Part Two

Hydro-planning for Peace

4 From Hydro-conflict to Hydro-co-operation

BACKGROUND

The broad strokes outlining the preceding picture of conflict and co-operation provide a background for further examination of the hydro-diplomacy taking place in the Middle East. The Jordan river basin has remained the focus of such activity over several decades. Similar efforts regarding the waters of Nile, the Euphrates and Tigris, the Litani, and the Asi (Orontes) are either pending or continuing, each occupying its place in the regional picture. While each basin has its own history of competition and negotiation regarding water, this chapter focuses upon recent developments between Israel and its Arab neighbours in their quest for adequate water supplies.

By 1991, several events combined to shift the emphasis on the potential for 'hydro-conflict' in the Middle East to the potential for 'hydro-co-operation'. The first event was natural, but limited to the Jordan basin. Three years of below-average rainfall caused a dramatic tightening in the water management practices of each of the riparians —Israel, Jordan, Lebanon, Palestinians,[1] and Syria—including rationing, cut-backs to agriculture by as much as 30 per cent, and restructuring of water pricing and allocations. Most water decision-makers agree that these steps, particularly regarding pricing practices and allocations to agriculture, were long overdue. Such actions imposed short-term hardships on those affected, but also showed that, during years of normal rainfall, there is still some flexibility in the system.

The next series of events were geo-political and region-wide. The Gulf War in 1991 and the collapse of the Soviet Union caused a realignment of political alliances in the Middle East, events which finally made possible the first public, face-to-face peace talks between the Arabs and the Israelis, in Madrid on 30 October, 1991. During the bilateral negotiations between Israel and each of its neighbours, it was agreed that a second series of talks[2] be established for multilateral negotiations on five subjects deemed 'regional'. Among the topics was that of water resources.

THE PROBLEM

Until the current Arab–Israeli peace negotiations began in 1991, attempts at Middle East conflict resolution always had approached political and resource problems separately. By separating the two realms of 'high' and 'low' politics, some have argued, each process was doomed to fail.[3] In all the water resource issues addressed—the Johnston Negotiations of the mid-1950s, attempts at 'water-for-peace' through nuclear desalination in the late 1960s, negotiations over the Yarmouk river in the 1970s and 1980s, and the Global Water Summit Initiative of groundwater was separated from the political differences between the parties.[4] The above negotiations all failed to one degree or another.

While political tensions have precluded any comprehensive agreement over the waters of the Middle East, unilateral development in each country has tried to keep pace with the water needs of growing populations and economies. As a result, demand for water resources in most of the countries in the region exceeds at least 90 per cent of the renewable supply. The only exceptions to this are Lebanon and Turkey. All of the countries and territories riparian to the Jordan river—Israel, Syria, Jordan, and the West Bank (Palestine)—currently use between 95 per cent and more than 100 per cent of their annual renewable freshwater supply.[5] Gaza exceeds its renewable supplies by 50 per cent every year, resulting in serious saltwater intrusion. In recent dry years, water consumption throughout the region has routinely exceeded annual supply, the difference usually being made up through overdraft of fragile ground water systems.

In water systems as tightly managed and exploited as those of the Middle East, any future unilateral development is likely to be extremely expensive if based on technology, or politically volatile if threatening the resources of a neighbour. It has been clear to water managers for years that the most viable options include regional co-operation as a minimum prerequisite.[6]

ATTEMPTS AT CONFLICT MANAGEMENT

Since the opening session of the multilateral talks[7] in Moscow in January 1992, the Working Group on Water Resources, with the United States as 'gavel-holder,' has been the forum through which problems of water supply, demand, and institutions have been raised among the parties to the bilateral talks—Israel, Jordan, and the Palestinians (with the exception of Lebanon and Syria). Talks have also taken place among Arab states from the Maghreb including Algeria, Mauritania, Morocco and Tunisia, and from the Gulf and Red Sea: Bahrain, Egypt, Kuwait, Oman, Qatar, Saudi Arabia, the United Arab Emirates and Yemen. Participating in the talks are also 'non-regional delegations', including representatives from governments such as Canada, China, the European Union, Japan, and Turkey; and from donor NGOs such as the World Bank.[8]

The two series of the current negotiations, the bilateral and the multilateral, are designed explicitly not only to close the gap between issues of politics and issues of regional development, but perhaps to use progress on each to help catalyze the pace of the other in a positive feedback loop. The goal of both is to achieve 'a just and lasting peace in the Middle East'. The multilateral working groups are intended to provide fora for relatively free dialogues on the future of the region, and in the process, to allow inter-personal relationships to form and confidence building to take place. Decisions are made through consensus only. Given the role of the Working Group on Water Resources in this context, the objectives thus far have been more in the nature of fact-finding and workshops, rather than tackling the difficult hydro-political issues of water rights and allocations, or the development of specific projects.

The Working Group on Water has met five times (Table 4-1 and Table 4-3). The pace of success of each round has fluctuated but, in general, has been increasing. The 'second' round, the first of the water group alone, has been characterized as, 'contentious', with initial posturing on all sides. Palestinians and Jordanians, then part of a joint delegation, first raised the issue of water rights, claiming that no progress can be made on any other issue until past grievances are addressed. In sharp contrast, the Israeli position has been that water rights is a bilateral issue, and that the multilateral working group should focus on joint management and development of new resources.

Since decisions are made by consensus, little progress was made on either of these issues. Nevertheless, plans were made for continuation of the talks, an achievement in itself.

Table 4-1: MEETINGS OF THE MULTILATERAL WORKING GROUP ON WATER RESOURCES

	Dates	Location
Multilateral organizational meeting[13]	28–9 January 1992	Moscow
Water Talks, Round 2	14–15 May 1992	Vienna
Water Talks, Round 3	16–17 September 1992	Washington, DC
Water Talks, Round 4	27–9 April 1993	Geneva
Water Talks, Round 5	26–8 October 1993	Beijing
Water Talks, Round 6	17–19 April 1994	Muscat

Table 4-2: REGIONAL TRAINING ACTION PLAN

Water Sector Level Courses

1. Concepts of integrated water resources planning and management
2. Water resources assessment, planning and management
3. Water quality management
4. Data collection and management systems
5. Alternatives in water resources development
6. Principles and applications of international water law

Water Sub-sector Level Courses

7. Management of municipal water supply systems
8. Rehabilitation of municipal water supply systems
9. Management of wastewater collection and treatment systems
10. Development of efficient irrigation systems

Specialized Courses

11. Environmental impact assessment techniques
12. Groundwater modeling
13. Public awareness campaigns for the water sector
14. Development, management and delivery of training programmes in the water sector

Table 4-3: CHRONOLOGY OF WATER-NEGOTIATION-RELATED-EVENTS

30 October 1991	First public, face-to-face peace talks between Arabs and Israelis are held in Madrid. Talks begin as bilateral, between Israel and each of its neighbours.
28–9 January 1992	Multilateral organizational meeting in Moscow. Peace process is designed along two tracks—the bilateral negotiations, involving separate direct negotiations between Israel and each of its neighbours, and the multilateral negotiations revolving around five regional subjects, including water resources. Goal is to allow framework for defining future of the region, as well as to include peripheral Arab states, other countries, and donor NGOs.
14–15 May 1992	First meeting of Multilateral Working Group on Water Resources in Vienna (dubbed the 'second' round of multilaterals). Little practical progress made due to venting and posturing on all sides. Palestinians and Jordanians first raise issue of water rights; Israel's position is that water rights are a bilateral issue. World Bank asks each party to compile a programme for regional water resources development, following three possible scenarios: no outside investment, current government plans, and unlimited resources. These scenarios would be examined in the US for any commonalties which could be culled to induce cooperation. Only decision reached is to plan for next round of talks.
16–17 September 1992	Third round of water talks in Washington, DC. Agreement on four general subjects for multilateral talks on water: enhancement of water data, water management practices, enhancement of water supply, and concepts for regional co-operation and management. Role of multilaterals clarified to plan for future region at peace, not to implement specific agreements.
27–9 April 1993	The fourth working group on water meeting in Geneva proves difficult following a disagreement over a Palestinian request that water rights be included in multilateral talks, otherwise the Palestinians would boycott inter-sessional activities.
May 1993	Israelis and Palestinians agree to discuss water rights in the Occupied Territories within the framework of the bilateral negotiations and Palestinians agree to participate in inter-sessional activities. This agreement, which came about in discussions at the working group on refugees meeting in Oslo, also called for American representatives of the water working group to visit the region.

15 September 1993	Declaration of Principles signed between Israelis and Palestinians, which includes several water-related items, including the creation of a Palestinian Water Administration Authority and a Water Development Programme. The Programme would include investigations of development of regional agricultural and desalination projects, and a Med-Dead canal (Gaza).
26–8 October 1993	Fifth round of Working Group on Water Resources meets in Beijing. Presentations are made in each of four topics and several projects are agreed to; priority needs assessment is presented and courses are approved.
17–19 April 1994	Sixth round of Working Group meets in Muscat, Oman. The meeting is productive after all parties agree to welcome a Palestinian announcement of the creation of a Palestinian Water Authority in the autonomous territories of Gaza and Jericho (Israel agrees provided it will not be seen as a precedent in other territories). Other endorsements include: an Omani proposal to establish a desalination research and technology centre; an Israeli proposal to lead an effort of water conservation and rehabilitation of municipal water systems; a German offer to study regional supply and demand; a US proposal to perform a study of wastewater treatment and reuse; and the US and EU would implement a regional water training programme to begin in June 1994.
7–9 June 1994	Bilateral talks take place between Israel and Jordan in Washington DC. Sub-agenda items are determined for talks leading to a Treaty of Peace, including several water-related topics.
26 October 1994	Treaty of Peace signed between the Hashemite Kingdom of Jordan and the State of Israel. The treaty includes several water related items on the development of the Yarmouk river, the Jordan river, brackish water desalination in Beit'shean, and brackish ground water desalination near Araba.
28 September 1995	Interim Agreement signed between Israel and the Palestinians, broadening the autonomous zone in the West Bank to major population areas, and recognizing Palestinian water rights to be specified in future negotiations.

The third round in Washington DC in September, 1992 made somewhat more progress. Consensus was reached on a general emphasis for the watersheds that the US Department of State had proposed in May, focusing on four subjects:

- enhancement of water data.

- water management practices.
- enhancement of water supply.
- concepts for regional co-operation and management.

Progress was also made on the definition of the relationship between the multilateral and bilateral tracks. By this third meeting, it became clear that regional water-sharing agreements, or any political agreements surrounding water resources, would not be dealt with in the multilateral talks, but that the role of these talks was to deal with non-political issues of mutual concern, thereby strengthening the bilateral track. The goal for the working group on water resources became to plan for a future region at peace, and to leave the pace of implementation to the bilaterals. This distinction between 'planning' and 'implementation' became crucial, with progress only being made as the boundary between the two was continuously pushed and blurred by the mediators.

The fourth round in Geneva in April 1993 proved particularly contentious, threatening at points to grind to a halt. Initially, the meeting seemed somewhat innocuous. Proposals were made for a series of inter-sessional activities surrounding the four subjects agreed to at the previous meeting. These activities, including study tours and water-related courses, would help capacity building (i.e., greater expertise) within the region while fostering better personal and professional relations between negotiators.

The issue of water rights was raised again, however, with the Palestinians threatening to boycott the inter-sessional activities. The Jordanians, however, who had already agreed to discuss water rights with the Israelis in their bilateral negotiations, helped work out a similar arrangement on behalf of the Palestinians. Settlement of the problem was not reached at that time, but both sides eventually agreed, after quiet negotiations in May during the meeting of the working group on refugees in Oslo.

The agreement called for three Israeli–Palestinian working groups within the bilateral negotiations, one of which would deal with water rights. The Palestinians also agreed to participate in the inter-sessional activities. In addition, the US representatives on the working group were called upon to visit the region. While some expected the visiting US representatives to take the opportunity to present a strong pro-active position on the issue of water rights, the delegates insisted that any specific initiatives would have to come from the parties themselves, and that agreement would have to be by consensus.

By July 1993, the inter-sessional activities had begun, with about twenty activities as diverse as a study tour of the Colorado river basin and a series of seminars on semi-arid lands which have since taken place. Recent emphasis has been on capacity building in the region. A series of fourteen courses for participants from the region has recently been designed by the US and the EU. These range in length from two weeks to twelve months and cover subjects as broad as concepts of integrated water management and as detailed as groundwater flow modelling.

Following a June 1993 agreement in the multilaterals on a joint US/EC proposal to conduct a regional training needs assessment in the Middle East water sector, a team of specialists developed a Priority Regional Training Action Plan. The plan included a series of fourteen courses offered to managers and professionals from the region over two years beginning in June 1994. The courses were endorsed at the fifth round of water talks in Oman in April 1994. The first course which explored concepts of integrated water resources planning and management, was held in Florida. The approved courses, which range in duration from two weeks to two years are shown in Table 4-2.

On 15 September 1993, the Declaration of Principles on Interim Self-Government Arrangements was signed between Palestinians and Israelis. The declaration defined Palestinian autonomy and the redeployment of Israeli forces out of Gaza and Jericho. Among other issues, it also called for the creation of a Palestinian Water Administration Authority. Moreover, the first item in Annex III, on co-operation in economic and development programmes, included a focus on:

> Co-operation in the field of water, including a Water Development Programme prepared by experts from both sides, which will also specify the mode of co-operation in the management of water resources in the West Bank and Gaza Strip, and will include proposals for studies and plans on water rights of each party, as well as on the equitable utilization of joint water resources for implementation in and beyond the interim period.

Annex IV describes regional development programmes for co-operation, including:

- the development of a joint Israeli-Palestinian-Jordanian Plan for co-ordinated exploitation of the Dead sea area;

- the Mediterranean sea (Gaza) - Dead sea canal;
- regional desalinization and other water development projects;
- a regional plan for agricultural development, including a co-ordinated regional effort for the prevention of desertification.

The Declaration of Principles also included a description of the mechanisms by which disputes might be resolved. Article XV describes these mechanisms:

1. Disputes arising out of the application or interpretation of this Declaration of Principles, or any subsequent agreements pertaining to the interim period, shall be resolved by negotiations through a Joint Liaison Committee to be established.
2. Disputes which cannot be settled by negotiations may be resolved by a mechanism of conciliation to be agreed upon by the parties.
3. The parties may agree to submit to arbitration disputes relating to the interim period, which cannot be settled through conciliation. To this end, upon the agreement of both parties, the parties will establish an Arbitration Committee.

Although the declaration was seen as a positive development by most parties, minor consternation was expressed by the Jordanians about the Israeli-Palestinian agreement to investigate a possible Med-Dead canal (per Uri Shamir 6/94). In the working group on regional economic development, the Italians had pledged $2.5 million towards a study of a Red-Dead canal as a joint Israeli-Jordanian project; building both would not be feasible. The Israelis pointed out in private conversations with the Jordanians that all possible projects should be investigated, and only then could rational decisions on implementation be made.

The Declaration of Principles, although a bilateral agreement, helped streamline some logistically awkward aspects of the multilaterals, by making the PLO openly responsible for the talks and separating the Palestinian delegations from the Jordanians.

By the fifth round of water talks in Beijing in October 1993, a routine of sorts seemed to be established. Reports were presented on each of the four topics agreed to at the second meeting in Vienna—enhancement of data availability; enhancing water supply; water management and conservation; and concepts of regional co-operation and management—and a new series of inter-sessional activities was announced.

THE OUTCOME

By the end of the fifth round of talks, the following agreements had been reached:

1. Enhancement of Data Availability
   - agreement on the need for regional data banks (banks, plural) because of Egypt (per Lawson 7/94),
   - a workshop would be held at USGS facilities in Atlanta as would additional workshops on the subject as part of the US-EU Priority Training Needs Assessment;
   - a workshop on the standardization of methodologies and formats for data collection would be held.

2. Enhancing Water Supply
   - feasibility studies are being conducted on facilities for the desalination of brackish water, by Japan in Jordan and by the EU in Gaza;
   - Canada compiled an exhaustive literature review on water technologies;
   - Oman's suggestion was accepted to conduct a survey on the current status of desalination research and technology;
   - a Canadian proposal for the installation of a rainwater catchment system in Gaza was accepted, marking the first concrete project to be accepted by the working group;

3. Water Management and Conservation
   - Austria ran a seminar on water technologies in arid and semi-arid regions, with special reference to the Middle East;
   - the US organized two seminars jointly sponsored by the water and environment working groups, one on the treatment of wastewater in small communities, and one on dry lands agriculture;
   - the World Bank is carrying out surveys of water conservation in the West Bank, Gaza, and Jordan.[9]

4. Regional Co-operation and Management
   - the UN is organizing a seminar on various models for regional co-operation and management;
   - the US is planning a workshop on weather forecasting;

- Jordan proposed that the working group define a 'water charter' for the Middle East, to define the principles of regional co-operation and determine mechanisms for water conflict resolution. The proposal was not adopted.

The sixth round of talks was held in Muscat, Oman in April 1994, the first of the water talks to be held in an Arab country, and the first of any working group to be held in the Gulf. Tensions mounted immediately before the talks as it became clear that the Palestinians would use the occasion as a platform to announce the appointment of a Palestinian National Water Authority. While such an authority was called for in the Declaration of Principles, possible responses to both its unilateral nature and to the appropriateness of the working group as the proper forum for the announcement was unclear. Only a flurry of activity prior to the talks guaranteed that the announcement would be welcomed by all parties. This agreement set the stage for a particularly productive meeting. In two days, the working group endorsed:

- an Omani proposal to establish a desalination research and technology centre in Muscat, which would support regional co-operation in desalination research among all interested parties. This marked the first Arab proposal to reach consensus in the working group;
- an Israeli proposal to rehabilitate and make more efficient water systems in small-sized communities in the region. This was the first Israeli proposal to be accepted by any working group;
- a German proposal to study the water supply and demand development among interested core parties in the region;
- a US proposal to develop wastewater treatment and re-use facilities for small communities at several sites in the region. The proposal was jointly sponsored by the water and environmental working groups;
- implementation of the US/EU regional training programme, as described in Table 4-2.

As mentioned above, the working group officially welcomed the announcement of the creation of the Palestinian Water Authority, and pledged to work with the authority on multilateral water issues.

Recent progress has been made in bilateral negotiations, both between Jordan and Israel and between Israel and the Palestinians. On 7 June 1994, the two states announced that they had reached an agreement on a sub-agenda for co-operation, building on an agenda for peace talks which had been agreed to on 14 September 1993, which would lead eventually to a peace treaty. This sub-agenda included several water-related items, notably in the first heading listed (in advance of security issues, and border and territorial matters),

Group A—Water, Energy, and the Environment

I. Surface water basins.

a. Negotiation of mutual recognition of the rightful water allocations of the two sides in Jordan river and Yarmouk river waters with mutually acceptable quality.
b. Restoration of water quality in the Jordan river below Lake Tiberius to usable standards.
c. Protection of water quality.

II. Shared groundwater aquifers.

a. Renewable fresh water aquifers—southern area between the Dead Sea and the Red Sea.
b. Fossil aquifers—area between the Dead Sea and the Red Sea.
c. Protection of the water quality of both.

III. Alleviation of water shortage.

a. Development of water resources.
b. Municipal water shortages.
c. Irrigation water shortages.

IV. Potentials of future bilateral co-operation, within a regional context where appropriate.

[Includes Red Sea-Dead Sea canal; management of water basins; and inter-disciplinary activities in water, environment and energy.]

On 26 October 1994 Israel and Jordan formalized a peace treaty after resolving the last and most contentious issue, shared water resources.

According to Annex II of the accord:

Israel will limit its withdrawals from the Yarmouk to 25 mcm/yr. Jordan has rights to the rest of the normal flow of the river plus 10 mcm/yr desalinated brackish spring water (out of a total of 20 mcm/yr to be desalinated);

Jordan will effectively store 20 mcm/yr of winter floodwater in Israel by allowing Israel to pump it from the Yarmouk in the winter months and having it returned from the Jordan in the summer. Floodwater in addition to current uses will be split between the two countries;

Two dams will be constructed—one each on the Yarmouk and the Jordan (Israel can use up to 3 mcm/yr of increased storage capacity).

Israel can expand by 10 mcm/yr pumping of ground water wells in the Arava/Araba, which according to the redefined border now fall within Jordanian territory.

An additional 50 mcm/yr will be developed through joint projects, to be determined by a Joint Water Committee;

The Joint Water Committee, comprised of three members from each country, will also collect relevant data on water resources, specify work procedures and details, and form specialized sub-committees, as needed.

Bilateral agreement has been forthcoming between Israel and the Palestinians as well. Between 1993 and 1995, Israeli and Palestinian representatives negotiated to broaden the 'Declaration of Principles' to encompass greater West Bank territory. On 28 September 1995, the 'Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip', nicknamed 'Oslo II', was signed in Washington DC. The question of water rights was one of the most difficult to negotiate with a final agreement postponed to be included in the negotiations for final status arrangements. Nevertheless, tremendous compromise was achieved between the two sides. Israel recognized the Palestinian claim to water rights—of an amount to be determined in final status negotiations—and a Joint Water Committee was established to co-operatively manage West Bank water and to develop new supplies.

According to the agreement, Israeli forces are scheduled to withdraw from six Palestinian cities in order from north to south, and from 450 towns and villages throughout the West Bank. The final status of Israeli settlements in the West Bank has yet to be determined. No territory whatsoever was identified as being necessary for Israeli annexation due to access to water resources, as some had predicted. In fact, the second and third cities scheduled for Israeli withdrawal—Tulkarm and Kalkilya—fall well within the 'red line' delineated in Israeli studies as being necessary to retain for water security.

OBSERVATIONS

Given the length of time that the region has been enmeshed in bitter conflict, the pace of accomplishment of the peace process has been impressive, no less so in the area of water resources. This may be due in part to the structure of the peace talks, with the two complementary and mutually reinforcing tracks—the bilateral and the multilateral. As noted earlier, past attempts at resolving water issues separate from their political framework, dating from the early 1950's through 1991, all failed to one degree or another. Once the taboo of Israelis and Arabs meeting openly in face-to-face talks was broken in Madrid in October 1991, the floodgates were open, as it were, and a flurry of long-repressed activity on water resources began to take place outside of the official peace process. This included several academic conferences on Middle Eastern water resources in, among other places, Canada, Turkey, Illinois, Washington DC (3) and, notably, the first Israeli-Palestinian conference on water resources in Geneva; unofficial 'track II' dialogues in Cairo, New Mexico, and Idaho; the establishment by the IWRA of the 'Middle East Water Commission' (responsible for this volume) to help facilitate research on the subject, and organization of the Middle East Water Information Network (MEWIN) to co-ordinate regional data collection.

While this flurry of water-related activity may have been moderately helpful in generating ideas outside the constraints of the official process, and more so in fostering better personal relations between the water professional of the region, many negotiators involved with the official process suggest that it has had limited influence. This is because as yet no mechanism exists to encourage dialogue between the tracks.[10]

Despite the relative success of the multilateral working group on water, and given its stated objective to deal with non-political issues of mutual concern, one might wonder where the process might go from there.[11] The working group has performed admirably in the crucial early stages of negotiations as a vehicle for venting past grievances, presenting various views of the future, and, perhaps most important, allowing for personal 'de-demonization' and confidence-building on which the future regional peace will be built.

Currently, however, there is some frustration on the part of many of the participants that it is not, by design, a vehicle for actually resolving any of the conflicting issues. The contentious topics of water rights and allocations, which some argue must be solved before proceeding with any cooperative projects, are relegated to the bilateral negotiations, where they take a relatively lower priority. Likewise, the principles of integrated watershed management are difficult to encourage: water quantity, quality, and rights all fall within the purview of different negotiating frameworks—the working group on water, the working group on the environment, and the various bilateral negotiations, respectively.[12] Finally, and perhaps somewhat related, are the limitations imposed by Syrian and Lebanese refusal to participate in any of the multilateral working groups. The result of this omission means that a comprehensive settlement of the conflicts related to the Jordan or Yarmouk rivers is precluded from discussion.

The question, therefore, arises whether a new track for a water dialogue may be useful, one falling between the regional support role of the multilateral working group and the narrow political focus of the bilateral negotiations. Perhaps a watershed-wide meeting would be helpful—for example, an Israel/Jordan/Syria group on the problems of the Yarmouk basin. Such dialogues could address all of the water-related problems of each watershed, including water rights, quantity, and quality. The focus might be broadened over time until it overlaps with the current multilateral working group to become a true regional water authority. By the same token, watershed dialogues relating to peripheral river basins—the Euphrates with Turkey, Syria and Iraq—would enhance questions of sources of water external to the core area as they relate to region-wide peace.

NOTES

1. We recognize the validity of the term 'Palestine' (see footnote 1, Chapter 1), but at the time referred to for this usage Palestine was recognized by Palestinians, but had little international usage, *per se.*
2. The word 'series' is used in this context to distinguish these formal activities from those often referred as 'second track diplomacy' wherein informal, low profile meetings between negotiators are arranged by 'honest brokers'. Such meetings are intended to establish interpersonal relations and to allow the airing of topics without the constraints of national position taking.
3. For particularly cogent presentations of this argument, *see*, Lowi, Miriam. *Water and Power: The Politics of a Scarce Resource in the*

Jordan River Basin. Cambridge: Cambridge University Press, 1993; and Waterbury, John. 'Transboundary Water and the Challenge of International Co-operation in the Middle East'. Presented at a symposium on Water in the Arab World, Harvard University, 1–3 October 1993.

4. For more details of these issues in the region's hydro-political history, *see* Wolf, A. *Hydropolitics Along the Jordan River: The Impact of Scarce Water Resources on the Arab-Israeli Conflict.* Tokyo: United Nations University Press, 1995.
5. For the hydrography of the region, *see* Kolars, John. 'Water Resources of the Middle East.' *Canadian Journal of Development Studies.* 1992.
6. *See,* for example, Biswas, A. et al., (ed.) *Water for Sustainable Development.* Oxford: Oxford University Press, 1993; and Lonergan, Stephen C. and David B. Brooks. *Parting the Waters: The Role of Freshwater in the Israeli-Arab Conflict.* Ottawa: International Development and Research Centre, 1994.
7. For an excellent description of the multilateral working groups in the context of the bilateral peace talks, *see,* Peters, Joel. *Building Bridges: The Arab-Israeli Multilateral Talks.* London: The Royal Institute of International Affairs, 1994.
8. The complete list of parties invited to each round includes representatives from: Algeria, Australia, Austria, Bahrain, Belgium, Canada, China, Denmark, European Union, Egypt, Finland, France, Germany, Greece, India, Ireland, Israel, Italy, Japan, Jordan, Kuwait, Luxembourg, Mauritania, Morocco, Netherlands, Norway, Oman, Palestine, Portugal, Qatar, Russia, Saudi Arabia, Spain, Sweden, Switzerland, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, United Nations, United States, the World Bank, and Yemen.
9. This has been done. For more information, *see* The World Bank. 'Water Conservation in the Occupied Territories'. Washington DC, April 1994.
10. The term 'Track II' refers to those activities outside of the official negotiations. There may be some confusion, because in the case of the Middle East peace talks, the official process is likewise divided in two—the bilateral negotiations and the multilateral working groups.
11. Biswas makes the argument for the systematic analyses of international water conflicts in, Biswas, Asit. 'Indus Water Treaty: The Negotiating Process'. *Water International* 17 (1992).
12. There is slightly more overlap than the institutional setting might indicate. Several of the regional delegates sit on both bilateral and multilateral groups, and each of the states have some sort of steering committee which fosters communication. Furthermore, the US team includes members who participate in both the water and the environment

working groups, which helps ensure that issues of water quantity and quality are not entirely separated.

13. After some confusion in numbering, it was eventually officially decided that the multilateral organizational meeting in Moscow represented the first round of the multilateral working groups. Subsequent meetings are therefore numbered correspondingly, beginning with two.

5 Techno-Political Decision-making for Water Resources Development in the Jordan River Watershed

The accord between Israel and the Palestine Liberation Organization (PLO) in Oslo on 13 September 1993, produced a Declaration of Principles which included proposals for an inter-state regional economic development plan (Israel/PLO, 1993). Regional economic development was conceived or as a key element in sustaining the peace process in the region. Similarly, regional watershed development was emphasized in an agenda for co-operation, signed between Jordan and Israel in June, 1994.

This chapter examines regional water-energy development alternatives considering both technical and political aspects of viability. Our considerations are in the context of sharing resources and benefits, taking into account the next possible multilateral peace agreement among Israel, Palestine, and Jordan. Syria, Lebanon, Egypt and Saudi Arabia could also share resources and benefits from some of these schemes.

WATER AND ENERGY: KEY ISSUES OF REGIONAL DEVELOPMENT

Hydro-Political Positions[1]

Before investigating specific projects, the major hydro-political issues facing each political entity are examined:

Israeli water issues

Sustainable yield of renewable fresh waters in Israel is approximately $1{,}500 \times 10^6$ m^3 per annum. Israel had already exceeded this level by the early 1970s, and had to cut 29 per cent from its national water budget from $1{,}987 \times 10^6$ m^3 in 1987 to $1{,}420 \times 10^6$ m^3 in 1991 due to severe drought. Israel accomplished this without losing net agricultural product or economic growth. Overall water savings in the agricultural sector were 39 per cent during the same period—from $1{,}434 \times 10^6$ m^3 in 1986 to 875×10^6 m^3 in 1991. Israel feels confident that it can continue to meet its own needs—perhaps with additional desalination plants—but also feels that it cannot relinquish any sizeable portion of the water it already uses.

Palestinian water issues

Israel took control of the West Bank in 1967, including the recharge areas for aquifers which flow west and north-west into Israel (at about 320×10^6 m^3/yr and 140×10^6 m^3/yr respectively) and east to the Jordan valley (about 125×10^6 m^3/yr). The entire renewable recharge of these first two aquifers is already being exploited and the third is close to being depleted. Total consumption within the West Bank is 35×10^6 m^3/yr, mostly from wells, for Israeli settlements (population 125,000); and 118×10^6 m^3/yr, from wells and cisterns, for some 1,200,000 Palestinians (Table 5-1, Table 5-2, Table 5-3).[2] Israel is dependent on the West Bank for a total of 430×10^6 m^3 per annum of its water supply out of a total $1{,}420 \times 10^6$ m^3, which accounts for 30 per cent of its annual water potential. Because any overdraft would result in saltwater intrusion along Israel's coastal plain, or eventually even into the mountain aquifers, Palestinian water usage has been severely limited by the Israeli authorities. Palestinians, on the other hand, have claimed first rights to all of the ground and surface water which originates on the West Bank, and have objected to Israeli controls. Palestinians were also to receive 70–170×10^6 m^3/yr from the Jordanian share of the Johnston negotiations of 1953–5, but to date have not.

Gaza is probably the most hydrographically desperate political entity in the region. Completely dependent on the 60×10^6 m^3/yr of annual groundwater recharge, Gazans currently use approximately 95 $\times 10^6$ m^3/yr. The difference between annual supply and use is made up by over-pumping in the shallow coastal aquifer, resulting in dangerous salt-water intrusion of existing wells and ever-decreasing per capita water availability, which is already the lowest in the region.

Jordanian water issues

Jordan will very soon exceed its renewable fresh water resources of 870 $\times 10^6$ m^3/yr. Only two major tributaries of the Jordan river system have not been fully developed—Wadi Mujib, with an annual flow of 78×10^6 m^3, and the Yarmouk, with annual flood flows of 168×10^6 m^3 (World Bank, 1988). Wadi Mujib, which is the third largest tributary flowing into the Dead sea, has no inter-state riparian complications as does the Yarmouk. One current question on sustainable water development in Jordan is whether it can afford to continue to develop fossil groundwater in deep sandstone aquifers, like the Disi, and if so, then 'for what'? and 'for how long'? These questions are critical, for the Disi is shared with Saudi Arabia (known as the Saq) and shows signs of rapid depletion.

ENERGY-WATER ISSUES

Energy issues relating to water resources are critical matters in the development of non-oil producing countries like Israel, Palestine, and Jordan. These countries are major riparians of the overburdened Jordan river system, and all have increasing demand for desalination and the treatment and recycling wastewater, both of which consume substantial amounts of energy.

The current energy sources in the region are heavily dependent on crude oil. Israel, for example, consumes 2.5 million tons of oil and 2.3 million tons of oil-equivalent of coal for the generation of electricity. The annual production of electricity amounted to 20.9 billion kWh at an installed capacity of 5,835 MW in 1991 (State of Israel, 1992). Because of its level of development, Israel is investigating the option of replacing its steam power generating system with nuclear plants in stages by the 21st century. A significant deficit in peak power supply has been a long standing problem, while substantial off-peak electricity is being wasted (Fig. 5-1). Although international networking of the electric supply is being discussed between Egypt and other Arab states, no alternatives have been suggested other than building a new pumped-storage unit and/or gas turbine generating units.

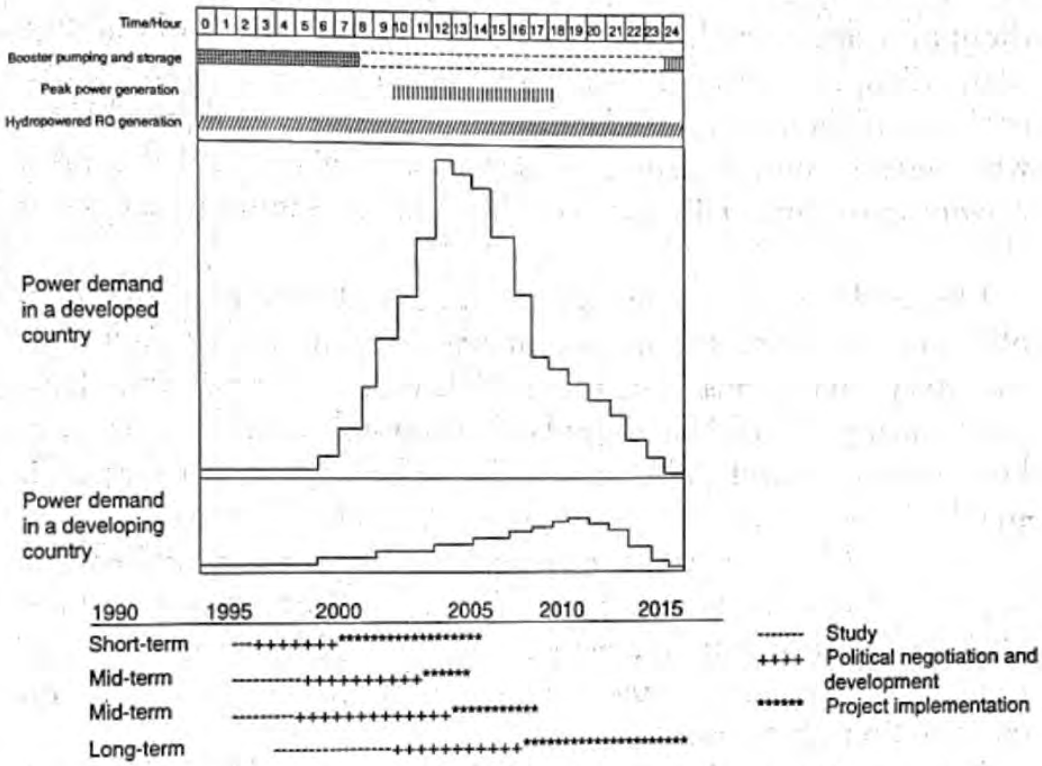


Fig. 5-1: Patterns of Daily Energy Generation and Use

A developed country's energy needs are closely related to its water supply. Substantial amounts of electricity can be consumed moving water from its sources to where it will be used. Pumping demand in Israel, for example, amounted to 1,528 KVA in 1991 (State of Israel, 1992), or 30 per cent of total expenditures on water supply by Mekorot, the national water development company. Israel, taking into account recent advances in desalination, is planning to introduce large-scale sea water desalination by the year 2000. Although this is likely to be dependent on low energy types of reverse osmosis, the energy cost will still be 50–60 per cent of the total depending on the price of electricity. Consequently the potential use of off-peak electricity will be a key element in minimizing the cost of water management and operation.

Techno-political Decision-making

Technical and policy water management options available to any watershed reaching the limits of its water supplies are listed in Table 5-1. Once the technical and policy options are known, the next, and probably the most crucial, step is to develop a method for evaluating the options against each other; that is, to create a hierarchy of viability. Many disciplines provide their own version of viability. Where an engineer might ask, 'Can it be done?' an economist might add, 'At what cost?' A political analyst could suggest, 'Is it politically feasible?' Anyone environmentally aware might counter, 'Should it be done at all?'

One problem with these varied standards of viability is that they often measure at cross-purposes, arriving at differing or even contradictory conclusions. Dinar and Wolf (1994), for example, have evaluated a potential Nile to Jordan basin water transfer, in terms of both economic and political viability. Their findings using each standard were diametrically opposite to each other: whereas an economic analysis suggested greater payoffs for co-operation between larger coalitions of states, a political investigation showed that the likelihood of such coalitions actually forming decreased as the size of the coalition increased, and that the most likely action was no co-operation whatsoever.

What we suggest here is a unified approach to overall viability which incorporates established measures for technical, environmental, economic, and political feasibility. Technical feasibility measures the physical parameters of a system or proposal—how much water might be produced? what is the quality? how reliable is the source? These physical parameters have well-defined quantitative values which might be used as indicators of viability. Quantity might be measured as volume of water produced by a project within a year. Likewise, quality might be evaluated in parts per million of total salinity or particular pollutants. A value for flux in a natural system or down-time in a technological project might be an indicator for reliability. On the other hand, control of flow variance (seasonal, multi-annual) can be counted as a positive factor. Relative environmental degradation can also be evaluated quantitatively, if impact assessments are performed uniformly between projects.

Economic viability has two aspects—financial, which measures the chances of acquiring financing for a project (often, but not always related to the amount of capital required), and efficiency. For relative water projects, one might use the results of a benefit/cost analysis and use the resulting net present value of benefits as a measure or, more directly, the cost per unit water which would result from each project. An important economic point is that costs are not fixed over time. A 'resource depletion curve' for any project would show at what rate the utility, or value, of a unit of water would begin to drop, and consequently, what the most efficient rate of development would be.

Table 5-1: WATER MANAGEMENT OPTIONS TO INCREASE SUPPLY OR DECREASE DEMAND

Unilateral Options

Demand

- Population control
- Rationing
- Public awareness
- Allow price of water to reflect true costs (including national water market)
- Efficient agriculture, including:
- Drip irrigation
- Greenhouse technology
- Genetic engineering for drought and salinity resistance

Supply

- Wastewater reclamation
- Increase catchment and storage (including artificial groundwater recharge)
- Cloud seeding
- Desalination
- Fossil aquifer development

Co-operative Options

- Shared information and technology
- International water markets to increase distributive efficiency
- Inter-basin water transfers
- Joint regional planning

The most tenuous measure is political feasibility. To incorporate this important parameter in an integrated model, one must use a relative scale for a value which is difficult to quantify. While we recognize the general lack of enthusiasm for quantitative political analysis because of its necessarily subjective nature (Ascher, 1989, for a good critique), we recommend the inclusion of results of a process such as the PRINCE Political Accounting System. Coplin and O'-Leary (1976) describe this method of incorporating each player's 'position', 'power', and 'salience', for any of a number of policy options to arrive at a relative ranking of political viability. They extended the process to provide an absolute measure of the likelihood of a policy action taking place (Coplin and O'Leary, 1983).

Two other qualitative measures might be used for political feasibility. For projects within a country, how well a proposal 'fits' with national goals might be evaluated. Population control, for example, which might be successful in western Europe or the United States, runs counter to both Israeli and Palestinian interests in numerical superiority. (Though even here at some not too distant time, population growth will impose an absolute ceiling on water availability). International projects might be determined in terms of relative measures for 'equity' of project costs and water distribution, and 'control' by each political entity of its own major water sources.

If the resources are available to perform a detailed feasibility study, the results can be described quantitatively. Listed below are the proposed measures of viability, followed by the possible quantitative standards which might be used (Table 5-2).

More often than not, the detailed data necessary for a quantitative evaluation are not available. In that case, two options exist. The first is to substitute qualitative values: +, 0, –, representing good, neutral, or poor; measures which are adequate for a preliminary analysis. We can then evaluate any possible option qualitatively with each measure of feasibility. This approach is illustrated in Table 5-3. By examining the results, we should get a sense of which options are more viable than others, and why. It should be remembered that these results are for a particular geographic location, and for a single point in time.

Table 5-3: POSSIBLE QUALITATIVE STANDARDS OF PROPOSED PROJECT VIABILITY MEASURES

Environmental
- quantity (10^6 m^3/yr)
- quality (ppm salinity or pollutants)
- reliability of source (standard deviation of flux)
- environmental impacts (details of potential damage)

Engineering
- suitabiity of site
- applicability and comparative outputs of various technologies

Economic
- efficiency (cost per unit of water, or net present value of)
- financial (capital necessary to finance project)

Political
- political probability from PRINCE model
- water distribution and control of source by each entity
- equity of project costs

Table 5-2: TECHNO-POLITICAL ASSESSMENT SHEET—AS OF JULY 1994

Techno-Political Alternatives	Technical feasibility				Environmental feasibility	Economic feasibility			Political feasibility	Total
	Quantity	Quality	Reliability	Sub-total		Financial viability	Cost/unit water	Sub-total		
Weight (%)	12.5%	5.0%	7.5%	25.0%	25.0%	12.5%	12.5%	25.0%	25.0%	
Category 1: Water conservation, including supply and demand management										
Population control	74.0	80.0	98.0	82.4	65.0	72.0	86.0	79.0	10.0	59.1
Irrigation sector	80.0	84.0	84.0	82.0	69.0	68.0	70.0	69.0	39.0	67.3
M & I sector	54.0	63.0	84.0	64.8	84.0	69.0	62.0	65.5	33.0	61.8
Market solutions	60.0	75.0	70.0	66.0	66.3	80.0	77.5	78.8	41.3	63.1
Category 2: Conventional alter-nat-ives without political constraints										
Renewable surface water development	26.0	58.0	50.0	39.6	48.4	54.0	62.0	58.0	60.8	51.7
Renewable groundwater development	27.0	50.0	52.0	40.2	46.4	60.0	58.0	59.0	72.8	54.6
Category 3: Non-conventional alternatives without political constraints Desalination										
- Brackish groundwater RO desalination in M & I sector	52.5	83.8	80.8	67.2	61.3	77.5	75.0	76.3	66.8	67.9

(*Contd.*)

(*Table 5-2 Contd.*)

Techno-Political Alternatives	Technical feasibility				Environmental feasibility	Economic feasibility			Political feasibility	Total
	Quantity	Quality	Reliability	Sub-total		Financial viability	Cost/unit water	Sub-total		
Weight (%)	12.5%	5.0%	7.5%	25.0%	25.0%	12.5%	12.5%	25.0%	25.0%	
- Seawater RO and/or MSF desalination in M & I sector	36.3	82.5	77.5	57.9	52.5	45.0	31.3	37.7	62.8	56.4
- RO desalination of brackish water: Peace Drainage Canal Project	31.0	66.0	62.0	47.3	55.8	61.0	61.0	61.0	69.0	58.3
Reuse and/or recycling treated wastewater										
- Reuse of treated urban wastewater for tree-crop irrigation	32.5	41.3	68.8	45.1	36.5	61.3	58.8	60.0	63.8	57.7
- Small scale recycling of treated industrial wastewater	36.3	66.3	72.5	45.2	60.3	60.0	45.0	52.5	57.5	55.4
Retention of *wadi* flash water										
- Small scale storage dam schemes for any use	27.5	65.0	52.5	42.5	48.0	47.0	43.8	45.4	62.3	49.5
- Small scale groundwater recharge scheme	25.0	66.3	65.0	45.3	46.8	60.0	57.5	58.8	62.3	53.3

(*Contd.*)

(*Table 5-2 Contd.*)

Techno-Political Alternatives	Technical feasibility				Environmental feasibility	Economic feasibility			Political feasibility	Total
	Quantity	Quality	Reliability	Sub-total		Financial viability	Cost/unit water	Sub-total		
Weight (%)	12.5%	5.0%	7.5%	25.0%	25.0%	12.5%	12.5%	25.0%	25.0%	
Category 4: Hydro-power/Storage										
Mini hydro-power (river development in Yarmuk)	31.5	60.0	47.5	42.0	40.0	31.7	40.0	35.8	38.5	39.1
Dead sea pumped storage	15.0	30.0	60.0	31.5	40.0	53.3	40.0	46.7	46.7	41.2
Mediterranean-Dead sea canal, without desalination	23.8	31.3	61.3	36.5	22.5	36.3	30.0	33.2	38.5	36.4
Red-Dead sea canal with/without solar pond for electricity development	21.3	30.0	28.8	25.3	22.5	33.8	30.0	31.9	31.0	27.7
Category 5: Co-generation alternative for water and energy										
MDS hydro-solar development with RO seawater desalination	40.0	72.5	60.0	52.5	45.0	33.8	33.8	33.8	35.3	41.7
Aqaba pumped-storage scheme with RO seawater de-salination	32.5	68.8	57.5	47.3	26.3	37.0	37.5	37.3	24.0	33.7
Red-Dead canal with solar pond/distilling de-salination (future tech.)	18.3	66.7	38.3	34.0	28.3	36.7	40.0	38.3	28.7	32.3

(*Contd.*)

(*Table 5-2 Contd.*)

Techno-Political Alternatives	Technical feasibility				Environmental feasibility	Economic feasibility			Political feasibility	Total
	Quantity	Quality	Reliability	Sub-total		Financial viability	Cost/unit water	Sub-total		
Weight (%)	12.5%	5.0%	7.5%	25.0%	25.0%	12.5%	12.5%	25.0%	25.0%	
Nuclear steam power plant with distilling seawater desalination	13.3	65.0	28.3	28.2	3.0	37.5	25.0	31.3	21.7	21.0
Category 6 : Water transfer project by tankers or bags										
Inter-state water transfer by tankers	33.0	75.0	55.0	48.0	64.0	53.0	50.0	51.5	75.8	59.8
Inter-state water transfer by bags (Medusa concept)	31.0	79.0	45.0	44.8	52.0	46.0	48.0	47.0	68.3	53.0
Inter-state water transfer by bags (Aquarius concept)	25.0	81.7	58.3	46.3	53.3	46.7	56.7	51.7	54.3	51.4
Category 7: Multi-lateral water transfer										
Nile-Gaza/Israel water pipeline	49.0	64.0	51.0	52.6	33.0	48.0	54.0	51.0	7.0	35.9
Iraq-Jordan water pipeline	36.0	47.0	27.0	35.5	30.2	44.0	54.0	49.0	10.4	31.3
Litani (Lebanon-Jordan) basin water transfer	38.4	67.0	51.0	47.9	43.2	56.0	59.0	57.5	9.6	39.6
Mini-mini-peace pipeline (Turkey-Syria)	31.3	55.0	53.8	42.8	34.0	45.0	61.0	53.0	23.8	38.4

(*Contd.*)

(*Table 5-2 Contd.*)

Techno-Political Alternatives	Technical feasibility				Environmental feasibility	Economic feasibility			Political feasibility	Total
	Quantity	Quality	Reliability	Sub-total		Financial viability	Cost/unit water	Sub-total		
Weight (%)	12.5%	5.0%	7.5%	25.0%	25.0%	12.5%	12.5%	25.0%	25.0%	
Mini-pipeline (Turkey-Syria-Jordan river basin, pipeline)	32.5	56.3	55.0	44.0	36.5	45.0	50.0	47.5	23.3	37.8
Mini-pipeline (Syria, Euphrates-Jordan basins)	32.5	57.5	65.0	47.3	34.0	45.0	50.0	47.5	23.3	38.0
Peace pipeline (Turkey-Persian Gulf, Red sea)	48.0	54.0	36.0	45.6	30.8	28.0	28.0	28.0	8.2	28.2
Peace canal (Turkey-Syria-Jordan River Basin, incl. security barrier)	32.5	47.5	37.5	37.0	18.0	27.5	31.3	29.4	5.5	22.5
Turkey-Israel submarine water pipeline	32.0	52.0	21.2	32.8	32.8	23.0	23.0	23.0	13.4	25.5
Mega watershed (Rift Valley groundwater development)	28.8	13.8	10.0	20.1	7.3	13.8	13.8	13.8	6.3	11.8

Note: Without 26 Oct. 1994 Treaty of Peace: Israel/Jordan. *See* Table 6-4, Chapter 6, for post-Treaty Evaluation.

Although the 'Total' column is provided for a measure of overall feasibility, it is recommended that, if the column is used at all, it is used with extreme caution. First, each measure does not necessarily have equal weight, and each was arrived at with both some subjectivity and some uncertainty. Adding or multiplying across would therefore only compound and accumulate error.

Also, by leaving the measures separate, one acquires a greater sense of why options are viable, and where emphasis can be placed for the future in order to help boost viability. Public awareness, for example, has been shown to be a very cost-effective method of saving water, but the total amount which can be saved is relatively small as compared to the total water budget. In contrast, unlimited water can be made available through desalination but at a relatively higher cost. The latter might change with technologic breakthroughs, but conservation gains are likely to remain fairly constant over time.

The second option in the absence of data necessary for a quantitative assessment is to substitute iterations of 'expert opinions', first described by Gordon and Helmer (1964) as the Delphi method.[3] Experts familiar with the technical and political landscapes of a particular watershed might be asked to rank available options as to their viabilities on a consistent scale. The viability measures themselves should also be weighted as to their relative importance for that particular watershed during a particular time frame. A variation on the weighting process is first described in detail in Kepner and Tregoe (1965).

It should be emphasized that this evaluation process should be repeated often to allow for the constant changes of so many of the parameters over space and time.

The evaluation process should also allow for interaction, with on-going feedback between the disciplines, to reflect real-world influences. For example, a project with extremely positive economic results might help overcome political reluctance to enter into cooperation. Likewise, political constraints can effectively veto a project which has been judged worthwhile in terms of its technical and economic value. Changes which can affect viability are shown in Table 5-4.

Table 5-4: CHANGES AFFECTING PROJECT VIABILITY

Technical and Environmental

- Fluctuations in seasonal and annual water supply, as well as long-term changes due to global warming
- Changes in water quality
- Technical breakthroughs
- Relative infrastructure for each party in
  - research and development
  - storage and delivery
- Changes in understanding of physical system

Economic

- Changing priorities for funding agencies
- Movement along the resource depletion curve
- Expense for water resources development
- Changes in efficiency of water use

Political

- Power relationships
  - riparian position
  - military
  - legal (e.g., clarity of water rights)
- Form and stability of government
- Level of hostility

SPECIFIC OPTIONS AND TECHNO-POLITICAL FEASIBILITIES

Perspectives of Non-conventional Water Development Alternatives

Conventional alternatives, which include surface water and ground water development, have the highest priority in water resources planning where there are still renewable fresh waters to be developed and intricate inter-state riparian questions do not result. This ideal situation does not exist in most countries of the Middle East, and the supplying of fresh potable water to their growing populations is an essential part of a water master plan for peace. Every possible source of water must be seriously considered, and water conservation is and will be an essential part of water management. After exploiting all of the renewable fresh water resources within their national boundaries, Israel, Palestine, and Jordan will have no choice except to seek extra-territorial sources of supply and/or non-conventional waters. Surplus waters from the periphery might be provided by means of long distance pipelines and/or tankers and sea borne bags, but these alternatives should not be brought on line until sources within the basin are being used at their most efficient. Therefore, development of non-conventional water alternatives is becoming imperative. A general list of water development priorities is shown in Table 5-5.

Non-conventional alternatives, which comprise desalination, and reuse of treated wastewater will be key issues to sustain water development into the 21st century, when no additional, renewable fresh water will be available. Fossil groundwater by contrast is usually too valuable an asset except as a strategic reserve which can be used for short-term relief during extreme drought or emergencies. The general characteristics of non-conventional water resources will be that they are generally more complex in development and operation than conventional sources, and are almost always more expensive. The great advantage of desalination and reuse of treated waste water is that there are few political constraints to their development. The unlimited supply of sea water is another advantage for desalination, especially since 70 per cent of the Arab and Israeli populations live near and along the sea coast. This situation favours Israel and the Gaza Strip; less so Jordan, which has sea access only at Aqaba; and is not helpful to the West Bank, which has no sea access.

Table 5-5: TECHNICAL-POLITICAL PRIORITIES: LOWER JORDAN SYSTEM AND DEAD SEA

Israel

- Water conservation, improving existing infrastructure and delivery systems
- Desalination including both brackish water and sea water
- Reuse of treated wastewater for tree and/or garden crop irrigation
- Retention of wadi flush water including groundwater recharge
- Mediterranean-Dead sea (MDS) conduit scheme for cogeneration
- Water management of the Jordan valley including desalination of brackish springs and waste saline water from drainage network, perhaps in conjunction with the West Bank and/or Jordan
- Dead sea pumped-storage for peak-power supply
- Inter-state water transfer and importation by tankers or bags including pipeline options from Nile and Turkey

Dead sea solar-pond scheme and/or Aqaba ocean heat-energy conversion scheme (future technology)

Palestine (West Bank)

Water conservation, improving existing infrastructure and delivery systems

Groundwater management of mountain aquifer

Retention of wadi flush water including groundwater recharge

Sanitation of wastewater including reuse for tree and/or garden crop irrigation

Water management of the Jordan valley including desalination of brackish springs and waste saline water from drainage network, perhaps with Israel and/or Jordan

Inter-state water transfer such as mini-peace pipeline from Turkey

Palestine (Gaza)

Water conservation, improving existing infrastructure and delivery systems

Groundwater management of coastal aquifer

Retention of flush water including groundwater recharge

Sanitation of wastewater including reuse for crop irrigation

Desalination of brackish groundwater and sea water

Inter-state water transfer and importation by tankers or bags, including water pipeline option from Nile

Jordan

Water conservation, improving existing infrastructure and delivery systems

Conventional unilateral river development including storage dams on the *Wadi* Mujib, Wadi Hasa and other small tributaries

Inter-state river development including storage dam on the Yarmouk (Al-Wuheda dam), taking into account the coupling of the MDS canal project.

Retention of wadi flush water including groundwater recharge

Sanitation of wastewater including reuse for tree and/or garden crop irrigation

Water resources management of fossil groundwater in Disi sandstone aquifer

Water management of the Azraq and Jordan valley including desalination of brackish springs and waste saline water from drainage network; perhaps with Israel and/or the West Bank (Palestine) in the Jordan Valley

Desalination of brackish water in Azraq, Jordan Valley including Aqaba-Disi hydro-powered brackish groundwater reverse osmosis desalination for co-generation (Murakami 1991)

Desalination of sea water in Aqaba region including hybrid pumped-storage scheme with hydro-powered reverse osmosis desalination

Red-Dead sea canal hydro-electric scheme or Dead sea pumped-storage scheme for peak-power supply

Dead sea solar-pond scheme and/or Aqaba (deep sea water) ocean heat-energy conversion scheme (future technology)

After renewable water resources have been utilized to the limits of sustainable yield, new strategies will become increasingly important: 1) water conservation will be essential to maintain and extend water yields; and 2) water politics and negotiations will be priority issues in any trans-boundary water development project. In addition, 3) environmentally sound, innovative, technological development with reasonable cost reduction will be a key issue in non-conventional water development, as defined below. A number of such projects have been suggested for application in the core area. A general description of them follows.

DESCRIPTION OF POSSIBLE PROJECTS

The schemes referred to above include, in order of conceptualizaton:

1. Mediterranean to Dead sea (Med-Dead) canal, or
2. Red sea to Dead sea (Red-Dead) canal,
3. Pumped storage, including locations at a) Aqaba, b) on the eastern and western shores of the Dead sea, and c) on the eastern shore of the sea of Galilee,
4. Jordan valley drainage canal, and
5. Desalination.

Med–Dead canal

The height differential between the Mediterranean sea, at sea level, and the Dead sea, 400 metres lower, suggests the possibility of linking the two water bodies to generate hydro-power. Such plans date back to the last century, but were studied seriously in the late 1970's, as rising oil costs encouraged Israel to investigate alternative energy sources. Initially, feasibility studies investigated three northern routes, eventually considered less viable for economic and environmental reasons, and a southern route, from Qatif in the Gaza strip through the Judean hills, to Massada on the south-western shore of the Dead sea. This last route has received maximum attention. Although plans were shelved in the 1980s as energy costs dropped, the project has recently been revived in the Israel-Palestine Declaration of Principles.

Pumping and power generation would proceed at two different levels: during a filling period of twenty years the Dead sea would be brought back to its historic water level. This would involve pumping

1,670 mcm/yr and would generate an average of 1,850 GWh/yr. Thereafter, 1,250 mcm/yr would be pumped, just matching the evaporation rate of the Dead sea, which would generate 1,450 GWh/yr. Several ancillary projects based on a supply of salt-water in the heart of the Negev desert have been proposed in conjunction with the canal project. These might allow for aquaculture, tourism along artificial lakes, and cooling water for industry. Most salient for this study, though, is the fact that the 400 metre drop to the Dead sea would provide the pressure necessary for reverse osmosis desalination, as will be explored later in this text.

Red–Dead canal

Similar in concept to the Med-Dead canal, the Red-Dead canal would exploit the 400 metre height differential between the Red sea and the Dead sea for hydro-power generation. The project was studied intensely in the late 1970's as Jordan's answer to Israel's Med-Dead studies, and has recently been mentioned as a possible joint project in the Israel-Jordan peace treaty. It should be noted that, because pumping rates must eventually match the Dead sea's evaporation rates, it would not be feasible to construct both canal projects.

The Red-Dead canal, as described in a Jordanian feasibility study by Harza Engineering, was designed as a peaking facility to operate eight hours per day, and would generate an average of 975 GWh/yr. As with the Med-Dead canal, a canal linking the Red and Dead seas would be conducive to ancillary projects, including aquaculture, tourism, and industry. Planners also discussed a desalination component although, because the hydro-power would be generated in a series of steps to the Dead sea, the loss of head may render reverse osmosis desalination uneconomical.

Pumped Storage

Just as height differentials can be exploited to generate hydro-power, they can also provide sites for pumped storage. Pumped storage is a method to meet peak energy demand by pumping from a lower water body when power needs and costs are low to a reservoir at a higher elevation. When energy demand and costs are at their peak, the water is dropped back down to the original water body, generating hydro-power in the process. While no new energy is generated, pumped storage helps smooth energy demand, alleviating the need to build more power-generating facilities. Good pumped storage sites have been identified throughout the core region, including one at Aqaba, two sites on the east and west coast of the Dead sea, and another on the eastern shore of the Sea of Galilee. It should be noted that pumped storage facilities do not, in themselves, provide new sources of water, but can provide energy and/or pressure for desalination.

Jordan Valley Salt/Peace Drainage canal

Agriculture in the core region accounts for more than 75 per cent of the total water demand. However, not all water applied to irrigation is consumed by evapotranspiration. Water which infiltrates past the root zone, referred to as agricultural drainage water, or return flow (RF), can sometimes be reclaimed. The problem with this water is that its quality is relatively poor, as it can include salts, pesticides, and herbicides.

Nevertheless, in regions where desalination is viable, the lower the salinity, the less expensive the desalting process. This RF is relatively less saline than other sources, with average total dissolved solids of 1,000–10,000 ppm, as compared with 33,000 ppm for sea water. (Drinking water generally requires less than 500 ppm.) Drainage projects can be implemented on both slopes of the Jordan river valley, allowing for relatively inexpensive desalination. These might also desalinize water from salt springs which at the present time further pollute the lower stem of the Jordan river.

Desalination

Oceans are the ultimate source and destination of all of the world's freshwater. As such, they offer a relatively unlimited supply of water for human uses, limited only by economical technology and potential environmental impact. Current research generally focuses on two methods to desalinize water:

1) *Flash distillation.* When water boils, only pure water turns to steam—the salts which are in solution remain behind in an increasingly saline brine. Flash distillation plants generally include a series of chambers ('multi-stage flash') at progressively lower pressures. Salt

water brought through the chambers flashes into vapour at lower temperatures in each chamber, resulting in extremely pure water. Flash distillation plants are more common where thermal, as against electrical, energy is available, and where seawater, rather than brackish water, is the source to be desalinized. Because this method best uses thermal energy, a common practice to reduce costs is to site distillation desalination projects next to traditional energy-generating plants. This takes advantage of the waste heat or excess power generated. Flash distillation currently accounts for 65 per cent of the world's desalination plants.

2) *Reverse osmosis.* This method of desalination involves pushing saline water at high pressures through selective membranes, which are designed to remove salts. This method more commonly uses electric energy, therefore allowing RO plants to be situated independent of power generating facilities. Such plants more commonly desalinize brackish water. Because this process requires mechanical pressure, costs for reverse osmosis desalination can be reduced when a large elevation drop exists along the water delivery system, as for example, along the Med-Dead or Red-Dead canal routes. Reverse osmosis desalination currently accounts for 23 per cent of the world's desalination plants.

Two problems limit desalination: economy and environment. Although drinking water is a completely inelastic good—that is, people will pay almost any price for it—water for agriculture, by far the largest use in the Middle East, should be cost-effective enough that the agricultural end-product remains competitive in the marketplace. Current cost estimates for desalination, approximately $1.60 to $2.70 per cubic meter to de-salt sea water, and from 30 to 50 cents for brackish water, leave desalinated water uneconomic for most uses. It also should be kept in mind that price estimates generally do not include pumping costs of getting the water to the end-users. Most sources for desalination are at sea level and along coasts, while consumers are more often at higher elevations and further inland. Therefore, the use of desalinized sea water is limited to the coastal area.

TECHNO-POLITICAL ALTERNATIVES IN ISRAEL, PALESTINE, AND JORDAN

The priorities for techno-political alternatives as assessed in the evaluation framework differ in each state depending on the development level of water resources. Techno-political priorities for the major riparians of the lower Jordan system and Dead sea are shown in Table 5-5.

Techno-political feasibility for specific projects within a watershed can be evaluated quantitatively, as described above. In our case the specific techno-political options available to the riparians of the Jordan river watershed are evaluated qualitatively, since the information necessary for most of these projects is not available, and can only be arrived at through detailed feasibility studies. These are transferred, following the PRINCE technique, into a feasability table (Table 6.3). Each option is listed in the first column of Table 6.3, followed by columns for the four measures of feasibility—technical (sub-divided into quantity, quality, and reliability), environmental, Economic (sub-divided into financial viability, and cost per unit water), and political.

Derivation of Percentage Values and 'Multiplying Across'

Overall feasibility for each project on the 'Techno-Political Assessment Sheet' is considered to be a function of four parameters — technical, environmental, economic, and political feasibility. Since each parameter is considered equally, each score (determined through 'Delphi' style discussions, on a scale of 0–100) is weighed by 25 per cent. For the first 'project' considered, 'Population Control', for example, the total feasibility measure, 59.1 was derived by adding each feasibility sub-total weighted by 25 per cent.

(82.5 × 25 per cent) + (65.0 × 25 per cent) = (79.0 × 25 per cent) + (10.0 × 25 per cent) = 59.1

Each feasibility sub-total, in turn, was derived by adding the components which make up each parameter, also weighed by the value given on the top line. The technical feasibility sub-total for 'Population control' of 82.4, was derived as follows:

([Quantity] 74.0 × [Weight] 12.5 per cent) + ([Quantity] 80 × [Weight] 5.0 per cent) + ([Reliability] 98.0 × [Weight] 7.5 per cent) × 4 = 82.4

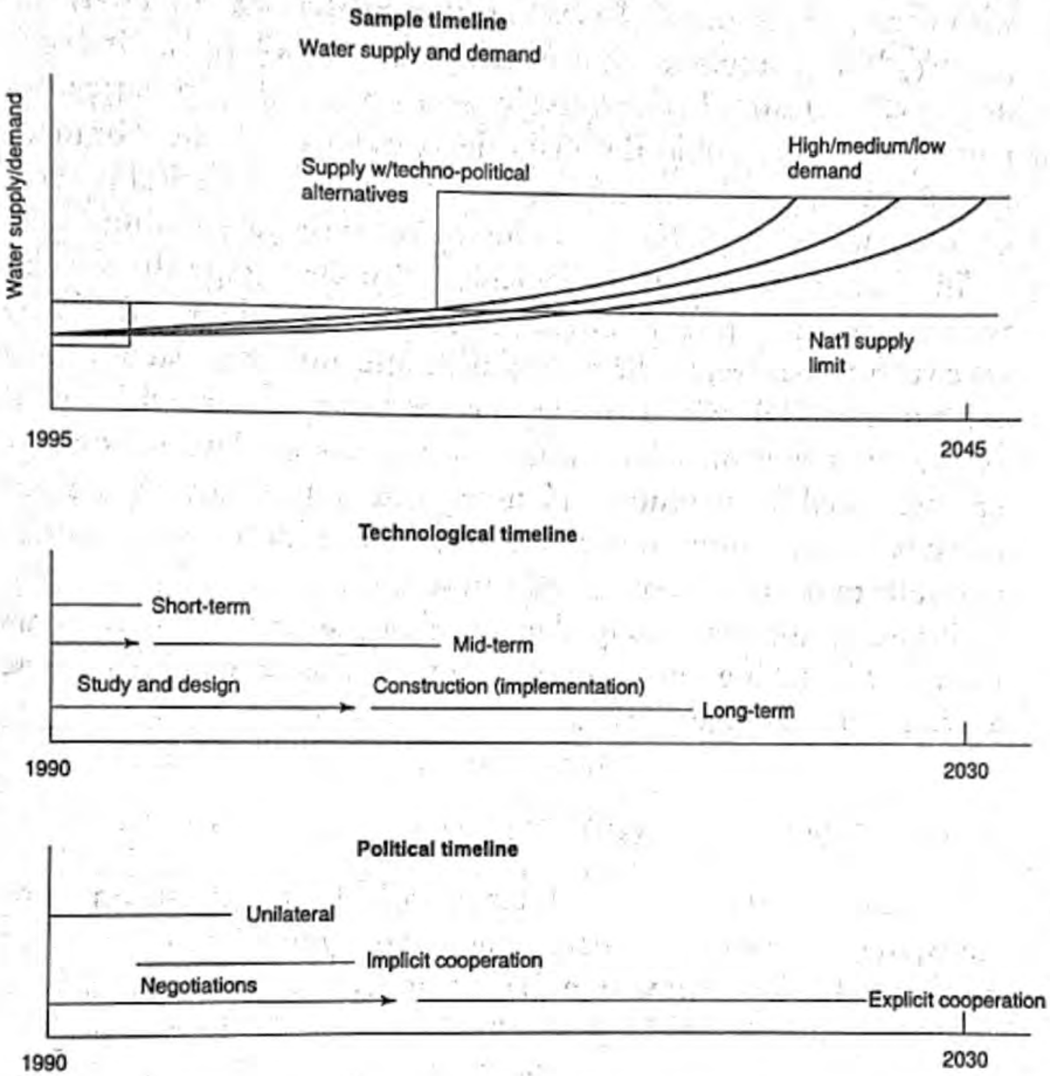


Fig. 5-2: Water Availability, Technological and Political Timelines

Each project is then evaluated for each measure, which in turn is given a relative weight, after Kepner and Tregoe (1965). The values reported were derived through a modified Delphi process, averaging subjective values assigned by the members of the Middle East Water Commission at a meeting in June, 1994. Multiplying across gives us a total value for the overall feasibility of each project.[4] Again, it should be remembered that these values are assigned for a particular geographical location for one specific point in time. This process should ideally be iterative to allow for changes in the system and interaction between the different aspects of viability.

In general, the relatively higher rankings of unilateral options indicate greater chances of succes, but the smaller values associated with them, which signify less water, suggest that while there is still some hydrologic room to manoeuvre within each political entity, such options are limited. Conversely, if co-operative measures become politically feasible, the quantities of water which could be made available are significant. This suggests, that the hypothetical rewards of co-operation might be used as incentives at the negotiating table.

In addition, time is a major variable in prioritizing specific projects within a basin. While negotiating, water rights and allocation may take years to resolve, in the meantime, some immediate steps can be implemented. Likewise, while most water managers agree that mega-projects involving inter-basin transfers or large-scale desalination may be best suited for the future, planning and evaluating such projects needs to be done immediately in order for the resulting water to arrive at results to be used 10 or 15 years from now.

Project priorities among the technical-political alternatives are evaluated by taking into account the projects' time schedules. These are illustrated in Figure 5-2.

TECHNO-POLITICAL OPTIONS

The evaluation framework, combined with chronological considerations, suggests the following schedule and planning timeline for water resources development within the Jordan river watershed (Fig. 5-3).

```
1990          1995      2000          2005      2010      2015
Short-term     ---+++++++*****************
Mid-term (1)   ----------++++++++++++++
Mid-term (2)   ----------++++++++++++++***********
Long-term        -------------------++++++++++*******************

        -------  Study, political negotiation and development,
        ++++     Project implementation,
        ******   Supplemental implementation.
```

Fig. 5-3: Scheduling Timelines for Water Resources Development in the Jordan Valley

1.*Short-term relief*: highest priority and urgent needs in water development and management—no political constraints.

- Water conservation and water demand management
-Reuse of treated wastewater (for supplemental tree-crop irrigation)
-Desalination (for potable water supply mainly by reverse osmosis)

2. *Mid-term relief* (1): high priority in the water-energy development plans included in strategic peace agreements between Israel, Palestine, and Jordan. These in turn may reinforce ongoing peace negotiations, with benefits for multilateral regional economic development opportunities in the Dead sea and Aqaba region:

Priority

1. The Lower Jordan Salt/Peace Drainage canal scheme with brackish water desalination
2. Mediterranean (Gaza) -Dead sea (MDS) conduit scheme with hydro-powered RO desalination for co-generation
3. Aqaba sea water pumped-storage scheme with hydro-powered RO desalination for co-generation
4. Red-Dead sea (RDS) or MDS canal hydro-electric scheme
5. Dead sea pumped-storage scheme

3. *Mid-term relief* (2): medium priority in the water supply alternatives with some bilateral negotiations with water rich countries such as Turkey, Albania, Greece, and south Asian countries:
-Interstate water transportation by tankers and/or bags

4. *Long-term relief*: medium to low priority (though no less important) with complicated multinational riparian negotiations and/or technical-economical-financial elements. These will be evaluated in Chapter Seven.

-Interstate water transportation by pipeline, canal, and others are illustrated in key map (2), including
-Nile-Gaza/Israel water pipeline,
-Iraq-Jordan water pipeline,
-Litani-Jordan basin (Lebanon-Israel) water transfer,
-Mini-peace pipeline (Seyhan-Ceyhan-Jordan river system),
-Turkish (Ozal's) Peace pipeline,
-Peace canal (Golan heights),
- Medusa bags (seaborne), and
-Trans-Syrian pipeline (Lake Assad to Yarmouk headwaters).

CONCLUSIONS

The inter-disciplinary needs of water resources planning draw the hydrologist, engineer, economist, and political analyst increasingly closer, and each will have to learn a necessary portion of the others' languages. Hydrologic variations in water supply and demand, political considerations of equity, control, and ideology, and economic measures of marginal utility and comparative advantage, all interact to determine overall feasibility of solutions to international water issues.

The international supplying and delivery of water is becoming increasingly more feasible with the growth of water deficits at the core. As this occurs, the political aspects of particular basins will take on greater importance in the process of water resources decision-making and planning. Too often, technological and political considerations both within and outside a given watershed are treated separately, inconsistently, and with little regard for each other. The process for incorporating both aspects in a unified 'techno-political' evaluation framework, as described here, may facilitate the beginnings of truly integrated planning.

NOTES

1. For more in-depth discussions of both the hydro-political positions and the technical and policy options available to the riparians of the Jordan basin, the reader is referred to Murakami (1994) and Wolf (1994).
2. As with all such figures, exact data and agreement among data sets is difficult or impossible to achieve. Lonergan and Brooks (Table 7, p. 72) show the following values: Domestic Water–Litres PC/day: Israel within Green Line = 125; West Bank: Israeli Settlements = 250; Palestinian Villages = 40; Towns = 100; Gaza Strip = 85.
3. *See* Linstone and Turoff (1975) for a good summary of the strengths, weaknesses, and applications of the Delphi method: Needham and de Loë (1990) for its applicability to water resources planning.
4. We recognize the extreme subjectivity of the outcome of this excercise, as necessitated by limited information. Nevertheless, we feel that the process described, however, provides a useful tool for systematic decision-making, incorporating the technical and political concerns of development inherent in any watershed.

6 Techno-Political Water and Energy Development Alternatives from the Mediterranean and Red Seas to the Jordan Rift Valley

INTRODUCTION

Owing to the unique geo-political character of the Dead sea and its valley, joint regional development planning received a prominent place in the September 1993 Agreement of Principles between Israel and the PLO (Israel/PLO, 1993). Regional economic development being conceived as a key element to sustain the peace process in the region, the protocol on Israel-PLO relations suggests that priority be given to certain projects including development of the Dead sea region and the Red sea (Aqaba)—Dead sea pipeline (RSDS) (Fig. 6-1). The weak point of the bilateral agreement was that it did not at that stage include the kingdom of Jordan as a major riparian state on the Dead sea and Jordan river. On 26 October 1994 this situation was rectified in part by the signing of a peace treaty between Jordan and Israel. Palestine, however, remained an outsider to those negotiations, and the need for a tripartite agreement continues.

As post-treaty details continue to be worked out, the Aqaba region will become even more important for water and power development both in the short-and the long-term. In addition, the Aqaba bay area has great potential for the development of international tourism, commerce and industry.[1] Owing to its hyper-arid climate, however, limited water supplies, exacerbated by political difficulties, have been the main constraint to development.

This study suggests a unified approach to regional water planning including two additional core projects for regional co-operation through the co-generation of water and electric power: the Mediterranean-Dead sea conduit scheme (MDS)[2] and the Aqaba sea water

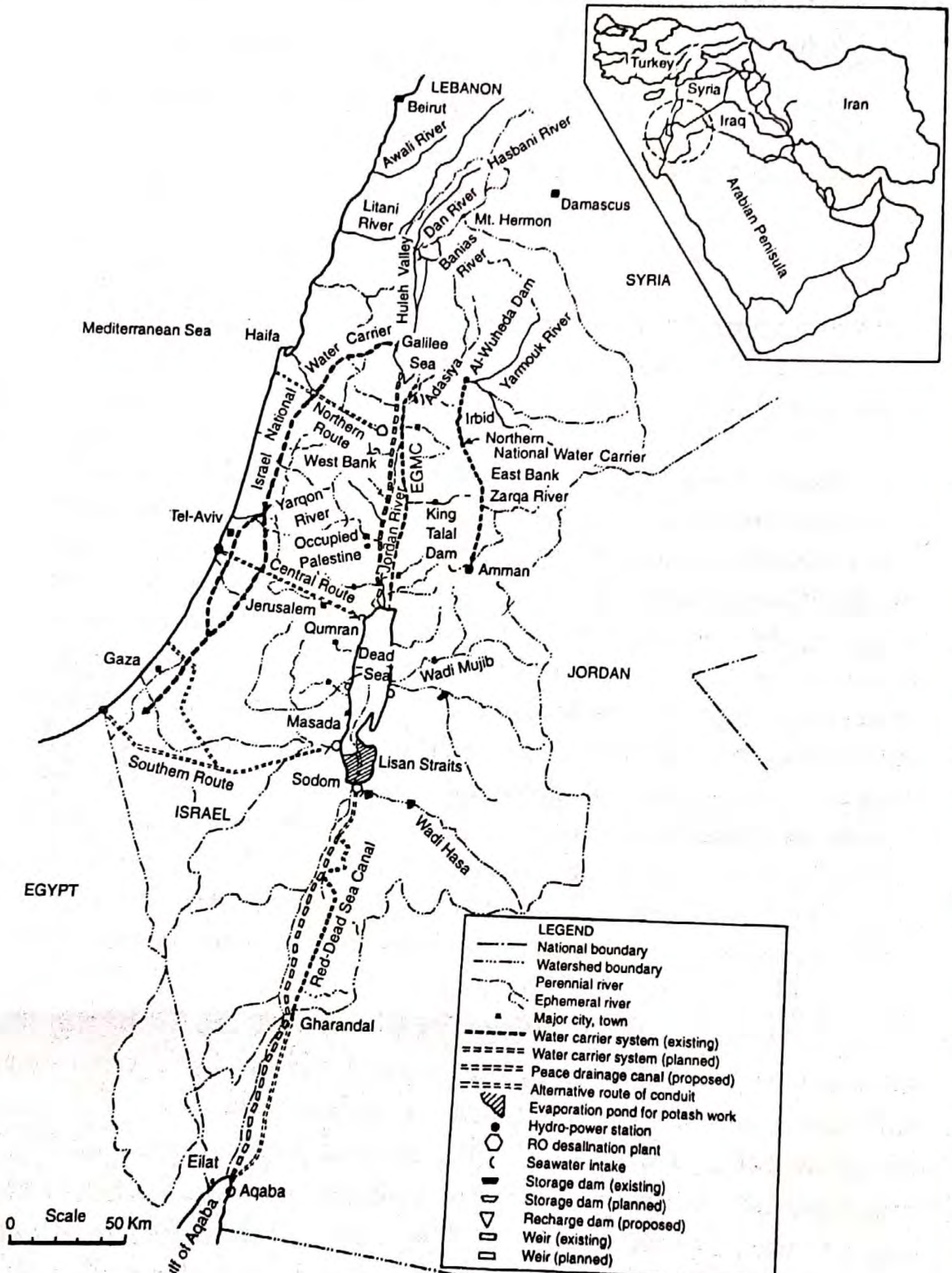


Fig. 6-1: Water Resources Development Project Alternatives in the Jordan River System

pumped-storage scheme (Fig. 6-1). These would take into account the following possible scenarios for sharing resources and benefits:

1) An interstate electricity grid or network including Egypt, Israel, Palestine, Jordan, Saudi Arabia, and perhaps Syria and Lebanon, to provide cheap off-peak electricity to pumped-storage schemes, could be incorporated in the Aqaba and RSDS and or MDS plan to provide peak energy and balance the grid.

2) Techno-political priority in the Dead sea region development portion of the inter-state regional development plan might be given to (a) an MDS conduit cogenerating scheme, and (b) an Aqaba hybrid pumped-storage co-generation scheme.

3) An inter-state coastal water pipeline, to connect the three states (Jordan, Israel, Egypt) , to share fresh potable water from a hydro-powered reverse osmosis desalination plant proposed for the Aqaba co-generating pumped-storage scheme.

4) An interstate sanitation and environmental management programme including wastewater recovery for tree crop irrigation and protection of the clean water environment of Aqaba bay.[3]

In a broader context, the Aqaba sea water pumped storage plan—with hydro-powered reverse osmosis (RO) desalination—is possibly of greatest importance for the economic development of the region. Such a scheme would be highly competitive when compared with a single purpose hydro-power scheme such as Dead sea pumped-storage or a Med/Dead or Red/Dead sea canal.

The funding for such schemes may be forthcoming. Even without an anticipated 'Marshal' type plan for a Mideast at peace, one might assume a certain 'peace dividend' for countries no longer locked in a regional arms race. This dividend might be re-allocated to peaceful development. Water resource improvement is high on the list of developmental priorities for all parties in the region, particularly in light of both imminent and on going influxes of immigrants and refugees. The pooling of investment resources and planning would allow for greater flexibility in design and, consequently, would lead to greater economic efficiency.

In view of such possibilities, it is necessary to review the water/energy development alternatives in the two inter-state regions of the Dead sea and Aqaba as shown in Table 5.4. This should be done in the context of sharing resources and benefits, meanwhile taking into account the next possible multilateral peace agreement among Israel, Palestine represented by the PLO and Jordan. It should also be remembered that the riparian states of Syria and Lebanon as well as neighbouring Egypt and Saudi Arabia could share resources and benefits resulting from such a peace arrangement.

After this review of local projects of possible benefit to the regional core, Chapter 7 examines the augmentation of core water supplies with additions from the periphery.

HISTORICAL BACKGROUND: NUCLEAR DESALINATION AND MED/DEAD SEA CANAL PROJECTS

Immediately after the Six-Day War in 1967, former US President Dwight D Eisenhower, Lewis Strauss of the Atomic Energy Commission, and Alvin Weinberg, Director of the Oak Ridge National Laboratories, developed a 'water for peace' project on a massive scale for the Mideast. It included a series of nuclear desalination plants that would have provided power and water for immense 'agro-industrial' complexes which, it was hoped, would have eased political tensions caused by refugees and water scarcity (Oak Ridge National Laboratory, 1971).

The plan was given a boost by the US Senate Resolution 155 (Congressional Quarterly Almanac, 1967), which expressed support for development at three likely sites in Egypt, Israel, and Jordan. Recently de-classified reports show that a fourth site, at Gaza, was also planned in conjunction with a project for refugee resettlement. The plan eventually faltered on political and economic grounds. Nevertheless, two years of co-operative research between Americans, Arabs, and Israelis, along with lessons learnst during the Johnston negotiations twelve years earlier, showed that, on the technical level at least, cooperation over regional water resources and planning was possible.

However, the idea of introducing nuclear desalination plants was too optimistic to apply worldwide to every country. This resulted from a failure to reduce costs, as well as an increasing concern regarding the environmental impact of nuclear development. There was also a specific concern about introducing nuclear technology in the Middle East.

Today, improved sea water desalination technology including the reverse osmosis (RO) process suggests its marginal feasibility for supplying the municipal and industrial (M and I) sectors in arid regions. Nevertheless, RO is not economically feasible for use with extensive crop irrigation.

In the early 1980s, fifteen years after the American vetoing of nuclear desalination plants, the Israelis began planning a canal, designed primarily for hydro-power, to bring Mediterranean sea water across the Negev desert and under the Judean hills, in order to drop it 400 meters to the Dead sea, the lowest point on earth.

Study of the Mediterranean-Dead sea (MDS) canal emphasized five main alternative canal routes from a total of 27 considered: 1) a northern route, 2) a southern route a, 3) a southern route b , 4) a central route , and 5) the Aqaba/Dead sea route , as shown in Fig. 6-1. The minimum length route, i.e., the 'central route' canal, would have been 72 km long, including a 15 km section of open canal and a 57 km tunnel 5 m in diameter (WPDC, 1983). The first 30 km section would have crossed Israeli territory, and the second 42 km section would have traversed the West Bank. This option was, however, put-aside for fear of possible saline (sea water) water leakage from the tunnel into fresh groundwater aquifers underlying the Judean mountain range upon which Israel relies for 30 per cent of its water supply. The possibility of potential environmental degradation effectively ended an earlier proposal for a canal project through the Jezreel and Jordan valleys (Stern and Gradus). In final analysis the 'Gaza-Ein Bokek' route with an 80 km tunnel was selected in 1982 to minimize capital costs and environment impact. The selected route, however, would cross the occupied Gaza strip, as shown in Fig. 6-1. For political reasons, an alternative route was considered which would move the entrance of the canal northwards into Israeli territory. This would have added $60 million to the cost, and 20 km to the planned 100 km-length (WPDC, 1985). Even had political problems in the Gaza strip been avoided, they would certainly have arisen *vis-á-vis* Jordan, which shares the Dead sea with Israel.

The Israeli MDS solar-hydro development project (see below p. 107) would have generated 800 MW electricity with annual production of 1.4–1.85 $\times 10^9$ kWh.[4] The official total project cost was estimated to be $1.89 billion (1990 prices). Later estimates ranged upward to $5 billion. The planned effect of the canal was to raise the level of the Dead sea by 17 m from 402 to 385 m below sea level. This would have meant that mineral processing plants in both countries would have had to be moved and potash production could have fallen by 15 per cent (WPDC, 1983). The value of the 800 megawatts (MW) installed capacity that would have been made available by this Med-Dead canal would have just equalled the cost of the project. Although the benefits of several ancillary projects for cooling or for artificial lakes made possible by the saltwater added viability to the scheme (Mediterranean-Dead sea Co., Ltd, 1983) the project was finally shelved due to the question of unfavourable project economies owing to the substantial decrease in the cost of crude oil after 1983.

Although an exciting project, the original Med-Dead canal focused on power generation rather than on water production. Moreover, it was unilateral in scope, bringing benefits only to Israel. In fact, Palestinians objected to the proposed site of the intake at Qatif, on the ground that it would further integrate Gaza with Israel. Jordan protested the anticipated rise in the level of the shared Dead sea. As a result, three separate resolutions condemning the proposal were brought before the United Nations General Assembly. Jordan took the opportunity, however, to investigate the possibility of a similar, but for the time even more short-lived, project of its own, the 'Red-Dead' canal, which is now being reconsidered.

The 'Red-Dead' canal would have been similar to the Med-Dead canal, with the major difference being the source of water for hydropower—in this case the Red sea. The flow of water from the Jordanian carrier would have forced Israel to cut back its own influx of water into the Dead sea, or the level would have risen high enough to flood the potash works of both Israel and Jordan as well as the seaside hotels on the Israeli shore.

Israeli interest then turned to salt water pumped storage from the Dead sea (WPDC, 1989). It should be noted that a United Nations mission suggested that the maximum level to have been reached by the Dead sea would have been 390.5 m. Because this level was comparable with previous equilibrium levels, it would not have flooded any religious or archaeological sites, nor would it have triggered earthquakes, nor would reflectivity have been increased.

The Original Red-Dead Canal Scheme

The project was designed as a peaking facility, with sea water being pumped to an elevation of 215 m, and then put into a series of canals and reservoirs to Safe, 200 km farther north (Fig.1). The Red-Dead sea canal hydro-electric project would have generated 334 MW (975 GWh per annum) for 8 hours a day for peak power demand (WPDC, 1983). The booster pumping scheme included two pumping stations with an installed capacity of 70 MW and a required power output of 615 GWh per annum. The estimated total construction cost was about JD 453 million at the 1990 price ($ 680 million) (JVA, 1981).

NEW OPPORTUNITIES FOR REGIONAL DEVELOPMENT

Despite the failure of these previously suggested projects to be approved, the best aspects of the regional approach—i.e., the Med-Dead or Red-Dead canals, emphasis on international economic co-operation, and comparatively safe and clean energy applications—can still be combined and integrated with new co-generation technology for water and electricity. These could subsequently, by the year 2000, be expanded into a new hybrid project for water and power. The project, in turn, could be incorporated into a badly needed regional water development plan for the entire Middle East. It is this potential situation which is discussed in the pages that follow.

Conceptual Framework

The core of the complex might be either a Med-Dead or a Red-Dead canal with a new emphasis on reverse osmosis desalination fueled by direct hydro-pressure based on a topographic head difference of 400–600 m. In contrast to the earlier plans, which focused on unilateral power generation and development, a new approach would make available, in sparsely populated areas, power for industry and water for fish ponds and even recreation on artificial lakes. This would benefit people from Egypt, Israel, Jordan, and Palestine. The scope of the project could be expanded, depending upon cost, financing, and which of the countries and territories of the region become involved. Greater benefits would accrue with larger scale involvement.

Regardless of whether the Red-Dead or the Med-Dead scheme is or will be chosen, the focus on water, rather than power, and an emphasis on co-operative regional development instead of unilateral benefits, would add both the economic and the political feasibility that earlier plans have lacked.

The original Med-Dead saltwater canal would have been situated in a particularly opportune position to foster regional co-operation. A similar new project can do the same. The originally proposed intake was to be located in or near the Gaza strip, the site of the most densely populated refugee camps in the world, which suffers from a severe groundwater overdraft. The canal itself would have run parallel to the Egyptian-Israeli border and then through the Negev-Sinai deserts. The cogeneration canal project proposed here could do the same. Ancillary developments plus new supplies of power and water (both fresh and salt or brackish) would do much to alleviate the desperate human needs of this area.

The Med-Dead route or the Red-Dead route would each face obstacles in terms of political viability, as have all plans for regional co-operation. However, the Mediterranean (Gaza)-Dead sea canal has just been revived in the 'Declaration of Principles', 13 September 1993, in which Annex-IV: Protocol on Israeli-Palestinian Actions suggests a project based on the Med-Dead canal.

The 400-metre drop into the Dead sea valley could provide not only hydro-power generation, but also make reverse osmosis desalination feasible. The hydro-pressure of 40–60 kg/cm^2 could be used directly to desalinize sea water by membrane permeation (RO) at a reasonable treatment cost of less than $\$1.00/m^3$.

Although a Red-Dead canal scheme would do much the same for Israel and Jordan, the topography and geology of the Red-Dead route are not favourable for combining hydro-power generation with a desalination plant in a single pressure pipe line system. Such a system, which would require a terminal end pressure at 40–60 kg/m^2 for RO, would necessitate initial pumping to a higher elevation—albeit off peak power would make this a relatively cheap operation. Thereafter, the distance and topographic profile from the Gulf of Aqaba to the Dead sea is relatively gradual and would necessitate a stepped descent. If open canals were included in the design, such stepping, would obviate the hydraulic head necessary for successful RO desalination in combination with hydro-power generation. A closed pipeline ensuring the necessary pressure would be more complicated and expensive to build. At the same time, much of the route crosses unstable lithology. The *Lisan Marl* thus involved is friable and easily dissolved, and at best would provide an unstable base for such construction, further exacerbated by the possibility of earthquakes in the Rift valley.

Conversely, the existing design of the Med-Dead (central) conduit route shows an ideal profile for placing a reverse osmosis desalination plant at the end of the pressure pipeline system, as well as a better lithologic configuration.

Other Options

Ideas exist for using sea water along the routes of either the Med-Dead or Red-Dead canals for the purpose of irrigation. Ample agricultural land is found along the routes, but these schemes will depend on the future development and progress in biotechnology for irrigating crops with sea water.

High-temperature solar electricity could also be generated using new technology including solar ponds. This would take into account the local weather which has 300 cloudless days a year. One estimate indicates that the Dead sea itself could support a 450 km^2 solar lake or pond, operating a 2,500 MW power plant, if relatively low saline sea water were made available (Stern and Gradus, 1981). Twenty-first century technology, however, will be needed to make solar energy a reality.

Brackish fossil aquifers have recently been discovered in this area, in and below the Nubian sandstone formation underlying the Negev and Sinai deserts. These aquifers could be tapped in the next century for at least $300 \times 10^6 m^3$ per annum of water. The cost of treating this water by reverse osmosis is estimated to be \$ 0.30–0.50/m^3 (Murakami, 1991 and 1993b). This unit cost would make it feasible for M and I water use, but not for crop irrigation. However, significant questions remain regarding the sustainability of these brackish fossil aquifers.

The Med-Dead Sea (MDS) Conduit Scheme for Cogeneration

Cogeneration traditionally refers to the use of waste heat from a conventional (oil or coal) energy-producing plant for the desalination of sea water by the distillation method. The co-generation scheme was first conceived to provide both hydro-electricity and freshwater from reverse osmosis sea water desalination plants in the early 1980s (Glueckstern, 1982). The use of a portion of the potential hydro-power to make reverse osmosis desalination cost-effective at the time was put aside, however, owing to its cost and a poor understanding of membrane technologies.

Discussion of the MDS in the early 1980s, given political limitations of the time, may not have sufficiently emphasized the concept of shared resources and the benefits of joint development. The new scheme proposed herein would comprehensively develop the Jordan river system including linkage of the MDS and the Al-Wahde dam on the Yarmouk in addition to other smaller streams flowing into the Jordan river and the Dead sea.

No previous attempt has been made to regionally link sources of both power and water. The key to this approach incorporates both electricity available through a regional grid and hydro-static pressure from the drop to the Dead sea, and takes into account recent innovative developments in membrane technology for reverse osmosis (RO) desalination which saves energy and makes RO desalination more cost-effective. It also recognizes recent changes in the Middle East political situation following the Gulf War in March 1991, the Israel-PLO Declaration of Principles in October 1993 (Israel/PLO, 1993), and the Israel-Jordan Peace Accord and Treaty in August and October 1994. These political actions make comprehensive basin development not only technically and financially feasible, but politically desirable, for the need for co-operative efforts to provide additional water has now become even more urgent.

Hydro-powered sea water Reverse Osmosis (RO) Desalination for Co-generation

The new co-generation scheme would exploit the elevation difference of 400 m between the Mediterranean sea and Dead sea (Fig. 6-2). Inflow to the Dead sea should balance evaporation. The water level of the Dead sea would be maintained at a steady-state with seasonal fluctuations of about 2 metres resulting from surface evaporation. Sea level would thus be sustained between 392.5 m and 390.5 m.

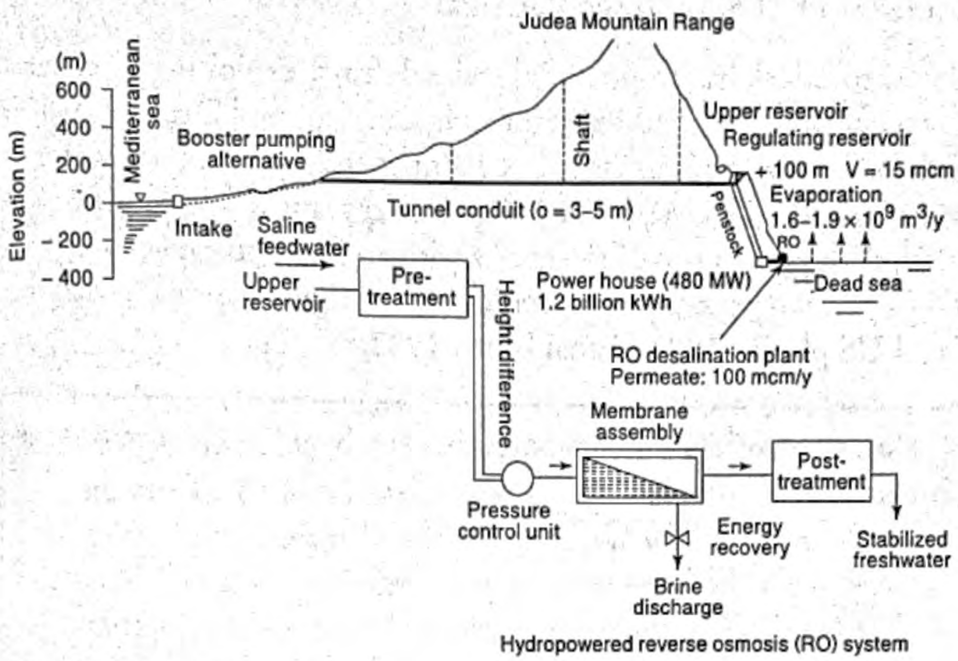


Fig. 6-2: Schematic Diagram and Profile of MDS Conduit Scheme for Cogeneration

A possible bi or trilateral development plan involving Israel, Palestine and Jordan in a Mediterranean-Dead sea conduit scheme (IJPMDS) would be a cogeneration alternative which could combine a hydro-electric power scheme with a hydro-powered sea water reverse osmosis (RO) desalination plant (Fig. 6-2). The IJPMDS scheme would have six major structural components, including:

1) an upstream reservoir (the Mediterranean) at zero sea level, with an essentially infinite amount of water,

2) a sea water carrier by tunnel, canal, and pipeline, with a booster pumping station,

3) an upper reservoir and surge shaft at the outlet of the seawater carrier to allow regulating water flow,

4) a storage type hydro-electric unit capable of reverse operation to allow the system to also work as a pumped-storage unit, if required,

5) a downstream reservoir (the Dead sea,) at its present surface elevation of approximately 400m below sea level, and

6) A hydro-powered reverse osmosis (RO) desalination plant, including a pre-treatment unit, a pressure converter unit, the RO unit, an energy recovery unit, a post-treatment unit, and regulating reservoirs for distribution of the resulting freshwater.

Estimates of Hydro-power Potential

The theoretical hydro-potential gained from exploiting the head difference between the Mediterranean sea (0 m) and Dead sea (-400 m) by diverting 56.7 m^3/s ($1.6 \times 10^9 m^3$ per annum) of sea water is estimated to be 194 MW. The hydro-power plant would produce 1.3×10^9 kWh per annum of electricity with an installed capacity at 495 MW assuming peak-power operation. These figures coincide with the Tahal US plan in 1981 (Tahal Israel, 1982).

> Estimates of the hydro-potential are based on equations as shown:
>
> (1) Pth = (9.8)(Ws)(Q)(He)
> (2) P = (Pth)(Ef)
> (3) Pp = (P)(24/8)
> (4) Wp = (365)(24)(Gf)(P)
>
> where, Pth: Theoretical hydro-potential (kw)
> Ws: Specific weight of sea water (=1.03)
> Q: Flow discharge (m^3/sec.)
> He: Effective difference head of water (m)
> P: Installed capacity (kw)
> Ef: Synthesized efficiency (=0.85)
> Pp: Installed capacity (Assuming 8 hrs/day peak operation)(kw)
> Wp: Potential power generation (output) per annum (kWh)

Methods of Cogeneration for the MDS

A booster pumping alternative can be applied to make an effective head difference of 500m. This takes into account an operating water pressure of 50 kg/cm^2 and cheap electricity during off-peak times. Sea water diversion capacity is estimated to be 50 m^3/s, including 39 m^3/s of intake water for the hydro-power unit and 11 m^3/s of feed water for the desalination unit.

The hydro-power unit would have a theoretical hydro-potential of 160 MW, and would generate 1.2×10^9kWh per annum of electricity with an installed capacity of 480 MW for peak-power operation for 8 hours a day. The installed capacity of the RO plant to produce $100 \times 10^6 m^3$ per annum of permeate is estimated to be

322,300 m^3/d with a load factor of 85 per cent (Murakami, 1991 and 1993a).

Marginal operation for RO is designed to use the system's hydro-potential energy in a penstock having 481.5 m of effective head. The unit would operate for 16 hours a day. The recovered energy (electricity) of 168×10^6 kwh per year from the brine reject water will be used to supply the post-treatment process or other purposes and will thus save electricity that might otherwise be taken from the national grid (Murakami, 1994).

A preliminary estimate of the project cost of the proposed RO unit is $ 389,355,000 for development capital and $ 44,387,000 per annum for O & M. The cost estimates are based on 1990 prices assuming that 1) plant life of 20 years, 2) membrane life (replacement) of 3 years, 3) 8 per cent interest during three years construction, 4) excluding cost-benefits from energy recovery and 5) excluding costs for source water and pipeline/distribution (Murakami, 1991 and 1993a).

THE AQABA HYBRID PUMPED-STORAGE SCHEME WITH HYDRO-POWERED SEA WATER REVERSE OSMOSIS (RO) DESALINATION

Construction of any new thermal and/or nuclear power stations in the region will benefit from a pumped-storage scheme for efficient energy use during off-peak time. Hybrid water-energy co-generation is an application of sea water pumped-storage with reverse osmosis (RO) desalination (Murakami, 1993b). The Aqaba scheme would use sea water which would be pumped directly during off peak time to an upper reservoir on the top of an escarpment at 600 m above sea level, and from there into a penstock yielding an effective water pressure of 55 kg/cm^2 at the end of the pipe. This would generate 600 MW of peak electricity, simultaneously producing 100×10^6 m^3/yr of fresh potable water (Murakami 1994). Off-peak electricity to boost the sea water up to the 600 m elevation would be supplied not only from a steam power plant at Aqaba but also from the most economical alternative sources whether steam or nuclear power plants in Egypt and Israel, or from other sources on the regional electric grid.

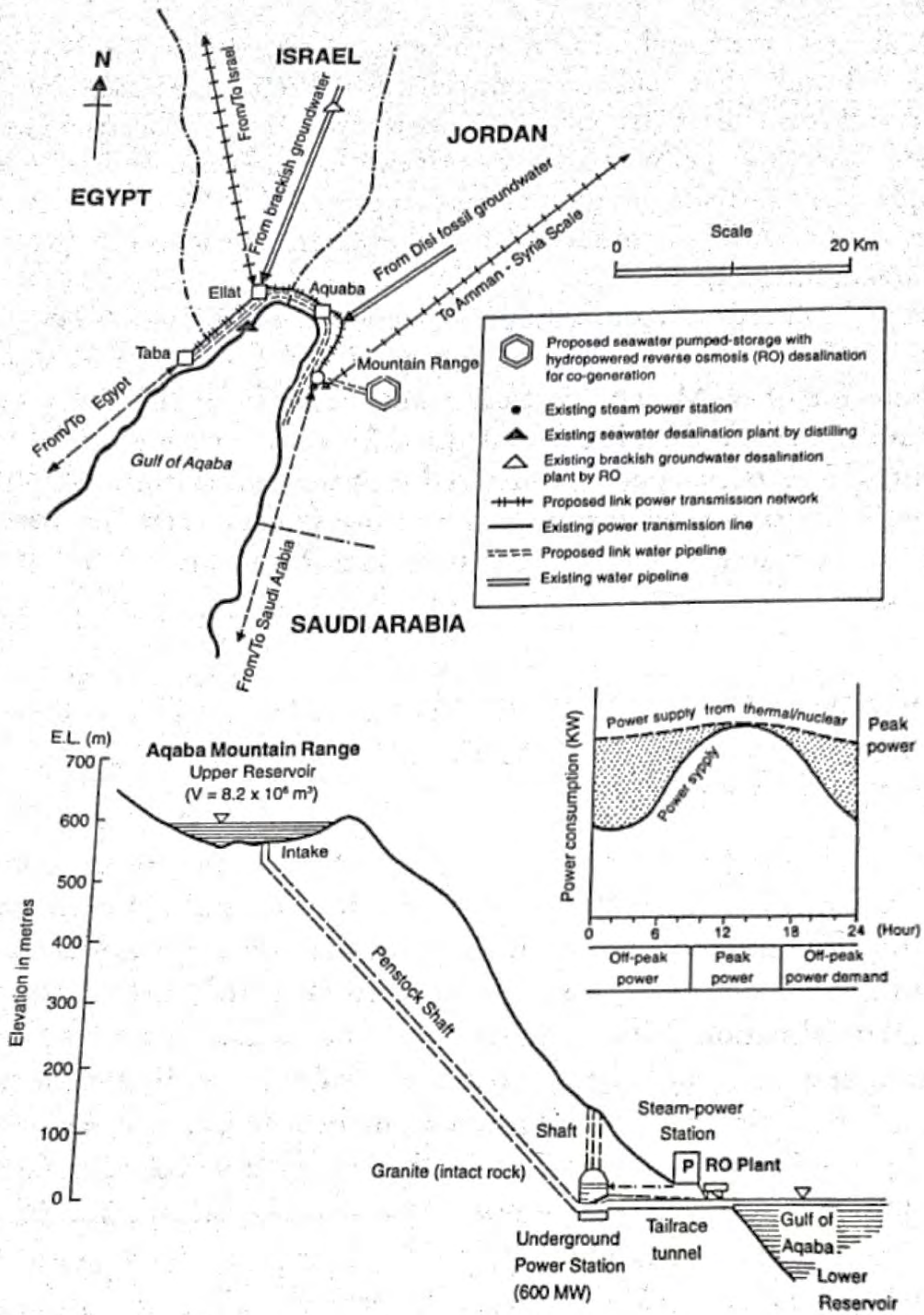


Fig. 6-3: Schematics of Aqaba Hybrid Sea water Pumped-up storage Scheme with Hydro-powered RO Desalination

Aqaba pumped storage (Technical Details)

The feed sea water requirements for producing $100 \times 10^6 m^3$ permeate (i.e., freshwater produced by its having permeated an RO membrane) per annum with 1,000 mg/l of the total dissolved solids (TDS) are estimated to be $333 \times 10^6 m^3$ per annum, assuming a 30 per cent recovery is an application of sea water pumped-storage with reverse osmosis ratio. The brine reject of $233 \times 10^6 m^3$ per annum, with a salinity of 57,000 mg/l of TDS, would then be released into the Dead sea (Murakami 1991, 1993c and 1994). The potential energy recovery (PER) from the brine reject is estimated to be 28,280 kw, assuming 20 per cent friction loss in RO circuit as shown below.

$$Per = 9.8 \times 1.03 \times (233 \times 10^6 / 365 / 86400) \times (587 \times 0.95 \times 0.8) \times 0.85$$

The annual product of electricity from the RO brine is estimated

Cost Estimates of the Hydro-powered Reverse Osmosis Desalination Plant

The per unit water cost of hydro-powered sea water reverse osmosis desalination for the annual product water of $100 \times 10^6 m^3$ is estimated to be $ 0.68/m³, which may be reasonable when compared with international water tariffs, e.g. , an estimated per unit water cost of $ 0.85–1.07/m³ for the 'Peace Pipeline' Project (David, 1991), and/or ii) estimated per unit water costs of $1.60/m³ by conventional reverse osmosis desalination using electricity from the national grid to produce pressures of 50–60 kg/cm² (Murakami 1993b). The recovered energy would be used to supply electricity for the post-treatment or to other pumps, thus replacing electricity taken from the national grid.

A schematic profile of the cogenerating sea water pumped-storage scheme is shown in Fig. 6-3. The design and specification for the hydro-powered sea water reverse osmosis desalination unit would be similar to that developed for the MDS conduit scheme for co-generation.

The marginal operation programme to optimize hydro-power generation and desalination is shown in Fig. 6-4.

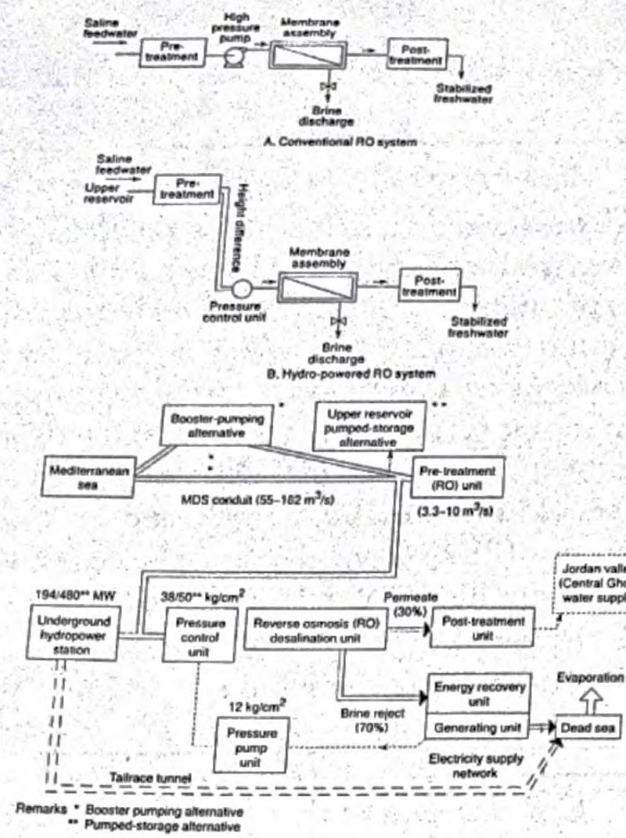


Fig. 6-4: Marginal Operation Programme for Hydro-powered Generation and RO Desalination

Cost Estimates and Water Economy

The cost of a unilateral 600 MW pumped-storage scheme is estimated to be $ 1.0×10^9 at 1990 prices. The total investment cost of the proposed hydro-powered sea water reverse osmosis (RO) desalination plant is preliminarily estimated to be US$ 389 million. The annual cost is estimated to be $ 18.5 million in financing major capital cost elements and $ 44.4 million in operation and maintenance (O & M) elements as shown in Table 6-1.

The costs of water thus produced has been examined in order to compare the unilateral pumped-storage scheme and the hybrid pumped-storage scheme with RO desalination. The annual benefit of the hybrid scheme is 1.4 times greater than the uni-lateral scheme, assuming tariffs of \$0.10/kWh of peak electricity and \$1.00/m^3 of fresh potable water. The cost and benefit elements are shown in Table 6-1.

The preliminary estimate of the per unit water cost of desalination to produce $100 \times 10^6 m^3$ per annum of freshwater from the RO plant is \$0.63 to \$0.74/m^3, by assuming the same design criteria and recovery unit including 175×10^6 kwh per year of electricity from the brine reject water.[5] The economy of this method can be seen when compared with either \$ 1.60–2.70/m^3 for conventional desalination such as for RO and MSF or the unilateral hydro-power scheme (Murakami, 1991).

Table 6-1: COST AND BENEFITS—THE UNILATERAL AND HYBRID SCHEMES

	Feed-water $10^6 m^3/s$	Electri-city $10^6 kWh/yr$	Permeate $10^6 m^3/yr$	Output/Sale $10^6 \$/yr$	Project Cost $10^6 \$$	Annual cost $10^6 \$$	Capital	O & M	Total Difference
Unilateral Pumped-storage:									
HP	50	1,482	–	148.2	1,000	100.0	5.0	105.0	+43.2
Hybrid Pumped-storage with RO:									
HEe		1,156	–	139.6	905	78.0	5.0	83.0	39
RO	11	(203)	100	100.0	390	37.2	44.4	81.6	
Total	50	1,359	100	239.6	1,295	113.2	49.4	162.6	+ 76.4

Method of Sharing Resources and Benefits

Fresh potable water amounting to $100 \times 10^6 m^3$ per annum from the Aqaba hydro-powered reverse osmosis (RO) desalination plant in the pumped-storage scheme could be shared among Jordan (Aqaba), Israel (Eilat), Egypt (Taba) and Saudi Arabia (Haq-l) in accordance with a possible agreement within the inter-state regional economic development programme. The non-oil producing state of Jordan, the national economy of which is not as strong as those of Israel and Saudi Arabia, would have an exclusive chance to export $100 \times 10^6 m^3$ per annum of fresh, potable water. It would also be able to export valuable peak electricity as well as importing cheap off-peak electricity from Israel, Egypt and Saudi Arabia.

The Aqaba hydro-powered sea water desalination plant will also save $17.5 \times 10^6 m^3$ of fossil ground water currently being pumped from the Disi aquifer to Aqaba for its municipal water supply. A schematic illustration of the method of sharing water and energy from the Aqaba hybrid sea water pumped-storage scheme with the hydro-powered reverse osmosis (RO) desalination system is presented in Fig. 6-3, which assumes the following inter-state cooperation scenarios;

1) An Inter-state electricity grid or network including Egypt, Israel, Palestine, Jordan, Saudi Arabia is incorporated in the plan to transfer inexpensive off-peak electricity, night and morning, to the pumped-storage scheme (buying) and to deliver valuable, day and evening peak electricity to neighbour states (selling).

2) An inter-state water pipeline system connecting three states (Egypt, Israel and Jordan) along the Aqaba coastline is constructed in order to share potable water from the hydro-powered reverse osmosis desalination plant at Aqaba , Jordan.

3) An inter-state sanitation and water environment management programme, which includes treated wastewater recovery for tree crop irrigation as well as protecting the clean water environment of Aqaba bay will be incorporated in the plan. The application of membrane separation technology, including micro-filter (MF) and/or ultra-filter (UF) techniques, will also be adopted in tertiary waste water treatment to reuse for limited irrigation (Murakami, 1994).

CO-OPERATION-INDUCING STAGES OF IMPLEMENTATION IN THE FRAMEWORK OF A REGIONAL WATER DEVELOPMENT PLAN

Negotiations underway in late 1994 and the winter of 1995 indicate the growing possibility of co-operative projects between Israel and the Arab states. Once legal and economic foundations have been laid for the ownership and distribution of current sources of water, and the existing water supply and demand system is functioning at maximum efficiency, a project with the scope of a Med-Dead or Red-Dead canal and Aqaba hybrid pumped-storage scheme could begin to be implemented. In order to achieve a maximum return from such efforts a comparison of the four feasibility elements: technology, environment, economy and politics (Murakami 1991, Wolf 1992, Wolf and `Murakami 1994) must take place.

At this point it will be vital to approach a unified solution to water problems in the core area by recognizing three stages of technological applications, 1) short-term (water conservation and re-use, thermal desalination plants), 2) mid-term (water transfer by tankers or bags, Med-Red/Red-Dead canals or hybrid-pumped storage schemes), and 3) long-term (water transfer by inter-state, large scale pipeline schemes). During this process economic, technical and environmental feasibilities should be constantly be reviewed, and the completion of each step taken as inducement for co-operation leading to completion of the whole.

As discussed in Chapter 5, the projects, ranked from earlier to newer ideas, include:

1. Mediterranean to Dead sea (Med-Dead)canal,
2. Red sea to Dead sea (Red-Dead)canal,
3. Pumped Storage, including Aqaba, the eastern and western shores of the Dead sea, and the eastern shore of the sea of Galilee,
4. Jordan valley salt drainage canal, and
5. Desalination.

It is now possible to suggest a time schedule for the application of the several technologies.

SHORT- TO MID-TERM SCHEME: IMMEDIATE STEPS

The first phase should begin immediately now that post peace negotiations between the PLO and Israel and Jordan and Israel are in progress. To cope with short- and mid-term urgent needs to supply water in Gaza, the most parched of the areas under discussion, a traditional, small-scale coal or oil-fired, dual-purpose energy/desalination plant or RO plant could be built on the Gazan shore (Murakami 1991; 1994; Murakami and Wolf 1994). The authors recognize the complexity of this situation and appreciate the detailed suggestions made elsewhere regarding an overall solution (Baskin 1994; Elmusa, 1994). Baskin, for example (guideline # 14, p. 33) suggests the immediate return of the safe yield of the Gaza aquifer (60 mcm/yr) to the Palestinians. While this act would go far to relieve the catastrophic water situation there, it would not suffice; therefore, the authors view their suggestions as meshing with, rather than contradicting many other related ideas.

The second priority area (taking into account the peace agreement between Israel and Jordan) in order to implement the suggested inter-state economic co-operation programme should be the Aqaba pumped storage project. At the same time, the feasibility of this project for joint use among Jordan, Israel, Egypt and Saudi Arabia should be examined. This review would take into account 1) energy savings, particularly in the form of fuel oil, and the positive impact of such reductions on the local and global environment, 2) long-term flexible supplies of peak electricity and freshwater, and 3) a reduction of political constraints as well as increasing geo-political and economic incentives for Jordan.

This facility would be designed for initial incorporation into the Med-Dead or Red-Dead canal projects. Co-ordination with other potential core projects is important in order to proceed rationally to the next phase. Both the Aqaba hybrid pumped-storage and Med-Dead sea canal would be ideally suited for development in such a step-wise fashion, dependent upon increasing confidence-building incentives. These projects also could be designed to be expanded, in order to incorporate additional components as future power and water needs grow, and to have a flexible capacity to re-allocate outputs and benefits corresponding to long-term changes in water and electricity demands.

MID- TO LONG-TERM SCHEME: A BASIN MASTER PLAN FOR THE JORDAN RIVER SYSTEM

Projects such as solar-powered desalination, hydro-powered reverse osmosis desalination, aquaculture, and inland commerce and industry in the area would become feasible with the linkage by conduit of the Mediterranean or Red sea to the Dead sea. Once intake and power generation facilities with or without RO desalination plants were in place, even under different sovereignties, the incentive to connect the various facilities, and later to develop consequent ancillary projects would be powerful enough to induce ever-increasing co-operation.

Storage capacity in the Dead sea basin for the MDS canal scheme for cogeneration should be considered a joint resource of the lacustrian states: Israel (300 km^2; 30 per cent), Jordan and Palestine (700 km^2; 70 per cent). Evaporation rates from the Dead sea's surface after impounding sea water from the Mediterranean have been estimated to be 1,908 mm per annum (Calder and Neal, 1984). This would allow a water budget for a Dead sea cogeneration scheme generating 1.2×10^9 kWh per annum of electricity and $100 \times 10^6 m^3$ per annum of freshwater (Murakami, 1991; Biswas, et al., 1994) (Table 6-2).

Table 6-2: WATER BUDGET OF THE DEAD SEA WITH NON-CONVENTIONAL TECHNO-POLITICAL ALTERNATIVE SCHEMES

Million Cubic Metre (mcm) per year

Flow Balance	before 1948	after 1967	pls MDS	pls MDS + PDC
Ground elevation below sea level (m)	E.L.-391	E.L.-406	E.L.-391	E.L.-392
Surface area of the Dead sea (km^2)	1,000	900	1,000	1,000
Annual flow potential from the whole catchment	1,600	1,600	1,600*	1,600*
Inflow from catchment of the Jordan river	1,100	400	224*	211*
Inflow from catchment of the Dead sea	500	400	223*	211*
Abstraction of flow from the whole catchment	nil	800	1,153*	1,178*
Evaporation from the Dead sea surface	-1,600	-1,500		
Evaporation after impounding seawater from Mediterranean sea			-1,900	-1,900
Tailrace water from MDS hydro-power station			1,220	1,220
Brine reject water from RO plant in MDS			233	233
Brine reject water from RO plant in PDC				25
Inflow potential from the whole catchment	1,600	800	447	422
Inflow potential from the whole catchment	0	-700	0	0

Note: Above figures are approximate water budget in mcm per year.
E.L.-391m had been a historical equilibrium water level of the Dead sea before 1930–48
It will take several decades to fill up the Dead sea with seawater at the historical equilibrium level (1,600–2,000 mcm).
* These figures are some residual flows from the catchment which could be developed in the future stage.

The water budget of the Dead sea indicates that a decrease in inflow from the Jordan river catchment would allow the additional introduction of Mediterranean water, thereby increasing the system's hydro-potential energy.

There are four main alternatives to cut the flows from the Jordan river catchment: In all cases the impounded or desalinized water reclaimed by these projects would be put to use, with negligible return flow to the Dead sea.

1) The Al-Wahde storage dam on the Yarmouk river, (or dams in Syrian territory upstream).

2) Storage dam schemes on the rift side-wadis on the East Bank, including Wadi Mujib and Wadi Hasa.

3) Flood retention-groundwater recharge dam schemes on the

Table 6-3: TECHNO-POLITICAL ASSESSMENT SHEET FOR THE DEAD SEA AND THE AQABA SCHEMES BEFORE AND AFTER 26 OCTOBER 1994

Techno-political alternatives	Technical feasibility				Environmental feasibility	Economic feasibility			Political feasibility	Total
	Quantity	Quality	Reliability	Sub-total		Financial viability	Benefit /cost	Sub-total		
Weight (%)	12.5	5.0	7.5	25.0	25.0	12.5	12.5	25.0	25.0	100
1. After the 'Treaty of Peace' between Jordan and Israel on 26 October, 1994										
Lower Jordan river 'Peace Drainage Canal' with RO desalination	31.0	66.0	62.0	47.3	55.8	61.0	61.0	61.0	69.0	58.3
Aqaba pumped-storage scheme with hydro-powered seawater RO desalination	32.5	68.8	57.5	47.3	45.0	52.9	53.6	53.3	53.0	49.6
MDS hydro-solar development with hydro-powered seawater RO desalination	40.0	72.5	60.0	52.5	45.0	33.8	48.3	41.1	35.3	43.5
Dead sea pumped-storage	15.0	30.0	60.0	31.5	40.0	53.3	40.0	46.7	46.7	41.2
Mediterranean-Dead sea canal, without RO desalination	23.8	31.3	61.3	36.6	22.5	36.3	30.0	33.2	38.5	32.7
Red-Dead sea canal without RO desalination	21.3	30.0	28.8	25.3	22.5	33.8	30.0	31.9	44.2	31.0

Techno-political alternatives	Technical feasibility				Environmental feasibility	Economic feasibility			Political feasibility	Total
	Quantity	Quality	Reliability	Sub-total		Financial viability	Benefit /cost	Sub-total		
Weight (%)	12.5	5.0	7.5	25.0	25.0	12.5	12.5	25.0	25.0	100
2: Before the 'Treaty of Peace' between Jordan and Israel on 26 October, 1994										
Lower Jordan river 'Peace Drainage Canal' with RO desalination	31.0	66.0	62.0	47.3	55.8	61.0	61.0	61.0	69.0	58.3
Aqaba pumped-storage scheme with hydro-powered seawater RO desalination	32.5	68.8	57.5	47.3	26.3	37.0	37.5	37.3	24.0	33.7
MDS hydro-solar development with hydro-powered seawater RO desalination	40.0	72.5	60.0	52.5	45.0	33.8	33.8	33.8	35.3	41.7
Dead sea pumped-storage	15.0	30.0	60.0	31.5	40.0	53.3	40.0	46.7	46.7	41.2
Mediterranean-Dead sea canal, without RO desalination	23.8	31.3	61.3	36.6	22.5	36.3	30.0	33.2	38.5	32.7
Red-Dead sea canal without RO desalination	21.3	30.0	28.8	25.3	22.5	33.8	30.0	31.9	31.0	27.7

Note: After 'Treaty of Peace' between Jordan and Israel on 26 October, 1994, some details on the cost estimates and environment impact analysis were added by M. Murakami. Assessment sheet before the 'Treaty of Peace', *see* the original (Wolf and Murakami 1994, Ref. 13) side-wadis on the West Bank (Occupied Palestine) and the Judean mountain range where limestone geology predominates.

4) Salvaging saline water including saline springs and irrigation return in the lower Jordan system between the Sea of Galilee and the Dead sea, by installing a 'Salt Drainage/Peace canal' 85 km long leading to a brackish water reverse osmosis (RO) desalination plant with an installed capacity of $75 \times 10^6 m^3$ per annum at the terminus of the Jordan river mainstream.

Among the above, the Al-Wahde dam scheme with an effective storage of $195 \times 10^6 m^3$, is Jordan's last major river development, and is urgently needed. This would add $155 \times 10^6 m^3$ per annum (or in less then 12 months) of renewable freshwater to the national water supply grid. The storage of winter flow will also reduce substantial amounts of discharge into the Dead sea. This could add 20 MW of hydro-potential (120×10^6 kWh per annum of electricity) (Murakami, 1993c). The product water of $100 \times 10^6 m^3$ per annum could be split equally between Israel, Palestine and Jordan. This water would be mainly used for M & I water supplies with the aim of supplying fresh potable water exclusively in the hot and arid low lands of the Jordan valley. (No pumping to higher elevations is recommended.)

Taking into account the new political implications of the Treaty of Peace between Jordan and Israel (26 October 1994), and recent evaluations of costs and environmental impact for the cogeneration schemes, a techno-political assessment was made in order to identify new priorities (as shown in Table 6-3). As a result, three such schemes have been assigned mid-term priority: the Jordan valley salt drainage/peace canal, the Aqaba hybrid sea water pumped storage for Cogeneration Plan, and the MDS conduit for cogeneration.

This study assigns first priority to the Jordan valley salt drainage canal (SDC) as an environmentally sound desalination option which would salvage $75 \times 10^6 m^3/yr$ of saline or brackish waters in the lower Jordan system (Figs. 5 and 6). The SDC and desalination plant would not only protect the water quality of the lower main stream, but would also supply new potable water from the brackish water it diverts. The per unit cost of this water would be \$ $0.48/m^3$.

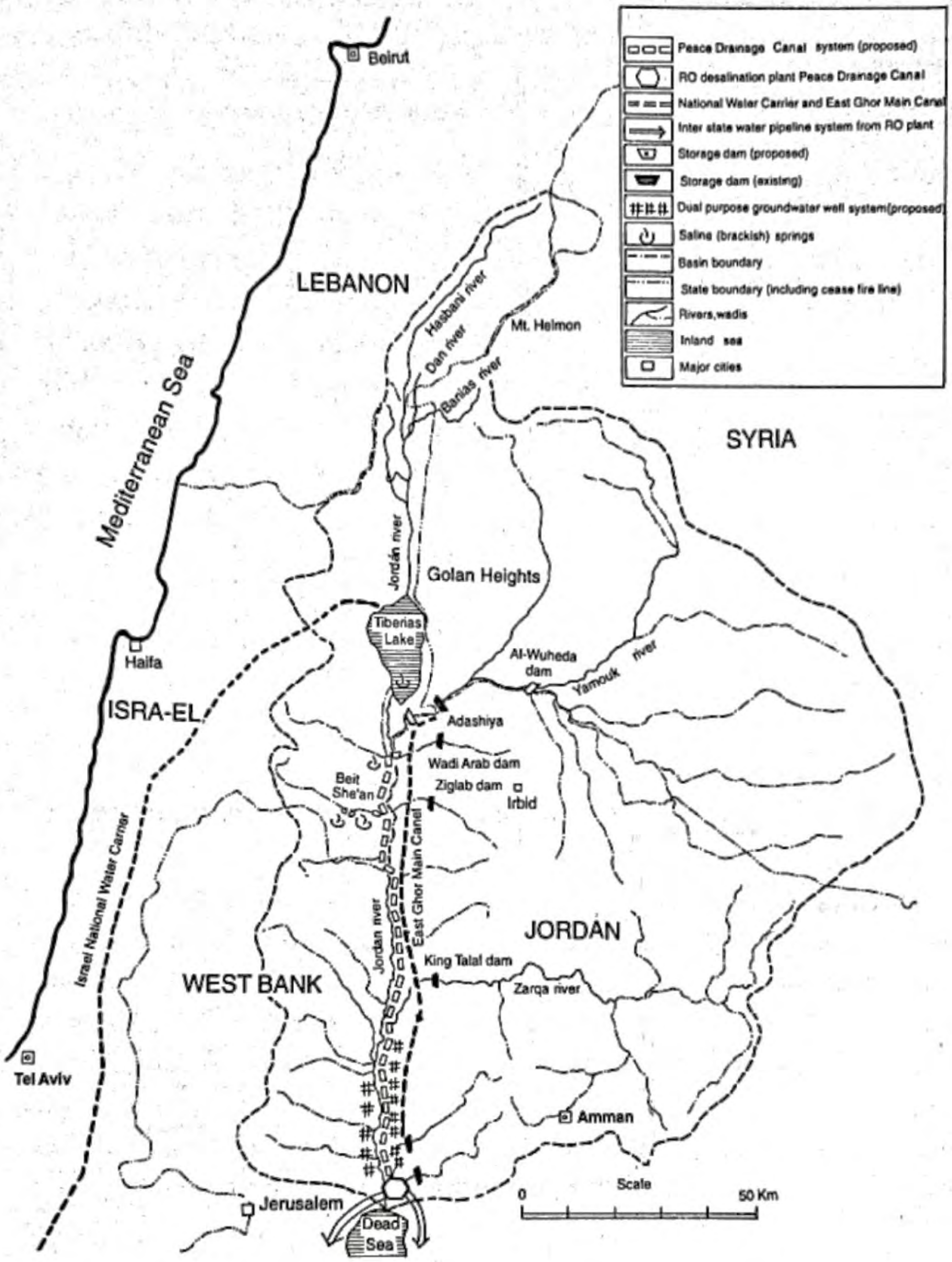
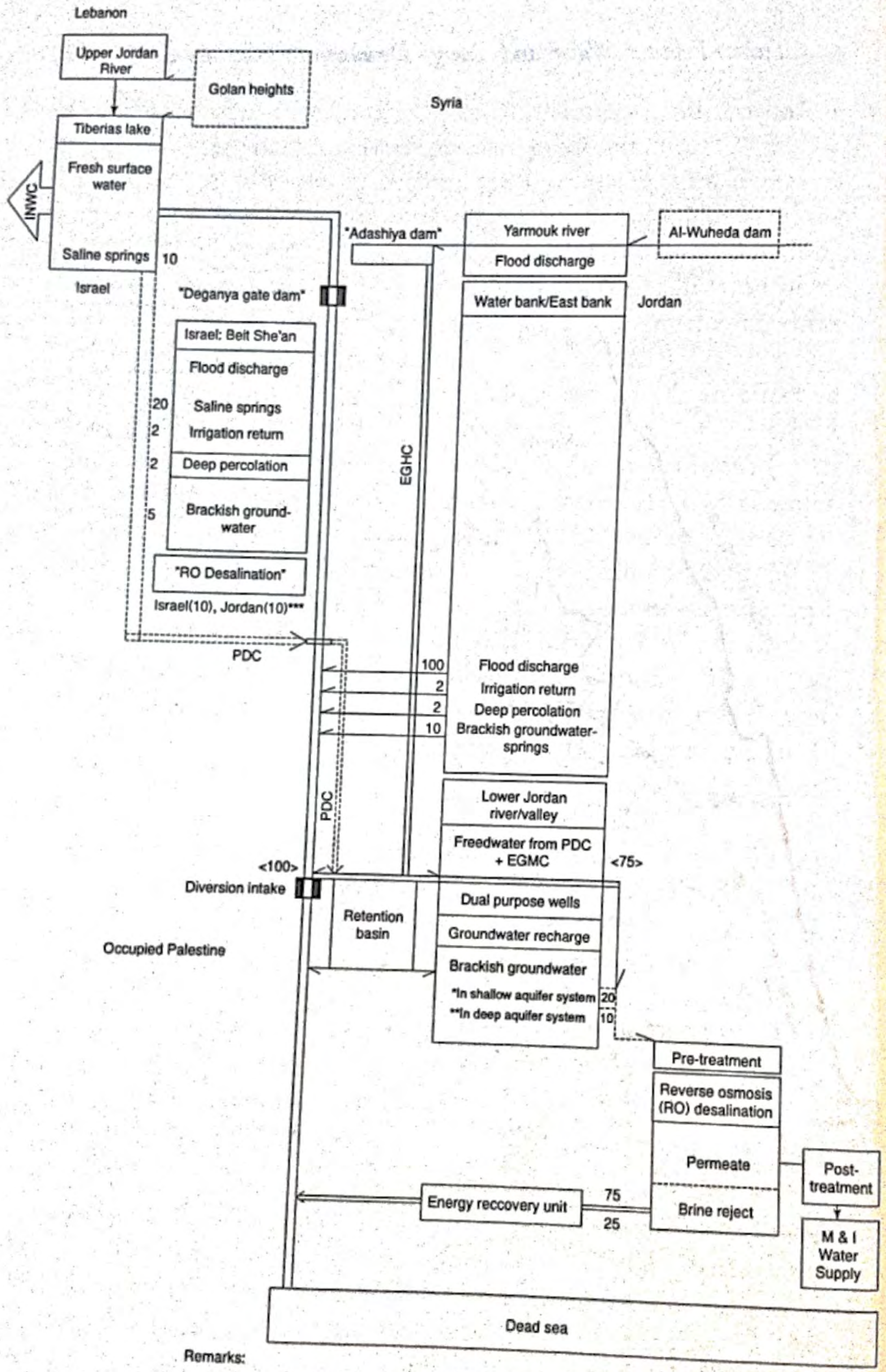


Fig. 6-5: Jordan River System and 'Salt/Peace Drainage Canal' Scheme



Remarks:

PDC: Peace Drainage Canal, EGMC: East Ghor Main Canal, INWC: Israel National Water Carrier
100, <100>: Unit in Million Cubic Meter
Plans in "Treaty of Peace" in October 1994 including "Adashiya dam", "Deganya gate dam", and "RO desalination plant" in Israel
*Brackish groundwater in shallow saquifer : Summer period
**Brackish groundwater in deep aquifer : Drought period
***Water allocation of RO permeate in "Treaty of Peace" of October 1994

CONCLUSIONS

The above plan, which includes the two strategic regions of the Dead sea and the Gulf of Aqaba, has attempted to evaluate some new non-conventional approaches to water resource management, which need to taken into account during the search for peace in the core of the Middle East.

Although costs have long been a constraint in considering sea water desalination, hydro-powered sea water reverse osmosis (RO) desalination in the Aqaba hybrid pumped-storage scheme would achieve substantial cost reductions by retrieving off-peak electricity from steam power plants elsewhere in the region. The per unit water cost of hydro-powered sea water RO desalination is preliminarily estimated to be \$ 0.63–0.74/m^3, which is 50 per cent or less than the cost of traditional RO (\$ 1.68/m^3) or MSF (\$ 2.7/m^3).[6]

Regardless of whether the Red-Dead or the Med-Dead plan is chosen, the Dead sea hydro-conduit development for cogeneration should be discussed in the context of a basin water master plan for sustainable development and management This should be based on the concept of sharing resources in order to provide the basis for peaceful collaboration between Israel and its neighbours.

The Aqaba hybrid pumped-storage scheme with hydro-powered sea water reverse osmosis desalination would be a feasible core project in an inter-state region including Jordan, Israel and Palestine, and with the possible integration of Egypt and Saudi Arabia. A comparative technical-political feasibility study including non-conventional alternatives should be carried out within the framework of an inter-state regional development master plan.

The new approaches described above offer an opportunity to introduce new applications of well-tried technology in order to solve long-standing water and energy problems that are possible sources of potential conflict. As the Romans established a *Pax Romanum*, so may imaginative water management provide a *Pax Aquarum* for the Middle East.

In the more distant future, population may well increase to a degree where even the minimization of agricultural water demands will fail to meet domestic and industrial water needs. At that time, not only sea water desalination but also water imports from the periphery may become critical, particularly for inland locations in Jordan and Syria.

Because such projects are of even greater complexity than those suggested for the core, their evaluation and planning should start now if imported waters are to be available in twenty to thirty years time. Until then, it must not be forgotten that the storage capacity of the Dead sea is fixed by economic, social and political constraints as well as by nature, and that unlimited amounts of water cannot be poured into its basin. This limitation has been considered in the scheme presented above and is shown in Table 6-3. It is further examined in Chapter 7 where import of water from the periphery is considered.

NOTES

1. *See* ISPAN, *Gulf of Aqaba Environmental Data Survey*, for a full description of intended developments in this area.
2. Current activity is focused upon the RSDS scheme. The authors feel, however, that the MDS project also should be considered. Technical and geological constraints associated with the RSDS project are discussed below.
3. *See* ISPAN, *Gulf of Aqaba* .
4. Assuming a gross water head of 444 to 472 m and a maximum discharge of 200 m^3/sec and an annual average flow intake of $1.23–1.67 \times 10^9 m^3$ (Tahal Israel, 1982).
5. It should be noted that the optional use of $100 \times 10^6 m^3$ feed water in the hydro-power sector would generate 143×10^9 kWh per annum of electricity or a \$ 5.91×10^6 potential shadow benefit (Output/Sales-Cost). The estimated per unit water cost of the hydro-powered sea water RO desalination is \$ 0.69/m^3(= 0.63 + 0.059).
5. The cost of \$0.74 includes the cost-benefit return of using sea water for hydro-power generation rather than RO.

7 Inter-unit Transfers from the Periphery to the Core

INTRODUCTION

Cost does not stop water projects. Water projects are often extravagant. Every drop of water used in the western United States is subsidized. The Colorado river desalination plant which sends cleaner water to Mexico is outrageously expensive when the alternative of retiring saline upstream fields is considered. Agriculture in the Central Valley of California exists only through taxpayer subsidies. Proponents of the proposed Three Gorges Dam on the Yellow river in China do not count its true costs.[1] The swimming pools of Los Angeles and Haifa would never have opened if the pumping costs of water were fully paid by their users. The agricultural programmes of every nation in the Mashreq cannot be justified on the basis of water costs, and yet they flourish.

Politics start and stop water projects. The 'rights' of American farmers and the fate of their congressional representatives are nourished by costly water. American relations with Mexico are in part guaranteed or imperiled by the quality of Colorado river water. The monolithic regime in China is celebrated by its technical monuments. And the aquatic recreation of the populace is ensured by vote hungry politicians.

Are these statements too cynical or unrealistic? Or would a dose of real politik cut through much of the confusion and delay surrounding regional water problems in the Middle East? The cost of one day's war exceeds any but the largest of water projects, and the pecuniary concern of European and American economists with regard to differences of a few cents in the costs per cubic metre of Middle Eastern water seem strange when compared to the hydro-follies found in their own countries.

The proposal which follows for linking the periphery, with its more abundant water supplies, to the needy core falls well within the technical and financial range of existing worldwide water projects. Its authors recognize the complexity surrounding such issues and present their ideas solely as an heuristic example of the type of long-term collaborative options that should be considered in attempting to solve the water problems of the Mashreq and its core. We do not propose that this is the answer, but hope that the following presentation will stimulate productive thinking on ways to approach periphery to core hydrologic relations.

The underlying principle with which our proposal has been conceived is one of political practicality. The best bargain is one where both sides feel they have gained. As will be indicated, every country involved would gain something it wants and would give up nothing it has, with the exception of Turkey which would receive both monetary and technical compensation for sharing a surplus commodity. The mutually satisfying inter-linkages would also go far to ensure the continued functioning of the system once in place. Moreover, the suggested system would augment, rather than interfere with, the plans for the core suggested in the preceding chapters.

SUGGESTED CONVEYANCES—PERIPHERY TO CORE

During past decades numerous proposals intended to alleviate water shortages in the Mashreq by means of imported water have been made. None of these have been accepted or put in place, but neither have those ideas disappeared. Therefore, with increasing need for supplemental water supplies and the slow resolution of project inhibiting political differences the possibility exists that one or more such schemes may find the light of day. A brief description of each of these major proposals follows in order to familiarize the reader with their attributes. To our knowledge no reliable cost/feasibility studies exist for the listed schemes, but such an omission does not rule out their eventually being made operable.

The schemes described are (Fig. 7-1):

1. A pipeline from the Iraqi Euphrates to Jordan,
2. President Ozal's Turkish peace pipeline,
3. A mini-peace pipeline,
4. A mini-mini peace pipeline,
5. A Golan Heights peace canal,
6. The trans-Syria pipeline,

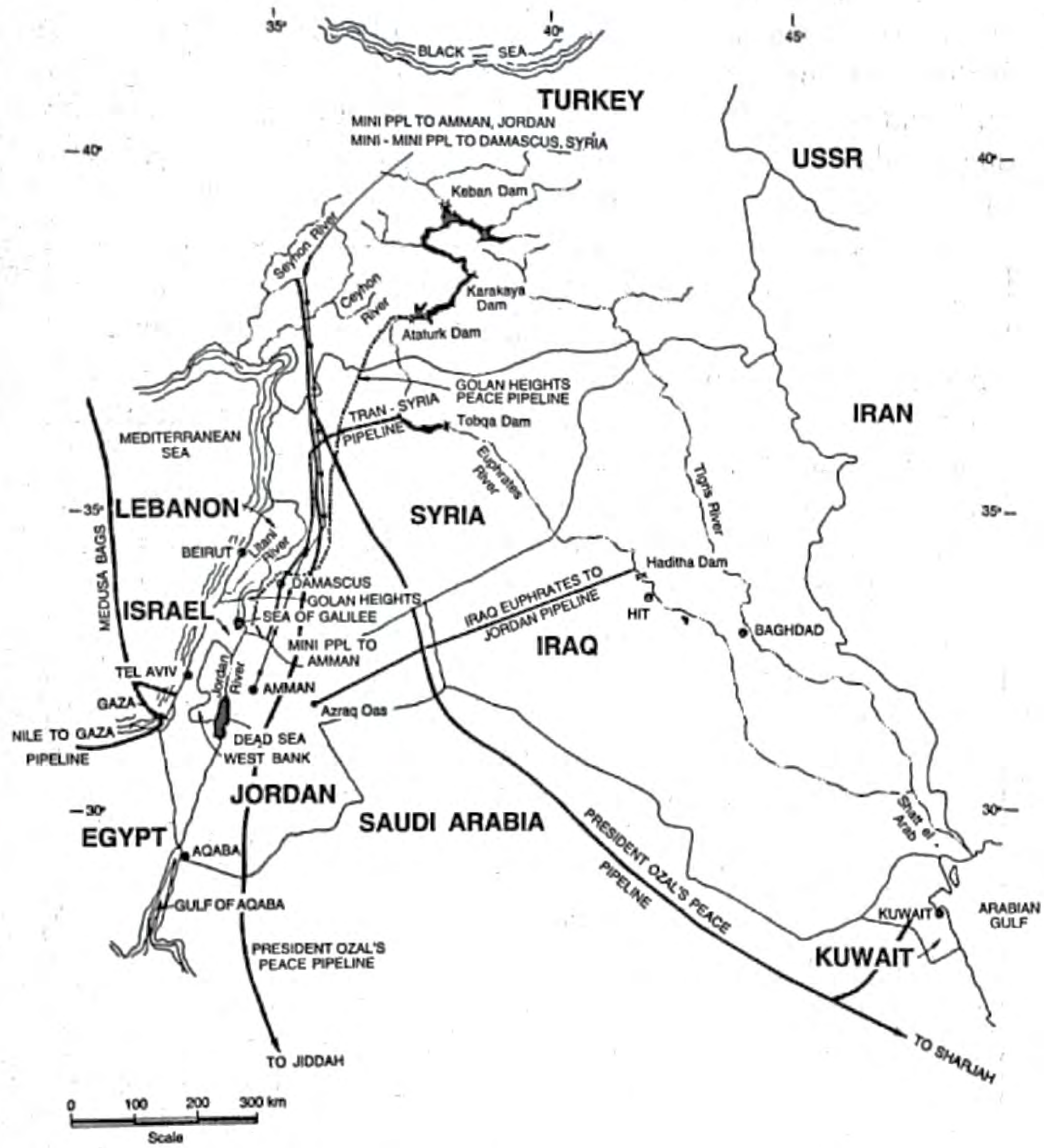


Fig. 7-1: Periphery to Core—Proposed Water Transportation Schemes

7. Medusa Bags (sea borne),

8. A Nile to Gaza pipeline. (*See* box below).

Similar ideas have been suggested in order to bring water directly to the GCC countries. While these will not be presented here, they include pipelines from Iran to Bahrein and/or Qatar, Iraq to Kuwait, and Pakistan (the Indus River) to the UAE. Similar to these is the suggested Nile to Gaza Pipeline which is included here but not in our analysis for the reasons stated above (Footnote 2, Chap. 1).

Nile to Israel Pipeline

Egypt's El-Salaam Canal/Pipeline is proposed to bring between 2,800 mcm/yr (for the first 26 km) and 1,500 mcm/yr (to El-Arish) in the northern Sinai. To meet the suggested Nile to Gaza requirements the capacity of the canal would have to be increased by 500 mcm/yr as well as extending its length 50 km to Gaza and another 15 km to Ashkelon. The total cost of this project has been estimated to be $695 million (1984 prices). Israel, upon receiving Nile water, might release an equivalent amount to Jordan or the Palestinians from the northern Jordan or the West Bank.

The offer of Egyptian water was first made by Anwar Sadat in 1981 in the face of resistance to the idea by both Israeli and Palestinian nationalists. Acceptance of substitute waters in place of those originating on the West Bank is deemed unacceptable by most Palestinians. Such an action, they feel, would indicate acceptance of the territorial *status quo*.

Another major objection to this project is that the inter-basin transfer of Nile waters would in the long run have to approved by the ten co-riparians on the river. It should also be noted that Nile waters as of December 1994 had yet to cross the Suez canal.

Euphrates–Jordan Pipeline

This is the first such scheme to be considered. Sir Hamilton Gibb and Company suggested that a pipeline be run from the Euphrates river in Iraq as far as Amman, Jordan. The original idea may have been based on the existence, at that time, of the TAP petroleum pipeline, for water would be pumped from the river into a pipeline which would follow an existing but unused oil pipeline across western Iraq and Northern Jordan. The line would terminate near the Azraq oasis and thereafter the water would flow to Irbid and Amman through an existing system. The line would have been about 610 km in length and would divert about 160 mcm/yr to Jordan. No cost estimates are available for this project, but based on an approximate unit cost of pipe installed, the cost would be about $1.8 billion.

The project was never carried out. Iraq's position *vis-á-vis* other Arab states makes it politically unviable. Perhaps more significant is the uncertainty surrounding the quantity and quality of water in the Euphrates river at the point of removal. These will depend upon developments upstream in Turkey and Syria.

President Özal's Peace Pipeline

In 1987 Prime Minister (later President) Türgut Özal proposed a 'Peace Pipeline' (PPL) intended to alleviate water shortages of Turkey's southern neighbours. The PPL would carry as much as 3.5 thousand m^3 water daily (1.28×10^9 m^3/yr) from the Seyhan and Ceyhan rivers in two lines. The western PPL would reach Jiddah in Saudi Arabia, and the eastern PPL would extend as far as Sharjah in the UAE. The contracting firm of Brown and Root at that time estimated a cost between $17 billion and $20 billion.

While technologically feasible, the offer evoked no official and scant private response from the potential recipients.The Arab memories of Ottoman rule combined with scepticism regarding the political reliability of a line's crossing so many intervening borders essentially vetoed the PPL's success. Questions regarding the amount and quality of the water sources also were raised, though subsequent conversations with GAP engineers by the present authors indicate that the headwaters of the Seyhan River should be able to provide the indicated amount (Kolars and Mitchell, 289–97; Kolars, in Bagis, 1994, 129–53). Cost considerations were mentioned in passing, but played little part in the rejection of the PPL.

A Mini Peace Pipeline

A shorter version of the peace pipeline was suggested by Kolars in 1991 at a World Bank seminar on water management (Kolars, World Bank, 1992). Based on President Özal's original proposal, this mini-peace pipeline would carry approximately 600 mcm water to Syria and as far as Amman, Jordan. Its cost would be proportionately less than the PPL, and the amount of water delivered smaller. Syria and Jordan would be the direct beneficiaries, although a domino effect might take place downstream on the Yarmouk river, making water available to Palestinians on the West Bank, and perhaps even to Israel.

This idea entered the growing ranks of periphery to core water projects and while never rejected, it faced the same criticisms as those leveled at the original PPL, although to a lesser degree.

A Mini-mini Pipeline

A mini-mini PPL was suggested by Hillel Shuval as a refinement of the mini-PPL idea. In this case, the line would extend only as far as Damascus and its southern environs. Delivery of its water would, it is hoped, take some pressure off the headwaters of the Yarmouk. The advantage offered by the mini-PPL is that only one border would have to be crossed (Turkey/Syria).

A Golan Heights Peace Canal

The idea of a Golan heights peace canal has been offered by Boaz Wachtel as an effort to both alleviate the water shortages in Syria, Jordan, Palestine and Israel and also as a means of answering questions of occupancy of the Golan Heights. Water for the project would be obtained from Lake Ataturk and would require about 1,100 mcm annually. Pipelines would lead across Turkey and Syria to the existing border between Syria and the Golan Heights. Thereafter, a 60 km open canal, 30 m wide and 3 m deep would lead to the south, forming an effective 'tank barrier'. Two smaller canals, 20 metres wide and 3 m deep, would parallel the main canal. They would carry water in the event of necessary repairs to the large canal as well as serving as buffer tank barriers, thus preventing incursions by either party occupying the heights. Thereafter, the flow would be split, half going to the Sea of Galilee, the other portion falling to the Yarmouk river where it could be stored in the reservoir (to be constructed) behind the Maqarin Dam. In both cases an estimated 700 MW hydroelectric capacity would be generated. Estimated building costs come to $1.5 billion (1994 dollar). No estimates are available for operating costs.

Project facilities would include: a tunnel through the mountains southwest of the Ataturk Dam, twin pipelines from the Ataturk reservoir to the Golan Heights, a lined canal/anti-tank barrier along the heights, and hydro-electric facilities on the Yarmouk river and Lake Tiberius.

Numerous objections have been raised to this scheme in addition to its cost. Primary among such caveats, is the unacceptable assumption that hostilities are inevitable on the Golan Heights, or that at the least, the territory will remain divided, for Syria demands complete return of the Golan as its fee for peace. Others contend that the peace canal would also increase Jordanian and Palestinian dependence on Israel for an uninterrupted flow of water.

The Trans-Syria Pipeline (TSP)

This suggestion represents an idea informally suggested by Syrian officials to the authors as members of the Middle East Water Commission. The TSP would take water from Lake Assad and bring it south by an all Syrian conveyor. Along the way, the major Syrian cities of Aleppo, Homs, and Damascus, would be served. Additional water would be emptied into the headwaters of the Yarmouk for division among Jordan, Palestine, and possibly Israel.[2]

This project differs from all other suggested pipeline schemes in that natural river systems would be used to convey water across international borders. This would satisfy an expressed Syrian desire to limit international boundary involvement. From an economic point of view, although some water would be lost to seepage and evaporation from river and reservoir surfaces, a significant amount of piping and tunneling would be avoided on the route between Turkey and Syria.

The main problems facing such an effort are political. Syrian and Turkish co-operation will depend upon and involve the sharing of waters from the Euphrates, Asi (Orontes), and Tigris Rivers. The water removed from Lake Assad for the TSP would have to be released by Turkey and would be in addition to any Syrian or Iraqi 'equitable share' agreed upon by the three riparians in concert. It should be noted that Iraq, though not an active player at the moment, must still be included to its satisfaction in any riparian settlement.

Medusa Bags

The technology represented in this concept has been developed and refined by James A. Cran.[3] Water from the Manavgat river on the south central coast of Turkey, which now flows unused into the Mediterranean sea, would be taken by pipeline to an offshore loading facility. Thereafter, it would be pumped into large reinforced fabric bags, towed by sea going tugs to the shores of Gaza or Israel and off loaded for use.

These 'Medusa Bags' would each be about 700 m long, 170 m wide, and 20 m deep, and contain about 1.5 mcm. A continuous cycle of full and empty bags assuring a continuous supply of water at the receiving end would require six bags and six tugs.

The total investment cost for the project is estimated to be about \$300 million, and the annual cost for operation and maintenance about \$12 million. At an interest rate of 12 per cent per annum, the cost of water would be about \$0.20/m^3, decreasing to about \$0.17/m^3 at an interest rate of 7.5 per cent.

There seem to be no major technical objections to this scheme save for its untried character. A 5000 m^3 bag has been successfully tested, but further work has been delayed by lack of financing. Politically, the Gazans object to any notion which would indicate that they accept the *status quo* regarding Israeli use of West Bank or other related waters. A counter argument is that if the water were delivered to Israel a similar amount of West Bank water would be released to Gaza. On the other hand, many Israelis object to being dependent on any water from foreign sources. There also remains the question of such sea borne Medusa water's being a practical answer to severe shortages now developing in inland Jordan and Syria.

A somewhat similar scheme, Aquarius linked bags, has been suggested by Christopher Savage. This would entail sea borne, smaller bags towed like links of sausage from Turkey to Israel. Scant information is available regarding this idea.

Given the various schemes described above, it is now possible to attempt the authors' own answer to the question of periphery to core water transfers.

A REGIONAL WISH LIST

Consideration of this periphery to core proposal begins with a list of water related items including something for every unit[4] in the region (Table 7-1).

Table 7-1: DESIRED WATER RELATED GOALS

Turkey	Help with Black sea flood control Help with integrated water system to serve western cities Additional foreign exchange Cooperation with Syria regarding Kurdish question Rapprochement concerning waters of the Asi river (Orontes) Rapprochement with Syria and Iraq over Euphrates waters
Syria	Rapprochement with Turkey over Euphrates waters Means to bring additional water to its cities (Aleppo, Homs, Damascus) No water pipelines crossing international borders (This notion has been stated by Syrians in positions of authority—*see* text.) Building of a trans-Syria pipeline as part of the urban water solution Resolution of Yarmouk headwaters question
Jordan	Additional water from the Yarmouk river Augmenting of limited water supplies, particularly to cities
Palestine West Bank	Completion of West Ghor canal with an additional share of water Control of the water which falls as precipitation on the West Bank, A larger share of the Yarqon-Taninim aquifer
Gaza	Additional supplies of 'Palestinian' water from the West Bank
Israel	Continuing use of its established share of West Bank water Additional water supplies for future use with guaranteed integrity

Let us assume 1200 mcm of Turkish water's being delivered from the north. (The quantity specified is somewhat arbitrary and could be increased or diminished depending upon negotiation as could the number of units served). As mentioned above, the absolute constraint upon this assumption is the settling of the issue of sharing Euphrates and Tigris rivers among the three riparians.[5] While at present seemingly intractable, these problems should be no more difficult to solve than those confronting the Arabs and the Israelis, many of which recently have been resolved.

THE ARTICULATED SYSTEM

As shown in Fig. 7-2, 1200 mcm of additional water is released by Turkey downstream in the Euphrates. In return for this water, Turkey receives direct monetary compensation, and/or compensation in combination with an improved situation on the Asi, and/or an acceptable resolution of the Kurdish question *vis-à-vis* Syria, and/or a variety of internal improvements with the technological and financial assistance of the World Bank, or the UN, or the United States, or possibly Israel.

This water is released into the Euphrates river instead of being piped to the south for two reasons. Syrian officials have specifically told members of the Middle East Water Commission that although they do not want water pipelines crossing their borders from Turkey or from Syria to Jordan, the transfer of water via natural channels is acceptable to them. The second reason is financial, no pipeline construction or maintenance expenses would be incurred from the point of entry in Turkey as far as the point of removal from Lake Assad in Syria. This would represent a saving unavailable in previous pipeline proposals.

A trans-Syria pipeline (TSP) would be constructed with the technological and financial help of concerned outsiders. This pipeline would transfer water for Lake Assad south to the headwaters of the Yarmouk river while servicing the main cities of Aleppo, Homs, and Damascus along the way. It should be noted that of the 400 mcm thus allocated, 200 mcm would serve urban areas, in order to relieve a serious and growing deficit therein, and 200 mcm would replace water from the sources of the Yarmouk in Syria which are at present being diverted for use in Syria. The TSP would also be available to transport additional amounts of Syrian water from Lake Assad southward to agricultural areas and/or for additional urban supplies.

The TSP would also be used to ship an additional 800 mcm directly from Lake Assad (67 per cent of the original 1200 mcm) to the Yarmouk river. Of this 800 mcm, 500 mcm would move downstream directly into The Sea of Galilee. It should be noted that the Sea of Galilee would serve only as a channel, not as a reservoir, for this flow, and that an equal amount (*see* below) would be simultaneously

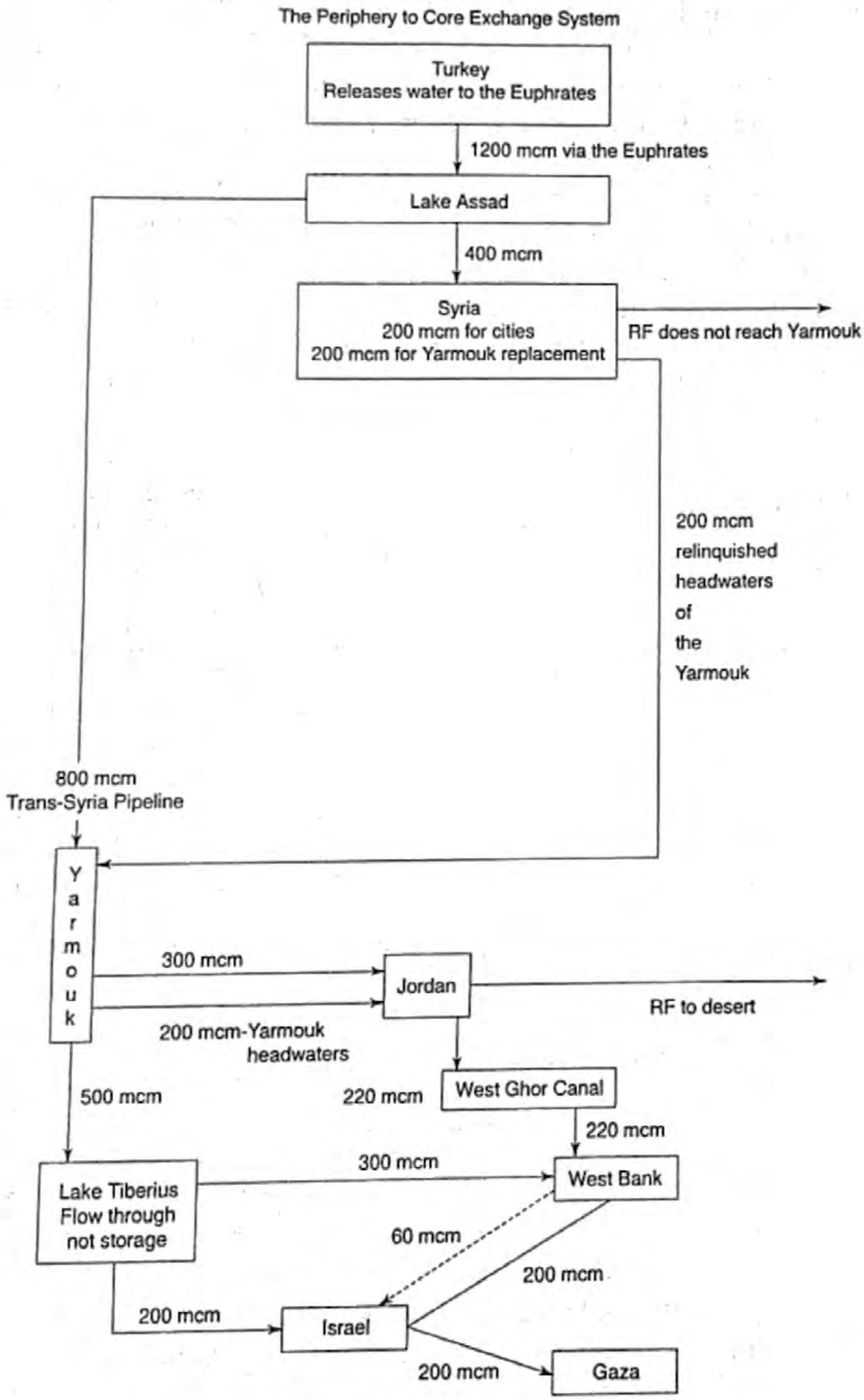


Fig. 7-2: The Periphery to Core Exchange System

removed for further shipment. Little or no additional storage is possible along the Jordan-Yarmouk system, therefore, the water mentioned here might also be scheduled for summer storage only. Jordan would receive the remaining 300 mcm as a much needed supplement.

At the same time, part of the natural flow of the Yarmouk amounting to 200 mcm, which has been replaced for Syria as stated above, reaches Jordan for use as indicated below.

Jordan would therefore receive 500 mcm of water by means of the Yarmouk. Of this amount, 60 mcm can be counted on as return flow (RF). It should be noted that this RF could be directed into the eastern desert where it could augment pasturage for herding, and would not interfere with previously discussed Dead sea hydro-power and sweet water generation plans for the regional core. Thereafter, 220 mcm would be directed to a newly constructed West Ghor Canal, fulfilling a long standing promise to that area. At present this amount of water is not needed in the Jordan valley, but environmental considerations for a healthy Jordan river as well as additonal water for Jordanian and Palestinian farmers and for increased tourism could easily absorb this quantity. Jordan would thus gain use of 340 mcm (Table 7-2 and 7-3).

Table 7-2: WATERS GAINED BY THE KINGDOM OF JORDAN

300 mcm	direct transfer
200 mcm	Yarmouk headwaters
60 mcm	Return Flow (to desert)
560 mcm	Sub total
220 mcm	to West Bank
340 mcm	Used in Jordan

The seaward slope of the West Bank would in turn receive 300 mcm of the 500 mcm sent directly to the Sea of Galilee. This in combination with the 220 mcm from Jordan and some desalinized byproduct (approximately 30 mcm) would give the West Bank 350 mcm for its own use and 200 mcm to pass on to Gaza.

Table 7-3: WATERS GAINED BY THE WEST BANK

20 mcm	from Jordan to West Ghor
300 mcm*	from Sea of Galilee
30 mcm	approximate return from RF desalination (for use in Dead sea valley settlements)
Sub total	550 mcm
-200 mcm	to Gaza
350 mcm	Total for use on the West Bank

Note: * – 60 mcm after use, down slope to Israel; this RF only from 300 mcm sent to the west slope of the West Bank.

Israel would receive 200 mcm directly from The Sea of Galilee for discretionary use (recharge of the coastal aquifer?) and 60 mcm return flow from the West Bank. This water would be in recognition of the West Bank's and Gaza's use of the Israeli NWC, the use of which would ensure that no attempt would be made to cut off Israel's share of these waters.

At the system's terminus, Gaza would obtain 200 mcm of West Bank water (i.e., Palestinian water, perceived as rightfully theirs) via an existing pipeline, another financial saving.

SUMMARY

In summary, comparison of the above schedule with the 'wish list' given in Table 7-1 indicates that many of the listed desires/needs would be fulfilled with no sacrifice on the part of any of the participants. Nor does the introduction of this relatively small amount of water into the core of the region in any way jeopardize the sequence of technological events or choices described in the preceding chapters. More specifically, the proposed scheme would maintain the level of the Dead sea prescribed in Chapter 6.

Construction costs would also be minimized. In place of a longer and more elaborate peace pipe line (PPL), or mini-PPL, or Peace Canal, two shorter, non-international water carriers would be built: the trans-Syria pipeline, and the West Ghor canal (which could take water directly from the Jordan river below its confluence with the Yarmouk), as well as two existing linkages from the Sea of Galilee to the northern part of the seaward slope of the West Bank,[6] and from the Israeli NWC to Gaza.

NOTES

1. *US Water News* (March 1995).
2. This latter inclusion was inferred but not stated; the matter being dependent upon the resolution of the Golan Heights controversy.
3. The authors wish to thank James Cran for these cost estimates.
4. It should be noted that the title which introduces this chapter uses the term 'inter-unit' rather than 'inter-basin' or 'international' to modify the notion of water transfers. The reason for this usage is that with the exception of desalinized water, any new sources of significant quantities of water in the Mashreq must perforce cross the boundaries of nation states as well as natural watersheds in order to reach their points of use. It is counter productive to fret over such perceived transgressions. In the United States individual states, operating under their federal umbrella, allow waters to cross natural and political boundaries with relatively little angst once details have been ironed out and arbitrated at that higher level. No such overarching panacea exists in the Middle East, but a substitute might be found in the concept of linked, mutually rewarding exchanges. It is suggested that thinking in terms of units without political or hydrologic modifiers may allow the discussion to proceed by avoiding nationalistic and/or positional rhetoric.
5. Syria and Iraq have already reached an agreement that 58 per cent of the water of the Euphrates crossing the border from Turkey into Syria will belong to Iraq, and the remaining 42 per cent to Syria. The remaining question is what overall share will be Turkey's and what Syria's and Iraq's? This is complicated by parallel issues regarding allegations by Turkey regarding Syrian support of Kurdish separatists, and Syrian overuse of the waters of the Asi (Orontes) river.
6. This line might not be necessary if a trade off between the waters of the Northeast Aquifer, currently used in the Jezraeël area, were replaced with water from the Sea of Galilee.

8 Epilogue as Prologue

It would be redundant and tedious to recapitulate the detailed descriptions and complex technical suggestions given in the preceding chapters. This epilogue, based upon what this study's authors have encountered, argued about together, and concluded, will attempt instead the briefest glimpse into what they perceive as the role of water in the Middle East.

In summary, our analysis emphasizes 1) the core's high variance in rainfall and the severe limitations on aquifers, 2) the importance of a mixture of hydro-technologies designed to meet the needs of this transitional region, 3) the combined production of hydro-electricity (HE) and reverse osmosis (RO) water, 4) the use of off-peak electricity for pumped storage to meet peak demand electric generation, 5) the careful balancing of the level of the Dead sea in order to accommodate introduction of either Mediterranean or Red sea water for HE and RO production, 6) the necessity of a combination of short-term, medium-term, and long-term responses to growing water shortages, 7) the need for long range planning to begin now, and 8) emphasis on cooperative regional development.

We do not present this study as the answer to the problems of supplying water to the core area. We hope only that our thoughts will stimulate others to seek the best possible comprehensive answer to the long-term hydrologic needs of the region. In this way peace can be achieved and reinforced.

We see the problems encountered, the negotiations attempted, and the resulting answers, as having worldwide application. Though the Middle East and the Mashreq are unique in many ways, they are also paradigms for the American south-west, the rivers of farther Asia, and even the more copious flows of Europe and the higher latitudes. This can be illustrated by a poet's perception of the future.

The American poet Carl Sandburg tells in a short verse how one night he was travelling on a train hurtling across the prairie. As he sat there staring into the dark, he mused on how in a hundred years all the train's passengers would be dust and the train itself an abandoned hulk or its metal recast into some other mode. He turned to a fellow passenger and asked him where he was going, and the passenger replied, 'to Kansas city'.

The locale we have discussed may be the Middle East rather than the Middle West, but all of us, the present authors and the audience whom they address, are like passengers on some train rushing through the dark to an obscure future. And yet, the painful process by means of which peace is being wrought in the Middle East is a positive one, applicable throughout the world. That this is so seems more possible today then even a scant decade ago. Such muted optimism is certainly possible when considering the role of water in the ongoing peace process. As described above, negotiations have progressed, new approaches to water acquisition and equitable sharing are under active discussion, and technological solutions to the growing water shortage are being studied and some are already being put in place.

Finally, we realize that our relationship to all natural sources of water, be they rivers, aquifers, or oceans is a truly symbiotic one. That if those sources suffer, so will we. We must learn to think holistically, from source to sea, and extend the time frame of our perceptions to spans of years and decades, to future droughts and surpluses and burgeoning populations. We must see the sources of water as living entities and become their advocates, so that all peoples may prosper in a healthy and sustainable environment.

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