Chapter 21 Conceptual Design

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Previous chapters provided backgrounds for this study, described the present status of petroleum pollution, experiments and analysis by the study team to uncover the true nature of the effluent water that causes pollution, presented analysis of the major issues of this study, development of the project scheme, or recommended facilities that should be installed to prevent and control petroleum pollution. This chapter translates the results of these preceding studies into the design of the facilities.

Although the design work done in this chapter is conceptual, the process of development is no different from detailed design of a process plant and follows the universal standard procedure; namely:

1. Development of material and energy balance, utility supply and consumption balance,
2. Planning of layout,
3. Preparation of process specifications for each piece of equipment,
4. Preparation of mechanical specifications for each piece of equipment,
5. Mechanical design of each piece of equipment,
6. Construction and installation study,
7. Preparation of plot plan, and
8. Estimation of cost (Chapter 22).

Since this conceptual design is not meant to be used for a feasibility study and not for construction, the steps are not very detailed. Nevertheless, this conceptual design is comprehensive and covers the entire spectrum of the design work and the cost estimation. The energy balance normally developed in the design of a process plant is not necessary because of the nature of the facilities to be installed.

21-1 Material Balance

This section develops a material balance for the waste water treating facilities and waste treatment centers as defined by preceding Chapter 20, "Project Scheme."

21-1-1 Basis for the Material Balance

The waste water treating facilities and waste treatment centers will be installed at Pointe-a-Pierre Refinery and Bernstein Main Storage. The following premises are made for calculation of the material balance.

(1) Pointe-a-Pierre Refinery

1. The oily waste water stream after being separated from the storm water stream is rated at 250 kiloliters per hour, or 37,736 barrels per day. This flow rate includes effluents which contain acids and alkalis. The oil content of the oily waste water stream is 3,000 ppm.

2. The oil contents of the oily water stream at the inlet of the treating facilities are as follows:

CPI, ppm	500
Dissolved Air Flotation with Coagulation (DAF), ppm	400

3. The amount of alum, the inorganic coagulant used for DAF, used is 3.5 times the oil at the inlet of DAF.

4. On the basis of the results of experiment, the amount of scum to be generated is 0.013 kiloliters/kiloliter of oily waste water.

5. The density of the scum is 0.62 grams/milliliter, based also on the results of experiment.

6. Accordingly, the amount of scum generated is calculated as follows:
   0.62 (gr/ml) x 0.013 (kl/kl) = 8 kg oil-containing scum/kL oily waste water

7. The floating oil recovered from the buffer tanks and CPI is supposed to contain 50 percent water and 20 percent emulsion, the latter in turn contains 35 percent water.

8. The solid matter of the scum exists as $Al(OH)_3$ and trapped oil. The former is formed from the added alum, or $Al_2(SO_4)_3 18H_2O$.

9. The cake of scum formed after dehydration by vacuum filtration contains 70 percent moisture.

(2) **Bernstein Main Storage**

1. The oily waste water stream is rated at 220 kiloliters per hour, or 33,500 barrels per day. This flow rate includes that which will be added in the future upon implementation of the firm projects. The oil content is supposed to be 8,496 ppm.

2. The oily waste water stream from Los Bajos Main Storage is rated at 180 kiloliters per hour, or 26,500 barrels per day. The oil content is supposed to be 282 ppm.

3. The oil contents of the oily water stream at the inlet of the treating facilities are as follows:

Los Bajos API Separator Inlet, ppm	270
Skimmer Pit Outlet, ppm	3,000
Oil Separator Outlet, ppm	1,500
DAF Inlet, ppm	1,000
DAF Outlet, ppm	100
ACA Outlet, ppm	50 max

4. The amount of alum, the inorganic coagulant used for DAF, used is 3.5 times the oil at the inlet of DAF.

5. On the basis of the results of the experiment, the amount of scum to be generated is 0.13 kiloliters/kiloliter of oily waste water.

6. The density of the scum is 0.62 grams/milliliter, based also on the results of experiment.

7. Accordingly, the amount of the scum generated is calculated as follows:
0.62 (gr/ml) x 0.13 (kl/kl) = 81 kg oil-containing scum/kL oily waste water

8. The floating oil recovered from the skimmer pit and CPI is supposed to contain 50 percent water and 20 percent emulsion; the latter in turn contains 35 percent water.

9. The solid matter of the scum exists as $Al(OH)_3$ and trapped oil. The former is formed from the added alum, or $Al_2(SO_4)_3 18H_2O$.

10. The cake of scum formed after dehydration by vacuum filtration contains 70 percent moisture.

21-1-2 Conceptual Flow and Material Balance

Figures 21-1 and 21-2 show conceptual flow diagrams of the waste water treating systems and waste treatment centers for Pointe-a-Pierre Refinery and Bernstein Main Storage, respectively.

21-2 Basic Concepts for the Conceptual Design

21-2-1 Pointe-a-Pierre Refinery

(1) Overall Design Philosophy for Waste Water Treating System

1) General Strategy

Initially when the refinery was constructed, storm water streams and oil water streams were not separated but used common sewers, API separators and guard basins. The two streams are being separated in the Upgrading Project in the tank yard area. In the process areas, however, these two streams are not separated.

Equipped only with gravity-induced separators, it is hardly possible to attain less than 150 ppm oil level, to say nothing of the 50 ppm target level. The results of the experiment done by the study team indicate that it is possible to reduce the oil content of the effluent water from the refinery to less than 50 ppm by the introduction of DAF. A system with DAF as the core facility is proposed.

To obtain the expected performance from the proposed facility, it is essential that the flow be stabilized within the design limits. For this purpose, the storm water should be completely separated from the oily waste water. It is also necessary to separate chemical oily waste water containing caustics and amines from the oily waste water stream, in consideration of COD control expected in the future.

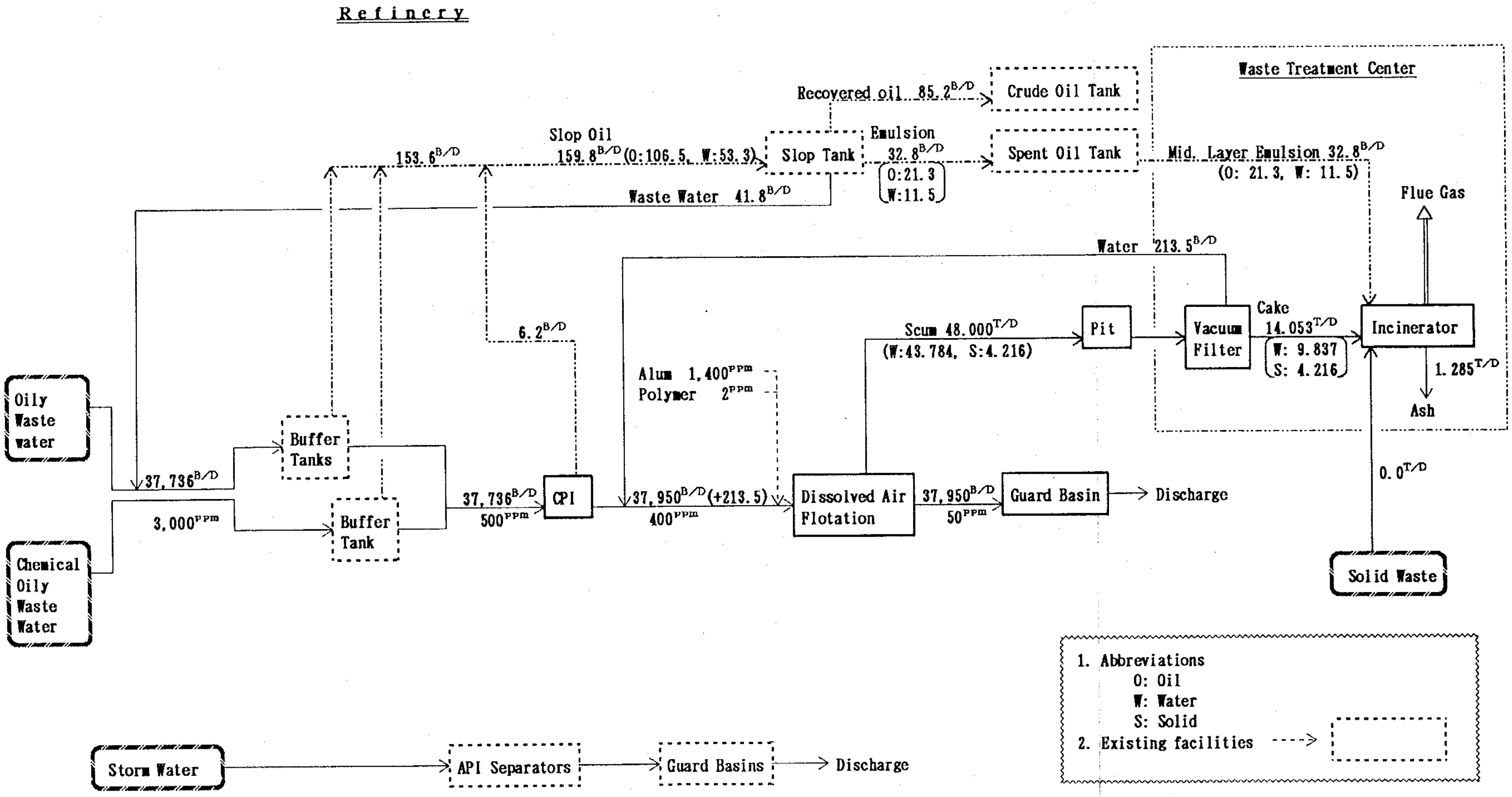


Figure 21-1 Conceptual Flow of Waste Water and Wastes Treatment System, Pointe-a-Pierre Refinery

Oilfield, Gathering Station and Tank Farm

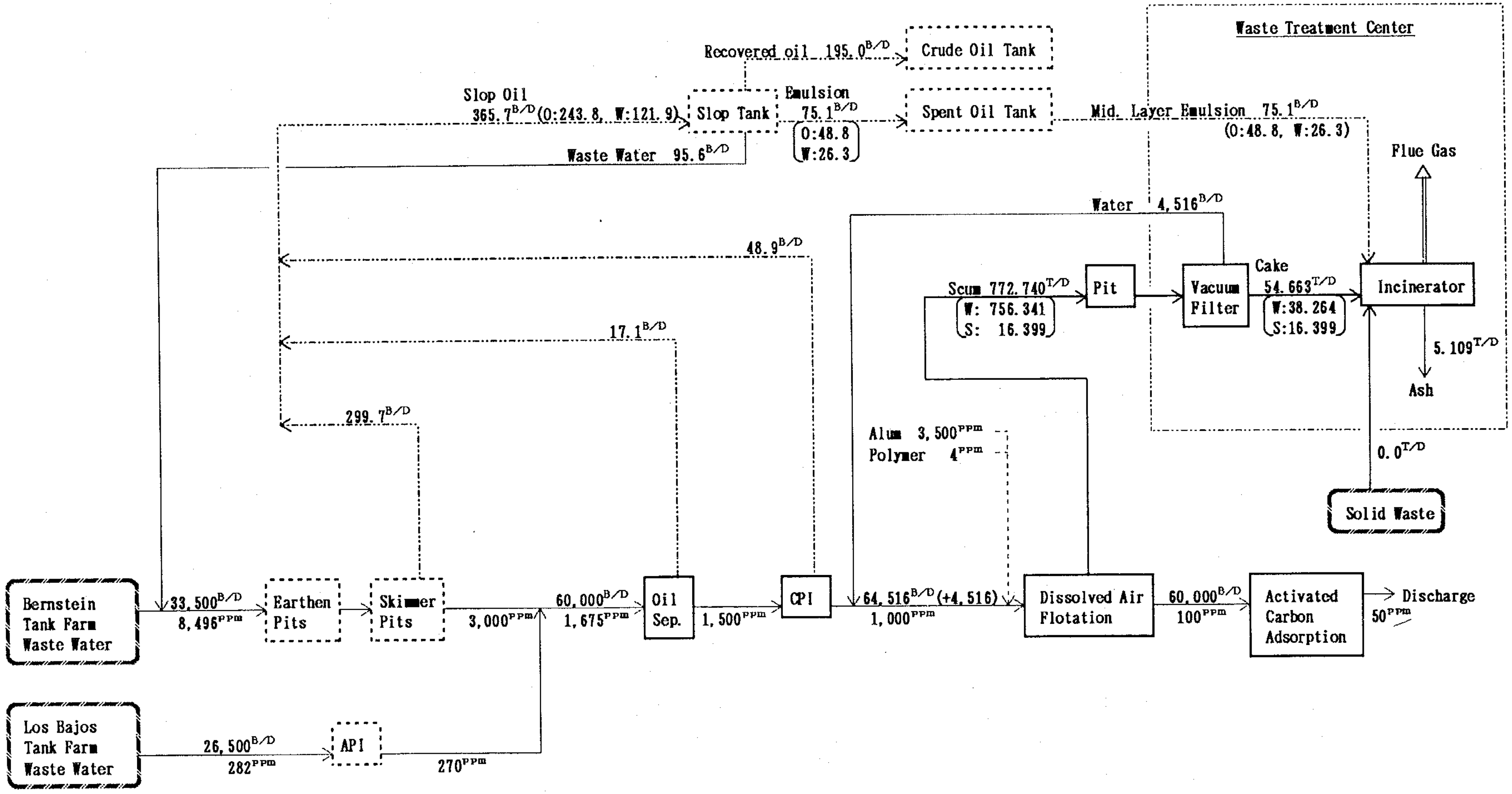


Figure 21-2 Conceptual Flow of Waste Water and Wastes Treatment System, Bernstein Main Storage

An incinerator will be necessary to incinerate the scum generated at the DAF unit. If the study being done by Trinidad Cement Limited (TCL) on the possibility of feeding the scum comes up with an affirmative result, the scum could be handed over to TCL and the incinerator dispensed with. With the result of the study still pending, this study proposes installation of an incinerator in the waste treatment center.

Figure 21-3 shows a schematic diagram of the proposed waste water treating system for Pointe-a-Pierre Refinery. The proposed system incorporates the following improvements.

1. Separate buffer tanks will be prepared for oily waste water and chemical oily waste water. These tanks provide storage capacity and help stabilize the feed rates to the treating facilities.

2. A system consisting of a CPI, DAF, guard basin and their associated facilities will be installed downstream of the buffer tanks.

3. Two separate pipelines will be installed traversing the refinery, one for oily waste water and the other for chemical oily waste water. The pipelines will run above ground on the existing pipe racks.

4. Each process unit will have its own separate pits for oily waste water and chemical oily waste water. The areas which may be contaminated by oil will be enclosed by spill walls to keep rain water out. These pits are connected with the oily pipelines.

5. These pits will have automatic level-controlling pumps to keep the liquid level in the pits constant. The fluids are discharged to the oily waste water and chemical oily waste pipelines, and sent to the buffer tanks.

6. A closed bleeding system will be employed for bleeding the bottom water from tanks. This system has already been adopted by Pointe-a-Pierre Refinery. The levels of bottom water are measured by a measuring tape covered with coloring paste before and after bleeding. Tanks are grouped according to their locations, and pipes connected with bleeding valves of these tanks converge to a pit installed for each group. These pits will have automatic level-controlling pumps. The oily waste water is sent to buffer tanks while keeping the liquid levels of the pits constant.

7. The waste treatment center will have a conveyer for the scum, dehydration unit, cake transporting system, incinerator and ashes storage facility.

8. The refinery is now implementing a program for modernizing the instrumentation as part of the upgrading project. The program consists in installation of a central control room and conversion of the existing system of instrumentation into a Distributed Control System (DCS). This program will provide surveillance of the entire refinery operation at the central control room.

At the request of Petrotrin, the proposed system will be controllable from the central control room. However, the incinerator needs to be controlled locally from the standpoint of safety of operation. It should be closely attended to by local personnel; un-attended operation controlled only remotely would not be practical. Likewise, the DAF unit needs to be closely attended to. Two operators will take care of both DAF and incinerator round-the-clock in shift. The following items will be monitored and controlled by the DCS system.

1. Buffer tanks
   Level indicators and flow rate controllers of the water discharged from the tanks

2. Levels of the suction pits for pumps with automatic startup device and high-level alarms
   Process area: 14 points
   Tank yard: 16 points
   Buffer tanks, CPI, guard basin: 3 points.

3. DAF unit
   (1) Flow indication and controlling of the feed water and pressurized water
   (2) Pressure indication of pressurized water tank
   (3) Level alarms for the feed water tanks, scum tank, alum solution tank, and polymer solution tank

A cable will be laid to the nearest satellite center of DCS to transmit signals. Transmission of signals will ride on the signal highway that will be laid from the satellite center to the central control room as part of the upgrading project. The proposed system does not include that portion of the cable. However, even the nearest satellite center is remote from the waste water treating system. Therefore, a new optical fiber cable will be laid to the central control room.

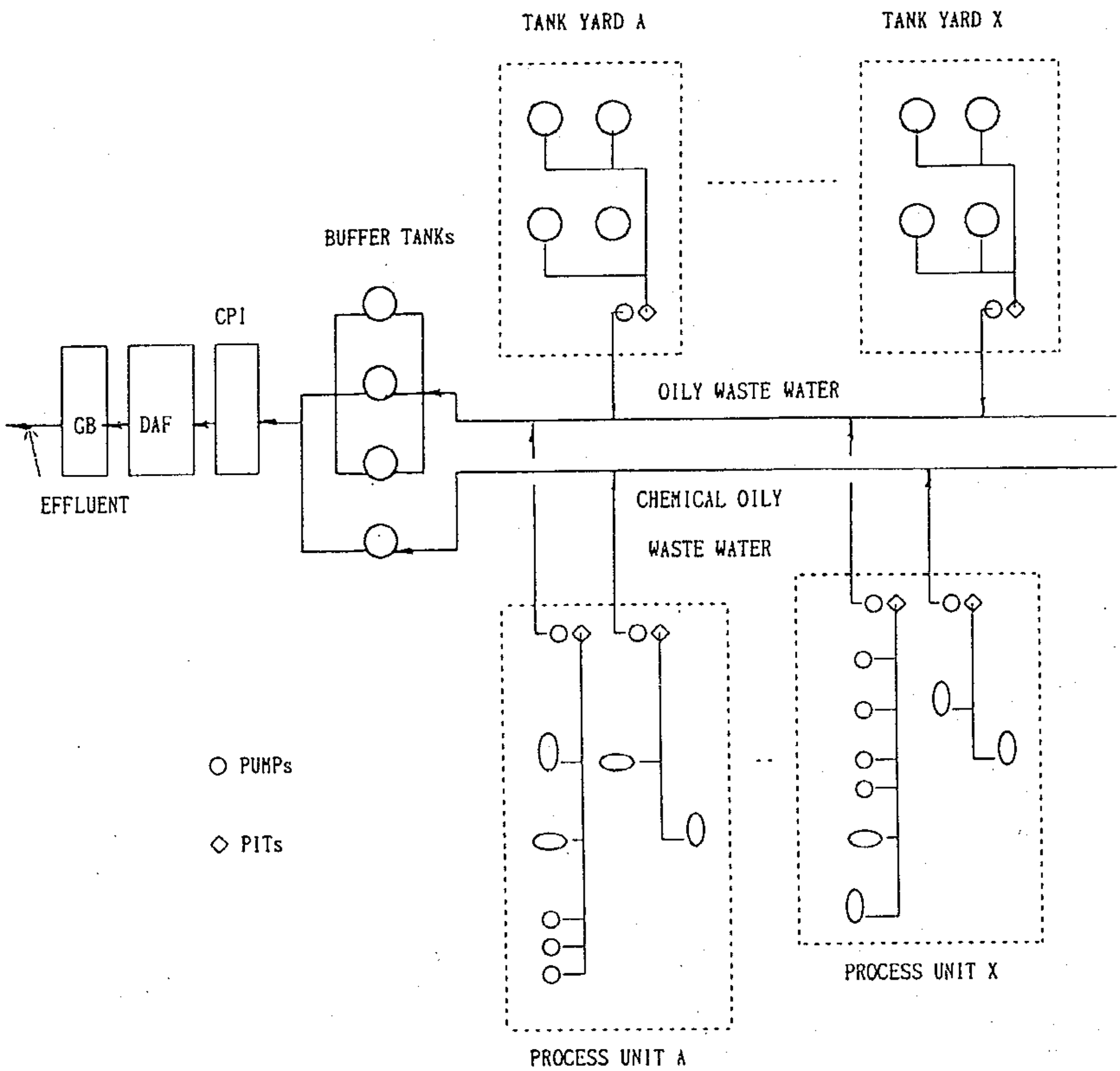


Figure 21-3 Proposed Waste Water Treating System, Pointe-a-Pierre Refinery

2) Reliability of the Waste Water Treating System

The waste water treating system will have one train. The target oil content of the effluent streams from the petroleum facilities to the public water, 50 ppm on a monthly average and 75 on a daily maximum, is an uncompromising condition which must always be met. As a provision for repair work, spares will be provided for such pieces of equipment which are considered to be subject to breakdown.

The operation of the system also emphasizes reliability of operation.

The following practices should be observed.

1. The levels of the buffer tanks should always be maintained low. In case of trouble with the waste water treating system, the buffer tanks could hold two days' equivalent of effluent water. The operation should be watched carefully to discover troubles before they develop into major ones. A system of maintenance which can quickly respond to a call should be established.

2. An inventory of adequate size should be maintained for various types and sizes of mechanical seals of rotating equipment and other parts liable to break down.

3. Cleaning, that of CPI for example, should be well scheduled to be done within the holding capacity of the buffer tanks.

(2) Design Conditions of Facilities of Waste Water Treating System

1) Estimation of Waste Water Flows

Table 21-1 gives estimated flow rates of oily effluent water from the process units.

These values were estimated from the data provided by Petrotrin, the planned upgrading program, and actual data obtained from the refineries of COSMO OIL CO., LTD. The amounts of waste water from the units with asterisk are added to give 216 cubic meters per hour.

The estimated amount of tank bleed water and waste water from areas enclosed by the spill wall of 24 cubic meters per hour and that of chemical oily waste water of 10 cubic meters per hour are added to give a total of 250 cubic meters per hour. This amount of 250 cubic meters per hour is adopted as the design basis.

Table 21-1 Estimation of Waste Water Discharges

(Unit: cubic meters per hour)

Processing unit	Throughput (Bls/day)	Petrotrin's estimate (Bls/day)		Design
No. 8 Topping unit*	135,000	6,750	40	40
No. 4 Vacuum distillation unit*	106,000	7,340	49	49
No. 3 Vacuum distillation Unit	18,000	159,000	1,053	30
FCC/GC*	30,000	5,608	37	40
Alkylation unit	3,000	-	-	-
No. 1 Vacuum distillation unit	18,000	39,600	262	30
D3 column*	3,000	4,100	27	30
No. 1 Reformer/Unifiner*	10,000	450	3	5
No. 2 Reformer/Unifiner*	15,000	510	3	5
No. 1 Hydrodesulfurization unit*	20,000	1,950	13	15
New visbreaker*	32,000	850	6	6
New sulfur recovery unit*	180 tons/day	920	6	6
No. 2 Hydrodesulfurization unit*	55,000	2,670	18	20

Note: Units with asterisk are used for design with allowances.

The oil content of water leaving the buffer tanks after surface oil has been recovered is estimated to be 500 ppm.

2) Buffer Tanks

(a) Conversion of Idle Tanks to Buffer Tanks

The following idle tanks are converted to buffer tanks.

1. For oily waste water
   NP Nos. 19 (about 5,000 kl), 20 (4,150 kl), 21 (4,150 kl) will be used. At 25 percent liquid level, these tanks have a holding time of about 36 hours, or 1.5 days
2. For chemical oily waste water
   One tank, NP No. 26 (about 3,000 kl) will be used. At 25 percent liquid level, the tank has a holding time of 110 hours, or 4.5 days.

(b) Modifications of Tanks

a) Inspection and Repairs

The tanks have rusted during idle periods. The tanks should be inspected on the inside and outside walls and on the bottom plates. They should be repaired as found necessary.

b) Painting

The tanks should be painted with anti-rust iron oxide paint.

c) Installation of Swing Suction Nozzles

Swing suction nozzles should be installed inside the tanks for the purpose of recovering floating oil. (Refer to Figure 21-4 "Buffer Tank".)

The following equipment is installed on each tank.

1. 4-inch pipe: 15 meters
2. 4-inch oil recovery nozzle equipped with a universal joint
3. A winch and wire on the outside

d) Vent

Six 10-inch vent pipes are installed on the roof of each tank to facilitate ventilation to prevent explosions stemming from auto-combustion of iron oxide that has been formed by hydrogen sulfide contained in the waste water. The vent is of elbow type, with a fire-arresting screen. The total number is 24 (6 x 4 tanks).

e) Pit for Recovery of Floating Oil and Oil Recovery Pump

One concrete-made pit, 2 meters wide, 2 meters long, and 2 meters deep, with a steel cover, is installed to hold the floating oil recovered from the four buffer tanks. The nozzles of buffer tanks are connected to the pit by underground pipes; the piping requirement is 4-inch x 15 meters x 4.

Specifications

Centrifugal pump, one unit
Fluid: oil (specific gravity: 0.85)
Capacity, kl/hr: 10
Pumping head, Kg-force/cm^2: 7

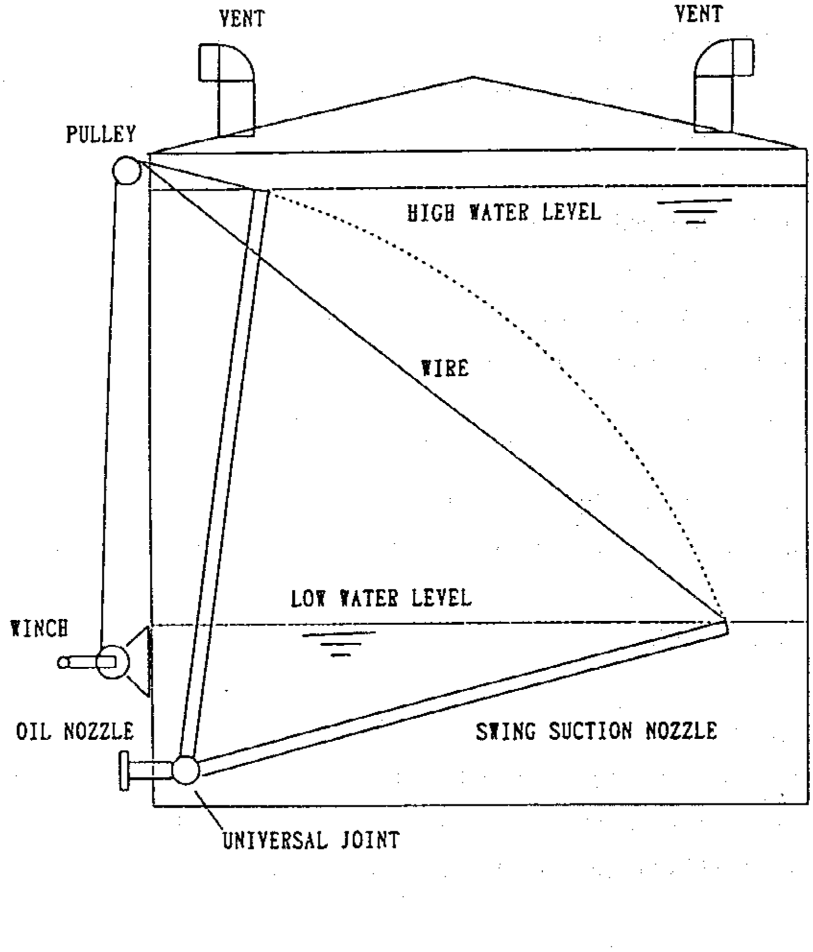


Figure 21-4 Buffer Tank

Motor: Explosion proof, increased safety construction 440 Volts, 3 phase, 60 Hz, 7 kWatts
Foundation and installation: standard
Electric work: 200 meter wiring

f) Discharge Piping from the Oil Recovery Pump

The pipe is laid to Slop Tank No. 54. Piping: 3-inch, 2,100 meters, on the existing above-ground pipe rack. Pressure drop: 2.0 Kg-force/cm^2 at 10 kl/h.

3) Corrugated Plate Interceptor (CPI)

(a) General

One CPI with a capacity of 250 kl/hour will be installed downstream of the buffer tanks. CPI intends to eliminate oil particles larger than 60 microns in diameter. The oil content at the inlet and outlet is supposed to be 500 and 400 ppm, respectively.

(b) Elevation

The unit is installed semi-underground. The waste water is fed from the buffer tanks by gravitation.

(c) Pit for Treated Water

One concrete-made pit, 5 meters wide, 10 meters long, and 3 meters deep, with a steel cover is installed to hold the water from the CPI. A feed pump to the DAF will be installed.

Specifications of the DAF feed pump:

Centrifugal pump, one unit
Fluid: water
Capacity, kl/hr: 250
Pumping head, Kg-force/cm^2: 3
Motor: Explosion proof, increased safety construction, 440 Volts, 3 phase, 60 Hz, 28 kWatts
Foundation and installation: standard
Electric work: 200 meter wiring

(d) Discharge Piping from the DAF Feed Pump

Piping laid to the inlet of the DAF: 8 inches, 20 meters.

(e) Oil Recovered by CPI

The recovered oil is sent to the recovery oil pit for the buffer tanks by a centrifugal pump.

Specifications of the recovery oil pump:

Centrifugal pump, one unit
Fluid: oil
Capacity, kl/hr: 1
Pumping head, Kg-force/cm^2: 2
Motor: 0.75 kWatts
Piping: 2-inch x 80 meters
Pit 1 meter wide, 1 meter long and 1 meter deep.

4) Dissolved Air Flotation (DAF)

(a) General

The capacity of the unit is 250 cubic meters per hour. Alum and an organic coagulant are used to recover oil by flotation. The DAF unit consists of the following major facilities: alum solution tank, polymer solution tank, coagulant injection facility, pressurized water tank, pressurized water preparation and injection facility, flotation bath, scum skimmer, electric facilities, measuring and controlling instruments.

(b) Treated Water

The treated water effluent from the DAF is directed to a guard basin downstream of the DAF through a 10-meter long 14-inch pipe by gravitational flow.

(c) Scum and Sludge Pit

A concrete-made pit with a steel cover, 3 meters wide, 2 meters long and 3 meters deep, is installed to receive the scum and sludge from the DAF unit. A pump and pipeline are installed to send the scum to the waste treatment center.

Specifications of the recovery oil pump:

3-rotored screw pump, one unit
Fluid: scums from DAF unit, specific gravity: 1.0
Capacity, kl/hr: 2.5
Motor: Explosion proof, increased safety construction, 440 Volts, 3 phase, 60 Hz, 900 rpm, 5 kWatts

Foundation and installation: standard
Electric work: standard
Piping: 3-inch x 30 meters

5) Guard Basin

A guard basin is installed to cope with emergencies with the DAF unit. The treated water is discharged to the sea through the guard basin. The guard basin is equipped with a device to recover floating oil.

(a) Basin

The dimensions are: 10 meters wide, 20 meters long and 2 meters deep.
The basin has a weir at the outlet to stop floating oil.

(b) Recovery Pump and Pit

Specifications of the recovery oil pump and pit:

Centrifugal pump, one unit
Fluid: oil
Capacity, kl/hr: 1
Pumping head, Kg-force/cm^2: 2
Motor: Explosion proof, increased safety construction, 440 Volts, 3 phase, 60 Hz, 0.75 kWatts
Foundation and installation: standard
Electric work: 200 meters of wiring
Piping: 2-inch x 200 meters to the oil recovery pit for the buffer tanks
Oil pit: concrete-made with a steel cover, 1 meter wide, 2 meter long and 1 meter deep.

6) Discharge Pipe

The effluent stream from the guard basin is discharged to the nearest shoreline by a 100 meter 14-inch underground pipe.

7) Waste Treatment Center

The waste treatment center will be installed mainly to dehydrate and incinerate the scum from the DAF unit. The center will operate 24 hours a day. The major facilities of the center are as follows:

1. Dehydration unit

2. Facility for temporary storage and transportation of the cake
3. Emulsion tank: 10 kl
4. Incinerator
5. Facility for temporary storage of ashes.

(a) Dehydration Facility

The dehydration facility consists of a vacuum filter and accessories.

Specifications:

1. Fluid: Scum from the DAF unit; specific gravity: 1, throughput, kl/h: 2.5
2. Water content of the dehydrated cake, %wt: 70
3. Treatment of the filtrate: The filtrate contains suspended solids and is therefore returned to the pit at the outlet of the CPI.
4. Pump:

   Capacity, kl/hr: 2

   Pumping head, Kg-force/cm^2: 2

   Motor: Explosion proof, increased safety construction, 440 Volts, 3 phase, 60 Hz, 0.75 kWatts

   Foundation and installation: standard

   Electric work: 30 meters of wiring

   Piping: 1.5-inch x 80 meters to the oil recovery pit at the outlet of the API separator.

(b) Cake Transportation and Storage Facility

A belt conveyer is used to lift the cake from the dehydration facility to the hopper of the temporary storage facility 10 meters high. The size of the hopper is 5 cubic meters.

(c) Incinerator

One incinerator will be installed.

Specifications:

1. Type: Rotary kiln type
2. Feeds:

   Cake from the DAF unit

   Throughput, kg/h: 600

   Water content, %: 70

   Heat of combustion, kcal/kg: 1,200

   Composition: oil, aluminum hydroxide, aluminum oxide

Emulsions

Throughput, kl/h: 0.2

Heat of combustion, kcal/kg: 5,800

Oil content, %: 65; Water content, %: 35

Miscellaneous oily wastes generated in the refinery

Throughput, undetermined

Auxiliary fuel: heavy oil is used. A five kiloliter tank is provided

(d) Ash Storage and Transportation Facility

A belt conveyer is used to lift the cake from the dehydration facility to the hopper of the temporary storage facility 10 meters high. The size of the hopper is 5 cubic meters. The ash is eventually used for reclamation.

8) Waste Water Mains

Figure 21-5 shows the routing of the main and lateral pipes.

(a) Oily Waste Water Main

A 10 inch-pipe is laid above ground over a distance of 4,700 meters on the existing pipe racks. The terminal flow velocity is 1.5 meters per second.

(b) Chemical Oily Waste Water Main

A 3-inch pipe is laid along the above pipe over a distance of 3,000 meters on the existing pipe racks. The terminal flow velocity is 1.1 meters per second.

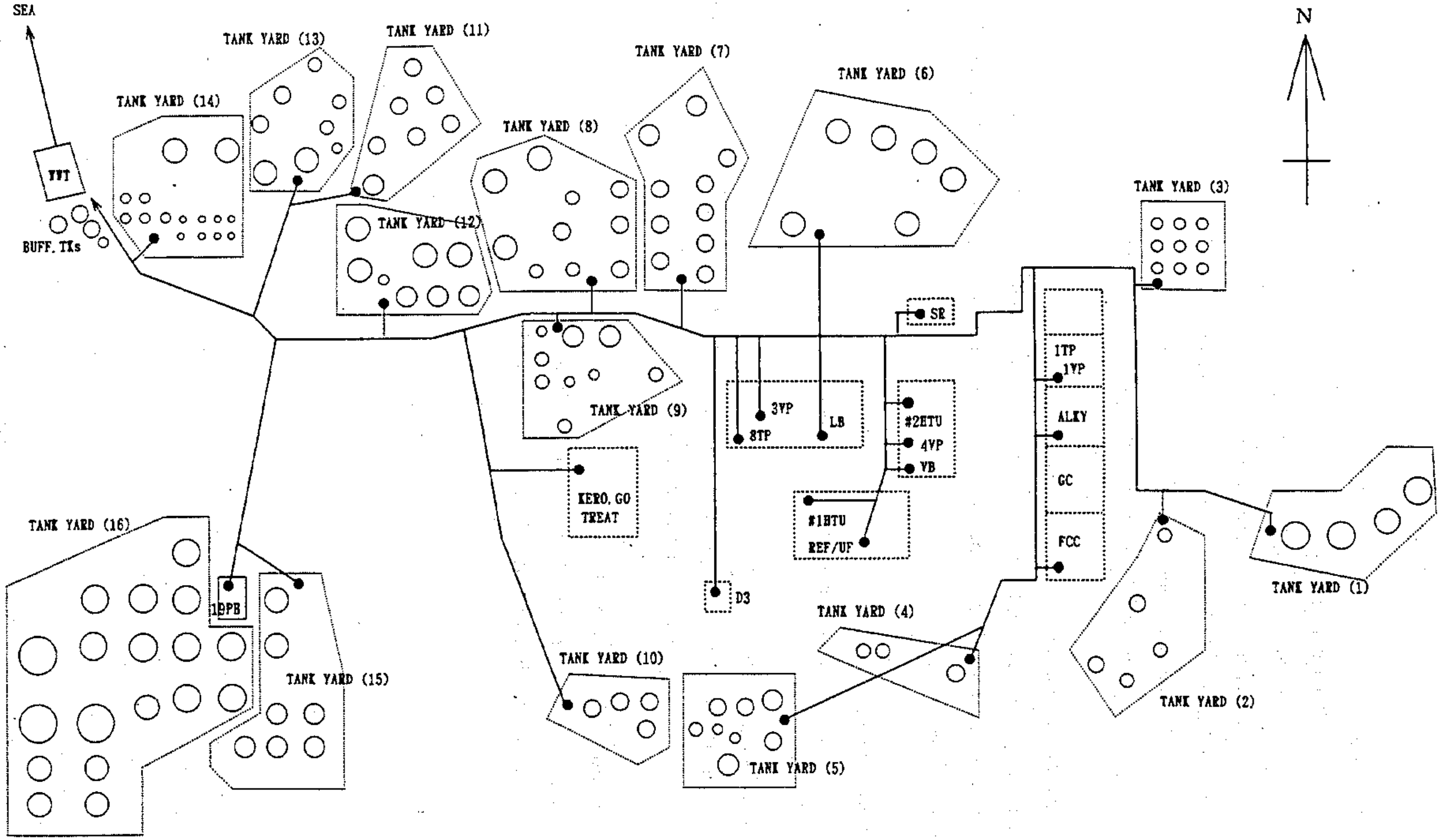


Figure 21-5 Location of New Waste Water Treatment Facilities, Pointe-a-Pierre Refinery

9) Oil Water Separation in the Process Area

(a) Basic Concept

The study team has set forth the following basic concept for the separation of oil and water in the process area.

1. Separation of the existing waste water pit

   The existing waste water pits are to be disconnected from the underground waste water piping system.

2. Installation of oily waste water pit

   An oily waste water pit, measuring one meter wide one meter long and one meter deep, will be installed in a process area where there is no pit at present. Oily waste water will be collected in the newly installed pit.

3. Installation of chemical oily waste water pits

   In the process areas where chemicals such as caustics and amines are handled, pits are to be installed and waste waters containing such chemicals collected in them. The chemical waste waters are to be neutralized as necessary in the process area and charged to the waste water pipeline system. Care must be exercised not to release hydrogen sulfide when the chemicals are neutralized.

4. Installation of automatic level-controlling pumps

   Automatic starting pumps with a level-controlling device will be installed at each pit.
   Specifications for chemical and non-chemical oily waste water pumps
   Waste water pump:
   Centrifugal pump
   Motor: Explosion proof (increased safety type), 440 Volts, 3 phase, 60 Hz
   Electric work: 100 meters of wiring

   Chemical waste water pump:
   Capacity, kl/hr: 5
   Pumping head, Kg-force/cm^2: 7
   Motor: Explosion proof (increased safety type), 440 Volts, 3 phase, 60 Hz, 3.5 kWatts
   Note: These are common specifications that will apply to all chemical pumps.

Electric work: 100 meter wiring

5. Connection with waste water main

   Pipelines will be laid above ground from the discharges of the local waste water pumps to the waste water mains. The sizes of the pipelines are:

   Oily waste water: commensurate with the amount of water

   Chemical oily waste water: 2 inch-pipe.

6. Separation of rain water by spill walls, modifications of sewage

   Such portions of the process areas that may be stained with oil are to be enclosed by spill walls 15 centimeters high made of concrete blocks. The insides of the spill walls are to be connected with oily sewers. New rain water sewers will be installed as necessary where drainage will be blocked by the spill walls. The new rain water sewers will be 20 centimeters wide, 15 centimeters deep and will be covered by grated plates. The rain water sewers will be connected with the main rain water sewers surrounding the process areas.

7. Replacement of the barometric condensers with surface condensers at Nos. 1 and 3 Vacuum Distillation Units

   Nos. 1 and 3 Vacuum Distillation Units will have their barometric condensers replaced by surface condensers. No. 4 Vacuum Distillation Unit operates with surface condensers. The barometric condenser discharges a large amount of oil-containing waste water. Therefore, the barometric condensers of Nos. 1 and 3 Vacuum Distillation Units must be replaced by surface condensers.

(b) Modifications of Individual Process Units

a) Lubricating Oil Facilities

The lubricating facilities include No. 3 Vacuum Distillation Unit, Furfural Extraction Unit and Dewaxing Unit.

1. Isolation of the two existing oily sewer pits

   There is one pit used commonly by the No. 3 Vacuum Distillation Unit area and the Furfural Extraction Unit area. There is also one in the Dewaxing Unit area. The exits from these two pits will be plugged.

2. Installation of automatic starting level-controlling pumps

Pumps with automatic starting devices will be installed to control the water levels in the pits.

Specifications

Pump for No. 3 Vacuum Distillation Unit

Capacity, kl/hr: 30

Pumping head, Kg-force/cm^2: 7

Motor: 10 kWatts

Pump for Dewaxing Unit

Capacity, kl/hr: 10

Pumping head, Kg-force/cm^2: 7

Motor: 5 kWatts

3. Piping connection to the waste water main

Pipes will be laid from the above pumps to the above-ground waste water main.

From No. 3 Vacuum Distillation Unit: 4 inches x 150 meters

From the Dewaxing Unit: 2 inches x 150 meters

4. Separation of rain water by the spill wall

No. 3 Vacuum Distillation Unit: 150 meters

Furfural Extraction unit: 100 meters

Dewaxing Unit: 120 meters

5. Modification of the rain water sewage

No. 3 Vacuum Distillation Unit: 50 meters

Furfural Extraction unit: 30 meters

Dewaxing Unit: 50 meters

6. Replacement of barometric condensers by surface condensers

Those of No. 3 Vacuum Distillation Unit will be replaced.

b) No. 8 Topping Unit

The following modifications will be made.

1. Isolation of the existing oily sewer pit

There is one oily water pit in this area. The exit of this pit is plugged. The effluent water stream from the desalter, now being discharged to the underground waste water pipe, is directed to this pit by opening the valve on the idle line from the desalter to the pit.

2. Installation of chemical oily waste water pit

   A chemical oily waste water pit, measuring one meter wide one meter long and one meter deep, will be installed to hold the spent caustic solution from the caustic treatment of butane.

3. Installation of automatic starting level-controlling pumps

   Pumps with automatic starting devices will be installed to control the water levels of the pits.

   Specifications

   Desalter waste water

   Capacity, kl/hr: 40

   Pumping head, Kg-force/cm^2: 7

   Motor: 13 kWatts

   Chemical waste water

   Common specifications for chemical pumps

4. Piping connection to the waste water main

   Pipes will be laid from the above pumps to the above-ground waste water mains.

   From the oily water pump: 4 inches x 250 meters

   From the chemical water pump: 2 inches x 250 meters

5. Separation of rain water by the spill wall

   A 150-meter spill wall will be built to separate the rain water.

6. Modification of the rain water sewage: 50 meters

c) No. 4 Vacuum Unit

The following modifications will be made.

1. Installation of a waste water pit

There is no waste water pit now. One oily water pit will be installed. The existing three underground oily pipelines, now connected to the oily water pipe, will be modified to be connected to the new pit. Requirement: 6 inches x 50 meters.

2. Installation of an automatic starting level-controlling pump
   A pump with an automatic starting device will be installed to control the water level in the pit.
   Specifications
   Capacity, kl/hr: 50
   Pumping head, Kg-force/cm^2: 7
   Motor: 16 kWatts

3. Piping connection to the waste water main
   A pipeline will be laid from the above pump to the above-ground waste water main.
   Requirements: 4 inches x 250 meters

4. Separation of rain water by the spill wall
   A 150-meter spill wall will be built to separate the rain water.

5. Modification of the rain water sewage: 50 meters

d) Gas Oil and Kerosene Treating Unit

Kerosene is treated with a fresh caustic solution; the spent caustic solution is used for the treatment of gas oil. After the emulsion is broken by applying high-voltage alternating current using Petreco's process, the mixture is allowed to stand still to separate oil and the spent caustic solution. The spent caustic solution is reacted with sulfuric acid to produce what Petrotrin call "Naphthenic Oil Residue", a marketable product. The wash tanks of kerosene and gas oil continuously discharge several tons of washing water per hour. There is no pit at present.

1. Installation of a chemical waste water pit, one meter wide, two meters long and two meters deep

2. Installation of an automatic starting level-controlling pump
   A pump with automatic starting device will be installed to control the water level in the pit.
   Common specifications for chemical pumps

3. Piping connection to the chemical waste water main

   A pipeline will be laid from the above pump to the above-ground chemical waste water main. Requirements: 4 inches x 300 meters

e) FCC Unit and GC, Alkyalation, Isomer, No. 1 Topping Unit, No. 1 Vacuum Distillation Unit

These units are all very old, and have the following features in common. Oily water streams are separated from the non-oily water streams. However, they are not necessarily separated from the rain water. There is no pit at the outlet of each plant area. Therefore, the oily water streams leave the plant yards without being finally checked at the border pits.

The rain water is not clearly separated by spill walls; rain water enters the oily waste water system.

The gas concentration system (GC) of the FCC unit washes the butane and butylene fractions with caustics. The spent caustic solution is sent to Petreco's unit.

The following modifications will be made.

1. Installation of a waste water pit

   There is no waste water pit now. Three oily water pits will be installed, one each in the FCC/GC area, the Alkylation/Isomer area, and the No. 1 Topping Plant area. The existing underground oily pipelines will be modified to be connected to the new pits.

   Requirements:

   6 inches x 70 meters for the FCC

   6 inches x 50 meters for the GC

   6 inches x 70 meters for the Alkylation/Isomer

   6 inches x 50 meters for No. 1 Topping Unit

2. Installation of automatic starting level-controlling pumps

   Three pumps, one for each group, with automatic starting devices will be installed to control the water levels in the pits.

   Specifications

   Pump for the FCC/GC

   Capacity, kl/hr: 40

Pumping head, Kg-force/cm^2: 7

Motor: 7 kWatts

Pump for the alkylation/isomer unit

Capacity, kl/hr: 10

Pumping head, Kg-force/cm^2: 7

Motor: 5 kWatts

Pump for the No. 1 Topping unit and No. 1 Vacuum distillation unit

Capacity, kl/hr: 30

Pumping head, Kg-force/cm^2: 7

Motor: 10 kWatts

3. Piping connection to the waste water main

   Pipes will be laid from the above pumps to the above-ground waste water main.

   From the FCC/GC: 6 inches x 500 meters

   From the alkylation/isomer: 2 inches x 100 meters

   From the No. 1 Topping/No. 1 Vacuum distillation unit: 4 inches x 100 meters

4. Separation of rain water by the spill wall

   FCC/GC: 150 meters

   Alkylation/isomer: 50 meters

   No. 1 topping unit: 50 meters

5. Modification of the rain water sewage

   Each plant group: 50 meters

6. Replacement of barometric condensers by surface condensers

   The replacement will be done on the No. 1 Vacuum distillation unit. The system of caustic washing in the GC unit will remain.

f) Nos. 1 and 2 Reformers and Unifiners

1. Installation of a common waste water pit for both units

   There is no waste water pit now. The existing sewage system will be modified to be connected with the new pit. The new sewer will be 100 meters long.

2. Installation of an automatic starting level-controlling pump
   Specifications
   Capacity, kl/hr: 20
   Pumping head, Kg-force/cm^2: 7
   Motor: 7 kWatts

3. Piping connection to the waste water main
   A pipe will be laid from the above pump to the 6-inch oily waste pipeline at the boundary of the No. 4 Vacuum distillation unit. Requirement: 4-inch x 150 meters

4. Separation of rain water by the spill wall: 150 meters
   A spill wall is installed to keep rain water out.

5. Modification of the rain water sewage: 50 meters

g) D3 Column

1. Installation of a waste water pit
   There is no waste water pit now. A new waste water pit will be installed and the existing sewage system will be modified to be connected with the new pit. The new sewer will be 30 meters long.

2. Installation of an automatic starting level-controlling pump
   Specifications
   Capacity, kl/hr: 30
   Pumping head, Kg-force/cm^2: 7
   Motor: 10 kWatts

3. Piping connection to the waste water main
   A pipe will be laid from the above pump to the oily waste water main. Requirement: 3-inch x 150 meters

4. Separation of rain water by the spill wall
   An 80 meter spill wall is installed to keep out rain water.

5. Modification of the rain water sewage: 30 meters

h) No. 1 Hydrodesulfurization Unit

1. Installation of a waste water pit

   There is no waste water pit now. A new waste water pit will be installed and existing sewerage system will be modified to be connected with the new pit. The new sewer will be 50 meters long.

2. Installation of an automatic starting level-controlling pump

   Specifications

   Capacity, kl/hr: 20

   Pumping head, Kg-force/cm^2: 7

   Motor: 7 kWatts

3. Piping connection to the waste water main

   A pipe will be laid from the above pump to the oily waste water main. Requirement: 3-inch x 150 meters

4. Separation of rain water by the spill wall

   An 80 meter spill wall will be installed to keep rain water out.

5. Modification of the rain water sewage: 30 meters

i) New Sulfur Recovery Unit

1. Installation of a waste water pit

   A waste water pit will be installed and a sewage system will be installed to be connected with the new pit. The new sewer will be 50 meters long.

2. Installation of an automatic starting level-controlling pump

   Specifications

   Capacity, kl/hr: 10

   Pumping head, Kg-force/cm^2: 7

   Motor: 5 kWatts

3. Piping connection to the waste water main

   A pipe will be laid from the above pump to the oily waste water main. Requirement: 4-inch x 150 meters

4. Separation of rain water by the spill wall
   An 80 meter spill wall will be installed to keep rain water out.

5. Modification of the rain water sewage: 30 meters

j) **New Visbreaker**

1. Installation of a waste water pit
   There is no waste water pit now. A new waste water pit will be installed and the existing sewage system will be modified to be connected with the new pit. The new sewer will be 50 meters long.

2. Installation of an automatic starting level-controlling pump
   Specifications
   Capacity, kl/hr: 10
   Pumping head, Kg-force/cm^2: 7
   Motor: 5 kWatts

3. Piping connection to the waste water main
   A pipe will be laid from the above pump to the oily waste water main. Requirement: 3-inch x 50 meters

4. Separation of rain water by the spill wall
   A 100 meter spill wall will be installed to keep rain water out.

5. Modification of the rain water sewage: 50 meters

k) **No. 2 Hydrodesulfurization Unit**

1. Installation of a waste water pit
   There is no waste water pit now. A new waste water pit will be installed and the existing sewage system will be modified to be connected with the new pit. The new sewer will be 50 meters long.

2. Installation of an automatic starting level-controlling pump
   Specifications
   Capacity, kl/hr: 20
   Pumping head, Kg-force/cm^2: 7

Motor: 7 kWatts

3. Piping connection to the waste water main

   A pipe will be laid from the above pump to the 6-inch oily waste water line at the boundary of the No. 4 Vacuum distillation unit. Requirement: 3-inch x 50 meters

4. Separation of rain water by the spill wall

   A 100 meter spill wall will be installed to keep rain water out.

5. Modification of the rain water sewage: 50 meters

10) Oil Water Separation in the Tank Yard

(a) Basic Concept

The study team has set forth the following basic concept for the separation of oil and water in the tank yards.

1. Grouping

   The tank yards are divided into a number of blocks. The following measures will be taken for each block.

2. Application of closed-bleeding system

   A closed bleeding system will be installed in each block. Those blocks which have already had closed-bleeding systems installed in the upgrading project will use the existing systems.

3. Installation of oily waste water and chemical oily waste water pits

   Each block will have (a) (chemical) oily waste water pit(s). A chemical waste water pit will be installed for the kerosene and gas oil tanks, because the bleed water contains caustic soda. The pits are made of concrete and have steel covers, each measuring one meter wide, two meters long two meters deep.

4. Installation of automatic level-controlling pumps

   Each pit has an automatic starting pump with a level-controlling device.

   Specifications for chemical and non-chemical oily waste water

   Centrifugal pump

Fluid: chemical and non-chemical oily waste water

Capacity, kl/hr: 20

Pumping head, Kg-force/cm^2: 7

Motor: Explosion proof (increased safety type), 440 Volts, 3 phase, 60 Hz, 7 kWatts

Foundation and electric wiring: standard as fits each location

5. Connection with waste water main

   A pipeline will be laid above ground from the discharge of each pump. Pipe size: 3 inches

(b) Modifications of Individual Tank Yard Block

a) Tank Yard-1

Tank members: Nos. 181, 182, 183, 184, total 4

1. Closed bleeding system

   The bleeding valves of the above four tanks will be connected and piped to the oily waste water pit: 3-inch x 300 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump

   Wiring: 50 meters

4. Connection with waste water main

   A pipe will be installed from the discharge of the level-controlling pump to the above-ground oily waste water main: 3 inches x 20 meters.

b) Tank Yard-2

Tank members: Nos. 150, 151, 154, 155, 159, total 5

1. Closed bleeding system

   The bleeding valves of the above five tanks will be connected and piped to the oily waste water pit: 3-inch x 600 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump

Wiring: 150 meters

4. Connection with waste water main

   A pipe will be installed from the discharge of the level-controlling pump to the above-ground oily waste water main: 3 inches x 180 meters.

c) Tank Yard-3

Tank members: Nos. 200, 201, 202, 203, 204, 205, 206, 207, 208 total 9

1. Closed bleeding system

   The closed bleeding system has already been installed.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump

   Wiring: 150 meters

4. Connection with waste water main

   A pipe will be installed from the discharge of the level-controlling pump to the above-ground oily waste water main: 3 inches x 60 meters.

d) Tank Yard-4

Tank members: Nos. 5, 6, 7, total 3

1. Closed bleeding system

   The bleeding valves of the above three tanks will be connected and piped to the oily waste water pit: 3-inch x 220 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump

   Wiring: 150 meters

4. Connection with waste water main

   A pipe will be installed from the discharge of the level-controlling pump to the 6-inch oily waste water pipe at the boundary of the FCC Unit area: 3 inches x 450 meters.

e) Tank Yard-5

Tank members: Nos. 30, 31, 33, 34, 35, 36, 37, S3, total 8

1. Closed bleeding system

   The bleeding valves of the above eight tanks will be connected and piped to the oily waste water pit: 3-inch x 220 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump

   Wiring: 250 meters

4. Connection with waste water main

   A pipe will be installed from the discharge of the level-controlling pump to the 3-inch line installed for Tank Yard-4: 3 inches x 550 meters.

f) Tank Yard-6

Tank members: Nos. 21, 22, 23, 24, 57, 60, total 6

1. Closed bleeding system

   A closed bleeding system has already been installed for four crude oil tanks, excepting Nos. 21 and 22. The bleed water pipe is being extended to No. 118. Therefore, this project will install a closed bleeding system from Tanks Nos. 21 and 22 to the bleeding pipe of Tank No. 23: 3 inches x 120 meters.

g) Tank Yard-7

Tank members: Nos. 27, 28, 29, 52, 54, 55, 56, 90, 91, 92, total 10

1. Closed bleeding system

   A closed bleeding system has already been installed for all tanks, except for No. 55. Therefore, the bleeding valve of Tank No. 55 will be connected with the closed bleeding system: 3 inches x 20 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump

   Wiring: 250 meters

4. Connection with waste water main

   A pipe will be installed from the discharge of the level-controlling pump to the above-ground oily waste water main: 3 inches x 60 meters.

5. Transfer of the middle-layer emulsion

   A pit and a pump will be installed at Tank No. 54 for transporting the emulsion to the waste treatment center.

   Pump

   Fluid: oil

   Capacity, kl/hr: 1

   Pumping head, Kg-force/cm^2: 3

   Motor: 0.75 kWatts

   Wiring: standard

   Piping: 2 inches x 2,200 meters

h) Tank Yard-8

Tank members: Nos. 7, 8, 83, 84, 85, 87, 89, 166, total 8

1. Closed bleeding system

   The closed bleeding system has already been installed for all these eight tanks. The closed bleeding system will be connected to the new oily waste water pit: 3 inches x 20 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump

   Wiring: 200 meters

4. Connection with waste water main

   A pipe will be installed from the discharge of the level-controlling pump to the above-ground oily waste water main: 3 inches x 70 meters.

i) Tank Yard-9

Tank members: Nos. 9, 10, 12, 14, 15, 16, 19, 20, 25, total 9

1. Closed bleeding system

   The closed bleeding system has already been installed for all tanks except for Tanks Nos. 20 and 25. The bleeding valves of Tanks Nos. 20 and 25 will be connected with the bleeding line: 3 inches x 40 meters. The system will be connected with the new pit: 3 inches x 20 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump
   Wiring: 150 meters

4. Connection with waste water main
   A pipe will be installed from the discharge of the level-controlling pump to the above-ground oily waste water main: 3 inches x 30 meters.

j) Tank Yard-10

Tank members: Nos. NP22, NP23, NP24, NP25, total 4

1. Closed bleeding system
   These tanks are all for kerosene. The bleed water contains caustic soda; therefore, the bleed water is treated as chemical oily waste water. The bleeding valves of the above four tanks will be connected and piped to the chemical oily waste water pit: 3 inches x 120 meters.

2. Installation of a chemical oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump
   Wiring: 100 meters

4. Connection with waste water main
   A pipe will be installed from the discharge of the level-controlling pump to the above-ground chemical oily waste water main: 3 inches x 800 meters.

k) Tank Yard-11

Tank members: Nos. 74, 75, 95, 96, 97, 98, 165, total 7

1. Closed bleeding system
   These tanks are for kerosene except for Tank No. 95 which is for gasoline. The bleed water contains caustic soda; therefore, the bleed water is treated as chemical oily waste water. The closed bleeding system has already been installed for these tanks. The closed bleeding line is connected to the new chemical oily waste water

pit: 3 inches x 20 meters.

2. Installation of a chemical oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump
Wiring: 100 meters

4. Connection with waste water main
A pipe will be installed from the discharge of the level-controlling pump to the above-ground chemical oily waste water main: 3 inches x 250 meters.

l) Tank Yard-12

Tank members: Nos. 1, 2, 3, 4, 76, 78, 81, 82, total 8

1. Closed bleeding system
These tanks are for gas oil except for Tanks Nos. 81 and 82. The bleed water contains caustic soda; therefore, the bleed water is treated as chemical oily waste water. The closed bleeding system has already been installed. The system will be connected to the new chemical oily waste water pit: 3-inch x 20 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump
Wiring: 200 meters

4. Connection with waste water main
A pipe will be installed from the discharge of the level-controlling pump to the above-ground chemical oily waste water main: 3 inches x 50 meters.

m) Tank Yard-13

Tank members: Nos. 41, 42, 65, 67, 68, 69, 163, 164, total 8

1. Closed bleeding system
These tanks are for gas oil except for Tank No. 68 which is for heavy fuel oil. The bleed water contains caustic soda; therefore, the bleed water is treated as chemical oily waste water. The bleed valves of these eight tanks will be connected to the new chemical oily waste water pit: 3 inches x 650 meters.

2. Installation of a chemical oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump
   Wiring: 300 meters

4. Connection with waste water main
   A pipe will be installed from the discharge of the level-controlling pump to the 4-inch chemical oily waste water pipe to be installed for the above Tank Yard-11: 4 inches x 180 meters.

n) Tank Yard-14

Tank members: Nos. 70, 72, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, total 15

1. Closed bleeding system
   The bleeding valves of the above 15 tanks will be connected and piped to the oily waste water pit: 3 inches x 650 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump
   Wiring: 100 meters

4. Connection with waste water main
   A pipe will be installed from the discharge of the level-controlling pump to the above-ground oily waste water main: 3 inches x 150 meters.

o) Tank Yard-15

Tank members: Nos. 113, 114, 119, 120, 121, 122, 123, total 7

1. Closed bleeding system
   The bleeding valves of the above seven tanks will be connected and piped to the oily waste water pit: 3 inches x 450 meters.

2. Installation of an oily waste water pit: 1 pit

3. Installation of an automatic level-controlling pump
   Wiring: 150 meters

4. Connection with waste water main

A pipe will be installed from the discharge of the level-controlling pump to the line from PH19 to above-ground oily waste water main: 3 inches x 100 meters.

p) Tank Yard-16

Tank members: the crude oil tanks in the West Crude Tank Area

1. Treatment of bleed water from crude tanks

   The bleed water from all crude tanks, including those in Tank Yard-6, will be collected at Tank No. 118 by the closed system. After crude oil is recovered in Tank No. 118, the oily water will be drained to PH19 from which the water is pumped to the main sump. The transfer line is converted to the oily waste water main.

2. Installation of an oily waste water pit: 1 pit

3. Installation of a pipe from Tank No. 118 to the pit: 6 inches x 30 meters.

4. Installation of an automatic level-controlling pump

   Wiring: 50 meters

5. Connection with waste water main

   A pipe will be installed from the discharge of the level-controlling pump to the above-ground oily waste water main: 4 inches x 350 meters.

21-2-2 Bernstein Main Storage

(1) Overall Design Philosophy for Waste Water Treating System

1) General Strategy

Bernstein Main Storage will play the role of the central tank farm for the onshore oil fields. Therefore, a complete series of waste water treating facilities will be installed here to treat the waste water originating here and also that from Los Bajos Main Storage. The general strategy is explained below.

1. The outlet of the existing API separator will be closed. A pump and a separator will be installed and the water will be sent to the new oil separator.

2. The new oil separator will have some buffer capacity. The waste water from Los Bajos will be mixed with the water originating in Bernstein.

3. The design throughput (cubic meters per hour) is:

Waste water from Bernstein Main Storage:	220
Waste water from Los Bajos Main Storage:	180
Total	400

4. The waste water treating system consists of a CPI, dissolved air flotation with coagulation (DAF) unit, activated carbon adsorption unit. It has been confirmed by a series of experiments done both in Trinidad and Tobago and in Japan that the DAF unit alone is unable to achieve the target 50 ppm owing to the substances dissolved in the waste water. Adsorption by activated carbon is needed to achieve the target level.

5. The separated oil recovered in the API separator, the new oil separator and , the CPI will be collected in a newly installed tank. The middle-layer emulsion will be separated in this tank and sent to the proposed waste treatment center.

6. Facilities to dehydrate and incinerate the scum generated by the DAF unit will be installed. Trinidad Cement Limited (TCL) is now studying the possibility of feeding scum to their kilns. If the study yields an affirmative result, the incinerator could be dispensed with. A waste treatment center is proposed in Bernstein Main Storage. The waste treatment center will have a scum transportation facility, dehydration facility, cake transportation facility, incinerator, and a facility to temporarily store the ashes.

On the basis of the above basic concept, a waste water treating system as shown in Figure 21-6 is proposed.

2) Reliability of the Waste Water Treating System

The waste water treating system will have one train. The principle for maintaining the reliability of operation is the same as that explained for Pointe-a-Pierre Refinery.

(2) Design Conditions of Facilities of Waste Water Treating System

1) Bernstein Main Storage

Figures 21-6 and 21-7 show the schematic flow and plot plan of the facilities of the waste water treating system.

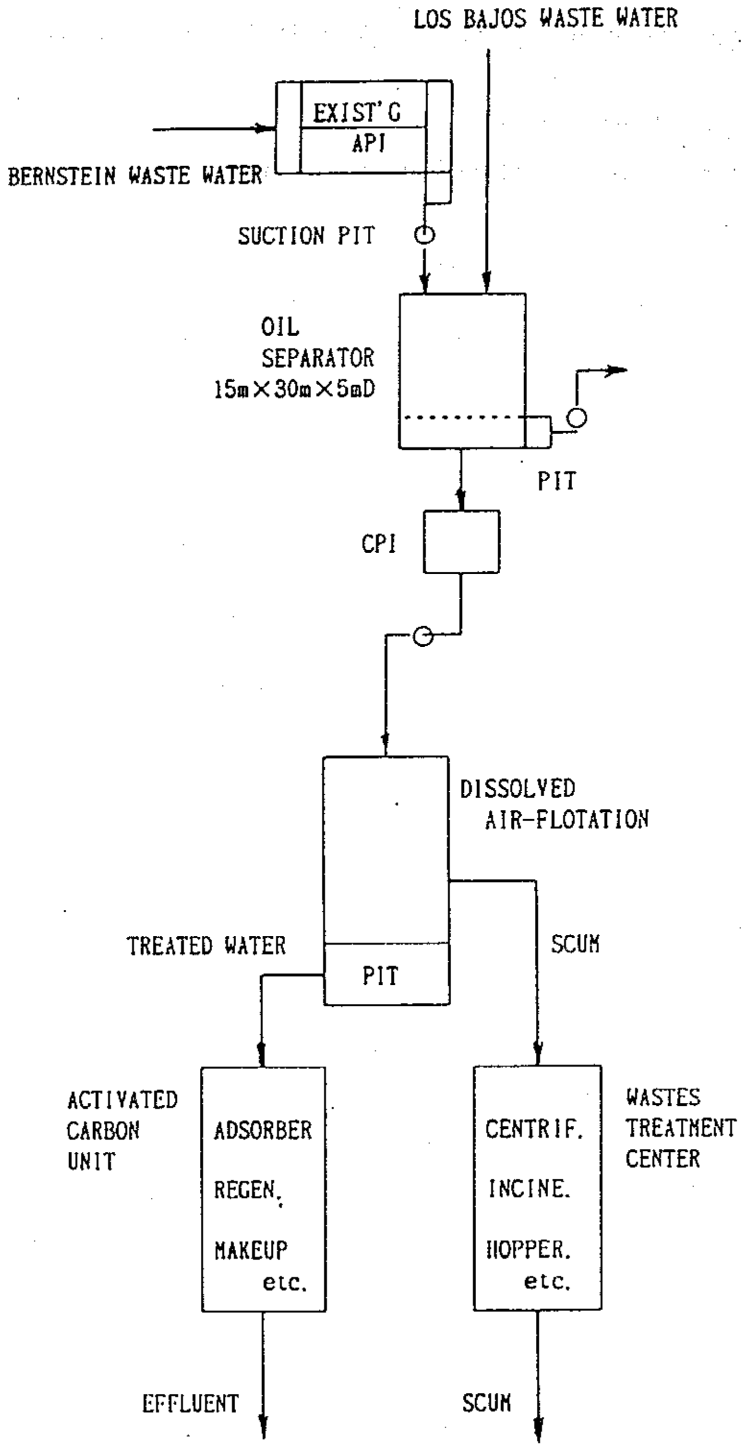


Figure 21-6 New Waste Water Treating System (Bernstein)

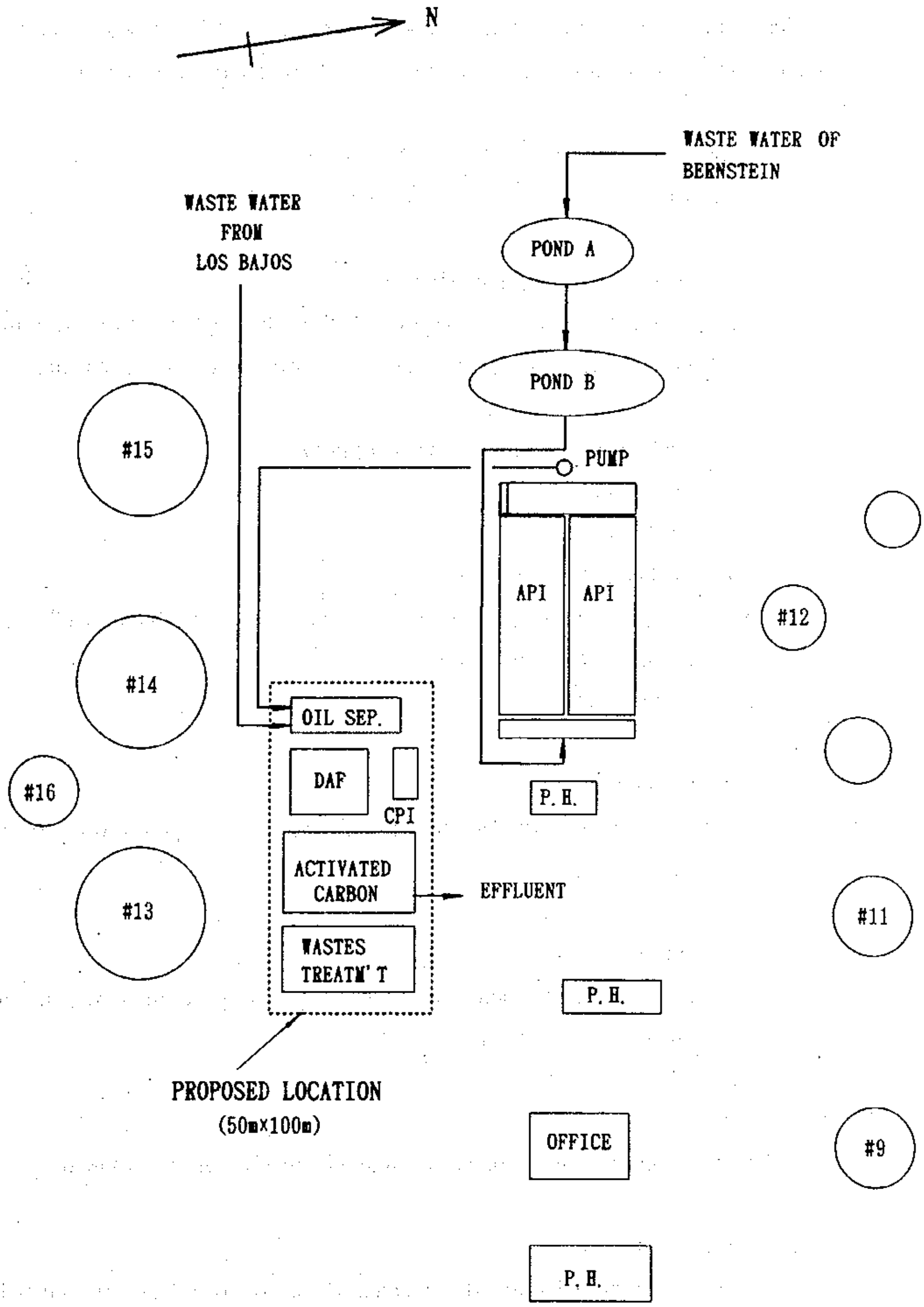


Figure 21-7 Plot Plan of the Waste Water Treating System (Bernstein)

(a) Diversion of the API Separator Outlet Water

The outlet to the Silver Stream River via an earthen pit will be closed. The water will be diverted to a newly installed separator. Figure 21-8 shows the planned separator.

1. Closure of the existing API separator outlet

   The exit will be closed with steel plate and sealed.

2. Installation of a water pump and suction pit

   The existing API outlet will be converted into the suction pit for the automatic level-controlling pump. A device to control the water level will be installed.

   Specifications for the oily waste water pump
   Centrifugal pump
   Capacity, kl/hr: 220
   Pumping head, Kg-force/cm^2: 3
   Motor: Explosion proof (increased safety type), 440 Volts, 3 phase, 60 Hz, 26 kWatts
   Electric work: 300 meter wiring
   Installation: standard

3. Waste water piping

   A pipeline will be installed from the discharge of the pump to the oil separator: 8 inches x 100 meters.

4. Slop oil pipe

   A pipeline will be installed from the API separator pit to the newly installed slop oil tank: 2 inches x 100 meters.

(b) Separator

A semi-underground concrete separator as shown on Figure 21-8 will be installed.

1. Oil separator basin

   Structure: semi-underground, concrete, 15 meters wide and 30 meters long and 5 meters deep, a floating oil skimmer to be installed at the 25 percent level. A pit measuring one meter wide, one meter long and five meters deep will be installed for recovered oil. Water will normally be maintained at the 25 percent level. At this level, the holding time is four hours.

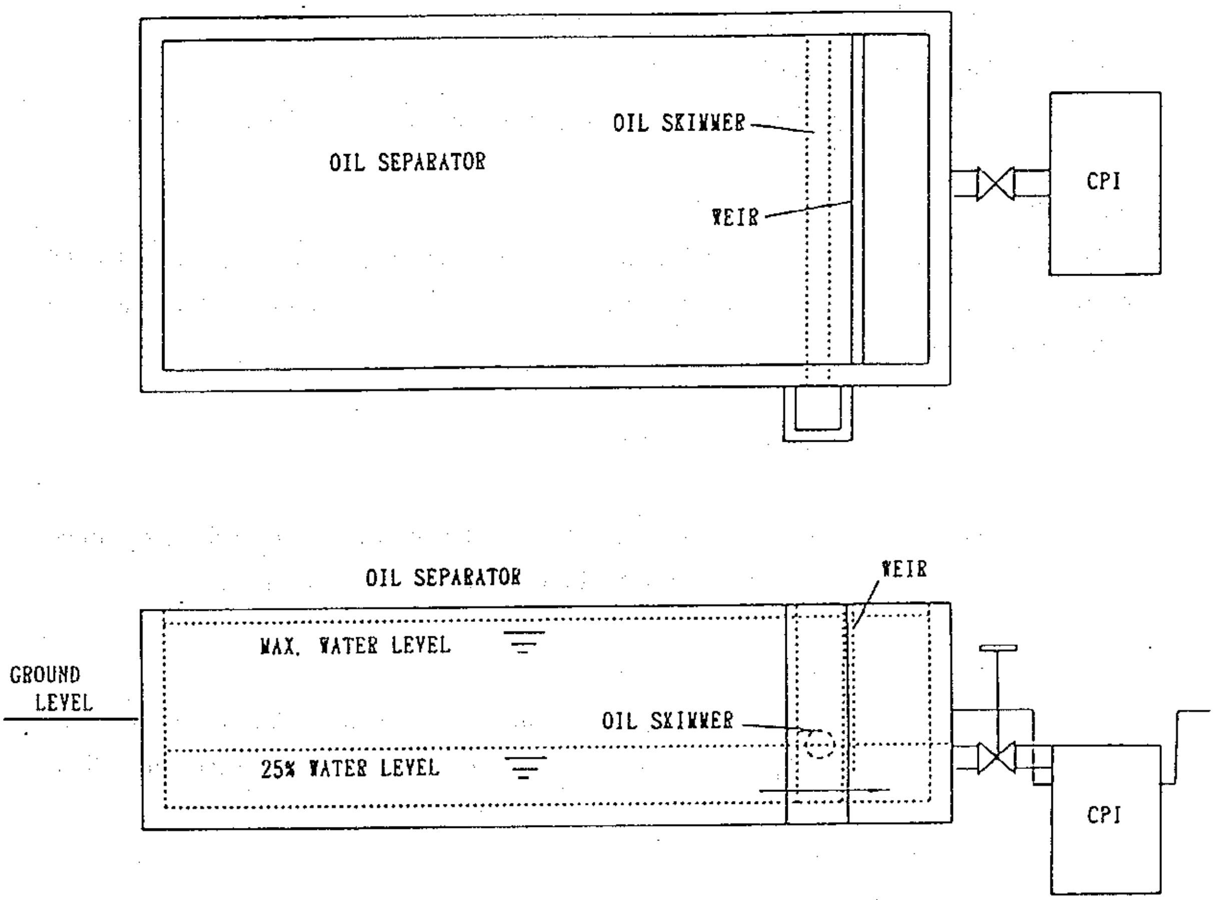


Figure 21-8 Oil Separator

2. Installation of an oil recovery pump
   Centrifugal pump with a device to control the water level
   Capacity, kl/hr: 1
   Pumping head, Kg-force/cm^2: 5
   Motor: Explosion proof (increased safety type), 440 Volts, 3 phase, 60 Hz, 0.75 kWatts
   Electric work: 300 meter wiring
   Installation: standard
   Pipeline from the discharge of the pump to the slop tanks: 2 inches x 50 meters

(c) CPI

A CPI will be installed downstream of the oil separator to eliminate oil particles more than 60 microns in diameter. The oil content is presumed to be 1,500 and 1,000 ppm at the inlet and outlet, respectively.

1. Capacity: 400 cubic meters per hour

2. Location: Semi-underground. The water is fed by gravity. A 16-inch valve will be installed at the outlet of the oil separator to be operated at ground level.

3. Pit for treated water
   A concrete-made steel-covered pit measuring five meters wide, three meters long and three meters deep will be installed. A pump to feed water to the DAF unit will be installed:
   Centrifugal pump
   Capacity, kl/hr: 400
   Pumping head, Kg-force/cm^2: 3
   Motor: Explosion proof (increased safety type), 440 Volts, 3 phase, 60 Hz, 45 kWatts
   Electric work: standard
   Installation: standard

4. Pipe to feed water to the DAF unit, 10 inches x 30 meters

5. Recovered oil
   The recovered oil will be sent to the newly installed slop oil tank by an automatic level-controlling pump.

Pump
Capacity, kl/hr: 0.5
Delivery line: 1 inch x 30 meters

(d) Dissolved Air Flotation (DAF) Unit

The DAF unit removes oil particles by flotation. The DAF unit will use alum and an organic polymer as coagulants. The DAF unit has the following facilities: a tank to dissolve alum, tank to dissolve the polymer, facilities to inject coagulants, pressurized water tank, pressurized water preparation and injection facility, skimmer to collect scum, electric equipment, measuring and controlling facility.

1. Capacity, cubic meters per hour: 450

2. Pit for treated water
A pit measuring 10 meters wide, five meters long and five meters deep will be installed to smooth the flow rate to the DAF unit. The level will normally be maintained at 25 percent of the depth.

3. Pump for charging the filter and activated carbon adsorption unit
A pump will be installed to deliver the waste water from the pit to the filter and activated carbon adsorption unit.
Centrifugal pump: 2
Capacity, kl/hr: 220
Pumping head, Kg-force/cm^2: 2.5
Motor: 440 Volts, 3 phase, 60 Hz, 30 kWatts
Electric work: wiring 130 meters
Installation: standard

4. Charge pipe from the discharge of the pump to the activated carbon adsorption unit:
12 inches x 20 meters

5. Scum pit
A concrete-made steel-covered pit measuring three meters wide, two meters long and three meters deep will be installed to hold the scum.

6. Scum pump

A scum pump will be installed to the waste treatment center.

3-rotored screw pump

Fluid: scum from the DAF unit, specific gravity: 1

Capacity, kl/hr: 35

Motor: 440 Volts, 3 phase, 60 Hz, 1,800 rpm, 45 kWatts

Electric work: wiring 130 meters

Installation: standard

Piping: 8 inches x 30 meters from the discharge of the pump to the waste treatment center

(e) Activated Carbon Adsorption Unit

The activated carbon adsorption unit will have an adsorption unit, regenerator of the activated carbon and associated facilities. The capacity is 400 cubic meters per hour. The effluent water will be discharged to the Silver Stream River.

(f) Slop Tank System

A slop tank will be installed to hold slop oil recovered from the waste water treating system and to separate the middle-layer emulsion to be returned to Wash Tank No. 17. The bottom water will be drained to the API separator.

1. Tank: 1,000 kl, one tank

2. Water pit: one meter wide, two meters long, and two meters deep

3. Waste water pump

Capacity, kl/hr: 10, with automatic level controlling device

Pumping head, Kg-force/cm^2: 2

Motor: Explosion proof (increased safety type), 440 Volts, 2 kWatts, with automatic starting device

Electric work: standard

4. Emulsion pump

Capacity, kl/hr: 20, with automatic level controlling device

Pumping head, Kg-force/cm^2: 4

Motor: Explosion proof (increased safety type), 440 Volts, 4 kWatts, with automatic

starting device
Electric work: standard

5. Piping
   Waste water: 2-inch x 200 meters
   Emulsion: 3-inch x 30 meters

(g) Waste Treatment Center

The waste treatment center will be operational 24 hours a day. The waste treatment center will mainly dehydrate and incinerate the scum from the DAF unit. The waste treatment center will have a dehydrating facility, storage and transportation facility for cake, a 20 kl tank, incinerator, and ash bin.

1. Dehydrator: a vacuum filter
   Feed: scum from the DAF unit with specific gravity at unity,
   Throughput, kl/hour: 35
   Dehydrated scum moisture content: 70 percent
   Filtrate: The filtrate is a water containing oil at more than 50 ppm and suspended solids; therefore, it will not be discharged to the environment, but pumped back to the DAF unit.
   Filtrate pump
   Capacity, kl/hr: 30
   Pumping head, Kg-force/cm^2: 3
   Motor: Explosion proof (increased safety type), 440 Volts, 3 phase, 60 Hz, 7.5 kWatts
   Electric work: wiring 30 meters
   Installation: standard
   Piping: 3 inches x 50 meters from the discharge of the pump to the DAF unit

2. Storage and transportation facility of cake
   Belt conveyer: from the dehydrator to the hopper of the storage facility, 10 meters. The storage facility will have a 10 cubic meter hopper

3. Incinerator
   Feed:
   (1) Cake of the scum from the DAF unit
   Throughput, tons per hour: 2.5

Moisture content, weight percent: 70

Heat of combustion, kcal/kg: 1,200

Components: oil, aluminum hydroxide, aluminum oxide

(2) Emulsion

Throughput, kiloliters per hour: 0.6

Heat of combustion, kcal/kg: 5,800

Components: 65 percent oil and 35 percent water

(3) Miscellaneous wastes

There will be miscellaneous wastes of undetermined quantity but their quantity will ot be large. Fuel oil will be used as auxiliary fuel. A 10 kiloliter tank will be installed.

4. Ash storage and transportation facility

Belt conveyer: 10 meters. A 10 cubic meter hopper will be installed at the top of the storage facility. The ash will be stored and transported to landfill areas.

2) Receipt of Waste Water from Los Bajos Main Storage

(a) Modifications of Los Bajos Main Storage

1. Closure of the water exit to the river and installation of a pit

The present exit will be closed by steel plate and sealed. A concrete-made steel-covered suction pit measuring two meters wide, five meters long and three meters deep will be installed on the opposite side of the present separator.

2. Automatic level controlling and starting pump

Centrifugal

Throughput, kl/hour: 180

Pumping head, Kg-force/cm^2: 15 including the difference in elevation between Los Bajos and Bernstein

Motor: Explosion proof (increased safety type), 2,200 Volts, 3 phase, 60 Hz, 110 kWatts

Electric work: wiring 50 meters

Installation: standard

(b) Waste Water Pipeline from Los Bajos to Bernstein

A pipeline will be laid between the discharge of the above pump and the oil separator of Bernstein on the existing pipe racks, 8 inches x 12 kilometers.

21-3 Specifications of Facilities

Based on the process specifications given in the previous section, this section presents mechanical specifications of the proposed facilities.

21-3-1 Pointe-a-Pierre Refinery

(1) Waste Water Treating System

Table 21-2 summarized the process design specifications of the waste water treating system at Pointe-a-Pierre Refinery.

Table 21-2 Process Design Specifications of the Waste Water Treating System at Pointe-a-Pierre Refinery

Fluid flow rates, m^3/hour	
Total inflow to the buffer tanks	250
Total effluent from the buffer tanks	250
Charge to CPI	250
Charge to DAF	250
Effluent from DAF	250
Inflow to the guard basin	250
Effluent to the Guaracara River	250
Oil and grease content, mg/liter	
Weighted average at the inlet of buffer tanks	3,000
Charge to CPI, ppm	500
Charge to DAF, ppm	400
Effluent from DAF	50 max.
Effluent to the Guaracara River	50 max.
pH value of untreated water, range	7 to 8
pH value of treated water, range	7 to 8

Source: Study team
Note: 1. The amount of oil on the flow rate is negligible.

Four idle tanks will be converted into buffer tanks. These are:

Buffer tanks for waste water

NP No. 19, kiloliters	5,000
NP No. 20, kiloliters	4,150
NP No. 21, kiloliters	4,150

Their combined holding time is about 1.5 days.

Buffer tank for chemical waste water

NP No. 26, kiloliters	3,000

Its holding time is 4.5 days.

The waste water and chemical waste water piping system, with pits, pumps and spill walls, will be installed traversing the refinery. These will follow the specifications given in 21-2, "Basic Concept for the Conceptual Design."

(2) Waste Treatment Center

Table 21-3 summarized process design specifications of the waste treatment center at Pointe-a-Pierre Refinery.

Table 21-3 Process Design Specifications of Waste Treatment Center at Pointe-a-Pierre Refinery

Wet scum from DAF	
Production, kilograms/hour	2,000
Water content, weight percent	91
Middle-layer emulsion	
Production, cubic meters/hour	0.2
Calorific value	5,800
Oil content, volume percent	65
Water content, volume percent	35
Dewatering facility	
Feed	Wet scum from DAF
Dewatered scum	
Water, weight percent	70
Oil, weight percent	16
Aluminum hydroxide, oxide, weight percent	14
Calorific value, kcal/kilogram	1,200

Source: Study team

(3) Instrumentation

The operation and monitoring of the waste water treating system will be done by a Distributed

Control System which is connected by an optical fiber cable via a satellite center to the central control room to be installed as part of the refinery upgrading program.

21-3-2 Bernstein Main Storage

(1) Waste Water Treating System

Table 21-4 summarizes the process design specifications of the waste water treating system at Bernstein Main Storage.

Table 21-4 Process Design Specifications of the Waste Water Treating System at Bernstein Main Storage

Fluid flow rates, m^3/hour	
Waste water from BMS API Separator	220
Waste water transported from Los Bajos Tank Farm	180
Combined waste water	400
Total inflow to the oil separator	400
Total effluent from the oil separator	400
Charge to CPI	400
Charge to DAF	440
Charge to Filter	440
Charge to ACA	400
Effluent to the Silver Stream River	400
Oil and grease content, mg/liter	
Skimmer Pit outlet	3,000
Oil Separator inlet	1,675
Oil Separator outlet	1,500
Charge to DAF, ppm	1,000
Effluent from DAF, inlet to ACA	100
Effluent from ACA	50 max.
Effluent to the Guaracara River	50 max.
pH value of untreated water, range	7 to 8
pH value of treated water, range	7 to 8

Source: Study team
Note: 1. The amount of oil is negligible on the flow rates

A slop tank with a capacity of 1,000 kiloliters will be installed. Its specifications are given in Table 21-14.

(2) Waste Treatment Center

Table 21-5 summarizes process design specifications of the waste treatment center proposed for

Bernstein Main Storage.

Table 21-5 Process Design Specifications of Waste Treatment Center at Bernstein Main Storage

Wet scum from DAF	
Production, kilograms/hour	32,200
Water content, weight percent	97.9
Middle-layer emulsion	
Production, cubic meters/hour	0.5
Calorific value	5,800
Oil content, volume percent	65
Water content, volume percent	35
Dewatering facility	
Feed	Wet scum from DAF
Dewatered scum	
Water, weight percent	70
Oil, weight percent	16
Aluminum hydroxide, oxide, weight percent	14
Calorific value, kcal/kilogram	1,200

Source: Study team

(3) Instrumentation

The instrumentation will be of locally controlling type.

(4) Pipeline from Los Bajos to Bernstein Main Storage

A new pipeline will be installed between Los Bajos Tank Farm and Bernstein Main Storage to transport waste water from the former to the latter. An 8-inch pipeline will be laid along the road over the distance of 12 kilometers. A pump will be installed at Los Bajos Tank Farm.

21-4 Design of Facilities

Based on the process specifications, conceptual designs of the relevant facilities are developed.

21-4-1 Pointe-a-Pierre Refinery

(1) Waste Water Treating System

The waste water treating system consists of a CPI (Corrugated Plates Interceptor), dissolved air flotation unit, guard basin, associated facilities and a Distributed Control System (DCS) for measurement and control.

1) Corrugated Plate Interceptor (CPI)

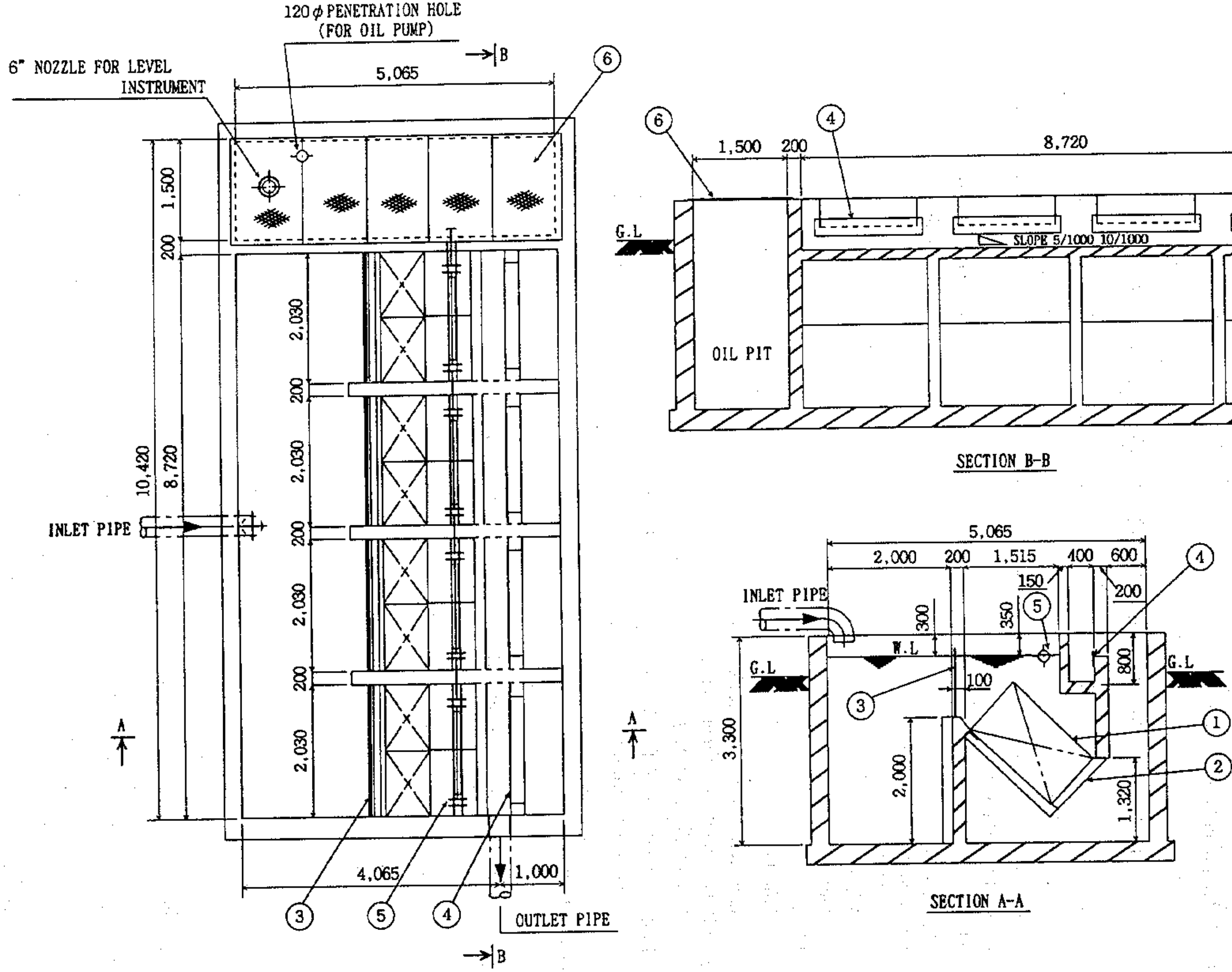
Table 21-6 gives design specifications of the CPI. The CPI unit consists mainly of a water tank, CPI, sludge pit and their accessories.

Table 21-6 Specifications of the CPI for Pointe-a-Pierre Refinery

Unit	Specifications
Capacity, m^3/hour	250
Material	Reinforced concrete
Flow type	Gravity flow
Dimension, millimeters	
Length	11,130
Width	5,660
Depth	3,600
Plate	
Number	8
Effective surface, m^3/pack	43.5
Upflow velocity, millimeters/second (for smallest droplet)	0.2
Pump, Capacity (m^3/hour) x Head (meter) x (kWatt)	
Recovery oil pump	1 x 20 x 0.75

Source: Study team

Figure 21-9 shows the floor plan and cross section of the CPI.



No.	PARTS NAME
1	PLATE PACK
2	PLATE PACK SUPPORT
3	DISTRIBUTION BAFFLE
4	OUTLET WEIR
5	OIL SKIMMER
6	STEEL COVER

Figure 21-9 Floor Plan and Cross Section of CPI

2) Dissolved Air Flotation Unit

Table 21-7 gives design specifications of the DAF unit and its associated facilities. Figures 21-10 and 21-11 shows the flow sheet and cross section of the dissolved air flotation unit.

Table 21-7 Specifications of the Dissolved Air Flotation Unit for Pointe-a-Pierre Refinery

Unit	Specifications
CPI treated water tank:	
Material	Reinforced concrete
Capacity, m^3	150
Dimension, meters	
Length	5
Width	10
Depth	3
Coagulator tanks:	
Material	Fiber-reinforced plastics (FRP)
Alum dissolution tank	
Number	2
Capacity, m^3	2.5
Diameter, meters	1.8
Height, meters	1.0
Polymer dissolution tank	
Number	2
Capacity, m^3	4.0
Diameter, meters	1.8
Height, meters	1.6
Mixing method	Aeration
Main separator	
Capacity, m^3/hour	250
Material	Reinforced concrete
Dimensions, meters (See Figure 21-11)	
A:	8.25
B:	0.75
C:	0.25
D:	0.125
E:	0.08
F:	0.25
H:	1.72
K:	7.65
L:	0.55

Pressurized tank	
Material	Carbon steel
Capacity, m^3	3.3
Dimension, meters	
diameter	1.4
height	2.1
Scum pit	
Capacity, m^3	18
Dimension, meters	
Width	3
Length	2
Depth	3
Guard basin	
Material	Reinforced concrete
Capacity, m^3	400
Dimension, meters	
Width	10
Length	20
Depth	2
Pump, capacity (m^3/hour) x head (meter) x (kWatt)	
Treated water pump	250 x 10 x 5.5
Pressurized tank feed pump	75 x 50 x 30
Transfer pump	250 x 10 x 5.5
Scum pump	2.8 x 10 x 5
Recovery oil pump	1.0 x 20 x 0.75
Alum dissolution pump	0.12 x 5 x 0.40
Alum injection pump	0.12 x 5 x 0.40
Polymer dissolution pump	0.18 x 5 x 0.40
Polymer injection pump	0.18 x 5 x 0.40
Air compressor-1	
Use	Pressurizing
Capacity, liters/minute	400
Discharge pressure, Kg-force/cm^2	8.5
Power, kilowatts	3.7
Air compressor-2	
Use	Aeration for mixing
Capacity, liters/minute	310
Discharge pressure, Kg-force/cm^2	7.0
Power, kilowatt	2.2

Motor, kilowatt	
Rotary bridge motor	0.4
Scraper motor	0.75
Note: The motors are explosion proof (increased safety type).	
Control board	
The control board holds the main switch, switches for the pumps, ammeters, voltmeters, level switches and meters, pressure meters.	

Source: Study team

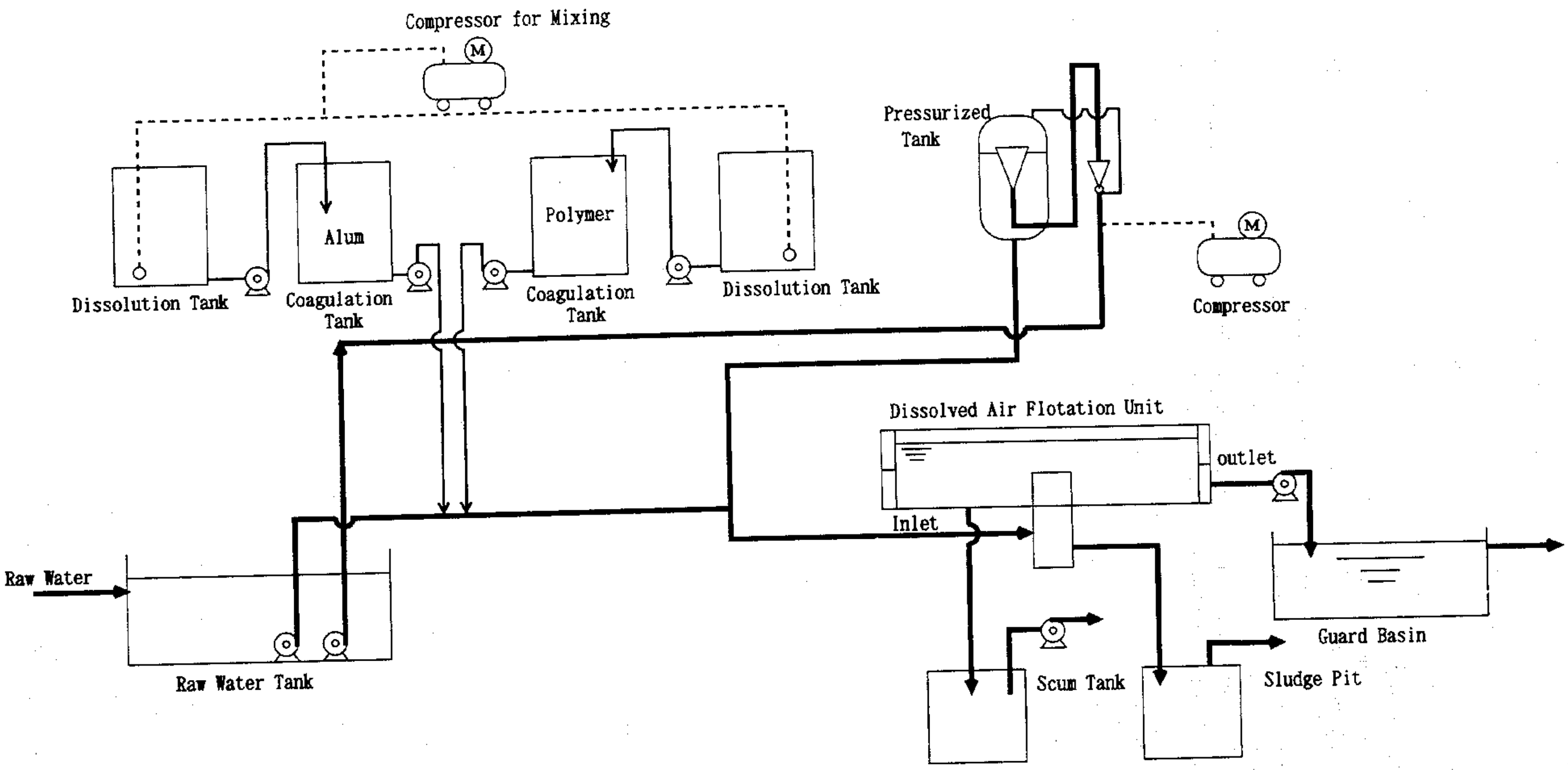
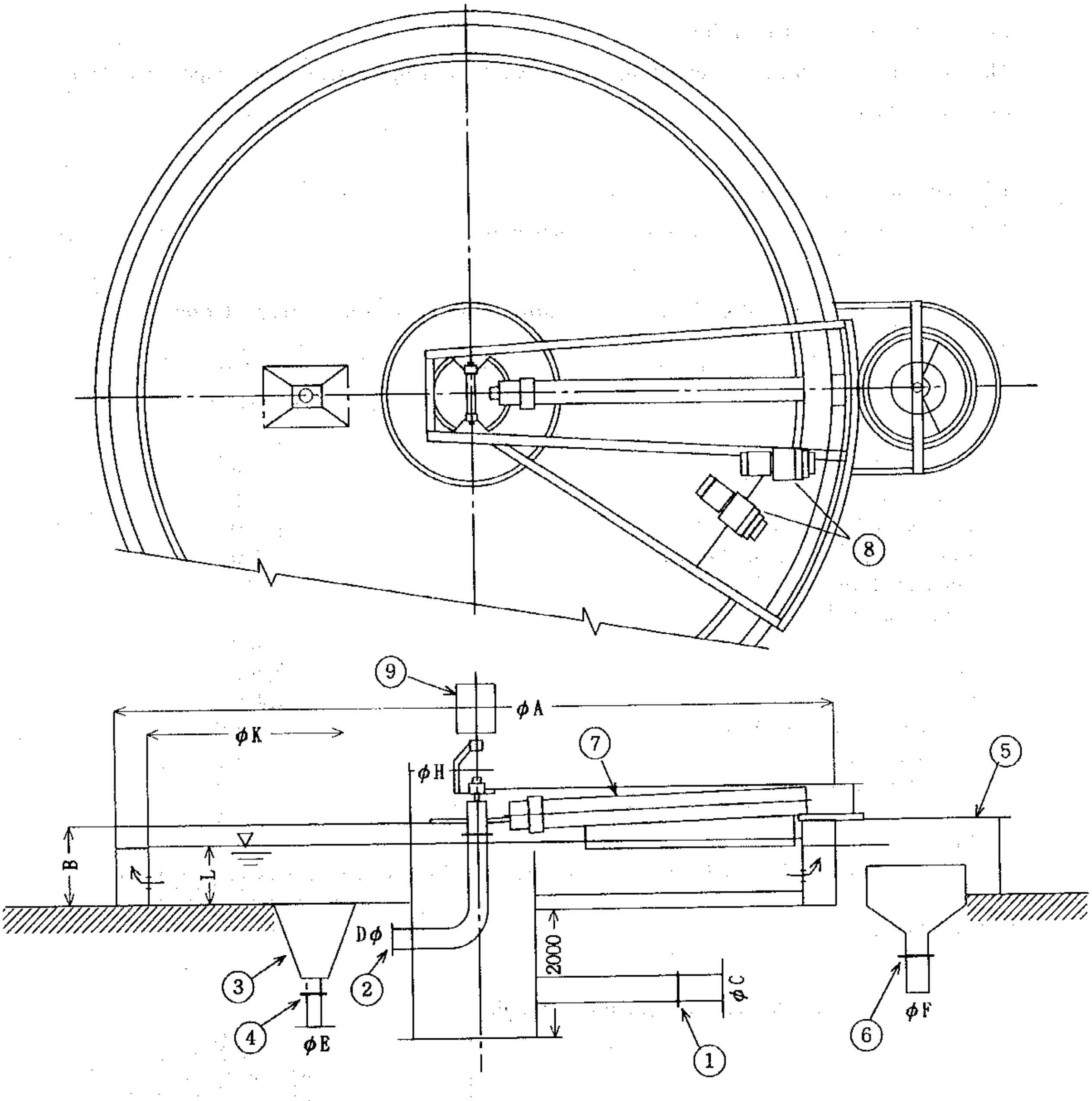


Figure 21-10 Flow Sheet of the Dissolved Air Flotation Unit



1. RAW WATER INLET
2. FLOATED OUTLET
3. SETTLED SLUDGE SUMP
4. SETTLED SLUDGE OUTLET
5. OVERFLOW TANK
   (LEVEL CONTROL EQUIPMENT)
6. TREATED WATER OUTLET
7. SPIRAL SCOOP
8. GEAR MOTOR
9. ROTARY CONTACT

Figure 21-11 Cross Section of the Dissolved Air Flotation Unit

(2) Waste Treatment Facilities

The waste treatment facilities consist mainly of a vacuum filter, incinerator, ash hopper and their associated facilities.

1) Vacuum Filter

Table 21-8 gives design specifications of the vacuum filter.

Table 21-8 Specifications of the Vacuum Filter for Pointe-a-Pierre Refinery

Unit	Specifications
Capacity, m^3/hour	3.2
Filtering surface area, m^2	6
Diameter of drum, millimeters	1,250
Effective drum width, millimeters	1,500
Number of filter chambers	12
Dimension, millimeters	
A:	2,900
B:	2,400
C:	1,800
Drum driving motor, kWatt	1.9
Vacuum pump, kWatt	11
Filtrate pump, kWatt	3.7
Sump supply pump, kWatt	1.5
Control board	
The control board holds the main switch, switches of motors, volt meters, ampere meters.	

Source: Study team

Figure 21-12 shows the cross section of the vacuum filter.

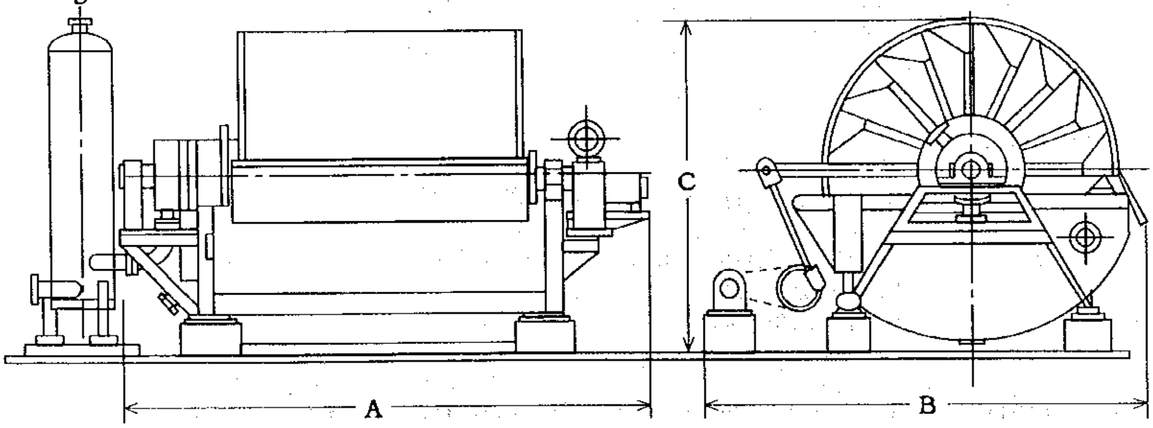


Figure 21-12 Cross Section of the Vacuum Filter

2) Incinerator

The incinerator consists mainly of a rotary kiln, burner, VA fan, conveyors, fuel tank, scum feed screw, and discharge screw and minor facilities. Table 21-9 gives design specifications of the incinerator.

Table 21-9 Specifications of the Incinerator for Pointe-a-Pierre Refinery

Unit Specifications	
Dimension of the unit, millimeters	
A:	15,000
B:	12,000
Width	1,800
Rotary furnace	
Dimension, millimeters	
Diameter	2,000
Length	5,500
Capacity, m^3	17.27
Driving motor, kWatt	2.2
Burner, liter/hour x kWatt	50 x 0.75
VA fan, m^3/hour x kWatt	160 x 3.7
Ejector fan, kWatt	15
Automatic ash screw, kWatt	0.4
Fuel consumption, liters/hour	
Minimum	70
Maximum	230
Treating capacity	
Scum, kg/hour	700
Emulsion, kg/hour	200
Site area, millimeters	4,500 x 17,000
Control board:	
The control board holds the main switch, ammeters, voltmeters, thermometers. The control mode is either automatic or manual.	

Source: Study team

Figure 21-13 shows the cross section of the incinerator.

	A × B × C (mm)
Bernstein Main Storage	20,500 × 17,000 × 3,400
Pointe-a-Pierre Refinery	15,000 × 12,000 × 2,000

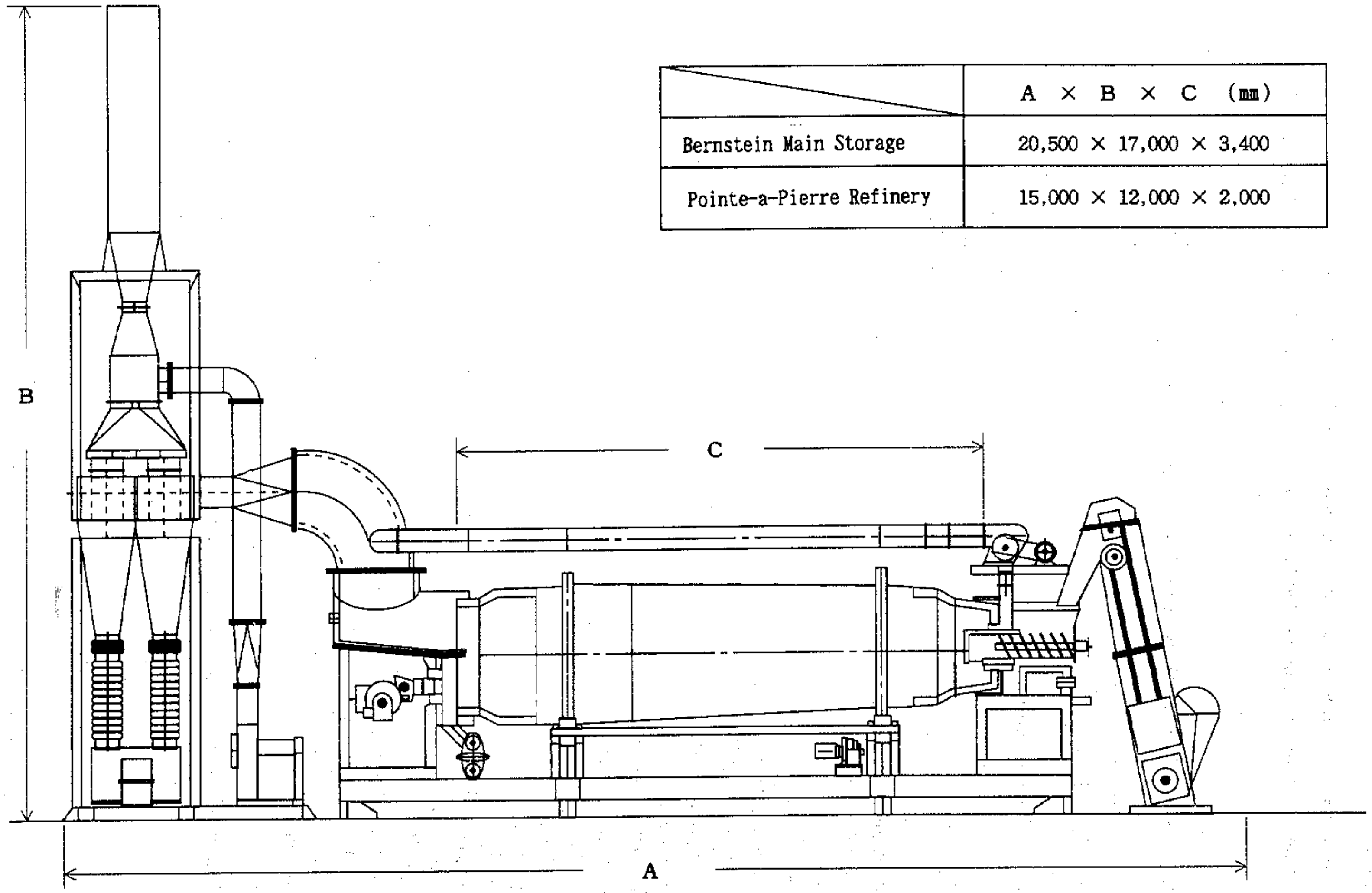


Figure 21-13 Cross Section of the Incinerator

(3) Instrumentation

The waste water treating system will be monitored and controlled by the DCS system to be installed at Pointe-a-Pierre Refinery. A satellite center will be installed close to the waste water treating system, with an optical cable connecting the satellite center to the central control room.

(4) Plot Plan

Figure 21-14 shows the plot plan of the proposed waste water treating system in Pointe-a-Pierre Refinery.

(5) Waste Water Gathering System

Table 21-10 summarized the facilities of the waste water gathering system.

21-4-2 Bernstein Main Storage

(1) Waste Water Treating Facilities

The proposed waste water treating system for Bernstein Main Storage consists of an oil separator, a CPI, a dissolved air flotation unit, pressure filters, an activated carbon adsorption unit, a backwash water tank, a treated water tank and their associated facilities.

1) Corrugated Plate Interceptor (CPI)

Table 21-11 gives the design specifications of the CPI. The components of the CPI are basically the same as the CPI for Pointe-a-Pierre Refinery.

Table 21-10 Facilities of Waste Water Gathering System for Pointe-a-Pierre Refinery

	Capacity kl/hr	Head Kg/cm^2	Motor kWatts
Buffer tanks, Guard basins			
Oil recovery pump from the buffer tanks	10	7	7
GB recovery pump	1	2	0.75
Automatic level-controlling pumps in the process area			
No. 3 Vacuum Unit	30	7	10
Dewaxing Unit	10	7	5
No. 8 Topping Unit	40	7	13
No. 8 Topping Unit for chemical waste water	5	7	3.5
No. 4 Vacuum Unit	50	7	16
Gas Oil and Kerosene Treating Unit for chemical waste water	5	7	3.5
Pump for FCC/GC	40	7	13
Pump for Alkylation Unit/Isomer	10	7	5
Pump for No. 1 TP/No. 1 VD	30	7	10
No. 1 and No. 2 Reformers and Unifiners	20	7	7
D3 Column	30	7	10
No. 1 HTU	20	7	7
New Sulfur Recovery Unit	10	7	7
New Visbreaker	10	7	5
No. 2 HTU	20	7	7
Automatic level controlling pumps in the tank yards			
15 pumps for Tank Yards-1 to 16	20	7	7
Tank Yard-7, pump for No. 54 Tank	1	3	0.75
Spill walls, total length, meters			1,660

Pipes	Size inch	Length meter
	1.5	80
	2	3,080
	3	12,300
	4	1,890
	6	1,040
	8	20
	10	4,700
	14	110

Source: Study team

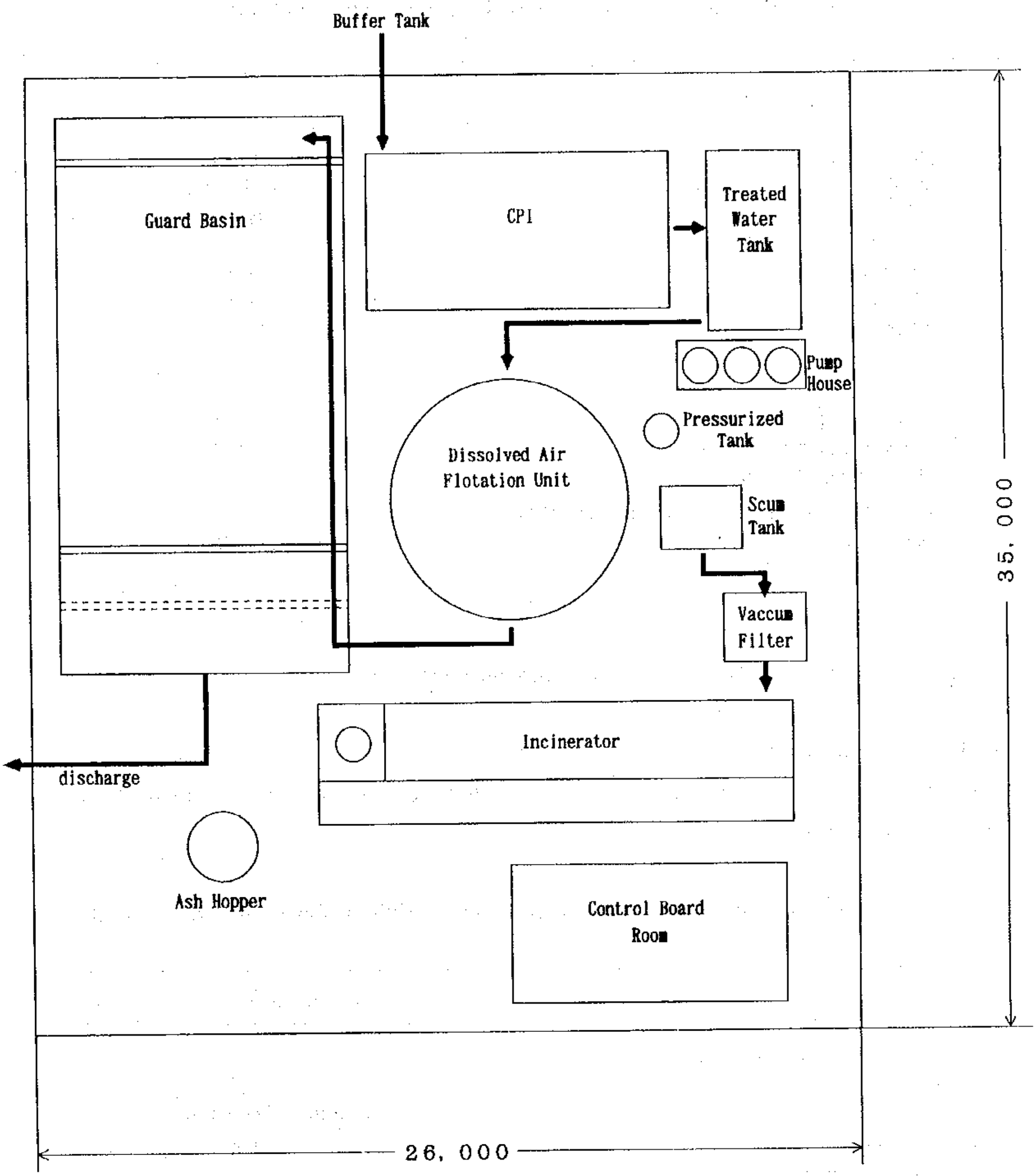


Figure 21-14 Plot Plan of the Waste Water Treating System (Pointe-a-Pierre Refinery)

Table 21-11 Specifications of the CPI for Bernstein Main Storage

Unit	Specifications
Capacity, m^3/hour	400
Material	Reinforced concrete
Flow type	gravity flow
Dimension, millimeters	
Length	16,300
Width	5,660
Depth	3,600
Plate	
Number	13
Effective surface, m^3/pack	43.5
Upflow velocity, millimeters/second (for smallest droplet)	0.2
Pump, capacity (m^3/hour) x head (meter) x (kWatt)	
Recovery oil pump	0.5 x 20 x 0.75

Source: Study team

The plot plan and cross section of the CPI are shown on Figure 21-9.

2) Dissolved Air Flotation Unit

Table 21-12 gives the design specifications of the dissolved air flotation unit proposed for Bernstein Main Storage.

Table 21-12 Specifications of the Dissolved Air Flotation Unit for Bernstein Main Storage

Unit	Specifications
CPI and DAF treated water tanks:	
Number	2
Material	Reinforced concrete
Capacity, m^3	100
Dimension, meters	
Length	5.7
Width	5.7
Depth	3.0

Coagulator tanks:	
Material	Fiber-reinforced plastics (FRP)
Alum dissolution tank	
Number	2
Capacity, m^3	11
Diameter, meters	2.9
Height, meters	1.6
Polymer dissolution tank	
Number	2
Capacity, m^3	9.0
Diameter, meters	2.7
Height, meters	1.6
Mixing method	Aeration
Main separator	
Number	1
Capacity, m^3/hour	440
Material	Reinforced concrete
Dimensions, meters (See Figure 21-11)	
A:	10.65
B:	0.90
C:	0.35
D:	0.15
E:	0.08
F:	0.30
H:	2.80
K:	9.80
L:	0.70
Pressurized tank	
Material	Carbon steel
Capacity, m^3	4.03
Dimension, meters	
diameter	1.4
height	2.7
Scum pit	
Capacity, m^3	18
Dimension, meters	
Width	3
Length	2
Depth	3

Pump, capacity (m^3/hour) x head (meter) x (kWatt)	
Treated water pump	440 x 25 x 30
Pressurized tank feed pump	120 x 50 x 30
Scum pump	35 x 10 x 7.5
Alum dissolution pump	0.48 x 5 x 0.75
Alum injection pump	0.48 x 5 x 0.75
Polymer dissolution pump	0.30 x 5 x 0.75
Polymer injection pump	0.30 x 5 x 0.75
Air compressor-1	
Use	Pressurizing
Capacity, liters/minute	850
Discharge pressure, Kg-force/cm^2	7.0
Power, kilowatts	7.5
Air compressor-2	
Use	Aeration for mixing
Capacity, liters/minute	400
Discharge pressure, Kg-force/cm^2	7.0
Power, kilowatt	3.7
Motor, kilowatt	
Rotary bridge motor	0.75
Scraper motor	1.00
Note: The motors are explosion proof (increased safety type).	
Control board	
The control board holds the main switch, switches for the pumps, ammeters, voltmeters, level switches and meters, pressure meters.	

Source: Study team

3) Activated Carbon Adsorption Unit

Table 21-13 gives the design specifications of the activated carbon adsorption unit

Table 21-13 Specifications of the Activated Carbon Adsorption Unit for Bernstein Main Storage

Unit	Specifications
Train	2
Pressure filter	
Number	2 (one for spare)
Capacity, m^3/hour	200

Flow linear velocity, meters/hour	13.2
Dimension, millimeters	
Diameter	4,600
Length	3,000
Filter surface, m^2	16.61
Backwash blower	
Number	2 (one for spare)
Capacity (m^3/hour) x head (meter) x (kWatt)	1,020 x 5 x 22
Backwash pump	
Number	2 (one for spare)
Capacity (m^3/hour) x head (meter) x (kWatt)	600 x 15 x 45
Backwash tank	
Material	Reinforced concrete
Capacity, m^3	300
Dimension, millimeters	
Width	7,700
Length	7,700
Depth	5,000
Transfer pump of backwash waste water	
Number	2 (one for spare)
Capacity (m^3/hour) x head (meter) x (kWatt)	20 x 10 x 15
Filter pump	
Capacity (m^3/hour) x head (meter) x (kWatt)	220 x 25 x 30
Activated carbon adsorption unit	
Number	2
Material	Carbon steel
Capacity, m^3/hour	220
Number of trays	5
Dimension, millimeters	
Diameter	3,600
Height	10,000
Linear velocity, meters/hour	21.6
Activated carbon regeneration furnace	
Capacity, kilograms-AC/day	2,500
Regeneration system	Batch system, fluid type
Fuel	Diesel fuel

Treated water tank	
Material	Reinforced concrete
Capacity, m^3	150
Dimension, millimeters	
Width	7,000
Length	7,000
Depth	3,000

Control board

This unit has three control boards: a low-voltage power board, control board and magnetic board. The control boards hold the main switch, switches for the motors, ammeters, voltmeters, pressure meters, level switches, and thermometers, site stands.

Source: Study team

Figure 21-15 shows the cross section of the activated carbon adsorption unit.

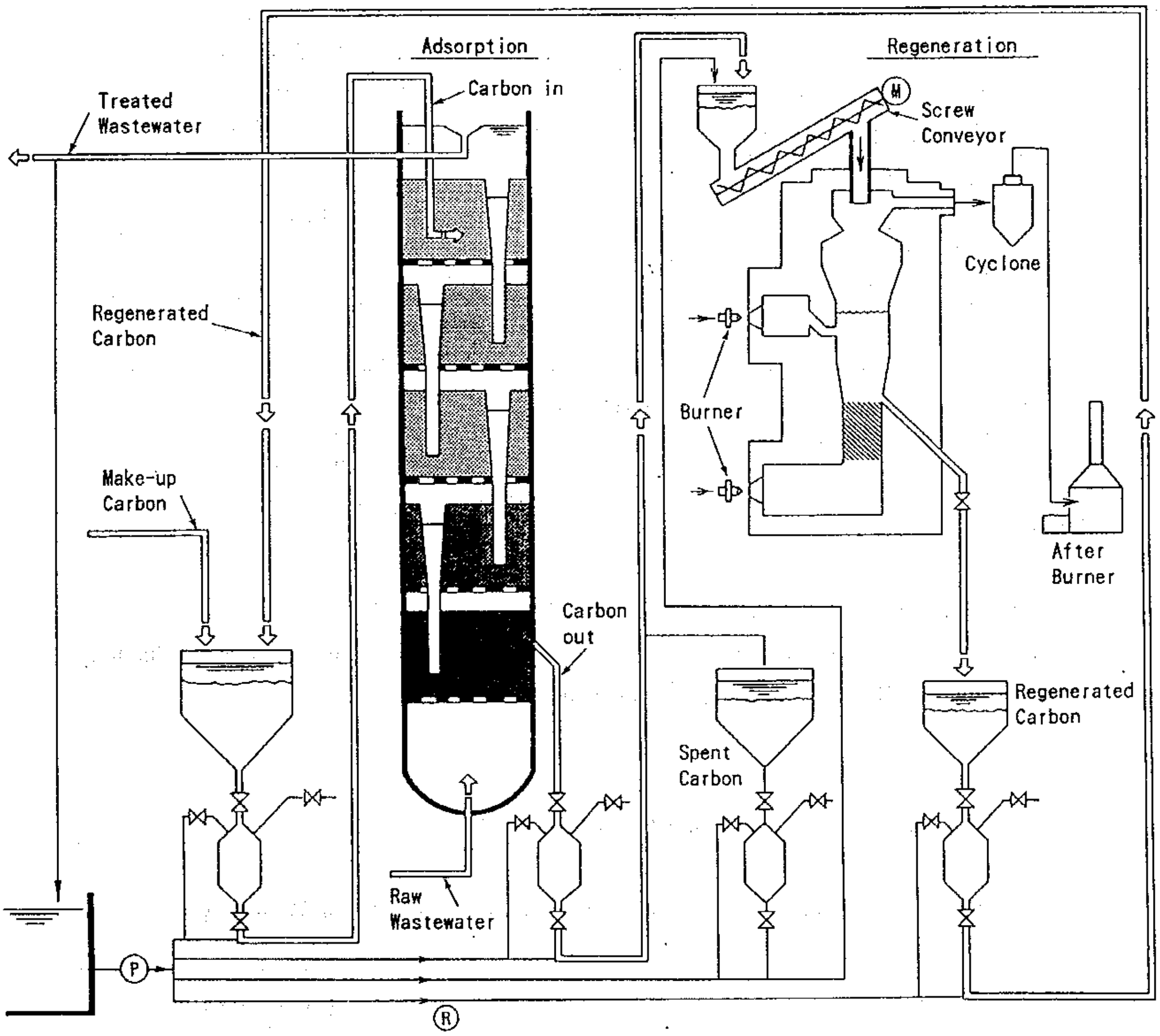


Figure 21-15 Cross Section of the Activated Carbon Adsorption Unit

4) Slop Tank System

Table 21-14 shows the specifications of the slop tank.

Table 21-14 Specifications of the Slop Oil System for Bernstein Main Storage

Facility	Specifications
Slop tank capacity, m^3	1,000
Water pit	
Material	Carbon steel
Dimension, meters	
Width	1
length	2
Depth	2
Pump, Capacity (m^3/hour) x head (meter) x (kWatt)	
Waste water pump	10 x 2 x 2
Emulsion pump	20 x 4 x 4

Source: Study team

(2) Waste Treatment Facilities

The proposed waste treatment center has essentially the same configuration as that for Pointe-a-Pierre Refinery. The capacity is however much larger.

1) Vacuum Filter

Table 21-15 gives the design specifications of the vacuum filter.

Table 21-15 Specifications of the Vacuum Filter for Bernstein Main Storage

Unit	Specifications
Capacity, m^3/hour	35
Filtering surface area, m^2	60
Diameter of drum, millimeters	3,140
Effective drum width, millimeters	6,000
Number of filter chambers	24
Dimension, millimeters	
A:	8,500
B:	4,450
C:	3,800

Drum driving motor, kWatt	12.5
Vacuum pump, kWatt	50
Number	2
Filtrate pump, kWatt	7.5
Sump supply pump, kWatt	2.5
Control board	
The control board holds the main switch, switches of motors, voltmeters, ammeters.	

Source: Study team

Figure 21-12 should be referred to for cross section of the vacuum filter.

2) Incinerator

Table 21-16 gives the design specifications of the incinerator.

Table 21-16 Specifications of the Incinerator for Bernstein Main Storage

Unit	Specifications
Dimension of the unit, millimeters	
A: 20,500	
B: 17,000	
Width	3,400
Rotary furnace	
Dimension, millimeters	
Diameter	2,600
Length	10,000
Capacity, m^3	53.07
Driving motor, kWatt	3.7
Burner, liters/hour x kWatt	350 x 7.5
VA fan, m^3/hour x kWatt	580 x 7.5
Ejector fan, kWatt	55
Automatic ash screw, kWatt	0.75
Fuel consumption, liters/hour	
Minimum	150
Maximum	700
Treating capacity	
Scum, kg/hour	2,500
Emulsion, kg/hour	600
Site area, millimeters	5,500 x 22,500
Control board:	
The control board holds the main switch, ammeters, voltmeters, thermometers. The control mode is either automatic or manual.	

Source: Study team

Reference should be made to Figure 21-13 for cross section of the incinerator.

(3) Plot Plan

Figure 21-16 shows the plot plan of the waste water treating facilities and waste treatment center proposed for Bernstein Main Storage.

(4) Offsite Facilities

A waste water transfer pump of 180 m^3/hour and the driving motor and associated facilities are installed at Los Bajos Main Storage. An 8-inch pipeline 12 kilometers long will be installed between Los Bajos Main Storage and Bernstein Main Storage. Table 21-17 gives specifications of the facilities for transportation.

Table 21-17 Facilities for Transporting Waste Water from Los Bajos Tank Farm to Bernstein Main Storage

Automatic level-controlling pump	
Capacity, kiloliters/hour	180
Pumping head, Kg-force/cm^2	15
Motor, kWatt	110
Pipe	
Size, inch	8
Length, kilometer	12

Source: Study team

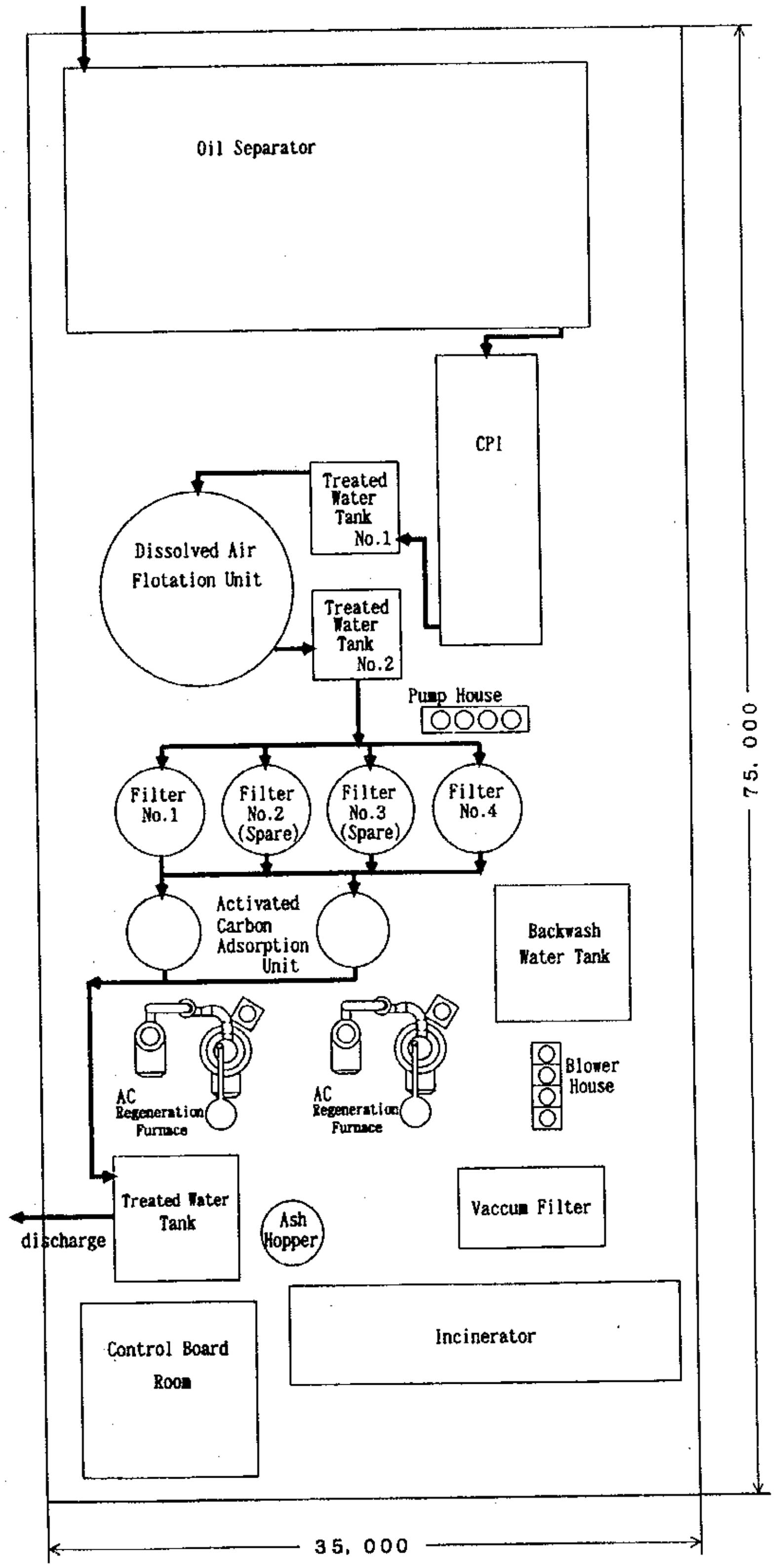


Figure 21-16 Plot Plan for Waste Water Treating Facilities and Waste Treatment Center for Bernstein Main Storage

Chapter 22 Costs

Chapter 22 Costs

22-1 Basis of Cost Estimation

This chapter develops investment costs and operation costs of the proposed facilities based on the design specifications presented in Chapter 21. The costs were estimated according to the following principle.

1. The costs are all Trinidad and Tobago costs, estimated based on the information on the local costs collected during the field survey and also on the information provided by Petrotrin after the third field survey. Although the consultants are based in Japan, the Japanese costs, which are higher than the Trinidad and Tobago costs in almost all cost items, are used only for references.

2. The year for the cost estimation is 1994.

3. The conversion rate to U.S. Dollars is 5.4 TT Dollars/U.S. Dollar.

4. Each plant cost is the installed cost including the import duty and value-added tax.

5. Estimation of the cost is based on the conceptual design of Chapter 21.

22-2 Investment Cost

Tables 22-1 and 22-2 give estimated installed costs of the proposed facilities and modifications in Pointe-a-Pierre Refinery and Bernstein Main Storage, respectively.

Table 22-1 Installed Cost of Facilities and Modifications at Pointe-a-Pierre Refinery

(Unit: thousand U.S Dollars)

	Civil Works	Equip-ment	Instal-lation	Total
CPI	45	5	13	63
DAF	120	260	50	430
Guard basin	30	5	10	45
Vacuum filter	20	221	5	246
Incinerator	100	409	172	681
Surface condensers	178	384	142	704
Tanks	40.	17	6	63
Pipes	43	284	35	362
Pumps	28	181	19	228
Pits, ditches, spill walls	19	19	7	45
DCS	98	344	68	510
Total	721	2,129	527	3,377

Source: Study team

Table 22-2 Installed Cost of Facilities and Modifications at Bernstein Main Storage

(Unit: thousand U.S Dollars)

	Civil Works	Equip-ment	Instal-lation	Total
Oil separator	316	4	18	338
CPI	73	5	16	94
DAF	150	325	63	538
ACA unit	680	10,531	732	11,943
Vacuum filter	30	832	5	867
Incinerator	150	1,230	212	1,592
Pipes	40	307	25	372
Pumps, pits	12	86	8	106
Slop tank	120	300	30	450
Total	1,571	13,620	1,109	16,300

Source: Study team

22-3 Operation Costs

The operation cost consists of variable operation cost and fixed operation cost; the former is considered to vary in proportion to the throughput while the latter is independent of the throughput. The variable costs are expressed in terms of U.S. Dollars per cubic meter of waste water treated.

The fixed operation cost normally includes maintenance cost, insurance cost, fixed assets tax, and labor and salary.

22-3-1 Pointe-a-Pierre Refinery

(1) Variable Operation Costs

The dissolved air flotation unit, vacuum filter, incinerator, and waste water gathering pipeline system have variable operation cost items.

1) Dissolved Air Flotation Unit

Table 22-3 shows the variable operation cost of the dissolved air flotation unit.

Table 22-3 Variable Operation Cost of the Dissolved Air Flotation Unit for Pointe-a-Pierre Refinery

(Unit: US Dollars/cubic meter of waste water)

Consumption		Unit cost	Cost
Capacity, 250 m^3/hour			
Elect. power	0.233 kWh/m^3	0.030 /kWh	0.007
Aluminum sulfate, liquid, g/m^3	1,400	0.06 /kg	0.084
Polymer flocculant, grams/m^3	2	3.0 /kg	0.006
Total			0.097

Source: Study team

2) Vacuum Filter

Table 22-4 shows the variable operation cost of the vacuum filter.

Table 22-4 Variable Operation Cost of the Vacuum Filter for Pointe-a-Pierre Refinery

(Unit: US Dollars/cubic meter of waste water)

Consumption		Unit cost	Cost
Elect. power	0.056 kWh/m^3	0.030	0.002

Source: Study team

3) Incinerator

Table 22-5 shows the variable operation cost of the incinerator.

Table 22-5 Variable Operation Cost of the Incinerator for Pointe-a-Pierre Refinery

(Unit: US Dollars/kilograms of waste)

Consumption		Unit cost	Cost
Capacity, Cake 600 kg/hour Emulsion 200 kg/hour Elect. power	0.027 kWh/m^3	0.030 /kWh	0.0008
Diesel oil	0.07 lit/kg	0.10 /lit	0.007
Total			0.0078
Total per cubic meter of waste water			0.025

Source: Study team

4) Pipeline System for Gathering Waste Water

Table 22-6 shows the variable operation cost of the pipeline system for gathering waste water.

Table 22-6 Variable Operation Cost of the Waste Water Gathering Pipeline System for Pointe-a-Pierre Refinery

(Unit: US Dollars/cubic meter of waste water)

Consumption		Unit cost	Cost
Elect. power,	0.471 kWh/m^3	0.030 /kWh	0.014

Source: Study team

5) **Total Variable Operation Cost**

Table 22-7 gives the total variable operation cost for Pointe-a-Pierre Refinery.

Table 22-7 Total Variable Operation Cost for Pointe-a-Pierre Refinery

(Unit: US Dollars/cubic meter of waste water)

Dissolved air flotation unit	0.097
Vacuum filter	0.002
Incinerator	0.025
Waste water gathering pipeline system	0.014
Total	0.138
Total, thousand U.S. Dollars/year	302

Source: Study team

(2) Fixed Operation Costs

In calculating the fixed operation cost, the combined costs of maintenance, insurance and fixed assets tax are assumed to be five percent of the initial plant cost. The labor and salary cost is calculated by the number of persons assigned times TT Dollars 4,500/month/head. Ten persons are assigned to form shifts of two persons each to attend to the entire system.

1) **Corrugated Plate Interceptor (CPI)**

Table 22-8 gives the fixed operation cost of CPI for Pointe-a-Pierre Refinery.

Table 22-8 Fixed Operation Cost of CPI for Pointe-a-Pierre Refinery

(Unit: thousand US Dollars per year)

Capacity (m^3/hour)	Maintenance Insurance Tax	Labor and Salary	Total
250	3.2	N.A.	3.2

Source: Study team
Note: N.A. stands for "Not applicable."

2) **Dissolved Air Flotation Unit**

Table 22-9 gives the fixed operation cost of the dissolved air flotation unit including the guard basin.

Table 22-9 Fixed Operation Cost of Dissolved Air Flotation Unit for Pointe-a-Pierre Refinery

(Unit: thousand US Dollars per year)

	Capacity (m^3/hour)	Maintenance Insurance Tax	Labor and Salary	Total
	250	23.75	N.A.	23.75
Guard basin	200 m^3			

Source: Study team

3) Vacuum Filter

Table 22-10 gives the fixed operation cost of the vacuum filter for Pointe-a-Pierre Refinery.

Table 22-10 Fixed Operation Cost of Vacuum Filter for Pointe-a-Pierre Refinery

(Unit: thousand US Dollars per year)

Capacity (m^3/day)	Maintenance Insurance Tax	Labor and Salary	Total
76.8 Scum	12.3	N.A.	12.3

Source: Study team

4) Incinerator

Table 22-11 gives the fixed operation cost of the incinerator for Pointe-a-Pierre Refinery.

Table 22-11 Fixed Operation Cost of the Incinerator for Pointe-a-Pierre Refinery

(Unit: thousand US Dollars per year)

Capacity (kg/hour)	Maintenance Insurance Tax	Labor and Salary	Total
600 Cake 200 Emulsion	34.05	N.A.	34.05

Source: Study team

5) Waste Water Gathering Pipeline System

Table 22-12 gives the fixed operation cost of the pipeline system for gathering waste water for Pointe-a-Pierre Refinery. This includes fixed operation costs associated with the surface condensers.

Table 22-12 Fixed Operation Cost of Waste Water Gathering Pipeline System for Pointe-a-Pierre Refinery

(Unit: thousand US Dollars per year)

	Maintenance Insurance Tax	Labor and Salary	Total
	70.10	N.A.	70.10

Source: Study team

6) Distributed Control System (DCS)

Table 22-13 gives the fixed operation cost for the distributed control system.

Table 22-13 Fixed Operation Cost of DCS for Pointe-a-Pierre Refinery

(Unit: thousand US Dollars per year)

	Maintenance Insurance Tax	Labor and Salary	Total
	25.50	N.A.	25.50

Source: Study team

7) Total Fixed Operation Cost

Table 22-14 gives the total fixed operation cost for the facilities and modifications proposed for Pointe-a-Pierre Refinery.

Table 22-14 Total Fixed Operation Cost for Pointe-a-Pierre Refinery

(Unit: thousand US Dollars per year)

	Maintenance Insurance Tax	Labor and Salary	Total
CPI	3.2	N.A.	3.2
DAF unit	23.75	N.A.	23.75
Vacuum filter	12.3	N.A.	12.3
Incinerator	34.05	N.A.	34.05
Gathering system, pumps, surface condenser, pits	70.10	N.A.	70.10
DCS	25.50	N.A.	25.50
Total	169	100	269

Source: Study team

22-3-2 Bernstein Main Storage

(1) Variable Operation Costs

The dissolved air flotation unit, activated carbon adsorption unit, vacuum filter, incinerator, and pipeline system have variable operation cost items.

1) Dissolved Air Flotation Unit

Table 22-15 shows the variable operation cost of the dissolved air flotation unit.

Table 22-15 Variable Operation Cost of the Dissolved Air Flotation Unit for Bernstein Main Storage

(Unit: US Dollars/cubic meter of waste water)

Consumption		Unit cost	Cost
Capacity, 440 m^3/hour			
Elect. power	0.151 kWh/m^3	0.030 /kWh	0.005
Aluminum sulfate, liquid, g/m^3	3,500	0.06 /kg	0.210
Polymer flocculant, grams/m^3	4	3.0 /kg	0.012
Total			0.227

Source: Study team

2) Activated Carbon Adsorption Unit

Table 22-16 shows the variable operation cost of the activated carbon adsorption unit.

Table 22-16 Variable Operation Cost of the Activated Carbon Adsorption Unit for Bernstein Main Storage

(Unit: US Dollars/cubic meter of waste water)

Consumption		Unit cost	Cost
Elect. power, kWh/m^3	0.2708	0.030 /kWh	0.008
Ind. water, m^3/m^3	0.021	0.084 /m^3	0.002
Comp. air, Nm^3/m^3	0.006	-	-
Nitrogen, Nm^3/m^3	0.005	1.28 /m^3	0.006
HCl, 35% liq., kg/m^3	0.001	0.114 /kg	0.0001
NaOH, 25% liq., kg/m^3	0.002	0.285 /kg	0.0006
Activated carbon, kg/m^3	0.042	2.86 /kg	0.120
Diesel fuel, liter/m^3	0.573	0.10 /liter	0.057
Total			0.194

Source: Study team

3) Vacuum Filter

Table 22-17 gives the variable operation cost of the vacuum filter.

Table 22-17 Variable Operation Cost of the Vacuum Filter for Bernstein Main Storage

(Unit: US Dollars/cubic meter of waste water)

Consumption		Unit cost	Cost
Elect. power,	0.306 kWh/m^3	0.030	0.009

Source: Study team

4) Incinerator

Table 22-18 shows the variable operation cost of the incinerator.

Table 22-18 Variable Operation Cost of the Incinerator for Bernstein Main Storage

(Unit: US Dollars/kilograms of waste)

Consumption		Unit cost	Cost
Capacity, Cake 2,300 kg/hour Emulsion 500 kg/hour Elect. power,	0.026 kWh/m^3	0.030 /kWh	0.0008
Diesel oil	0.048 lit/kg	0.10 /lit	0.0048
Total			0.0056
Total per cubic meter of waste water			0.039

Source: Study team

5) Pipeline System for Gathering Waste Water

Table 22-19 shows the variable operation cost of the pipeline system for gathering waste water.

Table 22-19 Variable Operation Cost of the Waste Water Gathering Pipeline System for Bernstein Main Storage

(Unit: US Dollars/cubic meter of waste water)

Consumption		Unit cost	Cost
Elect. power,	0.774 kWh/m^3	0.030 /kWh	0.023

Source: Study team

6) Total Variable Operation Cost

Table 22-20 gives the total variable operation cost for Bernstein Main Storage.

Table 22-20 Total Variable Operation Cost for Bernstein Main Storage

(Unit: US Dollars/cubic meter of waste water)

Dissolved air flotation unit	0.227
Activated carbon adsorption unit	0.194
Vacuum filter	0.009
Incinerator	0.039
Waste water gathering pipeline system	0.023
Total	0.492
Total, thousand U.S. Dollars/year	1,724

Source: Study team

(2) Fixed Operation Costs

In calculating the fixed operation cost, the combined cost of the maintenance, insurance and fixed assets tax is assumed to be five percent of the initial plant cost. The labor and salary cost is calculated by the number of persons assigned times TT Dollars 4,500/month/head. Ten persons are assigned to form a shift of two persons to attend to the entire system.

1) Corrugated Plate Interceptor (CPI)

Table 22-21 gives the fixed operation cost of CPI for Bernstein Main Storage including the oil separator.

Table 22-21 Fixed Operation Cost of CPI for Bernstein Main Storage

(Unit: thousand US Dollars per year)

Capacity (m^3/hour)	Maintenance Insurance Tax	Labor and Salary	Total
400 2,250 m^3 oil separator	21.60	N.A.	21.60

Source: Study team

2) Dissolved Air Flotation Unit

Table 22-22 gives the fixed operation cost of dissolved air flotation unit.

Table 22-22 Fixed Operation Cost of Dissolved Air Flotation Unit for Bernstein Main Storage

(Unit: thousand US Dollars per year)

Capacity (m^3/hour)	Maintenance Insurance Tax	Labor and Salary	Total
440	26.90	N.A.	26.90

Source: Study team

3) Activated Carbon Adsorption Unit

Table 22-23 gives the fixed operation cost of the activated carbon adsorption unit.

Table 22-23 Fixed Operation Cost of Activated Carbon Adsorption Unit for Bernstein Main Storage

(Unit: thousand US Dollars per year)

Capacity (m^3/hour)	Maintenance Insurance Tax	Labor and Salary	Total
400	597.15	N.A.	597.15

Source: Study team

4) Vacuum Filter

Table 22-24 gives the fixed operation cost of the vacuum filter for Bernstein Main Storage.

Table 22-24 Fixed Operation Cost of Vacuum Filter for Bernstein Main Storage

(Unit: thousand US Dollars per year)

Capacity (m^3/day)	Maintenance Insurance Tax	Labor and Salary	Total
1,246 Scum	43.35	N.A.	43.35

Source: Study team

5) Incinerator

Table 22-25 gives the fixed operation cost of the incinerator for Bernstein Main Storage.

Table 22-25 Fixed Operation Cost of the Incinerator for Bernstein Main Storage

(Unit: thousand US Dollars per year)

Capacity (kg/hour)	Maintenance Insurance Tax	Labor and Salary	Total
2,300 Scum 500 Emulsion	79.6	N.A.	79.6

Source: Study team

6) Pipes, Pumps, Pits, and Slop Tank

Table 22-26 gives the fixed operation cost of pipes, pumps, pits and slop tank.

Table 22-26 Fixed Operation Cost of Pipes, Pumps, Pits, and Slop Tank for Bernstein Main Storage

(Unit: thousand US Dollars per year)

	Maintenance Insurance Tax	Labor and Salary	Total
	46.40	N.A.	46.40

Source: Study team

7) Total Fixed Operation Cost

Table 22-27 gives the total fixed operation cost for the facilities and modifications proposed for Bernstein Main Storage.

Table 22-27 Total Fixed Operation Cost for Bernstein Main Storage

(Unit: thousand US Dollars per year)

	Maintenance Insurance Tax	Labor and Salary	Total
CPI	21.60	N.A.	21.60
DAF unit	26.90	N.A.	26.90
ACA unit	597.15	N.A.	597.15
Vacuum filter	43.35	N.A.	43.35
Incinerator	79.6	N.A.	79.6
Pipes, pumps, pits slop tank	46.40	N.A.	46.40
Total	815	100	915

Source: Study team

22-4 Miscellaneous Costs

An expansion in facility and operation always incurs unaccounted-for costs. These are increases in telephone calls, clerical work, managerial work, labor cost in other departments or sections, social insurances, stationery consumption, etc. These are collectively called "overhead." As is customary with expansions of process plants, incremental overhead cost is assumed to be 50 percent of the labor and salary cost. This incremental cost is reflected in the economic evaluation of this project.

22-5 Consultancy Fee for Basic Design and Contractors Selection

Before the government of Trinidad and Tobago enters into contract for engineering and construction of the waste water treating systems and waste disposal centers, the government may need to retain consultants to assist in basic design, preparation of BID documents, tendering, negotiations with candidate contractors and selection of the successful contractors. The consultancy fee varies very widely depending upon how much of the work the government can do for itself, and whether the design and construction work will be done on a lump-sum contract or a cost-reimbursable one. The study team estimates the consultancy fee at 350 thousand U.S. Dollars 1994 price on the assumption that the government will do a minimum of technical work and that the design and construction will be done on a lump-sum contract. The estimated consultancy fee does not include supervision on the design and construction works.

Chapter 23 Evaluation

Chapter 23 Evaluation

This chapter evaluates the proposed program for achieving the 50 ppm target in terms of economic benefits and costs.

23-1 Basis Premises

The following premises, on which the counterpart and the study team agreed and recorded in the Progress Report for the third field survey, are used for evaluation of the program.

1.	Project year	20
2.	Social discount rate, percent/year	10
3.	Fund source, percent loan	100
4.	Interest rate, percent/year	5.0
5.	Repayment of loan, percent of principal/year	10
6.	Construction period, year	1
7.	Operation period, year	19
8.	Shadow price factor	not used

23-2 Total Capital Requirements

23-2-1 Installed Plant Costs

Chapter 22 presented the following costs:

	Thousand U.S. Dollars
Pointe-a-Pierre Refinery	3,377
Bernstein Main Storage	16,300
Total installed cost	19,677

23-2-2 Calculation of Total Capital Requirements

Table 23-1 shows the total capital requirements for the proposed programs for Pointe-a-Pierre Refinery and Bernstein Main Storage.

Table 23-1 Total Capital Requirements

(Unit: thousand U.S. Dollars)

1. Plant cost

	Plant cost	IDC	Pre-operation cost	Total capital req'ment
Pointe-a-Pierre Refinery	3,377	84	10	3,471
Bernstein Main Storage	16,300	408	10	16,718
Total	19,677	492	20	20,189

Note: 1. IDC stands for interest during construction. IDC's are 0.5 years' interests on the loan for the plant costs plus calculated
2. Pre-operation costs are assumed to be 10 percent of annual salary and labor.

2. Consultancy fee

	Consul-tancy fee	IDC	Pre-operation cost	Total capital req'ment
Pointe-a-Pierre Refinery	60	4.5	N.A.	64
Bernstein Main Storage	290	22	N.A.	312
Total	350	26	N.A.	376

1. The consultancy fee is prorated to Pointe-a-Pierre Refinery and Bernstein Main Storage according to the plant costs.
2. IDC's are 1.5 years' interest.

3. Total cost

	Plant cost	IDC	Pre-operation cost	Total capital req'ment
Pointe-a-Pierre Refinery	3,437	88	10	3,535
Bernstein Main Storage	16,590	430	10	17,030
Total	20,027	518	20	20,565

23-3 Working Capital

It is assumed that spareparts equivalent to one percent of the installed plant cost and 25 percent of the annual requirements of consumables except for diesel fuel will be purchased before startup.

Table 23-2 calculates investments in working capital.

Table 23-2 Working Capital

(Unit: thousand U.S. Dollars)

Pointe-a-Pierre Refinery	
Spareparts	35
Consumables	
Aluminum sulfate	46
Polymer flocculant	3
Total	94
Bernstein Main Storage	
Spareparts	170
Consumables	
Aluminum sulfate	198
Polymer flocculant	11
Nitrogen	5
HCl	Negligible
NaOH	1
Activated carbon	105
Total	490
Total	584

23-4 Economic Costs

23-4-1 Initial Economic Costs

Chapter 22 estimated the plant costs. The total capital requirement and working capital are calculated as shown above. These costs are not economic costs but financial costs; the former and the latter are rigorously distinguished in the economic evaluation of investment programs. Usually, financial costs are calculated first and economic costs are calculated by deducting transfer cost items from the financial costs. Cost represents in monetary terms the amounts of material or human resources consumed. The transfer cost items are paid but not for consumption of resources, but are transferred from the investment program to other sectors within the country. In the case of this study, the taxes and duties fall into the transfer cost item which will be transferred from the petroleum sector to the government sector.

The equipment costs shown in Tables 22-1 and 22-2 include about 15 percent duty and 15 percent the value-added tax (VAT); therefore, the economic costs of equipment are estimated by removing them, or dividing the financial equipment costs by 1.30. Likewise, the costs of civil works and installation include 15 percent VAT; therefore, their economic costs are estimated by removing them, or by dividing their financial costs by 1.15. The economic cost of the consultancy fee is assumed to be equal to its financial cost. Items constituting working capital are imported goods, therefore, their economic value is assumed to be equal to the above working capital divided by 1.3. Table 23-3 summarizes initial economic cost items.

Table 23-3 Economic Costs of the Program

(Unit: thousand U.S. Dollars)

Installed cost	
Pointe-a-Pierre Refinery	2,723
Bernstein Main Storage	12,807
Total	15,530
Consultancy fee	
Pointe-a-Pierre Refinery	60
Bernstein Main Storage	290
Total	350
IDC	
Plant cost	
Pointe-a-Pierre Refinery	68
Bernstein Main Storage	320
Total	388
Consultancy fee	
Pointe-a-Pierre Refinery	4
Bernstein Main Storage	22
Total	26
Pre-operation cost	
Pointe-a-Pierre Refinery	10
Bernstein Main Storage	10
Total	20

Working capital	
Pointe-a-Pierre Refinery	72
Bernstein Main Storage	377
Total	449

Source: Study team

23-4-2 Economic Operation Costs

The economic operation costs are estimated by removing the transfer cost items from the financial operation costs. Table 23-4 summarizes economic operation costs.

Table 23-4 Economic Operation Costs

(Unit: thousand U.S. Dollars per year)

Pointe-a-Pierre Refinery	
Variable operation cost	263
Fixed operation cost	230
Total operation cost	493
Bernstein Main Storage	
Variable operation cost	1,499
Fixed operation cost	727
Total operation cost	2,226
Total	
Variable operation cost	1,762
Total fixed cost	957
Total	2,719

Source: Study team

Note: 1. Economic variable operation costs are obtained by dividing the financial variable operation costs by 1.15.

2. Economic fixed operation costs are obtained by dividing the financial MIT cost by 1.3 plus financial labor and salary cost.

23-5 Economic Burden of the Program

Tables 23-5, 23-6 and 23-7 calculate the economic burden of the program for Pointe-a-Pierre

Refinery, Bernstein Main Storage, and both combined, respectively, according to the basic given at the beginning of this chapter. Tables 23-8, 23-9 and 23-10 show the same obtained by the method universally employed by the multi-national oil companies, so-called Major Oil Companies of the U.S. and U.K.

Annual compensation the nation has to pay for the installation and operation of the proposed program on the premises of 23-1 are 818, 3,567 and 4,385 thousand U.S. Dollars per year for Pointe-a-Pierre Refinery, Bernstein Main Storage, and both combined, respectively. At throughputs of 60,000, 30,000 and 60,000 bpcd, the costs are calculated by Tables 23-5, 23-6 and 23-7 to be 0.04, 0.33 and 0.20 U.S. Dollars per barrel. On the other hand, Tables 23-8, 23-9 and 23-10 give 0.04, 0.35, and 0.22 U.S. Dollars per barrel for the corresponding throughputs.

Both methods give similar results. The method employed by Tables 23-5, 23-6 and 23-7 calculates compensations that give 10 percent discounted rates of return on zero equity, against interests, repayments, variable and fixed operation costs. Since the method employed by Tables 23-8, 23-9, and 23-10 are common in the international petroleum industry the results obtained by this method is used for evaluation.

23-6 Evaluation of the Economic Burden

Against the seriousness of the petroleum pollution and urgency of measures to meet the 50 ppm target, the cost of 4,769 thousand dollars per year, or 0.22 U.S. Dollars per barrel of crude oil, is justifiable for the following reasons.

23-6-1 Significance of the Economic Burden

The annual economic burden of the waste water treatment, 4,769 thousand U.S. Dollars, represents the following numbers in terms of the economic indicators of Trinidad and Tobago.

0.13 percent of GDP; GDP is about 20,000 million TT dollars.

0.54 percent of the petroleum sector's contribution to GDP; the petroleum sector accounts for 25 percent of GDP.

0.45 percent of the government revenue; the government revenue is about 6,000 million TT dollars.

4.00 U.S. Dollars per capita per year; the population is 1.24 million. It is also 0.13 percent of GDP per capita, 3,043 U.S. Dollars.

Table 23-5 Economic Cost of Waste Water Treatment, Pointe-a-Pierre Refinery

Unit: 1,000 US Dollars

Economic Analysis, Pointe-a-Pierre Refinery																					
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Plant Cost		2,723																			
Pre-operation Cost		10																			
Interest during Const.		68																			
Consultancy Fee	60																				
Interest on Cons. Fee	2	3																			
Repayment Statement																					
Outstanding Debt		2,866	2,579	2,293	2,006	1,719	1,433	1,146	860	573	287	0	0	0	0	0	0	0	0	0	0
Repayment		0	287	287	287	287	287	287	287	287	287	287	0	0	0	0	0	0	0	0	0
Interest Payment		0	143	129	115	100	86	72	57	43	29	14	0	0	0	0	0	0	0	0	0
Working Capital		72																			-72
Operation Cost																					
Variable Cost			263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263
Fixed Cost			230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230
Overhead			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Compensation			818	818	818	818	818	818	818	818	818	818	818	818	818	818	818	818	818	818	818
Cash Flow			-155	-141	-126	-112	-98	-83	-69	-55	-40	-26	275	275	275	275	275	275	275	275	347
NPV at 10 percent		-1																			
Throughput, BPSD		60,000																			
Cost, US$/Bbl		0.04																			

Table 23-6 Economic Cost of Waste Water Treatment, Bernsetin Main Storage

Pollution Prevention and Control within the Petroleum Sector in the Republic of Trinidad and Tobago

Unit: 1,000 US Dollars

Economic Analysis, Bernstein Main Storage, Base Case																					
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Plant Cost		12,807																			
Pre-operation Cost		10																			
Interest during Const.		320																			
Consultancy Fee	290																				
Interest on Cons. Fee	7	15																			
Repayment Statement																					
Outstanding Debt		13,449	12,104	10,759	9,415	8,070	6,725	5,380	4,035	2,690	1,345	0	0	0	0	0	0	0	0	0	0
Repayment		0	1,345	1,345	1,345	1,345	1,345	1,345	1,345	1,345	1,345	1,345	0	0	0	0	0	0	0	0	0
Interest Payment		0	672	605	538	471	403	336	269	202	134	67	0	0	0	0	0	0	0	0	0
Working Capital		377																			-377
Operation Cost																					
Variable Cost			1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499
Fixed Cost			727	727	727	727	727	727	727	727	727	727	727	727	727	727	727	727	727	727	727
Overhead			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Compensation			3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567	3,567
Cash Flow			-726	-659	-592	-525	-457	-390	-323	-256	-188	-121	1,291	1,291	1,291	1,291	1,291	1,291	1,291	1,291	1,668
NPV at 10 percent		4																			
Throughput, BPSD		30,000																			
Cost, US$/Bbl		0.33																			

Table 23-7 Economic Cost of Waste Water Treatment, Combined

Pollution Prevention and Control within the Petroleum Sector in the Republic of Trinidad and Tobago

Economic Analysis, Pointe-a-Pierre Refinery

Unit: 1,000 US Dollars

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Plant Cost		15,530																			
Pre-operation Cost		20																			
Interest during Const.		388																			
Consultancy Fee	350																				
Interest on Cons. Fee	9	18																			
Repayment Statement																					
Outstanding Debt		16,315	14,683	13,052	11,420	9,789	8,157	6,526	4,894	3,263	1,631	0	0	0	0	0	0	0	0	0	0
Repayment		0	1,631	1,631	1,631	1,631	1,631	1,631	1,631	1,631	1,631	1,631	0	0	0	0	0	0	0	0	0
Interest Payment		0	816	734	653	571	489	408	326	245	163	82	0	0	0	0	0	0	0	0	0
Working Capital		449																			-449
Operation Cost																					
Variable Cost			1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762
Fixed Cost			957	957	957	957	957	957	957	957	957	957	957	957	957	957	957	957	957	957	957
Overhead			100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Compensation			4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385	4,385
Cash Flow			-881	-800	-718	-637	-555	-473	-392	-310	-229	-147	1,566	1,566	1,566	1,566	1,566	1,566	1,566	1,566	2,015
NPV at 10 percent		3																			
Throughput, BPSD		60,000																			
Cost, US$/Bbl		0.20																			

Table 23-8 Economic Cost of Waste Water Treatment, Pointe-a-Pierre Refinery, Alternative Method

Pollution Prevention and Control within the Petroleum Sector in the Republic of Trinidad and Tobago

Unit: 1,000 US Dollars

Economic Analysis, Pointe-a-Pierre Refinery																					
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Plant Cost		2,723																			
Pre-operation Cost		10																			
Interest during Const.		68																			
Consultancy Fee	60																				
Interest on Cons. Fee	2	3																			
Repayment Statement																					
Outstanding Debt		2,804	2,524	2,243	1,963	1,682	1,402	1,122	841	561	280	0	0	0	0	0	0	0	0	0	0
Repayment		0	280	280	280	280	280	280	280	280	280	280	0	0	0	0	0	0	0	0	0
Interest Payment		0	140	126	112	98	84	70	56	42	28	14	0	0	0	0	0	0	0	0	0
Working Capital		72																			-72
Operation Cost																					
Variable Cost			263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263
Fixed Cost			230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230
Overhead			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Compensation			885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885
Cash Flow	-60	-2,805	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	342	414
NPV at 10 percent		1																			
Throughput, BPSD		60,000																			
Cost, US$/Bbl		0.04																			

Table 23-9 Economic Cost of Waste Water Treatment, Bernsetin Main Storage, Alternative Method

Pollution Prevention and Control within the Petroleum Sector in the Republic of Trinidad and Tobago

Unit: 1,000 US Dollars

Economic Analysis, Bernstein Main Storage, Base Case																					
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Plant Cost		12,807																			
Pre-operation Cost		10																			
Interest during Const.		320																			
Consultancy Fee	290																				
Interest on Cons. Fee	7	15																			
Repayment Statement																					
Outstanding Debt		13,152	11,837	10,522	9,206	7,891	6,576	5,261	3,946	2,630	1,315	0	0	0	0	0	0	0	0	0	0
Repayment		0	1,315	1,315	1,315	1,315	1,315	1,315	1,315	1,315	1,315	1,315	0	0	0	0	0	0	0	0	0
Interest Payment		0	658	592	526	460	395	329	263	197	132	66	0	0	0	0	0	0	0	0	0
Working Capital		377																			-377
Operation Cost																					
Variable Cost			1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499	1,499
Fixed Cost			727	727	727	727	727	727	727	727	727	727	727	727	727	727	727	727	727	727	727
Overhead			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Compensation			3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884	3,884
Cash Flow	-290	-13,194	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,985
NPV at 10 percent		0																			
Throughput, BPSD		30,000																			
Cost, US$/Bbl		0.35																			

Table 23-10 Economic Cost of Waste Water Treatment, Combined, Alternative Method

Pollution Prevention and Control within the Petroleum Sector in the Republic of Trinidad and Tobago

Unit: 1,000 US Dollars

Economic Analysis, Pointe-a-Pierre Refinery																					
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Plant Cost		15,530																			
Pre-operation Cost		20																			
Interest during Const.		388																			
Consultancy Fee	350																				
Interest on Cons. Fee	9	18																			
Repayment Statement																					
Outstanding Debt		15,956	14,361	12,765	11,169	9,574	7,978	6,382	4,787	3,191	1,596	0	0	0	0	0	0	0	0	0	0
Repayment		0	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596	0	0	0	0	0	0	0	0	0
Interest Payment		0	798	718	638	558	479	399	319	239	160	80	0	0	0	0	0	0	0	0	0
Working Capital		449																			-449
Operation Cost																					
Variable Cost			1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762	1,762
Fixed Cost			957	957	957	957	957	957	957	957	957	957	957	957	957	957	957	957	957	957	957
Overhead			100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Compensation			4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769	4,769
Cash Flow	-350	-15,999	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	2,399
NPV at 10 percent		1																			
Throughput, BPSD		60,000																			
Cost, US$/Bbl		0.22																			

0.38 percent of the export earnings; the export earnings are about 7,000 million TT dollars.

0.58 percent of the export earnings of crude oil and petroleum products; the export earnings by crude oil and petroleum products account for about 65 percent of the total export earnings.

Granted that, in view of the seriousness of the present petroleum pollution, onshore petroleum production cannot continue without satisfying the 50 ppm target, the question is whether to sustain such a cost in one way or another or to terminate onshore petroleum production. With the small incremental economic burden, 0.22 U.S. Dollars per barrel, termination of the onshore petroleum production would be out of the question. The export earnings of crude oil and petroleum products appear to be the most likely sources of funds for the waste water treating cost. The percentage, 0.58, is never too large to be diverted to the cause of pollution prevention and control within its own sector. An incremental cost corresponding only to 0.58 percent of the earnings from petroleum export does not harm the competitiveness of Trinidad and Tobago in the international petroleum market.

23-6-2 Economic Cost versus Economic Value of Crude Oil

The economic value of crude oil that comes to Bernstein Main Storage is calculated and compared with the economic treating cost of 0.22 U.S. Dollars per barrel. The facilities are mostly old and depreciated; the economic cost of the crude oil is for the most part that of steam. Assuming water produced with crude oil to be generated only from steam, 2.0 tons of steam is consumed per ton of oil, or per 6.3 barrels of oil (400 tons per hour of steam versus 30,000 bpcd of crude oil). To produce 2.0 tons of steam, heat equivalent to about one barrel of oil is consumed. In other words, economic value corresponding to one barrel of oil is consumed to produce 6.3 barrels of oil. Actually, excess associated gas is burned to generate steam; however, the associated gas should have an intrinsic economic value commensurate with its heating value, or with one barrel of oil. Assuming the economic value of the crude oil to be equal to the current posted price of a Venezuelan crude oil of similar quality, 12 U.S. Dollars per barrel, the economic steam cost is 1.90 U.S. Dollars per barrel of oil produced. Other economic costs of crude oil such as electric power, manpower, and maintenance cost should be much lower than the economic cost of the steam; their combined economic costs should not exceed two U.S. Dollar for the subject onshore fields. The onshore oilfields that send crude oil to Bernstein Main Storage are generating, per barrel of crude oil, an economic value of 12 U.S. Dollars at an economic cost of almost four U.S. Dollars or so. By balance, the onshore fields are generating an economic value of about eight U.S. Dollars per one barrel of oil produced. Against such economic value generation, this sector should be able to bear the 0.35 U.S. Dollars per barrel incremental economic burden.

23-6-3 Effect on Consumer Prices of Petroleum Products

It is not recommended to pass the economic burden on to the domestic consumers by increasing the retail prices of petroleum products. Usually, the cost of pollution prevention and control in a particular industry is passed on to its end users by inclusion of such costs in the prices of the commodities. Trinidad and Tobago, however, represents a special case. Large fractions of crude oil and petroleum products are exported; the domestic consumption is about five million barrels per year, about one tenth of the crude oil production. If the economic burden of waste water treatment, 4,769 thousand U.S. Dollars, is charged to the domestic consumers, it amounts to 0.033 TT dollars per liter on average for all petroleum products. This is too much to add to the present average retail price of about 0.4 to 0.5 TT dollars per liter.

23-6-4 Comparison with Other Countries

The Tenth World Petroleum Congress held in 1979 perhaps represented the petroleum industry of the time when it had to meet increasingly stricter water quality standards. The American Institute of Petroleum, perhaps one of the most reliable sources of information, presented to the congress estimated annualized cost ranging from 0.29 and 0.39 U.S. Dollars per barrel in 1985 price to meet ever stricter standards for waste water. The cost of this program, 0.22 U.S. Dollars per barrel in 1994 price, compares very favorably with the above estimates.

23-7 Socio-economic Benefit

The socio-economic benefits that could be brought about by this project are very versatile but not quantifiable. The following benefits are expected.

23-7-1 Benefits to Agriculture and Fishery

Presently, agriculture in the oilfield study area sometimes suffers from oil-contaminated irrigation water. The proposed program will eliminate contamination of river water with oil-in-water emulsion.

The inflow of dispersed oil particles into the Gulf of Paria will be substantially reduced. This will greatly improve the ecological environment of the Gulf of Paria, the most polluted marine water system of Trinidad and Tobago. This would certainly represent a concrete step toward restoration of the safe fishing conditions of the Gulf of Paria. Installation of facilities similar to those proposed by the program at Point Fortin Main Storage, Point Fortin Refinery, Point Ligoure Main Storage and good housekeeping of the facilities upstream of TB33 are needed in addition to the proposed program.

With the above measures properly and faithfully implemented, the concerned rivers and the Gulf of Paria will become visibly clean, completely free from floating oil and suspended oil particles. Fishes and other aquatic life, the species that have not become extinct because of petroleum pollution, will probably come back. One thing still remains unsolved, however, before these rivers and the Gulf of Paria can be declared safe for fishing. The effect on aquatic life of the dissolved substances, contained in the treated water to a maximum of 50 ppm, is not known. Their chronic effects are particularly important. Whether any of these substances accumulate in the bodies of aquatic life or dissipate through decomposition should be studied and monitored on a long-term basis. Even with this question remaining unanswered, the proposed program represents marked improvement over the present terrible aquatic conditions in the study area.

23-7-2 Reduction of Health Hazard

The present petroleum pollution is not assessed in terms of human health hazard. In the case of a large oil spill, there is a problem of acute toxicity due to inhalation of petroleum fumes by those who come close to the site of pollution. In the case of petroleum pollution in the study area, air is filled with odor of petroleum or petroleum-derived substances, indicating the possibility of excessive exposure to petroleum vapors of people working or living in these areas. By implementing the proposed program and recommendations in the next chapter, oil floating on the API and other types of separators will be greatly reduced, which in turn will reduce the emission of vapors to the atmosphere. This will certainly improve the health conditions at the work sites.

For people who do not contact petroleum, the health hazard would come from eating oil-contaminated seafood. Petroleum is a composite substance consisting of a variety of compounds. Petroleum is known to contain components which are reported to have carcinogenic effects, polycyclic aromatic hydrocarbons in particular. Presently, petroleum is discharged to rivers and the sea in the form of oil-in-water emulsions. Upon discharge to rivers and the sea, the effluent water is diluted; however, fish and other aquatic life could concentrate and accumulate oil in the body. Normal food, even after grilling or simmering, contains benzopyrine, a well-known carcinogen, at a maximum of 10 ppm. Oil-polluted seafood is known to contain 1,000 ppm benzopyrine. Consumption of seafood caught in the oil-polluted sea should be regarded as a dangerous practice. The proposed program will reduce this potential health hazard.

23-7-3 Favorable Environment for the Petroleum Sector

Trinidad and Tobago intends to expand the petroleum sector. Although the government wishes to diversify the economy, which depends heavily on petroleum, there is no promising candidate industry which can be fostered quickly. The serious petroleum pollution is a factor which could hinder smooth development of the petroleum sector. The proposed program will improve the polluted environment and will create conditions favorable for the expansion and development of the petroleum sector. The aesthetic values of the mountains, valleys, rivers and beaches will be restored; this will soften the opposition to expansion of the petroleum industry.

23-7-4 Business Opportunities and Introduction of New Technology

Introduction of the dissolved air flotation and activated carbon adsorption will stimulate other industries to adopt similar processes for better environmental protection.

A good portion of fabrication, civil work and installation will be done by local fabricators and constructors. These local companies can enjoy business opportunities and transfer of related technologies. The local element of the investment will be no less than four million U.S. Dollars in 1994 price.

23-7-5 Public Awareness of Environmental Conservation

The proposed program represents the first major undertaking for environmental protection ever staged by the government of Trinidad and Tobago. Such an action by the government will enhance public awareness of the importance of environmental conservation. The respect for the environment and sincere effort to protect it will have a profound educational impact on young minds.

23-7-6 Preservation of Bio-diversity

Species now endangered by petroleum pollution will be saved from extinction. This will help