WATER RESOURCES IN PALESTINE

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INTRODUCTION

- The water resources in Palestine are mainly the Jordan River, Wadi flows and groundwater (utilized mainly through wells and springs).

- The following table is a summary of the available water from these resources.

Available Water for the Palestinian Water Resources

Source of water	Natural flow or Recharge (Mcm/yr)
Jordan River	1485-1671
Wadi flow	110-120
Groundwater Basins	
Eastern	100-172
Northeastern	130-200
Western	335-450
Coastal	55-65
Total	**2,215 – 2,678**

Aquifer Basins in the West Bank and Gaza Strip

- Israel controls all aquifers in Palestine; although the major part of fresh water supply in Palestine originates from the three aquifers of the West Bank. In the West Bank, the aquifer system is comprised of several rock formations that are recharged from rainfall. In years of normal rainfall, some 600-650 Mcm/yr of rain infiltrate the soil and replenish the ground aquifers (PWA, 2005).

- The major groundwater system in the West Bank consists of three major basins, classified according to flow direction into: the Western, Eastern and Northeastern Basins. The West Bank aquifer system discharges approximately 600-660 Mcm/y.

The Western Aquifer Basin (WAB)

- It is considered the most important aquifer in the West Bank and the largest of all groundwater basins in Historical Palestine.

- It is a shared aquifer between the West Bank, Israel and Egypt, with a surface area of 11,398 km^2 where the area located within the borders of the West Bank forms the main recharge area for this Basin, estimated at about 1,596km^2, and located within the heavy rainfall area.

- This area provides the aquifer for more than 73% of the basin's water. The ground water in this aquifer basin moves to the West and North West, where the rock layers forming the basin tend to these directions Most of the rock formations within the borders of the West Bank are considered unsaturated and non-artesian due to close proximity to the recharge areas, and artesian and saturated towards the west, due to the increase in thickness of the rock and underlying aquitard formations.

The Western Aquifer Basin (WAB)

- Two main aquifers are present in this basin: the upper and the lower aquifers.
- The average thickness of these aquifers ranges between 600-900 meters.
- The basin has a safe yield of 443 Mcm/yr; Israel exploits most of the water of this aquifer about 95% through more than 500 deep groundwater wells. Israel limits Palestinian use from this aquifer to 21 Mcm/yr with a total number of wells of 134 (SUSMAQ, 2005).

The Northeastern Aquifer Basin (NEAB)

- The area of this basin in the West Bank is nearly 1,067.5 km^2.
- The annual groundwater recharge of this basin is approximated to be 145 Mcm. The mountains in the southern parts of this basin have peak elevations between 600-918 m asl.
- The central and northern parts of the Northeastern Basin have a relatively flat to hilly topography that rises about 300 to 600 m asl.
- This hilly area drains surface water to the west into shallow wadis, which recharge the coastal aquifer system as they meet the flatter coastal plain.
- The number of the Palestinian wells in the Northeastern Aquifer Basin is 76 wells with an average abstraction of about 16 Mcm/yr, whereas the most important and the largest utilization of this basin water is by Israelis through the wells and springs located outside the borders of the West Bank.

The Eastern Aquifer Basin (EAB)

- Large parts of this aquifer basin are located within the eastern borders of the West Bank.

- The area of this basin is estimated at 3,079.5 km^2. The mountains forming the highlands in this basin consist mainly of carbonate sedimentary rocks with deeply incised wadis draining to the east.

- The surface water divide runs parallel to the axis of the mountains, and surface water drains eastwards towards the Jordan River Valley with minimal infiltration in the carbonate rocks or soil profile due to the high degree of slope in the wadis.

The Eastern Aquifer Basin (EAB)

- The elevation of these mountains ranges from 600-1,000 m asl, yielding an elevation difference of more than 1,300 meters between the high mountain peaks and the adjacent Jordan River Valley.

- The majority of the Eastern Aquifer Basin area is located within the areas featured by scarcity of rain in general, while the western part is located within an area featured by heavy rainfall. The eastern aquifer basin has a safe yield of 175 Mcm/yr on average. The number of Palestinian wells in the eastern aquifer is 95 wells with an average abstraction of about 25 Mcm/yr.

The Coastal Aquifer Basin (CAB)

- The coastal aquifer is the main aquifer for groundwater in the Gaza Strip. Its depth ranges from several meters in the eastern and southeastern parts to about 120-150 meters in the western part.

- It extends along the coastal strip and consists of sand layers of kurkar with a mixture of clay and sandstone followed by non permeable layers of marl for a depth ranging between 800-1000 meters, followed by layers of limestone rock, where salinity exceeds 20 g/l of chloride .

The Coastal Aquifer Basin (CAB)

- The aquifer is characterized by high porosity and permeability.
- It is divided into four sub-aquifers which extend 1-3 km from the seacoast and then unified together, forming one aquifer. Impermeable and non-porous clayey and silty layers in the form of lenses define these sub-aquifers.
- Towards the east, these clayey lenses thin out and disappear gradually (Al-Agha, 1997). The aquifer is unconfined in many places in the strip, thus the infiltration of contaminants (sewage, fertilizers, pesticides and other sources) is easy through the surface soil layer.
- The annual recharge of Gaza Coastal is about 55-65 Mcm/yr .


N
0
25
50
Kilometers
Mediterranean Sea
Jordan
Dead Sea
Egypt
Safad
Haifa
Tabariya
Jenin
Al Khudara
Tulkarem
Northeastern Basin
Al Teera
Nablus
Qalqilyah
Yafa
Al Lod
Eastern Basin
Al Biran
Al Ramlah
Ramallah
Jericho
Asdoud
Jerusalem
Coastal Basin
Bethlehem
Hebron
Gaza
Khan Yunis
Rafah
Bir Al Saba'
Western Basin

Groundwater Aquifer Systems in the West Bank

- First Aquifer: The Shallow Aquifer
- Second Aquifer: The Upper Aquifer
- Third Aquifer: The Lower Aquifer
- Fourth Aquifer: The Deep Aquifer

First Aquifer: The Shallow Aquifer

- The Holocene (alluvial) aquifer,
- Pleistocene (Lisan Formation) aquifer,
- Miocene-Pliocene (Beida Formation) aquifer and
- Eocene (Jenin Subseries) aquifer represent the shallow aquifer.
- They are locally important.

Holocene (Alluvial Formation) aquifer

- This aquifer occurs in the Jordan Valley.
- It is important to agricultural uses.
- It is built up of sub-recent terrigenous deposits (alluvial fans) formed along the outlets of major wadis that flow eastward to the Jordan Valley and its thickness ranges from 0 to 100 m.
- These alluvial fans are still accumulating after large floods and consist of debris from neighbouring lithologies which are deposited according to their transport energy.
- The yield of the wells in this aquifer is about 20-100 m^3/hr. The water quality is variable (from 100 mg/1 to more than 2000 mg/l). Estimates of transmitting properties show that the aquifer varies from low potential to fair potential. The alluvial aquifer often directly overlies the Pleistocene gravel with which it is in hydraulic contact.

Pleistocene (Lisan Formation) aquifer/aquitard

- The Lisan formation is not considered an aquifer or an aquitard but rather both: an aquifer/aquitard. It is continuous along the Jordan Valley and varies in thickness; it may be up to 200 m thick. The Lisan Aquifer consists of unconsolidated beds of sand, gravel, cobbles, and boulders separated by impermeable layers of saline marls and other lacustrine deposits. These deposits are composed of clastic rocks of limestone, dolomite, and chert with a sand and clay matrix that form alluvial fans. It extends from Jericho in the south to Marj Na'ja and lower Wadi Fari'a to the north.

- The aquifer supplies agriculture in the Jordan Valley. Borehole yields vary from 20 to 100 m^3/h. Water quality is variable, with chloride concentrations from 50 mg/l up to 2200 mg/l in areas influenced by salt domes, hyper saline brines and/or Dead Sea water inflows south of Jericho. The sulphate concentration rises from 100 mg/l in the west to 900 mg/l near Jericho.

Miocene – Pliocene (Bedia Formation) aquifer

- This is the lower part of the Dead Sea group. Beida consists of three lithologies, well-cemented conglomerates, highly permeable, some indurated marl and sandstone and few freshwater limestone of minor aquifer potential.
- Beida is of local importance at the northeastern boundary of the West Bank in the Jordan Valley and Wadi Fari'a especially near the Bardala and Ein Beida areas.
- The thickness of the three combined lithologies can be up to 350 m in places. However, the aquifer is of limited extent and in most places only about 100 m thick.
- Water quality in the aquiferous conglomeratic portion is good (about 70 mg/l chloride).

Eocene (Jenin Formations) aquifer

- In this aquifer groundwater normally occurs within 100 m from ground surface and for this reason it is extensively used for irrigation.
- It consists of nummulitic limestone with chalk, chert bands and marl. The limestone is of limited thickness and contains chalk, chert and intercalations of marl, which reduce the groundwater supply potential of the aquifer. It has limited storage and water transmitting properties.
- The yield of this aquifer is highly dependent on rainfall. The thickness of this aquifer ranges between 90 – 670 m.
- An individual well yield is in the range from 20-100 m^3/hr.

- Water Quality tends to deteriorate towards the Jenin area due to over-pumping and heavy irrigation activities. TDS reaches 1650 mg/l in some parts of the aquifer, while chloride concentration reaches 679 mg/l, whereas the average nitrate concentration in the aquifer is 41 mg/l.

Second Aquifer: The Upper Aquifer

- **This aquifer consists of:**
- Turonian (Jerusalem Formation),
- Upper Cenomanian (Bethlehem and Hebron formations).

Turonian (Jerusalem) aquifer

- This formation consists of massive limestone (sometimes thinly bedded limestone), and dolomitic limestone with well developed karst features.
- It is part of the Upper Aquifer, but it is isolated from the main part of the Upper Aquifer in the south and parts of the eastern West Bank wherever the underlying Bethlehem Formation becomes a weakly permeable aquitard.
- The Jerusalem Formation is of large lateral distribution and thickness in the Tulkarem and Qalqilya areas (approximately 130 m thick). It forms a good aquifer especially where the saturation thickness is in tens of meters.
- Water quality is generally good but in some areas there is evidence of deterioration because of pollution by sewage and agro-chemicals.

Upper Cenomanian (Bethlehem and Hebron Formations) aquifer

- The Upper Cenomanian aquifer consists of the Bethlehem and Hebron Formations which are mainly interbedded dolomite and chalky limestone.
- In the southern and eastern part of the West Bank, the Bethlehem Formation is considered an aquitard, while to the north and west it has aquiferous characteristics.
- The Aquifer is an important regional source of water supply for domestic uses. It is heavily exploited in the areas near Tulkarem and Qalqilya. The well yields range from 40-400 m^3/hr. The well depths are less than 400m with some exceptions. The depth to water is rarely more than 200 m below ground surface. The Aquifer has high recharge values. Its water quality is generally good (30-70 mg/1 of chloride). The Lower Yatta Formation hydraulically separates the two regional aquifers (Upper and Lower Aquifers) across most of the West Bank, although to the north, the presence of Yatta limestone gives rise to minor springs and seepage. Water levels (heads) in the Upper Aquifer are generally higher than in the Lower Aquifer.

Third Aquifer: The Lower Aquifer

- The Albian (Lower Beit Kahil Formation) and to a lesser extent the Albian (Upper Beit Kahil Formation) and sometimes the lower part of Yatta Formation form the Lower Aquifer, which is a deep confined aquifer across most the West Bank.

- It is a regional source of drinking water. Individual well yields across the West Bank range from 150-450 m^3/hr.

- Well depths vary from 500 to 850 m.

- The high water bearing capacity and productivity is owed to the great thickness of dolomitic limestones and limestones.

- Water quality is generally good with chloride values in the 20-50 mg/1 range, though slightly higher salinities have been encountered towards the Jordan Valley.

Fourth Aquifer: The Deep Aquifer

- *Lower Albian (Ein Qinya) aquifer*
- *Neocomian (Ramali) aquifer*
- *(Oxfordian) Maleh aquifer*

Lower Albian (Ein Qinya) aquifer

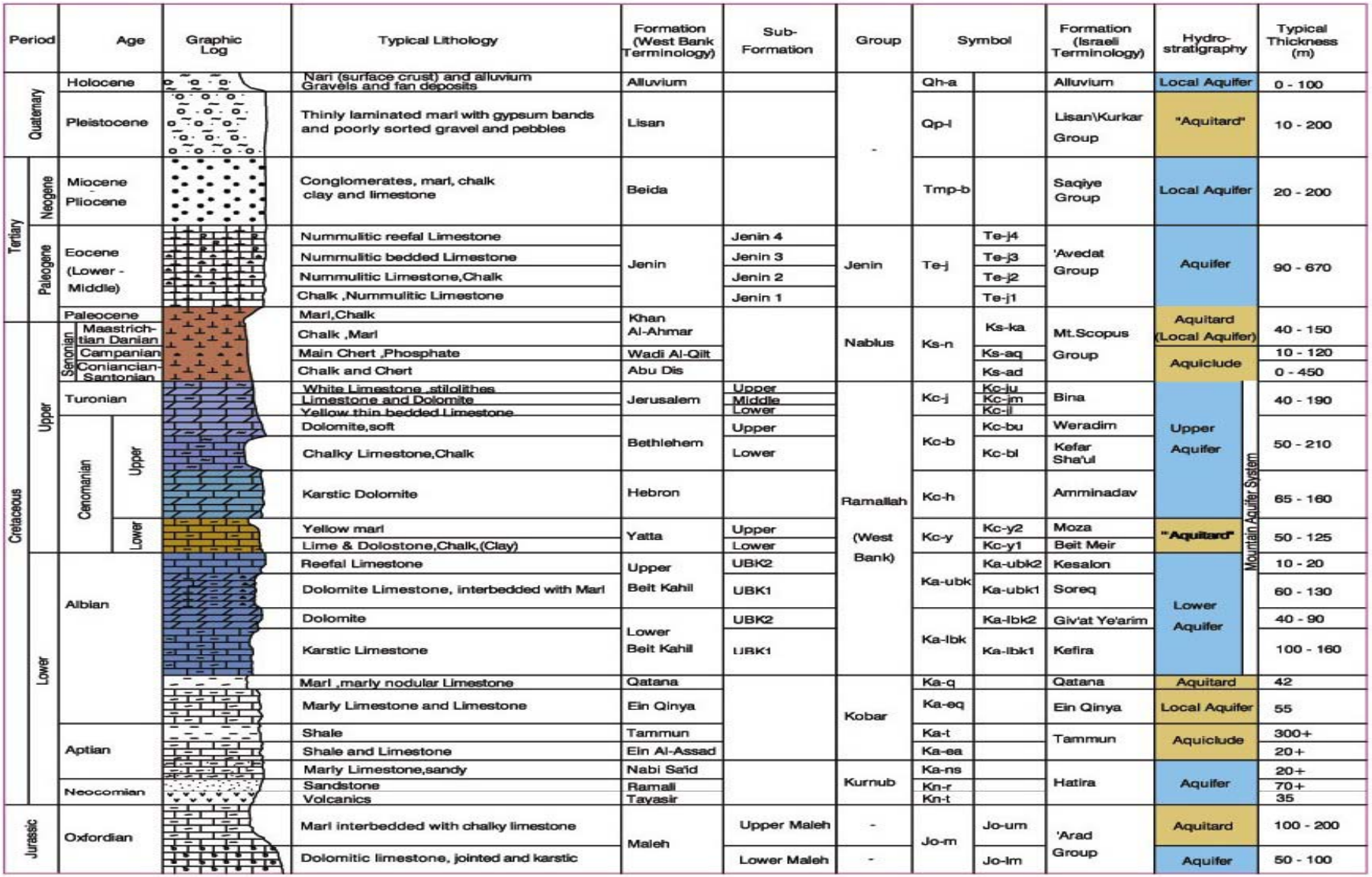
- The aquifer is not yet understood and it seems there is a great change in the characteristics of this aquifer from the middle to the north of the West Bank.
- In general, the aquifer seems to be of low potential. However, it was tested while drilling Ein Senia Well No.7 in Ramallah District.
- The test shows that it has some low aquifer potential that is not really sufficient for pumping water from it.

Neocomian (Ramali) aquifer

- It is mainly of Neocomian age .
- The Ramali is composed of primarily sandstone.
- Very little information is available on these deeper sediments because few wells penetrated to these depths.
- Edwin & Pauly, Phillips, and John Mecum oil companies drilled deep exploration wells for oil in Halhul (Halhul No.1) in Hebron District, and Abu Shkeidem (Ramallah No.1).
- The logs for these wells suggest that Ramali aquifer consists of sandstone of older formation. Its thickness is about 70 meters.

(Oxfordian) Maleh aquifer

- The Maleh aquifer system is mainly of Oxfordian age from the Jurassic period.
- It is made up of dolomitic limestone, interbedded ferruginous limestone, and marls.
- It is the lowest aquifer system expected in the West Bank.
- There is very little information on this aquifer system because no monitoring or production wells have been drilled to this depth.



Stratigraphic Section of the West Bank

LEGEND

- Dolomite
- Limestone
- Marl
- Conglomerate
- Megafauna
- Flint concretions
- Chalk
- Nari
- Sandstone
- Volcanics
- Relatively Permeable
- Relatively Impermeable

THANK YOU