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Ashkelon seawater desalination project — off-taker's self costs, supplied water costs, total costs and benefits

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Abstract

Total desalinated water costs to the Israeli Government, the "off-taker", from the Ashkelon seawater desalination plant consist of the contracted water costs at the plant's battery limits plus the government's own expenditures: a) its initial investments (tender administration, out-of-plant infrastructure required to integrate the product within the national and regional water supply systems, etc.), b) its annual infrastructure O&M, supervisory and administrative costs, and c) the projected additional costs associated with certain project risks assumed by it throughout the life of the project. The paper presents and reviews these risks and quantifies the Government's anticipated direct and indirect, fixed and variable costs, including several cost escalation scenarios anticipated due to the linkage of the contracted water price to various indices (using an item by item and index by index cost sensitivity analysis). The escalated desalinated water costs are then compared to the similarly anticipated but differently escalating costs of other water sources in Israel, to project, long-term, the resultant gap. The benefits foreseen from the project, and particularly those related to its specific site location, and its mandated daily, monthly and annual water supply schedules and product quality, are presented against: a) the background of Israel's current water supply system's water sources' sustainable capacity, reliability, quality and costs, b) the anticipated growth in demand by various consumer sectors and c) the continuous deterioration of groundwater quality. The resulting risk and cost-benefit analyses are relevant not only to the Ashkelon project, which, as the first large scale government sponsored seawater desalination project in Israel, is a pioneering case study, but also to all pending and future seawater desalination projects in Israel. Some of these are not and will not be BOT, as the Ashkelon project was, but BOO and turnkey contracts, but, though government's participation and the division of project risks may vary, the key cost-benefit issues, from the government's point of view, will remain the same. In this context, Israel's overall seawater desalination program, which is currently fixed at 315 million m^3/y by 2010, and its role within the Israeli Water Commission's long-range planning are briefly reviewed.

Keywords: Desalinated seawater costs; Desalinated seawater benefits; Desalination project risks; Israeli water supply and demand; Israeli conventional water supply costs; Israeli desalination program

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1. Introduction

The Ashkelon project pioneers large-scale seawater desalination in Israel. It will test not only the last word in desalination technology but also the government's new policy of privatizing the country's water sector. The plant's performance, costs and reliability, as well as the short and long term results of its BOT method of contracting, will thus be watched closely throughout the following years by all involved Israeli government ministries and agencies, including the Water Commission and the Water Desalination Administration whom I represent.

In fact, as all of us within the water sector in Israel know, the initiation of the project represented a major shift in the Israeli government's, and particularly the Ministry of Finance's position relating seawater desalination. For more than a decade the Ministry of Finance resisted the call of most water experts in Israel to supplement the country's conventional water supply sources by incorporating new, large seawater desalination plants. The Ministry's preferred solution to the national water crisis was to divert supplies from the agricultural sector, which had been the major potable water consumer, preferably by cutting demand through the rationalization of its subsidized water prices, i.e. increasing them to cover actual production and delivery costs, or, in the face of political opposition, by rationing.

Three main factors led to this change in position:

1. The repeated cycles of multi-year droughts that plagued the country, combined with the continuing and even accelerating growth in the price-inflexible demand by the municipal sector, reduced water levels and threatened the quality of all the major natural water storage reservoirs;
2. The allotments of water to the agricultural sector reached such a critically low level that they could not serve further as a source for meeting the disparities between available renewable supplies and municipal demand; and, most importantly:
3. The dramatic reduction in desalinated seawater costs due to recent advances in the reverse osmosis technology — the huge improvements in the performance, prices and reliability of the main items of equipment, membranes, high pressure pumps, energy recovery systems, etc.

It is this third factor, costs and/or costing, that is the main theme of this conference. I will, therefore, concentrate on these costs, as they relate specifically to the Ashkelon project. I will deal not only with the contracted water prices at the plant's battery limit, but also with our estimates for all other, government assumed, project costs. The sum of these costs, throughout the duration of the BOT contract, including an allowance for potential cost escalations under various inflationary scenarios, will be compared with the project's expected benefits and the costs of alternative water sources.

To present the resulting figures in the proper context, I will first discuss briefly Israel's overall water quality and supply and demand situation that underlies the first two factors noted above and the role of desalination as a whole within the Water Commission's long-range planning.

2. Israel's current and projected water supply sources, capacities, quality and costs

Table 1 presents the average annual capacities and quality ranges of Israel's current water supply sources.The main points brought out by this table are:

1. Israel's total annual renewable natural water sources amount to about 1,600 million m^3/y.
2. Israel's average potable water supply quality is characterized by relatively high TDS and chloride concentrations and extreme hardness.
3. Long-term monitoring by the Israel Hydrological Service indicates that the chloride,

Table 1
Capacities and quality ranges of Israel's current water supply sources

Source	Average annual replenishment and/or availability (million m^3/y)	Quality range		
		TDS (ppm)	Chlorides (ppm)	Hardness (ppm as $CaCO_3$)
Sea of Galilee	470–600	450–650	180–250	200–245
Yarmuk River	25–70			
Mountain Aquifer	300–350	100–700	50–400	
Coastal aquifer	240–300	200–1,200	100–700	50–750
Eastern Basin	250–350		25–2,000	
Other water sources*	200		20–900	
Total natural water	1,480–1,870			250–350
Recycled wastewater	300–500	650–1,500	170–500	250–350
Total all available water sources (2010)	1,785–2,370			

*Other aquifers and basins (Galilee, Carmel), floodwater, etc.

sodium, and nitrate levels in the main groundwater supplying aquifers are increasing annually at alarming rates due to agricultural irrigation and recharge with higher salinity Sea of Galilee water. These rates are expected to grow due to the increased usage of even higher salinity treated municipal wastewater.
4. Localized contamination of groundwater by pesticides, heavy metals and various industrial pollutants is, likewise, on the increase.

Table 2 presents the actual costs map for Israel's current water supply sources. The main points brought out by this table are:
1. Current natural potable water costs, as a function of their source (Sea of Galilee or aquifers) and location within the distribution grid, vary from 15 US¢/m^3 to 45 US¢/m^3.
2. The cost of water delivered by the National Carrier to the south of Israel is 30–35 US¢/m^3 without filtration costs and 37–45 US¢/m^3 including filtration costs. It is this specific cost, as well as the water quality, that should be compared to the Ashkelon plant's desalinated seawater cost and quality (see Section 9 below).
3. More relevant to national water planning is the comparison of desalinated seawater costs not with the average, historical, costs of existing potable water supplies, but with the costs of producing, treating and/or conveying new, alternative, potable water sources.
4. The main such alternative potable water source today (see comment in Section 3 below concerning the only marginal potential contribution of brackish water desalination, which costs 40–60 US¢/m^3) is desalinated municipal wastewater, with all its psychological public acceptance problems (even if its introduction is indirect, via aquifer recharge). It is seen that the full cost of this option is on the same order as seawater desalination: 50–60US¢/m^3.

3. Israel's overall seawater desalination program and its role within the Water Commission's long-range planning

Table 3 presents Israel's projected water demand by the various user sectors, according to quality. Table 4 presents the Water Commission's corresponding sources of supply.

Table 2
Israel's current water costs by source and location

Source	Cost (US¢/m^3)
Sea of Galilee water via National Carrier	
@ the National Carrier pumping station outlet at the Sea of Galilee	15
@ the National Carrier central filtration plant outlet near Nazareth*	25
@ the urban centers in the north of the coastal plain	28–30
@ the urban centers in the center of the coastal plain	32–35
@ urban centers in the south of the coastal plain (e.g. Ashkelon)	37–45
Mountain aquifer water	
@ well pump's discharge	25–30
@ at the inlet to regional water systems or the National Carrier	30–40
Coastal Aquifer water	
@ well pump's discharge	10–15
@ at the inlet to regional water systems or the National Carrier	15–25
Brackish well water	
@ well pump's discharge	10–15
@ direct users of brackish water	15–25
Desalinated brackish water	
@ desalination plant outlet (including brine disposal)	35–50
@ at the inlet to regional water systems or the National Carrier	40–60
Conventionally treated wastewater	
@ conventional treatment plant outlet after tertiary treatment**	0
@ potential agricultural users' sites (including storage and losses)	35–45
Desalinated wastewater	
@ treatment plant after desalination (including brine disposal)	30–40
@ potential users' sites after desalination and aquifer recharge	50–60
Others — floodwater catchments and aquifer recharge, water import, etc.	15–80

* Once the filtration plant, required to assure surface water quality, is put into operation.
** As required for disposal to the environment or agricultural reuse — treatment costs are born by the water users/polluters.

The main points brought out by these tables are:

1. Israel's utilization of its natural potable water sources is complete (almost 100%). Further increases on the supply side have to be through the development of non-conventional sources.
2. In fact, utilization of natural potable water sources over the past 15 years has exceeded natural replenishment, and this overuse has led to depletion of reserves and dangerously low aquifer levels. These aquifers must be rehabilitated within any long-range planning to avoid further quality deterioration due to saline water intrusion and to assure meeting targeted supply reliability goals. 100–200 million m^3/y of potable water, over ten years, have been allocated by the Israeli Water Commission for replenishing these reserves.
3. Brackish water sources near Israel's population centers and regional and national water grids are scarce and few and, therefore, of limited use in meeting the growing gap between supply

Table 3
Israel's projected water demand by water quality and user sectors (in million m^3/y)

Year	2005	2010	2015	2020
Agricultural				
Potable water	530	530	530	530
Brackish water	160	140	140	140
Treated wastewater	300	500	600	700
Total	**990**	**1,170**	**1,270**	**1,370**
Industrial				
Potable water	85	90	95	100
Brackish water	40	40	40	40
Treated wastewater	0	5	13	15
Total	**125**	**135**	**148**	**155**
Domestic				
Potable water	720	840	960	1,080
Nature conservation	25	50	50	50
Aquifer rehabilitation				
Potable water	100	200	0	0
Neighboring entities	100	110	130	150
Total demand	**2,060**	**2,505**	**2,558**	**2,805**

Table 4
Seawater desalination within Israel's projected sources of water supply (in million m^3/y)

Year	2005	2010	2015	2020
Potable water				
Natural sources	1,470	1,470	1,470	1,470
Desalinated brackish water	30	50	80	80
Desalinated seawater	100	315	500	650
Sub-total	**1,600**	**1,835**	**2,050**	**2,200**
Brackish water	160	140	140	140
Treated wastewater	300	450	520	600
Total	**2,140**	**2,425**	**2,710**	**2,910**

and demand. Increased desalination of brackish water requires tapping new saline sources that will not disturb the underground balance and interface between potable and high-salinity bodies of water. Desalting brackish water that is used currently by industry and agriculture for non-potable water uses will not add to the overall water balance, but will only ameliorate the (further) salinization of soil and ground-water, assuming proper locations for brine disposal, at a reasonable cost, are found.

4. The same will be true if treated wastewater currently used for agricultural irrigation, nature conservation and landscaping is desalinated

and incorporated into the potable water system, notwithstanding public opposition, through aquifer replenishment.

5. Agricultural use of potable water has been consistently reduced over the past five years and replaced by treated wastewater. This trend will continue as a matter of policy. The current level of irrigation with potable water is approaching a critical minimum. It will be limited to highly sensitive areas where aquifer contamination is a clear danger and will not be able to serve as a reserve for periods of drought.
6. The only practical source for large scale additional potable water is seawater desalination.
7. The Planning Division of the Israeli Water Commission has consequently developed and submitted to the Government a ten-year program (capacities, locations, time frame, budgets, etc.) for the desalination of a total of 500 million m^3/y of seawater by 2015.
8. This quantity will represent then about 25% of total potable water supply in Israel, and, together with the 80 million m^3/y of desalinated brackish water that will also be added to the system, about 28%.
9. To improve the quality of municipal water supplies, with whom the desalinated water will be preferentially blended, including the reduction of hardness, chlorides and nitrates, and, indirectly, also the quality of the municipal wastewater, which will be reused mostly for irrigation (thereby reducing the threat of soil and groundwater salinization), the ten-year plan dictates that all desalinated water in Israel must have a chloride concentration of only 10–80 ppm max. Boron concentration, which, likewise, threatens some sensitive important crops, is also limited in the plan to 0.4 ppm.
10. At this point in time, the Government has approved the construction of seawater desalination plants with a total output of 315 million m^3/y by year 2010.
11. The Ashkelon 100 million m^3/y plant, whose overall costs are presented in this paper, is the first step in implementing this program.

4. The Ashkelon desalination plant's projected benefits

The main benefits to be gained from the Ashkelon plant are:

1. Improvements in municipal water supply quality
2. Savings in pumping energy required to deliver water from the north
3. Increased water supply reliability

4.1. Improvements in municipal water supply quality

The Ashkelon plant's guaranteed water quality after post-treatment will be:

TDS	300 ppm max
Cl	20 ppm max
Na	40 ppm max
B	0.4 ppm max
pH	7.5–8.2
Langlier Index	0–0.5
Turbidity	0.5 NTU max.

The blending of this water with the National Carrier's at its nearest Ashkelon junction will significantly reduce the TDS, chloride and sodium concentrations in the regional water supplies, and most importantly their hardness and nitrate levels.

Domestic consumers will benefit from the softened water supply through a) reduced scaling and extended lifetimes of electric and solar water heaters and all house piping, particularly hot water piping; b) savings in household soap, laundromats and dish washers detergents, ion-exchange softening resins and regeneration salts; c) avoiding dried spots on dishes; and d) softer and cleaner laundered clothes.

Industrial consumers will save on their water softening and demineralization costs (1/3 of all the water used by Israeli industry is currently softened) and particularly on the high costs of disposing spent ion exchange regeneration solutions to approved sites (discharge to sewers is forbidden by law), on heat exchanger, hot water pipes and other equipment maintenance costs, and on cooling towers inhibitor costs.

The lower salinity municipal water supply will result in lower chloride and sodium levels in the municipal wastewater which is destined to be reused for irrigation, thus reducing damages to crops and soils. Wastewater usage by the agricultural sector could consequently be reduced by 15–20% from current requirements, which include such an excess in order to rinse salt concentrations from the crops' root zones.

The low nitrate levels will enable, through blending, the use of high nitrate well water. These would otherwise require nitrate removal by electrodialysis (ED), ion exchange or reverse osmosis. Israel's drinking water standard for nitrates has recently been tightened from 90 to 70 ppm max, and as soon as is practical will be further reduced to 45–50 ppm max. These limits make 30%, and will make as much as 60% of all coastal aquifer wells non-potable.

The value of all these benefits has been calculated by the Water Commission's consultants, ADAN Technical & Economic Services Ltd., Tel Aviv, as 5–15 US¢/m^3, depending on local water quality, its blend ratio with desalinated water and types of consumers. In the south of Israel, where a) water supplies consist of a mix of National Carrier water and local well waters with relatively high salinity and hardness, b) the blend ratio of Ashkelon plant product with this mixture will be high and c) consumers include the large municipal areas of Beersheva, Ashkelon, Shderot and Ofakim as well as all the chemical industries in the Negev, we have estimated a water quality improvement benefit of about 11US¢/m^3.

4.2. Savings in pumping energy required to deliver water from the north

The introduction of the Ashkelon plant's product to the National Carrier will reduce the amount of water delivered from the north and save about 3 US¢/m^3 in current pumping energy costs.

4.3. Increased water supply reliability

Continuous use of the Ashkelon plant's output will help maintain higher water levels in all the natural reservoirs and particularly the coastal aquifer, which serves as the long-term, multi-year capacitance for overcoming droughts. This will increase overall water supply reliability and enable the Water Commission, which controls water use and specific allotments to the various sectors, to maintain its target reliability of 85%. The alternative is reduction of annual water allotments with its consequences on economic activity.

Water levels in the smaller, regional, man-made reservoirs and their reliable and efficient use will also improve due to the scheduling of daily and monthly water outputs from the Ashkelon plant to conform to seasonal demand (and seawater temperature) variations (see Fig. 1 [1]).

We have estimated the value of the benefits from the total water supply reliability increase due to the Ashkelon plant, conservatively, on the basis of the incomes generated by the increased productivity of the lowest paying economic activity, agriculture, rather than the incomes generated by higher priority and more economic sectors such as tourism and industry. If water allotments to agriculture over a typical 10-year hydrological cycle are not cut as a result of the Ashkelon plant's added water supply by, say,

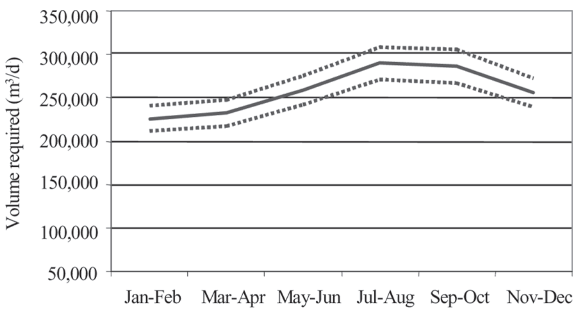

Fig. 1. Ashkelon plant's scheduled daily output according to month of year.

100 million m^3, then, using, again conservatively, the economic contribution of the least profitable crops, which will be the first to be curtailed, at 12 US¢/m^3, the benefits will total 12 million USD or 1.2 million USD/y, average, and 1.2 US¢/m^3 of supplied desalinated water.

That these are conservative low figures is borne out by recently published figures relating to the current average economic value of irrigated agricultural products per unit of water in Israel. Due to increased irrigation efficiency and the shift to higher value crops, this figure has increased by about 300% since 1970 and reached 25 US¢/m^3, i.e. about double the economic contribution figure used above.

The total value of all above benefits, as summarized in Table 5, is seen to be about 15 US¢/m^3.

5. The Ashkelon plant's contracted water costs

The Ashkelon plant's base total water price (TWP), averaged for the outputs of the two separately contracted 50 million m^3/y units and broken down into a base fixed price and the components of a base variable price, are shown in Table 6.

The fixed price will be paid bimonthly at a base rate of about NIS 21,900,000 each two months. The variable price will be paid as a function of actual water delivery.

Table 5
The Ashkelon desalination plant's projected benefits

Benefit	Unit value		Annual value	
	NIS/m^3	US¢/m^3*	10^6 NIS/y	10^6 USD/y
Improving water supply quality	0.490	11	49.0	11
Savings in pumping energy	0.133	3	13.3	3
Increased water supply reliability	0.053	1.2	5.3	1.2
Total	**0.676**	**15.2**	**67.6**	**15.2**

*In September 2004 exchange rate of 4.45 NIS/USD

Table 6
The Ashkelon plant's average base total water price

Cost item	NIS/m^3	US¢/m^3*	% of TWP	Linkage
Base fixed price	1.315	31.1	59.2	CPI
Base variable price				
Energy	0.565	13.4	25.4	electricity price**
Membranes	0.120	2.8	5.4	CPI & USD/NIS exchange rate
Filters	0.020	0.5	0.9	"
Chemicals	0.090	2.1	4.1	"
Post-treatment	0.040	0.9	1.8	"
Others	0.070	1.7	3.2	"
Subtotal	**0.905**	**21.4**	**40.8**	
Base total water price (TWP)	**2.220**	**52.5**	**100.0**	

*At the relevant base exchange-rate of 4.23 NIS/USD
**The "required revenue per kWh" as published by the Israel Public Utility Authority – Electricity

Base prices mean the prices at times of contracts signature — 25.11.01 for the first 50 million m^3/y unit and 20.8.02 for the second 50 million m^3/y unit. These prices are linked to the indices shown in the last column of Table 6. The linkage formulae dictate the following sensitivity of the TWP to variations in the respective indices:

a) each 1% change in the Israeli Consumer Price Index (CPI) will change the TWP by about 0.65%;
b) each 1% change in the electricity price approved by the Public Utility Authority – Electricity (increase or decrease) will change the TWP by about 0.25%;
c) each 1% change in the USD/NIS exchange rate will change the TWP by about 0.09%.

In September 2004 the adjusted TWP, taking into account all cost escalations as of the above contract signature dates, was 2.56 NIS/m^3 or, at 4.45 NIS/USD, 57.5 US¢/m^3.

6. The government's assumed project risks

The government's main assumed project risks are:

1. The necessary idling of plant capacity
2. Cost escalations
3. Uninsured events of force majeur
4. Costs related to termination of project due to events of default by seller.

6.1. Government requested idling of plant capacity

The government expects, conservatively, that during the life of the project, particularly after the current deficits in all natural reservoirs (the Coastal and Mountain Aquifers and the Sea of Galilee) have been made up by the continuous operation of all government contracted seawater desalination plants, there will be periods of extreme rainfall that will result in full or even overflow storage capacity. These situations will require the idling of some of the Ashkelon plant's capacity, since the contracted variable price of its desalinated water exceeds the variable costs of supplying water from all the available natural sources. (Note: During such periods of government-initiated idling of plant capacity, the government is required to pay only the fixed price component of TWP).

Based on long-term rainfall records it has been estimated that such idling will add up, cumulatively, to no more than 4 months of full plant capacity every ten years (120 months) or about 3% of total available plant capacity. An allowance for this expense has been made, accordingly, by adding 3% to the value of the fixed cost component of TWP, which will be paid also during the idling of the plant. At the current value of this component, the added cost is about 0.0455 NIS/m^3 or 1.0 US¢/m^3.

6.2. Cost escalations

The higher specific energy consumption of seawater desalination vis-à-vis the energy consumption in supplying water from other water sources in Israel (listed in Table 2 above), 3–3.4 vs. 0.4–1.0 kWh/m^3, means that energy cost escalations, that will correspond mainly to fuel price escalations, will increase the gap between the cost of the Ashkelon plant's product water and the costs of water from these alternative sources.

Furthermore, the capital recovery components of most alternative water sources costs in Israel (e.g. the National Carrier) relate to very long-term, sunk-cost investments which, unlike the capital recovery component of the Ashkelon desalination plant's TWP, are not linked to the CPI and/or the NIS/USD exchange rate and will not escalate with them.

All in all, not only is the Ashkelon plant's Base TWP higher than the costs of existing water supply sources, but the project is also significantly more sensitive to cost escalations. Should such escalations materialize, the average overall cost of water in Israel will be driven increasingly higher by the escalating desalinated seawater costs, and, if these will not be passed on to consumers, government subsidies will be required, with all their budgetary implications.

6.3. Uninsured events of force majeure

The government has assumed responsibility for risks associated with damages to the plant and/or non-performance of the contractor's responsibilities under the water sale agreement as a result of events of force majeure that do not fall within the insurance coverage required by the agreement. The definition of force majeure in this context includes war, terrorist activities and other events that are exceptional, unforeseen and beyond reasonable control, but excludes events such as shortage of materials, strikes and labor disputes, inclement weather and suspension and/or termination of permits and licenses. The government will compensate contractor for the direct costs (only) incurred by it as a result of delays in fulfilling its obligations due to an event of force majeure and in case of delays exceeding 180 days and the resultant termination of the agreement will assume its payment obligations to the project's financing organizations.

We have estimated, using tree based risk analysis techniques, that the government's exposure to these risks can be covered by a "self-insurance policy" with an annual premium of about 0.004 of the average outstanding debt on the plant throughout the life of the project. A corresponding allowance (or reserve) of about 2.6×10^6 NIS/y or 0.6×10^6 USD/y, equivalent to 0.026 NIS/m^3, or 0.6 US¢/m^3, has, accordingly, been set aside and added to the plant's TWP.

Though these figures are based on our subjective estimates of fault and event probabilities and resultant cost consequences, and other "guesstimates" would result in different expectancies or "premiums", it is our belief that had the government not assumed these force majeure risks (which, of course, may never materialize), all bidders would have protected themselves through higher allowances, penalizing bid and contracted water prices even more heavily.

6.4. Costs related to termination due to events of default by seller

To reassure lenders and facilitate the financing of the project, the government has obligated itself to compensate the contractor should it terminate the agreement due to any of a series of contractor default events by either the fair market value of the plant or an amount equal to the aggregate of all amounts owed to the financing organizations, the lesser of the two above sums.

We estimate that the government's exposure due to this risk can, similarly, be covered by a "self-insurance policy", but with a higher annual premium, about 1% of the average outstanding debt on the plant throughout the life of the project. The allowance for this premium is, correspondingly, about 6.5×10^6 NIS/y or 1.5×10^6 USD/y, equivalent to 0.065 NIS/m^3, or 1.5 US¢/m^3.

7. The government's Ashkelon plant related self costs

The government's direct initial investments in the Ashkelon project are shown in Table 7.

The contribution of these investments to the government's annual and unit water costs, including interest during construction, is exhibited

Table 7
The government's initial investments in the Ashkelon project

Item	Cost	
	NIS	USD*
Tender administration and construction supervision	7×10^6	1.6×10^6
Out-of-plant infrastructure		
Product storage	10×10^6	2.3×10^6
Product pumping station	30×10^6	6.7×10^6
Interconnection pipe to National Carrier	60×10^6	13.5×10^6
Other investments	1×10^6	0.2×10^6
Subtotal	**101×10^6**	**22.7×10^6**
Total	**108×10^6**	**24.3×10^6**

* In September 2004 exchange rate of 4.45 NIS/USD

in Table 8 together with budgeted government-incurred annual project-related costs and the allowances for government assumed risks identified in Section 6 above. It is seen that the government's total assumed costs add 8.9 US¢/m^3, or about 15.5%, to the current contracted TWP (2.56 NIS/m^3 or 57.5 US¢/m^3).

8. The government's current and projected TWC

The current (September 2004) total cost of desalinated water from the Ashkelon plant, consisting of contracted TWP and the government's own project related costs, is 66.4 US¢/m^3, as shown in Table 9.

These current total water costs were projected over the full life of the project on the basis of the following alternative scenarios and assumptions:

1. The electricity price approved by the Public Utility Authority will increases over the life of the project by:
   a. 0% — no change
   b. 25% — average 1% per year, uncompounded
   c. 50% — average 2% per year, uncompounded.
2. Average Israeli CPI increases over the life of the project will be:
   a. 0% — no change
   b. 50% — 2% per year, uncompounded
   c. 100% — 4% per year, uncompounded
3. The changes in the rates of exchange of the NIS/US dollar will correspond to the differences between the Israeli CPI and the US CPI, and over the life of the project these differences will be:
   a. 0% — no difference
   b. 25% — average 1% per year, uncompounded
   c. 50% — average 2% per year, uncompounded

Table 8
The government total assumed project costs

Item	Annual costs or allowance		Unit costs		% of TWC
	NIS/y	USD/y	NIS/m^3	US¢/m^3	%
Initial investments*					
Administration and supervision	0.6×10^6	0.1×10^6	0.006	0.1	0.2
Out-of-plant infrastructure	9.0×10^6	2.0×10^6	0.090	2.0	3.5
Subtotal	**9.6×10^6**	**2.1×10^6**	**0.096**	**2.1**	**3.7**
Annual running costs					
Chlorination	0.9×10^6	0.2×10^6	0.009	0.2	0.4
Product pumping	14.0×10^6	3.1×10^6	0.140	3.1	5.4
Infrastructure O&M	0.9×10^6	0.2×10^6	0.009	0.2	0.4
Supervisory and administrative	0.9×10^6	0.2×10^6	0.009	0.2	0.3
Subtotal	**16.7×10^6**	**3.7×10^6**	**0.167**	**3.7**	**6.5**
Allowances for costs related to government assumed project risks					
Necessary idling of plant capacity	4.5×10^6	1.0×10^6	0.045	1.0	1.8
Uninsured events of Force Majeur	2.6×10^6	0.6×10^6	0.026	0.6	1.0
Costs related to termination due to default by Seller	6.5×10^6	1.5×10^6	0.065	1.5	2.5
Subtotal	**13.6×10^6**	**3.1×10^6**	**0.136**	**3.1**	**5.3**
Total	**39.7×10^6**	**8.9×10^6**	**0.397**	**8.9**	**15.5**

* At an exchange rate of NIS/USD 4.45, 25 years amortization period and 7.5% annual interest (as used by the Israeli Ministry of Finance to evaluate the feasibility and economics of all state supported infrastructure projects).

Table 9
The Ashkelon plant's current total water costs

Item	Annual costs or allowance		Unit costs	
	NIS/y	USD/y*	NIS/m^3	US¢/m^3*
Current (September 2004) contracted total water price (TWP)	256×10^6	57.5×10^6	2.56	57.5
Government assumed costs	40×10^6	8.9×10^6	0.40	8.9
Total desalinated water cost	**296×10^6**	**66.4×10^6**	**2.96**	**66.4**

*In September 2004 exchange rate of 4.45 NIS/USD

For the worst case scenario, a combination of all assumptions (c) above, the total cost of the Ashkelon plant's desalinated water at the end of the project, including government costs, will reach 4.76 NIS/m^3, or 75 US¢/m^3 at the exchange rate that will exist at that time under the above assumptions. The corresponding projected costs of water supplies to the Ashkelon area from natural sources will be 2.5–3.2 NIS/m^3, or 40–50 US¢/m^3. The gap between the costs of these sources could potentially increase, therefore, from its current value of 0.96–1.31 NIS/m^3, or 21–27 US¢/m^3, to 1.6–2.2 NIS/m^3, or 25–35 US¢/m^3, a 20–30% increase.

9. The long-term cost-benefit equation

The current gap between the cost of natural water supplies in the south of Israel and total desalinated seawater costs from the Ashkelon plant, about 25 US¢/m^3 average, narrows to about 10 US¢/m^3 if the benefits from this higher quality water, as developed in Section 4 above, are introduced into the equation. This is shown in Table 10.

Though, as shown in Section 8 above, this gap will grow with time under most scenarios, we expect that so will the value of the benefits from the use of the higher quality desalted water from the Ashkelon plant (and all other seawater desalination plants constructed henceforth). Potable water supplies to agriculture have already been reduced to the barest minimum (the "agricultural sector's iron ration"), and the consumers of all additional, critically required water will soon be only households and industry, who already today pay for their existing and inferior-quality

Table 10
The Ashkelon plant's cost-benefit figures

Item	Annual costs or allowance		Unit costs	
	NIS/y	USD/y	NIS/m^3	US¢/m^3*
Contracted base total water price**	256×10^6	57.5×10^6	2.56	57.5
Government self costs	40×10^6	8.9×10^6	0.40	8.9
Total desalinated water cost	**296×10^6**	**66.4×10^6**	**2.96**	**66.4**
Desalinated water benefits	68×10^6	15.2×10^6	0.68	15.2
Net desalinated water cost	**228×10^6**	**51.2×10^6**	**2.28**	**51.2**
Average current Ashkelon area water supply costs	185×10^6	41.0 ×10^6	1.85	41.0
Difference	**43×10^6**	**10.2×10^6**	**0.43**	**10.2**

* In September 2004 exchange rate of 4.45 NIS/USD
**As of September 2004

water almost twice the current total desalted water cost. The economic consequences of water shortages to these consumers, whose demand is currently growing at a rate of 20–30 million m^3/y, will be significantly higher than the conservative values (based on lowest value crops) assigned to them in Section 4 above.

One point is clear: Israel's current, let alone future economic activities and standards of living require this additional high quality water and, more importantly, can afford it.

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References

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