THE EMPIRE OF IRAN

RECOMMENDATIONS ON ELECTRIC POWER DEVELOPMENT PROJECTS IN IRAN

JUNE 1972

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

THE EMPIRE OF IRAN

RECOMMENDATIONS
ON
ELECTRIC POWER DEVELOPMENT PROJECTS
IN IRAN

JUNE 1972

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

Preface

The Empire of Iran has a total area of 636,000 square miles comprising 60% of barren desert, 30% of forest land, etc. Fortunately, however, this country is abundant in petroleum resources. In recent years, Iran has been making remarkable economic progress by developing her rich petroleum resources and because of the international cooperation furnished by major advanced countries in the world.

In the future a great deal of energy including electric power will be required for promoting economic activities in different spheres, especially those in the fields of the mining and manufacturing industries so that Iran may extricate herself from her conventional economic patterns which rely solely upon agriculture. It is a matter of common knowledge that Iran has an abundance of petroleum and natural gas resources which can be utilized for thermal power generation, while she is not necessarily rich in water resources; viz. sources of water for industrial and mining use, water to irrigate arrable land and so forth. Nevertheless, it is believed that a considerable amount of hydro power generation could be made available, provided that certain water resource development projects are steadily implemented in a proper manner as a comprehensive development program in line with a national policy.

The importance of electric power development is clearly reflected in the 4th development plan (1968 to 1973) which is presently in effect. According to the results of a long range forecast on power demand and supply recently made public by the Government of the Empire of Iran, it is deemed to be rather difficult to satisfy the growing demand for electric power in view of the trend recorded from the initial stage of the said plan up to now.

It is reported that emphasis has been placed upon the development of water resources included in the 5th development plan which is under consideration. Information available in Japan in connection with the present situation of the power industry and relevant power development projects in Iran was not sufficient. Thus, it was believed essential that appropriate investigations should eventually be made on this subject in due course.

Because of the circumstances stated above, the Government of Japan requested the Overseas Technical Cooperation Agency (OTCA) to conduct field surveys for the said studies. In compliance with this request, OTCA organized a survey team composed of four members, headed by Mr. Keizo Nakagawa, Manager of Development Cooperation Department of the Overseas Electrical Industry Survey Institute.

The team visited Iran for a period of approximately one month from February 14, 1972 to undertake investigations required for their final studies in Japan.

After their return to Tokyo, the team prepared this report, based upon the results of their studies made by means of the data, findings and valuable information obtained during their stay in Iran.

It is my sincere hope that this report will be of great help to the acceleration of economic and technical cooperation between the two nations in the future.

In closing, on behalf of OTCA, I would like to take this opportunity to express my deepest gratitude for the kind cooperation and assistance extended to the team by Mr. G. R. Hazrati, Deputy Minister for Power of the Ministry of Water and Power, Mr. A. A. Sadegh Vaziri and Mr. M. Pooya as well as other leading personnel of the Iranian authorities concerned during their stay in Iran.

June 1972

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

Contents

Preface

Chapter I Recommendations

I – 1 Economic Evaluation of the Hydro Power Development Project in Iran 2

I – 2 On Development of Nuclear Power Plants in Iran 3

I – 3 Nurturing of Engineering Personnel 3

Chapter II Economic Evaluation of Karun 562 Project

II – 1 Role which the Karun River and Its Lower Basin Is Expected to Play in Economic Advancement in Iran 6

II – 2 Principle of Economic Evaluation 6

II – 3 Concrete Economic Evaluation and Its Results 9

II – 3 – 1 Assumptions 9

II – 3 – 2 Operation Method of Reservoir 10

II – 3 – 3 Available Data on Discharge 10

II – 3 – 4 Installed Capacity of Karun 562 Power Plant 10

Remarks 11

II – 4 Conclusions 18

Chapter I

Recommendations

Chapter I
Recommendations

I–1 Economic Evaluation of the Hydro Power Development Project in Iran (Citing economic studies on the multi-purpose development project located 562 km upstream from the estuary of the Karun River as an example of economic evaluation on hydro power development projects in Iran)

In recent years, the Empire of Iran has been proud of her industrial progress due to economic development programs which have been bearing fruit at a steady tempo since the "White Revolution". Along with the increase in her population, various industries in Iran are expected to sustain their high rates of growth because of the vast quantity of resources with which Iran is blessed and the industriousness of her people.

Since Iran, however, is not rich in hydraulic resources, it is believed that the effective utilization of such limited amounts of water resources will be an important key to her industrial progress in the future

The Karun River is the biggest one blessed with a large quantity of water. In addition, downstream from this river there exists an expansive plain which occupies a large area of this country.

This water and vast plain will constitute one core of Iranian economic prosperity in the industrial and agricultural fields in the future.

The team is of the opinion that among other things, the river, including its basin, should be developed in a manner of multi-purpose development by taking full advantage of this river flow from a long-range standpoint of view.

Nevertheless, it is not only difficult but also not very convincing to discuss the significance of this project for the distant future. Hence, economic evaluation was made on the project which is located 562 km upstream from the estuary of the River Karun (Refer to as "Karun 562") (Refer to Chapter II for details)

The economic feasibility of the project could not be fully justified with the data and findings made available to us up to now. However, it is believed that Karun 562 Project will become an advantageous project from an economic point of view if the necessary studies on the construction costs of the project and a review of its components are made in an appropriate manner in the near future. In this sense, it is essential that pre-feasibility studies be made on the project as soon as practical in order to understand its general economic features before undertaking a feasibility study of the project.

I–2 On Development of Nuclear Power Plants in Iran

The economic practicality of nuclear power plants has not yet been established in contrast to conventional thermal power plants from the worldwide viewpoint.

However, it is duly expected that the time when nuclear power plants will be more economical than conventional thermal power plants by the advancement of technology will come in the near future.

On the other hand, it is also expected that most of the fuel resources in Iran will be exhausted in 40 to 50 years. It is considered necessary that research in this field be started so that Iran may construct nuclear power plants by herself when such a time comes.

It is supposed that since highly developed techniques in many fields will be required for the construction of nuclear power plants, the said research will contribute to greatly enhance the technical standards associated with the construction of nuclear power projects directly or indirectly in this country. For this purpose, it is also required that the type of reactor, the time and site of construction should be examined, taking into deliberate consideration a concrete target of technical development in Iran, the degree of reliance on importation of nuclear fuel in the future as well as geographical conditions.

Regarding the construction of nuclear power plants which is executed for the purpose of development of techniques, the applied capacity of a unit should be rather small – less than 10% of its power system in general – by aiming not to afflict power systems because nuclear power projects are developed from a standpoint of national policy and their economy is apt to be regarded as a matter of secondary importance.

I–3 Nurturing of Engineering Personnel

The team is informed that there is a serious shortage of engineers in Iran, and this trend is likely to further accelerate in the future. In other words, the economic advancement which is taking place at a very quick tempo in this country makes it difficult for the supply of engineers and specialists to catch up with growing demand for such people in various spheres.

For the development of new projects to be of value to the economic advancement of Iran, it will be also a task of great importance and significance to nurture engineers and specialists who will participate in the formulation of development programs and their implementation in order to lay a firm basis for the perpetual prosperity of this land.

In reality, extensive training is being provided to different classes of personnel from technicians to managerial administrators working for the power industry under the auspices of the Ministry of Water and Power. In particular, it is worthy of attention that the foundation of Tehran Training Center and establishment of various training courses have steadily been obtaining excellent results. Among the overseas technical cooperation services furnished by the Government of Japan are included a system of receiving a number of foreign engineers for training in different fields and that of dispatching fully qualified and experienced personnel abroad as advisors to overseas governments on a Government–to–Government basis. As far as training in power engineering is concerned, it is mainly provided to groups divided into "Hydro-Power Generation Course" and "Thermal Power Generation Course", respectively. Another training course of transmission and distribution engineering is expected to be added to these two courses in 1973. Possible establishment of a management course for participants who had studied in Japan is also under consideration at present.

Besides such group training undertaken in Japan, there is an "individual training system" under which individual (person to person) training is extended with respect to different specialities of participants and/or projects. It is believed that the effective use of these training systems in Japan will apparently be of help to technical advancement in Iran.

Chapter II

Economic Evaluation of Karun 562 Project

Chapter II
Economic Evaluation of Karun 562 Project

The team has conducted a tentative economic evaluation on Karun 562 Project based upon the data and findings collected during recent investigations in order to decide whether feasibility studies on the project will be necessary or not in the near future.

II–1 Role which the Karun River and Its Lower Basin Is Expected to Play in Economic Advancement in Iran

It is no exaggeration to say that the Karun River is regarded as a "sole river with a large quantity of water" rather than the biggest river blessed with a sufficient volume of river flow in Iran. The plain spread out in the Lower Karun Basin is also the largest one in this nation.

It can be said that the "water" and "plain" stated above will become a core of future economic advancement in Iran. Judging from a long range stand-point, there is no doubt that a multi-purpose development should be performed for the effective utilization of water resources of the Karun River. This means that benefits accruing from the development of the Karun River will be further increased.

The main objectives of developing the Karun River should consist in the effective utilization of water resources as agricultural water, industrial water and potable water In this case, the electric power to be developed will be a "by-product" in view of the specific nature of this project.

The role which the multi-purpose development of the Karun River is to play in the economic prosperity in Iran is stated above. Since, to our regret, the estimate of future benefits of the project seems to be difficult and hardly convincing, the team has conducted the economic evaluation of Karun 562 Project on the basis that this project which constitutes a part of the multi-purpose development scheme of the Karun River is to be implemented in the near future.

II–2 Principle of Economic Evaluation

Economic evaluation has been made by means of comparing "costs" and "benefits" accruing from development. As for costs, they are assumed to be the total figures of annual costs of capital funds required for the construction of generating and irrigation facilities and expenses for their operation and maintenance.

It is considered almost unnecessary to build another transmission line linking to Karun 562 Power Plant because a trunk transmission line is to be constructed between Ahwaz and Esfahan. Therefore, the annual costs of the transmission line were not included in those of the project.

"Benefit" is the total figures of annual benefits attributable to the following items.

(1) Benefit by power generation at Karun 562 Power Plant

(2) Incremental benefit obtained by increased power generation at Karun 490 Power Plant downstream of Karun 562 Dam and at run-off type power plants further downstream of Karun 490 Power Plant The said benefit is attributable to the completion of Karun 562 Dam.

(3) Increased earnings caused by the increase of agricultural products in the irrigable areas due to the completion of Karun 562 Dam

(4) Effect of flood control by Karun 562 Dam

The benefit of power production given in (1) and (2) is composed of "benefit per KWh" and "benefit per KW" of the alternative thermal power plant.

The value of KW benefit of this project is equivalent to the total value of capital costs and operation and maintenance costs of its alternative thermal power plant whose construction would become unnecessary if the project were implemented, while KWh benefit is the value of fuel costs necessary for the said thermal power plant.

It was impossible for the team to collect enough data to evaluate the effects of flood control quantitatively. Consequently, the team was forced to omit the calculation of the benefit of flood control. In this respect, our team's view of measuring the effect of flood control upon the project is as given in Note 2). It could be said that the economic evaluation of Karun 562 Project has been made in a fairly conservative manner.

Note 1) Calculation of Capacity of An Alternative Thermal Power Plant Which would Be Made

Unnecessary by Power Generation of A Hydro Power Plant

The maximum output which a hydro power plant with a reservoir can generate at stability is the maximum output at the lowest water level depending upon the operation of a reservoir. Usually, such water level will take place at the end of the driest season in the driest year.

However, it must be remembered that the output of a hydro power plant at the water level stated above is not necessarily equal to that of its alternative thermal power plant.

Due consideration should be given to whether daily energy production which is decided by a rule of reservoir operation will fully meet power demand during peaking hours. A necessary quantity of discharge for the peak load will rely on the configuration of the said load.

The configuration mentioned above depends upon a combination of various categories of power demand. At the stage of relatively advanced industrialization, the daily load factor of a hydro power plant in order to achieve an alternative effect of a thermal power plant (namely, daily load factor obtained from daily discharge for generation in the driest season) is generally at least 20%.

Therefore, the capacity of the alternative thermal power plant is taken to be the smaller figure of the maximum capacity depending upon the daily average power of xKW together with daily load factor of 20% and the maximum output at the lowest water level of a reservoir.

Benefit accruing from completion of dam on the upper reaches is equivalent to the value of difference between the benefits of an alternative thermal power plant corresponding to a hydro power plant on the lower reaches before completion of the project and those of an alternative thermal power plant on the lower reaches after completion of the project.

The value of the benefit obtained in the said manner is variable depending upon not only the operation of reservoir on the upper reaches but also on the lower reaches.

Note 2) Way of Thinking regarding Benefit of Flood Control

The benefit of flood control is equal to the flood damages which would take place, were it not for flood control. However, the degree of flood damages is different according to the degree of advancement in localities downstream of the project. For example, in a narrow country such as Japan where dense populations and various industries are concentrated in one locale, if a flood occurs, not only are industries damaged but sometimes even a number of human lives are lost.

It is generally considered appropriate that the following evaluation method of benefit accruing from flood control should be adopted relative to such a locality.

When a given quantity of flood control is determined, the annual expenses, that is, the alternative justifiable cost of constructing a dam to cope with the said quantity can be deemed "the benefit of flood control".

It is obvious that large-scale agricultural and industrial land will appear along with future development. Hence, it is believed appropriate to evaluate the benefits of flood control of Karun 562 Dam by means of "alternative justifiable costs".

As a rule, flood protection is realized when a reasonable combination of control by dam, construction of levees and improvement of rivers is implemented. As for the general development process, at first some levees are constructed corresponding to the progress of the development of the lower basin.

In most cases, when the downstream parts of an area are developed to some degree, studies can be made on a reasonable combination of flood control by dam, levee construction and improvement of rivers.

As stated above, it is necessary to study a variety of factors in order to obtain the benefit of flood control in a reasonable manner. It is also essential that studies be conducted on river sections, topographical conditions on a bank as well as losses and damages which might be brought about by floods, only for the purpose of establishing a reasonable assumption thereby conducting the tentative economic evaluation of the benefits accruing from flood control.

II–3 Concrete Economic Evaluation and Its Results

II–3–1 Assumptions

The general features, construction costs and related basic calculations of generation facilities and the irrigation project on the lower reaches are principally based on the data and findings obtained during the recent investigation.

II–3–2 Operation Method of Reservoir

The following cases were studied in connection with the operation methods of Karun 490 Reservoir.

Case–A

Space between EL530 m and EL540 m should be reserved exclusively for flood control and the quantity of water between EL530 m and EL528 m is to be used for generation. The lowest water level for operation of reservoir is set at EL528 m. The team was informed during their stay in Iran that this was the method used in operating the reservoir.

Case–B

Space between EL530 m and EL540 m is reserved exclusively for flood control. As far as water stored below EL530 m is concerned, this case assumes that the reservoir is to be operated according to a basic operation rule of reservoirs which enable the flow condition to be average out as much as possible in order to elevate the utilization efficiency of discharge into the Lower Karun Basin.

The operation of Karun 562 Reservoir assumes that the annual flow will be averaged out throughout the year in harmonious combination with Karun 490 Reservoir located on the lower reaches.

In conducting the tentative evaluation, the two cases shown above were adopted with respect to independent operation of Karun 490 Reservoir. However, the operation of Karun 490 Reservoir will be subject to the rule shown in Case A in order to increase the benefits of generation in the case of combinative operation of Karun 490 Reservoir and Karun 562 Reservoir.

II–3–3 Available Data on Discharge

In making calculations the team utilized data on discharge obtained at the Gotvand Gaging Station. Since discharge was extremely large for three years from 1954 to 1956, the team employed the values of discharge covering the period between 1957 and 1966 for the sake of safety in calculations.

II–3–4 Installed Capacity of Karun 562 Power Plant

The capacity of Karun 562 Power Plant was proposed to be 420 MW according to the data the team has collected. Daily load factor of the power plant indicated approximately 65% even in the driest season if the above capacity is adopted. Therefore, it is considered essential that the efficiency of this power plant be increased as a power plant to be operated during peak load, by means of increasing its installed capacity. For this purpose, studies were made on the two cases given hereunder in connection with the installed capacity of Karun 562 Power Plant.

Case I–(1), II–(1) assumes that the capacity of Karun 562 Power Plant is to be 420MW.

Case I–(2), II–(2) assumes that the capacity of Karun 562 Power Plant is to be increased to 1,020 MW.

(Remarks) On Calculation of Benefit/Cost

In conducting calculations of benefit/cost, it has been assumed that benefits could be completely accrued from both the sectors of irrigation and generation at the same time upon completion of the two components of the project.

Benefit per KW and benefit per KWh were obtained, respectively on the assumption that the capacity of an alternative standard thermal power plant is 300 MW. KW benefit is $13.8 per KW, composed of a construction unit cost of $135/KW and $13.8/KW including interest at a rate of 6% per year, amortization covering durable period of 30 years as well as operation and maintenance costs. KWh benefit is calculated to be $\$8.27 \times 10^{-3}$/KWh on the basis that the average domestic purchase unit cost of fuel from the National Iranian Gas Co. (exclusive of Tehran and Ahwaz) is 21.4 cents/$10^6 \times$ BTU.

Benefits accruing from irrigation were divided according to the nature of soil, and thus increased net crop income was estimated to be $157.4/ha, $135/ha, and $125/ha, respectively. The annual costs of a dam and power plant include depreciation at a rate of 6% per year and operation and maintenance costs accounting for 1% of the total construction costs. The annual costs of irrigation are estimated at $67.5/ha and $63.4/ha in the respective areas.

The construction costs of Karun 490 and Karun 562 Power Plants in this report were just the same as those in the data our team has obtained in Iran. As for the construction costs to increas the capacity of Karun 562 Power Plant these were calculated by assuming that the construction costs for increased capacity are $100/KW.

Increased B/C ratio is less than 1 in Case (II)–1 and (II)–2. Notes given on Pages 18 & 19 indicate the construction costs of Karun 562 Power Plant so that the increased ratio of Benefit/Cost can be equal to 1.

	Item	Unit	Project Karum 490		Karum 562	
Case I	H. W. L.	m	530		685	
	L. W. L.	m	528	(528)	645	
	Gross Storage	$10^6 m^3$	2,900		5,300	
	Effective Storage	$10^6 m^3$	100	(100)	2,500	
	Drawdown	m	2	(2)	40	
	Max. Effective Head	m	160		155	
	Rated Head	m	–		145	
	Min. Effective Head	m	158	(158)	111	
	Evaporation Loss	m^3/s	5	(5)	5	
	Max. Discharge	m^3/s	728		345	
	Firm Discharge	m^3/s	194	(107)	186	
	Dependable Peak Discharge	m^3/s	728	(517)	295	((738))
	Max. Output	MW	1,000	(1,000)	420	((1,030))
	Firm Output	MW	262	(145)	177	
	Dependable Peak Output	MW	1,000	(700)	280	((700))
	Annual Energy	GWh	2,930	(2,907)	2,275	
	Flow at Gotvand (Dry season)	m^3/s	211	(117)	–	
	Diversion for Irrigation (Dry season)	m^3/s	138	(22)	–	
Case II	H. W. L.	m	530		685	
	L. W. L.	m	528	(505)	645	
	Gross Storage	$10^6 m^3$	2,900		5,300	
	Effective Storage	$10^6 m^3$	100	(1,100)	2,500	
	Drawdown	m	2	(25)	40	
	Max. Effective Head	m	160		155	
	Rated Head	m	–		145	
	Min. Effective Head	m	158	(135)	111	
	Evaporation Loss	m^3/s	5	(4)	5	
	Max. Discharge	m^3/s	728		345	
	Firm Discharge	m^3/s	194	(168)	186	
	Dependable Peak Discharge	m^3/s	728	(670)	295	((738))
	Max. Output	MW	1,000	((1,000))	420	((1,030))
	Firm Output	MW	262	(196)	177	
	Dependable Peak Output	MW	1,000	(780)	280	((700))
	Annual Energy	GWh	2,930	(2,756)	2,275	
	Flow at Gotvand (Dry season)	m^3/s	211	(185)	–	
	Diversion for Irrigation (Dry season)	m^3/s	138	(106)	–	

Note: ( ) : Independent at Karun 490
(( )) : Case I – (2), Case II – (2) at Karun 562

Supplement

Mark	Source	Page
1/	F. R. Vol.-III	VII-27
2/	F. R. Vol.-III	VI-2
3/	F. R. Vol.-III	VI-11
4/	R. R. Vol.-III P. R.	I-11, 12 II-17
5/	P. R.	II-33
6/	P. R. F. R. Vol.-III	II-25 VI-2, VII-11) estimated from those
7/	F. R. Vol.-I	II-11, 12
8/	S. R. I. Vol.-4	242, 243

F. R. : The Initial Karun River Project, Feasibility Report (Harza Eng. Co. Jan. '68)

P. R. : Karun River Development Preliminary Report (Government of Iran, May '67)

S.R.I.: The Electric Power Industry in Iran (Volume 4 in the Long Range Energy Study for Iran, Stanford Research Institute)

Case 1-(1)

Items	Benefits: Quantities	Unit Cost ($)	Annual Benefits (10^3\$)	Costs: Construction Costs (10^3\$)	Annual Costs (10^3\$)	Benefits Cost Ratio
(1) Without Karun 562						
Karun 490 Power						
Output	700 MW	13.8	9.660			
Energy	2,907 GWh	2.27/1,000	6,599			
Subtotal			16,259	175,000	12,852	
Irrigation	38,000 ha	(157.4)	5,981 1/	29,248 2/	2,410 3/	
Total			22,240	204,248	15,262	1 46
B/C						
(2) With Karun 562						
Karun 490 Power			20,451	175,000	12,852	
Output	1,000 MW	13.8	13,800			
Energy	2,930 GWh	2.27/1,000	6,651			
Karun 562 Power			9,028	250,000	18,360	
Output	280 MW	13,8	3,864			
Energy	2,275 GWh	2.27/1,000	5,164			
Subtotal			29,479	425,000	31,212	
Irrigation						
Gotvand	38,000 ha	(157.4)	5,981 1/	29,248 2/	2,410 3/	
Shushtar Island	16,000 ha 4/	(155)	2,475 5/	27,880 6/	2,295 6/	
" "	18,000 ha 4/	135 5/	2,430			
Shoeybieh	24,000 ha 4/	135 5/	3,240	19,680 6/	1,620 6/	
N. Ahwaz	9,000 ha 4/	128 5/	1,152	7,380 6/	608 6/	
Subtotal	105,000 ha		15,278	84,188	6,933	
Karun 413 Power						
- Karun 478 Power						
Output	61 MW	13.8	842			
Energy	534 GWh	2.27/1,000	1,212			
Subtotal			2,054			
Total			46,811	509,188	38,145	
B/C						1.23
Increased B (c)			24,571		22,883	
B/C						1.07

Case 1-(2)

Items	Benefits			Costs		Benefits
	Quantities	Unit Cost ($)	Annual Benefits (10^3 $)	Construction Costs (10^3 $)	Annual Costs (10^3 $)	Cost Ratio
(1) Without Karun 562						
Karun 490 Power						
Output	700 MW	13.8	16,259	175,000	12,852	
Energy	2,907 GWh	2.27/1,000				
Irrigation	38,000 ha	(157.4)	5,981	29,248	2,410	
Total			22,240	204,248	15,262	
B/C						1.46
(2) With Karun 562						
Karun 490 Power			20,451	175,000	12,852	
Output	1,000 MW	13.8	13,800			
Energy	2,930 GWh	2.27/1,000	6,651			
Karun 562 Power			14,824	310,000	22,766	
Output	700 MW	13.8	9,660			
Energy	2,275 GWh	2.27/1,000	5,164			
Subtotal			35,275	485,000	35,618	
Irrigation	105,000 ha		15,278	84,188	6,933	
Karun 413 Power - Karun 478 Power						
Output	61 MW	13.8	2,054			
Energy	534 GWh	2.27/1,000				
Total			52,607	569,188	42,551	
B/C						1.24
Increased B (c)			30,367		27,289	
B/C						1.11

Case II-(1)

Items	Benefits			Costs		Benefits
	Quantities	Unit Cost ($)	Annual Benefits ($10^3$$)	Construction Costs ($10^3$$)	Annual Costs ($10^3$$)	Cost Ratio
(1) Without Karun 562						
Karun 490 Power						
Output	780 MW	13 8	10,764			
Energy	2,756 GWh	2.27/1,000	6,256			
Subtotal			17,020	175,000	12,852	
Irrigation						
Gotvand	38,000 ha.	(157.4)	5,981	29,248	2,410	
Shushtar Island	16,000 ha.	(155)	2,475	27,880	2,295	
" "	18,000 ha.	135	2,430			
Shoeybieh	19,000 ha.	135	2,565	15,580	1,283	
Subtotal	91,000 ha.		13,451	72,708	5,988	
Total			30,471	247,708	18,840	
B/C						1.62
(2) With Karun 562						
Karun 490 Power			20,451	175,000	12,852	
Output	1,000 MW	13.8	13,800			
	2,930 GWh	2.27/1,000	6,651			
Karun 562 Power			9,028	250,000	18,360	
Output	280 MW	13.8	3,864			
Energy	2,275 GWh	2.27/1,000	5,164			
Subtotal			29,479	425,000	31,212	
Irrigation	105,000 ha.		15,278	84,188	6,933	
Karun 413 Power - Karun 438 Power						
Output	61 MW	13.8	2,054			
Energy	53 GWh	2.27/1,000				
Total			46,811	509,188	38,145	
B/C						1.23
Increased B (c)			16,340		19,305	
B/C						0.85

Note: The construction costs of the power plant including dam at Karun 562 are estimated at approximately $209,586 × 10^3 on the ground that B/C ratio is to be 1.0.

Case II-(2)

Items		Benefits		Costs		Benefits
	Quantities	Unit Cost ($)	Annual Estimate ($10^3$$)	Construction Costs ($10^3$$)	Annual Costs ($10^3$$)	Cost Ratio
(1) Without Karun 562						
Karun 490 Power						
Output Energy	780 MW 2,756 GWh	13.8 2.27/1,000	17,020	175,000	12,852	
Irrigation	91,000 ha.		13,451	72,708	5,988	
Total			30,471	247,708	18,840	
B/C						1.62
(2) With Karun 562						
Karun 490 Power			20,451	175,000	12,852	
Output Energy	1,000 MW 2,930 GWh	13.8 2.27/1,000	13,800 6,651			
Karun 562 Power			14,824	310,000	22,766	
Output Energy	700 MW 2,275 GWh	13.8 2.27/1,000	9,660 5,164			
Subtotal			35,275	485,000	35,618	
Irrigation	105,000 ha.		15,278	84,188	6,933	
Karun 413 Power - Karun 478 Power						
Output Energy	61 MW 534 GWh	13.8 2.27/1,000	2,054			
Total			52,607	569,188	42,551	
B/C						1.24
Increased B (c)			22,136		23,711	
B/C						0.93

Note: The construction costs of the power plant including dam at Karun 562 are estimated at approximately $287,192 X 10^3 on the ground that B/C ratio is to be 1.0.

II–4 Conclusions

According to the results of the team's tentative calculations, the combined B/C ratio of Karun 490 Project and Karun 562 Project exceed 1, which shows that this project is economically feasible. However, the B/C ratio of Karun 562 Project is not necessarily over 1. Efforts are usually made to the enhancement of investment effect as soon as possible in connection with the development of projects which will be commenced in advance. Therefore, in the case of irrigation projects, advantageous areas are apt to be developed first, and it is unavoidable that the B/C ratio of a project to be implemented later will become small. The problem is rather allocation of benefits between the "advance project" and the "project which follows". If the benefit cost ratio is more than 1, it may be conceivable that the advantageousness of a project could be recognized. However, in this case, the necessity of developing the project should be decided from a political standpoint. In this sense, the team studied the increased B/C ratio of Karun 562 Project only from an economic point of view. As far as the increased B/C ratio is concerned, it was computed in a conservative manner because the calculations were based on the data concerning discharge during the 10 years period which contained a relatively severe draught.

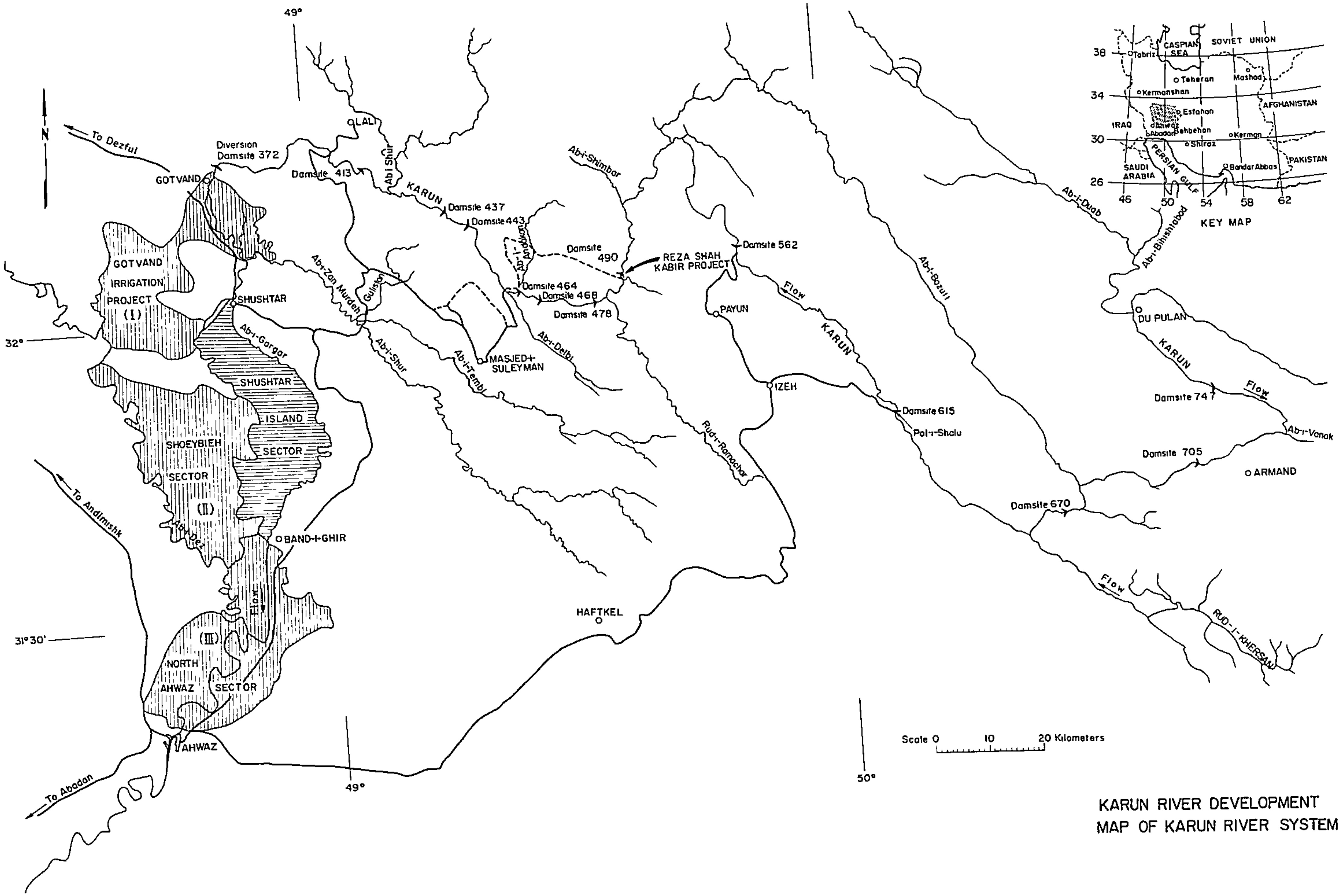
At any rate, B/C ratio in Case II is less than 1. Due to the shortage of required data for the studies, there are still doubtful points to be resolved.

(i) It is essential that investigations be made on the construction costs (250 million dollars) of Karun 562 Power Plant.

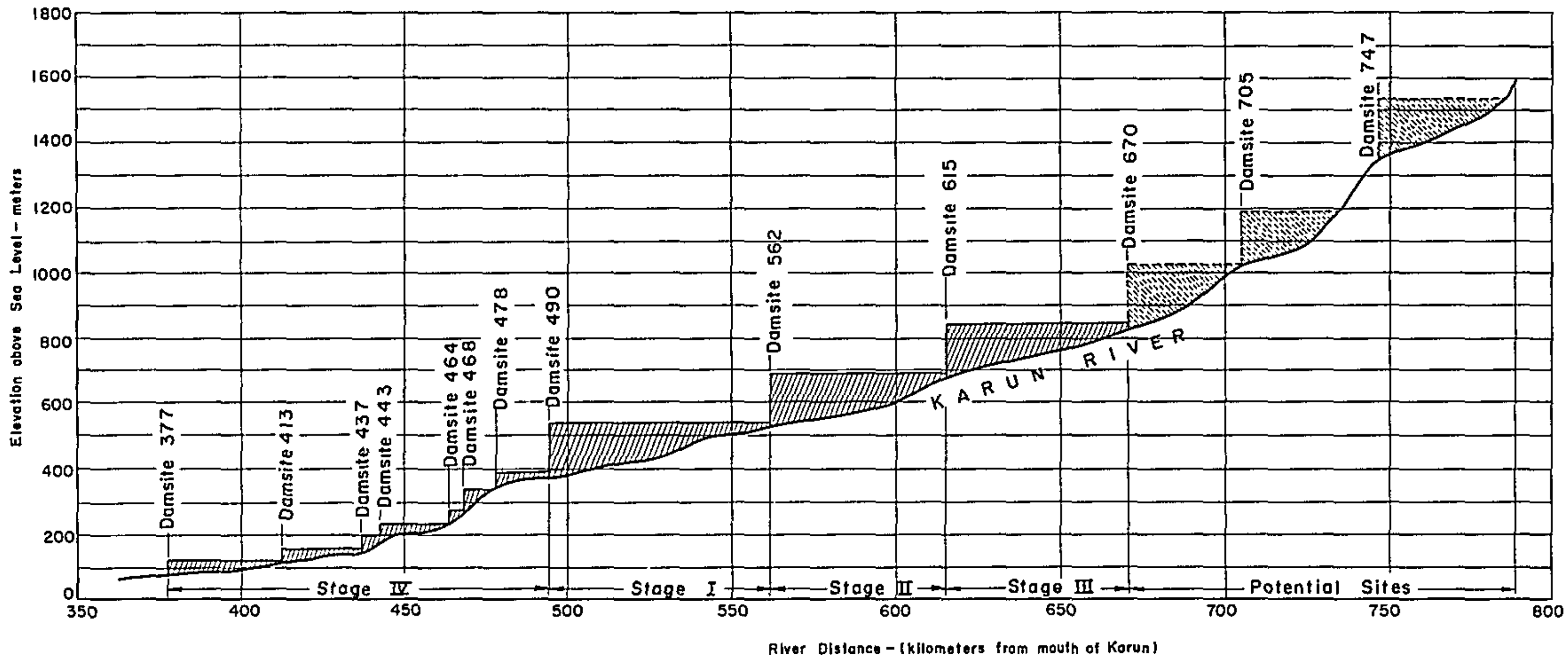
(ii) It is also believed necessary to reexamine the benefit of irrigation.

(iii) Comparisons between Case I–(1) and I–(2) or between Case II–(1) and Case II–(2) clearly indicate that the increased capacity of Karun 562 Power Plant will enhance the economy of the project. In this context, it is recommended that Karun 562 Project be reexamined. Although a number of problems may be raised during the course of this future reexamination of the project, Karun 562 Project will most likely to provide economic feasibility with respect to its increased B/C ratio.

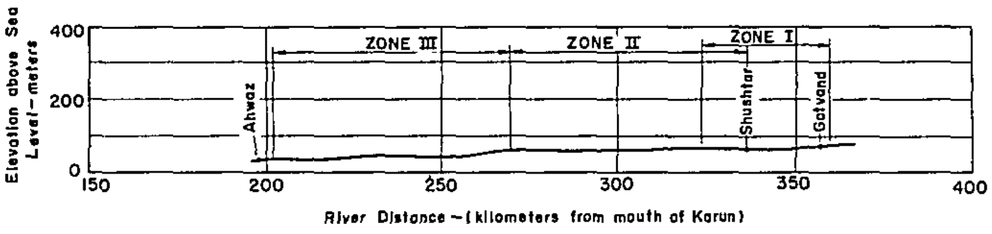
Therefore, it is essential to conduct supplementary investigations, particularly, in connection with (i) as soon as possible before undertaking feasibility studies on Karun 562 Project. Thus, it is believed appropriate that after recognizing any prospect for possible development of the project, the necessary feasibility studies should be performed.



KARUN RIVER DEVELOPMENT
MAP OF KARUN RIVER SYSTEM

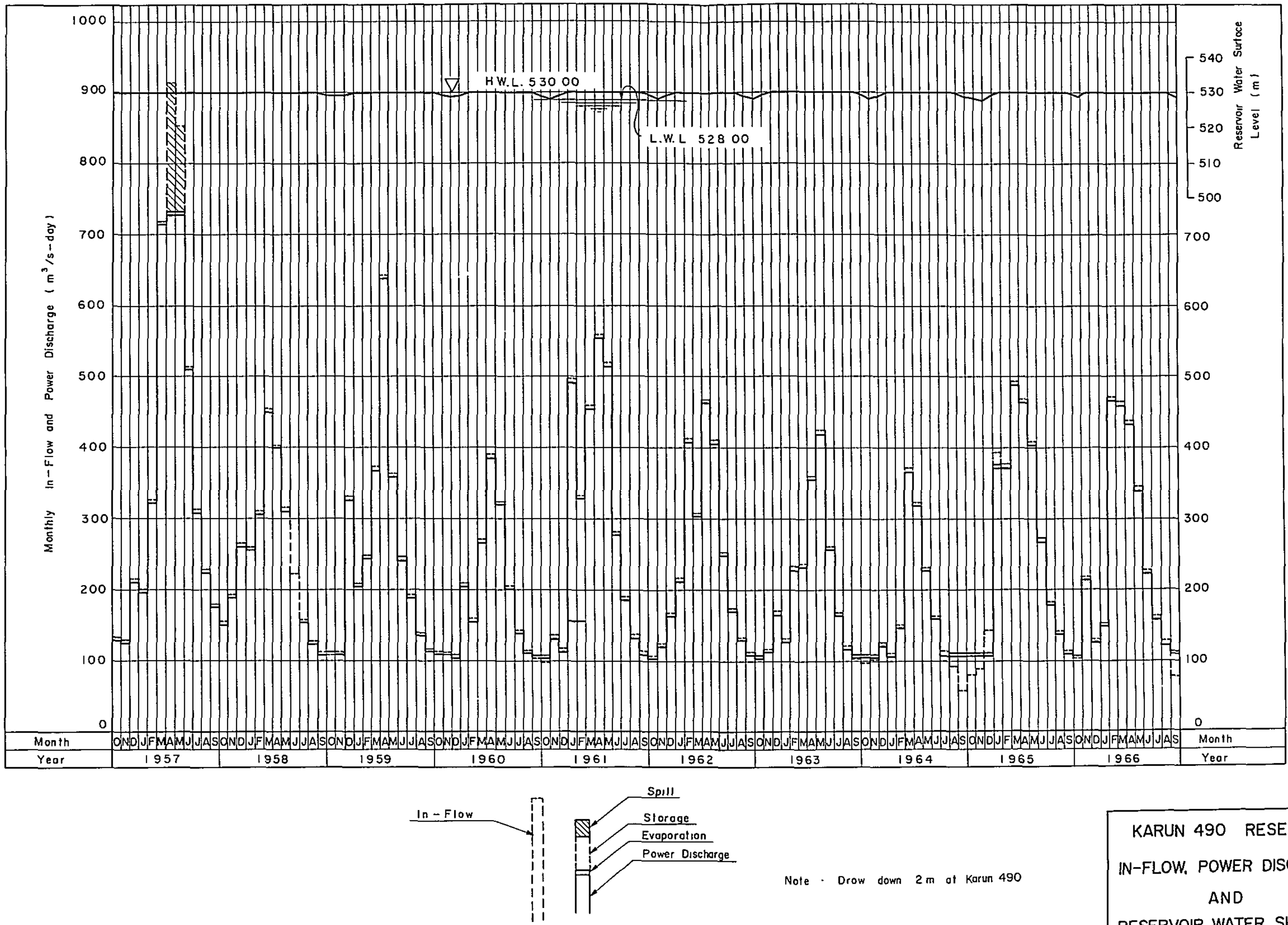


STORAGE AND POWER PROJECTS

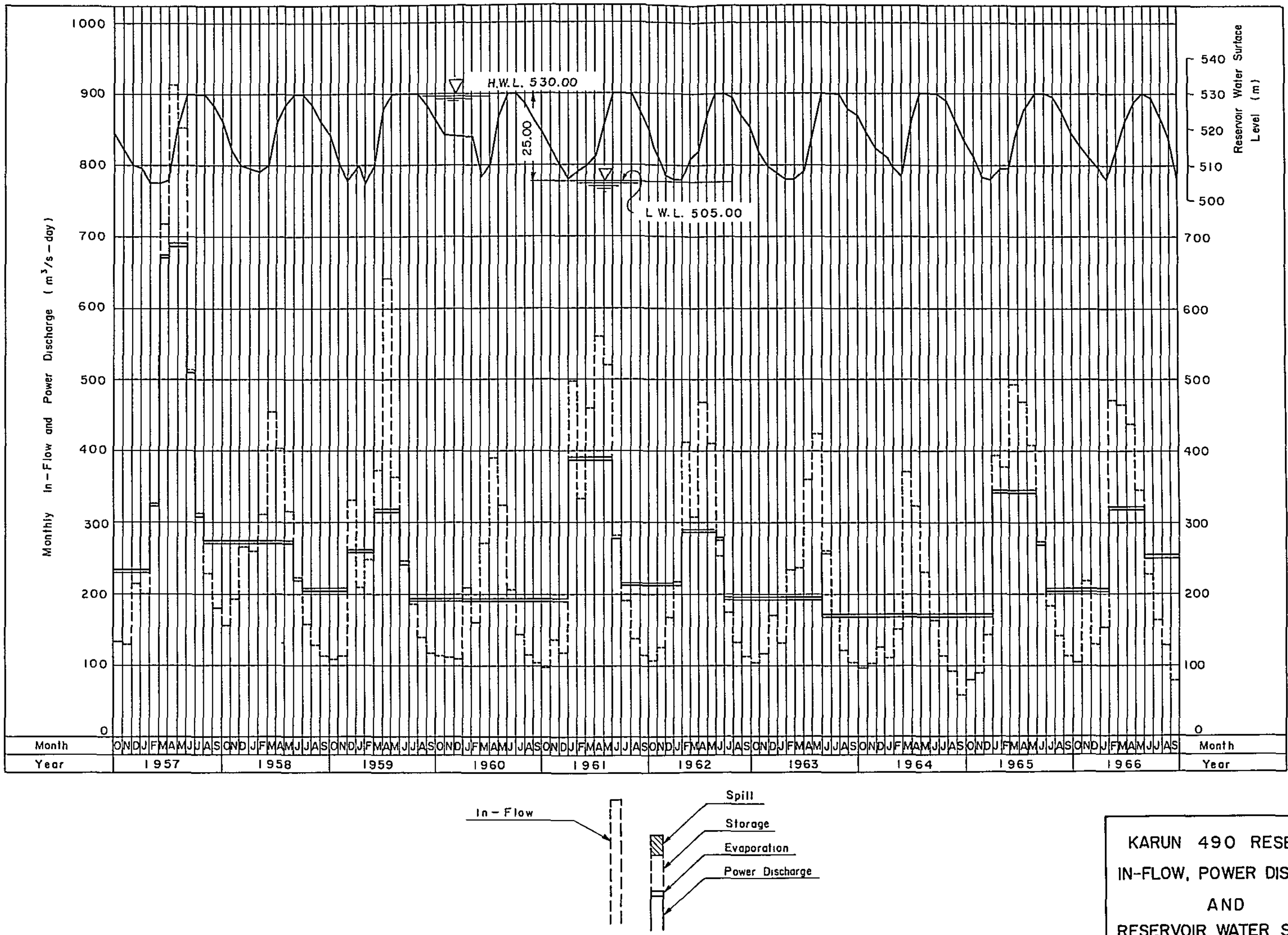


IRRIGATION PROJECTS

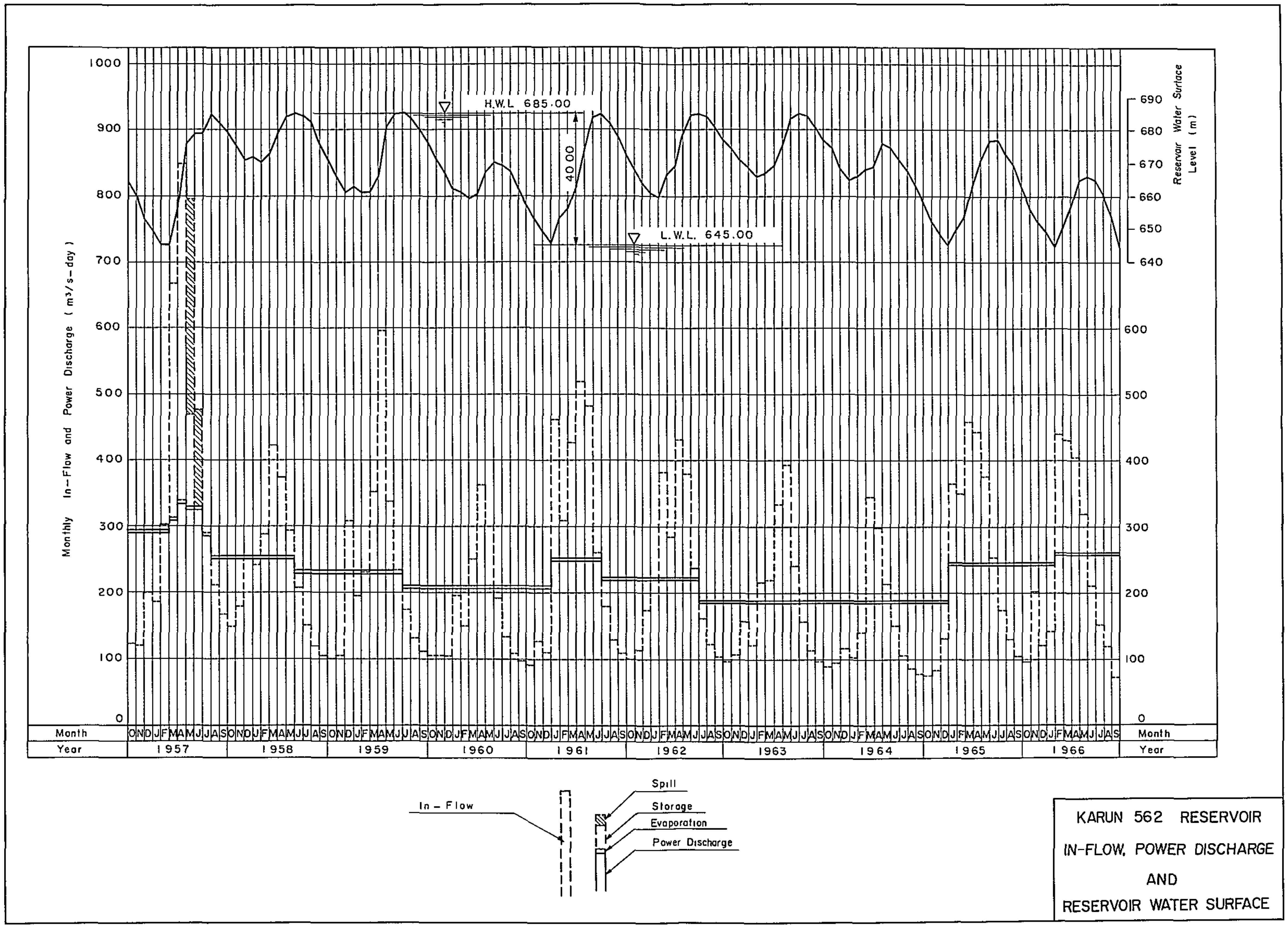
KARUN RIVER DEVELOPMENT PROFILE



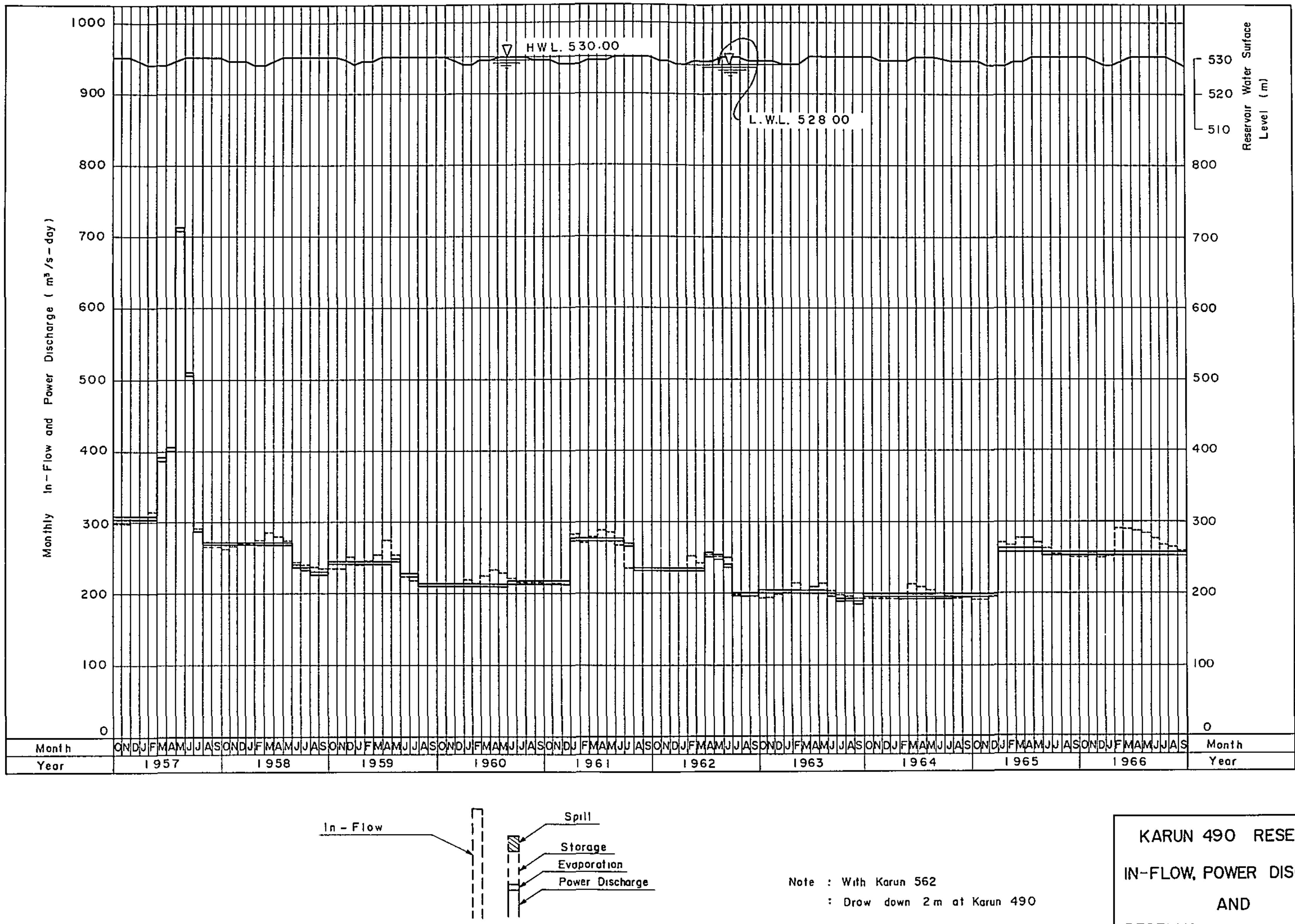
KARUN 490 RESERVOIR
IN-FLOW, POWER DISCHARGE
AND
RESERVOIR WATER SURFACE



KARUN 490 RESERVOIR
IN-FLOW, POWER DISCHARGE
AND
RESERVOIR WATER SURFACE



KARUN 562 RESERVOIR
IN-FLOW, POWER DISCHARGE
AND
RESERVOIR WATER SURFACE

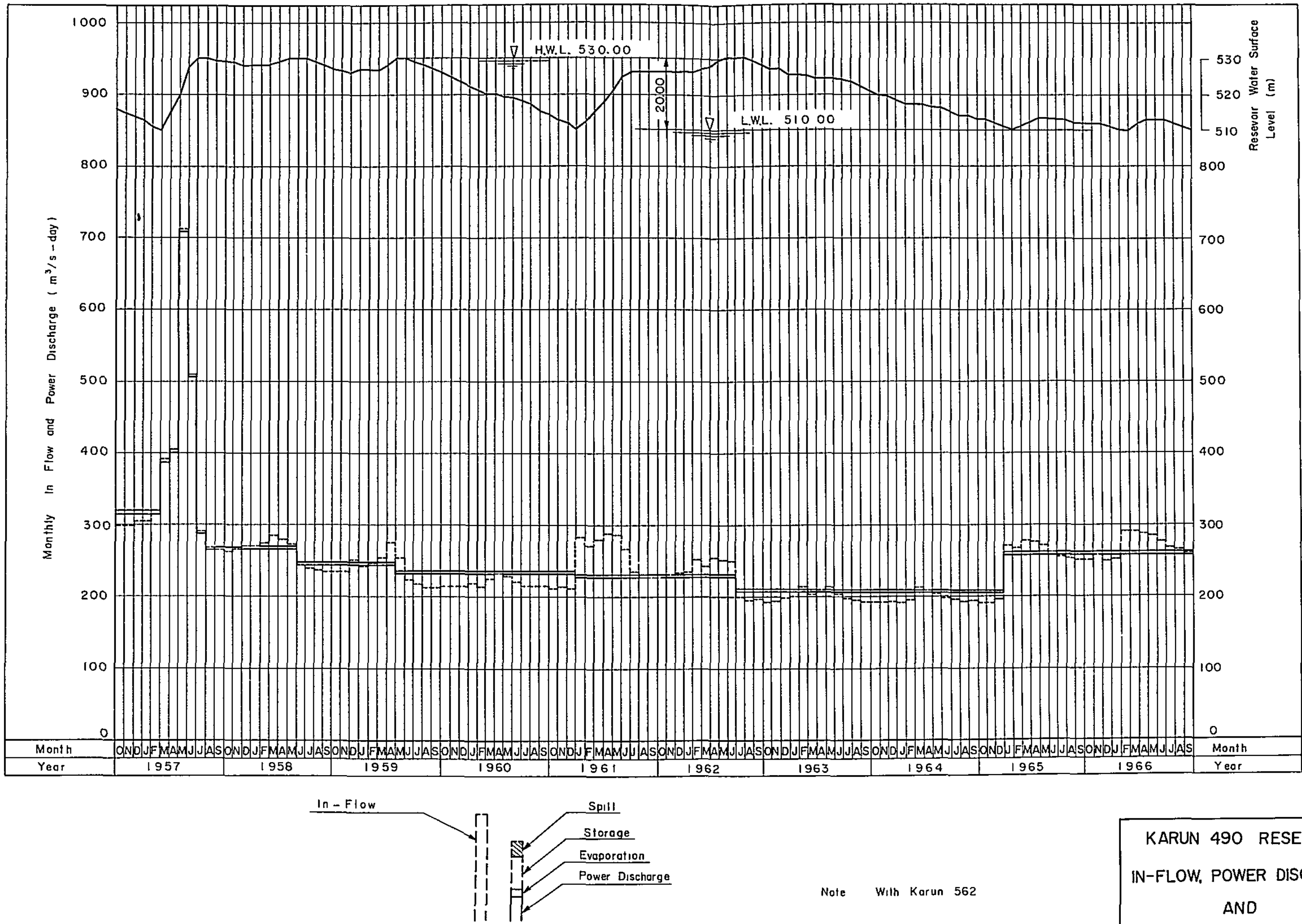


KARUN 490 RESERVOIR

IN-FLOW, POWER DISCHARGE

AND

RESERVOIR WATER SURFACE



KARUN 490 RESERVOIR

IN-FLOW, POWER DISCHARGE AND RESERVOIR WATER SURFACE