(6) Cover stone

Stone pieces used as cover stone is cast in the sea with the use of gut boat and bottom-openable barge laid on the outer side of the bulkhead. Diver workers go on surfacing cover stone by using a winch equipped on the diving boat.

(7) Estimation of required number of main machines

a. Determination of work period

In determining the work period for construction of rubble type bulkhead, it is necessary to consider the required number of machines to be used, the contents of work, operation efficiency and so forth. In view of the huge volume of rubble requirement of about 4,679,000 $m^3$ and the number of dump trucks available being approximately 50 to 60, the calculation is made on the assumption that the work period is 2.5 years and working day rate 25 days/month, and that the working hours on the land is 12 hrs/day and those of off-shore workings 10 hrs/day.

b. Number of machines to be used

The number of the main machines required on the above-mentioned conditions are estimated as shown in the following Table 10-6.

10.3.3 Work Plan for Construction of Corrugated Cell Type Bulkhead

(1) Work of rubble foundation

Rubble is used as corrugated cell foundation material. The bottom of corrugated cell is on DL-5m, and it will not be affected much by the force of waves. For the stability of the cell, the rubble sideslope gradient is specified to be 1:1.75. In regard to the production and on-land transportation of rubble and temporary pier, descriptions are given in the section "rubble type bulkhead".

The rubble carried to the temporary pier is transported by bottom-openable barge and cast in the place. As casting of rubble is made to DL-5m, the work is all performed by the barge and the gut boat is used for shaping sideslope faces.

Table 10-6 <u>Main Equipments for Rubbles Bulkhead</u>

| Spec. / Name | Specification | Quantity | Capacity | Number | Period | Remarks |
|---|---|---|---|---|---|---|
| Wheel Loader | 2.0 $m^3$ | 4,679,000 $m^3$ | 605 $m^3$/D | 11 | 30 months | |
| Dump Truck | 20 t | 4,679,000 $m^3$ | 104.4 $m^3$/D | 60 | 30 " | |
| Bulldozer | 10 t class | 2,001,000 $m^3$ | 55.5 $m^3$/Hr | 4 | 30 " | |
| Bottom Open Barge | 300 $m^3$ 34mx9.0mx2.9m | 2,182,000 $m^3$ | 2,250 $m^3$/D | 2 | 19.4 " | deeper than 5 m |
| Carrier with Grab bueket | 300t, 150 $m^3$ 30mx4.1mx2.6m | 496,000 $m^3$ | 750.0 $m^3$/D | 2 | 10.6 " | shallower than 5m |
| Diver | Dry Diving | 41,800 $m^3$ | rough leveling 30 $m^2$/D | 10 | 5.6 " | |
| Survey Boat | 30 PS | - | - | 1 | 30 " | |
| Supervision Boat | 30 PS | - | - | 2 | 30 " | Combining with plying boat |

Taking into account the rubbles caught in sand bed, the volume of rubbles to be used is estimated at 20% larger than the designed volume, that is

$$1,636,000\ m^3 \times 1.2 = 1,964,000\ m^3$$

(2) Work of corrugated cell

When setting to the construction of bulkhead to be built up to DL - 5.0 m, a cell assembly and shipment yard is prepared. The area of this yard should be large enough for the assembly of at least the number of cells to be installed in one day. Four cells can be carried and installed offshore a day. A yard with an area of 1,000 $m^2$ should be prepared on the shore of which, 500 $m^2$ is for five cells. Four cells plus one and another 500 $m^2$ to be used as materials stock yard or for other purposes.

For shipment of cells from the yard, they are loaded on a 120 ton pontoon by means of 15 ton lifting crane. The pontoon loaded with 2 cells aboard is carried to the construction site, towed by a 45 HP tug boat. If it is assumed that the boat runs at a rate of 5 kt or an average distance of 2.5 km a day, it can take the transportation two times a day.

From the pontoon which have arrived at the site, cells are lifted by a floating crane and installed as they are on the leveled bank foundation. In installation, the cells are combined on the joint sections under the guidance of a diver worker and based on the measured centerline data. Upon completion of cell installation, filler sand is charged in the cells by the use of a pump boat. The steps of operation are successively followed to elongate the cell line as far as to the planned point. Along with this cells installation work, cover stone is laid on the upper part of the cells. As cover stone, a weight of about 500 kg/ea. are used to ensure retention of the filler sand in the cells. Cover stone carrier boat travels the same course as that of rubble transportation. The work method is shown in Fig. 10-16 flow chart, Figs. 10-17 and 10-18.

(3) Determination of work period

Assuming that rubble is cast by bottom-openable barge (described in 10.3.2), the work period to build rubble bank's (1,964,000 $m^3$/2,250 $m^3$/ barge a day) is 17.4 months.

Including this period, the work period to assemble and install cells in parallel with the rubble casting work is estimated at 25 months.

(4) Principal Mterials and Equipment

Principal materials and equipment required for bulkhead by corrugated pipe cells are shown in Table 10-7 and 10-8.

Fig. 10-16 Working Flow of Bulkhead by Corrugated Pipe Cells

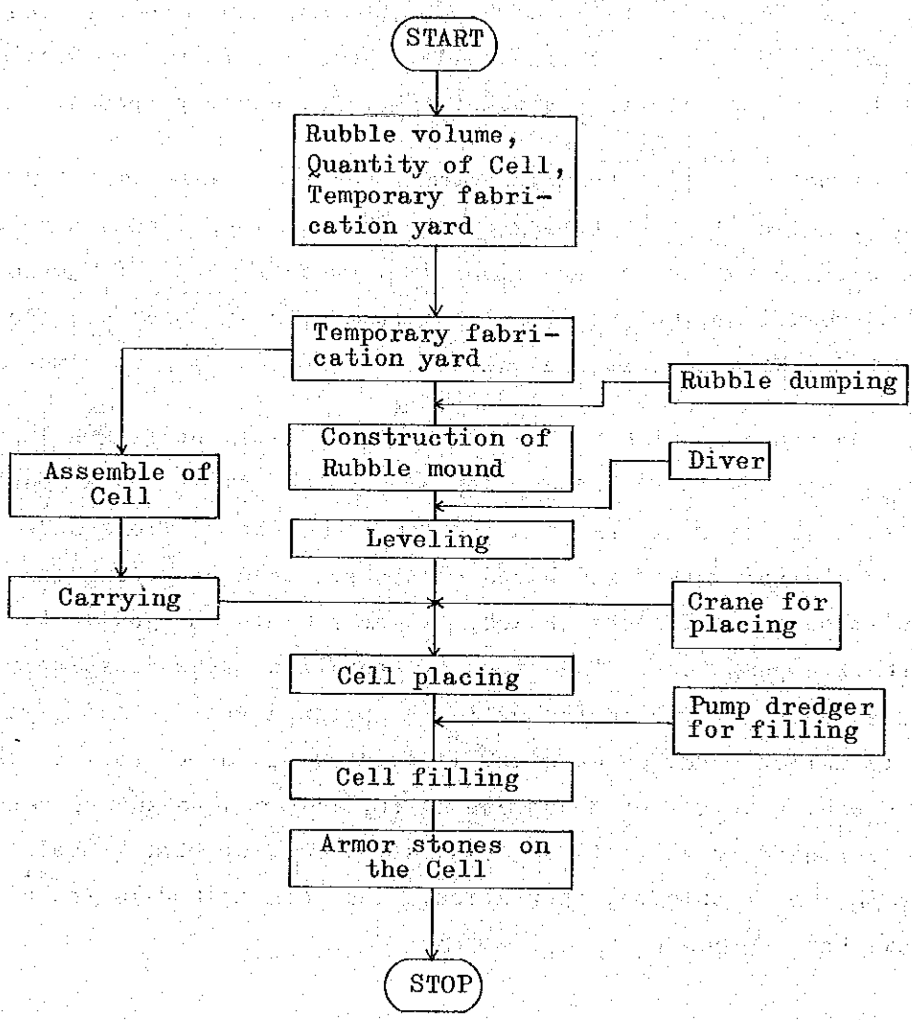


Fig. 10-17 Stage of Corrugate Cell Construction

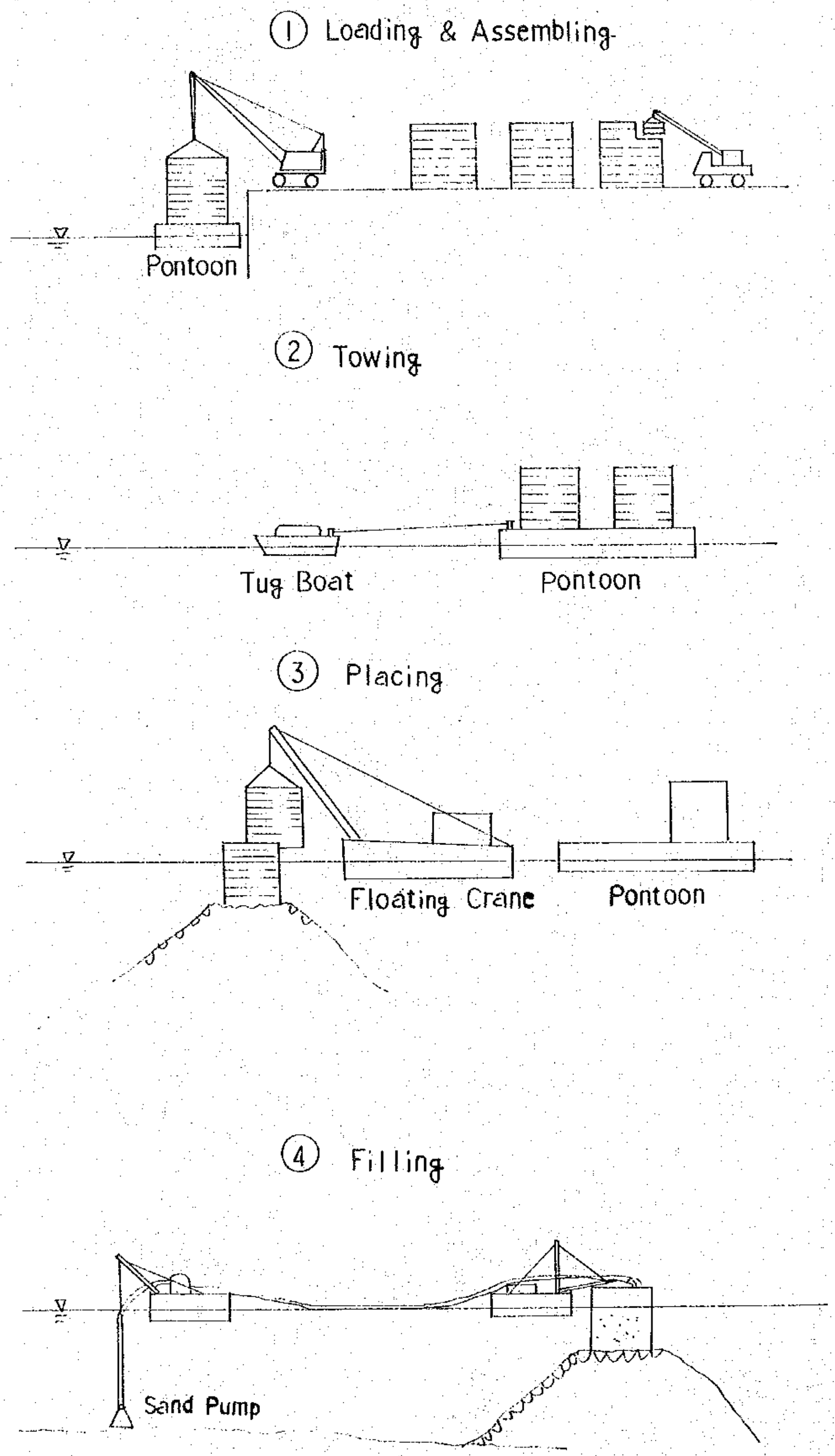


Fig 10-18 Bulkhead by Corrugated Pipe Cells

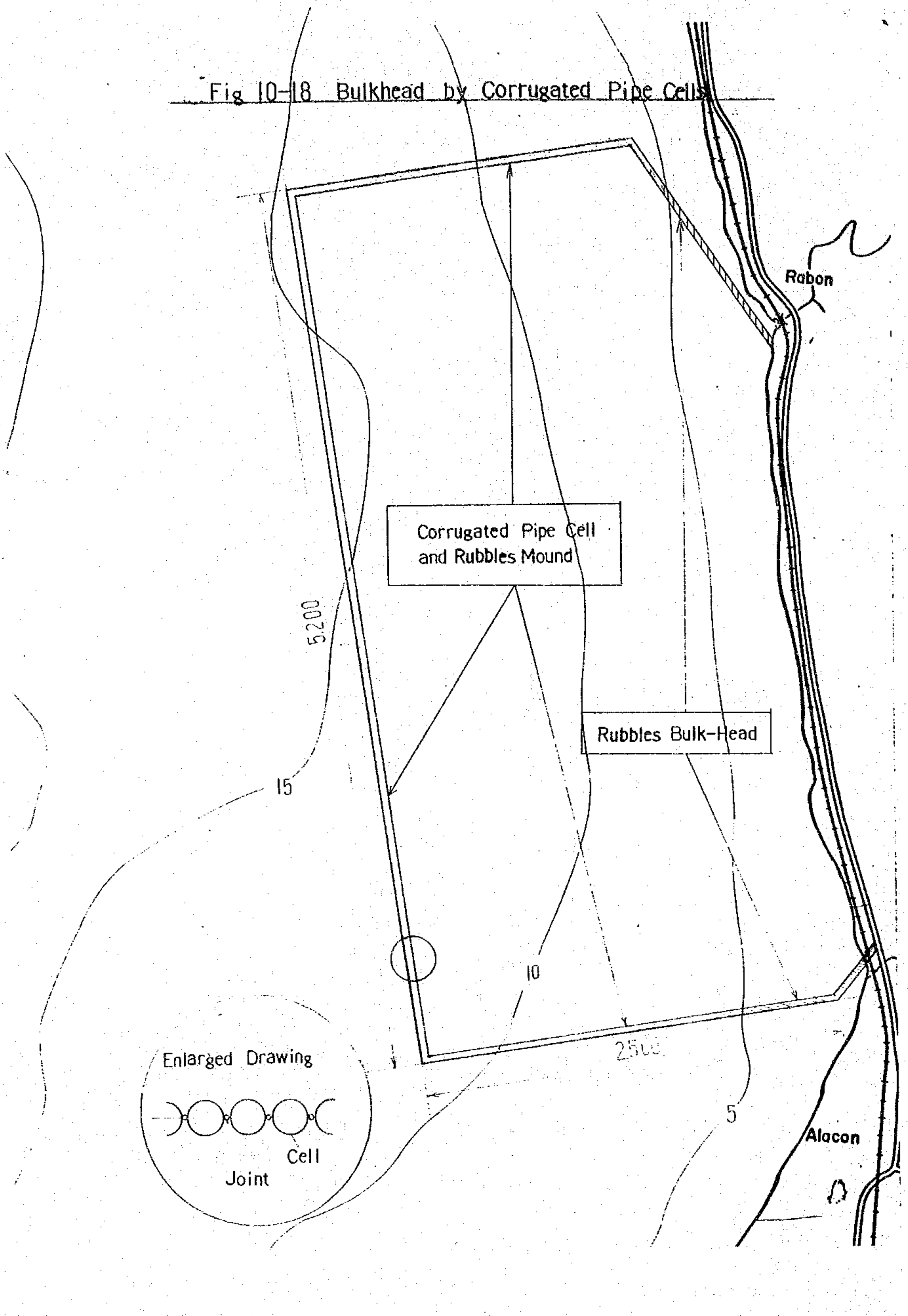


Table 10-7 Principal Materials of Bulkhead by Corrugated Pipe Cells

| Item \ Materials | Specification | Quantity | Remarks |
|---|---|---|---|
| Corrugated Cells | Ø = 7,720 mm<br>h = 7,750 mm | 957 pcs | |
| Rubble | 50 - 50kg/each | 1,964,000 $m^3$ | |
| Armor Stone | more than 500kg/stone | 22,400 $m^3$ | |
| Filling Sand | | 371,000 $m^3$ | |

Table 10-8 Principal Equipment Required for Bulkhead by Corrugated Pipe Cells

| Item \ Spec. | Specification | Quantity of works | Capacity | Number | Period | Remarks |
|---|---|---|---|---|---|---|
| Truck Crane | 10 t | 7,281 pcs | 2 pcs/day | 2 | Months 9.6 | Assembling |
| Truck Crane | 1 t | " | 2 " | 1 | 9.6 | " |
| Floating Crane | 15 t | " | 4 " | 1 | 9.6 | Carrying, Placing |
| Tug Boat | 40 HP | " | 4 " | 1 | 9.6 | " " |
| Deck Barge | 120 t | " | 4 " | 1 | 9.6 | " " |
| Plying Boat | 15 HP | " | 2 " | 2 | 9.6 | " " |
| Pump Dredger | 250 HP | 371,000 $m^3$ | | 1 | 9.6 | " |
| Bottom Open Barge | 300 $m^3$ | 1,964,000$m^3$ | 2,250$m^3$ " | 2 | 17.4 | Rubble Bulkhead |
| Carrier with Grab Bucket | 300 t<br>150 $m^3$ | 22,400 $m^3$ | 750$m^3$ " | 1 | 17.4 | Top of Cell - protection |

### 10.3.4 Construction Plan of Tailings Type Bulkhead

(1) Outline of working method

The tailings type bulkhead is constructed by extending the two pipe lines from the shore in such manner to enclose the reclamation land from the two ends of the pipeline installed beforehand along the seashore as shown in Figs. 10-19 and 10-20. The required volume of tailings is 16,556,000$m^3$.

Tailings are allowed to flow through either one of the two pipelines and when the tailings are deposited to the planned height, the supply line is switched to another pipe line. While tailings are being supplied through one pipe line, rubble is laid over the deposited tailings which have been supplied through another pipe line, and this line is extended by addition of pipes. Bulkhead construction advances ahead by repeating such alternate processes. Upon formation of bulkhead, cover stone is placed by means of gut boat under the guidance of diver worker (Fig. 10-21)

(2) Addition of Pipes

The time intervals of connecting a pipe to the prelaid pipe line is determined according to the required quantity of tailings for the bulkhead construction. Namely, the time interval is short at a shallow water depth, and it gets longer with deeper water depth.

If the length of one pipe is 6 m, the piep jointing time intervals are as shown in Table 10-9.

Fig 10-19 Working Method of Embankment by Tailings

Fig 10-20 Pedestal for the Pipes Along the Seashore Line

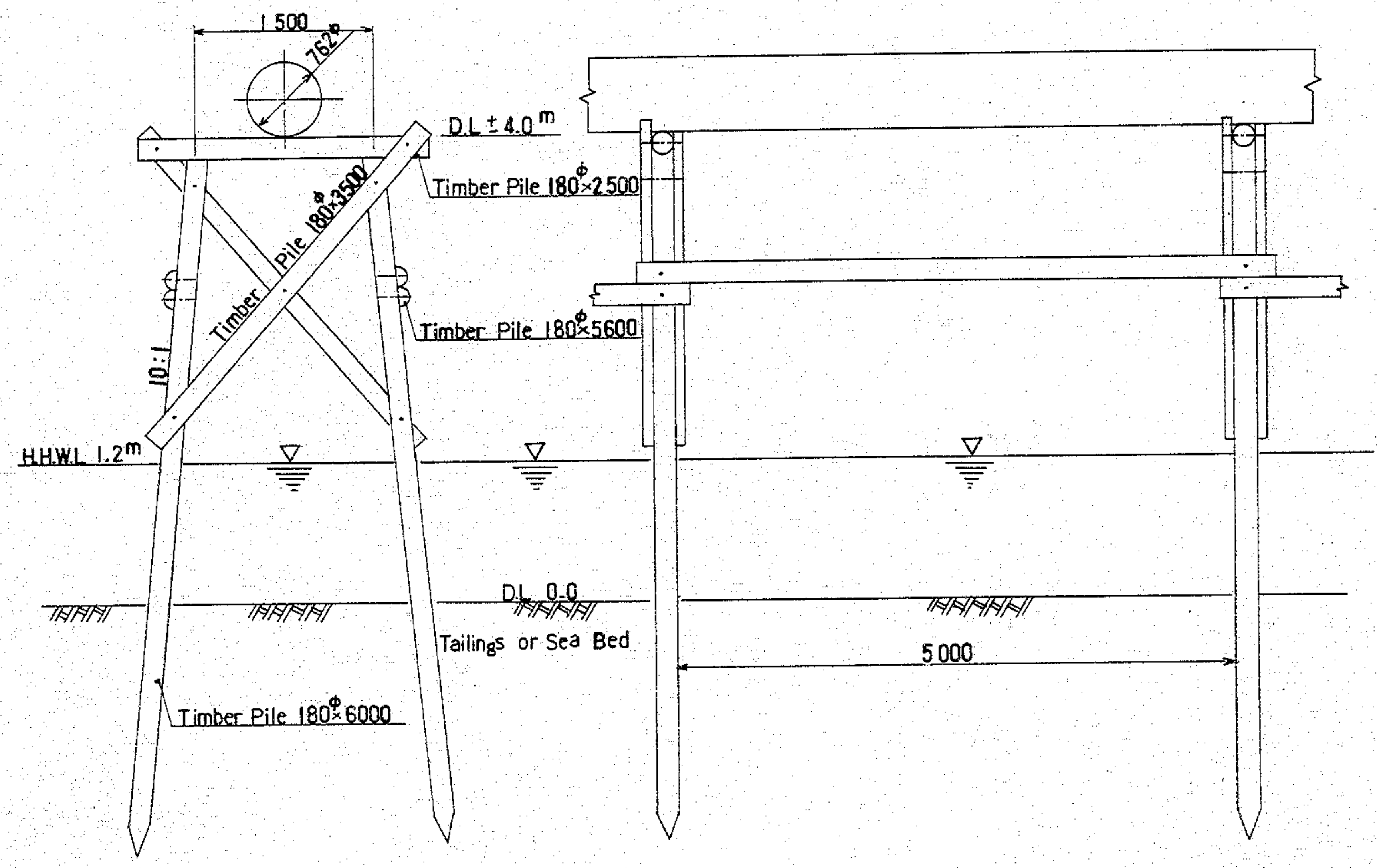


Fig. 10-21 Working Flow of Embankment of Tailings

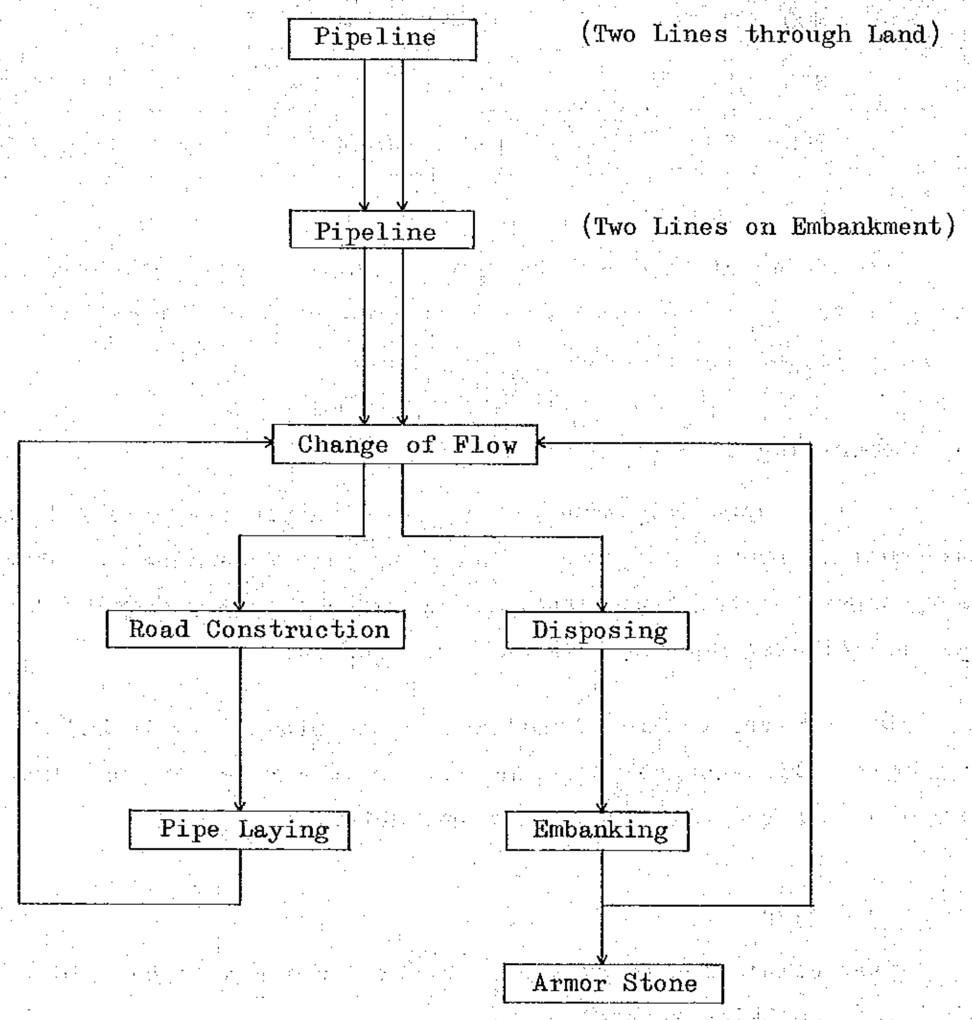


Table 10-9 Average Time Intervals Required for Pipe Joint Works

| Tailings volume (Bulk Density) | Depth | Average time intervals required for pipe joint works |
|---|---|---|
| 800 $m^3$/Hr. | DL 0 - 5 M | 90 Min |
| 800 " | 5 - 10 M | 320 Min |
| 800 " | 10 - 15 M | 690 Min |
| 800 " | 15 - 18 M | 1,085 Min |

Therefore, at DL 0 - 5 m, it is necessary to level the rubbles and add pipe for every 90 min. Pipes are carried to the place by truck and unload with the use of crane.

(3) Supporting base for pipes and road

As pipe supporting members, pile and rubble are proposed, however, a road must be provided on the bulkhead to permit passage of vehicles to carry pipes for the pipe lines, it is planned to lay and level rubble in the earlier stage on the bulkhead constructed.

The required volume of rubble for one pipe (6 m) is 209 $m^3$ including 30% as allowance volume. The rubble is carried by dump truck and laid over the bulkhead with the use of bulldozer.

(4) Armor stone

After completion of bulkhead, cover stone has to be laid to prevent tailings from being scoured.

The volume required for cover stone is estimated at 1,463,000 $m^3$, taking into account the gentle gradient of sideslope at $15^\circ$ an allowance of 30%. The weight of one stone piece is specified to be 0.8 to 1.0 t.

The cover stone is leveled by diver worker into a thickness of approximately 2.0 m.

(5) Determination of work period and principal equipment

The work period of tailings type bulkhead is dtermined according to the volume of tailings.

$$16,556,000\ m^3 \div 7,000,000\ m^3/year \fallingdotseq 2.4\ years = 28.8\ months$$

Therefore, the other works (construction of rubble road on which to place pipe line and placement of cover stone) will be designed to be performed in this work period. The on-land piping system has to be completed by the time bulkhead construction is started.
Principal equipment required for embankment of tailings is shown in Table 10-10.

Table 10-10 Principal Equipment for Embankment of Tailings

| Equipment | Specification | Quantity | Capacity | Number of equip. | Period | Remarks |
|---|---|---|---|---|---|---|
| Wheel loader | 2.0 $m^3$ | 1,828,000$m^3$ | 50.4$m^3$/hr | 5 | Months 28.8 | Armor stone & road |
| Dump truck | 20 t | 1,828,000$m^3$ | 8.7$m^3$/hr | 25 | 28.8 | " |
| Bulldozer | 10t class | 364,500$m^3$ | 56.0$m^3$/hr | 2 | 28.8 | For road construction |
| Carrier with grab bucket | 300t 150$m^3$ 30mx4.1x2.6m | 1,463,000$m^3$ | 750 $m^3$/day | 3 | 28.8 | Armor stone |
| Diver | Dry Diving | 187,600$m^3$ | 30 $m^3$/day | 9 | 28.8 | Leveling |
| Suspension boat | 30 PS | - | | 1 | 28.8 | Combining plying boat |

10.3.5 Construction Plan of classified Tailings Type Bulkhead

(1) Outline of work method

As mentioned earlier, the classified tailings type bulkhead uses underflow classified from tailings by cyclone.

The work method is nearly the same as that of tailings type bulkhead except for the point of using cyclone and two bank lines which are alternately constructed in a forward direction from the two intersections of the reclamation centere lines with the shore line (See Fig. 10-22).

The particle proportion of underflow and overflow will be 7:3.Overflow is cast inside the completed bulkhead but this casting should be made at a place near the seashore line in the reclamation land by conveying tailings to the

Fig. 10-22 Working Flow of Embankment by Classified Tailings

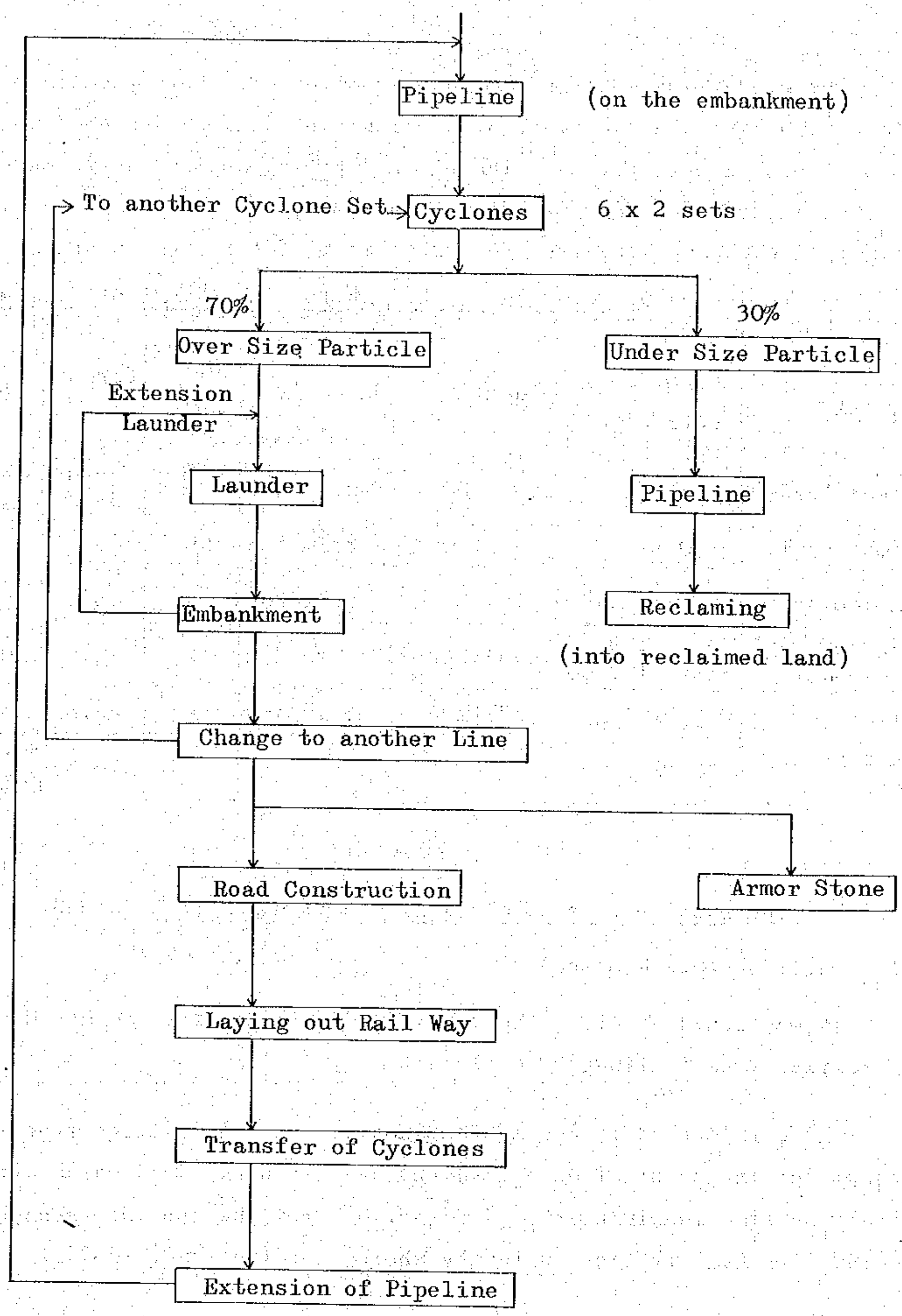
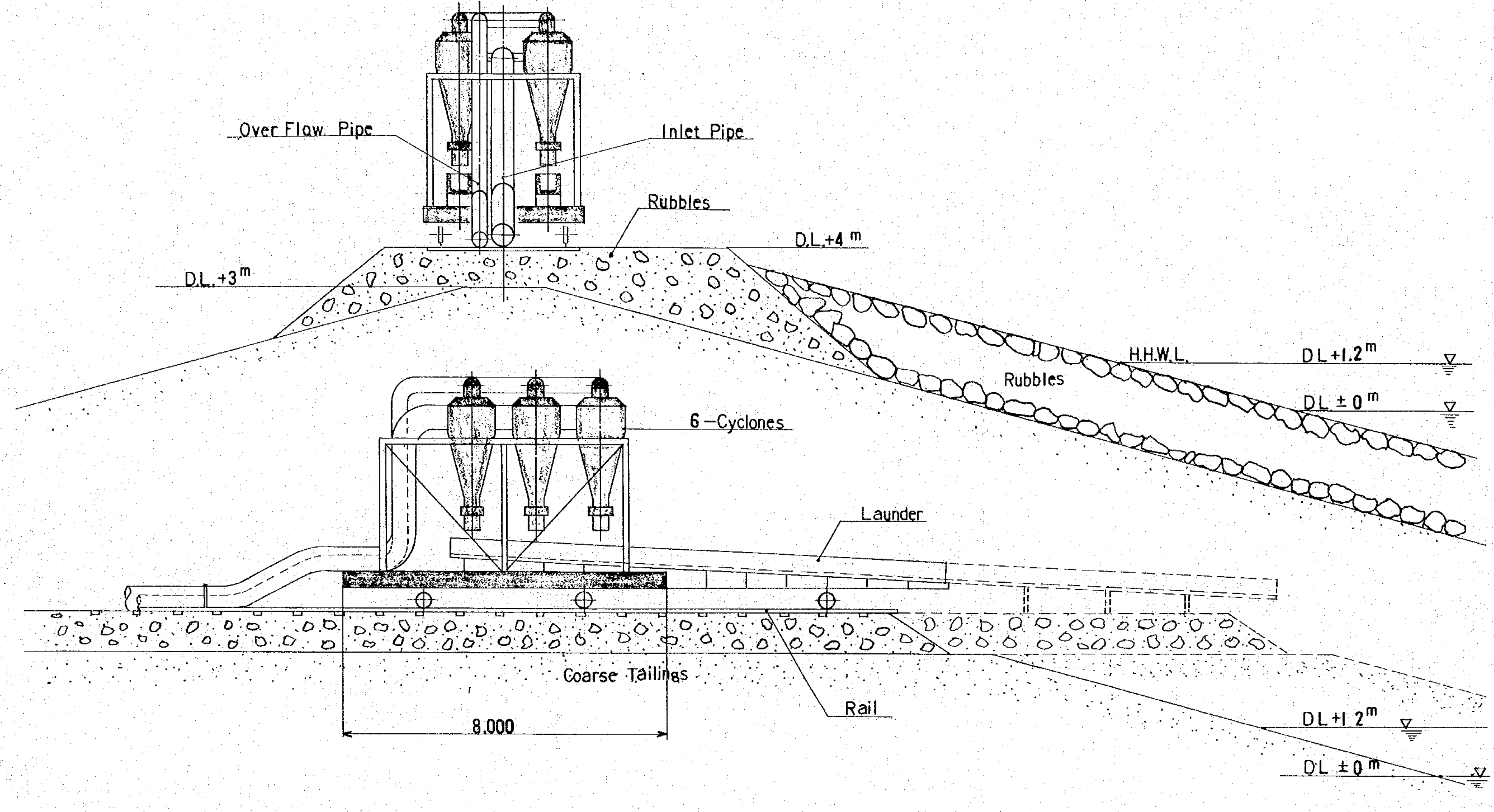


Fig 10-23




Unit : mm

place through pipe line to lessen water contamination as far as possible.

Cyclone should be designed to be mobile and laid along the rail, loaded on a cart.

(2) Cyclone Cart

The tailings carried through pipe line is separated by a cyclone (30") with a treating capacity of 540 $m^3$/hr, ea.

35,000 t/day x 1.80 $m^3$/t ÷ (540 $m^3$/hr x 24 hr) ≒ 5

spare cyclone . . . . . . 1

Namely, the number of needed cyclone is 6. These 6 cyclones are loaded on a cart to be carried along the bulkhead line. The cart is designed to be mobile on rails, as diagramed in Fig. 10-23.

The launder equipped on the cyclone cart is given 5% gradient for conveying underflow, and it is designed to provide additional wooden launder as attachment to the front edge to permit further carriage of about 20 m.

The rails will be placed at DL + 4 m and tailings be piled to the level of DL + 3 m.

(3) Extension of launder

The separated underflow is discharge foreward (in the progressing direction of bank construction) from the cart thru the launder mounted on the cyclone cart. Rubbles are spread over the face of bulkhead underflow on which wooden launder is extended.

(4) Placement of Rails

When the tailings, carried on the extended wooden launder, are piled up to the planned level, the tailings transporting route is switched to another pipe line to start anew the extension of bulkhead. At the place where tailings discharge is interrupted, the wooden launder is removed and the rubbles carried by the dump truck is leveled by bulldozer on which ties and rails are fixed. The rails on which the cyclone cart has passed are removed from there to be placed ahead of the car position. Therefore, it is planned to prepare for such repeated use rails with about 2.5 fold length of the distance the cyclone cart is moved at one time.

(5) Extension of pipe line

The cyclone cart is moved ahead, disconnected with the pipe line, and pipes are extended to the line to cover the distance the cart had forwarded.

Upon finish of the pipe extension, discharge of tailings is resumed. Bulkhead construction proceeds on forward motion by repeating such alternate operation of the two pipe lines.

(6) Cover stone placement

The sideslope of bulkhead is leveled by diver workers with the use of rubbles carried and casted by gut boat.

(7) Determination of work period and principal equipment required

The work period of classified tailings type bulkhead is determined according to the flow rate of tailings.

$24,000,000 \text{ m}^3 \div 7,000,000 \text{ m}^3/\text{year} = 3.4 \text{ year} = 41.2 \text{ month}$

Accordingly, the other work (stone covering, underwater leveling) will be made during the period. Principal equipment required for embankment by classified tailings is shown in table 10-11.

Table 10-11 Principal Equipment for Embankment by Classified Tailings

| Spec. / Equipment | Specification | Quantity | Capacity | Number of equip. | Period of using equipment | Remarks |
|---|---|---|---|---|---|---|
| Cyclone | NH-30 type | | $540\text{m}^3/\text{hr}$ | 12 | Month 41.2 | |
| Wheel loader | $2.0\text{m}^3$ | $1,828,000\text{m}^3$ | 50.4 " | 4 | 41.2 | Armor stone & road |
| Dump truck | 20 t | $1,828,000\text{m}^3$ | 8.7 " | 18 | 41.2 | |
| Bulldozer | 10 t class | $364,500\text{m}^3$ | 50.0 " | 2 | 41.2 | |
| Carrier with grab bucket | 300t, $150\text{m}^3$ 30x4.1x2.6m | $1,463,000\text{m}^3$ | $750\text{m}^3/\text{day}$ | 2 | 41.2 | Armor stone |
| Diver | Dry diving | $187,600\text{m}^2$ | $30\text{m}^3/\text{day}$ | 6 | 41.2 | Leveling |
| Supervison-boat | 30 PS | | | 1 | 41.2 | Combining plying boat |

### 10.3.6 Reclamation Plan (Reclamation inside completed bulkhead)

(1) Piping design

With regards to the piping design for land reclamation, the rubble type bulkhead and corrugated cell type bulkhead are the same in piping design as well as in their shapes (Reclaimed shape B Plan), while the raw tailings type bulkhead and classified tailings type are the same in the reclamation shape as that of the afore-mentioned Plan D, but differ from each other in piping design.

The reclamation piping plan is shown in Fig. 10-24 flow chart.

In drawing out a construction plan of reclamation land, the following instructions should be observed:

i) Make even throughout in the quality of the reclaimed land.

ii) Plan not to elevate the water level in the reclamation area.

iii) Set to the land fill work after quality materials are reclaimed from the enclosing bulkhead.

iv) Use coarse size materials for surfacing the land.

v) Provide the land surface a gradient from 1/500 to 1/1,000 for easy water drainage.

vi) In case the earth and sand in the surface layer are likely to be blown away by the force of wind, coat the area with sticky soil or put plants therein.

In the piping plan, the following are considered:

i) Make a plan to meet the draining distance of 6.9 km.

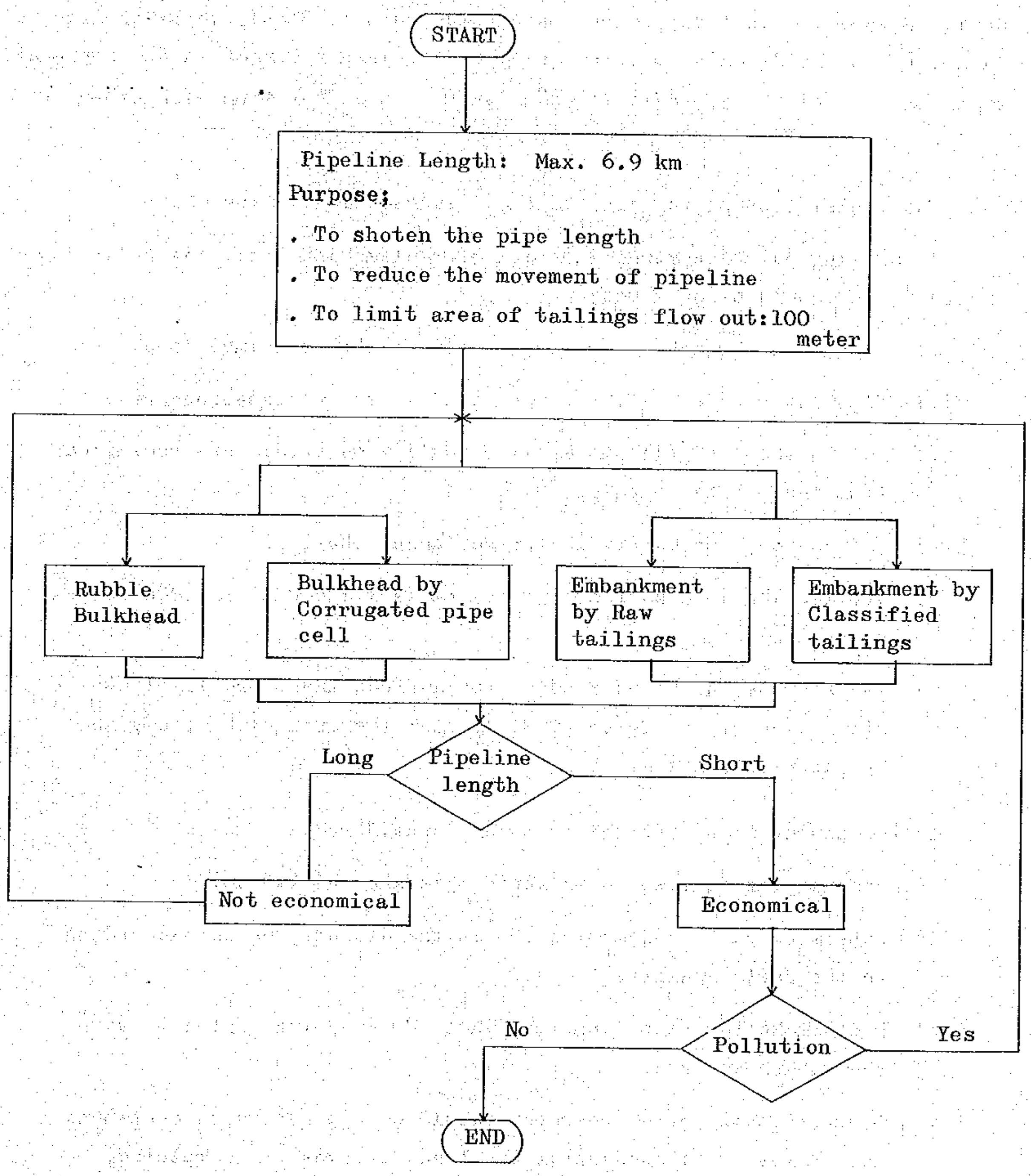
ii) Determine each reclamation lot at the discharging out according to the earth quality.

iii) Don't make the pipe line less than $120^{\circ}$ bending angles to save the waterhead loss.

iv) Disposal point of waste water should be a place where continued use of its is allowed until the land fill work is completed.

v) Repeated use of drain pipes by relocating them from the section where reclamation is finished to the section to be reclaimed next.

Fig. 10-24 Working Flow of Pipe Designing



vi) Because of relocation of pipes mentioned at v), preferably use branch pipes with the same length.

The extended length of pipe lines planned taking into account the above-mentioned conditions from i) to iv) is summed up in the following table.

Table 10-12 Designed Pipeline Length

| Pipe Name \ Type | Rubble type & Corrugated Cell Type | Raw tailings type & classified Tailings Type |
|---|---|---|
| Main Pipeline | 7,200 meters | 16,000 meters |
| Sub-Pipeline | 53,600 | 47,700 |
| Total | 60,800 | 63,700 |

A land reclamation plan is shown in flow sheet Fig. 10-25.

A piping plan is shown in Figs. 10-26 and 10-27.

(2) Quantity of Pipes

The reclamation area has to be divided into lots based on the required volume of earth to be provided. This division is seriously related to the replacement use of pipe line. The relation between the reclaimed earth and replaced use of pipes (quantities of replaced pipes) are studied hereunder. The earth volume required by reclamation depth are shown in the following table.

Table 10-13 Volume of Reclamation

Unit: $m^3$

| Type \ Depth (m) | 0 - 5 | 5 - 10 | 10 - 15 | over 15 |
|---|---|---|---|---|
| Rubble type and Corrugate cell type | 16,640,000 | 47,495,000 | 75,865,000 | |
| Tailings type and classified tailings type | 10,400,000 | 32,890,000 | 83,820,000 | 12,890,000 |

Fig. 10-25 Working Flow of Reclaiming

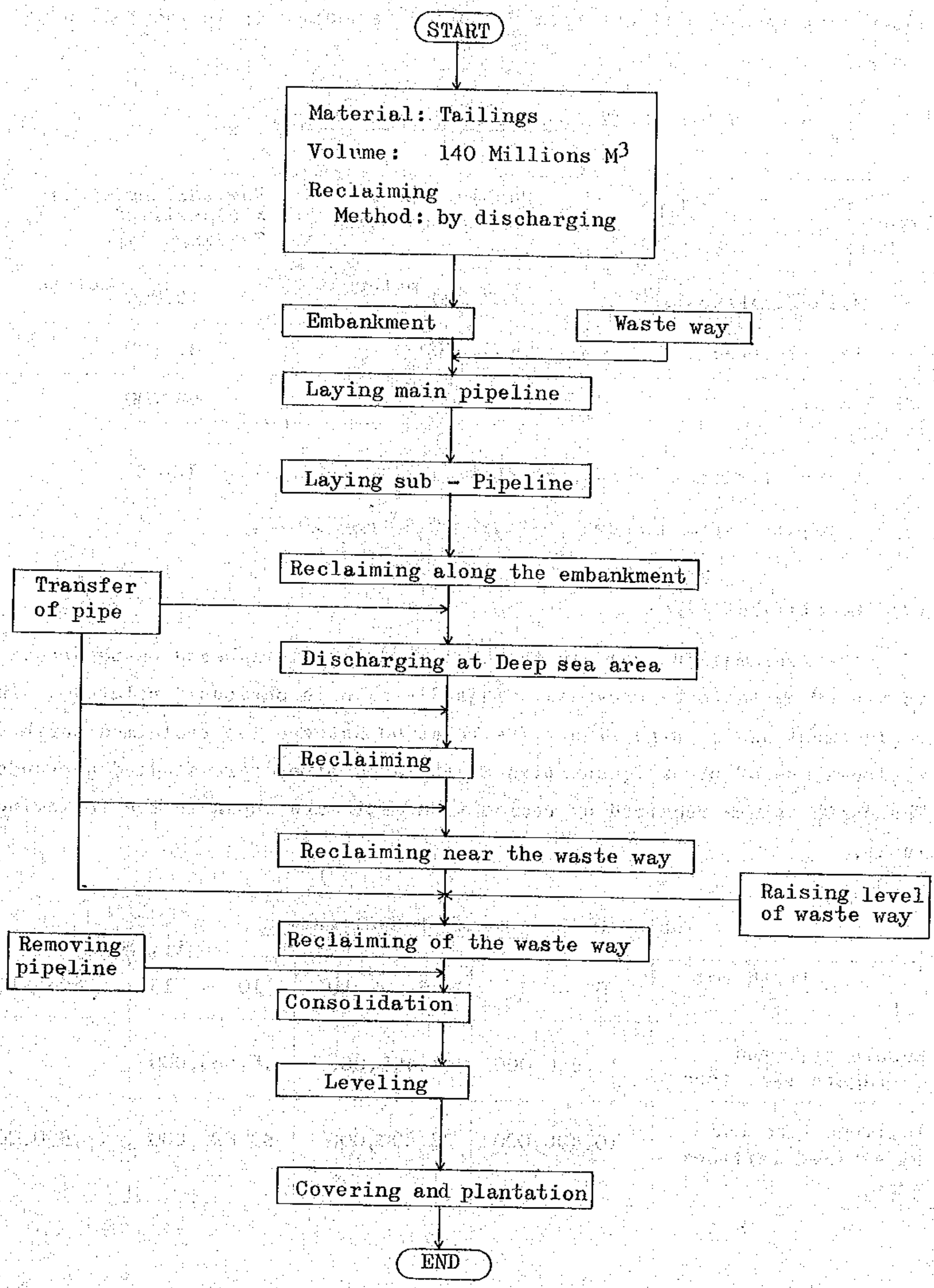


Fig 10-27 Rubbles Bulkhead and/or Bulkhead by Corrugated Pipe Call Type
Pipeline Arrangement

Main Pipline 7 200 m
Sub Pipline 53 600 m

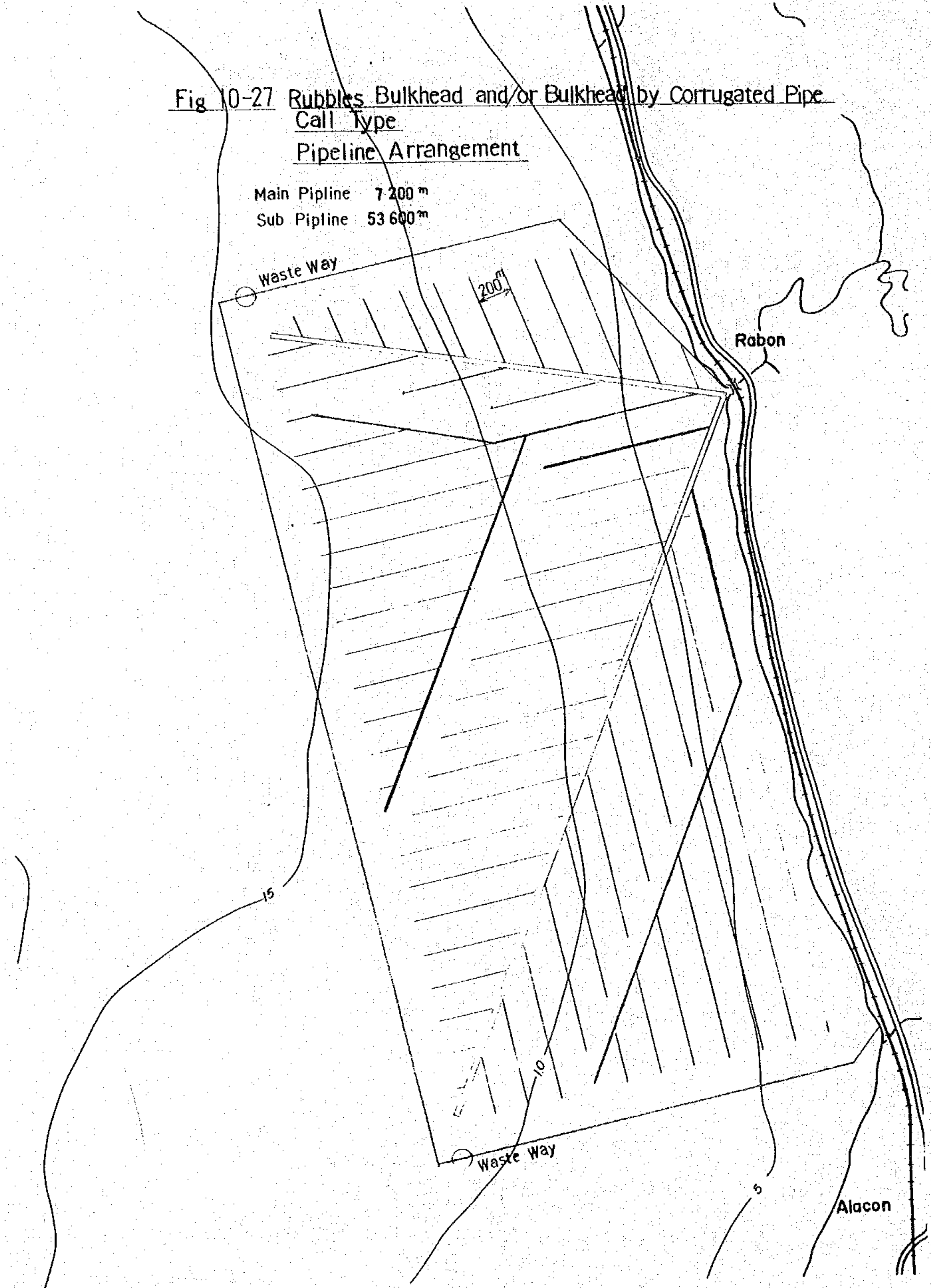
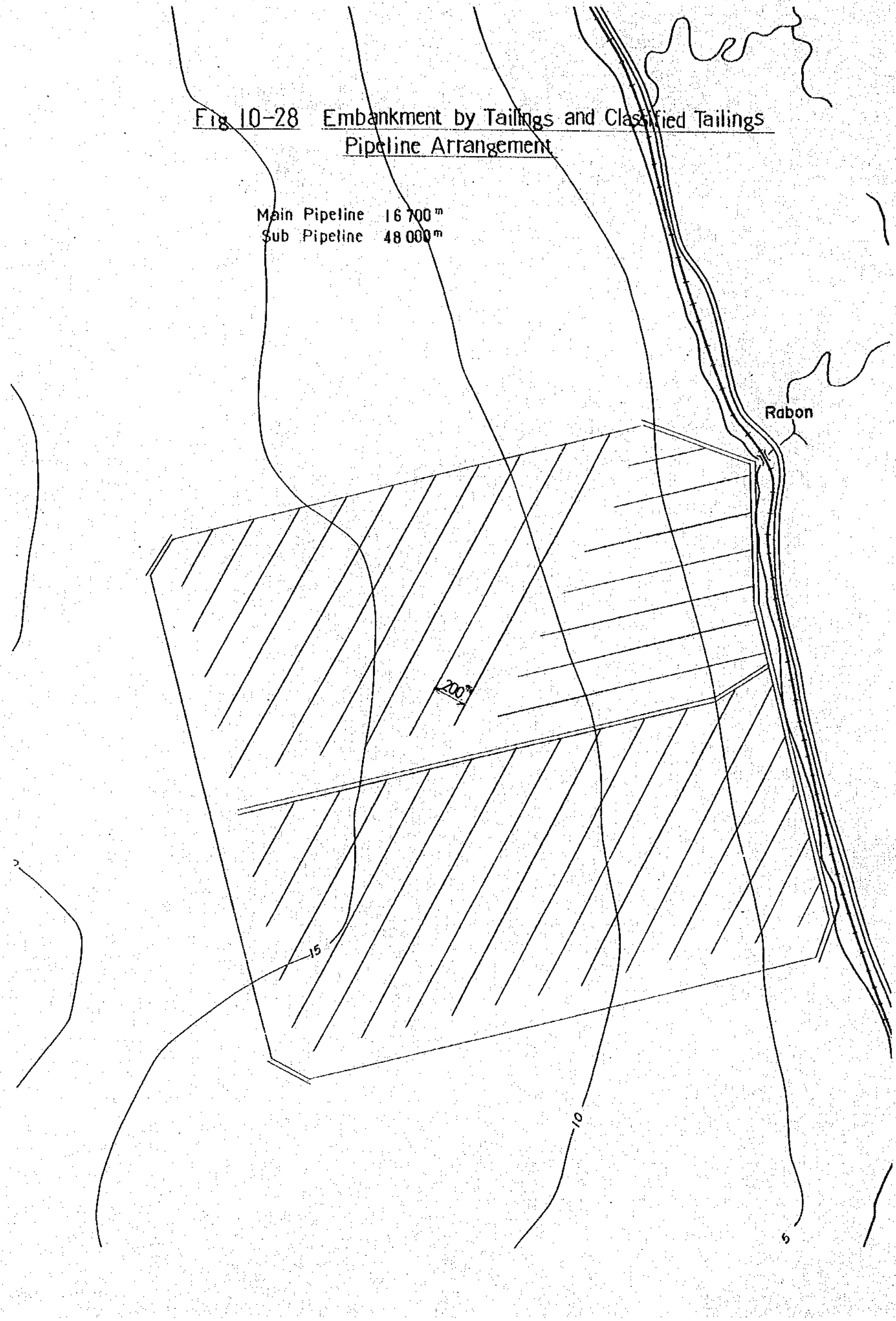


Fig.10-28 Embankment by Tailings and Classified Tailings Pipeline Arrangement



As for the total length of pipe lines necessary for reclamation, because the time length and times of replaced use delicately differ between pipes and the times of replaced use vary in relation to the volume of earth used for reclamation, the approximate value is sought by the following formula:

$$\left(\frac{Vx}{Va \times 3 \text{ years}}\right) \times L_{max} = \text{Length of replaced pipe lines}$$

Vx : Reclaimed volume

Va : Volume of tailings required per year (7,000,000 $m^3$)

3 years: Pipe abrasion years

L max : Max. pipe line length within Vx

The total length of replaced pipes derived from the above formula is shown in the following table.

Table 10-14 Pipe Length for Exchanging Unit: Meter

| Depth m / Type | 0 - 5 | 5 - 10 | 10 - 15 | over 15 | Total |
|---|---|---|---|---|---|
| Rubble type and Corrugated cell type | 3,750 | 9,605 | 15,800 | | 29,155 |
| Tailings type and classified tailings type | 1,388 | 5,300 | 19,950 | 3,888 | 30,526 |

Due to abrasions, pipes are rotated 120° a year and replaced with new ones every three years. The size of a single pipe is 762 mm in diameter and 6,000 mm in length. Accordingly, the required pipe quantity are the following:

Rubble type and corrugated cell type:

29,155 m ÷ 6.0 m/ea. = 4,860 (pcs.)

Raw tailing type and classified tailing type:

30,526 m ÷ 6.0 m/ea. = 5,088 (pcs.)

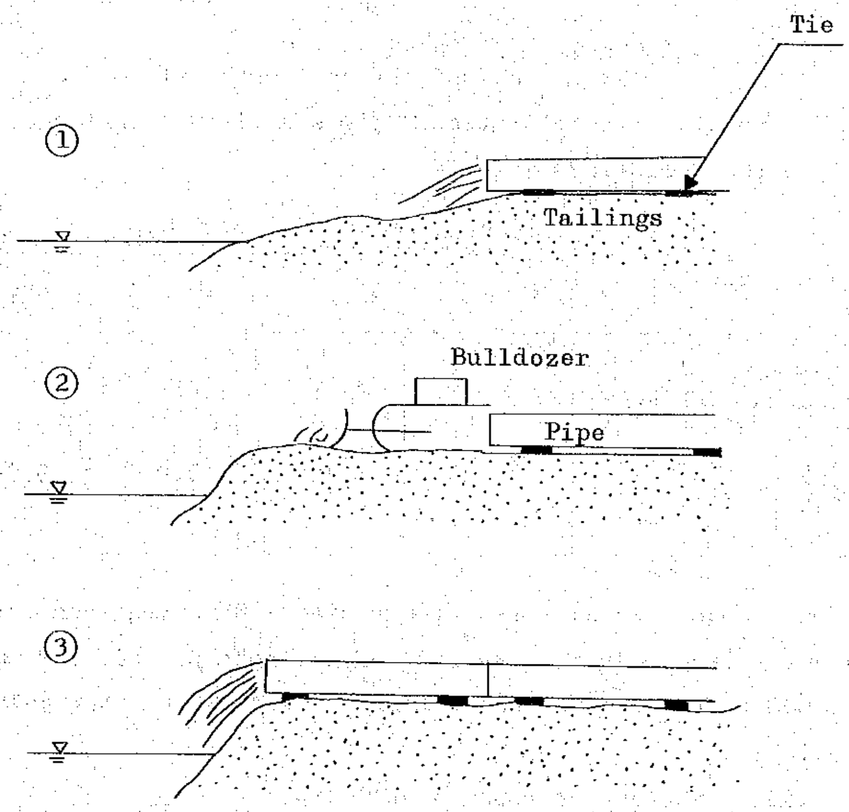
(3) Placement and Removal of Pipes

Placement and replacement of pipes are made by the use of pipe layer and its transportation is by truck. A sand-covered road with a width of 6.0 m and a height of DL + 4.0 m will be provided to transport the pipes.

a. Method of laying pipes in reclaimation land

Pipes are laid on DL + 4.0 m tailings foundation. Over the extended section of the tailings foundation, dry tailings of adequate particle size for surfacing are laid and paved into the specified surface level by using a swamp bulldozer. Then, pipes are laid one after the other for extension of the pipe line. Under the pipes are provided with two ties in 6.0 m pipe length.

Fig. 10-28 Pipe Laying Method




b. Main machines are in Table 10-15.

Table 10-15 Principal Equipment for Reclamation

| Equipment | Quantity | Application |
|---|---|---|
| 20 ton class Swamp bulldozer | 1 unit | Attached pipe layer, moving pipes & leveling tailings |
| 10 ton class Truck | 1 unit | Carrying pipes. |
| Cutting machine | 1 unit | Cutting bolt & not |

(4) Waste way

Waste way should be placed at an adequate location according to the conditions, the volume of discharged waste water, the area of reclamation land, and earth quality. There is no specific principles to follow in the determination of its location. However, if there is a danger of its bottom or side walls being scoured by water flowing out, special care should be provided to the structure of waste way itself.

At a reclamation land which can be influenced by ebb and flood of the tide, sea water may come in at the time of flood through the waste way to innundate the land that is drying up. Therefore, care should be taken also to the level of the waste way.

For this reason, the waste way should be provided on the level of H.W.L. at a place not directly facing the offing to keep it safer from the influence of ebb and flood of the tide and waves.

In Figs. 10-29, 10-30 and 10-31, is shown the structure of waste way on each type of rubble, corrugated cell and tailings.

For tailings type bulkhead, waste way is provided in a pipe structure, as shown in Fig. 10-31, with the pipes fixed at height of H.W.L. on the side of water inlet (reclaimed land side) and a height of L.W.L. on the water outlet side to keep the waste way safe from possible scouring phenomenon.

## 10.4 WORK SCHEDULE

(1) Preparatory Work

Preparatory work is classified into two main categories. These are; measuring work and temporary installation work. With the variation in bulkhead type, there are some differences in work duties, but as common main work items they can be listed on each work category as follows:

a. Measuring work

i) Sea area measurement

ii) On-land measurement

b. Temporary installation work

i) Development of quarry

ii) Installation of temporary road
(quarry → national road; national road → temporary pier)

iii) Installation of temporary pier

iv) On-land piping (along seashore line to reclamation center line)

Taking into account the fact that all the above work items are done simultaneously, the period of time necessary to perform the preparatory work is estimated at 6 months.

(2) Bulkhead Construction Work

The required work period for bulkhead construction varies according to the bulkhead structure. In the case of raw tailings type and classified tailings. type, the construction of bulkhead is started after the system is completed. These two types of bulkhead are estimated to be completed in 28.8 months and 41.2 months respectively. Rubble bulkhead required a large volume of rubble materials. Accordingly, working period varies with the production capacity of quarrying and the capacity of dump trucks (the number of trucks take used). Assuming that 60 trucks will be employed, the work period is estimated at 30 months, which is the same as that of tunnel section. The corrugated cell type permits option of a quick construction schedule and its work period is estimated to be 30 months, that is equal to the estimated work period of rubble bulkhead. Time schedule of the bulkhead is shown in Table 10-16.

## 10.5 ESTIMATION OF CONSTRUCTION COST

### 10.5.1 Conditions of Estimation

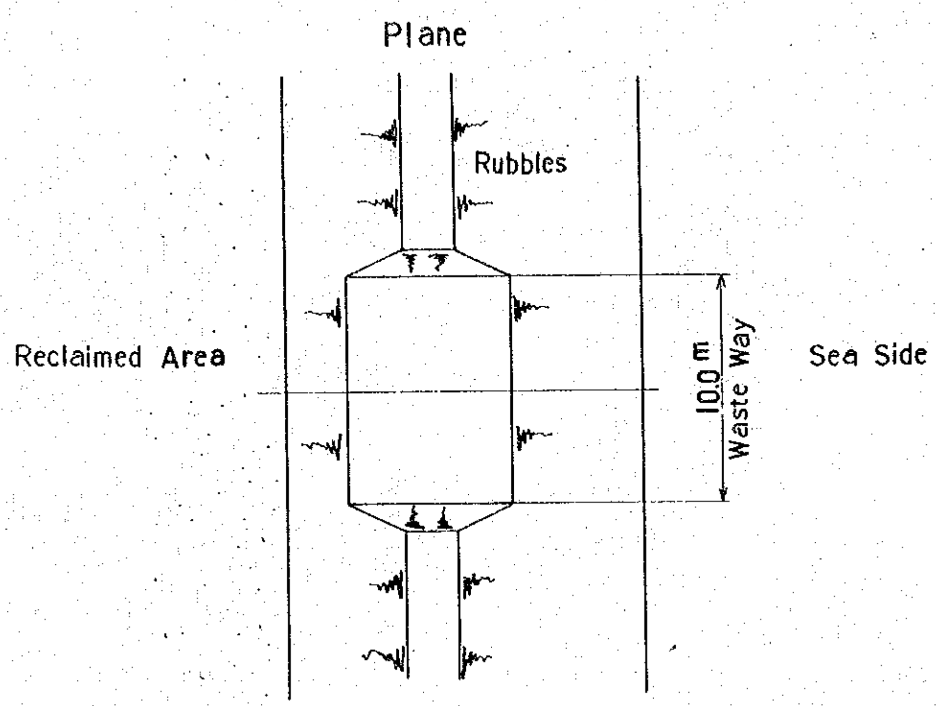
(1) The basic unit price used in the estimation are quoted from the following literatures:

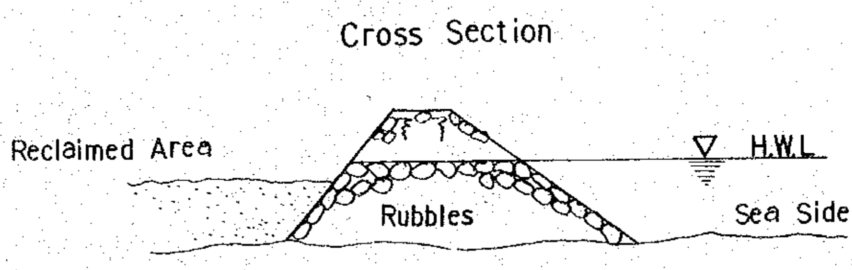
i) Estimation data of P.P.A.

ii) Equipment Rental Rates 1977 by the Associated Construction Equipment Lessors, Inc.

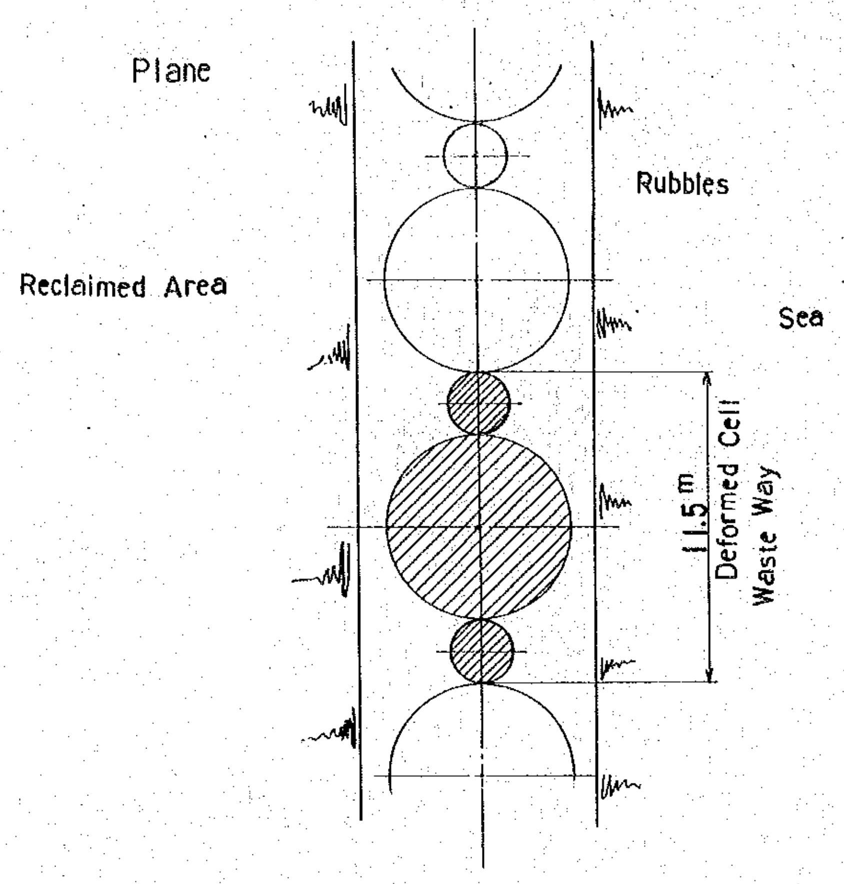
iii) Other data provided by trade firms or construction companies.

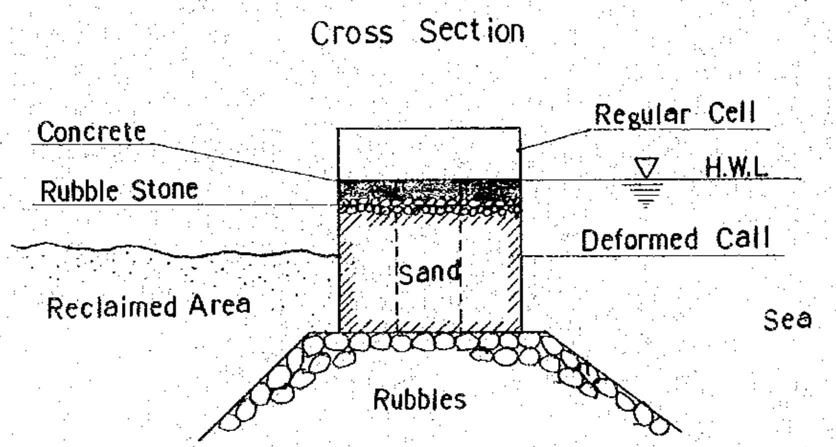
Fig 10-29 Waste Way of Rubbles Bulkhead



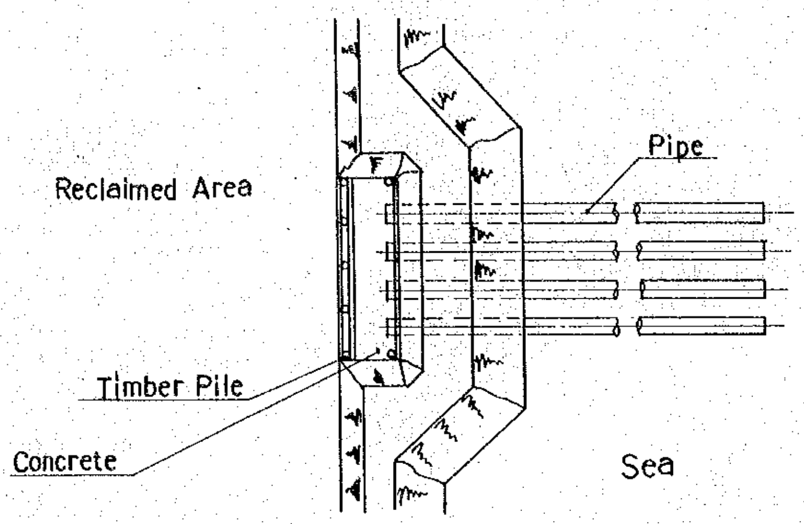
## Fig. 10-30 Waste Way of Corrugated Cell Bulkhead



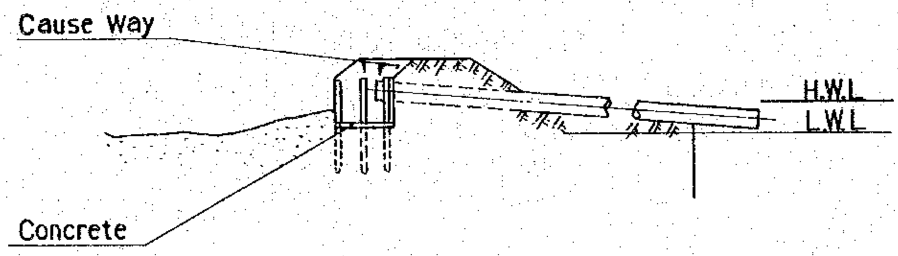



## Fig. 10-31 Waste Way of Tailings Bulkhead

Plane




Section



# Table10-16 Time Schedule of the Bulkhead Work

| | Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rubbles Bulkhead | Rreparatory Works | | | | | | | | | | | |
| | Survey & Temporary Works | | | | | | | | | | | |
| | Bulkhead Works | | | | | | | | | | | |
| | Dumping by Vessels | | | | | | | | | | | |
| | Dumping by Tracks | | | | | | | | | | | |
| | Reclaiming | | | | | | | | | | | |
| | Pipe Laying | | | | | | | | | | | |
| Corrugated Pipe Cell Bulkhead | Preparatory Works | | | | | | | | | | | |
| | Survey & Temporary Work | | | | | | | | | | | |
| | Bulkhead Works | | | | | | | | | | | |
| | Riprap Mound | | | | | | | | | | | |
| | Corrugate Plaicing | | | | | | | | | | | |
| | Reclaiming | | | | | | | | | | | |
| | Pipe Laying | | | | | | | | | | | |
| Embankment by Tailing | Preparatory Works | | | | | | | | | | | |
| | Survey & Temporary Works | | | | | | | | | | | |
| | Bulkhead Works | | | | | | | | | | | |
| | Cause way | | | | | | | | | | | |
| | Armor Stone | | | | | | | | | | | |
| | Reclaiming | | | | | | | | | | | |
| | Pipe Laying | | | | | | | | | | | |
| Embankment by Cycloned Tailing | Preparatory Works | | | | | | | | | | | |
| | Survey & Temporary Works | | | | | | | | | | | |
| | Bulkhead Works | | | | | | | | | | | |
| | Cause way | | | | | | | | | | | |
| | Armor Stone | | | | | | | | | | | |
| | Reclaiming | | | | | | | | | | | |
| | Pipe Laying | | | | | | | | | | | |

(2) The prices quoted are those registered for 1977.

(3) In preparing the construction plan of rubble bulkhead, the unit price of rubble applied is common to other types in the estimation of the construction cost.

(4) Rubble will be provided from a quarry developed under the direct management of the Philippine Government (the same method as adopted by PPA for construction of Navotas Part). Ex-quarry rubble price is assumed to be ₱4.5/MT (₱6.75/$m^3$).

(5) The construction cost estimated here covers the work of loading rubbles on trucks up to the completion of dumping the rubbles into the place.

(6) The estimated cost does not include import duty and customs clearance charge of steel members (C&F price + inland transportation cost).

(7) Because of the differences in the length of work period between the construction types, the supervision cost and boat cost are estimated in direct proportion to each work period.

(8) Estimation is made with respect to the direct construction cost only, exclusive of overhead.

(9) On rubble type and corrugated cell type bulkhead, the total cost, inclusive of the entire work from start to completion of bulkhead construction, is estimated.

(10) On raw tailings type and classified tailings type bulkhead, for which the work is started after slurry-transportation of tailings begins, the expenses incurred in connection with the piping work for bulkhead construction are included in the maintenance and administrative cost (land reclamation cost).

### 10.5.2 Bulkhead Type-Wise Construction Cost

(1) Construction Cost of Rubble Type Bulkhead

Table 10-17 Construction Cost of Rubble Bulkhead

| Item of Work | Specification | Quantity | X 1,000 ₱ Construction | Unit Price |
|---|---|---|---|---|
| *1) Quarrying work | | 4,679 x 1,000 $m^3$ | 31,583 | Peso 6.75/$m^3$ |
| Loading work | 11 units (2$m^3$ class) Wheel loaders | 4,679 x 1,000 $m^3$ | 21,952 | 4.69/$m^3$ |
| Carrying work | 60 units (20 ton class) Dump trucks | 4,679 x 1,000 $m^3$ | 110,113 | 23.53/$m^3$ |
| Leveling work | 4 units (10 ton class) Bulldozers | 1,530 x 1,000 $m^3$ | 2,873 | 1.88/$m^3$ |
| Dumping work (Bottom open barge) | 300$m^3$ Bottom open barge - 2 units 250pcs. Tag boat | 2,631 x 1,000 $m^3$ | 2,486 | 0.94/$m^3$ |
| Dumping work (Carrier with grab bucket) | 150 $m^3$ 250 pcs. | 518 x 1,000 $m^3$ | 1,485 | 287/$m^3$ |
| Underwater leveling work | Diving boats 10 units | 41.8 x 1,000 $m^2$ | 784 | 18.76/$m^2$ |
| Supervision | | 25 months | 1,734 | 69,360/ month |
| Charter of boat | Surveying boat 2 ea<br>Supervision " 2 ea | 1 set | 2,250 | |
| Temporary work | Pier construction | 1 set | 2,300 | |
| - " - | Temporary road, Working yard & Repairing shop | 1 set | 2,200 | |
| Total | | | 179,760 | |

Remarks: *1); The work shall be executed under the direct control of Philippines Government.

2.; Construction period : 30 months

(2) Construction Cost of Corrugated Cell Type Bulkhead

Of the construction cost items of this type of bulkhead, the work cost and stone surfacing cost for the rubble bulkhead sections are estimated by using the unit prices appearing in 10.5.2 (1) "rubble type bulkhead."

Table 10-18: Construction Cost of Bulkhead by Corrugated Pipe Cell

| Works | Items | Quantity | Unit Price Peso | x 1,000 peso Amount |
|---|---|---|---|---|
| 1. Corrugated Pipe Cells Work | Materials | 957 units | 72,851 / ea. | 69,718 |
| | Assembling | 957 units | 696/ ea. | 666 |
| | Carrying, Placing | 957 units | 1,630/ ea. | 1,560 |
| | Filling, Protection of top of Cell | 957 units | 2,124/ ea. | 2,033 |
| 2. Dumping Armor Stone Works | | 22,400 $m^3$ | | 847 |
| 3. Rubble Bulkhead Construction | | 1,964,000 $m^3$ | | 70,427 |
| 4. Supervision | Lavour cost | 17.5 months | 69,360/month | 1,214 |
| 5. Temporary work | Pier, Road, Working yards etc. | 1 unit | | 4,500 |
| Total | | | | 150,965 |

(3) Construction Cost of Raw Tailings Type Bulkhead

Table 10-19 Construction cost of Embankment by Tailings

| Work | Specification | Quantity | Construction Cost (x 1,000₱) | Unit Price (₱) | Remarks |
|---|---|---|---|---|---|
| Quarrying work | | x $10^3 m^3$ 1,828 | 12,667 | 6.75/$m^3$ | After examination of 10-5-2, the unit price is applied. |
| Loading work | (2.0$m^3$ class) Wheel loaders 5 unit | 1,828 | 8,573 | 4.69/$m^3$ | " |
| Carrying work | (20 ton class) Dump trucks 46 unit | 1,828 | 43,013 | 23.53/$m^3$ | " |
| Leveling work | (10 ton class) Bulldozers 2 unit | 365 | 686 | 1.88/$m^3$ | " |
| Dumping work | (150 $m^3$) Carriers with grab bucket 3 unit | 1,463 | 4,199 | 2.87/$m^3$ | " |
| Underwater Leveling work | Dry diving | 187,600$m^2$ | 3,519 | 18.76/$m^2$ | " |
| Supervision | | months 28.8 | 832 | /month 28,900 | |
| Boat Charter | Survey boat 2 units supervision boat 1 | 28.8 | 1,080 | /month 37,500 | |
| Temporary work | Pier construction Road Working shop, etc. | 1 set | 4,500 | | |
| Total | | | 79,069 | | |

Note: Construction period : 28.8 months

(4) Construction Cost of Classified Tailings Type Bulkhead

Table 10-20 : Construction Cost of Embankment by Classified Tailings

| Works | Secification | Quantity | Cost | Unit Price | Remarks |
|---|---|---|---|---|---|
| Purchase of Cyclone's bogy | NH -30 type Cyclone with Bogies (2 bogies) | 12 | x 1000 ₱<br>1,758 | ₱<br>146,500 | |
| Quarying work | | x $10^3 m^3$<br>1,828 | 12,667 | $6.75/m^3$ | |
| Loading work | Wheel loaders ( 2.0 $m^3$ class) 4 units | 1,828 | 8,573 | $4.69/m^3$ | |
| Carrying work | Dump trucks (20 t class) 33 units | 1,828 | 43,013 | $23.53/m^3$ | |
| Leveling work | Bulldozers 2 units (10 ton class) | 365 | 686 | $1.88/m^3$ | |
| Dumping work | Carriers with grab backet 3 units ($150m^3$class) | 1,463 | 4,199 | $2.87/m^3$ | |
| Underwater Leveling work | Dry diving | $187,600M^2$ | 3,519 | $18.76/m^2$ | |
| Supervision | | months<br>41.2 | 1,191 | /month<br>28,900 | |
| Boat charter | Survey boat 2 units Supervision boat 1 unit | 41.2 | 1,545 | /month<br>37,500 | |
| Temporary work | Pier, road, working road,& repair shop | 1 set | 4,500 | | |
| Total | | | 81,651 | | |

Note: Construction Period : 41.2 month

### 10.5.3 Land Reclamation Work (Piping) Cost (For 20 years)

Table 10-21: Construction Cost of Reclaiming (Pipe Laying)

| Works | Item \ Plan | Rubble type & corrugated cell type | Raw tailings type | Classified tailings type |
|---|---|---|---|---|
| Leveling work | Swamp bulldozer (20 ton class) | Peso 1,421,000 | Peso 1,488,000 | Peso 1,488,000 |
| Carrying & placing work | Truck (10 ton class) | 27,000 | 28,300 | 28,300 |
| | Swamp bulldozers with pipe layer (20 t class) | 632,000 | 661,000 | 661,000 |
| Removal & Carrying work | Swamp Bulldozers with pipe layer (20 t class) | 315,900 | 330,000 | 330,000 |
| | Truck 10 ton class | 27,000 | 28,300 | 28,300 |
| Joint work | Ties (pillow wood) | 612,000 | 641,000 | 641,000 |
| | Miscellaneous meterials | 486,000 | 508,000 | 508,000 |
| | Unskillful lavor | 46,000 | 48,000 | 48,000 |
| Cost of pipe | | 37,855,000 | 39,630,000 | 39,630,000 |
| Supervision fee on cyclone | | -- | -- | 652,000 |
| Total | | 41,420,000 | 43,363,000 | 44,015,000 |

Note: Construction period : 20 years

### 10.5.4 Water Passage (Timber Wall) Construction Cost

Table 10-22: Construction Cost of Channel (Timber Wall)

| Cost item \ Plan | B plan (Rubble type Corrugated Cell type) | D plan (Raw Tailings type, classified tailings type) |
|---|---|---|
| (Quantity) | 1,200 meters | 400 meters |
| Materials | 124,000 Peso | 42,000 Peso |
| Equipment | 1,756,000 | 602,000 |
| Labour | 57,000 | 31,000 |
| Total | 1,937,000 Peso | 675,000 Peso |

# CHAPTER 11

# OPERATION AND MAINTENANCE OF SYSTEM

# CHAPTER 11

## OPERATION AND MAINTENANCE OF SYSTEM

### 11.1 OPERATION CONTROL

#### 11.1.1 Routine Inspection

The operation control of the common line is considered comparatively simple because all the lines are on a down-slope.

Described below are the main instruction items for routine inspection:

a. The general operation control is done at the central office located at the starting point of the common line (Camp 4). The job duties are in the inspection of slurry feeding from the feeding line and flowing into the common line, confirmation and coordination based on the reports from the watching posts, the check and maintenance of flow meters and density meters.

b. Line inspection is done by using mini-battery locomotive in tunnels and jeep in plane fields. In mountain sections,the line is checked against defective portions produced by any outer causes, particularly, such portions where rock falls in the tunnel and at the portals of tunnel and abnormal conditions of underground water. In the field sections, defects at the joint sections of pipe and launder and the troubles of interfering the flow of slurry on the launder.

c. During the rainy season, at the time of typhoon in particular, careful attention has to be paid to the possible damages in facilities as well as the safety of patrol men. In the mountain sections, it is necessary to check damages of stone rolling down around the starting point of the line, bridges, and tunnel exits. It is also necessary to check the possible rise in water level in stream near seashore where the pipe line passes through.

d. In general, inspection will be made on three-shift a day, and management on one-shift a day (See 11.2).

#### 11.1.2 Periodic Inspection and Maintenance

Maintenance jobs are mostly related to abrasion problems of the flow line. Referential descriptions about periodic inspection and maintenance are given as follows:

(1) Inspection

In this TLPS, no portion of the line is laid in the earth. Therefore, abrasion check on launder line and pipe line can be done in a manner described in routine checking. This checking is usually done on the specific sections as mentioned. A measuring scale checks the abrasion of the launder while an ultrasonic thickness meter checks the thickness of pipes. The measured values are continuously followed and statistically summed up as guiding data for macroscopic maintenance care.

The most important tasks to be done in connection with abrasion problems are the detection of abraided portions and its location as well as foreseeing such conditions. From the results of the study on a number of slurry transportation examples, it is known that irregular abrasion frequently takes place on such portions as stepped diameter protions, steep down-slope, and portions subject to sucking air. In the design of the TLPS, consideration was given so that both bending ratio and gradient of line may not cause irregular abrasion. Such equipment as drop box and drop tank, which are used to absorb and utilize the drop force of the water, are liable, as mentioned in 7.4, to abrade irregularly, even if abrasion-preventive means are provided to it. Care should be paid also to abrasion at such portions asthe downstream side of flange connections.

For abrasion at limited portions,the pipe line is closely inspected from the inside by periodically sifting in the line. It is desirable to use the obtained results not only to repair the troubleshoot portions for recovering the initial state but to improve the portions for better maintenance.

(2) Maintenance

The line is planned to be used over a period of 20 years. Therefore, a systematic maintenance schedule should be prepared for continued use of the line during the period. The forecasted intervals of maintenance work are as shown in the following table:

| | Quantity | periodic inspection | Repair | Renewal |
|---|---|---|---|---|
| Top box | 6 | every 3 months | from 6 months to a year (parts) | |
| Drop tank | 45 | " | " | - |
| Underground fall | 2 | every 6 months | - | - |
| Pipe | 6.3 km | " | 1 year (rotate 120°) | 3 years |
| Launder | 19.7 km | 1 year | 10 years | - |

11.1.3 Communication System

In the pipeline method, long distance slurry transportation requires monitoring and control at the office situated at the starting point of the line. With the launder line method, it is essential to use partrol men as supplementary means. Accordingly, communication and coordination with patrol personnel become important.

For the entire lines, aside from communication with individual mines, an inclusive wire telephone communication system which has connections to each watching post is provided.

In tunnels or other places, there will be provided temporary telephone contact equipment. A system which permits at any time watching the movement of patrol men within the line at the control center should be established.

Because of continued twenty four (24) hour-operation basis, it is necessary to organize a system to permit contacts with safety personnel, similar to mine operations. As regards the control system, a plan is presented in the next section. For emergency countermeasures, the plans are given 7.4.10 and 7.4.11.

## 11.2 CONTROL SYSTEM AND PERSONNEL

The personnel required to run the system are shown below with indication of job titles and the range of patrol to be assigned. Patrol area is divided into three sections; mountain section, field section byond the crossing point of Bued river and sea area section. The former two sections are grouped as on-land section. For on-land patrol in the respective sections, a couple of patrol men will be assigned to each shift. For the sea area four (4) men are assigned to day shift and a couple of partrol men to each of the other two shifts. A foreman is assigned to one shift for each of on-land and sea area sections. As staff members, those with experience in slurry transportation, machine engineers, electrical engineers, and civil engineering specialists are assigned two persons respectively.

| | | | |
|---|---|---|---|
| Manager | | 1 | |
| General foreman | | 3 | |
| Foreman | | 6 | On-land 1 x 3 shifts = 3 |
| | | | Sea rea 1 x 3 shifts = 3 |
| Worker | On-land | 12 | Mountain section 2 x 3 shifts = 6 |
| | | | Field section 2 x 3 shifts = 6 |
| | Sea area | 8 | |
| Engineers | Slurry transportation | 2 | |
| | Machine | 2 | |
| | Electrical, measuring instrument | 2 | |
| | Civil engineering | 2 | |
| | Clerk | 1 | |
| | Secretary | 2 | |
| | Total | 41 persons | |

11.3 <u>RUNNING COST</u>

Of the running costs, the item which takes the largest portion is the expense for repair or replacement of abraded pipes. The data on tailings disposal of Atlas and Marcopper are used as the basic reference for this present project. As the pipes planned to be used for the construction of this project excel in abrasion resistance to those used in the above two mines, there is a possibility of reducing the total cost.

The estimated annual running costs are summarized in Table 11-1.

Table 11-1: Annual Runing Cost

Unit: Thousand Peso

| Section | | Item | Cost | Proportion | Remarks | | |
|---|---|---|---|---|---|---|---|
| Land Section | | Labour cost | 438 | 10 | Personnel; 41 persons | | |
| Land Section | Maintence Cost of Line System | Repair of launder | 112 | 3 | Repair of concrete: once/ten years | | |
| Land Section | Maintence Cost of Line System | Repair of pipeline | 252 | 6 | Rotation of Pipe: once / 1 year | | |
| Land Section | Maintence Cost of Line System | Replacement of pipe | 2,882 | 67 | Amount of Pipe: 1,300t/year once / 3 years | | |
| Land Section | Maintence Cost of Line System | Repair of drop box and tank | 136 | 3 | | | |
| Land Section | Maintence Cost of Line System | Repair of instrument | 16 | 0.4 | | | |
| Land Section | Maintence Cost of Line System | (Sub Total) | (3,398) | (80) | | | |
| Land Section | | Maintenance cost of structures (i.e. Tunnel road & related emergency facilities.) | 424 | 10 | | | |
| Land Section | | Total | 4,260 | 100 | | | |
| Sea Section | Bulkhead | | | | Reclamation | | Timber fence cost |
| | | | | | pipe cost | instal.C. | |
| Sea Section | Bulkhead | A. Rubble system | 2,278 | 0.35 | 1,892 | 179 | 207 |
| Sea Section | Bulkhead | B. Corrugated cell system | 2,278 | 0.35 | 1,892 | 179 | 207 |
| Sea Section | Bulkhead | C. Raw tailings system | 2,385 | 0.36 | 1,982 | 187 | 216 |
| Sea Section | Bulkhead | D. Classified tailings system | 2,421 | 0.36 | 1,982 | 210 | 220 |
| Total | | Cost in the case of adopting A system | 6,538 | | | | |
| Total | | -"- B system | 6,538 | | | | |
| Total | | -"- C system | 6,645 | | | | |
| Total | | -"- D system | 6,681 | | | | |

Remarks: Indicated at Sea section part is the raio against the total of both land and sea section.

# CHAPTER 12

# ECONOMIC EVALUATION

## CHAPTER 12

## ECONOMIC EVALUATION

### 12.1 BASIC IDEAS FOR EVALUATION

Generally, an investment in some Project is evaluated from the angle of investment efficiency or the profitability of the Project. Namely, the estimated cost of carrying out the Project (construction cost, operation expenses, etc.) is compared with the income gains obtainable by carrying out the Project (turn-over and direct or indirect effects upon the social economy).

However, the Project handled by this feasibility study is concerned with environmental improvement. Accordingly, there are fairly large differences in nature from projects of industrial investments or ordinary social developments. The present project involves many factors which should be assessed and studied. In particular, concerning the environments influenced by the implementation of this Project, exact assessment should be made based on the results obtained through scientific research while taking into consideration the social and political conditions.

The survey period of one month was too short for the team to sufficiently assess the present state of damages to agriculture, fishery, and other sectors caused by the outflowing tailings from the Baguio mines. The team was not also able to forecast the after-effects on the environments of the proposed project once implemented.

Needless to say, the survey team is not in a position to give judgment concering the issue on environments, taking into consisideration the social and political conditions in the Philippines.

In this Chapter, it is assumed that the construction and running costs of the TLP System which have been clarified as the result of the feasibility study will be finally redeemed thru the collected toll charge from the mine operators whose tailings are disposed of thru this system. The toll charge is calculated on some combined cases between some plans of the TLP system and some presumed interest rates. In regard to the feeder lines from the mines, the figures are excluded from this calculation.

## 12.2 TRIAL CALCULATION OF REDEMPTION

For calculation of the toll charge, the modified discounted cash flow method was employed. Namely, the construction costs, running costs and interest rates of loaned money to be disbursed during the construction period and over the whole period of operation are grouped as cash outflow and the toll charge (unknown) collected from mine operators according to the volume of tailings carried out in the form of slurry from each mine as cash inflow. Such toll charge was determined using the same discount rate as the interest rate of the loan (annual interest rate), that makes the current value of cash outflow equal to the total amount of cash inflow which is changed to the current value at the time the system starts actual operation.

Calculations were made on 35 cases by assuming five cases of construction and running costs and seven cases of interest rates. In the calculation, electronic computer was used.

The basic for calculation are as follows:

a. Both capital and operation costs will be incurred at the beginning of each year.

b. Interest will be paid at the end of each year.

c. Toll charge will be received at the end of each year.

d. The weight of transported tailings and the operation cost are constant throughout the operation period.

The numerical values (input data) used in the calculation are as follows:

a. Weight of transported tailings: 12,775,000 DMT/Y
(35,000 DMT/D x 365 days/Y)

b. Period: Construction 3 years
Operation 20 years

c. Capital cost (in million Pesos)

| Period / Case | -3rd year | -2 | -1 | +1 | +2 | +3 | +4 | Total |
|---|---|---|---|---|---|---|---|---|
| Case A | 148 | 148 | 148 | - | - | - | - | 444 |
| " B | 136 | 136 | 136 | - | - | - | - | 408 |
| " C | 71 | 71 | 71 | 41 | 41 | 21 | - | 316 |
| " D | 71 | 71 | 71 | 30 | 30 | 30 | 15 | 318 |
| " (E) | (71) | (71) | (71) | - | - | - | - | (213) |

(note) Case A : Rubble type method for making causeway is employed plus common line

Case B : Corrugated cell type method causeway is employed plus common line

Case C : Raw tailings type method making cause way is employed plus common line

Case D : Classified tailings type method causeway is employed plus common line

Case (E) : For the case of common line only

d. Operation cost (in million Pesos/Year)

| | |
|---|---|
| Case A | 6.6 |
| " B | 6.6 |
| " C | 6.7 |
| " D | 6.7 |
| " (E) | (4.3) |

e. Interest rate (annual rate %)

| | |
|---|---|
| Case 1 | 2 |
| " 2 | 3 |
| " 3 | 4 |
| " 4 | 6 |
| " 5 | 8 |
| " 6 | 10 |
| " 7 | 15 |

The result of calculation of the toll charge are as follows:

Table 12-1 The Result of the calculated Toll Charge

| Interest rate / CASE | 2% | 3% | 4% | 6% | 8% | 10% | 15% | Sea area embankment method |
|---|---|---|---|---|---|---|---|---|
| A | P/DMT 2.68 | 2.92 | 3.18 | 3.73 | 4.35 | 5.02 | 6.94 | Rubble type |
| B | 2.51 | 2.73 | 2.96 | 3.47 | 4.04 | 4.66 | 6.42 | Corrugated cell type |
| C | 2.04 | 2.19 | 2.35 | 2.70 | 3.08 | 3.48 | 4.61 | Raw tailings type |
| D | 2.05 | 2.20 | 2.35 | 2.70 | 3.07 | 3.47 | 4.57 | Classified tailings type |
| (E) | (1.38) | (1.49) | (1.61) | (1.88) | (2.17) | 2.50 | 3.42 | (For reference) about common line only |

The calculated toll charge has large differences between the groups of case A and case B and the groups of case C and case D, and it distinctively differs according to the interest rate of loaned money.

The mines concerned have to bear the slurry transportation cost, depreciation cost and the interest for the feeder line besides the toll charge in direct proportion to the volume of tailings transported by the common line.

On the basis of 1976 annual reports, the income, direct cost, after tax profit (some mines have not paid tax) per DMT of milled ore, tailings disp( al cost are shown in Table 12-2.

Table 12-2 Per-DMT Income, Direct Cost, After Tax Profit and Tailings Disposal Cost

(Unit : Peso)

| | Philex | B.C.I. | B.M.I. | Itogon | B.X. |
|---|---|---|---|---|---|
| Income | (₱/DMT) 52.35 | 143.35 | 31.44 | 110.15 | 475.00 |
| Direct Cost | 23.45 | 146.50 | 26.64 | 94.16 | 395.96 |
| After tax profit | 17.47 | 1.69 | 1.46 | △ 4.96 | 12.56 |
| Tailings disposal cost | No.1 Dam 1.3<br>No.2 Dam 1.2 | No.1 Dam (8 years) 0.94<br>No.2 Dam construction cost 2.16 | Pond 0.63 | Construction cost 0.53 | Pond (No answer) 0.5 (estimated) |

As for the percentages of toll charge to direct operation cost of respective mines, the figures of Philex and B.M.I. are high, namely, 8 to 10% in the case of 2% interest rate and 12 to 16% in the case of 10% interest rate. The toll charge percentages of other mines are markedly low because of their high direct operating costs.

When profits and toll charge are compared from the angle of bearing capacity, Philex and B.X. are found to have sufficient bearing capacity, while B.C.I. and B.M.I. earning profits are smaller than their payable toll charge.

However, comparison of the metal quotations in 1976 and those of April, 1978 tells that Cu price dropped a little from $0.64/lb to 0.60/lb, but Au rose about 40% in price from $127/Oz to $180/oz. When the earning capacities of the mines are estimated using the current metal prices, not only Philex and B.X. but also the two mines of B.C.I. and Itogon are considered capable of bearing the toll charge. B.M.I. still looks like being in a hard position.

Next, let us examine the issue of the tailings disposal method currently employed by the mines and the disposal cost.

The three mines of B.M.I., Atok and B.X., which have no large dams, will have to rely on the TLPS to continue their mining operations, if they will not be allowed to flush tailings into the rivers as what is done during rainy seasons.

Philex, B.C.I. and Itogon have large dams or have such dams under construction. Philex, whose tailings are expected to account for 80% of the tailings for the present Project, reportedly transport tailings to their No.1 Dam at a cost of 1.3 Pesos/DMT, inclusive of operation and depreciation expenditures. Their No. 2 Dam is scheduled to be completed in 1980 and usable until 1985 at a cost of 1.2 Pesos/DMT.

If their tailings are disposed of by the use of TLPS, it will cost them 2.04 Pesos/DMT under the conditions of Case C and interest rate of 2% which is the lowest in toll charge. And, if the cost of the operation and depreciation for the feeder line is assumed to be 0.5 Pesos/DMT, they will have to bear an expenditure of about 2.5 Pesos/DMT. This figure is about two times as large as their current dam disposal cost.

The present Project cannot be realized without the participation of Philex. Philex Corporation, which is to construct another tailings dams besides their existing one, has a view that they should avoid raising the tailings disposal cost by depending on the TLPS.

However, it is necessary to make not only a comparison in current costs but also to make a comprehensive study of the various factors which have to do with the matter, including such problems probably not yet studied enough on the side of Philex as the cost of No. 3 Dam for which they schedule to start construction in 1980 and actual operation in 1986, the availability of adequate dam sites in the future (the cost of dam construction is said to get higher the later the date of construction start), and the semi-permanent obligation to continue management of abandoned old dams under the severe conditions of steep terrain and heavy rains.

If the tailings disposal cost is assumed to rise two times as high as the current level to 2.4 Pesos/DMT in the future due to the above-mentioned conditional burdens, the use of TLPS will become feasible to them.

In the case of B.C.I.'s dam, it costs 2.16 Pesos/DMT for the dam construction only. This fact suggests that the use of TLPS will become less costly than using a newly constructed dam.

The situation of Itogon is similar to that of Philex.

The Project could be variously evaluated according to the estimated effect of the TLPS which is epxected to lessen the damages currently given to agriculture, the estimated value of reclaimed land, interest rate applied to funds, and so forth.

Therefore, it is necessary to make further study on this Project condering political and social factors.

# PART III

(APPENDIX)

# APPENDIX A-2

## (RESULT OF MINE SURVEY)

APPENDIX: A - 2 - 1: CHEMICAL ANALYSIS RESULTS ON SAMLES

National Science Development Board
NATIONAL POLLUTION CONTROL COMMISSION
Pedro Gil St. Corner Taft Avenue, Manila

Sample Information

SOURCE: Philex, B.C.I, Itogon, Atok, BX, Bued River, IRR Damsite, Rabon

DATE RECEIVED: February 16, 1978

DATE ANALYZED: February 20, 21, 22, 1978

SAMPLED BY : Mr. Kenichi Watanabe

A-2-1-1 : Results of Mercury Analysis

| Laboratory sample NO. | Station NO. | Mine | Station identification | ppb/Hg |
|---|---|---|---|---|
| 3135 | W-1 | Philex | Underground | 0.00 |
| 3136 | W-2 | Philex | Dam over | 0.00 |
| 3137 | W-3 | Philex | Upstream | 0.00 |
| 3138 | W-4 | B.C.I. | Acupan | 0.10 |
| 3139 | W-5 | B.C.I. | Dam over | 0.15 |
| 3140 | W-6 | B.C.I. | Balatoc downstream | 0.20 |
| 3141 | W-7 | Itogon | Slime over flow | 350.00 |
| 3142 | W-8 | Itogon | Tailing to pond | 40.00 |
| 3143 | W-9 | Itogon | Underground | 0.00 |
| 3144 | W-10 | Itogon | Dam over | 1.30 |
| 3145 | W-11 | Itogon | Downstream | 0.80 |
| 3146 | W-12 | Itogon | Downstream (B.C.I. & Itogon) | 0.50 |
| 3147 | W-15 | Atok | Underground | 0.00 |
| 3148 | W-16 | Atok | Upstream | 0.00 |

| LABORATORY SAMPLE NO. | STATION NO. | Mine | STATION IDENTIFICATION | ppb/Hg |
|---|---|---|---|---|
| 3149 | W-17 | Atok | Downstream | 0.00 |
| 3150 | W-18 | B.X. | Underground | 0.00 |
| 3151 | W-19 | B.X. | Overflow of dam | 0.00 |
| 3152 | W-20 | B.X. | Pond feed | 0.00 |
| 3153 | W-21 | B.X. | Cyclon feed | 0.00 |
| 3154 | W-22 | Bued River | Cayanga Bridge | 0.00 |
| 3155 | W-23 | IRR Dam Site | Downstream | 0.00 |
| 3156 | W-24 | IRR Dam Site | Downstream | 0.20 |
| 3157 | W-25 | Rabon | Sea water | 0.00 |
| | W-26 | Black MT | Emerald Cr. pond overflow | 0.20ppb |
| | W-27 | Black MT | Emerald + NaOH overflow | 0.20 " |
| | W-28 | Black MT | Tailings to pond | 0.00 " |
| | W-29 | Black MT | Tailings + NaOH | 0.00 " |
| | W-30 | Black MT | Downstream | 0.20 " |
| | W-31 | Black MT | Downstream + NaOH | 0.00 " |
| | W-32 | Black MT | Underground | 0.00 " |
| | W-33 | Black MT | Upstream of BX | 0.00 " |
| | W-34 | Bued River Camp 4 | | 0.00 " |
| | W-35 | Bued River Dongon Bridge | | 0.00 " |

Analyst: Signed by
VIOLETA L. PASCUA
Science Research Associate III

xxxxxxxxxxxxx: 24 February 1978

Noted by: Signed by
CLARITA C. CENTENO
Science Research Supervisor II

A - 2 - 1 - 2: Results of Cu, Zn, Cd Analysis

Unit: ppm

| Sta. No. | Station Identification | Cu | Zn | Cd |
|---|---|---|---|---|
| W - 1 | Philex Underground | 0.81 | nil | nil |
| W - 2 | Philex Dam Over | 0.07 | 0.04 | nil |
| W - 3 | Philex Upstream | 0.01 | nil | nil |
| W - 4 | B.C.I. Acupan | 0.11 | 0.24 | nil |
| W - 5 | B.C.I. Dam Over | 9.87 | 1.79 | 0.01 |
| W - 6 | B.C.I. Balatoc downstream | 1.48 | 0.66 | 0.01 |
| W - 7 | Itogen Slime overflow | 20.60 | 27.95 | 0.16 |
| W - 8 | Itogen Tailing to pond | 58.00 | 181.17 | 0.90 |
| W - 9 | Itogen Underground | nil | nil | nil |
| W - 10 | Itogen Dam over | 3.62 | 5.71 | 0.01 |
| W - 11 | Itogon Downstream | 2.40 | 4.02 | 0.01 |
| W - 12 | Itogon Downstream(B.C.I. & Itogon) | 1.37 | 0.98 | 0.01 |
| W - 13 | Atok Underground | nil | 0.01 | nil |
| W - 16 | Atok Upstream | 0.18 | 0.02 | nil |
| W - 17 | Atok Downstream | 0.06 | 0.01 | nil |
| W - 18 | B.X. Underground | 0.58 | 4.78 | 0.02 |
| W - 19 | B.X. Overflow of dam | 55.00 | 1.18 | 0.01 |
| W - 20 | B.X. Pond Feed | 446.90 | 2,472.00 | 7.76 |
| W - 21 | B.X. Cyclon Feed | 369.71 | 2,404.60 | 5.90 |
| W - 22 | Bued River Cayanga Bridge | 0.03 | nil | 0.00 |
| W - 23 | IRR Dam Site | nil | 0.08 | nil |
| W - 24 | IRR Dam Downstream | 0.08 | nil | 0.01 |
| W - 25 | Rabon Sea water | 0.15 | 013 | 0.08 |
| W - 26 | Black MT Emerald CR. Pond overflow | 0.17 | 0.04 | nil |
| W - 27 | Black MT Emerald + NaOH overflow | 0.20 | 0.04 | 0.02 |

| Sta. No. | Station Identification | Cu | Zn | Cd |
|---|---|---|---|---|
| W - 28 | Black MT Tailing to pond | 51.70 | 6.96 | 0.08 |
| W - 29 | Black MT Tailing to pond + NaOH | 75.10 | 9.05 | 0.18 |
| W - 30 | Black MT Downstream (BX + BM) | 0.52 | 0.34 | 0.03 |
| W - 31 | Black MT Downstream + NaOH | 0.33 | 0.38 | 0.07 |
| W - 32 | Black MT Underground (BX + BM) | 0.61 | 0.98 | 0.02 |
| W - 33 | Black MT Upstream of BX | nil | nil | nil |
| W - 34 | Bued River Camp 4 | 0.21 | 0.13 | 0.01 |
| W - 35 | Bued River Dongon Bridge | 0.26 | 0.07 | nil |

Date Analyzed: February 20 - 24, 1978 Date Reported: Feb. 24, 1978

Analyzed by : Signed by

MARISTTA V. PANGANIBAN
Sc. Research Associate 11

Signed by

NENITA C. LEYESA
Sc. Research Associate 1

Checked by : Signed by

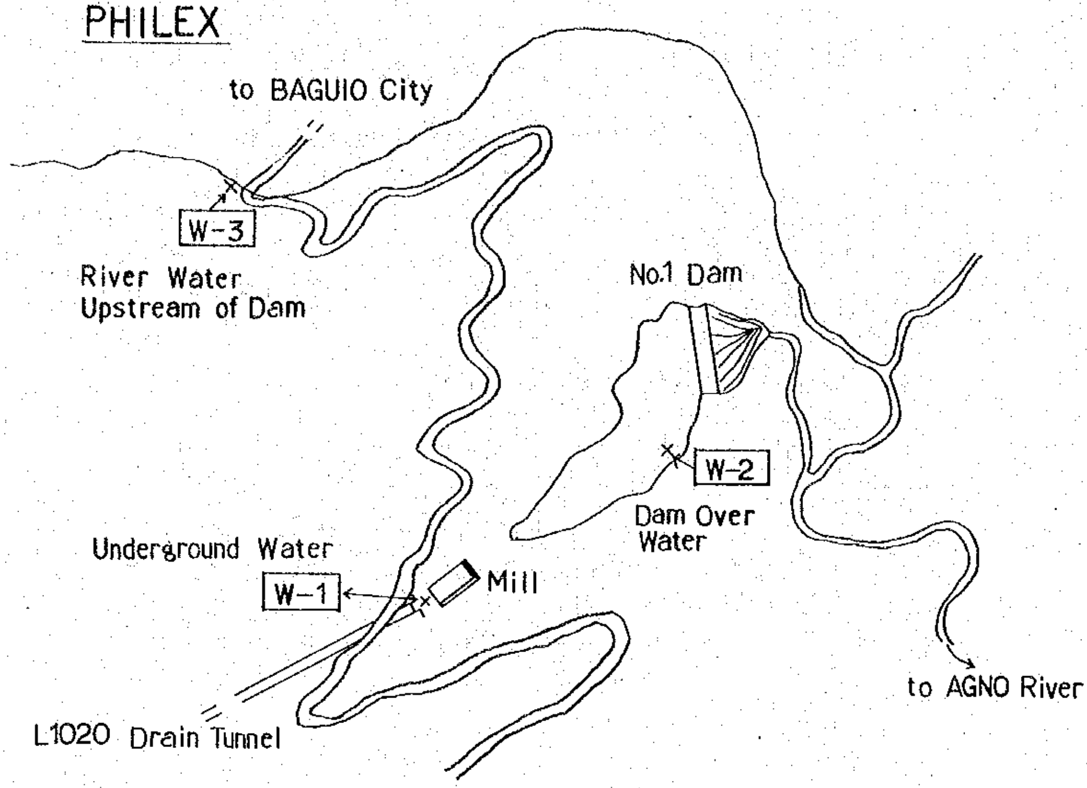
VIOLETA L. PASCUA
Sc. Research Associate 111

Noted by: Signed by

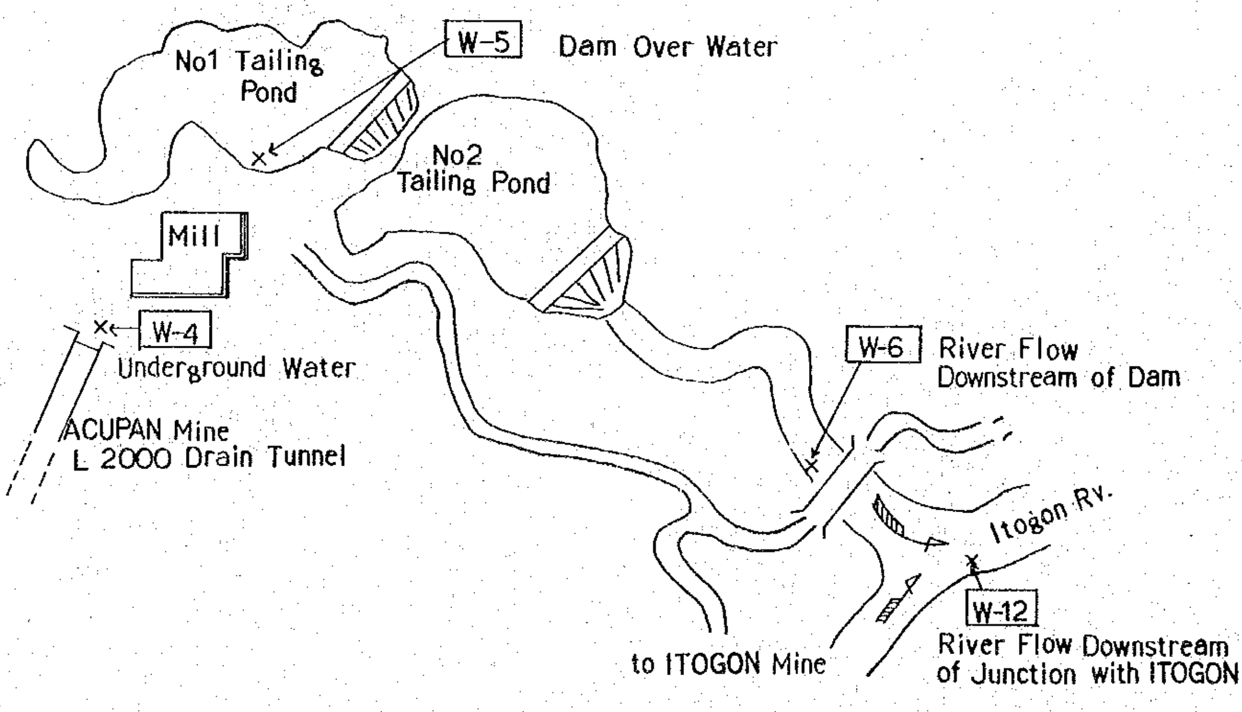
CLARITA C. CENTENO
Sc. Research Supervisor

# Sampling Point of Effluent Water

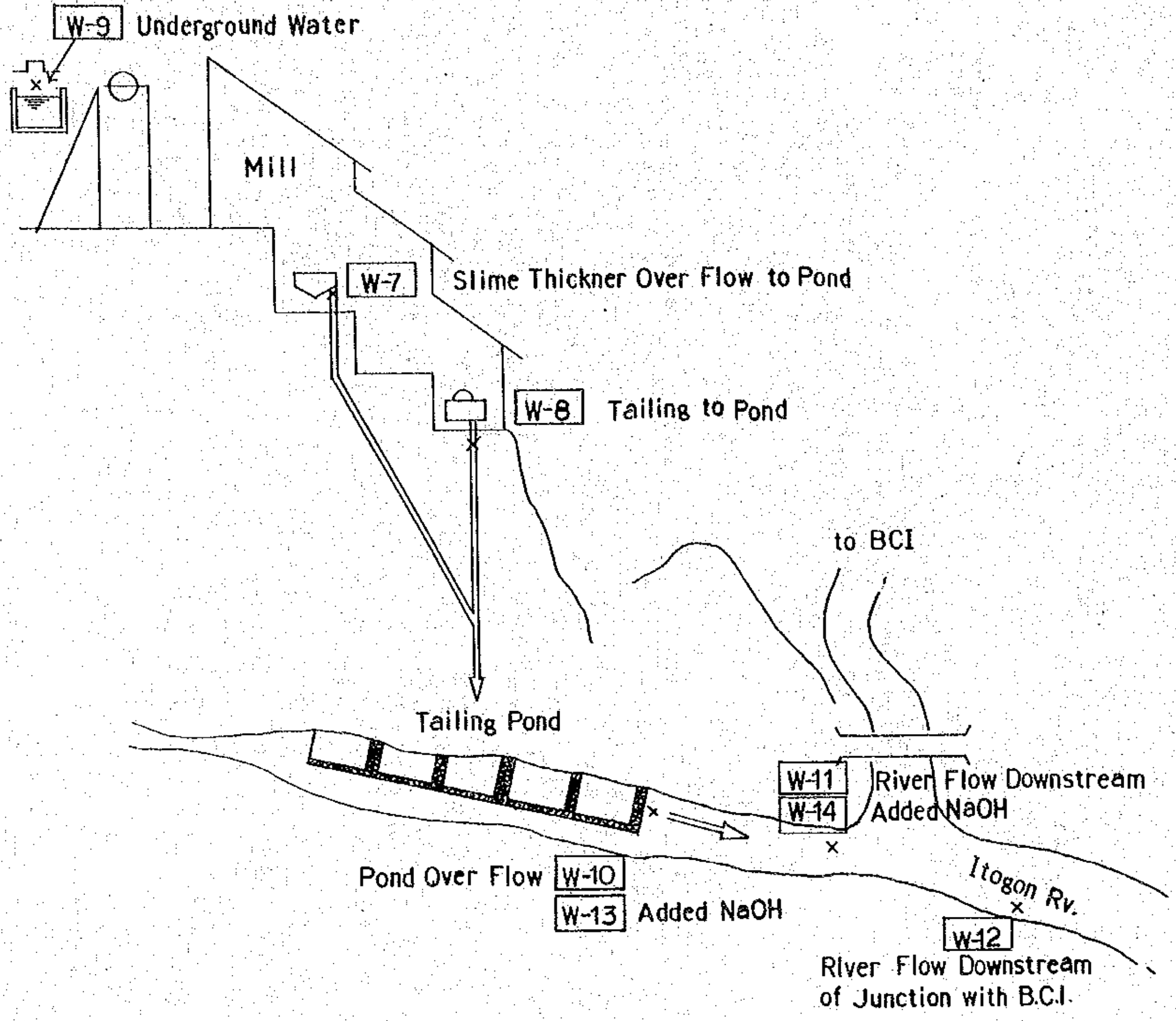
## PHILEX



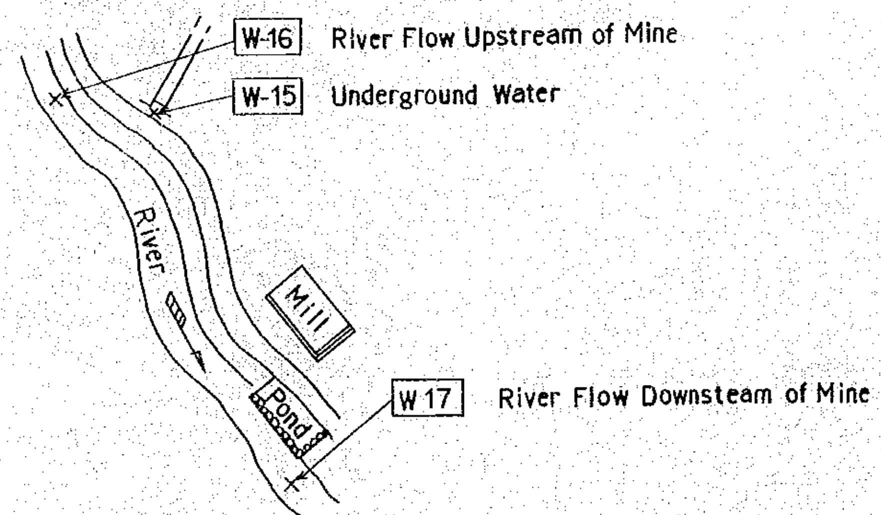

## B.C.I.



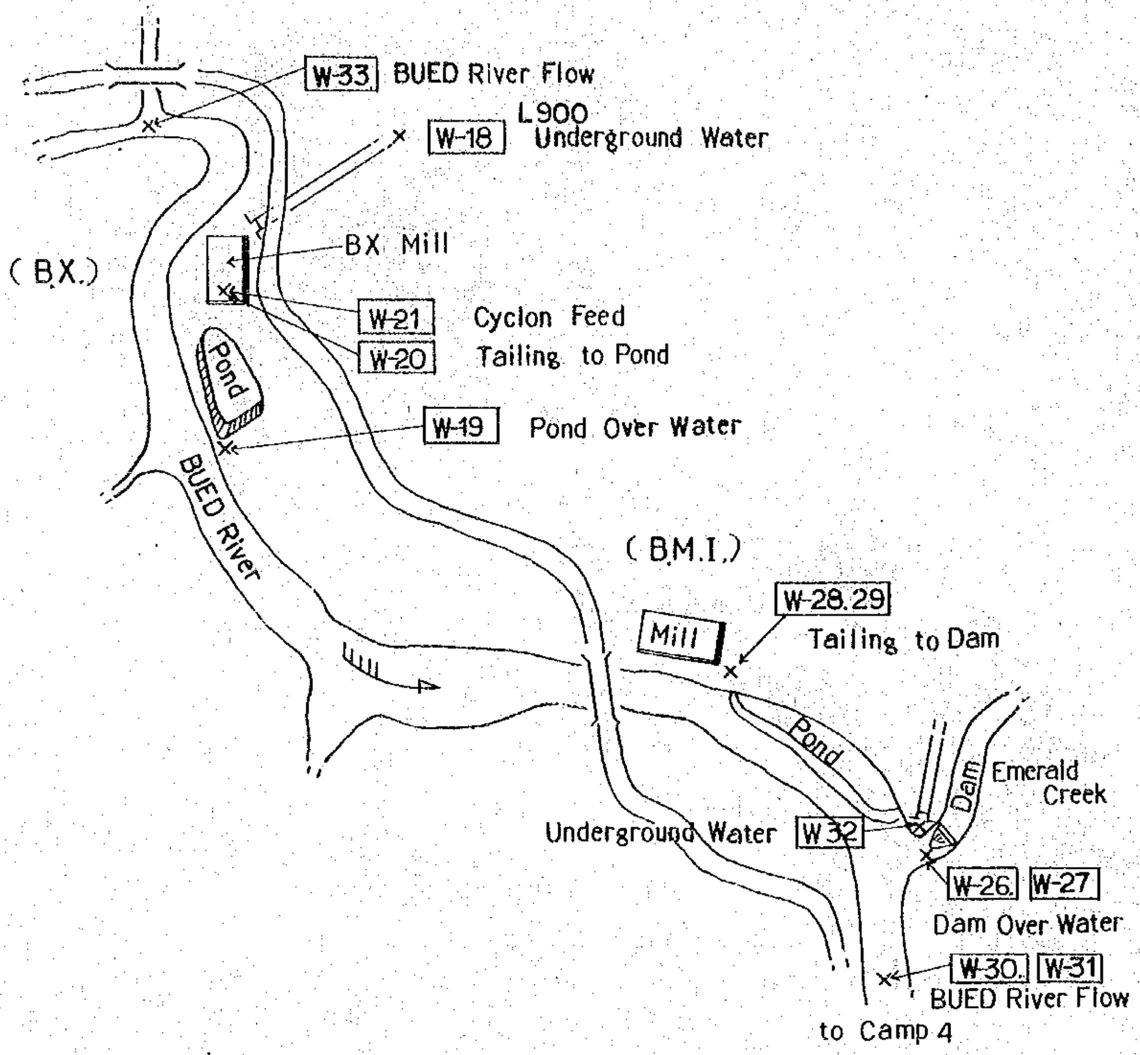
## ITOGON


W-9 Underground Water
Mill
W-7 Slime Thickner Over Flow to Pond
W-8 Tailing to Pond
to BCI
Tailing Pond
W-11 River Flow Downstream
W-14 Added NaOH
Pond Over Flow W-10
W-13 Added NaOH
Itogon Rv.
W-12
River Flow Downstream
of Junction with B.C.I.

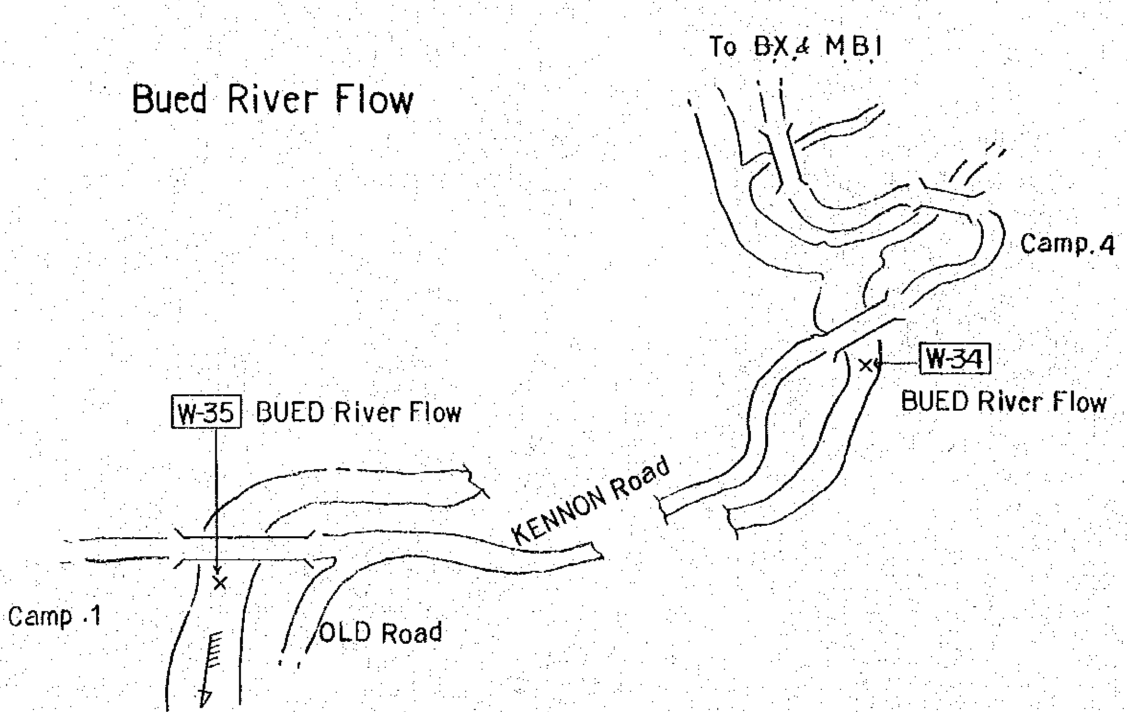
## ATOK


W-16 River Flow Upstream of Mine
W-15 Underground Water
River
Mill
Pond
W 17 River Flow Downsteam of Mine

B.X & B.M.I.




Bued River Flow



A-2-1-3 : Results of Cyanide Analysis

SOURCE : Itogon

ADDRESS :

DATE SAMPLED : Feb. 16, 1978

DATE ANALYZED : Feb. 16, 1978

SAMPLED BY : Mr. Kenichi Watanabe

| LABORATORY SAMPLE No. | STATION No. | STATION IDENTIFICATION | Cyanide, mg/L |
|---|---|---|---|
| 1 - 102 | W - 8 | Itogon Tail to Pond | 125.00 |
| 1 - 103 | W - 13 | Itogon Dam over, added NaOH | 17.50 |
| 1 - 104 | W - 14 | Itogon Downstream, added NaOH | 2.50 |
| 1 - 105 | W - 19 | BX Overflow of Dam | 8.60 |
| 1 - 106 | W - 20 | BX Pond Feed | 4.00 |
| 1 - 145 | W - 27 | Black MT Emerald Cr. Pond Overflow | 1.00 |
| 1 - 146 | W - 29 | Black MT Tailing to Pond | 125.00 |
| 1 - 147 | W - 31 | Black MT Downstream | 2.00 |

(BX & BM)

Remarks: : Analysis was done without distillation.

Signed by
Analyst: Ma. CONSOLACION D. NASOL
Science Research Associate 1

Signed by
Checked by: LUZVIMINDA V. RAMALLOSA
Science Reaearch Associate

Signed by
Noted by: CLARITA C. CENTENO
Science Research Supevisor

acd/

A-2-1-4: Sample Information (1)

| Station No. | Station Identification | pH | | Value of Chemical Analysis | | | | | | | | | | Sp. Gr. | Size Distribution Mesh - % | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | by Philippines | by Japan | Cu | | Zn | | As | Hg | Cd | Pb | CN | $SiO_2$ | | | | | |
| | | | | Phil. | Ja. | Phil. | Ja. | | | | | | | | +48 | ~200 | ~325 | ~325 |
| W - 36 | Philex Filtrate (F) | 7.40 | 8.50 | 0.07 | 0.01 | 0.01 | 0.47 | 0.02≥ | 0.001≥ | 0.02≥ | | | | | | | | |
| | Tailings Thickener Under Solid (S) | | | | | | | 3≥ | 0.2≥ | 1.0≥ | | | 53.95% | | 20.4 | 37.1 | 10.7 | 31.8 |
| W - 37 | Philex (F) | 7.60 | 8.60 | 0.15 | | 0.01 | | | | | | | | | | | | |
| | Miscellaneous Waste Water (S) | | | | | | | | | | | | | | | | | |
| W - 38 | Philex (F) | 7.50 | 8.30 | 0.15 | 0.03 | 0.03 | 0.76 | 0.02≥ | 0.001≥ | 0.01≥ | 0.29 | | | | | | | |
| | Dam Feed (S) | | | | 1,365 | | 74 | 3≥ | 0.2≥ | 1.0≥ | 28 | | 52.19% | 2.73 | 1.1 | 35.9 | 14.9 | 48.1 |
| W - 39 | Philex (F) | 7.25 | 9.00 | 0.09 | | 0.02 | | | | | | | | | | | | |
| | Tailings Thickener Feed (A) (S) | | | | 195 | | 63 | | | | | | | | 6.1 | 35.7 | 17.2 | 41.0 |
| W - 40 | B.C.I. (F) | 10.30 | 11.10 | 27 | 2.24 | 0.03 | 0.68 | 0.05 | 0.2≥ | 0.01≥ | | (0.1≥) * | | | | | | |
| | Tailings Cyclone Feed (S) | | | | 207 | | 962 | | 124 | 0.001≥ | 2.9 | | 55.08% | | 3.1 | 34.5 | 14.7 | 47.7 |
| W - 42 | Philex (F) | | 9.0 | | | | | | | | | | | | | | | |
| | Tailing Launder (Face) (S) | | | | | | | | | | | | | | 4.9 | 37.2 | 14.0 | 43.9 |
| W - 43 | Philex (F) | | 9.0 | | | | | | | | | | | | | | | |
| | Tailings Launder (Bottom) (S) | | | | | | | | | | | | | | 25.0 | 33.0 | 9.1 | 32.9 |

Note: 1) (F), Clarified Water : (mg/l), (S), Solid: (ppm)

*: Quantity is not sufficiant

2) Analysis in Philippines: By N.P.C.C.

3) Analysis in Japan : By Dowa Mining Co.

4) Data except PH, Cu, Zn were obtained in Japan.

Sample Information (2)

| Station No. | Station Identification | pH | | Value of Chemical Analysis | | | | | | | | | | SSp. Gr. | Size Distribution Mesh - % | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | by Phili-ppines | by Japan | Cu | | Zn | | As | Hg | Cd | Pb | CN | SiO2 | | | | | |
| | | | | Phil. | Ja. | Phil. | Ja. | | | | | | | | +48 | ~200 | ~325 | ~325 |
| W - 41 | B.C.I. Filtrate (F) | 10.00 | | 16 | | 0.02 | | | | | | | | | | | | |
| | Cyclone Over Flow Solid (S) | | | | | | | | | | | | | | | | | |
| W - 44 | Atlas (Car. Con) (F) | 9.75 | 10.40 | 0.07 | 0.01 | 0.03 | 0.42 | 0.02≥ | 0.001≥ | 0.01≥ | 0.29 | | | | | | | |
| | Tailings Thickener Under (S) | | | | 624 | | 69 | 3 ≥ | 0.2 ≥ | 1≥ | 23 | | 54.21% | 2.70 | 9.7 | 40.3 | 11.5 | 38.5 |
| W - 45 | Agno River's River Water (At the Bridge across No.3 National Way) | 8.05 | 8.30 | 0.01 | 0.03 | 0.02 | 0.58 | | | | | | | | | | | |
| W - 46 | Philex (F) | 7.35 | | | | | | | | | | | | | | | | |
| | Dam Feed (S) | | | | | | | | | | | | | | | | | |
| W - 47 | Philex (F) | | 8.60 | | 0.01≥ | | 0.56 | | | | | | | | | | | |
| | Tailings Thickener Feed (B) (S) | | | | 294 | | 68 | | | | | | 50.94% | | 1.9 | 30.8 | 14.7 | 52.6 |
| W - 35 | Philex (F) | | | | | | | | | | | | | | | | | |
| | Cu Concentrate Slurry (S) | | | | 23.54% | | | 30 | 0.2≥ | | | | 24.14% | 3.28 | | | | |
| E - 15 | Bued River's River Location Solid(s) (Reservation) Siltation (Brown color) | | | | 141 | | 160 | 10 | 0.2≥ | 1≥ | | | | | 4.8 | 47.6 | 15.8 | 31.8 |

Sample Information (3)

| Station Identification | Value of Chemical Analysis (in Japan) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cu | Zn | Pb | Fe | S | As | Hg | Cd | | | $SiO_2$ | $Al_2O_3$ | MgO | CaO | $Na_2O$ | $K_2O$ |
| 1. Philex Filtrate (F)<br>Tailings Thickner<br>Under Solid (S) | 827 ppm | 50 ppm | 51 ppm | 5.78 % | 0.05 % | 0.3 ppm | 0.2≥ ppm | Nil | | | 60.76 % | 16.40 % | 4.36 % | 2.38 % | 4.27 % | 0.88 |
| 2. Philex (F)<br>Tailings Sand on Dam-body (S) | 1,055 | 459 | 7 | 6.90 | 0.10 | 0.3 | 0.2≥ | Nil | | | 57.82 | 16.24 | 3.07 | 2.59 | 4.41 | 0.64 |
| 3. B.X. (F)<br>Cyclone Over (S) | 902.7<br>918 | 1.4<br>3,112 | 1.1<br>1,103 | 1 ppm<br>15.50% | 173 ppm<br>13.88% | 0.01<br>74 | 0.005<br>0.2≥ | 0.01 ppm<br>16 | | | 28.44 | 7.86 | 3.58 | 16.84 | 0.57 | 0.47 |
| 4. Bued River's<br>River Location<br>(Reservation)<br>Siltation (S) | 684 | 44 | 55 | 4.81 | 1.01 | 9 | 0.2≥ | 2 | | | 53.48 | 15.91 | 4.25 | 7.41 | 2.88 | 1.24 |
| 5. Bued River's River Bed<br>Siltation | 909 | 481 | 75 | 4.62 | 0.91 | 5 | 0.2≥ | 2 | | | 57.21 | 16.36 | 5.62 | 3.22 | 2.40 | 1.82 |
| 6. Bued River's<br>River Water | 0.1 | 0.3 | 0.05 | 3.2 ppm | 28 ppm | 0.01 | 0.0005 | 0.01 | | | 49 ppm | | | | | |

Note : 1) Analysed sample : Taken at the preparatory Survey.

2) Samples of above item Nos. 4,5,6 were taken at Camp 1 vicinity