ground water

Case Study/

Asymmetric Abstraction and Allocation: The Israeli–Palestinian Water Pumping Record

by Mark Zeitoun[1], Clemens Messerschmid[2], and Shaddad Attili[3]

Abstract

The increased attention given to international transboundary aquifers may be nowhere more pressing than on the western bank of the Jordan River. Hydropolitical analysis of six decades of Israeli and Palestinian pumping records reveals how ground water abstraction rates are as asymmetrical as are water allocations. The particular hydrogeology of the region, notably the variability in depth to ground water, variations in ground water quality, and the vulnerability of the aquifer, also affect the outcome. The records confirm previously drawn conclusions of the influence of the agricultural lobby in maintaining a supply-side water management paradigm. Comparison of water consumption rates divulges that water consumed by all sectors of the farming-based Palestinian economy is less than half of Israeli domestic consumption. The overwhelming majority of "reserve" flows from wet years are sold at subsidized rates to the Israeli agricultural sector, while very minor amounts are sold at normal rates to the Palestinian side for drinking water. An apparent coevolution of water resource variability and politics serves to explain increased Israeli pumping prior to negotiations in the early 1990s. The abstraction record from the Western Aquifer Basin discloses that the effective limit set by the terms of the 1995 Oslo II Agreement is regularly violated by the Israeli side, thereby putting the aquifer at risk. The picture that emerges is one of a transboundary water regime that is much more exploitative than cooperative and that risks spoiling the resource as it poisons international relations.

Introduction

The particular set of challenges related to the allocation and management of international transboundary ground water was considered in detail in the volume 43 special issue of *Ground Water*, notably Jarvis et al. (2005), Matthews (2005), and Eckstein and Eckstein (2005). The social, political, and legal aspects of ground water abstractions considered collectively in that body of work are gaining ever more prominence globally, as evidenced by two upcoming conferences devoted to the subject in the second half of 2008 in Tripoli and Kampala. The political tensions that may arise from borehole pumping may be nowhere more pressing than on the banks of the Jordan River, where ongoing negotiations between Palestinians and Israel seek for a second time to resolve the allocative conflict over one shared river, several small wadis, and four large aquifers, as shown in Figure 1. The region's hydrogeology has been discussed from technical, legal, social, and political economy perspectives (e.g., Rosenthal et al. 1999; Daibes-Murad 2005; Palestinian Water Authority [PWA] 2004; Feitelson 2006). However, to understand variations in ground water abstraction within Israel and Palestine, it is essential to understand the wider context of water use and allocation. "Hydroschizophrenia" is the term used by Nace in the 1970s and rejuvenated by Jarvis et al. (2005) to describe the incoherent distinction between surface water and ground water

[1]Corresponding author: Grantham Institute on Climate Change and the Environment, London School of Economics and Political Science; +44 207852 3618; fax +44 207 955 7412; m.zeitoun@lse.ac.uk

[2]Independent Hydrogeologist Ramallah, West Bank.

[3]Negotiations Support Unit, Adam Smith International, West Bank.

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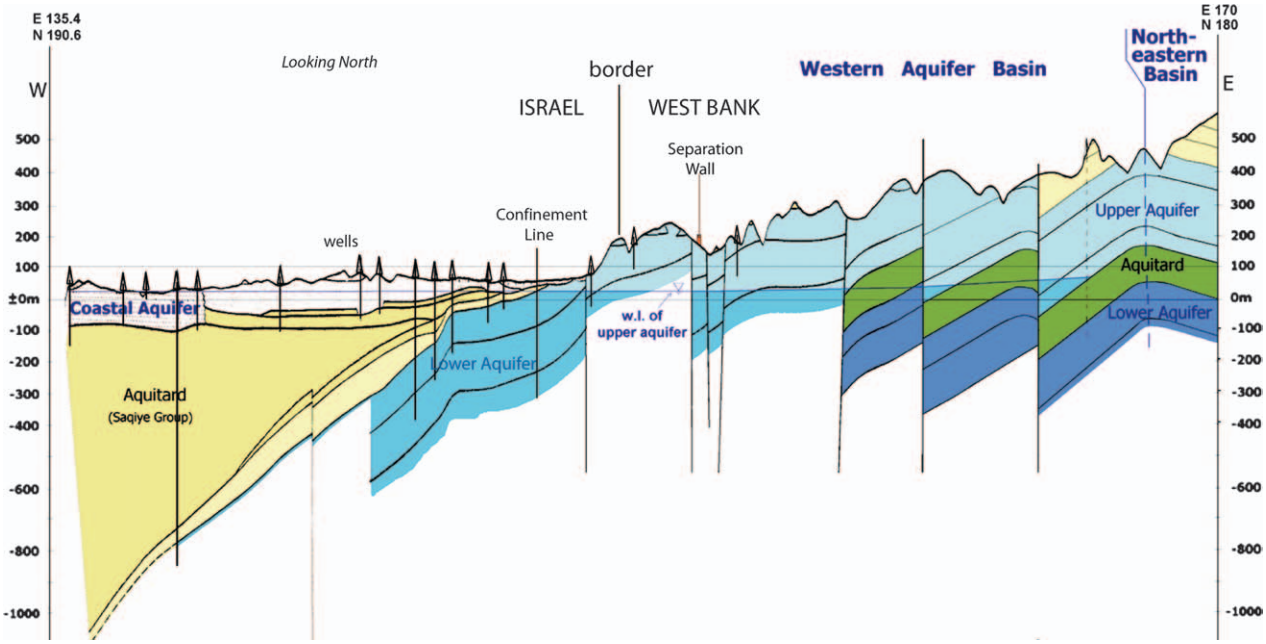

Figure 1. Surface water and ground water resources shared by Palestinians and Israel. Note: Pre -1967 wells on Palestinian side must reach deeper to lower aquifer than the more numerous and modern wells on the Israeli side. Asymmetric abstractions result in the primary accumulation and production areas migrating westward. Based on Messerschmid (2004).

management regimes so prevalent throughout the world. Considering that both sources are managed conjunctively and somewhat coherently in the case at hand, the potential diagnosis is that all are "normal." Behind this apparent engineering success, though, lies a relatively reckless management regime and a highly asymmetrical allocation that risks spoiling the water resource as much as poisoning international relations.

At the heart of this most enduring and famous of water conflicts is the 90% to 10% distribution of surface water and ground water transboundary flows in Israel's favor (Phillips et al. 2005). The purpose of this article is to deepen our understanding of the Palestinian-Israeli water conflict through a hydropolitical analysis that is informed by the highly detailed historical nationwide water pumping records as well as the hydrogeological situation. The Hydrological Service of Israel (HSI) has for more than 50 years been collecting and publishing statewide water production and consumption data. This and other partial sources of data have attracted several notable studies, including Turton (2003), Allan (2001, 146, 249), Thomas (2004), and Fischhendler (2008). The focus received by this relatively small but immensely political land has resulted in a fairly well-documented history of the environmental, institutional, and (chiefly) political drivers that have shaped both the domestic water policy and the international water conflict. Pumping and politics in the region, it would appear, are inseparable.

Overview of the Hydrogeology and Hydropolitics

Basic Hydrogeology

The extent of the four transboundary aquifers lying under the political borders of Israel and Palestine is shown in Figure 1, and their relative allocations are given in Table 1. By far, the highest capacity of the four are the Coastal Aquifer and Western Aquifer Basins (WAB),

Table 1
"Existing Extractions, Utilization, and Estimated Potential" according to the Terms of the Oslo II Agreement, Schedule 10 (MCM/year)

	Israeli		Palestinian				
Resource	**Wells**	**Springs**	**Wells**	**Springs**	**Total**	**Estimated Potential**	**Remainder**
WAB	340		20	2	362	362	0
Northeastern Aquifer Basin	103		25	17	145	145	0
EAB	40	No mention	24	30	94	172	78
Coastal Aquifer Basin	Not defined						
Jordan River	No mention						

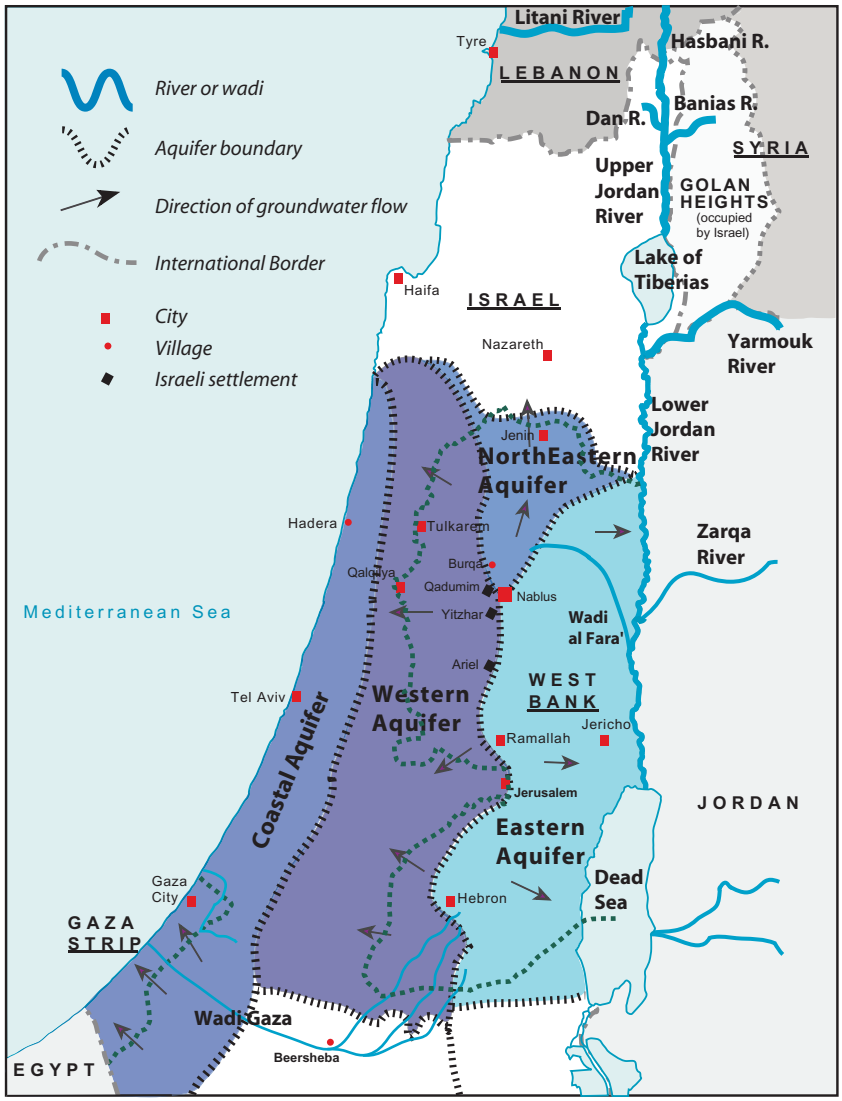

Figure 2. Basin formations and water levels in the Coastal Aquifer and WABs (near Tulkarem). Note: Pre-1967 wells on Palestinian side must reach deeper to lower aquifer than the more numerous and modern wells on the Israeli side. Asymmetric abstractions result in the primary accumulation and production areas migrating westward. Based on Messerschmid (2004).

a cross section of which is provided in Figure 2. As in so many other locations along the Mediterranean Sea, the Coastal Aquifer Basin has experienced severe sea water intrusion. Within the Gaza Strip, it is also susceptible to Eocene saline intrusion from adjacent and deeper aquifers in Israel (Vengosh et al. 2005; Weinthal et al. 2005) and nitrate contamination from agriculture and untreated waste water (SUSMAQ 2001a; al Farra and Amani 2005). With a hydraulic configuration corresponding to a "Model D" in Eckstein and Eckstein's (2005) conceptualization, Gaza is essentially "downstream" of Israel. The contamination suffered in Gaza poses no risk on ground water quality in Israel. Thus, while being the site of severe misery for inhabitants of Gaza, the Coastal Aquifer Basin does not draw the significant contention from the Israeli side so prevalent with the "upstream" WAB.

The water conflict in the WAB is shaped to a large extent by the folded karst limestone geology of the West Bank and Israel's foothills. As the main portion of what is often referred to as the "mountain aquifer" (which also includes the Eastern Aquifer Basins [EABs] and North Eastern Aquifer Basins), the Western Aquifer is by far the most valuable ground water resource in terms of both quantity and quality. Recharge in the Western Aquifer is the highest and most reliable, averaging between 350 and 400 MCM/year (Hughes et al. 2008). The karstic, high permeability of the aquifer has a direct bearing on the management of the ground water resources: ground water gradients are relatively flat, meaning that the water table can be several hundreds of meters below ground level in the more mountainous areas, individual borehole yields can be very high where they intersect conduit systems, and the aquifer can be highly vulnerable to contamination at outcrop.

Also configured as a "Model D" aquifer (Eckstein and Eckstein 2005), the aquifer's exposure in the West Bank outcrops makes it particularly vulnerable to surface contamination from Palestinian villages, towns, and

cities, and illegal Israeli settlements alike (Tagar et al. 2004; Rinat 2008). Thus far, only some local contamination has been detected (e.g., pollution in the Tulkarem area), but the threat is imminent. Hydrogeologists are growing weary of warning policymakers that by the time it is detected, it will be too late to do anything about it.

The WAB is also the site of the most extreme asymmetric Palestinian and Israeli abstraction rates. Israeli pumping superiority in the basin was guaranteed after its capture of the West Bank in 1967 and the implementation of pumping restrictions on the Palestinians immediately following it (el Musa 1997, chap. 4; Messerschmid 2005). The hundreds of wells sunk ever deeper on the Israeli side, and the increasingly greater capacity of vertical line shaft pumps, has given Israel a clear "hydraulic supremacy" over Palestinians, who rely on a few dozen aging low-capacity wells drilled before 1967 (Zeitoun 2008, figure 3.2). The 94% and 6% allocation of the basin and overabstractions from the Israeli side are the main sources of tensions here, as we see in the subsequent analyses.

Internal Tensions over Water

The international water conflict is informed also on both sides of the border by internal tensions within them. The political nature of internal Israeli water allocative policymaking described by Soffer (2002), Shnell (2001, 215), and the candid 2002 Israeli Parliamentary Committee of Inquiry (PCIIWS 2002) exposes quite a tense domestic scene. Water resource managers and academics tactically (and only temporarily) align with the Ministry of Finance in their call for economic costing of water. Environmentalists, meanwhile, lobby for preserving return flows (FOEME 2005, 2006). The agricultural lobby has an apparently unslakeable thirst for more subsidized water, as well as the political support and savvy to back this up (Kay and Mitchell 1998). Fischhendler (2008) discloses the consistent gap between the fresh water allocation caps placed on the agricultural sector by the Israel Water Commission (IWC) and the regular breach of these caps during wet years upon pressure from the lobby.

The internal Palestinian divisions are just as strong and perhaps more debilitating. Lingering tensions have formed between traditional well-owning families or municipalities and the strongly centralized and newly formed PWA, formed in 1995 (el Musa 1997). The effects of state-imposed central management on the traditional West Bank irrigation and water-sharing systems, for instance, has resulted in duplication or nonsensical water infrastructure projects, due also in part to interference from competing international donors (Trottier 1999). Indeed, almost since its inception, the PWA has suffered from a lack of both capacity and legitimacy that puts it at odds with the much better equipped and organic municipalities or the many Palestinian nongovernmental organizations that continue to fill crucial service gaps (Applied Research Institute of Jerusalem 1996; Oxfam 2003; PHG 2006). The internal tensions rarely lead to compromise solutions as with the healthy push-pull on the Israeli side (Klawitter 2006). The top-down imposing approach of the PWA reflects, rather, the same drive of international donors that other Palestinians institutions have bended to, that is, toward strong state control (Khan 2004; Keating et al. 2005). The mix of circumstances that have coevolved from interaction between the PWA donors and the Israeli state have in essence failed to "develop" the Palestinian water sector (Zeitoun 2008) to the point that the Palestinian side waits to purchase whatever water the Israeli side offers to sell to it.

Political History and Hydropolitical Eras

The span of the pumping and consumption records of Figures 3, 5, and 6 is classified into four hydropolitical eras, each of which is marked by a significant political event. The first period ranges from 1919 to 1948, during which time all of what is now the West Bank, Gaza, and Israel was administered as "British Mandate Palestine" (following the defeat of the Ottoman Empire during World War I). The State of Israel was established out of Palestine in 1948, following what Palestinians and some Israelis refer to as *al Nakba* ("the catastrophe," for the expulsion of 750,000 Palestinian civilians) and many Israelis term the war of independence. Jordan administered the West Bank during this second political period, while Gaza fell under Egyptian administration. In June 1967, Israel conquered the West Bank and Gaza (along with the Egyptian Sinai desert and the Syrian Golan Heights) during what is known as the "Six-Day War." The West Bank and Gaza were officially occupied by Israel during the third political period from 1967 until 1995, at which point the Oslo II Interim Agreement between Israel and the Palestine Liberation Organization led to limited autonomy over the lands to the newly created Palestinian Authority (PA). The fourth political period examined is the long post-Oslo decade that ends in 2006, with the effective end of the Oslo political process.

Pre-1948: The Era of Zionist Aspirations

Agriculture in British Mandate Palestine was an important source of food for the country and played a significant role in the economy (Commonwealth Office 1925; Gurevich 1930; Kamen 1991). The bulk of agricultural production by 1947 still relied on rainfall and springs, as only citrus plantations in the Coastal Plain and the Marj Ibn 'Amer (Yisre'el Valley) had larger scale irrigation schemes from ground water wells. A very rough estimate of the water thus consumed is given by British authorities as 500 MCM/year (Government of Palestine 1947). Zionist settlers arriving mainly from Europe had an eye on the resources for future state-building efforts, during what is referred to as the era of "Zionist Aspirations": "The issue of water in the Palestinian-Israeli conflict is an issue intertwined in asymmetries and power relationships, history and ideological beliefs. Not only did the early Zionists view water ideologically but they were also able to demonstrate their power over the Arab inhabitants through several schemes. The issue of water security and scarcity also played a large role in how the Zionists viewed and how Israel views water and the necessity to control it and

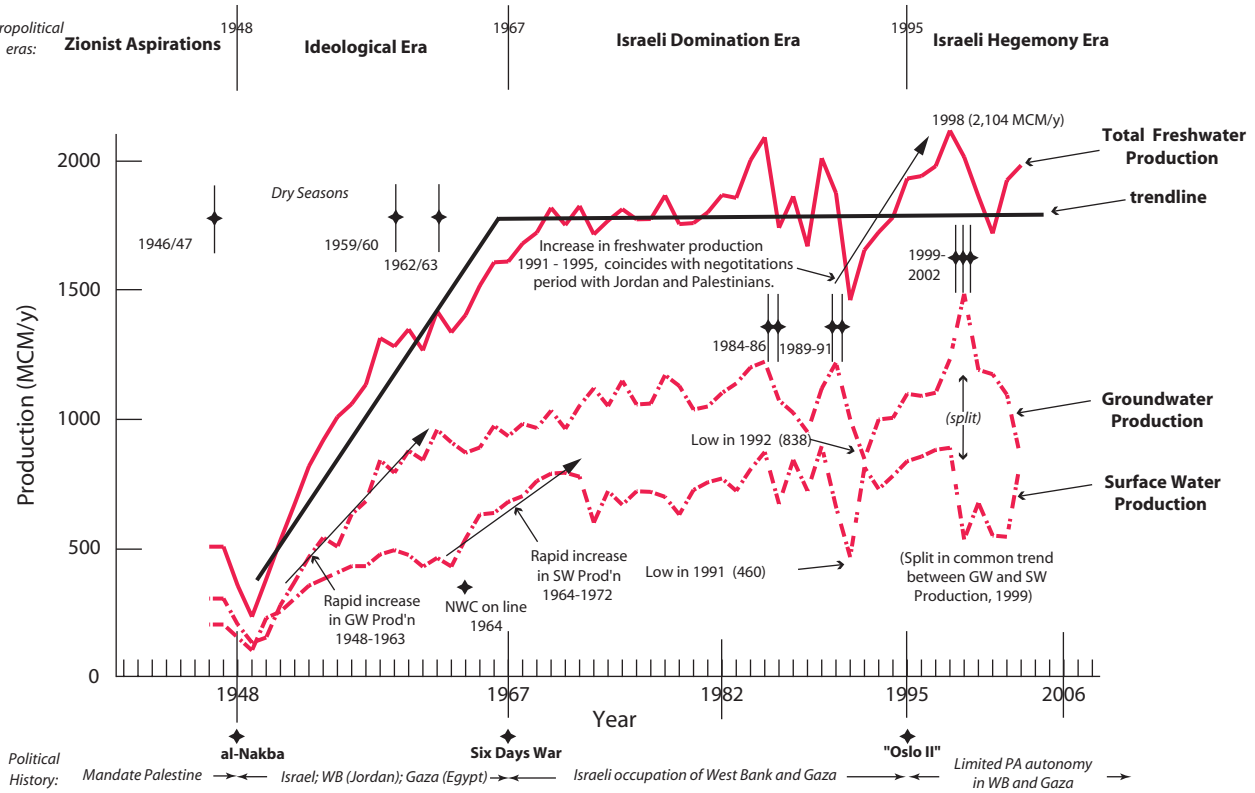

Figure 3. Fresh water production in Israel, 1948 to 2003. Note: Data mainly from IWC (2002). Fresh water production figures do not include production from waste water reuse or desalination techniques.

reluctance to share it. There is a kind of psychological scarcity, a scarcity of resource in the eye of the beholder" (Dinar 2003, 190). Declassified correspondence from the UK National Archives certainly attests to the ideological zeal of the early European settlers. World Zionist Organization chairman Weizmann had requested British and French authorities to include the Lebanese Litani River in Palestine (Foreign Office 1920), while the British authorities failed to prevent the settlement in the Negev desert and the illegal pumping of wells and laying of transmission lines from Gaza (Commonwealth Office 1937, 1938; Government of Palestine 1947).

1948 to 1967: The Ideological Era

The second hydropolitical era spanning from 1948 until Israel's conquest in the June 1967 war is termed the "ideological era" for the Israeli state's ambitious and successfully completed "hydraulic mission," that is, the state's drive to provide water for all its sectors. Feitelson and Haddad (2000, 345) speak of this period as the Israeli "resource expropriation era," which others have described as "[Zionist] ideology *dictated* water development. No plan for a new agricultural settlement was ever abandoned only because the cost of supplying water was too high" (Galnoor 1978, 345 [original emphasis]). With improvements in pumping technology, ground water development was the focus during this period and started with the easy to reach resources of the Coastal and WABs. Following the well-known Syrian-Israeli tensions and fighting, and the 1950s Johnston hydrodiplomatic mission (Frederiksen 2003), Israel in 1964 managed to exploit the surface water by damming the Lake of Tiberias and building the National Water Carrier (NWC). It was during this period that the HSI started to record data, having issued its first "Hydrological Year Book" in 1951.

1967 to 1995: The Era of Israeli Domination

The Israeli territorial acquisition and Arab states' losses in June 1967 resulted in a radical altering of the Jordan River Basin's hydropolitical map. Feitelson and Haddad (2000, 350) accentuate the importance of power relations between the two entities from the outset of this period: "The outcome of the six-day war changed both the hydrostrategic relationship of Israel and her neighbours, and the power balance between them. …This change in Israeli hydrostrategic situation and its evident military superiority effectively prevented the Arab side from challenging Israel's water plans or use." Indeed, a set of military orders effectively preventing development of water resources by Palestinians helped to maintain the superiority (el Musa 1997, chap. 4; Messerschmid 2005). The June 1967 war was not, however, motivated primarily by water resources (Rouyer 2000; Medzini 2001). Nonetheless, Israel's conquest of the entire territory on both shores of the Upper Jordan River, the head water of the Banias River, the west shore of the Lower Jordan River, and perhaps most important, the Western, North Eastern, and EABs, has had demonstrable effects on Israel water planning and practice, as we shall see.

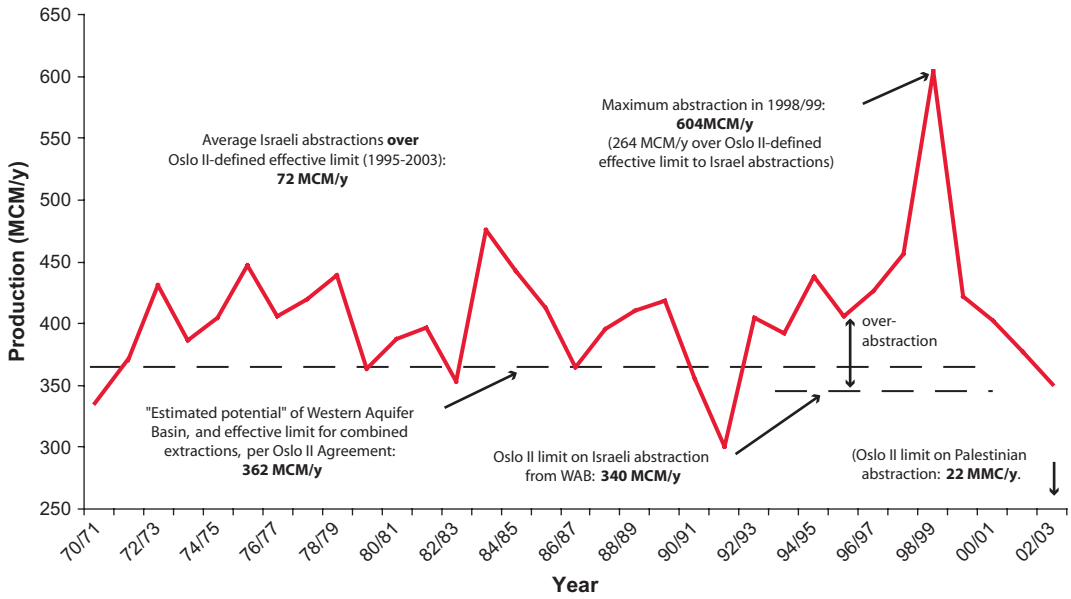

Figure 4. Israeli well and spring abstractions from the Western Aquifer Basin, 1970 to 2005. Note: Data from HSI (2004, 138). (1970/1971 data corrected).

1995 Onward: The Era of Israeli Hegemony

The fourth hydropolitical period is defined as one of Israeli *hegemony* for its formal and sharp break with the occupation period by way of the 1995 Oslo II Interim Agreement signed between the state of Israel and the Palestine Liberation Organization. The agreement was temporary and ultimately did not result in the establishment of Palestinian sovereignty over the West Bank and Gaza. With consent from Palestinian officials, the agreement did, however, shift the burden of responsibility for

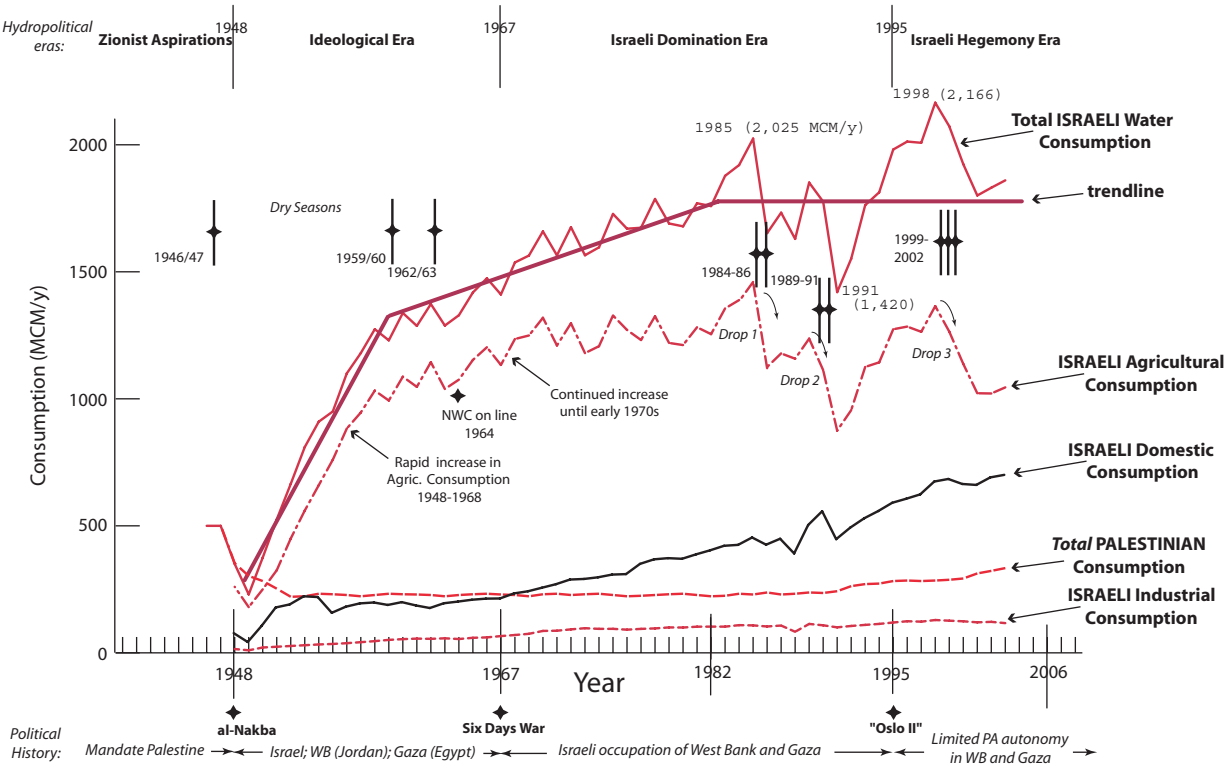

Figure 5. Comparison of Palestinian and Israeli consumption rates, 1948 to 2003. Source: Data mainly from IWC (2002). Palestinian data from GOP (1947), GTZ (1998), USAID (2002), and PWA (2003b, 2003c). Total water consumption and agricultural consumption include water produced through waste water treatment and desalination techniques from 1993 onward (roughly 200 MCM/year), explaining why the consumption figures here are in some cases greater than the production figures of Figure 3. Palestinian production through these methods is currently negligible.

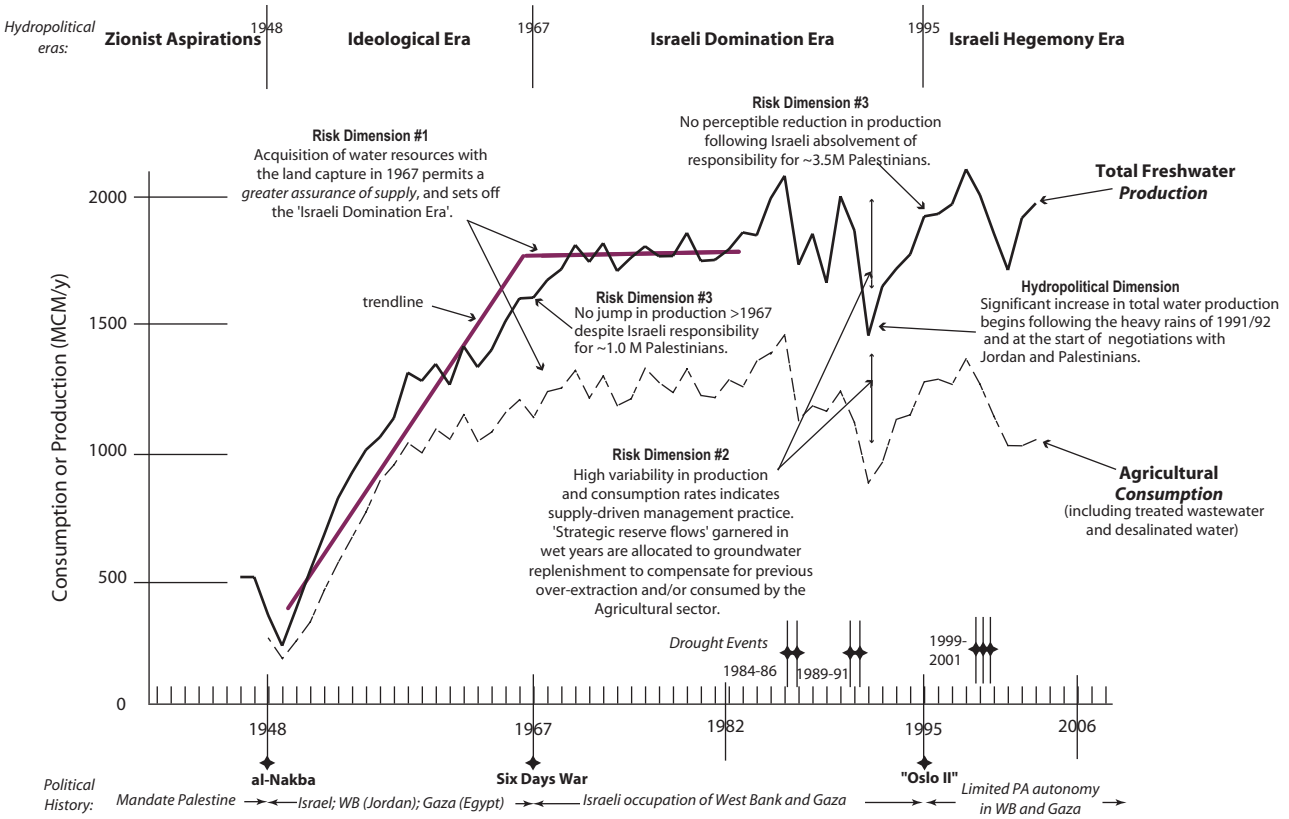

Figure 6. Israeli fresh water production and agricultural consumption showing four power-related dimensions of the water conflict. Source: Data mainly IWC (2002). Agricultural consumption figures include water produced through waste water treatment and desalination techniques from 1993 onward (roughly 200 MCM/year). Total fresh water figures do not.

provision of most basic services (education, health, welfare, and water) to the newly formed Palestinian government—
the PA. In the immediate wake of Oslo II, "Palestine" and Israel were by and large considered by the international community as formal equals. The dominative means of Israeli control over the West Bank and Gaza during the occupation were replaced with the softer hegemonic means of control, which are dependent on Palestinian consent (Zeitoun 2008), for instance, to cross-border trade arrangements skewed in Israel's favor (Khan 2004). The subsequent interaction between the multiple elements that compose the Israeli water sector and the newly formed PWA at the Joint Water Committee has been pointedly described as "domination dressed up as cooperation" (Selby 2003). Gordon (2008, 25) describes recent Israeli unilateral efforts are "a reorganisation of power in the territories in order to continue controlling the resources"—what Falah (2005) calls the "enclavisation" of the territory.

Water and the Oslo II Agreement

The water-related clauses of the 1995 Oslo II Agreement focus solely on ground water resources. Paragraph 3a of article 40 of the Oslo II Agreement lays out the principles of the water-sharing agreement according to the "existing quantities of utilization" plus additional quantities that the Palestinian side could develop from the EAB. The unstated rationale for such an arrangement was that all basins (except the EAB) were being fully exploited by 1995 and could not/should not be further developed. Schedule 10 of the Agreement also details "existing extractions, utilization and estimated potential" of each aquifer, as shown in Table 1. The quantity set aside for the Palestinians from the EAB was the full amount of the "remaining quantities" from that basin—78 MCM/year.

Not all the water allocated according to Table 1 is "equal." The roughly 94% (Israeli) and 6% (Palestinian) split of the WAB refers, as we have discussed, to the most reliable water supply in the region in terms of quality and is the cheapest to access and develop. The ground water of the more equitably shared EAB is of variable quality but has less reliable recharge and is more difficult to exploit. Schedule 8 of the Agreement further stipulates that "the increase of extraction from any water source, by either side, shall require the prior approval of the JWC", referring to the previously discussed Joint Water Committee. Taken together, the provisions of article 40 and schedules 8 and 10 render the usage quantities of Table 1 *effective limits* on abstraction for each side within the West Bank. Additional wells in the same aquifers on the Israeli side of the border are not, crucially, subject to Joint Water Committee deliberations. Abstraction above and beyond the Oslo II–defined usage quantities without the

approval of the JWC may subsequently be considered violations of the Agreement. We will note considerable evidence questioning the derivation of the figures of Table 1, and of their violations, as we proceed with the analysis of water production and consumption.

Israeli Water Production, 1948 to 2003

The water production records of the HSI distinguish between what is termed "boreholes" (ground water abstracted through wells) and surface water. So-called "new" water sources such as treated waste water, brackish ground water, and desalination are excluded from the water production record, though these are certainly not inconsequential in terms of the potential resolution of the conflict. The focus of this section's discussion is on ground water production, as shown in Figure 3.

Description and Analysis of Israeli Ground Water Production

Perhaps the most striking aspect of the production curves in Figure 3 is the great increase in Israeli ground water production during the "Ideological Era" from 1948 to 1967. The middle curve of the figure shows that ground water production increased from roughly 300 to 1000 MCM/year during this period, characterized by Zionist ideological objectives and facilitated by innovations in pumping technology. Israeli national objectives, and contestation with Syria and Jordan over control of the Jordan River.

As discussed, ground water was the only source of water to which the new State of Israel had uncontested access during this period. The leveling off of the ground water production curve during the "Israeli Domination Era" from the 1970s reflects attempts by Israeli water professionals to preserve the natural resource and the increased ability of the state to meet the water demand through the pumping of surface water (particularly from 1964 onward, as we shall see). The same period also marked the beginning of the internal Israeli water allocation tensions. The significant drought events of 1984 to 1986 and the corresponding initial caps imposed on abstractions by the agricultural sector are reflected in Figure 3 by the first drop in ground water production. The events seem to mark the beginning of the widely varying Israeli ground water pumping volumes that continue until the present. The 1989 to 1991 drought period was followed by the "century rain" (up to 2 m in some parts of the country) during the winter of 1991/1992.

Analysts have offered two perspectives to explain the steady growth in ground water production during the 1990s (with a high reached in 1998). A hydrological perspective considers the conjunctive use of surface water and ground water. This is most notable during 1992 and 1999 when ground water production is dramatically reduced due to a surplus of surface and soil water. The pumping of surface water during wet years and ground water during dry years is not "schizophrenic" but ultimately a gamble that heavy rains will always follow droughts.

Allan (2001), by contrast, approaches these changes from a hydropolitical perspective. He suggests that the increase in ground water withdrawals were a response to Israeli perceptions of a heightened risk of losing control of some of this water, in light of the negotiations it was entering with both Jordan and the Palestinians in the early 1990s (Allan 2001, 210). Whether or not it is driven more by hydrogeology or by politics, Israeli production from the WAB has since 1991 consistently surpassed the Oslo II–defined effective limits, as we shall see.

Analysis of Total Ground Water and Surface Water Production

Unlike the rapid and unobstructed development of ground water during the "Ideological Era," Israeli development of surface water sources in mid century was obstructed by the political wrangling of the demands of the Johnston mission (1953 to 1956) and the clashes with Syria (1964 to 1966). Surface water production (lower curve of Figure 3) increased dramatically upon completion of the Israel NWC in 1964. Taking water from the Lake of Tiberias (aka Lake Kinneret) at more than 200 m below sea level to distribute throughout the country, operation of the NWC resulted in a near doubling of surface water production over the following 8 years.

Comparison of the ground water, surface water, and total production curves of Figure 3 reveals interesting features in relation toward Israeli water policy vis-à-vis Palestine. The upper curve shows a strong relation between total water production and each of the four distinct hydropolitical eras. Total fresh water production increased steadily during the "Ideological Era," leveled off at the beginning of the "Israeli Domination Era," and has been erratic since that time, hovering widely around 1750 MCM/year. This link between total Israeli fresh water production and hydropolitical events is not readily explained away as coincidence.

The total production curve of Figure 3 also shows how production from the two main sources of fresh water have continued since 1964 in a conjunctive (and apparently lagged) manner—at least until the late 1990s. Surface water is typically more responsive than ground water both to variations in rainfall and to changes in policy. This may be not least of all simply because the flows are more visible and open to critical public scrutiny than is ground water. The water levels of the lake of Tiberias, it is widely acknowledged, may be as closely followed by environmental groups and the media as they are monitored by the scientists at the Kinneret Limnological Laboratory. Winter rains threatening to overspill the Alumot Dam at the lake and empty "unused" into the Lower Jordan River inevitably brings pressure on the water managers, as we shall see. Ground water resources are continually relied upon to fill the supply gap. The sharp decrease in surface water production by the late 1990s, driven mainly by dropping lake levels (Thomas 2004), was made up by increased production of ground water. The heavy rains contribute to artificial aquifer recharge by filling the aquifers naturally, of course, at the same time as

they reduce the demand upon the ground water. Unlike surface water, ground water seems responsive to policy driven by public pressure (and internal pressure from Israeli water planners) only following extended drought periods.

Israeli Overabstraction from the WAB

Israeli abstractions from the WAB are given in Figure 4, which is based on the data and a similar graph provided by the HSI. We observe that Israeli abstractions from wells and springs greatly exceed the 340 MCM/year—stipulated as the effective limit of Israeli abstraction in Oslo II—on average by 72 MCM/year from 1995 to 2005. This quantity does not include Palestinian production from the same aquifer, which was roughly 22 MCM/year before considering the reduction in Palestinian pumping due to the Separation Wall built inside the West Bank in 2002 (Gregory 2004; OCHA 2007; Messerschmid 2007b). Just as somberly, the unceasing production is much greater than the "estimated potential" defined in Oslo II as 362 MCM/year (HSI 2004, 138). Israeli abstraction from the WAB in 1998/1999 alone was 582 MCM/year. This is more than 1.5 times the suggested capacity of the resource and nearly equivalent to the *entire* volume of water consumed by Palestinians from all sources during the same year (Figure 5).

The data lead to two potential conclusions relating to politics, negotiating tactics, and the sustainable pumping hydrogeological debate. The concept of safe yield and sustainable limits of aquifers is highly contested, with Bredehoeft (1997) responding to Sophocleous, asserting the irrelevancy of aquifer recharge rate to sustainable pumping rates, in what is known as the *water budget myth*. Devlin and Sophocleous (2004) usefully draw the distinction between hydrogeologically defined "sustainable pumping" and broader sustainable water resources management. It is this latter issue that is in question here. First, the WAB's Oslo II–defined "potential" of 362 MCM/year is considerably lower than the basin's actual limits of sustainable development. The "McKenzie" review of studies on recharge to the WAB (SUSMAQ 2001b) ranges from 318 (1958 estimate) to 366 MCM/year. The Bachmat (1995) estimate of 330 MCM/year refers solely to the upper aquifer of the WAB, and other estimates, such as Rofe and Rafferty's figure of 836 MCM/year, are based on methodological errors related to political jurisdiction. The only integrated ground water flow model for both the coastal plain and the slopes and mountains (as chief recharge area), in SUSMAQ (2003, 2004), comes to long-term recharge values much closer to the actual observed and measured long-term average outflows of the basin of 389 MCM/year safe yield (and over 400 MCM/year expanded yield). The new process-based recharge modeling of Hughes et al. (2008), which includes returns from urban areas and irrigation, indicates recharge in the range of 287 to 430 MCM/year, with most confidence in the upper estimates.

The second possible conclusion is that the "estimated potential" is within the limits of the resource itself but is being pushed recklessly beyond these. The 362 MCM/year figure cited in the Oslo II Agreement may contestably be interpreted as the IWC's best guess at the aquifer's long-term sustainable yield (albeit contradicting actual measured outflows before Oslo). In that case, Israeli abstractions since the endorsement of the Agreement exceed the stipulated limit—consistently, putting the resource itself at risk. The implications for the fragility of the aquifer are considerable. The two major springs fall dry and the historical name of the aquifer—Yarkon-Taninim—no longer reflects the reality (Rinat 2008). The reduced outflow and lowered ground water levels also increase the risk of saline water being drawn into the northern part of the aquifer. But the damage is not only restricted to the land on the Israeli side of the border. The few, older, and shallower Palestinian wells inside the West Bank decrease in yield as water levels fall below pump installation levels, thus depriving Palestinians of their already minor share, especially during drought periods (Messerschmid 2007a). Furthermore, asymmetric pumping on either side of the border and lowering of water levels are already having an effect on the primary accumulation and production areas, which as we saw in Figure 2 are migrating westward. Abstracting ground water from the WAB in Israel thus becomes easier, while in the West Bank it becomes more difficult.

Given the confusion, it is perhaps not surprising to find in a recent poll taken of members of the Israeli Water Engineers Association that "over 96% of all respondents thought the water sector is in crisis, and over 91% thought that severe or very severe damage was caused to the water resources" (Feitelson 2005, 417). Selby's (2007) characterization of the Joint Water Committee as a forum for "joint mismanagement," it would appear, holds fast. These violations of the letter of the Oslo II Agreement occur in a broader political context that is structured more by power asymmetry than by balance of powers or the rule of law. Schedule 8 of the Oslo II Agreement places conditions on abstractions above the "existing use" limits to joint Palestinian and Israeli approval at the JWC. But while the JWC has been proven effective at monitoring abstractions within the political borders of the West Bank, it is not mandated to monitor—let alone control—abstractions from within Israel. Sole responsibility for monitoring or controlling the abstractions on the Israeli side of the border lies with the IWC. The IWC, for its part, is caught up in the domestic allocation politics between the different consumption sectors.

Israeli and Palestinian Water Consumption, 1948 to 2003

To develop a cohesive analysis of ground water abstractions, the wider picture of water use must be considered. The story emerging from an examination of Israeli and Palestinian water consumption through time (Figure 5) is of the various lobby groups upon water management policy, and the internal tensions that exist

between the groups, most notably the Israeli agricultural sector. By far the largest consumer of water, the agricultural sector has always been the main force driving, shaping, and obstructing Israeli water policy. The most striking feature of Figure 5 is the rapid increase in agricultural consumption during the "Ideological Era," which corresponds with the rapid increase in ground water production (from Figure 3). Agricultural consumption rose nearly fivefold from 260 MCM/year in 1948 to roughly 1200 MCM/year by 1968. The continued—albeit slower—growth toward the end of the Ideological Era was fueled by increased surface water production, made possible in large part by the hydraulic pumping capacity of the NWC and related water works at the Lake of Tiberias. The agricultural sector began using treated waste water in greater quantities (roughly 200 MCM/year) with the operation of the Dan Treatment facility in 1993.

Of note in Figure 5 are the three significant drops in agricultural consumption in the wake of drought periods. Cuts to the sector made following the emblematic events reveal that the agricultural sector—much more than the domestic or industrial sectors—has been affected by uncertainty in supply volumes (Dery and Salomon 1997). Such "excess" water beyond the agricultural consumption fresh water cap of 530 MCM/year is readily obtained by the sector through exemptions to the cap (Arlosoroff, personal communication, 2005) and continuous pressure from the agricultural lobby to avoid or reduce rationing (Fischhendler 2008, figure 3). The highly varying consumption rates (ranging from ~800 to 1300 MCM/year) demonstrate the relative elastic nature of the agricultural sector's consumption. While the total production remains roughly the same, in other words, the agricultural sector seems to be able to cope with variations of up to 500 MCM/year. Domestic consumption by comparison is relatively inelastic. These "extra" flows available to the agricultural sector during wet periods have been characterized as Israel's "strategic reserve" (Allan 2001), while Feitelson et al. (2007, 18) term agriculture the "buffer sector." The terms reflect the role these flows play in mitigating conflict over internal Israeli allocation.

The persistent variability reveals that it is pumping rates that are determined by policy, while consumption is determined in turn by how much is produced. Another way to express what may be a self-evident conclusion is that all the water that can be produced will be consumed in a supply-side management paradigm operated perpetually at the resource's limits. The policy is understandable when it comes to drinking water but is not a foregone conclusion when related to the agricultural sector. The allocation of the "strategic reserve" flows is determined by the IWC and Water Council in the highly politicized process we have discussed. Allocation of the buffer flows during wet years is also competed for, however, by the agricultural sector, flows for aquifer recharge, flows for the environment, and flows deemed to satisfy future Palestinian domestic demand. We turn now to briefly examine the consumption of this latter, Palestinian "sector."

From Figure 5, we see that *total* Palestinian consumption pales in significance when compared with the Israeli agricultural or even domestic sectors. A closer consideration of the numbers reveals an even more imbalanced story. The rate of increase in total Palestinian water consumption has remained consistently low since 1948. There are no sharp increases in consumption (or, by extension, in production) during periods of British, Egyptian and Jordanian, Israeli, or PA rule. Minor development efforts begun by government of Jordan through the West Bank Water Department it established in 1965 ended with the Israeli occupation of 1967 but with no demonstrable effect on consumption. The substantial increase in the number of illegal wells drilled in the Coastal Aquifer Basin within Gaza following the Israeli turnover of control to the PA similarly did not translate into an increase in overall abstraction and barely registers on Figure 5.

Despite roughly $700M invested in the sector from 1996 to 2003 (PWA 2003a) through the support of the international donor community, Palestinian efforts to embark on a "hydraulic mission" have failed. The average production from Palestinian wells drilled since 1995 stood at (only) 12.5 MCM/year by 2006, and no new well projects are currently planned. The stalled development alongside a continuously expanding population has actually resulted in a *decreasing* Palestinian per capita water consumption rate (Oxfam 2003; Lautze et al. 2005).

The most conspicuous feature of Figure 5, however, remains the significant disparity between Palestinian and Israeli consumption. Total Israeli consumption is consistently five to six times greater than Palestinian consumption, a striking imbalance even considering that Israel's population of over six million is roughly double that of the West Bank and Gaza. As we shall reinforce in the final section, Palestinian water consumption can be said to have little demonstrable effect on Israeli water allocation policy.

Summary Analysis of Water Production and Consumption

This section examines the production and consumption records within the broader Palestinian-Israeli water conflict. As Figure 6 shows, three hydropolitical dimensions of the water conflict may be observed, relating to the Israeli side establishing or maintaining (1) a greater assurance of supply; (2) minimal levels of Palestinian consumption; and (3) an upper hand in negotiations over potential reallocation.

Greater Assurance of Supply

We see from Figure 6 a leveling off around 1967 in total production rates at approximately 1750 MCM/year and in agricultural consumption rates at approximately 1200 MCM/year. Many analysts have interpreted the upper limits to production rates as a rational reaction to peaks in abstraction elsewhere, most notably in the

Coastal and WABs (e.g., Ben-Zvi et al. 1998; Feitelson 2002; Medzini and Wolf 2004; Schwarz 2004; Thomas 2004). The analysts may be underemphasizing the importance of the 1967 war, however. Though not motivated by it, Israel's conquest of the entire territory on both shores of the Upper Jordan River, the head water of the Banias River, the west shore of the Lower Jordan River, and the Western, North Eastern, Eastern, and Coastal Aquifer Basins has had demonstrable effects on Israel water planning and practice. The accumulation of control over water that came with the territory has resulted in a greater assurance of supply for Israeli water policymakers.

Without the relative guarantee of supply provided by the 1967 Israeli resource capture, two scenarios could be expected to have developed: either a leveling off of production and consumption at rates substantially lower than the actual ones, as further development would have been compromised by continued skirmishes with Syria and Jordan, or else spiraling production levels far exceeding the estimated sustainable yields in a typical response to the absence of an assured supply. That neither scenario has occurred reflects the new found confidence in Israel's capacity to exploit the flows following 1967 and its ability to sustain the supply-driven management paradigm ever since. Turton (2003) has suggested that the reduction of uncertainty in this case is a key instance of desecuritization: a process that may create an opportunity to address the fundamental drivers of a conflict. The drop in the Israeli public's interest in water issues following the 1967 resource capture (Feitelson 2002, 302) may reflect an unofficial (and certainly unspoken) desecuritization process. The basic drivers of the allocative conflict with the Palestinians were unfortunately *not* addressed, however, in the years following the war. Water issues were (re)securitized when they may have served ulterior political goals, as we shall see.

Maintaining Minimal Levels of Palestinian Consumption

We have described the flows available beyond the estimated sustainable yields of all transboundary sources during wet years as *strategic reserve* and discussed how they are allocated by the IWC. How Israeli water policymakers view these "excess" flows in light of the needs of Palestinians is revealing.

Consider, for instance, the experience of the relatively wet years of 2004 and 2005, whereby surface water levels in the Lake of Tiberias rose to the point of nearly overspilling the Alumot Dam, which blocks flows from the Lake of Tiberias to the Lower Jordan River. Contrary to Israeli custom of stopping pumping from the NWC during the Passover period (due to concerns raised by the orthodox Jewish community that this water may contain prohibited leavened foodstuffs), the pumps operated in 2004 at their full capacity around the clock. The break with tradition was justified by the Israeli Minister of Infrastructure in terms of the cost of the water that would be "wasted" if it were to overflow into the Lower Jordan River (Cohen 2004).

The likelihood of this "reserve" of water being considered for allocation to Palestinians must be contemplated in light of the fierce competition from the Israeli agricultural lobby, water professionals, the Ministries of Infrastructure and Finance, and environmental groups. The flows are competed for internally by the farmers for crops, water resource managers for aquifer recharge, and environmentalists for maintaining base flows. The water needs of the Palestinians are generally regarded solely under economic arrangements. Volumes of water sold by Israel to Palestinians do not even visually alter the Israeli water production curves. According to the Chief Hydrogeologist of Mekoroth, water sold by Israel to Palestinians in 2003 was 40 MCM/year (32,500 MCM/year) (Guttman and Percia 2006), or 2% of total Israeli fresh water production. The cooperative nature generated by the economic transactions is generally held to be greater than their economic rewards. Having increased from 27 MCM/year in 1995, the same authors suggest that the additional quantities sold to Palestinians is evidence of good will of the Israeli side, which has surpassed its commitments under the Oslo II Agreement. (Table 1 of Guttman and Percia [2006] shows that Israel sold 37.2 MCM/year to Palestinians in 1999 and 40.0 MCM/year in 2003. This is 9.3 and 12.1 MCM/year more than the amount being sold to Palestinians prior to the Oslo II Agreement and twice as high as the 4.5 MCM/year commitment therein.)

In 1999, the sales exceeded the commitments by roughly 4.8 MCM/year. As we have seen in Figure 3, however, Israeli overabstraction from the WAB alone during the 1998/1999 season was roughly 260 MCM/year. The violation of Israeli commitments under Oslo II thus trumps its surpassing of them by a ratio of roughly 57 to 1. Viewed as a sector willing and able to pay for the resource, the Palestinian side thus competes with the Israeli agricultural sector. With no representation at the decision-making table, however, a poor outcome of the competition for the Palestinian side is entirely predictable. Reserve flows are not up for negotiation to Palestinians under a context of reallocation and resolution of the water conflict but they may be purchased under economic terms written by the Israeli side. Considering the perspective, the "cooperation" and good will appear more exploitative than amiable.

One may attribute the emphasis given to minor achievements of cooperation (4.8 MCM/year sales of water over the commitment in Oslo II in 1999) with the downplaying of conflict (260 MCM/year violation of the same agreement in the same year) in a number of ways. How would the internal Israeli allocation politics be affected, for example, in the unlikely situation that the Palestinian side were able to exert more pressure than the agricultural lobby and purchase volumes of the order of 1000 MCM/year? Were the Palestinian side able to produce quantities that might threaten the interests of those lobbying internally for water in Israel, an intensification of the water conflict would certainly be expected. Such a situation remains hypothetical, as

Israeli water policy vis-à-vis Palestinians actively prevents it.

Israeli consumption rates were not perceptibly affected by the loss of responsibility in 1995 of roughly 2.5 million Palestinians, as Israeli-supplied water purchased by Palestinians at that time was on the order of only 30 MCM/year (Guttman and Percia 2006). The restrictive water-related military orders imposed in 1967 at the start of the Israeli occupation have in effect been replaced (and were later legitimized) by the terms of the 1995 Oslo II Agreement and the licensing procedure of the Joint Water Committee (Selby 2007). These arrangements have ensured that Palestinian water consumption is kept at a level that the Israeli side can accept, forecast, and contain.

Maintaining a Competitive Edge on Negotiations

One of the most relevant "hydroschizophrenic" features of Figure 6 is the steady increase in both total production and agricultural consumption from 1992 onward. Developing in the wake of the IWC's success in curbing the agricultural sector's thirst by the early 1990s, it is somewhat surprising to see the upward surge on the heels of the heavy rains of 1991. Increased agricultural consumption is in part due to the yearly renewals of the exemptions of agricultural allocation caps plus a lowering of rationing targets, as we have seen. The surge in total water production also coincides with the period of negotiations prior to the signing of the political agreements with Jordan and Palestine (the 1991 "Madrid" negotiations preceded the Oslo negotiations in the latter case). By the time inter *state* allocations were determined by 1994 and 1995, Israeli fresh water production levels had risen sharply to 1918 MCM/year up from the 1991 low of 1450 MCM/year. Fresh water production continued to rise in the years following the signing of the agreements, reaching a record peak of 2103 MCM/year in 1998.

Considering that the agricultural sector was associated with less than 2% of Israeli GDP by this time, the surge during the negotiations period is not explained by rational economic arguments, a point Fisher and Huber-Lee (2005) have made in other ways. The surge is more readily explained by a combined hydrogeological and hydropolitical consideration, as shown for a single well in Figure 7. The figure graphically demonstrates the previously discussed practice of pumping surface water during wet years and ground water during dry years.

Figure 7 shows that particularly from the 1970s onward, ground water abstraction can be observed to be closely related to rainfall, with high abstraction in dry years. Abstraction decreases slightly following several dry years but typically not to the point of averting damage to the aquifers (the so-called "red lines" set by hydrogeologists and the IWC that were breached in the late 1980s and the late 1990s). With the following wet winter, abstraction rates can be seen to drop as there is less dependence on ground water (as more soil water is available and less irrigation is required). Abstraction rates then continue to rise as most strikingly seen following the 1991/1992 winter's "century rain," until 1999. The pumping policy counts on the rapid recharge rate of the karst aquifer and gambles, as we have mentioned, with the expectation that heavy rains will follow drought periods. But the hydrogeological interpretation is not wholly sufficient to explain the surge in total water production. If ground water abstraction from the WAB were suddenly called upon to relieve the pressure on surface water resources, we would expect to see a corresponding decrease in production from other sources. As we noted in Figure 3, however, both surface water *and* ground water production steadily *increased* from 1991 and 1992 to 1995. This gives yet more credence to a political explanation to the phenomena.

The possibility that Israeli consumption rates were increased in order to improve the Israeli position at the negotiations table with Palestinians and Jordanians was first raised by Allan (2001, 210, 250). Wolf's (2000) research on the antinegotiations stance taken by Israeli proponents of the hydrostrategic discourse reveals that Minister of Agriculture Rafael Eitan and Water

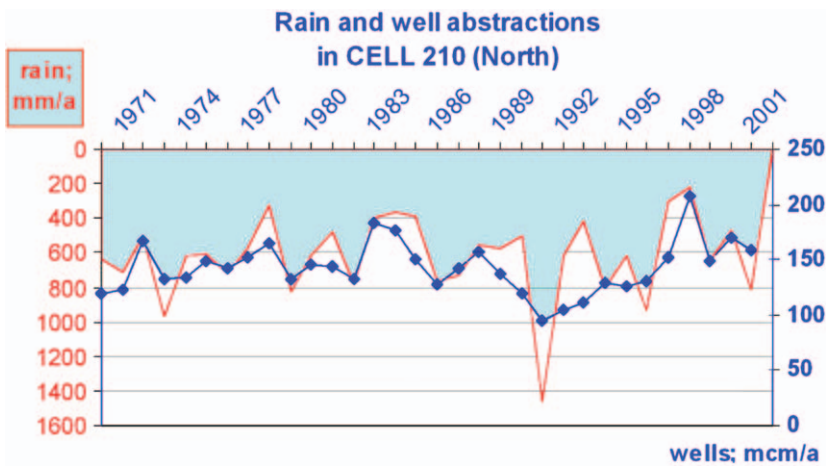

Figure 7. Rainfall, ground water levels, and abstraction rates of the northern section of the WAB. Data from HSI (2004).

Commissioner Dan Zaslavsky had no qualms about mixing hydrogeology and hydropolitics. Together, the civil servants in 1992 insisted that a report by the Jafee Centre for Strategic Studies—which showed the water territory that may safely be relinquished in a "land for peace" deal with the Palestinians—be "censored in its entirety" (Wolf 2000, 102). Wolf elaborates in a footnote that "when peace talks began in 1991, the document remained censored for fear its release would reveal Israeli negotiating strategy. To date, the document has not been released."

Without judging intentions, it may be impossible to weigh the relative importance of the environmental, scientific, domestic, and international drivers of the increased ground water consumption. After repeatedly testing his hypothesis—that Israeli water production increased to improve its negotiating position—on water professionals in the region, however, Allan (2005) maintains that "it is impossible to prove, but the coincidence is sublime." The review of evidence here suggests that the relation is somewhat stronger and that when contemplating the Israeli pumping record, one must consider hydropolitics along with hydrogeology.

Conclusions

The combined hydrogeological and hydropolitical interpretation of the Israeli and Palestinian pumping record has reaffirmed previous observations and shone new light on previously undiscussed aspects of the water conflict. We have seen that the state of Israel continues to pursue a supply-side water management policy, where—despite considerable effort aimed at increasing cuts to the Agricultural sector—the demand will be met one way or another. Meeting demand with increased mining of ground water sources during extended drought periods speaks to a somewhat reckless policy that depends entirely on the assumption that heavy rains will follow. The policy stands in stark contrast with a fundamentally cautious policy toward Palestinians—which consists of maintaining drilling bans while selling minor amounts of water after dry winters and marginally more following wet winters.

Israeli water production has been shown to be driven by internal tensions over allocations and management, emblematic events such as drought periods, and three hydropolitical aspects: the greater assurance of supply that came as a result of the land captured in 1967, the maintenance of minor levels of Palestinian consumption, and keeping an upper hand in negotiations over potential reallocation of the shared resources. The political nature of pumping is best shown in the Western Aquifer Basin, where the effective limits are either regularly exceeded or were set deliberately low for political purposes. The asymmetry of abstractions is also extreme. So long as current levels of abstraction and shared management are maintained, both Palestinian-Israeli relations and the health of the resource are at risk. Though power asymmetry may be a fact of life, domination and exploitation need not be. We anticipate that the interdisciplinary analytical approach taken here to combine pumping, power, and politics will encourage both multidisciplinary research in other water conflicts and potential leveling of the playing field of this one.

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