CHAPTER 7

WATER RESOURCES MANAGEMENT MASTER PLAN

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7.1 General

Strategic planning of water resources project planning may be defines as the several stages of investigation and study of national and regional priorities and of individual projects. The objective of this planning is to produce a program of viable schemes which will fulfill the targets for supplies of water which can be operated by the responsible authority, in harmony with other possible water users and without adverse effects of the environment. The terms to describe the stages in planning are subject to variations in use and interpretation. Some which have been used frequently are;

- Applications, requests, statements of needs
- Inventories of potential projects at desk study level, in terms of water need and water availability and access; the same sequence is applicable to domestic, agricultural or industrial projects.
- Identification of projects by name, during or after the inventories, and discussions with interested parties.
- Reconnaissance to clarify aspects not resolved during the inventory; classification to determine scope of further studies, if any, and order of priority according to needs and present supplies, health hazards, and alternative sources.
- Pre-feasibility study and screening to compare outlines of types of scheme which may fulfill the objectives, to compare approximate costs and revenue: to identify schemes which are obviously beneficial and can be recommended for design and construction: and to determine the requirements for surveys and investigations where the schemes are complex.
- Feasibility study to establish the need, to define precisely the scheme to meet the need, recommend a program for implementation, draw attention to possible problems, calculate capital and running costs and benefits, and indicate whether the project is technically and economically viable.
- Design – preliminary designs and/or detailed designs, contract documents, cost estimates and tender documents.
- Construction, implementation of civil and mechanical aspects, including operation and maintenance.
- Monitoring of progress in construction and expenditure of selected schemes, and thereafter of metering, billing and revenue collected; and of the standard of operation and maintenance.

Major items to be considered in such strategic planning are;

River gauging

Stream flows near the mouth of a river are affected by abstractions, return flows, springs, bed losses and other human or natural activities upstream. For rapid regional and national surveys, coefficients to allow for domestic and agricultural abstractions have been used. However for scheme-specific hydrology, traverses during the dry season, from main source to the mouth are advisable: these would record inflows, diversions, abstractions, losses and etc. Very few rivers have sufficient gauging stations for these estimations. Such traverse may be needed on most streams flowing from the Mount Lebanon Range to the coast, but they are generally not more than 30 km long.

Groundwater

One should emphasize that most of the classic methods of testing and analyzing aquifers assume homogeneous or layered sediments. In Karstic limestone formation, local conditions may be very variable. Thus any groundwater development should be phased, and groundwater piezometric levels that the aquifer is not exhausted.

Irrigation water needs

It is rightly said that irrigation is by far the largest user of water (10,000 to 15,000 m3/ha/year for traditional canal irrigation). Water-saving irrigation systems such as sprinkler and drip/mulch can greatly reduce the usage: say to 7,000 or 8,000 m3/ha/year. Nevertheless, careful monitoring, management and operation will be needed for pumped irrigation, if costs are to be covered by the benefits: high-yielding high pricing crops, and farmers who are willing and able to participate in the agriculture and infrastructure operation will be needed.

Conjunctive use, mobilization of groundwater reservoirs

The most promising prospect for increased exploitation of water resources is rightly said to be in development of groundwater. This is in two forms:

- the interception of groundwater flows which at present go to the sea (preserving enough outflow to hold back seawater intrusion)
- the drawing down of groundwater storage during the dry season, in places where the recharge of the aquifer can be expected during the following wet season.

Water sources

- An inventory of all springs should be made, including any which are not previously recorded, relatively small, or remote from communities; especially any which are not fully exploited and those which are high enough to provide supplies by gravity. Small springs should be included because, if properly capped, on yield as small as 5 lps can provide a domestic supply to over 5,000 people.
- Gravity supplies are preferable, even if a long pipeline is necessary, because of the simple low-cost operation, without mechanical or electrical problems.
- On both pumped and gravity-fed domestic supplies, the distribution system should include balancing storage/service tanks for each community. These should be supplied from the main pipe. Distribution to consumers should be from these tanks, and not from the main transmission pipe. The tanks, with regulated inlets, can ensure an equitable distribution of water, cater for daily peaks in

demand for which the main pipe may be inadequate; equalize pipe pressures and reduce leaks.

- All spring floes should be channeled through V-notches, weirs or flumes, which have standard ratings. These will allow quick, easy observations of flow, without the need for current meter measurements.
- Drilled wells should be fitted with a removable cap to allow a dipper to measure the water level in the well. A small diameter piezometer should be drilled nearby to allow the undisturbed static water level to be measured.

Planning of water resources

- The planning of water resources is influenced, not only by the required amounts, qualities and locations of sources and demands -- but also by other sub-sectors such as water treatment, disposal of wastewater, pollution of water resources by water discharges or by sea water intrusions; efficiency of use of water to meet domestic, industrial and irrigation needs; and reconciliation between various types of demand on particular water sources. Integrated water resources planning may include some or all of these other aspects.
- There are urgent needs for rehabilitation of existing water supply facilities, and the provision of new or expanded facilities where the lack of them may be adversely affecting health, quality of life and the general economy.

Water supply priority

- The stated policy of the government is that domestic water supplies have first priority among water demands. Annual water needs are expected to exceed the readily exploitable surface and groundwater resources within the next twenty years. Therefore measures to exploit the water resources most effectively should be supplemented by measures to reduce leakage, wastage and careless use, and to encourage water economy.
- Allocation of priorities becomes necessary where a choice has to be made between competing sectors in the use of a resource. MHER has identified priorities in the following order: domestic, industry, irrigation and hydropower. This priority for domestic supplies is particularly relevant in respect of high-elevation unpolluted springs, which are ideal for gravity-fed, safe, low-cost, simply-operated delivery of relatively small quantities. These have a significant effect on the health, productivity and quality of life of the people.
- Industries are often important for the national economy and standard of living, but they usually have skills and financial resources which allow them to have options; location, development of separate resources, recycling, in-house primary treatment and adaptation of lower-water-demand processes. In any case, for many industries, only a small part of their water has to be as high in quality as a potable domestic supply.
- Irrigation and domestic needs are those which are most frequently in conflict, particularly in areas outside Beirut. It is relevant to evaluate the effects on irrigation of giving priority to domestic needs.

Traditional irrigation may use 10,000 to 15,000 m3/ha/year, and 1.2 l/s/ha or more with losses from canals and deep percolation. Therefore one farmer irrigation one ha requires as much water as 2,000 villagers at 50 l/c/d. An allocation of water for domestic use in rural areas is rarely significant in terms of its effect on area of irrigation. Although irrigation by traditional canal systems, especially on permeable soils or Karstic formation, use much more water than other users, 30% to 50% can be saved by improved efficiency: there is already a rapidly increasing trend to the use of sprinklers and drip irrigation with plastic mulching. The adoption of such economies will significantly increase the land irrigable per unit of water.

- Hydro-power development does not compete with other usage in terms of quantities used, because water is usually returned to a river. However, the timing of water releases for power needs may not coincide with times required for irrigation or domestic supplies. Hydro-power also uses height, so that water is released at a lower level: this may reduce the conveyance heads for pipelines, and/or command areas for irrigation. Therefore compromises may be needed where hydro-power is combined with other water development. Run-of-river schemes may be successful where heads and sustained flows are available. Otherwise storage will be needed for year-round firm power.
- Storage dams may be difficult and costly, especially where steep stream bed slopes increase costs per unit of storage, where flashy floods require large spillway capacity and deposit sediments which take up water storage capacity, where construction materials are not readily available, where geological conditions may threaten stability or cause leakage from the reservoir, and where fertile land or houses are inundated by the works. Water leakage has been the main problem, and the detailed geotechnical, hydro-geological and hydrological studies are necessary as part of design, requiring several years.

Domestic water supply

- Communities not served yet or only inadequately served should be provided with at least a minimum standard of service before raising the standard of existing services.
- Priority should be given to restoration of damaged or inoperable facilities, and increasing the capacity of existing system, including network improvement and balancing storage, repairs to source works, detection and control of leakage and wastage.

Industrial water supply

- It has often been found possible for industries to reduce water use by improved processes, so that saving in water costs balance costs of improved processes.
- Incentives to control water use through improved processes and recycling may include legislation, differential tariff charges, advice and technical assistance and public awareness campaigns.

Irrigation water supply

- Damage to the existing infrastructure and delays in further development have reduced the irrigated areas. The priorities for rehabilitation, expansion and possible new development will depend not only on the availability of water and the cost of the works but also on agricultural, economic, marketing and social factors such as; 1) the number and type of beneficiaries (land owners, tenants, labour) and importance of agriculture in the local and national economy, 2) the existing area irrigated, cropping pattern and intensity, soil fertility and yield and income per ha, 3) existing water source, means of abstraction and application and water use per ha, 4) additional area of fertile soil under command, 5) optimum cropping patterns to suit soils, water flow pattern/growing seasons, markets, prices, 6) attitude of to paying or taking responsibility for operation and maintenance, changes in amount or source of water, adopting improved irrigation practice and/or cropping pattern, increases in cropping area or intensities and consequent increases in costs and works.

Thus water resources management in various areas should include the following considerations, as summarized previously in Table 6.3.1;

Supply Management

- Monitoring and control of surface and groundwater resources
- Strengthening of administrative capacity to practice direct control of water withdrawal
- Measures to use submarine springs
- Measures to reinforce groundwater storage
- Measures to fully use surface water by means of dam/hill-lake construction
- Assessment of possible negative environmental impact of dam construction
- Measures to retard melting snows
- Measures to retain rain water on the ground surface

Demand Management

- Rehabilitation of water supply distribution facility to reduce leakage (Leakage Control)
- Conservation measures to save water consumption (universal metering, tariff, retrofit and plumbing codes, public education)
- Strengthening of water supply service quality (service ratio)
- Reuse of treated wastewater for urban and irrigation use
- Industrial water recycling
- Rehabilitation of irrigation infrastructure
- Measurement and control of water consumed for irrigation
- Education and establishment of farmer's association for better operation of irrigation

Water Quality Management

- Consolidation of monitoring system of water quality
- Conservation measures for excessive use of fertilizer, pesticide and disposal of solid waste
- Strengthening of administrative and laboratory capacity of water sample testing

Wastewater Management

- Construction of wastewater collection and treatment systems

Data Management

- Consolidation of meteorological, hydrological and hydro-geological observation and monitoring system
- Construction, operation and maintenance of a database
- Strengthening of administrative capacity for data observation and management

Institutional Management

- Simplification and strengthening of administrative structure for coordination of decisions and actions related to the water sectors
- Establishment of the Water Resources Management Center

Watershed Management

- Reforestation
- Construction of snow dam(s)
- Environmental conservation

7.2 Water Demand Management Plan

7.2.1 Water Demand Management in Integrated Resource Planning

As demand of fresh water increases and renewable water resource becomes scarce, the value of water resources or the cost of water supply is becoming more expensive. Therefore, Demand management has become more important today than before proportionally to the increasing value of water resources.

Unlike most of the Middle East countries, Lebanon has reasonable amount of rainfall and therefore the potential of water resources development is high and the water resources can be developed at a relatively low cost. When the cost of resources development is low, demand management may not be an attractive option to initiate. Therefore, demand management initiatives are still in relatively early stage in Lebanon. However, although it may be early to initiate, many potential benefits of water demand management are recognized as:

- Eliminating, downsizing, or postponing the need for capital projects of water supply and sewerage system,
- Improving the utilization and extending the life of existing facilities,
- Avoiding new source development costs,
- Improving drought or emergency preparedness,
- Educating customers about the value of water,
- Improving reliability , safety margins and dependable yields
- Protecting and preserving environmental resources.

Among these benefits, eliminating, downsizing, or postponing the need for capita projects of water supply and wastewater system is the most attractive benefit.

Currently, international attention is paid to water demand management in order to ensure that capital is not wasted on the supply side of the water industry rather than strategically invested on the demand side. Integrated resource planning (IRP) is one of the leading methods to deal with this issue, which considers demand management option as well as supply option during planning stage. The centre point of this method is the costs and benefits of supply side measures (new dams, pipelines, treatment plants, ground-water source) are compared with demand management measures (leakage reduction, pricing, education, regulations, retrofitting, financial incentive for customers).

IRP is a comprehensive form of water utility planning that encompasses <u>least-cost analysis</u> of demand management and supply management options, as well as <u>open and participatory decision making</u>, <u>explicit consideration of risk and uncertainty</u>, and <u>recognition of the multiple institutions concerned with water resources</u> and <u>the competing policy goals</u> among them (Duane D. Baumann, 1997). A comparison of traditional utility planning and integrated planning is shown in Table 7.2-1.

Table 7.2-1 Traditional Planning and Integrated Planning Compared

Criteria	Traditional planning	Integrated planning
Orientation of the Planning Process		
Resources Options	Supply options, little diversity	Supply and demand options, diversity is encouraged
Resource evaluation criteria	Maximize reliability, minimize prices	Multiple criteria, including resource diversity, risk management, environmental quality, and public acceptance
Resource selection	Based on a commitment to a specific option	Based on the development of a mix of options
Resource ownership and control	Centralized, utility-owned	Decentralized, utilities and others
Planning Procedures		
Nature of process	Closed, inflexible, internally oriented	Open, flexible, externally oriented
Judgment and preferences	Implicit	Explicit
Decision tools	Dispute resolution	Consensus-building
Stakeholders' identity	Utility and its ratepayers	Multiple interests
Stakeholders' role	Disputants	Participants
Planning Objectives		
Scope of objectives	Single	Multiple, as determined in the planning process
Supply reliability	Constraint	Decision variable
Environmental quality	Constraint	Objective
Role of pricing	Cost recovery	Economic signal
Efficiency	Operational concern	Resource and priority
Trade-offs	Hidden	Openly addressed
Uncertainty	Uncertainty should be reduced	Uncertainty should be analyzed
Risk	Risk should be avoided	Risk should be managed

Source: Beecher (1995)

This approach provides benefits in a number of ways, including the followings (World Water Congress, 1999):

- There is more likelihood that the appropriate cost effective investment will be made in demand management, rather than a focus on a few select strategies,
- There is the potential for education in the cost of infrastructure provision, which is

particularly important in developing countries and emerging economies, where levels of service provision are often low, despite high losses and low levels of efficiency, and where capital funds are short; and

- There is the potential for a water utility to find out more information about its customer base, through the required attention to water end-use, which will ensure that demand forecasting and customer communication will be improved.

This approach requires a focus on water end-use. In other words, it requires a greater knowledge of where and how water is used by customers. Surveys, good metering, and analysis of demand data and other relevant data (demographic, weather-related, appliance changes), all are required.

Where possible, the water utility uses integrated resource planning methods in which the cost effectiveness of demand management measures is assessed from the combined perspective of the utility and the customers.

The water utility works with regulatory agencies to ensure that water utility regulation provides sufficient regulatory incentives to ensure that cost effective demand management measures attract reasonable levels of investment and that the cost of such measures can be recouped.

7.2.2 Water Demand Management Measures

There is a large variation in the types and scope of demand management activities. This is explained by the differences in climate, land use, political system, wealth level, water supply levels, etc. Demand management measures are explained below by being organized into the following four categories.

- Un-accounted-For Water (UFW) Control
- Water Conservation (beneficial reduction in water use)
- Wastewater Reuse
- Industrial Recycling

(1) Unaccounted-for Water Control

The leakage of water supply system means waste of water and loss of value. The supplied water abstracted from the source, then transmitted, treated and distributed to water customers is costly . This costly water is just wasted from the leakage-prone network without any beneficial use.

Unaccounted for water is composed of physical loss or leakage and none-physical loss or commercial loss, which includes illegal use, metered volume under-reading and unpaid volume of water. There are numerous methods for reducing the amount of unaccounted for water, some of them are listed below:

- replace/renovate deteriorated old network
- change the approach of leakage detection/control

- detect and repair underground leaks
- introduce pressure management
- change the domestic metering practice
- improve the design and operation of the distribution system
- change construction materials, especially for service pipe

Leakage control measures are summarized in the Table below. Major leakage control activities may be categorized into passive control and active control. Passive leakage control is a measure to find and repair a leak that occurs when there is a loss of pressure from supply, or to repair a significant leak that is apparent at the surface; both of which relying on the customer information. Active leakage control is regular surveys to reduce existing leakage by means of detection, repair and monitoring, by forming leakage detection and repair team. Even if leaks are repaired, they can recur with time. So continuous efforts are required to keep the network in an appropriate condition. Preventive control may be categorized in one of the active control measures, which reduces potential leaks through adequate planning, designing, construction work and maintenance. The active control may be effective if the network has an appropriate condition for regular repair. However, if the network is highly deteriorated and the leakage ratio is very high, i.e., more than 40-50 %, replacement of the network may be a more economical measure than the leakage detection and repair measure.

Table 7.2-2 Leakage Control Measures

Work process	Measures
1. Preparation	• Establishment of leakage management and planning organization • Training of staff and technology transfer • Provision of equipment • Updating record drawings and mapping
2. Planning	• Conduction of network analysis • Formulation of leakage control strategic plan • Development/selection of leakage detection technique • Evaluation of economic leakage level (cost of leakage and cost of leakage control)
3. Preliminary survey	• Surveys, maps and illegal connections • Production loss survey (source-water metering) • Consumption loss survey • Analysis of unaccounted for water
4. Monitoring	• Installation of monitoring pressure gauge and loggers • Installation of monitoring district meter • Installation of monitoring meter at strategic location • Monitoring activities
5. Rehabilitation	• Rehabilitation and renewal of distribution network
6. Active leakage control measures	• Regular leak detection (sounding, nigh-flow measurement, monitoring district flow etc) • Repairs of detected leaks • Distribution system pressure control to reduce area's overall leakage
7. Preventive control measure and others	• Change of material of pipe and valve • High standard of construction and supervision in the laying of pipeline • Control of illegal connections
8. Universal service connection metering	• Large users metering • Public users metering • Domestic users metering • Meter accuracy check • Meter testing, calibration, repair, and replacement • Establishment of periodical meter reading system (every two months)

(2) Water Conservation [1]

There are many water conservation measures that are usually operated simultaneously by the water utility in order to obtain a certain conservation goal.

a) Universal metering

Metering will discourage the careless, excessive use of water. According to one estimate, the introduction of meters can alone produce a 20 percent savings in water use (NRRI. 1994).

A full-metered system is an essential feature for the implementation of the conservation strategy as well as the leakage control. It is needed to put into effect the conservation-oriented tariff structures. It is also an important element for the policy of demand management that will provide better information to derive future water demands.

b) Water pricing

Pricing measures are conservation strategies because they involve understanding the true value or cost of water and conveying information about that value, through prices, to water customers.

Pricing water service depends on the practice of metering water-service customers. Once meter counters are installed and the consumptions are monitored, pricing works as a tool of demand management, which can manipulate water and wastewater demand.

Water for necessities (sanitation, cleaning and cooking) is far less responsive to price than water for more discretionary uses (unconscious wastage, lawn watering, car washing, swimming pools). The wastage can be minimized and the excess use optimised by the pricing mechanism.

There are many types of conservation-oriented rate structure depending on different objectives of the utilities and considering that the peak demand should be reduced. Besides conservation objective, the pricing strategy must be consistent with overall system goals such as cost-recover and revenue adjustment, and should be approved by regulatory or other governing bodies. Table x.x shows some of the alternative conservation rate structures.

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[1] Most part of this section is adopted and modified from "USEPA Water Conservation Plan Guidelines, Appendix A Water Conservation Measures" http://www.epa.gov/owm/water-efficiency/wave0319/appendia.pdf

Table 7.2-3 Conservation rate Structure

Rate	Definition	Objectives
Metered service	Customer bill vary with water usage	Send a price signal to customers, promoting efficiency and discouraging waste
Uniform rates	Price per unit is constant as consumption increases	Reduce average demand
Increasing-block rates	Price per block increases as consumption increases	Reduce average (and possibly peak) demand
Seasonal rates	Prices during season of peak use are higher than off-peak season	Reduce seasonal peak demand
Excess-use rates	Prices are significantly higher for above-average use	Reduce peak demand

Source: Constructed from NRRI. (1994)

c) Retrofit program

Water utility can promote conservation through a retrofit program. Retrofit involves making an improvement to an existing fixture or appliance in order to increase water-use efficiency. Retrofit program usually targets plumbing fixtures.

A basic retrofit fixture currently prevailing in water conscious countries may include low-flush toilet, low-flow faucet, and low-flow showerheads. Water utility can actively distribute retrofit fixtures. Water utility also may regulate water use by enforcing standards of low water-using fixtures and appliances.

Potential water savings from efficient fixtures is summarized in table below. With conventional fixtures, the water consumption per capita is 266 litres in total, while if efficient fixtures are adopted it will be 133 litres. Half of the water can be saved with efficient fixtures.

Table 7.2-4 Potential Water Savings from Efficient Fixtures

Fixtures	Fixture capacity		Per capita water use	Per capita water savings
		liter equivalent	(l/c/d)	(l/c/d)
Toilets				
Efficient	1.5gallons/flush	5.7	23	-
Low-flow	3.5gallons/flush	13.2	53	30
Conventional	5.5gallons/flush	20.8	83	60
Conventional	7gallons/flush	26.5	106	83
Showerheads				
Efficient	2.5 (1.7)gallons/min	9.5 (6.4)	31	-
Low-flow	3.0 to 5.0 (2.6)gallons/min	11.4 to 18.9 (9.8)	47	16
Conventional	5.0 to 8.0 (3.4)gallons/min	18.9 to 30.3 (12.9)	62	31
Faucets				
Efficient	2.5 (1.7)gallons/flush	9.5 (6.4)	26	-
Low-flow	3.0 (2.0)gallons/flush	11.4 (7.6)	30	4
Conventional	3.0 to 7.0 (3.3)gallons/flush	11.4 to 26.5 (12.5)	50	24
Sub-total (toilets, showerheads, and faucets combined)				
Efficient	-	-	79	-
Low-flow	-	-	131	52
Conventional	-	-	195	116
Cloth Washers				
Efficient	42 to 47.5gallons/load	159 to 79.8	48	-
Low-flow	-	-	-	-
Conventional	55gallons/load	20.8.2	62	14
Dishwashers				
Efficient	9.5 to 12gallons/load	-	6	-
Low-flow	-	-	-	-
Conventional	14gallons/load	-	9	3
Total				
Efficient	-	-	133	-
Low-flow	-	-	-	-
Conventional	-	-	266	133

Source: Amy Vickers. (1990).
(a) Efficient = post 1994, Low-flow = post 1980, Conventional = pre 1980
(b) For showerheads and faucets: maximum rated fixture capacity (measured fixture capacity). Measured capacity equals about two-thirds the maximum.
(c) Assumes four flushes per person per day; does not include losses through leakage.
(d) Assume 4.8 shower-use-minutes per person per day.
(e) Assume 4.0 faucet-use-minutes per person per day.

d) Information and education

Information and education are critical for the success of any conservation program. Information and education measures can directly ensure water savings, when customers change their water-use habits. These savings can be difficult to estimate. Also, public education alone may not produce the same amount of sustained water savings as other, more direct approaches (such as leak repairs and retrofits). However, educational measures can enhance the effectiveness of other conservation measures. For example, it is widely believed that information play a role in how water customers respond to changes in price. More generally, customers that are informed and involved are more likely to support the water system's conservation planning goals. The following table shows some typical education measures.

Table 7.2.5 Conservation Education Measures

Measures	Contents
Understandable water bill	Customers should be able to read and understand their water bills. An understandable water bill should identify volume of usage, rates and charges and other relevant information.
Information available	Water systems should be prepared to provide information pamphlets to customers on request. Public information and education are important components of every water conservation plan. Consumers are often willing to participate in sound water management practices if provided with accurate information. Furthermore, providing information and educating the public may be the key to get public support for a utility's water conservation efforts. An information and education program should explain to water users all the costs involved in supplying drinking water and demonstrate how water conservation practices will provide water users with long-term savings.
School program	Utilities can provide information on water conservation and encourage the use of water conservation practices through a variety of school programs. Contacts through schools can help socializing young people about the value of water and conservation techniques, as well as help utilities communicate with parents.
Public education program	Utilities can use a variety of methods to disseminate information and educate the public on water conservation.
Workshops	Utilities can hold workshops for industries that might be able to contribute to water conservation efforts. These might include, for example, workshops for plumbers, plumbing fixture supplies and builders, or for landscape and irrigation service providers.

(3) Wastewater Reuse

a) Wastewater reuse planning

The increase of water demand, the scarcity of water resources or the requirement of water pollution control has promoted the integration of water reuse into water resources management strategies. The wastewater reuse is also promoted by improvements in treatment process reliability, health risk assessment, and public confidence in the reuse systems. It is important that public acceptance of water reuse is vital to the water reuse. To optimise the net benefits from the implementation of wastewater reuse, an integrated planning is essential. Planning for wastewater reuse typically involves definition of the project, quality of requirements of water for a specific application, cost estimation, and identification of potential treated wastewater market.

b) Application of treated wastewater

Treated wastewater is most commonly used for non-potable (not for drinking) purposes, such as agriculture, landscape, public parks, and golf course irrigation. Other non-potable applications include cooling water for power plants and oil refineries, industrial process water for some facilities such as paper mills and carpet dyers, dust control, construction activities, concrete mixing, artificial lakes, and toilet flushing.

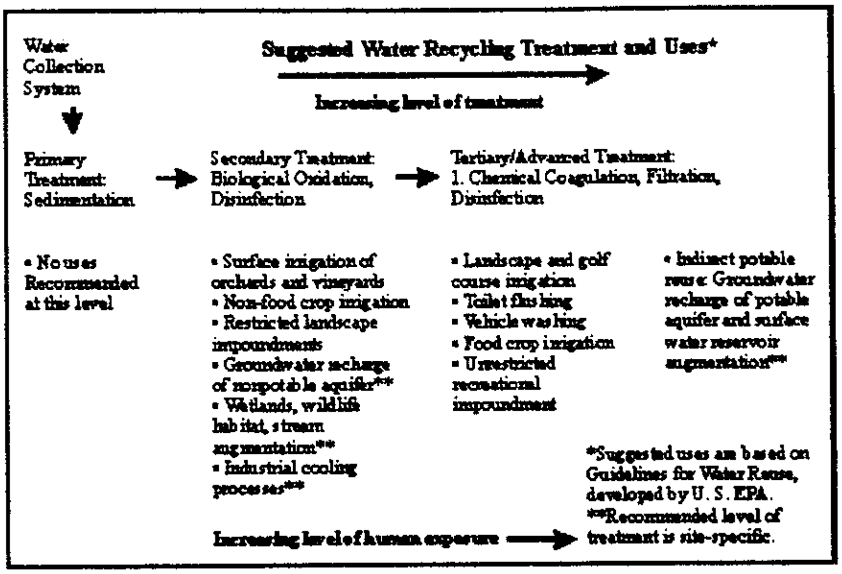
Potential application for reuse of treated wastewater in urban areas is to satisfy secondary water requirements. The development of dual distribution systems (one line for domestic water supply and the other for treated wastewater) is a growing practice worldwide, and particularly in areas with high rates of urban water usage. Dual distribution systems segregate the potable water supply from the non-potable system. Thus, a high quality system can be provided for drinking water and in-building applications .As for treated wastewater, it is provided for use in irrigation and fire protection. When retrofitting an existing system, the high cost of installing a second distribution system can often render a project economically unfeasible; however, it is more economically favourable to install the dual system as part of a new development. Dual distribution systems can be developed in two ways. One approach is to construct a city-wide system in which the wastewater is returned to a municipal wastewater treatment plant for processing before being redistributed to the population. The second approach is using small-scale individual systems where "gray water" from sinks, bathtubs, showers, and other sources of dilute non-fecal wastewater is redistributed to the system. This system is frequently applied to toilet flushing within business buildings and apartment complexes. In the urban application, protection of public health is a prime concern in the implementation of the dual distribution system water reuse.

Significant regional and seasonal variations exist in the water use patterns. For example, in urban areas, industrial, commercial, and non-potable urban water requirements account for the major water demand. For agricultural application, irrigation is the dominant component of water demand. Water requirements for irrigation applications tend to vary seasonally, whereas industrial water needs are more consistent.

Although technologically feasible at high cost, the direct use of treated wastewater for domestic needs is not recommended. Depending upon treatment and quality control, treated water may theoretically be used for many other purposes. However, its use will be generally restricted for various reasons including quality constraints, greater treatment requirements, availability of better quality water, economics, legal restrictions and public acceptance.

c) Treatment requirements

There are a variety of purposes for treated water reuse. Figure X.X shows types of treatment processes and suggested uses at each level of treatment. In general, primary treatment water is not recommended for any purpose; secondary treatment is required for surface irrigation and industrial cooling water; and tertiary treatment is required for food crop irrigation and toilet flushing. Water quality standards for specific uses are discussed in the section x.x in more detail.



Note: While there are some exceptions, wastewater in the United States is generally required to be treated to the secondary level. Some uses are recommended at this level, but many common uses of recycled water such as landscape irrigation generally require further treatment.

Source: USEPA. http://www.epa.gov/region9/water/recycling/index.html

(4) Industrial Water Recycling

a) Application of industrial water recycling

Industrial water recycling has been implemented successfully for industrial process in many countries[2]. Industrial applications for recycled water include cooling water; process water; commercial laundries; car washing establishments; pulp and paper industries, steel production; textiles; electroplating and semiconductor industries; and boiler-feed water. Major type of wastewater recycled in industries is cooling and boiler water, which is very easy to put into a recycling process. While textile and food processing industries are not major recycling industries because these industries require high quality of water for processing or higher treatment. Industrial uses vary greatly and additional wastewater treatment beyond secondary treatment is usually required according to quality requirements.

Advanced approaches for industrial recycling include cascading use of industrial process water between successive processes within an industry, and agricultural reuse of industrial plant effluent of cooling water and boiler water.

b) Incentive of industrial water recycling

Without any incentive and control, the industry is not willing to recycle the water. Industrial recycling can be promoted by several factors: <u>increased cost of water supply</u>; <u>regulation of</u>

[2] Japan is one of the leading countries in industrial recycling. Industrial water recycling has been operated more than 40 years and 78 % of industrial water is recycled and only 22 % comes form external sources.

groundwater use because the industry relies frequently on private wells; enforcement of industrial pollution control requirements, by which industries have to optimise discharge, and introduction of incentive program for recycling. In deciding how much to recycle, industries weigh the costs of getting water and treating it prior to disposal with those of adding equipment to treat and reuse wastewaters with in the plant.

c) Payback (costs and benefits) of recycling

Table x.x gives some ideas about advantages of industrial recycling. Given the proper incentives, industries of many types showed that they could cut their water needs 40 –90 percent with available technologies and practices, while at the same time protecting water from pollution. In the same cases, the payback period on the conservation investments was less than 12 months.

Table 7.2-6 San Jose, California: Industrial Water Conservation and Cost-Effectiveness, Selected Companies

Company	Water Use (1000 m³/year)		Water savings (%)	Payback Period on Investment (Months)
	Before conservation	After Conservation		
IBM [1]	420	42	90	3.6
California paperboard Corp.	2,473	689	72	2.4
Gangi Bros. Food Processing	568	212	63	10.8
Hewlett-Packard [1]	87	42	52	3.6
Advanced Micro Devises	2,098	1,318	37	7.2 [2]
Tandem Computers	125	87	30	12.0
Dyna-Craft Metal Finishing	193	140	27	2.4

[1] Water use rates apply only to one or more processes involving conservation measures.
[2] Payback based only on that portion of water savings with which costs could be associated.
Source: Postel. (1997).

7.2.3 Impact of Demand Management

Like water supply option, the implementation of demand management option generates both financial and social costs and benefits, or impacts. Table 7.2-7 identifies major impacts of demand management measures. For example, the major cost of leakage control is the operating costs; the social cost of public acceptance is very high in conservation; and the environmental benefits of wastewater reuse and industrial recycling may be outstanding.

In water resource planning, a least cost plan based on the evaluation of the financial, social and environmental costs of water supply and demand options, shall be figured out.

Table 7.2-7 Impact of Demand Management Measures

Management Items	Management measures		Physical, Social and Environmental Impact (Cost/Benefit)
Leakage	Rehabilitation of network	+	Water saving and decrease in capital investment for water supply system
		-	Increase in capita investment for distribution network
	Active leakage control	+	Water saving, Decrease in capital investment for water supply system
		-	Increase in O&M cost of leakage control
Conservation	Universal metering	+	Reasonable use of water, decrease in capital investment for water supply and wastewater system
		-	Meter installing cost
	Pricing	+	Reasonable use of water, decrease in capital investment for water supply and wastewater system
		-	Public acceptance
	Retrofit program	+	Reasonable use of water, decrease in capital investment for water supply and wastewater system
		-	Program cost, replacement and promotion costs, public acceptance
	Information and education	+	Reasonable use of water, decrease in capital investment for water supply and wastewater system
		-	Campaign costs
Wastewater Reuse	Crop irrigation use	+	Additional or alternate reuse for irrigation, rich nutrient reuse and water pollution mitigation
		-	Investment cost of conveyance of water to application sites
	Urban use	+	Increase in water supply and water pollution mitigation
		-	Tertiary treatment costs and investment cost of conveyance and distribution network
Industrial Water Recycling	Control of groundwater use	+	Water saving and mitigation of sea water intrusion
		-	Regulation cost and investment cost of industrial recycling
	Control of industrial effluent	+	Water saving and mitigation of water pollution
		-	Regulation cost and investment cost of industrial recycling

Note: "-" indicates negative impact and "+" positive impact

7.2.4 Water Demand Management Potential in Lebanon

(1) Un-accounted-For Water (UFW) Control

The present leakage ratio of distribution system is estimated to be very high around 45 % for the most areas of Lebanon. The leakage control measures can reduce the leakage ratio to 10 or 20 percent. The potential of leakage control as an effective demand management measure is therefore very high in Lebanon.

Passive control measure is currently practiced in water authorities but active leakage control is not. Active control may be effective if the network is in appropriate condition for regular repair. However, if the network is highly deteriorated and the leakage ratio is very high, replacement of the network may be a more economical measure than regular leakage detection and repair measure. Considering the current high rate of leakage in the most areas of Lebanon, therefore, more intensive rehabilitation and renovation for distribution networks may be required in the initial stage of leakage control. The Lebanese government has been implementing rehabilitation of existing water supply system under the National Emergency Rehabilitation Program (NERP). It is expected that the rehabilitation works of this program will reduce the leakage to an allowable level but may not reach a reasonable level since most of the leakage occurs around the service connections.

Following the rehabilitation, therefore, active leakage control and other leakage control measures shall be operated to reduce the leakage to an appropriate level. In planning, an economically feasible leakage level shall be identified for setting a target leakage level.

(2) Water Conservation

In Lebanon, the population density is very high in the urban areas and most of the inhabitants live in high-tall apartments without home garden. Such lifestyle uses less water than individual housing style. Therefore, water conservation measures may not be so effective in the urban areas.

In addition, public water supply is always intermittent, low pressure and unstable in the most areas of Lebanon. Therefore, the current consumption of most of inhabitants is suppressed and many inhabitants ensure their water needs by keeping public water in private tanks or digging private boreholes. Under this situation, the inhabitants are forced to manage their water use rationally. In a sense, water conservation is already adopted working in Lebanon although there may be lots of leaks and waste from the old fixtures. Conservation measures may not be effective currently but may be more effective as a future measure in Lebanon.

Once the water pressure is recovered and continuous water supply is achieved the water consumption will possibly increase under the current un-metered system, in which the water tariff is set at fixed amount. To prepare for future conservation measures, a full water metering system should be adopted in a quick and feasible way.

Without a metered system, only educational and regulation measures can work as demand management measures. Promotion of low water consuming fixtures and appliances is another measure. This may be regulated by building plumbing codes. Also the wastage and excessive uses shall be discouraged by public awareness campaigns through all available media.

The table below shows per capita consumptions by type of use estimated by the Lebanese consultants and those in USA by fixture type. Currently, most of the consumptions are low except toilet use, compared with USA. Even in the current suppressed supply, toilet water can be reduced by replacement with efficient fixtures. In modern life, toilet water is one of the most water consuming appliances.

Table 7.2-8 Comparison of Per Capita Consumption by Type of Use

(unit: l/c/d)

Type of use	Bcharre in 1999 [1]	Kesrwan in 1996 [2]	USA, Conventional Fixtures [3]	USA, Low-flow Fixtures [3]	USA, Efficient Fixtures [3]
Toilet use	67.4	71.5	83	53	23
House cleaning, cooking, water drinking, hand and face washing	9.6	14.7	50	30	26
Shower	28.6	18.9	62	47	31
Laundry	6.4	13.6	62	55	48
Dish-washing	6.2	29.2	9	7.5	6
Total	118.2	147.9	266	192.5	134

Source: [1] BTD (1996), [2] MEW, BTD. (1999)
Note: [3] Derived from Amy Vickers. (1990).

In Lebanon, the current per capita consumption is reasonably low. However, there is high possibility that per capita demand will increase easily to 200 liter or more once the capacity of water supply meets the demand. This high consumption level will again demand expensive capital investment of water supply and wastewater. A reasonable per capita target will be studied and set up for future appropriate level of capital investment.

(3) Wastewater Reuse

Lebanon has signed several agreements of the Mediterranean Action Plan (MAP) for the protection of Mediterranean Sea from pollution[3]. The objective adopted by the Mediterranean counties is provision of secondary treatment in all coastal cities with more than 100,000 inhabitants and of preliminary or primary treatment in all towns with more than 10,000 inhabitants. The Lebanese government identified priority areas for the construction of new wastewater treatment plans in order to protect inland water sources from pollution. Under these protection works, many secondary wastewater treatment plants are proposed, studied and designed. Treated wastewater will become gradually available for reuse applications. Wastewater reuse shall be considered in these proposed treatment plants.

[3] The MAP has adopted the WHO/UNEP Faecal Coliform standard for recreational water suitable for bathing.

Application of wastewater for specific purpose requires at least secondary treatment. However, no secondary level of treatment plant is currently operating in Lebanon. A secondary treatment plant will start operating in 2004 in Ba'albeck. The treated wastewater is planned to be used for irrigation in the area.

National Waste Management Plan (1982) evaluated potential of wastewater reuse for several application purposes in Lebanon, except for urban applications. The evaluation results updated by this study are presented below. In summary, potential large application purpose of treated wastewater is crop irrigation in Lebanon.

a) Crop irrigation

Irrigation is the largest water use in Lebanon and it is practiced through most of the country. Treated wastewater may be substituted for, or blended with, existing supplies. Water reuse may enable irrigation of new land for a wide variety of the crops grown in Lebanon. Consequently, crop irrigation is potentially a major use of treated wastewater in Lebanon, especially in the rural areas. The application of treated water, which contains rich nutrient, may reduce fertilizer use in the agricultural land.

In some of the wastewater plants such as Ba'albeck, Zahle and Sour, the treated wastewater reuse for irrigation has been already integrated into the sanitation scheme in their planning[4].

b) Urban applications

Another potential application of treated wastewater is to satisfy secondary water requirements in urban areas. The urban area in Lebanon is highly populated and most of the inhabitants reside in high-rise buildings. This living style is economically advantageous to operate dual distribution system. Even though advantageous, it is difficult to adopt a city-wide dual system because retrofitting of the existing system is costly. Small-scale individual systems, especially in a building and housing complex, may be technically and economically more feasible although minor.

c) Green belt, park irrigation, recreational impoundments

Other urban water reuse options include sub-potable uses, such as for recreational lakes, parks and playgrounds, and toilet flushing. Irrigation of public landscaped areas and creation of recreational lakes and wetlands as wildlife habitats may be potential uses although these uses are not major in Lebanon.

d) Industrial

Water using industries exist near the large metropolitan areas of most cities. Cooling water is the largest water demand. Treated wastewater is generally suitable for cooling or wash water. Industries have widely varying requirements for other uses, some of which may permit use of

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[4] The untreated wastewater is currently being reused during the summer months for irrigation of bout 20 hectors of fruit and vegetable gardens in the city of Ba'albeck. This type of reuse poses health risks.(WB, 2002)

treated water, although conveyance costs may be high. To pay off reuse of treated wastewater for industrial water, there should be high volume uses such as cooling water and process water.

e) Forest irrigation

Forested land has declined in Lebanon and limited reforestation has been taken place. Most of suitable lands are at elevation of 1,000 to 2,500 meters. Treated water might be used for irrigation following reseeding. Suitable lands may be adjacent to the smaller population centers, but usually not near major cities. Consequently, potential use for this purpose is minor except in mountain area communities.

f) Groundwater recharge

Groundwater recharge with treated wastewater using the treatment capability of soil is commonly practiced. However, in Lebanon, the usually thin soil cover and underlying cavernous limestone formations, except alluvial areas, would require a high level of treatment where waters from wells, springs or streams are used for domestic supply. Some potential may exist in alleviated areas such as Akkar Plain or Bekaa Valley. In Lebanon, since there is plenty of rain in the rainy season, rainwater recharge may be more feasible.

g) Control of seawater intrusion into coastal groundwater basins

Because of excessive withdrawals of groundwater, many of the coastal groundwater basins have been intruded by seawater. The generally fractured, fissured and cavernous limestone groundwater reservoirs are not suitable for seawater intrusion control by injection of treated wastewater unless a high degree of treatment is obtained. Land for percolation ponds is limited and costly. At least secondary treatment would be needed. The recharge of treated wastewater in these formations, which later may be used for domestic use, would involve generally unacceptable public health risks. The potential to apply treated wastewater may be small.

(4) Industrial Recycling

In Lebanon, the public water supply is not reliable. So many industries rely on private wells to ensure stable, inexpensive supply. To dig a borehole, industries need permission from MEW but there is no monitoring and control system of actual groundwater abstractions and thus they can withdraw groundwater at their will. Consequently, many of the coastal groundwater basins have been intruded by seawater, because of excessive withdrawals of groundwater.

Unless for reasonable incentives or regulations, the industries will not adopt recycling in their factories. In Lebanon, like in other countries, a control of groundwater withdrawal or a regulation of industrial effluent will lead to wide adoption of recycling in the industry. To make these control measures effective, the management organization, such as water authorities, should control major abstractions and discharges to sewers, and legislation should give them the appropriate powers. Also advice and technical assistance to introduce recycling and public awareness campaigns will be required.

In Lebanon, textile and food processing are one of the major industries. Water recycling in these industries is not so feasible financially, as they require high quality of water for processing. Therefore, industrial recycling may not spread to great extent in Lebanon.

(5) Summary of Demand Management Potential for Lebanon

Based on the observation above, demand management potential of each measures for Lebanon is conceptually identified and summarized in Table 7.2-9. However, it should be advisable that actual applicability of each measure to the specific district depends on the difference of regional characteristic.

The result of the conceptual study indicates that rehabilitation of the distribution network and universal metering are high priority measures. In the mid-term, active leakage control is worth operating followed by several conservation measures and regulation of groundwater withdrawal and pollution control measures for the industry.

Table 7.2-9 Water Demand Management Potential in Lebanon

Current Conditions		Management Measures	Benchmark of Potential Savings	Management Potential		
				Immediate	Mid-term	Long-term
Leakage	Leakage ratio is very high at around 45 %.	Rehabilitation of network	10 % of total consumption	+++	+	-
		Active leakage control		+	+++	+++
Conservation	Due to inability of public water supply, inhabitants are forced to manage their water use in limited supply. Actual per capita water consumption is low.	Universal metering	10 –20 %savings in total consumption	+++	++	+
		Pricing	20- 30 % savings of indoor use	-	++	+++
		Retrofit program		+	++	+++
		Information and education		+	++	+++
Wastewater Reuse	There is no wastewater treatment and no wastewater reuse in practice. Only unplanned wastewater reuse is practiced in agricultural area.	Crop irrigation use	can be used most of treated wastewater	+	++	+++
		Urban use	can be used a small part of treated wastewater	-	+	+
		Industrial use, Forest irrigation use, Groundwater recharge	minor	-	-	+
Industrial Water Recycling	No recycling is identified. There is no incentive to adopt recycling.	Control of groundwater use	can be recycled 75 % of industrial use	-	+	++
		Control of industrial effluent		-	+	++
		Incentive program of recycling		-	+	+

Note: "+++" indicates high potential or priority, "++", medium, "+" low, and "-" very low or no.

7.2.5 Possible Water Demand Management Strategy

The possible country strategy of water demand management is conceptually described below and the outcomes are shown in figure 7.2-1.

Figure 7.2-1 Demand Management Strategy

Management Measures/Regulations		Year						
			2005	2010	2015	2020	2025	
(Water supply options)								
Leakage	Rehabilitation of network							
	Active leakage control							
Conservation	Universal metering							
	Pricing, Retrofit program, Information and education							
Wastewater Reuse	Crop irrigation use							
	Urban use, Industrial use, Forest irrigation use, Ground water recharge							
Industrial Water Recycling	Control of groundwater use and industrial effluent							
	Incentive program of recycling							

Note: Thickness of bar indicates degree of management intensity.

a) Leakage control

Mainly due to the incapability of water supply facilities, most of the areas of Lebanon suffer from chronic water shortage. As a base of implementation of water demand management, a functional water supply system shall be completed first. National Emergency Rehabilitation Program (NERP) 2&3 year program is currently being implemented and will continue for other several years for completion. The objective of this program is the rehabilitation of the existing systems to their original condition and of their extensions where high shortage or lack of supply is experienced. The rehabilitation works under this program are expected to improve the distribution networks. This study assumes that the completion of the NERP program will improve the leakage ratio to 35 %.

For further reduction, active leakage control including preventive measures shall be implemented. To set up the target leakage level for active leakage control, an economically feasible leakage level shall be studied together with detailed leakage ratio after the rehabilitation works. This study assumes that the target leakage ratio is 25 %.

About half of the supplied water, which is produced by costly development, conveyance, treatment and distribution, is currently just wasted without being beneficially used. The leakage ratio of around 45 % is estimated under low pressure and intermittent supply conditions. However, once water resources are developed, the pressure becomes high and continuous supply is achieved. The ratio may increase to 60 to 70 %. Therefore, water resource development followed by water supply expansion shall be implemented simultaneously with leakage control measures.

b) Conservation

To implement conservation strategy as well as leakage control, a full-metered system shall be pursued as quickly as possible.

The estimated current per capita consumption is not so high due to the incapability of the water supply system. Conservation measures of pricing, retrofit and education do not work effectively at the current consumption level. Once the water supply capacity is improved, conservation measures will become effective measures. As water supply capacity improves, conservation measures shall be gradually operated to derive reasonable water demand.

c) Wastewater Reuse

Irrigation is the greatest potential users for treated wastewater. Treated wastewater can be used with additional investment for conveyance facility in the rural areas, at the time when secondary wastewater treatment plant becomes operational in Lebanon. Therefore, irrigation use of treated wastewater shall be promoted at maximum if its demand site is close to the treatment site in the resources management strategy.

While, in urban area, even if treatment plant is operational, tertiary treatment and distribution network is required for the citywide system. This system may not be feasible and it is not adopted in Lebanon. However, housing complex and building-wise system is economically more feasible where the demand area is close to the treatment site although this demand will be not large even in future.

One of the great demands for treated wastewater may be Beirut International Airport. In Greater Beirut Area, one of the two secondary wastewater treatment plants is planned to be located next to the airport. This airport consumes large amount of water and will need more water in the future because a rapid increase of tourists from outside the country is anticipated. It may be feasible that a part of the secondary treated wastewater in the plant shall be used for this airport after tertiary treatment.

Other options for treated wastewater reuse such as groundwater recharge may not be technically feasible in Lebanon as stated in the previous section. These purposes of wastewater reuse shall not be recommended in the management strategy. However, when water is scarce and the value of water is more expensive, these options may become economically feasible.

d) Industrial recycling

To mitigate excessive groundwater abstractions and water pollution caused by the industry, groundwater withdrawal and industrial effluent shall be controlled. These measures give incentives to the industries to save water and adopt treatment plant and recycling system. To help industry adopt recycling, management organizations, MEW or water authorities, shall give technical and financial advice and assistance. Moreover, public awareness campaigns shall be conducted. The control of industrial groundwater abstractions and water pollution shall be started but it may not be possible to start controlling as soon as possible due to the weakness of current management ability. As a result, industrial recycling will be implemented later.

7.3 Institutional, Legal and Legislative Management

A department or division responsible for operation and maintenance of database and for enhancement of data collecting mechanisms needs to be created within MEW, because the works expected are so diverse and an integrated and systematic efforts shall be continuously exercised from a single source.

Water Resources Management Center

To collect global supply and demand data, reconstruction of meteorological and hydrological stations and construction of monitoring wells are urgently required, and capacity building in water authorities is also needed. To grasp yield of groundwater and volume of private irrigation, new water legislation shall be pursued. These actions need to be programmed urgently by the qualified staff that may mobilize financial and technical resources. A Water Resources Management Center (WRMC) may be created within MEW to undertake these exercises. Activities thereof, such as planning for reconstruction of meteorological stations, preparation of water legislation, etc., have been made in the past in each of the government units without horizontal coordination. But, here in WRMC, they will be made coherently for pursuit of a single target of the integrated water resources management. WRMC shall be manned with qualified specialists consisting of a hydrologist, a hydrogeologist, a water supply engineer, an irrigation engineer and a GIS specialist besides technicians and computer operators. These specialists should be those, who can fully technically communicate with their counterparts in the Meteorological Division, LRA, water authorities, and others. A director of WRMC, who shall lead these specialists, should be a water resources management specialist, who can help policy formulators by drafting a water resources management strategy with full perception of the Lebanon's water balance and practicable development scenarios.

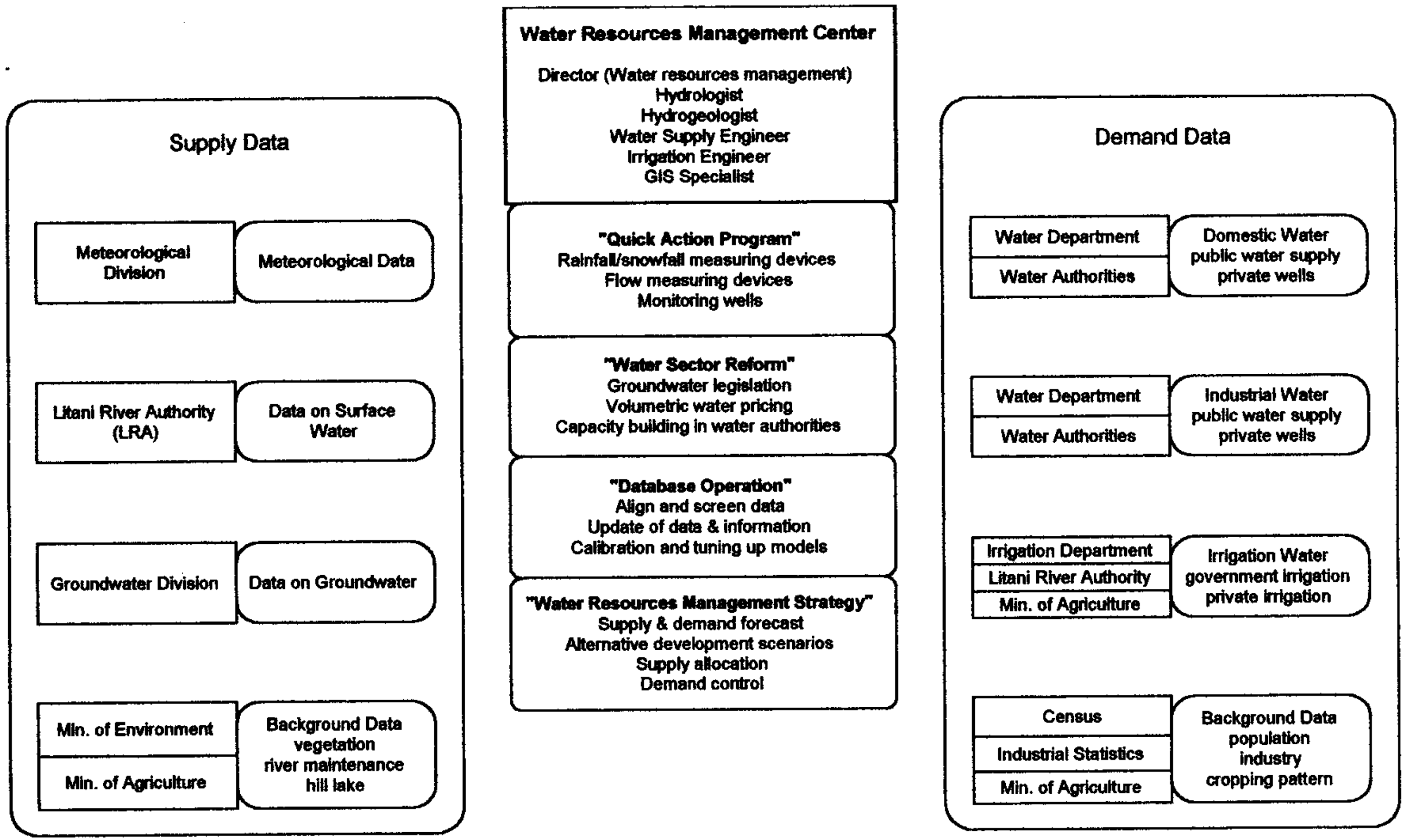


Figure 7.3-1. Organizations and Their Outputs

The first job of WRMC will be to formulate a quick action program for reconstruction of meteorological and hydrological stations and construction of monitoring wells. If financial resource is limited, inexpensive rainfall and snowfall measuring devices and flow measuring devices may be installed in a short period of time without a large investment. For monitoring purpose, wells of small diameter may be drilled, and device to measure water level, pH and electric conductivity shall be installed. If this action program is implemented with a suitable fund, collection of the entire supply data will become possible, and the fatal deficiency of the database may be remedied.

The second job, which should be pursued simultaneously with the first one, will be to interact with other divisions of MEW, LRA and water authorities to work out more accurate demand data or demand projections for the domestic and industrial water supply and the irrigation water supply. This job would include promotion of the water sector reform including the groundwater legislation, volumetric water pricing and the capacity building on the side of the water supply organizations. It is targeted to enhance and streamline water supply organizations and control over groundwater exploitation for the more accurate measurement and the possible demand control in the not too distant future.

The basic job of WRMC is continuous and ceaseless updating of supply and demand data and calibration of hydrological and hydrogeological models in the database. It is expected that the Meteorological Division and LRA (surface flow) have already aligned and screened the data by eliminating and correcting irregularities caused by misreading, mistranscription or malfunction of measuring devices. It will be still necessary to screen the data series before they are finally inputted, as have been learned by the master plan study team.

The final and central job of WRMC is forecasting of the water balance and formulation of strategy or master plan on the integrated water resources management based on the former. If the future imbalance or shortage of supply in a certain geographical area is foreseen, various development scenarios shall be worked out and applied in close coordination with the related organizations, and a concrete measures for development of supply or control of demand have to be proposed.

To create, align the personnel, give legal authority, and technical and financial resources to this WRMC, a decree or a resolution of the Council of Ministers may be necessary. Such a decree or a resolution shall establish the following effects:

- WRMC shall and is able to collect all the data and information required to measure and estimate supply of and demand for water in collaboration by all the related agencies and individuals.
- It shall be a technical institution. Its technical advice, recommendation or report shall be duly respected by the related agencies, which formulate policy, plan or project that may influence the supply of and the demand for water.
- Its advice to the agencies, which collect the data and submit them to it, to improve

quality of the data shall not be neglected.

- It is able to freely seek for technical and financial assistance from bilateral and multilateral sources.
- Its operational budget shall be allocated on the priority basis.

7.4 Watershed Management

It is reported that in old times a considerable part of the national land had been covered with the famous Lebanon Cedar bringing the prosperity to the area. It is easily imagined that rain water was retained on the ground surface, deposit of snow lasted for a longer time in the shade of a Cedar tree, and surface flows were kept in rivers throughout a year at those times. At present, colonies of the Cedar remain in a quite limited part of the land, ground surface is exposed directly to the sunshine without vegetation in most parts, and most of water created by rain and snow has been lost unused to the sea.

It is essential that the land surface is covered by forest for sustainable conservation of watershed. Fortunately, creation of the natural Cedar reserves has been practiced in some parts in Lebanon, and it is recommendable to accelerate this activity for future successful management of water resources. Followings are brief explanation of such activity;

Al-Shouf Cedar Reserve, The Largest Cedar Sanctuary

The Barouk mountain is the largest extent national sanctuary of the famous Cedar of Lebanon, and as such provides the setting for a unique complex of wildlife and natural resources. The reserve is classified by Birdlife International, as an Important Bird Area (IBA). Of the country's remaining 2,200 ha of cedar forests, some 550 ha lie within the borders of the 6 forests of the Shouf Cedar Reserve alone, sheltering over two million cedar trees. These include the Barouk forest (400 ha), Ain Zhalta – Bmohral forest (110 ha) and the Maaser wl Shouf forest (6 ha).

Running the length of the Mount Lebanon range parallel to the Mediterranean, the reserve covers 5% of surface of the whole country, at an altitude between 1,000 and 2,000 m. It stretches between the Beirut – Damascus highway to the north and the town of Jezzine to the south, with 70% of its land within the Shouf proper, and the remaining 30% in the Western Bekaa. The territory of the reserve is adjacent to nine villages with a total population of 50,000, whose municipal lands lie within its jurisdiction.

The reserve provides an impressive backdrop to one of the main repositories of the country's historical and cultural heritage. The head offices of the Society are located next to the Joumblatt palace of Mukhtara, a unique example of Lebanese mountain palace architecture, itself only a few miles away from Beiteddine – the summer residence of the Lebanese president and one of the country's chief tourist attractions. Further along the road is Deir el Qamar, the best-preserved old town in Mount Lebanon. The headquarters of the reserve are located at the old Victoria hotel in Ain Zhalta. There are also archeological sites of notable interest within the reserve itself, including fortress of Qab Elias and the shrine of the Old Testament prophet job.

Entrances are open in Maaser Al-Shouf, Barouk and Ain Zhalta.

Activities include: hiking and trekking, bird watching, mountain-bike riding, snow shoeing, horse-back riding, donkey rides, yoga, van tours and educational trails.

Al-Shouf Ceder Nature Reserve

Al-Shouf Ceder Nature Reserve is considered to be an extravagant portrait amidst the miscellaneous natural sceneries in Mount Lebanon. Its mountains are highly elevated, deeply steeped, and covered by forests of cedar, oak and pinewood trees, comprising surface areas that constitute a rare shelter and refuge for wildlife in Lebanon in view of its biodiversity and cultural heritage.

The Al-Shouf Cedar Nature Reserve was established in 1996 by law number 532 passed by the Lebanese Parliament.

The surface area of territories covered by the reserve is about 5% of Lebanon's surface area, stretching out to a surface area of 50,000 ha, of which 70% lies in the regions of Al-Shouf and Aley, and the remaining 30% lies in West Bekaa.

The Al-Shouf Cedar Society, a non-governmental organization found in 1994, undertakes the administration of the reserve.

The project comprises several objectives, being the most important enumerated as follows: conservation of natural and cultural heritage, scientific research and monitoring, sustainable development, environmental awareness and eco-tourism.

The reserve is considered as the last extension of the Lebanese Cedar to the south.

The reserve comprises 7 cedar forests, three of which are principal, characterized by a very rich biodiversity and natural regeneration unparalleled in the remaining cedar forests in Lebanon, where about 20,000 visitors are received annually.

Maaser Al-Shouf Cedar Forest:

Its surface area is 6 – 7 ha and comprises the oldest cedar trees. It lies close to the road that links Shouf with West Bekaa and comprises trails for miscellaneous visits regarding time and surface area.

Barouk Cedar Forest:
Its surface area is approximately 400 ha, one of the largest cedar forests in Lebanon. It comprises several trails for all ages and the visitors may enter it by van or walking.

Ain Zhalta – Bmohray Cedar Forest:

It lies in the north sector of the reserve having a surface area of 110 ha. It comprises a hilly pond constructed by Al-Shouf Cedar Society with financing from the Japanese Embassy in Lebanon, so as to preserve the stability of wildlife existent in the area as well as putting out fires that may break out, along with the educational trails dedicated for school students whose ages range between 4 – 12 years and the nature advocates, in addition to a place for bird watching and animal observation near the hilly pond.

(All information from the brochure prepared by the management team of Al-Shouf Cedar Nature Reserve)

7.5 Water Demand Scenarios

Future water demand and provision of future water supply system are forecasted based on three scenarios: without, moderate and radical demand management. The target of management measures for the year 2030 by scenario is projected in Table 7.5-1.

Table 7.5-1Water Demand Management Scenario (Draft)

Demand Scenario	Degree of Demand Management	Demand Management Measures						
		Leakage Control	Conservation			Reclaimed Water Reuse		Industrial Recycling
Demand Scenarios								
High	No	No	No			No		No
Medium	Moderate	Moderate	Moderate			Moderate		Moderate
Low	Radical	Radical	Radical			Radical		Radical
Target by Demand Scenario in 2030								
Parameter		Leakage (%)	Per Capita Consumption (l/c/d)			Reuse Rate (%) of Treated Water		Recycling Ratio (%)
			Beirut	Urban	Rural	Urban Use	Irrigation Use	
High	No	35	200	190	185	0	0	0
Medium	Moderate	25	170	160	155	5	50	50
Low	Radical	10	150	140	135	10	75	75

A scenario "Extra High" would be added to above three scenarios in order to consider requirement from the MEW as summarized above.

Table 7.5-2 Scenarios of Water Demand Projection (Draft)

			Scenario of Water Demand Projection (Target in 2030)			
			Low	Medium	High	Extra High
Water Supply						
Population Person)			6,756,000	6,920,000	7,114,000	As Proposed
Other Parameters			As Estimated Above			
Irrigation						
Irrigation Area (ha)			111,260	123,580	123,580	210,000
Irrigation Efficiency (%)	Surface Irrigation		60	60	50	50
	Sprinkler Irrigation		70	70	60	60
	Drip Irrigation		80	80	70	70
or						
Unit Water Demand (m3/ha)	Surface Irrigation	Field Crops	8,650	8,650	10,380	10,380
		Market Crops	9,820	9,820	11,780	11,780
		Fruit Crops	101,610	101,610	12,730	12,730
	Sprinkler Irrigation	Field Crops	7,420	7,420	8,650	8,650
		Market Crops	8,420	8,420	9,820	9,820
		Fruit Crops	9,830	9,830	10,610	10,610
	Drip Irrigation	Field Crops	6,490	6,490	7,420	7,420
		Market Crops	7,360	7,360	8,420	8,420
		Fruit Crops	7,960	7,960	9,100	9,100

a) Lowt demand management

No management measure will be implemented. Per capita consumption will increase rapidly and reuse and recycling activities are not implemented. The future water demand of this scenario is the largest. This scenario may be realizable if water resources are plenty and cheap even in the coming future.

b) Moderate demand management

Moderate management measures will be implemented and the future water demand of this scenario is moderate. It may be the most possible scenario in Lebanon. The target parameter for the year 2030 is explained as follows:

- The leakage will be 25 % of the total demand
- The per capita consumptions will be 170 liter, 160 liter and 155 liter for Beirut, urban areas and rural areas, respectively.
- 50 % of the treated water will be used mainly for irrigation purpose.
- 25 % of the industrial water will be recycled.

c) Radical demand management

This scenario is radical, in which we find very low leakage ratio, less per capita consumption but still enough for a basic life, and high rates of treated wastewater reuse . Industrial recycling shall be achieved also. It needs great management efforts. If the Lebanese realizes that the water is very scarce and valuable, this scenario may work. The target parameter for the year 2030 is explained as follows:

- The leakage will be 10 % of the total demand
- The per capita consumptions will be 150 liter, 140 liter and 135 liter for Beirut, urban areas and rural areas, respectively.
- 75 % of the treated water will be used mainly for irrigation purpose
- 50 % of the industrial water will be recycled.

7.6 Preparation for Economic Evaluation

Economic evaluation means the analysis of a project from a viewpoint of the country as a whole to judge whether an investment will generate worthwhile public benefit. In economic evaluation, financial cash inflow and outflow should be adjusted according to the principle of cost-benefit analysis. After adjustments of cash flow, Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit-Cost Ratio (B/C) are calculated. From those figures, it becomes evident whether this project is meaningful and efficient from the viewpoint of a country.

7.6.1 Basic Assumptions for Economic Evaluation

On estimating the economic cost and benefit, the following conditions and assumptions are applied.

(1) Price Level

The basic price for cost and benefit estimates are set at prices of base year. Base year of the Study is 2002 as previously discussed. Foreign exchange rate is set at LBP 1,507 to US$ 1.00 based on the official exchange rate at the end of year 2002.

(2) Opportunity Cost of Capital

Opportunity cost of capital represents the permissible economic rate of return for projects. In Lebanon, 12 or 14% of opportunity cost of capital is generally applied to assess the economic viability. In this study 12% of opportunity cost of capital is applied from the viewpoint of social purpose and basic human needs for water resources development.

(3) Economic Value

In economic analysis, financial goods/services of cost (input)/benefit (output) have to be converted into economic value.

To convert financial values of non-tradable goods and services into economic values, the following points have to be considered: (a) exclusion of all taxes and duties, and (b) conversion factors for shadow pricing; skilled labor, unskilled labor, and consumer goods (e.g. 80% of conversion factor is applied for converting unskilled labor cost in the "Project Appraisal for Ba'albeck Water and Wastewater Project, May 2002" by World Bank.).

On the other hand, economic values of tradable goods and services are estimated based on the international market prices.

(4) Economic Life

Various components with different character are used and installed for construction of the facilities and equipment/machinery for the Project. However, the economic life of each component is hard to define correctly because it varies depending on the conditions such as maintenance and weather.

In the various study reports of the country, the economic life of the facilities and equipment/machinery is put together and set at from 30 to 40 years. However, the economic life is to be assumed by each component according to the following manner as applied in the Awali Conveyor Project for Beirut Water Supply;

- Dam and Tunnels	: 100 years
- Civil works	: 40 years
- Distribution System	: 50 years
- Mechanical and electric Equipment	: 15 years

The components, if its economic life is less than economic evaluation period, have to be considered a periodical replacement during the evaluation period.

(5) Time Horizon for Evaluation

The economic evaluation period is set over the years until the target year of 2030.

(6) Cost Estimation

To facilitate the financial and economic analysis, unit costs for broad elements of the Project are analyzed from various existing reports and information. Unit costs also serve to develop the tariff structure in the financial analysis. The basic method of the Project Cost estimation is summarized as follows:

- The project costs are estimated based on the unit costs of respective projects such as; 1) water resources development, 2) extension and rehabilitation of municipal water supply system, 3) extension of sewage network system and wastewater treatment plant, and 4) extension of irrigation system.

- All costs related to water resources development such as dam, reservoir, and well are allocated to final consumption system (municipal water system and irrigation system) in proportion to respective size of the demand and use.

- Operation and maintenance costs of these projects are estimated respectively as a percentage of the capital cost of the above projects.

- All these financial costs are converted into economic costs as mentioned above.

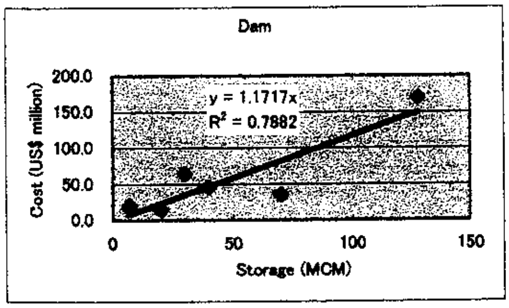
7.6.2 Cost for Surface Water Development

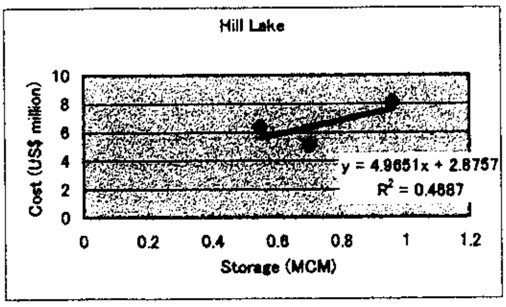
The construction costs for dams and hill lakes were extracted from the previous study reports available in MEW and are summarized in Table 7.3-1. Since the scope of the Study does not include the feasibility study, the detail cost estimate is excluded from the Study. Therefore, the rough cost estimate was conducted based on figures in Table 7.6-1. There is a tendency that the cost increases as the storage volume becomes large; however, the unit cost to develop 1 m^3 of water decreases contrary because the large dam is more economical. Therefore, the unit cost of dam is determined as follows depending on the scale of dam.

Over 50 MCM Storage Volume	1.3 US$/$m^3$ of water
10 – 50 MCM Storage Volume	1.5 US$/$m^3$ of water
<10 MCM Storage Volume	3.0 US$/$m^3$ of water

Table 7.6-1 Cost for Dam and Hill Lake Construction

No.	Dam/Hill Lake	Storage (MCM)	Dam Type	Cost (US$ million)	Estimated Year	2002 Cost (US$ million)	Unit Cost (US$/$m^3$)
201	Janneh	30	Rockfill	63.5	2000	64.1	2.14
204	Boqaata	7	Rockfill	20.6	1999	21.0	3.00
207	Bisri	128	Earthfill	131.1	1995	169.5	1.32
301	Noura Et Tahta	70	Rockfill	34.3	2000	34.7	0.50
303	Bared	40	Rockfill	45.2	1999	46.0	1.15
502	Younine*	20	Earthfill	14.6	2000	14.8	0.74
503	Massa	7	Earthfill	16.89	1999	17.2	2.46
						Average	1.62
208	Habach Hill Lake	0.55	NA	6.3	2000	6.4	11.64
401	Lebaa Hill Lake	0.96	NA	8.0	2001	8.1	8.44
402	Azzibe Hill Lake	0.70	NA	5.0	2001	5.1	7.29
						Average	9.12





Source: Literature Extraction from MEW

Original cost was adjusted to that in 2002 by applying inflation rates discussed in the section of Economic Profile.

Development of water by hill lakes costs much more than dams. This is due to coating works to prevent seepage from a lake. Thus, the unit cost of hill lakes is assumed to be 9.0 US$/$m^3$ of water.

Since the original costs were estimated in different years, they were adjusted to costs as of 2002 by applying the following inflation rates.

Year	1995	1996	1997	1998	1999	2000	2001
Rate (%)	12.0	8.0	2.6	2.3	0.7	0.0	1.1

Costs in Table 7.6-1, except for Bisri dam, are based on rough estimate because the feasibility study/detail design has not been conducted yet for those dams. Thus the cost breakdown is not available and it was assumed that figures in Table 7.3-1 include the direct and indirect costs. Unlike those dams, the feasibility study for Bisri dam was conducted in 1995. According to the feasibility study report, indirect costs were estimated as follows.

Contingency:	direct cost x 20%
Price escalation:	4%
Engineering & administration cost:	(direct cost + contingency) x 15%
O/M cost:	1% of direct cost

The unit cost to develop 1 m^3 of water should consider the initial cost normally in terms of loan repayment, O/M cost and developed volume of water that is more than the storage volume as long as the dam inflow is stable. However, the Study is not associated with the feasibility study of dams/hill lakes. Thus, for the calculation sake, the construction cost (direct + indirect) divided by storage volume proposed by MEW is assumed to be the unit cost to develop 1 m^3 of water.

If all proposed dams and hill lakes were necessary to be constructed, the total cost would amount to approximately US$ 1.21 billion as shown in Table 7.6-2.

Table 7.6-2 Estimated Cost for Dam and Hill Lake Construction

Code	Dam	Hill Lake	Storage Capacity (MCM)	Cost (US$ million)
301	Noura Et Tahta		70.00	91.0
302	Qarqaf		20.00	30.0
303	Bared		40.00	60.0
304	Iaal		10.00	15.0
305	Nahar El Jaouz		20.00	30.0
306	Dar Beachtar		55.00	71.5
307		Kouachra	0.35	3.2
308		Aydamoun	0.30	-
309		Otolbi	1.00	9.0
310		Qamouaa	1.00	9.0
311		Brissa	1.00	9.0
312		Balaa	1.00	9.0
313		Laqloq	0.80	7.2
201	Janneh		30.00	45.0
202	Chabrouth		8.00	24.0
203	Mayrouba		20.00	30.0
204	Boqaata		7.00	21.0
205	Azzounie		8.00	24.0
206	Damour		60.00	78.0
207	Bisri		128.00	166.4
208		Habach	0.55	5.0
209		Qaisamani	0.55	5.0
210		Maaser Elshouf	2.00	18.0
500	Qaraoun		160.0	-
501	Assi		37.00	55.5
502	Younine		7.00	21.0
503	Massa		7.00	21.0
504		Yammouneh	4.50	40.5
505		Jriban	1.00	9.0
506		Sbat	1.00	9.0
507		Rachaya	1.00	9.0
401		Lebaa	0.96	8.6
402		Azzibe	0.70	6.3
403		Kfarhouneh	1.20	10.8
601	Kfarsir		10.00	15.0
602	Khardale		128.00	166.4
603	Ibl al Saqi		50.00	75.0
Total Cost				1,207.4

7.6.3 Consideration for Project Benefits

Basically benefits quantifiable with monetary measures are determined and used in the economic analysis. Accordingly the benefits of respective project are assessed based on the following criteria.

(1) Municipal Water Supply System

<Households with Connections in the Current Situation>

Incremental welfare per household derived from; 1) Change in tariff (expected to decrease), and 2) incremental water supply capacity per capita.

Under the current system, households pay annually LBP243,000 (highest tariff; Beirut WA) and LBP65,000 (lowest tariff; Becharre WA) for a domestic water supply of $1m^3$/day. The current tariff of Beirut/Mount Lebanon Water Authority is calculated to be around US\$0.44/m^3. However, these households are supposed to get less than the promised water amount caused by intermittence of water supply. So the implicit tariff might be much higher than US\$0.44/m^3. Incremental water supply with project will obviously lower this implicit price.

<Households with New Connections under the Project>

Incremental welfare per household derived from; 1) Change in tariff between actual price and tariff with project (expected to decrease significantly), and 2) incremental water use per capita (expected to increase significantly).

Tanker delivery is a prime source of water supply in outside urban area of Lebanon. Its price is very costly (US\$3~5/m^3 according to the report of Staff Appraisal Report Lebanese Republic, Coastal Pollution Control and Water Supply Project, Jan 22, 1997, World Bank) compared to the current tariff of Water Authority (US\$0.44/ m^3 ; the highest in Lebanon).

Table 7.6-3 Household Income

Region		Household income (thousand of LBP/month)	persons/household	Income/person (thousand of LBP /month)
Beirut		2,069 (US$1,355)	4.3	481 (US$315)
Mount Lebanon	Beirut Suburbs	1,724 (US$1,129)	4.5	383 (US$251)
	Rest of ML	1,946 (US$1,274)	4.4	442 (US$289)
	Total	1,815 (US$1,189)	4.5	407 (US$267)
North Lebanon		1,235 (US$809)	5.4	229 (US$150)
South Lebanon		1,135 (US$743)	4.9	231 (US$151)
Nabatieh		1,089 (US$713)	4.4	248 (US$162)
Bekaa		1,264 (US$828)	5.0	253 (US$166)
Total		1,540 (US$1,009)	4.8	321 (US$204)

Source: Conditions de Vie des Menages en 1997, Etudes Statistiques, CAS
Note: LBP/US$ = 1,527.0 (as of December 1997)

From financial point of view, tariff must be set considering "willingness to pay" and "ability to pay" of users judging from their income. It is generally recognized that 2 to 4% of household income is available for water charges. Household income survey of respective region was conducted in 1997 and the result is shown in Table 7.1-1. This table can be applied to judge and determine the appropriate water tariff reflecting the inflation over the years to date.

From the point of cost recovery, however, it is noted that the various reports apply the Long-run Marginal Cost (LRMC) method with the appropriate discount rate at the time, viz. 5 or 10%, in studying water price in Lebanon. Accordingly, the water tariff must be determined through the most careful analysis and consideration of financial gaps between the users' "willingness to pay" and "ability to pay" and LRMC.

(2) Sewage System

Various approaches are used to assess benefits of sewage network system; the increase of property value, and the improvement of health. However, these approaches cannot be applied because required data are not available.

Consequently, the following two approaches are used in evaluation of project:

To assess the increase in households' welfare resulting from the project, based on estimates of the quantity of water used, of costs of wastewater discharge under the current system without project and under the project, and

Benefit from the reuse of treated wastewater in irrigation; namely the incremental farming income considering the available volume of treated wastewater and the irrigated area.

(3) Irrigation System

Farming income derived from cost (input) and revenue (output) stream under the situation without project and with project is used in evaluation of project, taking into account various conditions such as crops, yields, farmers gate price for domestic consumption, border price for export, producers cost, and other miscellaneous cost of the respective areas.

Farming incremental income is the benefit of irrigation project that can be calculated from the balance of above farming income without project and with project.

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7.7 Water Resources Observation and Monitoring Plan

7.7.1 Surface Water Observation and Monitoring Plan

In the past before civil war, LRA was managing 81 gauging stations in total. All equipments will be replaced and seven (7) new stations are recommended to be added in this plan. The location and name of such stations are shown in Figure 7.7-1 and Table 7.7-1.

Gauging stations will be equipped with automatic water level and rainfall recorder.

For the time being, observations of snowfall are not done in Lebanon due mainly to budgetary limitation. However, snow is one of the most important parameter to define volume and pattern of seasonal runoff yield, since during winter season considerable part of highly-elevated river basins are covered with snow and deposit of snow on the mountainous slope has a close correlation with the seasonal pattern of river runoff. In 2002, Saint Josef University has installed snowfall measurement facilities in the high mountainous areas. In Lebanon, And in addition to these, it is recommended to install fifteen (15) snow observation stations as the first priority to cover major river basins, and sixteen (16) stations as the second priority as given in Figure 7.7-2 as well as in Table 7.7-2.

Snow gauzing stations are recommendable to consist automatic depth recording system and rainfall recorder with heater and also wind velocity and direction meter.

Table 7.7-2 Station for snowfall

River	Sub-basin	X	Y	Z	Priority
Kebir	1	200,653	278,067	1,700	1
Bared	14	192,362	273,217	1,700	1
	15	187,346	275,538	1,200	1
Abou Ali	18	182,174	262,687	2,600	1
	19	174,578	267,206	1,500	1
Jouz	23	168,982	250,500	1,530	1
Ibrahim	27	171,314	239,569	1,950	1
Kelb	31	162,959	226,786	2,200	1
Beirut	34	151,448	214,151	1,200	1
Damour	38	150,804	205,836	1,250	1
Awali	42	146,076	193,069	1,700	1
Litani U	55	168,758	222,508	2,100	1
Litani M	59	151,400	201,815	1,300	1
Assi	66	199,023	261,827	2,100	1
Indiv	98	186,910	2,567,173	1,600	1
Kebir	2	204,425	284,368	1,250	2
Ostuene	6	199,161	285,239	1,250	2
Abou Ali	20	174,827	255,599	1,300	2
Jouz	24	163,261	250,624	1,350	2
Ibrahim	28	164,718	239,664	1,600	2
	29	156,426	237,465	1,000	2
Kelb	32	155,578	224,650	1,500	2
Damour	39	141,821	201,815	900	2
Awali	43	139,653	185,775	1,100	2
Zahrani	49	132,593	170,364	950	2
Litani U	54	198,304	217,991	1,900	2
Assi	65	218,724	240,918	1,900	2
Hasbani	70	160,065	165,506	2,100	2
Chekka	81	167,324	255,474	1,400	2
Batrouan	84	157,830	243,369	1,500	2
Jounie	87	148,040	229,141	1,200	2

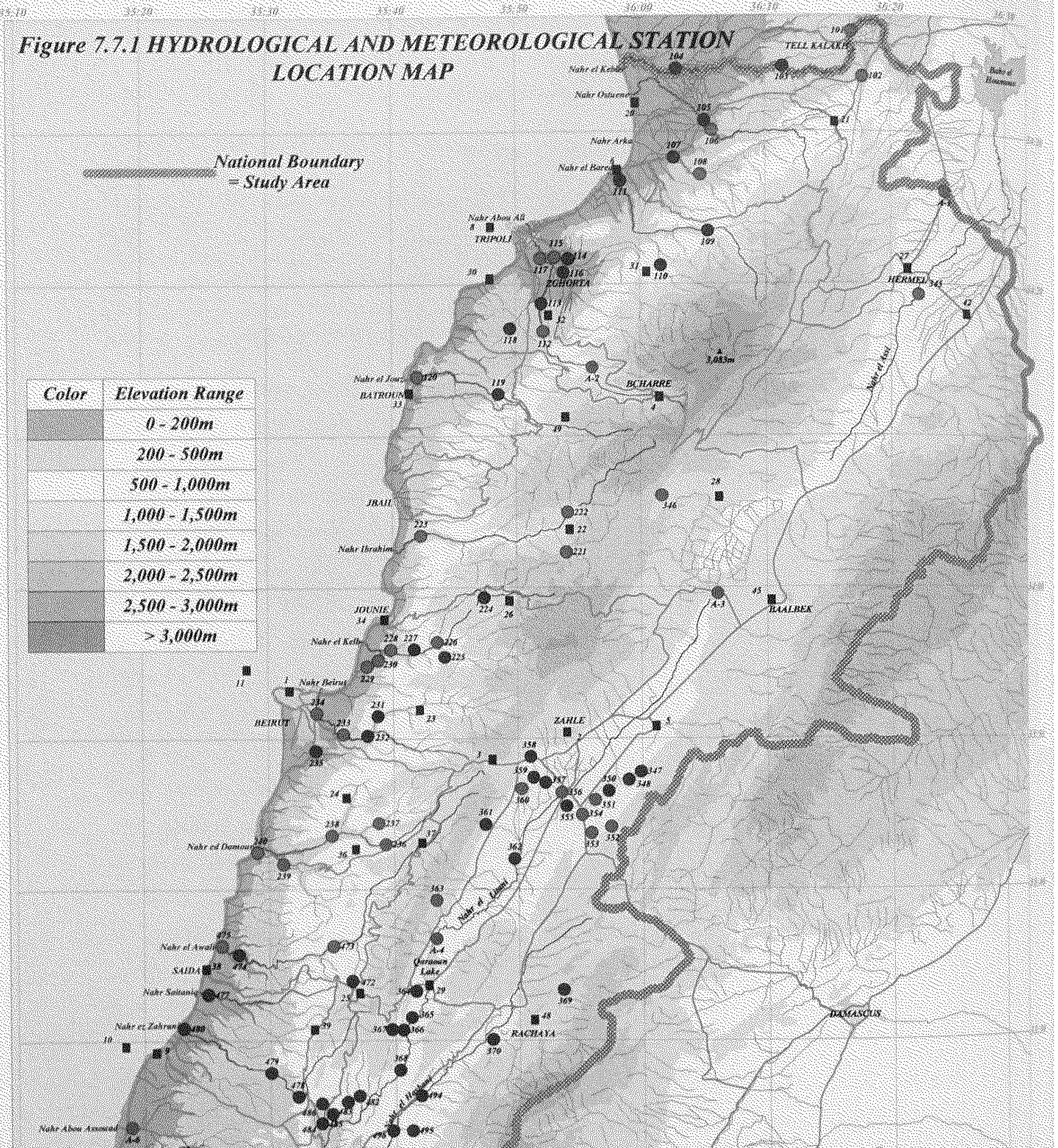


Figure 7.7.1 HYDROLOGICAL AND METEOROLOGICAL STATION LOCATION MAP

Table 7.7-1 List of Hydrological Station to be Newly Established

Station No.	Basin	River	Station	CA(km2)	EL(m)	Latitude			Longitude		
A-1	Assi	Oronte	Border of Srya								
A-2	Abou Ali	Abou Ali	Cedar								
A-3	Litani	Litani	Near Baal Bek								
A-4	Litani	Litani	Qaraoun Dam								
A-5	Hasbani	Hasbani	Border of Israel								
A-6	Abou El A	Abou El A	Sea Mouth								
A-7	Wadi Ain	Wadi Ain	Sea Mouth								

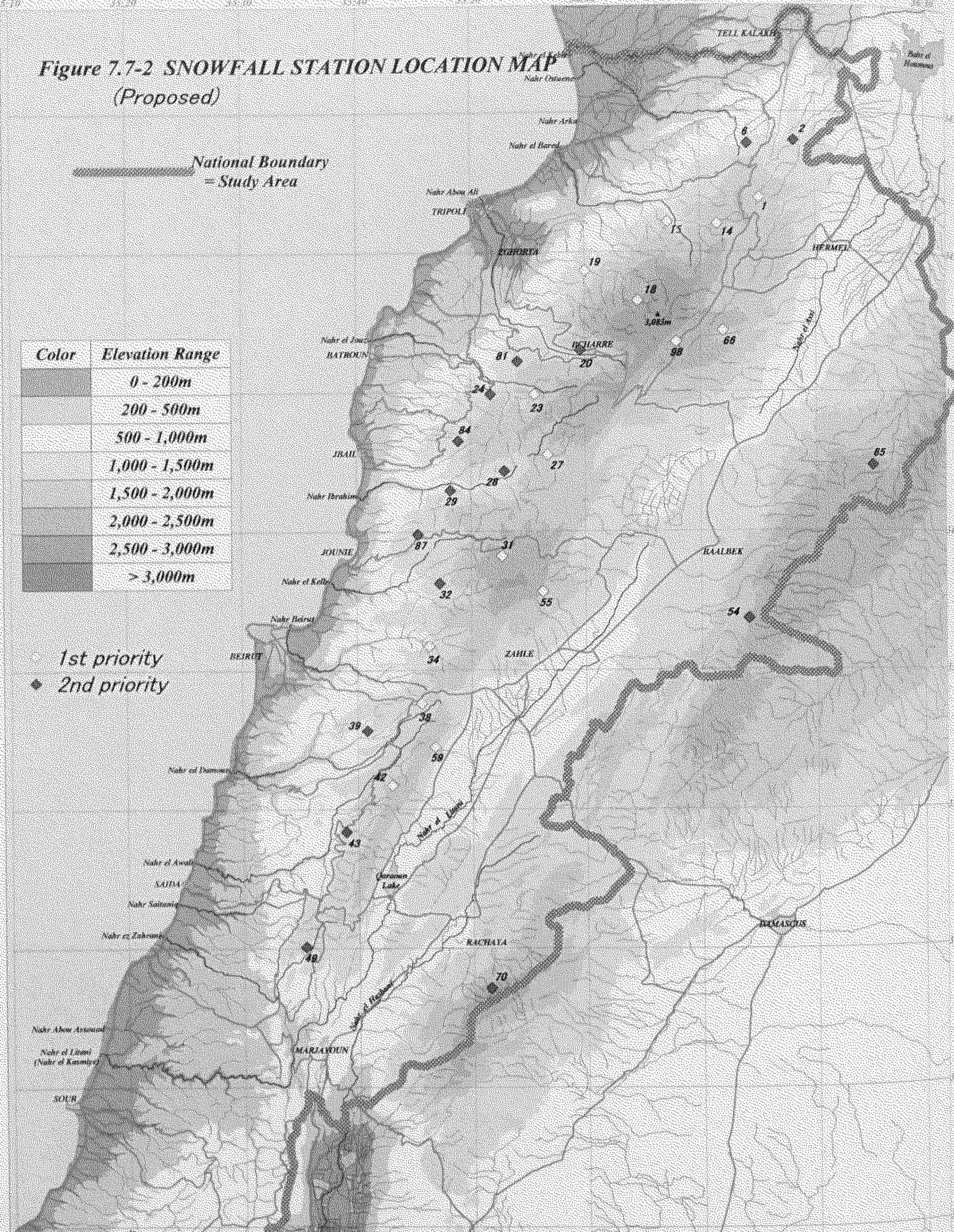


Figure 7.7-2 SNOWFALL STATION LOCATION MAP
(Proposed)

7.7.2 Groundwater Observation and Monitoring Plan

In order to grasp the existing conditions of groundwater in Lebanon, it is recommendable to install at least several tens of groundwater observation and monitoring stations. Nineteen (19), eleven (11), sixteen (16) and thirty seven (37) stations are selected taking hydro-geological conditions of the basins into consideration, as shown in Figure 7.7-3 and as listed in Table 7.7-3.

Visual concept of the groundwater observation and monitoring station is as given below;

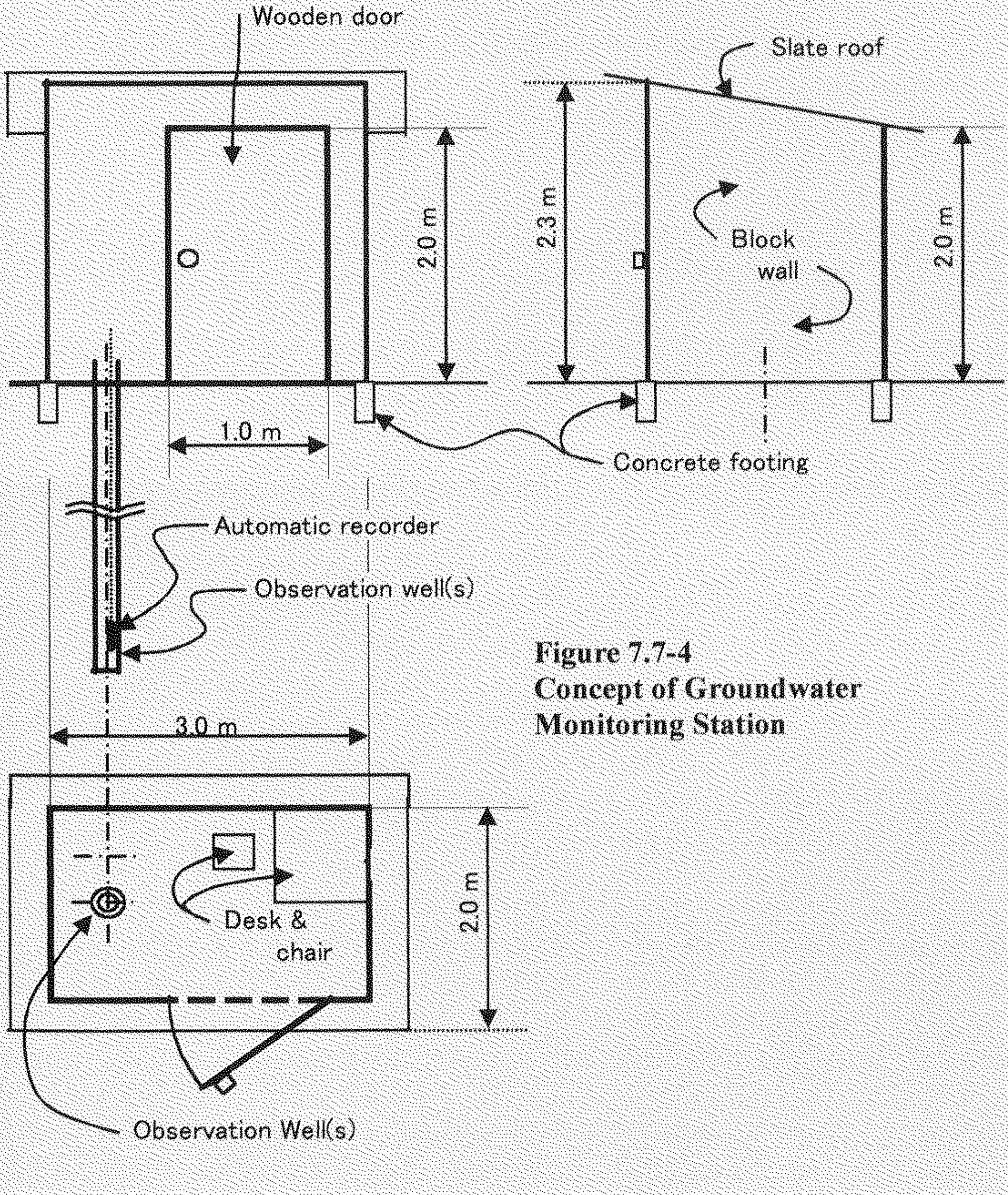


Figure 7.7-4
Concept of Groundwater Monitoring Station

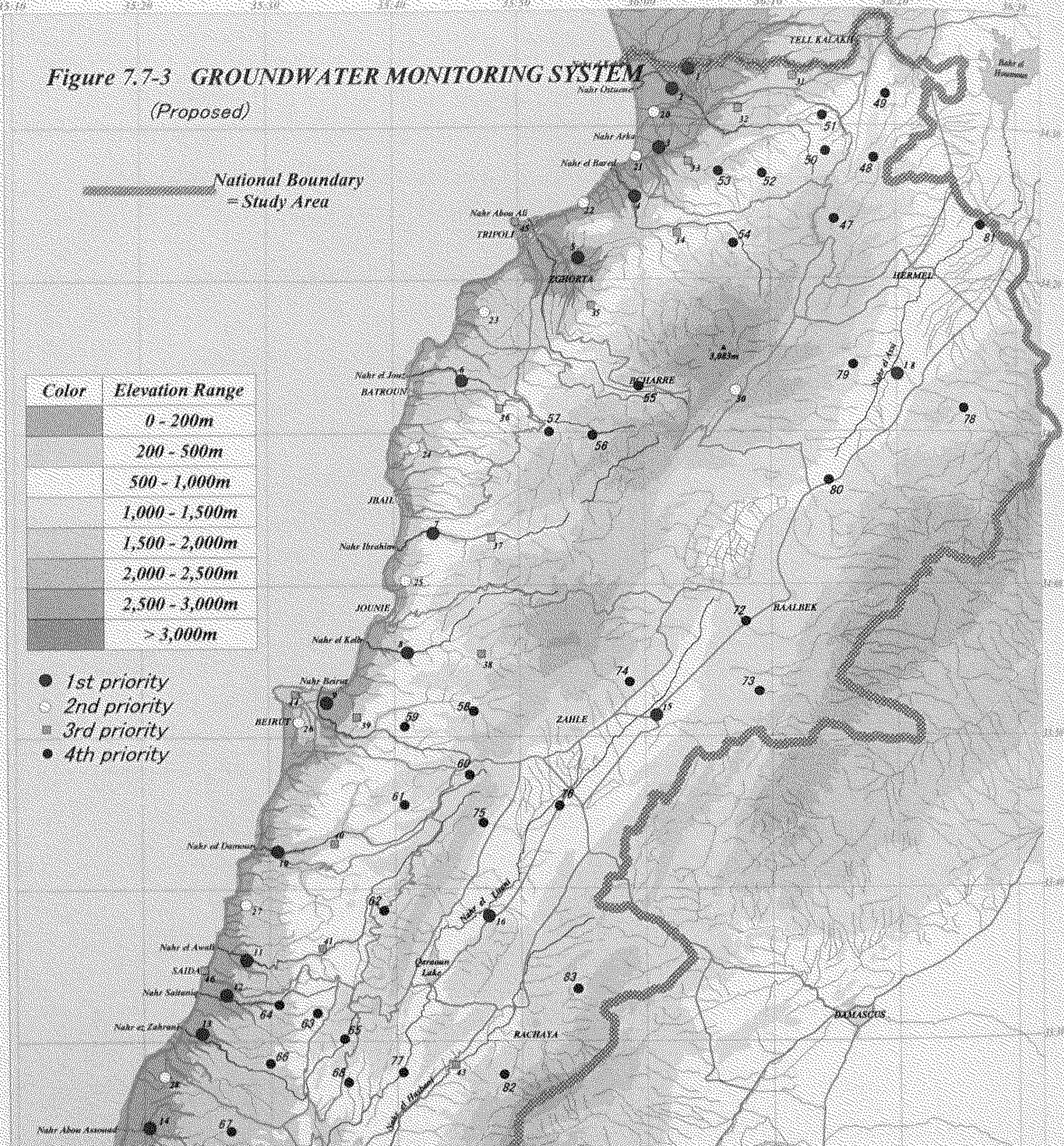


Figure 7.7-3 GROUNDWATER MONITORING SYSTEM
(Proposed)
National Boundary
= Study Area
Color
Elevation Range
0 - 200m
200 - 500m
500 - 1,000m
1,000 - 1,500m
1,500 - 2,000m
2,000 - 2,500m
2,500 - 3,000m
> 3,000m
1st priority
2nd priority
3rd priority
4th priority
TELL KALAKH
TRIPOLI
ZGHORTA
BATROUN
BCHARRE
HERMEL
JBAIL
JOUNIE
BAALBEK
BEIRUT
ZAHLE
SAIDA
RACHAYA
DAMASCUS
MARJAYOUN
SOUR
Nahr el Jouz
Nahr Ibrahim
Nahr el Kalb
Nahr Beirut
Nahr el Damour
Nahr el Awali
Nahr Saitani
Nahr ez Zahrani
Nahr Abou Assouad
Nahr el Litani
(Nahr el Kasmiye)
Nahr el Litani
Qaraoun Lake
Nahr Arka
Nahr el Bared
Nahr Abou Ali
3,083m

Table.7.7-3 Groundwater Monitoring Stations

No.	Sub-basin	Basin Name	X*1	Y*1	Z*2	Geology*3	Type*4	Priority
1	5	Kebir	181,501	297,758	20	QA/Ba	A(100)	1
2	9	Ostuene	181,128	295,271	21	QA/Ba	A(100)	1
3	13	Akar	178,268	287,850	40	$QA/Ba/C_{45}$	B(50,150)	1
4	17	Bared	174,827	281,010	150	ML/C_{45}	B(50,200)	1
5	22	Abou Ali	166,826	273,134	100	$a/ML/C_{45}$	B(100,200)	1
6	26	Jouz	152,358	257,132	400	C_6/C_{45}	B(50,250)	1
7	30	Ibrahim	147,820	236,648	700	C_4	A(500)	1
8	33	Kelb	146,155	222,671	400	J_6	A(350)	1
9	37	Beirut	133,000	216,500	40	q/C_2	A(100)	1
10	41	Damour	126,367	195,847	250	C_4	A(250)	1
11	45	Awali	120,933	181,839	250	C_6	A(300)	1
12	48	Saintaniq	117,549	175,531	200	E_2/C_6	B(50,150)	1
13	51	Zahrani	115,857	171,138	180	E_2/C_6	A(150)	1
14	53	A. Asouad	108,411	161,611	150	E_2/C_6	B(50,150)	1
15	58	Litabi Upper	180,068	218,451	880	n2	A(100)	1
16	60	Litani Middle	155,578	195,400	830	q5	B(100,200)	1
17	64	Litani Lower	109,793	155,120	180	C_{45}/C_6	B(50,200)	1
18	69	Assi	207,285	255,090	850	q/n	A(100)	1
19	73	Hasbani	137,601	152,314	600	C_4	B(100,200)	1
20	75	Olient	179,221	291,788	25	QA/Ba	B(50,150)	2
21	78	Abda	175,532	286,897	15	QA	A(100)	2
22	80	Minie	168,857	281,508	20	qd/m2	B(50,200)	2
23	83	Chekka	156,753	264,801	300	$E/C_6/C_4$	B(50,300)	2
24	86	Batrouan	145,974	250,127	450	m/C_4	B(50,500)	2
25	88	Jounie	144,428	232,377	400	C_4	A(400)	2
26	91	Aaramoun	128,943	212,369	50	$qd/E/C_4$	B(100,200)	2
27	92	Barja	123,781	189,670	400	C_4	A(400)	2
28	94	Sarafand	111,934	168,249	170	E_2/C_6	B(50,200)	2
29	97	Sour	106,694	145,069	150	E_2/C_6	B(50,200)	2
30	98	Yammoune	186,910	256,173	1600	q/C_{34}	B(50,700)	2
31	4	Kebir	198,497	296,763	355	Ba	B(50,250)	3
32	8	Ostuene	191,823	293,032	300	Ba	B(50,250)	3
33	12	Akar	181,252	285,902	300	P/C_{45}	B(50,150)	3
34	16	Bared	180,465	277,279	500	C_{45}	A(500)	3
35	21	Abou Ali	170,806	269,237	700	C_4	A(500)	3
36	25	Jouz	157,830	253,194	800	C_4	A(400)	3
37	29	Ibrahim	156,426	237,465	1000	J_6	A(500)	3
38	32	Kelb	155,578	224,650	1500	C_1/C_2	A(500)	3
39	36	Beirut	135,500	214,000	320	C_2/J	B(100,200)	3
40	40	Damour	133,026	195,439	700	C_4	A(400)	3
41	44	Awali	130,105	183,975	650	C_4	A(100)	3
42	63	Litani Lower	125,289	151,016	450	$e2/C_6/C_4$	B(50,150)	3
43	72	Hasbani	150,138	168,855	850	mcg/J	A(150)	3
44	Beirut	Mid town	129,000	217,000	50	qd/m2a	A(50)	3
45	Tripoli	Mid town	161,000	277,500	15	a/m2	A(50)	3
46	Saida	Mid town	116,500	181,200	25	q	A(50)	3

No.	Sub-basin	Basin Name	X*1	Y*1	Z*2	Geology*3	Depth*5	Priority
47	1	Kebir	200,653	278,067	1,700	C_2/C_1	350	4
48	2	-"-	204,425	284,368	1,250	C_{45}	150	4
49	3	-"-	209,732	294,400	780	C_{45}	100	4
50	6	Ostuene	199,161	285,239	1,250	C_{45}	500	4
51	7	-"-	199,990	290,918	600	C_{45}	500	4
52	10	Akkar	192,155	284,783	700	J	400	4
53	11	-"-	185,978	285,321	420	C_{45}	250	4
54	15	Bared	187,346	275,538	1,200	J	1000	4
55	20	Abou Ali	174,827	255,599	1,300	$C_2/B/J$	D>500	4
56	23	Jouz	168,982	250,500	1,530	J	D>500	4
57	24	-"-	163,261	250,624	1,350	B/J	D>500	4
58	34	Beirut	151,448	214,151	1,200	J	D>500	4
59	35	-"-	141,942	212,634	700	C_1/J	300	4
60	38	Damour	150,804	205,836	1,250	J	D>500	4
61	39	-"-	141,821	201,815	900	C_{12}/J	450	4
62	43	Awali	139,653	185,775	1,100	C_1/J	D>500	4
63	46	Saintaniq	131,110	174,552	1,000	J	300	4
64	47	-"-	124,912	173,966	400	C_6	100	4
65	49	Zahrani	132,953	170,364	950	C_1	450	4
66	50	-"-	123,572	167,307	350	C_4	150	4
67	52	A. Asouad	118,839	159,182	500	C_4	100	4
68	61	Litani L	133,497	163,370	700	E	100	4
69	62	-"-	125,875	139,290	800	E	300	4
70	95	Sour	116,704	130,662	700	C_4	300	4
71	96	-"-	111,762	138,368	450	C_4	150	4
72	58/69	Litani/Assi	188,300	225,900	1,005	q/C_4	500	4
73	56	Litani U	190,524	217,028	1,400	C_4	200	4
74	57	-"-	172,800	222,651	1,300	C_4	200	4
75	59	Litani M	151,400	201,815	1,250	J	500	4
76	58/60	Litani U/M	163,500	201,700	860	q/E	300	4
77	60L	Litani M	142,000	166,600	660	J	100	4
78	67	Assi	215,388	249,816	1,400	C_4	200	4
79	68	-"-	203,123	258,522	1,300	C_4	300	4
80	69U	-"-	199,000	242,100	990	q/C_4	300	4
81	69L	-"-	220,500	278,100	660	q/C_4	200	4
82	71	Hasbani	155,134	166,962	1,300	J	150	4
83	99	K. Kaouk	166,154	177,197	1,150	J	150	4

*1: UTM cord by 1/50,000 Topomap.
*2: Read from 1/50,000 Topomap.
*3: Read from 1/50,000 Geological map.
*4: Type A= 1 OW, Type B= 2 OW.
*5: Required depth estimated (A type).

7.7.3 Water Quality Observation and Monitoring Plan

(1) Current Issues related to Water Quality Monitoring Management

1) Institutional and Administrative Issue

The Environment Law No. 444 was enacted in July 2002 for the purpose of environmental protection/reservation including water pollution. The law regulates not only the protection of the public water body but also the penalty clauses for the case that effluent polluters such as factory and wastewater treatment establishment discharge the wastewater exceeding the effluent standards. The law, however, has just been approved/enacted in the parliament and has not yet fulfilled its original tasks because of the administrative malfunction of the central government.

Ministry of Environment (MOE) is the main organ which should control water pollution nationwide in Lebanon. However, the ministry has the following administrative problems to implement its function for water monitoring.

- Lack of human resources for the water quality monitoring
- Unorganized inspection system for the water quality monitoring
- Insufficient budgetary allocation to implement water quality monitoring management
- No database of water quality monitoring data/information
- No actual implementation of nationwide continuous water quality monitoring program

Actually, the inspection for the wastewater from the factories and wastewater treatment facilities has not been carried out by MOE. The requirement regulated in the Law has not been put into practice.

2) National Plan/Study

A national plan related to water quality monitoring management has not been prepared in Lebanon. However, the following studies related to water quality monitoring were conducted by the international donors.

- Environmental Master Plan for Litani and Lake Qaraun Cacthment Area" by SIDA (MVM Consultant AB, 2000)
- "Coastal Pollution Control and Water Supply Project" (World Bank, 1997)
- Inception Report prepared by LEDO (The Lebanese Environment and Development Observatory) (Ministry of Environment, 2002)

SIDA (MVM Consultant AB) conducted the environmental survey including water quality for the study area of the upper Litani and Qaraun Lake. However, the study did not mention the water quality monitoring management.

The World Bank conducted the study on coastal water pollution and water supply projects for the major target areas of Kesroun, Saida, Sour and Nabatiye. They stated only the environmental management plan for the project during the construction and operation stage, but did not provide the nationwide water quality monitoring management plan as well as SIDA.

LEDO (The Lebanese Environment and Development Observatory) was financed by EU (European Union) and was incorporated with the study of CAMP (The Coastal Area Management Programme). The study aims at the acquisition of environment-related data, reduction of awareness gap among the stakeholders and system development for the continuous monitoring. CAMP projects, on the other hand, provide the development and management plan as a part of UNEP Mediterranean Action Plan for the sustainable management in the coastal areas of South Beirut, Damour, Sarafand and Naqoura located in South Lebanon. However, the overall management plan for water quality was not mentioned.

(2) Proposed Water Quality Monitoring Plan

1) Purpose of Water Quality Monitoring

The measures for the water pollution will comprise two aspects, namely, one is the measure by developing the environment-related facilities such as wastewater treatments and another is the measure by the knowledge-base development such as development of monitoring system.

The monitoring should fulfill its function for the administrative enforcement for controlling the water quality based on the regulated law or environmental/effluent standards. The administrative force should be resorted when the effluents from the establishments exceed the standards based on the inspections or the water quality of the public water area exceeds the environmental standards.

The water quality monitoring should have the following purpose;

- Protection of water body from water pollution
- Minimizing water pollution at the point sources
- To assess the compliance with the clauses regulated in Law 444
- Implementation of continuous monitoring of water quality of the public water body and the wastewater from the factories and wastewater treatment facilities
- Development/Construction of water quality monitoring database
- Sustainable activity of fishery
- Support of fish life, bathing water, etc.
- Reinforcement of public awareness by disclosing of water quality database

1) Basic Requirement for Water Quality Monitoring Management

a) Basic Requirement for Water Quality Monitoring

As said before, the water quality monitoring will be one measure for conservation of water quality. In order to implement the water quality monitoring, the basic requirement should be established in various aspects. The following frameworks should be provided for the water quality monitoring management;

- Extension of knowledge/awareness for water quality monitoring
- Provision of basic policy on water quality monitoring
- Planning, construction, operation and maintenance of water quality monitoring equipment/devices
- Budgetary allocation for planning, construction, operation and maintenance of water quality monitoring
- Establishment of departments/division for water quality monitoring in central/local government levels
- Establishment of inspection organ for the establishments of factories or domestic wastewater treatment plants
- Establishment of inspection organ of operation of solid waste disposal sites
- Cooperation with international agencies for the common purpose of the preservation of the closed water area such as the Mediterranean Sea

b) Target of Water Quality Monitoring

The water quality monitoring should be conducted for the water area nationwide. The target for water quality monitoring shall be as follows.

- Public water area of rivers, sea and springs
- Wastewater from factories and domestic wastewater treatment facilities
- Treated water of water treatment facilities

c) Proposed Station for Monitoring

The monitoring stations should have the following requirement;

- The points which can identify the state of water pollution
- The areas of rivers, lake and coastal areas which have been identified as hot spots with respect to water pollution by the existing reports ("Assessment of the State of the Environment" or Inception Report of LEDO prepared by MOE)
- At least 1 point for main 17 rivers in Lebanon
- The areas which have high naturalness such as Yammoune or Ammiq wetland
- The areas which can share other data such as hydrological data through network systems

The followings monitoring stations shown in Table 7.4-1 are proposed based on above requirement;

Table 7.7-4 Proposed Stations for Water Quality Monitoring

Name of Water Body	Number of Sampling Point			
	Sampling Point			Total
1. River	Downstream	Middle Reach		
Nahr el Kebir	1			1
Nahr Ostuene	1	1		2
Nahr Arka	1			1
Nahr el Bared	1	1		2
Nahr Abou Ali	1	1		2
Nahr el Jouz	1	1		2
Nahr Ibrahim	1	1		2
Nahr el Kelb	1	1		2
Nahr Beirut	1	1		2
Nahr el Damour	1			1
Nahr el Awali	1			1
Nahr Saitaniq	1			1
Nahr el Zahrani	1			1
Nahr Abou Assouad	1			1
Nahr el Litani	1	4		5
Nahr el Hasbani	1	1		2
Nahr el Assi	1	1		2
Sub Total	17	13		30
2. Lake	River Inflow	Mid of Lake	Outlet to River	
Qaraoun Lake	1	1	1	3
Sub Total	1	1	1	3
3. Coastal Water				
Tripoli	1			
Batroun	1			
Jbail	1			
Jounie	1			
Beirut	2			
Damour	1			
Saida	1			
Sarafand	1			
Sour	1			
Sub Total	10			
4. Spring Water				
Ral el Assi	1			
El Yammoune	1			
Afqa	1			
Chekka Bay	1			
Jeita	1			
Chtaura	1			
Chamsine	1			
Anjar	1			
Ammik	1			
Ain Zerka	1			
Wazzani	1			
Ras el Ain	1			
Sub Total	12			
Total	61			61

d) Proposed Organization for Water Quality Monitoring

MOE should conduct continuous monitoring for public water area and wastewater from factories and domestic wastewater treatment facilities. It is advisable that MOE should establish the Water Quality Monitoring Department to monitor the water quality or inspect the wastewater from above establishments. As for the drinking water, MOPH (Ministry of Public Health) should conduct the inspection for raw water and treated water of the purification plants. The proposed organization and execution procedures for water quality monitoring management scheme are shown in Figure 7.7-5, 7.7-6 and 7.7-7.

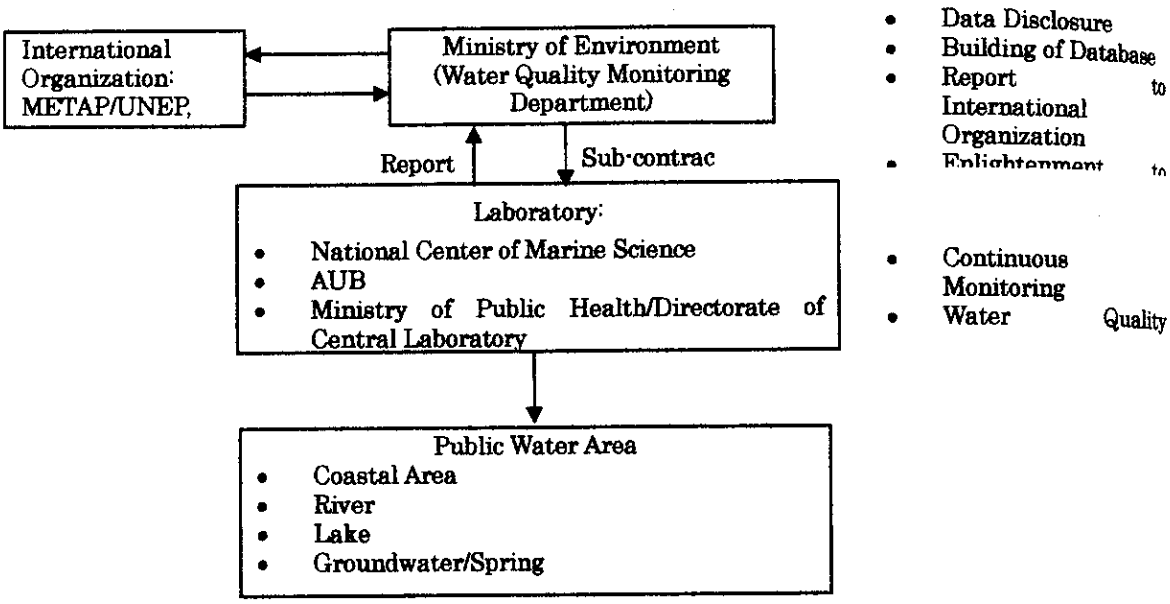


Figure 7.7-5 Proposed Organization for Public Water Area

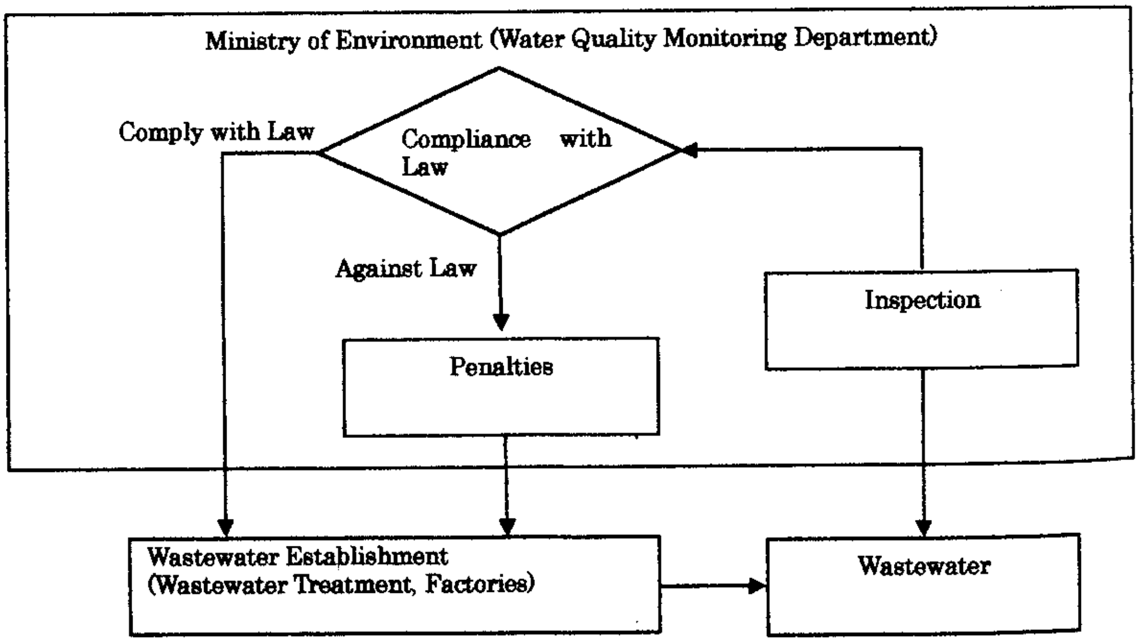


Figure 7.7-6 Procedures for Water Quality Monitoring Management for Wastewater

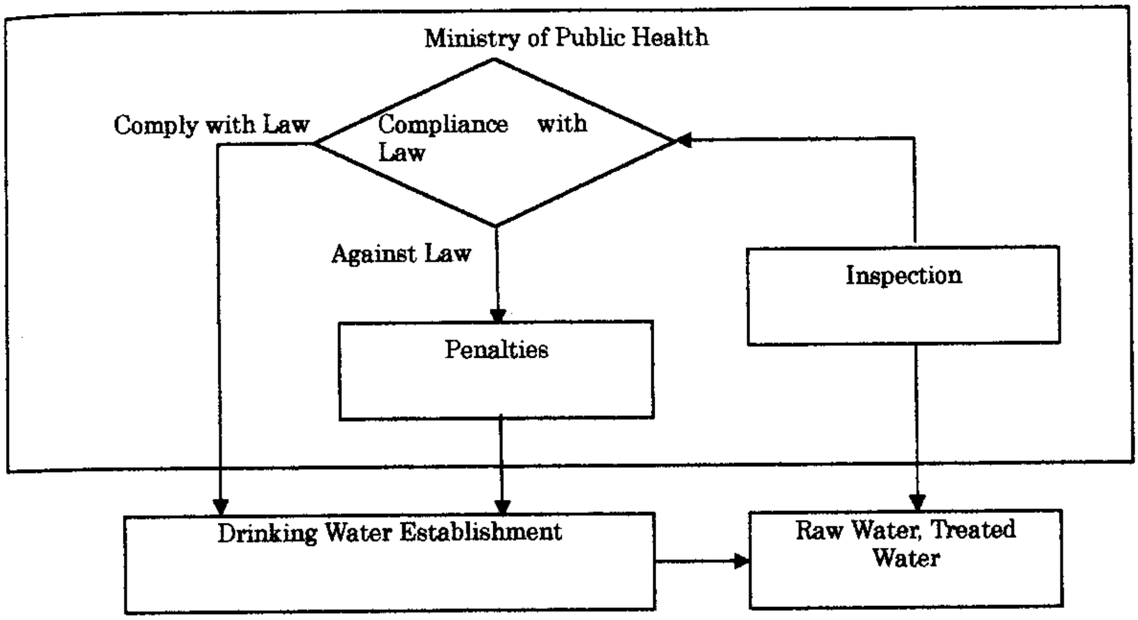


Figure 7.7-7 Procedures for Water Quality Monitoring Management for Drinking Water

e) Monitoring Parameters and Frequency

The parameters for water quality monitoring should be based on Lebanese standards. Therefore, the following parameters for water quality monitoring are proposed in Table 7.4-2 for the public water area, wastewater and water source for water supply. The frequency for water quality monitoring is also proposed as monthly.

Table 7.7-5 Proposed Monitoring Parameters for Public Water Area

Target Area		
Public Water Area 1. For Rivers, Lakes and Springs	Wastewater	Water Sources for Water Supply
pH	pH	pH
Electric Conductivity	Electric Conductivity	Electric Conductivity
BOD (excluding lakes)	BOD (excluding lakes)	Salinity
COD (excluding rivers and springs)	Oil and Grease	Alkalinity
DO (Dissolved Oxygen)	Total Suspended Soil	Total Coliform
Oil and Grease	Total Coliform	Fecal Coliform
Total Suspended Soil	Fecal Coliform	Phosphate
Total Coliform	Nematode eggs	Ammonia
Fecal Coliform	Phosphate	Nitrate
Phosphate	Ammonia	Nitrites
Ammonia	Nitrate	Chlorides
Nitrate	Fluoride	Calcium
Fluoride	Sulfate	Magnesium
Sulfate	Sulfide	Sodium
Sulfide	Chlorine	Potasium
Chlorine	Phenols	Fluoride
Phenols	Arsenic	Sulfate
Arsenic	Cadmium	Iron
Cadmium	Chromium	Herbicide and Pesticides
Target Area		
1. For Rivers, Lakes and Springs (Continued)	Wastewater	Water Sources for Water Supply
Chromium	Copper	Silver
Copper	Iron	
Iron	Lead	
Lead	Selenium	
Selenium	Silver	
Silver	Zinc	
Zinc		
2. For Sea Water		
pH		
COD		
DO		
Oil and Grease		
Total Coliform		
Fecal Coliform		

f) Data Management

At present, the database of water quality monitoring has not been prepared. MOE should develop/build the database system of water quality monitoring which can be easily accessed by the public. All monitoring data for the target areas should be collected, rearranged and input into the database. MOE also should provide the assessment report for the attainment of water quality standards for all water body types and effluents. The data/information should be prepared in GIS system to be spatially and in time-series.

Literature Cited

MVM Consultant AB. (2000). Environmental Master Plan for Litani and Lake Qaraun Catchment Area.

The World Bank. (1997). Coastal Pollution Control and Water Supply Project.

Ministry of Environment. (2002). Inception Report prepared by LEDO

CHAPTER 8

TECHNOLOGY TRANSFER

CHAPTER 8 TECHNOLOGY TRANSFER

The system consisting of GIS database and digital balancing model (DBM) is being constructed as a supporting tool of the preparation of water resources management plan and policy. An application of the system enables plan/policy making efficiently, securing large volume of data and visualizing analyzed result. Since the system is beneficial to water related authorities in Lebanon and requires the periodical update by the Lebanese side, the Study Team has conducted counterpart training so as to enable counterparts to operate, maintain and update the system themselves.

8.1 Phase I Training

As mentioned in the Inception Report, three sub-model trainings and one intensive training were initially planned. However, as shown in the following table, training subjects were modified, considering significance to explain the concept and algorithm of the digital balancing model. The total number of trainings during the Phase I Study was maintained same.

4 months test run of the system from January to April 2003 was intended by providing counterparts with draft manual and a set of system so that problems and user-friendliness of the system could be checked. However, due to the security of system inclusive of data, the test run was cancelled by mutual agreement between the counterparts and JICA Study Team. Instead, the counterparts will check the draft manual during this period.

Table 8.1-1 Initial and Actual Training Programs (Phase I)

Initial Training Plan			Actual Training Conducted		
Type of Training		Subject	Type of Training		Subject
Sub-Model	1st	Software, Supply Sub-model	Sub-Model	1st	Software, Supply Sub-model
	2nd	Demand Sub-model		2nd	DBM Operation
	3rd	Balance Sub-model	DBM Workshop	1st	Overview of DBM
Intensive	1st	Sub-model, System		2nd	Algorithm of DBM

DBM: Digital Balancing Model, Software: GIS software, such as ArcView, Spatial Analyst

Participants in each training are 7 counterparts from MEW (counterpart agency). Table 8.1-2 summarizes the training programs, discussion & results, and so on. Some photos during the training are shown in Figure 8.1-1.

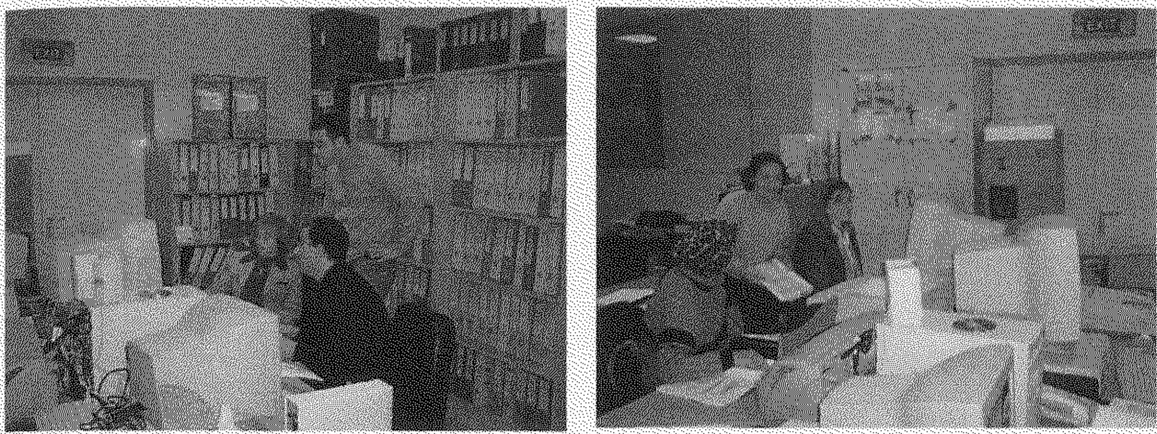
The sub-model training consisted of explanation, exercise in handling the system and questionnaire to evaluate counterparts' understanding in order to improve the training. Water demand projection, assessment of water resources and examination of demand & supply balance were scheduled to be conducted by the end of February, submission of the Interim Report. This Study schedule might have limited understanding of participants because the trainings were always associated with hypothetical conditions but not real/actual conditions of Lebanon.

Workshop focused on explanation and discussion of DBM specifications to meet users' demand

and practicability of DBM. In accordance with discussions during the workshop, DBM was revised and revised DBM was planned to be explained to counterparts in Phase II; however, due to the cease of the Study, a planned intensive training to MEW in Phase II was cancelled.

Table 8.1-2 Training Summary of GIS Database and Digital Balancing Model (Phase I)

Type of Training	Item	Contents
Sub-Model 1st	Date	September 7, 2002 (9:00 – 11:30)
	Place	JICA Study Team Room in MEW
	No. of participants	6 persons
	Subject	1) GIS outline and examples: definition of functions, space analysis and so on 2) ArcGIS & Spatial Analyst outline: basic functions and operations 3) Exercise: adding data, adding point data from Excel, creating thematic maps, creating raster data & counter maps 4) Supply sub-model: explanation of concepts
	Results	Concepts of sub-model seemed to be difficult to understand. A practical operation is required to improve the understanding of participants.
Sub-Model 2nd	Date	December 21, 2002 (9:00 – 11:30)
	Place	JICA Study Team Room in MEW
	No. of participants	7 persons
	Subject	1) Outline of Digital Balancing Model (DBM): system flow 2) DBM operation: calculation of water demand & supply, output of data & calculation results, data management, update of data 3) Exercise: system operation
	Results	Participants understood the system and its operation. On the other hand, there is a request to have more practices to manipulate DBM well.
DBM 1st	Date	November 11, 2002 (10:00 – 11:00)
	Place	JICA Study Team Room in MEW
	No. of participants	7 persons
	Subject	1) Overview concepts and basic specifications of DBM 2) Information sharing of water resources 3) Discussions about DBM
	Results	The further discussion is required to determine the detail specifications of DBM.
DBM 2nd	Date	November 25, 2002 (10:00 – 11:30)
	Place	JICA Study Team Room in MEW
	No. of participants	6 persons
	Subject	1) Basic specification of DBM 2) Algorithm of water demand estimate 3) Algorithm of possible water supply evaluation
	Results	The counterparts from MEW agreed the DBM specifications proposed by the JICA Study Team.



Exercise in GIS Database during the Sub-model Training

Digital Balancing Model Workshop (Discussion of Specifications)

Figure 8.1-1 Photos during Training and Workshop of GIS & DBM in Phase I

8.2 Phase II Training

In phase II, the Study Team has conducted GIS training for LRA (Litani River Authority). LRA has purchased 14 licenses of ArcGIS, and is going to utilize GIS in their routine tasks. In LRA, GIS training was expected to focus on what their tasks are supported by ArcGIS. Thus, the training consisted of explanation of basic GIS & examples, and exercises of ArcGIS for water resources management as shown in Figure 8.2-1. Since intensive training for a lot of counterparts was expected, the trainings were conducted for 4 days. Table 8.2-1 shows the time table of each training.

< One Session>

1. What GIS. (15 minutes)
   -Definition of GIS
   -Basic functions of GIS
   -Examples of GIS

2. How to use ArcGIS for water resources management. (90 minutes)
   -Select by attributes.
   -Select by location.
   -Create thematic maps.
   -Measure area and length.
   -Add point data from excel files.
   -Georeference (geometrical correction).

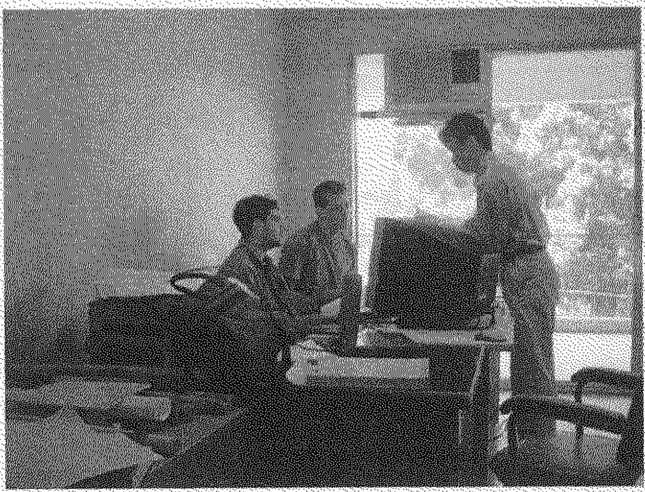
3. Q&A (15minutes)

Figure 8.2-1 Content of GIS Training (Phase II)

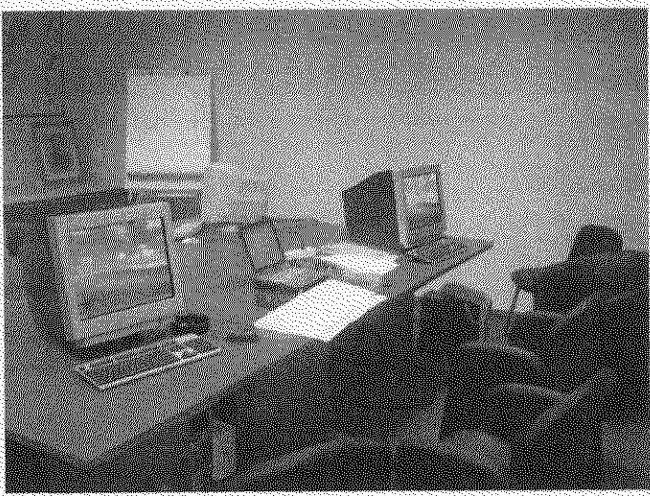
Table 8.2-1 Time Table of GIS Training (Phase II)

Date	Time	Description
7-July	9:00-11:00	First session in Bir Hassan Office.
	11:30-13:30	Second session in Bir Hassan Office.
8-July	9:00-11:00	First session in Becharaa el Khoury Office.
	11:30-13:30	Second session in Becharaa el Khoury Office.
9-July	9:00-12:00	Additional training in Bir Hassan Office.
14-July	9:00-12:00	Additional training in Bir Hassan Office.

Some photos during the training are shown in Figure 8.2-2.



During Training in Bir Hassan Office



Training Room in Becharaa el Khoury Office

Figure 8.2-2 Photos during Training of GIS in Phase II