4-2-3 Comparison of Alternatives

(1) Principles of Various Sewage Treatment Processes

The standard composition of a unit process in each sewage treatment process and the principle of the reactor are summarized on Table 4-3.

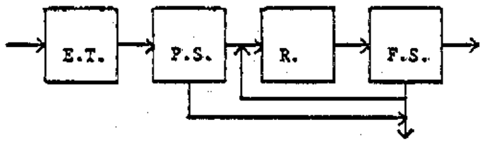
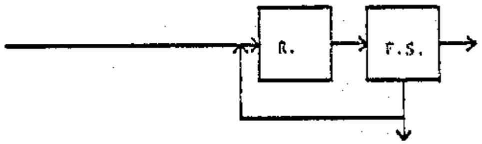
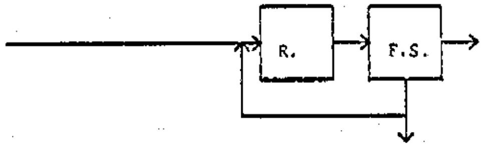
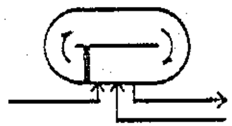
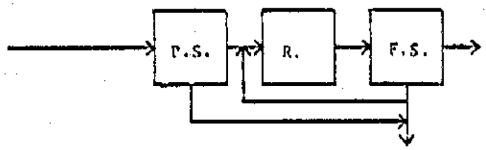
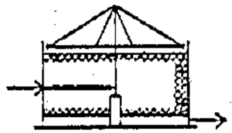
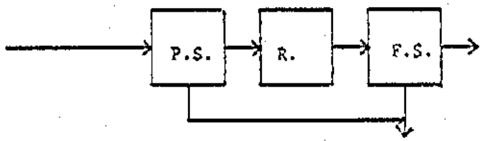
1) Conventional Activated Sludge Process

Inflow sewage enters first a grit chamber where grit and screenings are removed from the raw sewage. This then flows into a flow equalization tank to alleviate the flow and load fluctuation, thereby supplying a constant flow to the primary sedimentation tank. In the primary sedimentation tank suspended matter is separated from sewage, and the supernatant overflows into an aeration tank containing return sludge from the final sedimentation tank and is mixed and aerated. The soluble organic matter in the sewage is removed by the action of activated sludge composed of aerobic micro organisms in the aeration tank. The mechanism of treatment by activated sludge is as follows.

* Formation of activated sludge composed of aerobic microorganisms, with zooglea bacteria as the foundation
* Adsorption of organic matter by activated sludge
* Oxidation and assimilation of adsorbed matter

Then the mixed liquor of sewage and activated sludge is separated into sludge and supernatant, which is chlorinated in a disinfection tank to be discharged into a receiving water body. A part of the settled sludge is handled and disposed as excess of sludge and while the rest is returned to the aeration tank.

Table 4-3 Principle and Characteristics of Various Treatment Processes

Process Name	Standard Composition of Process	Principle of Reactor	Characteristics of Process
Conventional Activated Sludge Process		 Sewage flows down at the horizontally baffled flow with the activated sludge, meanwhile the organic matter in sewage is adsorbed, oxidized and assimilated by the activated sludge.	Because of the short detention time and high organic loading, the reliability in respect of the flow and load variation is so lack that the process requires for a equalization tank and primary sedimentation tank so as to equalize and alleviate such variations.
Extended Aeration Process		- ditto -	Because of the long detention time, the reactor is able to adsorb such variations and a primary sedimentation tank is eliminated in the process.
Oxidation Ditch Process		 Sewage recirculates with the activated sludge, meanwhile the organic matter in sewage is adsorbed, oxidized and assimilated by the activated sludge.	- ditto -
High-Rate Trickling Filter Process		 While sewage distributed on the media by a rotating distributor passes down through the media, the organic matter is adsorbed, oxidized and assimilated by the biological film fixed on the media and the corpulent film falls down from the media by itself.	To prevent the rotating distributor nozzles and the filter from clogging, a primary sedimentation tank is necessarily installed prior to a reactor.
Rotating Biological Reactor Process		 While sewage passes through the rotating disks, the organic matter is adsorbed, oxidized and assimilated by the biological film fixed on the disks and corpulent film falls down from the disks.	To alleviate the loading in the reactor, a primary sedimentation tank is required prior to the reactor.

E.T. Equalization Tank P.S. Primary Sedimentation Tank
R. Reactor F.S. Final Sedimentation Tank

2) Extended Aeration

This process is the same in principle as the conventional activated sludge process. However, by keeping organic loading low and by prolonging aeration time of the activated sludge, the amount of organic matter diminishes and microorganisms goes into the endogenous respiration whereby the microorganisms oxidize and degrade their own cellular matter to obtain energy and some of them starve. Thus sludge generation is kept to a minimum.

3) Oxidation Ditch

This process is regarded as a kind of extended aeration in principle, and is a kind of mechanical agitation process in which rotors are installed in a recirculating ditch to mix, agitate and aerate.

4) High-Rate Trickling Filter

The conventional activated sludge, extended aeration and oxidation ditch processes are classified as suspended biological treatment, while the tricking filter is a kind of fixed biological film treatment in which a film is formed on the surface of gravel media and acts to remove organic matter from the sewage. The main components of the film are bacteria, fungi (mold and enzyme), algae and protozoa. The removal of organic matter involves the three following stages:

* Adsorption of organic matter by the biological film
* Oxidation and assimilation of adsorbed organic matter
* Falling-off of biological film from gravel media due to overgrowth

The trickling filter is classified into conventional and high-rate processes depending on how much organic and hydraulic loading are. The conventional trickling filter process has good characteristics and can remove 75 to 85 percent of BOD and SS; but the site requirement, is 5 to 15 times more than that of the high-rate process, and, because of frequent generation of filter flies and offensive odors, has been discounted as an alternative.

5) Rotating Biological Reactor

While in a trickling filter, sewage passes through gravel media fixed by biological film, the disk fixed by biological film rotates in sewage. The rotating disk is ordinarily 1 to 4 m diameter and 0.7 to 25 mm thick and several tens of disks are connected to a driving axis at intervals of about 2 cm. The disks are made of styrofoam, polychloride, polyethylene, plastic, woodrack, waterproof veneer etc.. Sewage flows slowly between disk parallel to the disc surfaces, the disks rotating with approximately 45 percent of their surface area being submerged at any one time. As a result of rotation, a biological film is formed on the disk surface in a week, and this promotes the BOD degradation under the aerobic conditions by oxygen absorption from the air.

(2) Characteristics of Each Treatment Process

1) Conventional Activated Sludge process

(a) General Characteristics

* For normal municipal sewage of with BOD of 100 to 300 mg/l, an 85 to 95 % removal is achieved, making it superior to other processes.
* Transparency of treated water is high.

* Stability under variable temperatures is inferior to that of other processes.
* Sludge generation is considerable.

Table 4-4 Performance Example of Conventional Activated Sludge Process

Name of Plant	Abashiri Sewage Treatment Plant								Sayamadai Sewage Treatment Plant							
Location	Abashiri City, Hokkaido Pref.								Sayama City, Saitama Pref.							
Dry Weather Daily Max. Sewage Flow	9,377 cu.m/day								7,700 cu.m/day							
Type of Sample	Influent				Effluent				Influent				Effluent			
Season	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.
Air Temp. (°C)	6.4	18.2	10.0	-4.4	6.4	18.2	10.0	-4.4	16.3	24.3	11.1	6.4	16.3	24.3	11.1	6.4
Water Temp. (°C)	13.2	16.8	15.8	11.3	13.1	19.0	17.0	12.6	19.1	25.5	16.9	12.4	19.0	24.6	17.1	13.0
Transparency (cm)	3.7	4.2	4.0	3.8	50.0	46.0	47.5	31.0	2.9	3.4	3.1	3.1	68.2	97.8	82.8	60.3
pH	7.16	7.64	7.47	7.67	7.00	6.61	7.05	7.06	7.6	7.5	7.5	7.6	6.5	6.5	6.6	6.8
B O D (mg/l)	282	268	260	152	9	10	13	14	391	436	227	245	17.4	8.4	9.3	15.8
C O D (mg/l)	154	150	136	129	16	20	18	20	115	103	93.4	124	9.8	6.1	8.6	13.5
S S (mg/l)	234	206	162	233	6	6	5	11	206	153	126	212	6.0	4.0	4.9	7.4
Coliform Group. (N/cm^3)	2.6×10^5	4.0×10^5	5.3×10^5	1.3×10^5	0	0	0	0	3.0×10^4	2.7×10^5	2.1×10^4	2.6×10^4	70	11	4	4

Note: Sp. - Spring, Su. - Summer, A. - Autumn, W. - Winter

(b) Maintenance and Operation

Staff level needed for maintenance and operation is high owing to the many points to be inspected, and a high and complicated technology for the adjustment of MLSS, air supply, return sludge volume, etc. is required. However, since the operational system for the conventional activated sludge process is well established in comparion with other processes, if highly qualified and experienced engineers are engaged, the maintenance and operation are facilitated.

(c) Costs

Aeration system, the aeration tank volume and air supply are less than in the extended aeration system, but additional facilities, such as a equalization tank and a primary sedimentation tank, are necessary of cope with fluctuations in quantity and quality. Therefore, there is almost no difference between these two systems in terms of construction costs and this is also true of maintenance and operating costs.

2) Extended Aeration Process

(a) General Characteristics

* Though this process depends how good or bad maintenance and operation are, performance is generally inferior to that of the conventional activated sludge process.
* Transparency of treated water is high.
* Over a range of water temperatures, stability remains excellent.
* Nitrification is to be expected. By aerating sewage for a long time under the low organic loading condition, autotrophic bacteria such as nitrosomonas can live in the activated sludge and act to promote nitrification, which stabilizes the treated water quality.
* The generation of excess sludge is controlled to a minimum by long aeration. The volume of sludge production is in general 0.5% of treated water compared with 1 to 2 % in the case of the conventional activated sludge process.

Table 4-5 Perrormance Example of Extended Aetacion Process

Name of Plant	Toyama Sewage Treatment Plant								Sakuragaoka Sewage Treatment Plant							
Location	Aomori City, Aomori Pref.								Tama City, Tokyo Metro.							
Dry Weather Daily Max. Sewage Flow	7,600 cu.m/day								2,625 cu.m/day							
Type of Sample	Influent				Effluent				Influent				Effluent			
Season	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.
Air Temp. (°C)	-	22.9	7.7	0.4	-	22.9	7.7	0.4	-	-	-	-	13.9	22.4	7.8	3.2
Water Temp. (°C)	-	16.5	12.8	8.3	-	18.7	13.1	7.7	-	-	-	-	12.0	15.9	14.3	13.6
Transparency (cm)	-	3.5	3.0	3.0	-	> 30	> 30	> 30	-	-	-	-	8.2	16.7	27.8	9.8
pH	-	7.4	7.9	8.0	-	7.6	7.2	6.9	7.5	7.0	7.3	7.4	7.2	7.1	7.4	7.3
B O D (mg/l)	-	213	258	280	-	6.7	7.5	5.4	134	138	144	216	17	19	8	15
C O D (mg/l)	-	106	117	134	-	9.0	10.0	9.9	73	92	77	83	26	29	10	23
S S (mg/l)	-	219	398	250	-	9.5	10.1	8.3	179	176	203	199	48	37	11	31
Coliform Group. (N/cm^3)	-	11.8×10^4	46.0×10^3	45.5×10^3	-	720	14	1	-	-	-	-	0	0	0	0

Note: Sp. – Spring, Su. – Summer, A. – Autumn, W. – Winter

(b) Maintenance and Operation

Because of the elimination of a primary sedimentation tank and the reduction in size of sludge handling facilities owing to the low sludge generation, inspection points are fewer and equipment to be installed is structurally simple. Therefore, this process does not require the high technology of the conventional activated sludge process, but it does require more than the oxidation ditch process.

(c) Costs

With the exception of the large site requirement, in spite of the large aeration tank volume and air supply, construction and maintenance and operation costs are almost the same as those of the activated sludge process because the primary sedimentation tank is dispensed with and sludge generation is below.

3) Oxidation Ditch

(a) General Characteristics

The general characteristics of the oxidation ditch are the same as those of the extended aeration. In this process, furthermore, denitrification is rendered possible by the methods of the operation and control, and troubles associated with nitrification can be avoided. The bacteria utilize oxygen in the nitrates generated by long aeration to produce bubbles of nitrogen and carbon dioxide gases, which adhere to the activated sludge, reducing its density. The activated sludge surfaces in the final sedimentation tank. The oxidation ditch process is able to complete the reaction of nitrification to denitrification by changing the operational procedure.

Table 4-6 Performance Example of Oxidation Ditch Process

Name of Plant	Tufutu Sewage Treatment Plant								Yumoto Sewage Treatment Plant							
Location	Tomakomai City, Hokkaido Pref.								Nikko City, Tochigi Pref.							
Dry Weather Daily Max. Sewage Flow	2,140 cu.m/day								3,250 cu.m/day							
Type of Sample	Influent				Effluent				Influent				Effluent			
Season	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.
Air Temp. (°C)	8.0	18.0	5.0	1.0	8.0	18.0	5.0	1.0	8	16	-1	-6	11	16	-1	-6
Water Temp. (°C)	9.8	15.4	12.6	8.1	10.9	15.9	11.9	4.9	25	26	16	18.5	16	22	10	7.5
Transparency (cm)	5.2	7.5	4.5	4.9	> 48	> 47	> 45	> 44	8	6	12	15	20	19	17	30
pH	7.4	7.2	7.2	7.2	7.1	7.2	7.4	7.5	6.8	6.6	6.8	6.8	7.0	7.2	7.0	7.0
B O D (mg/l)	229	119	203	185	4.4	5.9	3.2	4.5	110	103	70.0	84.3	16.1	19.5	16.3	19.3
C O D (mg/l)	90.9	56.7	84.0	78.4	9.5	8.2	9.2	11.1	73.7	68.8	45.8	56.7	11.0	15.5	11.7	15.0
S S (mg/l)	135	99	155	166	5	6	6	7	154	183	193	236	27	21	23	28
Coliform Group. (N/cm^3)	9.2×10^4	2.0×10^5	1.4×10^5	4.6×10^4	320	360	100	80	6.5×10^3	6.4×10^3	6.5×10^3	7.3×10^3	0	0	0	0

Note: Sp. - Spring, Su. - Summer, A. - Autumn, W. - Winter

(b) Maintenance and Operation

In relation to the ease of maintenance and operation, the same characteristics as those of extended aeration are applicable to this process. However, this process is simpler because it uses a mechanical agitator differing from the extended aeration process, which uses blower equipment which requires air filters, air ducts, water pipes for cooling and soundproofing and anti-vibration devices.

(c) Costs

Since the oxidation ditch is shallow, the site requirement area is larger than that of extended aeration. Construction costs are almost the same as these of the conventional activated sludge process for the same reasons as in the extended aeration process. But maintenance and operating costs, though dependent on the method of the operation and control, are generally higher than those of the conventional activated sludge process.

4) High-Rate Trickling Filter

(a) General Characteristics

* The BOD removal is 65 to 75 % and is inferior to other processes.
* The metabolic activity of microorganisms is affected by water temperature and is sharply reduced below 10 °C, but the effect is not so severe as that in the conventional activated sludge process.
* The filter fly, which lives about 30 cm above the filter floor, is gray-white in color, is 2.5 to 4.5 mm in size in the case of the imago, and has a range of only 100 m, but can be carried on the wind to unexpected distances and cause trouble to local residents. The offensive odor which comes from the anaerobic decomposition of sewage, sludge and dead biological film, may occur.

Table 4-7 Performance Example of High-Rate Trickling Filter Procece

Name of Plant	Gyoda Sewage Treatment Plant								Tsushima-Shi Sewage Treatment Plant							
Location	Gyoda City, Saitama Pref.								Tsushima City, Aichi Pref.							
Dry Weather Daily Max. Sewage Flow	10,920 cu.m/day								12,217 cu.m/day							
Type of Sample	Influent				Effluent				Influent				Effluent			
Season	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.
Air Temp. (°C)	20.4	28.1	15.7	8.7	-	-	-	-	21.4	27.8	15.2	9.4	21.8	27.3	14.7	9.9
Water Temp. (°C)	19.2	21.8	15.8	13.9	19.3	22.4	15.1	12.8	22.1	26.3	21.4	17.7	24.2	24.7	21.8	16.8
Transparency (cm)	5.3	5.5	5.3	3.7	12.7	26.6	16.7	14.1	4.3	4.9	5.3	4.9	12.6	15.1	13.0	12.5
pH	7.2	7.1	7.4	7.9	7.4	7.2	7.5	7.7	6.92	6.85	7.00	6.95	7.08	7.07	7.28	7.18
B O D (mg/l)	120	93.2	112	198	26.9	14.9	15.4	22.6	119	122	108	117	45.3	43.7	47.6	49.0
C O D (mg/l)	60.9	58	70.2	117	27.5	17.3	23	27.3	66.3	65.1	60.1	64.2	33.6	32.2	31.1	36.2
S S (mg/l)	92.6	81.4	100	182	28.8	11.8	20.8	24.7	93.0	88.2	84.9	87.5	32.1	29.8	32.4	35.2
Coliform Group. (N/cm³)	-	-	-	-	4	0	1	0	8.4×10^4	7.8×10^4	8.7×10^4	6.2×10^4	620	830	516	616

Note: Sp. - Spring, Su. - Summer, A. - Autumn, W. - Winter

(b) Maintenance and Operation

While the conventional activated sludge process requires highly complicated technology for the control of MLSS, air supply, return sludge rate, etc., in this process such technology is in principal structurally not necessary except for in the adjustment of distribution interval, equal distribution, prevention of filter clogging, the control of filter fly and offensive odor occurrence. Though the rotating distributor rotates by itself by maintaining a constant head at the distribution nozzles, the main bearing is sealed by mercury which tends to spill over under rapid hydraulic loading. A special technique is required to reseal the bearing.

(c) Costs

From an economical view point, the high-rate trickling filter process is most suitable. Construction costs are slightly lower than for other activated sludge processes because of the need for a primary sedimentation tank. As for the maintenance and operating costs, owing to the large head of water required between treatment facilities in comparison to that of activated sludge processes and recirculation of the sewage, the power requirement for pumping is heavy but the rotating distributor moves by itself, so total maintenance and operational costs are favorable.

5) Rotating Biological Reactor

(a) General Characteristics

* Performance is equivalent to that of the conventional activated sludge process.
* Since fine suspended solids tend to carry over, the transparency of the treated water is lower than that from the activated sludge process.
* When the water temperature drops, the BOD removal rate is reduced.
* Nitrification is to be expected.

Table 4-8 Performance Example of Rotating Biological Reactor Process

Name of Plant	Nozawa-Onsen Sewage Treatment Plant								Koyasan Sewage Treatment Plant							
Location	Nozawa-Onsen Village, Nagano Pref.								Koya Town, Wakayama Pref.							
Dry Weather Daily Max. Sewage Flow	9,700 cu.m/day								4,000 cu.m/day							
Type of Sample	Influent				Effluent				Influent				Effluent			
Season	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.	Sp.	Su.	A.	W.
Air Temp. (°C)	-	-	-	-	-	-	-	-	15.0	21.2	8.0	0	15.0	21.2	8.0	0
Water Temp. (°C)	13.8	19.2	13.7	10.0	14.5	20.2	13.1	10.6	-	17.6	11.2	6.0	10.8	18.6	11.8	6.7
Transparency (cm)	3.1	5.0	4.3	2.7	26.0	36.3	25.6	31.5	-	5.4	6.1	8.2	20.5	34.4	26.8	41.6
pH	7.26	6.9	7.3	7.45	6.89	7.24	7.09	7.04	-	6.99	7.31	7.10	6.30	6.44	6.14	6.11
B O D (mg/l)	149	108	120	257	5.2	6.5	7.0	13.4	-	72.0	50.0	56.7	10.4	6.1	8.9	7.2
C O D (mg/l)	94.3	68.7	77.2	133	14.9	13.6	14.5	17.0	-	70.7	51.8	38.9	2.3	11.7	10.1	9.3
S S (mg/l)	149	123	135	182	7.0	6.3	8.2	11.9	-	138.2	69.2	63.0	-	9.1	10.6	8.8
Coliform Group. (N/cm^3)	6.8×10^5	5.4×10^5	5.5×10^5	2.7×10^5	1	0	10	0.3	-	6.8×10^4	6.2×10^4	4.9×10^4	-	1.9×10^3	1.7×10^3	1.1×10^3

Note: Sp. - Spring, Su. - Summer, A. - Autumn, W. - Winter

(b) Maintenance and Operation

As opposed to the case of the activated sludge process, this process does not require aeration and sludge return equipment; therefore,inspection points are few and high technology is not required. However, the operational system is not yet well established, and maintenance is more difficult than in the oxidation ditch and high-rate trickling filter processes.

(c) Costs

Because of the expensive rotating disks, construction costs are higher than for other processes. Maintenance and operating costs are relatively low owing to the absence of complicated equipment other than the rotating disks.

(3) Comprehensive Evaluation of Alternatives

The characteristics of each sewage treatment process are summarized in Table 4-9. As for general characteristics, the conventional activated sludge, extended aeration and oxidation ditch process, which belong to the suspended biological treatment process, are superior to the rotating biological reactor and high-rate trickling filter. In terms of reliability shock loading, flow variation and entry of toxic matter, there is little difference between the processes, since the standard composition of each process is designed to accommodate such unforeseeable circumstances. In ease of maintenance and operation, the oxidation ditch and high-rate trickling filter process are superior to other processes. And the high-rate trickling filter is most economic.

As mentioned above, and given the absence in the Philippines of municipal sewage treatment plants and qualified experienced engineers, maintenance in considerations and difficulty in procurement of replacement parts should figure prominently in the selection of the sewage treatment process. For these reasons, the oxidation ditch and high-rate trickling filter processes are strongly recommended even though they are respectively less deficient in the economical aspect and general characteristics. Hereinafter, the economic aspects of both processes shall be centered on and discussed.

(4) Comparison of Oxidation Ditch and High-Rate Trickling Filter

1) Site Requirement

The form of the plant site is irregular and the mostly usable level land is occupied by existing facilities arranged in a disorderly way. Utilizing these facilities as they are, the newly-constructed facilities would have to be placed in difficult areas, making layout very difficult.

Table 4-9 Operational Characteristics of the Alternative Processes

Item	Conventional Activated Sludge	Extended Aeration	Oxidation Ditch	High-Rate Trickling Filter	Rotating Biological Reactor
General Characteristics					
Performance	Very Good	Good	Good	Fair	Very Good
Transparency	Good	Good	Good	Fair	Fair
Stability for Water Temp.	Very Sensitive	Sensitive	Good	Sensitive	Very Sensitive
Nitrification	Little Expectable	Expectable	Expectable	Slightly Expectable	Expectable
Environmental Impacts	Moderate	Moderate	Slightly Heavy	Heavy	Moderate
Flexibility					
for Shock Loading	Good	Good	Good	Fair	Fair
for Load Variation	Good	Good	Good	Fair	Fair
for Toxic Matter	Good	Good	Good	Fair	Good
Maintenance and Operation					
Ease of Operation	Difficult	Easy	Very Easy	Very Easy	Easy
Establishment of Operational System	Sufficiently Establish	Sufficiently Established	Established	Established	Insufficiently Established
Inspection Points	Many	Few	Moderate	Few	Moderate
Necessity for High Technology	Necessary	Moderate	Not Necessary	Not Necessary	Not Necessary
Costs					
Construction Cost	Moderate	Moderate	Moderate	Low	High
Maintenance Cost	Moderate	Moderate	High	Low	Moderate
Site Requirement	Moderate	Moderate	Large	Slightly	Large

Therefore, the layout of the oxidation ditch and high-rate trickling filter process is to be made under the following conditions.

* In the case of the oxidation ditch process, all existing facilities except the primary sedimentation tank are to be demolished and removed. As previously mentioned in connection with the standard composition of the process, the process does not require a primary sedimentation tank owing to the reliability flow and load variation. However, since the existing primary sedimentation tank has already been completed and is a relatively large structure whose demolition and removal would be expensive, the layout planning is to be made on the assumption that the tank is still to be used. If the existing primary sedimentation tank is used, the deficit due to the difficult layout, increase in number of inspection points, generation of unstable raw sludge, and increase of sludge volume will raise maintenance and operation costs; while for the increase of sewage flow during rain, part of the sewage would be treated in the primary sedimentation tank before being discharged into the river, and the other would undergo secondary treatment after settling treatment. Moreover, an improvement in performance is expectable. In the high-rate trickling filter process, the sludge handling process uses air drying after non-heating digestion, but since the generated sludge in the oxidation ditch process is stable after self-oxidation, the air drying process after thickening and storage was selected.

* In the case of the high-rate trickling filter, the existing facilities are to be used, and in relation to the not-yet-constructed trickling filter and final sedimentation tank, the layout planning shall be made

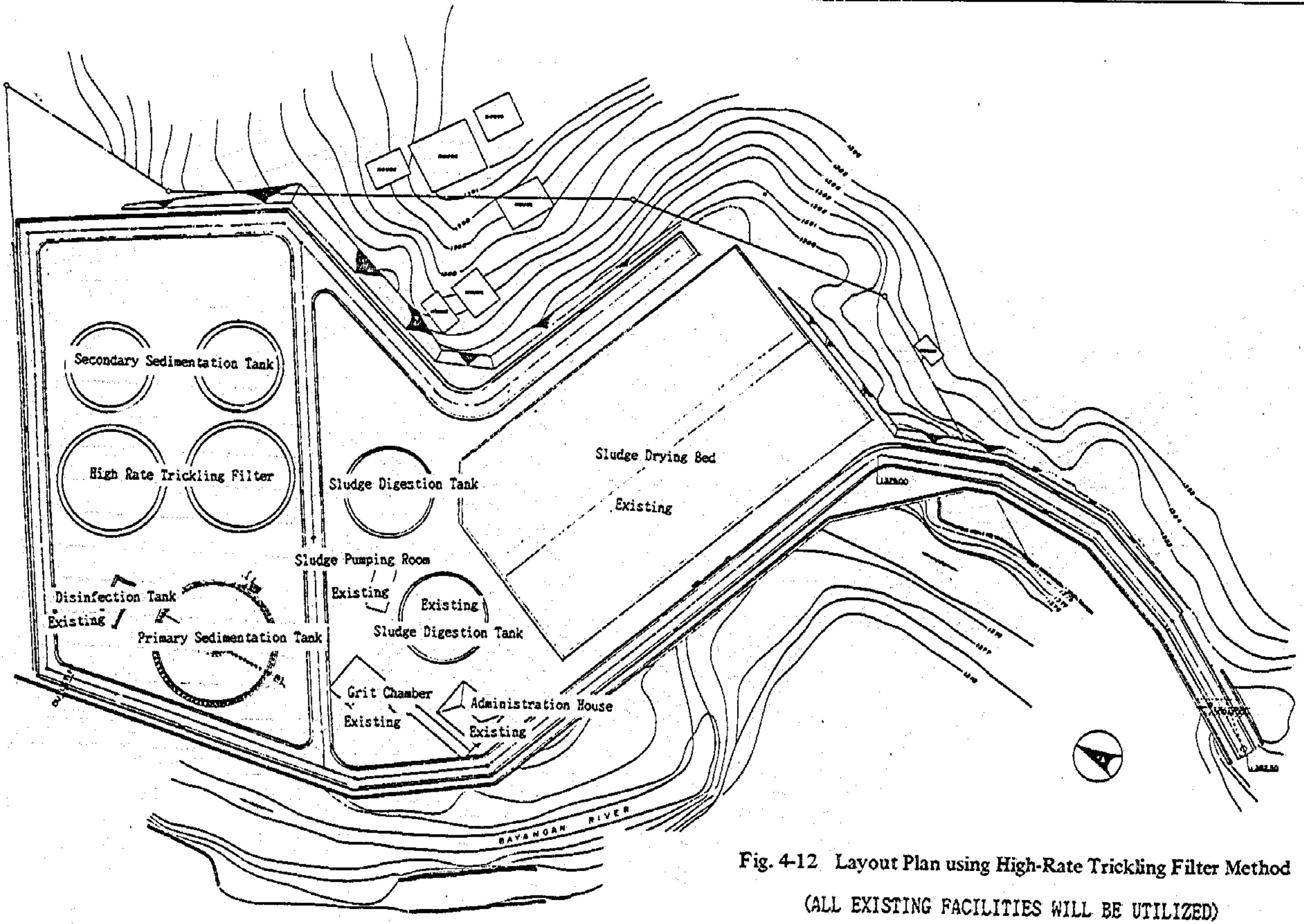


Fig. 4-12 Layout Plan using High-Rate Trickling Filter Method

(ALL EXISTING FACILITIES WILL BE UTILIZED)

SCALE 1 : 1000

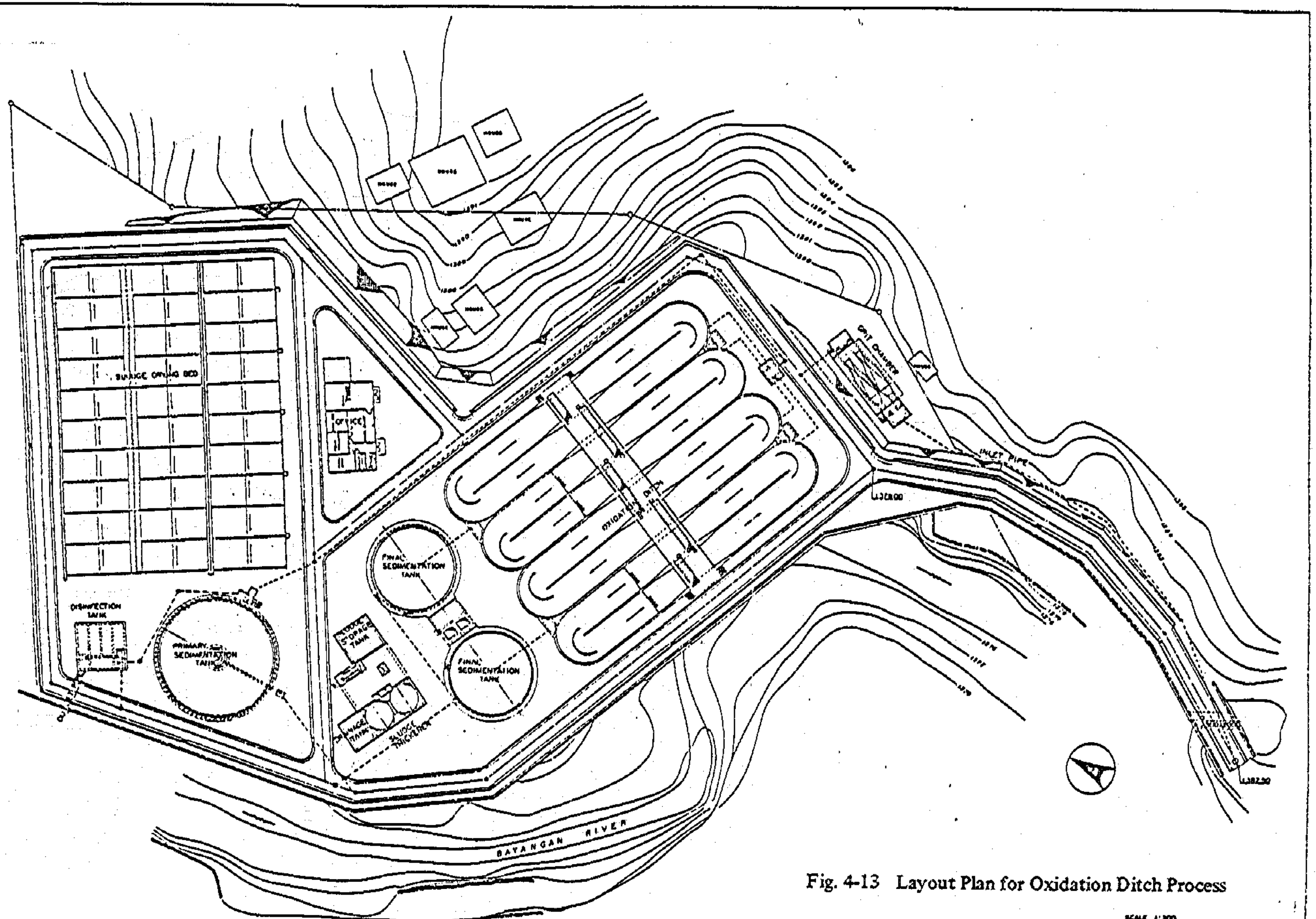


Fig. 4-13 Layout Plan for Oxidation Ditch Process

SCALE 1:300

by revising from only one module to two modules. The layouts are shown in Figures 4-12 and 4-13. Both sewage treatment processes are containable in the given plant site even if the space restriction of the layout is different; the site requirement is not so great a problem in this case.

2) Maintenance and Operating Costs

Maintenance and operation costs are composed of the expenses for personnel, power, chemicals, repairs and others.

(a) Personnel Expenses

Taking into account the easy maintenance and operation of both sewage treatment processes, a staff composed of one manager, two engineers and three laborers is recommended. Based on salary levels in Baguio City, the annual incomes for each staff member are assumed to be ₱36,000 for the manager; ₱24,000 for each engineer; and ₱12,000 for each laborer; and the total annual personnel expenses are expected to be ₱120,000, as follows.

Manager :	₱36,000 x 1 person =	₱ 36,000
Engineer:	₱24,000 x 2 persons =	₱ 48,000
Laborer :	₱12,000 x 3 persons =	₱ 36,000
Total:		₱120,000

(b) Power Expenses

Power expenses for electricity account for the bulk of overall maintenance and operation costs. The electricity charge rate applied is different depending on the type of user, and the system for the commercial use is applied to the sewage treatment plant. Besides the existing system, the Baguio Water District is charged at a special discount rate because of the big power requirement and is status as a public utility. The same applies to the sewage works, and there is still the possibility that the special reduced rate instead of the general one be applied; but this will depend on the negotiation between the Baguio City Government and BENECO.

Thus power expenses are to be estimated for the above two cases: (1) in the case of application of the general charge system; and (2) the special reduced rate applied to Baguio Water District.

From the results of the topographical survey, sewage is able to enter into the existing primary sedimentation tank through the newly-constructed grit chamber by gravity if it is not insisted that the existing facilities be used. Therefore, estimations of power costs shall be made for the following three cases, where the existing primary sedimentation tank is used.

Case I : High-rate trickling filter in which all existing facilities are used

Case II : High-rate trickling filter in which all existing facilities other than the primary sedimentation tank are newly reconstructed.

Case III : Oxidation ditch process in which all existing facilities other than the primary sedimentation tank are newly reconstructed.

The results shown in Tables 4-10, 4-11, and 4-12 indicate that annual power costs will be approximately ₱770,000 for Case I, ₱530,000 for Case II and ₱1,180,000 for Case III, if the general charge system is used; and approximately

Table 4-10 Estimation of Energy Requirement and Electrical Cost

Item		Case I	Case II	Case III
Sewage Flow	m^3/day	8,600	8,600	8,600
	m^3/year	3,139,000	3,139,000	3,139,000
Energy Requirement	kWh/day	1,380	970	2,080
	kWh/year	503,700	354,050	759,200
Energy Demand	kW/month	130	65	280
Electrical Charge I (Based on General Charge)				
Demand Charge (25₱/kW x 12)	₱/year	39,000	19,500	84,000
Energy Charge (1.45₱/kWh)	₱/year	730,365	513,373	1,100,840
Total	₱/year	769,365	532,893	1,184,840
Electrical Charge II (Based on Discount Charge)				
	₱/year	554,070	389,455	835,120

Note: The details of the special discount charge system applied to the Baguio Water District are unknown, but the data indicate that the average cost is approximately ₱1.1 per kWh.

Table 4-11 Energy Requirement (Case I and II–High-Rate Tricking Filter Process)

No.	Equipment Name	Power Rating	Quantity	Effective Power	Calculation	kWh/day
(1)	Grit Elevator	1.5	2	(3.0)	3.0 kW x 24 h x 0.7	(50.4)
(2)	Comminutor	1.5	1	(1.5)	1.5 x 24 x 0.8	(28.8)
3	Conveyor	0.2	2	0.4	0.4 x 24 x 0.7	6.7
(4)	Main Pump	11.0	5(1)	(44.5)	44 x 1/2 x 24 x 0.9 x 0.7	(332.6)
5	Clarifier	1.5	1	1.5	1.5 x 24 x 0.8	28.8
6	Raw Sludge Pump	2.2	3(1)	4.4	4.4 x 24 x 0.3	31.7
7	Recirculation Pump	7.5	5(1)	30.0	30 x 24 x 0.8	576.0
8	Excess Sludge Pump	2.2	3(1)	4.4	4.4 x 24 x 0.3	31.7
9	Chlorine Dosing Pump	0.4	1	0.4	0.4 x 24 x 0.8	7.7
10	Blower for Gas Agitation	3.7	2(1)	3.7	3.7 x 24 x 0.8	71.1
11	Clarifier	0.75	2	1.5	1.5 x 24 x 0.8	28.8
12	Filtrate Pump	1.5	2(1)	1.5	1.5 x 24 x 0.8	28.8
13	Filtrate Pump	0.75	2(1)	0.75	0.75 x 24 x 0.8	14.4
14	Other				approx.	150.0
	Total			48.55 (97.05)	(approx.	1380.0)

Note:In Case II, the grit elevator, comminutor and main pump are not used and the total energy requirement is 970 kWh/day.

The figure in parentheses in the quantity column of indicates the number of standby out of the total.

Table 4-12 Energy Requirement (Case III–Oxidation Ditch Process)

No.	Equipment Name	Power Rating	Quantity	Effective Power	Calculation	kWh/day
1	Conveyor	0.2	2	0.4	0.4 kW x 24 h x 0.7	6.7
2	Clarifier	1.5	1	1.5	1.5 x 24 x 0.8	28.8
3	Rotor	22.0	8	176.0	8.5 x 24 x 7100 m^3	1448.4
4	Clarifier	0.75	2	1.5	1.5 x 24 x 0.8	28.8
5	Raw Sludge Pump	2.2	3(1)	4.4	4.4 x 24 x 0.3	31.7
6	Return Sludge Pump	5.5	3(1)	11.0	11.0 x 24 x 0.75	198.0
7	Excess Sludge Pump	2.2	3(1)	4.4	4.4 x 24 x 0.3	31.7
8	Thickened Sludge Pump	2.2	3(1)	4.4	4.4 x 24 x 0.3	31.7
9	Sludge Thickener Clarifier	0.4	2	0.8	0.8 x 24 x 0.8	15.4
10	Chlorine Dosing Pump	0.4	1	0.4	0.4 x 24 x 0.8	7.7
11	Sludge Storage Tank Stirring Pump	5.5	1	5.5	5.5 x 24 x 1/2 x 0.8	52.8
12	Others				approx.	200.0
	Total			210.3	approx.	2080.0

₱550,000; ₱390,000; and ₱840,000; respectively, if the special discount is applied. The effect of the cost reduction by applying the discount charge system is by no means negligible.

(c) Cost of Chemicals

Because no sludge dewatering process is used, coagulants are not necessary in this plant, therefore chemicals for chlorination are required only in normal operation. In many cases chlorination is not carried out in the Philippines even for water supply. Whether on not chlorination is carried out depends on the decision of Baguio City Government, to estimate the maintenance and operation cost on the safety side, the cost of chemicals is also to be totaled.

Planned Sewage Flow	8,600 m^3/day
Average Dosage	3 mg/l
Cost of Chemical	₱1,300 per 50 kg gas cylinder
Quantity Used	
Daily	8,600 m^3/day x 3 mg/l x 10^{-3} = 25.8 kg/day
Yearly	25.8 kg/day x 365 days = 9,417 kg/year
Annual Cost of Chemicals	9,417 kg/year x ₱ 1,300/50 kg = 244,842 Peso/year

(d) Repairs and Other Expenses

In Baguio City, the large sums for repair or replacement of public facilities equipment is ordinarily appropriated from the reserve fund of the city's general budget. Therefore, the cost of repairs and expenses for minor replacement parts, is taken to amount annually to ₱ 100,000.

Total annual maintenance and operating costs are summarized in Table 4-13.

Table 4-13 Comparison of Annual Maintenance and Operational Cost

Item	High-Rate Trickling Filter	Oxidation Ditch
Personnel Expenses	₱120,000	₱120,000
Energy Cost	₱390,000 to ₱530,000	₱840,000 to ₱1,180,000
Cost of Chemicals	₱240,000	₱240,000
Repairs and Other Expenses	₱100,000	₱100,000
Total	₱850,000 to ₱990,000	₱1,300,000 to ₱1,640,000

Note: The energy cost of the high-rate trickling filter uses the value in Case II.

3) Conclusion

Compared to the high-rate trickling filter, the oxidation ditch process shows good characteristics, that is to say, good performance, high water transparency, high reliability over a range of water temperature, nitrification capability (denitrification is also possible by the operational method) and less effect on the surrounding environment. But, with the exception of the large site requirement, maintenance and operation costs are clearly higher than those of the high-rate trickling filter process.

Though the sewage treatment process to be selected depends on what characteristics those concerned deem to be important, selection of the high-rate trickling filter process is recommended strictly in accordance with the principle of "Cost Minimum," when it is considered that maintenance and operating costs will be shouldered by the beneficiaries.

Through the discussion with the LWUA and Baguio City Government, the opinion that the selection of the oxidation ditch process was desirable for the following reasons was presented.

* This project emanated from the law suit on the water pollution of the Balili River; therefore, concern for the treatment performance is very strong.
* Baguio City Government presently has several disputes on environmental issues and would like to consider very carefully the conservation of the surrounding environment.
* Based on the results of estimated maintenance and operating costs, the amount to be borne per resident is well bearable.

As a result, the oxidation ditch process was selected.

4-2-4 Outline of the Sewage Treatment Plant

(1) Particulars

Particulars of the sewage treatment plant are as follows.

- Name :	Baguio Sewage Treatment Plant	
- Location:	Lucban Valley, Baguio City	
- Site Area:	1.38 hectare (Available Area 1.24 ha.)	
- Ground Elevation:	Present	ave. 1,378 m
	Planned	1,379 m
- Surrounding Land Use:	North	Field
	East	Residential Area
	South	Field
	West	Residential Area
- Sewer System:	Separate System	

- Treatment and Disposal System: Sewage - Oxidation Ditch Process; Sludge - Thickening-Storage-Air Drying
- Receiving Water Body: Name Balili River; High Water Level 1,377 m; Planned Water Level 1,377 m
- Target Year: 1986
- Planned Sewage Flow: Daily Mean Sewage Flow 8,600 m^3/day (Approx. 2.27 MGD); Hourly Maximum Sewage Flow 17,200 m^3/day (Approx. 4.54 MGD)

The flow sheet for treatment and the hydraulic profile are shown in Figure 4-4 and 4-15 and the outline of main facilities in Table 4-14.

(2) Description of the Sewage Treatment Facilities

Sewage collected through the sewer system in the Baguio City which covers most of the Balili River basin flows into the grit chamber of the sewage treatment plant initially by gravity. Floating materials in the sewage are removed by coarse and fine screens and sand settles in the grit chamber, which is equipped with a mechanically operated fine screen and is used during normal operation and the other, with a manually operated fine screen, is used temporarily when removing settled grit. The coarse-screened material is transferred manually into the cage and sand is eliminated manually into the container which is operated by vertically and horizontally movable chain block unit. The screenings at the fine screen in the normally used chamber are removed mechanically by the operation of buttons; in the temporarily used one they are removed manually into the cage. In an emergency, sewage is bypassed to a disinfection tank by shutting the gate to the grit chamber and opening the stop log.

- Treatment and Disposal System:	Sewage - Oxidation Ditch Process Sludge - Thickening-Storage-Air Drying
- Receiving Water Body:	Name Balili River High Water Level 1,377 m Planned Water Level 1,377 m
- Target Year:	1986
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Fig. 4-14 Flow Sheet for Treatment

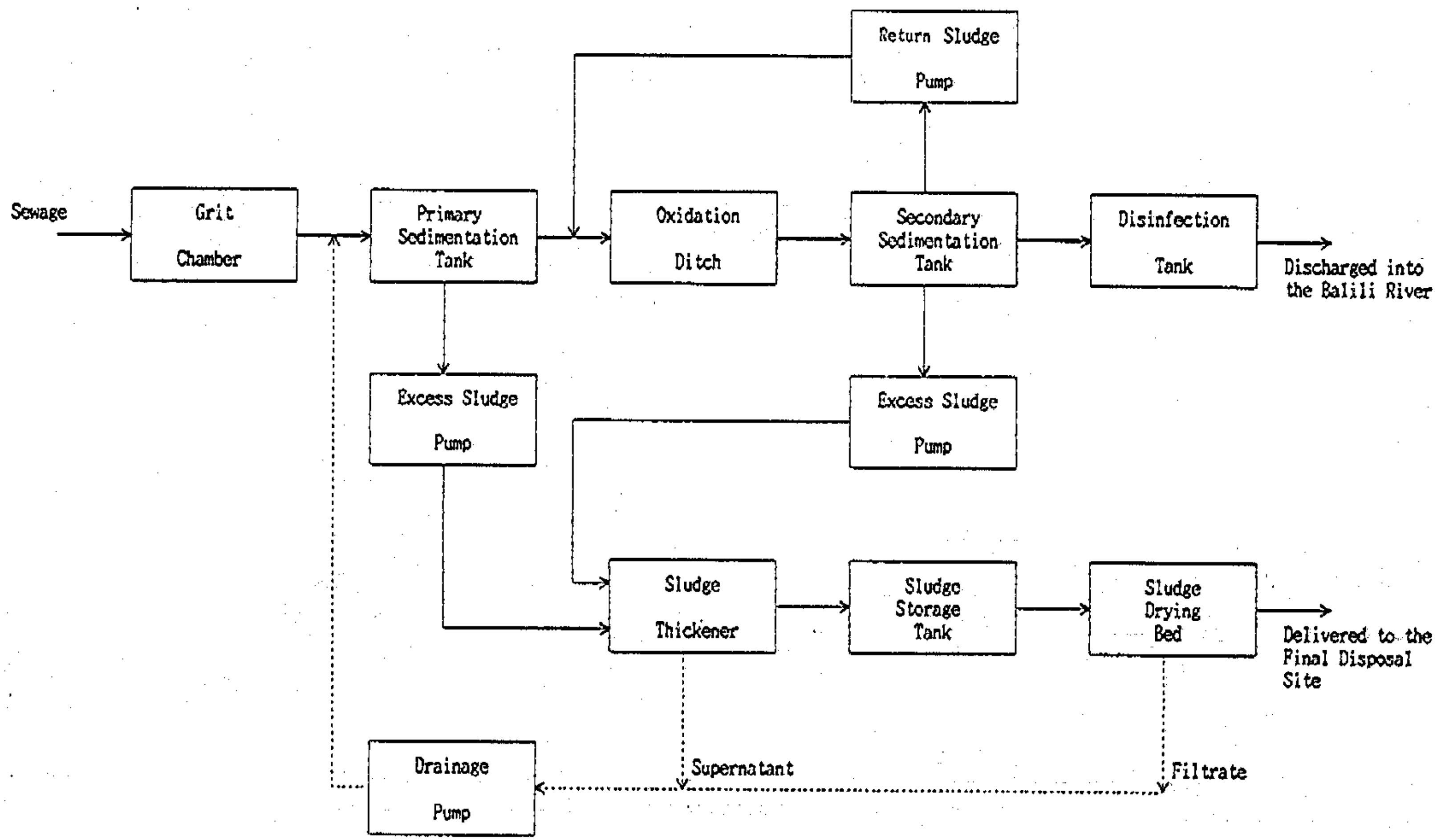


Fig. 4-15 Hydraulic Profile

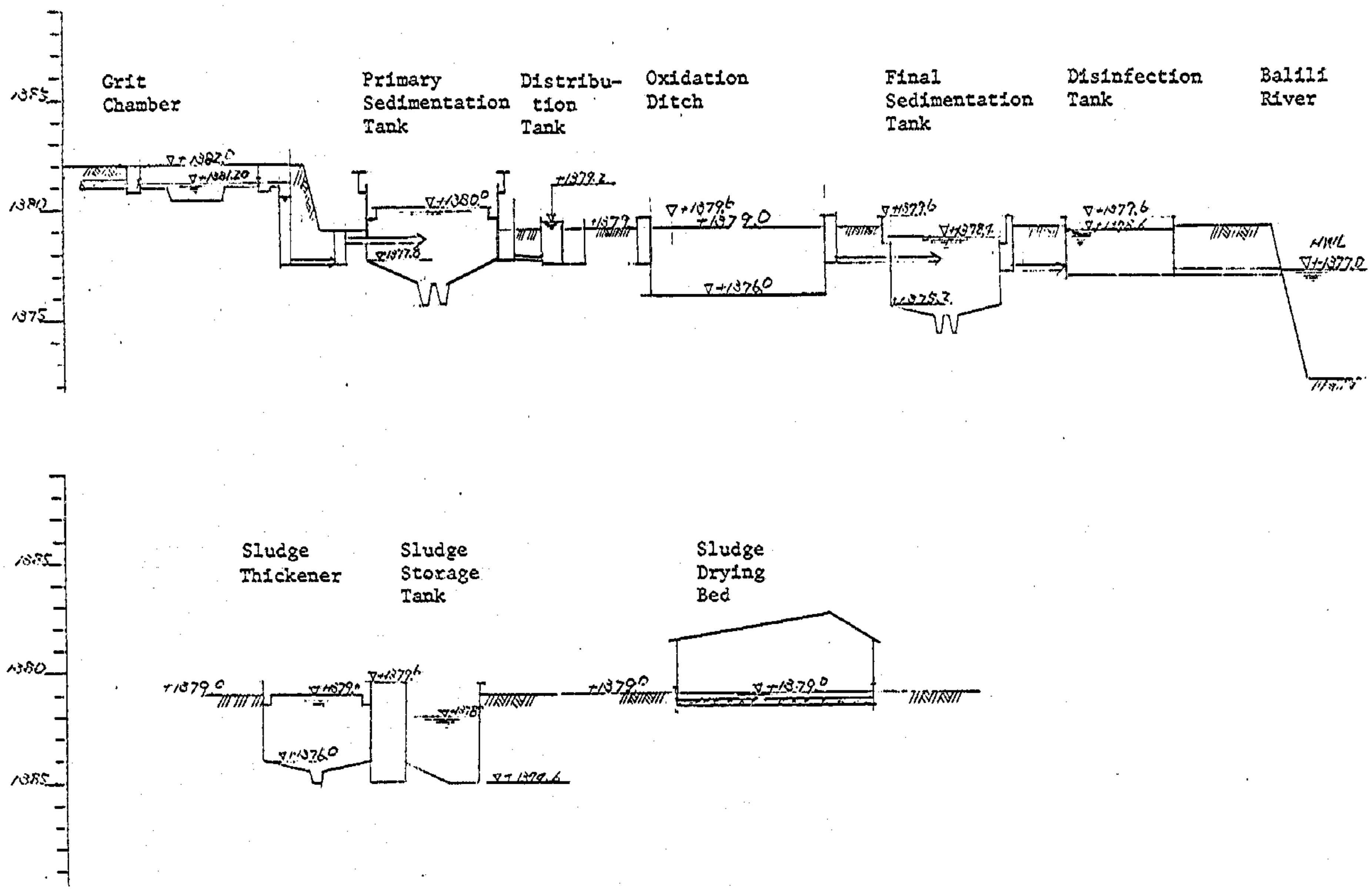


Table 4-14 Outline of Main Facilities

Facility Name	Dimensions	Quantity	Capacity
Inflow Pipe	Dia. 600 mm	1	
Grit Chamber	Parallel Flow W 2.20 m x L 4.30 m	2 (1-Standby)	Overflow Rate 1,818 m^3/m^2/day Average Velocity 0.30 m/sec
Primary Sedimentation Tank	Radial Flow Circular Tank Dia. 21.34 m x D 2.17 m	1-Existing	Sedimentation Time 2.17 hr Overflow Rate 24.1 m^3/m^2.day Weir Rate 128 m^3/m.day
Oxidation Ditch	Recirculation Flow Ditch W 10.00 m x L 56.00 m x D 3.00 m	4	BOD-SS Loading 0.053 kg/SS-kg/day BOD Volumetric Loading 0.186 kg/m^3/day Sludge Age 18.8 days Aeration Time 18.1 hr Sludge Return Ratio 100 %
Final Sedimentation Tank	Radial Flow Circular Tank Dia. 15.00 m x D 3.20 m	2	Sedimentation Time 3.16 hr. Overflow Rate 24.4 m^3/m^2.day Weir Rate 91.3 m^3/m.day
Disinfection Tank	Horizontally Baffled Flow Rectangular Tank W 2.00 m x L 6.00 m x 4 channels x W 2.00 m	1	Contact Time 16.0 min.
Return Sludge Pump		6	
Raw Sludge Pump		2	
Excess Sludge Pump		2	
Drainage Pump		2	
Sludge Thickener	Radial Flow Circular Tank Dia. 5.20 m x D 3.00 m	2	Thickening Time 27.0 hr. Overflow Rate 28.9 kg/m^3.day
Sludge Storage Tank	Rectangular Tank W 6.00 m x L 6.00 m x D 2.50 m	1	Storage Time 2.2 days
Sludge Drying Bed	Covered Air Drying Bed W 11.00 m x L 13.50 m	15	Thickness of Sludge Layer 0.30 m Drying Time 16.3 days

Abbreviation: W - Width, L - Length, D - Effective Water Depth

The effluent from the grit chamber then enters by gravity into the existing primary sedimentation tank in which scum is eliminated mechanically, and sludge settles to be separated from the sewage and is scraped to the sludge pit in the center by a clarifier. The supernatant outflows to the succeeding oxidation ditch after the flow at the V-notch type measuring chamber has been measured. The 30 % of biological oxygen demand (BOD) and 40 % of suspended solids (SS) are expected to be removed in the primary sedimentation tank. The clarifier is operated continuously and the withdrawal of sludge is made by the on-off operation of pumps or by setting a timer.

In the oxidation ditch equipped with rotors, sewage is mixed, agitated and aerated with return sludge of an equivalent volume to sewage pumped up from the final sedimentation tank. The soluble organic matter is adsorbed, to be oxidized and assimilated by activated sludge. The mixed liquor of sewage and activated sludge is divided into liquid and solid, namely supernatant and sludge in the final sedimentation tank which follows and the supernatant is chlorinated in the disinfection tank and then discharged into the Balili River. Part of the settled sludge in the final sedimentation tank is drawn off by pumps to be returned to the oxidation ditch through the V-notch type measuring chamber and the rest is also drawn off to be sent to the sludge thickener as excess sludge. In the disinfection tank, hypochlorous calcium in the form of tablets is used for chlorination in consideration of its easy handling and safety.

The sludge in the primary sedimentation tank is withdrawn by pumps to be sent to the measuring tank in which it is mixed with excess sludge before entering the sludge thickener. The thickened sludge is withdrawn by gravity, measured by an electro-magnetic flow-meter and flows into the sludge storage tank where it is agitated by stirring pumps so as not to settle and aerated to prevent deteriorating and to keep its aerobic condition. The stored sludge is introduced into the sludge drying bed which is covered with polycarbonate plate to accelerate evaporation and to maintain even during the rainy season. All work in the bed including the introduction of sludge and the removal of sludge cake is done manually.

The screenings and sand removed in the grit chamber, scum in the primary sedimentation tank and the sludge cake generated in the sludge drying bed is delivered to the outside of the plant for landfill disposal by truck.

(3) Organization for Maintenance and Operation

The maintenance and operational work of the sewage treatment plant is divided into three: (1) operational work; (2) water quality analysis work; and (3) maintenance work.

1) Operational Work

The work is mainly composed of setting the operational condition of sewage treatment facilities, operating the equipment, supervising the operation and preparing daily and monthly reports on the operational condition and the equipment condition.

2) Water Quality Analysis Work

The objective of the water quality analysis is to study the treatment performance through sampling, analyzing and recording and to clarify the relationship between the treatment performance and the operational condition.

3) Maintenance Work

The work includes inspection, and simple repair and replacement of equipment, and cleaning of the building, structure and equipment. Since the sewage treatment plant is thought likely to be a nuisance by the local residents, it is of special importance that the plant should be well maintained.

Given the ease of maintenance and operation of the selected sewage treatment plant, the following organization is recommended.

Plant manager (1) ─┬─ Engineers (2)
                   └─ Laborers (3)

Here the figures in parentheses indicate the number of staff members.

* The plant manager is responsible for the direction and supervision of engineers and laborers.
* One engineer is in charge of the operational work and the other is in charge of the water quality analysis as aforementioned.
* The laborers divide the work as shown in Table 4-15 under the direction and supervision of the plant manager and also assist in operational work and water quality analysis work in accordance with the directions of the engineers.

Table 4-15 Content of Major Maintenance Work

Item	Daily Work	Regular Work
Inspection	Inspection of pumps, clarifiers, rotors, measuring devices, etc.	Inspection of building, structures, gate, fence and so on. Inspection of the surroundings of buildings. Inspection of chemicals. Inspection of electric and instrumental equipment. Taking care of in-site trees and grass
Repair and Supply		Repair of buildings, structures, gate, fence and so on. Supply of consumption articles such as ground-packing of pumps. Supply of chemicals, oil etc. Repair of trouble equipment Painting of equipment
Cleaning	Removal and delivery of screenings and scum. Removal and delivery of sludge cake. Cleaning of the administrative quarters.	Cleaning of the premises. Removal and delivery of grit. Cleaning of overflow weirs.

4-3 Basic Design Drawings

Basic design drawings are presented hereafter.

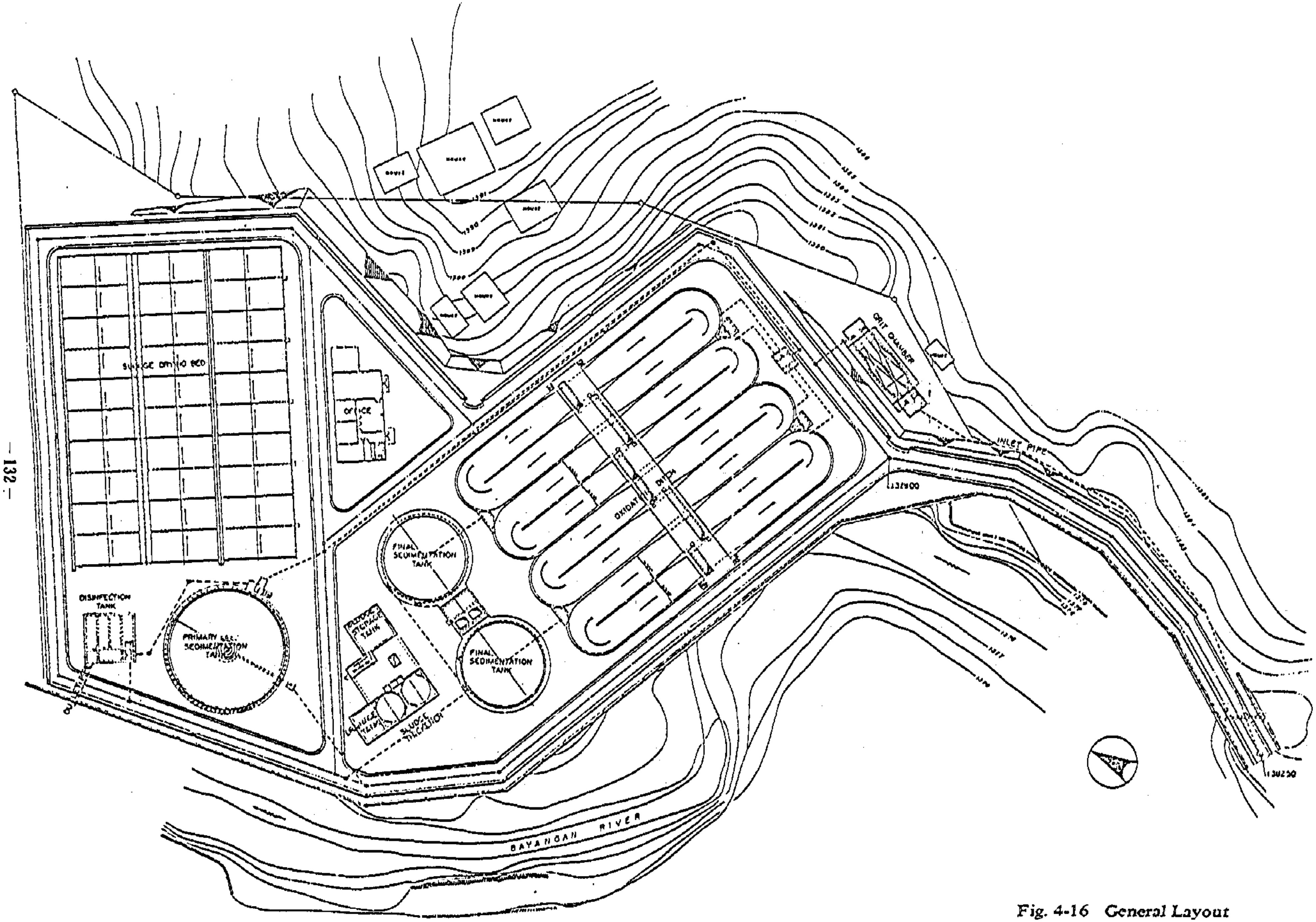


Fig. 4-16 General Layout

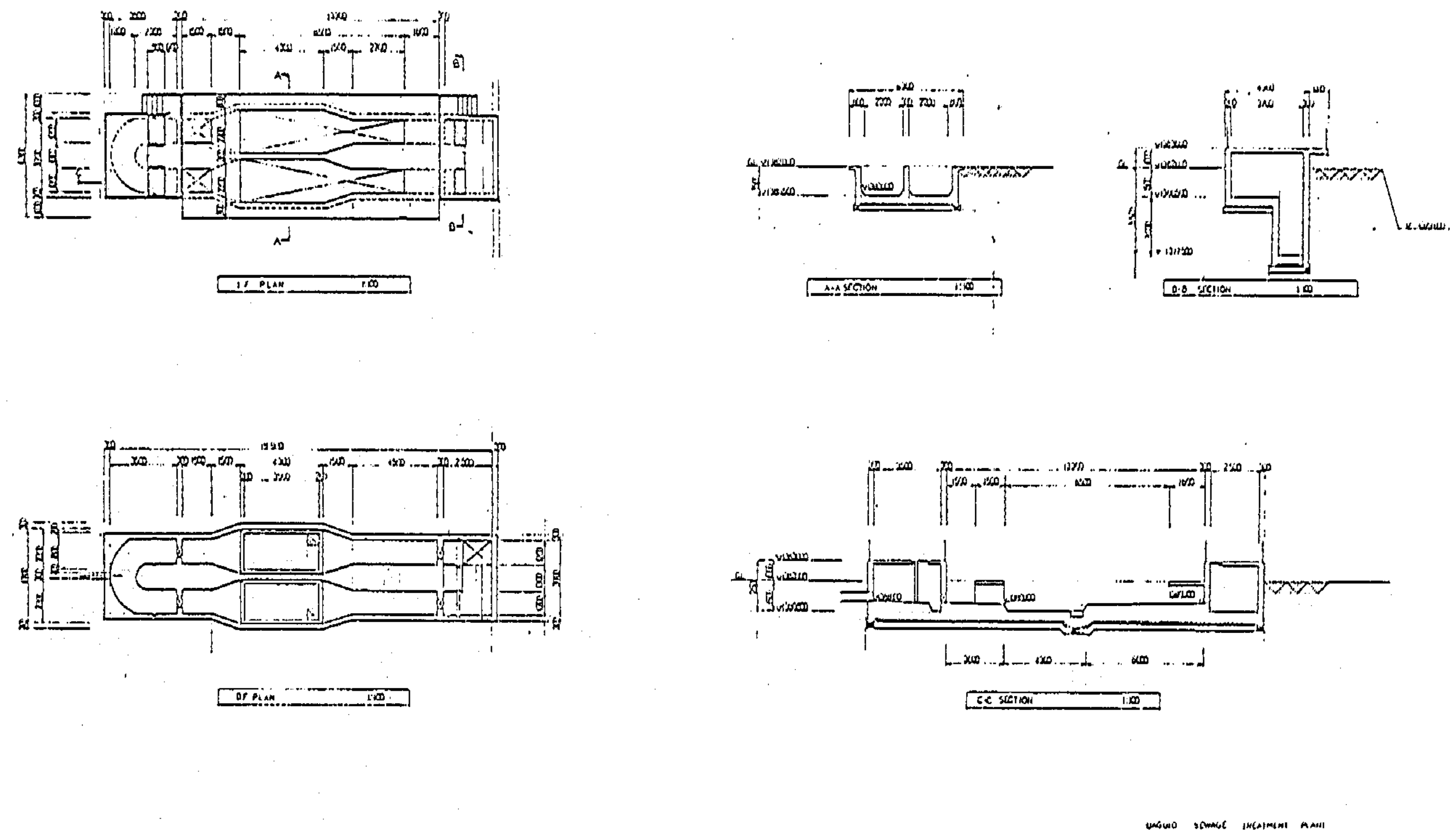


Fig. 4-17 Grit Chamber

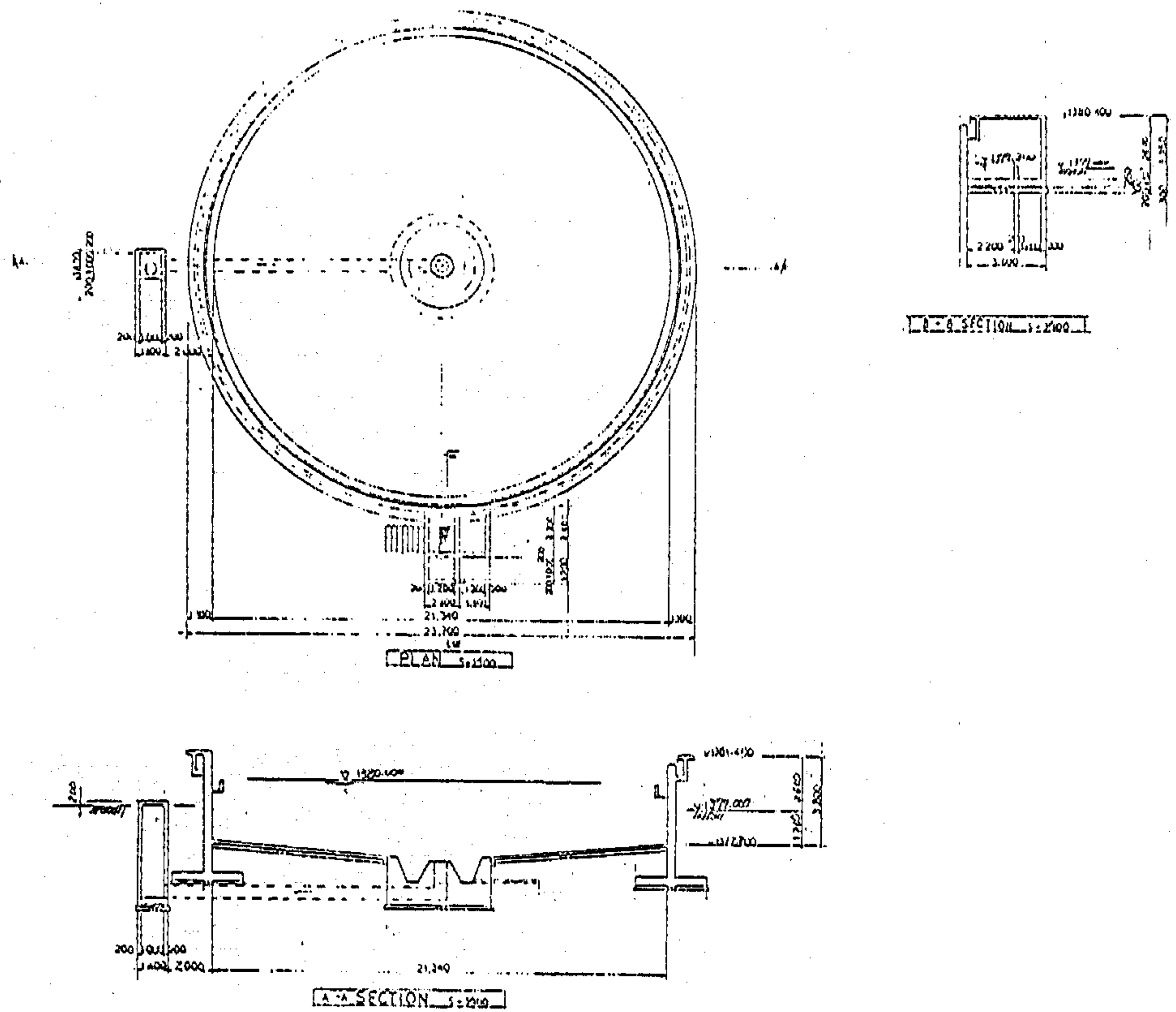


Fig. 4-18 Primary Sedimentation Tank

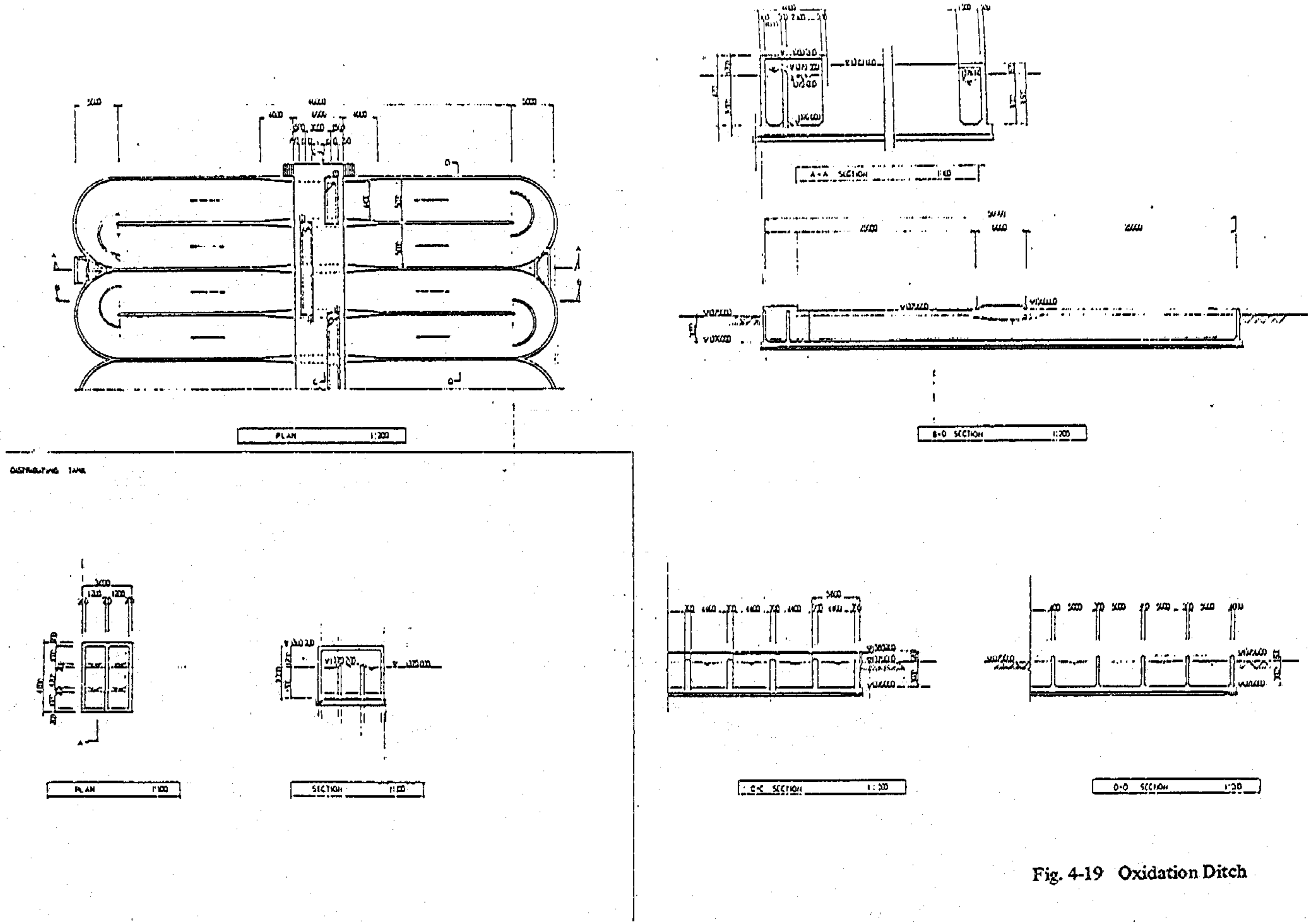


Fig. 4-19 Oxidation Ditch

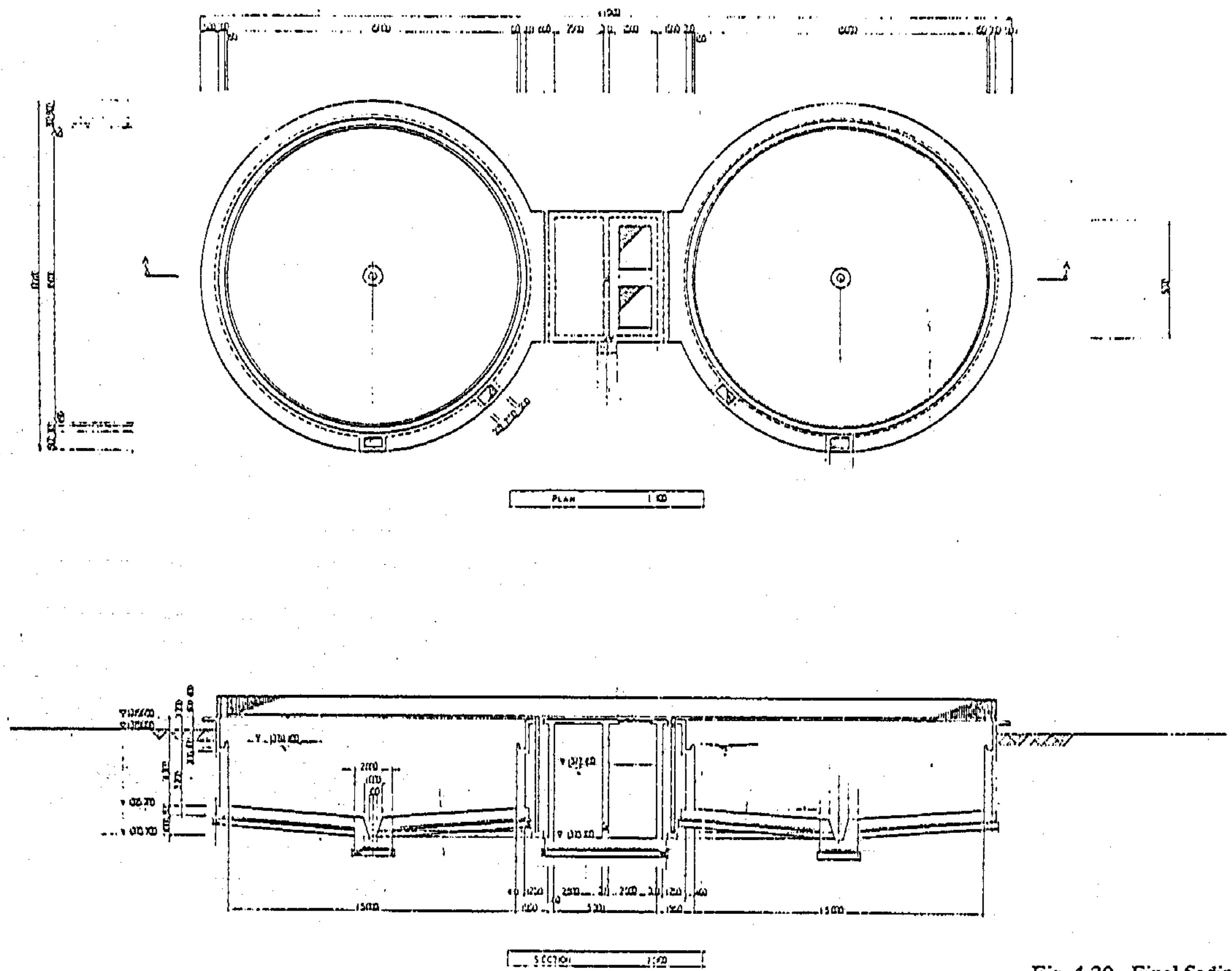


Fig. 4-20 Final Sedimentation Tank

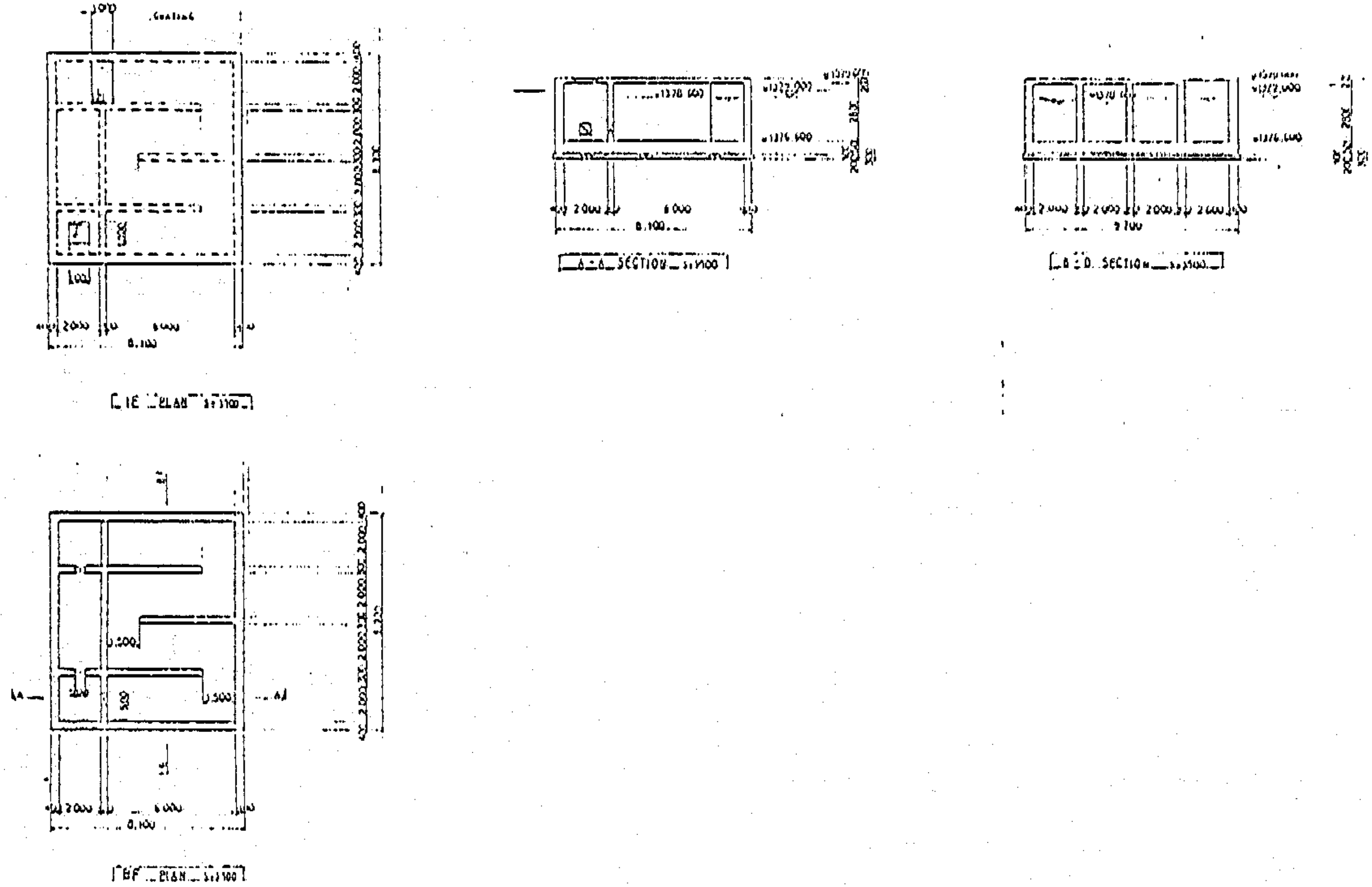


Fig. 4-21 Disinfection Tank

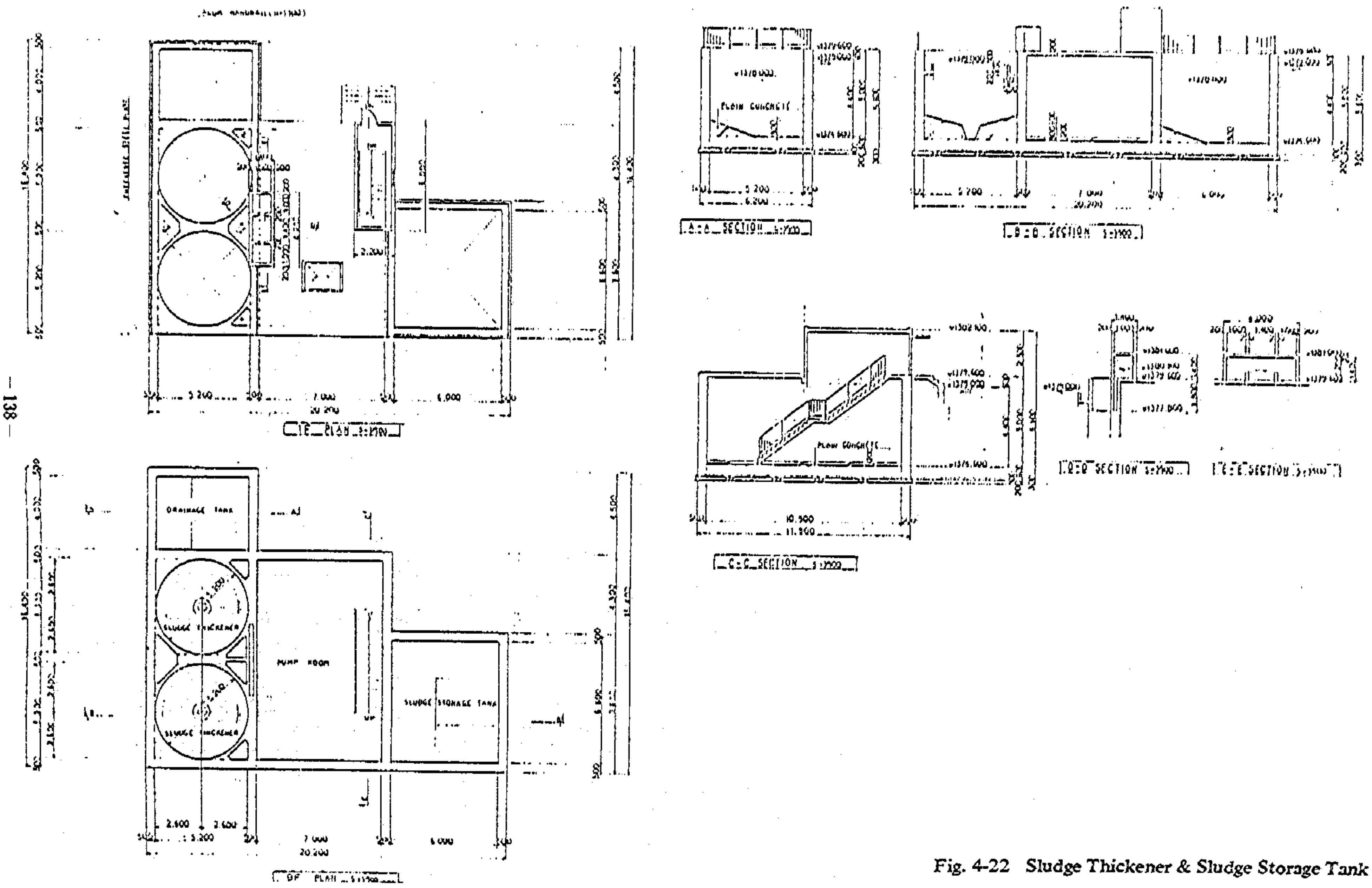


Fig. 4-22 Sludge Thickener & Sludge Storage Tank

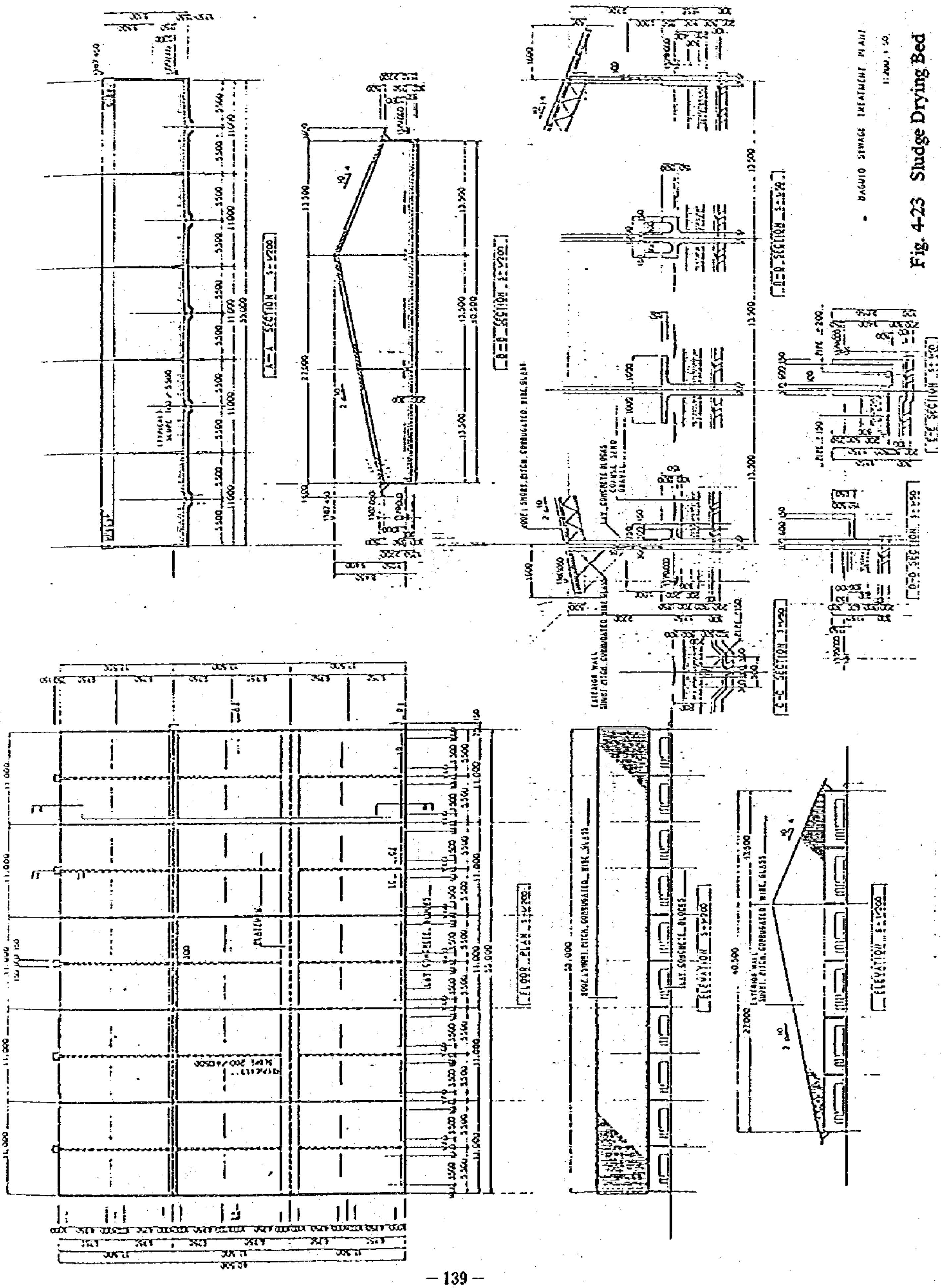
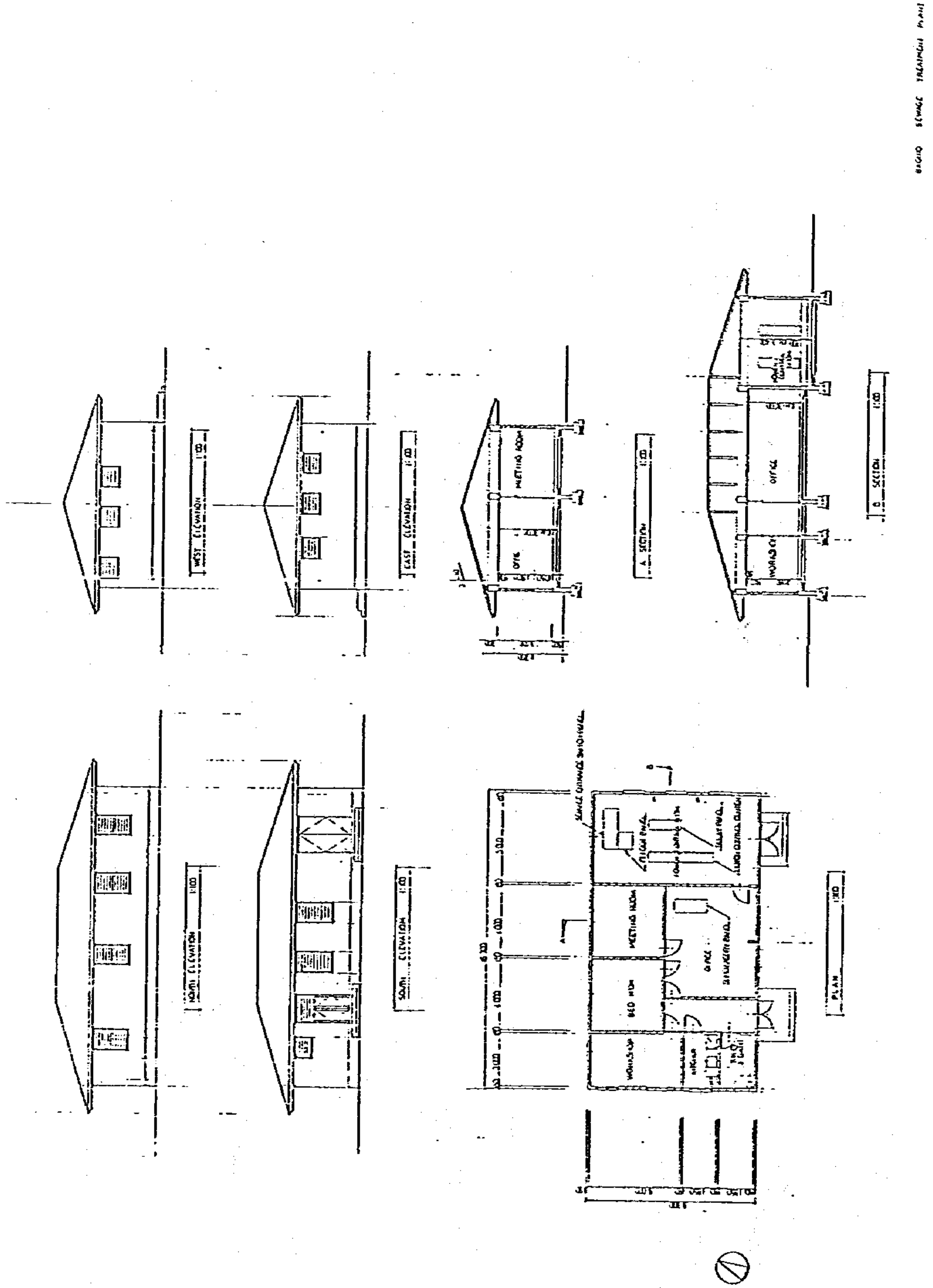
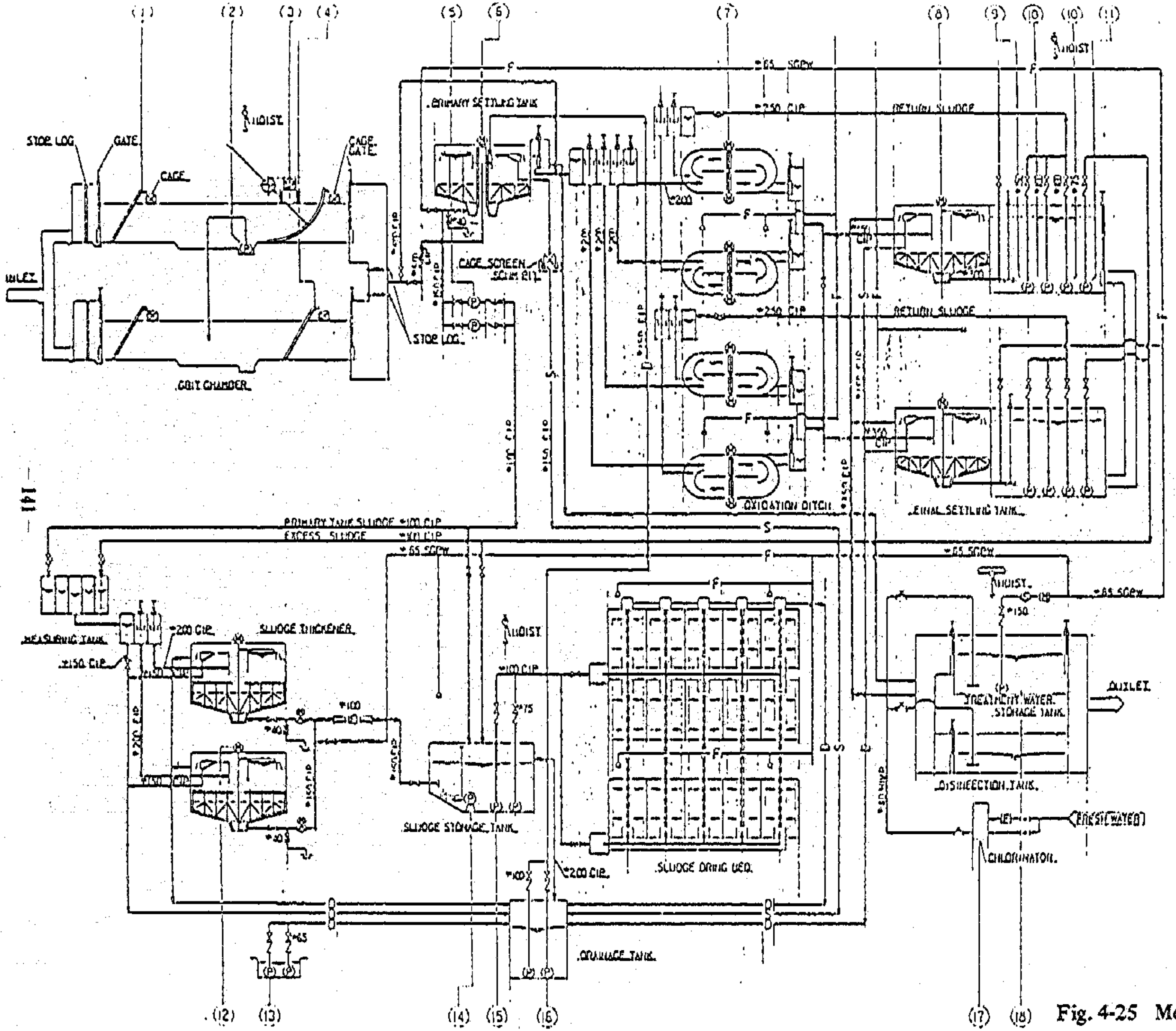


Fig. 4-23 Sludge Drying Bed


SEWAGE TREATMENT PLANT
WEST ELEVATION 1:100
EAST ELEVATION 1:100
A SECTION 1:100
B SECTION 1:100
NORTH ELEVATION 1:100
SOUTH ELEVATION 1:100
PLAN 1:100
WORKSHOP
BED ROOM
OFFICE
MEETING ROOM



EQUIPMENT SCHEDULE

ITEM	EQUIPMENT NAME	UNIT	DESCRIPTION
1	COARSE SCREEN	2	
2	NO.3 DRAINAGE PUMP	1	
3	FINE SCREEN	1	
4	FINE SCREEN	1	
5	PRIMARY TANK SLUDGE PUMP	2(1)	
6	CLARIFIER	1	
7	AERATOR	6	
8	CLARIFIER	2	
9	RETURN SLUDGE PUMP	2	
10	RETURN SLUDGE PUMP	4	
11	EXCESS SLUDGE PUMP	2	
12	THICKENER	2	
13	NO.1 DRAINAGE PUMP	2(1)	
14	STIRRING PUMP	1	
15	SLUDGE SUPPLY PUMP	2(1)	
16	NO.2 DRAINAGE PUMP	2(1)	
17	CHLORINATOR	1	
18	TREATMENT WATER PUMP	1	

BAGHU SEWAGE TREATMENT PLANT

Fig. 4-25 Mechanical Equipment Flow Sheet Plan

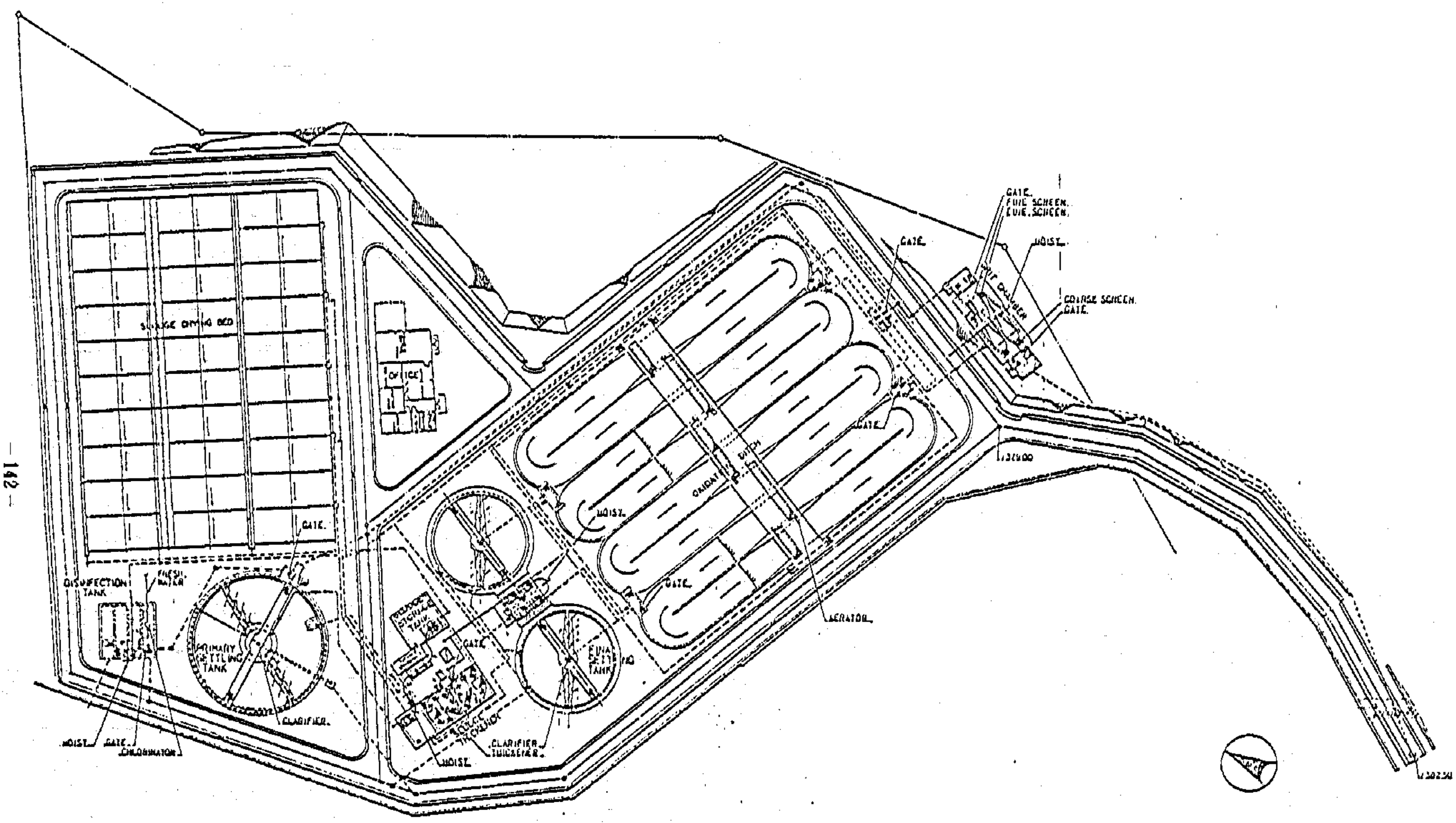


Fig. 4-26 Mechanical Equipment Layout Plan (1)-1 (Horizontal Aerator)

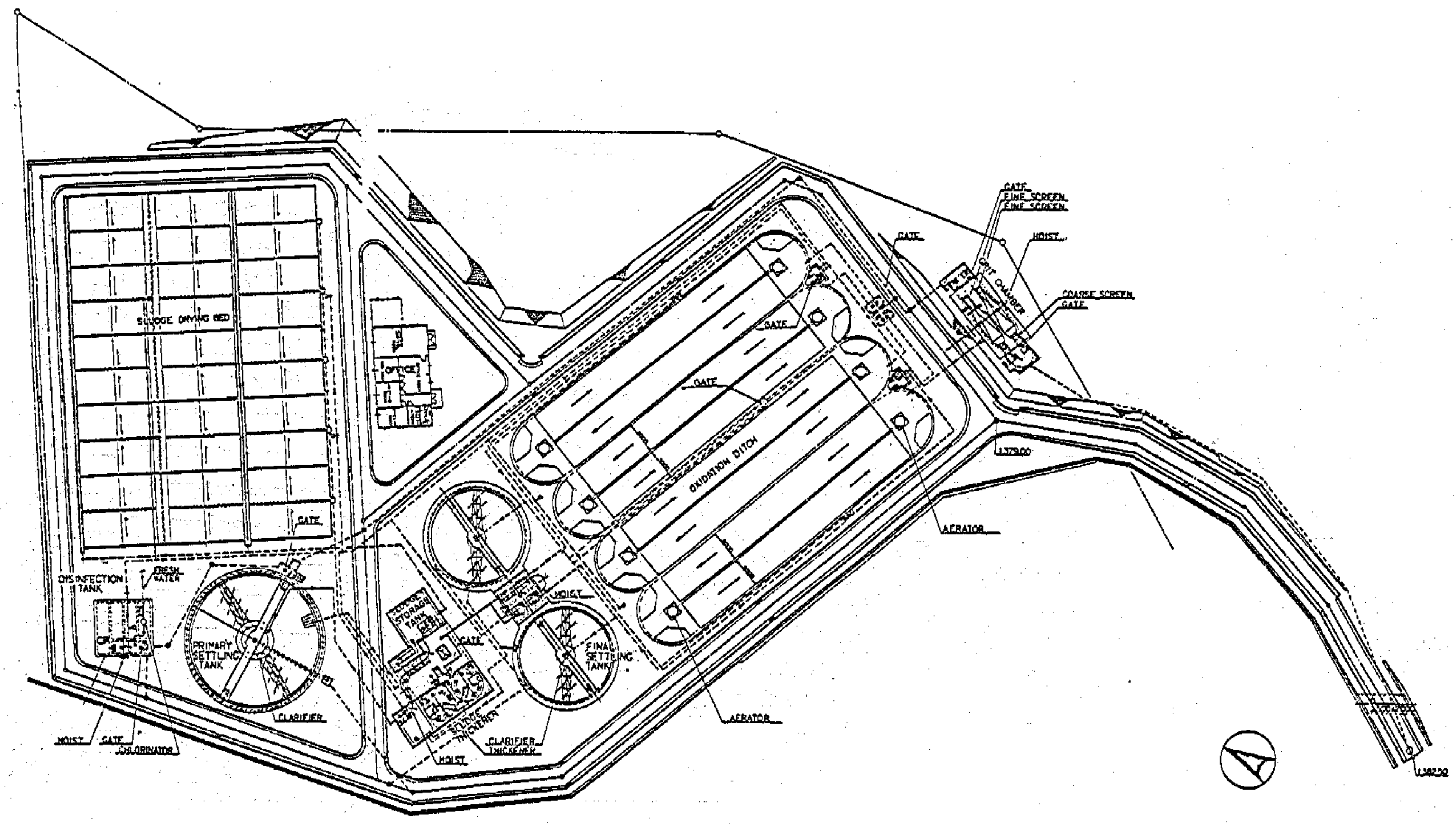


Fig. 4-27 Mechanical Equipment Layout Plan (1)-2 (Vertical Aerator)

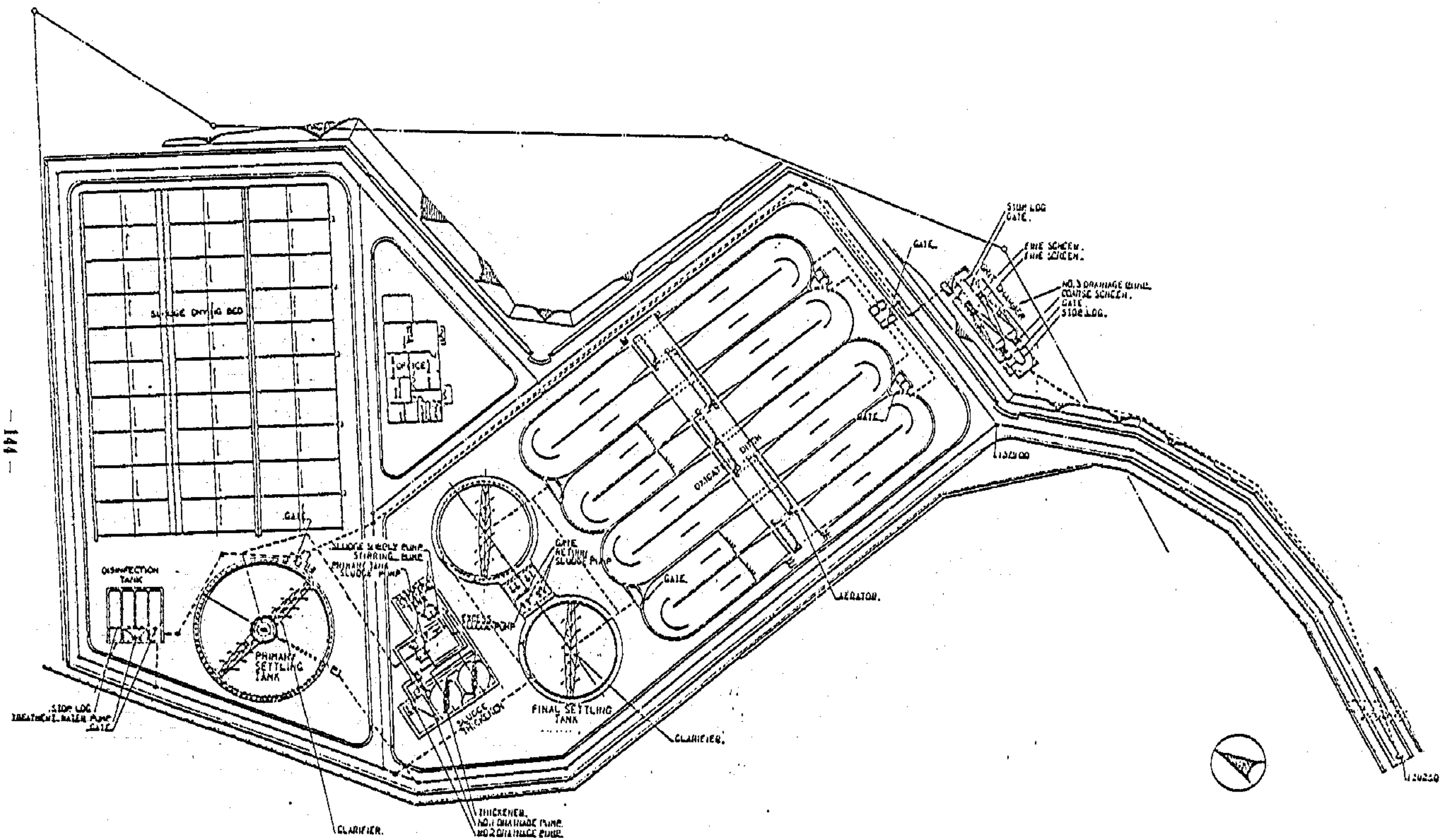


Fig. 4-28 Mechanical Equipment Layout Plan (2)

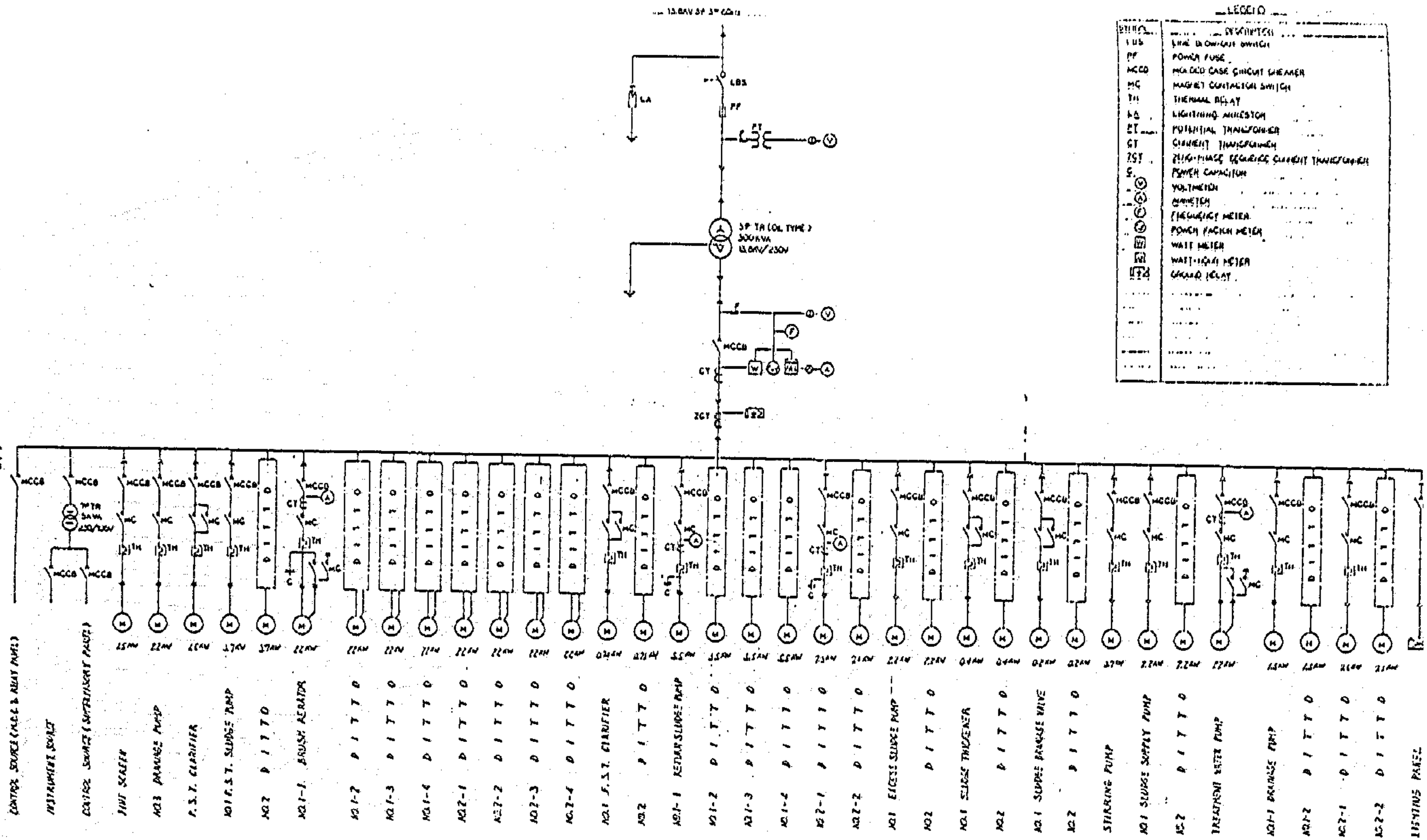


Fig. 4-29 Single Line Diagram

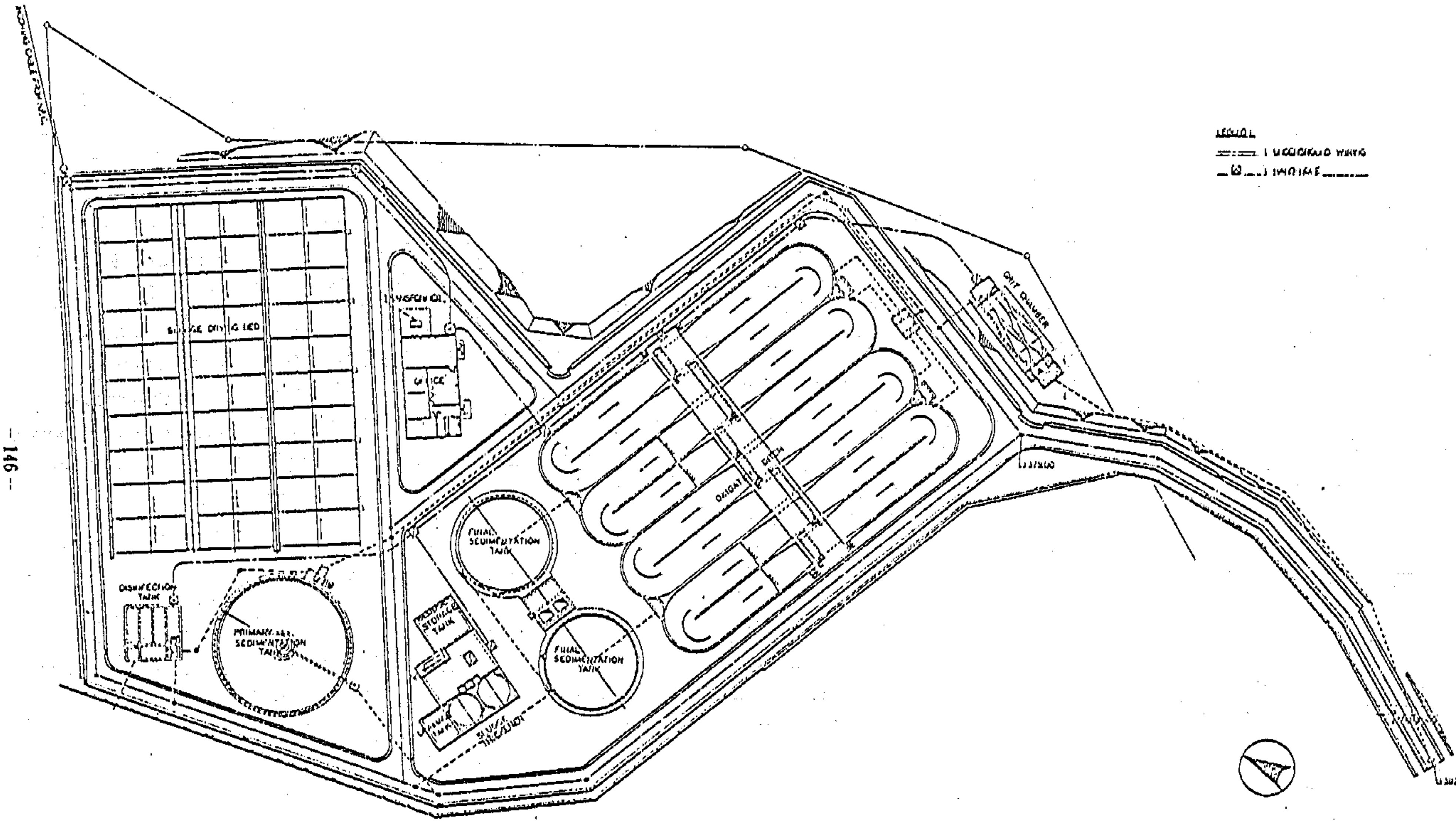


Fig. 4-30 Power Distribution Plan

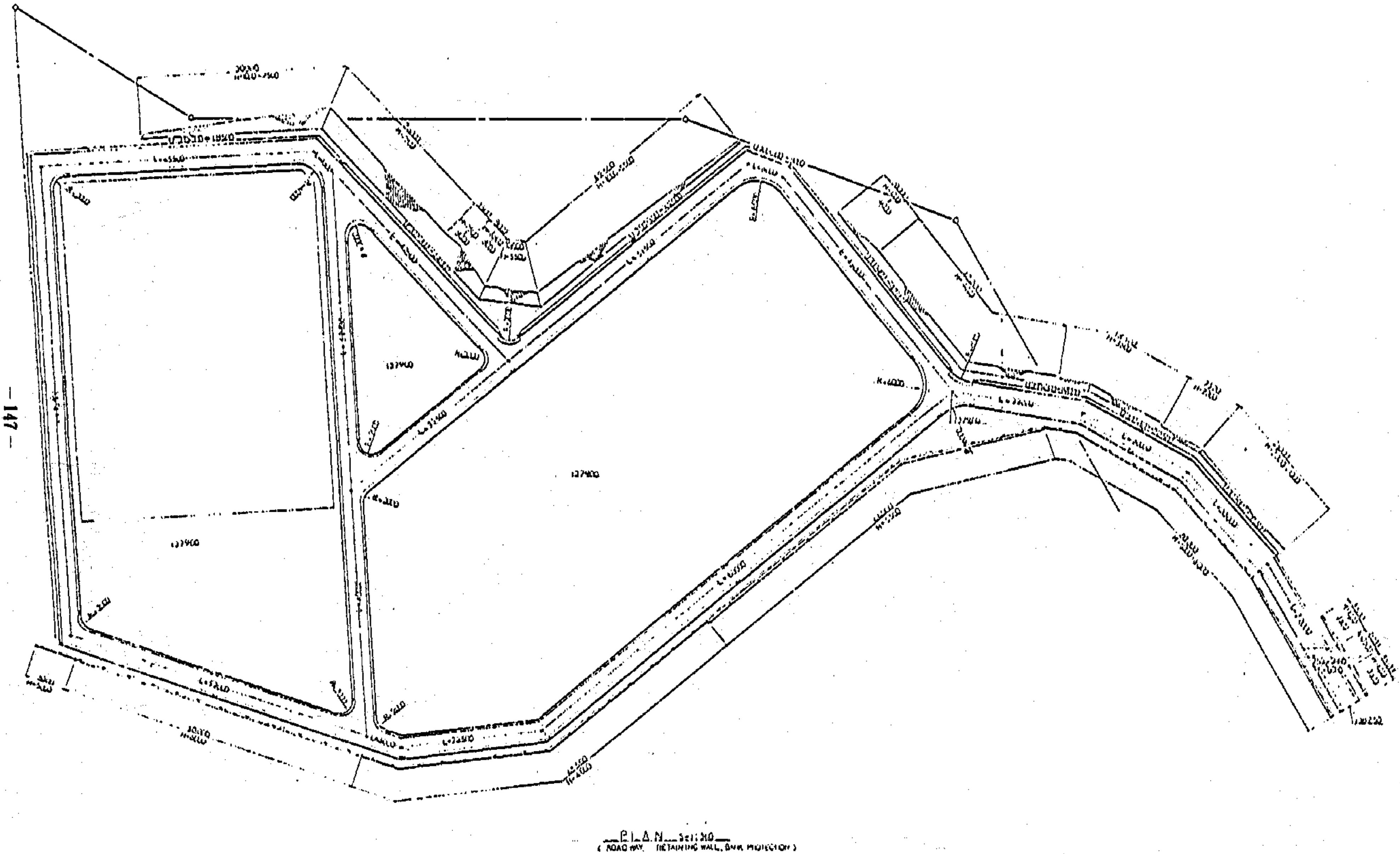


Fig. 4-31 Roadway

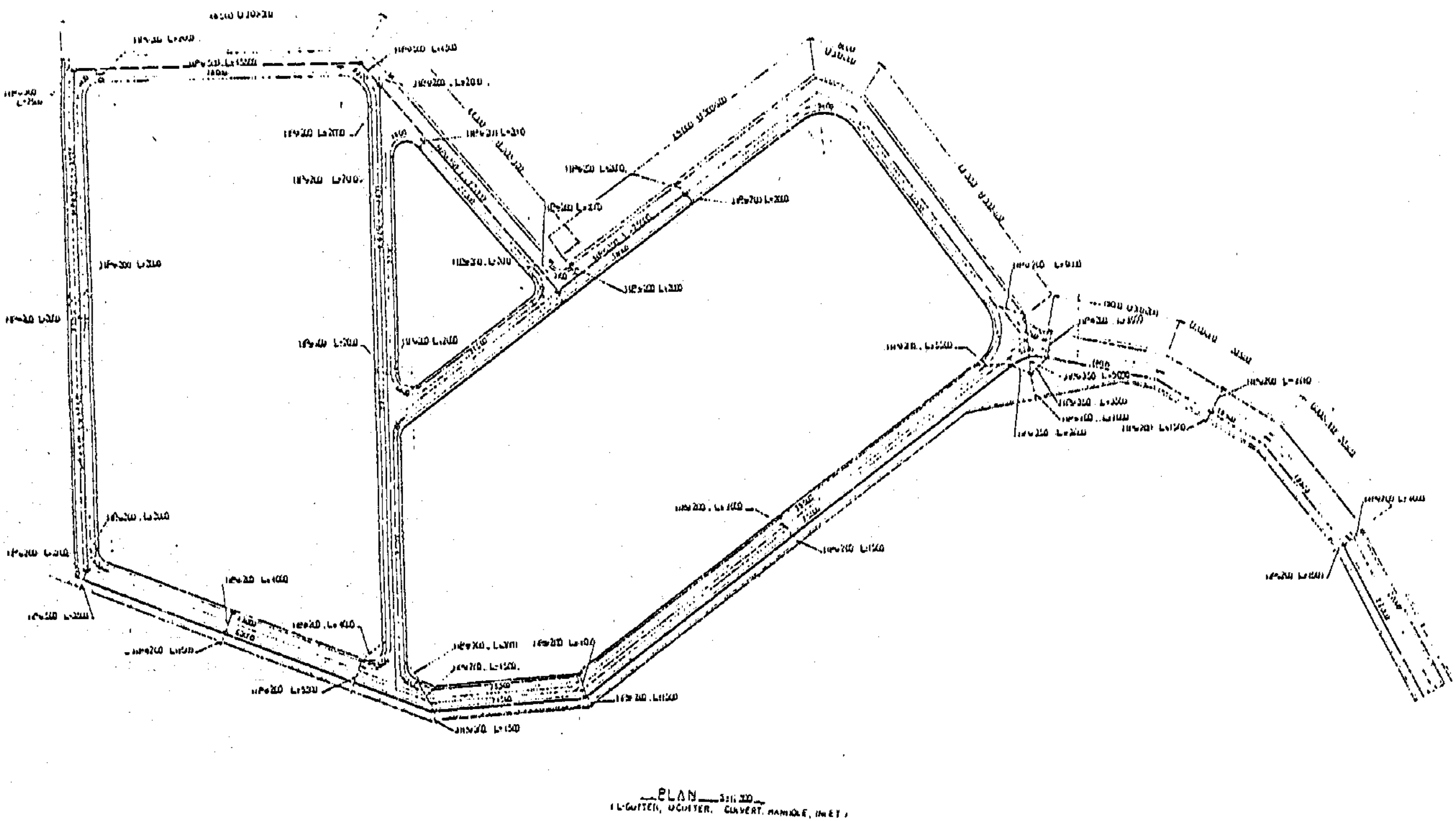


Fig. 4-32 Drainage Plan

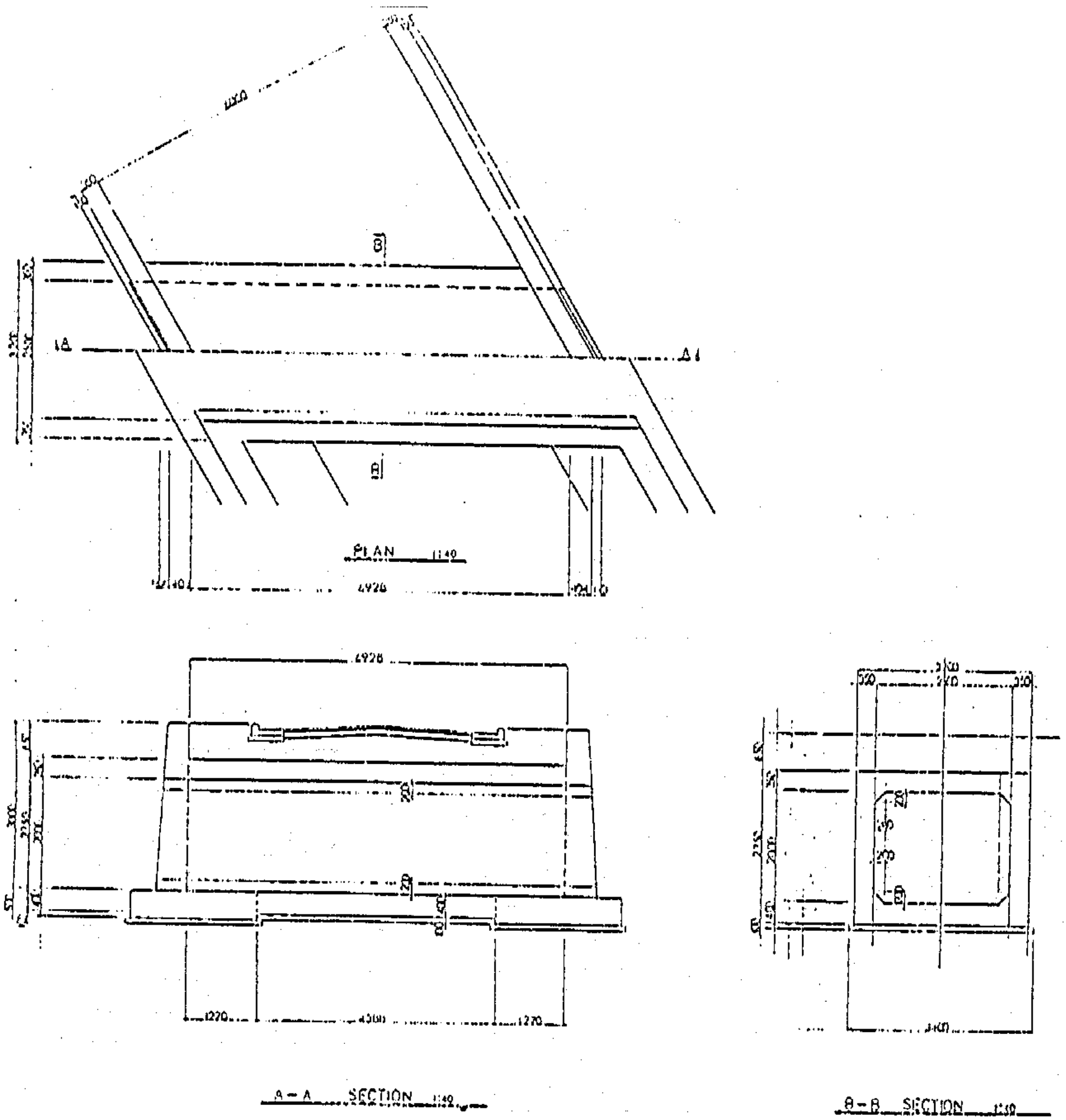


Fig. 4-33 Box Culvert

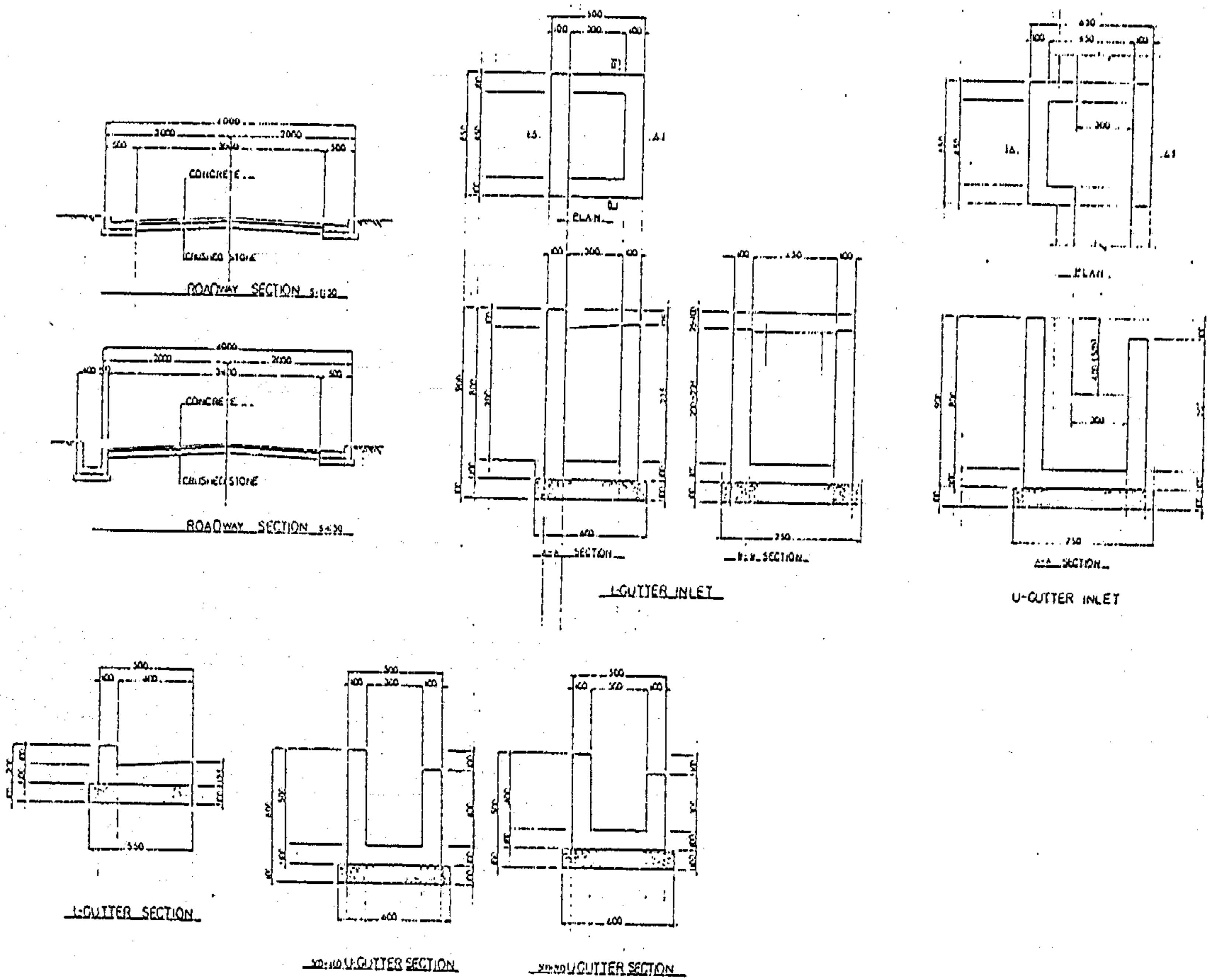
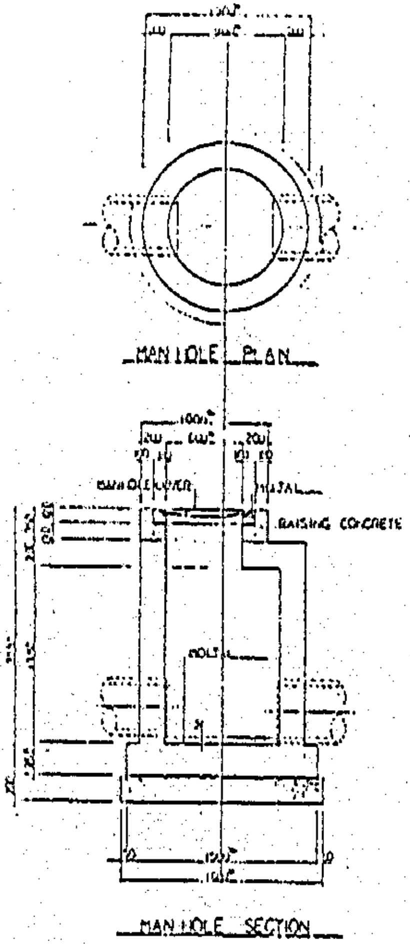
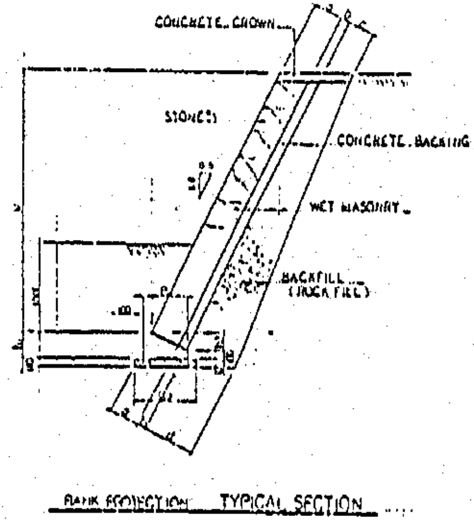


Fig. 4-34 Gutter & Roadway

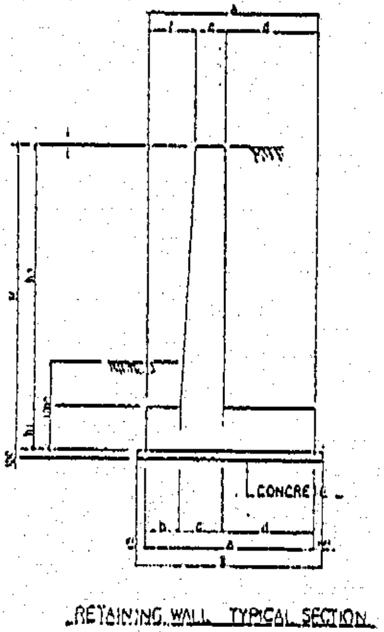




DIMENSION (mm)				
H	a	b	c	d
[illegible]	350	100	300	400
3000	350	150	250	450
4000	350	150	250	500
4500	350	150	250	[illegible]
5000	350	150	250	[illegible]
5500	350	150	250	800
6000	350	150	250	[illegible]
6500	350	150	250	[illegible]
7000	350	150	250	1000
7500	350	150	250	1050
8000	350	150	250	1100

FOUNDASION

DIMENSION (mm)				
b	h1	h2	D1	D2
100	300	[illegible]	670	720
150	360	[illegible]	650	780



DIMENSION (mm)										
H	h1	h2	a	b	c	d	e	f	g	
100~3500	500	[illegible]	310	400	600	1100	300	550	[illegible]	
4000	500	3500	[illegible]	[illegible]	[illegible]	[illegible]	300	100	[illegible]	
5000	500	4500	[illegible]	[illegible]	[illegible]	1400	[illegible]	150	[illegible]	
5500	[illegible]	[illegible]	[illegible]	[illegible]	800	[illegible]	[illegible]	[illegible]	[illegible]	
6000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Fig. 4-35 Bank Protection & Retaining Wall

CHAPTER 5

CHAPTER 5 PROJECT IMPLEMENTATION

5-1 Organization

The executing agency of this plan will be the Local Water Utilities Administration (LWUA). The LWUA is an independent government agency and has been established with the principal aim of implementing water supply and sewerage systems for provincial cities having populations of more than 20,000.

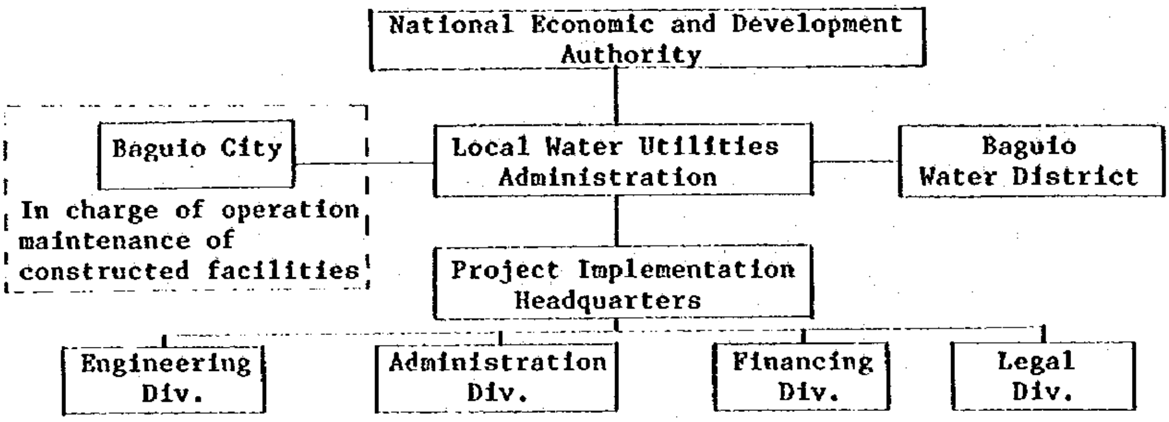
The organization for project implementation is shown in Figure 5-1. The headquarters for this project are located at the LWUA, and are composed of engineering, administration, finance and legal divisions.

The Baguio Water District will assist in operation of the proposed sewerage system and preparation of basic data on water use in the subject area.

This district is exclusively independent public enterprise set up to provide drinking water in the Baguio area. The operation of this organization is being financed by levying of water charges for an average monthly supply volume of approximately 450,000 cu.m. In addition, as a central government agency the LWUA is providing guidance and administration for the operational plan and technical matters to this public organization.

The operation and maintenance of constructed facilities are to be handled by Baguio City. The operation of this public sewerage system will be based on the collection of public sewerage system service charges.

Fig. 5-1 Organization for Project Implementation



5-2 Scope of Construction Work

Under this proposed plan, areas to be financed by the Japanese Government are the civil, mechanical and electrical works of the sewerage treatment facilities. The Philippines will shoulder the cost of land acquisition for the construction site, site preparation, necessary infrastructures, connection of main sewer to the treatment facilities, improvement of existing sewer system, and take on the responsibility for operation and maintenance of completed facilities.

(1) Scope of Construction Work to be Covered by Japan

1) Sewage Treatment Facilities (Civil Work & Mechanical/Electrical Facilities)

a) Grit Chamber
b) Primary Sedimentation Tank (utilizing existing concrete structure)
c) Oxidation Ditch
d) Final Sedimentation Tank
e) Disinfection Tank
f) Sludge Thickener

g) Sludge Storage Tank

h) Sludge Drying Bed

2) Administration Facilities

a) Administration Building

b) Water Quality Analysis Equipment & Apparatus

3) Utilities

a) Power Substation

b) In-plant Roads

(2) Scope of Construction Work to be Covered by the Philippines

1) Site Preparation

a) Removal of existing structures with the construction site and leveling excluding primary sedimentation tank

2) Infrastructures

a) Supply and connection of electricity, water, and telephone of which supply conditions are described below:

Power Supply

The required power for the proposed sewage treatment plant shall be provided by BENECO as stated on the minutes of discussion.

The facilities of its supply from BENECO's transforming substation to the site shall be constructed by Baguio City.

The outline of the facilities are listed as follows:

- Receiving Electric Capacity
  3 ϕ, 300 kVA Transformer (13.8 kV/210 V)
- Receiving electric Voltage
  13.8 kV
- Laying Method
  Flexible Hard Polyethylene Pipe
- Cable Size
  60 sq.mm x 3 c
- Power Receiving Point
  Power control room in the administrative quarter.
  Cable route inside of the site is shown in Figure 4-29.

Water Supply

As it was also stipulated on the minutes of discussion, the water supply shall be provided by Baguio City. The outline of facilities are listed as follows:

- Use
  Drinking water and miscellaneous use
- Size of pipe
  25 ϕ mm
- Location
  The pipe with a gate valve shall be installed up to the boundary line of the site.

Telephone Equipment

A local telephone circuit with a telephone and a safe guard equipment shall be furnished in the office room of the administrative quarter.

b) Provision of sites for field office of construction works and for storage of construction materials.

c) Construction of access roads

3) Inflow Pipe

4) Facilities Management

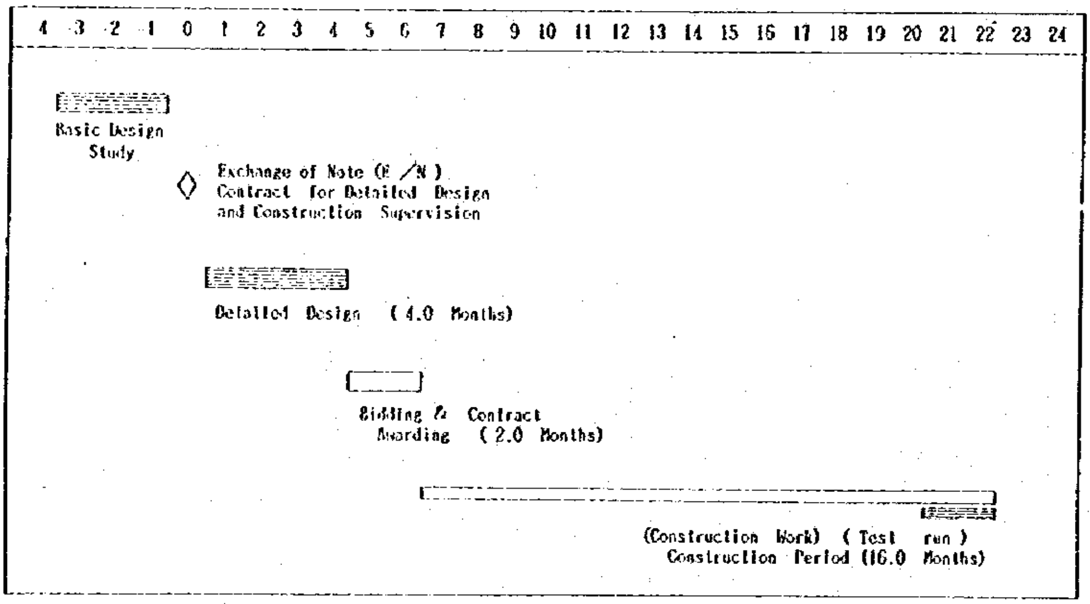
a) Operation and maintenance of completed facilities

b) Improvement of existing sewer system and further implementation

5-3 Overall Implementation Schedule

The overall implementation schedule of the proposed plan is as shown in Figure 5-2.

Fig. 5-2 Overall Project Implementation Schedule



CHAPTER 6

CHAPTER 6 OPERATION AND MAINTENANCE

6-1 Management of Facilities

The management of constructed facilities are to be handled by Baguio City. The operation of this system will be basically financed by the collection of service charge from the user of this sewage system. In case of lack of funds, however, the city has decided to make financial assistanc for its proper operation.

6-2 Operation Organization

The treatment method employed in this project is the simplest type of operation among the activated sludge treatment methods. Once the principle of activated sludge treatment method and the technique for operation and control have been acquired, it is easy to conduct day-to-day system operation.

As this sewage treatment plant is selected taking into account the ease of maintenance and operation, the following organization is recommended.

Plant Manager (1)
- Engineer in charge of operation (1)
- Specialist in charge of water quality Analysis (1)
- Laborers (3)

For the detailed description, please refer page 4-52.

6-3 Cost for Operation and Maintenance

1) Yearly running costs for operation and maintenance of the treatment facilities are estimated to be between 1,300,000 and 1,640,00 Pesos. The range of this estimate is wide because of difference in the bases of calculation : one is based on the general electri-

cal power rate for public utilities; and the other on the special charge rate presently adopted to the Baguio Water District by BENECO.

2) Since approximately 25 percent of water supply in the proposed service area of this sewerage system is considered to be consumed for commercial and service uses such as hotels and restaurants, and remaining 75 percent is for general households. Thus, the above-mentioned running costs are 975,000 Pesos to 1,230,000 Pesos for households alone according to the share of water consumption. This figure is equivalent to 8.40 to 10.60 Pesos per month per household connected to the sewer system.

3) Presently, 5.00 Pesos per month are charged to each connection as the public sewerage system service fee. Therefore, new estimated service fee will be increased up to 13.40 to 15.60 Pesos upon completion of the proposed sewage treatment plant. This is some 56 percent of monthly water rates (26.00 Pesos per faucet for a minimum 10 cu.m) and may be by no means a low price for many consumers.

Thus, it is considered necessary that the city shall pay sufficient attention to get the cooperation of the public by deepening a understanding of the importance of public hygiene and preventive system by means of official publication and others as required. As to the detailed description on the Maintenance and operation costs, please refer page 4-39.

6-4 Operation Program

(1) Normal operation

1) Grit chamber

All gates and screens etc shall be manually operated except mechanical grit removing which is driven by motor continuously.

Two grit chambers shall be provided and one is for normal use and equipment with mechanical grit remover, and another is spare for temporary use during cleaning and removal sand and deposited substance in the chamber of normal use.

Removed substance shall be delivered out of site in adequate container.

2) Primary sedimentation tank

Sludge scraper shall be operated continuously and the sludge suction pump shall be operated manually with push button and also automatically with self-timer.

The raw sludge is delivered directly to sludge thickener.

3) Oxidation ditch

Aerators are used to supply oxygen and to get flow circulation, but the aerators shall be so operated as to avoid over-aeration and to save power consumption.

- Aeration shall be operated automatically with timer and flow velocity shall be kept over 0.1/m/sec and care shall be paid not to be over-aerated due to excess supply of oxygen and also to get effective de-nitrogen action.

- Timer device shall be set "on-off" schedule for day and night time separately.

- Oxidation ditch shall have movable weir and the water level in the ditch can be adjusted.

In case of small volume of inflow, the water level is lowered to decrease the load to aerator and to save the power.

4) Sludge of final sedimentation tank

Sludge scraper shall also be operated continuously same as primary sedimentation tank.

Withdrawal of sludge is done by both return sludge pump and excess sludge pump. Both of them shall be operated manually with push button and automatically with timer as well.

The sludge shall be returned at a rate of 50 to 200% of the influent flow rate so as to maintain the optimum MLSS (Suspended-liquor Suspended Solid) in the ditch.

The excess sludge shall be withdrawn automatically with timer considering inflow rate and consistency of sludge.

The excess sludge shall be delivered directly into sludge thickener.

5) Disinfection tank

Effluent of treated water from the plant shall be disinfected with calcium-hypochlorite.

There are two forms of calcium-hypochlorite, granule and powder.

Granular form shall be put in a basket and hang into the water allowing natural dissolving.

In case of powder, powder is dissolved with water in the tank and fed automatically at constant rate.

The selection of form of disinfectant is the choice of the city authority considerating the procurement.

The feeding rate is about 3 to 5 ppm as Cl of effluent rate.

6) Sludge treatment

Raw and excess sludge is delivered to the sludge storage tank by gravity after being concentrated in the thickener tank.

Withdrawal of sludge from thickener shall be operated automatically with timer, scraper of sludge thickener and agitator pump of sludge storage tank shall be operated continuously.

The sludge from sludge storage tank to drying bed is conveyed by pump of manual operation with push button.

7) Electrical facilities

The basic idea for electrical facilities are :

- All equipments are operated by local panel (post type) located at vicinity of respective equipment.

- The status of equipments - running, stop or out of order - are indicated on the monitor panel with alarm system in the electric control room.

(2) Necessary Consideration for Plant Operation

To alleviate the burden of beneficiaries, every efforts to reduce the maintenance and operation cost should be always made. The following ways are considered.

1) At the initial operation

At the initial operation, the sewage inflow rate into the sewage treatment plant, which depends on the improvement of the existing sewer system, is expected to be much lower than the planned sewage flow, or the treatment capacity of the plant. In such case, it is useless to operate all of equipment, and partial operation of required equipments corresponding to the flowrate is recommended to reduce power charge and other expense.

2) During the rainy season

During the rainy season, the sewage flow is predicted to increase due to the inflow of storm which enters into the sewer through cracked pipes, defective joints, faulty manholes and submerged manhole covers. When such increased sewage flow enter into the oxidation ditch, the activated sludge in the ditch is feared to be flushed out. Since the river flow also increases during the rainy season, it is advisable that sewage inflow into the ditch shall be restricted to such amount as necessary to maintain the proper rate of activated sludge and surplus sewage be by-passed to the disinfection tank after the sedimentation treatment in the primary sedimentation tank.

3) Disinfection

The disinfection of water is rarely implemented even for water supply in the Philippines. Since the river itself is contaminated during the rainy season, the disinfection of the treated sewage is not so effective. It is worth considering to do a disinfection during rainy season only at the occurrence of the epidemic diseases.

(3) Handling and Disposal of Excess Sludge

The drying of the sludge is a combination of two processes, that is, infiltration and evaporation. The daily average volume of dried sludge or sludge cake is estimated to be 1.23 ton as dry solids and 5.6 cu.m as sludge with a moisture content of 78%. The dry sludge is generally used as fertilizer and soil improving admixture of agricultural use and/or disposed for reclamation, etc.

Baguio City is responsible for the disposal of dried sludge as well as the acquirement of the appropriate site for land disposal.

The element of organic matter in the sewage sludge mainly consist of suspended matter in waste water and cell and/or remains of bacteria in the activated sludge. And so, these dried sludge is easily decomposed by the action of bacteria and may affect adversely to the crops.

Therefore, careful study and preliminary investigation are necessary before using the dried sludge itself as fertilizer.

In Japan, there are some cases of using dried sludge as fertilizer and/or soil improving admixture for citrus fruits, but in most case, sludge is processed to compost.

The major purpose of processing to compost can be stated as following three points.

1) Decomposition of organic matter

As there exist lot of easily-decomposable organic matter in the sludge, these organic matter is decomposed rapidly and cause the lack of oxygen in the soil and also newly created organic matter may result to the poor germination and root rot of crops.

Therefore, it is necessary to stabilize by decomposing the organic matter in the sludge in the process of compost.

2) Elimination of pathogene, parasite's eggs and weed's seeds

As the sludge may contains above-mentioned noxious matter, elimination of these matter and non-activation is necessary in order to be used for agricultural purpose.

3) Improvement of handling convenience

The average moisture content of de-watered sludge by drying bed method is 75 - 80% and difficult to handle easily, unstable in quality and also has an offensive odor problem due to putrefaction.

To solve these problems, the processing to compost is very useful to lower the moisture content, stabilize the organic matter and improve the handling convenience and storage easiness.

6-5 Laboratory Equipment

The laboratory equipment, as shown in Table 6-1, so as to be able to analyse the following water quality items is provided.

(1) Water Temperature, Atmospheric Temperature
(2) Appearance
(3) Transparency
(4) Odor
(5) pH
(6) Total Evaporation Residue or Total Solids (TS)
(7) Ignition Residue (IR)
(8) Ignition Loss (IL)
(9) Suspended Solids (SS)
(10) Dissolved Matter
(11) Settleable Solids
(12) Alkalinity
(13) Acidity
(14) Dissolved Oxygen (DO)
(15) Oxygen Saturation Percentage
(16) Biochemical Oxygen Demand (BOD)
(17) Relative Stability
(18) Chemical Oxygen Demand (COD)
(19) Ammonia Nitrogen (NH_4-N)

(20) Nitrite Nitrogen (NO_2-N)

(21) Nitrite Nitrogen (NO_3-N)

(22) Phosphate

(23) Chlorine Ion (Cl^-)

(24) Sulfate Ion (SO_4^-)

(25) Iodine Consumption

(26) Sulfide

(27) Residual Chlorine

(28) Chlorine Requirement

(29) Anionic Surfactants

(30) Color

(31) Coliform Group Bacteria

(32) Biological Examination

(33) Mixed Liquor Suspended Solids (MLSS)

(34) Organic Suspended Solids in Activated Sludge

(35) Sludge Volume - 30 min. (SV-30)

(36) Sludge Index

Sludge Volume Index (SVI)

Sludge Density Index (SDI)

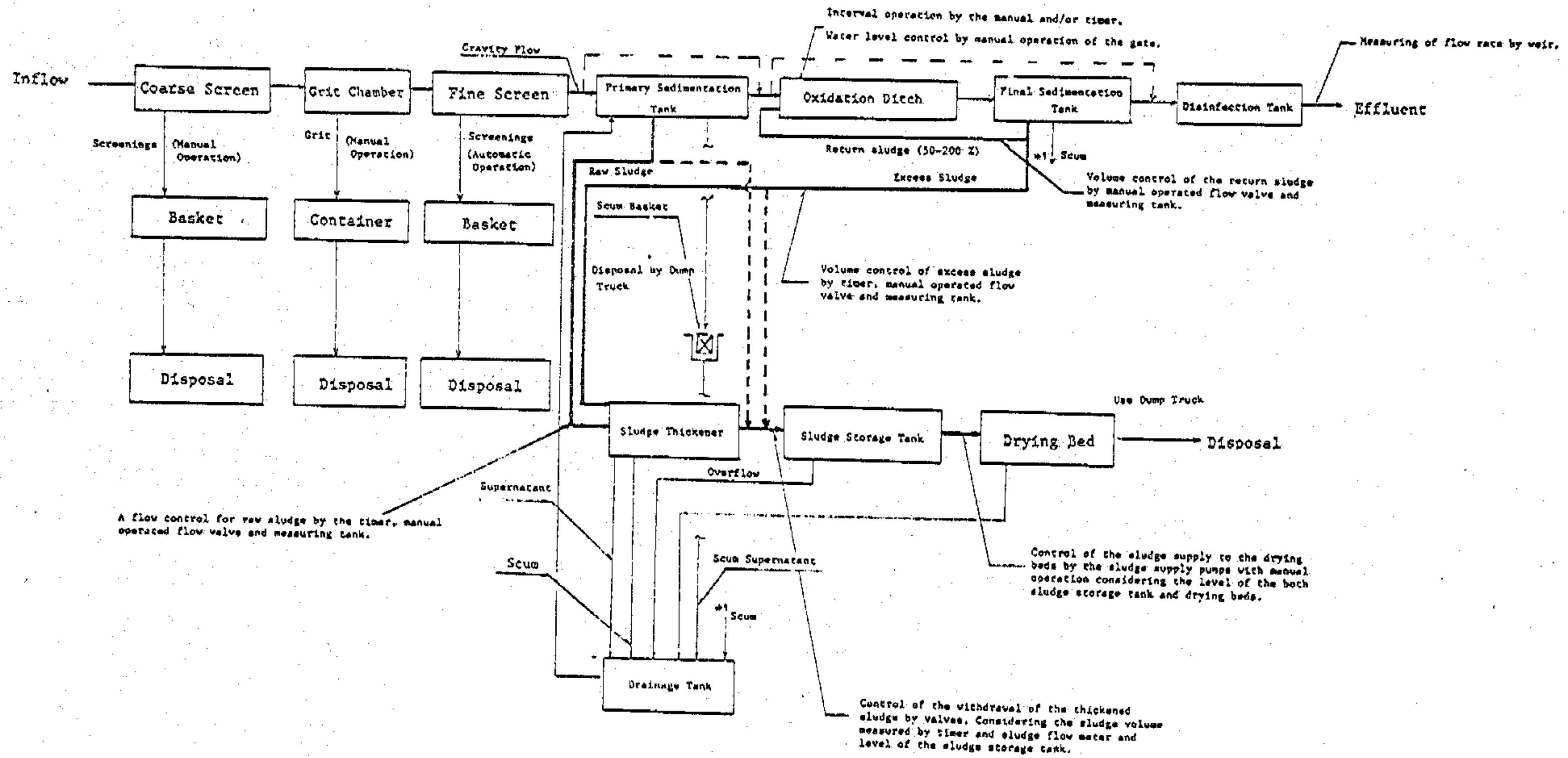
(37) Mixed Liquor Dissolved Oxygen (MLDO)

(38) Oxygen Utilization Rate

Table 6-1 List of Laboratory Equipment

Name	Quantity
(1) Drying Shelf	1
(2) pH Meter	1
(3) Spectrophotometer	1
(4) Drying Oven	1
(5) Analytical Balance	1
(6) Rough Balance	1
(7) Pure Water Generator	1
(8) Electric Hot Plate	1
(9) Bacteria Incubator	1
(10) Electric Water Bath	1
(11) Hot Air Sterlizing Oven	1
(12) Autoclave	1
(13) Colony Counter	1
(14) Magnetic Stirrer	2
(15) Bunsen Burner	2
(17) BOD Meter Incubator Unit with Water Bath	1
(18) Microscope	1
(19) Glasswares & Supports	1 set
(20) Chemical Reagent and Consumable Goods	1 set

Fig. 6-1 Flow Diagram of the Operation System



CHAPTER 7

CHARPTER 7 PROJECT EVALUATION

With regard to the propriety and assistance effect of this project, study and consideration is made from the following stand points.

7-1 Diminution of Contamination of Water Quality of Balili River and its Effect

1) The significance of improving the sewage system.

The sewer piping system in Baguio City was installed long time ago, but the waste water has being discharged into the river without any treatment because there is no treatment facility. Therefore, Balili river has been greatly polluted with this sewage and this problem on the environmental public pollution is the main reason and the background of the request for this project.

Upon completion of this project, the long pending problem since the lawsuit against Baguio City by the La Trinidad city which is situated downstream of Baguio City and strongly claiming the improvement of water quality of Balili River will be settled.

2) Reduction of pollution of water quality and settlement of a law-suit

The treatment method of this plant is one of popular sewage treatment system in Japan and treated water quality is stable and expected to be 20 to 30 ppm for BOD and under 30 ppm for SS meeting the sanitary requirements. However, when considering the public pollution, great attention shall be paid for the mental element of the problem. The river water is utilized for the irrigation of vegetable in La Trinidad and they have been complaining that the market of vegetable is considerably reduced by the reason of river pollution. The completion of treatment plant won't always solve the all problem.

The city authorities must make utmost effort not only to operate the plant safely and reliably but also to pay big attention for the understanding of public sufferer with sufficient explanation and zeal standing on their place.

7-2 Study on the Capacity of the Facility

This project covers the watershed of Balili river within the present sewage service area of Baguio City and the target year is set at 1986 when the project is scheduled to be completed. The capacity was carefully studied not to be overcapacity due to uncertain long term schedule and forecast.

As the present status of sewage system of the city is badly deteriorated and damaged, and also management and maintenance is not adequate, the sewer drainage system using existing piping network without improvement is not practical and effective because of its extreme inefficiency. The improvement and development of the existing sewer system is essential to the effectiveness of this project. Although the execution of this improving works of piping system is the responsibility of Baguio City, the scrupulous investigation of existing status and consultation with the city authority have been made, and the collection ratio of sewage was set at 80% and the design criteria were studied accordingly.

This ratio seems to be adequate and improving work of piping system is considered not to be the excessive financial burden to the city.

CHAPTER 8

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS

For implementation of this plan, following recommendations are presented to both governments of Republic of Philippines and Japan:

1) It is desirable that the Philippine government would make technical guidance regarding the operation, maintenance and management of the sewage treatment system and also take into consideration for the budget for the renewal of equipments and others for the Baguio City.

2) The sewage system functions effectively in good combination of both piping system and treating facilities.

   Therefore, the Philippine government is advised to make positive technical assistance to the Baguio City for the reconditioning and improvement of its sewer piping system. In addition to this, please refer to the comments stated in the end of this chapter regarding urgent problems of improving sewer piping system.

3) Though the transfer of technology and training on the operation and maintenance of this plant, will be made during construction and test run period, these training is too short to transfer the necessary technology and also it is impossible to train properly in accordance with the different conditions of dry and rainy seasons in Baguio district.

   In this connection, it is recommended to both Philippine and Japanese Government to consider and realize on-the-job training program before the completion of this project.

Comments on the Required Measures Concerning the Existing Sewer System

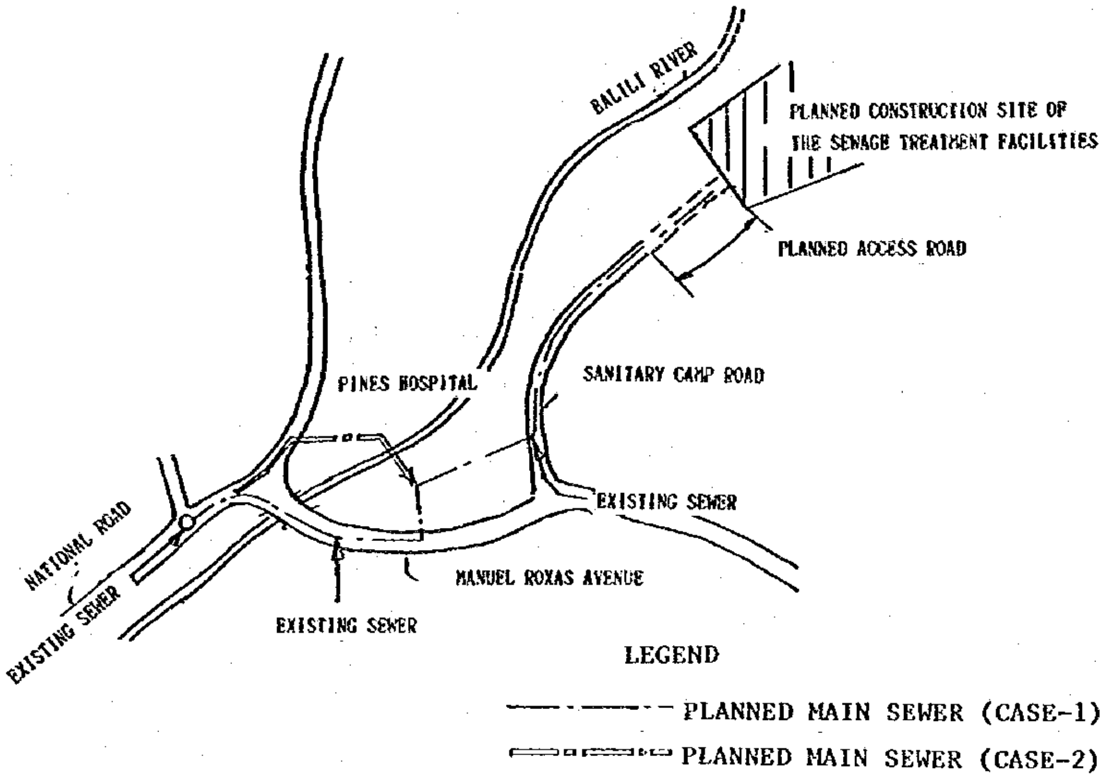
(1) Construction of main sewers to connect existing sewers to the planned sewage treatment plant

Since the main sewers downstream near the Balili river are damaged/clogged as observed through the field survey, new sewer main pipes should be constructed at least for the section from the junction point of Manuel Roxas Avenue and national road to the sewage treatment plant, an approximate distance of 650 m (see Figure 8-1). A complete sewerage system will be established connecting three existing main sewers, which convey sewage collected in the entire sewered area of the basin to the new sewers in its course.

Two possible routes for the new main sewers after the point where they enter Manuel Roxas Avenue were determined referring to the field survey and discussion with city staff members. One is the route which runs in an easterly direction through asphalted Manuel Roxas Avenue past the private road toward the north as far as Sanitary Camp Road. Upon entering Manuel Roxas Avenue, the sewer will cross the Balili River by means of water pipe bridge. The other route follows existing sewers along the National Road on the left bank of the Balili River as far as Pines Hospital and crosses the Balili River aerially to get to Sanitary Camp Road. The selection of the route should be made on the basis of the availability of existing sewers and the possibility of acquiring the required land rather than on that of construction costs, which are comparable.

After passing Sanitary Camp Road, the planned new sewer should be constructed under the planned access road with a section of length 50 m to connect to the sewage treatment plant. It was recommended that a gravity type R.C. main sewers should be laid with a diameter of 600 mm and slope of 2.5 % to accommodate a planned hourly maximum flow of 0.199 m^3/sec. Approximate direct construction costs were estimated at Peso 1,500,000 (see Appendix 4). It is recommended that a more detailed survey be made for the implementation of the construction work by the city with technical assistance by the LWUA.

Fig. 8-1 Possible Route of New Main Sewer



Sewage generated from the area situated between the northern part of Manuel Roxas Avenue and National Road cannot be collected by means of gravity type sewers to the sewage treatment plant. The city government must study and decide the measure for the area with the option of constructing a small pumping station or septic tank, thereby establishing a small sewage treatment area.

(2) Improvement and expansion of existing sewer system

Most creeks have become sewers as a result of the clogging/leakage of major sewers as described in the section "Situation of Existing Sewer System and Water Pollution in the City". It is recommended that cleaning and improvement of sewers be provided immediately in the area within a radius of one kilometer from the junction point of National Road and Magsaysay Avenue. With regard to the work to be implemented for completion of the upcoming project, Baguio City explained its intention to take necessary action with technical assistance from the LWUA through a meeting with those people concerned.

With reference to the city budget, improvement/expansion of sewers should be proceeded with with effective sewage collection as a priority, even using existing sewers as necessary. It is also recommended that the following method of pipe-laying and kind of sewers be adopted/used to prolonging the life of the sewerage system.

* Method of sewerage pipe-laying for main sewers

  In view of the topographical characteristics and economic conditions of Baguio City, pipes in all areas are not necessarily to be laid under roads as in Japan. However, main sewers should be constructed under the road with the required earth cover. In addition, distances between manholes for maintenance of the sewer systems are to be reduced and manhole covers are to be improved even if this is costly.

* Kind of sewers

  Concrete pipes without reinforcement less than 10 inches in diameter are available in the Philippines. These pipes may be used for branch lines but R.C. pipes should be used for main sewers to bear load under major roads.