Detergents (as LauryhSulphate)		
Oils, Grease and Fats		
Metals: (Specify each)		
Organohalogen compounds (Specify)		
Organophosphorus compounds (Specify)		
Mineral Oils		
Hydrocarbons of Petroleum origin		
Other Toxic substances		
Any other relevant characteristics		

I hereby make application for a license to discharge the above mentioned effluent/s to waters under the Environmental Protection Act 1992, no. 22 of 1992 in accordance with the plans and particulars submitted.

Signed: _____ Date: _____

ANNEX IX

COMMENTS:

The consultant has prepared a very detailed and comprehensive report which in fact goes beyond the scope of his terms of reference. The document presents specific data on the environment impact being caused by both sugar mills in Belize but at the same time presents general considerations on the agro-industrial pollution in the country together with recommendations regarding the management of industrial wastes which could be applied to the whole Belizean industry.

In addition to the two sugar mills, the consultant has visited one of the two distilleries ("Cuello Distillery"), two breweries, one fish farming and processing operation and two citrus processing plants. A summary of the visits is presented in Chapter I, "Preliminary Surveys" and complemented with the information available in Annex I "Company Visits and Reports". The consultant has confirmed to the Government and UNIDO that presently the industrial water pollution is the major problem being faced by the Belizean authorities in order to solve the problems related to industrial pollution in the country. And within the agro-industrial plants visited, the sugar production and citrus processing comprise the two sub-sectors which would need very special and urgent attention. In addition to the present project, UNIDO immediate assistance to the Government of Belize consists also of project SI/BZE/92/802 - "Conversion of Citrus Waste to Energy" which is dealing specifically with the industrial wastes being generated by the other major source of agro-industrial pollution in the country.

The report presents in Chapter II ("Sugar Factory Surveys"), conclusions and immediate recommendations to be adopted by the Government authorities/local plant managers of the two sugar manufacturing units: Belize Sugar Industries - BSI and Petrojam Ltd. The corresponding Tables and Charts illustrating the results of the sugar factory surveys are presented as Annex VII. In Chapter III ("New River Survey"), the results with an appropriate discussion of a number of surveys of the New River is also presented. And in Chapter IV ("Industrial Pollution Control Monitoring Programme"), complemented with tables and a model form presented in Annexes VII and VIII, very objective references to be used by the Government authorities in the preparation of a programme for controlling and monitoring the industrial pollution in the country is synthetically and clearly given. Finally, the summary of the conclusions and recommendations is presented in Chapter V.

In UNIDO's views the implementation of the conclusions and recommendations proposed by the consultant could be divided basically into two groups: (i) At the Government institutional level, which would consist essentially of the upgrade of the Department of Environment - (DOE) (physical facilities and human resources) along with the establishment of an industrial pollution control and monitoring programme; and (ii) At the industrial and micro-level where a series of specific activities would have to be carried out in order to establish new treatment units or improve the efficiency of the waste treatment systems being used by the agro-industrial sector in general and by the two sugar manufacturing companies, in particular.

Based on the report, it seems to UNIDO that in order to start solving the problems of generation of industrial wastes in the country and somehow be in line with the idea of having Belize as an ecotourism destination, it would be required:

(i) To upgrade technically the Department of Environment (DOE) through:

a) additional training of staff (as proposed in Annex IV of the report);

b) the establishment of a laboratory for waste water control and water quality testing within DOE (with the equipment as listed in Annex V of the report).

(ii) To establish an industrial pollution control and monitoring programme where the following activities would be included:

a) establishment of an effluent discharge system;

b) establishment of a "Biotic Index" for all waters in Belize;

c) establishment of a data bank for water quality and limits of discharge acceptable within the country;

d) establishment of a dynamic system of effluent license procedure;

e) introduction of regulations governing the safe disposal of solid wastes and establishing the limits of air pollution; and

f) establishment of a legal framework for the implementation of the industrial pollution control an monitoring programme.

(iii) To introduce the specific recommendations presented throughout the report regarding either the establishment of new waste water treatment stations in some of the plants visited (as for instance the Petrojam Ltd.) or the adjustment of the existing systems as the case of the Belize Sugar Industries - BSI, among other agro-industrial units.

ANNEX X

BIBLIOGRAPHY

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Memorandum No 1, Water Quality Guidelines, D.O.E., Dublin, Ireland 1990. Technical Committee on effluent and water quality standards.