AGRICULTURAL LAND AND WATER RESOURCES DEVELOPMENT COURSE

DESIGN OF HEADWORKS

Appendix

1983

Ministry of Agriculture, Forestry and Fisheries (MAFF)
Japan International Cooperation Agency (JICA)
The Japanese Institute of Irrigation & Drainage (JIID)

Contents

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I. Agronomical Measure & Engineering Measure

(1) Characteristics of Rice Cultivation in Japan

It is said that the Japonica type rice planted in the south Yangtze River basin was transported to Kyushu (west Japan) from China in the first century B.C. or in more earlier period.

The rice was prefered to the Japanese nation, and rapidly spread over the Honsyu the largest main Island, and it reached to Aomori Prefecture the northern most prefecture of Honshu in the thirteenth century.

To another island, Hokkaido, rice was interoduced in the 18th 20th century, and made the northern boundery of rice cultivation in Japan.

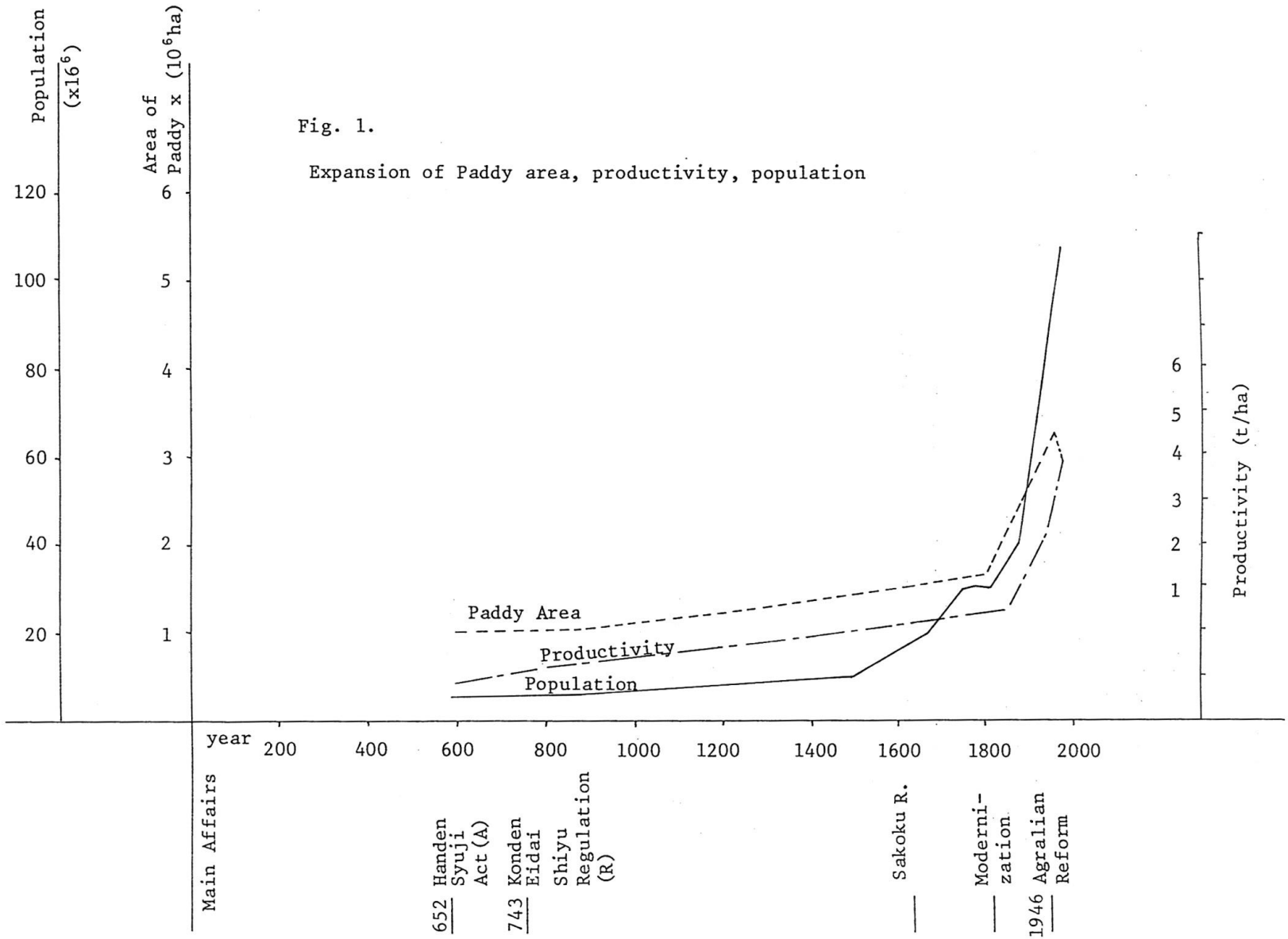
The historical extention at the area, under paddy in Japan is given below.

Period	Area under paddy in hectars
(a) 1st century to the 8th century A.D. (900 years)	1,050,000 ha
(b) Middle of the 8th century to the 18th century (1000 years)	1,650,000 ha
(c) Middle of the 8th century to the end of 19th century	2,656,000 ha
(d) End of the 19th century to late 20th century (80 years)	3,300,000 ha

Corresponding to the nations wide population, These tendancy in the advancement of rice cultivation is shown in Fig. 1.

Fig. 1.

Expansion of Paddy area, productivity, population



(2) Characteristics of rice cultivation in Japan

1) Control of water — Development of Irrigation and Drainage system

a. Limited Climate condition — Stabilization of condition for cultivation. Necessity of "irrigation for draught

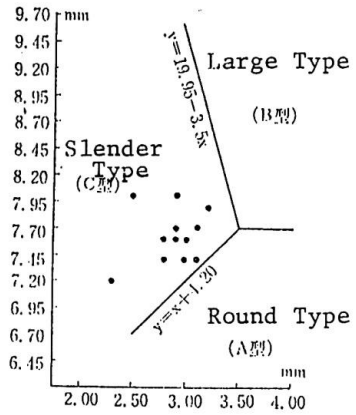
b. Steep topography — Easy introducing of irrigation water by gravity

2) Improvement of variety

a. Anti-cold variety — introducing to the northern (colder)

b. Short - "term" — avoiding from the devastation by typhoon.

*(variety of Rice)



3) Attainment of high productivity

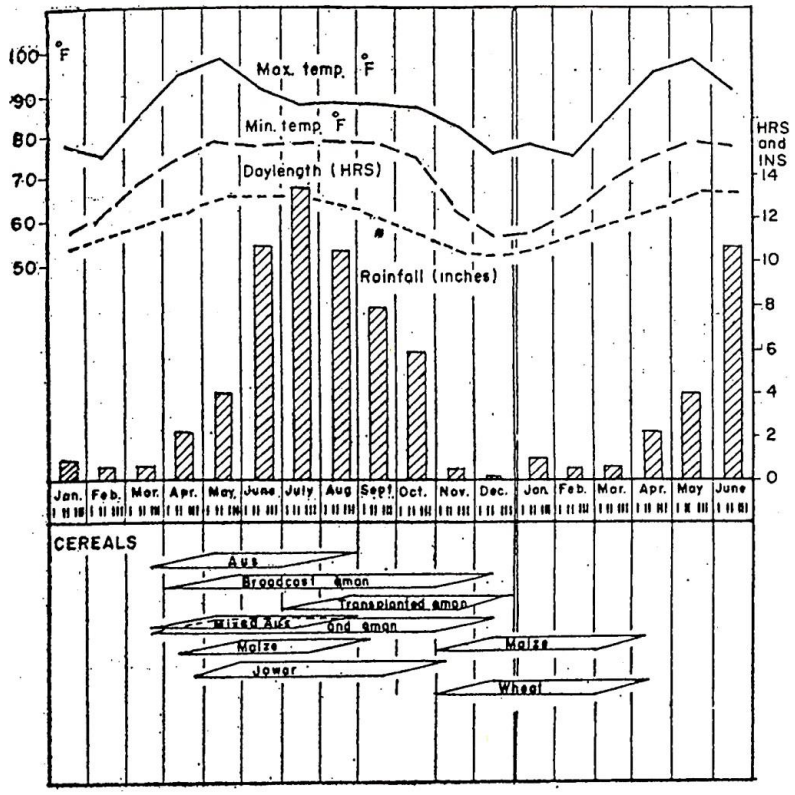
* Total Territory : 372 x 1000 km^2

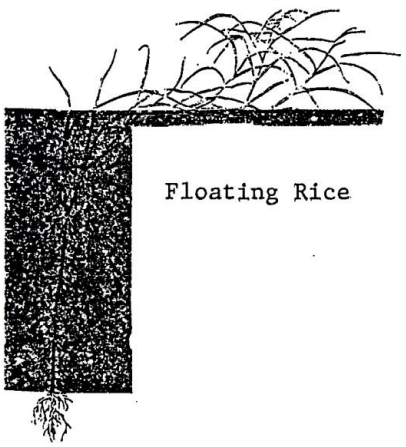
low land	15%
terrace	11%
hilly	11%
mountain	63%

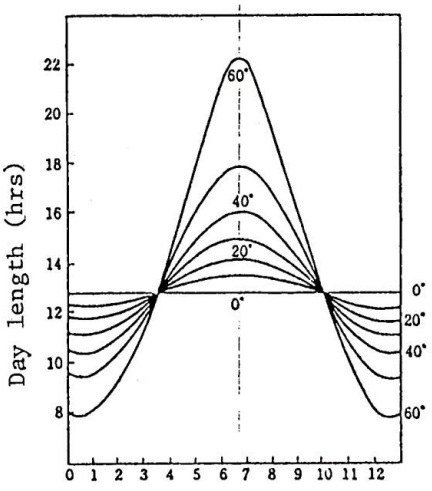
4) Agronomical Measure and Engineering Measure

As for the development of rice cultivation, there exist the two types of measures, one is Agronomical measure, and the other is engineering measure.

Here, the rice cultivation in Bangladesh is exemplified as the typical representative of agricultural measures. There exist three characteristic variety, to adopt the natural condition, they are, Aus, Aman, and Boro variety. Those are exemplified in the next page, with environmental factors.







Lattitude and Day length

Fig. 2-1 Crop calendar and environmental factors in the Ganges Kobadak area Bangladesh

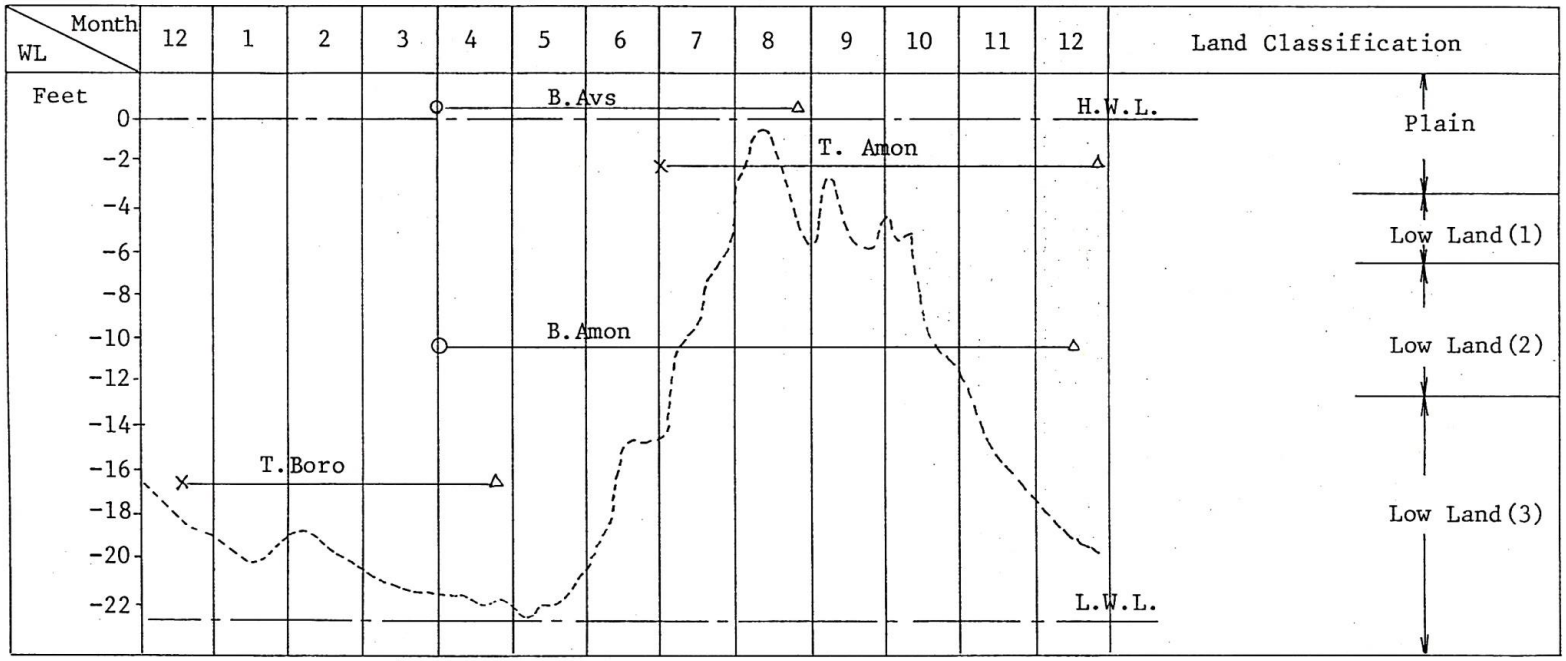


Fig. 2-2; Cropping pattern in Bangladesh

5) Development of Irrigation Facilities (Engineering Measure)

At the earlier period it is said that rice was cultivated in the lower delta, or the muddy swamps, along rivers as the rain-fed condition. As mentioned before, irrigation was necessary for the stable cultivation, and the easy topographic condition, made it easy.

At the end of 19th century, the river water at the draught might be occupied, and this made the strict water right among the districts. According to the development of engineering works, new irrigation system has been developed at the site, where, even though, considered as the unable site, by constructing reservoir, big Head Works, and canal system to provide new irrigation water for the new area.

Longitudinal River profile in Japan, and present water utilization is shown below,

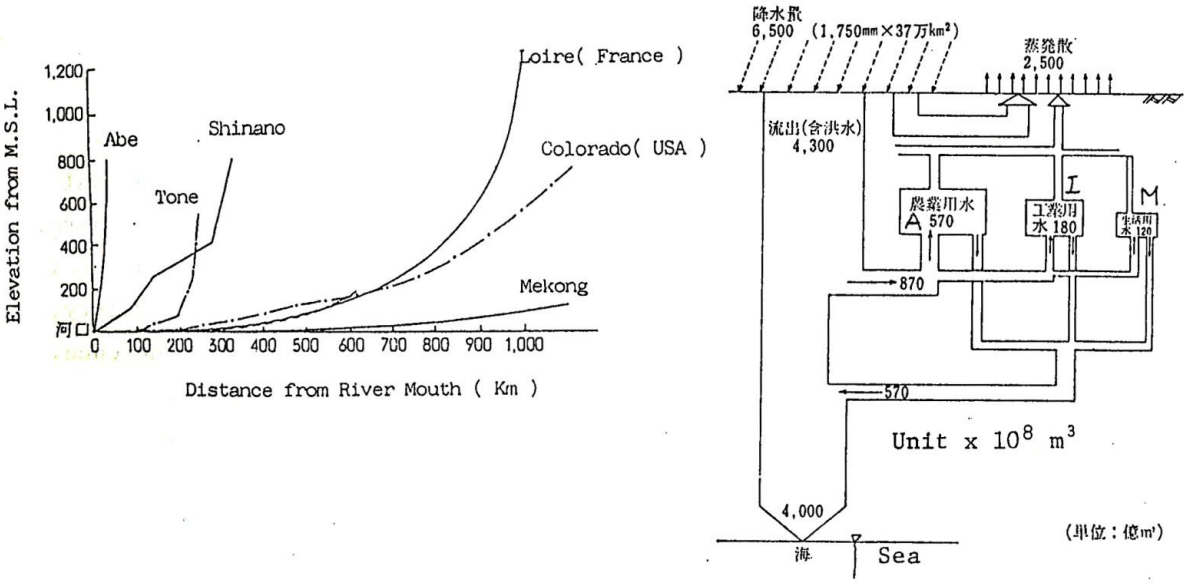


Fig. 3; Longitudinal River Profile and Present water utilization

In Japan it would be concluded that the attainment of high productivity in rice cultivation was the result by the so called engineering measure which means the construction of irrigation and drainage system.

However, to attain the further agricultural development, conjunctive development both Agronomical and engineering measure's should be necessary.

II. Case Study on Fukagawa Irrigation System

As the typical development on the irrigation system in the field, the Fukagawa Irrigation system in Hokkaido is shown.

Fukagawa district is located around lattitude 42 deg north and longitude 142 deg. East, along the Ishikari River, central part of Hokkaido, the northern most island in our country.

Up to the middle 17th century, the wide area of Hokkaido had been left as the non-reclamated island.

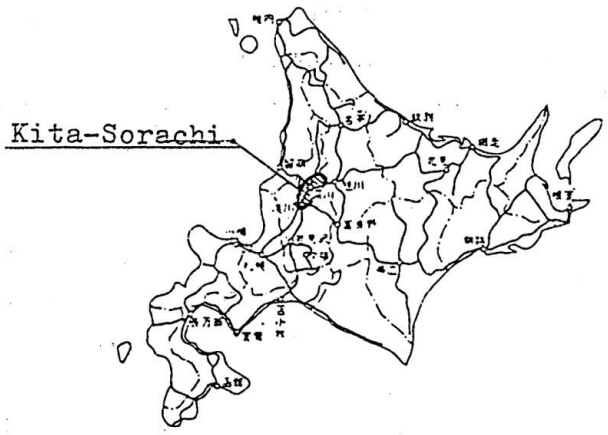


Fig. 4; Location Map of Fukagawa Irrigation System

Original inhabitants in Hokkaido, were engaged mainly fishery and hunting. In the middle of 19th Century, newly arised Meiji government, instead of old Tokugawa Shogunate, perceived the national advantage of development on this island.

There existed two principal factors for the new leaders, one was the abundant natural resources such as, forestry, coal, agriculture, fishery etc., and the other was necessity for the defence.

The upland farming system was firstly adopted from America or other European countries, because of the rice cultivation was considered as the unavailable farming for the strict cold weather condition.

At very beginning of the reclamation, farmer's can get enough income through there upland farming practice.

However, only taking out from soil fertility with poor input of fertilizer the farmers life was faced to the critical coundition, and they strongly desired the rice cultivation, for almost all the new transmigrated farmers were will experienced in the rice cultivation at their native

In the Fukagawa district, test cultivation of paddy was attempted by one of the farmers, in 1896, at model paddy, he made by using the small flow, and it marked the successful completion.

The record on the trial said that the harvested rice from model farm (area 6000 m^2) was ton. This might be caused by the good weather condition.

This great result was rapidly transferred among the farmers, and their desire for the paddy cultivation was extremely heightened.
However, water resources, those small flows were limited, and to satisfy the water demand for the entire area (5,000 ha), the irrigation facilities from river Ishikari, or River Uryu (its Branch) should be constructed.
Only farmer's effort, it was impossible to make a proper design on the said system and farmers made a organization for Construction Corporation, called Doko Kumiai, in order to request the execution of the Project.
At that age, all the cost for the construction as well as operation and maintenance of the system, had to be borne by farmers themselves.
In compliance with their strong request Hokkaido Regional Government had decided to carry out, the Feasibility Study on the Fukagawa Irrigation System, and they were performed in 1901 to 1903, and judged that the project was feasible.
By the design, Uryu river irrigation system was adopted as the most appropriate system after the comparative study.
Thus, at the time, when the construction of the system was being started, the farmers in the upper reaches of the Uryu River, claimed that the intake should be changed into the other river basin.
After the receiving the claiming, the government co-ordinated both farmer's organization, and judged that the system should be changed into the Ishikari main river.
The necessary study was carried out by the Hokkaido Regional Government, however, the cost of the new system was increased by changing its system and increased amount was estimated, about 25%.
Fukagawa farmer's organization, could not bear the total cost, especially, the additional 25% for they were the product from the administration, and strongly, persistently, the financial aid by the Government, and finally got the approval on the 25% financial support.
The construction was commenced in 1915, and completed 1917.
The outline of this project was as follows.

(1) Name of the Project : Fukagawa Irrigation System
(2) Benefit area : 4857 ha (upland → paddy)
(3) Numbers of farmers house hold: 370
(4) Main works
    1) : Intake
    2) : Main Canal : (Tunnel and Open channel)

Capacity : 7,506 $m^{3/s}$, i = 1/6,000, v = 0.64 m/s 0.46 m/s
(warming for water)

3) : Pump station

After the completion, of the main works, paddy area expanded as scheduled, however the intaking of the irrigation water from main river was not stabilized, for the structural reason, on the free intake.
To stabilize the intake temporary weir by gabion was made for some years, and finaly, construction of fixed type weir was planned, and completed in 1930.

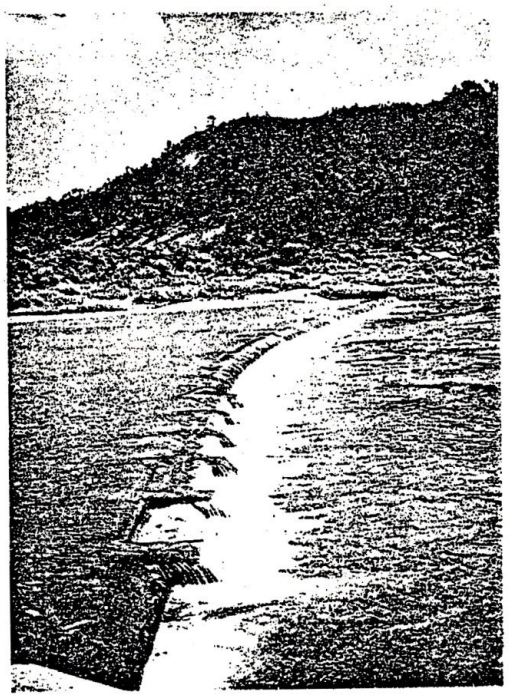


Fig. 5
Fukagawa Head works (1930)

Thus, the intaking of water from the river was improved, but as the benefit area of the Fukagawa irrigation system was composed mainly peat soil and sandy soil, the percolation was big, and this caused total shortage of irrigation water.
During the draught, they often installed the wooden plate to dam up for the increasing of irrigation water, but this load the water right-quarrel along the river, especially between - The Sorachi - system. To solve this quarrel, the government planned additional construction, to move the lower intake to the weir-site, with the heightening of fixed weir, and installation of sediment flush gate in 1950.

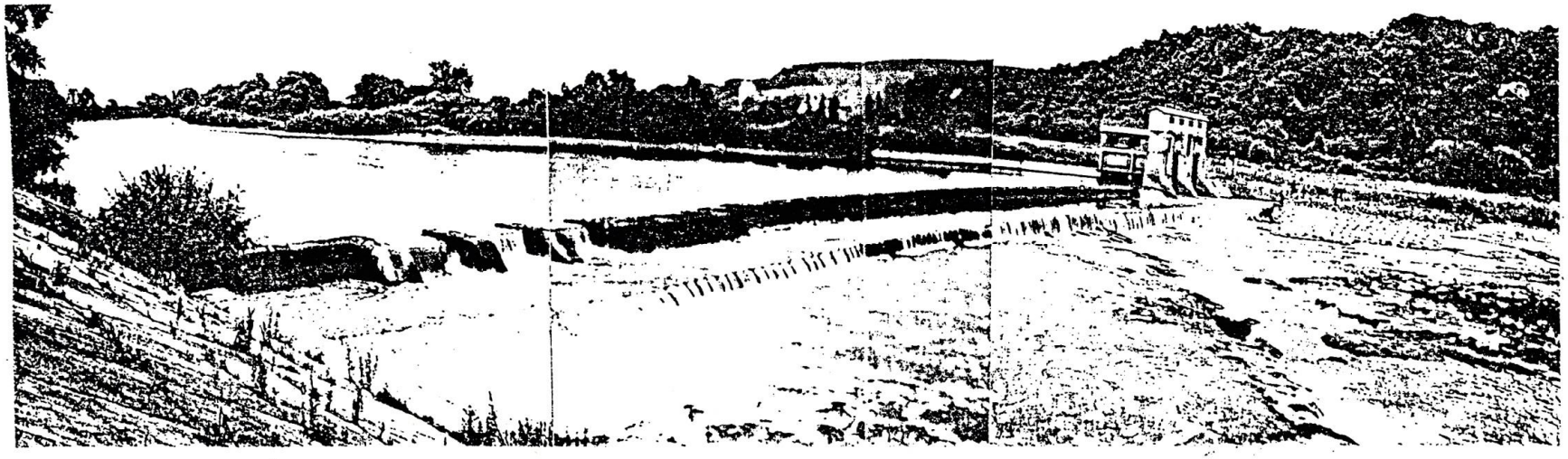


Fig. 6 Fukagawa Head Works (after installation of flushing gate)

(Photo taken in 1975)

In 1975, the farmer's organization, in this district, requested the rehabilitation project on those system, as the weir were facing to the dangerous failure by the piping, coused dropping of river-bed at downstream. The scoured depth at the head-work was measured at 4 m deep, and Government decided the project is to be performed.

As already mentioned, in Japan the development on intaking from the rivers are as follows;

(1) Free intake

(2) Fixed weir

(3) Fixed weir with small flush-gate, and

(4) Movable weir

At the very beginning of the rehabilitation project, I was ordered at the direct responsible position of this project; from 1977 ∿ 1980.

Th: most urgent matters to be settled was as follow.

(1) decision of weir-site

Their existed the discrepancy between the farmr's at left bank-side (Sorachi-system) and right bank-side (Fukagawa-system) on the water utilization, or those in the upstream and downstream.

After the field reconaissance, and checking the original design of the weir, the reason why the fired weir could be born, for 50 year's in spite of the 4 m deep river bed scoring.

That was the sheet pile-setting at the fixed weir as shown below.

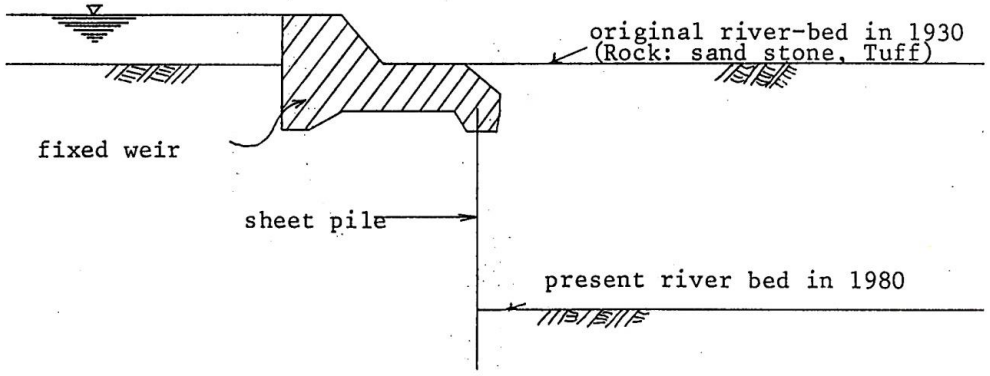


Fig. 7; Section of Fixed Weir

In 1981, the tremendous flood estimated provability 1/500) attached to the Ishikari river basin, and cuased the big damage along the river, by failure of the river-dyke & others.

At the Fukagawa Head works, the right bank side of the weir abutment was scored with 120 m width, however, fixed weir could survive from the attacking.

Thus, for the safety design, on the weir, following measure's should be taken into account;

(1): Sheet pile against piping action (being considering the river bed sinking after the construction of weir), or adequate river bed protection works.

(2): Protection of Abutment portion of weir by setting the Wingwall.

On the design of new head-works, above two great points were taken into account, and the movable gate with maximum length in 41.600 m are to be adopted as shown in next Fig.

At the same time, taking all those important factors into the design. Co-ordination, was carried out among followings;

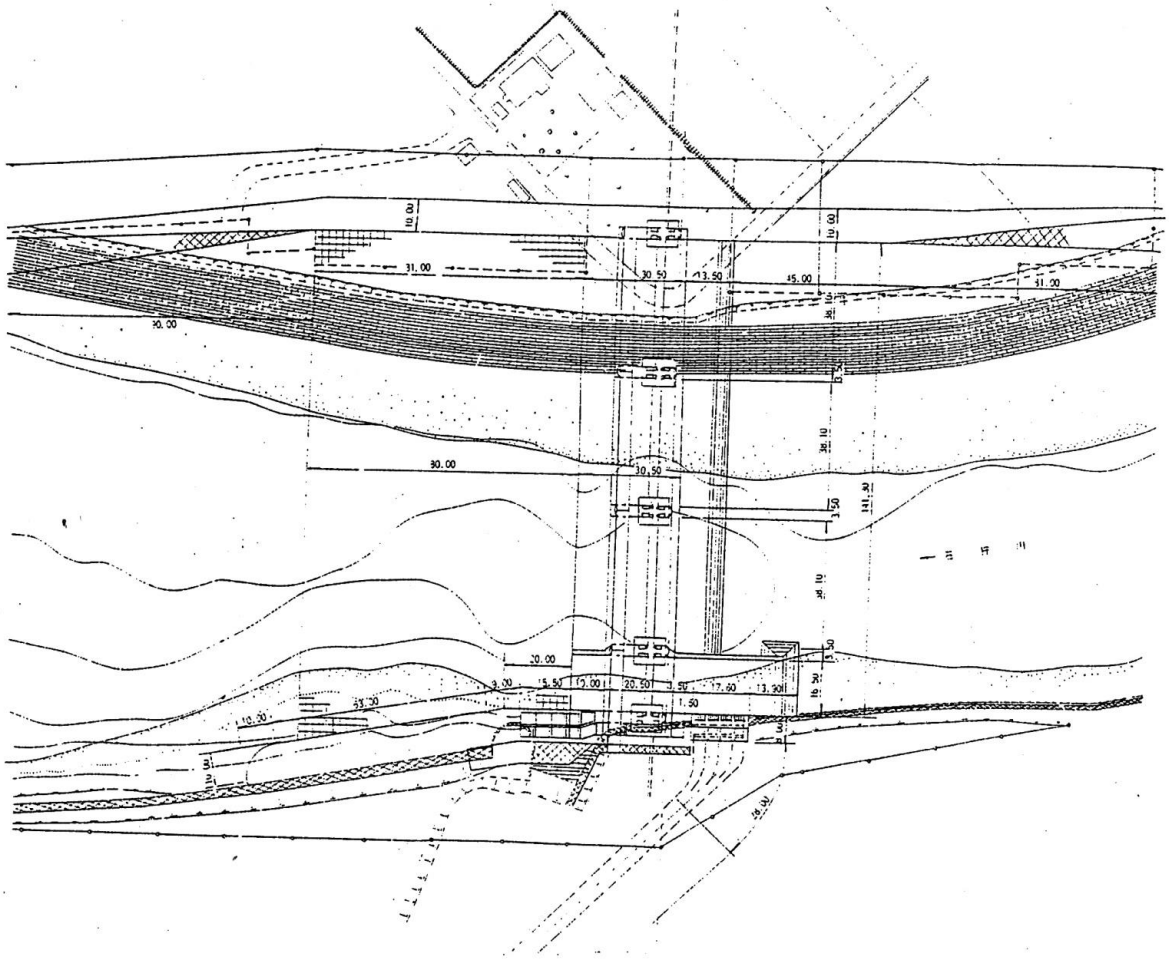
(1): Land owner at the job site

(2): Ministry of construction; (based on the River Law)

(3): Farmer's organization

Thus; weir site was selected to the 300 m down-stream from the existing weir.

Plan



Front Look

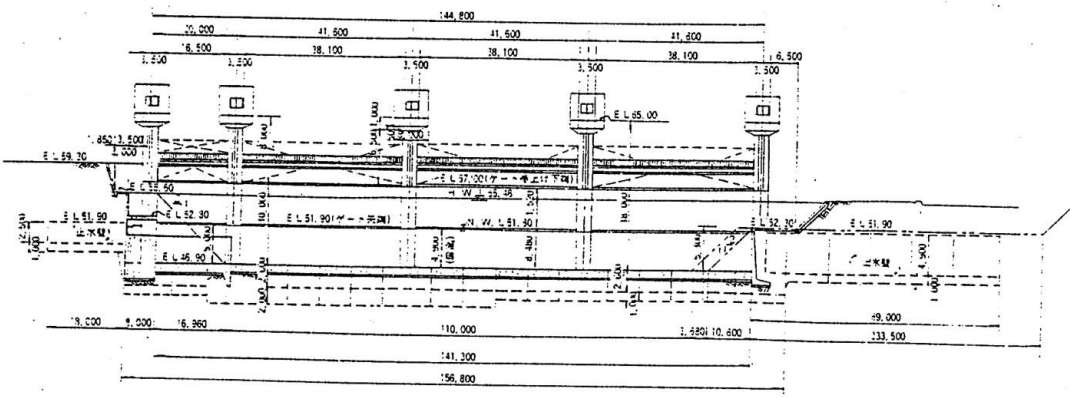


Fig. 8; Kita-Sorachi Head Works

II. Pipe Line System

(1) Characteristics of pipe-line system in paddy

In Japan many reasons for the adoption of pipe-line system in paddy area are considered as follows;

1) Unadequate topographic condition for the open canal system.
2) Water resources (lake, or rivers) for the beneficial area are located in the low position.
3) Quantity of water resources is shortaged, and repeating use by the using of drained water at the lowest is adopted.
4) Saving of agricaltural land by setting the pipe in the underground, and
5) Saving the operation and maintenance labour requirement.

As mentioned above, the adoption of pipe-line system, brought the many benefits, however, difference on the hydraulic phenomena between open-canal system, and pipe line system, should be taken into the original design, for, the users (farmers) have been traditionaly experienced in the open canal system.

The typical difference on the hydraulic phenomena are as follow;

1): Instead of upstream on the open canal system; the lowest position is likely to be the hydraulic advantage portion.

From the investigation, the typical example is shown below;

(2) Outline of Project Area:

Benfit area: 208 ha (paddy 131 ha, upland 43 ha, orchard: 10 ha, others: 23.3 ha)

Among the benefit area, pipe-line system covers the 120 ha)

The major problem, to be settled was how to operate pipe line system, with equal water distribution.

(3) Pipe line system

In this area, pipe line system was designed as the open type pipe line system by using the gravity pressure.

General system diagram is shown in the following Figures.

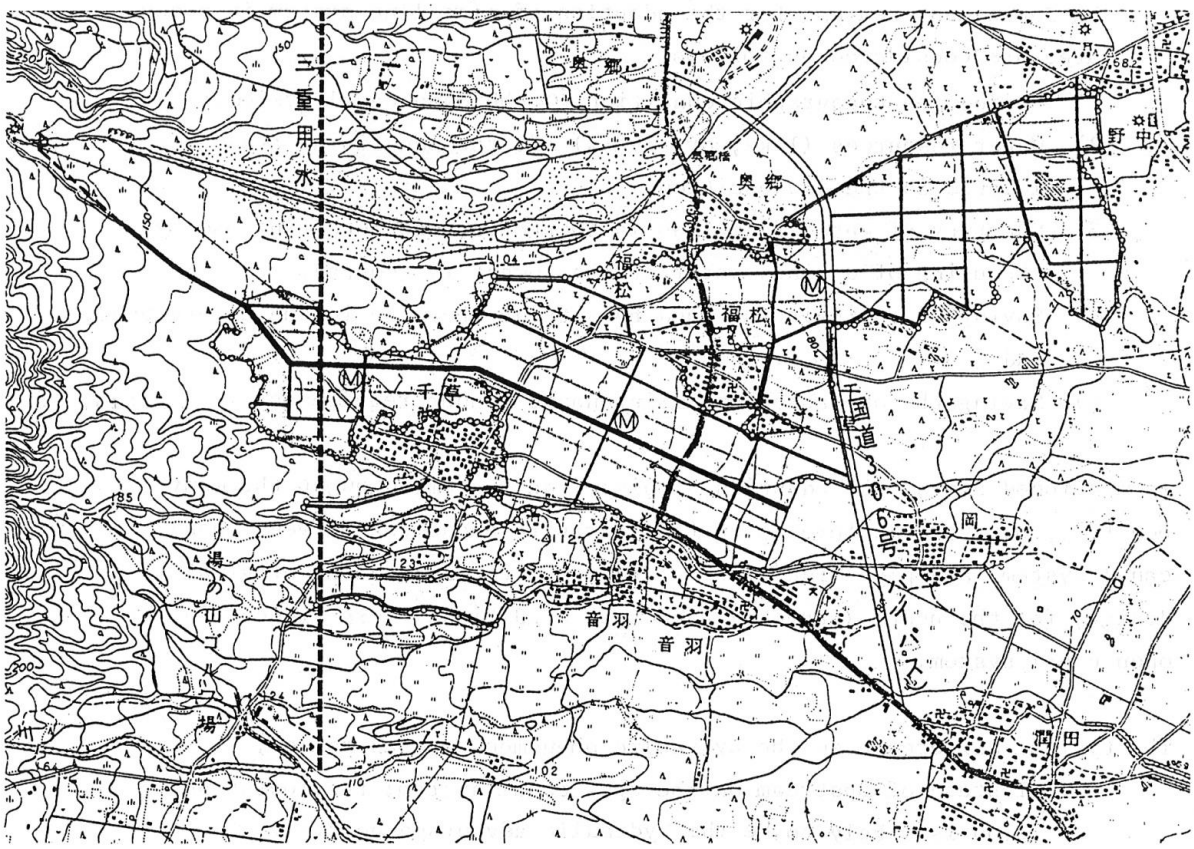


Fig. 9; Location Map of the Pipe Line System

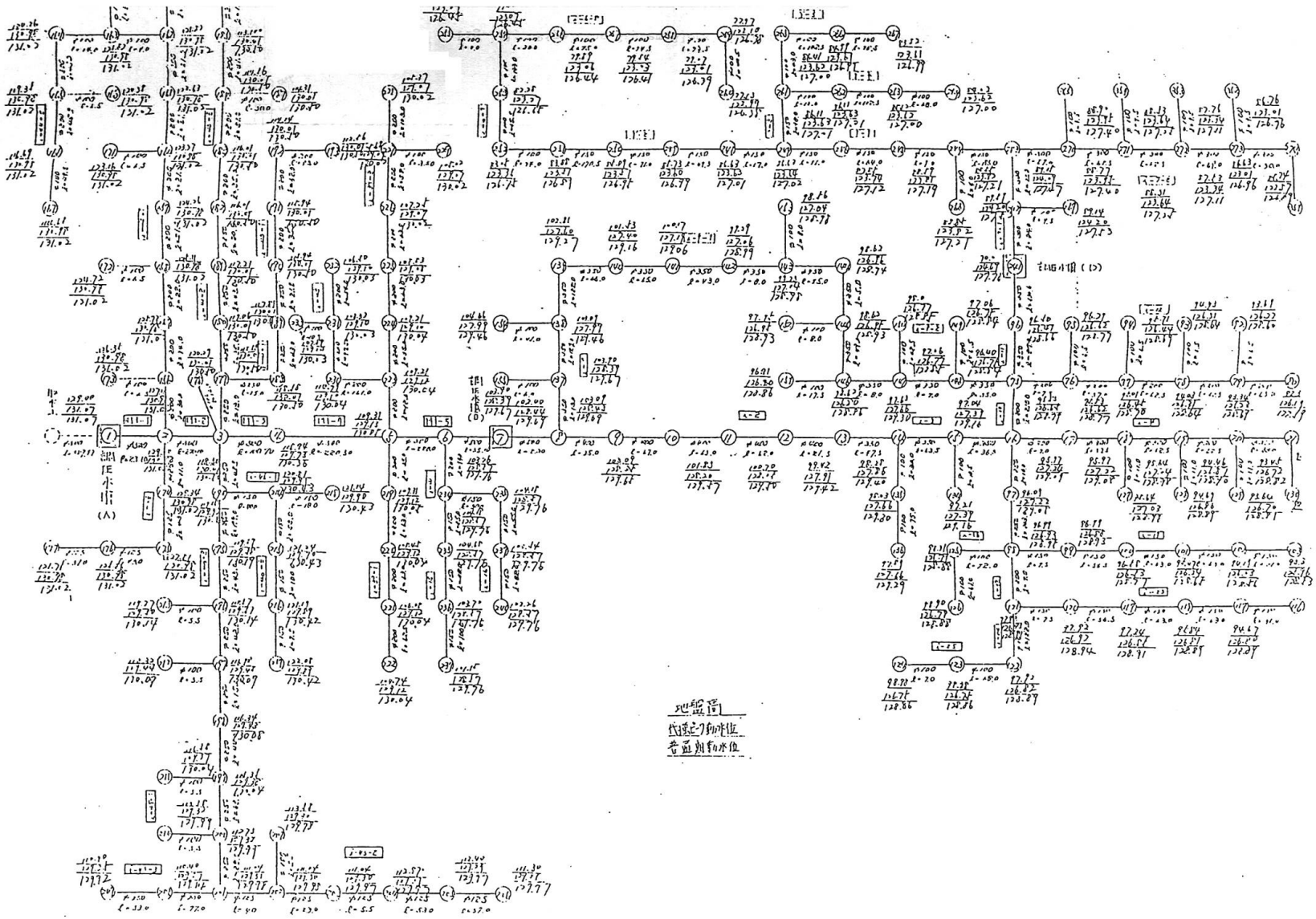


Fig. 10; Pipe Line System Block Diagram (1)

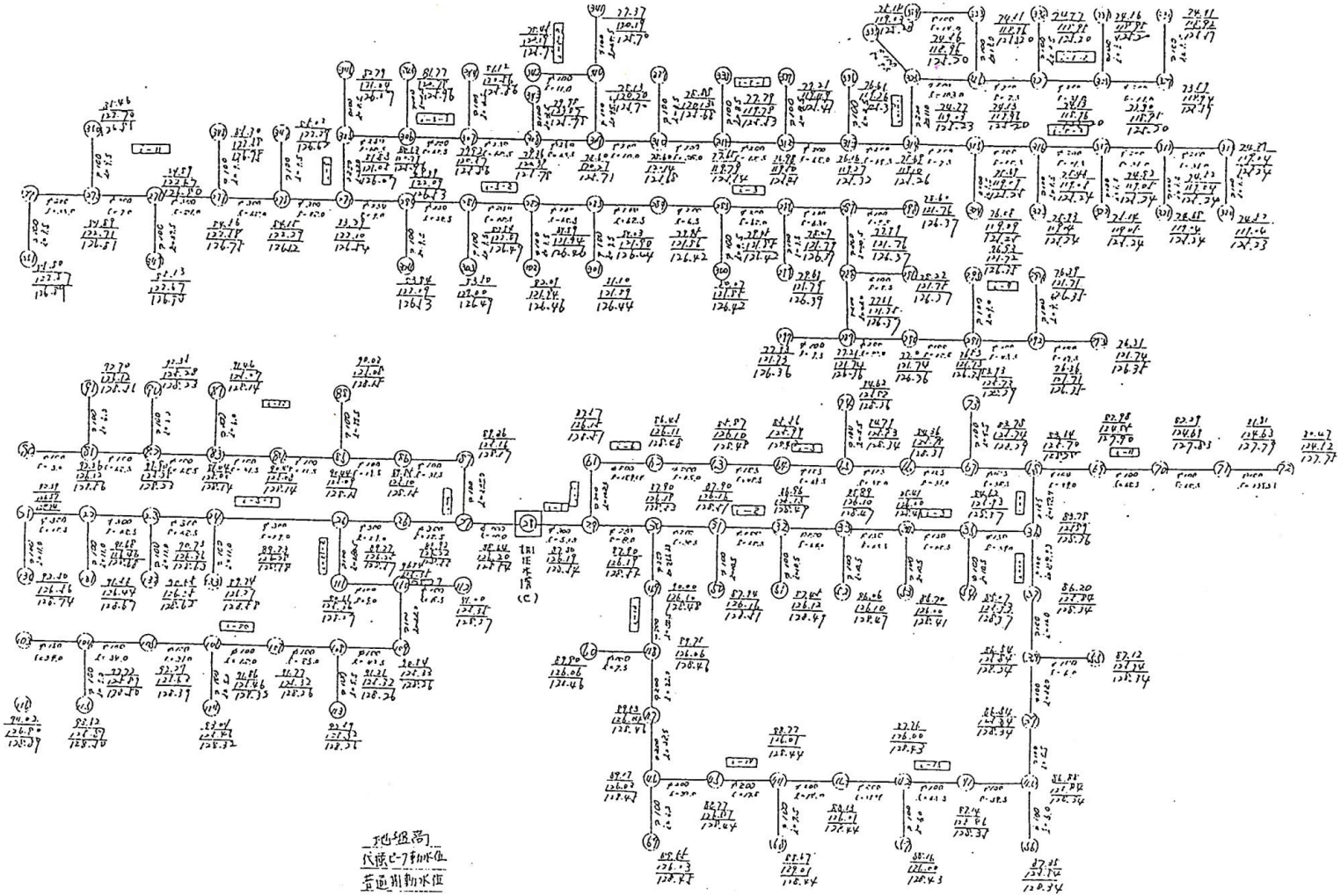


Fig. 11; Pipe Line Ssytem Block Diagram (2)

In the system, there exist four regulating tanks to adjust the pressure and discharge.

The details of those tanks are as follows;

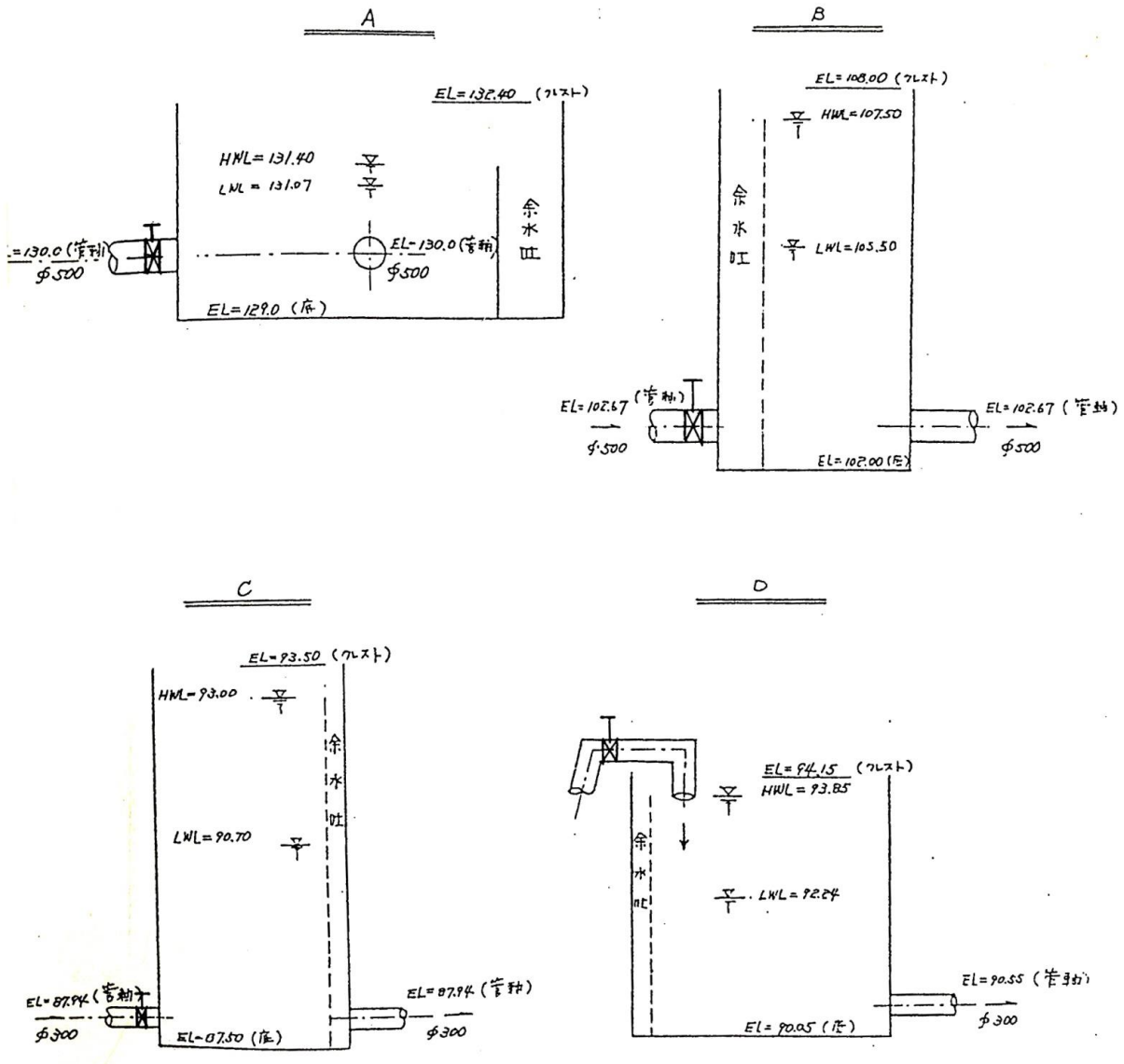


Fig. 12; Detail of Regulating Tanks

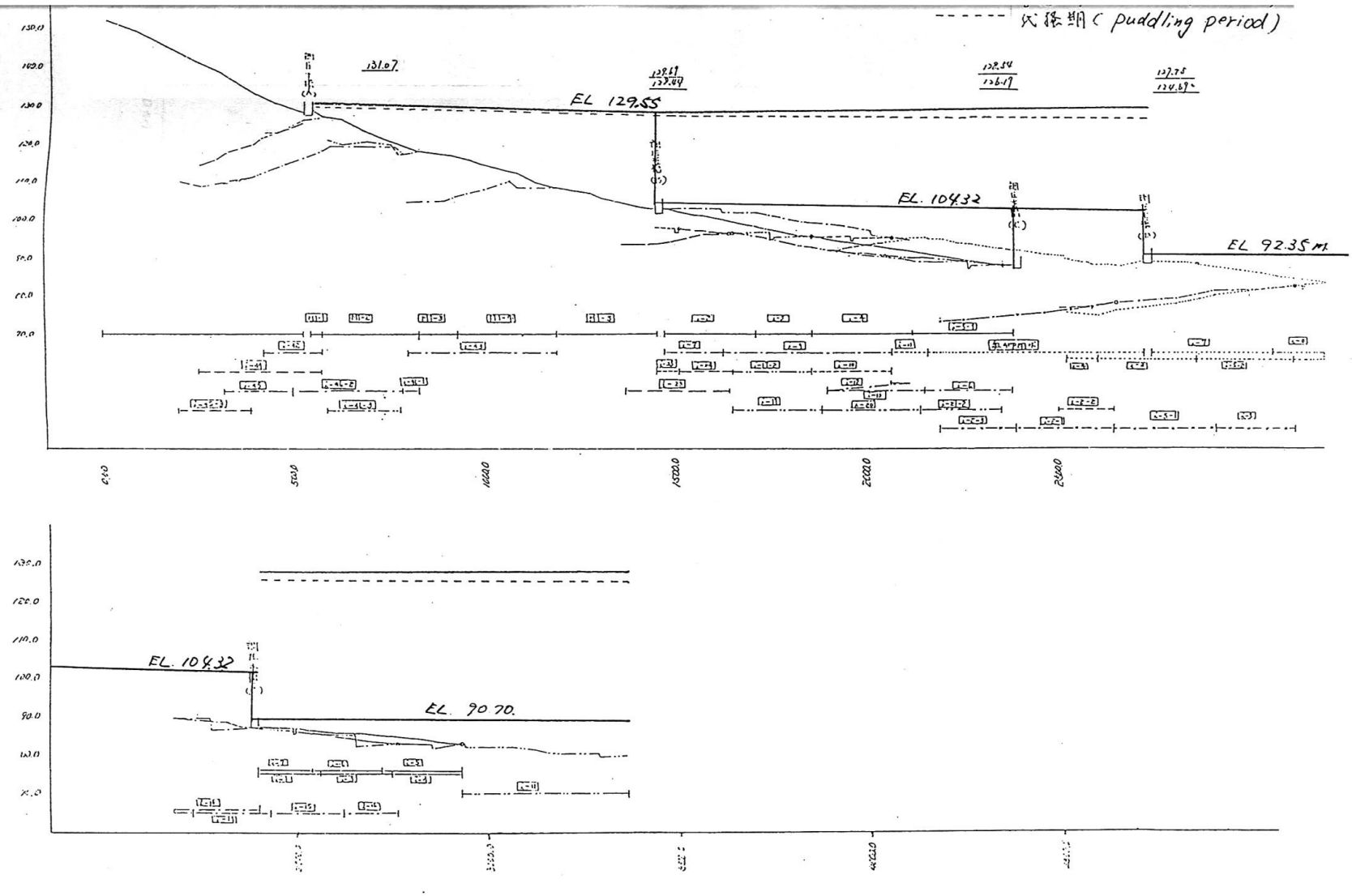


Fig. 13; Hydraulic Longitudinal Profile

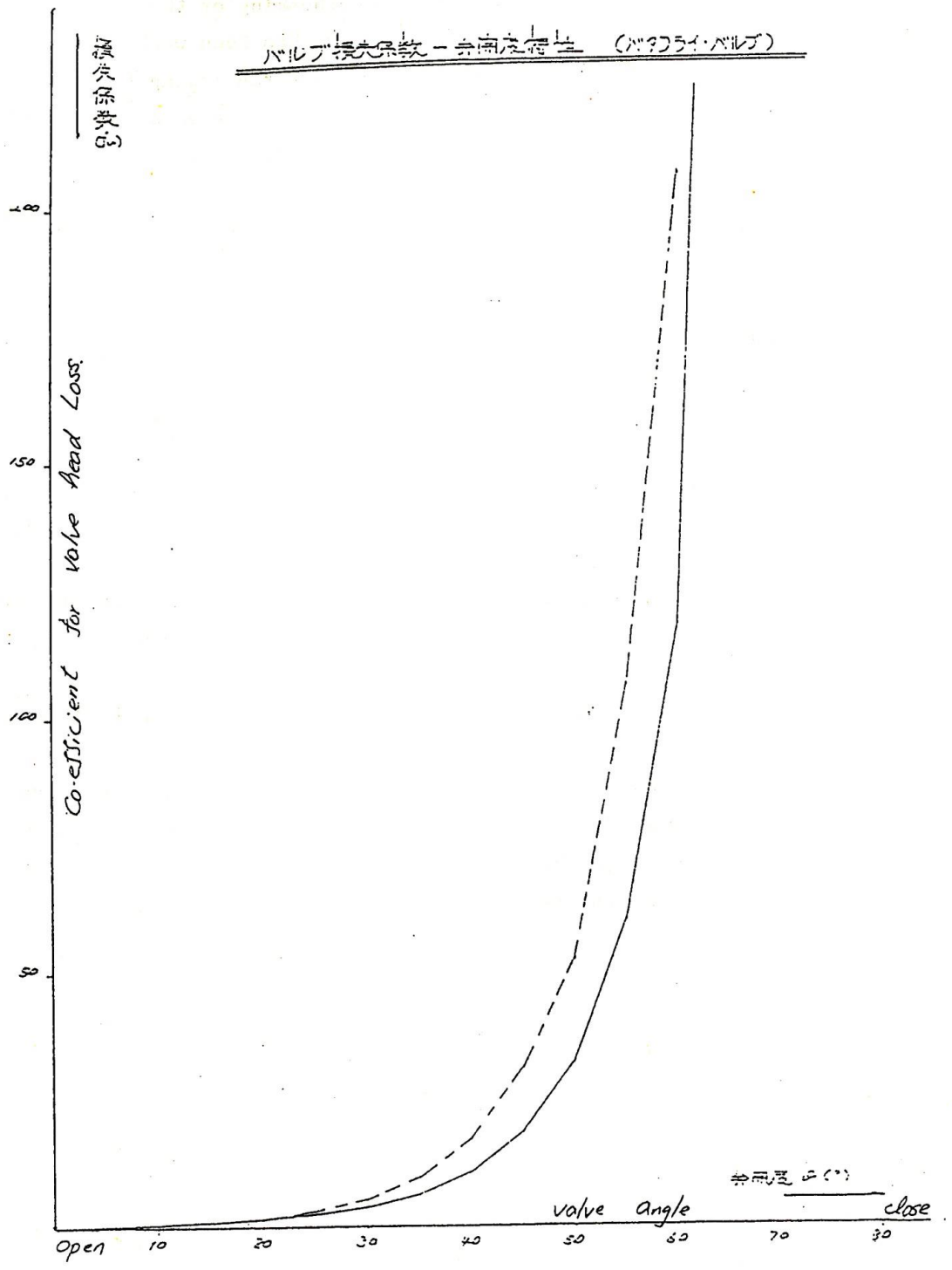


Fig. 14; Hydraulic Characteristics of Butterfly Type Valve

After the visual inspection at the job site, and checking of the design and the operation method, following basic problems, has been washed out;

(1): There are no operation standard at the each regulating tank.

(2): Controll valves at the regulating tank were operated not by supply-side, but by demand side (farmers) especially by the lowest beneficallies.

(3): Hydraulic design for the distribution to the each plot by pipe line, are afford for the appropriate discharge.

Thus, the unequality on the distribution of Irrigation water was serious problem among the blocks.

Firstly, through the hydraulic design, the counter-measure works at the regulation tanks were studied.

Longitudinal, hydraulic pressure head was calculated as shown in next Figure, and the head to be consumpted at the regulation tank were computed, and shown in the same Figure.

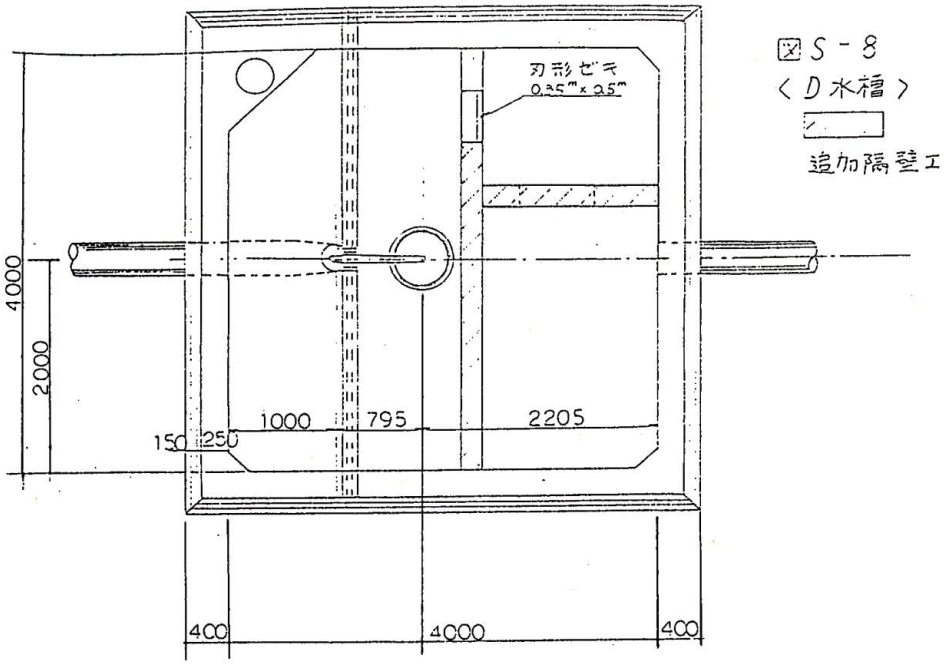
At the original design, the selection of valve type was not appropriate, for the characteristics on the regulation of discharge, by valve, was shown in the attached Figure,

In this case, valve type was butterfly Type vlave, and the available range for the regulating is 30° ~ 60°.

Thus, sub-merged disc-valve type was proposed as the appropriate valve, and attached modifying of the regulating tank was also sudjested, for the easy operation of the system by the supply-side.

Those works are shown in next Figure.

Plan



Section

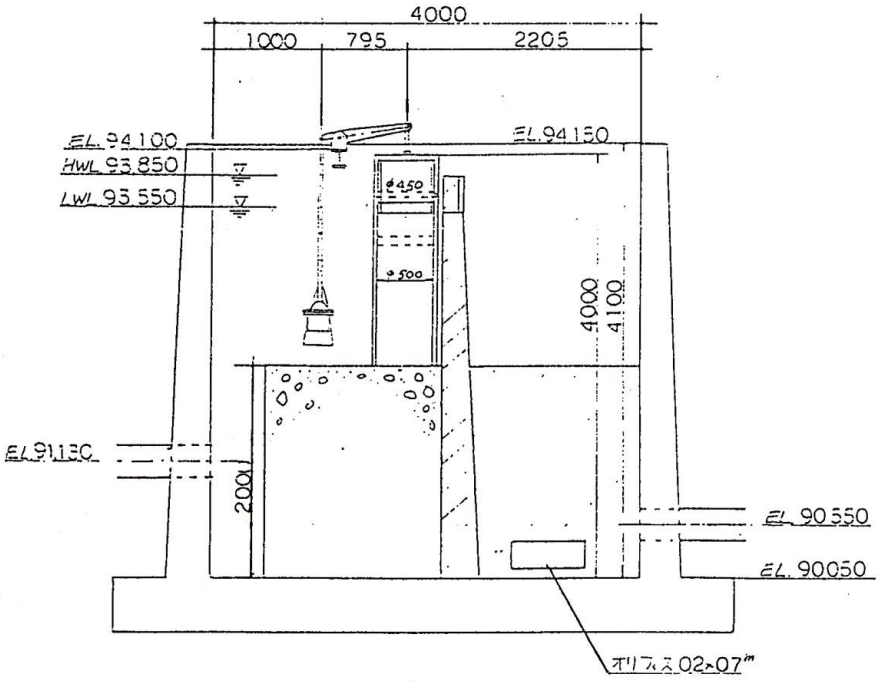


Fig. 15; Proposed Modification of Regulating Tank