German-Lebanese Technical Cooperation Project

Protection of Jeita Spring

Delineation of Groundwater Protection Zones
(project component 2)

Final Project Workshop
11 July 2014

Dr. Armin Margane
2. Integration of water resources protection aspects into landuse planning

- Determination of the vulnerability of the groundwater system, preparation of an inventory of hazards to groundwater, and determination of the risk of groundwater pollution;
- Delineation of groundwater protection zones for the Jeita Spring and, if possible, other springs and wells used for drinking water supply in the Jeita groundwater catchment;
- Support of the relevant governmental institutions in implementing the proposed protection zones and urgent protection measures;
- Providing advice to MoEW concerning the establishment of a legal basis for the implementation of protection zones for ground and surface water resources.
In porous aquifers:
relatively uniform infiltration and groundwater movement
- travel time, e.g. 50 days (Germany) or 10 days (Switzerland)

In karst systems groundwater protection is very difficult:
- diffuse infiltration through fractures (matrix)
- concentrated infiltration through karst network (sinkholes, dolines, conduits)
- non-uniform GW flow

International practice:
**Delineation using GW vulnerability maps**
- EPIK (used in CH)
- COP (proposed for entire EU), modified
Vulnerability Maps are used as a Decision Tool in the Land Use Planning Process.

High Vulnerability: Areas with a high Pollution Risk.

- Which Measures need to be Implemented to Protect the Resources against Pollution?

Low Vulnerability: Areas with a low Pollution Risk.

- Where could Sites and Activities which are Possibly Hazardous to Groundwater be located, such as Waste Disposal Sites, Wastewater Treatment Plants, Industrial Estates, etc.?
<table>
<thead>
<tr>
<th>Component 2: Groundwater Vulnerability Mapping EPIK &amp; COP</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Geology ► geological mapping</td>
</tr>
<tr>
<td>- Karst features ► karst feature mapping</td>
</tr>
<tr>
<td>- Soil ► soil mapping</td>
</tr>
<tr>
<td>➢ Groundwater Vulnerability Map</td>
</tr>
<tr>
<td>➢ Groundwater Protection Zones</td>
</tr>
</tbody>
</table>
Factors determining protective effectiveness of the rock and soil cover:
- mineralogical rock composition,
- rock compactness,
- degree of jointing and fracturing,
- porosity,
- content of organic matter,
- carbonate content,
- clay content,
- metal oxides content,
- pH,
- redox potential,
- cation exchange capacity (CEC),
- thickness of rock and soil cover
- percolation rate and velocity.

GW vulnerability map
COP Method
C – Concentration of flow,
O – Overlying layers and
P – Precipitation

COP-Index:
COP-Index = (C score) * (O score) * (P score)

- soil
- lithology and thickness of overlying rock layers
- confined / unconfined GW
- infiltration in sinkholes
- infiltration by sinking streams
- slope
- vegetation cover
- rainfall amount
- rainfall intensity
Groundwater Vulnerability

**O FACTOR (Overlying layers)**

<table>
<thead>
<tr>
<th>Layer index</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 250</td>
<td>1</td>
</tr>
<tr>
<td>250 - 1000</td>
<td>2</td>
</tr>
<tr>
<td>1000 - 2500</td>
<td>3</td>
</tr>
<tr>
<td>2500 - 10000</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 10000</td>
<td>5</td>
</tr>
</tbody>
</table>

**P FACTOR (Precipitation)**

\[ \text{Intensity} = \frac{P}{N} \]

where:
- \( P \) is rainfall (mm/year)
- \( N \) is number of rainy days

**C FACTOR (Concentration of flow)**

\[ \text{Score} = c = \text{sf} \cdot \text{sv} \]

\[ \text{Distance to sinking stream (ds)} = \begin{cases} < 30 \text{ m} & 0 \\ 10 - 100 \text{ m} & 0.1 \\ > 100 \text{ m} & 0.2 \\ \end{cases} \]

\[ \text{Distance to swallow hole (dh)} = \begin{cases} < 500 & 0 \\ 500 - 1000 & 0.1 \\ 1000 - 2000 & 0.2 \\ 2000 - 2500 & 0.3 \\ 2500 - 3000 & 0.4 \\ > 3000 & 0.5 \end{cases} \]

**COP Index**

\[ \text{COP Index} = C \cdot O \cdot P \]

where:
- \( C \) is concentration of flow
- \( O \) is overlying layers
- \( P \) is precipitation

**O Score**

\[ \text{OS} = \text{O} \cdot [\text{OS}] + [\text{OL}] \]

**P Score**

\[ \text{PS} = [\text{OP}] + [\text{PI}] \]

**C Score**

\[ \text{C} = \text{C} \cdot \text{OS} \cdot \text{PS} \]

**Vulnerability classes**

- Very high
- High
- Moderate
- Low
- Very low
Protection of Jeita Spring

Groundwater Vulnerability
Protection of Jeita Spring

Based on new geological map prepared by BGR

**Geology**

**Upper Aquifer**

**Lower Aquifer**
Surface Karst Features Mapping

Spatial Distribution of Dolines

Legend
- Jeita Spring Groundwater catchment (BGR)
- villages
- Jeita Cave System
- River
- Roads
- dolina

Protection of Jeita Spring
range of influence of riverbed infiltration (sinking streams)
Protection of Jeita Spring

Tracer Injection (uranine)

Flow velocities
Hydrogeological interconnections

Mixing 5 kg uranine with water

flushing with 80 m³ water
Protection of Jeita Spring

Groundwater Flow

Mean travel times

10 days traveltime

Mean travel times:
- 62 h
- 42 h
- 36 h
- 264 h
- 144 h
- 42 h
- 33 h
- 24 h
- 70-200 m/h
- 150 m/h
Protection of Jeita Spring

Range of influence of dolines reduced

Range of influence of sinking streams changed
Groundwater Protection Zones

Very high = Zone 2A / 2
High = Zone 2B

<table>
<thead>
<tr>
<th>Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>very high</td>
<td>70.9%</td>
</tr>
<tr>
<td>high</td>
<td>9.5%</td>
</tr>
<tr>
<td>moderate</td>
<td>0.7%</td>
</tr>
<tr>
<td>low</td>
<td>0.2%</td>
</tr>
<tr>
<td>very low</td>
<td>18.8%</td>
</tr>
</tbody>
</table>
Groundwater Protection Zones for Jeita, Afqa, Rouaiss, Assal and Labbane springs

<table>
<thead>
<tr>
<th>COP GW- Protection zones</th>
<th>C4 Springs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeita Spring</td>
<td></td>
</tr>
<tr>
<td>2a</td>
<td>10.1%</td>
</tr>
<tr>
<td>2b</td>
<td>11.7%</td>
</tr>
<tr>
<td>2</td>
<td>49.2%</td>
</tr>
<tr>
<td>3a</td>
<td>4.5%</td>
</tr>
<tr>
<td>3b</td>
<td>24.5%</td>
</tr>
</tbody>
</table>

71% zone 2

chateau d'eau water conservation area
zone 1: 50 m upstream, 15 m to each side, 10 m downstream of the spring and 10 m to each side of related water infrastructure, e.g. conveyor line, reservoir, etc. until entry into the actual water supply infrastructure; Zone 1 includes the area over the cave and underground river with a rock cover of less than 100 m;

zone 2A: groundwater travel time < 10 days, very high groundwater vulnerability, possible direct infiltration into underlying Jeita underground river: buffer zone 250 m from projected course;

zone 2B: groundwater travel time < 10 days, high groundwater vulnerability;

zone 3A: groundwater travel time > 10 days, very high groundwater vulnerability and

zone 3B: all other parts of the groundwater catchment.
Landuse in zone 1 by the water utility must consider the following:

Oil, grease, lubricants, pesticides, fungicides, batteries and any substances that are potentially hazardous to water should not be stored or used in zone 1.

Constructions, other than required for the operation and maintenance of the water conveyance system, are not allowed.

Modifications required in Protection Zone 1:

A fence must be erected along the canal at 10 m distance from the canal. Houses and commercial businesses at the canal must be removed (10 m distance).

Construction ban in the critical zone (risk of cave collapse)
New residential buildings should not be allowed to be built downgradient of the new wastewater collector line (escarpment collector).

The stormwater drainage along the main road (Jeita - Faraiya highway) should be enlarged to ensure that all stormwater can be drained to a location outside protection zone 2A.

The following activities shall not be allowed in zones 2A and 2B:

- Gas stations,
- Industrial sites,
- Commercial businesses using hazardous substances,
- Quarries, rock cutting facilities, brick factories,
- Dumping of waste,
- Animal farms,
- Slaughterhouses,
- Application of pesticides and chemical fertilizers.
Modifications required in Protection Zone 2A

Wastewater:
- urgent implementation of KfW, EIB & Italian Protocol WW projects
  (following centralized approach: treatment & effluent discharge outside catchment)
- enforce connection to the new wastewater network
- in all houses the existing drainage must be diverted to the new collection system and the existing cesspits must be closed
- new network in protection zone 2A must be constructed in such a way that leakage of untreated wastewater into groundwater is not possible

Gas stations should be forced to install double-layer tanks (in zones 2A, 2B)
In zone 2A some gas stations may need to be removed (not in compliance with environmentally sound practices)
Modifications required in Protection Zone 2B

Waste dumps: all existing illegal waste dumps should be removed. Deposition of construction waste should not be allowed in protection zones 2A and 2B, but only at designated locations in zone 3. The construction waste must not contain any other substances than rocks, cement and bricks.

The slaughterhouses located in zone 2, in Aajaltoun (Murr) and Ghosta should be closed.

[The animal farms in the Beit Chebab, Mar Boutros, Safilee and Hemlaya area pose a high risk to Kashkoush spring > Kashkoush spring is almost continuously highly polluted and cannot be used due to this]
Groundwater Protection Zones

- CIL group housing projects
- gas stations
- Aajaltoun Valley

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George Matta housing project

Underground river
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Groundwater Protection Zones

Zone 2A

Zone 2B

Jeita Spring

Data basis: BGR, IKONOS, 2013
To achieve a successful implementation of GW protection zones the following measures are needed:

**Awareness campaigns**

**Boundaries of GW protection zones**
have to be clearly marked

**Control mechanism**
(environmental rangers)

Signposts for protection zones in Jordan implemented by MWI & BGR 1999-2010: 33% of national drinking water sources protected
Groundwater Protection Zones

Protection Zone 1 for Assal Spring

reservoir

restaurant

water distribution system

chalets

140 m
Protection of Jeita Spring

Groundwater Protection Zones

Distance from ski stations

Assal Spring

flow velocity: 150 m/h (< 20 h)

2,700 m

2,000 m

Ski lift and gas station
Hotels: the building of new or extensions of exiting hotels with more than 20 rooms should not be allowed in zone 2.

Restaurants: new restaurants should not be allowed unless they are connected to the new wastewater collection system.

Ski lift stations: It is also recommended not to allow building new or extensions of exiting ski lift stations unless environmental impact assessments (EIAs) have been prepared proving that negative impacts on water resources (groundwater and surface water) cannot occur. The gas station at the ski lift must be removed or equipped with a double-layer tank and leakage detection and alarm system.

Skidoo and quad bike rentals: No new or extensions of existing skidoo and quad bike rentals should be allowed. The existing skidoo and quad bike rentals should not be allowed to store fuel or undertake repairs on their premises.

Army: The army check point at Wardeh has to consider environmental-friendly operation. Fuel should not be stored here.
Groundwater Protection Zones

Protection of Jeita Spring

Groundwater Protection Zones

Labbane Spring

chalets

Runoff (stormwater?) close to spring

dumping of waste

No fence - public access
No guard
Integration of Water Resources Protection Aspects into Landuse Planning


Technical Report 5: Hydrogeology of the Groundwater Contribution Zone of Jeita Spring (~ June 2013)


www.bgr.bund.de/jeita
Integration of Water Resources Protection Aspects into Landuse Planning

Special Reports 1 / 2 / 5 / 6 / 11 / 17: Tracer Tests 1-5 (July 2010 - July 2012)

Special Report 7: Mapping of Surface Karst Features in the Jeita Spring Catchment (October 2011)

Special Report 9: Soil Survey in the Jeita Spring Catchment Balance (November 2011)

Special Report 12: Stable Isotope Investigations in the Jeita Spring Catchment (~ April 2013)
Thank you for your kind attention

www.bgr.bund.de/jeita

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