NO. 1

WATER AUTHORITY OF JORDAN
HASHEMITE KINGDOM OF JORDAN

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR IMPROVEMENT OF WATER SUPPLY SYSTEM TO GREATER AMMAN IN THE HASHEMITE KINGDOM OF JORDAN

DECEMBER 1996

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PREFACE

In response to a request from the Government of the Hashemite Kingdom of Jordan, the Government of Japan decided to conduct a basic design study on the improvement of water supply system to greater Amman and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Jordan a study team from June 2 to July 16, 1996.

The team held discussions with the officials concerned of the Government of Jordan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Jordan in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Hashemite Kingdom of Jordan for their close cooperation extended to the teams.

December 1996.

Kimio Fujita
President
Japan International Cooperation
Agency

December, 1996

Letter of Transmittal

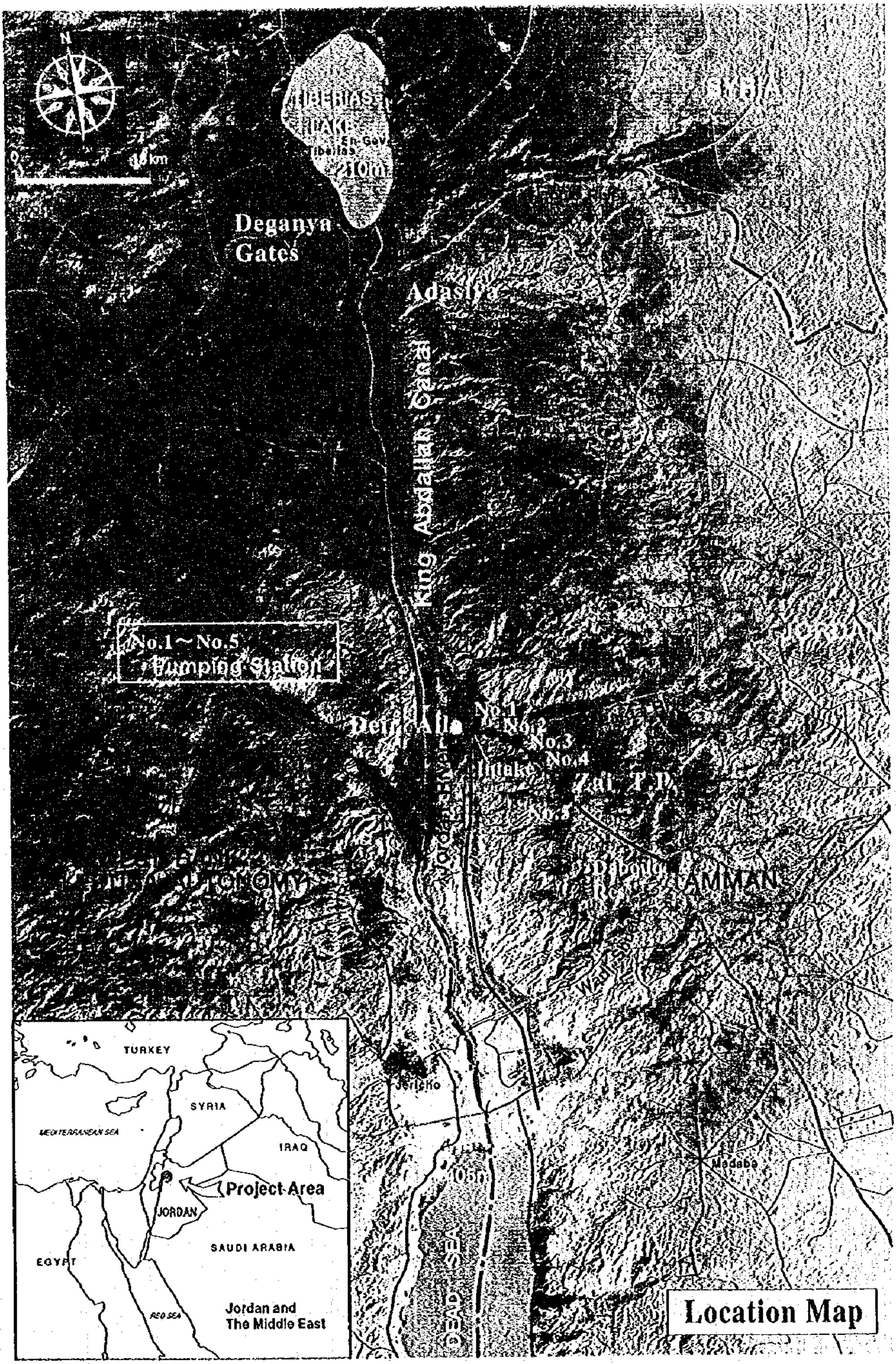
We are pleased to submit to you the basic design study report on the improvement of water supply system to greater Amman in the Hashemite Kingdom of Jordan.

This study was conducted by Tokyo Engineering Consultants Co., Ltd. in association with Nippon Koei Co., Ltd., under a contract to JICA, during the period from May to December 1996. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of the Hashemite Kingdom of Jordan and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Kazufumi Momose
Project manager,
Basic design study team on
the improvement of
water supply system to
greater Amman
Tokyo Engineering Consultants Co., Ltd.
in association with
Nippon Koei Co., Ltd.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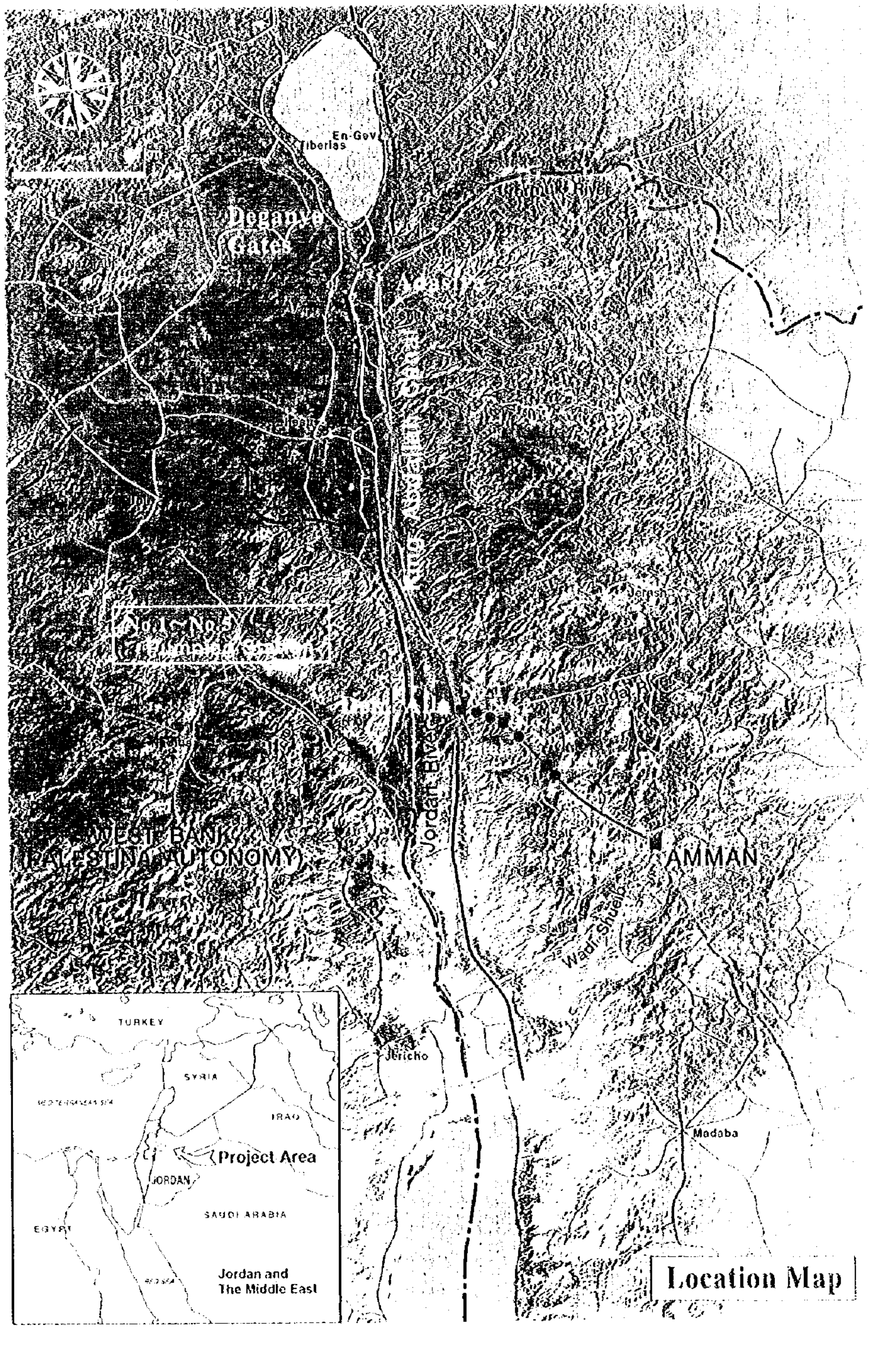
No.2
No.3
No.4
Intake
Zai T.P.
No.5
Dabouq
AMMAN
Jericho
Madaba
DEAD SEA
TURKEY
SYRIA
MEDITERRANEAN SEA
IRAQ
Project Area
JORDAN
SAUDI ARABIA
EGYPT
RED SEA
Jordan and The Middle East
Location Map



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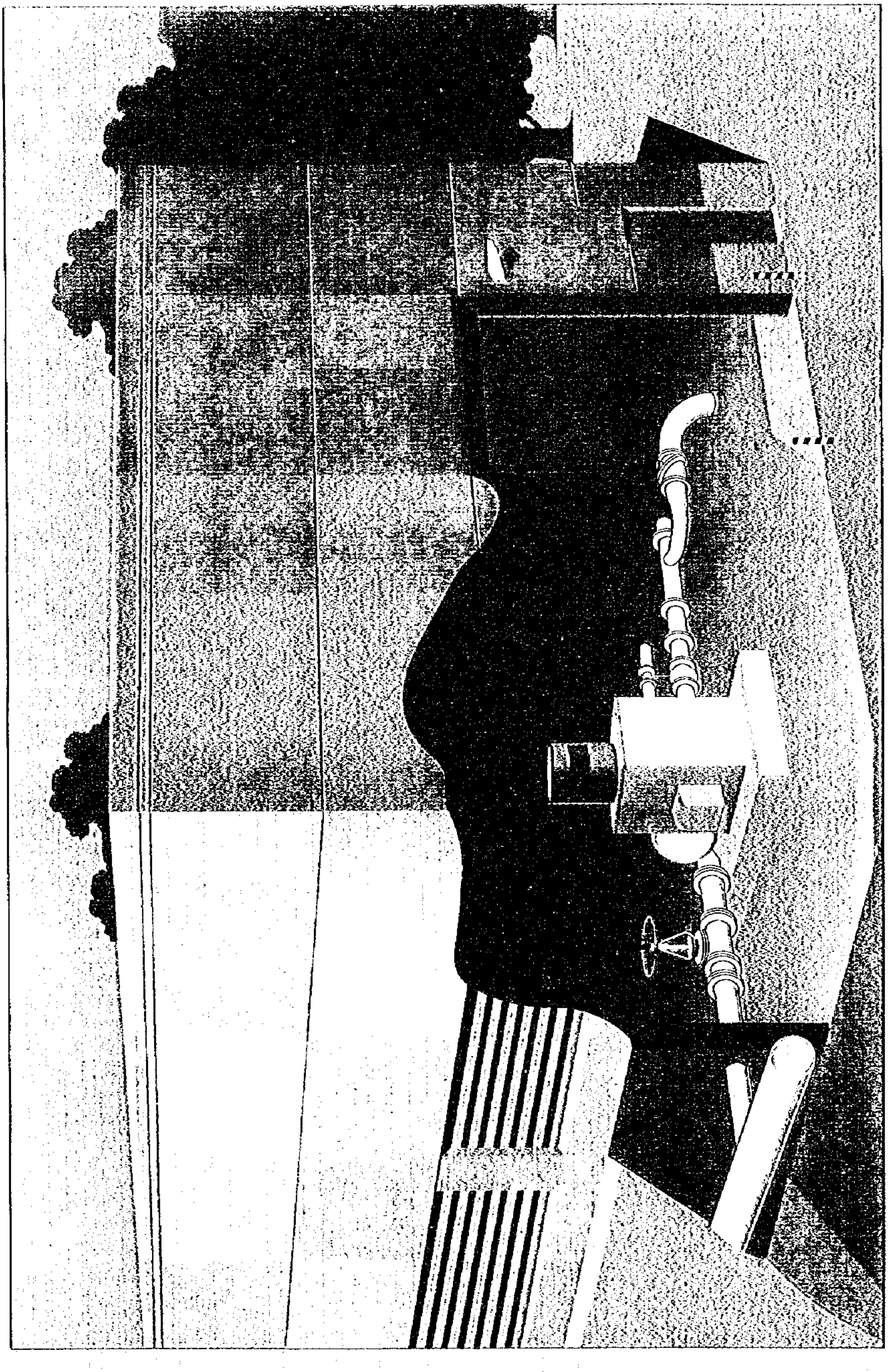
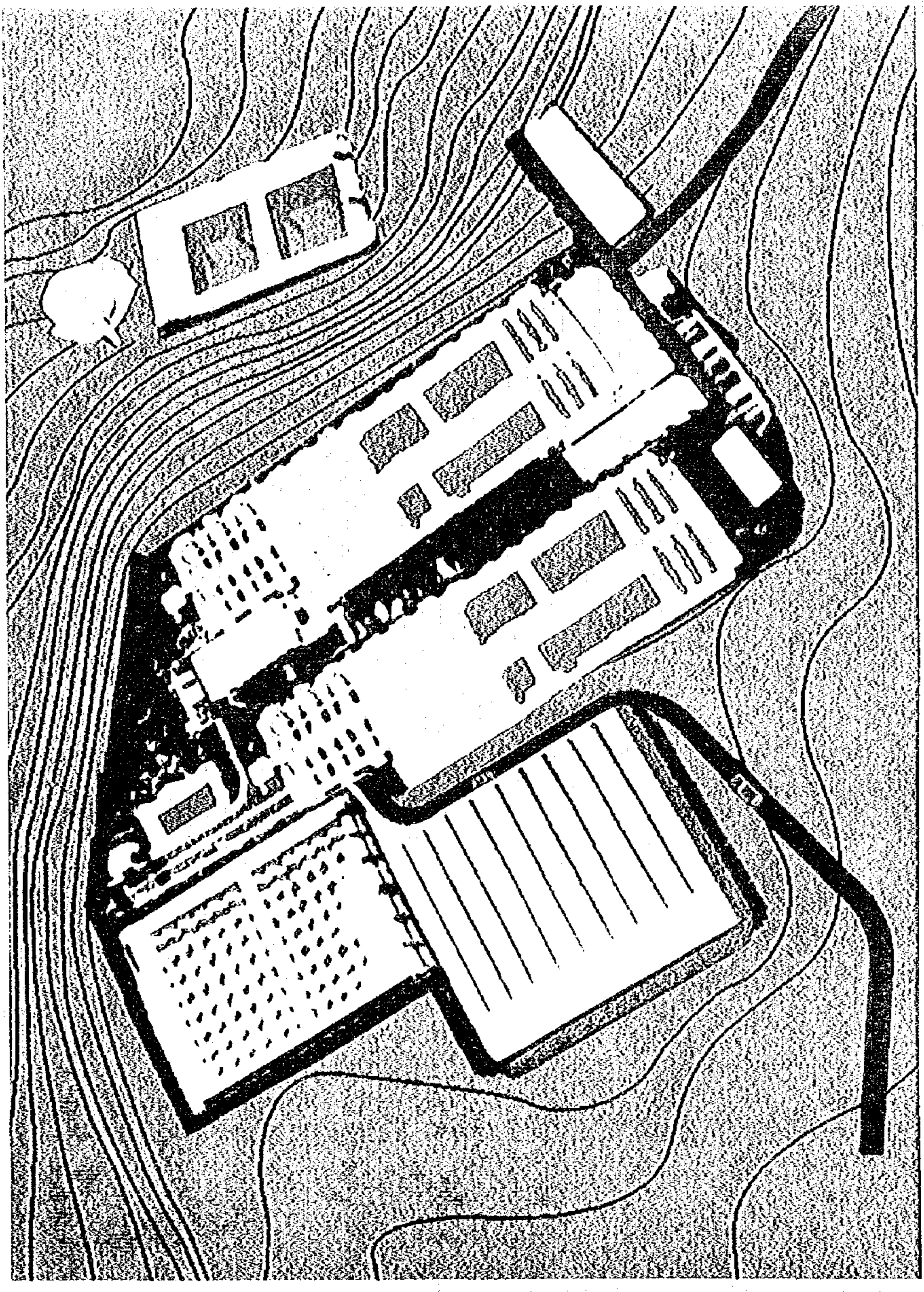


PUMP HOUSE BIRDS-EYE VIEW



ZAI WATER TREATMENT PLANT
BIRDS-EYE VIEW

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ABBREVIATION

ADAP	Adasiya Deir Alla Project
GTZ	Deutsche Gesellchaft fur Technishe Zusammenareit
JVA	Jordan Valley Authority
JICA	Japan International Cooperation Agency
KAC	King Abdullah Canal
KfW	Kreditanstalt fur Wiederaufbau
MOP	Ministry of Planning
MWI	Ministry of Water and Irrigation
WAJ	Water Authority of Jordan

Chapter 1
Background of the Project

Chapter 1 Background of the Project

The Hashemite Kingdom Jordan with her land of 89 thousand km² and her population of 3,823 thousand in 1993, is bordered with Egypt, Israel, Syria, Iraq and Saudi Arabia. Her per capita GNP was 1,190 US dollars in 1993. Her economy with deep relation with her neighboring oil-producing countries, had long been suffered from trade deficits. After the gulf crisis, her economy has further worsened because of stagnant trade with the neighboring countries, shrinkage of export markets, increase of population due to many returnees from the gulf countries, decrease of remittance inflow. As a result, her financial situation is now in a severe situation.

The population increased at high growth rate of 3.2% in 1992. With the increase of the population, water demand for domestic as well as agriculture increased as well and reached to 1,300 MCM in 1993. On the other hand, water supply volume is only 980 MCM in the same year, less than the water demand. Groundwater which accounts for 54% of the water supply has been over-extracted to try to meet the water demand. As a result, water tables are lowered and contents of water have lots of minerals so that further water supply from the groundwater is difficult.

Water to Amman comes, in addition to groundwater, from the King Abdul Canal (KAC). The water is taken at Deir Alla in the KAC and boosted with intake pumps and four booster pumps to the Zai water treatment plant. After treatment, water is again pumped to Amman. The difference in elevation is 1,100 m between Deir Alla and Amman. This Deir Alla - Zai system (DAZS) had never fulfilled its 45 MCM/year capacity since its inauguration of 1985 due to insufficient raw water at Deir Alla. The water supply situation is, therefore, severe with supplying only two days per week during summer periods.

However, the Peace Treaty concluded in October 1994 between Jordan and Israel has brought Jordan with additional water which has come from the Yarmouk river, Tiberias lake etc. As a result, available raw water is sufficient at Deir Alla for the DAZS. Its 45 MCM capacity is, however, lowered to about 37 MCM capacity now due to abrasion of pump impellers etc. Therefore, in order to utilize the available water at Deir Alla to the fullest, the DAZS needs rehabilitation as well as expansion.

The government of Jordan has requested the government of Japan rehabilitation of the intake pumping station and four booster stations as well as expansion of the Zai treatment plant. In response, the government of Japan sent a JICA preliminary study mission to Jordan in January 1996, to evaluate the request. The mission found that the request was reasonable to conduct the "basic design study", further step towards appraising Japanese grant-aid project. The mission also found that the contents of the requested project would be too large for the Japanese grant-aid project so that the contents of the basic design study is limited to four booster stations and Zai water treatment plant.

Chapter 2
Contents of the Project

Chapter 2 Contents of the Project

2.1 Objectives of the Project

The annual rainfall around Amman is only about 300 mm, and is concentrated in the months between November and March. Accordingly, there is no stream flow in the rivers during the dry months and the surface water cannot be used as a stable water source for the water supply systems in Jordan. The water supply systems depend entirely on ground water, excepting the Zai water supply system, which is the topic of this Study. Originally, spring water and ground water in Amman were used as water sources, but since the amount of water from these sources was limited, water was fetched from remote wells outside the city. All renewable ground water sources in Jordan were developed so that today the ground water level has decreased and the quality of water has deteriorated. As a result, the water supply situation in Jordan (including areas around Amman) is very severe, with water being rationed frequently especially during the dry period when the demand is high.

As a result of the Peace Treaty signed in October 1994 between Jordan and Israel, surface water was shared from the Yarmouk river and Lake Tiberias in Israel, which mitigated the severe water supply situation in Jordan to some extent. However, the water supply is limited, and the severe situation continues today. Rehabilitation and expansion of existing facilities for mitigating the severe water supply situation in Amman has become an urgent topic. The government of Jordan prepared two plans, described below, for dealing with the problem of inadequate drinking water supply.

1) Plan for renewing the deteriorated raw water pumps and transmission pumps in the Zai system (between Deir Alla and Amman), procuring and installing materials and equipment required for restoring the planned water supply of 45 million m^3/year for the Zai system.
2) Plan for expanding the water supply of the Zai system from 45 million m^3/year to 90 million m^3/year.

The present Study has the objectives of restoring the water supply of the Zai system to 45 million m^3/year by rehabilitation, further expanding it to 90 million m^3/year (250,000 m^3/day), and to convey and supply this water to the Amman city area by procuring and installing the necessary materials and equipment and constructing facilities for the same. The No. 1 to No. 4 pumping stations in the Zai system, the raw water main between the No. 1 pumping station to the Zai treatment plant, and the Zai treatment plant fall in the scope of this Study; the distribution facilities between the Zai treatment plant and the Dabuk distribution reservoir do not fall within the scope of this Study.

2.2 Basic Concept of the Project (Part 1 Rehabilitation Portion)

After the Peace Treaty was signed, and from March 1996, the amount of usable water increased since water could be conveyed from Israel to Jordan and the Zai system between Deir Alla and Amman could operate continuously since the intake water was adequate. However, the supplied amount is 37 million m^3/year or 100,000 m^3/day, which is about 80% of the planned figure of 45 million m^3/year or 123,000 m^3/day. To restore the planned supply capacity, the raw water pumps can be replaced by new pumps with the existing capacity. However, this is not economical since expansion of this system is contemplated in the near future, and further installations of additional pumps of the same capacity would become necessary. Consequently, replacement plans should take into account the effective use of pumps for planned increase in capacity in the future, even during the rehabilitation stage.

The following items are included in the basic policy for rehabilitation:

* A capacity of at least 123,000 m^3/day should be available.
* Rehabilitation should be planned assuming that the capacity of the facilities will shortly be expanded to 90 million m^3/year (250,000 m3/day).
* The rehabilitation plan should not lead to excessive investments even if the expansion plan is not implemented, and should be consistent with the objectives of the Study if the expansion plan is implemented.
* Existing pipelines should be utilized
* Stoppage period of pumps due to construction work should be minimized as far as possible.

2.2.1 Pump Studies Considering Expansion

(1) Plan considering expansion

The part 1 Study concentrates mainly on rehabilitation, but the facilities planned for rehabilitation should also be consistent with the expansion scheduled in the near future so that unnecessary investments are avoided. Therefore, this aspect will be investigated here.

As described later, for the expansion plan (to increase the capacity of the pumping stations) four alternatives listed below can be considered using the existing pipelines even during the expansion stage. (The field survey confirmed that the existing pipeline can be used except for a partial section.)

Alternative A: Replace the four existing pumps with four new pumps (58.0 m^3/min., three duty pumps and one standby pump)

Alternative B: Replace the four existing pumps with four new pumps (43.0 m^3/min., procuring the required number of standby pumps separately)

Alternative C: Replace the four existing pumps with five new pumps (43.0 m^3/min., Four duty pumps and one standby pump)

Alternative D: Add four new pumps of the same capacity (25.0 m^3/min.) as the existing pumps.

(2) Comparison of Alternatives

Table 1 shows the comparison of the Alternatives.

Table 1 Comparison of Alternative for Expansion

Alternative	A	B	C	D
Salient feature	The existing four pumps (4 duty and no stand-by pump) in each pumping station in No.1 to No.4 are replaced with the new four pumps (3 duty and 1 stand-by).	The existing four pumps (no stand-by pump) in each pumping station in No.1 to No.4 are replaced with the new four pumps (4 duty). In addition, one stand-by pump are procured and stored in storage.	The existing four pumps (no stand-by pump) in each pumping station in No.1 to No.4 are replaced with the new five pumps (4 duty and 1 stand-by).	Four new pumps with the same capacity as the existing pumps are added.
 Duty  Stand-by				
Pump specification				
Diameter (mm)	ϕ 550× ϕ 450	ϕ 450× ϕ 300	ϕ 450× ϕ 300	ϕ 350× ϕ 250
Discharge (m3/min.)	58.0	43.5	43.5	25.0
Total head (m)	300~314	300~314	300~314	300~314
Number	4 (including 1 stand-by)	4 *	5 (including 1 stand-by)	8 (including 1 stand-by)
Suction velocity (m/s)	4.07	4.56	4.56	4.33
Other works				
Existing 4 pump	Remove	Remove	Remove	Utilize
Existing header pipe	Replace (existing diameter is ϕ 450)	Utilize	Utilize	Utilize
Pump house expansion	No necessary	No necessary	Necessary for 1 pump	Necessary for 4 pumps
Others	Suction velocity is too large, 6.08 m/s when existing header pipe is used	--	--	No space for pump house expansion
Cost	Second largest	Smallest	Second smallest	Largest
Technical Aspect			◎	
Selected alternative		◎		

* In addition, one pump is procured for stand-by.

(3) Selection of Alternative

Alternative B is selected because of the following reasons:

For Alternative A, the pump diameter becomes very large necessitating the complete replacement of header pipes on the suction and discharge sides. This requires water supply stoppage for prolonged periods, therefore this Alternative is not acceptable. Moreover the header and suction pumps cannot be accommodated in the existing pump house.

Alternative D requires the same space as the space of the existing pumping station and this additional space is not available in the existing pumping station. The cost for this Alternative is higher than the cost for Alternatives B and C.

Comparing Alternatives B and C, the duty pump capacities for both Alternatives are the same. Considering maintenance aspects, C is superior to B because a standby pump is permanently available. However, in the existing facility, a system similar to B is being implemented, therefore no additional problems are expected if B is selected. Considering cost, C requires expansion of pump house, and an additional set of distribution pipelines and valves. Alternative B satisfies the various conditions of this Study, and is the most economical, therefore Alternative B is selected.

For the expansion stage, four existing pumps of dia. 350 x dia. 250 x 21.4 m^3/min. x 286 m x 1,850 HP each will be replaced by four pumps of dia. 450 x dia. 300 x 43.5 m^3/min. x 300 - 314 m x 3200 - 3500 kW each, and the required number of standby pumps will be procured and stored.

2.2.2 Pumps for Rehabilitation

Rehabilitation works are studied within the scope of the expansion work.

(1) Alternative plans

The two Alternatives listed below are considered.

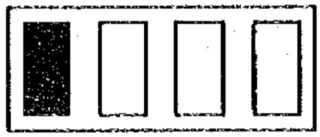
Alternative B-1: Replace the existing two pumps with pumps of increased capacity. Procure one spare pump for each pumping station.

Alternative B-2: Replace one existing pump with a pump of increased capacity. Procure two pumps for standby operations to be shared among four pumping stations.

(2) Comparison of Alternatives

Table 2 shows the comparison of the two Alternatives.

Table 2 Comparison of Alternative for Rehabilitation

Alternative	B-1	B-2
Salient Feature	 Existing pump (21.95m³/min.) New pump (43.5m³/min.) Bolded pumps are for stand-by	 Existing pump (21.95m³/min.) New pump (43.5m³/min.)
1. Capacity	Normal period Two new pumps 43.5m³/min. x 2 sets = 87.0 m³/min. [100%] Repair period Two existing pumps + One new pump 18 x 2 set +43.5 x 1 set = 79.5 m³/min. [91.4%]	Normal period Three existing pumps + One new pump 18 x 3 sets + 43.5 x 1 set =97.5m³/min. [112%] Repair period Three existing pumps 18m³/min. x 3 set = 54.0 m³/min. [62.1%]
2. Stand-by	One stand-by pump is installed in each pumping station	Two stand-by pumps are procured and stored for four pumping stations.
3. Scope of work	New pump (43.5 m³/min.) 2 sets per pumping station x four pumping stations = 8 new pumps New motor 2 sets x 4 pumping stations	New pump (43.5 m³/min.) 1 set per pumping station x four pumping stations = 4 new pumps New pump (43.5 m³/min.) 2 sets procured for four pumping stations New motor 1 set x 4 pumping stations
4. Cost	Large	Small
5. Technical Aspect	◎	
6. Selected Alternative		◎

(3) Selection of Alternative

Alternative B-2 was selected because of the reasons below.

From the technical aspects, such as pump maintenance, Alternative B-1 is preferable to Alternative B-2 because there is a permanent standby pump. However, B-2 is selected so that initial investment can be reduced. During repairs, the pumps will be stopped for a short period so that the procured standby pump can be replaced.

Accordingly, in the rehabilitation stage, looking at the intake side of all the pumps, one pump at the farthest end will be replaced and the other three pumps utilized. The total capacity after rehabilitation will be 97.5 m³/min. through one new pump of dia. 450 x dia. 300 x 43.5 m³/min. x 300 - 314 m x 3200 - 3500 kW, and three existing pumps of dia. 350 x dia. 250 x 21.95 m³/min. x 286 m x 1850 HP. There is no need to install a permanent standby pump. Two pumps will be procured as standby pumps and shared among four pumping stations. For utilizing the four discarded pumps, WAJ should study locations in Jordan where these pumps can be effectively utilized.

2.2.3 Main Pump Motor and Its Starting Method

Shortening the water stoppage period as far as possible during the rehabilitation work of the pumping station is a very important factor that needs to be considered. In addition to considerations of efficiency and safety during operation, there should be no significant changes to header pipes in and around the existing pump house, and the construction period should be shortened to the maximum extent possible. In view of the above points, the starting method of the squirrel-cage rotor type induction motor, which has the same starting method as that of the existing pump motor, should be changed to the reactor starting method for this Project.

(1) Selection of motor

Based on the results of comparison shown in the table below, the squirrel cage rotor type induction motor, which is the same as the existing motor, is selected.

Table 3 Comparison of Induction Motor

Type	Characteristic on operation	Space for installation
Squirrel-cage rotor type	Generally, starting current is large. But, it can be suppressed by starting equipment.	· Can be installed on the same arrangement with the existing motor location. · Dimension of motor foundation must be expanded.
Wound rotor type	Can be started without excessive starting current.	· Dimension is larger than the squirrel-cage rotor type · Cannot be installed on the existing motor location. · Starting register needs expansion of pump house to install it.

(2) Selection of starting method

Since the motor used for this Project is a large motor of the 3000-kW class, the starting current needs to be suppressed. From the results of comparison of various starting methods shown in Table 4, the reactor starting method is selected.

Table 4 Comparison of Starting Method for Induction Motor

Starting Method	Characteristics
Direct (Line) starting	· On starting time, the current is as large as about 8~10 times of normal operative condition flows to motor. This starting current on the induction motor of large capacity gives large shock to power transmission system. Therefore, this starting method cannot be recommended to this Project.
Star-Delta starting	· This method is not applied to H.T. motor because its terminal structure is complex. (Generally, this method is applied to L.T. motor of capacity less than 100 KW.)
Reactor starting	· Starting current can be suppressed to about 5~7 times of current on normal operative condition . · Starting reactor can be installed in the existing pump house.
Kondrfer-system starting	· Starting current can be suppressed to about 4~5 times of current on normal operative condition . · Dimension of starting system is large, therefore it cannot be installed in the existing pump house.

2.2.4 Main Transformer for Power Receiving

By using the reactor starting method for the pump motor, the starting current can be suppressed to 1.5 times the starting current in the existing pump motor. To suppress the drop in voltage due to this starting current within a suitable range (less than 8 to 10% of the rated voltage approximately) and to start the motor correctly, each pump house requires the main transformer to have a capacity of approximately 16 MVA in the rehabilitation stage and a capacity of approximately 20 MVA in the expansion stage. Accordingly, transformers with a rated capacity of 10 MVA should be added to each pumping station, and this transformer should be run in parallel with the existing transformer to balance the current flow.

(1) Necessary Capacity of Transformer

Table 5 Necessary Capacity (MVA) of Transformer

Stage	NO.1 PS	NO.2 PS	NO.3 PS	NO.4 PS
Existing (For reference)	10	10	10	10
On Rehabilitation				
· In case to operate one (1) new motor	14	14	14	14
· In case to operate one (1) new motor and three (3) existing motor	16	16	16	16
On Expansion (For reference)	20	20	20	20

(Note) These capacity is calculated with following conditions ;

1) Starting method of motor ; Reactor starting (65% tap)

2) Power factor of motor in normal operative condition ; 95% of lag

3) Percent impedance (%Z) of transformer ; 7.3%

(2) Comparison of installation plans for main transformer

Based on the required transformer capacity above, the three plans described below may be considered for installing transformers in the rehabilitation stage. These plans are proposed after considering the following items:

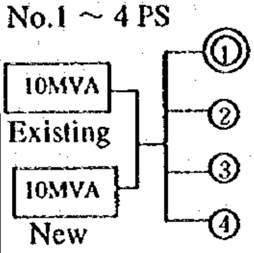
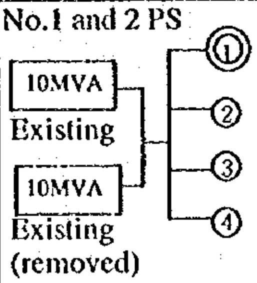
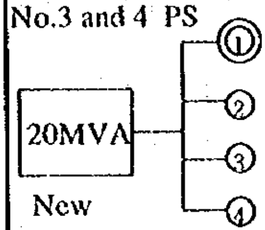
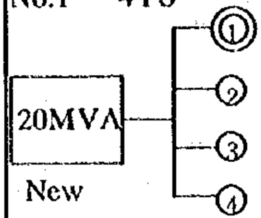
* The required transformer capacity is 16 MVA.
* When installing additional transformer to supplement the inadequacy of existing 10 MVA transformer and running the transformers in parallel, a transformer of 10 MVA (the same capacity as the existing transformers) should be used and the current flow should be balanced.
* If an existing transformer is replaced with a new transformer, the required capacity of the new transformer is 16 MVA or greater. Therefore, transformer with a standard rating of 20 MVA should be installed.

Based on the results of comparison shown in Table 6, Alternative E is recommended (parallel operation of existing 10 MVA transformer and new 10 MVA transformer). A 20 MVA transformer is difficult to transport up the steep slope to the pumping station and requires heavy construction machinery to install it in the station. In the expansion stage, each pumping station requires a transformer of 20 MVA capacity, but since the total capacity of the transformers in the rehabilitation stage is 20 MVA, these transformers can be used in the expansion stage also without the need for replacement or addition.

There is also a plan for increasing the required capacity during rehabilitation by 6 MVA, and increasing the capacity by an additional 4 MVA during the expansion stage. However, this plan involves an overall increase in cost amounting to 60% compared to the initial cost for the 10 MVA installation and is uneconomical. The capacity of the transformers should be increased to 20 MVA at the rehabilitation stage.

Existing equipment are to be operated while carrying out rehabilitation work such as adding high voltage transformers and changing the pump starting methods. Since new electrical panels cannot be accommodated in the existing electric room, the store adjacent to the existing electric room should be modified and used as an additional electric room accommodating the new electric panels.

Table 6 Transformer Alternative

Alternative	E	F	G
Salient Feature	No.1 ~ 4 PS 	No.1 and 2 PS  No.3 and 4 PS 	No.1 ~ 4 PS 
Specification	10 MVA transformers are added to each of No.1 ~4 pump station to run under parallel connection with existing transformers	For No.1 and No.2 pump stations, 10 MVA transformers are removed from No.3 and No.4 pump stations. For No.3 and No.4 pump stations, new 20 MVA transformers are installed.	Existing transformers of each pump station are replaced with new 20 MVA transformers.
Comment	· Existing transformers are used effectively. · Weight of a 10 MVA transformer on transportation is about 24 tons. For the 10 MVA transformer and construction machine, there is possibility to be transported on steep slope road around of pump station.	· Existing transformers are used effectively. · Weight of a 20 MVA transformer on transportation is about 32 tons. For the 20 MVA transformer and construction machine, there is difficult to be transported on steep slope road around of pump station.	· Existing transformer should be utilized to other sites. · Weight of a 20 MVA transformer on transportation is about 32 tons. For the 20 MVA transformer and construction machine, there is difficult to be transported on steep slope road around of pump station.

(Note) ◎ ; New pump motor　　O ; Existing pump motor

2.2.5 Control and Telemetry Equipment

Existing equipment mainly consist of electronic components. More than 10 years have elapsed since their manufacture in the first half of the eighties. Procurement of spare parts in the future is likely to be difficult. However, the existing equipment can be used during the rehabilitation stage on the prerequisite that they will be improved in the near future during the expansion stage.

In conclusion, the existing control systems (same operating methods as the current operating methods) should be used during the rehabilitation stage, and replace with centrally monitored and control systems during the expansion stage. During the expansion stage, all pumping stations should be automatically operated according to the level of water in the reservoirs, and the existing control system (controlling the number of pumps according to level of water in the reservoir) should be retained in the pumping stations. However, to reduce the frequency of starting the pumps, discharge control by discharge valves should be incorporated.

2.2 Basic Concept of the Project (Part 2 Expansion Portion)

As described below, it has been confirmed that usable water sources are available and demand for conveyed/treated water quantity will be generated in the Amman city area.

2.2.1 Ensuring Water Sources

The quantity of water used in the Zai system by WAJ before the Peace Treaty was 35.6 million m^3/ year, as shown in Table 7. However, this quantity increased to 78.6 million m^3/ year (short term in Table 7) after the Peace Treaty was signed, and is being supplied since 1995. When the construction of the Adasiya dam on the Yarmouk river is completed (scheduled for completion around the year 2000), the surplus water in winter will be available for use in summer, and the usable water quantity will increase to 110.6 million m^3/ year (long term in Table 7).

The usable water quantity mentioned above is not constant throughout the year but varies depending on the season. The short term breakdown is 34.6 million m^3 in summer (154 days) and 44 million m^3 in winter (211 days). If these quantities are converted to quantities per day used for deciding the scale of water facilities, the figures become 225 thousand m^3 in summer and 209 thousand m^3 in winter. When the Adasiya dam is constructed (long term plan), the quantities will become 42.6 million m^3 in summer (154 days) and 68.0 million m^3 in winter (211 days). However, if the quantity of the Mukheiba well that supplies water to Irbid city is excluded, the figure becomes 90 million m^3/ year, which works out to 221 thousand m^3 per day in summer and 265 thousand m^3 per day in winter.

Pipelines from Tiberias lake (Deganya gate) in Israel to the KAC canal have already been laid during the short term plan, and water is being conveyed through these pipelines since March 1996. With this progress, the capacity after the Peace Treaty has increased to 78.6 million m^3/year from 35.6 million m^3/year before the Peace Treaty. The stoppages in the Zai system because of shortage of intake water have been eliminated.

Table 7 Usable water quantity in the Zai system

(Units: million m^3)

Water source			Effective water quantity at the Adasiya point in the Yarmouk river					Water Sources for WAJ		WAJ's
					Jordan			From	From	Usable
Term	Year		Total	Israel	Sub-total	JVA	WAJ	Muheiba Well	Other 2)	Quantity
Past	Up to 1994	Annual	232.7	107.2	125.5	110.5	15.0	20.6	-	35.6
		Summer	60.1	19.7	40.4	-	3.0	8.6	-	11.6
		Winter	172.6	87.5	85.1	-	12.0	12.0	-	24.0
Short term	From 1995	Annual	183	25	158	110	48	20.6	10	78.6
		Summer	59	12	47	-	6 (26)1)	8.6	-	34.6
		Winter	124	13 (33)	111 (91)	-	42 (22)	12	10	44.0
Long term	After completion of Adasiya diversion dam(estimated in 2000)	Annual	215	25	190	110	80	20.6	10	110.6
		Summer	67	12	55	-	34	8.6	-	42.6
		Winter	148	13	132	-	46	12	10	68.0

Summer: From May 15 to October 15 (154 days - 5 months)

Winter: From October 16 to May 14 (211 days - 7 months)

For short term and long term water sources, the references for "Dry Years" are used, but the for water quantities in the past, the average values for the years from 1981 to 1994 (excluding 1992) are used.

1) 26 = 20 (return flow) + 6

2) Desalinated water or water from Deganya gate (Tiberias Lake)

The objectives of the long term plan are to construct a dam or a weir at the Adasiya point in the Yarmouk river, and make effective use of the surplus water in winter. The design of the intake weir was scheduled for completion in June 1996, but it has been delayed. Assuming that the design is completed by the end of 1996 and construction work starts in 1997, the dam will be completed in 2000. Upon completion, the intake water rate will reach 110.6 million m^3/year. However, 20.6 million m^3/year will be diverted to Irbid, the third largest city in Jordan, which faces a similar severe water shortage, and 90 million m^3/year will be reserved for Amman.

2.2.2 Water Demand

The current water demand for Amman city, which has several ongoing projects, is estimated as shown in Table 8.

Table 8 Water demand for Amman and supplied required from the Zai system (annual average)

(Units: million m³/year)

	Water demand for Amman					
Year	1991	1995	1997	2000	2005	2010
Water from source other than Zai system	80.2	80.2	80.2	80.2	80.2	80.2
Estimated demand (source 1)				143.5	163.2	182.9
Estimated demand (source 2)	110.8	128.3		154.0	184.6	221.2
Estimated demand (source 3)		110.7	120.0	134.0	157.3	180.7
Water required from Zai system (source 1)			(48.0)	63.3	83.0	102.7
Water required from Zai system (source 2)	30.2	48.1	(63.0)	73.8	104.2	141.0
Water required from Zai system (source 3)		30.5	39.8	53.8	77.1	100.5

Source : Water Conveyance System from Adasiya to Deir Alla-Zai, April 1996

Source 1 : Water Resources of Jordan: Past Status and Future Potential by Elias Salcindi et al, 1993

Source 2 : Jordan River Basin Management Study, Dec, 1993 by the Regional Office for Integrated Development(ROID, Munther Haddadin)

Source 3 : Disi-Mudawwara to Amman Water Conveyance System, Final Conceptual Study Report by Harza Group et al, 1995

If the lowest demand (source 3) is adopted from the three types of demand predictions in the table above, the water supply from the Zai system in 1997 should be 39.8 million m³/year for a satisfactory situation. This figure for water supply is almost the same as the supply quantity from the Zai system in 1996 (approximately 39 million m³/year). However, during the site survey from June to the first half of July in 1996, WAJ had rationed the water supply two days a week as is done every year. Therefore, the demand prediction according to source 3 is very much on the lower side.

The water demand is high in summer and low in winter, but the table above gives the average annual figure. The summer demand in Jordan is difficult to predict because the water supply is constantly being rationed. However, in case of Japan, the summer demand is taken as 20 to 30% in excess of the average water demand. During a study in 1995 of Zarqa city, adjacent to Amman and the second largest city in Jordan, the demand in summer increased to 20% above the average demand (source: Improvement of the Water Supply for Zarqa, July 1996, JICA).

If the excess demand in summer is taken as 20%, the required water supply from the Zai system in summer, excluding the figure from source 3, which is the smallest, is as shown in Table 9, and is estimated to be 253 to 288 thousand m³/day in the year 2000.

Table 9 Required Water Supply From Zai System for Satisfying Demand in Amman (summer)

(Units: thousand m³/day)

Year	1991	1995	1997	2000	2005	2010
Required water supply from Zai system (source 1)				253*	318	381
Required water supply from Zai system (source 2)	145	203		288	386	507

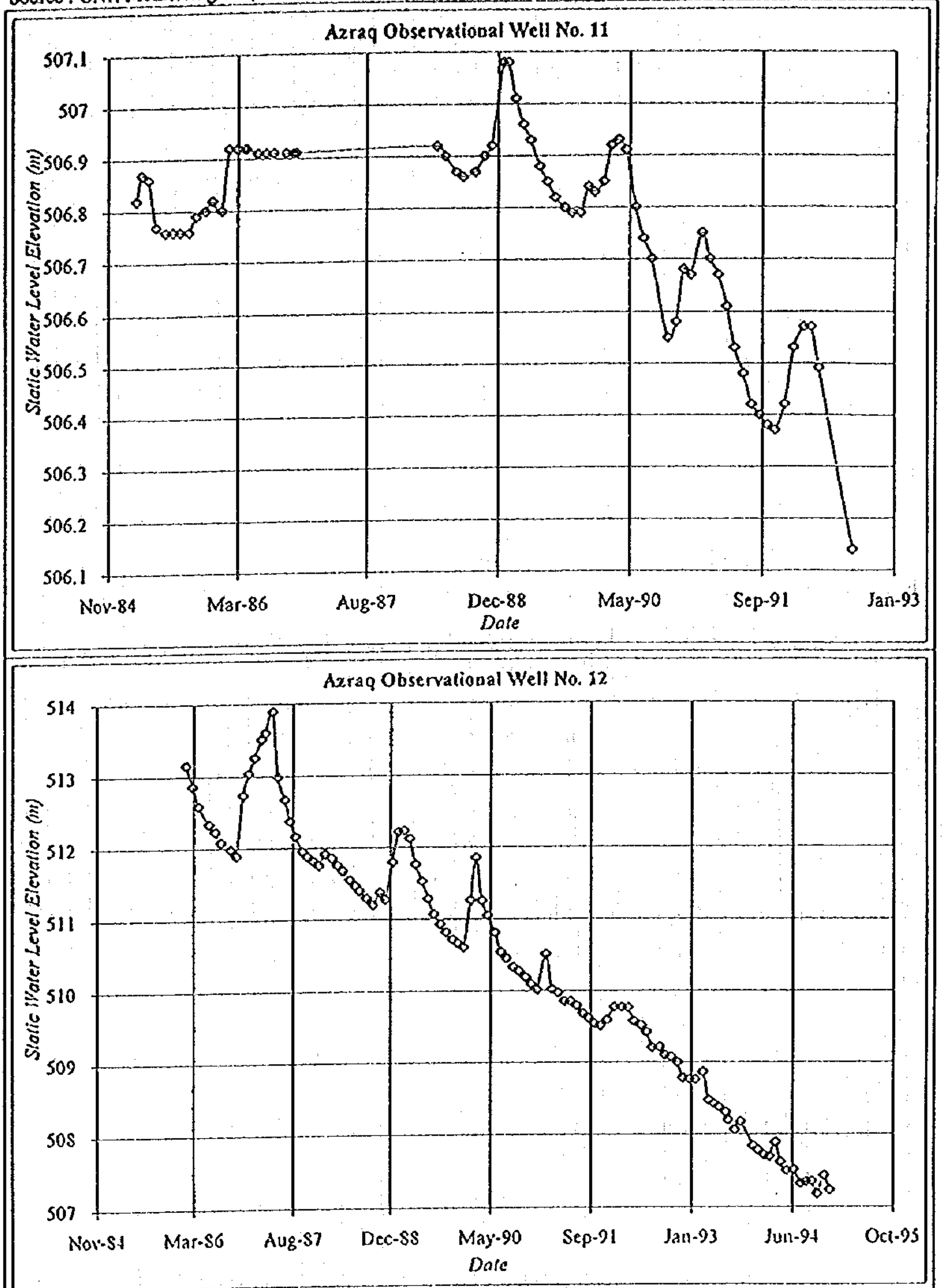
* 253

= (Annual average demand x 1.2) - (water from source other than Zai system)

= {143.5 (from Table 8) /365 x 1.2 - 80.2 (from Table 9)/365} x 1000

The water demand given above if expressed in demand per person is approximately 100 to 150 liters, and is only about one third the demand per person in Japan. Furthermore, the estimate for water sources other than the Zai system is not likely to change in the future. Although the demand per person is small, there is a limit on the water sources other than the Zai system and on the water sources in Jordan for satisfying this demand, therefore excessive use of ground water continues. The ground water level is decreasing year after year, and the quality is deteriorating (Fig. shows the change in water level of the ground water level at Azraq, 100 km east of Amman. Since the demand in the rainy season from November to April decreases, the pumped-up water quantity also decreases, therefore the water level is restored temporarily). If excessive water is pumped up this way, there is a possibility that the existing water sources will dry up. The quantity of excess water pumped up currently is 40 million m³, which is approximately half the annual water figure of 80 million m³.

Source : G.W. Monitoring Sec, MOWI



BASIC DESIGN STUDY ON THE PROJECT FOR INPROVEMENT OF WATER SUPPLY SYSTEM TO GREATER AMMAN	**Fig. 1** Ground Water level in AZRAQ BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	

2.2.3 Design Flow Rate of Facilities

Compared to the demand of 253 to 288 thousand m³/day generated in summer (year 2000), the usable quantity from water sources (long term) in the Zai system is 221 thousand m³/day in summer. Therefore, the design flow rate of facilities should be 221 thousand m3/day. On the other hand, 265 thousand m³/day of water (long term) can be used in the Zai system in winter, but the demand is less than the usable quantity, therefore a part of the usable quantity will not be used in winter.

The design flow rate is decided based on this concept for the Project. The design flow rate is set at 250 thousand m³/day (90 million m³/year), which is twice the rate of the existing facilities considering that the existing facilities will be used effectively and expansion carried out progressively.

2.2.4 Expansion Plan

(1) Treatment plants

It is physically possible to modify existing treatment plants and increase their capacities, but this will lead to prolonged water supply stoppages in future and will have adverse effects on the residents of Amman, and is therefore impractical. In principle, the number of treatment plants similar to existing plants, should be increased. However, as described later, a part of the facilities such as raw water regulating basins and clean water reservoirs that can be shared, should not be increased.

(2) Conveyance pipelines and conveyance pumps

The plans for conveyance pipelines in response to the doubling of flow rate (design flow rate) include the method of installing additional conveyance pipelines (Alternative II), and the method of utilizing existing conveyance pipelines without laying additional pipelines (Alternative I). With the doubling of the flow rate, the power consumption for pumps will increase in Alternative I, while the cost for laying additional conveyance pipelines can be economized. In this case, the head of the pump to be installed additionally will be the actual head of existing pump (difference in altitudes of the pumping stations) plus the friction losses (due to doubling of flow rate). The increase in head for this case is shown in Table 10.

Table 10 Head When Using Existing Conveyance Pipelines and Doubling The Flow Rate

	45 million m^3/year	90 million m^3/year	Increase in head
No. 1 conveyance pump	286m	300m	4%
No. 2 conveyance pump	286m	300m	4%
No. 3 conveyance pump	286m	308m	6%
No. 4 conveyance pump	286m	314m	9%
Transmission pump	198m	257m	30%

As seen in the table above, the percentage increase in head for pump stations No. 1 to No. 4 is comparatively small at 4 to 9%. This shows that the head in most cases is only the actual head and friction loss is negligible. If the percentage increase in head is as small as the figures indicate, there is a high possibility that the conveyance pipelines of existing facilities can withstand the increased flow rate. As explained later, detailed studies were carried out on the ability of conveyance pipelines to withstand pressure. The results of the studied showed that excluding a part of the pipelines, the existing pipelines can withstand the increased pressure due to the doubling of the flow rate.

While construction costs are incurred and operating and maintenance costs economized for Alternative H, the construction costs can be economized and operating and maintenance costs are incurred for Alternative I. To determine the Alternative that is most beneficial, the "net present value" of both alternatives were calculated. The results of the studies showed that Alternative I was more beneficial, and thus this alternative was selected (Refer to Reference 3). That is, existing conveyance pipelines will be utilized in the expansion stage.

2.3 Basic Design

2.3.1 Design Concept

(1) Design concept considering natural conditions

1) Temperature

The four-month period from June to September in Jordan is dry and the temperature is high. Direct sunlight is not conducive to the placing of concrete. The months from October to May is suitable for the placing of concrete. If concrete is placed during the summer season, it should preferably be done in the evening and night time. A large quantity of water should be dispersed for the concrete to harden in order to prevent evaporation due to the dry atmosphere and high temperatures, if concrete is placed in the day time in the presence of direct sunlight.

2) Rainfall

Rainfall is maximum in the period from January to March, and the maximum rainfall is about 90 mm. Snow also falls two to three times in the vicinity of the Zai treatment plant. Work may have to be stopped because of these snows.

3) Wind

Assembly of reinforcing bars and form works should be avoided in strong winds. Strong and adequate supports are needed for reinforcing bars and formworks to be assembled. In general, winds will not affect the progress of the construction work.

4) Topography and geology

The existing pumping stations are located on steep gradients and careful considerations are necessary when carrying heavy objects such as transformers and pumps to the stations. Roads from Deir Alla to the Zai treatment plant through various pumping stations are paved, but the roads have steep slopes in places.

The foundation ground of pumping stations and treatment plants consists of sandstone. The pumping stations are constructed on cut out rock beds. The sandstone foundation of treatment plants (for expansion facilities) is considered to reach to 6 to 7 m, but if it does not reach up to the foundation substrate of settling basins and filter basins, the said part needs to be replaced with lean-mix concrete, and the construction of the settling basin needs to be changed from the retaining wall construction to rigid frame construction.

5) Earthquakes

Seismic loads should be considered in the design loads of structures because Jordan experiences earthquakes.

(2) Design concept considering social conditions

The main religion in Jordan is Islam, therefore the implementation plans should consider religious aspects, such as Ramadan.

Since there are no residential areas in the vicinity of the pumping stations, there are no water supply and sewage facilities. Generators, water supply tanks, and purification tanks need to be provided at the construction sites.

(3) Design concept considering special circumstances related to construction and the construction industry

Many types of construction machinery can be procured within the country. Automation is common and the level of construction is comparatively high. Most construction machinery can be purchased locally.

Surplus soil can be used from the soil disposal site at Zarqa (approx. 30 km) east of Amman.

Most of the equipment and machinery required for construction are locally available in Jordan. Value added tax (VAT) is applicable to construction equipment and machinery in Jordan, but VAT is exempted for projects receiving foreign aid (borne by the implementing organization).

(4) Design concept considering utilization of local contractors (construction companies and consultants) and local machinery and equipment

Trained local contractors are available in civil, mechanical, electrical, architectural fields and can be utilized as sub-contractors for the work enabling the project cost to be reduced.

(5) Design concept considering operation and management ability of implementing organizations

WAJ has built up its experience with the Zai system over a long period, and the expansion facilities for this Project are similar to those in the existing system, therefore WAJ is considered to have operating and maintenance skills that are adequate for the expansion facilities. On the other hand, the balance of current account for WAJ shows a deficit. If such deficit situation will continue, operation and maintenance of the facilities improved might become weak. In order to avoid such situation, WAJ should take initiatives for achieving better financial balance by tariff modification, decreasing unaccounted-for-water etc.

(6) Design concept considering the establishment of grades and scope of facilities, equipment and machinery

WAJ's level of technology for operations and management for existing facilities is adequate. Therefore, the grade for facilities during expansion is kept the same as the grade for existing facilities.

(7) Design concept considering implementation period

1) The schedule for implementation is given below for completing the rehabilitation work by the end of fiscal year 1997.

October 1996	Approval by the Japanese government
November 1996	Exchange of notes, contracts with consultants
November 1996	Implementation design
March 1997	Tenders, evaluation, selection of contractors, signing contracts
April '97 - March '98	Procurement and installation of equipment

2) The expansion plan is divided into two parts - expansion of treatment plants and expansion of pumping stations. The schedule for the stages is given below.

<u>Treatment plants</u>

May 1998	Approval by the Japanese government
June 1998	Exchange of notes, contracts with consultants
August. '98 to Jan. '99	Implementation design
February 1999	Tenders, evaluation, selection of contractors, signing contracts
March '99 to Nov. 2001	Construction period

<u>Pumping stations</u>

First Stage

August 1998	Approval by the Japanese government
September 1998	Exchange of notes, contracts with consultants
Nov. '98 to Feb. '99	Implementation design
March 1999	Tenders, evaluation, selection of contractors, signing contracts
April '99 to Mar. 2000	Construction period

Second Stage

May 2000	Approval by the Japanese government
June 2000	Exchange of notes, contracts with consultants
July 2000 to Dec. 2000	Implementation design
Jan.. 2001	Tenders, evaluation, selection of contractors, signing contracts
Feb. 2001 to Dec. 2001	Construction period

2.3.2 Basic Plan (Part 1 Rehabilitation Portion)

(1) Overall Plan

Out of the various facilities in the Zai system, each one pump and its motor are replaced in the Nos. 1, 2, 3 and 4 pumping stations (PS). Also each 10 MVA transformers are installed in the four PS. As a result, 45 MCM/year water can be conveyed to the Zai water treatment plant.

(2) Procurement Design

The scope of rehabilitation works are shown in Table 11.

Table 11 Contents of Rehabilitation Works

1. Pump

Equipment or Item	Existing Equipment	Rehabilitated Equipment	Reason of Rehabilitation
Number	One pump out of the four pumps is removed	One new pump is installed	Three existing pumps is kept.
Stand-by pump	None	None	Two stand-by pumps are procured and stored for four pumping stations.
- Specification of Pump			
Diameter (mm)	ϕ 350× ϕ 250	ϕ 450× ϕ 300	Size increase due to discharge amount increase
Discharge amount per one pump	21.95m3/min.	43.5m3/min.	
Total Head (No. 1 and No.2 PS)	286m	300m	Friction loss increase due to discharge amount increase
Total Head (No. 3 PS)	286m	308m	ditto
Total Head (No. 4 PS)	286m	314m	ditto
Speed of Rotation	2980 rpm	1490 rpm	It is reduced to mitigate pump abrasion resulted from silt
Impeller Material	Stainless cast steel (SCS1)	Stainless cast steel (SCS1)	
Body Material	Cast Steel (SC46)	Cast Steel (SC46)	Stainless Steel is used in casing ring
Shaft Seal	Gland Packing	Gland Packing	Cover is mounted
Bearing Cooling	Oil Pan + Cooling Water	Oil Pan + Cooling Water	
- Accessory			
Suction Pressure Gauge Number Type	For Existing Pumps 12 Bourdon-tube	For Existing Pump 12 Diaphragm	The out-of-order existing gauges are replaced with diaphragm type to mitigate damage due to silt
Delivery Pressure Gauge Number Type	For Existing Pumps 12 Bourdon-tube	For Existing Pump 12 Diaphragm	ditto
Pipes and Valves		1 lot	

2. Motor

Equipment or Item	Existing Equipment	Rehabilitated Equipment	Reason of Rehabilitation
Number and Stand-by	One motor is removed	One motor is installed	1 set/ PS x 4 PS = 4 motors
- Specification			
Type	Horizontal-shaft squirrel-cage 3-phase induction motor	Horizontal shaft squirrel-cage 3-phase induction motor	The existing type is easy to maintain and well managed.
Protection and Cooling	Open-type Drip-proof Forced Air Cooling	Open-type Drip-proof Forced Air Cooling	The existing type is easy to maintain and well managed.
Pole Number	2 P	4 P	Due to Decrease of Pump Rotation
Voltage and Frequency	6600v、50Hz	6600v、50Hz	
Output Power	1850HP (each in the four PS)	3200KW (No.1, No.2 PS) 3300KW(No.3 PS) 3500KW(No.4 PS)	Due to total Head Increase
Starting Method	Line-start	Reactor Start	To reduce start current

3. 33 KV Power Receiving Facilities

Equipment	Existing Equipment	Rehabilitated Equipment	Reason of Rehabilitation
Disconnecting Switch	Outdoor type, Manual operation, 36KV, 800A	Outdoor type, Manual operation, 36KV, 800A	For the new transformer
Circuit Breaker	OCB, Outdoor type, 36KV, 600A, 25KA	OCB, Outdoor type, 36KV, 600A, 25KA	ditto
Lightening arrester	Outdoor type,	Outdoor type,	ditto
Transformer	Oil-immersed outdoor type, 33/6.6KV, 10MVA, 3 ϕ	Oil-immersed outdoor type, 33/6.6KV, 10MVA, 3 ϕ	Due to increase of starting current resulted from increase of a motor (from 21.95 to 43.5 m3/min.)
Protection-relay panel	Metal enclosed type of self-standing	Metal enclosed type of self-standing	Control and protection for new circuit breaker, transformer etc.
Wire, Cable			

4. H.T. (High Tension) and L.T. (Low Tension) Facilities

Equipment	Existing Equipment	Rehabilitated Equipment	Reason of Rehabilitation
H.T. power receiving panel	Metal enclosed type of self-standing	Metal enclosed type of self-standing	For receiving electricity from new transformer
H.T. motor panel (including starting reactor)	Metal enclosed type of self-standing (including Line Start)	Metal enclosed type of self-standing (including starting reactor)	Due to increase of motor output
Bus-linkage panel	—	Metal enclosed type of self-standing	For parallel operation of two transformers
Station service transformer panel	Metal enclosed type of self-standing	Metal enclosed type of self-standing	Due to increase of power supply to auxiliary equipment
L.T. power panel	Metal enclosed hinged type	Metal enclosed type of self-standing	Due to increase of auxiliary equipment
Compressor panel	Metal enclosed hinged type	Metal enclosed hinged type	For operation of new compressor
Modification for existing facilities	—		
Wire, Cable			

5. Delivery Valve

Equipment or Item	Existing Equipment	Rehabilitated Equipment	Reason of Rehabilitation
Diameter	ϕ 300	ϕ 450	Due to change of Motor Diameter
Type	Ball Valve	Ball Valve	
Drive Mechanism	Oil Hydraulic	Motor-operated	Existing Oil Unit is not adequate for increased number of valves. Motor-operation is easier.
Pressure Class	ANSI300	ANSI300	Same as the existing flange specification
Number	One out of four valve is removed	One valve is installed	

6. Delivery-side Joint

Equipment or Item	Existing Equipment	Rehabilitated Equipment	Reason of Rehabilitation
Diameter	ϕ 300	ϕ 450	Due to change of Pump Diameter
Material	Steel Pipe	Steel Pipe	Same as the existing
Pressure Class	ANSI300	ANSI300	Same as the existing flange specification
Number	One out of four is removed.	One is installed	

7. Pipes

Equipment or Item	Existing Equipment	Rehabilitated Equipment	Reason of Rehabilitation
Diameter	ϕ 300	ϕ 450	Due to change of Pump Diameter
Material	Steel Pipe	Steel Pipe	Same as the existing
Pressure Class	ANSI300	ANSI300	Same as the existing flange specification
Number	One out of four is removed.	One is installed	

8. Compressor

Equipment or Item	Existing Equipment	Rehabilitated Equipment	Reason of Rehabilitation
Type	Reciprocating 3-phase	Reciprocating 3-phase	
Discharge Pressure	42.2 Kg/cm2	45.0 Kg/cm2	Adequate for expansion
Piston Volume	1.52 m3/min.	1.40 m3/min.	ditto
Number	Removal of 8 sets (= 2/1 PS x 4 PS)	Installation of 8 sets (= 2/1 PS x 4 PS)	Existing equipment needs frequent repair.

9. Ventilation Suction Gallery

Equipment or Item	Existing Equipment	Rehabilitated Equipment	Reason of Rehabilitation
Operation Method	Motor-driven Shutter	Manually-operated Shutter	Always open for ease of maintenance.
Number	Removal of 64 sets (= 16/1 PS x 4 PS)	Installation of 64 sets (= 16/1 PS x 4 PS)	

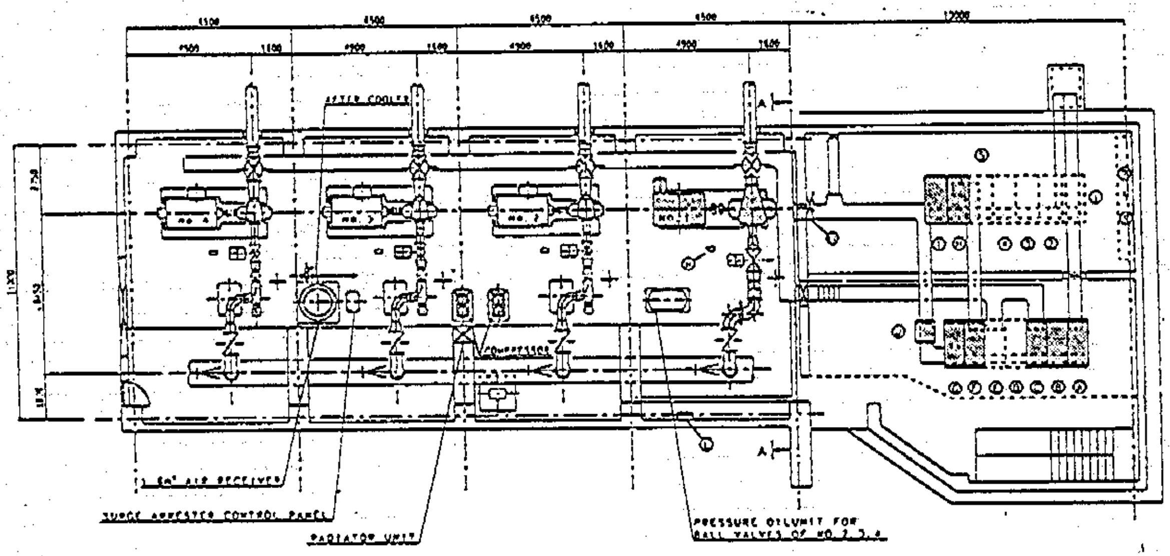
(3) Drawings

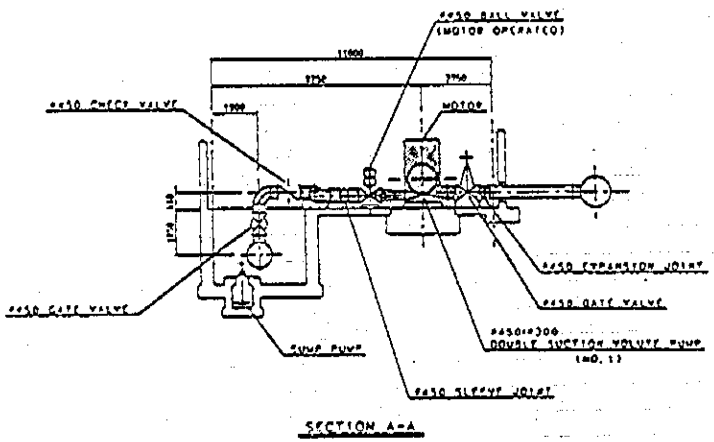
Fig. 2 Layout of Pump, Motor and Electric Panel Room (for No. 1 to No.4 Pumping Stations)

Fig. 3 Single-line Diagram (for No. 1 to No.4 Pumping Stations)

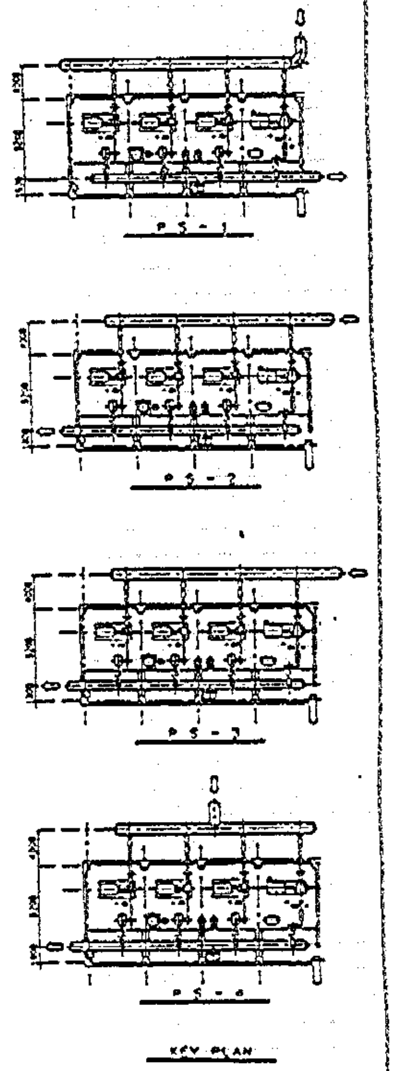
Fig. 4 Wiring Diagram (for No. 1 to No.4 Pumping Stations)

Fig. 5 Existing Electric Power Supply to Zai System (for reference)





SECTION A-A



KEY PLAN

Rehabilitation Portion

NO	DESCRIPTION	REMARKS
1	33KV CONTROL PANEL	EXISTING
2	INCOMING PANEL	↑
3	NO.1 NO.2 PUMP PANEL	
4	NO.3 NO.4 PUMP PANEL	
5	TRANSFORMER PANEL	
6	NO.1 CAPACITOR PANEL	
7	NO.2 CAPACITOR PANEL	
8	NO.3 CAPACITOR PANEL	
9	NO.4 CAPACITOR PANEL	
10	DISTRIBUTION PANEL A	↑
A	NO.1 INCOMING PANEL	NEW
B	NO.1 PUMP PANEL(CAPACITOR P)	↑
C	NO.1 PUMP PANEL(CAPACITOR P)	↑
D	NO.3 PUMP PANEL(CAPACITOR P)	EXISTING
E	NO.2 PUMP PANEL(CAPACITOR P)	↑
F	[illegible] PANEL	NEW
G	TRANSFORMER PANEL	
H	ISOLATOR PANEL	
I	33KV CONTROL PANEL	
J	380V SWITCH BOARD	
K	COMPRESSOR CONTROL PANEL	
L	NO.1 EXHAUST FAN PANEL	↑
M	NO.2 EXHAUST FAN PANEL	EXISTING
N	NO.1 PUMP CONTROL PANEL	NEW
O	NO.2 PUMP CONTROL PANEL	EXISTING

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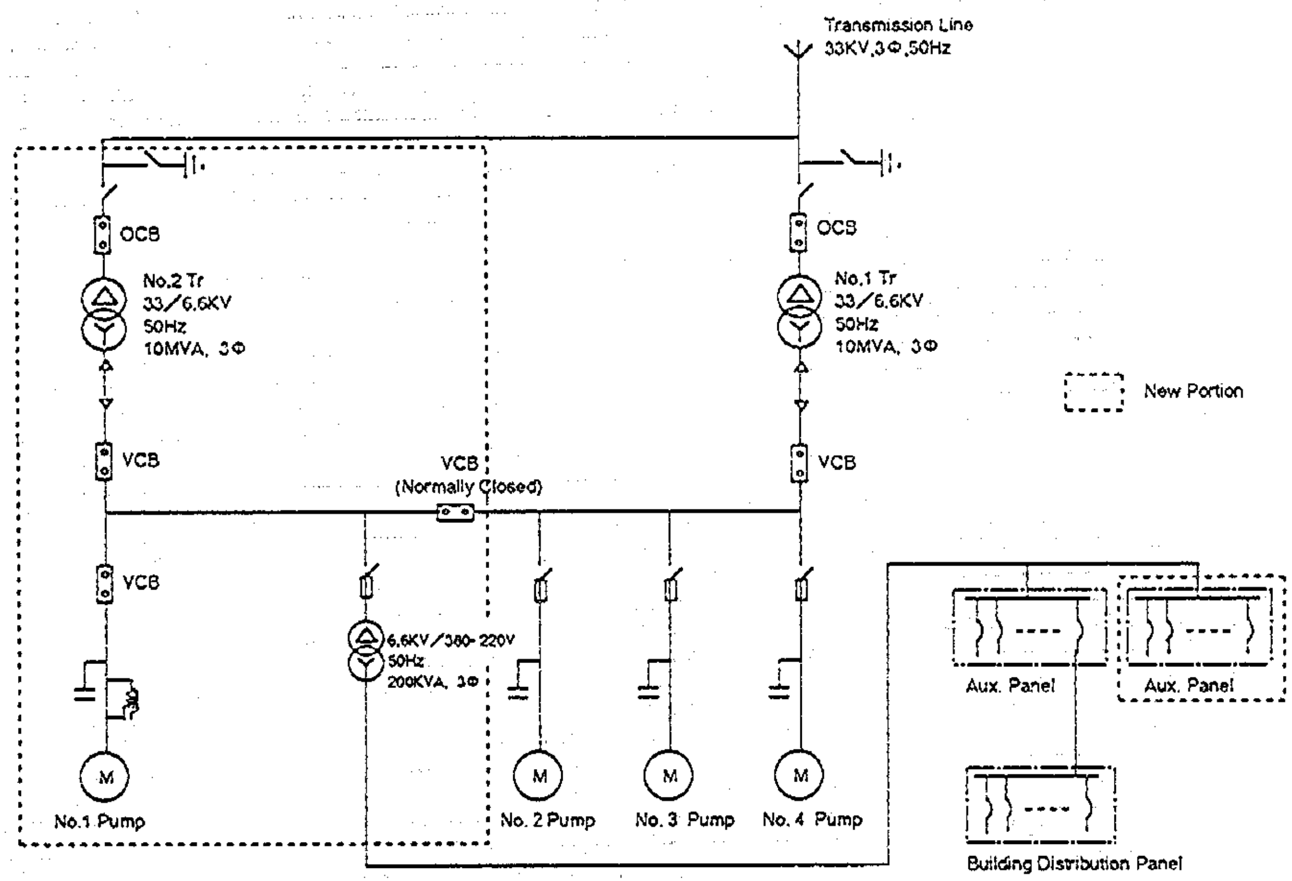
TO GREATER AMMAN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2
Layout of Pump, Motor and Electric Panel Room
(for No. 1 to No.4 Pumping Stations)



No.1 PS	3,200KW
No.2 PS	〃
No.3 PS	3,300KW
No.4 PS	3,500KW

1,850Hp (1,388KW)	1,850Hp (1,388KW)	1,850Hp (1,388KW)
〃	〃	〃
〃	〃	〃
〃	〃	〃

BASIC DESIGN STUDY ON THE PROJECT
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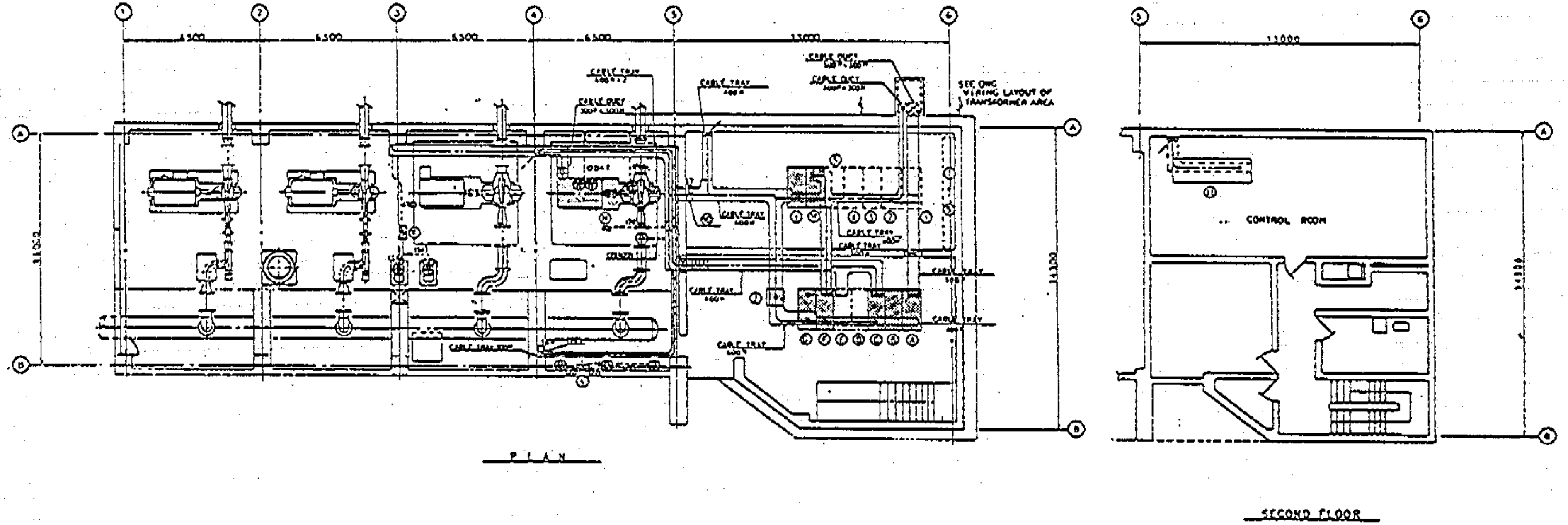
Fig. 3
Single-line Diagram
(for No. 1 to No.4 Pumping Stations)



Rehabilitation Portion

NO	DESCRIPTION	REMARKS
(A)	NO1 INCOMING PANEL	NEW
(B)	NO1 PUMP PANEL (CAPACITOR P)	
(C)		
(D)	NO2 PUMP PANEL (CAPACITOR P)	FUTURE
(E)		
(F)	TR PRIMARY & BUS TIE PANEL	NEW
(G)	TRANSFORMER PANEL	
(H)	ISOLATOR PANEL	
(I)	33 KV CONTROL PANEL	
(J)	380V SWITCH BOARD	
(K)	COMPRESSOR CONTROL PANEL	
(L)	NO1 EXHAUST FAN PANEL	
(M)	NO1 PUMP CONTROL PANEL	

NO	DESCRIPTION	REMARKS
(1)	33 KV CONTROL PANEL	EXISTING
(2)	INCOMING PANEL	
(3)	NO1, NO2 PUMP PANEL	
(4)	NO3, NO4 PUMP PANEL	
(5)	TRANSFORMER PANEL	
(6)	NO1 C PACITOR PANEL	
(7)	NO2	
(8)	NO3	
(9)	NO4	
(10)	DISTRIBUTION PANEL A	
(11)	INSTRUMENT CONTROL PANEL	

NOTE

1. CABLE TRAYS DUCTS AND SUPPORTS MATERIALS SHALL BE SS.
2. MATERIALS FOR CABLE TRAYS DUCTS AND THESE SUPPORTS SHALL BE COATED WITH HOT DIP GALVA NIZE

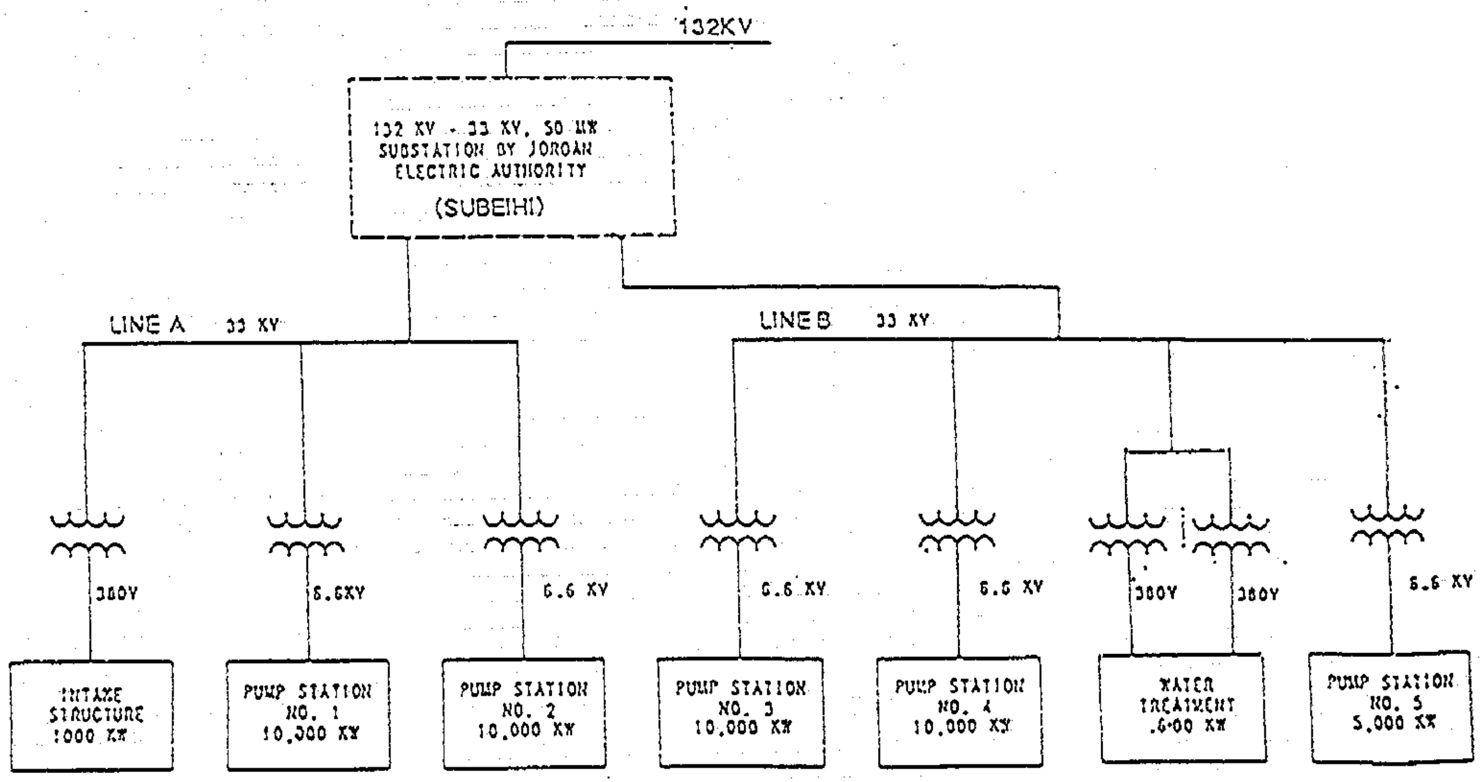
BASIC DESIGN STUDY ON THE PROJECT FOR INPROVEMENT OF WATER SUPPLY SYSTEM TO GREATER AMMAN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 4

Wiring Diagram

(for No. 1 to No.4 Pumping Stations)



BASIC DESIGN STUDY ON THE PROJECT FOR INPROVEMENT OF WATER SUPPLY SYSTEM TO GREATER AMMAN	Fig. 5 Existing Electric Power Supply to Zai System (for reference)
JAPAN INTERNATIONAL COOPERATION AGENCY	

2.3.2 Basic Plan (Part 2 Expansion Portion)

(1) Overall Plan

Three of the four pumps (excluding one pump already rehabilitated) and motors in each of the pumping stations No. 1 to No. 4 of the Zai system are to be renewed, and one surge tank is to be additionally installed to increase the planned capacity after rehabilitation from 45 million m^3/year to 90 million m^3/year (250 thousand m^3/day) in the expansion stage. The items below form the basic concept.

* Formulate the basic plan utilizing the existing facilities effectively (conveyance pipelines, pump houses, pump wells, transformers, surge tanks, chemical dosing equipment, raw water regulating basins, etc.)
* 660 m of conveyance pipeline from the No. 4 pump to the Zai treatment plan cannot withstand the internal water pressure and need to be replaced. However, to bring down the overall project costs, this replacement is not included in the Project. This work should be carried out independently by Jordan.
* After expansion, the Zai system will supply treated water to the Amman city area with the other facilities constructed in the separate Projects, the "Adasiya - Deir Alla" project, and the "No. 5 pumping station to Dabouk service reservoir" project. Accordingly, the control of flow rate of raw water, treated water, and delivered water is very important, and the control equipment for the Zai treatment plant is considered to be the most equipment for the three projects mentioned above.
* No problems in particular are found in the design concept and functions of existing facilities. Consequently, the same system as in the existing facilities will be used, in principle.

<u>Pump Expansion</u>

(2) Facilities Plan

Each pumping station consists of the pump house (pumps, motors, electrical equipment, etc.), transformers, storage tanks, and surge tanks. The pump house and transformers are installed on level ground after filling up the depression. On the other hand, storage tanks are installed about 20 m above the pump house (after cutting off the apex of the mountain) to match the pump characteristics.

Pumps and motors are replaceable equipment and are to be installed in the existing pump house. However, the surge tanks will be added in the future. This is because one more surge tank of the same size as the existing one needs to be installed in the pump house when the design flow rate is increased. After expansion, the capacity of the surge tank should be doubled. The surge tank can be installed at any arbitrary position, and the frequency of maintenance is also comparatively small, therefore the position should be considered based on the condition of the soil, foundation, laying of special H.T. lines, and buried pipes.

Additionally, the topographical and geological conditions given below need to be considered when installing the No. 1 pump.

* Since the surge tank is installed south of the existing conveyance pipelines, it would be preferable to install it by the side of existing surge tank, but there is no space. Therefore, the surge tank is to be installed on the gentle slope on the north side of the existing tank near the storage tank and rainwater drain.
* The ground has a rising gradient from the eastern side of the pump house toward the north, and a part of the surface has been cut away. Backfill can also be observed at some locations (an area of about 10 m x 35 m at the pump suction header pipe part north of the pump house). Excluding the above-mentioned parts, no problems are anticipated in the ground. The bearing ability of the ground was also confirmed from the results of checks by poling the ground.

(3) Machinery and Equipment Plans

1) Pump, motor, transformer for receiving power

After rehabilitation, the pumping capacity of each pumping station will be: dia. 350 mm x dia. 250 mm x 21.95 m^3/min. x 286 m x 1850 HP x 3 currently, dia. 450 mm x dia. 300 mm x 43.5 m^3/min. x 300 - 314 m x 3000 - 3500 kW x 1 after rehabilitation. The total capacity of the pumping station will be 45 million m^3/year (approximately 123 thousand m3/day).

During the expansion stage, the pumps in each pumping station together with the three existing non-renewed pumps are to be replaced with dia. 450 mm x dia. 300 mm x 43.95 m^3/min. x 300 - 314 m x 3000 - 3500 kW specifications, same as the pumps renewed during the rehabilitation stage. Accordingly, all pumping stations after the expansion will operate four pumps of similar capacity. With the expansion of these pumps, the following facilities will become necessary:

* Two standby pump (kept in the store) is available at each pumping station which were procured in the rehabilitation stage and no standby pumps are be procured in the expansion stage.
* One additional surge tank to be installed in each pumping station for preventing the water hammering action.
* Three motors to be provided at each pumping station (same specifications as during the rehabilitation stage - reactor starting squirrel cage induction motors)(no standby motor)

The transformer capacity required for each pumping station is 20 MVA but since 20 MVA has been provided at the rehabilitation stage, no expansion is necessary.

2) Control and telemetry equipment

Since the operators have been using the monitoring and control system through graphic panels currently without any problems, the same system can be adopted in future, but because of the reasons below an overall renewal needs to be carried out.

* Existing capacity per pump (before rehabilitation) is the same at all pumping stations, and it has been designed so that the same flow rate is used at all pumping stations. In practice, however, the discharge rate of each pump is not the same at all stations. To regulate this rate, storage tanks (regulating reservoirs) are installed at all pumping stations. For this Project, however, existing tanks are to be used even after expansion to reduce costs. This will result in a reduction in the regulating capacity of the tanks. To compensate this, the degree of opening of the delivery valves should be controlled in addition to controlling the number of pumps on the pump side, which is done conventionally. Large-scale changes in the automatic control functions (software for built-in programmable controller) are needed, but the manufacturer (Bristol-Babcock of the USA) has already stopped manufacture of similar types of equipment, therefore changes in program are not possible. Moreover, procurement of spare parts for electronic equipment being used is likely to become difficult in the near future.

* The existing equipment have been manufactured in the first half of the eighties, and do not have the automatic function of generating operation and maintenance reports (daily reports).

3) Description of machinery and equipment

The machinery and equipment in each pumping station after expansion is shown in Table 12.

1. Pumps

Equipment name and items	Existing equipment 1	Existing equipment 2 (at rehabilitation)	Equipment at expansion (per pumping station)	Overall equipment after expansion (per pumping station)
Number	3 pumps (removal)	1 pump (+ 2 standby for 4 PS)	3 pumps (installation)	4 pumps (+2 standby for 4 PS)
Diameter (mm)	φ 350× φ 250	φ 450× φ 300	Same as left	Same as left
Discharge rate (per pump)	21.95m³/min.	43.5m³/min.	Same as left	Same as left
Total head (No.1 PS)	286m	300m	Same as left	Same as left
Total head (No.2 PS)	286m	300m	Same as left	Same as left
Total head (No.3 PS)	286m	308m	Same as left	Same as left
Total head (No.4 PS)	286m	314m	Same as left	Same as left
Standby pump		300 m	None	1
Standby pump		314 m	None	1
Speed of rotation	2,980 rpm	1,490 rpm	Same as left	Same as left
Impeller material	Stainless cast steel (SCS1)	Stainless cast steel (SCS1)	Same as left	Same as left
Body material	Cast steel (SC46)	Cast steel (SC46)	Same as left	Same as left
Shaft seal	Gland packing	Gland packing	Same as left	Same as left
Bearing cooling method	Oil bath + cooling water	Same as left	Same as left	Same as left
- Pump accessories				
Suction pressure gauge Number Type	 3(removal) Bourdon tube	 1 Diaphragm type	 3(installation) Same as left	 4 Same as left
Delivery pressure gauge Number Type	 3(removal) Bourdon tube	 1 Diaphragm type	 3(installation) Same as left	 4 Same as left
Other Pipes and Valves			1 set	

2. Motor

Equipment name and items	Existing equipment 1	Existing equipment 2 (at rehabilitation)	Equipment at expansion (per pumping station)	Overall equipment after expansion (per pumping station)
Number	3 (removal)	1	3	4
Type	Horizontal shaft, squirrel cage 3-phase induction motor	Same as left	Same as left	Same as left
Protection and cooling	Open type drip-proof, forced air cooling	Same as left	Same as left	Same as left
No. of poles	2 P	4 P	Same as left	Same as left
Voltage, frequency	6,600v、50Hz	6,600v、50Hz	Same as left	Same as left
Motor output (No. 1 PS)	1,850HP	3,200KW	Same as left	Same as left
Motor output (No. 2 PS)	1,850HP	3,200KW	Same as left	Same as left
Motor output (No. 3 PS)	1,850HP	3,300KW	Same as left	Same as left
Motor output (No. 4 PS)	1,850HP	3,500KW	Same as left	Same as left
Starting method	Direct line	Reactor starting	Same as left	Same as left

3. High Tension and Low Tension Facilities

Equipment name and items	Existing equipment 1	Existing equipment 2 (at rehabilitation)	Equipment at expansion (per pumping station)	Overall equipment after expansion (per pumping station)
H.T. receiving panel	Metal-enclosed, self-standing type	1 no. (removal)	Same as left, 1 no.	Same as left, 2 no.
H.T. motor panel	Same as above (including direct line starter), 3 no. (removal)	Same as left (including starting reactor), 1 no.	Same as left, 3 no.	Same as left, 4 no.
Ventilation panel	Same as above, 1 no. removal	Same as left, 1 no.	Same as left, 3 no.	Same as left, 4 no.
Modification of existing panel	- (removal)	-	1 set	-
Wires, cables	-	-	1 set	-

4. Control and Telemetry Equipment (Pumping Station)

Equipment name and items	Existing equipment 1	Existing equipment 2 (at rehabilitation)	Equipment at expansion (per pumping station)	Overall equipment after expansion (per pumping station)
Monitoring and operation panel (including graphic panel)	Metal-enclosed, self-standing type, 1 no. (removal)	-	Metal-enclosed, self-standing type, 1 no.	Same as left, 1 no.
Signal I/O panel	Same as above, 1 no. (removal)	-	Same as above, 1 no.	Same as left, 1 no.
Control telemetry equipment	1 no.	-	1 no.*	1 no.
Battery and battery charger	1 no.	-	1 no.*	1 no.
Flow meter	Ultrasonic type, 1 no. (removal in Nos. 1 and 4 PS)	-	Ultrasonic type, 1 no. (installation in Nos. 1 and 4 PS)	Ultrasonic type, 1 no.
Modification of existing VHF telephone equipment	-	-	1 set	-
Wires, cables	-	-	1 set	-

* One number of each to be installed in the Dabouk service reservoir also.

5. Delivery Valves

Equipment name and items	Existing equipment 1	Existing equipment 2 (at rehabilitation)	Equipment at expansion (per pumping station)	Overall equipment after expansion (per pumping station)
Number	3	1	3	4
Diameter (mm)	ϕ 300	ϕ 450	Same as left	Same as left
Type	Ball valve	Ball valve	Same as left	Same as left
Drive mechanism	Hydraulic	Motor driven	Same as left	Same as left
Pressure class	ANSI300	ANSI300	Same as left	Same as left

6. Delivery Side Joints

Equipment name and items	Existing equipment 1	Existing equipment 2 (at rehabilitation)	Equipment at expansion (per pumping station)	Overall equipment after expansion (per pumping station)
Number	3	1	3	4
Diameter (mm)	ϕ 300	ϕ 450	Same as left	Same as left
Material	Steel pipe	Steel pipe	Same as left	Same as left
Pressure class	ANSI300	ANSI300	Same as left	Same as left

7. Suction and Delivery Pipes

Equipment name and items	Existing equipment 1	Existing equipment 2 (at rehabilitation)	Equipment at expansion (per pumping station)	Overall equipment after expansion (per pumping station)
No. of sets	3	1	3	4
Diameter (mm)	ϕ 300	ϕ 450	Same as left	Same as left
Material	Steel pipe	Steel pipe	Same as left	Same as left
Pressure class	ANSI300	ANSI300	Same as left	Same as left

8. Surge Tank

Equipment name and items	Existing equipment 1	Existing equipment 2 (at rehabilitation)	Equipment at expansion (per pumping station)	Overall equipment after expansion (per pumping station)
Type	Horizontal	Horizontal	Horizontal	Horizontal
Size	D 1,900x10,700		D 1,900x10,700	D 1,900x10,700
Pressure class	ANSI300		ANSI300	ANSI300
Number	1		1	2

(4) Basic Design Drawings

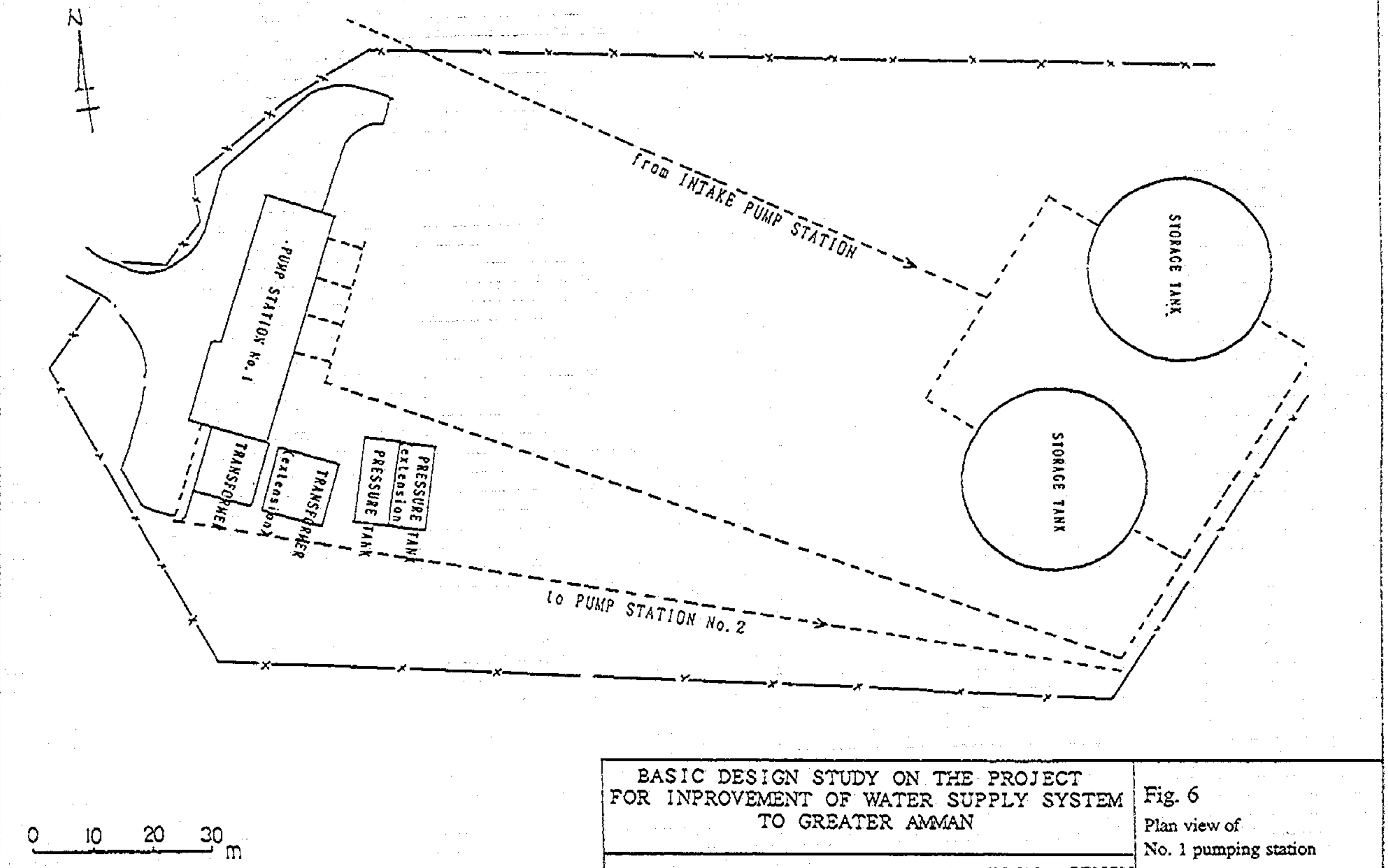


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Fig. 6
Plan view of No. 1 pumping station

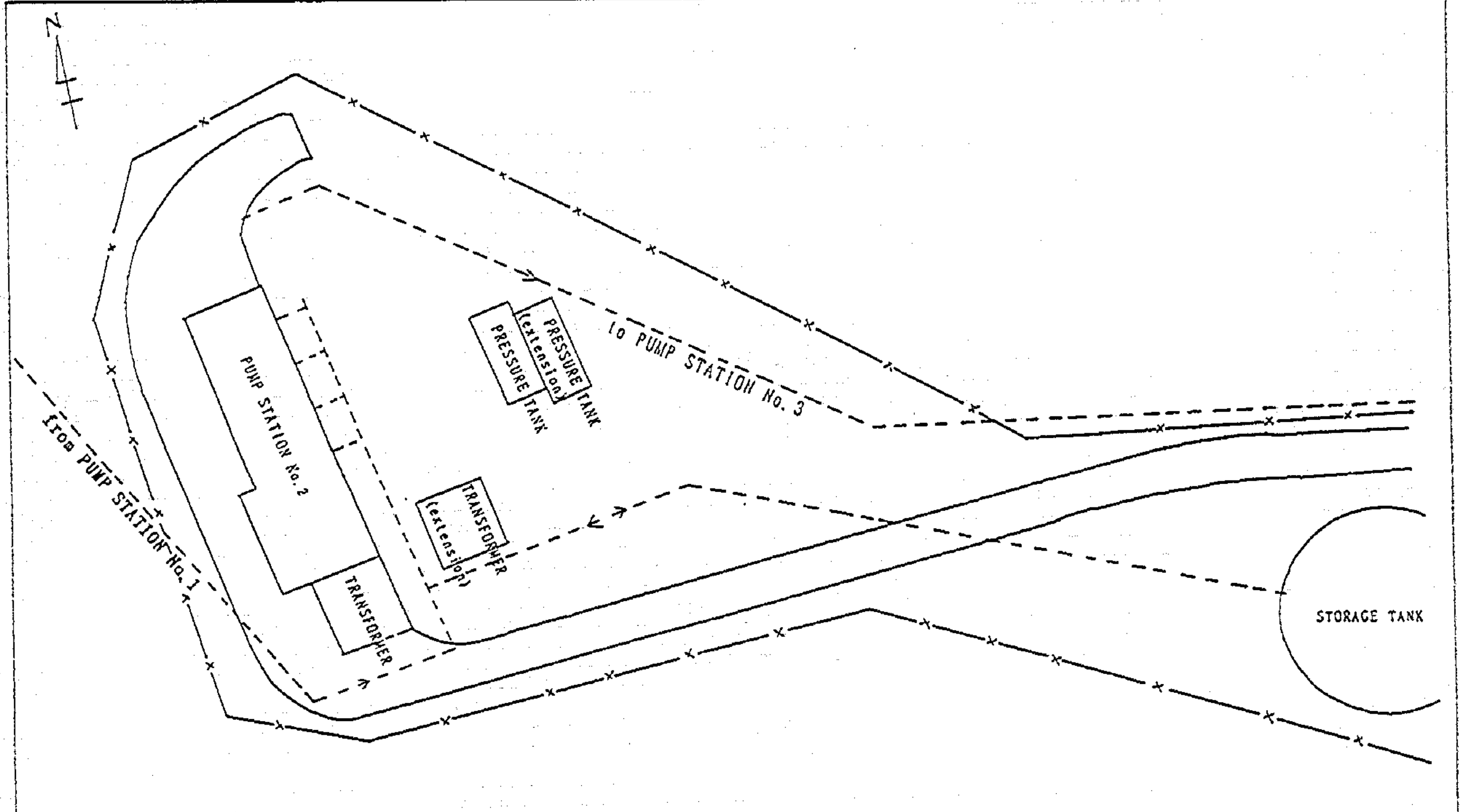

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Fig. 7
Plan view of
No. 2 pumping station

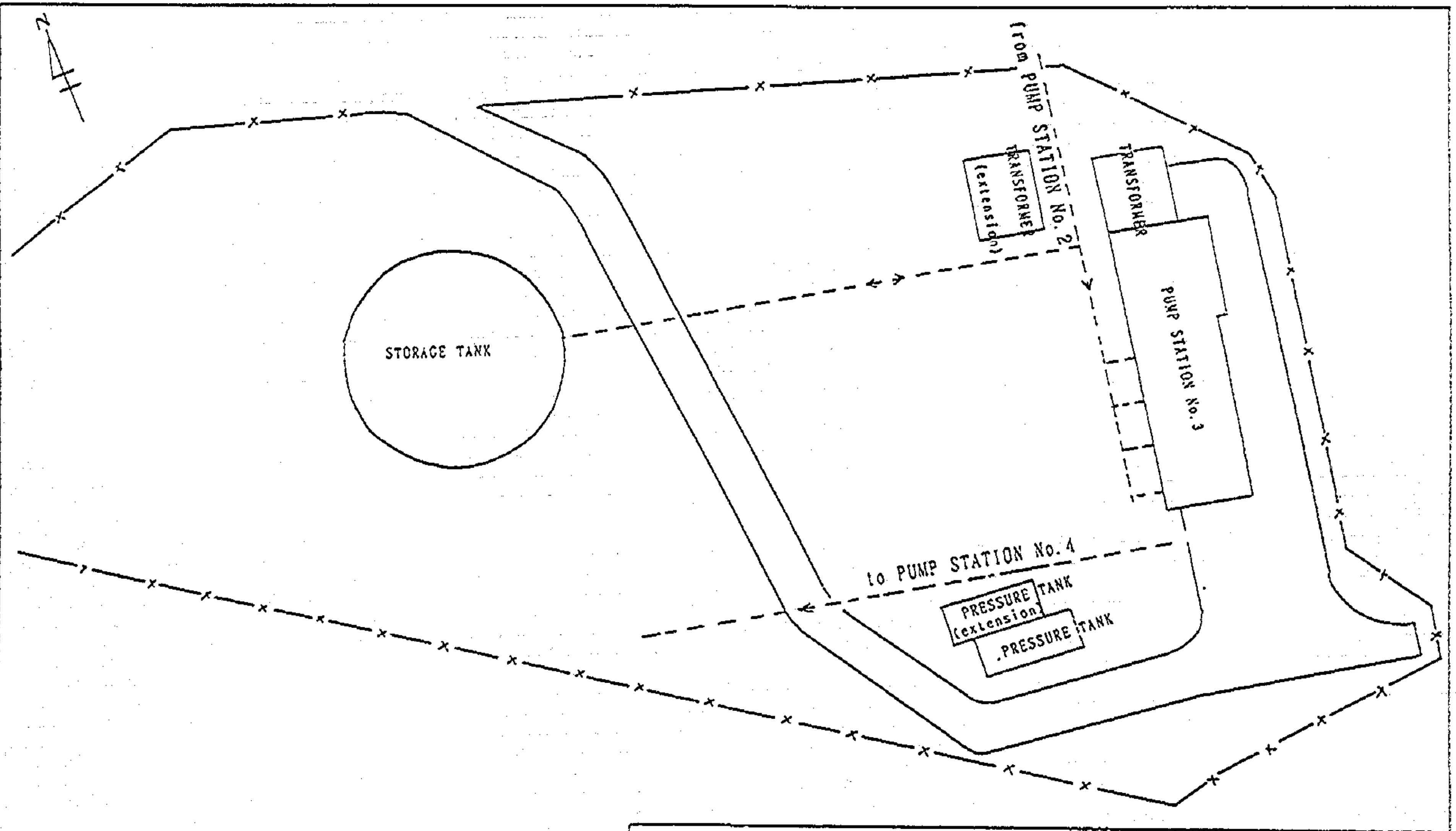

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Fig. 8 Plan view of No. 3 pumping station

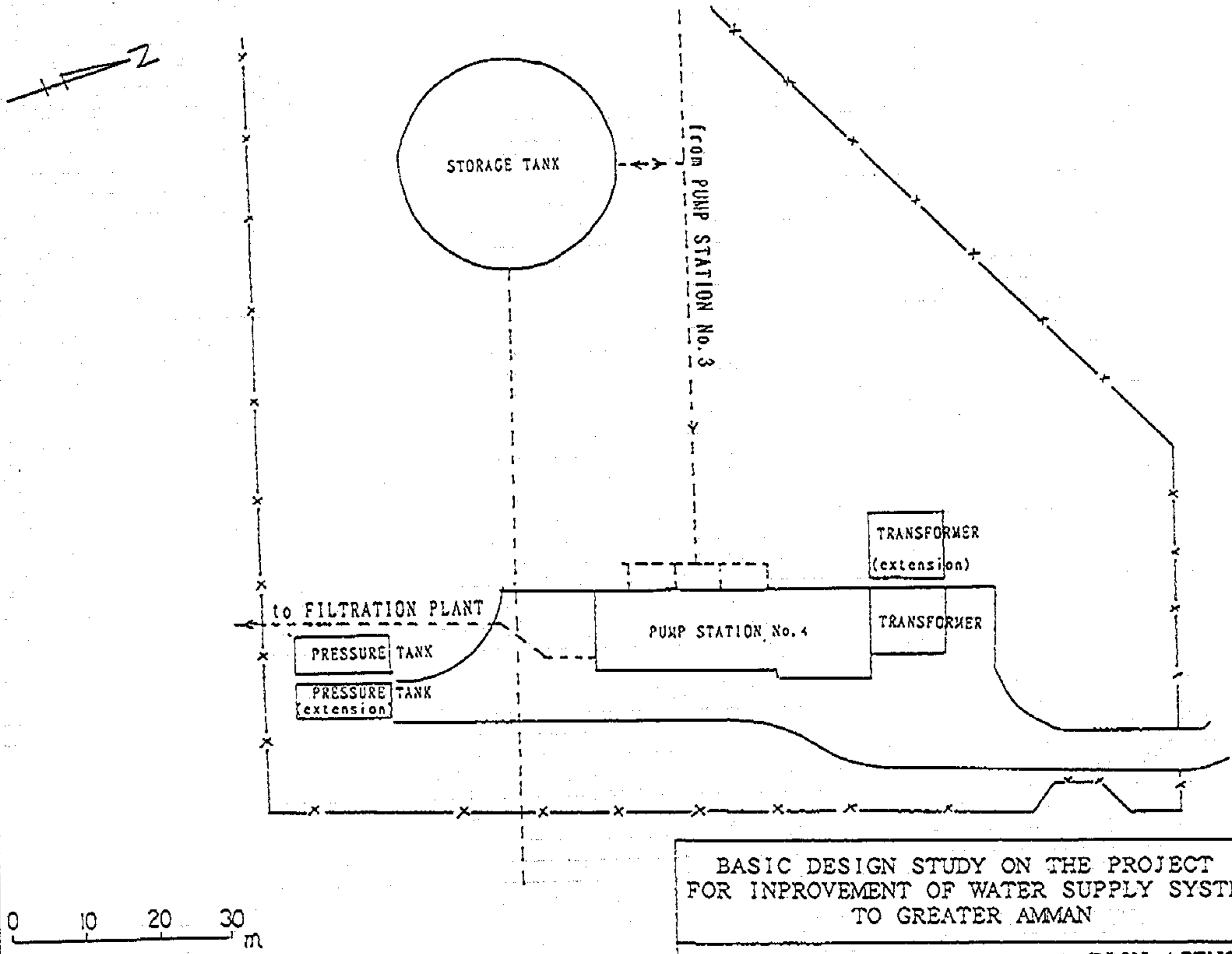

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Fig. 9
Plan view of
No. 4 pumping station

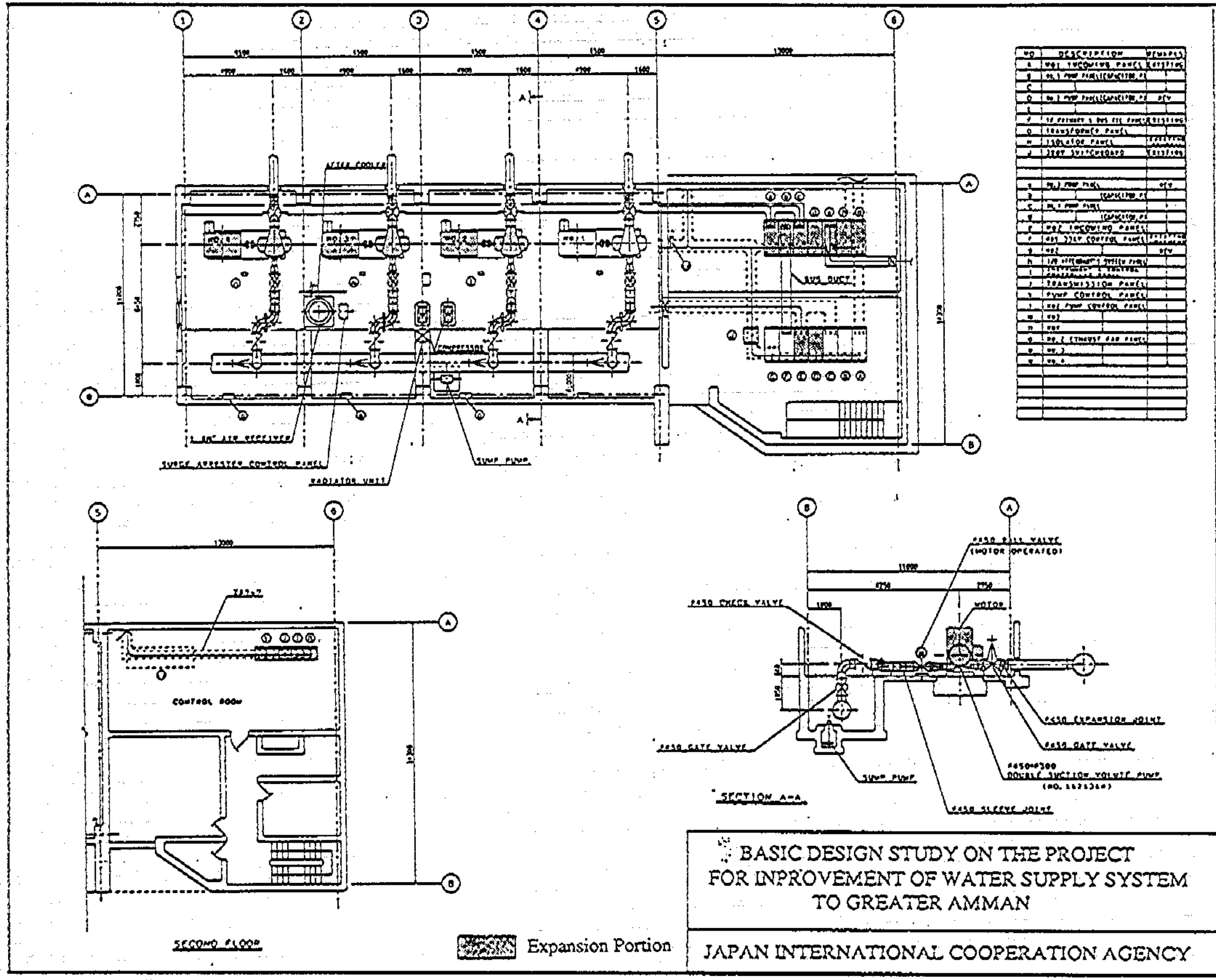

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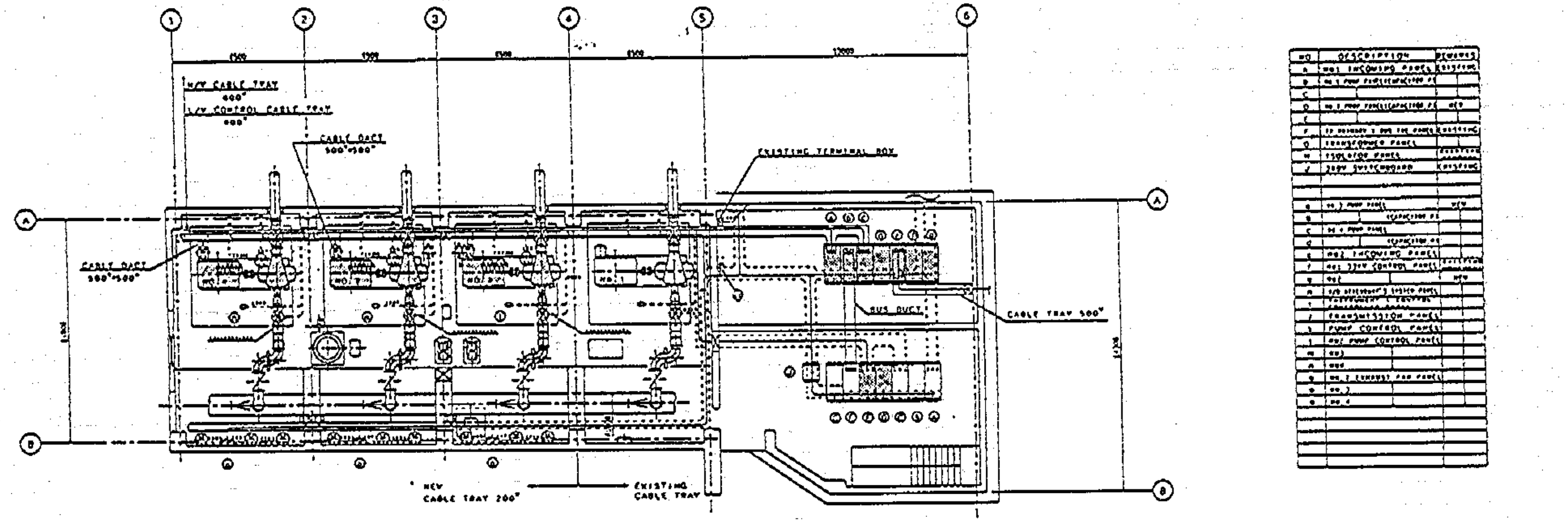
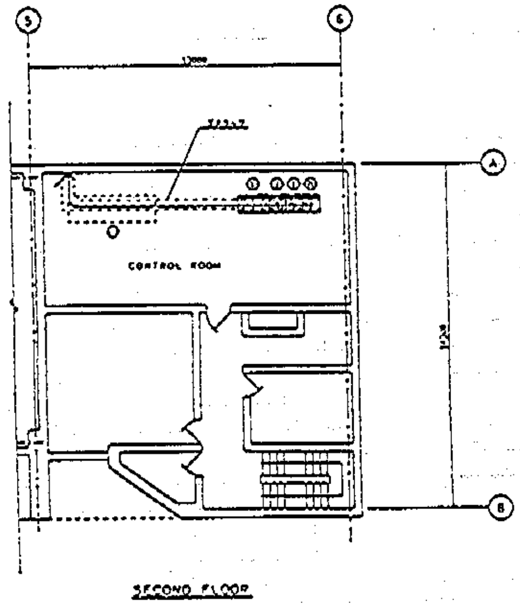
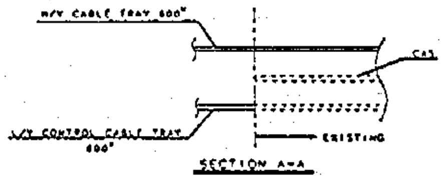
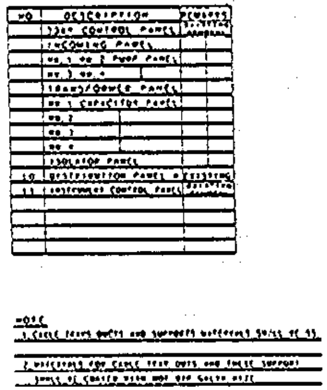
Fig. 10
Layout of equipment in pumping station
(No. 1 to No. 4)









Expansion Portion

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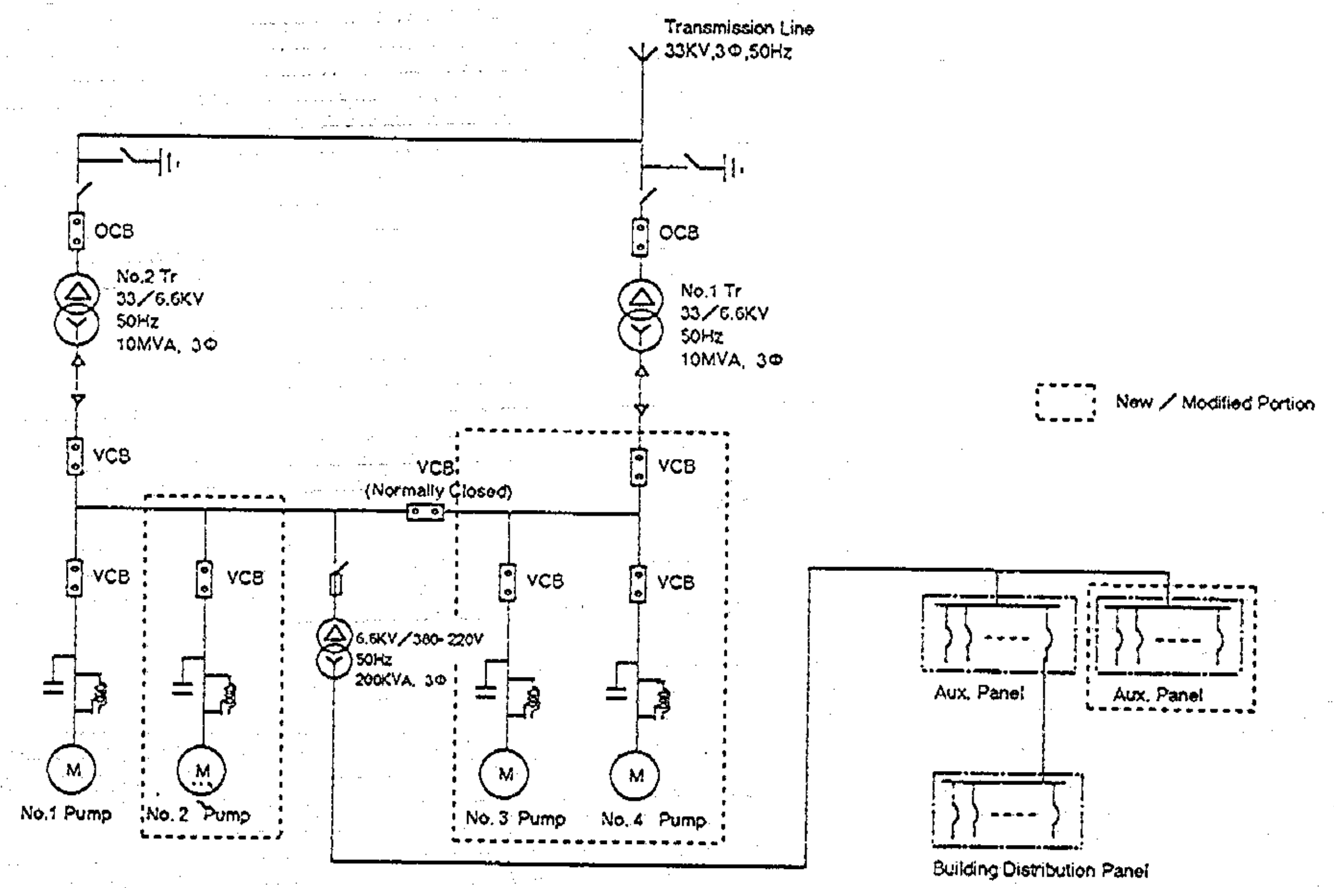
Fig. 11
Wiring diagram of pumping station



No.1 PS	3,200KW	3,200KW
No.2 PS	〃	〃
No.3 PS	3,300KW	3,300KW
No.4 PS	3,500KW	3,500KW

3,200KW	3,200KW
〃	〃
3,300KW	3,300KW
3,500KW	3,500KW

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Fig. 12
Single line diagram of pumping station