JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF ENERGY
TEHRAN REGIONAL WATER BOARD
THE ISLAMIC REPUBLIC OF IRAN

# THE STUDY
# ON
# WATER MANAGEMENT
# IN
# THE WESTERN AREA OF THE CAPITAL TEHRAN
# IN
# THE ISLAMIC REPUBLIC OF IRAN

# FINAL REPORT

# SUMMARY REPORT

NOVEMBER 2001

SANYU CONSULTANTS INC.

| Exchange Rate |
| --- |
| US$ 1.0 = Rls 8,000 |
| (May 2000～March 2001) |

# PREFACE

In response to a request from the Government of the Islamic Republic of Iran, the Government of Japan decided to conduct a study on Water Management in the Western Area of the Capital Tehran and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Shoichiro Higuchi of SANYU CONSULTANTS INC. to Islamic Republic of Iran, two times between May, 2000 and August, 2001. In addition, JICA set up an advisory committee headed by Mr. Hidetomi Oi, Development Specialist between April, 2000 and September, 2001, which examined the Study from Specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Islamic Republic of Iran and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Islamic Republic of Iran for their close cooperation extended to the Team

November 2001

Takao Kawakami
President
Japan International Cooperation Agency

October 15, 2001

Mr. Takao Kawakami
President,
Japan International Cooperation Agency
Tokyo, Japan

**Letter of Transmittal**

Dear Mr. Kawakami,

We are pleased to submit hereby the Final Report of the Study on Water Management in the Western Area of the Capital Tehran in the Islamic Republic of Iran. This report incorporates advises and suggestions of authorities concerned of the Government of Japan and your good agency as well as the comments made by the Tehran Regional Water Board (TRWB) of the Ministry of Energy and other responsible agencies of the Government of Iran on the formulation of the project during technical discussions on the draft final report, which were held in Tehran.

In the light of urgent importance of solving water shortage problems prevailing over the western area of the capital Tehran, the Study is to supplement and strengthen the Master Plan Study on the National and Regional Water Resources initiated already by the Government of Iran.

Potential resources of both surface water and groundwater are limited in the Tehran capital area and the use of available water resources has been stretched to the limits. Almost river may be the last source of surface water remained unused within the territory of water allocation of the area. 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.

In view of critical condition of balance between demand and supply of water and of need for sustainable development of the capital area as a whole, the Study aims to furnish full information

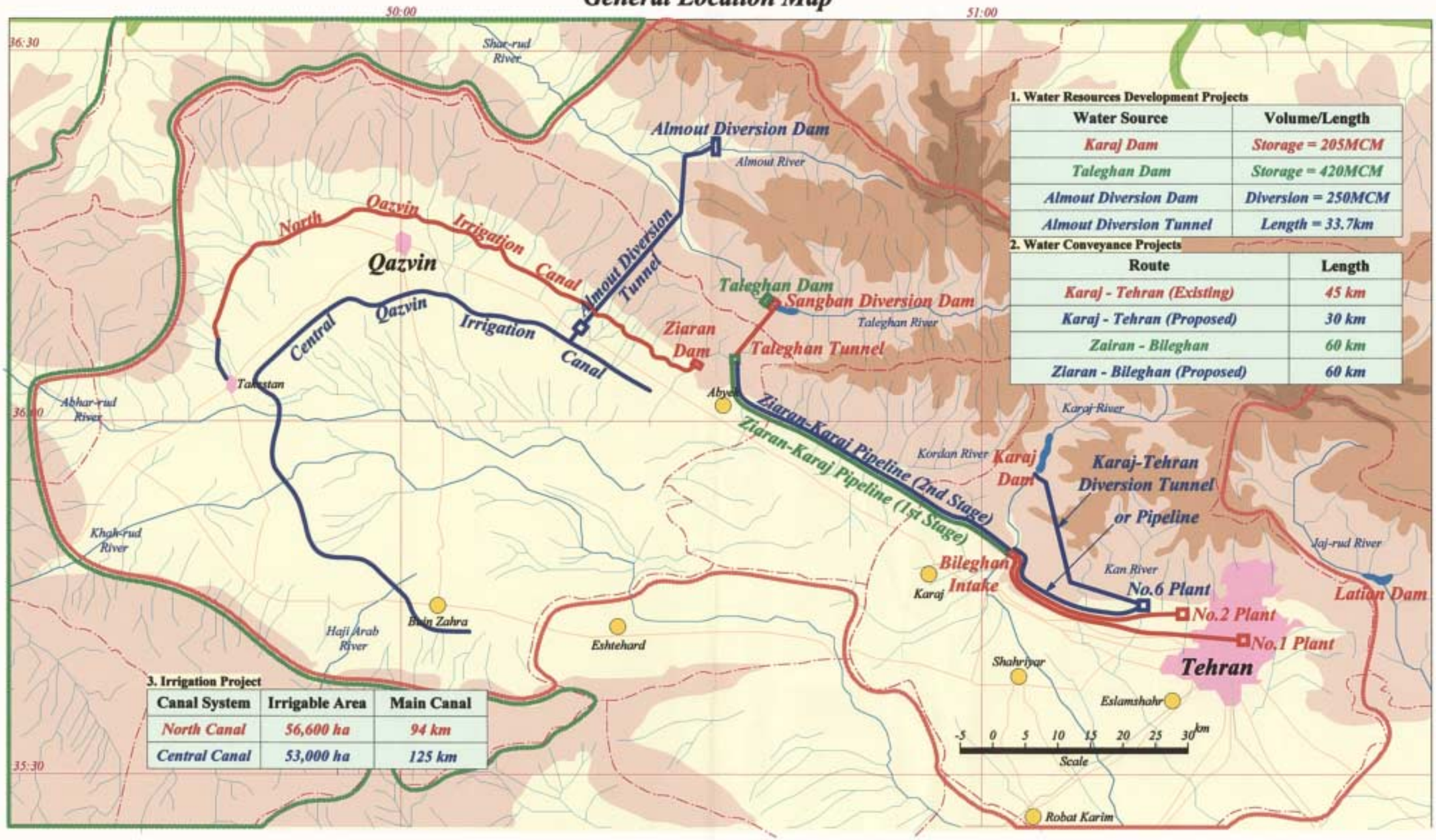
regarding the demand and supply of water so that the Government of Iran can make decision for further implementation of the Project under due consideration of not only technical aspects but also economic and other situation of the country. The magnitude of environmental influence that might be caused by Project would not be considerable.

We wish to take this opportunity to express our heartfelt gratitude to your Agency and other authority concerned of the Government of Japan as well as to the TRWB and other agencies of the Government of Iran for close cooperation and assistance extended to us during the course of our investigations and studies.

Very truly yours,

Shoichro Higuchi
Leader of the Study Team

# General Location Map




**1. Water Resources Development Projects**

| Water Source | Volume/Length |
|---|---|
| Karaj Dam | Storage = 205MCM |
| Taleghan Dam | Storage = 420MCM |
| Almout Diversion Dam | Diversion = 250MCM |
| Almout Diversion Tunnel | Length = 33.7km |

**2. Water Conveyance Projects**

| Route | Length |
|---|---|
| Karaj - Tehran (Existing) | 45 km |
| Karaj - Tehran (Proposed) | 30 km |
| Zairan - Bileghan | 60 km |
| Ziaran - Bileghan (Proposed) | 60 km |

**3. Irrigation Project**

| Canal System | Irrigable Area | Main Canal |
|---|---|---|
| North Canal | 56,600 ha | 94 km |
| Central Canal | 53,000 ha | 125 km |

| LEGEND OF PROJECTS | |
|---|---|
| | Existing Project |
| | Project under Construction |
| | Proposed Project |

| LEGEND OF BOUNDARIES | |
|---|---|
| | Study Area (Part) |
| | Related River Basins (Part) |

# Contents

# Executive Summary

## Western Area of the Capital Tehran

The western area of the capital Tehran comprises Tehran City and four regions of Tehran, Karaj, Hashtgerd and Qazvin that extend westward of Tehran City. Tehran City, the capital of the Islamic Republic of Iran, is the center of the national activities such as politics and socio-economy. Tehran and Karaj regions lie adjacent to Tehran City holding numbers of satellite cities of Tehran and neighboring agricultural zones. Hashtgerd region is located between Karaj and Qazvin where residential and industrial developments of large-scale are under progress designated by the government as the new development area. Qazvin region of Qazvin Province holds a vast agricultural area of about 350,000 ha forming a supply center of food to the capital area and has been expanding as a new industrial zone.

## Population and Water Demand

Total population of the western capital area is 11.7 million in 2001 and is projected to increase to 17.4 million in 2021. On the other hand, the present water demand of 4,675 MCM is forecasted to increase to 5,630 MCM in 2021 accompanied by increasing population and industrial, urban and agricultural development of the area. Domestic and industrial water demand of 1,595 MCM at present is projected to increase to 2,320 MCM in future while agricultural water demand is estimated to increase to 3,310 MCM from the present demand of 3,080 MCM. In Tehran City, present water consumption of 910 MCM will increase to 1,230 MCM in future providing a serious anxiety of water shortage in the area.

## Potential and Available Water Resources

(1) Surface Water

Major sources of surface water in the area are Karaj, Latian and Lar dams under operation at present and Taleghan storage dam and Almout diversion dam that are going to be developed in near future. Small streams originated from Taleghan mountains are also providing surface water in the area. Total potential resources of such water are evaluated at 2,460 MCM, of which 1,390 MCM are being utilized at present and available resources in future are estimated at 1,965 MCM including the present use. Potential and available water resources are absolutely insufficient against the demand of water in the western capital area, 5,630 MCM, and as high as 80% of the potential resources are to be utilized in order to satisfy the demand, requiring strict management of water developed.

(2) Groundwater

There lies a large scale groundwater aquifer with the storage capacity of 42,000 MCM underneath the plain of 8,200 $km^2$ in the western capital area. Presently about 3,300 MCM of groundwater are extracted from 26,000 deep and shallow wells and utilized for domestic, industrial and agricultural purposes. Recharge of groundwater from precipitation and surface flow in the area is, however, not adequate as compared with extraction and over-extraction becomes obvious in many places showing draw-down of groundwater tables and reduction of groundwater production, providing serious problems on the management of groundwater resources.

**Water Allocation Plan**

On the basis of increasing water demand due to population growth and urban, industrial and agricultural development, water allocation plans of short-term in 2006, medium-term in 2011 and long-term in 2021 are prepared. Comparison between the present situation and the long-term plan is summarized as below;

| Use of Water | Present Situation in 2001 | | | Long-term Plan in 2021 | | |
|---|---|---|---|---|---|---|
| | Surface Water | Ground Water | Total | Surface Water | Ground Water | Total |
| Domestic/Industrial | 640 | 955 | 1,595 | 980 | 1,340 | 2,320 |
| Agricultural | 750 | 2,330 | 3,080 | 1,335 | 1,975 | 3,310 |
| **Total** | **1,390** | **3,285** | **4,675** | **2,315** | **3,315** | **5,630** |

Present use of surface water of 1,390 MCM will increase to 2,315 MCM in future with an increment of 925 MCM supplied by Taleghan dam, Almout water diversion and re-used water from sewage treatment plant. Use of groundwater in future is restricted at the present level in consideration of impending and critical conditions of groundwater resources.

**Water Sources and Water Resources Development Projects**

The existing and proposed water sources and water utilization projects that will be managed in future are summarized in the next table.

It is, however, necessary to carry out urgently the study and implementation for the following projects, in order to achieve the projected water allocation plan:

- Rehabilitation works of existing Taleghan tunnel and Qazvin north irrigation canal system, which have been under operation for a long period of more than 25 years and partly deteriorated.
- Study and implementation of the new water conveyance facility connecting the Karaj river downstream of Karaj dam and proposed No.6 water treatment plant in Tehran City in order to realize the utilization of the Taleghan water of 150 MCM in 2011 and 310 MCM in 2021.
- Feasibility study of Almout water diversion project should be carried out together with the study for Qazvin central irrigation project because both projects are closely related each other.
- Inventory survey for the existing shallow and deep production wells to identify their pumping function, extracted amount of groundwater, necessity of rehabilitation, etc together with implementation of rehabilitation program and construction of new production wells.

**Outline of Existing and Proposed Water Sources and Water Utilization Project**

| Project | Status | Outline |
|---|---|---|
| 1. Water Sources Project | | |
| Karaj Dam | Operation | Arch dam H=180m, V=205MCM, A.W 4.35MCM |
| Taleghan Water Diversion | - do - | Sangban weir, Tunnel 9km, Ziaran dam A.W 200MCM |
| Taleghan Dam | Construction | Fill dam H=104m, V=420MCM, A.W 450MCM |
| Almout Water Diversion | Plan | Almout weir, Tunnel 33.8km, A.W 250MCM |
| 2. Water Conveyance Project | | |
| Karaj-Tehran No.1, No.2 | Operation | L=40km, Q=2.7$m^3$ in No.1, 8.0$m^3$ in No.2 |
| Karaj-Tehran No.6 Plant | Plan | L=24km, Tunnel or Pipeline Q=15$m^3$/sec |
| Ziaran-Karaj, Stage 1 | Construction | Steel Pipeline L=60km, Q=5$m^3$/sec |
| Ziaran-Karaj, Stage 2 | Plan | - do - L=60km, Q=5$m^3$/sec |
| 3. Tehran Water Work Project | | |
| Water Treatment Plant | Operation | No.1～No.4 Capacity 18.7$m^3$/sec, Annual Yield 535MCM |
| - do - No.5 | Construction | Capacity 6.75$m^3$/sec |
| - do - No.6 | Plan | Capacity 12.0$m^3$/sec |
| Sewerage Plant | Plan | No.1 Capacity 9.5$m^3$/sec, No.2 Capacity 13.9$m^3$/sec |
| 4. Irrigated Agriculture Project | | |
| Karaj Irrigation | Operation | Area 20,000ha, Main Canal L=38km, |
| Kordan Irrigation | - do - | Area 5,000ha, Weir, Main canal L=12km, |
| Qazvin North Irrigation | - do - | Area 48,200ha, Main Canal L=94km, |
| Qazvin Central Irrigation | Plan | Area 53,000ha, Main Canal L=125km, |
| 5. Groundwater Development | | |
| Shallow and Deep Wells | Operation | Shallow well 15,000, Deep well 11,000 A.W 3,300MCM |
| Groundwater Recharge | Plan | Recharging pond/dam, underground dam |
| 6. Rehabilitation Projects | | |
| Qazvin North Irrigation | Plan | Concrete structure and gates in canal system |
| Taleghan Water Diversion | -do- | Taleghan tunnel, Ziaran dam and telemeter system |
| Water Pipeline in Tehran City | -do- | Prevent of water leakage through pipeline of 8,000km |

Note: V=Reservoir Capacity, A.W=Available Water, H=Height and L=Length

**Improvement of Water Management**

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 classified as 1) watershed management, 2) river flow management, 3) water source management, 4) water allocation management, 5) groundwater management, 6) irrigation water management and 7) domestic water management.

**Almout Water Diversion Project**

In order to satisfy the urban water demand of Tehran City in future, the Taleghan water of 310 MCM per annum is necessary to be conveyed to Tehran in 2021. As the Taleghan water has been planned and used for Qazvin irrigation since 1970s with the program of future expansion of irrigation area in Qazvin plain, the Almout Water Diversion Project becomes necessary to compensate for the Taleghan water and to supply irrigation water to Qazvin plain. The project includes the tunnel with a long distance of 33.8km having the high viability to be implemented. The outline of project is as follows;

- Diversion Water Amount 250 MCM
- Downstream Release 60 MCM
- Almout Diversion Dam Concrete weir H=10m, L=56m
- Almout Water Pipeline Steel pipe, L=6.0km, Q=22.5$m^3$/sec
- Almout Tunnel D=4.0m, L=33.8km
- Project Cost US$123.6 million
- Water Cost US$0.05/$m^3$

**Qazvin Irrigation Project**

(1) Outline of Irrigation Project

The existing irrigation area is estimated at 81,000ha or 23% of total farm area supplied by the Taleghan water of 200 MCM in combination of groundwater. In future irrigation area will be expanded supplied by the Almout water, small river waters and groundwater to be exploited, etc. Conceptual plan of Qazvin irrigated agricultural development is as shown below.

**Outline of Qazvin Irrigation Canal System**

| Item | Existing North Area | | Proposed Central Canal | |
|---|---|---|---|---|
| 1. Irrigable Area (ha) | North, Higher | 38,600 | North, Lower | 38,100 |
| | Takestan | 9,000 | Central | 60,900 |
| | **Total** | **47,600** | **Total** | **99,000** |
| 2. Net Irrigation Area (ha) | North, Higher | 28,900 | North, Lower | 28,500 |
| | Takestan | 6,700 | Central | 45,500 |
| | **Total** | **35,600** | **Total** | **74,000** |
| 3. Irrigation Intensity (%) | | 75 | | 75 |
| 4. Available Irrigation Water (MCM) | | | | |
| Talegan water | | 140 | | - |
| Almout water | | - | | 210 |
| Groundwater | | 260 | | 610 |
| **Total** | | **400** | | **820** |
| 5. Recharging Water | | - | | 40 |
| 6. Irrigation Canal System | | | | |
| Main Canal | Q=30$m^3$/sec, L = 94km | | Q=22.5$m^3$/sec, L=125km | |
| Secondary Canal | 12 units, L = 220km | | 10 units, L=150km | |
| 7. Production Wells | | 800units | | 1,600units |

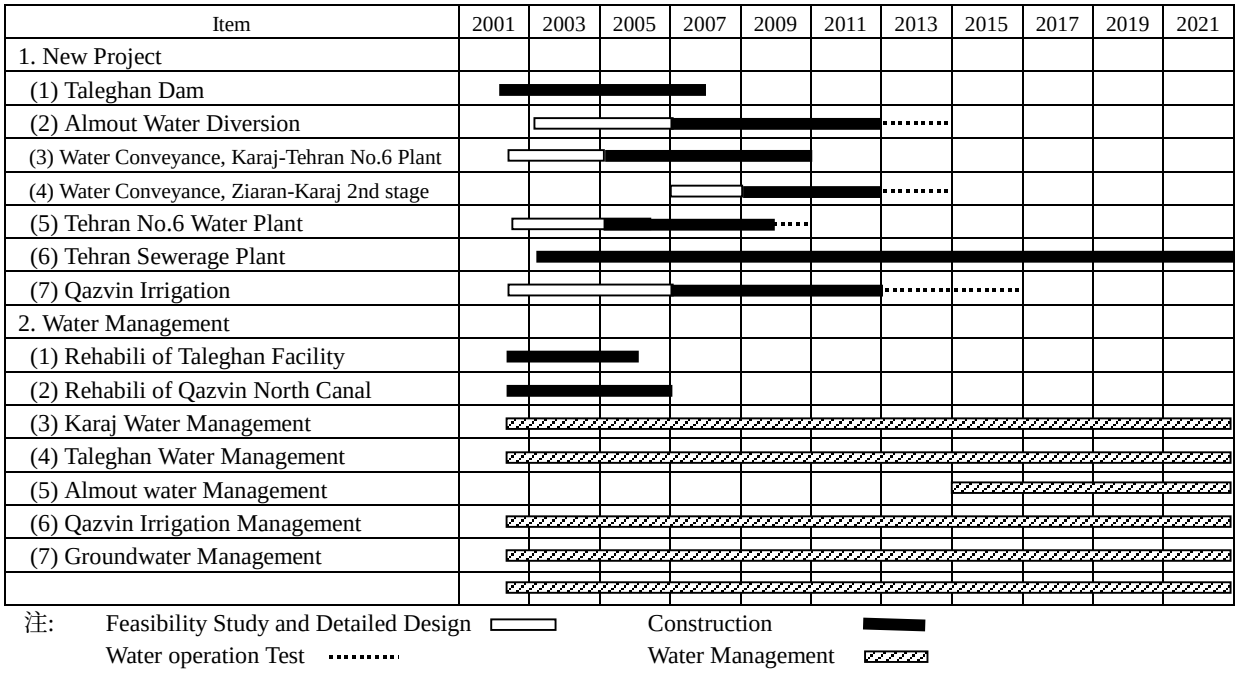
**Project Evaluation**

The project cost for irrigation canal system is estimated at US$41.5 million. Total project cost including the Almout water diversion project is US$165.1 million (123.6 million + 41.5 million). Project benefit is estimated at Rls 81 billion (about US$10 million) on the financial basis and Rls 147 billion (about 18.4 million) on the economic basis. Economic Internal Rate of Return (EIRR) estimated based on the project cost and project benefit shows relatively high value of 14.5%. The investment cost per ha is estimated at US$5,900. As for financial evaluation, farm income per farm household will increase from Rls 4.8 million at present to Rls 6.8 million under with project condition.

**Implementation Schedule of Water Resources Development and Management Program**

As mentioned in the above, it is necessary to implement the various water resources development and water management projects to achieve the water allocation plans proposed in the Master Plan and to satisfy the increasing future water demand in the western capital area. The implementation schedule for the development and management is proposed as follows;

**Implementation Program of Water Resources Development and Management Projects**




**Conclusion and Recommendation**

(1) General Description

At present in 2001, 4,675 MCM per annum of water, 1,390 MCM from surface sources and 3,285 MCM from groundwater, are consumed in the western capital area of Tehran with 1,595 MCM supplied for urban use and 3,080 MCM for agriculture. This order of water supply and use will be extended to 5,630 MCM in 2021 inclusive of 1,965 MCM of surface water, 359 MCM of re-use water and 3,315 MCM of groundwater for 2,320 MCM of urban use and 3,310 MCM for agriculture,

supported by the governmental policy of population absorption in the capital area. Potential resources of both surface water and groundwater are limited in the area and the use of available water resources has been stretched to the limits. Of the potential surface water resources of 2,460 MCM, present use accounts for 1,390 MCM (57%) and the usable water in future will be, at most, 1,965 MCM or 80% of the potential. On the other hand, groundwater resources, which provide 3,285 MCM per annum of water at present, have 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.

Water supply in Tehran City depends on stored water in Karaj dam and Latian dam connected with Lar dam and groundwater. Supply from surface sources has, however, leveled off since 1993 due to hydrological limitation and in turn extraction of groundwater has been increasing rapidly indicating obvious decline of groundwater tables at many locations. Surface water sources remain undeveloped within the territory of the area are Taleghan river and Almout river, and aiming at conversion of use of Taleghan water from agriculture in Qazvin plain to water supply in the capital area, the government has started construction of the Taleghan storage dam at immediate downstream of the existing Taleghan diversion dam and also construction of water pipeline to connect the outlet of the Taleghan tunnel and Karaj river has just completed in 2001. Both Taleghan and Almout rivers belong to Qazvin province and therefore development of Almout water to compensate for such a conversion of water use is indispensable. Irrigated agriculture in Qazvin plain is also to be expanded in order to expect smooth implementation of the water conversion plan, and is absolutely necessary for wide and equitable distribution of social benefit arising from the implementation of the water diversion project. Fortunately, implementation of the Almout water diversion project is judged feasible and viable from both engineering and economic points of view.

Moreover, to cope with increasing water demand towards the target year of 2021 opportunely, related works such as rehabilitation of existing water diversion facilities, construction of Karaj to Tehran water diversion facility, phase 2 work of water pipeline between Ziaran and Karaj are to be studied and implemented timely. Integrated water management program, development of surface water resources and groundwater management are to be properly implemented as described in the following paragraphs.

In the area, water supply works for both urban water supply and irrigation and sewerage are conducted by semi-governmental companies and they are well managed including activities for tariff collection. In order to cope with increasing demand of water accompanied by the growth of population, development and management of water resources will become more essential. However, such an effort inevitably has a limit, and necessary measures to restraint demand of water, such as control of population growth in the capital area, is to be surveyed when longer view after 2021 is

taken into consideration.

(2) Integrated Water Management Program

Total available water for domestic, industrial and agricultural uses in the Study Area is estimated at about 5,600 MCM in 2021, consisting of the surface water of 2,300 MCM and groundwater of 3,300 MCM. This volume of available water is not thoroughly sufficient to satisfy the future water demand when the per capita value of available water, 320 cubic meter only, is taken into consideration, because this value is considerably smaller as compared with the world average. Accordingly, the integrated water management program to use and allocate the developed water properly and effectively among various water demands becomes inevitably necessary and is to be implemented urgently. In this concern, it is recommendable to pay the particular attention 1) reservoir operation and reservoir water use, 2) combination water use for surface water and groundwater, 3) evaluation and management of groundwater resources, 4) water allocation rule with reasonable and equitable use, and 5) water use on the service area level to minimize the water losses.

(3) Surface Water Sources Development

Potential surface water in the Study Area is evaluated at 2,460 MCM, of which 1,965 MCM could be developed and available to cover the proposed water demand toward 2021 in the area. However, the following study and implementation for the water sources development are to be carried out properly and on schedule.

- The new Karaj water conveyance project to convey the Karaj water to the proposed No.6 water treatment plant through a tunnel under gravity or a pipeline with pumping station has to be urgently studied and implemented.
- It is important to complete the Taleghan dam project just on schedule. It is also urgently necessary to survey, study and implement the rehabilitation of the existing Taleghan tunnel.
- As for the Almout surface water, it is very important and urgently necessary to implement the Almout Water Diversion Project to divert the Almout water to Qazvin irrigation.

(4) Groundwater Management

Present use of groundwater of 3,300 MCM is judged to be the maximum limit taking into account the available recharging water in the area such as rainfall, surplus surface water in rivers, return flow from irrigation and domestic and industrial water supply, etc. It is recommendable to study and implement the groundwater management in order to carry out the effective and sustainable use of groundwater, including 1) establishment of monitoring and evaluation system including the rehabilitation of monitoring wells and the provision of new organization to evaluate and control the groundwater properly and accurately, and 2) study and implementation of groundwater recharge program by recharging dam and dike in the Khah-rud river basin in Qazvin plain and the Kordan river basin in Hashtgerd region.

(5) Promotion of Information Disclosure

For development and management of regional resources such as water, measures to exceed

stereotyped solution are required. Mutual understandings and reliance on the necessity of development and management of resources are essential between inhabitants of donor basins and persons who are to benefit in order to achieve the most effective solution. Precise awareness is the base of mutual understandings and reliance, and the best shortcut to achieve a success is to promote constitution of common consent through deep discussions among persons concerned. Disclosure of necessary information to support such discussions is therefore necessary, and the seminar and workshop conducted at the occasion of the presentation of the Draft Final Report would be a good example for information disclosure.

## 1. Introduction


The capital area of Tehran has expanded rapidly and largely westward after the revolution with its population increased from about 5 million in 1979 to 7.5 million at present in 2001, that are projected further to grow to 10.7 million in 2021 indicating 200% of growth during 40 year period. Being located in the western border of the capital Tehran, regions of Tehran, Karaj and Hashtgerd have also been expanding as the satellite cities of Tehran with the present population of 3.4 million increased from 0.5 million at the time of revolution. This expansion urged the improvement of social infrastructure such as highway, railway, power transmission lines, gas pipeline and communication network together with development of residential areas. Development of water sources and provision of water use facilities are however still outdistanced by other public sectors, providing major source of anxiety about serious water shortage at present and more in near future.

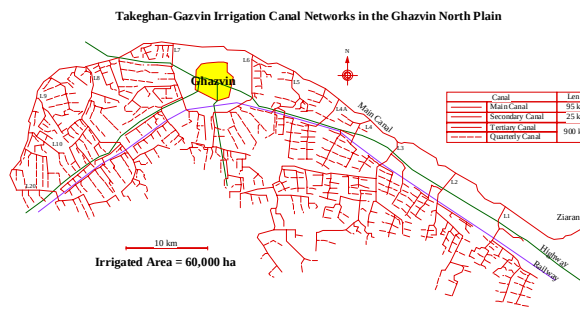
*Taleghan Mountain near Abyek*

At present in the year 2001, approximately 910 MCM of municipal water are consumed annually in Tehran, of which 340 MCM are supplied from Latian dam constructed on Jaj-rud river located in the east of Tehran City and 300 MCM are provided from Karaj dam on Karaj river in the west of Tehran, supplemented by 270 MCM of groundwater. Both dams are multi-purpose for water supply and irrigation, however, rapid increase of demand for municipal water supply due to migration of urban population and industries has forced conversion of water use from irrigation to municipal water supply. As a result of such a conversion, consumption of groundwater has increased rapidly from approximately 100 MCM in 1993 to 300 MCM in 1997 showing obvious over-extraction. It has accordingly forced the scale-downs of irrigation as well as dependence on groundwater in the agricultural areas of southern Tehran plain and downstream reaches of Karaj and Jaj-rud rivers. Decreasing progress of production as well as levels of groundwater together with contamination of water quality due


to waste-water from municipal areas has become serious social problem in the area.

Demand of municipal water supply in Tehran in 2021 is estimated at 1,230 MCM corresponding to the projected population of 10.7 million with an increase of 320 MCM against the present demand of 910 MCM.

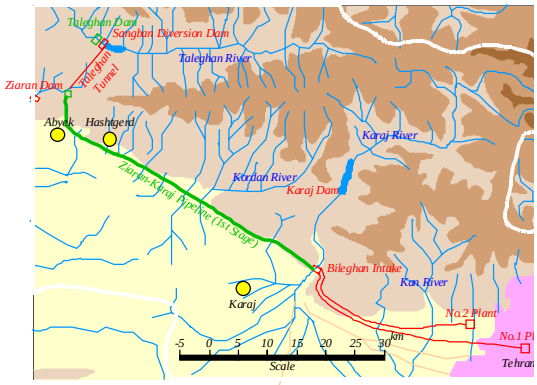
About 350,000 ha of agricultural area extend in the Qazvin plain located adjacent to the western area of the capital Tehran, forming the center to support the food security of the capital Tehran. In the northern Qazvin plain, the irrigated agricultural development project was completed in the early 1970's with water diverted trans-basin from the Taleghan river combined with groundwater in the plain and has been in operation for more than 30 years forming a stable and fertile rural community. At present about 50,000 ha are being irrigated with the Taleghan water of 150 to 200 MCM annually, combined with about 400 MCM of groundwater extracted from deep and shallow wells.




***Existing North Qazvin Irrigation System***

***Existing Taleghan Diversion Dam***

In the light of urgent needs of additional source of water for the western area of the capital Tehran, the government of Iran has formulated as the national strategy the plans; 1) to construct a water pipeline of about 60 km long connecting the outlet of existing Taleghan tunnel with Karaj river in order to utilize about 120 MCM of Taleghan water for irrigation purpose in Karaj area and 2) .to



construct a storage dam at the immediately downstream of the existing diversion dam envisaging to divert additional 160 MCM of Taleghan water. In this connection, construction of the water pipeline has just completed in 2001. Construction of the proposed storage dam has been determined as the emergency project by the cabinet with the presidential order of immediate action in 1998, and dam construction has just commenced at the middle of 2001 by the Tehran Regional Water Board. Completion of dam construction is expected in 2006 to 2007. Of 450 MCM of water available annually from the Taleghan storage dam, 270 MCM, 150 MCM and 30 MCM were allocated respectively to irrigation in Qazvin plain, urban water in Tehran City and environmental use in the downstream reaches along the Taleghan river, according to the initial plan of water operation at the dam. However, to cope with the immediate needs of water at present and in near future in Tehran City, government of Iran has been planning to convey all of Karaj dam water to Tehran City and use a part of Taleghan water in Karaj area for water supply as well as irrigation.

It is however projected that the use of Taleghan water in the western capital areas of Tehran would result serious damage for irrigation in Qazvin plain, and new water resources development plan to divert Almout river water has been under consideration by the Tehran Regional Water Board. Almout basin is located adjacent to Taleghan basin having a potential of about 250 MCM of water diversion that can be supplied to Qazvin plain.

***Existing Bileghan Intake from where Karaj dam water is Conveyed to Tehran City***

On the basis of comprehensive understandings on the existing and future developments of the area focusing especially on appropriate projection of demands of water required in various water user sectors, existing situation of impending balance of water between demand and supply, exhausting resources of surface and groundwater, it is inevitably necessary and urgent to set up an integrated water management plan consisting of proper and timely water resources development plan, effective and stable water use management plan and reasonable and rational water allocation plan for sustainable growth of the area toward the target year of 2021.


The National and Regional Water Resources Master Plan (the Master Plan), being prepared since 1996 by the Ministry of Energy, was completed in 2000. The Tehran Regional Water Board (T.R.W.B) under the Ministry of Energy has a deep concern to the Master Plan study on the Central Region, especially for the

Tehran capital area that is the most important area in the country and suffered from chronic water shortage problems. The Master Plan was prepared based, however, on the socio-economic and hydrological data up to 1993/94 with analyses starting from 1996 as the present conditions showing a slight time lag as compared with the actual situation. The Master Plan is also open to charge of emphasizing the logical plans of allocation of water between increasing demands and possible supplies, without focusing too much on the engineering measures to realize such allocation plans.

Under these circumstances, T.R.W.B requested the Japanese Government to carry out the Study on Water Management in the Western Area of the Capital Tehran, on the basis of the Master Plan and including engineering study on the viability of the water diversion plan from Almout river on a pre-feasibility study level, under the technical cooperation of the Japanese Government. In response to the request of the government of Iran, the government of Japan has made efforts towards extending technical cooperation through Japan International Cooperation Agency (JICA) to establish a rational and practical water management plan including water diversion plan from the Almout basin to the Qazvin plain.

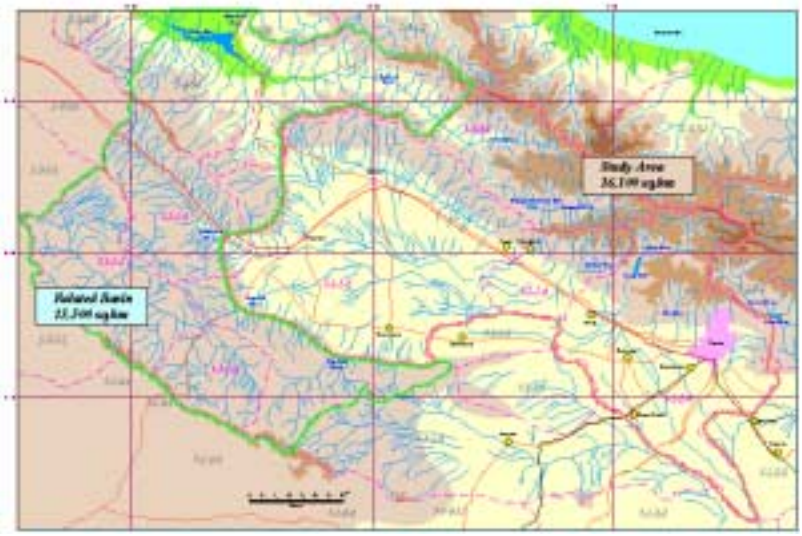
The objectives of the Study are summarized as follows;

1) to make a long-term projections of increasing water demands for various water uses in the western area of the capital Tehran up to the project target year of 2021,
2) to grasp potential surface and ground water resources in the Study area and to evaluate present and future surplus or deficit of water on the basis of water balance between demand and supply,
3) to formulate short-term and medium term plans of management/allocation of water to be diverted from the Taleghan river,
4) to conduct a pre-feasibility study on the water diversion plan from the Almout river and a conceptual plan of Qazvin irrigation project to cope with a long-term solution of water allocation and management in the Study area, and
5) to carry out technology transfer to the counterpart personnel in the course of the Study.

## 2. Present Conditions of the Study Area

### 2.1 Scope of the Study Area

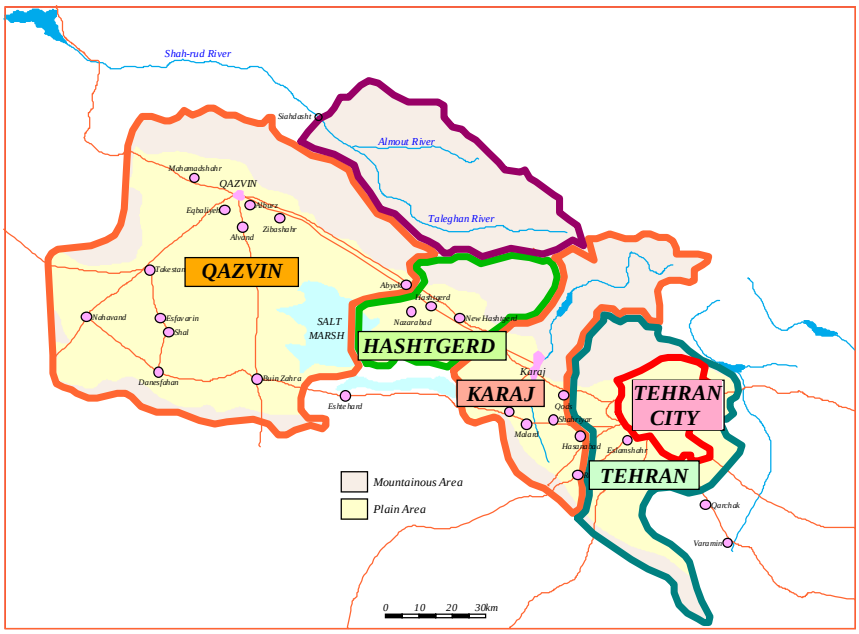
The Study Area covers 16,100km$^2$ consisting of the service areas; namely 1) Tehran city and four (4) regions of 2) Tehran, 3) Karaj and 4) Hashtgerd, and 5) Qazvin plain that utilize developed water from surface and groundwater sources, and the river basins of Karaj, Taleghan and Almout that are the main sources of surface water for use in the service areas. In addition, the Study deals with related river basins of about 15,500km$^2$, including 1) three rivers of Abhar-rud, Khah-rud and Haji Arab which flow into the Qazvin plain providing water for irrigation uses in the southern Qazvin plain and 2) a part of the Sefied-rud river basin where the Manjil dam is under operation and probable influence of the proposed Taleghan and Almout water diversion will be the subject for discussion.



The service areas in the Study Areas are generally located at the elevations from 1,500 to 1,100m with its northern part lying over the mountainous topography with elevations of 2,000 to 2,500m, while the river basins of Karaj, Taleghan and Almout are located in the Alborz mountains with elevation varying from 2,000m to 4,000m. Such areas are categorized into plain and mountain areas as summarized below;

**Topographical Division of the Study Area**

| Division | Total Area (km$^2$) | Plain Area (km$^2$) | Mountain Area (km$^2$) |
|---|---|---|---|
| Taleghan & Almout Basin | 2,450 | - | 2,450 |
| Tehran Service Area | 6,400 | 3,540 | 2,860 |
| Qazvin Service Area | 7,250 | 5,290 | 1,960 |
| Total | 16,100 | 8,830 | 7,270 |




**Beneficiary Division of the Study Area**

***Tehran City*** is located at the eastern corner of the Study Area, holding a large population of about 7.5 million at present (2001) and utilizing urban water of 910 MCM supplied mainly from Karaj and Latian dams and groundwater. It is, however, anxious that the area would face serious water shortage problems in near future due to increasing water demand accompanied by growing population.

***Tehran region*** is defined as the surrounding area of Tehran City covering Eslamsher, a part of Varamin, Ray and Shahriyar, forming the agricultural zone to support food security of Tehran City formerly, holding at present a large expansion of residential and industrial areas as the satellite cities of Tehran and requiring larger demand of water for municipal, industrial and agricultural uses in future. Most of water are served mainly by groundwater.

***Karaj district***, extending along the Karaj river, has been developed as the satellite town of Tehran City and holds a large population of 2.1 million including 1.85 of urban population at present. The irrigated agricultural area in the Shahriyar and Robatkarim has been decreasing suffered from severe water shortage due to decreasing irrigation water provided from Karaj dam. Groundwater resources in the district have also been decreasing due to conversion of use of Karaj dam water from agriculture to urban water supply in Tehran City, together with over-extraction of groundwater in the area.

***Hashtgerd region*** is the new residential and industrial area nominated by the Government at present under development. The present population of 290,000 is expected to increase considerably to 820,000 in 2021. However, groundwater only is the source of water for urban and industrial uses in

the area and decreasing tendency of groundwater is obvious in recent years. The Kordan river flows southward in the area and empties unused into the salt marsh. This river water is used only for the medium/small-scale irrigation in the upper basin.

***Qazvin plain***, consisting of Qazvin, Takestan and Buin Zahra districts, has a large extent of fertile farm area of about 350,000 ha. The Taleghan water has been distributed to the irrigation area of about 77,000 ha in the northern part of the plain of which net irrigation area is limited to about 50,000 ha because of lack of water, while the central area of 60,000 ha is expected to be irrigated in future by additional water which becomes available after completion of the proposed Taleghan storage dam and Almout water diversion project. Groundwater development by shallow and deep wells has been accelerated in the plain and about 1,200 MCM per annum of groundwater is presently used mainly for irrigated agriculture. The southern highland area is expected to be developed in future by groundwater after strengthening the recharging function of three rivers, Abhar-rud, Khah-rud and Haji Arab.

### 2.2 National and Regional Economy

Iran embarked on the Third 5-year Economic, Social and Cultural Development Plan, covering the period 2000/01-2005/06. Policies undertaken in the plan include structural adjustments in governmental administration and public enterprises, promotion of free market-oriented economic competitiveness by removing non-tariff trade barriers, budget and tax reforms, and establishment of a comprehensive social safety net to protect the most vulnerable segments of the population. These policies are aimed at a number of important objectives; in particular, a GDP growth rate averaging 6% over the period and the creation of 765,000 new employment opportunities annually.

GDP Growth Rate at 1982/83 Constant Prices

| Sector | 1991/92 (B. Rials) | 1996/97 (B. Rials) | 1998/99 (B. Rials) | Growth Rate (%) 1991/92 – 1998/99 |
|---|---|---|---|---|
| Oil | 2,517 | 2,566 | 2,410 | -0.61 |
| Non-oil | 9,308 | 12,128 | 13,034 | 4.93 |
| Total | 11,825 | 14,694 | 15,445 | 3.89 |

Strategic policies for the areas of water resources development aims to 1) to achieve sustainable development in water resources, 2) to develop surface water resources to increase agricultural production together with rehabilitation of the existing irrigation networks; 3) to promote the re-use of waste water, and to strengthen water resources conservation management in respect of quantity and quality; and 4) to strengthen water demand management by taking into account appropriate water allocation to different users. Also, strategic policies for the areas of agricultural development aims to 1) to attain self-sufficiency in food production by effective utilization of various resources available in the country; 2) to achieve sustainable development in agriculture; 3) to promote

agricultural investments and agro-industry activities; 4) to create employment opportunities in the agricultural sector; and 5) to accelerate development in rural areas to solve the problems inherent to urban areas such as excessive population pressure, high unemployment, high water consumption, etc.

As mentioned above, the water resources and agricultural policy initiatives are aimed at freeing the utilization of water resources from substantial dependence on the limited ground water resources and turning it to newly-exploited surface water resources. In this respect, the major objective of this Project conforms to the strategic policies of the plan.

Sectoral Structure of GDP at 1982/83 Constant Prices (%)

| Sector | 1986/87 | 1991/92 | 1996/97 | 1997/98 | 1998/99 |
|---|---|---|---|---|---|
| **Oil** | **14.2** | **21.3** | **17.5** | **16.0** | **15.6** |
| **Non-oil** | **85.5** | **78.7** | **82.5** | **84.0** | **84.4** |
| - Agriculture | 26.9 | 26.4 | 26.0 | 26.1 | 27.7 |
| - Manufacturing | 11.6 | 16.4 | 15.8 | 16.5 | 17.1 |
| - Construction | 6.6 | 4.3 | 4.8 | 4.5 | 4.0 |
| - Trade | 10.6 | 10.6 | 10.0 | 10.3 | 10.4 |
| - Real Estates | 12.7 | 11.7 | 12.3 | 11.4 | 11.0 |
| - Others | 17.4 | 9.3 | 13.6 | 15.2 | 14.2 |

The industrial sector has continued to be dominated by relatively few but large public enterprises that account for approximately 70% of the GDP in the manufacturing sector. Public enterprises have relied on relatively capital-intensive production while the private sector has been characterized by labour-intensive production. Real growth in the industrial sector in 1377 (1998/99) reached 4.9% while the share of industrial contribution to the GDP continued to increase, having reached 17.1%. The construction sector was the most dynamic sector in 1375 (1996/97), having significantly grown by 10.6% due to the expansion in both housing and commercial construction in Tehran, partly as a result of local government policies to relieve shortages of housing and office space. The industrial production value in the Study Area in 1996/97 amounted to 12,538 billion rials, being 15.1 % of the national total. The share of the value in the Study Area is highest at 91.4% for Tehran, and lowest at 0.2% for Savojbolagh where the fledgling industrial cities, Hashtgerd and Hashtgerd Jadid are located. Nevertheless, Hashtgerd, Hashtgerd Jadid and Alburz have large potential for rapid industrialization in the near future.

Agriculture continues to play an important role in the Iranian economy, contributing 27.7% of the GDP (1996/97) and accounting for 23.1% of the working population. Rural areas in the Study Area are characterized by a predominantly subsistence agricultural economy with severe irrigation water shortage, small land holdings (e.g. 2.5 ha for the Karaj and Kordan irrigation areas and 3.0 ha for the Qazvin irrigation area). Agriculture in the Study Area is generally not commercialized and exhibits

low productivity. Disparities in income and employment opportunities are wide and persistent due to small land holdings and unavailability of adequate irrigation water throughout the year. Apart from the disadvantaged segment of the rural population, food security is guaranteed in the case of higher income groups who are practicing a multiple cropping system along the irrigation networks based on comparative geographical advantages. Given the fact that the irrigation networks in the Karaj and Kordan irrigation areas have recently dried up completely, making the comparative geographical advantages ineffective, the viability of regional agriculture is severely threatened.

### 2.3 Population

According to the National Water Resources Master Plan, total population in the western area of the capital Tehran is 11.75 million at present (2001) that will increase to 17.37 million in 2021. Urban population occupies 85% of the total population and will increase at a growth rate of 2.1% per annum toward 2021. This increasing population will bring about serious water shortage problems in the Study Area. Rural population will, however, decrease from 1.0 million in 1996 to 800,000 in 2021 due to migrant from rural to urban area. Figure 4 shows the present and future population projected in the Master Plan.

**Population at Present and in Future**

| | Tehran City | Tehran Region | Karaj Region | Hashtgerd Region | Qazvin Region | **Total** |
|---|---|---|---|---|---|---|
| Present（2001） | 7,500 | 1,010 | 2,100 | 290 | 810 | **11,750** |
| Future（2021） | 10,730 | 1,420 | 3,240 | 820 | 1,160 | **17,370** |
| Incremental Rate (%) | 1.43 | 1.41 | 1.54 | 2.83 | 1.43 | **1.48** |

Note: See 4.1.1 of Chapter 4 of Main Report for more details.

### 2.4 Existing Water Demand

#### (1) Domestic and Industrial Water Demand

The water demand for domestic and industrial uses in the western area of the capital Tehran is evaluated at 1,595 MCM at present (2001) of which 910 MCM or 57% of the total are shared by municipal water demand in Tehran City, as summarized below;

**Domestic and Industrial Water Demand at Present (2001)**

(Unit: MCM)

| | Tehran City | Tehran Region | Karaj Region | Hashtgerd Region | Qazvin Region | **Total** |
|---|---|---|---|---|---|---|
| Present Demand in 2001 | 910 | 150 | 415 | 30 | 90 | **1,595** |

#### (2) Irrigation Water Demand

There extends a large farm area of 540,000 ha in the western capital area, where the dry farming for winter crops such as wheat and barely is predominant. Present irrigation area in 2001 is estimated at

277,000ha or 50% of the total farm area, where sugar beet, oil seed, bean, feeder crops, orchard, vegetable, etc, are cultivated and their products are consumed in the capital area. Cropping area under irrigation in each region in 1998 is as shown in the following table.

**Cropping Area Under Irrigation（1998）**

Unit: ha

| Region | Grain | Industrial Crops | Feeder Crops | Vegetable | Orchard | Total |
|---|---|---|---|---|---|---|
| Tehran | 19,340 | 100 | 7,180 | 7,090 | 7,220 | 40,940 |
| Karaj | 16,270 | 370 | 5,680 | 5,390 | 10,080 | 37,790 |
| Hashtgerd | 10,830 | 850 | 3,380 | 850 | 5,550 | 21,460 |
| Qazvin | 51,810 | 5,290 | 14,170 | 11,390 | 33,200 | 115,860 |
| **Total** | **98,250** | **6,610** | **30,410** | **24,720** | **56,050** | **216,040** |

Note: Irrigation area is slightly small as 216,040ha in 1998 due to lack of irrigation water in the dry year.

Present irrigation area and irrigation water demand are estimated in the following table and their variation is shown in Figure 5.

**Estimated Irrigation Area and Water Demand at Present (2001)**

| Item \ Region | | Tehran | Karaj | Hashtgerd | Qazvin | **Total** |
|---|---|---|---|---|---|---|
| Irrigation Area | （$10^3$ha） | 64.5 | 51.4 | 29.1 | 132.3 | **277.1** |
| Irrigation Demand | (MCM) | 710 | 565 | 350 | 1,455 | **3,080** |

### (3) Total Water Demand and Water Sources

Total water demands by water sources are summarized as shown in the following table and Figure 6.

**Total Water Demands by Water Sources in 2001**

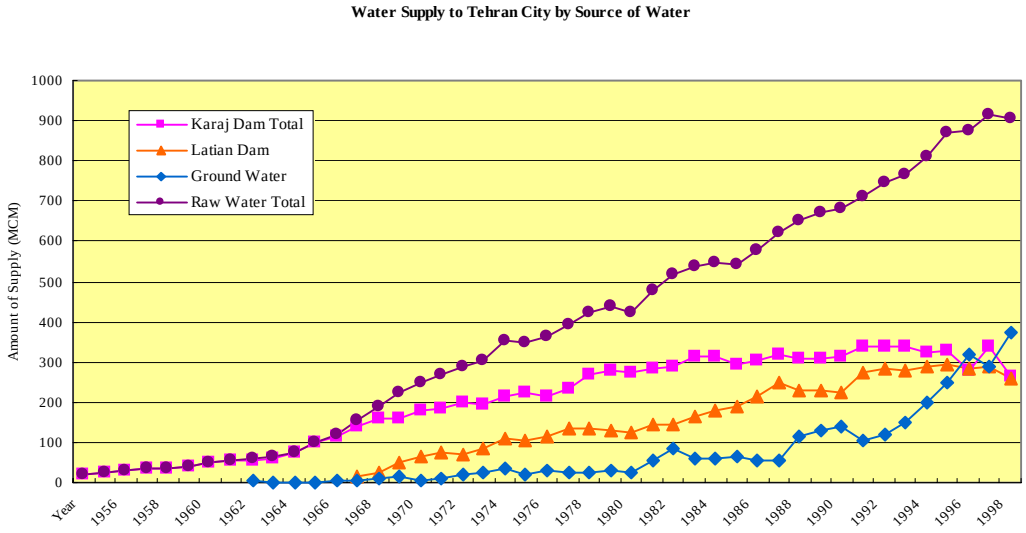
Unit: $10^6m^3$

| Objective | Water Sources | Tehran City | Region | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | | | Tehran | Karaj | Hashtgerd | Qazvin | |
| Domestic & Industrial Use | Surface Water | 640 | - | - | - | - | **640** |
| | Groundwater | 270 | 150 | 415 | 30 | 90 | **955** |
| | **Sub-total** | **910** | **150** | **415** | **30** | **90** | **1,595** |
| Agriculture Use | Surface Water | - | 170 | 135 | 60 | 385 | **750** |
| | Groundwater | - | 540 | 430 | 290 | 1,070 | **2,330** |
| | **Sub-total** | **-** | **710** | **565** | **350** | **1,455** | **3,080** |
| **Total** | **Surface Water** | 640 | 170 | 135 | 60 | 385 | **1,390** |
| | **Groundwater** | 270 | 690 | 845 | 320 | 1,160 | **3,285** |
| | **Total** | **910** | **860** | **980** | **380** | **1,545** | **4,675** |

In the western area of the capital Tehran, potential resources of both surface and groundwater are limited and, on the other hand, demand of water has been increasing accompanied by rapidly increasing population. The use of available water resources has been stretched to the limits already, and groundwater tends to decrease showing annual imbalance of more than 700 MCM toward the

final dry up if proper measures are not taken immediately.

Due to the above reason in Tehran in the past years, volume of water supplied from each source has been almost constant except groundwater which indicates drastic increase as shown below:




Groundwater use at present occupies a large volume of 3,285 MCM equivalent to 70% of total water use of 4,675 MCM. Urban water supply in Tehran City depends mainly on the surface water being conveyed from Latian, Lar and Karaj dams while the domestic and industrial water in the other regions on the groundwater. A large volume of groundwater of 2,330 MCM is used for agriculture as compared with the small surface water of 750MCM. Surface water for agriculture, amounting to 385 MCM only, is mainly used in Qazvin plain.

## 3. Water Resources

### 3.1 Surface Water Resources

Iran has a variable climate. In the northwest, winters are cold with heavy snowfall and subfreezing temperatures during December and January. Spring and fall are relatively mild, while summers are dry and hot. Being located in the northern part of the country, the Study Area belongs to the semi-arid climatic zone. The Study Area is located, in a macroscopic view, in the depression surrounded by arêtes of the great Alborz mountain massif, west Zagros highlands and the western part of the Kaveer salt desert, specified by its altitude ranging from 800 m to 4,300 m above mean sea level. Precipitation in the Study Area is also Mediterranean. Summer is completely dry and precipitation occurs only in winter season. Nearly 90% of annual precipitation is brought in the months from October to June with the maximum amount corresponding to 15% of the annual total in the months February, March and April to June.

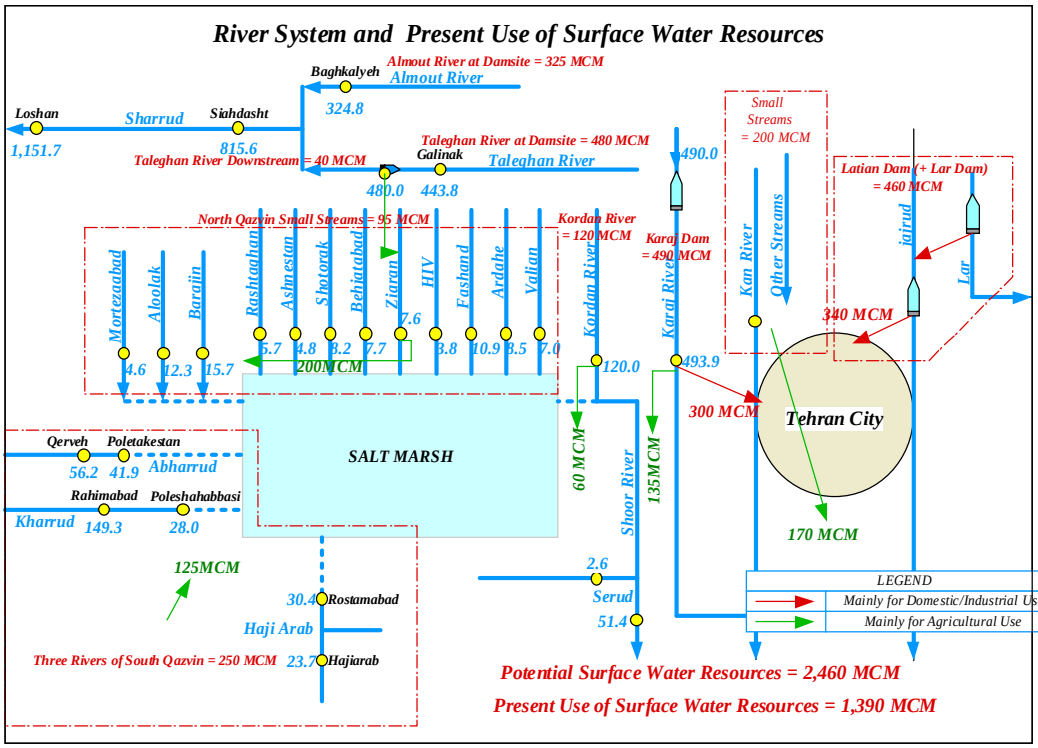



Figure 7 shows the seasonal flow of major rivers in the Study Area. About 75% to 80% of annual runoff appears in the wet season from March to July. Being located in the Alborz mountains, Karaj, Taleghan and Almout rivers are blessed with rich runoff in spring to early summer due to melting snow, however, amount of runoff is small in summer due to less or even no rainfall and in winter due to precipitation given in a form of snow pile. On the other hand, river basins of Abhar-rud, Khah-rud and Haji Arab in the southern Qazvin show very small runoff yield of 20 to 30mm because of small rainfall of 200mm/year in the basins and the flat topography where evaporation

losses and natural recharge of surface water into groundwater aquifer are usually accelerated. All rivers show the large fluctuation of annual runoff in wet and dry year. Surface water of those rivers is rather difficult to be utilized effectively so as to meet various water demands without controlled by the storage dam and/or unless utilized in combination with the groundwater.

The potential and available surface water resources in the Study Area are given in Figure 8. The potential water is given in terms of average annual runoff while the available water is defined as the volume of water that can be actually used for domestic, industrial and irrigation purposes excluding losses in the reservoir and through water diversion, necessary water in the downstream area for river maintenance and environmental uses, etc. The potential surface water resources in the Study Area is evaluated at 2,460 MCM of which 1,390 MCM or 57% is used at present and 1,965 MCM or 80% will be available in future by the water resources development by means of construction of the Taleghan dam, implementation of Almout water diversion and recharging of small stream water into groundwater aquifer. The available water of small streams from the Taleghan mountains and the three rivers of southern Qazvin plain is not clarified in the Master Plan.

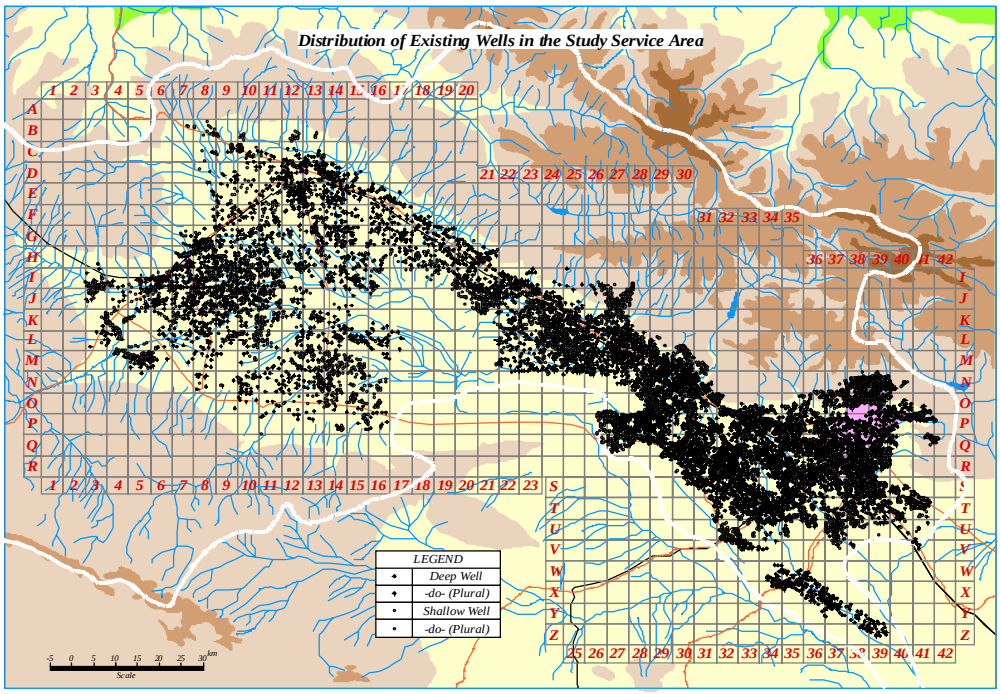
**Potential and Available Water in Surface Water Sources**

Unit: $10^6 m^3$

| | Latian & Lar | Karaj Bileghan | Kordan | Taleghan Damsite | Almout | Taleghan D.S. | Tehran North | Qazvin North | Qazvin South | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Potential Water | 460 | 490 | 120 | 480 | 325 | 40 | 200 | 95 | 250 | **2,460** |
| Present Available | 340 | 435 | 60 | 200 | 0 | 0 | 170 | 60 | 125 | **1,390** |
| Future Available | 400 | 435 | 60 | 450 | 250 | 0 | 170 | 60 | 140 | **1,965** |

### 3.2 Groundwater Resources

15,000 shallow wells and 11,000 deep wells has been excavated extracting groundwater of about 3,285 MCM at present. The average depth of shallow and deep wells is 30m and 80m respectively, with the water table of wells located 30m below the ground surface. Figure 9 shows the annual amount of groundwater extraction summarized in each grid of 5km x 5km. The black circle shows magnitude of annual extraction. Although groundwater extraction was concentrated in the southern area of Tehran City in the past, it has been expanding to the northern area in recent years accompanied by the movement of residential area together with a lack of domestic water supply from surface water sources. Large groundwater extraction of 40 to 50 MCM/Grid (1.6～2.0 $MCM/km^2$) has been made in Tehran City, Karaj urban and industrial areas, Hashtgerd industrial area and Qazvin City. In accordance with the evaluation of groundwater extraction given in the Master Plan as well as reviewing study made by JICA Team, consumption of groundwater in the Study Area reaches as large as 3,285 MCM in annual volume, which is about 2.4 times of the surface water use of 1,390 MCM.




**Number of Wells and Groundwater Use in Region**

| | | Tehran City | Tehran Region | Karaj Region | Hashtgerd Region | Qazvin Region | **Total** |
|---|---|---|---|---|---|---|---|
| 1.Number of Well | Shallow Well | 6,800 | 2,500 | 1,800 | 2,100 | 1,900 | **15,100** |
| | Deep Well | 2,400 | 3,800 | 1,400 | 900 | 2,400 | **10,800** |
| | **Total** | **9,200** | **6,300** | **3,200** | **3,000** | **4,300** | **26,000** |
| 2.Groundwater Use ($10^6 m^3$) | Domestic Industry | 270 | 150 | 415 | 30 | 90 | **955** |
| | Agriculture | 0 | 540 | 430 | 290 | 1,070 | **2,330** |
| | **Total** | **270** | **690** | **845** | **320** | **1,160** | **3,285** |

Figure 10 presents the storage changes of groundwater resources in the Study Area. Cumulative storage capacity of groundwater aquifers has turned to decrease in 1996/97 and since then exhausting tendency of groundwater resources is remarkable in most areas except northern Qazvin aquifer. Serious situations are found in Karaj, Hashtgerd and southern Qazvin plain where some countermeasures for conservation of groundwater resources are needed as early as possible. In accordance with JICA study for groundwater balance, about 760 million cu.m is assumed to be deficient every year in the western capital area and about 1,600 MCM of groundwater has been consumed excessively from the level of sustainable use of groundwater at present. Existing conditions of groundwater use are summarized as below;

**Existing Groundwater Conditions**

Unit: MCM

| | Tehran City | Region | | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | | Tehran | Karaj | Hashtgerd | Qazvin North | Qazvin South | |
| (1) Area km$^2$ | 530 | 1,290 | 940 | 780 | 1,650 | 3,040 | **8,230** |
| (2) Saturated Capacity by Groundwater | 700 | 3,300 | 5,600 | 2,100 | 10,200 | 20,500 | **42,400** |
| (3) Unsaturated Capacity | 830 | 2,660 | 3,120 | 1,970 | 2,890 | 5,590 | **17,060** |

Note: (1) Saturated capacity by groundwater means the existing potential groundwater estimated by volume below the existing water level.
(2) Unsaturated capacity means empty volume above the water level.

It is anxious in those areas that available groundwater will be lost in future, unless the present level of over-extraction from the wells is controlled and surplus surface and other water is recharged.

## 4. Water Demand Projection

### (1) Domestic and Industrial Water

Based on the forecasted population shown in Figure 4 and per capita water demand given in Figure 24, water demands for domestic and industrial uses are projected as summarized below;

**Population and Domestic and Industrial Water Demand at Present and in Future**

| | Tehran City | Tehran Region | Karaj Region | Hashtgerd Region | Qazvin Region | **Total** |
|---|---|---|---|---|---|---|
| 1. Population ($10^3$) | | | | | | |
| Present (2001) | 7,500 | 1,000 | 2,100 | 300 | 800 | **11,700** |
| Future (2021) | 10,700 | 1,400 | 3,300 | 800 | 1,200 | **17,400** |
| Incremental Rate (%) | 1.43 | 1.40 | 1.57 | 2.67 | 1.50 | **1.44** |
| 2. Domestic and Industrial Water Demand ($10^6 m^3$) | | | | | | |
| Present (2001) | 910 | 150 | 415 | 30 | 90 | **1,595** |
| Future (2021) | 1,230 | 190 | 600 | 120 | 180 | **2,320** |
| Incremental Rate (%) | 1.35 | 1.27 | 1.45 | 4.00 | 2.00 | **1.45** |

Source: Water Resources Master Plan by Iranian Government

- The domestic and industrial water demands of Tehran City and Karaj region in 2021 show the large amount of 1,230 MCM and 600 MCM respectively, occupying about 80% of the total demand.
- Though the present water demand of Hashtgerd region is as small as 30 MCM, future demand will increase to 120 MCM, equivalent to four times of the present demand, in association with the new residential and industrial development in the area.
- Numbers of small cities in Qazvin region will expand in future with increase of water demand to 180 MCM in 2021, which is two times of the present demand of 90 MCM.

**(2) Irrigation Water**

Future irrigation area and irrigation water demand are also estimated as shown in the following table against the present values.

**Present (2001) and Future (2021) Irrigation Area and Water Demand**

| Item \ Region | | Tehran | Karaj | Hashtgerd | Qazvin | **Total** |
|---|---|---|---|---|---|---|
| Irrigation Area ($10^3$ha) | Present (2001) | 64.5 | 51.4 | 31.9 | 132.3 | **280.1** |
| | Future (2021) | 79.1 | 40.0 | 23.7 | 158.2 | **301.0** |
| Irrigation Demand ($10^6m^3$) | Present (2001) | 710 | 565 | 350 | 1,455 | **3,080** |
| | Future (2021) | 870 | 440 | 260 | 1,740 | **3,310** |
| Incremental Rate (%) | | 1.23 | 0.78 | 0.74 | 1.20 | **1.07** |

- Irrigation area in the southern part of Tehran region will increase in future due to availability of the reused water to be supplied from sewerage treatment plant.
- Irrigation area and water demand in Karaj and Hashtgerd regions will decrease in future due to migration of population from rural area to urban area and conversion of water use from agriculture to municipal and industrial use.
- In Qazvin region, holding a large irrigation area of 132,000ha and utilizing irrigation water of 1,465 MCM at present (2000), irrigable area and water demand will further increase toward 2021 to 158,000 ha and 1,740 MCM because of additional water to be supplied from new sources such as the Almout water.

**(3) Total Water Demand**

Total water demands by water sources are summarized as shown in the following table and Figure 6.

**Total Water Demand and Water Source**

Unit: $10^6 m^3$

| Objective | Water Sources | Tehran City | Region | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | | | Tehran | Karaj | Hashtgerd | Qazvin | |
| **1. Present（2001）** | | | | | | | |
| Domestic & | Surface Water | 640 | - | - | - | - | **640** |
| Industrial Use | Groundwater | 270 | 150 | 415 | 30 | 90 | **955** |
| | **Sub-total** | **910** | **150** | **415** | **30** | **90** | **1,595** |
| Agriculture Use | Surface Water | - | 170 | 135 | 60 | 385 | **750** |
| | Groundwater | - | 540 | 430 | 290 | 1,070 | **2,330** |
| | **Sub-total** | **-** | **710** | **565** | **350** | **1,455** | **3,080** |
| **Total** | **Surface Water** | 640 | 170 | 135 | 60 | 385 | **1,390** |
| | **Groundwater** | 270 | 690 | 845 | 320 | 1,160 | **3,285** |
| | **Total** | **910** | **860** | **980** | **380** | **1,545** | **4,675** |
| **2. Future（2021）** | | | | | | | |
| Domestic & | Surface Water | 980 | - | - | - | - | **980** |
| Industrial Use | Groundwater | 250 | 190 | 600 | 120 | 180 | **1,340** |
| | **Sub-total** | **1,230** | **190** | **600** | **120** | **180** | **2,320** |
| Agriculture Use | Surface Water | - | 420 | 265 | 60 | 590 | **1,335** |
| | Groundwater | - | 450 | 175 | 200 | 1,150 | **1,975** |
| | **Sub-total** | **-** | **870** | **440** | **260** | **1,740** | **3,310** |
| **Total** | **Surface Water** | 980 | 420 | 265 | 60 | 590 | **2,315** |
| | **Groundwater** | 250 | 640 | 775 | 320 | 1,330 | **3,315** |
| | **Total** | **1,230** | **1,060** | **1,040** | **380** | **1,920** | **5,630** |

- Total water demand in future reaches 5,630 MCM, with the increment of 955 MCM against the present demand of 4,675 MCM. This increment will be covered mostly by the water diverted from Taleghan and Almout rivers together with the reused water to be supplied from Tehran sewerage treatment plant. The groundwater use in future is 3,315 MCM, which is almost same amount, as a whole, as compared with the present use. However, groundwater use in Karaj and Hashtgerd regions will decrease because of critical situation of groundwater resources in these areas, while that in Qazvin region will increases due to additional recharge of groundwater by imported water from Almout river. As a whole, groundwater for the domestic and industrial use will increase and on the other hand that for agricultural use will decrease.
- Increment of Tehran urban water supply in future will be completely covered with the Taleghan water of 310 MCM.
- Since the large volume of groundwater is required for the domestic and industrial uses with priority in regions of Tehran, Karaj and Hashtgerd, groundwater use for agriculture in these areas is unavoidable to be reduced.

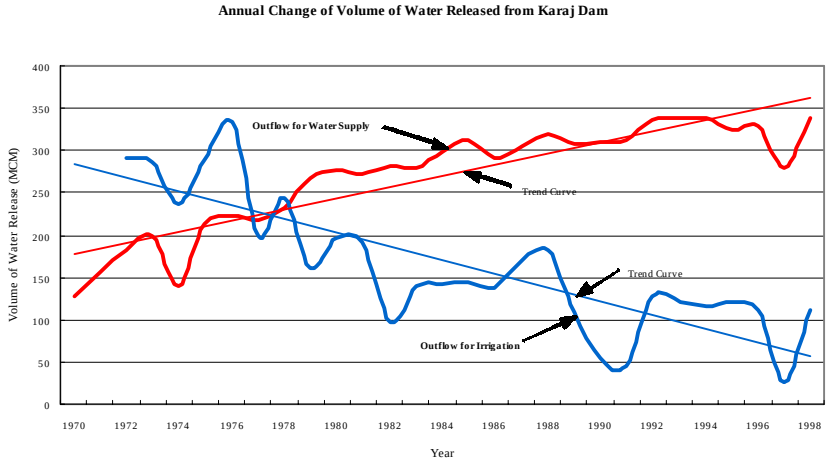
## 5. Water Operation and Allocation

### 5.1 Surface Water Operation


Karaj Dam

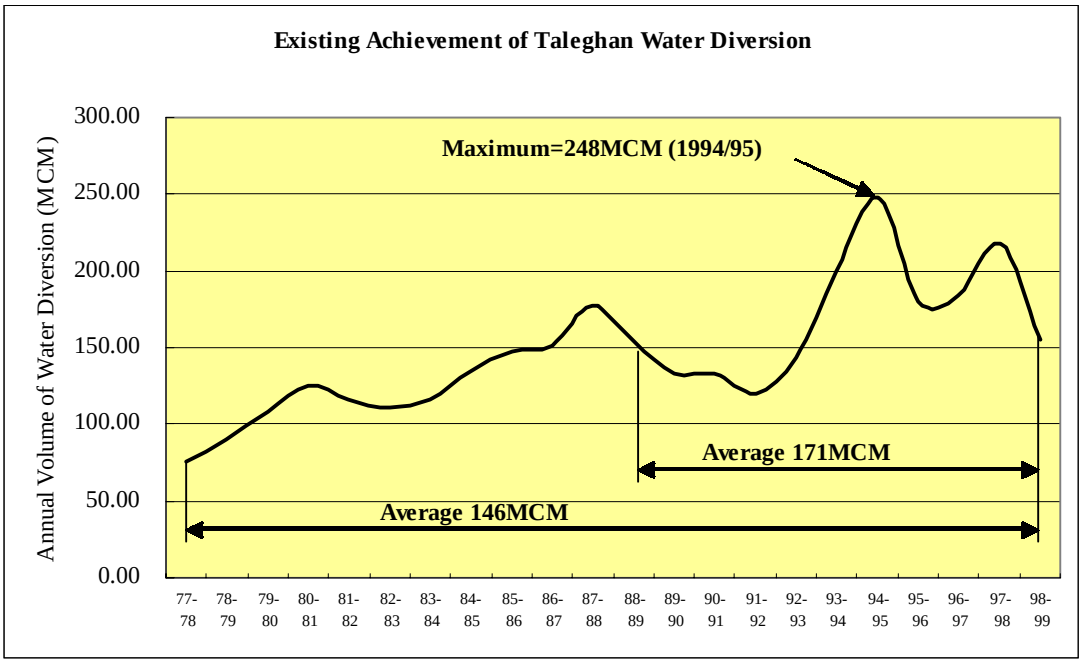
Operation of Karaj Dam

Even though no specific rule for operation of the reservoir is established, however as a whole, Karaj dam had been operated well until the late 1980s. Operation has been disordered ever since, and this is due to change of monthly pattern of water release from the reservoir. Total volume of outflow from the reservoir has been maintained at almost same order, 430 MCM more or less. Allocation of Karaj water has however shifted rapidly from agricultural use to domestic purposes. Water use for domestic purpose including industrial use has been increasing due to growing population in Tehran City, while agricultural water use has decreased. In the project target year of 2016, operation of Karaj dam is so planed to allocate 270 MCM of annual water to domestic and Industrial supply in Tehran City and 165 MCM for irrigation use in Karaj region. It is unavoidable that the dam may face relatively frequent short of water which would occur once in 2 years. And more serious is that the shortage of water will be distributed unevenly, more shortage in water supply sector and less shortage in irrigation. Even when the priority of water use is given to water supply sector, reservoir water is released for irrigation as far as water is available, if the reservoir is operated without adopting a rule for operation. Unrestricted use of reservoir water for irrigation promotes consumption of reservoir water and exerts a influence on water use for domestic purpose in the next time step. In order to avoid this situation, it is necessary to establish a specific rule of reservoir operation, so called the “Lower Operation Rule Curve”, as shown in Figure 19.



Operation of Existing Taleghan Diversion Dam

According to the existing operation of Taleghan diversion dam, 146 MCM of Taleghan water as the average annual volume during the period from 1977/78 to 1998/99 or 171 MCM for the recent ten year period from 1989/90 to 1998/99 has been conveyed to Qazvin plain for irrigation. On the other hand, a part of Taleghan water is envisaged to be transferred to the western area of the capital Tehran in order to cope with the immediate need of water for domestic and industrial purposes due to rapidly increasing population.




Excess water is still available in Taleghan river, and water balance study made based on the daily record of river discharge revealed the following results:

When the priority of water allocation is given to water to Karaj area, about 120 MCM minimum or 140 MCM on average of water will be transferred from Taleghan to Karaj through a water conduction pipeline now under construction, while about 120 MCM minimum or 170 MCM on average will be conveyed from Taleghan to Qazvin, under the Scenario-1 of short-term development plan at the year 2006 as shown in Figure 20. Considering the importance of water supply that can not be suspended, the minimum guarantee would be about 120 MCM that are stable and safety even in critical dry year which would occur once in 10 years. About 170 MCM of water on average distributed to Qazvin plain, that is the recent demand of water on Taleghan water diversion, is almost same amount as compared with the existing achievement (173 MCM as an average in recent 14 years). The minimum amount of water in a critical dry year will be about 120 MCM.

Operation of Taleghan Storage Dam

According to the Master Plan in the project target year of 2016, operation of Taleghan storage dam is so planed to allocate 310 MCM of annual water to domestic and industrial supply in Tehran City and 140 MCM for irrigation use in the Qazvin plain. It is however unavoidable that the dam may face relatively frequent short of water since the average annual inflow into the reservoir, some 490 MCM, is not sufficient to meet the demand of water, 450 MCM. Actually, simulated results of reservoir operation without giving any specific rule show that shortage of water would occur once in 3 years. More serious is that the shortage of water will be distributed unevenly, more shortage in water supply sector and less shortage in irrigation. This situation is the same as the operation of Karaj dam. It is therefore recommendable to set up the lower rule curve for operation of the reservoir. Simulated result of reservoir operation with the lower rule curve is shown in Figure 21.

Operation of Proposed Almout Diversion Dam

Function of diversion dam is to divert water within the limitation of requirement from the service area or capacity of the facility. In case of the proposed Almout diversion dam, it is essential to divert as much available water as possible within the limitation of the capacity of diversion facility because that such excess water can be used as the source of water for recharge of groundwater that may be expected to be over-extracted whenever surface water is too short.

### 5.2 Operation of Groundwater

For the purpose of the evaluation of groundwater resources as well as the formulation of the Master Plan with limited resources in the future, a simulation of groundwater till 2021 is planned with the use of MODFLOW and MODPATH. The simulation examines the system response of basin till 2021 by cases with water allocation: Secnario-2 (medium-term plan for the year 2011) and Scenario-3 (long-term scenario for the 2021). This simulation study is to outlook the degree of groundwater lowering achieved by effort to examine basin responses by re-producing the hydrological phenomena and materializing the groundwater development plan. In this context, the both conditions of Case 1 and 2 are made for forecasting the timing of drying up of the groundwater resources, and the evaluation of “mining yield of groundwater basin” with planned future water demand.

If Marginal Depth is settled at 100 or 150 m, the obstacles for pumpage is taken place at wide range between Tehran and Hashtgerd for the case 1. As the result of simulation for the Case 2, even the groundwater extraction is decreasing from that of Case 1, the area shown in high draw-down is wider than that of Case 1. It is extended far to the south of Tehran. This should indicate the “mining of groundwater resources” in particular Tehran, Karaj and Hashtgerd region. Amount extracted on Master Plan must be managed, as far as possible, within minimum necessity to supplement shortage especially at water sources in domestic use, with respect to the “concept of basin yield” which is

useable yield within sustainable amount in groundwater basin.

### 5.3 Water Allocation Plan

The domestic water use of ***Tehran City*** is 910 MCM at present (2001) supplied by the Latian, Lar, and Karaj dams and groundwater. Water processed by No.1, No.2, No.3 and No.4 treatment plants is supplied to residential area of Tehran City. The water supply facility including water pipeline and treatment plant is presently operated at the maximum capacity and has no allowance to increase the supply capacity. The water demand in 2006 is proposed to increase to 1,020 MCM in the Master Plan. Although the water pipeline works, stage 1 from Ziaran to Karaj to convey the Taleghan water will be completed in 2001 and could supply about 120 MCM of Taleghan water to Bileghan site in Karaj district, the new water supply system from the Karaj to Tehran No.6 treatment plant is not completed yet at the year 2006. Accordingly Karaj dam has to supply 340 MCM tentatively of water together with over-extraction of groundwater by 340 MCM to meet the demand as a short-term solution. The water demand will increase gradually and reaches 1,230 MCM in 2021. The new water conveyance system consisting of the water diversion tunnel from Karaj to No.6 water treatment plant or the water pipeline from Bileghan to No.6 plant by pumping system will be completed by the year 2011 and could supply the Karaj and Taleghan water to Tehran, while the Taleghan water of about 310 MCM developed by Taleghan dam will be conveyed through Ziaran-Karaj pipeline to Bileghan and then supplied to the No.1 and No.2 water treatment plant through the existing water pipeline from Bileghan to No.1 and No.2 plants. Increasing water demand toward 2021 could be sufficiently satisfied by those water allocation plans. This situation is visualized in Figure 11.

The water demand at present (2001) in ***Tehran region*** is 150 MCM for the domestic and industrial uses and 710 MCM for agricultural use. The former is mostly supplied by groundwater, while the latter by the surface water of 170 MCM and groundwater of 540 MCM. The future water demand in 2021 is 190 MCM for the domestic and industrial uses and 870 MCM for agricultural use. The domestic and industrial water demand will not increase so much in future as compared with the present use and could be supplied sufficiently by groundwater. Agricultural water however will increase remarkably due to availability of reused water of about 250 MCM from sewage treatment plant to be constructed in Tehran City. Accordingly the groundwater use for agriculture will decrease to 450 MCM from 540 MCM at present. This situation is visualized also in Figure 11.

The water demand of ***Karaj region*** at present (2001) is 415 MCM for the domestic and industrial uses and 565 MCM for agriculture. Out of total demand of 980 MCM, the water supply by groundwater occupies a large volume of 845 MCM (86%) and as a result the lowering of groundwater table has accelerated in the area. The surface water use is only 135 MCM provided from the Karaj dam to Shahriyar irrigation area. Once the Shahriyar irrigation area received 300 MCM of water from Karaj dam but now it has reduced to 135 MCM due to conversion of Karaj dam

water use from agriculture to water supply in Tehran city that has a first priority. The water demand in 2006 of Karaj region is also 980 MCM with no increase as compared with the present demand. However, the surface water use for agriculture will increase to 215 MCM, about twice of the present value, because the Taleghan water conveyed through the water pipeline from Ziaran to Bileghan becomes available for irrigation. Shahriyar area will be recovered by the water to stabilize irrigated agriculture and in turn groundwater extraction for agriculture will be reduced. The water demand of 980 MCM in 2011 will be kept at the same order even in 2021, with the domestic and industrial water increasing from 500 MCM in 2011 to 600 MCM in 2021 and agricultural water decreasing from 480 MCM to 440 MCM. The domestic and industrial water of 600 MCM and agricultural water of 175 MCM have to depend on groundwater resources due to lack of surface water. The remaining agricultural water of 265 MCM will be covered by 165 MCM of Karaj dam water and 100 MCM of reused water conveyed from the sewage treatment plant. It is anxious that the large quantity of groundwater, 845 to 775 MCM per annum in total, has to be used continuously from 2001 to 2021 in Karaj district, where is suffered from severe water shortage problem of groundwater. Accordingly, groundwater use of Karaj district proposed in the Master Plan may not be materialized without the suitable groundwater recharge plan. This situation is visualized in Figure 12.

The present (2001) and future (2021) water demand at ***Hashtgerd region*** is 380 MCM, mostly supplied by groundwater. Small surface water of 60 MCM from the Kordan river is used for agriculture. The groundwater table in Hashtgerd has decreased year by year due to over-extraction in new residential and industrial areas and very scarce recharging water available in the district. It will be necessary to study the use of surplus surface water in the Kordan river to recharge the groundwater because the surplus water in the Kordan river after irrigation use empties unused to the large Salt Marsh lying in the eastern end of the Qazvin plain. This situation is visualized also in Figure 12.

The present (2001) water demand in ***Qazvin plain*** is 90 MCM for the domestic and industrial uses and the large volume of 1,455 MCM for agriculture. Those water demands are mostly supplied by the groundwater except the Taleghan surface water of 200 MCM and small stream water of 185 MCM. The Taleghan water supply to Qazvin irrigation will increase to about 300 MCM in 2011 when the Taleghan dam construction will be completed and the usable Taleghan water reaches about 450 MCM of which 150 MCM will be allocated to the domestic water in Tehran City In addition to the existing northern Qazvin irrigation area, the Taleghan water of 300 MCM will cover a part of the central plain where dry farming prevails at present. Since the Taleghan water of 310 MCM will be allocated to Tehran domestic water in 2016, the Almout water resources shall be developed for Qazvin irrigation instead of Taleghan water. The Almout water of about 250 MCM will be diverted and used in the central Qazvin irrigation area in addition to the Taleghan water of 140 MCM that will be used in the northern irrigation area. In accordance with the Master Plan, 1,070 MCM of

groundwater is allocated for agricultural use at present and even in future taking into account the sustainable extraction of groundwater. However the usable groundwater in the Qazvin plain in future will increase because of the increasing return flow from irrigation practice by use of Taleghan and Almout water and by groundwater recharge development in the Khah-rud and Haji-Arab river basins. This situation is visualized in Figure 13.

Figure 14 shows the water allocation scenario under the present situation. The Karaj water of 300 MCM is used for Tehran urban water supply and 135 MCM for the irrigation in Shahriyar area. The Taleghan water of 200 MCM is used for Qazvin irrigation.

Figure 15 shows the water allocation scenario as the short-term plan (2006). Under this plan, the Karaj water of 340 MCM, at the maximum capacity, is to be supplied to meet the increasing urban water demand of Tehran city. The Taleghan water of 120 MCM is to be allocated to the Shahriyar irrigation area to recover the stabilized irrigated agriculture, while 170 MCM is allocated to the Qazvin irrigation. Allocation of Taleghan water to Qazvin plain will decrease by 30 MCM, however, this order of decrease will be covered by reduction of water losses within the irrigation system when rehabilitation works have been completed at this time. 30 MCM of Taleghan water being utilized for groundwater recharge at present will be replaced by the use of surface water of small streams originated from the northern mountains.

Figure 16 show the water allocation scenario at the medium-term (2011). Under this plan, the new water supply system from Karaj to No.6 water treatment plan will be completed and the Karaj dam water of 150 MCM is supplied directly to Tehran, while the Karaj water of 170 MCM and the Taleghan water of 150 MCM is supplied from Bileghan to No.1 and No.2 water treatment plants through existing pipeline. The Shahriyar area will receive newly the reused water of 100 MCM from the Tehran sewage treatment plant in addition the existing Karaj water of 115 MCM. Available water from Taleghan river will increase to 450 MCM after completion of Taleghan storage dam, allowing allocation of 150 MCM for Tehran water supply through the Bileghan intake and 300 MCM for Qazvin irrigation. The central agricultural area of the Qazvin plain will be developed to use 130 MCM of Taleghan water. Recharging projects of groundwater in the northern stream and southern rivers in the Qazvin plain will be accelerated and the usable groundwater will increase.

Figure 17 shows the water allocation scenario at the long term (2021). Under this plan, the Karaj water of 270 MCM through the new water supply system to No.6 water treatment plant and the Taleghan bulk water of 310 MCM through existing pipeline will be fully supplied to Tehran to satisfy the increasing water demand. The Almout water of 250 MCM will newly developed to compensate the Taleghan water and used in the central Qazvin plain. Qazvin northern area receives the Taleghan water of 140 MCM and central area is irrigated by the Almout water of 250 MCM.

## 6. Water Source and Water Utilization Projects

As aforementioned in the paragraph 3.1, potential resources of surface water are evaluated at 2,460 MCM per annum of which 1,390 MCM are developed at present and 1,965 MCM will become available in future in 2021. However, in order to realize the said volume of water, 1,965 MCM in future, the following projects of water resources development and water utilization have to be managed or further promoted by the government under the administration of T.R.W.B.

**Outline of Existing and Proposed Water Sources and Water Utilization Project**

| Project | Status | Outline |
|---|---|---|
| 1. Water Sources Project | | |
| Karaj Dam | Operation | Arch dam H=180m, V=205MCM, A.W 4.35MCM |
| Taleghan Water Diversion | - do - | Sangban weir, Tunnel 9km, Ziaran dam A.W 200MCM |
| Taleghan Dam | Construction | Fill dam H=104m, V=420MCM, A.W 450MCM |
| Almout Water Diversion | Plan | Almout weir, Tunnel 33.8km, A.W 250MCM |
| 2. Water Conveyance Project | | |
| Karaj-Tehran No.1, No.2 | Operation | L=40km, Q=2.7$m^3$ in No.1, 8.0$m^3$ in No.2 |
| Karaj-Tehran No.6 Plant | Plan | L=24km, Tunnel or Pipeline Q=15$m^3$/sec |
| Ziaran-Karaj, Stage 1 | Construction | Steel Pipeline L=60km, Q=5$m^3$/sec |
| Ziaran-Karaj, Stage 2 | Plan | - do - L=60km, Q=5$m^3$/sec |
| 3. Tehran Water Work Project | | |
| Water Treatment Plant | Operation | No.1～No.4 Capacity 18.7$m^3$/sec, Annual Yield 535MCM |
| - do - No.5 | Construction | Capacity 6.75$m^3$/sec |
| - do - No.6 | Plan | Capacity 12.0$m^3$/sec |
| Sewerage Plant | Plan | No.1 Capacity 9.5$m^3$/sec, No.2 Capacity 13.9$m^3$/sec |
| 4. Irrigated Agriculture Project | | |
| Karaj Irrigation | Operation | Area 20,000ha, Main Canal L=38km, |
| Kordan Irrigation | - do - | Area 5,000ha, Weir, Main canal L=12km, |
| Qazvin North Irrigation | - do - | Area 48,200ha, Main Canal L=94km, |
| Qazvin Central Irrigation | Plan | Area 53,000ha, Main Canal L=125km, |
| 5. Groundwater Development | | |
| Shallow and Deep Wells | Operation | Shallow well 1,500, Deep well 1,100 A.W 3,300MCM |
| Groundwater Recharge | Plan | Recharging Pond/Dam, Underground Dam |
| 6. Rehabilitation Projects | | |
| Qazvin North Irrigation | Plan | Concrete Structure and Gates in Canal |
| Taleghan Water Diversion | Plan | Taleghan Tunnel, Ziaran Dam and Telemeter System |
| Water Pipeline in Tehran City | Plan | Prevent of Water leakage through Pipeline, L=8,000km |

Note: V;=Reservoir Capacity, A.W=Available water, H=Height and L=Length

### (1) Taleghan Water

The existing Taleghan water diversion facility consists of Sangban diversion dam on the Taleghan river, Taleghan diversion tunnel of 9km long constructed underneath the Taleghan mountains and Ziaran regulating dam on Ziaran river in Qazvin plain. The facility has the design discharge capacity of 30 cu.m/sec and has diverted the Taleghan water of about 200 MCM per annum to the irrigation area in the northern Qazvin plain. This facility has been operated for 30 years since 1970s and will require the rehabilitation works to be urgently surveyed and implemented before the diversion of bulk Taleghan water of 450 MCM after completion of the Taleghan dam construction.

The water pipeline of stage 1 from the outlet of the existing Taleghan tunnel at Ziaran to Bileghan

intake at Karaj is under construction and will be completed within the year 2001. This pipeline is planned to convey a part of Taleghan water to the Tehran water supply through Bileghan intake and designed with a steel pipe of 1.8m diameter and 60 km long having a discharge capacity of 5 $m^3$/sec.

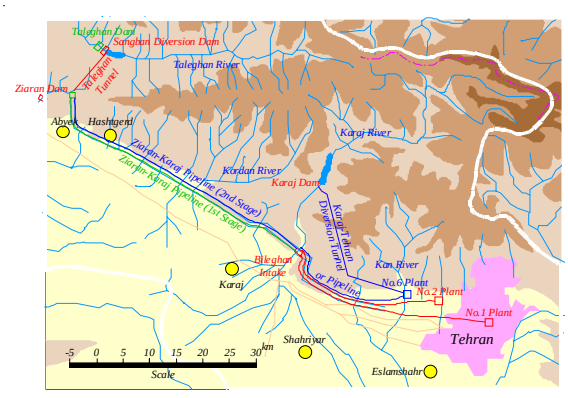
Construction of the proposed Taleghan dam with the effective storage capacity of 320 MCM is commenced in the middle of 2001 and expected to be completed by 2006. After completion of the dam, usable water from Taleghan river will increase to 450 MCM per annum, which is allocated to Tehran water supply and Qazvin irrigation. Allocation of Taleghan water is different in the short-term and long-term water use plan proposed by JICA Team.

The water pipeline of stage 2 from Ziaran to Bileghan will be installed after completion of Taleghan dam in accordance with the program of conveyance of more than 300 MCM of Taleghan water to Tehran City by the year 2016.

Taleghan water of 200 MCM at present, 170 MCM during the period of the short-term plan, 300 MCM during the medium-term plan and 140 MCM during the long-term plan is supplied to Qazvin plain. More information regarding Qazvin irrigation is given on Figure 29.

**(2) Karaj Water**

Karaj water of about 300 MCM per annum is presently conveyed to No.1 and No.2 water treatment facilities in Tehran City and used for domestic uses. No.1 and No.2 plants have the treatment capacities of 2.7$m^3$/sec and 8.0 $m^3$/sec respectively and are under full operation to meet the large domestic water demand required in Tehran City. The remaining water of 135 MCM of Karaj dam is supplied to the Shahriyar agricultural area through the right and left irrigation canals originated from the Bileghan intake. However, the Shahriyar area has suffered from chronic water shortages because the Karaj water is allocated to the domestic water in Tehran City with the first priority and the allocated water of 135 MCM to Shahriyar is insufficient to cover the irrigated agricultural area of about 30,000ha in the area.

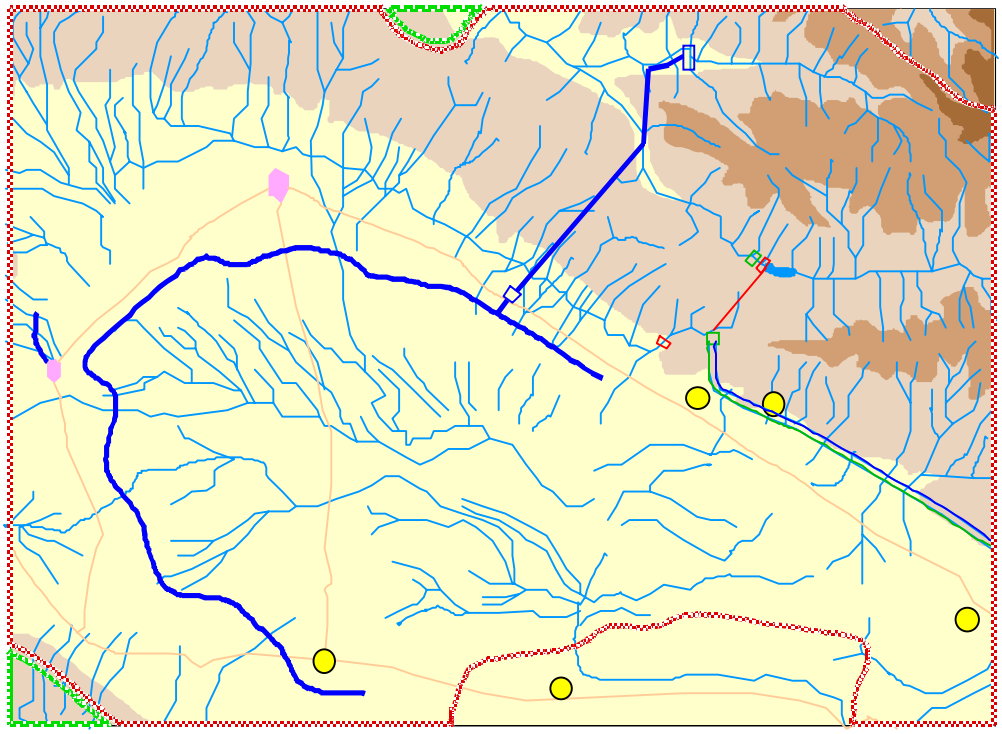



The new water diversion tunnel to link the Khuzan Kola site located immediately downstream of the Karaj re-regulating dam with the No.6 water treatment plant to be constructed in Tehran City or new water pipeline to connect Bileghan and No.6 Plant with pumping head of more than 200m will be urgently implemented in order to supply the Karaj and Taleghan water to Tehran City to cope with

increasing water demand in the northwestern area of relatively highly elevated in Tehran City.

**(3) Almout Water**

Proposed Almout diversion dam is designed as floating type with the cut-off wall to prevent seepage and piping action through the alluvial foundation of 20 to 30m in depth. Diversion tunnel is designed with the discharge capacity of 22.5 cum/sec, the circle section with the diameter of 4.0m and the hydraulic gradient of 1 to 1,500. More detailed information is given on Figures 25 and 26. 250 MCM per annum of water diverted from Almout river is conveyed to Qazvin plain through the diversion tunnel to serve about 53,000 ha of irrigated farmland to be developed in the central Qazvin plain. The combined deep wells are to be provided and operated mainly in summer season when the volume of water diverted from Almout river becomes small.



It is necessary to carry out urgently the study and implementation for the following projects:

- Rehabilitation works for existing Taleghan tunnel and Qazvin north irrigation canal system, which have been under operation for a long period of more than 25 years and partly deteriorated.
- Study and implementation of the new water conveyance facility connecting downstream of Karaj dam and proposed Tehran No.6 water treatment plant since the Taleghan water of 150 MCM becomes available for water supply of Tehran City at the end of 2001.