The Jerusalem Institute for Israel Studies
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Altering the Water Balance as a Means to Addressing the Problems of the Dead Sea

An Independent Assessment of Alternatives for a "Water Conduit" and the Achievement of Its Objectives

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This report has been prepared in the context of work that was undertaken by the Jerusalem Institute for Israel Studies and overseen by a broad-based steering committee. The work was undertaken alongside the background of the current Study Program managed by the World Bank (www.worldbank.org/rds), which reflects a consensus among the Beneficiary Parties to investigate the feasibility to reverse the degradation of the Dead Sea by transferring water from the Red Sea (the RSDSC Project).

The current study seeks to highlight the costs and implications of various alternatives – using water from the Red Sea and from the Mediterranean Sea to achieve the objectives of the project. The study presents the additional costs entailed in choosing any other alternative than the least expensive alternative and its advantages and disadvantages, alongside the uncertainty and risks entailed.

This project does not claim to identify the most appropriate solution. Rather, its findings are intended to provide a factual dimension, perspective, and critique for use when applicable at the national and international decision-making levels on all matters related to addressing the water deficit of the Dead Sea and its implications. Unlike the World Bank project, the context for this work is solely Israeli – although naturally undertaken with awareness of international needs and constraints – and thus is not subject to the obligations inherent in collaborative work.

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Synopsis

This study examines a representative sample of alternatives for the construction of a water conduit that would convey water from either the Red Sea or the Mediterranean Sea to the Dead Sea. The study focuses on conceptually defining the alternatives and on refining the economic formula for comparative analyses. It computes the costs of each alternative and presents the additional cost entailed in choosing any single alternative compared with the least expensive one, noting the advantages and disadvantages of each alternative.

The work was undertaken alongside the background of the current Study Program managed by the World Bank (WB) (www.worldbank.org/rds). This Program reflects a consensus among the Beneficiary Parties (Israel, Jordan and the Palestinian Authority) requesting the WB to investigate the feasibility to reverse the degradation of the Dead Sea by transferring water from the Red Sea (the RSDSC Project).

In the past, freshwater flowed into the Dead Sea, primarily from the Jordan River and balanced the water volume that had evaporated from the lake. Following the construction of regional and local freshwater supply systems upstream flow almost entirely ceased, and together with creation of manmade industrial evaporation basins, a negative water balance within the lake has been created, which takes the form of a continuously declining sea level and shrinking surface area of the sea.

The concept of a water conduit is intended to alter the lake's negative water balance by pumping and conveying seawater and its byproducts (reject-brine after desalination) into the Dead Sea, in conjunction with desalination and the generation of hydroelectric energy. Such a conveyance would change the natural condition and entail environmental and economic risks that cannot be fully predicted, giving rise to uncertainty regarding the possible consequences of the proposed project.

In light of the complexity of the project and the many uncertainties involved, this document recommends that if it is decided to pursue the project, implementation should take place on a modular basis. Plans for modular implementation – in the form of separate stages, flow quantities, extent of desalination, and rate of implementation – must accommodate uncertainty and scenarios of potential

deterioration. Moreover, planning should address the nature of the modular implementation, monitoring of the consequences, and the minimal amount of time needed to ascertain and study the consequences before deciding whether to advance from one stage to the next. The planning also requires an organizational structure to manage the modular implementation, detect problems, identify their severity, and decide whether to move forward or, if necessary, suspend the project if it is found to be extremely destructive.

The methodology and economic evaluations in the current work, whose principal purpose is to generate a basis for comparison, are "cost effectiveness" analyses of six alternatives for the conveyance of seawater and its byproducts: one alternative that conveys freshwater and two alternatives that provide freshwater to the Amman region with no connection to the Dead Sea. The alternatives evaluated are presented solely at the basic conceptual level, and should not be seen as a recommendation or alternative to the modular planning, which should indeed be promoted in accordance with the recommendations of this project. The economic analysis refrains from overall "cost-benefit" analyses because of the difficulty inherent in quantifying the benefit that would be derived from public resources such as stabilizing the water level of the Dead Sea.

Nonetheless, the analysis does quantify the benefits (positive and negative utility) derived from the project in supplying freshwater to Amman as well as for Dead Sea tourism and industry, and it uses these figures to calculate the relevant costs, independent of the objective of stabilizing the Dead Sea water level or the complementary objective of rehabilitating the Jordan River south of the Sea of Galilee. The indirect costs of the various alternatives are not fundamentally different in the case of conveyance of seawater and its byproducts. Therefore inclusion of these costs does not affect the conclusions, which focus on the cost variance among the alternatives. In contrast, in the case of conveyance of freshwater, indirect costs are lower and their inclusion reduces the cost variance. In any event, addition of indirect costs to direct costs provides an indication of the scope of the inclusive costs of realizing the objective of stabilizing the water level of the Dead Sea and of complete or partial rehabilitation of the lower Jordan River (presented in the Executive Summary and in Article 8.3 of the full document).

The estimated costs of construction and operation of the alternatives are presented in the table below as cash flow in dollar values and adjusted to the

The Alternatives		NPV at a 7% rate discounted, for a period of 30 years Current value in millions of dollars as of the beginning of the first year of the project
I. Single-purpose alternatives: Provision of 200 MCM/year freshwater to Amman (no connection to the Dead Sea)		
R	**water for Amman; Aqaba – Amman**	**3,677**
M	**water for Amman; Sea of Galilee – Amman**	**2,732**
II. Dual-purpose alternatives: Provision of 200 MCM/year freshwater to Amman and conveyance of 800 MCM/year seawater/desalination reject-brine to the Dead Sea		
R1 - optimal alternative from the Red Sea	**From the Red Sea in "upper pipeline"**	**6,142**
M2 - optimal alternative from the Mediterranean Sea	**From the Mediterranean Sea via Beit She'an**	**4,492**
III. Triple-purpose alternative: Provision of 200 MCM/year freshwater to Amman and Conveyance of 800 MCM/year freshwater (to the Dead Sea via the Jordan River channel) all desalination at the Mediterranean Sea-shore)		
M3	From the Mediterranean Sea via Bet She'an	7,386
III. Triple-purpose secondary alternative: Provision of 200 MCM/year freshwater to Amman; 100 MCM/year freshwater to the Dead Sea via the Jordan River channel; and 700 MCM/year seawater/desalination concentrate to the Dead Sea		
M2a	From the Mediterranean Sea via Bet She'an	5,251

beginning of the first year of the project's implementation at a discounted rate of 7% and for a period of 30 years. The table is divided **in accordance with the declared objectives that form the purpose of the project.** The first section of the table (I) refers to **single-purpose** alternatives whose objective is to provide 200 million cubic meters (MCM) per year of freshwater to Amman, with no connection to the Dead Sea. The second section (II) refers to **dual-purpose** alternatives whose objectives are the provision of 200 MCM/year of freshwater

to Amman and an additional 800 MCM/year of seawater to the Dead Sea. The third section (III) refers to a **triple-purpose** alternative whose objectives are the provision of 200 MCM/year of freshwater to Amman and the conveyance of 800 MCM/year of freshwater to the Dead Sea by way of the Jordan River channel. This section includes a secondary alternative which includes in addition to providing 200 MCM/year of freshwater to Amman, conveyance of 700 MCM/year of saltwater to the Dead Sea, and the additional conveyance of 100 MCM/year of freshwater for the partial rehabilitation of the water flow in the lower Jordan River.

Cross-referencing the costs of the alternatives with the purposes they are intended to achieve yields the following findings:

- The optimal alternative for solely providing freshwater to Amman is from the Sea of Galilee, supplemented with expansion of the desalination facilities in Israel (alternative M – direct cost: $2.7 billion). Choosing this alternative would mean that Israel bears the additional environmental damage resulting from desalination while Jordan, for its part, is dependent on water supplied by Israel. Alternatively, the provision of water from Aqaba (alternative R – direct cost: $3.7 billion) would cost an additional $1 billion but would alleviate the two problems mentioned above.
- The least expensive alternative for approximately stabilizing the water level of the Dead Sea and providing water to Amman is to bring water from the Mediterranean Sea by way of Beit She'an (alternative M2 – direct cost: $4.5 billion). This would entail an additional cost of $1.5 billion that is also intended to bring the Dead Sea water level to a state of approximate stability. Achieving these objectives, without depending on Israel, by means of a conduit from the Red Sea (alternative R1 – direct cost: $6.1 billion) would cost an additional $1.6 billion.
- The optimal alternative for approximately stabilizing the Dead Sea water level, providing water to the Kingdom of Jordan, and bringing water to the lower Jordan River is by conveying water from the Mediterranean Sea by way of Bet She'an (alternative M2a – direct cost: $5.2 billion). This would entail an additional cost of approximately $0.8 billion, with 100 MCM/year of desalinated water being conveyed to the lower Jordan River channel.

Executive Summary

This document examines a representative sample of alternatives for the construction of a water conveyance from either the Red Sea or the Mediterranean Sea to the Dead Sea. The study focuses on conceptually defining the alternatives and on refining the economic formula for comparative analyses. It calculates the costs of each alternative and presents the additional cost entailed in choosing any of the alternatives over the least expensive alternative as well as the advantages and disadvantages of each alternative.

The work was undertaken alongside the background of the current Study Program managed by the World Bank (WB) (www.worldbank.org/rds). This Program reflects a consensus among the Beneficiary Parties (Israel, Jordan and the Palestinian Authority) requesting the WB to investigate the feasibility to reverse the degradation of the Dead Sea by transferring water from the Red Sea (the RSDSC Project).

The concept of a water conveyance inherently carries with it uncertainties, which the World Bank reports explore in detail and are also surveyed in this document. Such conditions of uncertainty make apparent that the only option is to implement the project on a modular basis, allowing credible quantitative analysis of all the consequences that would follow actualization of the project in its entirety. This document presents a conceptual evaluation of a conveyance with approximately half the flow capacity of the full flow capacity – that is, approximately 1,000 MCM/year – and the possibility of incorporating desalination systems by means of which the amount of water conveyed to the Dead Sea could be reduced to 200-600 MCM/year. It should be emphasized that the alternatives examined here are presented at the basic conceptual level only and should not be seen as a recommendation or an alternative to the modular planning that should be promoted in accordance with the recommendations of this document.

The analysis of the characteristics of each alternative presented here is intended to provide a foundation for comparative economic analysis and is based on the unique features of each individual route and on an identical set of engineering components and operation whose costs are estimated using standardized assumed values for similar components in Israel. For each of the alternative routes that appear in this document, two basic conveyance options are examined: the first

of these assumes continuous conveyance and generation of electricity, and the second includes conveyance and pump-storage for 16 hours with electricity generation during eight peak hours.

This document examines six alternative routes for conveyance of 1,000 MCM/year, of which 200 MCM/year of freshwater would be supplied to the Amman region and an additional 200 MCM/year divided equally between Israel and the Palestinians. Four of the six alternatives are from the Red Sea (R1-R4) and two are from the Mediterranean Sea (M1-M2). Additionally, an alternative is examined that would roughly simulate reviving the water flow to the lower Jordan River (M3), as well as an alternative that would provide 200 MCM/year of freshwater to Amman from Aqaba (R) with no connection to a seawater conveyance to the Dead Sea. In order to establish a basis for comparison, an alternative was also evaluated for supply of 200 MCM/year to Amman from the Sea of Galilee (M) at the expense of Israel's National Water Carrier and the replacement of this water with desalinated water that would be produced at the Mediterranean seashore.

For each of the routes, the document examines conveyance of seawater by pipes, in conjunction with tunnels and canals according to need and circumstance. For the Red Sea alternatives, the alignments roughly follow the routes presented in the World Bank published study and adjusted in accordance with the physical conditions of the Arava valley and its eastern peripheries. Among the Mediterranean Sea alternatives, M1 follows a route from Ashkelon to the proximity of Qumran, while M2 follows a route from Caesarea to the Dead Sea by way of the Beit She'an valley. The alternative M3 follows an identical route to M2 but differs from it by the concept of desalination and conveyance to the Dead Sea.

The methodology and economic assessments adopted in this work are "cost effectiveness" analyses whose principal purpose is to identify the cost variance among the different alternatives. The analysis refrains from comprehensive cost-benefit analyses because their application depends in part on the method of quantification employed, which in turn is subject to controversy regarding the benefit derived from a public resource such as stabilization of the Dead Sea water level or rehabilitation of the lower Jordan River. Nevertheless, it should be noted that the resulting benefits in themselves are not subject to controversy, and indeed stabilization of the Dead Sea water level is the goal and principal purpose of the project. To the extent possible, the analysis does indeed quantify some of

the benefits relating to the secondary objectives of the project and use these to calculate the costs relevant to the objective of stabilizing the water level of the Dead Sea and the complementary objective of rehabilitating the lower Jordan River. This is done by deducting the values of the benefits of the secondary objectives from the costs of the multi-purpose alternatives being assessed. The indirect costs of the alternatives do not fundamentally differ among themselves with respect to the conveyance of seawater/reject-brine after desalination, and their inclusion therefore does not affect the conclusions, which focus on the cost variance among the alternatives. In contrast, the indirect costs of conveying freshwater to the Dead Sea through the Jordan River channel to the Dead Sea are lower, and their inclusion therefore reduces the differences in cost. In any event, addition of the indirect costs to the direct costs yields an indication of the scope of the overall costs of realizing the objective – stabilization of the water level of the Dead Sea and full or partial rehabilitation of the lower Jordan River (presented in Chapter 8.3 of the full document).

This document examines the distinct alternatives for conveyance of 1,000 MCM/year and does not cover combinations of alternative conveyances and routes. During the course of this study various ideas were floated for combinations that would include conveyance of freshwater from different sources and in differing amounts to the lower Jordan River. Evaluation of such options would require, first and foremost, identifying the objectives and combinations needed to achieve them. Only after that would it be possible to evaluate them along the lines of the evaluations presented in this report. One example of such an integrated option is presented in this document as secondary alternative M2a, which is identical to the Mediterranean Sea alternative M2, which entails the desalination of 200 MCM/year in the Beit She'an region to be conveyed to Amman, with the addition of 100 MCM/year desalinated water for conveyance to and partial rehabilitation of the lower Jordan River.

The economic analysis in this document focuses on the possible alternatives for realization of the principal objectives: providing freshwater to Jordan (Amman district) and conveying water to the Dead Sea after pumping it from the Red Sea or the Mediterranean Sea. The simultaneous provision of freshwater to Israel and to the Palestinian Authority would generally be more expensive than alternatives entailing desalination at the Mediterranean seashore, and therefore, although its

cost is calculated, it is not included in the comparative economic analysis. The calculations are based on the following:

- Categorization of the alternatives in accordance with the objectives sought;
- Definition and summary analysis of the geological aspects and engineering requirements of each of the alternatives;
- Summary analysis and quantification of the investments required for each of the alternatives.

Table A presents an assessment of the costs of implementing and operating each of the alternatives in terms of cash flow in dollar value,[1] adjusted to the beginning of the first year of implementation at a discounted rate of 7% and for a duration of 30 years (in accordance with accepted practice for viability studies of infrastructures such as roads[2]).

The table is divided into three sections in accordance with the objectives and purpose of the project:

- The first section (I) refers to **single-purpose** alternatives whose objective is solely the provision of 200 MCM/year of freshwater to Amman;
- The second section (II) refers to **dual-purpose** alternatives whose objectives are the provision of 200 MCM/year of freshwater to Amman and an additional 800 MCM/year of seawater to the Dead Sea;
- The third section (III) refers to a **triple-purpose** alternative whose objective is the provision of 200 MCM of freshwater to Amman and the conveyance of 800 MCM/year of freshwater to the Dead Sea via the Jordan River channel (all the water conveyed is desalinated at the seashore). This section includes a secondary alternative entailing the provision of 200 MCM/year to Amman, the conveyance of 700 MCM/year of seawater to the Dead Sea, and an additional conveyance of 100 MCM/year of freshwater for the partial rehabilitation of the river flow in the lower Jordan River.

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[1] All financial calculations are presented in US dollar value.

[2] This is the practice of the Ministry of Finance for economic analysis of infrastructure-related projects.

The Alternatives		NPV at a 7% rate discounted, for a period of 30 years Current value in millions of dollars as of the beginning of the first year of the project
I. Single-purpose alternatives: 200 MCM/year freshwater to Amman (no connection to the Dead Sea)		
R	water for Amman; Aqaba – Amman	3,677
M	water for Amman; Sea of Galilee – Amman	2,732
II. Dual-purpose alternatives: 800 MCM/year seawater/desalination reject-brine to the Dead Sea; 200 MCM/year freshwater to Amman		
R1	**"Upper pipeline" from Red Sea – continuous**	**6,142**
R2	"Lower pipeline" from Red Sea – continuous	6,684
R3	"Upper tunnel" from Red Sea – continuous	6,547
R4	"Lower tunnel" from Red Sea – continuous	8,103
M1	From the Mediterranean Sea via Qumran – continuous flow	5,128
M2	**From the Mediterranean Sea via Beit She'an – continuous**	**4,492**
III. Triple-purpose alternative: Provision of 200 MCM/year freshwater to Amman; Conveyance of 800 MCM/year freshwater to theDead Sea via the Jordan River channel.		
M3	Freshwater from the Mediterranean Sea via Beit She'an – continuous	7,386
III. Triple-purpose secondary alternative: Provision of 200 MCM/year freshwater to Amman; 100 MCM/year freshwater to the Jordan River channel; and 700 MCM/year seawater/desalination concentrate to the Dead Sea		
M2a	From the Mediterranean Sea via Beit She'an – continuous	5,251

Table A: Net present value as of the beginning of the first year of project implementation for the various alternatives. Among the dual-purpose alternative, R1 is the least expensive of the Red Sea alternatives and M2 is the least expensive of the Mediterranean Sea alternatives (emphasized); the difference between them amounts to $1,650 million.

Principal Findings:

1. Each alternative was evaluated on the basis of continuous transmission and intermittent transmission in combination with the storage of water for the purpose of electricity generation during hours of peak demand, using Israel's electricity tariffs according to demand and time of use. In this context the additional investment required for water storage and electricity generation during peak hours was assessed and measured against the present value received from sale of electricity during peak hours, paid during the seventh year of the project and calculated for the beginning of the first year of the project's implementation, at a discounted rate of 7%. According to this assessment the rates of return vary between pairs of alternatives by 33% to 68%. In other words, the additional investment, under the above conditions, is not profitable.[3] The analysis that follows will, therefore, explore only alternatives for continuous transmission.

2. The estimated indirect cost (increase in cost of the product) inherent in the scenarios that would affect the chemical industries at the Dead Sea can not be accuratly determined. This cost depends, among other factors, on the amount of water flow. The assumption for the purposes of our study is that the indirect costs would be negligible for a small flow of water. However, it could reach approximately $1,150 million (in present value adjusted to the first year of the project's implementation) in the event that the conveyance of seawater and its byproducts is of a volume that leads to the formation of a full and permanent stratification of the body of water in the Dead Sea. The Israeli side would bear approximately 65% of this cost, given the relative size of the Israeli industry compared to the Jordanian. With respect to tourism (hotels), however, we estimate an addition of $150 million (net). It follows, therefore, that the order of magnitude of indirect costs of the water conveyance project on a scale capable of stabilizing the Dead Sea water level is approximately $1 billion adjusted to present value for the first year of the project's implementation.

[3] This conclusion is not necessarily applicable to all situations; various planning alternatives are possible – in terms of volume of conveyance and the routes and level of storage – that could alter the economic calculations regarding the profitability of including water storage for electricity supply during peak hours.

The Alternatives		[1]	[2]	[3]
		NPV of the direct cost of the project for its two principal objectives	NPV of the direct cost of stabilizing the water level of the Dead Sea	NPV of the direct and indirect costs of stabilizing the water level of the Dead Sea
		At 7% discount rate for 30-year period		
		Millions of dollars as of the beginning of the first year of the project's implementation		
R1	From Red Sea – "upper pipeline"	6,142	4,612	5,612
R2	From Red Sea – "lower pipeline"	6,684	5,154	6,154
R3	From Red Sea – "upper tunnel"	6,547	5,017	6,017
R4	From Red Sea – "lower tunnel"	8,103	6,573	7,573
M1	From Mediterranean Sea via Qumran	5,128	3,598	4,598
M2	From Mediterranean Sea via Beit She'an	4,492	2,962	3,962

Table B: Present value of the costs of dual-purpose alternatives at the beginning of the project's implementation. (1) The direct costs of the project for its two components; (2) The direct costs of approximate stabilization of the Dead Sea level only (deducting the costs of providing freshwater to Amman); (3) The direct and indirect costs of stabilizing the Dead Sea water level (deducting the combined negative values for industry and tourism). The manner of calculation is presented in detail in the full document in Chapter 8.3 and Table 8.7.

3. With respect to the single-purpose alternatives whose objective is solely to provide freshwater to Amman (Category I in Table A), we see that alternative R (Aqaba-Amman) is more expensive than alternative M (Sea of Galilee-Amman and desalination at the Mediterranean seashore) by $945-1,030 million. It follows that the cost of water in Amman would reach approximately $1.5-1.6 and $1.1-1.2 per cubic meter, respectively. That is, the Mediterranean

Sea alternative is less expensive by approximately $0.4 per cubic meter and amounts to a savings of approximately $80 million per year.

4. With respect to the dual-purpose alternatives that include provision of 200 MCM/year to Amman and conveyance of 800 MCM/year of sea water/ reject-brine to the Dead Sea (Category II in Table 1), the findings may be summarized in two key values: the direct costs of implementing and operating the project with respect to its two components, and the inclusive costs of the component of stabilizing the water level of the Dead Sea (Table 2, columns 1 and 3, respectively). The inclusive costs are supplemented by a rough estimate of the indirect costs resulting from the effects of the change of the lake's level on the chemical industries and hotels, and they are reduced by the estimated value of the profit derived from desalination and the conveyance of freshwater to Amman. The direct and indirect costs of the approximate accomplishment of the objective of stabilizing the water level of the lake are of the order of magnitude of $5,612 and $3,962 million for the optimal alternative from the Red Sea and from the Mediterranean Sea, respectively (Table 2, column 3).

5. The difference in costs between the optimal alternatives from the Red Sea and from the Mediterranean Sea in present value adjusted to the beginning of the first year of the project's implementation discounted by 7% for a period of 30 years is $1,650 million (Tables A and B).

6. Regarding the triple-purpose alternative that combines rehabilitation of the lower Jordan River with provision of freshwater to Amman and approximate stabilization of the water level of the Dead Sea (Category III in Table A). The findings focus on the direct costs of implementing and operating the project with respect to its three components as compared to those of the parallel alternative having only two components (alternatives M3 and M2 in Table 1, respectively). The estimated direct cost of alternative M3 in present value as of the beginning of the first year of the project's implementation is $7,386 million (Table A). By crediting the value resulting from provision of 200 MCM/year of freshwater to Amman and debiting the indirect cost depreciated in the case of conveyance of freshwater to the Dead Sea, we derive the overall cost of achieving the objectives of rehabilitating the lower Jordan River and providing freshwater (not saltwater) to the Dead Sea: $6,281 million. This

alternative is more expensive than the M2 alternative by approximately $2,319 million. The higher cost can apparently be attributed to realization of the objective of rehabilitating the lower Jordan River and stabilizing the Dead Sea water level by means of freshwater. The additional cost of the alternative of conveyance of freshwater (M3) can also be attributed to the removal of a great deal of the uncertainty inherent in the project entailing the conveyance of seawater/reject-brine to the Dead Sea.

7. In order to complete the picture, we also examined a triple-purpose alternative that includes partial rehabilitation of the lower Jordan River through the conveyance of 100 MCM/year of freshwater. The basis for calculations was alternative M2 with the addition of desalination of 100 MCM/year diverted to the Sea of Galilee to flow into the Jordan River channel. That is, in this secondary alternative, entitled M2a, the amount of seawater/reject-brine conveyed in a tunnel/pipeline parallel to the Jordan River is reduced from 800 to 700 MCM/year, and instead 100 MCM/year of freshwater would be conveyed through the Jordan River channel to the Dead Sea. The estimated direct cost of this alternative, in present value as of the beginning of the first year of the project's implementation, discounted by 7% for a period of 30 years, is $5,251 million (Table 1). By crediting the value derived from provision of 200 MCM/year of freshwater to Amman and debiting the indirect cost of the project, we find that the overall cost of partial rehabilitation of the lower Jordan River and approximate stabilization of the Dead Sea water level is $4,721 million. The additional cost of this alternative compared to M2 totals $759 million – an addition that is relevant to the benefits of partial rehabilitation of the lower Jordan River.

8. A single-purpose process is also conceivable, with the sole objective of partial rehabilitation of the lower Jordan River. Such a process, if limited to the quantity discussed above, would not require a conduit and could be based on reducing the transmission of freshwater from the Sea of Galilee westwards via Israel's National Water Carrier. In this case the annual alternative cost would equal the cost of desalination of approximately 100 MCM at the Mediterranean shoreline. Assuming that the cost of desalination is approximately 65 cents/cubic meter, and at a discounted rate of 7% for a

period of 30 years, the cost would be roughly on the order of magnitude of that noted above: approximately $750 million.

9. In addition to the lower costs that would be incurred, the Mediterranean Sea alternatives have advantages in terms of the water pumping-facility sites and the sites for their introduction to the Dead Sea. The possibility of combining the pumping of water to the conduit with the pumping of cooling water at one of the major power stations could reduce expenses and the loss of shoreline. Conveyance of seawater/reject-brine to the northern Dead Sea could have an advantage in terms of damage to the chemical industry that is concentrated at the southern portion of the lake. It is reasonable to assume that the phenomena likely to result following the addition of seawater to the Dead Sea would be moderated in the southern Dead Sea, where the original Dead Sea water is pumped for industrial purposes. The Mediterranean Sea alternatives also have the advantage of possible inclusion of rehabilitation of the lower Jordan River.

10. The costs specified in this document are approximate estimates for a project on a scale roughly half that of the conveyance examined by the World Bank, adopting the low electricity costs used by the World Bank, which are characteristic of the costs in the Kingdom of Jordan. These facts are significant for consideration of the overall costs of the project but not for the purposes of comparison among the alternatives and their relative costs for achieving the project's objectives.

Without taking into account considerations of profitability, cost, or funding sources, and considering the probability of a Jordanian undertaking that would have the support of other governments and international institutions to promote the Red Sea alternatives, it is appropriate to address the relevant implications of the project and develop an approach for Israel. The following observations are relevant in this regard:

a) The concrete version of this project now being assessed by the World Bank is sometimes termed the "Peace Conduit." This name indicates that cooperation among Israel, Jordan, and the Palestinian Authority is the salient aspect guiding Israel with respect to the initiative for the stabilization of the water level of

the Dead Sea in general and with respect to the RSDSC version in particular. In the direct context of this salient aspect as it relates to Israel, it should be recalled that the RSDSC version in its various alternatives is a "package" that includes, in addition to the objective of stabilizing the water level of the Dead Sea, the provision of freshwater to the region of Amman, Jordan's capital. From the Jordanian perspective this additional objective is critical. If this version of the project is not implemented, Israel could consider – for political reasons – allocating waters from the Sea of Galilee to the Kingdom of Jordan for a reasonable (or symbolic) price, to be supplemented by desalination at the Mediterranean Sea shore, as at least a partial solution to Amman's water deficiency problems (a possibility examined below in the context of alternative M).

b) The methodology employed here is a "cost effectiveness" assessment. At the same time it should be noted that while stabilization of the Dead Sea water level undoubtedly has benefits that are difficult to quantify, we should be attuned to the likelihood of negative-value outcomes on the chemical industries operating at the Dead Sea. Israeli industries would share the risk of negative-value outcomes with Jordanian industries, yet Israel would carry the lion's share of this risk, in accordance with its larger relative share of the industries on both sides of the Dead Sea.

c) Given that Israel is likely to suffer harm as a result of the construction of the conduit, it should be a full partner in preparation of the project, including the designation of routes and procedures for modular implementation and oversight (such as those proposed in this study) in order to minimize the risks. Moreover, this project will require an international treaty that would commit all the governments and bodies engaged in constructing the conduit to agree to take all necessary measures to minimize risks and control damage. These measures could include the cessation of an ongoing process and/or not advancing to the next stage in the event of indication of substantive negative effects on the Dead Sea and direct and/or indirect damage to Israel.

d) From Israel's perspective, supplementing the rehabilitation of the drainage basin of the southern Jordan River for the purpose of stabilizing the level of

the Dead Sea entails significant negative-value outcomes. The calculations presented here do not include the indirect negative environmental outcomes entailed in the large-scale desalination that would be required at the Mediterranean seashore. The ideas that have been put forward for substantive rehabilitation of the Jordan River using the waters saved by neighboring countries do not appear feasible to the authors of this document. The possibility of importing water from northern Mediterranean countries may reduces environmental degradation but entails technological, political, and economic uncertainties that make implementation doubtful.

e) In light of the substantive current and future uncertainties, which remain even following the comprehensive and thorough assessment of the World Bank, this document unequivocally recommends that if it is decided to pursue this project, it should be implemented in a modular manner. Modular implementation is thus not another alternative but rather a fundamental component of planning and an integral part of any plan to further pursue this project. Planning for modular implementation, in terms of stages, quantities of flow, desalination, and rate of implementation, must first and foremost accommodate uncertainties and possible negative scenarios. It is recommended that a portion of the plans be dedicated to comprehensive consideration of the modular nature of implementation, including monitoring the consequences of each stage and taking into account the minimal amount of time needed to ascertain and study the consequences of each stage before deciding whether to advance to the next stage. Finally, it is recommended that the planning of the project includes an organizational structure to oversee modular implementation, detect problems, assess their severity, and take decisions (which might be quite difficult) regarding progress to the next stage or, should it be necessary, suspension of the project in the event serious damage is indicated.