CHAPTER 7.

WATER MANAGEMENT PLAN

CHAPTER 7 WATER MANAGEMENT PLAN

7.1 Basic Concept of Water Management

7.1.1 Necessity of Water Management

The western area of the capital Tehran is located at the semi-arid climatic zone and the water resources such as precipitation, surface water and groundwater in the area are limited, while the urban, industrial and agricultural development have been rapidly and largely accelerated to stabilize the socio-economy holding a total population of 10 million at present. Under this situation, numbers of surface and groundwater resources development projects have been implemented and the developed water is being managed for the domestic, industrial and agricultural uses by governmental agencies concerned and water users in the beneficial area. Various new water resources development plans to cope with the increasing water demands in future are under study by various agencies.

Developed water seems, however, not always to be used properly and effectively so as to meet the water demand because of unsuitable management of water sources such as the river flow, reservoir water, groundwater, etc, as well as of water uses including water allocation between water sources and demands for the domestic, industrial and agricultural uses within the service area.

The new water resources development plans also seem not to be set up always with proper considerations for the potential and available water resources, reasonable and equitable water demands and allocation between demands and available supplies, and project viability from viewpoint of technical, economical and environmental feasibility, etc.

Potential resources of both surface water and groundwater are limited in the Study Area and the use of available water resources has been stretched to the limits. Almout river may be the last source of surface water remained unused within the territory of water allocation of the capital area of Tehran. Groundwater has tended to decrease showing annual imbalance of more than 700 MCM toward the final drying up unless proper measures are taken immediately. In order to expect the sustainable development of the area within the available resources, such resources are to be managed and operated properly and effectively. Important issues of management and operation includes 1) establishment of operation rule of water source facilities to allocate necessary volume of water among water users within the minimum risk of water deficit, 2) combination use of surface water and groundwater to allocate water effectively and rationally, 3) establishment of water allocation rule for reasonable and equitable water use among users and 4) improvement and maintenance of water use manners and facilities to minimize losses of water. Necessary activities of water management may be categorized into seven definite items as outlined below;

7.1.2 Water Management Component

(1) Objective of Water Management

Objective of water management is to monitor, evaluate and control the potential and available water resources consisting of precipitation, surface water and groundwater, to project the increasing water demands for various water user sectors of urban and rural water supply such as industry, agriculture, hydropower, tourism, environment, etc., and to allocate water between available sources and demands in both qualitative and quantitative means.

(2) Water Management Component

The water management in the western capital area of Tehran will be composed of the following component.

<u>Watershed Management</u>

The watershed management is carried out for the larger river basins of Karaj, Taleghan and Almout including their small tributary sub-basins to stabilize and increase the conservation capacity aiming at fostering the water resources within the river basins. The natural conditions of the watershed such as rainfall, snowfall, runoff yield, land use, land sliding and soil erosion, devastated situation of tributaries, etc are surveyed and the conservation plan such as reforestation, expansion of grass land and natural grazing, protection of land sliding and soil erosion, river training, etc are set up and implemented.

<u>River Flow Management</u>

The river flow management is carried out for the Karaj, Taleghan and Almout rivers, three rivers flowing into the south Qazvin plain, namely Abhar-rud, Khah-rud and Haji Arab, and the important tributaries in order to monitor and evaluate the variation of river flow and to grasp the potential and available water, to control release of water for requirement in downstream service area, river maintenance and spillage of flood.

Water management activities to select the control points along the river, to monitor and evaluate water levels and discharges in the river throughout a year including the flood and drought variation and to control allocation of water according to actual flow condition at the control point are carried out.

<u>Water Sources Management</u>

Water sources management means water operation management at the Karaj and Taleghan dam/reservoirs and the Bileghan, Taleghan and Almout diversion dams. The water source management requires preparation of proper rules for reservoir and diversion operation, monitoring of inflow and reservoir water level, and the control of outflow released to the service area and the downstream river course. The management also includes the monitoring work for the accumulation of sediment-transport, expansion of aquatic weeds on reservoir area, water quality population in the reservoir, land sliding at the reservoir banks to be caused by fluctuation of reservoir water level, etc.

Water Conveyance Management

The water conveyance management is carried out at the irrigation canal system in the Karaj and Qazvin irrigation systems and the water supply pipeline system covering Tehran city and other urban areas. The management work requires evaluation of discharge to be released on weekly basis, monitoring of the discharge fluctuation within the system, and control of gates and valves in the system, etc. The water conveyance management is made focusing especially on minimizing the water losses in the system and distributing the programmed discharge accurately to the service area.

Groundwater Management

The groundwater management is carried out covering the entire area where groundwater is extracted for domestic, industrial and agricultural uses in the Study Area. The management work requires installation of monitoring wells, monitoring works at the monitoring wells, evaluation of monitored data and control of operation of the production wells. In order to carry out the proper and useful management of groundwater, studies on hydrogeological structure of groundwater aquifer, potential of recharging capacity, variation of water levels, water yield by pumping operation, water sources to recharge groundwater, etc shall are carefully carried out.

Water Use Management on Service Area Level

The water use management is carried out at the irrigated field of on-farm level and in the service area of water supply on water connection basis by water users' group. The management requires adoption of proper irrigation method, minimization of water losses, equitable water allocation, education of water users' group, collection of reasonable water fare, water right, etc. The water use management is carried out inviting participation of water users in the service area.

Water Quality Management

It is anxious that the water pollution problem will rise accompanied by the urban, industrial and agricultural development. The water quality management requires the monitoring works of water quality in rivers, reservoirs, water conveyance systems, groundwater, and drained water from domestic and industrial uses, etc and the quality control works at factory, water treatment plant, sewerage plant, etc.

7.1.3 Important Issues for Implementation of Water Management

The important issues to implement the proposed water management program effectively and successfully are as follows;

(1) Strengthening of Water Management Organization

Although water management organizations to operate and maintain the existing project facilities have been set up already and carried out their activity, such organization to work out integrated water management covering the above component has not been set up yet. It is necessary to strengthen and expand the existing water management organization in order to implement the rational and effective management.

Although the water users' organizations are formulated in the irrigation project area, their ability to manage irrigation water is still poor and is to be improved through training and education programmed by the government organization.

(2) Strengthening of Monitoring and Evaluation Work

The monitoring and evaluation work for the watershed, river flow, water sources, water conveyance system, groundwater, water use in the service area, etc have to be strengthened. On the basis of the results obtained through the monitoring and evaluation works, the database including G.I.S related to the water management have to be constructed and put into periodical review.

The Database will cover the watershed conditions, hydrological and hydrogeological conditions, potential and available water evaluated at each water source, various water demand evaluated and projected, water operation results at the reservoirs and water use facilities, water operation rule, water conveyance result including water loss, fluctuation of groundwater resources such as water levels and extraction, etc.

(3) Establishment of Water Operation and Water Allocation Rule

Water operation rule of the project facilities and rules of water allocation at the control points in the river systems including guideline and criteria have to be set up properly and equitably and the public relation activities on those rules have to be made against the water users and other people living in the river basin and project area. Otherwise the water management company to mange the water will not succeed to get consensus for the operation and allocation rules from the water users' groups and others.

(4) Implementation of Proper Operation at Water Use Facility

The Water management company under T.R.W.B is requested to carry out the proper operation for the water use facility such as reservoir and water conveyance system, and also to take care the facility maintenance.

(5) Identification of Rehabilitation for Existing Project Facility

The existing project facilities under operation for more than 20 years are probably deteriorated and require rehabilitation works in order to carry out proper and effective water management. It is necessary to carry out the inventory survey to grasp the deteriorated conditions of the facilities and then implement the rehabilitation works with priority orders.

(6) Identification of New Projects

In case the new projects for water resources development, water supply works and irrigated agricultural development are required and identified by the study on the integrated water management, such projects have to be verified from viewpoint of not only project feasibility but also impacts to other water uses and environment in the entire basin of water allocation.

(7) Improvement of On-farm Irrigation Practice

The existing irrigation practice of on-farm level in the Karaj and Qazvin irrigation systemss and the other private irrigated agriculture has brought about a large losses of irrigation water amounting to 60 to 70% of the diverted water. Accordingly the irrigation practice of on-farm level has to be improved. Major improvement works are the on-farm development including farm ditches and roads, the irrigation method suitable for crops, irrigation schedule for different crops, rotation irrigation method by water users' group, application method of irrigation water during night, etc.

(8) Participation of Water Users' Group and N.G.O

In the case when the water management plan is studied, formulated and implemented by the governmental organization, it is necessary for the water users' groups related to the water management in the basin and the non-governmental organizations to participate and to offer, advice and recommend the water management practice in the service area and basin-wide. The water users' group and N.G.Os will discuss with the government for various subjects on water right, water fare, responsibility of water use, etc and conclude the agreement on the use of water.

7.2 Watershed Management

The Karaj, Taleghan and Almout river basins are the important watershed as the sources of large amount of surface water supplied to the western capital area. The following watershed conservation will be required to foster the water resources properly and effectively in the basins.

(1) Land Use Management

- The large plateau area lies in the Taleghan and Almout basin and has been used for natural grazing and dry farming area. Some area has been devastated in recent years due to increasing number of sheep feeding and expansion of dry farming area. It may be necessary to control the sheep feeding and dry farming area to prevent the soil and gully erosion and stabilize the existing plateau. It is also necessary to expand the bush and grass area to cover the devastated plateau area by setting up the greenery program.
- When the Taleghan dam and Almout diversion project has been be completed, both basin areas

will be developed as the resort in the territory of Tehran capital area. Accordingly, T.R.W.B is required to study the land allocation plan for the reserved natural grazing and wood area, farm land area, recreation area, public use area, etc. taking into account the topographical and geological conditions as well as maintenance of the project facility such as dam and water diversion facility, Otherwise. T.R.W.B will face many difficulties in the management of the watershed and the project area.

- Karaj basin is formed with rocky mountain without a large plateau area like Taleghan and Almout basins. However the area along the Karaj reservoir and the downstream of the Karaj river has been used for recreation of Tehran people and as a result the Karaj water being used for Tehran water supply has been polluted. It is necessary accordingly to restrict private activities and to install the public sanitation facility along the river and reservoir area.

(2) Land and Soil Erosion Protection

- There are many places being suffered from land and soil erosion in the Taleghan and Almout basins. In the Almout basin, some villages were evacuated by the large-scale land sliding. The land sliding and gully erosion have occurred generally in the devastated basin area without vegetation and the area along the tributary with a steep slope and rapid flow and by the scouring energy of heavy rainfall and melted snow runoff. Both river therefore have brought about a large sediment-transport, which becomes obstructs for the water use and maintenance of reservoir and river.
- It is necessary to carry out the inventory survey and protection works for the land and soil erosion sites. The protection method will be either covering ground surface with bamboo and bamboo grass, installation of many weep holes to take out the saturated water in land and groundwater, construction of masonry wall to protect the land sliding, river training at the tributary with a steep slope and rapid flow, or construction of Sabo dam to deposit transported sediment material, etc.

(3) Tributary Stabilization and Development

There exist many villages along the tributaries in the Taleghan and Almout basin utilizing tributary water for the domestic water supply and irrigated agriculture.

Those tributaries are however formed with the steep slope, and their river bed and banks are largely eroded by the rapid flow with strong scouring energy, so that the existing water supply facility is easily destroyed by flood requiring the repairing works every year.

It is necessary to carry out the river improvement works in the tributaries by means of construction of weirs, drops, protection of river bed and banks to stabilize the tributary flow and use the water for villages.

(4) Evaluation of Specific Runoff Yield

The specific runoff yield varies considerably from river to river in the Study Area. For example, 500 to 550mm are observed in the Taleghan and Almout basins, 300 to 250mm in the Shar-rud and mountainous basins in the north Qazvin, and only 30 to 10mm in three river basins in the south Qazvin. It is judged that the upper basin of Taleghan and Almout presents the high runoff yield due to rich precipitation, snow piling in winter and snow melting runoff in spring like a reservoir, topography with seep slope and less land use for agriculture, etc, while three basins in the south Qazvin has the very low yield due to scarce precipitation, flat topography losing rain water by evaporation and agricultural uses and geology to allow easy recharge of the surface water into groundwater aquifer.

It is necessary to evaluate the runoff yields at the proposed control points on monthly basis based on the analysis of rainfall and runoff in order to judge the potential and available water resources and use it for the water resources and irrigation development plan.

7.3 River Flow Management

(1) Installation of New Gauging Station

Although gauging stations are provided at the important sites in the Study Area, additional gauging stations will be further required taking into account the proper and effective water management, especially for the evaluation of potential and available water. For example, no gauging station has been operated at the proposed site of the Taleghan dam and therefore runoff is assumed based on the data collected at Galinak station in spite of the fact that the dam is under construction. The following new gauging stations will be required for the future water resources development and management in the Study Area.

- Immediate downstream of Taleghan dam-site to measure the dam-site runoff and river maintenance flow released from Taleghan dam in future.
- Proposed site of Almout water diversion dam to measure the accurate runoff, which is used for the water diversion plan.
- The conjunction point of Taleghan and Almout to measure the releasing water to the Shah-rud river.
- Additional gauging stations along Khah-rud and Haji Arab rivers to measure the variation of runoff along the river courses to set up the recharging plan of groundwater.

(2) Observation of River Flow

- Observation of river flow is generally carried out well and data are well compiled but the observation for sediment-transport and water quality at the major stations have to be carried out more precisely. The water quality is to be tested in the spring season and dry season, because the water in the spring season presents generally good quality as compared with the water in the dry season due to the snow-melted water in the spring season.

- It is necessary to evaluate carefully the rich runoff during three months from Farvardin to Khordat (April to June) in wet and dry years extracted from the past observation record because the potential and available water for the water use, reservoir storage and groundwater recharge can be judged on the basis of runoff during those three months.
- The water use of small streams in the Study Area for irrigation and groundwater recharge is simply assumed in the Master Plan. It is necessary to evaluate runoff of small streams accurately by means of direct measurement or analysis because the large amount of such water is planned to be used for irrigation and recharge in the Master Plan.
- It is desirable to transmit the water level and discharge data at the major stations to the water monitoring center in T.R.W.B, although the reservoir operation data of Karaj, Latian, etc are already transmitted.

7.4 Water Allocation Management

The water allocation management of the river flow including the reservoir water to the service area have to be carried out based on the balance between availability of existing river flow and increasing water demand in the beneficial area in consideration of the reasonable and equitable allocation and priority of water supply among water user sectors in the beneficial area.

In case of the water allocation for new projects and new water demand, the existing water allocation including the water right and surplus water in the river flow is to be carefully studied and then the allocation for the new projects and demands is to be defined.

It case of the water allocation by the trans-basin water diversion project, the land use, water demand, environment, etc. in the downstream reaches of the rivers have to be carefully studied and then the water allocation to the downstream shall be defined with priority. Only the surplus available water could be allocated to the new beneficial area to be served by the trans-basin water diversion plan.

The past water allocation plan in the Study Area has been carried out without deep consideration for the above guideline but only with priority to Tehran urban water supply.

Although the Tehran urban water supply has the first priority in the future water allocation plan in the Study Area, the water allocation to the other area and other water demand also has been carefully studied in the Master Plan and JICA Review taking into account the all of potential and available water at the different water sources in the Study Area and the possibility of its full utilization to the beneficial area as explained in 5.4 “Water Allocation Scenarios”

The particular care in the proposed water allocation by JICA Review is described below;

The allocation of Karaj dam water in 1970s was 250MCM for irrigated agriculture in the Karaj plain and 180MCM for the Tehran urban water supply. This water allocation has been changed in recent years due to increasing water demand in Tehran and is defined to 135MCM for Karaj agriculture and 300MCM for Tehran water supply. Accordingly, Karaj agriculture has suffered from water shortage problem and low agricultural productivity. Although the excessive extraction of groundwater has covered slightly the water shortage of Karaj water, the groundwater level at present has been drawn down considerably and its yield has become small at present.

In order to improve the above worst situation in the Karaj agricultural area, the following water allocation plan is proposed by JICA Review:

In the short term plan (2006), Taleghan water of 120MCM is allocated to Karaj agriculture and its available water reaches to 215MCM with inclement of 80MCM as compared with the present allocation of 135MCM from Karaj dam only. In the medium and long term plan (2011 to 2021), the reused water of 100MCM will be newly allocated in addition to Karaj water of 115 to 160MCM, which will increase toward 2016, and total allocated water becomes 265MCM in 2026.

The irrigated agriculture will be stabilized in future by the increasing surface water allocation and the groundwater yield will also increase due to recharging effort of the increasing return flow of irrigation.

- The allocation of Taleghan water to Qazvin plain is 200MCM at present.
  In the short term plan (2006), the present allocated water of 200MCM will be slightly reduced to 170MCM by minimization of the existing canal water losses and recharging water to groundwater. This minimization could be carried out by the rehabilitation of canal system and increasing capacity of recharging ponds to use tributary water without released into the salt marsh. In addition, the maximization of water diversion from the Taleghan river by through the existing diversion facility is carried out. In accordance with the detailed water operation study, the maximum water diversion of 290MCM per annum at the average year is possible and the allocation of 170MCM for Qazvin and 120MCM for Karaj could be satisfied.

- In the medium term plan (2011), availability of the Taleghan water will increase to 450MCM after completion of Taleghan dam and as the result its water allocation is proposed at 150MCM for Tehran Water supply and 300MCM for Qazvin Plain. The increasing water demand in Tehran city in 2021 could be sufficiently covered with the allocation water of 150MCM together with the other water allocated from Lar, Latian and Karaj dam.
  Because the water allocation to Qazvin plain will increase to 300MCM, the irrigated agricultural development in the plain will be expanded.

- In the long term plan (2021), allocation of Taleghan water to Tehran water supply will increase largely to 310MCM in 2021 due to increasing population in Tehran city. Since the allocation of Taleghan water to Qazvin plain is reduced to 140MCM in 2021, the deficit of 170MCM should be compensated by the Almout water diversion project.
- The Almout river has the potential water of more than 300MCM per annum at the proposed water diversion site but the allocated water to Qazvin plain is defined at 250MCM taking into account the water allocation to the downstream water use along the Almout river.
- As mentioned above, the increasing water allocation to Tehran water supply gives large influence to the irrigated agriculture in Karaj and Qazvin plain. It is necessary therefore to carry out the careful study on the irrigated agricultural plan to be changed by the variation of water allocation in both plains in parallel with the water allocation plan to Tehran city, otherwise, the irrigation area in both plains will face the large water management trouble and its agricultural activity will be suspended.
- In the Study Area, alternation of water allocation will occur in different water sources such as tributary water and groundwater. For example, the water allocation to domestic and industrial water converted from irrigation use, to the recharging water of groundwater from surface water in tributaries, etc. It is always necessary to study carefully the alternation of water allocation because such alternation always brings another alternation of area and water demand in the existing beneficial area requiring new available water resources in the river basin.

7.5 Water Sources Management

The surface water in the Study Area presents large seasonal fluctuation such as rich water in spring season and no or poor water in the other season. The following water sources management is in principal required to use such fluctuated water properly and effectively so as to meet the water demand in the beneficial area.

- Water management by reservoir dams to store a spring rich water and use it for the water demand in the other season.
- Combined water management of surface and groundwater to use a rich surface water in spring season for the water demand and groundwater recharge and to supplement the poor surface water in the other season by groundwater supply.

Existing Karaj dam and Taleghan dam under construction are operated applying the water management method prepared for the reservoir dam, while the existing Taleghan and proposed Almout diversion dams are operated by the combination method of the surface and groundwater. The water sources of those dam and diversion dam will be managed with the following rule.

(a) Reservoir Water Management

The existing Karaj dam and Taleghan dam under construction are originally planned to allocate 60 to 70% of reservoir water for the irrigation and 40 to 30% for the water supply. However the future operation of those dams has to be altered to allocate 60 to 70% for Tehran urban water supply and 40 to 30% for the irrigation in the Karaj and Qazvin plain because of the high priority given to the increasing Tehran urban water supply. Accordingly the water management at the reservoir is to be studied taking into account the following conditions:

- The reservoir will receive a plenty of inflow in spring season from Farvardin to Khordat (April to June) while only small inflow in other seasons. On the other hand, irrigation requires much water to be released from the reservoir in spring and summer season but no water in winter season, while the urban water supply requires mostly constant water release from the reservoir throughout a year. Accordingly, the reservoir operation for the water supply requires to store the more spring inflow than the operation for the irrigation because the reservoir is to cover the water supply demand for a long period from summer to winter with a small inflow.

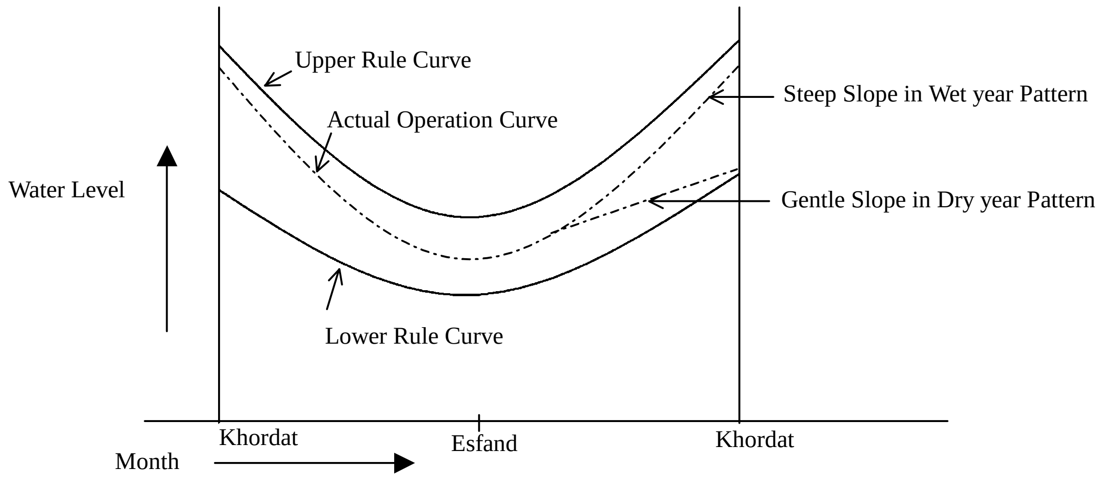
- The reservoir will reach generally the full water level at the end of spring season from Ordibehesht to Khordad (May to Jun) and approach the lowest water level at Esfand (March) if it is operated only for water supply because the monthly reservoir inflow from Sharival (September) to Esfand (March) is too small to cover the urban water supply demand supplemented by the reservoir water. (In case of the irrigation water supply, the lowest water level appears in Sharival after the end of irrigation season)

- If the reservoir water level does not reach the full water level at the end of spring season due to less reservoir inflow in a dry year, the proposed irrigation area under the normal year condition can't be fully irrigated and will be reduced depending on the available reservoir water at the end of spring season, otherwise the urban water supply from summer to winder could not be satisfied with the reservoir water.

- Since the summer crops are already planted at the end of spring season (the end of Khordat), the actual reduction of the irrigation water in a dry year has to be done for the winter crops such as wheat and barely from Farvardin to Ordibehesht before the commencement of summer crop plantation. Namely control water level to restrict the use of irrigation water from Farvardin to Ordibehesht has to be set up by the reservoir operation study based on the past records of reservoir inflow and outflow together with the demand for water supply and irrigation.

- The carry-over capacity in the reservoir to reserve the storage in preparation for unforeseen drought in next dry year will also be estimated by the reservoir operation study. Both reservoirs of the Karaj and Taleghan dams show very low runoff of about 300MCM in the dry year of 1989 to 1991, corresponding to the supply amount of Tehran urban water only. Accordingly the reservoir operation study shall be carried out so as to cover such low inflow by the carrying over reservoir water.

- The necessity of flood control to cut the peak flood discharge during spring season is also to be studied. In the year of 1969, the abnormal flood discharge of more than 300MCM per month, corresponding to the effective capacity of both dams, occurred and its control method is to be considered in the reservoir operation study.
- The upper rule curve will be set up for flood control, while the lower rule curve to preserve the storage during the season of low inflow in a dry year is established as shown in the following figure;
  The operation of the reservoir has to be done monitoring the reservoir inflow, flood, variation of reservoir water level, outflow, etc and placing the fluctuated water level between the upper and lower rule curve.



When the actual operation curve shows the steep slope than the upper and lower curve, it is judged that the reservoir is operated with the wet year pattern and will reach the full water level at the end of spring season. On the contrary the gentle slope shows the operation with the dry year pattern and the reservoir will not reach the full water level at the end of spring season.

(b) Combined Management for Surface and Groundwater

The surface water of the existing Taleghan and proposed Almout water diversion project is mainly managed for irrigated agriculture and groundwater recharge. The following manner will be applied for the combined water management.

- The rich surface water in spring season is diverted by the diversion dam to the irrigation beneficial area as large as possible. When the surplus water is existing after irrigation use, such water is conveyed to the recharging ponds and recharged to groundwater.

  The diversion water in the winter season also is used for groundwater recharge because of no irrigation water requirement.

- It is desirable to divert the water of 80 to 90% for the river discharge because the river discharge is fluctuated daily and weekly and rather difficult to divert fully. In case the diversion water is not sufficient to cover the irrigation demand in summer season, such deficiency shall be covered by the extraction of groundwater by deep wells.

  Namely the spring irrigation water is mainly supplied by the diversion surface water, while the summer irrigation by the combination of surface and groundwater.

- It is necessary therefore to study previously the potential recharging capacity for aquifer layer in the beneficial area and the availability of surface water to be recharged in the combined management of the surface and groundwater.

- It is also necessary to monitor the aquifer conditions such as the water level fluctuation of groundwater by installing the monitoring wells.

7.6 Irrigation Water Management

The irrigation water management is one of the important one because the irrigation requires the large water use quantity as compared with the other water use and includes many kinds of water losses on the process of the water use. The irrigated agricultural development in Qazvin plain is the largest and important project in the Study Area covering the farm area of about 350,000ha and using the rich surface water of the Taleghan and Almout river as well as bulk groundwater in the plain. However the irrigation water management up to now has been suffered from many problems. It is recommendable to carry out the proper irrigation water management by the following manner.

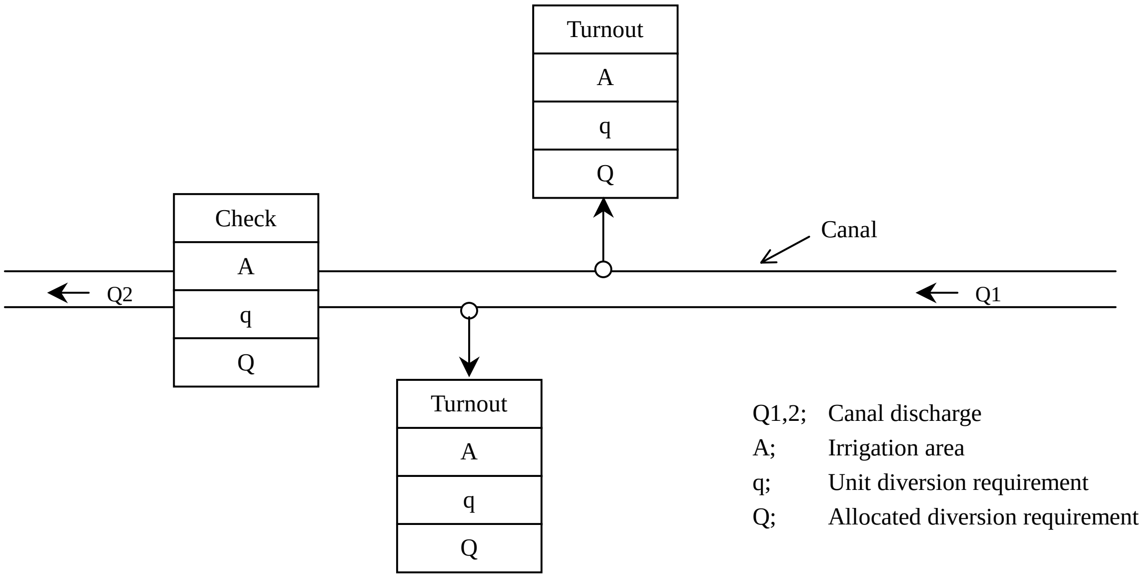
(a) Water Diversion Management in Irrigation Canal

Irrigation water released from reservoirs and weirs is generally distributed and diverted by canals to farm area. If the proper management for the water distribution and diversion through canal system could not be carried out, the large water losses will take place during irrigation season. The following water diversion management shall be carefully implemented.

(b) Preparation of Canal Flow Diagram

The existing diversion discharge capacity at turnouts and checks in the canal is designed based on the irrigation water demand in the detailed design stage. However, this capacity is the maximum discharge one during irrigation season and actual capacity at the water operation in the canal shall be changed by irrigation schedule on weekly or 10 day basis depending on the cultivation area, cropping pattern, unit irrigation requirement, irrigation method, canal losses.

Accordingly the operation and maintenance (O/M) company in the project management shall firstly prepare the flow diagram of the canal system as shown in the following figure. The diagram consists of main, secondary and tertiary canals and shows the position of turnouts and checks in the canal.



Notes (1) A is actual irrigation area which will be changed every irrigation season by the proposed area of irrigation association.
(2) q is unit irrigation requirement (λ/sec/ha) which is changed on weekly or 10 days basis and cropping pattern and estimated by O/M office
(3) Q is diversion discharge on weekly or 10 days basis at turnouts and estimated by A and q.
(4) Q1 and Q2 is the canal discharge to be controlled by checks and estimated by accumulation of Q.

The O/M company shall prepare the computer program to estimate the diversion discharge correctly and quickly at the turnouts and checks based on the above flow diagram.

(c) Estimation of Diversion Discharge at O/M Company

The O/M company will estimate the diversion discharge on weekly or 10 days basis at one month before next irrigation season and indicate to the Irrigation Association by the following procedures and manners.

- Irrigation Association (I.A) shall be established at each turnout level which is generally consisting of 50 to 100 farmers and covering the irrigation area of 100 to 400ha.
- I.A submits firstly the proposed irrigation area including cropping pattern at least one month before the next irrigation season to the O/M company for his approval.
- O/M company estimates the diversion discharge at each turnout and check as well as the water use quantity in whole irrigation canal system during irrigation season, while O/M

company checks the available water in the reservoir and rivers to be able to cover the water use quantity through the next irrigation season.

- If available water is not sufficient in the dry year or other reasons, the proposed area by I.A will be reduced based on the available water and indicated to I.A from O/M company. In case of sufficient available water, the proposed area by I.A is of course approved by O/M company.
- O/M company shall evaluate the unit diversion requirement (λ/sec/ha) at the end of irrigation season based on the monitoring result of diversion water during irrigation season such as water deficit or excess water at each turnout. The unit irrigation requirement for next irrigation season will be adjusted by the evaluation result.

(d) Water Diversion Practice at Canal

The water diversion operation in the canal shall be carried out maintaining the constant water level at the checks and regulators and adjusting the opening degree of the turnout gates in accordance with designed diversion discharge as mentioned in the above.

Gate keepers shall adjust firstly the check gate so as to release the design discharge to the downstream canal under the constant water level in front of the gate and then adjust turnout gates so as to divert the estimated diversion discharge to farm area.

In case the water level at the checks is fluctuated during water diversion operation, the diversion discharge at turnouts or releasing discharge to the downstream canal will not be coincided with the designed one, so that gate opening degree shall be readjusted.

(e) Irrigation Water Management on Farm Level

Irrigation water management on farm level is carried out by farmers establishing Irrigation Association and taking into account the following items;

- Irrigation association (I.A) shall select a representative who will arrange the farmer's request for the irrigation water use and discuss the O/M company.
- Proper on farm development consisting of farm diches for irrigation water, farm road and land leveling shall be constructed by I.A. under technical guidance of the O/M company.
- Rotation irrigation system to control the irrigation water at farm ditches shall be set up in I.A. (For example rotation with once to week or 10 days)
- In upland crop irrigation, the water supply during 24hrs is difficult because irrigation is carried out by border and furrow method. Accordingly the night reservoir and farm pond to store the water supplied in night shall be provided, otherwise the night water will be wasted to drainage canal without use.

- Mechanical irrigation such as sprinkler and drip irrigation will be applied for valuable crops such as orchard and industrial crops in order to minimize the irrigation losses and irrigation labour force.
- Irrigation losses on farm level is 40% for the gravity irrigation such as basin, furrow, border but 10 to 5% for the mechanical one.

7.7 Groundwater Management

Even in the recent drought since 1997/98, huge amount of groundwater was still stored beneath the Qazvin-Tehran Plain. 42 billions of groundwater was expected based on the current groundwater tables at the timing of Sep. 2000, as below:

Regions	Area sq. km	Groundwater Storage of Saturated zone MCM	Storage Capacity of Unsaturated Zone MCM	Annual In (+) recharge MCM	Annual Out (-) well-qanat extraction+ evaporation+ outflow MCM
Tehran City	530	700	830	643	643
Tehran	1,290	3,300	2,660	619	645
Karaj	940	5,600	3,120	328	452
Hashtgerd	780	2,100	1,970	203	250
Qazvin north	1,650	10,200	2,890	529	817
Qazvin south	3,040	20,500	5,590	776	1,049
Total	8,230	42,400	17,060	3,098	3,856

During the drought, the groundwater extraction was intensified by irrigation and cities water supplies, particularly at Qazvin south and Karaj city. Consequently, those heavy exploitation caused abrupt drop of groundwater table and subsequent dry-up of production wells. To cope with groundwater obstacles, conceptual plans, including cut-down of extraction amount, artificial-recharge and alternative water sources, were elaborated in the Study.

Throughout the evaluation of groundwater resources in the Study, constrains in conjunction with management of groundwater resources are stood out in relief, as below:

- **Constrains on Institution and Organization:** Major constrain in institutional and organization is lack of clear policy on water development and management plan with quantitative and qualitative target. It results in increment of uncontrolled water use in hazardous zone where is suffering by serious groundwater imbalance, such as Karaj, Hashtgerd, Tehran.
- **Constrain on Physical and Technical Matters**: Major constrains on the physical and technical matters are lack of substantial information in terms of factual groundwater extraction and actual condition of monitoring network, which can provide basic information to formulate concrete plan for overcoming the present and future water imbalance. In addition above, the water quality

data are not sufficient in basin-wide evaluation to protect the groundwater from the surface pollution sources.

- **Constrains on Operation**: Major problem in the present operation is low-capability of operational staff in TRWB due to the insufficient number of staff, as well as shortage of technical know-how. Besides, the existing monitoring network bears a number of issues such as insufficient numbers of wells, inaccurate location and elevation of wells and insufficient consideration of water quality as described in Supporting report.

For eliminating the constrains, new groundwater survey and re-settling the groundwater monitoring networks are to be required.

7.7.1 Groundwater survey to be required

The hydrogeologic survey has been carried up to now. However, such information is not sufficient to realize the above conceptual plans. Further surveys are required for the achievement of plans, as below.

(1) Survey and study on preset groundwater situation and constraints.

- Inventory survey for present groundwater projects,
- Survey on relevant information to existing monitoring wells,
- Survey on present constraints on groundwater use and development.

(2) Survey and study on available groundwater in the Plain.

- Examination of present meteo-hydrological observation system,
- Examination of present groundwater observation network,
- Inventory survey of production wells and groundwater sources,
- Preparation of hydrogeological maps,
- Experimental drilling,
- Geophysical survey,
- Experimental observation of springs and groundwater level,
- Groundwater sampling survey,
- Analyses and clarification of regional meteo-hydrology,
- Analyses and clarification of local geology and hydrogeology,
- Analyses and clarification of regional aquifer property,
- Preparation of simulation model for present groundwater sources,
- Simulation study on present available groundwater sources, and
- Study and analyses on present groundwater balance in the basin.

(3) Survey on Groundwater Demands

- Inventory survey of present water supply scheme,
- Study and analyses on basic elements of domestic water supply,
- Study and analyses on basic elements of irrigation,
- Study and analyses on basic elements of industrial water supply,
- Study and analyses on basic elements of other groundwater supply, and
- Estimation of present groundwater demand in each water field and integrated water demand in the basin.
- Clarification of future groundwater demands

(4) Survey on Present Natural and Social Environment

- Inventory survey of existing groundwater quality observation stations,
- Inventory survey of prospected groundwater pollution sources,
- Execution of sample groundwater quality testing,
- Clarification of groundwater quality pollution system in the basin, and
- Execution of Initial Environmental Examination with an emphasis on quality of groundwater

(5) Study on Future Groundwater Imbalance in the Plain

- Review of the JICA Study, and
- Projection of future groundwater balance.

(6) Preparation of Groundwater Resources Management Model

- Experimental observation of springs, surface streams, and groundwater level,
- Additional geophysical survey for modelling,
- Adjustment of simulation model with additional data,
- Preparation of groundwater resources management model,
- Simulation study on future available groundwater sources, and
- Study and analyses on future groundwater balance in the basin.
- Clarification of Groundwater Potential for Development,

These surveys and studies are must be made with close relationship to a groundwater basin management system, called as “Water (Groundwater) Resources Management System (Centre)” stated below.

7.7.2 Water Resources Management System

In addition to above surveys, the “Water Resources Management System” is recommended to be established in TRWB with objectives of :

- to clarify the available groundwater resources in as a whole on the basis of the scientific and technical water analyses in the Plain,
- to clarify the future groundwater demand in the Plain in the several water fields, such as domestic water supply, irrigation, industrial water supply, and others required, as well as the demand of water in the surrounding area as that of Tehran city,
- to examine the future groundwater balance between the available water and water demands,
- to clarify the development potential on the basis of the general water policy in the target regions,
- to elaborate of the concrete development/management plans in the Plain such as:

  - Domestic water supply and irrigation development plans,
  - Quantitative and qualitative management projects on groundwater extraction,
  - Artificial groundwater recharge plans,
  - Effective usages of re-used water, and
  - Trans-basin water diversion to the Plains.

The system is composed of three (3) components: “Database System”, “Management Model”, and “Groundwater Observation”. When the system is established in the TRWB, following works must be achieved:

- Preparation of plan of detailed “Groundwater Monitoring System”,
- Selection of required component of the system,
- Preparation of proposed configuration of the system,
- Execution of site survey for cost estimate,
- Collection of data and information on designing of the system,
- Design of the system,
- Cost estimate of proposed system.
- Preparation of implementation schedule of the system,
- Examination of technical and economical feasibility, and
- Preparation of proposed plan for establishment of the system.
- Detailed topographic survey at required sites,
- Preparation of concrete project features,
- Preparation of concrete locations of monitoring wells,
- Detailed survey on monitoring wells; soil, geology, groundwater, etc.,
- Core drilling survey,
- Collection of data and information on monitoring well design,
- Design of monitoring well network,
- Cost estimate of monitoring well network,

- Preparation of project implementation schedule,
- Examination of technical and economical feasibility,
- Project evaluation, and etc.

7.7.3 Installation of Monitoring Well

(1) Present Networks

In the Plain, about 670 wells have been employed for groundwater observation since the 1980's by the TRWB, and measurement have been made on monthly basis. In spite of some unrecorded or inaccurate data contained in these, most of data is useful in evaluating groundwater resources, especially as calibration data of future Groundwater Management Model. This is revitalized as a future Management Model to control the groundwater basin in management plan.

(2) Required types for groundwater monitoring in the Plain

With reference to constrains on present network stated above and necessary measurements for groundwater level to monitor and manage groundwater quantity, four types of observation programs are suggested at the initial phase of groundwater monitoring, as below:

<table>
<tr><th colspan="4">Required types for Groundwater Monitoring</th></tr>
<tr><th colspan="2">Type of Observation Programs</th><th>Observation Objectives</th><th>Stations applied to Observation</th></tr>
<tr><td rowspan="2">Areal Measurement</td><td>Regional Monitoring</td><td>Monitoring groundwater level of aquifer covering all the Plain to manage the groundwater resources with future Groundwater Management Model and other analytical approaches</td><td>Stations used existing observation wells with re-allocation and new drilling wells.</td></tr>
<tr><td>Local Monitoring</td><td>Monitoring detail groundwater level and potentiometric surface of upper aquifer centred by Tehran, Karaj, Hashtgerd and Qazvin and for local groundwater flow and quality modelling in the future.</td><td>Newly proposed stations by selecting among existing wells</td></tr>
<tr><td rowspan="2">Long-term Measurement</td><td>Monitoring for Quantity</td><td>Monitoring time-series groundwater level used in future Groundwater Management Model</td><td>Newly proposed stations nearby existing station, and by newly drilled</td></tr>
<tr><td>Monitoring for Quality</td><td>Monitoring time-series groundwater level and groundwater quality, and preparation of local groundwater flow and future quality models</td><td>Newly drilled stations</td></tr>
</table>

The detail of respective observation program, in terms of locations, number, timings and well structure, is discussed as below.

(a) Area measurement (Regional monitoring)

As of 1999/2000, about 400 existing wells have been observed tin the Plain. However, most of them are settled in major cities and farming areas and are not employed by continuous observation. In some areas, the number of station is not sufficient to imagine the potentiometric surface. Furthermore, their positions are often inadequate to measure the precise movement from deep wells or from confined aquifer.

(b) Objective

The observation is aiming to monitor the groundwater table of Alluvial aquifer covering all the Plain and to manage the groundwater resources with future Groundwater Management Model and other analytical approaches.

(c) Number of wells to be renewed

Re-allocation of wells is required for the present network. In the case, appropriate rate of well-density ranging a one (1) well every 25 to 30 km^2 (at initial phase of monitoring program in regional scale) is taken into a consideration, new installations of wells accompanied with re-allocation of the present network are required at 130 stations as below:

Number of wells to be renewed						
Sub-Area	Coverage Area for Monitoring	Proposed density. of well	Required No. of wells	Converge area of existing wells	Area required to be monitored	No. of wells newly installed
	km^2	km^2	Nos.	km^2	km^2	Nos.
Tehran City	530	26	20	260	270	10
Tehran	1,290	25	50	500	790	30
Karaj	940	26	35	650	290	10
Hashtgerd	780	26	30	520	260	10
Qazvin north*	1,650	27	60	810	840	30
Qazvin south*	3,040	30	100	1,800	1,240	40
Total	**8,230**	**-**	**295**	**4,540**	**3,690**	**130**

* Note: area of Salt marsh is excluded from coverage area for monitoring

(d) Implementation firm

The re-allocation and incidental installations of wells of present network might be achieved by the TRWB. TRWB has capable workforce to drill and rehabilitate old monitoring wells..

(e) Timing of measurements

Monthly measurement on the network is needed to define the changes in groundwater levels in response to seasonal recharge and abstractions.

(f) Measuring procedures

Other appropriate procedures related to the measurements are described in previous paragraph as “Basic course for groundwater measurements” for the present network.

(3) Arial measurement (Local monitoring)

The requirement for groundwater-level measurements in the local monitoring may give rise to conflicts in the design and operation of groundwater monitoring network, proposed network comprises dense measurement points which are needed to define groundwater-level contours. In most instances to be expected, this means a relation between heavy extraction in industrial use and the suffering drop of groundwater table, and recharge effect through rivers and artificial recharge facilities, which are in contact with aquifer.

(a) Objective

The observation is aiming to monitor detail groundwater level and potentiometric surface of alluvial aquifer centered by high extraction and recharging areas, and to obtain and accumulate the basic data to formulae groundwater quality model to cope with groundwater pollution in the future.

(b) Number of wells

The density of these observation points does not have to be as great as that needed for contouring water levels, and one well every 5 to10 km^2 of aquifer is adequate for local scale of measurements in particular high withdrawal area. If the rate of density is applied to coverage of observation (extending over 1,000 km^2 resulting in groundwater path-line analysis as stated in previous paragraph), the required number of stations is at least counted to 150 wells. With concern to density of groundwater path-lines near industrial areas, as well as alignment of irrigation canals and rivers (as being capable for recharging groundwater), 100 stations are planned to be placed on the covering range. This number of measurements near by selected positions is to be carried out with the use of exiting production wells and observation wells.

(c) Timing of measurements

The ideal frequency at which to take readings depends upon how quickly the aquifer responds to recharge, but it may be normally several a year to find this out. As a minimum it is necessary to take all these readings twice in a year, at the end of March or the begging of April and in Late October or early November, when the groundwater level are at their maximum and minimum values respectively.

(d) Measuring procedures

Appropriate procedures for the measurements are same as regional monitoring doing at present network as described in previous sub-section.

(4) Long-term measurement for future Groundwater Management Models for Quantity

In the Plain, the longest period of continuous records of groundwater table is long as 10 years since 1990. However, these records are observed only in monthly basis. At least, daily information is needed for future Groundwater Management Model requirements for respective sub-areas to estimate groundwater balance and time-series movement in responding to uncertainty rainfall pattern, and human activity as temporary withdrawal and canal-gate control.

(a) Objective

The observation is aiming to monitor time-series groundwater level, and to provide essential information for future Groundwater Management Model.

(b) Number of wells

Required wells are of 80, which are placed every 100 km^2. This number is thought of initial settings for the beginning stage of observation networks.

(c) Preparation of installation

The wells must be newly installed for observing piezometric head near by existing wells. It is important that new wells have to be carefully located on same hydrologic conditions as those of existing wells for holding common history on existing records. The preparatory survey therefore is required for appropriate positioning of them before commencement of well drilling. The preparatory survey in general includes both geophysical investigation and hydrogeologic reconnaissance survey.

(d) Equipment to be installed and timing of measurements

The measurement is recommendable to be carried out by the pressure logger, which is equipped with the advent of reliable pressure sensors being utilized for measuring changes in water levels. This can adapt for long-term continuous monitoring. It also offers several advantages in ease of accurate measurement as well as an easy data processing. These loggers allow the collection and analysis of water level data over an extended period of time. The timing of measurements is once a hour is recommendable in concern for data quality required by future Groundwater Management Model.

(e) Well structure

New wells must be designed to observe the piezometric table. The wells have to be efficient structure on site hydrological characterization along with the lithological features, hydraulic characteristics of aquifers and aquiclude and well yield. Hence, the wells are to be cased through all sections, of which are screened at aquifer part and plugged at aquiclude and vadose (surface) zone.

(5) Long-term measurement for future Groundwater Management Model for Quality

If groundwater level program is carrying out in the coverage for future Groundwater Management Model, the long-term measurements have to be required in parallel with areal measurement described above.

(a) Objective

The observation is made for monitoring the time-series changes in groundwater level and groundwater quality, and preparation of local groundwater flow and future quality models near the industrial zone and urban areas, such as Tehran, Karaj, Hashtgerd and Qazvin.

(b) Number of wells

Because of the requirement to be functioning as piezometer, the newly drilling must be carried out. Required number of them is of 40.

(c) Equipment to be installed and timing of measurements

In order to modernize the observation work, the applications of the automatic recorder are to be installed for hourly measurements as specified manner in those of long-term measurement for future Groundwater Management Model.

(d) Well structure

Well is functioned as piezometer with enough space for data logger as those of applying to long-term measurement.

(6) Summary of required observation program

The observation required for groundwater monitoring (quantity) contains both types of newly drilling stations and using existing wells. New wells must be equipped with appropriate casing works, and are prepared for long-term measurement. While, existing wells are planned for areal measurement. The required numbers of drillings, timing of measurements and measuring devices are summarized as follows:Summary of required observation program				
Type of measurement	Required number of observation stations (nos. of stations)	Stations applied to observation and number of new drilling wells(Nos.)	Timing of measurement	Measuring devices
Areal measurements	130	Stations used existing observation wells with re-allocation and new wells (130 wells).	monthly measurement	manual with portable water level meter (electric probe and etc.)
Areal measurements	100	Newly proposed stations by selecting among existing wells (no new drilling well).	seasonal measurement	a above
Long-term measurements for Quantity	80	Newly drilled wells located near by existing observatories(80 wells)	hourly measurement and processing to daily data	data logger (pressure logger)
Long-term measurements For Quality	40	Newly drilled stations (40 wells).	as above	as above
Total number of Stations and wells	350 stations	-	-	-

CHAPTER 8.

ALMOUT WATER DIVERSION PROJECT

CHAPTER 8 ALMOUT WATER DIVERSION PROJECT

8.1 Conceptual Plan of Almout Water Diversion

8.1.1 Necessity of Water Diversion Project in Western Capital Area

As mentioned in CHAPTER 4 and 5, the various water demand in the western capital area will considerably increase but the existing available surface and groundwater in the Study Area is limited and very difficult to cover the proposed water demand in future.

In the beginning of 1990s, T.R.W.B decided to convey a part of Taleghan water being used for irrigation in the north Qazvin plain to Tehran urban water supply and has implemented the Taleghan water conveyance project from the outlet of existing Taleghan tunnel to Bileghan site on the Karaj river. The project is mostly completed now and could convey the Taleghan water of 150MCM to Karaj side at the end of 2001.

In addition, the Taleghan dam project also is commenced at the middle of 2001 to take more water controlling rich runoff in spring season and to convey it to Tehran urban water supply.

Taleghan water is originally planned for irrigation in Qazvin plain and its water of 200MCM per annum has been used for its purpose since 1970s. It is necessary accordingly to take the consensus of peoples in Qazvin plain to transfer the Taleghan water to Tehran urban water supply from the Qazvin irrigation even if Tehran water supply has the high priority to use any water.

According to JICA Team study, for the implementation schedule of water management allocation of the Taleghan water to Tehran urban water supply and Qazvin irrigation is proposed as follows;

Allocation of Taleghan Water proposed by JICA Team

Year	2001 (Present)	2006	2008	2014
To Tehran City	0	Completion of **Taleghan Dam**	150 MCM	310 MCM
To Qazvin Plain	200 MCM		300 MCM	140 MCM
Total	200 MCM		450 MCM	450 MCM

When the Taleghan water of 310 MCM is supplied to Tehran city in 2014, an available irrigation water for the Qazvin plain is decreased to 140 MCM from 300 MCM in 2008 and will face a large water shortage. Accordingly, the Almout water of more than 185 MCM, as explained in Chapter 10.1.1, should be developed and supplied to the Qazvin plain for compensating decreased amount of irrigation water to be supplied from the Taleghan.

The Almout river with an average annual runoff of more than 300MCM adjoins the Taleghan river. However the water resources development to divert the Almout river water to Qazvin plain was not studied in the past because the water diversion plan from the Almout river required the tunnel with a long distance of more than 30km, which is rather difficult to construct with the tunnel technology in the past and also the conveyance plan of Taleghan water to Tehran city was not existing in the past.

The conveyance of the Taleghan water to Tehran urban water supply should be implemented with the first priority to stabilize the socio-economy in the Tehran capital area, while the new technology to excavate a long tunnel with the Tunnel Boring Machine (T.B.M) has been developed and prevailing recently in the world.

If the Almout water diversion plan could be implemented, the proposed water conveyance plan of Taleghan water to Tehran city would be easily solved getting the consensus of peoples in Qazvin plain and also the irrigated agriculture in Qazvin plain would be more expanded by the Almout water. It is necessary therefore to carry out the study of viability on the Almout water diversion plan.

8.1.2 Proposed Water Diversion Plans

(1) Proposed Water Diversion Plans in the Master Plan

Four alternative water diversion plans are proposed with the preliminary conceptual level in the Master Plan as shown in Figure 8.1.2.1. Those plans, however will not be suitable and recommendable by the review of JICA Team with the following reason;

- The plan of No.1 and No.2 is proposed to divert the Almout water to Taleghan reservoir with the full water level of 1,780m. In this plan, the water diversion site shall be selected at the place with the elevation of more than 1,800m in the Almout river to divert the water by gravity flow. As this site has a small catchment area of 142km^2 presenting poor annual runoff of 70MCM, the plan is not economical taking into account a small diversion water amount against the tunnel with a long distance of about 23km.
- No.3 plan is proposed to divert the water to Ziaran reservoir site with the elevation of 1,450m in Qazvin plain from the Khooban site with the elevation of 1,500m in the Almout river. As this site also has a small annual runoff of 150MCM against the tunnel length of 33.5km, the plan will be disadvantageous. The detailed study for this plan is made by JICA Team as described in 8.3.
- No.4 plan is proposed to divert the water to Qazvin plain with the elevation 1,250m from the conjunction point of the Almout and Taleghan river. The proposed site in the plan can get a rich annual runoff of 390MCM but locates at the low elevation of 1,055m, which requires the high pumping head of more than 200m to convey the Almout and the Taleghan water to Qazvin plain. Accordingly this plan also is not feasible from economical aspect. The detailed study for this plan by JICA Team is explained in 8.3.

(2) Proposed Water Diversion Plan by JICA Team

JICA Team has studied five alternative plans consisting of two plans for A and D which are the same plans of No.3 and No.4 in the Master Plan and the another three plans of B, C-1 and C-2 selected newly by JICA Team.

In addition, JICA Team proposed No.5 and No.6 plans to divert the water from the Dou Hezar and the Seh Hezar river to the Almout river in order to study the possibility to divert the more water to Qazvin plain. However, this plan also requires the high construction cost and is not recommendable.

(3) Proposed Water Diversion Plan in Comments on Draft Final Report

After the submission of the draft final report, TRWB indicate a new alternative water diversion plan in his comments on the draft final report. The new alternative plan, here called as Alt-A', is a plan for diverting water of the Almout, Andah-rud and tributaries located upstream from the diversion tunnel between the Andah-rud and the diversion dam on the Almout. This plan is not recommendable because of its high water cost and small diversion water amount.

(4) Outline of All Alternative Plans

The outline such as catchment area, annual runoff, tunnel length, etc for the all alternative plans mentioned in the above is summarized in the following table. (For detailed study for Almout water diversion plans, see "8.3 Alternative Diversion Plan".)

Outline of Alternative Plans

Plan No.	Water Diversion Plan	Catchment Area	Annual Runoff estimated	Diversion Water Amount
①&②	the Almout ⇒(Tunnel L=23km) ⇒ Taleghan Reservoir	A≦142 km^2	70 MCM[*1)]	70 MCM
③= Alt-A	the Almout ⇒ Ziaran Reservoir	A=247 km^2	150 MCM	120 MCM
Alt-A'	the Almout ⇒ Qazvin North Canal	A=317+101+37= 455 km^2	230 MCM	180 MCM
Alt-B	the Almout ⇒ Qazvin North Canal	A=330 km^2	160 MCM	130 MCM
Alt-C-1	the Almout ⇒ Qazvin Central Canal	A=475+112 = 587 km^2	310 MCM	250 MCM
Alt-C_{Direct}	the Almout ⇒ Qazvin Central Canal	A=475 km^2	250 MCM	210 MCM
Alt-C-2	the Almout ⇒ **the Taleghan (P)** ⇒ Qazvin Central Canal	A=475+112+ 358 = 945 km^2	350 MCM	270 MCM
④= Alt-D	**the Almout & the Taleghan (P)** ⇒ Qazvin Central Canal	A= 721+391 = 1,112 km^2	390 MCM	220 MCM
⑤+Alt-C-1	the Dou Hezar ⇒ (Tunnel L=20km) ⇒ the Almout ⇒ Qazvin Central Canal	A= 90+587 = 677 km^2	50[*1)] + 310 = 360 MCM	280 MCM
⑥+Alt-C-1	the She Hezar ⇒ (Tunnel L=23km) ⇒ the Almout ⇒ Qazvin Central Canal	A= 170+587 = 757 km^2	100[*2] + 310 = 410 MCM	310 MCM

Note : (1) [*1)] : Unit Runoff = 0.47 MCM/ km^2, [*2)] : Unit Runoff = 0.60 MCM/ km^2, (2) The tunnel inlet elevations of Plans ①&② will be approx. EL.1,800 m because of the Taleghan reservoir F.W.S of El. 1,780m.

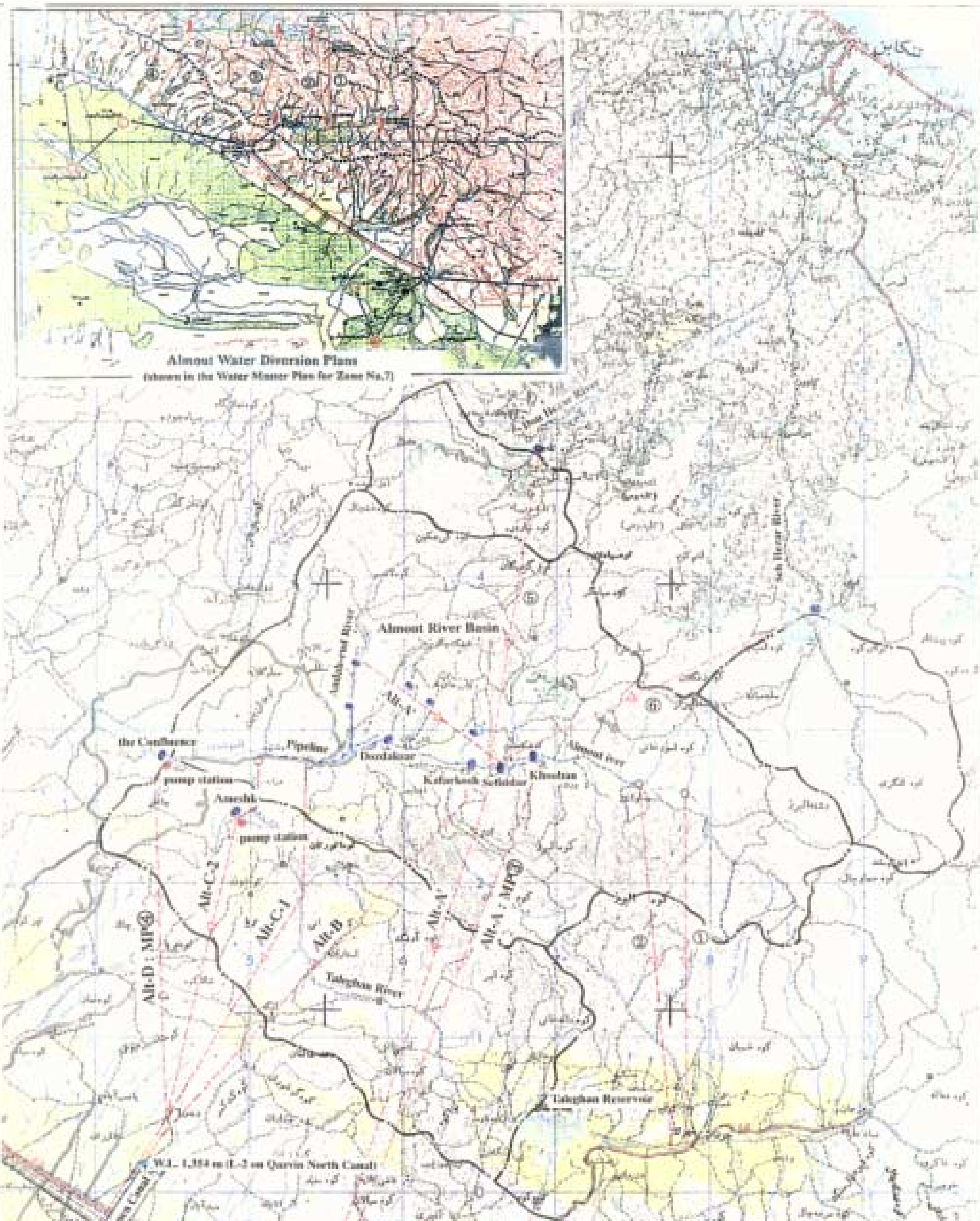


Figure 8.1.2.1 Alternative Almout Water Diversion Plans

Estimated Water Cost of Alternative Plans

Estimated Water Cost of Alternative PlansPlan No.	Project Cost (10^3 US$)			Depreciation Cost (10^3 US$)	O/M cost (10^3 US$)	Available Water (MCM)	Water Cost (Rls/m^3)
	⑤or⑥ *1)	Alt-C-1	Total				
①&②	-	-	67,700	5,530	1,350	70>	790<
③= Alt-A	-	-	97,050	7,930	1,940	120	660
Alt-A'	-	-	130,030	10,620	2,600	180	590
Alt-B	-	-	100,980	8,250	2,020	130	630
Alt-C-1	-	107,260	107,260	8,760	2,150	250	350
Alt-C_{Direct}	-	-	105,800	8,640	2,120	210	410
Alt-C-2	-	-	121,060	10,000	2,690	270	380
④= Alt-D	-	-	111,290	9,510	3,260	220	460
⑤+Alt-C-1	59,600	107,260	166,860	13,630	3,340	280 *2 >	480<
⑥+Alt-C-1	67,700	107,260	174,960	14,290	3,500	310 *2 >	460<

Note : *1) = Construction Cost = Diversion Dam Cost + Tunnel Cost,
Diversion Dam Cost = 5,600,000 US$ (fixed), Tunnel Cost = Tunnel Length (m) x 2,700 US$/m
*2) = 250 MCM + 0.6 x Annual Runoff estimated
- For the project cost of Alt-A – Alt-D, see Chapter 8.3.3.1 and Table 8.3.3.1 in the Supporting Report.

8.2 River Features of Almout and Taleghan Downstream

8.2.1 River System

The Almout and Taleghan rivers are located in east-southeastern portion of the drainage area of the Sefid-rud river. Both rivers join at the upstream end of Shah-rud river approx. 100 km far from the Manjl reservoir. The river bed elevation of the confluence, where is approx. 36 km far from Qazvin city to the northeastern direction, is approx. EL. 1,055m that is about 200 m lower than the farmland elevation in Qazvin plain. The river profiles of the Almout and the Taleghan are shown in Database Map No. 8.2.1.1 "Almout and Taleghan River Systems" and Table 8.2.1.1 in the Supporting Report.)

Taleghan dam is under construction at Sangban site in the Taleghan river approx. 39 km upstream from the confluence with the Almout. The Talegan river downstream from Taleghan damsite has a catchment area of 391 km^2 and an annual runoff of approx. 50 MCM in average. The Taleghan river is formed with V shaped valley, where no village is existing along the river at the downstream of Asfaran site. The access road to the riverbed is existing near Ameshk and Asfaran villages. The river has a steep river slope of 1/60 at Ameshk site and 1/50 at Asfaran site.

The Almout river has a drainage area of 721 km^2 and an annual runoff of 340 MCM at the confluence with the Taleghan. The river bed width varies place to place in a range of less than 600m and is covered with alluvial plain where farmland is expanding. The slope of Almout river is 1/70 at the confluence with the Taleghan and 1/60 at the site of Almout diversion dam approx. 16 km upstream from the confluence.

Major Features of Almout and Taleghan Rivers

Description	Almout River		Taleghan River downstream from Taleghan damsite	
	At the confluence with the Taleghan	At the site of Almout diversion dam	At the confluence with the Almout	At Ameshk site
Distance from the confluence	0 km	16 km	0 km	5.5 km
Riverbed elevation	EL. 1,055 m	EL. 1,293 m	EL. 1,055 m	EL. 1,130 m
Drainage area	721 km^2	475 km^2	391km^2	358 km^2
Annual runoff	340 MCM	250 MCM	50 MCM	40 MCM
Slope of river bed	1/70	1/60	1/76	1/61
Length of the river	53 km	-	39 km	-
Average width of basin	13.6 km	-	10.0 km	-
Annual sediment estimated		700 m^3/km^2		

8.2.2 Topographic and Geologic Conditions

(1) Available Data

Topographic and geologic data including map are collected by the governmental agencies, the local copmanies and JICA own survey and investigation works. Major data used for the study are as follows;

Available Topographic Maps

Maps	Prepared by:	Remarks
1. 1/50,000 and 1/250,000 Topographic Maps	Army	All of the Study Area
2. 1/10,000 Topographic Map	JICA Study Team (by entrusting NCC with mapping work)	Area along the Almout, Taleghan downstream and Shah river (partly)
3. 1/2,000 Topographic Map - Almout river near Haranak village (192 ha) - Taleghan river near Asfaran village (49 ha)	JICA Study Team (by employing local survey company)	
4. Cross Section and Profile on Almout River (7 sections, total length = 7,966 m)	JICA Study Team (by employing local survey company)	

Available Geologic Data

Geologic Data	Prepared by:	Remarks
1. 1/2,500,000 and 1/250,000 Geologic Maps	Geological Survey of Iran	
2. 1/50,000 Geologic Map	JICA Study Team (by employing local geological company	
3. Core Drilling (7 holes, total length = 441m) - Kafarkosh site on the Almout (4 holes, L=221 m), - Riverbed near Dozdaksar on the Almout (1 hole, L= 60 m) - Ameshk site on the Taleghan (1 hole, L= 80 m) - Tunnel inlet near Dozdaksar (1 hole, L =80 m)	JICA Study Team (by employing local geological company)	
Laboratory Soil Tests for River Dike of Almout Diversion Dam	JICA Study Team (by employing local geological company	

(2) Geomorphology

"Almout" and "Taleghan rivers" are deeply down-cutting the catchments and are merged into a "Shahrud River" at the middle course. In between rivers, three (3) ridges, namely as Takht-e-Soleyman, Hessarchal, and Taleghan ridges, are isolated as distinct sub-parallel ranges. These ranges are extending in E-W direction and are conformable with the general bearings of Alborz mountains. The geomorphology featured for Alamout and Taleghan basin are summarized as below:

a) Features of Alamout River and Basin

The terrain of the Alamout basin is reflected by a differential degree of erosion due to rock types. Peaks in rugged mountain are resulting in hard formation (Karaj Formation). Other gentle relief is derived form soft deposits (Neogene and Quaternary Formation). Alamout river is flowing in slightly serpentine course which reflects the structure of the underlying rocks. The river has developed V-shape asymmetrical valley with slope of 15° to 30°and generally slope of river bed is 3.6%. The general pattern of the drainage is a "trellis system", comprising of a number of more or less right (N to S and S to N) streams flowing to a confluence with the main river.

b) Features of Taleghan River and Basin

The terrain of the Taleghan basin is relatively gentler than that of Almout basin. The river has developed U or V-shape valleys rimmed by high ridges with rather uniform crests. Local deep canyons with precipitous wall are topped by relatively flat plateaus and narrow gorges alternating with open-valley. Most of the subsidiary and torrential streams are deeply incised and generally lie in narrow slope sided gorges which, in many places, have walls rising to jagged summits and sheer palisade cliff. The area located the proposed tunnel routes is represented as ascending series of mountains with the high elevation of 2500 to 2800 m at the middle of alignments.

(3) Geology

The Basins include various rocks of the Precambrian to Recent, The most common lithological types are of volcanic rocks and congregates, marl, mudstone, sandstone and evaporates. A brief description of the main geologic units in basins, at proposed tunnels and diversion dam-sites are as summarized below:

a) Precambrian- Permian Formations

This characterized by Dorud Formation and Ruteh Formation, and are consist of various sedimentary rocks: sandstone, shale , mudstone, siltstone, limestone, dolomite and quartzite. These are comformably layered each other with complex structures. The distribution range is restricted to north of Almout basin.

b) Lower Triassic – Jurassic

The main formation are of Elika formation Shemshak formation comprising of limestone and dolomite, mudstone, siltstone and sandstone. The small outcrops expose in Alamout basin.

c) Eocene (Karaj formation)

The sequences of Karaj formation is featured by both volcanic and sedimentary origins: tuffs, limestone, basic to dacitic lava, basalt, basanite and andesite, acid indicated by agglomerates, gypsum and etc. This sequence widely overlies in the Taleghan basin, so that the most of tunneling section are underlain by this formation.

d) Upper Red formation

Upper Red formation is the deposits of intermontane basin of Alamout, having a complex stratigraphy owing to lateral interchange free mudstone and siltstone and gypsiferous mudstone. This is correlative with the basement of proposed diversion dams at the Almout river.

e) Pleistocene and Recent

Pleistocene deposit representing as “Terraces” are graded to several different levels and commonly reflect conformable erosion surfaces on the underlying rocks. Recent deposits overlie on “Terrace” deposits and carry thick silty clay, sand, boulders, scree and talus and moraines along riverbeds as observed at proposed diversion dam site.

f) Intrusive Rock

All dykes, sill and intrusive rocks containing monzonite, granites and dolerites, are probably post-Paleogene and there are some post Neogene lamprophyr.

(4) Faulting Systems and Seismicity

In the basins, faulting is not widespread, but apparently limited to some major faults. It is possible to have old buried faults at deeper depths inherited from past tectonic evolution. Several major faults with E-W to WNW-ESE trend pass near the Basins. Among others are the Fishan and the Shahrak Faults. Along with faulting systems, the tectonic setting of the basins are still in active with compressive tectonic stresses resulting in the present complex geological structures in Alborz Mountains. Average rate of mobilization or slip associated with seismic activity is within the range of 6 to 1 6 mm/yr in the direction of maximum shortening (N40E). As well, 50 to 100 percent of active deformation occurs seismically in Alborz Mountains.

Largest earthquake near the basins was “Rudbar-Tarom earthquake” took place on 20th June 1990 (M_0 8.8 X 10^{19} Nm, M*7.2) . This was acknowledged with at least 80 km of surface faulting along three discontinuous fault segments. Other records of earthquake is summarized as below:

- The Ray-Taleghan earthquake of February 23, 958 (Ms7.7 at 67kn)
- The east Buin-Zahra earthquake of May, 1 1 77 (Ms7.2 at 80kn)
- The Mazandaran-Gilan earthquake ofAugust 15, 1485 (Ms7.2 at 33kn)
- The Taleghan earthquake ofApril 20, 1608 (Ms7.6 at 4kn)

8.2.3 Surface Water Condition

(1) Almout River

Annual runoff of the Almout river at the diversion damsite of each alternative plan is summarized as follows:

Annual Runoff of the Almout River

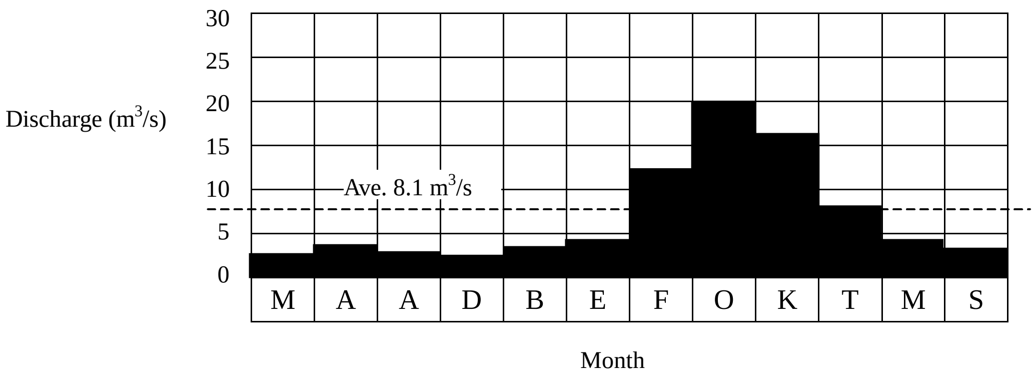
Description	Almout River				Tributary
	Khooban Site (Alt-A)	Kafarkosh Site (Alt-B)	**Dozdaksar Site (Alt-C-1 & C-2)**	The Confluence (Alt-D)	**Andah-rud River (Alt-C-1 & C-2)**
Drainage Area	247 km^2	330 km^2	**475 km^2**	721 km^2	**112 km^2**
Annual Runoff	150 MCM	160 MCM	**250 MCM**	340 MCM	**60 MCM**

As shown in Chapter 8.3, the recommendable Almout water diversion plan is Alt-C-1 which is a plan to divert the Almout water at Dozdaksar and the Andah-rud water, a tributary of the Almout, located in right bank approx. 2.6 km downstream from the Almout diversion dam. Annual runoff of the Almout at Dozdaksar is estimated to be 250 MCM and its monthly runoff is as shown below:

Monthly Runoff of the Almout at Dozdaksar

Month	Mehr	Aban	Azar	Day	Bah.	Esf.	Far.	Ord.	Kho.	Tir	Mor.	Sha.	Total
Q(MCM)	8.4	11.0	10.0	9.5	9.7	11.5	37.6	58.5	48.0	25.8	13.0	8.9	255.5 250
Monthly Rate (%)	3.3	4.3	3.9	3.7	3.8	5.9	14.7	22.9	18.8	10.1	5.1	3.5	100%
							66.6% (=2/3)						

Runoff of Almout at Dozdaksar



(2) Taleghan River

Annual runoff of the Taleghan river located downstream from Taleghan damsite is as follows:

Annual Runoff of the Taleghan Located Downstream from Taleghan Damsite

Description	Ameshk Site	The Confluence
Drainage Area	358 km^2	391 km^2
Annual Runoff	40 MCM	50 MCM

8.3 Alternative Water Diversion Plan

8.3.1 Basic Approach for Study on Water Diversion Plan

The basic approach for the study on the Almout water diversion plan is as follows;

The Taleghan Runoff Characteristics

(1) Taleghan river water could be diverted to the Qazvin plain because the water diversion tunnel between the Almout and Qazvin plain shall pass through the Taleghan river. However Taleghan water diversion plan has less possibility due to the following reasons.

- The Taleghan runoff at Ameshk site is estimated to be approx. 40 MCM/annum after completion of Taleghan dam. This small annual runoff should be used as a river maintenance flow necessary for the downstream portion from Taleghan dam.
- In case the Taleghan runoff of 40MCM at Ameshk is diverted to Qazvin plain, it is necessary to construct a pump station with a high pump head of more than 140 m, which will require high costs for construction and operation, because the river bed of the Taleghan at Ameshk site is relatively low as 1,130 m.

Elevation of Tunnel Outlet

(2) There are three alternative elevations at tunnel outlet elevations for comparative studies as shown below:

- In case the tunnel outlet is placed near the existing Ziaran reservoir site to regulate and convey the diversion water through the reservoir and the existing Qazvin north canal, the tunnel outlet elevation shall be placed at 1,450m.
- In case the tunnel outlet is provided so as to connect directly with the existing Qazvin north canal, the tunnel outlet elevation will be 1,354m.
- In case the tunnel outlet is planned so as to irrigate the central part of Qazvin plain by new irrigation canal (Qazvin central canal) instead of the Qazvin north canal, the tunnel outlet elevation will be 1,250m. Of course, 3 to 4 alternative tunnel alignments shall be studied in this plan taking into account the alternative intake sites to divert the Almout water.

Tunnel Excavation

(3) The Almout water diversion plan requires a long distance tunnel of 32 to 35km between the Almout river and the Qazvin plain. The tunnel shall be excavated by applying T.B.M method (Tunnel Boring Machine) to minimize the construction period of tunnel.

(4) In case the T.B.M method is applied for the tunnel excavation, the tunnel will be designed with circle section and diameter of more than 3.5m at least taking into account construction equipment installed in tunnel during construction such as blower, electrical cable, drainage and water supply pipes, lighting facilities, wagon to haul a bulk tunnel muck, etc.

(5) The diversion tunnels are designed to have an invert slope of 1 to 1,500 and flow in the tunnels will be open channel flow having a velocity of approx. 2.0 m/sec.

(6) The bottom of tunnel circle section shall be furnished with flat invert for purpose of tunnel inspection by car during operation and maintenance period.

(7) The diversion tunnel of 32 to 35 km long will be constructed dividing into four divisions as shown in 8.5.2.

(8) When the water diversion capacity is set up with 10.0 to 22.5 m^3/sec, the diameter of the tunnels will be 3.5 m to 4.0 m. A 3.5 m is a minimum diameter for construction and a 4.0 m is necessary diameter to flow 22.5 m^3/sec. The discharge of Almout river could be mostly diverted except the flood season discharge. Namely 60 to 80 % of the annual runoff of the Almout and the Taleghan could be diverted by diversion dam without a storage dam.

Disadvantage of Storage Dam Construction

(9) In accordance with the topographical and geologic conditions in the Almout, Kafarkosh site is most suitable damsite for storing the Almout water.

The major features of the storage dam at Kafarkosh site are roughly estimated as shown below:

Catchments Area	330 km^2	Dam Type	Rockfill Dam
Reservoir Area	1.4 km^2	Dam Crest Length	600 m
Reservoir Inflow	160 MCM	Dam Height	100 m
Normal Water Level	EL. 1,510 m	Excavation in Riverbed	30 m
Dead Water Level	EL. 1,470 m	Embankment Volume	12 MCM
Active Storage Capacity	50 MCM	Active Storage Capacity / Embankment Volume	4.2
Total Storage Capacity	70 MCM		

Note: Even if the storage dam is constructed at Kafarkosh site, Almout diversion dam should be constructed at Dozdaksar site to divert river water of more than 185 MCM.

(10) The storage dam at Kafarkosh site has the following disadvantages:

- Both banks in the reservoir area are consisting of loose overburden, which will cause land sliding and soil erosion by the fluctuation of the reservoir water level during reservoir operation.
- Dam will be required to provide a reservoir capacity for large dead storage of approx. 20 MCM taking account the sediment transport of approx. 700 m^3/km^2/year.
- Rockfill dam of approx. 100 m high and containing about 12 MCM of embankment will be required to store 70 MCM only.
- Deep riverbed excavation of more than 30 m will be required to remove alluvial deposit at the damsite.
- Some villages, farmland, existing public road and electrical line, etc., which require high cost for resettlement and compensation, are submerged into the reservoir.

8.3.2 Suitable Discharge Capacity of Tunnel

Almout water diversion plan is formulated to divert the river discharge being fluctuated monthly without control by the reservoir dam because the construction of the reservoir dam is difficult in the Almout river as mentioned in the above 8.3.1 (10) and 60-80% of annual runoff in the Almout river could be diverted by the diversion dam as mentioned below:

The Almout river shows a rich discharge in spring season but poor discharge in the other season as shown in the following table;

Monthly Average Discharge of Almout River

m^3/sec

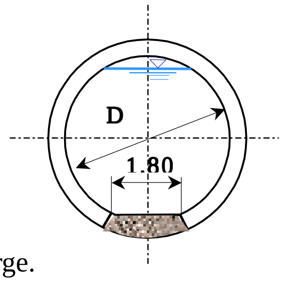
	Meh	Aba	Azr	Day	Bah	Esf	Far	Ord	Kho	Tir	Mor	Sha	Total
Baghkalyeh sta.	4.2	5.4	4.7	4.5	5.1	7.5	17.8	28.2	23.8	11.8	6.2	4.4	10.3
Dozdaksar Damsite	3.2	4.2	3.9	3.7	4.0	4.3	14.0	21.8	17.9	9.6	4.9	3.4	8.1

The value showing in the above table is monthly average one and the daily peak discharge in spring season shows 30 to 50 m^3/sec in the daily observation data.

It is judged, however, that the Almout discharge could be mostly diverted to Qazvin plain in case the tunnel with discharge capacity of 20 to 25m^3/sec is provided at Dozdaksar diversion damsite.

Annual diversion amount by the tunnel with different diameter is estimated with the following conditions:

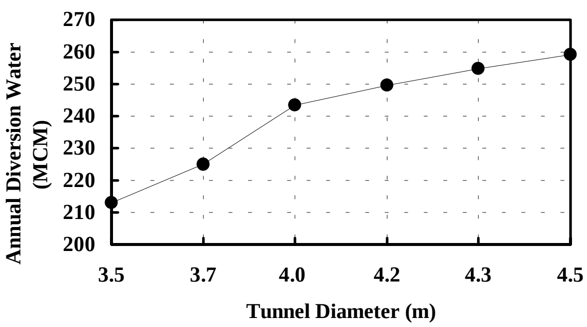
- Design discharge of tunnel is estimated by the tunnel hydraulic gradient of 1 to 1,500 taking into account the discharge velocity of 2.0m/sec.
- The Andah-rud tributary water also is diverted.
- The diversion damsite is Dozdaksar site.
- River maintenance flow is considered as 10% of daily discharge.
- Estimation for diversion amount shall be made based on daily discharge.



The estimation result is summarized in the following table.

Annual Diversion Amount by Tunnel with Different Diameter

Tunnel Diameter (m)	3.5m	3.7m	4.0m	4.2m	4.3m	4.5m
Design Discharge (m^3/sec)	15.0	17.5	22.5	25.0	27.5	30.0
Hydraulic Area (m^2)	8.812	9.883	12.032	12.924	13.987	14.788
Annual Diversion Amount (MCM) at Dozdaksar site	181.2	190.2	202.8	207.4	211.1	214.3
Annual Diversion Amount (MCM) at Andah site	31.7	34.8	40.6	42.3	43.7	44.8
Total	**212.9**	**225.0**	**243.4**	**249.7**	**254.8**	**259.1**



It is judged that the tunnel with the diameter of 4.0m is the most suitable one, in the above table, because the annual diversion amount increases largely from the diameter of 3.5m to 4.0m, but does not increase so much from 4.0m to 4.5m.

8.3.3 Alternative Water Diversion Plan

There are five alternatives of A, B, C-1, C-2 and D as shown below.

Outline of Alternative Plans

Alternative	Location of Diversion Dam		Length of Pipeline & Tunnel (km)		Location of Outlet
	On Almout river	on Taleghan river	Pipeline	Tunnel	
Alt-A	near Khooban (CA=247km^2)	-	-	33.5	Ziaran Reservoir W.L. 1,450 m
Alt-A'	① near Sefiddar (CA=317km^2) ② on Andah-rud (CA=101km^2) ③ on right bank 3 tributaries (CA=37km^2)	-	0.3	34.3	Qazvin North Canal (beginning) W.L. 1,360 m
Alt-B	near Kafarkosh (CA=330km^2)	-	0.3	34.8	Qazvin North Canal (L-2) W.L. 1,354 m
Alt-C-1	① near Dozdaksar (CA=475km^2) ② on Andah-rud (CA=112km^2)	-	Main: 6.0 Branch: 2.5	33.8	Qazvin Central Canal (planned) W.L. 1,250 m
Alt-C-2	① near Dozdaksar (CA=475km^2) ② on Andah-rud (CA=112km^2)	near Ameshk (CA=358km^2) **Pump Station** **(Q=1m^3/sec, H 140m)**	Main: 9.1 Branch: 2.5	32.8	Qazvin Central Canal (planned) W.L. 1,250 m
Alt-D	at the Confluence (CA=721(A)+ 391(T) = 1,112km^2) **Pump Station (Q=10m^3/sec, H 210m)** -		-	31.7	Qazvin Central Canal (planned) W.L. 1,250 m

Note: For detail of alternative plans, see Table 8.3.2.1.

(1) Alt-A, Alt-A' and Alt-B

The diversion dam sites of the Alt-A and Alt-B plans are located near Khooban village with riverbed elevation of approx. 1,500 m and Kafarkosh village with riverbed elevation of approx. 1,400 m respectively. The Alt-A' is a plan for diverting water of the Almout, Andah-rud and 3 tributaries located upstream from the diversion tunnel between the Andah-rud and the diversion dam on the Almout. The diversion dam site on the Almout of the Alt-A' is located near Sefiddar village approx. 4 km downstream from Khooban village with riverbed elevation of approx. 1,450 m. These plans can divert the Almout water by the gravity flow to the Qazvin plain. However, these plans are not recommendable because the amount of diversion water is only 120 - 180 MCM and the water costs come to be very high. (refer to Chapter 8.3.3 and Table 8.3.3.1 in the Supporting Report.)

(2) Alt-C-1 and Alt-C-2

The diversion dam site is selected at Dozdaksar site with the elevation of 1,293 m in order to divert the Almout water to central Qazvin plain with the elevation of 1,250 m by gravity flow. The plans can divert the Almout water of 250 MCM to the Qazvin plain by gravity flow.

The Alt-C-1 is a plan for diverting only the Almout and Andah-rud river water. And the Alt-C-2 is a plan for diverting the Taleghan water by pumps with a high pump head of approx. 140 m in addition to the Almout and Andah-rud river water diversion by gravity flow. The pump will be about 1 m^3/sec in capacity and can supply additional diversion water of 20 MCM. The Alt-C-1 is recommendable because this plan can supply the Almout water of 250 MCM with the lowest water cost to central Qazvin plain. However, it is necessary to continue the irrigation water supply of 140MCM from Taleghan dam to the high land covered with the existing Qazvin north canal after completion of the Almout water diversion project.

Outline of Project Facilities

(a) Drainage Area, Inflow and Diversion Water Amount

Alternative	Almout River			Other Rivers			Total	
	Drainage Area (km^2)	Inflow (MCM)	Diversion Water Amount (MCM)	Drainage Area (km^2)	Inflow (MCM)	Diversion Water Amount (MCM)	Inflow (MCM)	Diversion Water Amount (MCM)
Alt-A (Khooban Site) (to Ziaran Diversion Dam = W.L. 1,450m)	247	150	120	-	-	-	150	120
Alt-A' (Sefiddar Site) (to Qazvin Northl Canal = W.L. 1,360m)	317	160	130	A*1) :101 Tri : 37	50 20 Total = 70	30 20 Total = 50	230	180
Alt-B (Kafarkosh Site) (to Qazvin North Canal = W.L. 1,354m)	330	160	130	-	-	-	160	130
Alt-C-1 (Dozdaksar Site) (to Qazvin Central Canal = W.L. 1,250m)	475	250	210	A*1) :112	60	40	310	250
Alt-C$_{Direct}$:5)	475	250	210	-	-	-	250	210
Alt-C-2 (Dozdaksar Site + Ameshk Site) (to Qazvin Central Canal = W.L. 1,250m) **Pump Station (Q=1 m^3/sec, H 140m) required**	475	250	210	A*1) :112 TA*2) :358	60 40 Total = 100	40 20*4) Total = 60	350	270
Alt-D (the Confluence Site) (to Qazvin Central Canal = W.L. 1,250m) **Pump Station (Q=10 m^3/sec, H 210m) required**	721	340	-	TC*3) :391	50	-	390	220*4)

Note : *1) : Andah-rud river (Tributary of Almout river),

*2) : Taleghan river basin at Ameshk site not including Taleghan dam drainage area of 1,100 km^2,

*3) : Taleghan river basin at the confluence with Almout river not including Taleghan dam drainage area of 1,100 km^2,

*4) : Water amount pumped up from Pump Station.

(b) Project Facilities

Alternative	Diversion Dam Nos.		Tunnel Length (km)	Pipeline Length (km)	Open Canal Length (km)	Pump Station	
	on Almout	on Other River				Discharge (m^3/sec)	Pump Head (m)
Alt-A	1	-	33.5	-	5.0	Gravity Flow	
Alt-A'	1	A[*1)] : 1 Tri : 3	12.0+ 34.3	0.3	5.0	Gravity Flow	
Alt-B	1	-	34.8	0.3	5.0	Gravity Flow	
Alt-C-1	1	A[*1)] : 1	33.8	6.0[*3)] + 2.5[*4)]	-	Gravity Flow	
Alt-C$_{Direct}$[:5)]	1	-	36.8	0.6	-	Gravity Flow	
Alt-C-2	1	A[*1)] : 1 T[*2)] : 1	32.8	9.1[*3)] + 2.5[*4)]	-	Gravity Flow + Pump Station 1	 140
Alt-D	1		31.7	-	-	10	210

Note : *1) : on Andah rud river (tributary of Almout river),
*2) : on Taleghan river at Ameshk,
*3) : Main Pipeline = from Dozdaksar Diversion Dam to Tunnel Inlet (ϕ2,000mm x 3 rows)
*4) : Branch Pipeline = from Andah-rud Diversion Dam to Main Pipeline (ϕ1,800mm x 1 row)
*5) : In case of Alt-C$_{Direct}$, a tunnel inlet is located at 600m downstream from Almout diversion dam.

(3) Alt-D

The diversion dam site of Alt-D is selected at the confluence point of the Almout and the Taleghan rivers. The site is located at the downstream end of both rivers and has a rich annual runoff of about 390 MCM. However the river bed elevation at the diversion dam site is approx. 1,055 m which is very low and requires the pump station with a high pump head of approx. 210 m to take and divert the river water to the tunnel inlet. Accordingly this plan requires a high construction cost and O/M cost, and therefore this plan is not recommendable.

8.3.4 Optimum Water Diversion Plan

The project cost and O/M cost of each alternative plan are estimated as shown in Table 8.3.3.1 in the Supporting Report, and summarizes as shown below.

Project Cost and Water Cost of Each Alternative Plan

Alternative Plans	Exit or not exit of Pump Station	Project Cost (10^3 US$)	Depreciation Cost[*1)] (10^3 US$)	O/M Cost[*2)] (10^3 US$/Year)	Available Water (MCM)	Water Cost (Rls/m^3)
Alt-A	W/O P.S.	97,050	7,930	1,940	120<**185**	670
Alt-A'	W/O P.S.	130,030	10,620	2,600	180<**185**	590
Alt-B	W/O P.S.	100,980	8,250	2,020	130<**185**	630
Alt-C-1	W/O P.S.	107,260	8,760	2,150	250	350
Alt-C$_{Direct}$	W/O P.S.	105,800	8,640	2,120	210	410
Alt-C-2	W/ P.S.	121,060	10,000	2,690	270	380
Alt-D	W/ P.S.	111,290	9,510	3,260	220	460

*1) For Pump Station : i = 8 %, n = 25 years, Amortization rate = 0.0937,
For Other Facilities : i = 8 %, n = 50 years, Amortization rate = 0.0817
*2) For Pump Station = 5 % of Construction Cost of Pump Station, For Other Facilities = 2 %

From economical view points, the alternative plan of Alt-C-1 which requires the lowest water cost is recommendable.

8.4 Preliminary Design of Water Diversion Facilities

The Almout water diverted to central Qazvin plain will be mainly used for irrigation purpose, and the development projects necessary for this purpose will be as follows:

Purpose	Project	Main Facilities involved in the Project
1) Almout Water Diversion	1-1) Almout Diversion Dam Project (refer to Chapter 8.4.1)	- Almout Diversion Dam - Intake Structures
	1-2) Water Diversion Tunnel Project (refer to Chapter 8.4.2)	- Pipeline, Open Canal - Tunnel - Regulating Ponds
2) Irrigation of Central Qazvin plain	2-1) Qazvin Central Canal Project (refer to Chapter 10.3)	- Open Canal and its Related Structures

8.4.1 Preliminary Design of Almout Diversion Dam

(1) Location of Almout Diversion Dam

The Almout diversion dam will be constructed on the Almout near Dozdaksar village judging from the following site conditions. (refer to Figure 8.4.1.1) :

1) The diversion dam must be constructed on the Almout river having a river bed elevation of higher than EL. 1,285 m in order to divert the Almout water to central Qazvin plain with ground elevation of EL. 1,250 m or less by gravity flow.
2) The location of the diversion dam must be upstream from desolate wide valley located in right bank approx. 500 m upstream from Dozdaksar.
3) In order to introduce rich and clean river flow of a tributary of the Almout located in left bank 650 m upstream from Dozdaksar, the location of the diversion dam must be downstream from the mouth of the tributary.

By the reasons mentioned above, the site of Almout diversion dam is selected on the Almout approx. 600 m upstream from Dozdaksar. (refer to Figure 8.4.1.1)

(2) Site Geology

The site is approximately 600 m upstream of Dozdaksar village with co-ordinates between North latitudes 36°24'35"and longitudes 50°33". The damsite exists in high central Alborz range, a region known as Alamut-Alam Koh mountains.

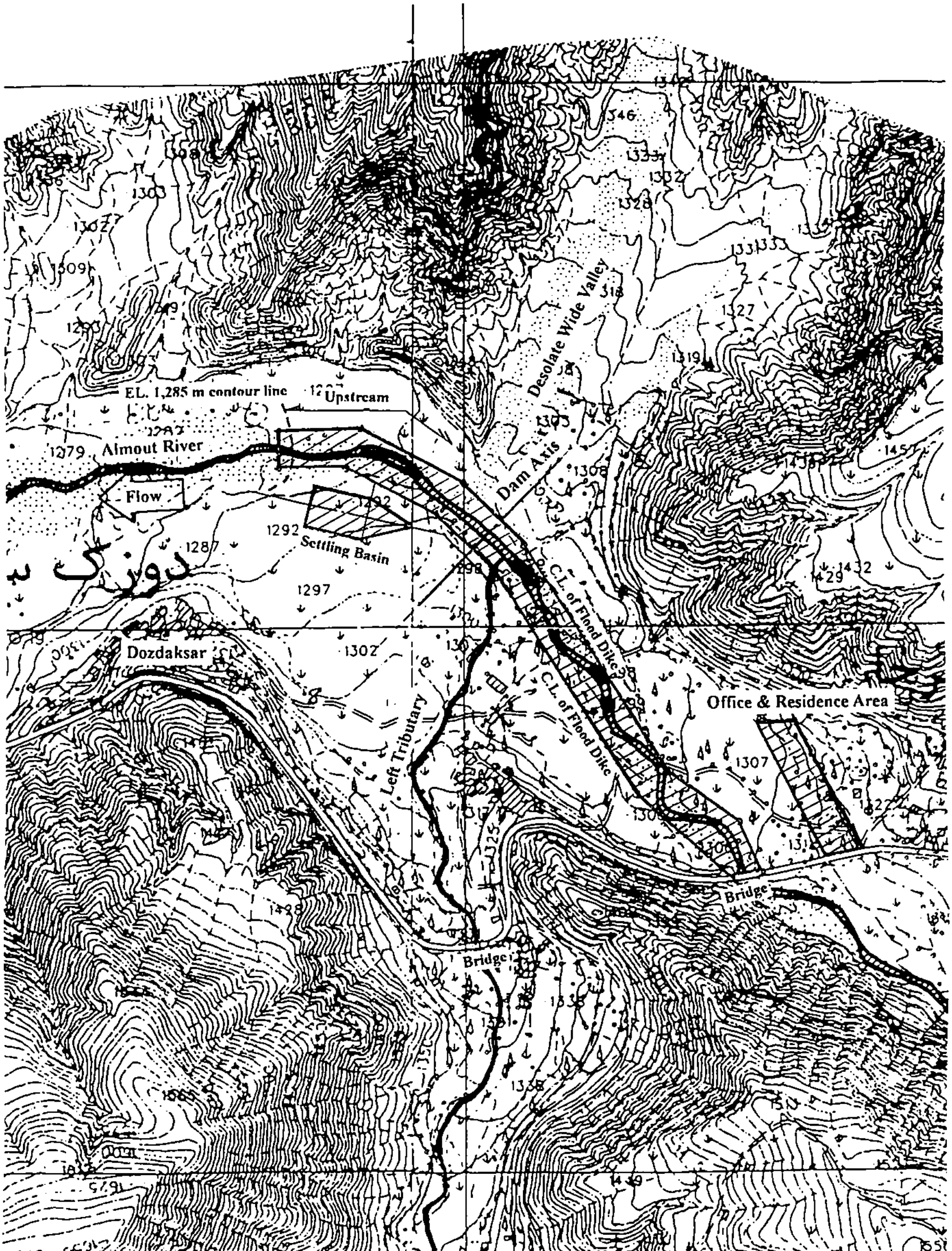


Figure 8.4.1.1 Location of Almout Diversion Dam

Topographic and geologic aspects adjacent to the site is summarized as below:

Geology adjacent to the site			
Morphology		Shape of valley is approx. asymmetrical. Slope of right abutment is from 13° to 17° while left abutment is from 15°to 20°. River bed is lain at the elevation of 1,293 m, and having 350 m long with the slope gradient of 1.4%.	
Bedrock		Bedrock is consisting of brownish brown to reddish brown marl with intercalation of thin beds; siltstones, sandstones and conglomerates. Layers dip towards the right bank with the angle of 30° to 35° in right abutment and that of 40° to 45° in the left. The ratio of marl in the all facies reaches 90 to 95%. Terrace (I) deposit is well cemented and overlays the Upper Red Formation.	
Overburden		"River Alluvium" is composed of gravels, sands and cobbles with some fine-materials with the thickness of 30 to 45 m.. "Terrace (I) Deposit" is made up of well-cemented massive conglomerates; mixed with coarse gravels, cobbles and sands; and is exposed at the upper portions of both abutments. "Young Terrace Deposit" is comprising of fine grained clays and sandy-clay, and is cropping out solely in left bank	
Geo-technical Para-meter	**Gsi**	Left bank = 30-32	Right bank = 43-45
	δ e (Mpa)	10-12	10-12
	C(Mpa)	0.13-0.15	0.26-0.3
	ψ(deg)	19-21	22-25
	Em(Gpa)	0.6-0.7	1.0-1.6
Reservoir		In the case of a proposed plan with 10 m dam height and the N.W.S. of EL.1,299 m. The reservoir area is approx. 0.03km^2 with length of 0.4 km. Reservoir is covered by the Quaternary deposit, so that the cut off wall is required in the upper section composed of the Alluvium overlain above the bed rocks.	
General Evaluation & Remarks		Fair morphologic and poor to fair geo-mechanical parameter. However the basement is mostly baring as impervious, cut-off wall in the Alluvium is required up to the basement.	

The proposed dam site is mainly oriented along the axis of the Zevarak syncline (Zevarak is the name of a village near the geosyncline axis) and is almost covered by reddish mudstones and siltstones of Neogene Upper Red Formation. This has suffered by heavy erosion and has formed unstable steep slope along with down-cutting of river, which cause landslide. In the survey, a number of scarps of landslides were traced and increase their number in concordant slope with geological bedding.

(3) Dam Type

The concrete floating dam with spillway gates is applied for the Almout diversion dam taking into account the following damsite conditions.

- The dam foundation is consisting of alluvial deposit with sand/gravel and cobbles and a deep depth of more than 30m and high permeability. It is necessary therefore to prevent the uplift through dam foundation and to dissipate the flow energy to score the riverbed.
- Large sediment transport is brought at the damsite in flood season. It is necessary to study the structure so as to release the sediment transport to the downstream smoothly.
- The river training works will be required due to the river with a steep slope of 1 to 60 which gives the scouring damage to the river banks and beds.

(4) Design Flood

The flood with a return period of 50 years will be enough for the design flood of the Almout diversion dam because few people is living in the areas along the Almout. The 50-year flood is estimated by using flood data of Galinac gauging station on the Taleghan river and Bagh Kalaye gauging station on the Almout river.

$Q1 / Q2 = (A1 / A2)^{0.6}$

where

Q1 : flood at Almout diversion site

Q2 : flood at Galinac (refer to Table 8.4.1.1 in the Supporting Report)

or Bagh Kalaye (refer to Table 8.4.1.2 in the Supporting Report)

Return Period (Year)	25	**50**	100
Probable Flood (m^3/sec) : Galinac	261.4	**295.1**	328.5
Probable Flood (m^3/sec) : Bagh Kalaye	240.1	**276.7**	313.1

A1 : catchment area of Almout diversion site = 475 km^2

A2 : catchment area of Galinac (775 km^2.) or Bagh Kalaye (678 km^2)

$Q1 = Q2 \times (A1 / A2)^{0.6}$ = Galinac Data : $295.1 \times (475 / 775)^{0.6} = 220$ m^3/sec

$Q1 = Q2 \times (A1 / A2)^{0.6}$ = Bagh Kalaye Data : $276.7 \times (475 / 678)^{0.6} = 224$ 230 m^3/sec

Based on the computation above, the design flood is decided to be 230 m^3/sec.

(5) Design Requirements and Necessary Countermeasures

It is said that the basic principle of design is to produce a satisfactory, functional structures at a minimum total cost. To accomplish this, the following items should be considered (refer to Figure 8.4.1.2).

Design Requirements and Necessary Countermeasures

Design Requirement	Necessary Countermeasures
1. The diversion dam must be stable under all loading conditions.	- The diversion dam section should be safe against sliding, shearing, overturning, etc. under design loading conditions.
2. Seepage flow through dam foundation must be controlled to prevent excessive uplift pressures, piping and excessive water loss through seepage.	- To provide sufficient concrete floor thickness against uplift pressures. - To provide curtain cut-offs to prevent piping and to reduce seepage loss.
3. The diversion dam must be safe against inflow design flood.	- To provide spillway to safely pass a design flood of 230 m^3/sec. - To provide overflow dam section to keep dam safety against a malfunction of sluiceway gates. In order to pass approx. 45 m^3/sec corresponding to 20 % of the design flood through the overflow dam section of 20 m long, H.W.L. is set at EL. 1,300.5m that is 1.5 m higher than N.W.S.
4. The diversion dam must keep function required to divert the river water into intake.	- The normal water surface is set at EL. 1,299 m, that is 6.0 m higher than the riverbed elevation, in order to provide a space for sediment. - Sediment deposited upstream the diversion dam should be removed every year and should be used to fill deeply scoured riverbed portions that may occur downstream the diversion dam. For carrying out the removing work of sediment under dry condition, a bypass canal should be provided along left side flood dike. - A settling basin is provided as a part of intake structures for introducing more clean water to central Qazvin plain. - To flash out sediment as much as possible, roller gate sections will be provided between sluiceway section and overflow dam section.
5. The diversion dam and river channel must be protected from scour caused by spillway discharge and from degradation of riverbed that may occur by the diversion dam construction.	- It will take various protection forms such as concrete floors with wet stone pitching, curtain cut-offs, riprap, ground sill, etc.

Note: Necessary machinery for removing sediment from the reservoir area is shown in Table 8.4.1.3 in the Supporting Report.

(6) Hydraulic Design

(a) Flood Discharging Capacity of Spillway

The spillway consists of sluiceway section, roller gate section, fish ladder section and overflow dam section and the sections except fish ladder section can pass flood of the Almout. The overflow dam section, is provided for safety of the diversion dam against a malfunction of sluiceway gates. The overflow dam section can pass a river flow of approx. 45 m^3/sec at H.W.L. 1,300.5m.

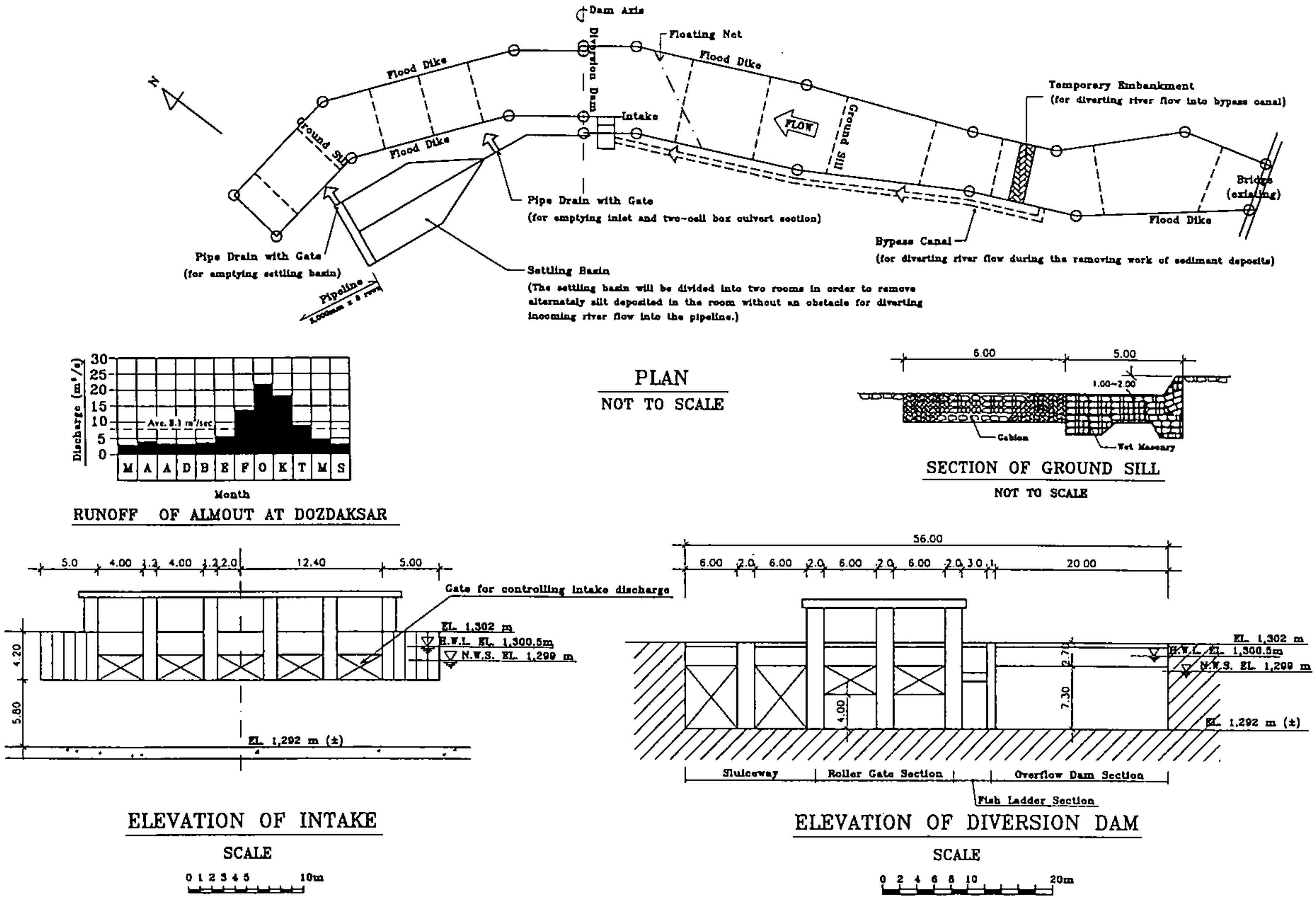


Figure 8.4.1.2 Schematic Illustration of Almout Diversion Dam

Flood Discharging Capacity of Spillway

Description	Sluiceway Section	Roller Gate Section	Overflow Dam Section	Total
H.W.L.	EL. 1,300.5	EL. 1,300.5	EL. 1,300.5	
Crest Elevation	EL. 1,292	EL. 1,296	EL. 1,299.3	
H : Water Head (m)	8.5	4.5	1.2	
L : Crest Length (m)	6 x 2 = 12	6 x 2 = 12	20	
Q : Discharge (m^3/sec)	505*1)	195*2)	45*2)	745>230m^3/sec

*1) : dc = 2/3 x 8.5 = 5.66m, q = $(2.14 \times dc)^{3/2}$ = 42.1 m^3/sec, Q = 42.1 x 12 = 505 m^3/sec
*2) : Q = 1.7 L $H^{3/2}$ (Broad Crested Weir)

(b) Head Losses in Intake Structures

The intake structures consist of three sections such as inlet section, two-cell box culvert section and settling basin section (refer to Database Map Nos. 8.3.1.2 “Site Plan” and 8.3.1.6 “Profiles of Inlet and Settling Basin”).

(i) Head Losses in Inlet Section (L = 27 m)

- Typical section = five-cell box culvert:
- Q = 22.5 m^3/sec
- A = 4.0m (B) x 1.2m (H) x 5 = 24.00m^2
- P = (1.2m x 2 + 4.0m) x 5 = 32.00m
- V = 22.5 / 24.00 = 0.938 m/sec
- Hv = $V^2/2g = 0.938^2/2 \times 9.8$ = 0.045
- R = A / P = 0.75
- I = $(n \times V / R^{2/3})^2 = (0.015 \times 0.938 / 0.75^{2/3})^2$ = 1/3,400

- Entrance loss : he = 0.5 v Hv = 0.023m
- Outlet loss : ho = 1.0 x Hv = 0.045m
- Friction loss : hf = 27.0 x 1/3,400 = 0.010m
- Total (1) : 0.078m 0.10m

(ii) Head Losses in Two-cell Box Culvert Section (L = 101 m)

- Typical section = two-cell box culvert:
- Q = 22.5 m^3/sec
- A = 4.0m (B) x 3.1m (H) x 2 = 24.80m^2
- P = (3.1m x 2 + 4.0m) x 2 = 20.40m
- V = 22.5 / 24.80 = 0.907 m/sec
- Hv = $V^2/2g = 0.907^2/2 \times 9.8$ = 0.042
- R = A / P = 1.216
- I = $(n \times V / R^{2/3})^2 = (0.015 \times 0.907 / 1.216^{2/3})^2$ = 1/7,000

- Entrance loss : he = 0.5 v Hv = 0.021m
- Outlet loss : ho = 1.0 x Hv = 0.042m
- Friction loss : hf = 101 x 1/7,000 = 0.014m
- Total (2) : 0.077m 0.10m

(iii) Head Losses in Settling Basin Section (L = 200 m)

Hydraulic Parameter	Beginning Point	End Point
B (m)	6.00 x 2 = 12.0	80.00
H (m)	3.80	6.00 (0.20)*1)
A (m^2)	45.60	480.0
V (m/sec)	0.493	0.047
Hv (m)	0.012	0.0
P (m)	27.20	92.00
R (m)	1.676	5.217
I	1/36,000	0

*1) : critical water depth (dc : m) on the vertical wall at downstream end :
$dc = 0.467\ q^{2/3} = 0.467 \times (22.5/80.0)^{2/3} = 0.20$ m

- Entrance loss : he = 0.5 v Hv = 0.006m
- Outlet loss : ho = 1/3 x dc = 0.067m
- Friction loss : hf = 200 x 1/72,000 = 0.003m
- Total (3) : 0.076 m 0.10m

(iv) Total Head Losses in Intake Structures

Total head losses in intake structures = Total (1) + Total (2) + Total (3) = 0.3 m

The water level at the end of intake = N.W.S. 1,299 m – 0.3 = 1,298.7m 1,298 m

The water level at beginning point of main pipeline is planned to be EL. 1,298 m by taking allowance of approx. 0.7 m.

(c) Hydraulic Design of Settling Basin

According to Mr. T. Yamamoto, professor of Tokyo Educational University, the width (B) and length (L) of settling basin are calculated by using following formula.

B = Q / (h・u), L = K・h・U / vg

where,

h : water depth on sediment deposited on base floor of the settling basin = 6.0 m
u : critical velocity for suspended sand particle = 0.8 x vg = 0.8 x 0.057 = 0.05
K : safety factor = 1.5～2.0 = 2.0
vg : critical settling velocity of minimum sand particle to be deposited on the settling basin

specific gravity of flow	Sand particle	0.2 mm	0.3 mm	0.5 mm	1.0 mm
1.064 (t/m^3)	vg (m/sec)	0.015	0.032	0.057	0.10

U : mean velocity of flow in settling basin = 0.15~0.20 m/sec ≒ 0.20 m/sec

B = 22.5 / (6.0 x 0.05) = 75 m < 80 m, L = 2.0 x 6.0 x 0.2 / 0.057 = 42 m < 85 m

The width and length of the settling basin were decided to be 80 m and 85m respectively

(7) Structural Design

(a) Design of curtain cut-offs

The Almout riverbeds near Dozdaksar village are composed of sand mixed with gravel and boulder, and the diversion dam is constructed on that pervious foundation. In the case of pervious foundation, the diversion dam should be designed to be safe against piping and uplift pressures. Analysis of the safety of the foundation against piping and of uplift pressures will be made based on Bligh's theory.

According to Bligh, the seepage flow creep along the line of contact between solid body under the concrete floor and permeable sand, losing head proportional to the length of its travel.

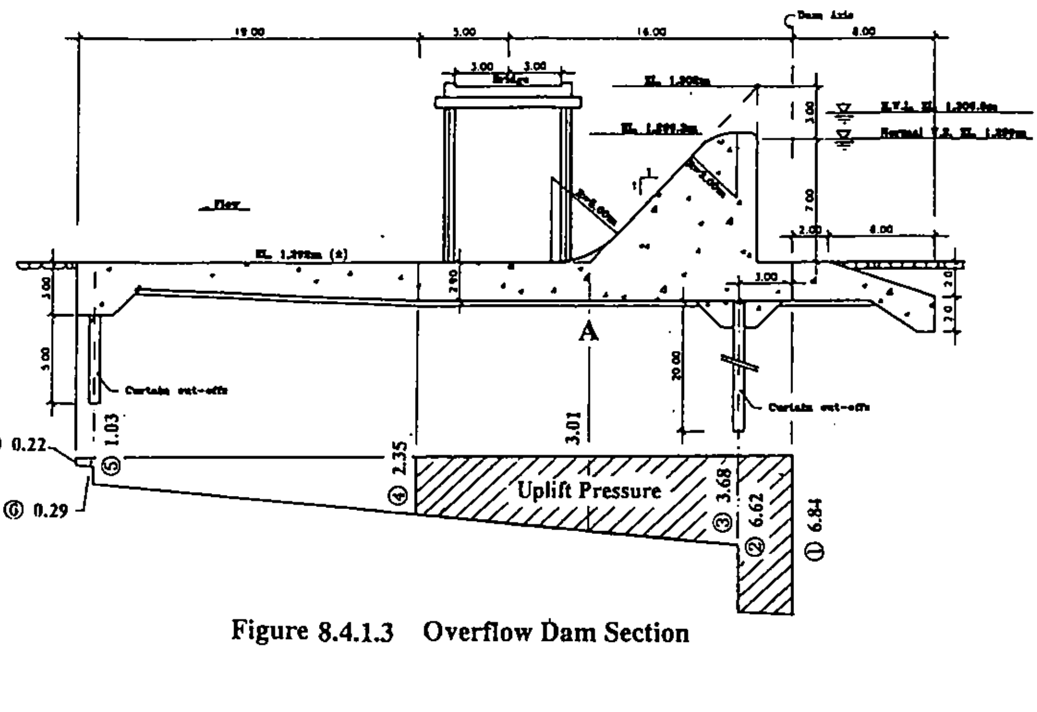


Figure 8.4.1.3 Overflow Dam Section

In Figure 8.4.1-3, length of creep would be :

L = 2.2 + 20 x 2 + 40 + 5 x 2 + 3 = 95.2 m

The loss of head per unit length of creep would be :

C = H / L = 7.0 / 95.2 = 1 / 11 < 1/9 (Safe Hydraulic Gradient as shown in table below)

Recommended Safe Hydraulic Gradients by Bligh

Foundation Materials	Recommended Safe Hydraulic Gradients
1. Light sand and mud	1/18
2. Fine micaceous sand	1/15
3. Coarse grained sand	1/12
4. Sand mixed with gravel & boulder	**1/9 to 1/5**

(b) Thickness of Concrete Floor

Creep length to point A (refer to Figure 8.4.1-3) : La = 2.2 + 20 x 2 + 12 = 54.2 m

Residual uplift pressure at A : Ua = H x (1- La / L) = 7 x (1- 54.2 / 95.2) = 3.01 t

Necessary thickness of concrete floor would be :

T = Ua / (G-1) = 3.01 / (2.4 – 1) = 2.15 m < 2.2 m (design thickness)

where, G = Unit weight of concrete floor = 2.4 t / m^3

(c) Stability of Dam Body against Sliding

The stability of overflow dam section against sliding at N.W.S is as follows (refer to Figure 8.4.1.3) :

Point	Creep length upto each point Lb : (m)	Residual uplift pressure at each point U = (1 – Lb / 95.2) : (t / m^2)
①	2.2	6.84
②	5.2	6.62
③	45.2	3.68
④	63.2	2.35
⑤	81.2	1.03
⑥	91.2	0.29
⑦	92.2	0.22

Residual uplift pressure : $\sum$U = 1/2 x (6.84 + 6.62) x 3.0 + 1/2 x (3.68 + 2.35) x 18.0 = 74.46 t

Weight of Overflow Dam Section

(i) 1/2 x (2.7 + 10.0) x 7.3 x 2.4 = 111.25 t

(ii) 2.2 x 2.1 x 2.4 = 110.88 t

Total W = 222.13 t

Water Pressure : P = 1/2 x 1.0 x 7.0^2 = 24.5 t,

Coefficient of internal friction of the foundation material :f = tan ϕ = tan 35 ° 0.7

Safety Factor for Sliding = (W – U) x f / P = (222.13 – 74.46) x 0.7 / 24.5 = 4.2 > 2 o.k

(8) Design Drawings

Based on the considerations above and Engineer’s experience, the design drawings of pre-feasibility level are provided for Almout diversion dam project as shown below.

Database Map No.	Title of Drawings
8.4.1.1	Geologic Conditions of Almout Diversion Damsite
8.4.1.2	Location of Borrow Area
8.4.1.3	Location Map
8.4.1.4	Site Plan
8.4.1.5	Elevations of Diversion Dam and Intake
8.4.1.6	Sluiceway Section and Roller Gate Section
8.4.1.7	Fish Ladder Section and Overflow Dam Section
8.4.1.8	Profiles of Inlet and Settling Basin
8.4.1.9	Alternative Spillway Plan (Rubber Dam Plan)

8.4.2 Preliminary Design of Pipeline and Tunnel

The water diverted at the Almout diversion dam is conveyed to Qazvin plain with the pipeline and tunnel. The preliminary design for the pipeline and tunnel on pre-feasibility level is carried out taking into account the following conditions; (refer to Figure 8.4.2.1) :

(1) Water Level

In accordance with the hydraulic analyzes to divert a designed discharge of 22.5m^3/sec, the water level at the major site is defined as follows;

- Diversion Damsite W.L 1,299m
- Inlet of Pipeline W.L 1,298m
- Inlet of Tunnel at Almout River W.L 1,276.5m
- Tunnel Crossing Site at Taleghan River W.L 1,271m
- Outlet of Tunnel at Qazvin Plain W.L 1,254m

(2) Water Pipeline

The water pipeline is proposed at the site between the diversion damsite and tunnel inlet in the Almout river and with the long of 6.0km and designed discharge capacity of 22.5m^3/sec. The branch pipeline to convey additional water at the Andah-rud tributary with a length of 2.5km also is proposed.

The water in the pipeline is to be conveyed under the pressure with a head of 70m to the tunnel inlet. The following items are studied in the preliminary design.

- The pipeline of 6.0km passes through paddy field of 4.5km, river bed of 0.6km, asphalt road of 0.7km and mountain foot of 0.2km and reaches the tunnel inlet. Foundation along the pipeline alignment is formed with the consolidated alluvial layer having a enough bearing capacity to support the pipeline, in case the alluvial plain is excavated into a depth of 4 to 5m for embedding the pipe.

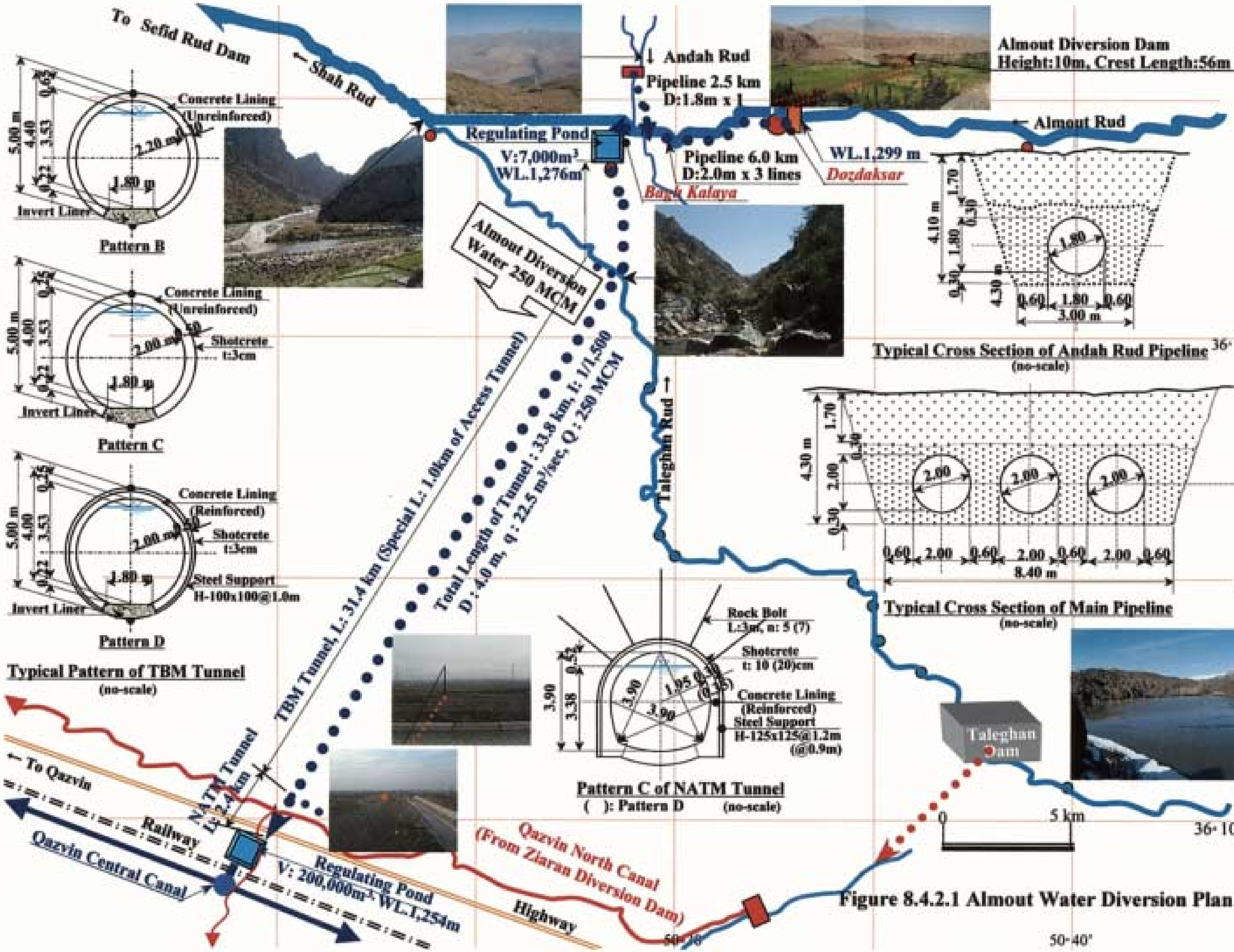


Figure 8.4.2.1 Almout Water Diversion Plan

- The pipeline is designed with steel pipe with a diameter of 2.0m and three rows in the main line and 1.8m and one row in the branch line. The discharge velocity is approx. 2.4m/sec.
- The regulating pond with a capacity of 7,500m^3 is to be provided to dissipate flowing energy in the pipeline and control fluctuated discharge daily.

(3) Tunnel Inlet at Almout Basin

The tunnel inlet at the Almout river basin is proposed at the mountain foot near Bagh Kalaye Village about 6km downstream from the proposed diversion damsite taking into account not only the topographic and geologic conditions but also the following conditions;

- The site to be able to place the tunnel with the shortest distance from the Almout to Qazvin plain.
- The site to be able to keep the designed intake water level of 1,276.5m to diver the water to Qazvin plain.
- The site to have less environmental impact to tunnel construction such as resettlement of villages, tombs, farm lands, etc.
- The site to have no dangerous conditions such as land sliding, soil erosion, rock fall, etc.

(4) Tunnel Crossing Site in the Taleghan River

The tunnel after passing through the mountain between the Almout and Teleghan river shall cross the Taleghan river and then shall pass through again the mountain between the Taleghan river and Qazvin plain.

Since the tunnel at the crossing site in the Taleghan river shall be embedded in the riverbed from view point of easy construction method and cheaper construction cost and also easy maintenance during the water conveyance, the designed water level of the tunnel at the crossing site is approx. 1,271 m. The crossing of the Taleghan river by aqueduct and deep siphon shall be avoided. Accordingly the tunnel crossing site in the Taleghan river is placed at the riverbed with the elevation of approx. 1,267 m near Dine Kooh village.

It is rather difficult to access this tunnel crossing site because of no access road, the steep river slope, V type valley with a short river width, etc. Access road for construction shall be constructed along the river course with the embankment of gravel and rock.

As the tunnel crossing structure is embedded in the riverbed, the access road for the operation and maintenance will not be required, except the periodical inspection.

(5) The tunnel outlet at Qazvin plain shall be selected at the site behind the existing railway and along No.2 secondary canal of Qazvin north canal. The site is lying between the existing large

thermal power plant site and Chicken cottages and has a large uncultivated area, where the regulating pond is provided to control the outflow for the tunnel.

(6) Tunnel Alignment

The tunnel alignment is placed at the elevation of 1,280m to 1,250m under the high mountain with the elevation of 2,000 to 2,500m. The geological conditions along the tunnel alignment is as follows;

- The mountain is formed mainly with volcanic rocks such as andesite and basalt belonging to the Karaj Formation and mud stones and conglomerates belonging to the Upper Red Formation. Those rock layer where the tunnel is excavated is assumed to be very hard and consolidated and low permeability, although some cracks, fishers and faults are existing.
- It is assumed that the tunnel formed with the above rock formation could be excavated with T.B.M method (Tunnel Boring Machine). In accordance with the tunnel excavation experience in the existing Taleghan tunnel having the similar geological condition, the tunnel length of more than 80% could be excavated without protection of steel support and many water leakages.
- However, the tunnel alignment of about 2.0km at the Qazvin plain is to be placed at the consolidated overburden. It is required accordingly to protect the excavated surface by steel support and steel sheet and to provide the drainage system to drain leakage water.
- Though the tunnel have a long distance of 33.8km, the tunnel construction is carried out with the following 4 Divisions;

Division 1	Almout to Talegan	8.0 km
Division 2 & 3	Taleghan to Qazvin plain	23.4 km
Division 4	Overburden reach in Qazvin plain	2.4 km

(7) Tunnel Section

The tunnel section is designed as follows based on the geological conditions along the tunnel and hydraulic conditions to release the discharge of 22.5m^3/sec.

- The tunnel inner section is designed with the circle type of the diameter of 4m through the rocky mountain, while the horseshoe type through the overburden area at Qazvin plain. The hydraulic slope is 1 to 1,500 and the discharge velocity is approx. 2.0m/sec.
- The tunnel structural section is designed with concrete lining thickness of 30cm at the section without steel support and 50cm at the section with steel support. Shotcrete, wire net, rock bolt will be used to protect the rock falls after tunnel excavation. Steel support with type of H-100 to 125 will be used.

- As the geological investigation works along the tunnel alignment was not carried out due to the pre-feasibility study level, tunnel structural section is assumed as follows based on the surface geological reconnaissance, existing geological information in the Almout and Taleghan mountain and the past excavation data for the existing Taleghan tunnel.

Pattern of Design Ground Support (Per Unit Length of TBM and NATM Excavations)

Grade of Base Rock	Classification of Application Base	Method of Ground Support	Method of Lining	Pattern of Ground Support
C_H-C_M Grade	The base rock with fear of collapse and fall of rocks in the long term, having the development of small cracks in it even though it is still hard	Shotcrete of fiber mortar if necessary	Plain concrete lining	B
C_M-C_L Grade	Having the development of cracks there is a fear of fall of rocks immediately. The base rock with fear of collapse and fall of rooks for a long term	Shotcrete of fiber mortar (t = 3cm) {Rock bolt and steel support H-125 @1.2m with shotcrete of mortar t=10cm}*2		C
D Grade	The natural ground which needs the ground support to prevent too much variation toward the inner cross-section acting earth pressure by the looseness of the ground	Steel ring ground support with shotcrete (H-100 @1.0) {Rock bolt and steel support H-125 @0.9m with shotcrete of mortar t=20cm}*2	Reinforced concrete lining	D

Note) 1. The invert liner (invert segment) is applied all through the patterns of ground support of TBM.

2. *2 applied for NATM excavation.

(8) Preliminary Design Result

The preliminary design result is summarized as follows.

1) Pipeline

Main Pipeline: Steel pipe : Length 6km, ф2.0m, 3 rows

Branch Pipeline: Steel pipe : Length 2.5km, ф1.8m, 1row

Designed Discharge: Main pipeline : 22.5m^3/sec, Branch pipeline : 4 m^3/sec

2) Tunnel

Tunnel Length: 33.8 km in Total

Design Discharge : 22.5m^3/sec

Hydraulic Slope : 1 to 1,500

Tunnel Hydraulic Section : Circle or Horseshoe type with diameter of 4m

Tunnel Concrete Living Thickness : 20cm for tunnel without support,
50cm for tunnel with support.

8.5 Construction Plan

8.5.1 Diversion Dam and Pipeline Works

As the construction of diversion dam is not a large scale and does not require the particular construction methods, it could be easily carried out by Iranian Contractor taking into account the following attention;

- It is easy to access the construction site by the existing provincial road from Qazvin city. Only some access roads will be provided at the damsite.
- Construction materials of sand and gravel and cobbles for concrete and masonry works are easily available at the Almout riverbed being formed with a large alluvial plain. Borrow area of the earth materials for the dike works in the river training is scattered at both banks along the river.
- Gate and steel pipes can be manufactured by Iranian factory.
- The cut-off works with a depth of 20m is only difficult works due to the river bed consisting of alluvial layer with large cobbles.
- As many villages, farm land, irrigation system, provincial and village roads are existing along the river, the particular attention shall be paid for those properties during construction.
- Construction quantity of the diversion dam and pipeline is summarized as follows.

Item	Quantity	Remarks
1. Diversion Dam		
Foundation excavation	60,000m^3	Sand & gravel materials
Dike embankment	320,000m^3	
Concrete Works	40,000m^3	
Cut off Wall	2,300m^2	Depth of 20m
Intake roller gate	5 units	2.0m height × 4.0m width
Spillway radial gate	2 units	7.5m height × 6.0m width
Spillway roller gate	2 units	3.5m height × 6.0m width
2. Pipeline		
Main pipeline	6.0km	φ2.0m x 3 rows
Branch pipeline	2.5km	φ1.8m x 1 row

8.5.2 Tunnel Works

As the tunnel works require a long tunnel distance of 33.8km and are excavated with T.B.M machine, it will be carried out with the foreign contractors having the technology and deep experience for the works. The construction plan for the tunnel works proposed by JICA Team is as follows;

(1) Construction Diversion

The tunnel of 33.8km is divided four construction divisions as follows;

Number of Division	Name of Tunnel	Length	Excavation Volume	Concrete Volume
Division 1	Almout mountain tunnel	8.0km	156,000m^3	38,000m^3
Division 2	Taleghan mountain tunnel	12.0km	240,000m^3	58,000m^3
Division 3	Qazvin mountain tunnel	11.4km	239,000m^3	59,000m^3
Division 4	Qazvin plain tunnel	2.4km	52,000m^3	22,000m^3

- The tunnels of Division 1, 2 and 3 are proposed to be excavated with T.B.M but Division 4 by NATM (New Austrian Tunnelling Method)
- Division 1 tunnel is excavated from the tunnel inlet at the Almout river to the outlet at the Taleghan river by one T.B.M. All temporary works such as contractor's camp and workshops, concrete plant, access road, etc is provided at the Almout river basin. Tunnel mucks shall be hauled to the spoil bank along the river.
- Division 2 tunnel is excavated from the tunnel inlet at the Taleghan river to the outlet of Qazvin mountain tunnel by one T.B.M. The particular access road of 6km long from Ameshk village to tunnel inlet will be provided for construction purpose along the Taleghan river with steep slope of 1 to 60 and some water falls of 3 to 4m. The contractor's camp and other facilities for construction are provided at the plateau area near Ameshk village. The tunnel mucks will be wasted at the spoil bank to be constructed by weirs and drops along the river as shown in Database Map.
- Division 3 tunnel is excavated from its outlet to the center of the Taleghan mountain. The inclined adit shall be installed at the outlet to have tunnel mucks and tunnel concrete. Many depressions are existing at the mountain foots in Qazvin plain and could be used easily for the spoil bank of Division 3 tunnel.
- Division 4 tunnel is excavated from its outlet to the outlet of Division 3 tunnel. As the tunnel alignment is consisting of consolidated overburden, the tunnel section shall be protected with steel support and sheet and drainage facility to drain leakage water through tunnel section is required. The tunnel mucks will be used for the embankment material for the canal construction and regulating pond required in the new central canal works.

(2) Tunnel Construction Equipment

Construction equipment to be used for the tunnel works is proposed as follows.

(in case of Division 2)

Construction Equipment	Dimension	Remarks
1. Common Equipment		
Water supply pipe	ф100mm×12km	
Lighting facility	40W at 10m interval	Lighting in tunnel
Electrical cable	12km with transformer	
Drainage pipe	ф150mm×12km	
Dust discharge pipe	ф400mm×12km	Vinyl pipe
Water supply pump	1 unit with boosters	Water supply to T.B.M
Drainage pump	ф150mm×24 units	
Air ventilation	400cu.m/min×24 units	15.5kw×2×24
Dust collector	500cu.m/mix×1 unit	
Dust water treatment plant	20cu.m/mix×1 unit	
2. Excavation Equipment		
TBM (Improved Open-Type)	excavation dia.: 5m	Disk-cutter:17 inches (432mm)
Attached cars to follow of TBM	8 to 10 nos.	
Battery locomotive	12 ton x 6sets (max.)	
Rail-Type muck-car	6m^3 x 4cars/train×6sets (max.)	Dump type
Carrying in equipment & material		with battery locomotive
3. Shotcrete Equipment		
4. Lining Equipment		
Steel Form (L:12m)	Dia.: 4.4m (for pattern B), 2set &: 4.0m (for pattern C, D), 1 set	
Agitator Car	6m^3 use, 10 nos.	
Concrete pump	30 m^3/hr×1 unit	
Battery locomotive	10 ton x 8 sets (max. addition)	

(3) Construction Schedule

Diversion and pipeline works could be constructed within three years but tunnel works will require a long construction period of 5 years as follows.

Item	2006	2007	2008	2009	2010	2011
1. Diversion Dam & Pipeline Works						
(1) Diversion dam						
(2) Pipeline work						
2. Tunnel Works						
(1) Tunnel Division 1 8,000m						
Temporary works						
Excavation works (32 months)				250m/month		
Concrete Works						
(2) Tunnel Division 2 12,000m						
Temporary works						
Excavation works (48 months)				250m/month		
Concrete Works						
(3) Tunnel Division 3 11,400m						
Temporary works						
Excavation works (45 months)				255m/month		
Concrete Works						
(4) Tunnel Division 4 2,400m						
Temporary works						
Excavation works (24 months)				100m/month		
Concrete Works						

8.6 Project Cost Estimation

8.6.1 Construction Cost

The construction cost is estimated with the following process.

- Calculation of working quantity based on the design drawings and construction plan.
- Collection and review of the prevailing unit price for the civil works and steel mechanical works.
- Estimation of tunnel construction works by using the foreign technology such as T.B.M and NATM.
- Construction cost is classifying into the foreign and local portion.
- Construction cost is estimated by US$ currency.

The estimated construction cost is summarized as follows.

Unit: 10^3 US$

	Total Amount	Foreign Portion	Local Portion
1. Almout and Andah Diversion Dam Works			
Sub-total	**4,600**	**2,300**	**2,300**
2. Pipeline Works			
Sub-total	**15,700**	**7,850**	**7,850**
3. Tunnel Works			
Division Ⅰ 8.0 km	19,200	14,400	4,800
Division Ⅱ 12.0 km	30,700	23,030	7,670
Division Ⅲ 11.4 km	30,800	23,100	7,700
Division Ⅳ 2.4 km	12,300	9,220	3,080
Sub-total	**93,000**	**69,750**	**23,250**
4. O/M facility			
Sub-total	**2,500**	**2,000**	**500**
Total	**115,800**	**81,900**	**33,900**

8.6.2 Project Cost

Project cost shall include the other expenses of engineering, administration, land acquisition, environmental mitigation, etc in addition to the construction and is estimated as follows;

Unit: 10^3US$

Item	Total Amount	Foreign Portion	Local Portion
1. Construction Cost	115,800	81,900	33,900
2. Engineering & Administration Expenses	5,800	4,060	1,740
3. Land Acquisition Expenses	1,100	0	1,100
4. Environmental Mitigation Cost	900	0	900
Total	**123,600**	**85,960**	**37,640**
	100%	69.5%	30.5%

8.6.3 Water Cost

The water cost is estimated with the following conditions.

Project Cost	123,600,000US$
Depreciation Cost (P.C. x 0.0817)	10,098,000US$
O&M Cost (2% of Project Cost)	2,472,000US$
Total	12,570,000US$
Available Water	250,000,000 m^3/year

Water cost = 0.050US$/$m^3$ = 400 Rials/m^3

CHAPTER 9.

EIA FOR ALMOUT WATER DIVERSION PROJECT

CHAPTER 9 EIA FOR ALMOUT WATER DIVERSION PROJECT

9.1 Summery of Almout Water Diversion Project

(1) Title

The title is Almout Water Diversion Project.

(2) Objective

The objective of the Project is to formulate the Almout water diversion plan to divert the Almout river water by transbasin to Qazvin plain for purpose of the irrigation.

(3) Project Area

The Project area is the Almout river basin covering the basin area of about 720 km^2 and especially the area along the river course with a length of about 30km between Haranak village site and the conjunction site of the Almout and Taleghan river. Location map of the Environmental Study Area is shown in Figure 9.1.1.

In accordance with the study of several alternative water diversion plans from the Almout river to Qazvin plain, the following plan is proposed as the most suitable plan.

Items	Alternative C-1
・Diversion Site	・Dozdak Sar ・Area; Diversion Dam site: 10 ha Camp house: 2 ha
・Type of Flow	Gravity flow
・Intake Elevation	1,299 m
・Outlet Elevation at Qazvin	1,250 m
・Diversion Water Quantity/year	250 MCM
・Diversion Dam	One Unit
Main Pipeline Length	6.0 km
Branch Pipeline Length	2.5 km
Tunnel Length	33.8 km

9.2 Existing Environmental Conditions

9.2.1 Natural Environment

(1) Natural Conditions

(a) Topographical and Geological Conditions

The Almout river basin is located at the coordinates between North latitudes 36 ° 17’ 22” to 36 ° 31’ 21” and longitudes 50 ° 22’ 50” and 50 ° 52’ 50”.

The total basin area is 721 sq.km at the conjunction point of the Taleghan river. The basin belongs to the high central Alborz range with the elevation of 3,000 to 4,000m and is formed with the following topographical conditions;

High mountain area with elevation of 2,000 to 3,500m	………………	70 %
High plateau area with elevation of 1,500 to 2,000m	………………	20 %
Alluvial plain with elevation of 1,000 to 1,500m	………………	8 %

The landform classified by the elevation is shown in Database Map (Fig 2.2.1.1).

Mountain and plateau areas are generally formed with steep slope and weathered rock formation covered with thin overburden, where no vegetation exists due to cold climate in winter and no rainfall from June to October.

Although many springs and tributaries are found in mountain and plateau area and release a rich flow in spring season from April to July, they have scarce or no water in the other season. A number of landslides and soil erosions have occurred in the area caused by topography with steep slope, no vegetation, poor soil, and scouring energy of melting snow flow in spring season.

The alluvial plain is expanding along the river course with a width of 100 to 500m and relatively steep slope of 1 to 50. Although the plain is formed with a thick sand and gravel materials, paddy plantation has been dominant by farmland preparation with soil transportation and spreading on the plain. Although no pedagogical survey has been carried out in the basin, it seems that different soil texture can be recognized as follows;

Region	Soil Texture		
	Light	Medium	Heavy
North-North eastern	○		
East-South eastern		○	
Southern	○	○	
Central		○	○
Western		○	○

Data Source; Lar Consultant

Although soil depth at mountain area is shallow as 0 to 20cm, that in plateau area is deep as more than 1.0m

Geological conditions in the basin are the same as that of Alborz mountain range and are formed with the rock formations of silt and sand stone, conglomerate, green tuff, marl, etc. Long and many faults exist along the east-west direction in the river basin. Earthquakes of 5 to 6 Richter have occurred in the basin as shown in Table 9.2.1.

Table 9.2.1 Major Earthquakes of the Basin in 20th Century

date	Ms	mb	km
1901	5.4		6
1962		5.5	84
1962		5.0	92
1963			97
1964		5.1	89
1980	4.8	5.0	85
1980		5.4	92
1980	4.7	5.1	85
1990	5.2	4.9	109
1990	5.0	4.6	60
1990	5.1	4.7	72
1990	4.9	5.4	81
1990	5.3	5.8	69
1991	5.0	5.7	99

Data Source; Lar Consultant

(b) Climate Conditions

The Almout river basin shows the moderate climate conditions as shown in the following data as compared with the semi-arid condition in Qazvin and Tehran area.

Item	Almout	Qazvin/Tehran
Summer Temperature	22℃	27℃
Winter Temperature	2℃	3℃
Annual Average Rainfall (Winter)	480mm	300～250mm
Annual Evaporation	1,800mm	2,500mm

Rainfall in the mountain area shows often the high value of 800mm but that in winter season from November to March changes to snowfall. Since the climate in summer is very cool, many peoples living in Qazvin city have used the Almout basin as the summer resort area.

(c) Surface and Ground Water Conditions

(i) Almout River System

The Almout river originates at the Alborz mountain area with the high elevation of 3,500m, flows down with the direction from the east to west and joins the Taleghan river. The river length is about 50km presenting a very steep slope of 1 to 30 in the upstream and 1 to 50 in the downstream. There are 13 large tributaries as shown in Table 9.2.2.

Table 9.2.2 Major Tributaries in Almout River

Name	Length (km)	Discharge (λ/sec)	Annual Runoff (10^3m^3)
Baqdasht	2.5	15	470
Zavarak	0.8	20	630
Moalemkelayeh	1.0	60	1,890
Haranak	1.0	10	310
Kafarkosh	1.0	12	380
Dozdaksar	6.0	15	470
Evanak (Ⅰ, Ⅱ)	0.5	60	1,890
Varak (Ⅰ, Ⅱ)	0.5	60	1,890
Koushkdasht (Ⅰ)	0.5	60	1,890
Koushkdasht (Ⅱ)	0.5	40	1,260
Gazorkhan	0.5	70	2,210

Data source; Lar Concultant

(ii) River Runoff

Average monthly runoff of the Almout river at Baghkalyeh station with a catchment area of 678km^2 and a long term observation record of more than 30 years is shown in Table 9.2.3 These data have been estimated by comparing the runoff of the Taleghan river at Galinak station and the Shahrud river at Siahdasht station.

Table 9.2.3 Monthly Runoff of Almout, Taleghan and Shahrud

River	Catchment Area (km^2)	Meh 10	Aba 11	Aza 12	Day 1	Bah 2	Esf 3	Far 4	Ord 5	Kho 6	Tir 7	Mor 8	Sha 9	Total
		Low Water						High Water				Low Water		
1. Runoff (MCM)														
Almout	678	11.2	14.0	12.7	12.0	12.4	20.1	46.1	75.5	61.7	31.7	16.5	11.5	325.3
Taleghan	775	10.8	14.5	13.3	11.4	11.9	21.8	66.4	116.4	94.4	39.4	17.3	10.7	428.3
Shahrud	2,445	19.2	31.3	33.9	29.8	33.8	68.4	143.2	177.4	151.5	81.4	32.0	13.7	815.6
2. Runoff Yield (mm)														
Almout	678	16.5	20.6	18.7	17.7	18.3	29.6	68.0	111.4	91.0	46.8	24.3	17.0	480
Taleghan	775	13.9	18.7	17.2	14.7	15.4	28.1	85.7	150.2	121.8	50.8	22.3	13.8	553
Shahrud	2,445	7.9	12.8	13.9	12.2	13.8	28.0	58.6	72.6	62.0	33.3	13.1	5.6	334
3. Discharge (m^3/sec)														
Almout	678	4.2	5.4	4.7	4.5	5.1	7.5	17.8	28.2	23.8	11.8	6.2	4.4	10.3
Taleghan	775	5.2	5.6	5.0	4.3	4.9	8.1	25.6	43.5	36.4	14.7	6.5	4.1	13.6
Shahrud	2,445	2.9	12.1	12.7	11.1	14.0	25.5	55.2	66.2	58.4	30.4	11.9	5.3	25.9

Data source; Lar Consultant

As is clear in the above Table, the runoff during the high water season from April to July occupies a large portion of 65 to 75% against the annual runoff because of melted snow flow in spring to early summer. The period from August to November is the low water season due to no rainfall and less melted snow flow, while the period from December to March also is the low water season because rainfall in this period is mostly changed to snow and accumulates in the high mountain as the snow pile.

The maximum discharge during flood season in the Almout river is 100 to 120 cubic-meter/sec at June to July and brings about some flood damage for the paddy area, while the minimum discharge is 2.0 to 3.0 cubic-meter/sec at October and November, which gives no influence for the water use in the basin because of no cropping season.

It is said that the large sediment load of 200 to 300 m^3/km^2/year will appear at the flood season in the Almout and Taleghan rive caused by the soil erosion and land sliding in the basin and the strong scouring energy of the river with the steep river slope of 1/30 to 1/50.

9.2.2 Ecological Environment

The ecological environment of the proposed project area and its vicinity have been studied in more detail by using available data and field surveys including fish sampling at the area expanding in the southern part of the Caspian Sea and sample analysis of the river water quality at three locations. These ecological habitats in the Almout river basin are identified in paddy fields, plantation area, village gardens, shrub lands, main rivers course and tributaries, and valley and mountainous areas.

The flora diversification of the basin has been established with regard to habitants and the inventories of the plants have listed in the Supporting Report. Mammals, birds, reptiles and fishes species in the basin have also been illustrated in Database Map (Figure 9.2.2.1 and Table 9.2.2.1 to 9.2.2.21).

The ecological environment conditions are summarized as follows.

(a) Flora Diversity

Iran is rich in flora diversity. The country protects a total of around 8000 plant species in the 150 families and is one of the major countries of endemism in the field of the world.

Endemics of Iran have been listed on the base of defined IUCN (International Union for the Conservation of Nature and Natural Resources 1994), and about 22 percent (%) of them are endemics, which belong to 85 families of the total one. In total there are the number of 1727 endemics in the country. Over the whole country there is an average of 10.5 endemic species per unit (million hectare) and major provinces of dominant endemic are Azarbaijan, Khorasan, Fars, Lurestan and Tehran province. Tehran and Lurestan provinces, among others, are the richest in endemics.

Nearly 60 % of endemic species of Iran belong to *Papilinonacae family* (394 species) that also has been identified in the Study Area, *Compositae family* (393 species), *Labiatae family* (129species) and *Umbelliferae family* (100 species). With regard to the genus class in the classification of taxonomical hierarchy, the huge numbers of endemic species within the Iranian flora are e.g. *Astragalus*, *Cousinia*, *Acantolimon*, *Onosma* (the four (4) of these species identified in the study area) and *Dionoysia genus.*

This implies that *Astragalus* (common name: Milk vetch) is probably one of the largest numbers of flowering plants in the world and Iran as well. All of these dominated genus inhabitant in the

Irano-Turanian Region. In addition, genus classification *Cousinia* with 210 spiny species, in which nearly 74 % of them are endemics and its distribution dominates on the mountainous areas with steeps slope and cold atmospheric condition in the Irano-Turanian Region. It plays an important role of the conservation of soil erosion.

In respect to the category of threatened, the basic statuses of Iran flora are as follows:

Only 15 % of endemic plants in Iran are annuals plant and shrubs/tree species and the rest 85 % are herbaceous perennials. About 3.9 % of the total number of VU (Vulnerable) and EN (Endangered) species are annuals. Therefore Iran's endemic flora is rich in herbaceous perennials life form.

Concerning to the human impacts, 32 % of VU/EN species have been affected by human activity such as over grazing, illegal harvesting for medical and for other purposes.

Allium hirtifolium that is identified species in the Study Area, and genus *Danae racemosa* in the *Liliaceae* family are extremely example plants that have been badly damaged by the influence of mankind. In the olden times, in spite of the both species being well distributed, but nowadays face over harvesting by human.

The status of flora in the Almout river basin has been identified to segregate woodland and shrubs and almost of this area is whole covered with shrubs. The two kinds of flora inhabit segregation due to ensuring survival. These plants species in the Study Area have been recorded rich in diversity of 251 species in the 63 families (long list Table 9.2.2.2 to 9.2.2.11). The short list of species in the EIA study is made of the base of the IUCN 1994 Red Data List classification to focus the threatened species (Table 9.2.2.1). As mentioned above, so many EN/VU species have been identified in the Study Area, i.e. *Astragalus, Cousinia, Acantolimon, Onosma and Allium hirtifolium* that listed in the species Red Data List of IUCN as EN/VU and LR (Lowe Risk) species. Some typical plants in the project area are illustrated in distribution map in Figure 9.2.2.1.

The classification of IUCN mainly focus on rare, threatened and endangered species, but, there are still number of species which are seriously declining due to quite widespread and even common, but identified too familiar to be place within the published categories as IUCN. Moreover, the major current efforts in international organizations have been concentrated on listing threatened species, however every species inhabits not only play major role in ensuring survival of the existing species, but they are also the main source background of existing environmental conditions and future speculation as well.

(b) Fauna

(i) Mammals

An abundant mammal in Iran is described like a showcase of wild habitants from the European, the African and Asian regions as well as endemic Iranian species. Some examples are 1) Fat dormouse, Badger and Roe deer, which inhabit in northern and northwestern area of Iran are European original species, 2) Desert hedgehog, Egyptian fruit bat and Honey badger, which inhabit in the south and southwest are African in origin, 3) Palm squirrel, Indian gerbil and Asian black bear, whose distribution is in the east to southeast, belong to the fauna of the Indian subcontinent and 4) Persian squirrel, Firouz's jerboa and Persian ibex, are native mammals of Iran as some samples of many others original species.

22 species of mammals intotal have been recorded in the Study Area (Table 9.2.2.12 to 14). Six (6) endemic/rare species of these animals also have been listed in the Study Area, namely *Panthera pardus* (Persian leopard), is listed in the species Red Data List of IUCN as EN (Endangered) species. *Capra aegajrus* (Persian ibex) has been identified in the Red Data List of IUCN as VU species and highly protected by DOE in the designated Hunting Free Zones as well. According to the latest census by DOE, about 203 in numbers of Persian ibex has been recognized in this region.

Canis lupus (Persian red wolf) also listed as a LR:lc (Lower Risk: least concerned) species of the IUCN and CITES (Convention on International Trade in Endanger Species of Wild Fauna and Flora). Inhabiting numbers of this species about 40 wolves in and around Study Area. In addition, many other species inclusive of *Myotis mystacinus* (Whiskered bat) and *Miniopterus schreibersi* (Schreiber's bat) have been identified as the threatened (Protected) species in the Hunting Free Zones by local framework. The biggest animal of this area *Ursus arctos* (Big brown/Grizzly bear) has been identified as a top of the ecological system. Another mammalian species *Sub scrofa* (Wild boar) inhabits as a popular and nuisance animal to agricultural products. This population is about 170. The distribution map of these habitants is illustrated in Figure 9.2.2.2.

All of these EN and VU species are not confined to the project area and its vicinity inclusive of proposed site and alignment of diversion dam/tunnel and inhabit either in other regions of mountainous areas, water zones or throughout the country.

In this basin, some kinds of animals/endemic species such as wild bear or leopard that depend on living things in the river as in part of feedings may be affected by their food shortage during the construction phase. These animals prey on insect, fish, small vertebrate and invertebrate living things such as crabs.

(ii) Birds

Many species of birds are identified in the Study Area (Database Map Table 9.2.2.15 and 9.2.2.20). It is clear from the Table, habitat areas of these species are widely spread from Europe to China and therefore these include resident species as well as migratory ones e.g. *Caracias gerrulus* (European roller), *Streptopelia senegalensis* (Laughing dove) and *Sturnus vulgaris* (Common starling). The two VU species are *Neophron percnopterus* (Egyptian vulture) and

Aegypius monachus (Black vulture) and one species of the Lower Risk least concerned (LR:lc) is *Miluas migrans* (Black kite). As shown in the Table, there are five (5) and more protected species according to the DOE of Iran in 1996, *Neophron percnopterus* (Egyptian vulture) is a small species. It also eats insects and other bird eggs and it is one of the few creatures to use a tool. In order to break into a egg the vulture drops rocks on it to crack it open. The parents incubate 1 to 2 eggs for about 40 days. The distributions of map of various kinds of birds are illustrated in Database Map (Table 9.2.2.13 and 9.2.2.14).

(iii) Reptiles

Testudo horsfieldii (Tortoise) in the *Testudinida* family that is sub species of *Testudo graeca* UV classified has been present in the Study Area (Database Map Table 9.2.2.21). This species tortoise has a moderately domed shall and a small spur in the thigh part of each front limb. They court in spring and the eggs usually 2 or 3 in a clutch are laid in May to June. It generally hatches in September to October, although this varies with the local climate. The most abundant of family is *Colubridae* (small to medium size slender snake) of about twenty (20) species.

All these species are not confined to the project area and its vicinity. They are distributed throughout the country of aquatic zone and some of them are found in the arid zone too.

(iv) Fishes

There are 23 families and 139 species of fish in inland water of Iran. The *Cyprinidae* family (English name called 'carp species') comprises fifty-eight percent (58 %) of total species and the *Balitoridae* family (English name called 'loach species') contains ten percent (10 %) of total one of inland water in Iran. The total percentage of the two (2) families is sixty-eight percent (68 %) and the other families of twenty-one (21) families comprise less than five percent (5 %) each other.

It is clear from mentioned above that the *Cyprinidae* family (Carp species) is the most abundant in the country, which consists of two genera e.g. *Barbus (barbell)* with 16 species and *Capoeta (lenkoran)* with 8 species respectively. Its *Capoeta (lenkoran)* genus is widely spread living in every freshwater zone and therefore the 2 families (*Cyprinidae* and *Balitoridae)* are living in same as resident. In addition, fish specie of Caspian Sea that the Almout and Taleghan rivers flow into the sea is also rich in diversity and Tigris and Euphrates rivers basin as well.

Recent year, there are some endangered and threatened fish species such as *lranocypris typhlops* (Cave fish**)**, *Acipenser nudiventris* and *Huso huso* (Beluge/European sturgeon) due to habitat limited by development project, illegal fishing and habitat deterioration by surface water quality pollution, but these species do not identified both of the Almout and Taleghan rivers by field survey so for.

In order to identify the fish species in the Almout and Taleghan rivers basin, samples of the fish have been taken low water levels conditions of these rivers in September. Some fishes species are migratory in limited area and their distribution is depended on the altitude of living and water temperature. Field survey of fish sampling has been conducted at the five (5) times in total for obtaining the characteristics of fish such as taxonomical category, population, fish figure size and so forth.

In accordance with conventional sampling techniques, i.e. cast and scoop netting along longitudinal transects and measured quadrate farming of the streambed and use electro-shocker (1.7kilo watt/hour), specimens were captured at the sampling locations. The location of fish sampling is three (4) stations, i.e. 1) the first location is close to the Garma Rud village, 2) the second location is close to the Kalan village 3) the third location is close to the Bagh Dasht, and 4) the fourth location is close to Shir Kuh village along the Taleghan river (see Figure 9.2.2.3). The fish population of the rivers has been estimated by mean of Lecren Method. Finally the sampled specimens of fish brought buck to the laboratory by the bottle of formalin liquid 10 % concentration that fixed them to inspect taxonomical category.

Fish species by sampling in the Almout and Taleghan rivers are listed by taxonomical classification (Table 9.2.5(1) to (3)). The characteristics of fish in the both rivers are quite similarly classification with three (3) orders on the base of taxonomy i.e. Cypriniformes, Salmoniforme, and Teraodontiformes. The family *Cyprinadae* in the Cypriniformes inhabits with four (4) genus (*Alburnoides, Barbus, Capoet* and *Leuciscne*) and six (6) species (*bipunctatus, capito, lacerta, mursa, capoeta and cephalus*). They are considered the most dominant of fish in the Almout river basin. An additional abundant species, *Nemachelus angrea* (Angora loach) in the Teraodoniformes has been recognized the population of 125 numbers by the field works in the limited area of 80 m length of river and 10 m width of that at a time.

With regard to the Red Data List of IUCN classification, several threatened species of fish inclusive of endemic are presented in the Sefiudrud river.

The Critically Endangered (CR) is *Acipenser nudiventris* (Ship/Sheap Sturgeon) and *Huso huso* (Beluga, Giant sturgeon) is EN and Near Threatened (NT) is *Petromyzontidae* (Caspiomyzon wagneri) and three species at VU (Vulnerable) are *Acipenser gulddenstadti,*(Russian/Persioan Sturgen), *Acipenser persicus/stellatus* (Kura sturgeon) and Conservation Depend (CD) is *Acanthalburnus microlelepis* (Black brow bleak) and four species are Dada Deficient (DD) or Least Concern (Lc). Many species of fish are important for ecosystem of water bodies as well for food and ornamental.

9.2.3 Socio-economic and Culture

The area can be categorized difference between primary and secondary impacts. The two (2) categories of the environmental study area are shown in below:

- The primary impact area: Active Population Zone (APZ)
- The secondary impact area: Impact Population Zone (IPZ)

(a) The Active Population Zone: (APZ)

The proposed diversion dam site and alignment diversion dam/tunnel directly affect the inhabitants in the Active Population Zone (APZ). While the APZ divided into two regions: 1) the region where located in low land of Almout river basin, i.e. Almout Paein district, and 2) the region where located in higher land of Almout river basin, i.e. Almout Bala district.

The name of villages that are located in the both sides along the Almout river in the APZ are as follow: Kafarkosh, Haranak, Medan (these three (3) villages belong to Almout Paein) and Laman, Shutorkhan, Dozdaksar, Shahrak, Baghkelayeh, Baghdasht, Shirkuh and Ameskh (These eight (8) villages belong to Almout Bala). The distribution map of these villages is illustrated in Figure 9.2.3.1.

From in this figure, almost of all the area affected where is located the diversion dam site and alignment of diversion dam/tunnel is Almout Bala district.

(b) The impact population Zone: (IPZ)

Considering the impacts on the implementation of proposed diversion project, this zone is affected by the indirect impacts during operation phase due to operation of diversion dam, pipeline and long tunnel and maintenance facility as well. Consequencetly, Rudbar Shahrestan is the component of IPZ zone.

Some characteristics of the two (2) zones and other districts for references are summarized in Table 9.2.4

Table 9.2.4 Population and Area and Population Density (1990-1997)

Name of Division	Nam of District	No. of Villages	Population	No. of Households	Area (km^2)	Density (persons/ km^2)	Employment	
							Male	Female
Roudbar Almout	Paein (APZ)	37	4,131	1,013	1,320.4	3.1	880	130
	Bala (APZ)	39	4,775	1,245	1664.3	2.9	1,037	302
	Moallen Kalayen	23	6,033	1,466	767.0	7.9	1,205	286
	Total/Average	99	14,939	3,724	3751.6	4.0	3,122	718
Roudbar Sharestan	Dastjerd	23	2,325	5,40	1096.5	2.1	649	523
	Shahrestan (IPZ)	41	7,624	1,658	1714.3	4.5	2,160	621
	Mohammad	44	10,040	2,093	1569.5	6.4	3,138	765
	Total/Average	108	19,898	4,291	4380.3	4.5	5,947	1,909

Source: Organization of Plan and Budget in Qazvin Province, Encyclopedia of Villages in Qazvin Area Statistic of Population and Houses in 1996, (1999)

(2) Population Characteristics in APZ

In the Rudbar Almout division, there are 22 abandoned villages and about 94 to 99 villages exist at present. The statistical characteristics of eleven (11) villages selected in APZ are as shown in Table below.

Village Name	No. of Resident unit	No. Families	Population of Aged Category				No. of Literacy	
			Total	0-14	15-64	>65	Male	Female
Kafar	12	13	46	15	24	7	18	23
Haranak	47	50	228	82	125	21	97	90
Mejan	87	90	438	193	212	33	163	163
Laman	44	44	192	74	101	17	66	85
Shotor Khan	43	43	203	72	114	27	71	87
Dozdak Sar	18	18	95	35	57	3	28	44
Shahrak	62	66	247	81	145	21	97	103
Bagh kallareh	24	24	90	23	52	15	38	41
Bagh Dasht	50	51	235	90	125	20	92	93
Shirkah	7	7	41	19	20	2	11	16
Ameshk	8	8	44	14	24	6	17	19
Total	402	414	**1859**	698	999	172	698	768
							1466	
Note:							1466/**1859**: (80 %)	

(3) Infrastructure

This section describes the existing conditions of infrastructure of project area and affected area such as road network, water supply, electricity and broadcasting, educational facility, medical facility and necessity of the environmental study.

(a) Roads and Transportation

Provincial and village roads are existing in the project area. Donkeys or horses usually use for the transportation of goods and agricultural products in mountain areas. There are three main access roads to connect the out side area and these roads are, i.e. Akbarabad , Esfaran and Bahramabad roads. There are some villages with asphalt-paved road, e.g. Kafar kosh, Shotor Khan and Shahrak village.

(b) Water Supply System

The water supply system for drinking water of the eight (8) villages in the eleven is could not treat and it is used to surroundings spring. Only in the remaining three (3) villages tap water is available. Water use for agriculture is used river water of Almout river in all of the villages except Ameshk. In case of the Ameshk, its location is high altitude and lack of a pumping system and therefore spring water is being used for agriculture. In this region, the irrigation water of agricultural land in need has been the shortage of available in deed. These existing conditions of water supply system are listed in Table below.

Name of Villages	Source of Water Supply	Water use for Agriculture
Kafar	Untreated tap water (spring)	River
Haranak	Same as above	Same as above
Mejan	Same as above	Same as above
Laman	Untreated tap water (spring) shared by Shotor Khan village Same as above	Same as above
Shotor Khan	Untreated tap water (spring) shared by Laman village	Same as above
Dozdak Sar	Treated tap water	Same as above
Shahrak	Same as above	Same as above
Bagh kallareh	Same as above	River and Spring
Bagh Dasht	Untreated tap water (spring)	Same as above
Shirkah	Same as above	Same as above
Ameshk	Same as above	Spring

Source: Lar Consultant

(c) Electricity and broad casting

The majority of villages is connected to electricity network and covered by radio and TV broadcasting. The almost of all the villages have Islamic Councils and some services such as Cooperatives. Center for rural services facilities is shared with neighboring villages. These conditions are well listed in Table below.

Unit: (number)

Name of District	Electricity	Radio broadcasting	TV broadcasting
Almout Bala	32	39	37
Almout Parin	23	36	20
Moalem Kelaye	13	18	13
Total	68	93	70

Source: Lar Consultant.

(4) Education

According to 1996 census, the numbers of 13,589 children are counted in the age group of 6 years and more in Roudbar Almout district. In this group, the literacy ratio for male and female are 72.7 percent (%) and 61.6 percent (%) respectively. As shown in the Table below the literacy ratio is more than illiterate one, and literacy ratio of male is more than female one.

Unit: (%)

Age group	Male		Female	
	Literacy ratio	Illiteracy ratio	Literacy ratio	Illiteracy ratio
6-10	95.8	4.2	96.0	4.1
11-14	98.5	1.5	99	1.1
15-24	97.9	2.1	95.8	4.2
25-64	59.4	40.5	39.3	60.8
> 65	20.7	79.3	2.8	97.2
Average	72.8	24.2	61.6	38.4

Source: Lar Consultant

The education system in the eleven (11) of the study villages is summarized in Table below. It is clear from the table that the almost of all villages have several facilities for the elementary and advance levels is available the villages near by.

Name of Village	Elementary School	Secondary School	High School	No. of Students	
				Female	Male
Haranak	Utilizing Haranak facilities	Utilizing Haranak facilities	Utilizing Shahrak facilities	11	8
Kafar	*	*	Same as above	65	50
Mejan	*	Utilizing Haranak facilities	Same as above	76	72
Laman	*	Utilizing Mohmoudabad facilities	Same as above	27	33
Shotor Khan	*	Same as above	Same as above	45	55
Dozdak Sar	Utilizing Mohmoudabad facilities	Same as above	Same as above	40	35
Shahrak	*	Same as above	*	31	30
Bagh kelayeh	Utilizing Shurestan facilities	Utilizing Shahrak facilities	Utilizing Shahrak facilities	8	12
Bagh Dasht	*	Utilizing Mohmoudabad facilities		50	40
Shirkah	*	-	-	3	4
Ameshk	*	Utilizing Mohmoudabad facilities	-	2	4

Source: Lar Consultant,   In the columns donated by asterisk (*) mean the available equipment

(5) Health and Medical services and Diseases

The numbers of medical services are summarized in Table below. The numbers of five (5) medical centers in the area trace are identified and villagers have access other health facilities with the service available.

Unit: (number)

Name of District	Bath	Medical center	Pharmacy	Health house	Physician	Dentist	Dental technician	Midwife nurse	Health technician	Veterinary surgeon & technician
Almout Bala	17	2	0	9	0	0	0	6	4	0
Almout Paein	11	2	2	6	1	1	1	6	2	0
Moalem Kelaye	13	1	1	4	2	1	1	3	3	1
Total	41	5	3	19	2	2	2	15	9	1

Source: Lar Consultant   Note: In the columns denoted by asterisks mean the available facilities

By balancing the conditions of health facility in various villages, it is understandable that Shotor Khan and Shahrak are among the only villages, which will benefit from Health Centers. Other villages are have been used the facilities of these two. In almost of all villages have an equipment of private baths.

No endemic diseases were identified or announced in any villages except for Daman village where Malt fever was recognizes as a common disease, which cause by faultily food.

Illegal disposal of solid waste in the villages has not been controlled to follow up any organized plans/programs. Sometimes local people have been conducted to treat burning of solid waste, discharging into waste banks/rivers and valleys

The sewage system in seven (7) of the eleven (11) villages is equipped with septic unit system (wells) and four (4) other villages' sewage is discharged into the river.

(6) Present Land Use in the Affected Area

The existing Agricultural Land Use data have been made to know the existing agricultural water use demand and the amount of agricultural products by each village that is located in the downstream area on the both sides along the Shahrud river. The existing Landuse/crops categories have been identified clearly the characteristics of them by total of the district. The major land use categories and agricultural products in this area are the rice (about 40 % of total), wheat (irrigation, about 16 % of total) and barley (irrigation, about 11% of total). The Table 9.2.5 shows the existing agricultural Landuse pattern in the downstream area and the mapping is illustrated in Figure 9.2.3.2.

9.2.4 Water Quality

The surface water quality in the Almout river presents generally good condition for drinking, based on the water quality test at Baghkolaye station. It is said that fertilizer and pesticides in agricultural development, domestic wastewater, household garbage, etc will pollute the river water especially the low water in summer and winter season.

Water quality test in the EIA study carried out to get the latest situations of pollution load at three sampling stations (the up-stream, the middle-reaches and the down-stream) in the Almout river (see Figure 9.2.4.1). Laboratory tests of water quality are summarized in the following Table.

Unit (ppm)

Item	pH	DO	EC	BOD_5	COD	$PO4^-$	$NH4^-$-N			$NO2^-$-N			$NO3^-$-N		
							up	mid	don	up	mid	don	up	mid	don
	8.2	8.9	621	11	31.7	0.3	0.47	1.1	3.2	0.07	0.17	0.22	4.43	4.0	4.9

Note: Values in the column show the average of three sampling stations except for Nitrogen compounds (N-)

The levels of BOD and COD are judged to be relatively high as compared with the international standards.

The levels of $NH4^-$-N, $NO2^-$-N and $NO3^-$-N have also been measured increasing toward the down stream along the river. In this test, the most significant water pollution impact is the contamination of Nitrogen compounds by the agricultural chemicals such as insecticides, herbicides and fertilizers come from the surrounding agricultural lands. Domestic wastewater effluent (sewage) is also another contributing to the pollution load.

9.3 EIA by the Project

9.3.1 Study on Initial Environmental Examination (IEE)

The initial environmental examination (IEE) is studied together with Lar consultant to identify the issues for the Environmental Impact Assessment (EIA) study for the water diversion plan.

(1) Natural Condition

(a) Land Sliding and Soil Erosion

The land sliding and soil erosion have occurred in the river reaches between Haranak and Baghdast village, where the intake facility of the water diversion plan is proposed. When the reservoir dam is proposed in this river reach, the reservoir capacity will be easily filled by the collapsing and sliding materials at both banks of reservoir which are brought from the water level fluctuation in the reservoir. It is not recommendable to propose the reservoir dam at this river reaches. When the diversion dam is proposed, it shall be required to provide the particular scouring sluiceway to remove a large amount of sediment load in the diversion site.

(b) River Bed with Steep Slope

The riverbed slope is very steep as 1/50 to 1/70 at the river reaches where the water diversion is proposed. It is necessary to take a particular care to protect the riverbed from scouring flow energy in the diversion plan. The river training works will be required at the upstream and dam stream of the diversion dam site.

(c) Water Diversion by Transbasin

As the Almout water diversion plan is set up by the transbasin method, the following items shall be carefully studied.

- Potential water use for irrigated agriculture at the downstream area and for river maintenance taking into account fish migrant and growth of aquatic grasses.
- Estimation of surplus water to be diverted to Qazvin plain taking into account the above potential water use.
- Impact to the existing Sefied-rud reservoir located at the end of the Shah-rud river and under operation for irrigation and hydropower purpose.

(2) Ecological Condition

(a) Greenery Area

Although the mountain and plateau areas have no vegetation except some plateau area covered with natural grazing in only spring season, the large greenery areas consisting of trees, grazing and farmlands exist at the alluvial plain along the river course. These greenery areas are very important one from viewpoint of ecological conditions and living conditions of inhabitant in the Almout basin and shall be preserved. It is necessary accordingly to avoid the lost of greenery areas by the Almout water diversion project.

(b) Fish Migrant

Various kinds of fishes are living and migrating in the river. In order to maintain the fish migrant, the fish way and ladder shall be planned in the diversion dam taking into account migrating characteristics of different fish species. In the river training works, it is desirable to design the structure by masonry works instead of concrete works and the river channel with rapid and slow flow velocity, meandering shape and sandbank taking into account fish migrant.

(3) Socio-Economic Condition

(a) Losses and Resettlement in Dam Plan

In case of the diversion dam plan, the losses of farm lands, villages, greenery areas, public and private utility, social infrastructures, shall be surveyed and studied.

(b) Irrigated Agriculture and Socio-Economic Development in Downstream Area

As the downstream area of damsite and along the river course will become the donor basin because the existing surface water is donated to Qazvin area. Accordingly the irrigated agriculture and socio-economic development in the downstream area will be set up in order to take the people consensus for the project implementation.

(c) Social Infrastructure

Social infrastructure such as provincial and village road, domestic water supply system in villages, public electric and telephone lines, etc. in the river basin shall be improved to give the better living conditions to inhabitant in the donor basin.

(d) Cultural Assets

Very old and important cultural assets are existing in the high land of the Almout basin. The particular care for those assets and access road to them shall be paid during construction period.

(4) Mitigation Plan for Impact of Implementation

(a) Contractors Camp and Workshop

Contractor’s camp and workshop area shall be selected far from the existing village and farm areas and constructed with sufficient sanitation facility and treatment plant for wasted water.

(b) Construction of Diversion Dam

- River diversion in the temporary works shall be constructed not so as to take place the riverbed scouring and sediment accumulation during flood season.
- In the earth works such as excavation and fill works including treatment at borrow area and

spoil bank, the particular care shall be paid for the land sliding and soil erosion, the reduction of green area, the protection of existing infrastructures and farm lands etc. at the working site. The borrow area and spoil bank shall be treated after collection of soil material and deposit of excavated material so as to be able to use for farm land, grazing area, recreation area, etc.

- In the concrete and drainage works, the particular care shall be paid for the wasted and drainage water in the works not so as to pollute the river water and groundwater.
- In the water operation of the diversion dam, the particular operation rule to divert the irrigation water to Qazvin and release the irrigation and river maintenance water to the downstream area shall be set up. It is necessary to monitor and evaluate the releasing water to the downstream area during water operation at the diversion dam site.

(5) Checklist and Matrix

Checklist and matrix based on the study on I.E.E are prepared as shown in Table 9.3.1 and 9.3.2.

9.3.2 Impact by Water Diversion

The water diversion by transbasin will give generally a large impact to the land use, ecological conditions, socio-economic conditions, agriculture, etc in the downstream area. The Almout diversion project, however, will not give a large impact to the downstream area, because there are not existing many villages and large farm area, specific fishes and aquatic plant, etc along the river.

Of course, there is existing some agricultural area along the river in the downstream and the irrigation water shall be allocated to such area.

(1) Water Allocation in Almout River Basin

As the paddy field of about 1,000ha is expanded and has used the Almout water for its irrigation, the water diversion plan is set up to diver the water of 250MCM per annum from the annual runoff of 310MCM at the proposed damsite. The comparison of monthly discharge between the Almout river and diversion amount is shown in the following table.

Monthly Average Discharge of Almout River and Diversion Water

Unit: m^3/sec

River	Meh	Aba	Aza	Day	Bah	Esf	Far	Ord	Kho	Tir	Mor	Sha	Total
	Autumn		Winter				Spring			Summer			
Almout River	4.2	5.4	4.8	4.5	5.1	7.5	17.8	28.2	23.8	11.8	6.2	4.4	10.3
Diversion Water	3.1	4.6	4.7	4.3	4.1	5.4	12.2	18.5	15.8	9.1	3.7	2.1	8.0
Downstream Water	1.1	0.8	0.1	0.2	1.0	2.1	5.0	9.7	8.0	2.7	2.5	2.3	2.3

The discharge of more than 2.0m^3/sec is released to the downstream during spring to summer season and can cover sufficiently the irrigation water demand in the paddy field.

As the autumn and winter season does not require the irrigation water, the water to be released to downstream is limited at 0.1 to 0.2m^3/sec only for the river maintenance.

(2) Decreasing Discharge at Shiahdasht station in Shah-rud River

The Almout river reaches the Shiahdasht station in the Shah-rud river after joining the Taleghan river. The paddy area of about 1,000ha also is developed in Shiahdasht area and requires irrigation water.

Average annual runoff at Shiahdasht is about 815MCM, which will decrease by the Taleghan and Almout water diversion. The comparison of monthly discharge between the Shiahdasht station and diversion water of Taleghan and Almout is shown in the following table.

Decreasing Monthly Discharge at Shiahdasht Station by Water

Unit: m^3/sec

	Meh	Aba	Aza	Day	Bah	Esf	Far	Ord	Kho	Tir	Mor	Sha	Total
	Autumn		Winter				Spring			Summer			
Shiahdasht	7.5	11.7	12.7	11.1	12.6	25.5	53.5	66.2	56.6	30.4	12.0	6.1	26.0
Taleghan Water	3.5	5.7	4.9	4.4	4.8	9.3	27.8	40.7	33.9	14.6	6.6	3.2	14.0
Almout Water	3.1	4.6	4.7	4.3	4.1	5.4	12.2	18.5	15.8	9.1	3.7	2.1	8.0
Downstream Water	0.9	1.4	3.4	2.4	3.7	10.8	13.5	7.0	6.9	6.7	1.7	0.8	4.0

Shiahdasht station will have still sufficient water to release the downstream in spring to summer season to cover the irrigation water, even if both waters of the Taleghan and Almout are diverted to Qazvin plain.

(3) Upgrading of the existing Irrigation System

There are existing several irrigation systems with masonry weirs crossing the river, intake installed at river banks and canal on the farm land. Though available water by those irrigation facility will be guaranteed by the water release from the diversion dam as mentioned above, the water level in the river is considerably decreased and the intake by the system will be fairly difficult. Accordingly. The upgrading works to introduce the irrigation water smoothly by the system shall be planned and implemented for farmers engaging in irrigated agriculture in the Almout river basin.

9.3.3 Impact by Construction and its Mitigation Method

Construction works for diversion dam, pipelines and tunnel will bring about the following impact to the existing natural ecological and socio-economical conditions. Of course those impact is not serious and can be solved and mitigated easily by applying the proper countermeasures.

(1) Land Acquition and Compensation

Some land acquition and compensation will be required at the diversion damsite, the area along the pipeline, spoil bank of tunnel muck, access road, etc. There is no village resettlement in the construction site but some farm land will be lost by the works. It will be necessary to provide some new farm area at the site near tributary mouth where can easily get the irrigation water.

(2) Management of Contractor’s Camp and Workshop

Contractor's camp and workshops shall be provided at the site far from the existing village and with the following facility.

- Sufficient sanitary facility, waste water treatment plant grabage box and yard, electrical and water supply system, etc.
- Safety measures providing fence, guardman, clinic, illumination system access road with sufficient width, alarm signal, fire fighting facility, etc.

(3) Earth and Concrete Works

The following countermeasures for the earth and concrete works shall be required.

- Proper treatment for the excavation site, borrow area and spoil bank so as to prevent the land sliding, inundation, polluted water, etc.
- Provision of storage pond and treatment equipment for the wasted and polluted water released from drainage works and concrete works.
- Suspension of night works to prevent noise of construction equipment.

(4) Tunnel Works

The following countermeasures for the tunnel works shall be required.

- Protection method for land sliding at the inlet and outlet and rockfall and water leakage at the inside of tunnel.
- Installation of facility and equipment with sufficient capacity for drainage, water supply, ventilation illumination at inside and outside of tunnel.
- Proper arrangement of spoil bank for large quantity of tunnel mucks.

(5) Necessity of Rural Development

As the Almout river basin is the donor basin to transfer the Almout water to Qazvin plain and inhabitant in the basin will be suffered from construction works, the following rural development works shall be implemented.

- Installation of dispensary, mosques, school, public hall, etc.
- Provision of irrigation facilities, domestic water supply system and culture fish ponds.
- River training works to protect flood and road networks among villages.

9.4 Impact of Taleghan and Almout Water Diversion to Manjil Dam

9.4.1 Background

Two major tributaries of Qezel Ozan and Shah-rud join near the town of Manjil to form the Sefid-rud river that flows northward finally emptying into the Caspian Sea as visualized in Figure 9.4.1.1.. The Manjil dam (Sefid-rud dam) was constructed in 1961 at immediate downstream of the conjunction of two tributaries, at a location with the catchment area of 57,800 sq.km having an average annual inflow of about 4,650 MCM (80.4 mm of runoff yield). The dam is the major source of water consumed for irrigation, domestic water supply, fishery and environmental uses in the Giran plain. Outline of the dam/reservoir is given below:

- Purpose:	Agricultural water supply and power generation
- Location:	At Manjil, 80 km south of Rasht
- Dam Type:	Concrete buttress
- Dam Height:	120 m from foundation
- Spillway Capacity:	6,000 cu.m/sec
- Reservoir Capacity:	1,672 MCM original, reduced now to 1,133 MCM
- Reservoir Area:	5,500 ha
- Irrigation Service Area:	196,000 ha original, expanded now to 235,000 ha
- Power Capacity:	87 MW
- Annual Power Production:	300 GWh

Of the average annual inflow of 4,540 MCM covering the period of 30 years from 1969/70 to 1998/99, 3,546 MCM or 78% of the total is conveyed from the Qezel Ozan river while remaining 994 MCM or 22% is from the Shah-rud river as shown in Figure 9.4.1.2. Effective capacity of the reservoir was 1,672 MCM at the initial stage of operation in the early 1970s according to the Feasibility Report of the Taleghan Multipurpose Water Development Project, however, massive accumulation of sediment since then mainly from the watershed of Qezel Ozan has reduced about 539 MCM of the effective capacity to 1,133 MCM at present, according to the information provided by the Sefid-rud Dam Control Office.

According to the information provided by the Sefid-rud Dam Control Office, about 3,644 MCM of water has been demanded from the Sefid-rud dam, including 2,668 MCM for irrigation, 200 MCM for fish raising, 174 MCM for domestic consumption, 20 MCM for Industrial use and 582 MCM for environmental purpose. More details are given in Figure 9.4.1.3.

9.4.2 Water Resources Development in the Sefid-rud Basin

In the Sefid-rud river basin, ten (10) storage dams/reservoirs are under construction or under study as shown below:

Water Resources Development Projects in the Sefid-rud Basin

Dam	Catchment Area (sq.km)	Annual Inflow (MCM)	Dam Type	Dam Height (m)	Effective Capacity (MCM)	Irrigation Area (ha)
Sefid-rud	57,800	4,500	Buttress	120	1,100	196,000
Astur	42,600	2,611	Buttress	151	840	-
Givin	603	102	Earth-fill	97	42	7,000
Hashtad	1,878	150	Earth-fill	50	90	9,760
Shahre	242	202	Earth-fill	79	106	-
Taham	161	37	Earth-fill	124	83	500
Golabar	1,130	75	Earth-fill	85	61	7,630
Talevar	6,441	283	Earth-fill	79	421	30,000
Ramin	67	10	RCC	63	20	200
Taleghan	960	480	Earth-fill	141	330	58,000

Of the above storage dams proposed or under construction in the basin, the Astur dam now under study is the most important because that it is proposed to strengthen the function of the Sefid-rud dam by means of providing additional capacity to regulate flood runoff of the river during the months of Far. (April) and Ord. (May) that are mostly spilled out from the Sefid-rud dam unused due to insufficient storage capacity of the dam. Locations of these dams/reservoirs are described on a diagram of the Sefid-rud river system given in Figure 9.4.2.1.

9.4.3 Existing Operation of the Sefid-rud Dam

As is aforementioned in 9.4.1, annual demand of water from the Sefid-rud dam is reported at 3,644 MCM. Operation study of the Sefid-rud dam made under the present situation with the effective capacity of 1,133 MCM and without the proposed Taleghan and Almout water diversion plans revealed the fact that the dam would face frequent shortage of water as shown in Figure 9.4.4.1 and Table 9.4.4.1, and as summarized below:

Average Annual Figures of Sefid-rud Dam Operation

(Present Situation with the Effective Capacity of 1,133 MCM)

(Unit: MCM)

Inflow	Water Demand	Outflow	Spillage	Shortage
4,657	3,644	3,275	1,388	371

In the light of drastic reduction of the effective storage capacity of the reservoir caused by accumulation of sediment transported from the catchment area, the study also covers an influence of such accumulation of sediment over the reservoir area, the also covered the case of computation giving the effective capacity of 1,672 MCM provided at the immediately after the construction of the dam.

Average Annual Figures of Sefid-rud Dam Operation

(Present Situation with the Effective Capacity of 1,672 MCM)

(Unit: MCM)

Inflow	Water Demand	Outflow	Spillage	Shortage
4,657	3,644	3,547	1,120	97

The study explains that the Sefid-rud dam faces frequent shortage of water presently and would face occasional shortage even with the initial capacity of 1,672 MCM, if water demand of 3,644 MCM per annum is adopted. Reduction of the effective storage capacity of the Sefid-rud dam due to accumulation of sediment over the reservoir area results increase of spillage from 1,120 MCM to 1,388 MCM and in turn decrease of outflow from 3,547 MCM to 3,275 MCM, thus increasing shortage of water from 97 MCM to 371 MCM. Comparison is summarized as follows:

Average Annual Figures of Sefid-rud Dam Operation

(Comparison between Effective Capacities, 1,133 MCM and 1,672 MCM)

(Unit: MCM)

Case	Inflow	Demand	Outflow	Spillage	Shortage
With Initial Capacity	4,657	3,644	3,547	1,120	97
With Present Capacity	4,657	3,644	3,275	1,388	371
Difference	-	-	(-)272	268	274

Computations made on the premise that seasonal demands of water for various purposes are those reported from the Dam Control Office also shows frequent shortages of water even under the present situation of the reservoir without proposed Taleghan and Almout water diversion plans. Even with the initial condition of the reservoir having an effective storage capacity of 1,672 MCM, occasional shortage of water is resulted with an average annual value of 97 MCM. Comparison study presents the influence of a massive deposit of sediment in the reservoir, indicating increase of 270 MCM of spillage and also increase of 270 MCM of water shortage.

In accordance with the information collected at the Sangar diversion dam, it has been observed that the supply of water from the Sefid-rud dam is not short except the recent two years, 1998/99 and 1999/2000. Statistical evaluation of hydrological figures explains that the year 1998/99 was the critical dry year that would occur once in 230 years in the case of inflow into the Sefid-rud dam.

From the above considerations there may be some possibility that the demands of water are over-estimated as compared with actual requirements.

9.4.4 Influence of Taleghan and Almout Water Diversion

In order to evaluate the extent of influence of proposed Taleghan and Almout water diversion on the existing and future operation of the Sefid-rud dam due to possible reduction of the inflow into the reservoir, preliminary study of reservoir operation was made. In this connection, possible reduction of the inflow into the reservoir has been evaluated from water balance simulation study made at the proposed Taleghan storage dam as well as at the proposed diversion dam on the Almout river as follows:

Possible Reduction of Inflow into the Manjil Reservoir

(Unit: MCM/year)

Present Situation	After Taleghan/Almout Diversion	Reduction
4,657	4,095	562

Note: Figures are given in average in 29 years from 1969/70 to 1997/98.

Because of only preliminary study to evaluate the influence of proposed water diversion from the Taleghan and Almout rivers over the existing situation of the Sefid-rud dam operation, the study excludes future possible influence of other dams/reservoirs proposed or under construction in the Qezel Ozan basin. The study also excludes influence of losses from the reservoir due to evaporation and seepage instead of counting surplus due to precipitation over the reservoir area.

It is noted here that actual requirements of water as achieved and recorded at present and in future at the Tarik and Sangar diversion dams should be the basis for the study, however, such data are not available. The study was therefore made on condition that the demands of water for various purposes at the Sefid-rud dam are those collected from the Dam Control Office, as given previously in Figure 9.4.1.3.

Figure 9.4.4.1 and Table 9.4.4.1 present monthly changes of various parameters of Sefid-rud reservoir operation comparing conditions without and with the proposed Taleghan and Almout water diversion. Simulated results of reservoir operation in terms of average annual values are summarized as under:

Average Annual Figures of Sefid-rud Dam Operation

(Comparison between without and with Taleghan/Almout Water Diversion)

(Unit: MCM)

Case	Inflow	Demand	Outflow	Spillage	Shortage
Without Taleghan/Almout Water Diversion	4,657	3,644	3,275	1,388	371
With Taleghan/Almout Water Diversion	4,095	3,644	3,078	1,019	567
Difference	(-)562	-	(-)197	(-)369	196

Relatively serious impact of the proposed Taleghan and Almout water diversion on the operation of Sefid-rud dam is resulted from the study and, in turn, influence on the supply of water in the service area of the Sefid-rud dam will be unavoidable. Simply speaking, about 560 MCM of reduction of the inflow into the Sefid-rud reservoir will result reduction of the spillage from the reservoir by 370 MCM and increase of water shortage by 200 MCM.

9.4.5 Necessary Countermeasures to Compensate for Possible Impact

There would occur about 1,020 MCM of spillage from the Manjil reservoir even after diversion of water from the Taleghan and Almout rivers that is enough to cover the shortage of water. In order to regulate peak flow of both Qezel Ozan and Shah-rud rivers without wasted through useless spillage, it is suggested to expect such functions of dams/reservoirs under construction or proposed, such as the Astur dam, in upstream reaches of the basin and to construct a storage dam on the Shah-rud river near Loshan. Construction of the Astur dam with the effective storage capacity of 840 MCM will bring the following effects of the operation of the Sefid-rud dam: Summarized results of computation are given in Figure 9.4.5.1 and Table 9.4.5.1.

Average Annual Figures of Sefid-rud Dam Operation

(with Taleghan/Almout Water Diversion and with Astur Dam)

(Unit: MCM)

	Case	Inflow	Demand	Outflow	Spillage	Shortage
(1)	Present Situation	4,657	3,644	3,275	1,388	371
(2)	With Taleghan/Almout Water Diversion	4,095	3,644	3,078	1,019	567
(3)	With Astur Dam Construction	4,095	3,644	3.444	667	202
	Difference: (3)-(1)	(-)562	-	169	(-)721	(-)169
	Difference: (3)-(2)	(-)562	-	366	(-)352	(-)365

Construction of the Astur dam would contribute to reduce shortage of water from 567 MCM for the case with the proposed Taleghan and Almout water diversion plans to 202 MCM. Occasional shortage of water will still remain even after construction of the Astur dam, however, situation will be improved greatly indicating much smaller amount of shortage, 202 MCM, as compared with the existing condition of 371 MCM.

Construction of the Shah-rud dam on the Shah-rud river near Loshan in addition to the construction of Astur dam will also bring some improvement on operation of the Sefid-rud dam, however, effect may be rather small to meet the cost for the implementation of the project as given in Figure 9.4.5.2 and Table 9.4.5.2, and as summarized below:

Average Annual Figures of Sefid-rud Dam Operation

(with Taleghan/Almout Water Diversion and with Astur/Shah-rud Dams)

(Unit: MCM)

	Case	Inflow	Demand	Outflow	Spillage	Shortage
(1)	Present Situation	4,657	3,644	3,275	1,388	371
(2)	With Taleghan/Almout Water Diversion	4,095	3,644	3,078	1,019	567
(3)	With Astur/Shah-rud Dams Construction	4,095	3,644	3.478	635	168
	Difference: (3)-(1)	(-)562	-	203	(-)753	(-)203
	Difference: (3)-(2)	(-)562	-	400	(-)384	(-)399

Operation of the Sefid-rud dam simulated for four (4) cases, namely, (1) present situation, (2) after implementation of the proposed Taleghan and Almout water diversion plans, (3) with diversion plans and construction of the Astur dam and (4) construction of the Shah-rud dam in addition to the case (3) are thus compared as per Figure 9.4.5.3 and Tables 9.4.5.3 and 9.4.5.4.

Suitable site for construction of a dam on the Shah-rud river was preliminarily inspected by the JICA Study together with a possible idea to divert a part of water transbasin from the Chach-rud river. In order to control future production of sediment, it is recommendable to urge implementation of watershed management program covering the entire Sefid-rud basin.

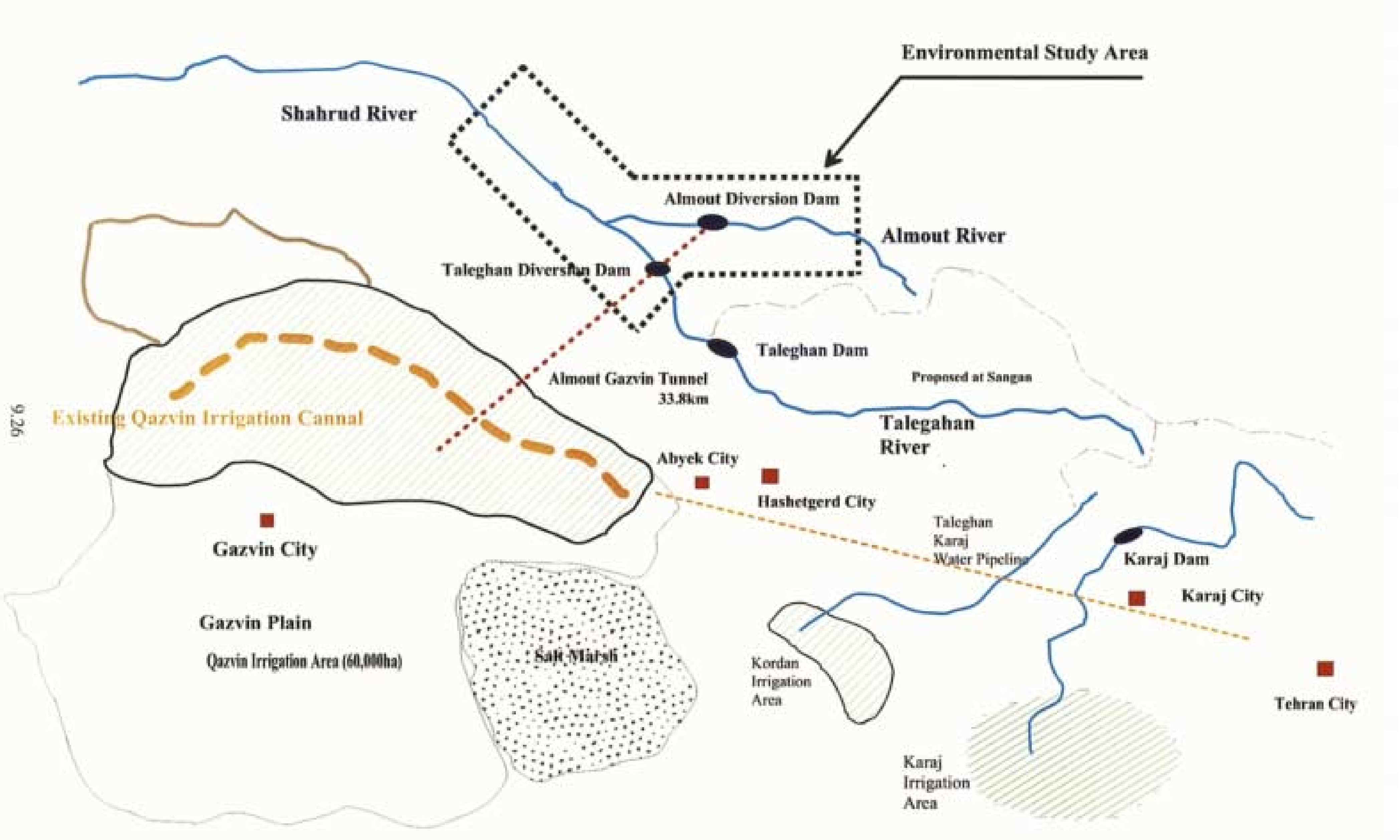


Figure 9.1.1 Location Map of the Environmental Study Area

Table 9.2.5 (1) List of Fish Species in the Almout River Basin

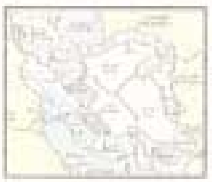
Taxonomical Hierarchy				Common name	Range	Habitat	Size	Remark
Order	Family	Genus	Species					
Cypriniformes	Cyprinidae				**Order cypriniformes:** A enormously successful group of freshwater fish, this order contains nearly 2,700 species and includes the carps, minnow, barbs, algae, eaters and loaches. Cypriniform fish dominate the streams, rivers and lakes of Eurasia and North America and are also found in Africa. They have scaled bodies and scale less heads, a single dorsal fin and their swim bladders are connected inner ear, which give them acute hearing abilities. Of the 5 families in the group, the carp family (Cyprinidae) is the largest with over 2000 species.			
		Alburnoides 	bipunctatus	Grass/crucian carp	Eurasia and North America	Rivers, streams lakes	1-1.3m	A native of China, the grass carp has been introduced into many other areas for two reasons. 1) In China and southeast Asia this fish is a valuable commercial species. 2) in Europe and Russia, this plant eating fish used to control vegetation in canals and reservoirs. Although as an adult, the grass carp is entirely herbivorous, young fishes feed on insect larvae and crustaceans. Grass carp spawn in river in summer. The eggs float at the surface water and must have warm water to grow well.
		Barbus 	Capito/barbus	Barbel	Europe, Britain, south to Alps	Lowland river, stream	50-90cm	A slender, long-bodied fish, the barbel a characteristic high dorsal fin and two pair of sensory barbels around its fleshy lips. it is a bottom living fish, which most active at night and at dusk. It feed on aquatic insect larval, mollusks and crustaceans. Barbel breed in late spring, often migrating upstream spawning. They shed their eggs in shallow gravel-bed of rivers, where they lodge among the stones until they hatch from 10 to 15 days.
			Lacerta	Kura barbel				
			Mursa	Nursa				

Table 9.2.5 (2) List of Fish Species in the Almout River Basin

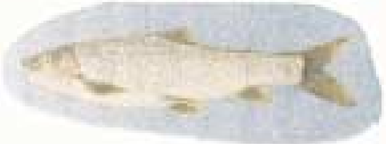
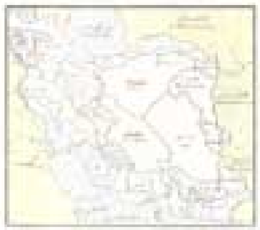
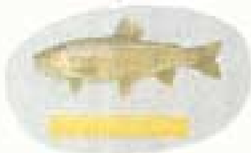
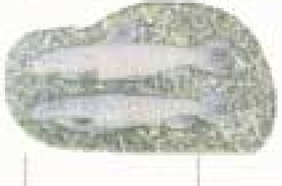
Taxonomical Hierarchy				Common name	Range	Habitat	Size	Remark
Order	Family	Genus	Species					
		Capoeta 	Capoeta	Lenkoran	Europe, W.Asia, England to Russia	Lowland rivers, lakes	35-46cm	This species is the distribution some Asian countries and the southern basin of Caspian Sea and inhabits downstream of river, spring water zone and muddy pond. It feeds on an aquatic insects and breeds during March to July. Body length grow up to be about 35 cm and for suitable for sport fishing.
		Leuciscus 	Cephalus	Caucasian of European chub	N. Europe and Asia	River, stream	15-30cm	A slim-bodied fish, it moves in large schools and feeds on insects and their larvae, some plants and other terrestrial invertebrates which fall into the water. Although normally a river fish, some dace occur in lake, Dace spawn in spring, often in gravel-bottomed shallow streams, and shoals gather in the breeding area before spawning. The eggs lodge among the gravel where they remain until they hatch about 25 days later.
	Balistoridae	Nemacheilus 	Angorae	Angora loach	England, across Europe and North Asia to Siberia and	Small fast flowing rivers, lakes	10-15cm	The sluggish stone loach is a bottom living fish. It spends the day hidden among stones, where it is well camouflaged by its irregular markings and is active at night or in dull daylight. It eats bottom-living things such as crustaceans, insect larvae and worms. In spring or early summer, they breed, shedding its sticky-surfaced eggs over stones or plants. The eggs usually hatch in over 2 weeks.
Saimoniformes	Salmonidae				This order contains one (1) family, Saimonidae, with 76 species, including salmon, trout, whitefishes, graylings and charrs. Members of the orders occur in freshwater and marine environments, manly northern hemisphere. Some migrate from the sea to rivers to spawn. Most species are predatory. These figures are as follows: Salmon inhabits marine and trout inhabits a rivers and Japanese name 'Ito' is huge body length species of the fresh water and Japanese name 'Iwana' inhabits a river of clean and cold water in high mountain.			
		Oncorhynchus 	Mykiss (gairdneri)	Rainbow trout	America, introduced worldwide	Marin, rivers	25-140cm	Now a days, farmed a large quantities, rainbow trout are extremely popular with anglers and are an important food fish. It is feed mainly on insects and its larvae, mollusks and crustaceans. In their natural range, rainbow trout spawn in spring in shallow, gravel bottom streams. The female makes a shallow nest in the gravel and deposits her eggs which are fertilized by male and covered over.

Table 9.2.5 (3) List of Fish Species in the Almout River Basin

Taxonomical Hierarchy				Common name	Range	Habitat	Size	Remark
Order	Family	Genus	Species					
Saimoniformes		Salmon	trutta fario	Brown trout	Europe, introduced world wide	Marine, rivers, lakes	25-140cm	There are two forms of this well-known food and angling fish: (1) the sea trout, which migrates from river to sea and back to river to breed, (2) the smaller brown trout, which spends all its life in fresh water. They are alike physically , but sea trout have silvery scales with scattered black markings, and brown trout have numerous dark spots. Both forms feed on fish and crustaceans. Trout spawn in winter in gravel bottomed fresh water; the female makes a shallow neat for her eggs. The young hatch in spring and remain in the gravel for a few weeks.
								
		Salmon	tairdneri/trutta 	Salmo trout	Same as above	Same as above	Same as above	
Acipenserifor mes: Sturgeon	Acipenserifo rmes				There are 2 families in this order. First there are the 24 families of sturgeon which are mainly freshwater and coastal fishes of temperate regions, the marine species of which migrate into rivers to spawn. All have 5 roes of body plates along the side of body. Second there is the paddlefish family, sturgeon freshwater fishes with long paddle like snouts and no body plates.			
		Huso	**huso (EN)** 	Beluga	Basins of Caspian and Black seas, Adriatic Sea	Sea, rivers	5m	Huge heavy fishes, belugas certainly weight up to 1200 kg and more sometimes. They are now relatively uncommon, partly because of river pollution interfering with their migrations, and partly because of pressure of fishing. The taking of eggs for caviar from mature female is damaging to stocks. Particularly these fishes mature late-males at 14 years and females at 18 years. A single female may contain up to 7 million eggs. Belugas migrate into river in winter or spring and spawn on rocky river beds. The newly hatched young immediately start moving towards the sea, feeding on small bottom-living thing invertebrates.

Source: Lar Consultant

Reference

1) The Encyclopedia of Animals. The Simon & Schuster Editions Rockefeller Center (1998), ISBN 0-684-85237-3

2) The Inland Water Fishes of Iran, Asghar Abdoli, (2000) ISBN 964-6902-01-4

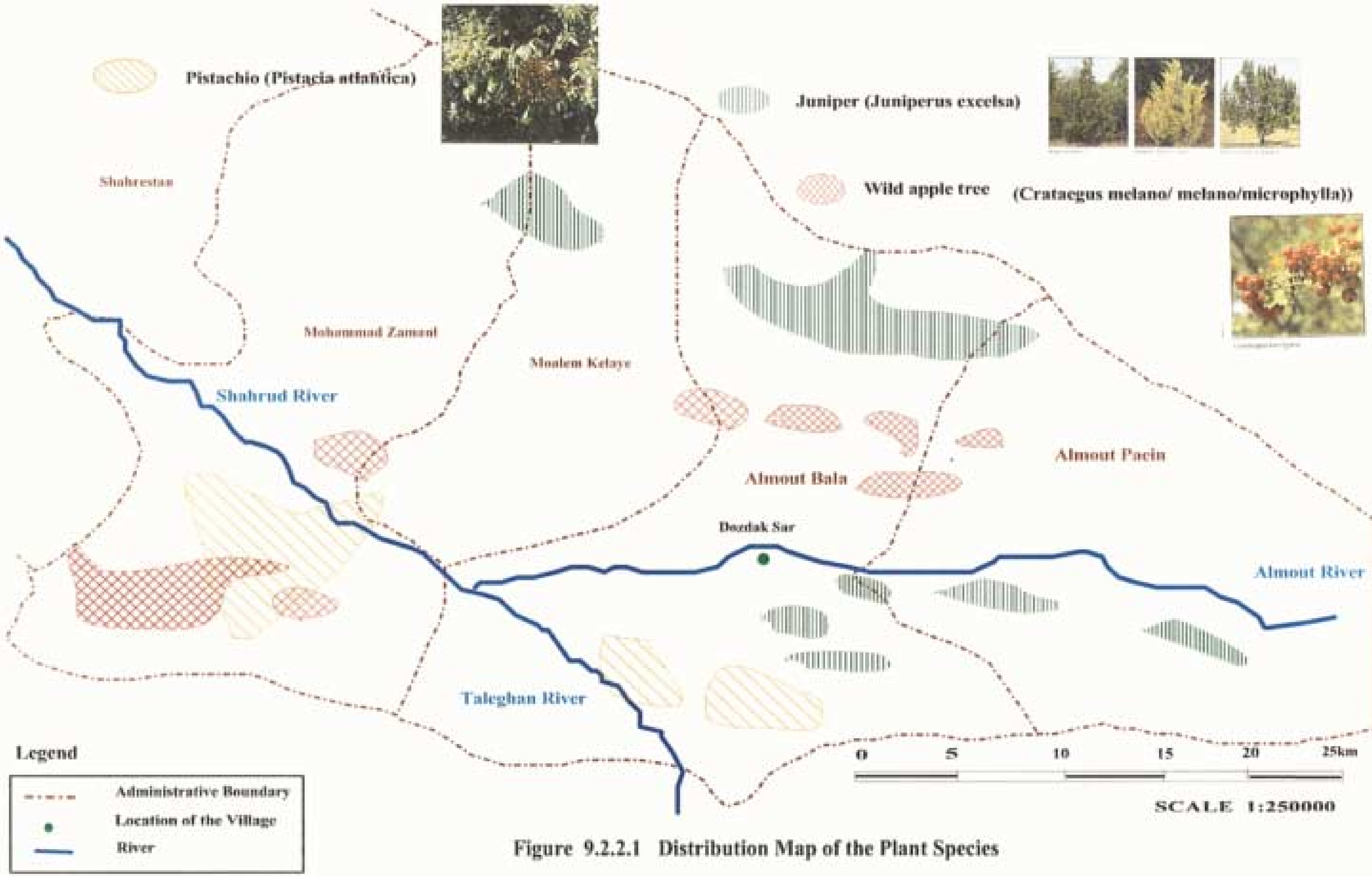


Figure 9.2.2.1 Distribution Map of the Plant Species

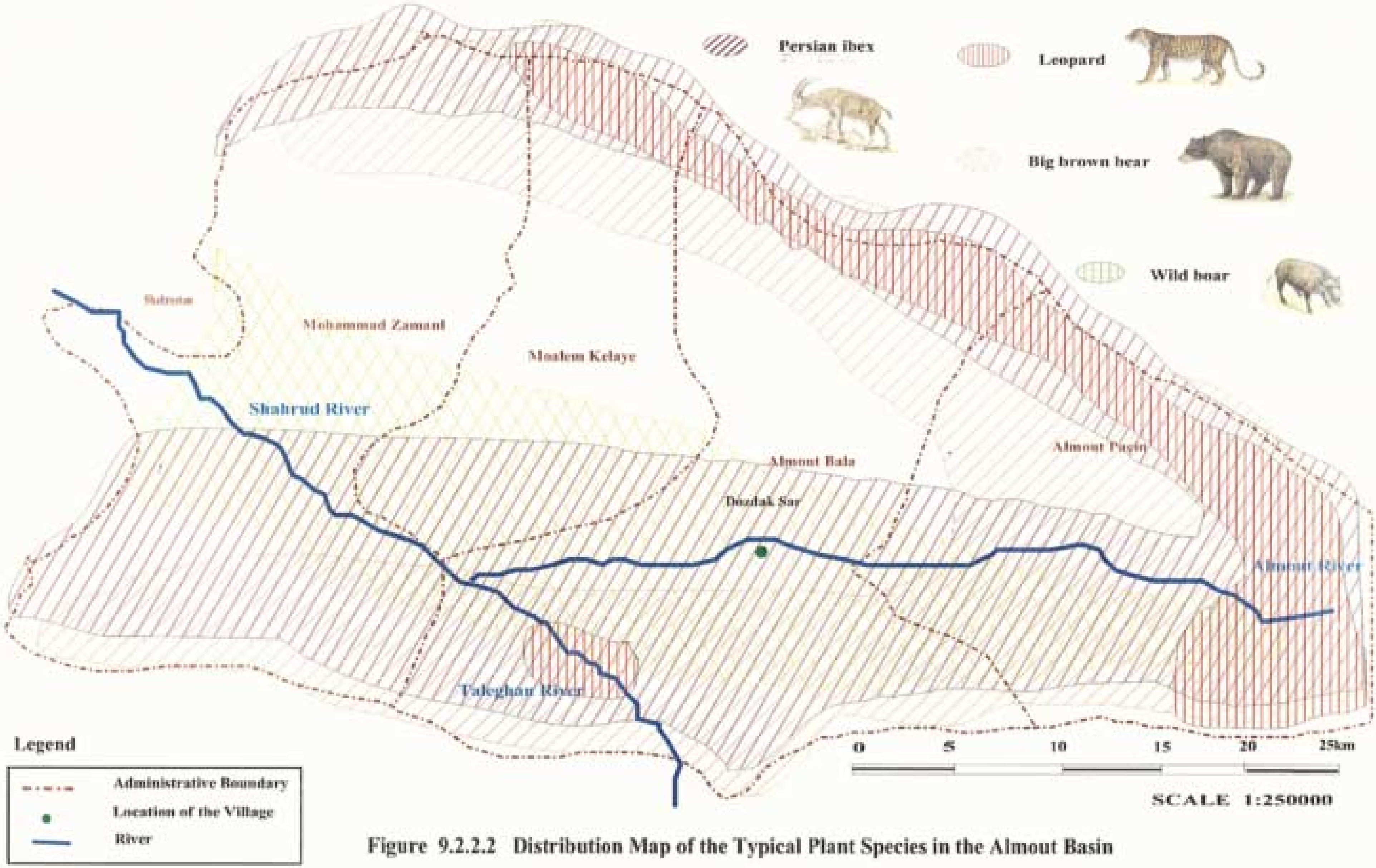


Figure 9.2.2.2 Distribution Map of the Typical Plant Species in the Almout Basin

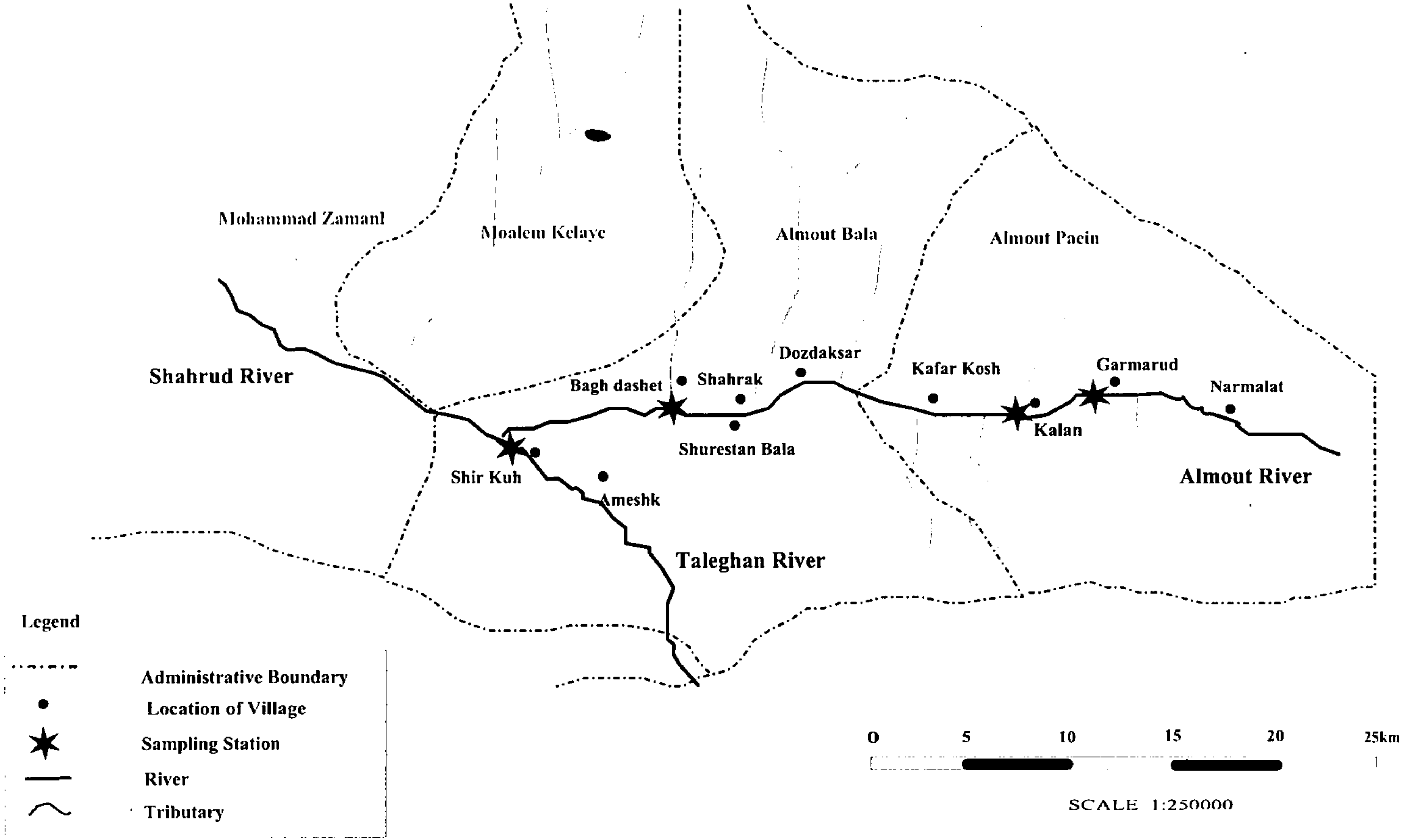


Figure 9.2.2.3 The Sampling Locatios for the Fish Species in the Alamout river

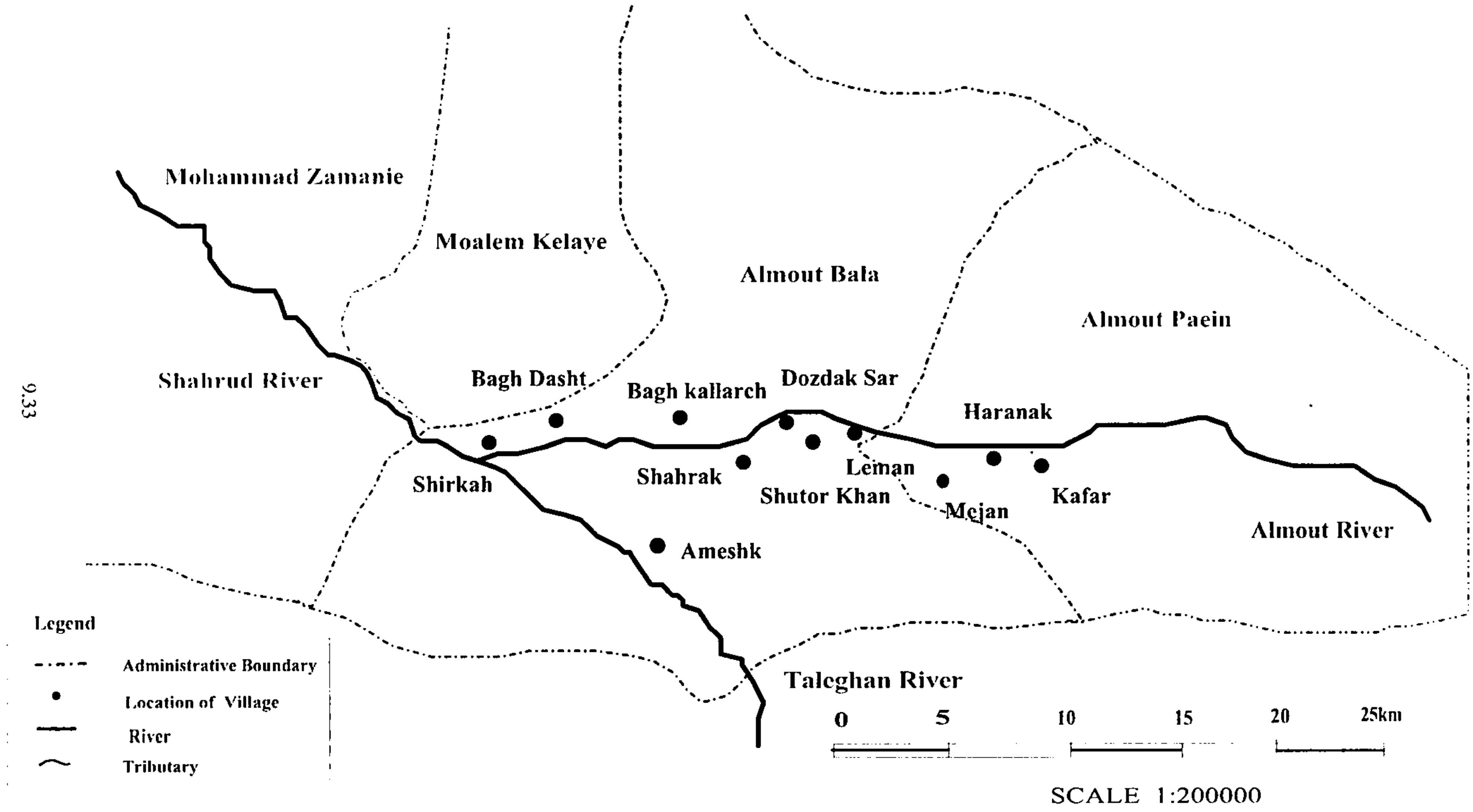


Figure 9.2.2 Distribution Map of the Study Village

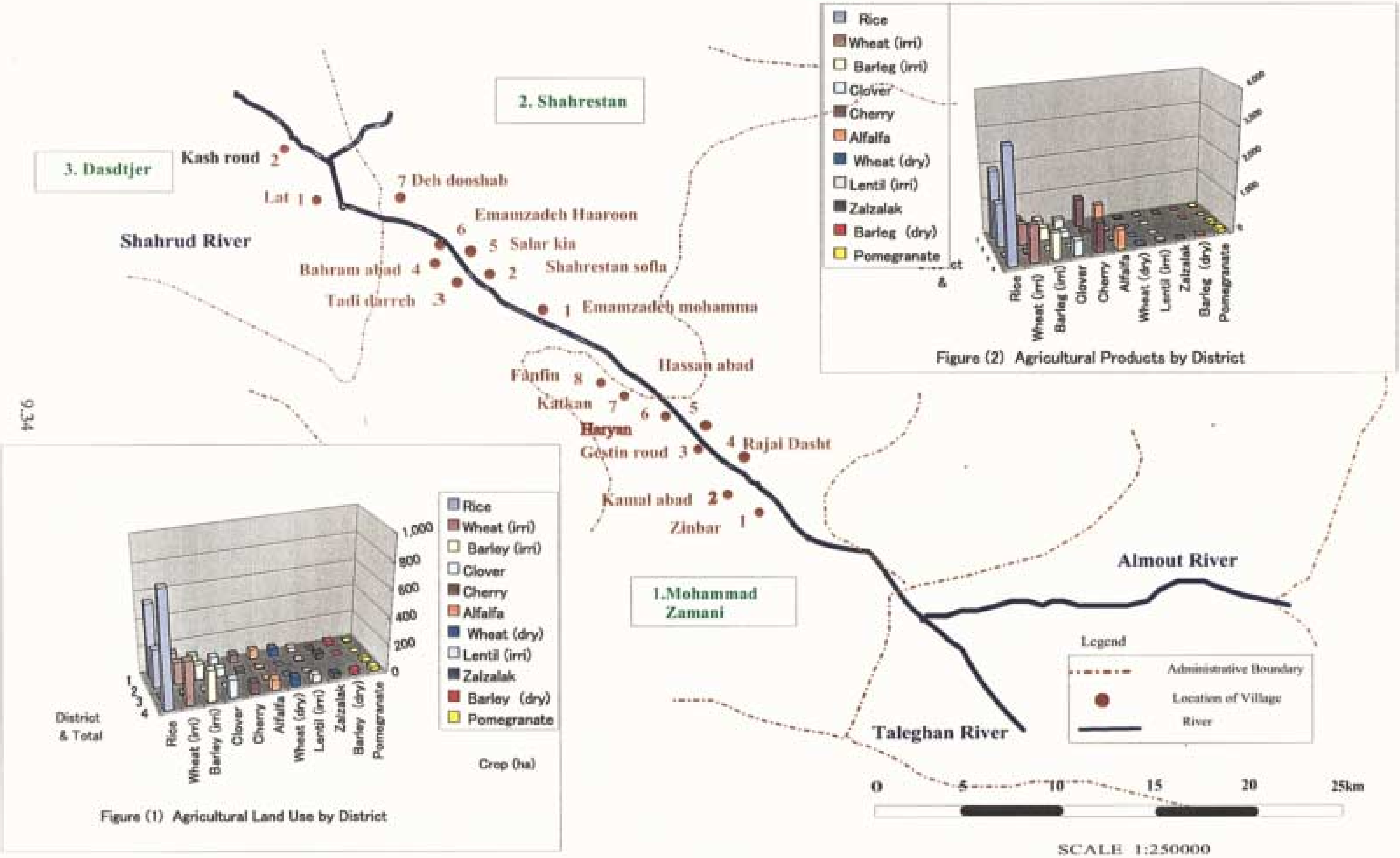


Figure 9.2.3.2 Location of Villages for the Agricultural Land Use Map in the Almout River Basin

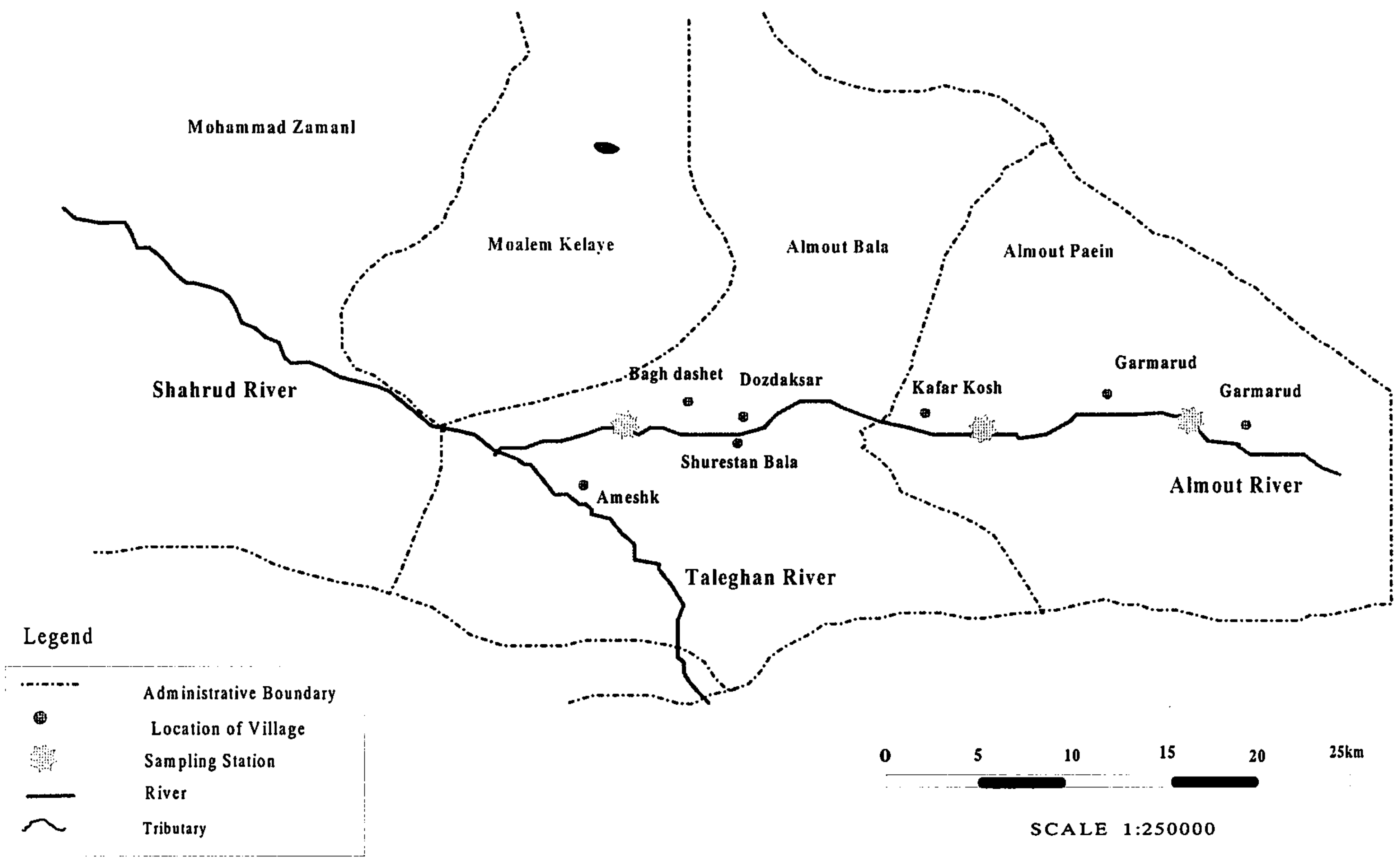


Figure 9.2.4.1 The Sampling Stations for the Water Pollution in the Alamout river

Table 9.2.5 Existing Agricultural Land Use of the Downstream Area

District		Sub Total : Mohammad Zamani			Sub Total : Shahrestan			Sub Total : Dastjerd			Ground Total		
No.	Items / Crop name	Area under cultivation	Yield (kg)	Production (ton)	Area under cultivation (ha)	Yield (kg)	Production (ton)	Area under cultivation (ha)	Yield (kg)	Production (ton)	Area under cultivation (ha)	Yield (kg)	Production (ton)
1	Rice	549.0	24,500	1,923.5	287.0	18,500	1,234.9	13.0	4,100	26.8	849.0	47,100	3,185.2
2	Wheat (irri)	157.0	20,300	459.7	159.0	20,500	553.7	11.0	6,000	31.2	327.0	46,800	1,044.6
3	Barley (irri)	106.0	21,800	334.1	119.0	18,700	379.9	8.0	2,800	22.0	233.0	43,300	736.0
4	Clover	71.0	28,000	264.0	66.0	10,600	178.0	1.0	2,800	2.8	138.0	41,400	444.8
5	Cherry	68.0	92,000	783.0	17.0	24,000	82.0				85.0	116,000	865.0
6	Alfaifa	73.0	56,000	511.0	5.2	13,500	33.9	1.0	4,500	4.5	79.2	74,000	549.4
7	Wheat (dry)	62.0	4,700	36.0	0.0	0	0.0	2.0	300	0.6	64.0	5,000	36.6
8	Lentil (irri)	35.0	5,700	33.0	19.0	3,950	15.5	1.0	400	0.4	55.0	10,050	48.9
9	Zalzalak	0.2	6,000	0.6	41.0						41.2	6,000	0.6
10	Barley (dry)	36.0	3,601	16.0	0.0	0	0.0				36.0	3,601	16.0
11	Pomegranate	5.7	36,000	34.4	0.5	4,000	2.0	24.0	11,000	82.0	30.2	51,000	118.4
12	Hazelnut	6.6	8,000	14.0	18.0	2,950	13.6	3.0	1,400	2.1	27.6	12,350	29.7
13	Apricot	21.1	56,000	84.4	3.0	11,000	10.0				24.1	67,000	94.4
14	Pea (irri)	15.5	5,000	12.5	0.5	1,100	0.6	1.0	400	0.4	17.0	6,500	13.5
15	Bean	12.0	3,300	8.2							12.0	3,300	8.2
16	Black cherry	10.5	96,000	147.0				1.0	5,000	5.0	11.5	101,000	152.0
17	Walnut	6.0	15,000	15.0	2.5	2,000	2.8	2.0	2,200	2.2	10.5	19,200	20.0
18	Berry	5.5	18,000	11.6	0.5			2.0			8.0	18,000	11.6
19	Lentil (dry)	7.5	2,300	6.9							7.5	2,300	6.9
20	Fig	1.4	10,000	4.3				6.0	2,700	7.5	7.4	12,700	11.8
21	Grape (irri)	2.5	27,000	17.0	1.5	10,000	7.5	1.5	8,000	6.5	5.5	45,000	31.0
22	Plum	2.2	33,400	17.8							2.2	33,400	17.8
23	Apple	2.2	24,000	26.4							2.2	24,000	26.4
24	Tomato	1.6	19,000	10.1							1.6	19,000	10.1
25	Potato	1.5	15,000	11.5							1.5	15,000	11.5
26	Dogberry	0.0	0	0.0	1.5	75,000	6.3				1.5	75,000	6.3
27	Senjed	1.4	4,900	1.7							1.4	4,900	1.7
28	Olive	0.1	4,000	0.4	1.0			0.1			1.2	4,000	0.4
29	Persimmon	1.2	9,000	3.6							1.2	9,000	3.6
30	Pear	1.0	18,000	9.0							1.0	18,000	9.0
31	Quince	0.6	6,000	1.8							0.6	6,000	1.8
32	Plum (others)	0.4	28,000	3.8							0.4	28,000	3.8
33	Peach	0.2	18,000	1.8							0.2	18,000	1.8
34	Pistachio	0.1	700	0.1							0.1	700	0.1
	Total	1,264.0	719,201.0	4,804.2	742.2	215,800.0	2,520.7	77.6	51,600.0	194.0	2,083.8	986,601	7,518.9

Table 9.3.1 Checklist for Preliminary Survey

Environmental Factor			Evaluation			Remark
	Item	Description	A	B	C	
Natural Environment	Topography/Geology	1. Change of topography		○		Slightly changed by diversion dam and tunnel inlet structure
		2. Land slide/collapse	○			Easily caused by steep slope, fluctuation of reservoir water level and poor soil property in overburden of both river banks
		3. Soil erosion	○			Easily caused by no vegetation condition and flow energy of melted snow in the overburden with steep slope
		4. Sediment load	○			Easily caused by the steep river slope of 1/50 and materials brought from land sliding and soil erosion
		5. River bed scouring	○			Easily caused by the steep river slope of 1/50 and flood energy in spring season
		6. Earthquake		○		Existing of earthquake phenomenon but less impact to diversion dam and tunnel structures
	Meteorology	7. Temperature/rainfall			○	Cold temperature in winter and scarce rainfall but no impact to diversion dam and tunnel structure
	Surface/Ground Water	8. Water diversion by transbasin	○			Large reduction of the existing discharge by water diversion
		9. Change of surface water regime	○			Large change of monthly runoff regime by water diversion
		10. Decreasing of water level in river	○			Large decreasing of river water level by water diversion
		11. Impact on groundwater		○		Some impact on groundwater level at the downstream area
		12. Impact on downstream area	○			Difficulty to use the river water by decreasing water level and discharge by water diversion
Ecological Environment	Forest/Greenery Area	13. Greenery area and rare/original species		○		Some reduction of existing greenery area by diversion dam construction
		14. Terrestrial Fauma wild animal, bird and insect		○		Some impact by construction of diversion dam and roads:
		15. Aquatic Biots fish, aquatic grass, algae and zooplankton)	○			Large impact by discharge reduction by water diversion, river closing by dam, change of river course, etc. Necessity of fish way.
Social Environment	Rural Community	16. Population increases	○			Large impact by population increases related to construction works
		17. Resettlement		○		No resettlement of villages, public facilities, etc except some farm lands
	Agriculture	18. Farm land use			○	No impact to existing farm land use, but necessity of new farm land along the river
		19. Irrigation water use and water right		○		Some impact to existing irrigation system by construction but necessity of new system
		20. Fishery		○		No impact to existing fishery activity due to prevailing of culture fish
	Social Infrastructure	21. Provincial and village road		○		Some replacement and maintenance for existing road
		22. Domestic water supply system			○	No impact to domestic water supply system in villages, because of the water sources by tributary and groundwater
		23. Electrical/telephone system			○	No impact to existing electrical/telephone system by diversion dam
	Others	24. Public health/sanitation		○		Some impact by contractor's camps and construction
		25. Water-born diseases			○	No existing water-born diseases
		26. Landscape		○		Some deterioration of land scape by construction
		27. Cultural assets			○	Existing of important ruin and historical monument but no impact to them by project
		28. Tourism and recreation			○	Important tourism area of Qazvin people but no impact to it by project
Pollution	Pollution	29. Air Pollution		○		Some influence to air pollution by construction equipment
		30. Water Pollution	○			Large impact to water pollution by drainage water during construction and waste water by contractor's camp
		31. Soil contamination		○		Some impact to soil contamination by construction material such as fuel and cement
		32. Noise and vibration		○		Some impact by heavy construction equipment

Note: A: Large impact B: Slight impact C: No impact

Table 9.3.2 Matrix for Preliminary Survey (Scoping)

Environmental Factor			During Construction of Diversion Dam/Tunnel							During Operation/Maintenance		
Item		Description	Contractor Camp & Work Shop	River Diversion	Earth Works	Concrete & Grouting Works	Drainage Works	Borrow Area & Spoil Bank	Construction Equipment Operation	O/M Office	Water Operation	Facility Maintenance
Natural Environment	Topography/Geology	1. Change of topography	-	●	○	-	-	○	-	-	-	-
		2. Land slide/collapse	-	-	○	-	-	○	-	-	○	○
		3. Soil erosion	-	-	○	-	-	○	-	-	○	○
		4. Sediment load	-	○	○	-	○	-	-	-	●	○
		5. River bed scouring	-	●	-	-	-	-	-	-	○	-
		6. Earthquake	-	-	-	-	-	-	-	-	-	-
	Meteorology	7. Temperature/rainfall	-	-	-	-	-	-	-	-	-	-
	Surface/Groundwater	8. Water diversion by transbasin	-	●	-	-	-	-	-	-	●	-
		9. Change of surface water regime	-	○	-	-	○	-	-	-	○	-
		10. Decreasing of water level in river	-	○	-	-	-	-	-	-	●	-
		11. Impact on ground water	-	○	-	-	○	-	-	-	○	-
		12. Impact on downstream area	-	○	-	-	-	-	-	-	○	-
Ecological Environment	Forest/Green Area	13. Green area and rare/original species	○	○	○	-	-	○	-	-	-	-
	Terrestrial Fauna	14. Wild animal, bird and insect	-	-	○	-	-	-	-	-	-	-
	Aquatic Biots	15. Fish, aquatic grass, algae, etc	-	○	○	○	-	-	-	-	○	○
Social Environment	Rural Community	16. Population increases	○	-	-	-	-	-	-	○	-	-
		17. Resettlement of farm land	-	-	○	-	-	○	-	-	-	-
	Agriculture	18. Farm land use	-	-	○	-	-	○	-	-	○	○
		19. Irrigation Water use/Water right	-	○	-	-	-	-	-	-	○	○
		20. Fishery	-	-	-	-	-	-	-	-	○	○
	Social Infrastructure	21. Provincial and Village road	-	-	○	○	-	-	-	-	-	○
		22. Domestic water supply system	-	-	○	○	-	-	-	-	-	-
		23. Electrical/Telephone system	-	-	-	-	-	-	-	-	-	-
		24. Public health/sanitation	○	-	○	○	-	-	-	○	-	-
		25. Water-born diseases	-	-	-	-	-	-	-	-	-	-
		26. Landscape	-	-	○	○	-	-	-	-	-	-
		27. Cultural assets	-	-	-	-	-	-	-	-	-	-
		28. Tourism and recreation	-	-	-	-	-	-	-	-	-	-
Pollution	Pollution	29. Air pollution	-	-	-	-	-	-	○	-	-	-
		30. Water pollution	○	○	○	●	●	-	○	○	○	-
		31. Soil contamination	-	○	○	○	○	-	○	-	-	-
		32. Noise and vibration	○	-	-	-	-	-	○	-	-	-

Note: ● Large impact ○ Slight impact - No impact

Figure 9.4.1.1 Location Map of Existing and Proposed Dams in the Sefid-rud River Basin

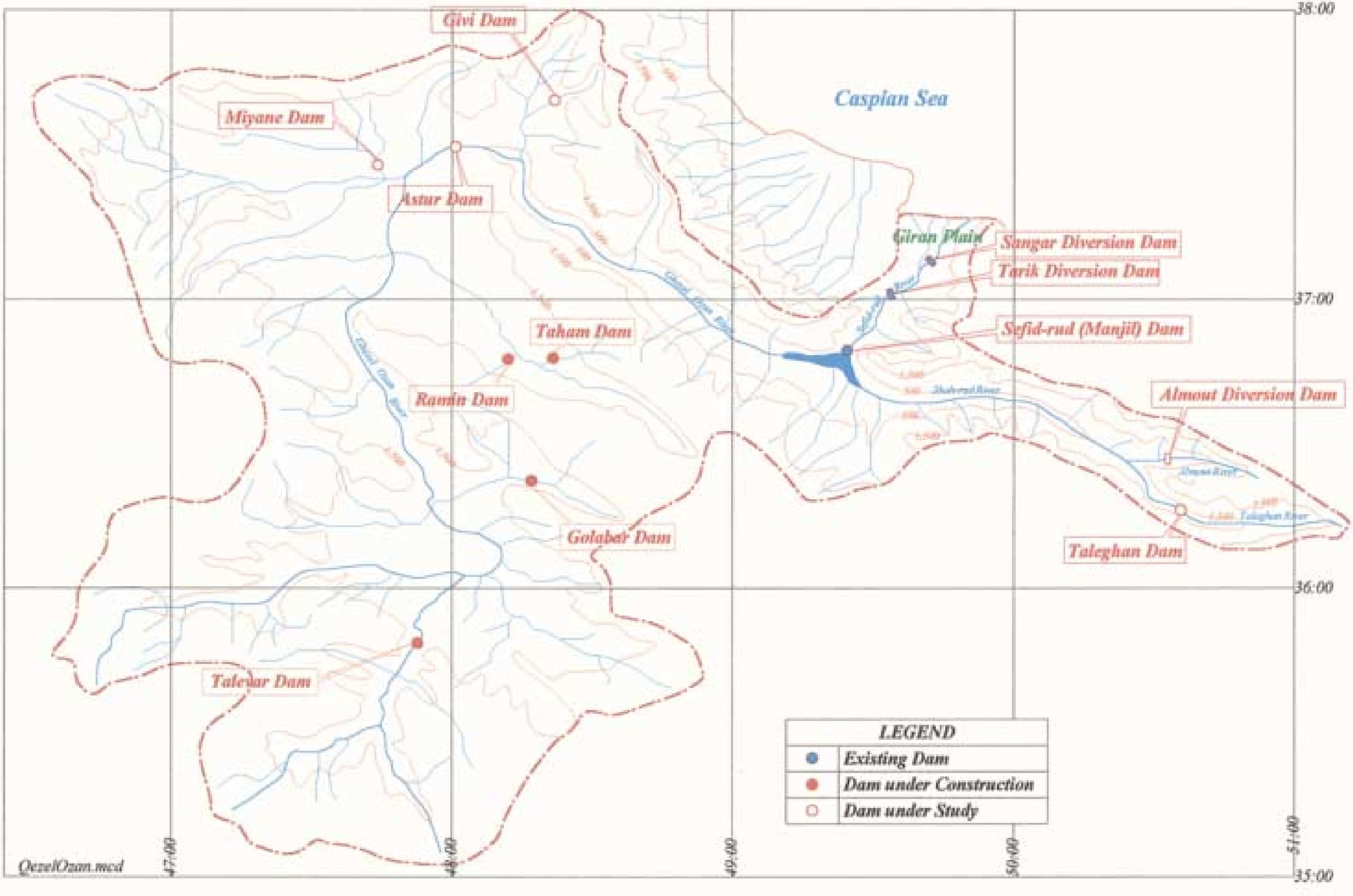


Figure 9.4.1.2 Manjil Dam Inflow by Source of Water

Average (1969-1998)

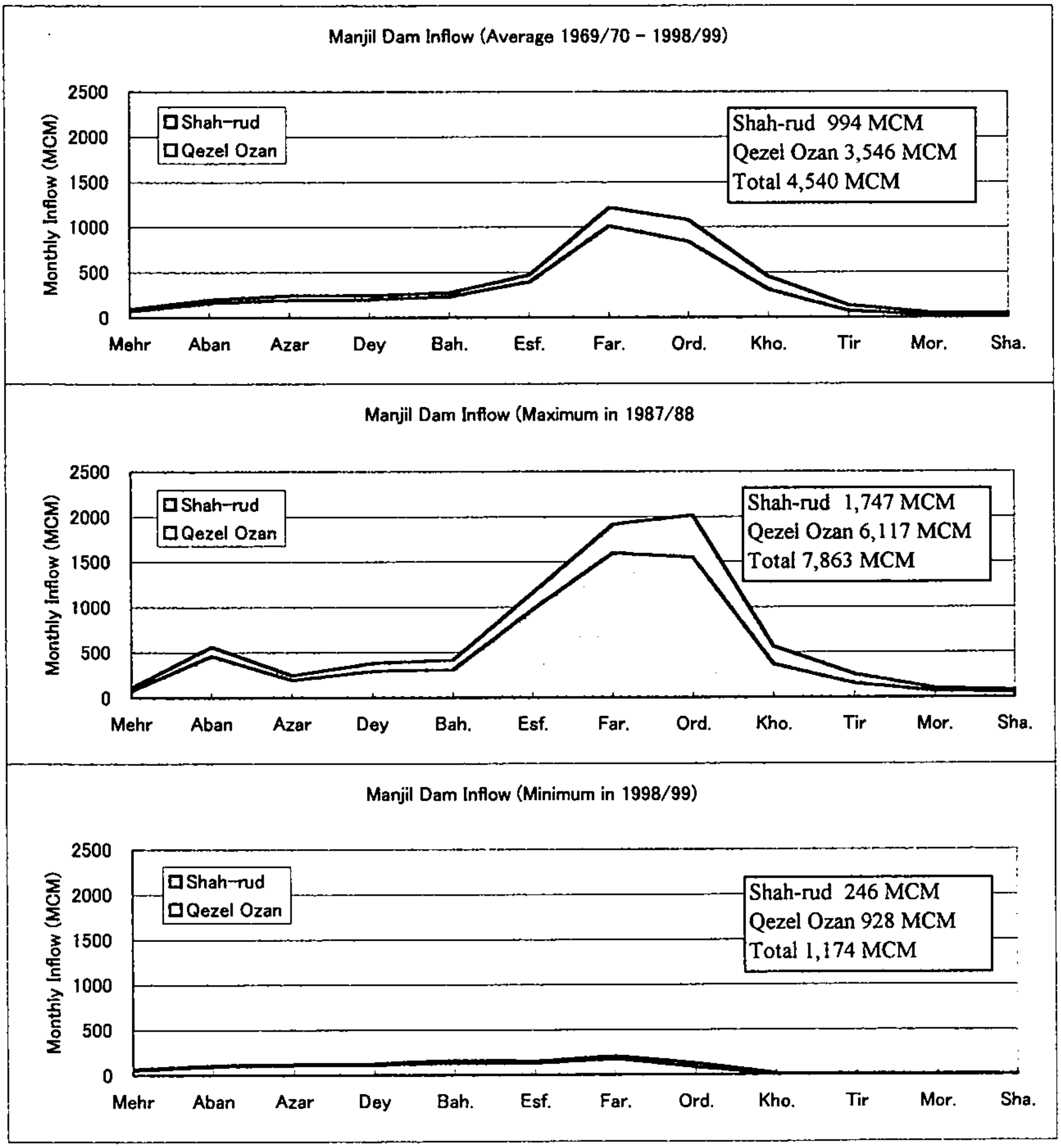
	Mehr	Aban	Azar	Dey	Bah.	Esf.	Far.	Ord.	Kho.	Tir	Mor.	Sha.
Qezel Ozan	71.5	163.1	199.5	204.0	230.9	392.8	1011.1	841.2	306.6	69.1	27.4	28.9
Shah-rud	25.8	39.7	48.4	43.9	48.4	81.8	206.5	239.7	147.4	65.5	26.4	20.6

Maximum in 1987

	Mehr	Aban	Azar	Dey	Bah.	Esf.	Far.	Ord.	Kho.	Tir	Mor.	Sha.
Qezel Ozan	82.7	462.3	196.9	294.0	310.9	974.0	1596.6	1548.1	368.4	156.7	69.7	56.6
Shah-rud	33.7	107.2	52.2	92.5	111.1	188.4	323.3	467.7	200.7	102.8	36.4	30.8

Minimum in 1998

	Mehr	Aban	Azar	Dey	Bah.	Esf.	Far.	Ord.	Kho.	Tir	Mor.	Sha.
Qezel Ozan	54.6	95.3	109.2	113.3	137.9	131.3	175.2	84.4	5.1	3.8	13.9	4.4
Shah-rud	15.9	14.1	16.8	18.6	28.5	23.6	39.9	46.3	16.7	11.7	7.0	6.5

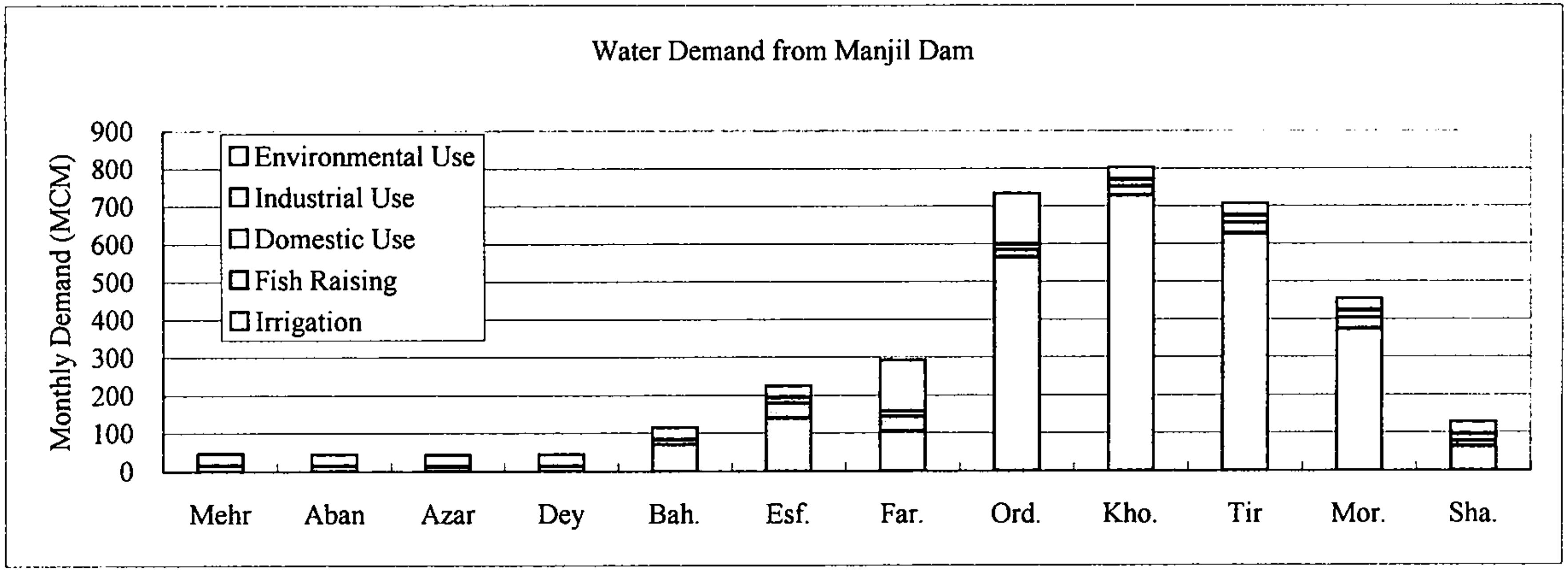


Sefidinfsepout.xls

Table 9.4.1.3 Monthly Distribution of Water Demand from the Sefid-rud Dam

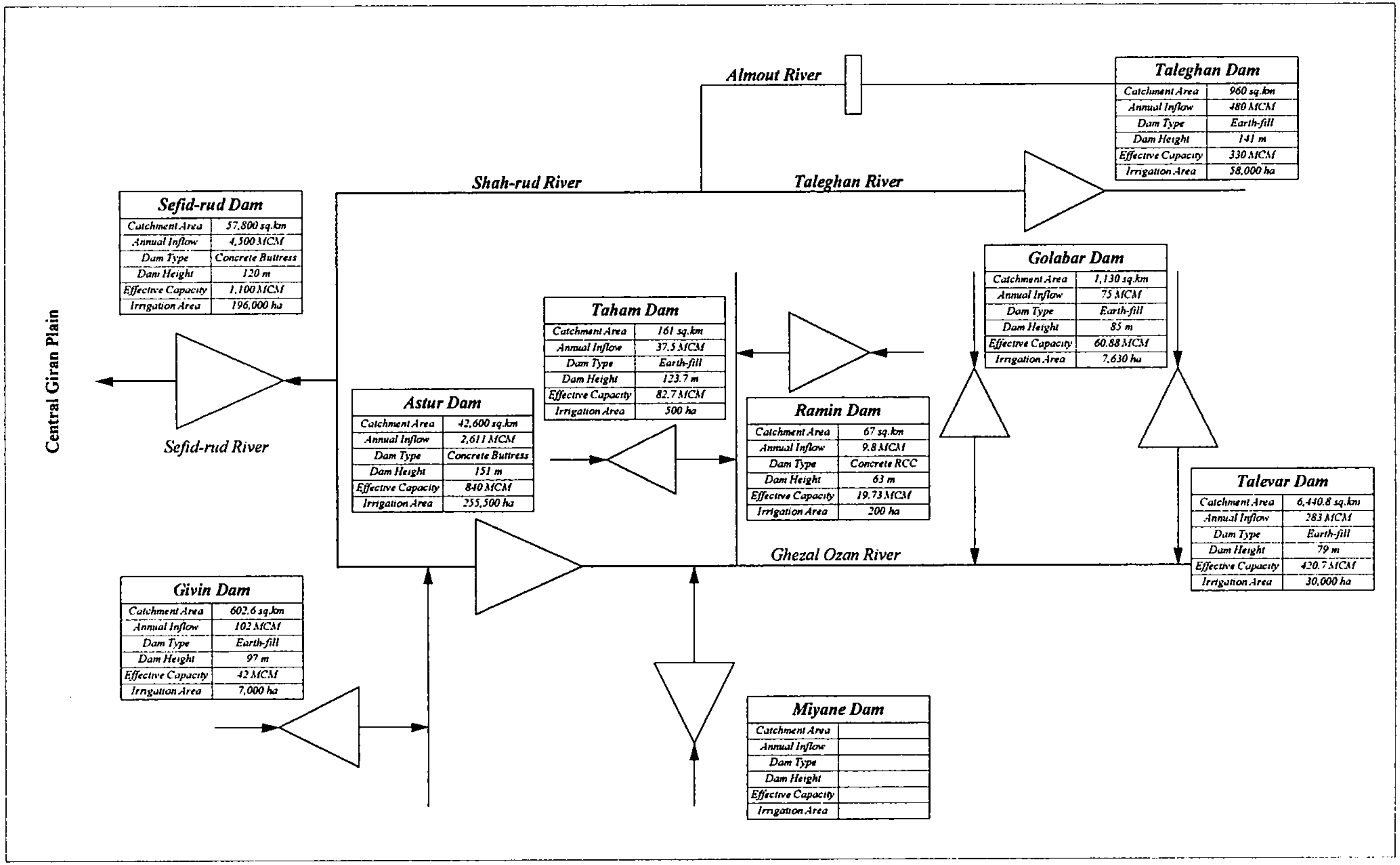
(Original from Mahab Report)

Month	Irrigation		Fish Raising		Domestic Use		Industrial Use		Environmental Use		Total Demand	
	cu.m/sec	MCM	cu.m/sec	MCM	cu.m/sec	MCM	cu.m/sec	MCM	cu.m/sec	MCM	cu.m/sec	MCM
Mehr	0.000	0.0	0.000	0.0	5.633	14.6	0.694	1.8	12.000	31.1	18.327	47.5
Aban	0.000	0.0	0.000	0.0	5.093	13.2	0.579	1.5	12.000	31.1	17.672	45.8
Azar	0.000	0.0	0.000	0.0	4.591	11.9	0.540	1.4	12.000	31.1	17.131	44.4
Dey	0.000	0.0	0.000	0.0	4.784	12.4	0.540	1.4	12.000	31.1	17.324	44.9
Bah.	27.006	70.0	0.000	0.0	4.900	12.7	0.502	1.3	12.000	31.1	44.408	115.1
Esf.	55.866	140.0	15.962	40.0	5.227	13.1	0.559	1.4	12.000	30.1	89.614	224.6
Far.	38.830	104.0	14.937	40.0	4.930	13.2	0.597	1.6	50.000	133.9	109.294	292.7
Ord.	210.604	564.0	7.468	20.0	5.340	14.3	0.672	1.8	50.000	133.9	274.084	734.0
Kho.	271.840	728.0	9.335	25.0	6.124	16.4	0.747	2.0	12.000	32.1	300.046	803.5
Tir	233.760	626.0	11.202	30.0	6.650	17.8	0.747	2.0	12.000	32.1	264.359	707.9
Mor.	139.280	373.0	11.202	30.0	6.759	18.1	0.747	2.0	12.000	32.1	169.988	455.2
Sha.	23.525	63.0	5.601	15.0	6.199	16.6	0.672	1.8	12.000	32.1	47.997	128.5
Annual	84.602	2,668.0	6.342	200.0	5.527	174.3	0.634	20.0	18.449	581.8	115.554	3,644.1



ManjilDemand.xls

Figure 9.4.2.1 Diagram of Sefid-rud River System



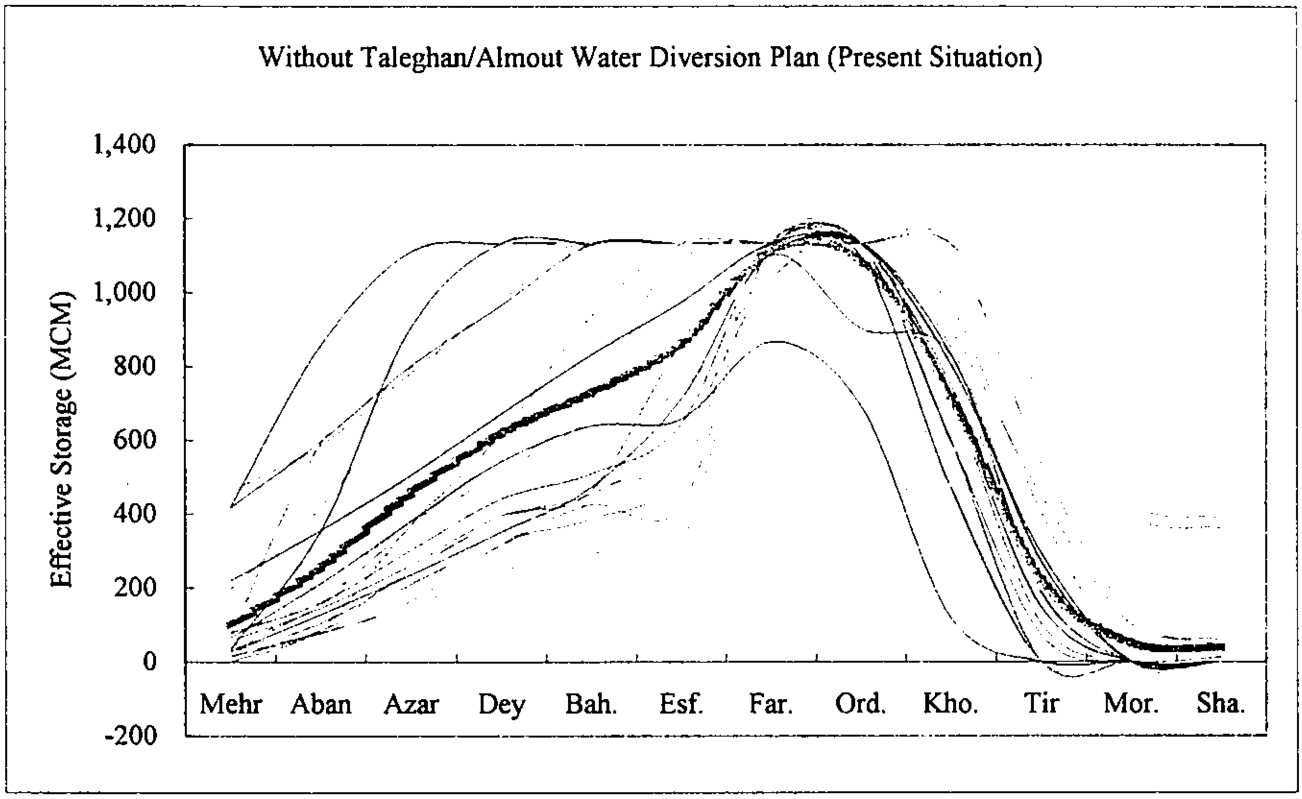
QezelOzanDia.mcd

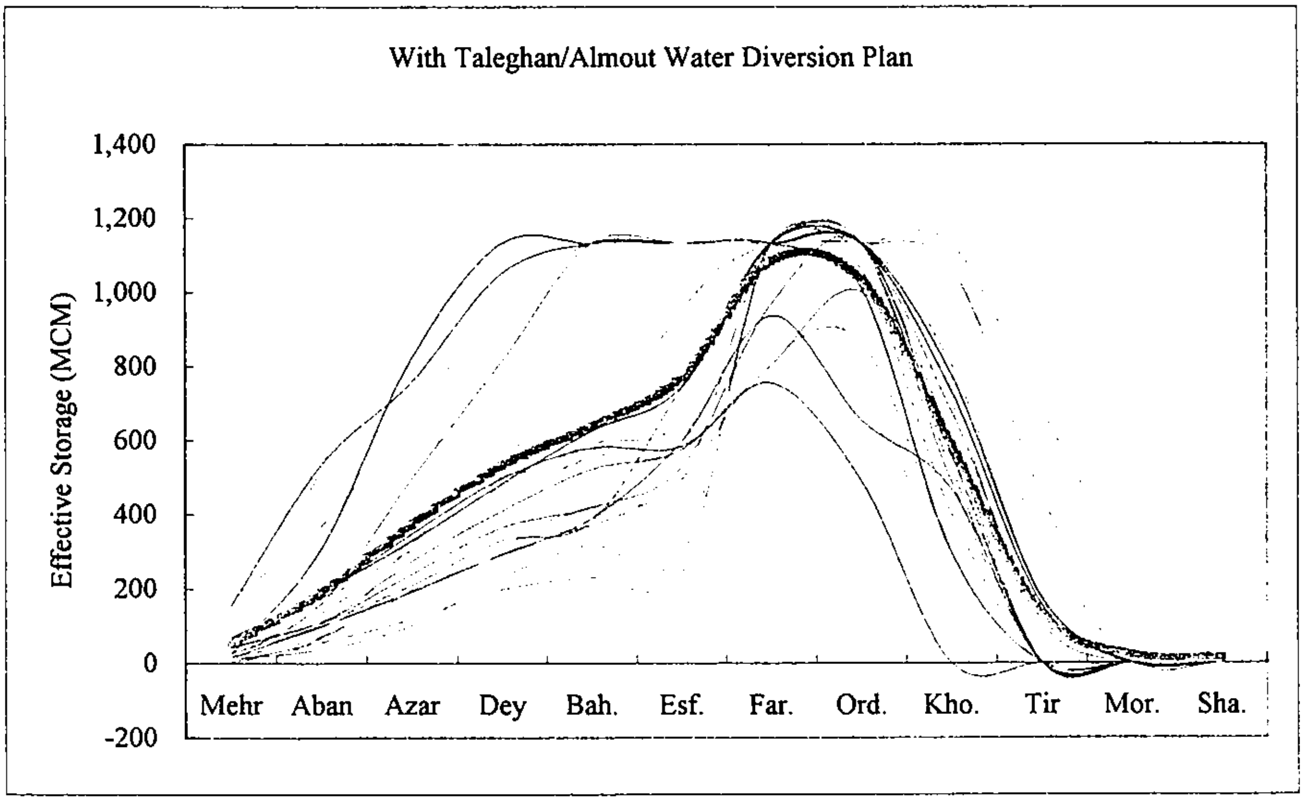
Table 9.4.4.1 Comparison of Manjil Dam Operation (with and without Taleghan/Almout Water Diversion, ES=1,133MCM)

Year	without Diversion Plan				with Diversion Plan				Difference			
	Inflow (1)	Outflow (2)	Spillage (3)	Shortage (4)	Inflow (5)	Outflow (6)	Spillage (7)	Shortage (8)	Inflow (5)-(1)	Outflow (6)-(2)	Spillage (7)-(3)	Shortage (8)-(4)
69-70	4,141.99	3,007.03	1,361.56	637.07	3,580.33	2,755.07	825.27	889.03	(561.66)	(251.96)	(536.29)	251.96
70-71	3,460.01	3,301.51	158.50	342.59	2,772.31	2,772.31	0.00	871.79	(687.70)	(529.20)	(158.50)	529.20
71-72	6,894.05	3,644.10	2,889.74	0.00	6,056.49	3,634.38	2,230.38	9.72	(837.56)	(9.72)	(659.36)	9.72
72-73	4,389.00	3,341.16	1,408.05	302.94	3,693.74	3,106.92	778.55	537.18	(695.26)	(234.24)	(629.50)	234.24
73-74	5,505.00	3,371.62	2,119.66	272.48	4,937.68	3,175.54	1,762.13	468.56	(567.32)	(196.08)	(357.53)	196.08
74-75	3,741.92	3,252.49	503.15	391.61	3,047.79	2,989.99	57.80	654.11	(694.13)	(262.50)	(445.35)	262.50
75-76	4,594.03	3,577.38	1,016.65	66.72	3,872.06	3,284.73	587.33	359.37	(721.97)	(292.65)	(429.32)	292.65
76-77	3,311.94	3,311.94	0.00	332.16	2,882.50	2,882.50	0.00	761.60	(429.44)	(429.44)	0.00	429.44
77-78	3,456.38	2,986.95	469.43	657.15	2,822.38	2,676.02	146.36	968.08	(634.00)	(310.93)	(323.07)	310.93
78-79	4,459.28	3,308.63	1,150.65	335.47	3,747.89	3,036.69	711.20	607.41	(711.39)	(271.94)	(439.45)	271.94
79-80	3,998.35	3,047.86	950.49	596.24	3,461.87	2,838.01	623.86	806.09	(536.48)	(209.85)	(326.63)	209.85
80-81	5,551.26	3,644.10	1,785.84	0.00	4,832.34	3,499.70	1,332.64	144.40	(718.92)	(144.40)	(453.20)	144.40
81-82	3,558.33	3,059.12	620.53	584.98	3,134.13	2,960.07	174.06	684.03	(424.20)	(99.05)	(446.47)	99.05
82-83	5,925.54	3,644.10	2,238.63	0.00	5,428.05	3,566.07	1,861.98	78.03	(497.49)	(78.03)	(376.65)	78.03
83-84	3,490.35	3,327.76	205.40	316.34	3,020.63	3,020.63	0.00	623.47	(469.72)	(307.13)	(205.40)	307.13
84-85	6,268.77	3,402.50	2,866.27	241.60	5,635.50	3,234.03	2,401.47	410.07	(633.27)	(168.47)	(464.80)	168.47
85-86	3,908.61	3,343.82	564.79	300.28	3,460.71	3,179.00	281.72	465.10	(447.90)	(164.82)	(283.07)	164.82
86-87	3,631.59	3,100.10	531.49	544.00	2,941.47	2,846.55	94.92	797.55	(690.12)	(253.55)	(436.57)	253.55
87-88	7,863.45	3,644.10	4,159.37	0.00	7,167.76	3,545.99	3,621.77	98.11	(695.69)	(98.11)	(537.60)	98.11
88-89	3,326.08	2,602.60	783.46	1,041.50	2,990.38	2,467.95	522.42	1,176.15	(335.70)	(134.65)	(261.04)	134.65
89-90	3,064.26	2,931.51	132.75	712.59	2,708.70	2,708.70	0.00	935.40	(355.56)	(222.81)	(132.75)	222.81
90-91	3,125.03	2,697.14	427.89	946.96	2,831.39	2,572.51	258.88	1,071.59	(293.64)	(124.63)	(169.01)	124.63
91-92	6,738.79	3,644.10	2,706.90	0.00	5,994.84	3,644.10	2,134.54	0.00	(743.95)	0.00	(572.36)	0.00
92-93	4,557.82	3,457.40	1,488.21	186.70	4,136.93	3,282.24	1,070.89	361.86	(420.89)	(175.16)	(417.32)	175.16
93-94	7,432.38	3,498.12	3,934.26	145.98	6,805.87	3,305.37	3,500.50	338.73	(626.51)	(192.75)	(433.76)	192.75
94-95	6,431.56	3,644.10	2,633.46	0.00	5,949.96	3,644.10	2,290.59	0.00	(481.60)	0.00	(342.87)	0.00
95-96	5,336.69	3,477.75	2,012.94	166.35	4,818.69	3,355.32	1,478.63	288.78	(518.00)	(122.43)	(534.31)	122.43
96-97	2,597.28	2,597.28	0.00	1,046.82	2,286.97	2,286.97	0.00	1,357.13	(310.31)	(310.31)	0.00	310.31
97-98	4,265.43	3,110.05	1,155.38	534.05	3,735.56	2,949.94	785.62	694.16	(529.87)	(160.11)	(369.76)	160.11
Average	4,656.04	3,275.05	1,388.81	369.05	4,095.00	3,076.60	1,018.40	567.50	(561.04)	(198.45)	(370.41)	198.45
Maximum	7,863.45	3,644.10	4,159.37	1,046.82	7,167.76	3,644.10	3,621.77	1,357.13	(293.64)	0.00	0.00	529.20
Minimum	2,597.28	2,597.28	0.00	0.00	2,286.97	2,286.97	0.00	0.00	(837.56)	(529.20)	(659.36)	0.00

ManjilOut1133MhbMod.xls

Figure 9.4.4.1 Manjil Dam Operation (w/o and with Taleghan/Almout Water Diversion Plan)





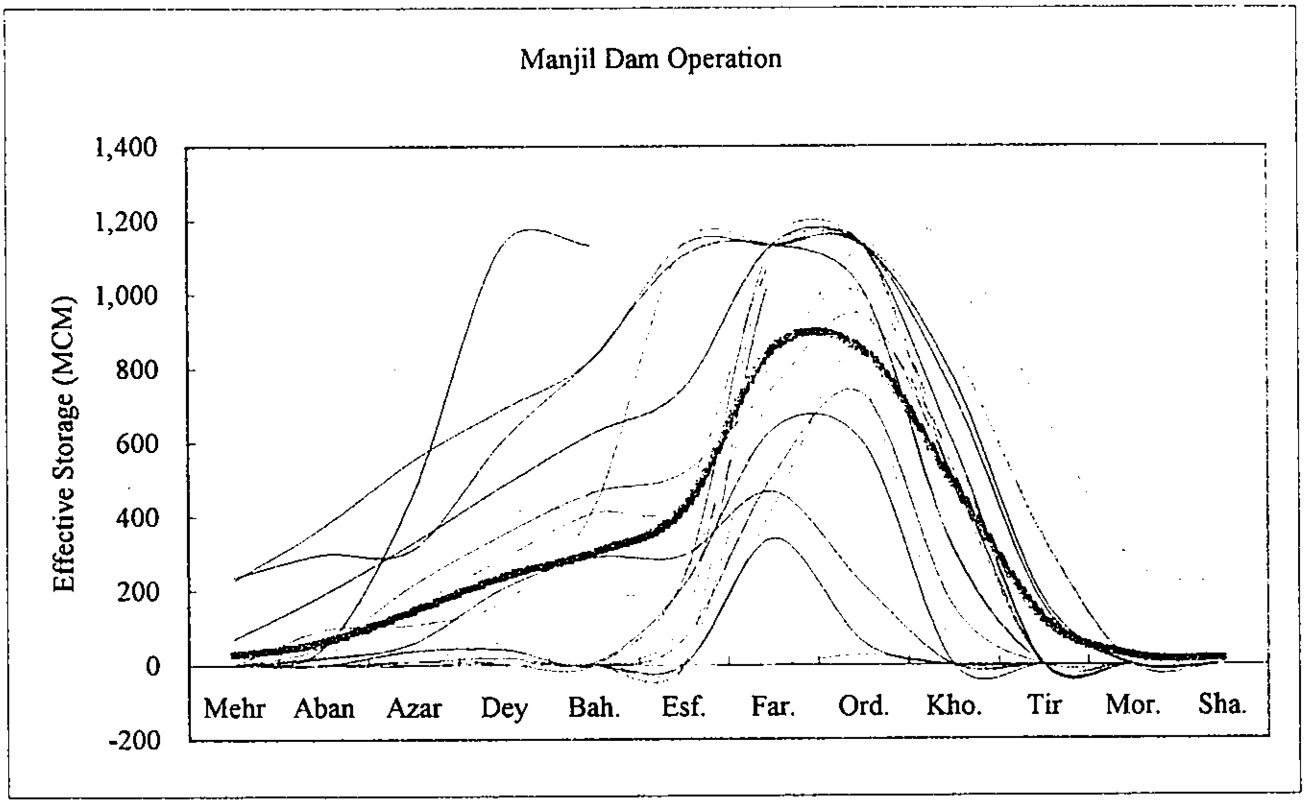
ManjilOpeGraphMod.xls

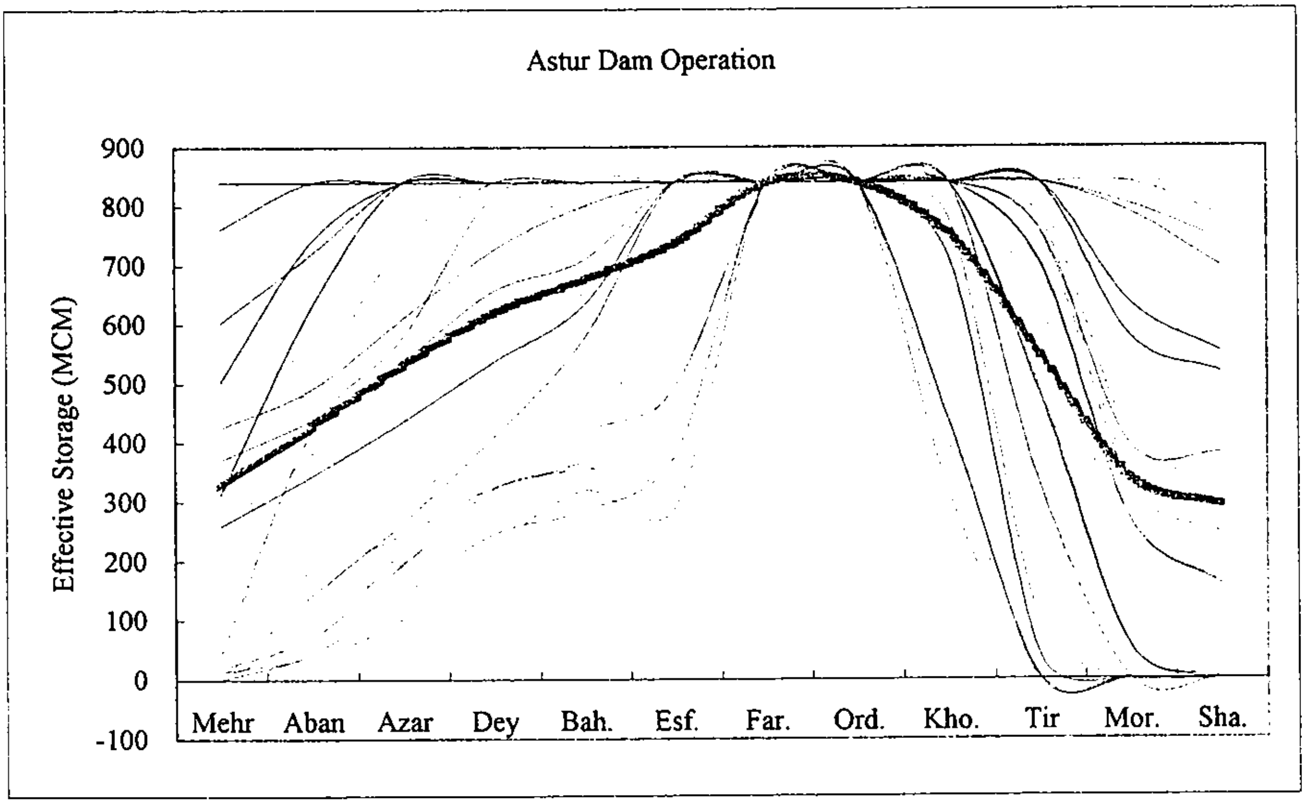
Table 9.4.5.1 Comparison of Manjil Dam Operation (with and without Taleghan/Almout Water Diversion, with Astur Dam)

Year	without Diversion Plan				with Diversion Plan/Astur Dam				Difference			
	Inflow (1)	Outflow (2)	Spillage (3)	Shortage (4)	Inflow (5)	Outflow (6)	Spillage (7)	Shortage (8)	Inflow (5)-(1)	Outflow (6)-(2)	Spillage (7)-(3)	Shortage (8)-(4)
69-70	4,141.99	3,007.03	1,361.56	637.07	3,760.52	3,607.26	379.86	36.84	(381.47)	600.23	(981.70)	(600.23)
70-71	3,460.01	3,301.51	158.50	342.59	2,772.35	2,772.35	0.00	871.75	(687.66)	(529.16)	(158.50)	529.16
71-72	6,894.05	3,644.10	2,889.74	0.00	5,216.46	3,634.38	1,390.36	9.72	(1,677.59)	(9.72)	(1,499.38)	9.72
72-73	4,389.00	3,341.16	1,408.05	302.94	4,231.23	3,644.10	778.85	0.00	(157.77)	302.94	(629.20)	(302.94)
73-74	5,505.00	3,371.62	2,119.66	272.48	4,894.72	3,644.10	1,250.62	0.00	(610.28)	272.48	(869.04)	(272.48)
74-75	3,741.92	3,252.49	503.15	391.61	3,427.61	3,427.61	0.00	216.49	(314.31)	175.12	(503.15)	(175.12)
75-76	4,594.03	3,577.38	1,016.65	66.72	3,644.10	3,644.10	0.00	0.00	(949.93)	66.72	(1,016.65)	(66.72)
76-77	3,311.94	3,311.94	0.00	332.16	3,130.43	3,130.43	0.00	513.67	(181.51)	(181.51)	0.00	181.51
77-78	3,456.38	2,986.95	469.43	657.15	2,857.66	2,857.66	0.00	786.44	(598.72)	(129.29)	(469.43)	129.29
78-79	4,459.28	3,308.63	1,150.65	335.47	3,622.19	3,622.19	0.00	21.91	(837.09)	313.56	(1,150.65)	(313.56)
79-80	3,998.35	3,047.86	950.49	596.24	3,587.62	3,587.62	0.00	56.48	(410.73)	539.76	(950.49)	(539.76)
80-81	5,551.26	3,644.10	1,785.84	0.00	4,136.74	3,644.10	492.64	0.00	(1,414.52)	0.00	(1,293.20)	0.00
81-82	3,558.33	3,059.12	620.53	584.98	3,673.75	3,644.10	29.65	0.00	115.42	584.98	(590.88)	(584.98)
82-83	5,925.54	3,644.10	2,238.63	0.00	4,822.05	3,644.10	1,177.95	0.00	(1,103.49)	0.00	(1,060.68)	0.00
83-84	3,490.35	3,327.76	205.40	316.34	3,644.10	3,644.10	0.00	0.00	153.75	316.34	(205.40)	(316.34)
84-85	6,268.77	3,402.50	2,866.27	241.60	5,365.13	3,644.10	1,721.03	0.00	(903.64)	241.60	(1,145.24)	(241.60)
85-86	3,908.61	3,343.82	564.79	300.28	3,644.10	3,644.10	0.00	0.00	(264.51)	300.28	(564.79)	(300.28)
86-87	3,631.59	3,100.10	531.49	544.00	3,188.00	3,188.00	0.00	456.10	(443.59)	87.90	(531.49)	(87.90)
87-88	7,863.45	3,644.10	4,159.37	0.00	6,425.85	3,644.10	2,781.75	0.00	(1,437.60)	0.00	(1,377.62)	0.00
88-89	3,326.08	2,602.60	783.46	1,041.50	3,732.26	3,307.94	424.32	336.16	406.18	705.34	(359.14)	(705.34)
89-90	3,064.26	2,931.51	132.75	712.59	2,708.70	2,708.70	0.00	935.40	(355.56)	(222.81)	(132.75)	222.81
90-91	3,125.03	2,697.14	427.89	946.96	2,831.38	2,831.38	0.00	812.72	(293.65)	134.24	(427.89)	(134.24)
91-92	6,738.79	3,644.10	2,706.90	0.00	5,154.83	3,644.10	1,294.53	0.00	(1,583.96)	0.00	(1,412.37)	0.00
92-93	4,557.82	3,457.40	1,488.21	186.70	4,498.79	3,644.10	1,070.89	0.00	(59.03)	186.70	(417.32)	(186.70)
93-94	7,432.38	3,498.12	3,934.26	145.98	6,782.75	3,644.10	3,138.65	0.00	(649.63)	145.98	(795.61)	(145.98)
94-95	6,431.56	3,644.10	2,633.46	0.00	5,626.83	3,644.10	1,967.49	0.00	(804.73)	0.00	(665.97)	0.00
95-96	5,336.69	3,477.75	2,012.94	166.35	5,107.46	3,644.10	1,478.59	0.00	(229.23)	166.35	(534.35)	(166.35)
96-97	2,597.28	2,597.28	0.00	1,046.82	2,861.75	2,861.75	0.00	782.35	264.47	264.47	0.00	(264.47)
97-98	4,265.43	3,110.05	1,155.38	534.05	3,633.42	3,633.42	0.00	10.68	(632.01)	523.37	(1,155.38)	(523.37)
Average	4,656.04	3,275.05	1,388.81	369.05	4,102.85	3,442.49	668.18	201.61	(553.19)	167.44	(720.63)	(167.44)
Maximum	7,863.45	3,644.10	4,159.37	1,046.82	6,782.75	3,644.10	3,138.65	935.40	406.18	705.34	0.00	529.16
Minimum	2,597.28	2,597.28	0.00	0.00	2,708.70	2,708.70	0.00	0.00	(1,677.59)	(529.16)	(1,499.38)	(705.34)

Manjil2OutAstur.xls

Figure 9.4.5.1 Manjil Dam and Astur Dam (with Taleghan/Almout Water Diversion Plan)





ManjilOpeGraphMod.xls