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Project Exchange Meeting - Lessons learnt from Technical Cooperation in Jordan and Lebanon

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List of Abbreviations

asl	Above mean sea level
AFD	Agence Française pour le Développement
BGR	Federal Institute for Geosciences and Natural Resources
BMBF	Federal Ministry of Education and Research
BMP	Best Management Practice
BMZ	German Ministry of Economic Cooperation and Development
DSS	Decision Support System
CDR	Council for Development and Reconstruction
EIA	Environmental impact assessment
EIB	European Investment Bank
ETP	Evapotranspiration
FC	Financial cooperation
GIZ	German Society for International Cooperation
GW	groundwater
GWR	Groundwater recharge
KfW	German Bank for Reconstruction and Development
LRA	Litani River Authority
MCM	Million cubic meters
MENA	Middle East and North Africa
MoEW	Ministry of Energy and Water
MOU	Memorandum of Understanding
MWI	Ministry of Water and Irrigation
NMS	National Meteorological Service
NaWaROP	National Water Resources Observation Program
NRA	Natural Resources Authority
PPP	Public Private Partnership
SI	Stable isotope
SW	Surface water
TC	Technical cooperation
USAID	United States Agency for International Development
JVA	Jordan Valley Authority
WAJ	Water Authority Jordan
WEAP	Water Evaluation And Planning
WEBML	Water Establishment Beirut and Mount Lebanon
WIS	Water Information System
WW	Wastewater
WWTP	Wastewater treatment plant

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1	Site Selection for Wastewater Facilities in the Nahr el Kalb Catchment – General Recommendations from the Perspective of Groundwater Resources Protection	January 2011
2	Best Management Practice Guideline for Wastewater Facilities in Karstic Areas of Lebanon – with special respect to the protection of ground- and surface waters	March 2011
3	Guideline for Environmental Impact Assessments for Wastewater Facilities in Lebanon – Recommendations from the Perspective of Groundwater Resources Protection	November 2011
4	Geological Map, Tectonics and Karstification in the Groundwater Contribution Zone of Jeita Spring	September 2011
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7	Groundwater Vulnerability Mapping in the Jeita Spring Catchment and Delineation of Groundwater Protection Zones using the COP Method	February 2013
7b	Vulnerability Mapping using the COP and EPIK Methods	October 2012
Special Reports		
1	Artificial Tracer Tests 1 - April 2010*	July 2010
2	Artificial Tracer Tests 2 - August 2010*	November 2010
3	Practice Guide for Tracer Tests	Version 1

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4	Proposed National Standard for Treated Domestic Wastewater Reuse for Irrigation	July 2011
5	Artificial Tracer Tests 4B - May 2011*	September 2011
6	Artificial Tracer Tests 5A - June 2011*	September 2011
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9	Soil Survey in the Groundwater Contribution Zone of Jeita Spring	First Draft November 2011
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1 - 1	Addendum No. 1 to Main Report [Quantification of Infiltration into the Lower Aquifer (J4) in the Upper Nahr Ibrahim Valley]	June 2012
2	Locating the Source of the Turbidity Peaks Occurring in April - June 2012 in the Dbayeh Drinking Water Treatment Plant	June 2012
3	Locating the Pollution Source of Kashkoush Spring	September 2012
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5	Preliminary Assessment of the Most Critical Groundwater Hazards for Jeita Spring	June 2013
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1	Jeita Spring Protection Project Phase I - Regional Sewage Plan	October 2011
2	Jeita Spring Protection Project - Feasibility Study - Rehabilitation of Transmission Channel Jeita Spring Intake – Dbaye WTP	May 2012
3	Jeita Spring Protection Project - Environmental Impact Assessment for the Proposed CDR/KfW Wastewater Scheme in the Lower Nahr el Kalb Catchment	Draft June 2013 (BGR contribution)

* prepared in cooperation with University of Goettingen

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1 Introduction

Both technical cooperation projects, *Integration of Landuse Aspects into Landuse Planning* (Jordan) and *Protection of Jeita Spring* (Lebanon) are funded by the BMZ and part of German Development Aid contributing to the achievement of the UN Millennium Goals by improving access to clean drinking water (MDG7).

Since 1959, BGR has cooperated in bilateral Technical Cooperation projects with Jordan in various fields (geological mapping, mineral resources exploration, geophysics, engineering geology, groundwater). Over this time period extensive experience has been gained on the Jordanian side in the various institutions where capacity was developed (NRA, WAJ, MWI). Since the late 1960s, BGR has been supporting the water sector in Jordan. Water resources assessments were jointly done for the entire country between 1985 and 1999. The first National Water Master Plan (NWMP) was prepared together with GIZ in 1977. The second, much more elaborate NWMP has been supported between 1992 and 2005 by BGR. Since the mid 1990s, water resources protection is the focus of bilateral cooperation projects with BGR. Since 2008, BGR and GIZ have supported the countrywide preparation of WEAP models for water resources management.

BGR is cooperating with Lebanon only since 2010 in the field of water resources protection.

Naturally renewable water resources of Jordan are much scarcer than those of Lebanon. Therefore, Jordan started much earlier than Lebanon to seriously address water resources management and protection. By comparison, Lebanon has significantly more water, however, until now water resources availability has not been studied due to the lack of monitoring data for all relevant water balance components. The groundwater (GW) system has not yet been studied in Lebanon because there is no geological survey institution. A water resources assessment in Lebanon must be based on GW catchments, rather than on surface water catchments. The first such assessment was done by BGR in the Jeita GW catchment. A nationwide water resources assessment is still missing. The main reason is that water resources monitoring is not done in Lebanon in such a way that a water resources assessment would be possible.

Water resources monitoring is very extensive in Jordan and has been done since the late 1930s. Many stations have been converted in recent years to telemetry in order to have real time data and decrease costs for data collection. Monitoring is extensively used for all kinds of hydrogeological assessments and for decisions of water resources allocation. On the other hand Lebanon is still lacking adequate water resources monitoring and institutional mandates in this field are unclear and fragmented.

In both countries, Lebanon and Jordan, the supply with fresh drinking water is a challenge because besides the seasonal variation of availability of resources, continuous deterioration of water quality is a threat to the ecosystem and to the socio-economic development. Jordan has addressed this issue with success since almost 20 years and has largely integrated water resources protection needs into landuse planning. In Lebanon, contamination of water resources is a serious threat to development since a long time and has continued to spread in the absence of enforcement of water protection measures. In Lebanon groundwater, as the main water source in arid and semi-arid countries, has been neglected for the past in terms of quality and must become subject to institutionalized groundwater management in order to ensure a sustainable usage.

Currently, Jordan has more than 20 operational wastewater treatment plants (WWTPs), which were mainly established since the 1970s; parts already existed in the Ottoman period (e.g. in Salt). Since then, capacity and treatment methods of WWTPs have continuously been upgraded and a large share of treated wastewater is reused. The Water Strategy (2008) of MWI previews a treated wastewater (WW) reuse of more than 250 MCM in 2022. However, the planning of WW facilities does often still not sufficiently integrate geoscientific aspects, such as impact on water resources and georisks.

In Lebanon planning for WW facilities has only started recently and only a small share of the country is connected to an adequate WW collection and treatment system. Many WWTPs do not function properly or still provide only very basic treatment (primary treatment; e.g. Ghadeer). The BGR project has extensively worked in providing geoscientific advice to the investment planning in the WW sector and many documents prepared in this framework would be useful for improved planning in Jordan and other countries, not only in the MENA region.

Both, Jordan and Lebanon are dominated by limestone aquifers. However, due to climatic differences, in Lebanon these limestones are much more intensively karstified compared to Jordan. Groundwater vulnerability is therefore much higher in Lebanon than in Jordan.

Jordanian institutional capacities in the water sector are relatively good and the mandates of the institutions (MWI, WAJ, JVA) are clearly assigned while Lebanese water sector institutions are relatively weak and mandates and responsibilities are often overlapping and fragmented. The weak institutional capacity and lack of interest in water has led to extremely low data availability, low reliability and a general lack of commitment for data sharing.

In Jordan, water planning is relatively well coordinated among the water sector institutions and there is a good donor coordination. The opposite is the case in Lebanon: there is no adequate water planning, no adequate coordination of planning among the water sector institutions and there is sometimes a lack of donor coordination.

The overall goal of the BGR project exchange meeting Jordan - Lebanon was to gather decision-makers from both countries' water sector to learn from the experiences, which had been gained in relevant fields covered by Technical Cooperation projects of BGR. It was the aim to enhance exchange of experiences across borders and to profit from lessons learnt in daily work, to discuss what might still be missing in either Jordan or Lebanon and which aspects need to be addressed in the future, e.g. in the framework of future development aid projects. At the same time, it is important for BGR to better understand these needs and improve planning of new technical cooperation projects. In seven working sessions, both sides presented their specific problems, their way of managing it as well as their lesson learnt, in terms of coordinated approaches with BGR, other donors, as well as their independent actions. For each topic, strategies were analyzed and recommendations were formulated. The topics covered were:

- Delineation of GW Protection Zones,
- Physical Implementation of GW Protection Zones,
- GW Recharge Assessment/Water Balance,
- GW Monitoring,
- GW Management using WEAP and
- Integration of Geoscientific Aspects into Planning in the Wastewater Sector).

The results of the discussions are presented in this document.

2 Delineation of GW Protection Zones

The most important areas for protection of groundwater are commonly protection zones 1 and 2. The main criteria for delineating the boundary between zone 2 and 3 is the GW travel time. Most commonly a travel time of 50 days is used (MARGANE, 2003b), assuming that microbiological constituents would be reduced to acceptable levels. In porous aquifers, GW flow is more homogeneous than in fractured aquifers and karst aquifers. Here, groundwater protection zones are commonly defined based on assumed groundwater flow velocities (MARGANE et al., 2007). The maximum actual flow velocity ($v_{a\text{-}max}$) is used to define the outer boundary of protection zone 2:

$$v_{a\text{-}max} \approx 2^* \, v_n$$

where

v_n - mean pore water velocity ($v_n = v / n_0 = K^*I/n_0$)

n_0 - effective porosity

In karst aquifers, however, GW vulnerability maps are commonly used to define GW protection zones. This is extensively done e.g. in Switzerland and was done in Lebanon for the delineation of protection zones of Jeita spring (MARGANE & SCHULER, 2013). Delineation of GW protection zones in karst aquifers requires the use of tracer tests, in order to determine the GW catchment (or contribution zone) and mean flow velocities in the saturated zone.

In Jordan, the first GW protection zones were delineated in 1999 for the spring of Pella (MARGANE et al., 1999). Following this, the main delineations of GW and surface water (SW) protection zones took place in the framework of the Groundwater Resources Management (GWRM) project, i.e. between 2002 and 2010:

- Qunayyah spring (HOBLER et al., 2004);
- Wadi al Arab wellfield (HOBLER et al., 2004)
- Rahoub spring (MARGANE et al., 2007);
- Corridor wellfield (BORGSTEDT et al., 2008);
- Hallabat wellfield (MARGANE et al., 2009);
- Wadi Shuayb springs (MARGANE et al., 2009);
- Lajjun, Qatrana, Sultani, Ghweir wellfields (MARGANE et al., 2010);
- Mujib dam (MARGANE et al., 2008);
- Wala dam (MARGANE et al., 2009).

further delineations were done within the current project Water Aspects in Landuse Planning (WALP):

- AWSA wellfield (GASSEN et al., 2013);
- Hidan wellfield (GASSEN et al. 2013).

A guideline for GW protection zone delineation was developed in 2002 (MARGANE & SUNNA, 2002) and adopted by the Jordanian Government in July 2006. The guideline for GW protection zone delineation was further developed in 2003 in the framework of the BGR-ACSAD Cooperation (MARGANE, 2003) and later adopted by UNESCO Cairo. A guideline for GW vulnerability mapping was also first developed for Jordan (MARGANE, 2002) and later developed for the Arab region in the framework of the BGR cooperation with ACSAD (MARGANE, 2003).

In Addition, a guideline for SW protection zone delineation was developed in 2007 (MARGANE & SUBAH, 2007).

In 2009, 33% of the drinking water resources of Jordan were legally protected on the ground through implemented protection zones.

Groundwater vulnerability mapping was proposed to be used for GW protection zone delineation in karst aquifers of Jordan, especially in the more intensively karstified areas of northwestern Jordan. There, the first GW vulnerability map was prepared in 1996 for the Irbid area (MARGANE et al., 1996, 1999). Later on, several other GW vulnerability maps were prepared in Jordan:

- South Amman area (SUBAH et al., 1999),
- Qunayyah spring (BROSIG, 2005),
- Karak - Lajjun area (MARGANE et al., 2005),
- Corridor wellfield (BORGSTEDT et al., 2008),
- Hallabat wellfield (MARGANE et al., 2010).

All Jordanian GW vulnerability maps that were prepared by BGR are based on the German GLA method (HOELTING et al., 1994). This method complies with the existence of heterogeneous hydrogeological settings in a groundwater catchment.

In Lebanon, the COP method, which was developed within the framework of the COST620 project of the EU for EU-wide use in karst aquifers, was used to delineate the GW protection zones in the Jeita GW catchment. For application in Lebanon, the COP method had to be modified.

In Jordan, the extent of all groundwater catchments or groundwater contribution zones was defined based on a 'traditional' approach, i.e. based on a delineation of the GW contribution zone derived from the geological structure, as far as it was known. Tracertests were not used as until now their application was not accepted by the responsible institutions. Therefore, delineation of GW catchments leaves large uncertainties about their actual extent, actual GW flow velocities, and thus, the GW protection zones themselves. To determine these parameters, and thus, adding a much higher precision to the GW system, tracer tests have been extensively used in Lebanon to define the groundwater contribution zone of the Jeita karst spring (Margane et al., 2013). Based on these studies and the resulting GW flow velocities, GW protection zones were established. This 'modern' approach has been proven to be highly valuable to achieve reliable data about the GW system in absence of GW observation data and shall serve as an example for other catchments in Lebanon. The experience that was gained during the application of tracertests in Lebanon could be transferred to Jordan, if Jordan authorities would accept using such methods.

The objective of this session was to discuss how to obtain the scientifically best result in order to achieve the most effective GW protection, not to impose unjustified landuse restrictions and to make protection zone delineations better legally defensible.

2.1 GW Protection Zone Delineation in Lebanon – Example Jeita Spring (Armin Margane)

Abstract

The general setting of the project area was described with its high topographic gradients, geological structure and tectonic features, high rainfall. The reasons for the differences in the approaches concerning GW protection zone delineation, i.e. traditional versus modern approach, were made clear. It was described why and where GW vulnerability maps are used for GW protection zone delineation. The differences between the GLA method (used in Jordan) and the COP method (used in Lebanon) were shown. It was explained why the COP method was modified by the project to be applicable in Lebanon. The delineated GW protection zones and the consequences for landuse planning were detailed.

The full presentation is enclosed in this document as ANNEX 3.1.

2.2 GW Protection Zone Delineation in Jordan Example Ain Rahoub & Hallabat Wellfield

Abstract

The various measures applied by different BGR projects over the past almost 20 years were presented. The zoning scheme used in Jordan since 1999 (similar to the German approach) and the areas where GW and SW protection zones were delineated and shown. At the examples of the Ain Rahoub and Hallabat, the principles of GW protection zones delineation (traditional method) were depicted. The main shortcomings are: used data were often scarce and sometimes not reliable; the geological structure was often not known in detail, i.e. GW catchment could not be reliably delineated. The main problems concerning GW protection zone delineation are:

- Inadequate data for delineation (flow velocity; safety margin higher than necessary)
- Most water supply facilities in poor conditions (rehabilitation urgently needed for adequate protection)
- Protection of supply system (often vandalized; no access to water for bedouins)
- Control of proposed measures necessary (Environmental Rangers > need training)
- Awareness Campaigns for decision makers and local population necessary

- Water resources protection must be truly integrated into landuse planning process (design of wastewater projects, waste disposal sites, industrial sites)

The full presentation is enclosed in this document as ANNEX 3.2.

2.3 Delineation of Groundwater Protection Zones in AWSA and Hidan well field (Niklas Gassen)

Abstract

The GW protection zones proposed for the AWSA (Azraq) and Hidan well fields were presented.

AWSA well field is located 85 km east of Amman, close to the former Oasis of Azraq. Groundwater is abstracted from the shallow aquifer complex, which is extensively overexploited by governmental and agricultural wells. This led to the ebbing of the four major springs feeding the Azraq Oasis and therefore also to the disappearance of the Oasis itself. The upper aquifer complex consists of Neogene to Quaternary basaltic layers and lower Cretaceous consolidated sediments, with good hydraulic properties for groundwater abstraction. Water levels are only a few meters below ground close to the Qa'a of Azraq and around 20 m.b.g.l. in the vicinity of AWSA well field. Protection Zone 2 was calculated with the cylinder formula and has a radius of 185 m around each well. Protection Zone 3 was determined with the help of a numerical groundwater model for the Azraq Basin (GAJ et al., 2013). It comprises an area of 435 km², including the groundwater catchment of the whole well field.

Hidan well field is situated 18 km southwest of Madaba, in the reasonably deep incised wadi Hidan. It is abstracting around 10 MCM/a from the A7 aquifer, supplying Madaba with drinking water. During the rainy season, the well field regularly has to be shut down due to bacteriological contamination and elevated turbidity. Possible sources of pollution are manifold, ranging from agricultural activities in the wadi to the improper disposal of waste water from households and animal farms. The Wadi es Sir (A7) aquifer has good hydraulic properties with a permeability of up to 40 m/d. As groundwater flow and therefore also contaminant transport takes place in conduits and enlarged void spaces, much higher flow velocities can occur. The direct infiltration of surface water from the wadi into the groundwater could be proven by a tracer test. Hence, the influence of the surface water was considered for the delineation of protection zones 2 and 3. For protection zone 2, the groundwater velocity as well as a buffer zone around the wadi was considered. The shape of protection zone 2 comprises an area of 23.6 km².

Protection zone 3 includes an area of 1953 km² and consists of the entire surface water catchment.

The full presentation is enclosed in this document as ANNEX 3.3.

2.4 Discussion

Points of discussion:
- how accurate should delineations be ? are the boundaries of protection zones legally defensible ?
- what is currently acceptable and implementable in terms of landuse restrictions ?
- how can we technically reach the optimal result ?
- Can numerical modeling replace field investigations, e.g. tracer?

2.4.1 Karst System

In Lebanon, tracertests were used to delineate the GW catchment of Jeita. Such investigations could not yet be applied in Jordan due to objections mainly from WAJ laboratory. However, tracertests are the only means to successfully delineate the GW contribution zone. Although in Jordan the geological structure is relatively well known on a medium to small scale, the understanding of the geological structure is not detailed enough for GW catchment delineations.

In Lebanon, high karstification of geological system leads to partly high SW – GW interaction: in the Jeita catchment, infiltration rate of streams is approx. 23%, with seasonal variation. Seasonal variation in overall infiltration leads to fluctuation in GW level by up to 200 m and a change of flow velocities by 1:10. SW – GW interaction does also impose an additional challenge on GW protection due to the increased complexity of the hydrogeological system, i.e. the consideration of topographical boundaries (MARGANE et al., 2013).

In Jordan, the level of karstification is much lower. In the Hidan wellfield area, downstream of Wala dam, SW-GW interaction and groundwater flow paths were studied by applying tracer tests, using naphtionate and NaCl (GASSEN & XANKE, in prep.). During the rainy season, high bacteriological contamination occurs in the wellfield, most probably as a result of infiltrating SW upstream of the wellfield. This SW-GW interaction was taken into consideration for the delineation of protection zones for the Hidan wellfield.

2.4.2 Tracer tests

In Lebanon, tracertests have been conducted since the 1920s to identify hydrogeological connections in the groundwater systems. However, only in the framework of the BGR project, tracertests have been applied systematically to delineate the GW catchment of Jeita spring. In Jordan, delineation of GW catchments is still based on the knowledge of the geological structure (structure contour lines) and GW contour lines. Both, geological structure and GW contour lines are, however, not reliable enough. GW contour lines are established on heterogeneous data, i.e. GW levels, measured at different times, whereas a contour map must be based on data from the same time. It is emphasized that more efforts must be undertaken to come to an improved data base for water levels (based on water level readings of WAJ, every time when the pumps are changed).

In Jordan, tracertests are difficult to apply: during the tests, pumping of wells must be stopped, which is difficult to accept for WAJ. Respective wells are needed continuously and no resources can replace these wells in times of interruption of abstraction. Water users are afraid about the potential health impact of tracers (this should be explained by the authorities to the general public). Water users and the public opinion play a more important role nowadays. Since the 'Arab Spring', politicians and with regards to water resources, especially the WAJ laboratory, are more careful to apply activities that might cause a public outcry, whether justified or not.

When applying tracertests, the tracer should not be visible in drinking water resources. At the beginning, several tracertests might be necessary to identify the required suitable amount of tracer, starting with a low concentration that would be increased step by step.

2.4.3 Stable Isotope Studies for GW Catchment Delineation

(see also presentation 8 / chapter 4.1)

In Lebanon, more than 800 stable isotope (SI) samples have been taken at different intervals so far: Jeita Spring (daily), Afqa, Assal, Labbane and Rouaiss Spring (2 weeks), rainfall (every 10-15 days) and snow samples (integral samples and 10 cm intervals). Samples were analyzed in the BGR laboratory in Hannover. This research based approach had benefits for both sides. On the free market, these analyses would have cost more than 100,000 Euro. It was only possible because BGR had an interest in the related research and the laboratory and staff was available.

Analyses of environmental tracer (CFCs/SF6, He/tritium) in Lebanon show that the mean residence time of GW is 1-2 years, proving high flow velocities. Also, mean elevation of the GW catchment of Jeita is proven by the composition of stable isotopes and thus, the high contribution via surface water infiltration, originating from the high C4 plateau, to the discharge of Jeita Spring.

Related studies have not yet been conducted in Jordan but would be highly useful there. Composite stable isotope samples of rainfall (input) and of springs (output) should be taken on a regular basis to identify pattern in SI composition and draw conclusions concerning the mean elevation of the GW catchments and mean residence times. Stable isotope and tracer studies would have a high scientific benefit resulting in a better understanding of GW flow mechanisms.

2.4.4 Vulnerability Mapping

Natural vulnerability of the GW system must be taken into account in site selection for infrastructure and landuse planning. In Lebanon, the COP method (VIAS et al., 2002, 2006) was used and modified (decrease of diameter of sinkholes and extent of influence of sinking streams) to assess the GW vulnerability within the Jeita catchment (MARGANE & SCHULER, 2013). The COP method was specifically developed for karst aquifers and therefore, it is advised to use this method in Jordan and Lebanon instead of the EPIK method. Data compiled for the application of the COP method are a bit more extensive than for the GLA method. Therefore, more field work might be necessary to achieve a reliable COP map. E.g. karst feature mapping has never been done in Jordan and soil maps are available only for a small part of the country.

GW vulnerability maps are useful for general landuse decisions. However, for decisions concerning individual sites, e.g. in the framework of EIAs, more detailed investigations must be conducted.

GW vulnerability assessment of productive aquifers is not only important for the present, but also for potential future use.

2.4.5 Protection Zones

Zone 1 must be totally fenced and operational room must not be equipped with toilets, as it is partly the case in Jordan.

In the Jeita catchment, 70% are Protection Zone 2, which would be impossible to implement. Therefore, a modification of Zone 2 into Zone 2a and Zone 2b (MARGANE & SCHULER, 2013) is proposed. Houses, which will not be connected to a WW scheme within the next years, should be subject to frequent sludge collection and centralized treatment. However, in Lebanon, there is no WW Authority that can take responsibility for this, instead, the Water Establishments are in charge for WW, even though being totally under-staffed (recruitment stopped by law) and with a lack of specific expertise in most of the necessary fields. WW treatment is therefore outsourced to companies. The operation of WWTPs is not always adequate (e.g. Ghadeer WWTP/Beirut which has only primary treatment, a rudimentary network, and where the sea outfall is not operational)

In Jordan, Protection Zone 2 is based on the 50 day GW travel time but limited to a maximum of 2 km upstream of the spring or well. The GW contribution area, however, is subject to change, according to GW pumping rates. Transmissivity values are not well known and differ considerably. More efforts should be undertaken to conduct pumping tests at all wells and wherever possible use nearby monitoring wells for calculation of storage coefficients.

The interaction of SW and GW is considered in Lebanon (MARGANE & SCHULER, 2013), as well as in Jordan (GASSEN, 2013), where in both cases the influence of losing streams was integrated through buffer zones along the streams.

2.4.6 Monitoring

In Lebanon, more than 300 dilution (tracer) tests have been conducted to assess discharge and streamflow and to obtain rating curves (water level vs. discharge quantity). Also, two ADCPs (Acoustic Doppler Current Profiler) and 8 multiparameter probes (In-Situ Troll 9500) were installed. The In-Situ system has the advantage of exchangeable sensors, which makes it easier to use because they can be easily removed and replaced, which is not the case for most other systems. The Trolls can be used via telemetry, however, the Water Establishment expressed its inability to buy SIM cards, so that, in spite of installed telemetry units, until now there is no telemetric use of the systems. Other options for handover of the equipment were therefore pursued (Litani River Authority).

In Jordan, spring discharges (800 springs) are measured manually at best 1-2 times a month (approx. 150 springs), which is insufficient to establish annual discharge values. Continuous discharge measurements, as done in Lebanon in the framework of the BGR project, should be done in Jordan to establish better discharge curves that help to understand the GW flow (fast flow and slow flow components) within the karst network.

2.4.7 Geological Mapping

In Lebanon, the previous existing geological map (prepared in the 1940s) was highly incorrect as it turned out during the BGR field work. This could not be foreseen prior to the launching of the project and therefore, a new geological map was established during the first project phase. Assessment of the hydrogeological system in the Jeita catchment is based on a newly established geological map that was used to aggregate hydrogeological units. Since tectonic features are of major importance for the GW flow regime, tectonics and the geological structure were also assessed.

In Jordan, detailed geological mapping was done until recently but many details are still missing. Unfortunately, the Natural Resources Authority (NRA) is no more able to conduct the extensive field work required for geological mapping. In some areas where BGR prepared GW protection zones (e.g.

Wadi Shuayb) geological mapping had to be done by BGR because of the poor degree of precision (and incorrect georeferrencing) of the existing maps.

2.5 Recommendation

- Better assessment of tectonic features and geological structure in both, Jordan and Lebanon
- Establish an updated and detailed geological map for Lebanon
- Measure spring discharges of all major springs by ADCPs in both, Jordan and Lebanon
- Generate updated GW contour maps based on actual GW level readings > WAJ: take water levels at all GW wells when pumps are changed
- For water quality monitoring: use the flexible In-Situ systems
- Collect environmental tracer, helium, tritium, ^{18}O and ^{2}H and conduct related hydrogeological studies
- Tracertests are a reliable and safe means to assess GW flow characteristics and should therefore be standard for hydrogeological investigations in karst systems, also in Jordan
- Previous conducted research (e.g. tracertest) should be presented to the other involved institutions (and the public) to inform about the usability of the method
- More extensive data collection and field investigations needed, especially in Lebanon, which is largely trailing behind in GW and SW monitoring
- GW modeling may be an additional method to the above mentioned but is only useful if all necessary data in adequate quality are available. Otherwise, GW models may lead to wrong results and conclusions!
- GW Protection Zones should be updated every 10 – 20 years, based on new data
- Apply Memorandum of Understanding (MOU) between governmental institutions and ministries in order to arrange cooperation where all parties benefit from

3 Physical Implementation of GW Protection Zones

The physical implementation of delineated GW and SW protection zones is a challenge because it needs concerted efforts by different institutions and stakeholders. Overlapping ministerial responsibility makes the design of the legal framework for protection zones difficult while the power of municipalities must be taken into consideration. In both countries, Jordan and Lebanon, municipalities play in the meantime a major role in landuse planning.

After setting up the legal framework and related landuse restrictions in the specific groundwater protection zone, a legal entity that is furnished with the right to impose fines and penalties, must ensure that laws are followed on the ground and appropriate protective measures are taken.

Landuse licensing committees, as existing in Jordan, aim to ensure that human activity on the ground is coherent with environmental and water resources protection. For each type of activity, one specific committee will be responsible. Since there are several different committees (e.g. mining, gas stations, hazardous wastes, olive presses), the Central Licensing Committee assigns the planned project to the respective committee. In frequent meetings, the inter-ministerial groups analyze and discuss the subject, starting at the beginning of the project development. If a committee concludes that an Environmental Impact Assessment (EIA) is necessary, the EIA Committee is addressed.

Licensing Committees are good examples of a coherent approach of landuse planning. It continuously involves the collaboration of different ministries, which are responsible for the specific subject and resources protection while taking transparent landuse decisions. In Lebanon, such bodies are not existing but would contribute to a better exchange of experience and knowledge of the different governmental bodies and thus, to better landuse planning. It is highly recommended to follow the Jordanian example.

The Environmental Rangers are a police task force of the Jordanian Ministry of Interior and work closely together with the Ministry of Environment, established in 2006 by Royal decree. The Rangers are tasked to locate and record violations against environmental laws. By doing so, they have become an important agency to apply groundwater protection measures on the ground. BGR Jordan works closely together with the Rangers and provided equipment and training related to GW protection. A GIZ expert was assigned to the Rangers for this task. The Rangers are therefore also an example for Lebanon to be followed. In Lebanon a decree is still pending to establish an Environmental Police.

3.1 Landuse Licensing Committees (Zakkaria Hajj Ali)

3.1.1 Abstract

The investment in Jordan increased rapidly in many sectors recently. Hence, it was necessary to control the investment projects by the Jordanian government in term of land-use, water resources and many other elements. The implementation of the controlling takes place through the licensing committees.

There are many licensing committees composed out of representative persons from different ministries and departments in order to adjust and organize the applications that are submitted by the investors to establish and construct new economic projects. Those committees are responsible to give a permission or rejection to the applicants from the governmental side based on specific parameters and procedures.

Due to the limited water resources in Jordan, the Ministry of Water and Irrigation took part in the licensing committees to insure the safety of the requested projects in term of water. Furthermore, there is an internal committee in the ministry to follow and discuss the submitted projects applications and decisions of each committee.

3.2 Cooperation with Rangers Department (Mohammad Al Hyari)

3.2.1 Abstract

Water resources protection in Jordan through protection zones is of major importance to ensure drinking water for domestic supply. To enforce the national water resources protection guideline a memorandum of understanding between the Ministry of Water and Irrigation and the Royal Department for Environment Protection (RDEP) was signed in 2011. The RDEP has currently 800 Environmental Rangers working in 18 branch offices all over the Kingdom. It is an administrative unit of the Public Security Department and an executive arm of the Ministry of Environment (MoEnv).

Within the RDEP a special Water Resources Protection (WRP) Team has been operating since the beginning of 2010. This team acts as an extension team to the local branches distributed throughout the whole Kingdom of Jordan. One aim of the WRP team is to enable the Rangers to record and react to any case of violation within the protection zones. The team is directly supported and trained by a GIZ adviser in the application of GPS (Global Position System) and the use of GIS (Geographic Information System). Until today the team trained about 270 Rangers countrywide in the application of GPS.

As a result of the cooperation between the institutions, the Rangers could actively contribute to the delineation of new groundwater protection zones in Hidan and AWSA well fields by identifying potential pollution sources in the project areas. The local branch office next to the adjacent project area was involved and especially trained. Potential pollution sources were first identified by analyzing satellite images. In order to investigate the identified sites in the field, inspection sheets for the protection zones were developed and then applied by the rangers. The results of the inspection sheets are entered into a database. Through the involvement of the local branches, a constant

monitoring and a regular update of the database containing the pollution sites is now possible.

The Hazards to Groundwater, identified by the rangers through their investigations, include animal farms, vegetable farms, manure dumping sites, residential areas not connected to a sewer system, waste dumps and car washing sites. The locations, recorded by GPS, were processed with GIS, displayed in a map and included in the work for the delineation of the groundwater protection zones by BGR/MWI.

The full presentation is enclosed in this document as ANNEX 3.4.

3.3 Protection of Jeita Spring (Zeina Yaacoub)

3.3.1 Abstract

Discusses the possibility to implement the proposed GW protection zones for Jeita spring through a Ministerial Decision of the Ministry of Environment (MoE). For this it needs a commitment from other ministries to collaborate on this matter. Environmental sound practices would need to be imposed on existing landuses contaminating the water resources, such as gas stations and industries. New industries and gas stations should not be permitted. A problem for this implementation is the severe lack of awareness at all levels and the overlapping competences of the ministries. Concerning proposed landuses they often have different opinions. The Environmental Police is proposed by draft law but not accepted yet by the Council of Ministers. For the time being, local authorities should fill this gap in enforcement and control. MoE needs a sufficient number of staff to monitor pollution in the field.

Due to recent amendments in the laws more and more claims are won in court and the polluter-pays principle is applied. An environmental judge was assigned to rule such court cases. However, a review of the existing legislations and new regulations are needed.

The full presentation is enclosed in this document as ANNEX 3.5.

3.4 Discussion

Points of discussion:
- what are shortcomings concerning implementation of GW protection zones ?
- how can we reach a better control of the proposed landuse restrictions ? Is a compensation system that creates a win-win situation necessary ? (environmental fund)
- is there a need for to amend the legal framework ?
- are the decisions of the Landuse Licensing Committees supported by adequate data/information ? do they take legally defensible decisions or can (are) their decisions be challenged in court ?

- does the work of the Environmental Rangers lead to less violations with regards to pollution ?

3.4.1 Landuse Licensing Committees

The following landuse licensing committees that contain a representative from MWI exist in Jordan:

- General landuse licensing committee > decides all important cases and passes on less important cases to the related subcommittees
- Gas stations licensing committee
- Biodiesel and synthetic fuel licensing committee
- Olive press licensing committee
- Mining exploration licensing committee
- Mining exploitation licensing committee
- EIA technical committee
- Oil shale technical committee
- Hazardous wastes licensing committee

In Jordan, all licensing committees work, based on the same information and data, considering, among others, water resources protection (potential impact on drinking water abstractions, geological outcrop/ subcrop, GW vulnerability, existing GW protection zone). All steps of licensing follow a standardized outline/template of report that includes a specification about the location, results and recommendations of the committee in charge. A request must be agreed upon by all members to pass. If one member disagrees the request is rejected.

Furthermore, MWI, JVA, WAJ, BGR and MoMA are working together since 2009 in order to include water resources in the landuse master plans, which are prepared by MoMA to regulate the recommended landuses for each land plot at the municipality level. The main aim of this cooperation is to avoid potential contamination. The integrated aspects include relevant water infrastructure such as wells, springs, dams and wadies. MWI, JVA and WAJ provide MoMA with all related data and shape files to insure the protection of the water resources. The BGR project contributes the protection zones shape files and water the resources protection guideline so that these can be taken into consideration when preparing the landuse master plan.

However, committees face the issue that requests about licensing are not referenced to geographic coordinates but instead to land plots. Land plots can be very large in size, which makes the assessment more difficult because the request landuse activity can have different effects on the underlying GW resources, depending on the exact location.

In Lebanon landuse licensing is ruled by Landuse planning department decrees and decisions. Each landuse activity is generally licensed following the approval of a relevant related committee. These committees include representative of the Landuse Planning Department who's decision is mandatory for the permit in addition to representatives from the governmental institutions (governorate, ministries and municipality), related to the planned activity.

However, some gaps in the ruling laws allow in many cases some individuals (e.g.: governor, minister of industries, etc.) to disregard the decision of the relevant committee and impose its own opinion without any need for justification.

In addition, in some relevant permitting processes, the opinion of the ministry of environment is not considered as mandatory. Such permits (e.g., gas stations) are sometimes issued in disregard of their possible negative impact on water resources and other components of the environment.

This fact was partially resolved by the late approval of the EIAs decree in August 2012, however many activities are not covered by this decree. Furthermore, the application of this decree is at its initial stages, in complete absence of a relevant database on which any environmental assessment can be based (vulnerability maps, geology, hydrology, etc). The lack of knowledge of the groundwater system in Lebanon renders the task of its protection quite difficult. The landuse licensing process is still disregarding protecting the groundwater especially due to the lack of related information on which such decisions could be based.

3.4.2 Environmental Rangers/Police

In Jordan, the Environmental Rangers applied already many fines (up to 10,000 JD and imprisonment) on violations of environmental laws due to their executive power, which results from their linkage to the General Security. In order to build capacity in water resources protection, Rangers are involved in the process of implementation of landuse restrictions for GW protection zones set by MWI. The Rangers conducted partly the respective hazard assessment/mapping in close coordination with BGR. By conducting workshops and capacity building, staff of the Rangers is continuously dealing with the scientific background of water resources protection. In addition, one permanent staff of the MWI is present in the Rangers control unit. Nowadays, the Rangers have all relevant water resources maps for their work.

Problems of law execution are mainly related to a high fluctuation in staff in the Ranger’s unit, which threatens the efficiency and sustainability of capacity building and thus, in the effectiveness of the Rangers.

Legal penalties for violations are applied according to the availability of Ranger's staff in the field. In fact, many violations are not prosecuted. Therefore, penalties in form of social discrimination of delinquents may contribute to better law compliance. A public accessible online GIS, in which all violations are located, specified and visualized, makes law-breaking transparent and therefore puts social pressure on delinquents.

Rangers in Jordan are also included in many awareness campaigns, which have been conducted together with their partners such as MWI, WAJ and BGR concerning the issue of water resources protection and protection zones. They play a vital rule in those awareness campaigns through their participation, speeches and presentations.

In Lebanon, no environmental police is currently existing, despite of the long time existence of a respective draft decree that isn't ratified yet.

3.4.3 Implementation of GW Protection Zones

In Lebanon, landuse restrictions are difficult to apply because they are mainly seen (and communicated) as a limitation to development. Raising awareness about the value of clean water resources as well as raising awareness about the benefit of cleaner production (e.g. organic farming, recycling of hazardous substances, e.g. solvents), better waste management (recycling of waste, reuse of construction waste e.g. for small dams) and compensation must be promoted.

At institutional level, overlapping responsibilities of ministries is a big problem because in fact, all necessary environmental laws have existed in Lebanon for a long time. However, the problem relies in their enforcement.

It is not necessarily the implementation of laws (in general) and their guidelines and procedures, which are the obstacles or problem but also the law itself that makes it difficult to implement due to non-specificity. A proper institutional platform for implementation is missing and judges should be trained in water issues.

3.5 Recommendation

- In Jordan: provide site specific coordinates for requested landuse that shall be licensed
- In Lebanon, existing committees should be strengthened through cooperation. The opinion of the ministry of environment must be considered as mandatory in the licensing process.
- In Lebanon individual decisions must be subject to responsible control.
- There is a need to create a database related to surface and groundwater resources in order to get rigid information that are crucial

for any EIA, and thus to landuse licensing. The landuse department later must always consider the GW vulnerability in its planning and decisions.

- Make cases of violations public in order to increase awareness and make transparent who is the polluter
- Communicate GW Protection as a chance instead of a threat to development, as it is often understood in public
- Promote the need of an environmental police, which is equipped with executive power, in Lebanon, and provide an understandable related capacity building to assigned staff.
- Promote the establishment of a Water Court

4 GW Recharge Assessment/Water Balance

In karstified groundwater catchments, the delineation of the contribution zone is a very extensive task. In order to achieve the most reliable results, different scientific methods must be applied in parallel. Besides using artificial tracer tests, environmental tracers are advised to collect in the field, i.e. Helium, tritium, CFC (chlorofluorocarbons), chloride and isotopes, such as deuterium (2H, δD) and oxygen-18 (^{18}O, δ^{18}O). Each precipitation event shows a characteristic composition of environmental tracers, depending on the origin of the weather regime and elevation of occurrence of the precipitation event. The composition of tracers in water will change over time, depending on flow paths and residence times on or over the ground. Therefore, the composition of tracers in spring discharges allows assessing the mean residence time of groundwater in the system and the mean elevation of the groundwater contribution zone. Information about this is an important detail for the establishment of a water balance based on reliable groundwater recharge rates.

In the groundwater catchment of Jeita, stable isotopes were used to proof the complex surface water-groundwater interaction of highly karstified aquifers (MARGANE et al., 2013). Through application of this method, a reliable water balance was established and areas that must be considered in groundwater protection measures could be identified. In Jordan, these studies can contribute to a more reliable assessment of the extent of certain spring catchments in order to improve protection effectiveness.

4.1 Use of Stable Isotope Analyses and environmental Tracers to characterize GW Recharge and Flow Mechanism in the Jeita Catchment (Armin Margane)

Stable isotope sampling is frequently used in groundwater studies to:

- study the groundwater recharge mechanism
- study evaporation effects
- determine the mean elevation of a groundwater catchment
- determine the mean residence time of groundwater in an aquifer system.

Other applications are:

- testing leakage of dams
- testing tightness of pipelines, concrete conveyors and canals

Most frequent application is in karst aquifers to determine hydrogeological interconnections and delineate GW catchments (Switzerland, France, S-Germany). Many tracer substances are organic colors and toxicologically safe for human consumption in the amounts they would be occurring in GW after injection (FIELD & NASH, 1997; FIELD et al., 1995; BRÜSCHWEILER, 2007; FLURY & WAI, 2003).

4.1.1 Abstract

Rainfall in Lebanon comes commonly from the W or NW and follows 4 typical trajectories. Isotopic composition of rainfall reflects these differences in origin but also rainfall becomes more and more depleted in heavy isotopes with increasing elevations. Groundwater recharge is high in both aquifers (J4 and C4), around 60% in the Lower Aquifer (Jurassic limestone, J4) and around 80% in the Upper Aquifer (Upper Cretaceous, C4). There is only little evaporation. This leads to a very light isotopic composition of the GW in the Upper Aquifer and distinctly heavier isotopic composition in the Lower Aquifer. Composite rainfall samples were taken in the Jeita catchment every 10-15 days at 6 stations with different elevations (90-1600 m asl) and springs were sampled at 1, 15 or 30 days intervals. Isotopic composition of the springs shows an immediate response to snowmelt. Kashkoush spring has a lower average elevation of its GW catchment compared to Jeita spring. The J4 outcrop area of Jeita spring has an average elevation of 1,020 m but the isotopic composition reflects large contribution from higher elevated GW catchments (2,000 – 2,200 m asl). This confirms the assumption of high amounts of inflow into the Lower Aquifer from the Upper Aquifer through river bed infiltration (on average 23% of surface water flow).

Conclusions of stable isotope sampling:

- Pronounced seasonal variation of $\delta^{18}O$ and $\delta^{2}H$ with fast response to snowmelt
- Significant difference between Jeita/Kashkoush and C4 springs
- Response of C4 springs fits with catchment elevation

- Difference in composition between Jeita and Kashkoush spring points to lower average catchment elevation of Kashkoush spring
- Jeita spring must be fed by contribution from higher elevations (more than 30%)

Also, electric conductivity (EC) and chloride content decrease in rainfall with distance from the coast and elevation. This can also be used, if monitored over long enough time periods to identify the source/GW catchment of springs.

It is recommended to use stable isotope sampling and analysis in Jordan for related GW studies and research.

Helium/Tritium, Chlorofluorocarbons (CFC) and SF6 samples were taken from Jeita, Daraya (Jeita siphon terminale), Assal, Labbane and Kashkoush springs. They show that the GW residence time is 1-2 years (He/Tritium) and 1-6 years (CFC/SF6 method), respectively. Similar studies are recommended to be conducted in Jordan to determine the mean residence time of spring water in certain GW catchments, especially in the NW.

The full presentation is enclosed in this document as ANNEX 3.6.

4.2 GW Recharge Assessment / Water Balance (Armin Margane)

Groundwater resources assessments depend on the quality of the assessment of the individual components. While individual components, like rainfall, surface water runoff, spring discharge and GW abstraction, can be monitored sufficiently well, groundwater recharge (GWR) and evapotranspiration (ETP) can often not be measured adequately. Measurements or estimations based on different methods may be possible for individual sites but assessments are not easy on the catchment scale. Several attempts to determine GWR have been made in Jordan but still large uncertainties exist. Countrywide GWR estimations range between 275 and 462 MCM, a considerable difference. Significant amounts of groundwater are used, an increasing share of which is coming from fossil aquifers, thus constituting GW mining. Due to the large over-abstraction the responding decline of water levels in the main aquifers is in the meantime considerable (~ 3 m/a). Since monitored GW abstractions were in the range of 440 MCM/a from renewable aquifers, but water level declines were even then around 3 m/a, lower estimations of GWR seem to be more justified. In view of the extremely scare water resources of Jordan and of the immense external and internal pressures, further research for a more accurate estimation of GWR is essential.

4.2.1 Abstract

For the Lebanese participants the characteristics of the GW system in Jordan is explained (geological structure, GW flow). The different methods to calculate GWR applied in the BGR North Jordan project and by others are explained. It is pointed out that under the unclear input, GWR estimations using the chloride mass balance are not useful (only few chloride data in rainfall, but regional distribution required; elevation and distance dependency). Also, estimations based on GW level fluctuations should only be used if external influences can be excluded and the specific yield is known from pumping tests. Most promising are GWR calculations in well-defined GW catchments with good spring discharge records. However spring discharge monitoring must be improved (by use of ADCPs). Recharge assessments based on climatic balance using rainfall-runoff calculations and the curve number method are not appropriate in Jordan as they neglect the underlying rock characteristics, infiltration possibility (geology not considered, only soil properties !), indirect infiltration, etc. Since surface water runoff stations are largely not available to calibrate such estimations, they commonly provide runoff/ETP/GWR values which are not logical given the geological context (e.g. Corridor wellfield; BORGSTEDT et al., 2008).

The full presentation is enclosed in this document as ANNEX 3.7.

4.3 Discussion

Points of discussion:
- how accurate are our water resources assessments ?
- how can we come to a better quantification of GW recharge ?
- To which extent is SW/GW interaction investigated and integrated into GW resources management?

GW recharge (GWR) is the most important component of the water balance and it needs a better understanding about it. GWR is the basis for water resources planning. Sustainable abstraction rates can only be reached if GWR is better defined. GWR probably lower (280 MCM/a) than currently assumed (395 MCM/a). More efforts must be undertaken to come to better GWR estimates. Improved long-term monitoring of baseflow and spring discharge contribute to a better understanding of the GW system.

Isotope analyses clearly contribute to a better and more reliable understanding of GWR and the hydrogeological balance, however, analyses are very costly on the free market. Samples must be taken, analyzed, processed and interpreted by experts.

In Lebanon, samples were analyzed in the BGR laboratory in Germany. In Jordan, the WAJ laboratory or University of Jordan may be appropriate partners but needs a cooperation agreement (currently MWI pays for water analyses of WAJ and WAJ analyses are relatively expensive).

4.4 Recommendation

- Intensify applied research concerning GWR (e.g. BMBF funded projects)
- Include stable isotope analysis and GWR calculations in the budget of future hydrogeological projects (Technical Cooperation or BMBF research projects)
- Assess various possibilities of cooperation with laboratories to conduct the analyses there
- Collaborate with relevant existing academia in Lebanon in order to promote the use of stable analyses and environmental tracers to characterize GW recharge and flow mechanism.

5 GW Monitoring

Reliable water planning must be based on solid data and information regarding the quantitative hydrological regime in a catchment as well as the qualitative composition of resources. Only if this precondition is met, sustainable water management can be achieved and failed investments in infrastructure can be avoided.

However, so far, GW quality assessments have been a neglected issue in Jordan and Lebanon and it is mainly limited to the sampling of groundwater outflow, i.e. spring discharges. In turn, quantitative parameters are commonly more favored. In order to be able to establish a water balance, climate data, groundwater level, groundwater outflow (springs) and surface runoff needs to be monitored simultaneously.

GW monitoring is an extensive field that may involve different institutions. For example, in Jordan, quality parameters are monitored by WAJ lab, whereas climate is monitored by the Meteorological Service and MWI and surface runoff and groundwater level by MWI. In order to avoid a duplication of monitoring, cooperation between all involved institutions is needed to harmonize monitoring. The establishment of a monitoring plan was instigated by previous BGR projects but is still missing. Such a plan would define where monitoring is needed for which purpose, by which means and in which frequency.

Establishing and maintaining a monitoring system can be costly. In order to make decision makers willing to finance monitoring they must understand the value of the system, i.e. the usage of data and the derived information and related management decisions. In Jordan, an extensive rehabilitation of the monitoring network (surface water, groundwater and climate) was launched by the MWI, concentrating the data in one institution while also sharing the responsibility of climate stations with the Meteorological Service. This approach can be an example for Lebanon, where the national monitoring network has been lacking investments and maintenance since the beginning of the civil war in 1975. In Lebanon, GW monitoring wells are still missing so that e.g. the calibration of GW models is not possible. The meteorological observation network comprises only 35 stations of the National Meteorological Service (NMS), which are not heated so that e.g. precipitation records are very wrong. Spring discharge measurements are not appropriate as they are not continuous. The calculated resulting spring discharge can be wrong by more than 50%.

5.1 Telemetry Water Resources Observation Network (Hussein Hamdan)

5.1.1 Abstract

A concept for a National Water Resources Observation Program (NaWaROP) was developed by GIZ. MWI has decided to update its monitoring system to telemetric data transfer (using GPRS; Telemetric Water Resources Observation Network, TeWaRON). One of the main objectives is to facilitate updating of official data on National Water Resources, e.g. related to the Water Master Plan (now WEAP models). The network will be established through several contracts:

In total the monitoring network comprises:

- 80 automatic rainfall stations, 240 rainfall stations with standard precipitation gauges, 40 rainfall totalizers; 90 stations were operated in 1995 (MARGANE & ZUHDY, 1995); oldest records: 1922 (MARGANE & ZUHDY, 1995)
- 800 springs (discharge measurements, 233 springs of class A: 1*/month, 64 springs of class B: 1*/3 months, 504 springs of class C: low discharge or difficult access, not monitored) (MARGANE & ZUHDY, 1996) ; oldest records: 1937
- 24 streamflow gauging stations (MARGANE et al., 2002)
- 220 GW level recorders (mostly Stevens drum recorders) MARGANE & ALMOMANI, 1995)
- ~ 100 GW quality monitoring stations
- ~ 5000 GW well abstraction meters

DPP	***TeWaRON1***	***BGR/ESCWA***	***TeWaRON 2***	***TeWaRON 3***	***TeWaRON 4***
2010	2010	2011	2011/12	2012 (Tendering)	2013
GIZ	MWI	BGR/ESCWA	MWI	MWI	MWI
SEBA	SEBA	OTT	Campbell	Campbell	Sutron
7xGW 2xMet 1xRain 1x Discharge	8xGW 2xDischarge 6xMet	11xGW 1xMet	15xGW 5xMet 15xPrec	15xGW 5xMet 10xRain	15xGW 10xRain
11 stations	16 stations	12 stations	35 stations	30 stations	25
Total= 104					

Advantages of telemetric monitoring are:

- Reliable data (prevention of typing errors)
- Online status control (battery etc.)
- Alarm in cases of instrumental malfunction (SMS, phone call, etc.)
- Automatic data visualization and validation possible

Further steps: improvement of old and establishment of new hydro-meteorological monitoring stations through KfW fund (6.4. Mio EUR); telemetric measurement of water quality parameters and water levels in dams. Improvement of Water Information System (WIS) database.

Lessons learnt: limited loss of stations due to vandalism, very stable network and good connectivity at all sites, low running costs: < 3 JOD/month/station).

The full presentation is enclosed in this document as ANNEX 3.8.

5.2 Discussion

Points of discussion:
- do we have the appropriate monitoring network to assess water resources ? what is missing and what must be done ?
- how can the monitoring concept be improved ?
- does monitoring of quality and quantity have consequences for water resources exploitation ? what is missing ?
- Is the importance of monitoring, with all financial consequences, acknowledged by decision makers ?
- how can we come to a better assessment of available quantities and qualities of water resources ?

In Jordan, MWI has launched the rehabilitation of 200 GW, 50 SW and 100 meteo stations for a total of approx. 10 Mio JD (excl. land acquisition and borehole drilling), using the offer of SEBA (PPP project). All monitoring data shall be imported and stored in a central database DEMASdb (www.seba-hydrocenter.de/projects) that can be accessed online, also those of other providers, such as OTT. Data transmission from stations to the database is done via a telemetric system that depends on the GSM coverage. Coverage is good in all of the country. DEMASdb database is linked to central database, the Water Information System (WIS).

These data are managed and owned by MWI. However, based on a MoU, meteo data is partly shared with the Meteorological Service in order to avoid operating redundant meteo stations. Access to these meteo data is limited to MWI staff and Meteorological Service staff. To publish these data is difficult, because the Meteorological Service sells their data. Data shall be shared in the framework of the BMBF funded TERENO MED Project (http://www.ufz.de/tereno-med/). The Guidelines and standards of TERENO shall be implemented in the MWI monitoring within the next 5 years.

After 4 years of experience with the rehabilitation program, many components must be evaluated. For example, which measurements are needed at which station as well as how to continue maintenance of the stations. Maintenance might be outsourced, knowing that consultants might not keep the quality standard. The evaluation shall also give answers whether the locations of the stations are suitable or not.

In Lebanon, monitoring is fragmented (LRA/Meteorological Service) and of insufficient quality (few (or no, e.g. GW level, GW quality) monitoring stations, scarce and irregular spring discharge measurements, no telemetry, poor stations, no maintenance, no rehabilitation), i.e. monitoring of water resources must be renewed from the ground.

5.3 Recommendation

- Experience in Jordan shows that a step by step upgrading of the monitoring network is recommended: after the first tender, more companies were attracted to the project and therefore, prices decreased
- Use infrastructure/database system that can deal with equipment from different providers
- Before tendering: establish a monitoring management plan that includes:
    - which parameters need to be measured
    - where should stations be located in order to fulfill the intended task

- Telemetry: check network coverage and system to be used (GSM or GPRS, push or poll; cost factor)
- Responsibility for maintenance (contractor)
- Data management (handover from contractor to gov. institution); integrate data into central database system; create routines to make monitoring data available for other procedures e.g. Water Master Plans, WEAP or GW models
- Annual monitoring report: present/visualize data and identify required actions/responses

- Establish an inter-ministerial database that can be accessed by all governmental institutions

6 GW Management using WEAP

Water Evaluation and Planning (WEAP; SEI, 2011) is an appropriate software to obtain a water balance and has been widely used within BGR's technical cooperation within the MENA Region (DROUBI et al., 2008; NOUIRI, 2011; LE PAGE et al., 2012; SCHULER & MARGANE, 2013). So far, WEAP has been acknowledged as a practical Decision Support System (DSS) for water management in various countries (e.g. Jordan, Lebanon, Morocco, Syria and Tunisia), hence, the extent of practical and independent application differs.

The purpose of WEAP models is to provide decision makers with actual information concerning water resources availability and to facilitate decision related to water resources allocation. In the framework of technical cooperation with ACSAD a coupling of WEAP with MODFLOW was achieved so that WEAP now includes the surface and groundwater system. It must, however, be emphasized that the modeling results depend very much on the understanding of the entire water system. It should be known where an interaction between surface and groundwater occurs (influent / effluent).

In Jordan, WEAP has been used for several years to model all surface water catchments, supported by donor activities (BGR, GIZ). Nowadays, the software is institutionalized and models are continuously maintained. However, so far, in only 2 of these catchments (Azraq, Amman-Zarqa) WEAP models are connected with MODFLOW models.

In Lebanon, WEAP is a relatively recent tool, which is exclusively related to donor activities and not independently applied. There, a major challenge is to ensure sustainability of WEAP models beyond donor activities.

WEAP is usually based on topographically delineated surface water catchments. In karstified regions, this approach fails because the extent of a groundwater catchment may be highly different to the respective surface water catchment (MARGANE et al., 2013). The WEAP water balance for the Jeita catchment accommodates this fact and groundwater boundaries were used for the model instead of surface water boundaries. In Jordan, this is not foreseen yet. In this context, the discussion about the effectiveness and usefulness of coupling MODLFOW with WEAP (MASSMANN et al., 2011) should be discussed with respect to data availability.

6.1 The WEAP model of the Jeita GW catchment, (Philip Schuler)

6.1.1 Abstract

This balance presents the first WEAP model for the groundwater (GW) contribution zone (GWCZ) of Jeita spring. It shall serve as a practical tool for decision makers to model climate change scenarios and water management options, for instance managed aquifer recharge (MAR) in the catchment of Jeita to increase discharge of the spring.

The modeling approach comprises the sub-division into 13 sub-catchments, according to: 1. Hydrogeology (J4 Aquifer – Aquitard Complex – C4 Aquifer), 2. Direction of surface runoff and 3. Spring and reservoir catchments. Data input is done using monthly time steps, considering one average water year. Catchment processes are modeled by the Rainfall Runoff Method (simplified coefficient) above the J4 Aquifer and the Aquitard and by the Rainfall Runoff Method (soil moisture model) above the C4 Aquifer in order to model snow accumulation and snow melt.

Calibration was done based on subjective criteria, including adjusting modeled to observed spring discharge, infiltration/groundwater recharge (GWR) rates, as well as streamflow of Nahr el Kalb at Daraya gauging station.

The results show, that from a total annual precipitation of 620 MCM (404.5 MCM rain; 215.3 MCM snow), 110 MCM are subject to direct evapotranspiration (ET) (incl. crops without applied irrigation), 141 MCM to direct surface runoff (SR) and 370 MCM to direct groundwater recharge (GWR) (154.4 MCM from rainfall; 215.3 MCM from snowmelt). Annual irrigation demand between May and September is 17 MCM (with an irrigation efficiency of 75%) while domestic water demand sums up to 10 MCM (incl. 35% network losses and 50% GW return flow).

Annual modeled discharge of Jeita sums up to 171.4 MCM. 23% of discharge originates from rainfall on the Aquitard Complex, 38% from the J4 Aquifer and 39% from the C4 Aquifer. Altogether river bed infiltration constitute 46.2 to Jeita spring discharge (80.1 MCM/a). Approximately 32% of Jeita's discharge originates from riverbed infiltration of Nahr Ibrahim (14% originate from infiltration of Nahr es Salib and Nahr es Zirghaya). In Ibrahim valley, 23% of streamflow infiltrates towards the J4 Aquifer, making this infiltration of high importance to Jeita spring.

Due to the high infiltration along streams in karstified valleys, the project recommends MAR (Managed aquifer recharge). In Nahr es Salib Valley, MAR could increase the annual discharge of Jeita Spring by 17.5 MCM to 188.9 MCM.

MAR may become more crucial if climate change predictions turn out to become real. For an optimistic outlook (Scenario 2; referring to IPCC A1B scenario), a decrease of precipitation by 10%-15% and an increase of temperature by 1.5°C in winter and 1.75°C in summer will reduce discharge of Jeita by 19% to 140 MCM per year until the year 2040. In case of a slightly higher temperature increase (scenario 1 (also IPCC A1B but using the less optimistic results): decrease of precipitation by 15%-20% and an increase of temperature by 1.75°C in winter and 2.0°C in summer) discharge of Jeita spring will decrease to 129 MCM (25%).

The full presentation is enclosed in this document as ANNEX 3.9.

6.2 The Role of Decision Support Systems in Integrated Water Resources Management – Lebanon (Abbas Fayad)

6.2.1 Abstract

Principally Lebanon has enough water but may be facing water scarcity in case climate change predictions (see presentation Schuler) are correct. This problem adds to already existing pressures on the water sector from the Syrian refugee crisis, pollution and increased competition about water usage between the agricultural sector and the domestic sector (drinking water). Data on all components of the water balance are largely missing due to inadequate monitoring. Planning, investment, monitoring and operation functions are fragmented and lacks coordination.

The basic constraints to nationwide WEAPS models are that:

- the comprehensive national water database is incomplete due to very limited monitoring,
- the catchment boundaries of groundwater resources are not defined yet,
- the impact of pollution is not quantified,
- baseline climate conditions are highly uncertain (few climatic stations, no measurement of snow due to not heated systems),
- the baseline conditions for surface water resource are uncertain (interaction between SW and GW not considered (where effluent, where influent)),
- there is no definition of baseline conditions for ground water resource (determination of available GW resources),

- for management, operation and planning there is no coordination between institutions so that the usage of WEAP models is uncertain.

In summary, Lebanon has started to recognize that the preparation of WEAP models is useful but is far from being able to establish meaningful models for the country because of a general lack of required input data and often incorrect concepts (GW - SW interaction). It has thus problems to establish overall water resources availability and properly manage allocation of water resources to the different sectors.

The full presentation is enclosed in this document as ANNEX 3.10.

6.3 Decision Support System WEAP (Ali Breazat)

6.3.1 Abstract

WEAP models are prepared a) for the entire country and b) at the surface water basin level and c) on an administrative scale. The basin models comprise:

- Yarmouk
- Amman-Zarqa
- Azraq
- Jordan Valley
- Dead Sea side wadis
- Sirhan
- Hammad
- Mujib
- Hasa
- Jafr
- Wadi Araba North
- Wadi Araba South
- Disi

The input data are taken from the time period 2000 - 2012 and are derived from WIS database, WAJ and JVA data and the National Water Strategy (2008). All models run to 2030.

Scenarios comprise e.g.:

- climate change (2002-2020)

- Red Sea - Dead Sea conveyor (2002-2030)
- Treated wastewater reuse (2002-2030)
- Demographic - economic scenarios (2002-2030)
- Loss reduction (2002-2030)
- Desertification (2002-2030)
- Demand sites for Syrian refugees

The full presentation is enclosed in this document as ANNEX 3.11.

6.4 Discussion

Points of discussion:
- Is WEAP more suitable for water resources assessments and management than GW models ?
- do we have adequate data for what we want to achieve with the WEAP models ?
- is WEAP truly used as a management tool, and is related information shared between relevant institutions ? what is missing ?
- Are the established WEAP Models continuously managed/updated and does a dialog between modeler and users exist ?
- What are the challenges in using the results ? Is their reliability usually acknowledged ?

In Jordan, WEAP is now recognized as the only existing decision support system (DSS) for water allocation and water management planning. A specific unit within the MWI, equipped with 6 permanent staff, in responsible for maintenance and application of the existing WEAP models. This unit shall also ensure the sustainability of capacity building or the relevant staff by distributing the experience and expertise on multiple persons. Besides this, the MWI cooperates with universities to maintain the models and build capacity for potential future staff.

Sustainability of the established models shall be ensured by detailed documentation in order to ease future usage.

The Jordanian WEAP models are based on either surface water catchments or on administrative boundaries. They can be used by different ministries by contacting the MWI with their request to develop future prospects/scenarios. Many requests are now coming from municipalities directly and the Ministry has to answer them.

In Lebanon, WEAP is still in the beginning of application and the application is exclusively limited to donor activity (e.g. by the BGR Project, the MED EUWI project at MoEW and by the LRA/USAID Project in the Litani River Basin). Sustainability of the models and of trained staff is highly uncertain. The BGR WEAP model is based on the groundwater catchment, instead of the traditional approach of using the SW catchment as reference. Since SW and GW catchment can differ extensively in karst areas (MARGANE et al., 2013), this approach is justified and recommended in karstified catchments.

All (WEAP) models must be able to be evaluated in terms of reliability of the modeling output. Therefore, all input data and their reliability must be documented.

6.5 Recommendation

- Quality management: prior to the development of a WEAP model, a management plan must be established that outlines the procedures of documentation
- Establish a central geodatabase with all used shape and raster files, incl. all existing metadata and reliability
- Establish a climate database, incl. all existing metadata and reliability
- The groundwater contribution and SW-GW interaction must be considered
- Institutionalization of WEAP: involvement of all relevant stakeholders
- In the framework of continuous (donor driven) WEAP activity, any future project shall assess the independent application of WEAP, outside donor activity to assess the actual needs for the framework of the project

7 Integration of Geoscientific Aspects into Planning in the Wastewater Sector

Wastewater planning aims to protect water resources by collecting and treating wastewater and thus preventing the discharge of wastewater into the environment. In many countries of the Middle East wastewater constitutes the main pollution risk. While wastewater (WW) schemes have been implemented in Jordan since more than 30 years, planning for WW schemes has just begun in Lebanon. The experience in Jordan shows, however, that planning of WW facilities needs to integrate geoscientific expertise for two reasons:

- the planned WW system (collector lines, WWTP and effluent discharge) should not have any negative impact on the underlying GW.

- the planned WW system can be impacted by geo-risks (flooding, land subsidence, liquefaction, rockfalls, landslides, sinkholes/cave collapse, earthquakes, active faults).

Often these geoscientific aspects are not sufficiently studied when selecting the WWTP and collector sites. EIAs need to cover these aspects in adequate detail.

A wrong location of a WW treatment system may actually increase the pollution risk for surface and groundwater resources. Depending on the hydrogeological setting, the overflow of a treatment plant or the discharge of the effluent may directly infiltrate into groundwater. Therefore, especially in karst areas, the site of WW treatment facilities, as well as the alignment of the WW collector lines must be chosen according to the potential negative impact on groundwater resources. Infiltration of surface water into groundwater must also be considered. In steep areas, like the Mount Lebanon mountain range, geo-risks play a major role for planning of WW facilities. In highly vulnerable areas, like 70% of the Jeita GW catchment, leakages of untreated WW into GW must be avoided.

The cooperation between the Financial Cooperation Project of KfW and the Technical Cooperation Project Protection of Jeita Spring is a good example how groundwater aspects are integrated already in the beginning of the infrastructure planning. In fact, technical cooperation must start prior to financial cooperation in order to provide advice on time.

Besides site selection, the question of reuse of treated wastewater in agriculture is an important aspect, especially in a water scarce country as Jordan. Reuse of the effluent must not be harmful to the underlying groundwater resources and therefore, location of reuse must consider the vulnerability of groundwater resources (MARGANE & STEINEL, 2011). In Jordan, where 60% of treated wastewater is planned to be reused (Water Strategy 2008), groundwater protection aspects in management of treated WW reuse are an important aspect in order not to threaten the already scarce water resources.

7.1 Geoscientific Advice for Planning in the Wastewater Sector in Lebanon (Armin Margane)

7.1.1 Abstract

The integration of water resources protection aspects into the investment planning and implementation process in the wastewater sector was one of the main objectives of the Jeita project. It comprised:

- Support of CDR and other institutions concerning the prioritization of wastewater projects as well as the design and site selection for WWTPs, collector lines and effluent discharge locations;

- Support of CDR concerning the preparation of EIAs for WW projects, with regards to their impact on the water resources;
- Preparation of best practice guidelines for the implementation of wastewater projects with special consideration of the aspect of ground and surface water protection.

In the Jeita project, BGR is closely working together with another German funded project, implemented by KfW for the establishment of a WWTP and related WW network.
In an area in which 80% of the surface is considered either as high or very high vulnerable to GW, planning of WW facilities is a challenge. Other problems are the extremely high topographic gradients, the general lack of electricity, the large spacing between residential areas and geo-risks. Currently, wastewater is discharged into injection wells, open cesspits or nearby creeks/rivers/wadis. At the beginning of the BGR project, there was no adequate WW master plan. Municipalities play a major role and can block any such project if they don't accept it. When the BGR project started the boundaries between the proposed different WW projects were unclear and many large projects were on halt due to different reasons. BGR undertook a tracertest and could show that the main proposed WWTP site would have had a very negative environmental impact on the water supply of the Greater Beirut Area. Due to the high GW vulnerability in the catchment, it was proposed to follow a centralized approach and locate the WWTP site downstream of Jeita spring. The main collector line had to be planned following the escarpment. WW collection is by gravity only and avoids pumping because of the potential pollution risk. The Environmental Impact Assessment (EIA) was conducted together with the consultant of KfW and CDR. WW reuse could not be adopted in the planning process because a related standard for treated WW reuse is still lacking in Lebanon. The BGR project has proposed a related standard and recommends the use of GW vulnerability maps for the decision where WW reuse could be allowed. Because EIAs did not follow a standard outline and did not always cover geoscientific aspects, an EIA guideline for WW facilities was proposed. Also a Best Management Practice (BMP) guideline for WW facilities in karst areas was prepared by BGR in order to improve planning for WW facilities. The BMP cover:

- site selection and design process for wastewater treatment plants, collector lines and effluent discharge points
- selection of the optimal treatment method
- criteria for treated wastewater reuse
- criteria for sludge management
- proposal for monitoring of the treated wastewater effluent, sludge quality and effects of wastewater reuse and sludge application

The full presentation is enclosed in this document as ANNEX 3.12.

7.2 Discussion

Points of discussion:
- is planning of wastewater facilities adequately considering impact on water resources ? what is missing and why ?
- are EIAs truly considering potential impacts on water resources ?
- are treatment methods appropriate in the local context ?
- where is treated wastewater reuse applied and on which criteria is the decision based ?
- is the standard for treated WW reuse appropriate to ensure no impact on GW quality ?
- how is sludge managed ? what is the concept ?
- are all WW treatment systems operated and managed appropriately ? How is the acceptance of WW treatment systems in local communities ?
- where is reuse of treated WW practiced and what are the criteria and conditions ? Is reuse accepted by local farmers and consumers ?
- how is sludge from WW treatment managed ?

Nowadays, WW treatment is more difficult in Jordan than prior to the ‘Arab Spring’. Citizens do more often object WW projects/operation and put pressure on their local municipality and MWI/WAJ. In the framework of SMART 2 (http://www.iwrm-smart2.org/), an implementation strategy for WWTPs has been developed and in the Ajloun area, springs are intended to be protected by decentralized WW systems.

Nowadays, sludge becomes a resource. In two WWTPs supported by German agencies, energy is generated. Right now, the MWI is trying to concentrate all the sludge in one location for further use. Donors seem to be very interested in reuse of WW sludge.

In Lebanon, no standard or guideline for the reuse of treated wastewater and for sludge management was adopted so far, despite the BGR project’s proposal (MARGANE & STEINEL, 2011). The cooperation of technical cooperation with FC cooperation ensures that water protection measures are fully taken into account already at the beginning of the planning. By combining TC and FC in the Jeita Spring Protection Project, the practical usage of GW vulnerability maps and protection zones can be demonstrated and thus, be addressed to many stakeholders.

7.3 Recommendation

- Combine any WW planning with geoscienitific expertise
- Coupling of Financial Cooperation with Technical Cooperation is a Win - Win situation.

8 References

8.1 Reports and Publications BGR Jeita/Lebanon

Reports

MARGANE, A., SCHULER, P., ABI RIZK, J., STOECKL, L. & RAAD, R. (2013): Hydrogeology of the Groundwater Contribution Zone of Jeita Spring. – Technical Cooperation Project 'Protection of Jeita Spring', Technical Report No. 5, prepared by BGR, 299 p., data DVD; Raifoun.

KOENIGER, P. & MARGANE, A. (2013): Stable Isotope Investigations in the Groundwater Contribution Zone of Jeita Spring. – Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 12, prepared by BGR; Raifoun.

MARGANE, A., SCHULER, P. & ABI RIZK, J. (2013): Jeita Spring Protection Project - Environmental Impact Assessment for the Proposed CDR/KfW Wastewater Scheme in the Lower Nahr el Kalb Catchment - BGR contribution. – Technical Cooperation Project 'Protection of Jeita Spring', Advisory Service Document No. 7, prepared by BGR, 163 p., data DVD; Raifoun.

ABI RIZK, J & MARGANE, A. (2013): Meteorological Stations installed by the Project. – Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 18, prepared by BGR; Raifoun.

DOUMMAR, J., MARGANE, A., GEYER, T. & SAUTER, M. (2013): Artificial Tracer Tests 4C - May 2012. - University of Goettingen, prepared for BGR; Special Report No. 17, 11 p.; Goettingen/Germany.

RAAD, R. & MARGANE, A. (2013): Risk estimation and management options of existing hazards to Jeita spring. – Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 19, prepared by BGR; Raifoun.

RAAD, R. & MARGANE, A. (2013): Hazards to Groundwater and Assessment of Pollution Risk in the Jeita Spring Catchment. – Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 16, prepared by BGR; Raifoun.

RAAD, R. & MARGANE, A. (2013): Preliminary Assessment of the Most Critical Groundwater Hazards for Jeita Spring. – Technical Cooperation Project 'Protection of Jeita Spring', Advisory Service Document No. 5, prepared by BGR, 48 p.; Raifoun.

MARGANE, A. & SCHULER, P. (2013): Groundwater Vulnerability in the Groundwater Catchment of Jeita Spring and Delineation of Groundwater Protection Zones using the COP Method. – Technical Cooperation Project 'Protection of Jeita Spring', Technical Report No. 7, prepared by BGR, 117; Raifoun.

MARGANE, A. (2013): Preliminary Assessment of Jeita Cave Stability. – Technical Cooperation Project 'Protection of Jeita Spring', Advisory Service Document No. 4, prepared by BGR, 20 p.; Raifoun.

DOUMMAR, J., MARGANE, A., GEYER, T. & SAUTER, M. (2012): Vulnerability Mapping using the COP and EPIK Methods. - University of Goettingen, prepared for BGR; Technical Report No. 7, 42 p.; Goettingen/Germany.

MARGANE, A. (2012c): Locating the Source of the Turbidity Peaks Occurring in April - June 2012 in the Dbayeh Drinking Water Treatment Plant. – Technical Cooperation Project 'Protection of Jeita Spring', Advisory Service Document No. 2, prepared by BGR, 50 p.; Raifoun.

MARGANE, A. (2012b): Quantification of Infiltration into the Lower Aquifer (J4) in the Upper Nahr Ibrahim Valley - Addendum No. 1. – Technical Cooperation Project 'Protection of Jeita Spring', Advisory Service Document No. 1-1, prepared by BGR, 42 p.; Raifoun.

MARGANE, A. (2012a): Quantification of Infiltration into the Lower Aquifer (J4) in the Upper Nahr Ibrahim Valley. – Technical Cooperation Project 'Protection of Jeita Spring', Advisory Service Document No. 1, prepared by BGR, 62 p.; Raifoun.

RAAD, R., MARGANE, A. & SAADEH, E. (2012): Environmental Risk Assessment of the Fuel Stations in the Jeita Spring Catchment - Recommendations from the Perspective of Groundwater Resources Protection. – Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 14, prepared by BGR, 126 p.; Raifoun.

DOUMMAR, J., MARGANE, A., GEYER, T. & SAUTER, M. (2012): Artificial Tracer Tests 5C - September 2011. – Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 11, prepared by University of Goettingen, 16 p.; Goettingen.

MUELLER, K. & MARGANE, A. (2012): Jeita Spring Protection Project - Feasibility Study - Rehabilitation of Transmission Channel Jeita Spring Intake – Dbaye WTP. – Financial Cooperation Project 'Jeita Spring Protection' & Technical Cooperation Project 'Protection of Jeita Spring', prepared by GITEC & BGR, 118 p.; Ballouneh.

MUELLER, K. & MARGANE, A. (2011): Jeita Spring Protection Project Phase I - Regional Sewage Plan. – Financial Cooperation Project 'Jeita Spring Protection' & Technical Cooperation Project 'Protection of Jeita Spring', prepared by GITEC & BGR, 141 p.; Ballouneh.

RAAD, R. & MARGANE, A. (2011): Soil Survey in the Investigations in the Groundwater Contribution Zone of Jeita Spring. – Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 9, prepared by BGR, 47 p.; Ballouneh.

ABI RIZK, J. & MARGANE, A. (2011): Mapping of Surface Karst Features in the Jeita Spring Catchment. – Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 7, prepared by BGR, 59 p.; Ballouneh.

MARGANE, A. & ABI RIZK, J. (2011): Guideline for Environmental Impact Assessments for Wastewater Facilities in Lebanon. – Technical

Cooperation Project 'Protection of Jeita Spring', Technical Report No. 3, prepared by BGR, 27 p.; Ballouneh.

MARGANE, A. & STEINEL, A. (2011): Proposed National Standard for Treated Domestic Wastewater Reuse for Irrigation. – Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 4, prepared by BGR, 42 p.; Ballouneh.

STEINEL, A. & MARGANE, A. (2011): Best Management Practice Guideline for Wastewater Facilities in Karstic Areas of Lebanon – with special respect to the protection of ground- and surface waters. – Technical Cooperation Project 'Protection of Jeita Spring', Technical Report No. 2, prepared by BGR, BGR archive no. 012xxxxx, 147 p.; Ballouneh.

MARGANE, A. (2011): Practice Guide for Tracer Tests. – Technical Cooperation Project 'Protection of Jeita Spring', , Special Report No. 3, prepared by BGR, BGR archive no. 012xxxxx, 26 p.; Ballouneh.

MARGANE, A. (2011): Site Selection for Wastewater Facilities in the Nahr el Kalb Catchment – General Recommendations from the Perspective of Groundwater Resources Protection. – Technical Cooperation Project 'Protection of Jeita Spring', Technical Report No. 1, prepared by BGR, BGR archive no. 012xxxxx, 155 p.; Ballouneh.

DOUMMAR, J., MARGANE, A., GEYER, T. & SAUTER, M. (2011b): Artificial Tracer Tests 5A - June 2011. - Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 6, prepared by University of Goettingen, 15 p.; Goettingen.

DOUMMAR, J., MARGANE, A., GEYER, T. & SAUTER, M. (2011a): Artificial Tracer Tests 4B - May 2011. - Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 5, prepared by University of Goettingen, 17 p.; Goettingen.

DOUMMAR, J., MARGANE, A., GEYER, T. & SAUTER, M. (2010): Artificial Tracer Tests 2 - August 2010. - Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 2, prepared by University of Goettingen, 27 p.; Goettingen.

DOUMMAR, J., MARGANE, A., JIN, Y., GEYER, T. & SAUTER, M. (2010): Artificial Tracer Tests 1 - April 2010. - Technical Cooperation Project 'Protection of Jeita Spring', Special Report No. 1, prepared by University of Goettingen, 33 p.; Goettingen.

SCHULER, P. & MARGANE, A. (2013): A Water Balance Model of the Jeita Groundwater Catchment using WEAP. – German-Lebanese Technical Cooperation Project Protection of Jeita Spring, Technical Report No. 6, 117 p.; Raifoun/Lebanon.

Publications

MARGANE, A. & MAKKI, I. (2012): Hydrogeological Investigations in a Karst Aquifer for Investments in the Wastewater Sector to Protect the Drinking Water

Resources of Beirut. – IAH 2012 Congress, proceedings, p. 228; Niagara Falls/CDN. [download presentation from: www.bgr.bund.de/jeita]

MARGANE, A. & DOUMMAR, J. (2012): Delineation of the Groundwater Contribution Zone for Jeita Spring, Lebanon, using Tracer Tests in a Karst Aquifer System. – IAH 2012 Congress, proceedings, p. 81; Niagara Falls/CDN. [download presentation from: www.bgr.bund.de/jeita]

KOENIGER,, P., MARGANE, A. & HIMMELSBACH, T. (2012): Stable isotope studies on altitude effect and karst groundwater catchment delineation of the Jeita spring in Lebanon. – IAH 2012 Congress, proceedings, p. 227; Niagara Falls/CDN.

MARGANE, A. & MAKKI, I. (2012): Water Resources Protection for the Water Supply of Beirut. – Conference Proceedings “Hydrogeology of Arid Environments” March 2012, Hannover, pp. 89-91; Stuttgart (Borntraeger).

ABI RIZK, J. & MARGANE, A. (2011): Surface Karst Features Mapping for the Groundwater Catchment Area of Jeita Spring. – Conference Proceedings “Hydrogeology of Arid Environments” March 2012, Hannover, p. 190; Stuttgart (Borntraeger).

MARGANE, A. & MAKKI, I. (2011): Safeguarding the Drinking Water Supply of the Cities of Beirut and Damascus by Water Resources Protection in Karstic Environments. - World Water Week 2011, Abstract Volume, pp. 28-29, Stockholm.

MARGANE, A. & TOLL, M. (2011): Integration of water resources protection aspects into the planning of wastewater facilities in Lebanon and Syria In: BAZ, I.: Water and Climate Change in the MENA-Region – Adaptation, Mitigation and Best Practices, International Conference, Berlin, April 28 - 29, 2011. [http://www.menawater-2011-berlin.de/abstracts/Armin_Margane.html]

MARGANE, A. & MAKKI, I. (2010): Reducing Pollution Risks for the Water Supply of Beirut in a Karst Aquifer. - World Water Week 2010, Workshop 5: Management of Groundwater Abstraction and PollutionAbstract Volume, pp. 245-246, Stockholm.

8.2 Reports BGR Jordan (GW projects)

Reports

GASSEN, N. & STOECKL, L. (2013): Conceptual Model for a Tracer Test in Wadi Hidan, Technical Cooperation Project “Water Aspects in Land Use Planning”, Technical Report No.1, 36 p; Amman.

GASSEN, N.(2013): Delineation of Groundwater Protection Zones for AWSA Well Field, Technical Cooperation Project “Water Aspects in Land Use Planning”, Technical Report No.2, 98 p; Amman.

GASSEN, N.: (2013): Delineation of Groundwater Protection Zones for Hidan Well Field, Technical Cooperation Project “Water Aspects in Land Use Planning”, Technical Report No. 3 (Draft), 78 p; Amman.

MARGANE, A., SUBAH, A., HAMDAN, I., ALMOMANI, T., HAJALI, Z., MA'MOUN, I., AL-HASSANI, I. & SMADI, H. (2010): Delineation of Groundwater Protection Zones for the Lajjun, Qatrana, Sultani and Ghweir Wellfields. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 9, prepared by BGR & MWI, BGR archive no. 012xxxxx, 292 p.; Amman.

MARGANE, A., SUBAH, A., HAMDAN, I., HAJALI, Z. & ALMOMANI, T. (2010): Delineation of Groundwater Protection Zones for the Springs in Wadi Shuayb. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 14, prepared by BGR & MWI, BGR archive no. 012xxxxx, 98 p.; Amman.

MARGANE, A., SUBAH, A., HAMDAN, I., BORGSTEDT, A., ALMOMANI, T., AL-HASSANI, I., HAJALI, Z., JABER, A., SMADI, H. & MA'MOUN, I. (2009): Delineation of Groundwater Protection Zones for the Hallabat Wellfield. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 13, prepared by BGR & MWI, BGR archive no. 012xxxxx, 182 p.; Amman.

MARGANE, A., BORGSTEDT, A., HAMDAN, I., SUBAH, A. & HAJALI, Z. (2009): Delineation of Surface Water Protection Zones for the Wala Dam. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 12, prepared by BGR & MWI, BGR archive no. 012xxxxx, 126 p.; Amman.

MARGANE, A., SUBAH, A., HAJALI, Z., ALMOMANI, T., KOZ, A. (2008): Delineation of Surface Water Protection Zones for the Mujib Dam. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 10, prepared by BGR & MWI, BGR archive no. 012xxxxx, 132 p.; Amman.

HAHNE, K., MARGANE, A. & BORGSTEDT, A. (2008): Geological and Tectonical Setting of the Upper Wadi Shuayb Catchment Area, Jordan. – Technical Cooperation Project 'Groundwater Resources Management', Special Report No. 7, prepared by BGR & MWI, BGR archive no. 012xxxxx, 23 p.; Amman.

BORGSTEDT, A., MARGANE, A., SUBAH, A., HAJALI, Z., ALMOMANI, T., KHALIFA, N., JABER, A. & HAMDAN, I. (2007): Delineation of Groundwater Protection Zones for the Corridor Wellfield. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 8, prepared by BGR & MWI, BGR archive no. 012xxxxx, 191 p.; Amman.

MARGANE, A., BORGSTEDT, A., TREIDEL, H. & HUSSIN, W.A.O. (2007): Delineation of Groundwater Protection Zones for the Ja'ar Municipal Wells. – Technical Report No. IWRM_07_14, , prepared by BGR & LWSA Abyan, BGR archive no. 0127703, 93 p.; Sana'a.

MARGANE, A. & BORGSTEDT, A. [Edts.] (2007): Delineation of Groundwater Protection Zones for the Amran Municipal Wells. – Technical Report No. IWRM_07_13, , prepared by BGR & LWSA Amran, BGR archive no. 0127705, 68 p.; Sana'a.

MARGANE, A., BORGSTEDT, A. & SUBAH, A. (2007): Training Course on Groundwater Protection Zone Delineation. – Technical Report No. 9, prepared by BGR & MWI, BGR archive no. 0127704, 168 p., 1 CD; Hannover and Amman.

MARGANE, A. & SUBAH, A. (2007): Guideline for the Delineation of Surface Water Protection Areas. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 6, prepared by BGR & MWI, BGR archive no. 0126943, 117 p., 1 CD; Amman.

MARGANE, A., BORGSTEDT, A., SUBAH, A., HAJALI, Z., ALMOMANI, T. (2006): Delineation of Groundwater Protection Zones for the Rahoub Spring. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 7, prepared by BGR & MWI, BGR archive no. 0126944, 97 p.; Amman.

MARGANE, A., SUBAH, S., KHALIFA, N., ALMOMANI, T., OURAN, S., HAJALI, Z., OURAN, S., JABER, A., ATRASH, M., HIJAZI, H. & TARAWNEH, R. (2005): Mapping of Groundwater Vulnerability and Hazards to Groundwater in the Karak – Lajjun Area. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 5, prepared by BGR & MWI, BGR archive no. 0126002, 138 p., 1 map; Amman.

MARGANE, A. (2004): Guideline for Groundwater Monitoring. – Technical Cooperation Project 'Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region', Technical Reports Vol. 7, prepared by BGR & ACSAD, BGR archive no. 122917:7, 318 p., 1 CD; Damascus.

MARGANE, A. (2003): Guideline for Sustainable Groundwater Resources Management. – Technical Cooperation Project 'Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region', Technical Reports Vol. 6, prepared by BGR & ACSAD, BGR archive no. 122917:6, 235 p., 1 CD; Damascus.

MARGANE, A. (2003): Guideline for the Delineation of Groundwater Protection Zones. – Technical Cooperation Project 'Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region', Technical Reports Vol. 5, prepared by BGR & ACSAD, BGR archive no. 122917:5, 329 p., 1 CD; Damascus.

MARGANE, A. (2003): Guideline for Groundwater Vulnerability Mapping and Risk Assessment for the Susceptibility of Groundwater Resources to Contamination. – Technical Cooperation Project 'Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region', Technical Reports Vol. 4, prepared by BGR & ACSAD, BGR archive no. 122917:4, 177 p., 1 CD; Damascus.

MARGANE, A. & SUNNA, N. (2002): Proposal for a National Guideline for the Delineation of Groundwater Protection Zones. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 1, prepared by BGR & MWI, BGR archive no. 0125645, 161 p.; Amman.

MARGANE, A. (2002): Criteria for the Preparation of Groundwater Vulnerability Maps. - Technical Cooperation Project ‘Groundwater Resources Management’, Technical Report No. 2, prepared by BGR & MWI, BGR archive no. 0125646, 118 p.; Amman.

MARGANE, A. & ALMOMANI, M. [Edts.] (2002): Preliminary Draft – National Water Master Plan, Vol. IV – Groundwater Resources. - Technical Cooperation Project ‘Groundwater Resources Management’, Technical Report No. 3, prepared by BGR & MWI, BGR archive no. 125647: 4, 68 p.; Amman.

HOBLER, M., MARGANE, A., ALMOMANI, M. & SUBAH, A. (2001): Groundwater Resources of Northern Jordan, Vol.4: Hydrogeological Features of Northern Jordan. - Technical Cooperation Project ’Advisory Services to the Water Authority of Jordan’, BGR & WAJ, BGR archive no. 112708:5, 84 p.; Amman.

MARGANE, A., HOBLER, M., OURAN, S. & AL ZUHDY, A. (1999) Groundwater Resources of Northern Jordan – Special Report No. 5: Hydrogeological Proposal for the Delineation of a Groundwater Protection Area for the Tabaqat Fahl (Pella) Spring. - Technical Cooperation Project ‘Groundwater Resources of Northern Jordan’, BGR & WAJ, BGR-archive no. 119256; Amman and Hannover.

MARGANE, A., HOBLER, M. & SUBAH, A. (1997): Groundwater Resources of Northern Jordan, Special Report No. 3: Mapping of Groundwater Vulnerability and Hazards to Groundwater in the Irbid Area. - Technical Cooperation Project ’Advisory Services to the Water Authority of Jordan’, BGR archive no. 118708, 50 p., 10 app., 4 ann.; Amman.

MARGANE, A., HOBLER, M. & HAMMOUDEH, A. (1996): Groundwater Resources of Northern Jordan, Special Report No. 2: Proposal for an exploration Drilling Program of the Ram Group Aquifer in the Dead Sea – Amman Area. - Technical Cooperation Project ’Advisory Services to the Water Authority of Jordan’, BGR & WAJ, BGR archive no. 118707, 35 p., 6 ann.; Amman.

MARGANE, A. & AL ZUHDY, Z. (1996): Groundwater Resources of Northern Jordan, Vol.1, Part 2: Spring Discharge in Northern Jordan. - Technical Cooperation Project ’Advisory Services to the Water Authority of Jordan’, BGR & WAJ, BGR archive no. 112708:2 and 3, 12 p., 5 app., 3 maps; Amman.

MARGANE, A. & AL ZUHDY, Z. (1995): Groundwater Resources of Northern Jordan, Vol.1, Part 1: Rainfall in Jordan. - Technical Cooperation Project ’Advisory Services to the Water Authority of Jordan’, BGR & WAJ, BGR archive no. 112708:1, 12 p., 3 app., 1 map; Amman.

MARGANE, A. & ALMOMANY, M. (1995): Groundwater Resources of Northern Jordan, Vol.2, Part 1: Groundwater Abstraction in Northern Jordan. - Technical Cooperation Project ’Advisory Services to the Water Authority of Jordan’, BGR & WAJ, BGR archive no. 118701:1, 35 p., 1 app., 1 map; Amman.

MARGANE, A. (1995): Groundwater Resources of Northern Jordan, Vol.2, Part 2: Monitoring of Groundwater Levels in Northern Jordan. - Technical

Cooperation Project 'Advisory Services to the Water Authority of Jordan', BGR & WAJ, BGR archive no. 118701:2, 71 p., 3 app., 3 maps; Amman.

MARGANE, A. & RAYYAN, M. (1995): Groundwater Resources of Northern Jordan, Special Report No. 1: Upgrading of the Borehole Filing System of the Water Resources Studies Directorate. - Technical Cooperation Project 'Advisory Services to the Water Authority of Jordan', BGR & WAJ, BGR archive no. 118706, 4 p., 1 app.; Amman.

MARGANE, A. & HOBLER, M. (1994): Groundwater Resources of Northern Jordan, Vol.3: Structural Features of the Main Hydrogeological Units in Northern Jordan. - Technical Cooperation Project 'Advisory Services to the Water Authority of Jordan', BGR & WAJ, BGR archive no. 118702:1-3, 57 p., 30 app., 38 ann.; Amman.

MARGANE, A., HOBLER, M. & SUBAH, A. (1999): Mapping of Vulnerability and Hazards to Groundwater in the Irbid Area, N-Jordan. – Zeitschrift Angewandte Geologie, 45, 4: 175-187; Hannover.

SUBAH, A, HOBLER, M., RAYYAN, M. &. HIJAZI, H. (1999): Mapping of Groundwater Vulnerability and Hazards to Groundwater in the Area South of Amman. - Unpubl. report prepared by Technical Cooperation Project BMZ No. 89.2105.8, BGR-Archive No. 112708, 62 p.; Amman.

Publications

GASSEN, N., HAMDAN, I., SUBAH, A., JABER, A., EL-FAHEM, T. (2012): Groundwater Resource Protection in Jordan – A case study from AWSA and Heedan Well Fields, Poster at the 1st Conference for Hydrogeology of Arid Environments, March 2012, Hannover, Germany.

MARGANE, A. (2010): Artificial groundwater recharge and protection zones in arid areas - Wadi Wala Dam, Jordan. - In: STEENBERGEN, F. van & TUINHOF, A.: Managing the Water Buffer for Development and Climate Change Adaptation - Groundwater Recharge, Retention, Reuse and Rainwater Storage, pp 26-29.

SUBAH, A., BORGSTEDT, A. & MARGANE, A. (2008): Delineation and Implementation of Water Resources Protection Zones in Jordan Practical Experiences. – World Water Week 2008, MENA Seminar, Innovations in Groundwater Governance in the Mena Region, Paper 14, p. 22.

MARGANE, A., BORGSTEDT, A. & SUBAH, A. (2008): Delineation and Implementation of Groundwater and Surface Water Protection Zones in Jordan – Practical Experiences. - The Fourth Environmental Symposium of German - Arab Scientific Forum for Environmental Studies, October 7-8, 2008, Conference Proceedings, pp. 92-95; Fez, Morocco.

MARGANE, A., BORGSTEDT, A. & SUBAH, A. (2008): Water Resources Protection Efforts in Jordan and their Contribution to a Sustainable Water Resources Management. – pp 325-345; In: ZEREINI, F. & HOELZL, H.: Climatic

Changes and Water Resources in the Middle East and in North Africa, 552 p.; Heidelberg (Springer).

JOUSMA, G., ATTANAYAKE, P., CHILTON, J., MARGANE, A., NAVARRETE, C.M., MELO, M.T., GUERRERO, P.N.L., POLEMIO, M., ROELOFSEN, F., SHARMA, S.K., STREETLY, M., SUBAH, A. & AL-YAQOUBI, A. (2006): Guideline on Groundwater Monitoring for General Reference Purposes. – IGRAC/UNESCO, 165 p.; Utrecht.

MARGANE, A., HOBLER, M. & SUBAH, A. (2006): Case Study: Groundwater Vulnerability Mapping in the Irbid Area in Northern Jordan. – pp 209-212 in: SCHMOLL, O., HOWARD, G., CHILTON, J. & CHORUS, I.: Protecting Groundwater for Health – Managing the Quality of Drinking-water Sources. – WHO, 678 p.; London & Seattle (IWA publishing).

MARGANE, A., SUBAH, A., KHALIFA, N. & ALMOMANI, T. (2005): Groundwater Vulnerability Mapping in the Karak – Lajjun Area. – Proceedings of UNESCO-IHP Jordan Workshop on Aquifer Vulnerability, 11 p.; Zarqa (Hashemiyya University).

MARGANE, A., HOBLER, M., DROUBI, A., SUBAH, A. & KHATER, A.R. (2004): Groundwater Vulnerability Mapping in the Arab Region. – In: ZEREINI, F. & JAESCHKE, W.: Water in the Middle East and North Africa – Resources, Protection and Management, 145-155; Heidelberg (Springer).

MARGANE, A. (2003): Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region – Volume 6: Guideline for Sustainable Groundwatr Resources Management. – UNESCO Cairo Office, 235 p.; Cairo.

MARGANE, A., HOBLER, M., ALMOMANI, M. & SUBAH, A. (2002): Contributions to the Groundwater Resources of Northern and Central Jordan Jordan. - Geol.Jb., C. 68, 52 p.; Hannover.

MARGANE, A., HOBLER, M. & SUBAH, A. (1999): Mapping of Groundwater Vulnerability and Hazards to Groundwater in the Irbid Area, N-Jordan. - Zeitschr.Angew.Geol., 45, 4, 175-187; Hannover.

MARGANE, A. (1999) : Mapping of Groundwater Vulnerabilty and Hazards to Groundwater in Developing Countries. – Proc. 29th IAH-Congress 6-10 Sep 1999, 87-92; Bratislava.

8.3 *Reports BGR ACSAD (GW Guidelines, WEAP)*

MARGANE, A. (2003a): Guideline for Groundwater Vulnerability Mapping and Risk Assessment for the Susceptibility of Groundwater Resources to Contamination. – Technical Cooperation Project ‘Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region’, Technical Reports Vol. 4, prepared by BGR & ACSAD, BGR archive no. 122917:4, 177 p., 1 CD; Damascus.

MARGANE, A. (2003b): Guideline for the Delineation of Groundwater Protection Zones. – Technical Cooperation Project ‘Management, Protection and

Sustainable Use of Groundwater and Soil Resources in the Arab Region', Technical Reports Vol. 5, prepared by BGR & ACSAD, BGR archive no. 122917:5, 329 p., 1 CD; Damascus.

MARGANE, A. (2003c): Guideline for Sustainable Groundwater Resources Management. – Technical Cooperation Project 'Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region', Technical Reports Vol. 6, prepared by BGR & ACSAD, BGR archive no. 122917:6, 235 p., 1 CD; Damascus.

MARGANE, A. (2004): Guideline for Groundwater Monitoring. – Technical Cooperation Project 'Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region', Technical Reports Vol. 7, prepared by BGR & ACSAD, BGR archive no. 122917:7, 318 p., 1 CD; Damascus.

8.4 Other References

BRÜSCHWEILER, B. (2007): Markierstoffe im Bereich von Trinkwasserfassungen - Abklärung zur Humantoxizität der Fluoreszenztracer. - GWA, 5, 2007, pp. 355-359.

BUNDESGESUNDHEITSBLATT (1997): Human- und Ökotoxikologische Bewertung von Markierungsmitteln in Gewässern. - Bekanntmachungen, 10, 1997; Berlin. [identical with: Grundwasser, 2, 1997, pp. 61-64.]

FIELD, M.S. & NASH, S.G. (1997): Risk assessment methodology for karst aquifers: (1), estimating karst flow parameters. - Environmental monitoring and Assessment. 47, 1, pp. 1-21.

FIELD, M.S., WILHELM, R.G., QUINLAN, J.F., ALEY, T.J. (1995): An Assessment of the Potential Adverse Properties of Fluorescent Tracer Dyes used for Groundwater Tracing. - Environmental Monitoring and Assessment, 38, pp. 75-96.

FLURY, M. & WAI, N.N. (2003): Dyes as Tracers for Vadose Zone Hydrology. - Reviews of Geophysics, 41, 1, 1002, 37 p.

GAJ, M., MASSMANN, J., VASSOLO, S., SCHELKES, K. (2013): Development and Application of a Decision Support System (DSS) for Water Resources Management of the Azraq Basin, Jordan. Technical report, prepared by BGR, Hannover.

HOELTING, B., HAERTLÉ, T., HOHBERGER, K.-H., NACHTIGALL, K.H., VILLINGER, E., WEINZIERL, W. & WROBEL, J.-P. (1995): Konzept zur Ermittlung der Schutzfunktion der Grundwasser-ueberdeckung.– Geol.Jb., C, 63, p. 5–24; Hannover. – [translated into English by the Federal Institute for Geosciences and Natural Resources: Concept for the Determination of the Protective Effectiveness of the Cover above the Groundwater against Pollution.– Ad-hoc Working Group on Hydrogeology, 28 p.; Hannover]

LE PAGE, M., BERJAMY, B., FAKIR, Y., BOURGIN, F., JARLAN, L., ABOURIDA, A., BENRHANEM, M., JACOB, G., HUBER, M., SGHRER, F., SIMONNEAUX, V. & CHEHBOUNI, G. (2012): An Integrated DSS for Groundwater Management Based on Remote Sensing. The Case of a Semi-arid Aquifer in Morocco. In: Water Resources Management, 26, pp. 3209-3230.

MASSMANN, J., HENNINGS, V., SCHELKES, K. & DROUBI, A. (2011): Investigation of climate change scenarios in the MENA-region using the WEAP-Modflow decision support system. Conference Proceedings, Water and Climate Change in the MENA-Region: Adaptation, Mitigation and Best Practices, pp. 43-44, Berlin, Germany, September 2011.

NOUIRI, I. (2005) Case Study Application - Zeuss Koutine Aquifer, Tunisia. ALL_WATER_gw: Software for Groundwater Resources Management Optimization; 56 p.

STOCKHOLM ENVIRONMENTAL INSTITUTE (SEI) (2011): User Guide for WEAP21. Stockholm Environment Institute and Tellus Institute, 335 p.; Boston/USA.

VIAS, J.M., ANDREO, B., PERLES, M.J., CARRASCO, F., VADILLO, I. & JIMENEZ, P. (2006): Proposed Method for Groundwater Vulnerability Mapping in Carbonate (Karstic) aquifers: the COP method: Application in Two Pilot Sites in Southern Spain. - Hydrogeology Journal, 14 (6), pp. 1-14.

ANNEX 1: Workshop Program

Objectives

- experience-based internal learning process for BGR:
    - what can/must we do scientifically better in Jordan/Lebanon to reach to optimal result ?
    - which partner organizations are best suited for which task ?
    - where are we concerning a better water resources management, monitoring and protection (status) ? what can/should be done (in future projects to reach a better management and protection of water resources (institutional capacities, scientific aspects, areas) ?
    - how can we reach sustainability of the project results ?
    - what can we learn for projects with similar objectives in other countries ?

  ► institutional learning for BGR project planning

- learning process for our partner institutions:
    - is the institutional organization suited for the tasks we have to address (is institutional reorganization needed, is more qualified staff needed in certain fields, is capacity building in certain areas needed, are there institutional overlaps) ?
    - what must be done to improve water resources management, protection and monitoring ?
    - how can sustainability of what we have done in technical cooperation projects together with BGR be ensured (institutional organization (allocation of staff), funding, project budgets, cooperation with other donors in the same field) ?

  ► partner country institutional planning

Project Exchange Meeting -
Lessons learnt from Technical Cooperation in Jordan and Lebanon

Workshop Schedule

Date & Time	Issue
Wednesday, 30-OCT-2013 (1) Morning session	**Delineation of GW protection zones** (review of technical approach): traditional methods versus tracer tests Presentation 1: Margane: GW Protection Zone Delineation in Lebanon - Example Jeita Spring Presentation 2: Margane: GW Protection Zone Delineation in Jordan - Example Wadi Shuayb Springs Presentation 3: Niklas Gassen: GW Protection Zone Delineation in Jordan - Example Wadi Heidan and AWSA (Azraq) wellfields Points of discussion: - how accurate should delineations be ? are the boundaries of protection zones legally defensible ? - what is currently acceptable and implementable in terms of landuse restrictions ? - how can we technically reach the optimal result ? - Can numerical modeling replace field investigations, e.g. tracer?
(2) Afternoon session	**Physical implementation of GW protection zones** (where are we concerning reaching our objective with respect to: landuse planning, training of Environmental Rangers (Jordan), Landuse Licensing Committees (Jordan)) Presentation 4: Jordan Ali Subah: Status of legal framework, cooperation among related institutions Presentation 5: Jordan Zakkaria Hajj Ali: Landuse Licensing Committees (which committees for which purpose, who is chairing the committees, how is a decision taken (based on which data), what is documented ?)

	Presentation 6: Jordan Mohammad Hiyari: Control of landuse restrictions in GW protection zones by the Environmental Rangers Presentation 7: Zeina Yaacoub: Implementation of Jeita GW protection zones Points of discussion: - what are shortcomings concerning implementation of GW protection zones ? - how can we reach a better control of the proposed landuse restrictions ? Is a compensation system that creates a win-win situation necessary ? (environmental fund) - is there a need for to amend the legal framework ? - are the decisions of the Landuse Licensing Committees supported by adequate data/information ? do they take legally defensible decisions or can (are) their decisions be challenged in court ? - does the work of the Environmental Rangers lead to less violations with regards to pollution ?
Thursday, 31-OCT-2013 (3) Morning session	**GW recharge assessment/water balance**: what can we learn from the application of stable isotope and other environmental tracer analyses (LB) and can they contribute to a better understanding of the GW recharge process Presentation 8: Margane: Use of stable isotope analyses and environmental tracers to characterize GW recharge and flow mechanism in the Jeita catchment Presentation 9: Jordan NN or Margane: Assessment of the water balance in Jordan - methods and uncertainties Points of discussion: - how accurate are our water resources assessments ? - how can we come to a better quantification of GW recharge ?

	- To which extent is SW/GW interaction investigated and integrated into GW resources management?
(4) Afternoon session	**GW monitoring** – experiences with telemetric stations in JO, database, interpretation of data & reporting, consequences for well (field) management; how can GW monitoring be improved in Lebanon ? Presentation 10: Hussein Hamdan (GIZJordan): The GW monitoring network of Jordan Presentation 11: Dr. Nabil Amacha (LRA/LB): Water resources monitoring in Lebanon - current status [participation cancelled] Points of discussion: - do we have the appropriate monitoring network to assess water resources ? what is missing and what must be done ? - how can the monitoring concept be improved ? - does monitoring of quality and quantity have consequences for water resources exploitation ? what is missing ? - Is the importance of monitoring, with all financial consequences, acknowledged by decision makers ? - how can we come to a better assessment of available quantities and qualities of water resources ?
Friday, 01-NOV-2013 (5) Morning session	**GW management using WEAP** (does WEAP really help us in achieving our objective to manage the water resources wiser, are we prepared for emergency situations (e.g. water shortage periods) and climate change ? what is lacking ?) Presentation 12: Philip Schuler: The WEAP model of the Jeita GW catchment - current status - climate change scenario - water use options (dams scenarios)

	Presentation 13: Abbas Fayad (MoEW/LB): The Role of Decision Support Systems in Integrated Water Resources Management in Lebanon Presentation 14: Ali Breazat (MWI Jordan): Countrywide WEAP models - current status - current usage - data needs Points of discussion: - Is WEAP more suitable for water resources assessments and management than GW models ? - do we have adequate data for what we want to achieve with the WEAP models ? - is WEAP truly used as a management tool, and is related information shared between relevant institutions ? what is missing ? - Are the established WEAP Models continuously managed/updated and does a dialog between modeler and users exist ? - What are the challenges in using the results ? Is their reliability usually acknowledged ?
(6) Afternoon session	**Integration of geoscientific aspects into planning in the wastewater sector** (what are the lessons learnt from the experience of close collaboration between technical and financial cooperation in Lebanon) Presentation 15: Margane/Ismail Makki (CDR): Integration of geoscientific aspects into planning in the wastewater sector in Lebanon Points of discussion: - is planning of wastewater facilities adequately considering impact on water resources ? what is missing and why ? - are EIAs truly considering potential impacts on water resources ? - are treatment methods appropriate in the local context ? - where is treated wastewater reuse applied and on which criteria is the decision based ? - is the standard for treated WW reuse appropriate

	to ensure no impact on GW quality ? - how is sludge managed ? what is the concept ? - are all WW treatment systems operated and managed appropriately ? How is the acceptance of WW treatment systems in local communities ? - where is reuse of treated WW practiced and what are the criteria and conditions ? Is reuse accepted by local farmers and consumers ? - how is sludge from WW treatment managed ?

ANNEX 2: Workshop Participants

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ANNEX 3: Presentations

Council for Development and Reconstruction (CDR)
Ministry of Energy and Water (MoEW)
Water Establishment Beirut and Mount Lebanon (WEBML)

Federal Institute for Geosciences
and Natural Resources (BGR),
Hannover, Germany

German-Lebanese Technical Cooperation Project

Protection of Jeita Spring

GW Protection Zone Delineation in Lebanon
Example Jeita Spring

Project Exchange Meeting Jordan - Lebanon
30 October 2013

Dr. Armin Margane, BGR

Groundwater Protection Zones

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

Means of Charcterization of Groundwater Flow in a Karst System

Groundwater infiltrates into the underground (recharge)

- direct recharge (at the place where it rains) or
- indirect recharge (along the surface water flow path)
  e.g. in the river bed (Jeita catchment: 23% of SW flow) or depressions

Mount Lebanon: mainly karstified limestone (dissolution by carbonic acid)

groundwater moves along fractures, faults, dissolution channels (conduits)

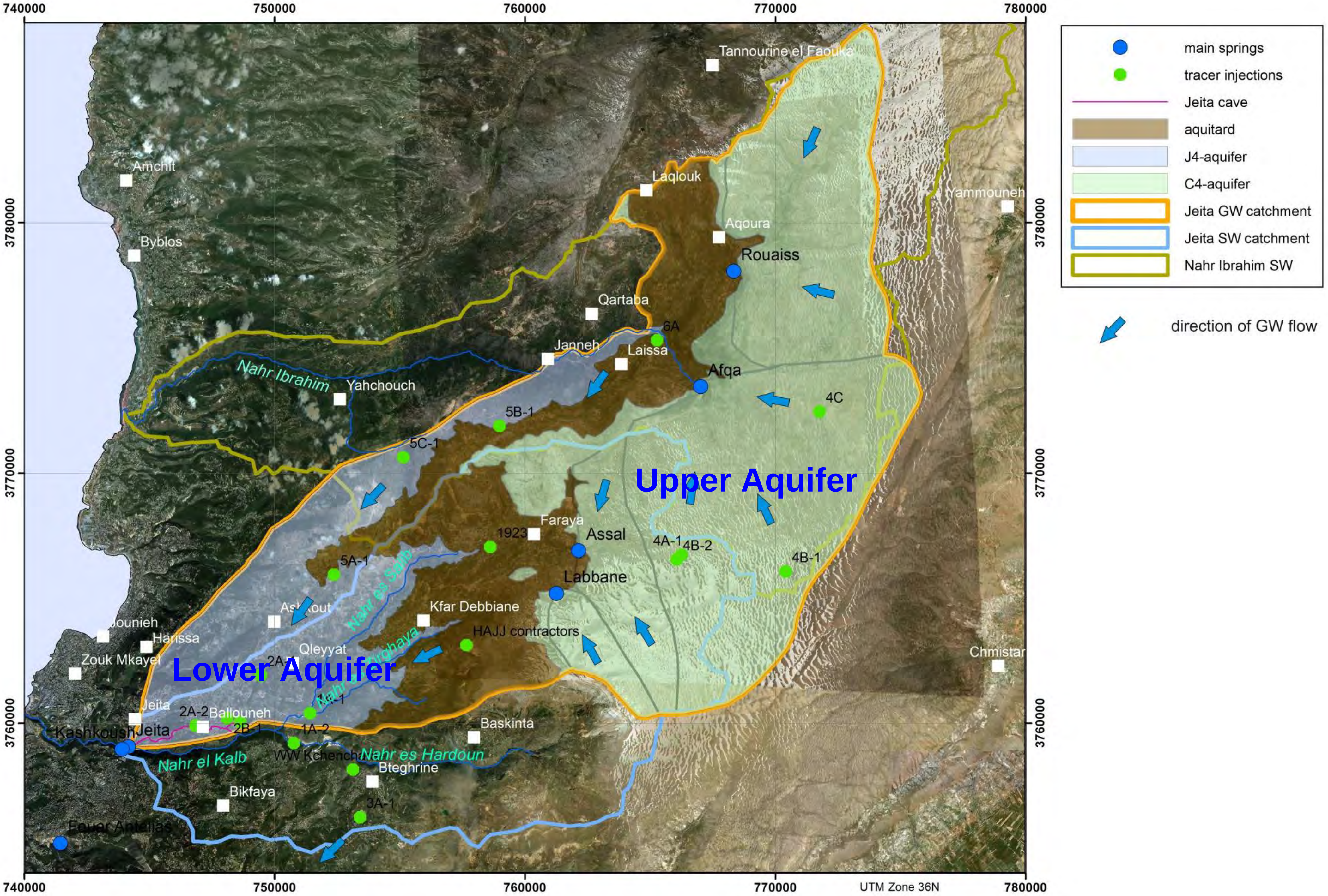
- high flow velocities (70-200 m/h; up to 2000 m/h in large conduits !)
- high water level fluctuations (dry/wet season)

How to determine groundwater flow directions/velocities, groundwater contribution zone ?

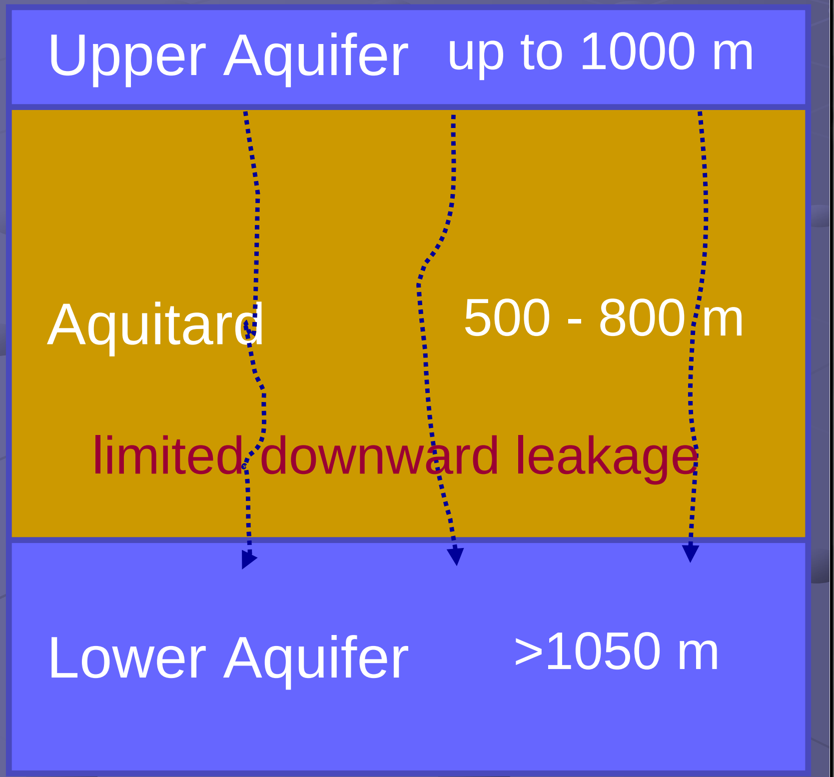
► tracer tests
► geochemical data (and environmental tracers)
► isotope data (oxygen 18, deuterium, tritium)

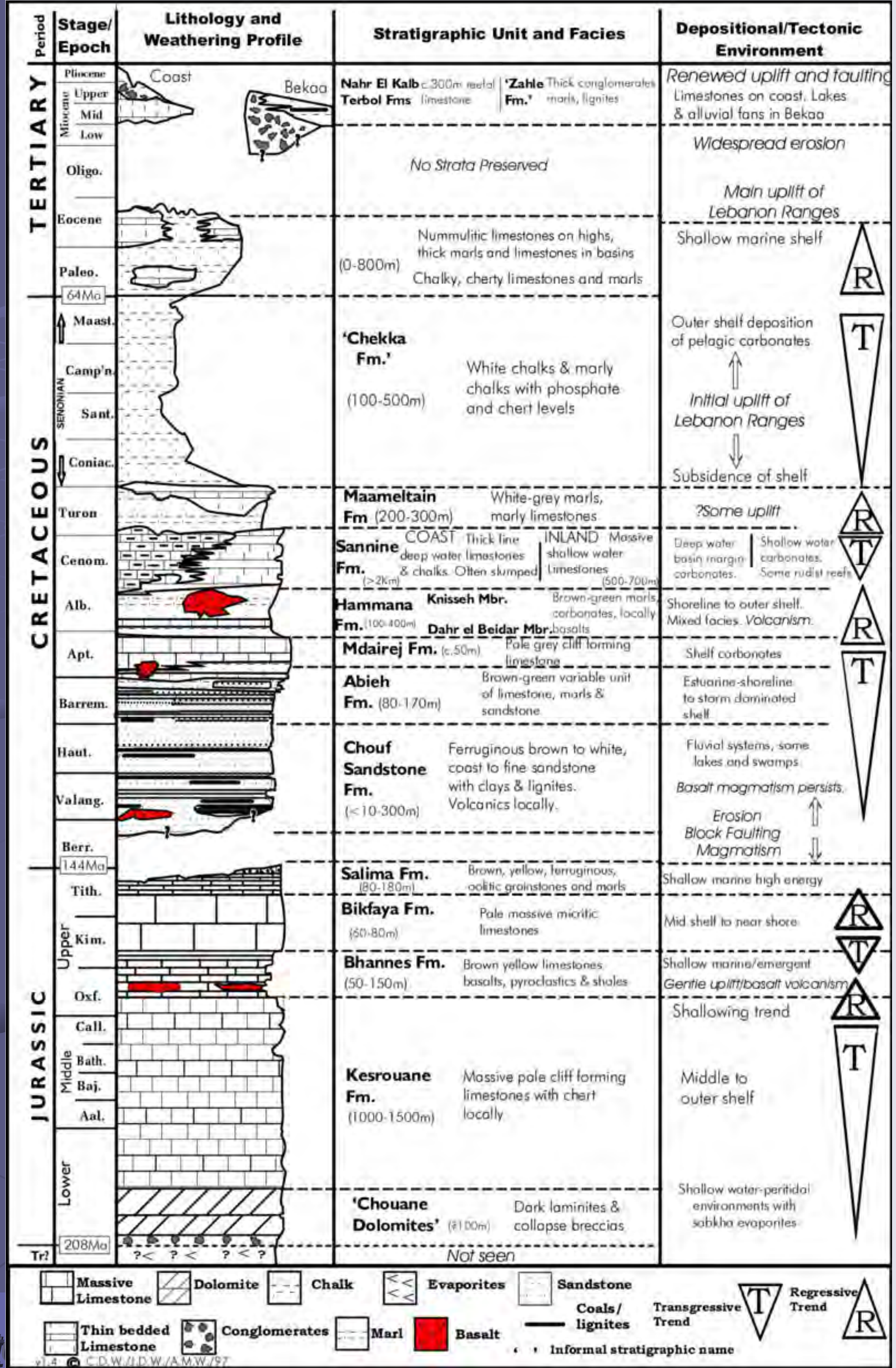
Groundwater System

Based on new geological map prepared by BGR



Lithostratigraphy





Source: C. D. Walley

Aquifers

C4

C3

} C2b

C2a

C1

} J7

J6

J5

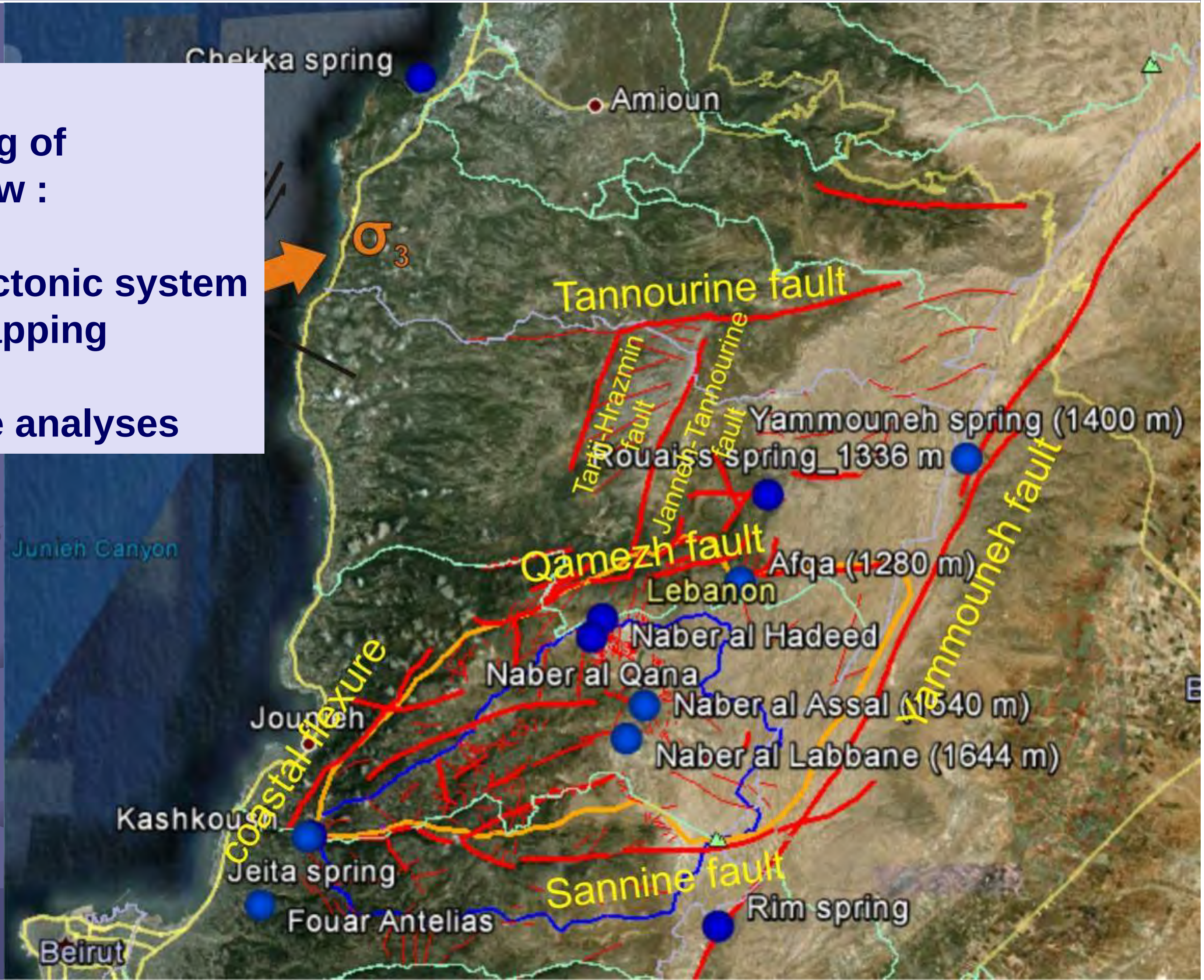
J4

Groundwater Flow

controlled by
- structure (base) and
- tectonics

key elements to understanding of groundwater flow :

- **analysis of tectonic system**
- **geological mapping**
- **tracer tests**
- **stable isotope analyses**



Tracer Tests

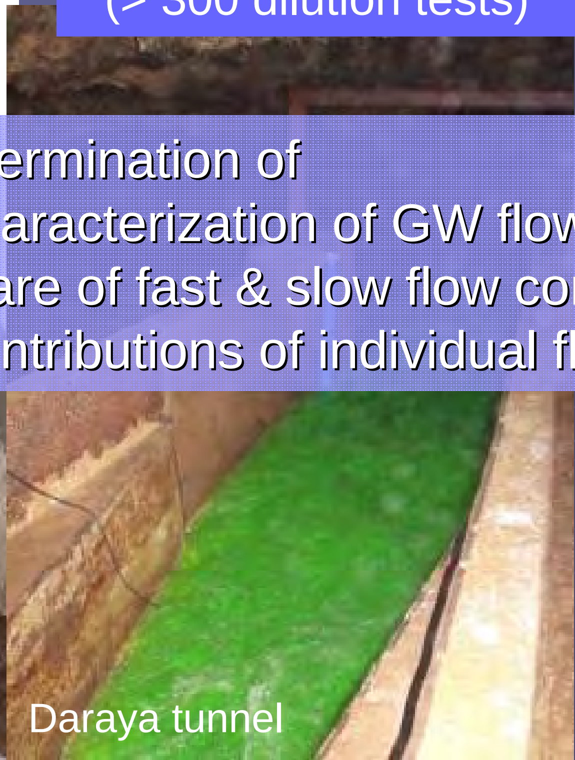
Determination of
- GW catchment boundaries
- flow velocity
- interaction GW – SW
- characterization of GW flow
(share of fast & slow flow components)

Spring Monitoring

- multiparameter probes
- gauging stations (weir, ADCPs)
- direct discharge measurement (> 300 dilution tests)

Determination of
- characterization of GW flow (share of fast & slow flow components)
- contributions of individual flows


Labbane spring


Daraya tunnel


Kashkoush spring

Jeita spring

Multiparameter probes parameters:
Water level
Temperature
EC
pH
ORP
DO
(ammonium)
(ISE)

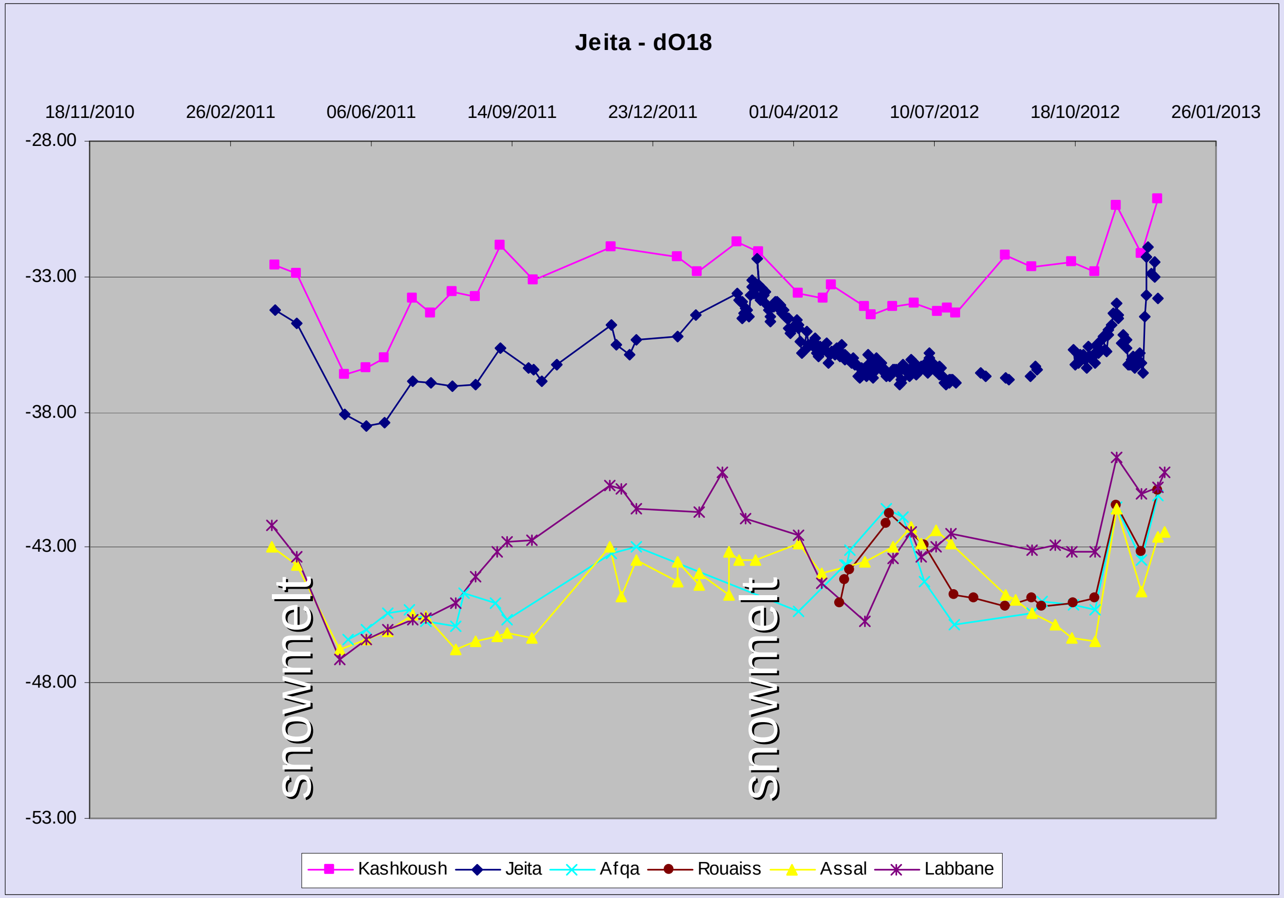
Telemetric data transfer

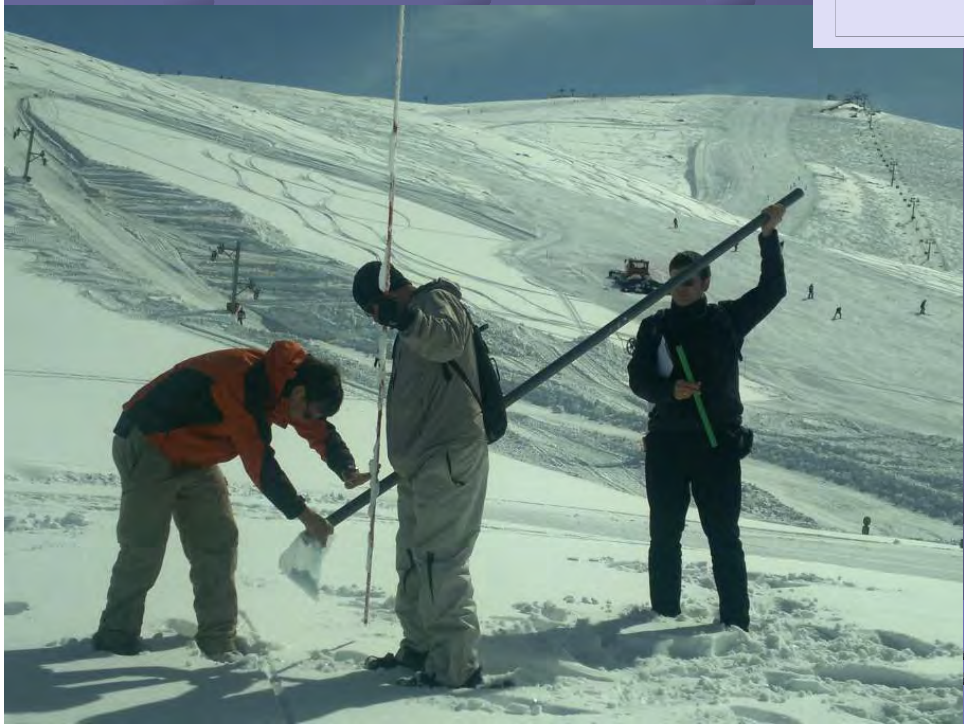
Assal spring

Isotope data

- deuterium/oxygen-18
- tritium/helium
- CFC (chlorofluorocarbon)

D/18O > 700 analyses
- 6 springs
- rainfall – 6 stations @ diff elev.
- snow sampling campaigns



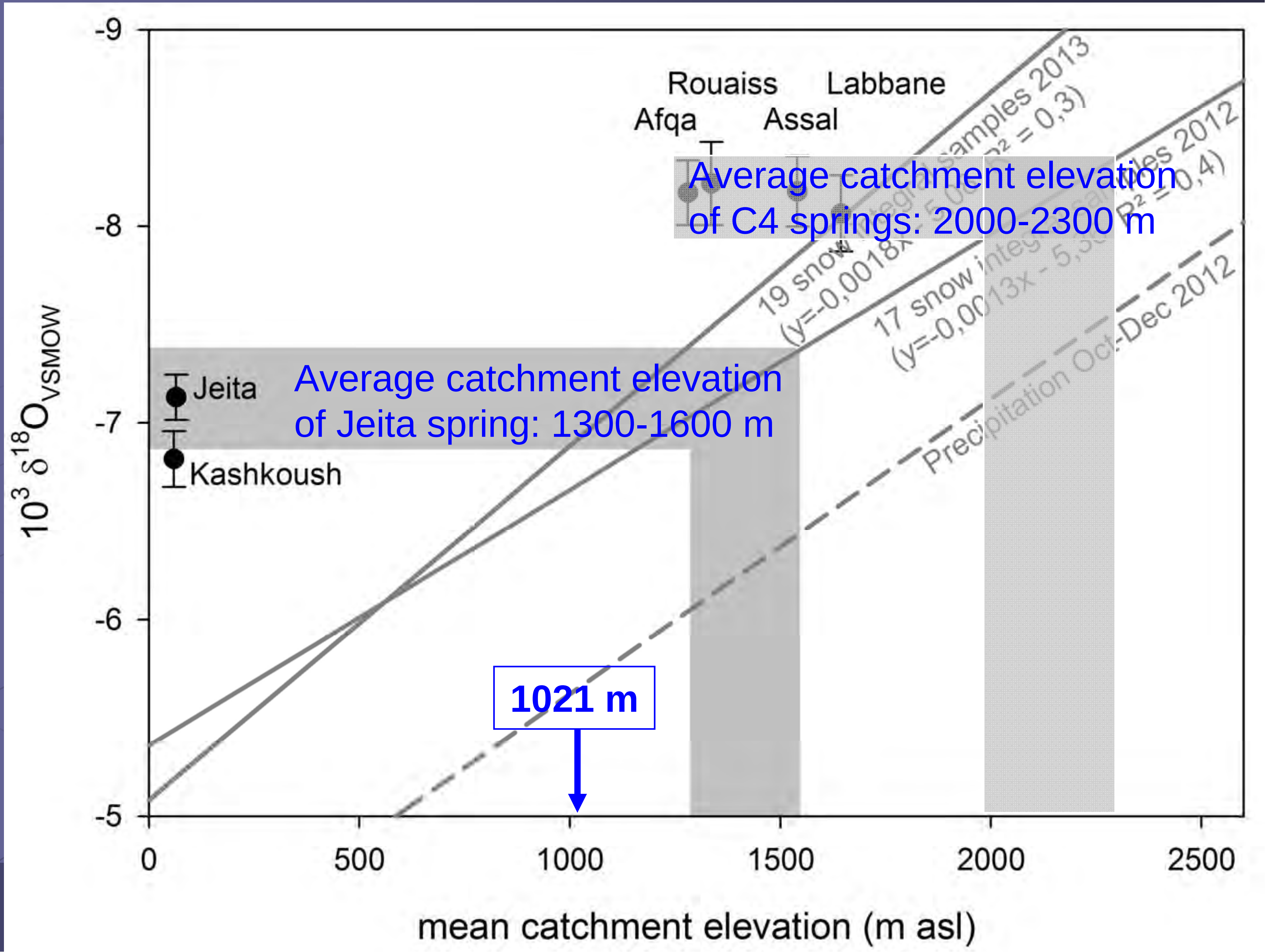


D/^{18}O
Springs Jurassic Aq (J4) :
- Jeita : daily
- Kashkoush : every 15 days

Springs Upper Createaceous Aq (C4) :
- Assal, Labbane, Afqa, Rouaiss : 15 days

Rainfall: Jeita, Sheile, Aajaltoun, Raifoun, Kfar Debbiane, Chabrouh : every 15 days
Snow: integral & 10 cm depth intervals, 2 winter seas.

Isotope data



Groundwater Protection Zones

Jordan

Mainly limestone aquifers, moderate kartification, high fracturation

- considered to behave like a porous aquifer
- development of karst network unknown
- flow velocities unknown (no tracer tests), recharge unknown (not all discharge measured)
- interconnection of SW – GW system not studied yet
- no systematic analysis of spring discharge: slow flow – fast flow components
- no systematic analysis of stable isotopes in rainfall, springs and wells

Lebanon

Mainly limestone aquifer, very high karstification, high fracturation

- well developed karst network (many well explored caves, submarine springs)
- typical karst groundwater system
- flow velocities known hrough tracer tests
- interconnection of SW – GW system studied
- systematic analysis of spring discharge: slow flow – fast flow components
- systematic analysis of stable isotopes in rainfall and springs

Groundwater Protection Zones

GW protection zone delineation in Lebanon using GW vulnerability concept for mixed aquifer types

- Comparative study of EPIK method (only applicable in karst aquifers) and COP method
- EPIK has many disadvantages (GOLDSCHEIDER, 2002); e.g. recharge and thickness of unsaturated zone are not taken into account

GW protection zone delineation in Jordan using traditional methods used mainly for porous aquifers

- Approximation of flow velocity

Delineation of GW protection zones needs to follow a standard approach (guideline).
Implemented in Jordan > not yet in Lebanon

Guideline for Groundwater Resources Protection

The Ordinance on the Delineation of a Groundwater Protection Zone for a groundwater well or spring consists of the following elements :

- A statement about the legal basis for the issuance of the ordinance,
- The hydrogeological study, defining the hydrogeological boundaries of the groundwater protection zone,
- The administrative boundaries of the groundwater protection zone, defined by the Committee on Groundwater Protection Zone Delineation, and to be based on the hydrogeological study,
- A list of restrictions for activities and land uses in the different groundwater protection zones, as defined by the Committee on Groundwater Protection Zone Delineation,
- An inventory of all potential sources of contamination for the entire groundwater protection zone, to be included in the hydrogeological study,
- An analysis of the susceptibility of the water supply source to those contamination sources, to be included in the hydrogeological study, including an evaluation of the degree of threat arising from each potential pollution hazard,
- A surveillance and monitoring scheme for compliance with defined restrictions,
- A contingency plan that describes how water supply is planned to be maintained in case of groundwater contamination and
- A remedial action plan that describes which measures are going to be implemented to avoid groundwater contamination in case of accidental contamination.

Guideline for Groundwater Protection Zone Delineation

2002: proposal to Higher Committee for Groundwater Protection

2003: guideline elaborated for ACSAD as a basis for implementation in the Arab region

Protection

Arab Centre for the Study of Arid Zones and Dry Lands
ACSAD
Damascus

FEDERAL REPUBLIC OF GERMANY
Federal Institute for Geosciences and Natural Resources
BGR
Hannover

TECHNICAL COOPERATION

PROJECT NO.: 1996.2189.7

Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region

Volume 5

Guideline for the Delineation of Groundwater Protection Zones

Damascus

September 2003

Guideline for Groundwater Vulnerability Mapping

2002: proposal for Jordan

2003: guideline elaborated for ACSAD as a basis for implementation in the Arab region

Comparison of
- GLA method
- PI method
- EPIK method
- COP method
- DRASTIC

Protection

Arab Centre for the Study of Arid Zones and Dry Lands
ACSAD
Damascus

FEDERAL REPUBLIC OF GERMANY
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Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region

Volume 4

Guideline for Groundwater Vulnerability Mapping and Risk Assessment for the Susceptibility of Groundwater Resources to Contamination

Damascus

April 2003

Groundwater Vulnerability Maps

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. ?

Groundwater Vulnerability Maps

Uses:

- Land Use Planning (Planning Authorities):
  - ➢ Selection of Areas for Activities Hazardous to Groundwater,
  - ➢ Protection of very Productive Aquifers (conservation)
- Water Resources Management (Water Authorities):
  - ➢ Groundwater Protection Zone Delineation and Definition of Land Use Restrictions,
  - ➢ Protection of Resources which may be Important in the Future,
  - ➢ Design of Groundwater Monitoring Networks,
  - ➢ Environmental Impact Assessments,
  - ➢ Detection of Pollution Sources and Pathways.

Need for Detailed Investigations

All Methods of Intrinsic Vulnerability Mapping are Highly Subjective and Difficult to Validate !

Mapping scale: 1:50,000 – 1:100,000

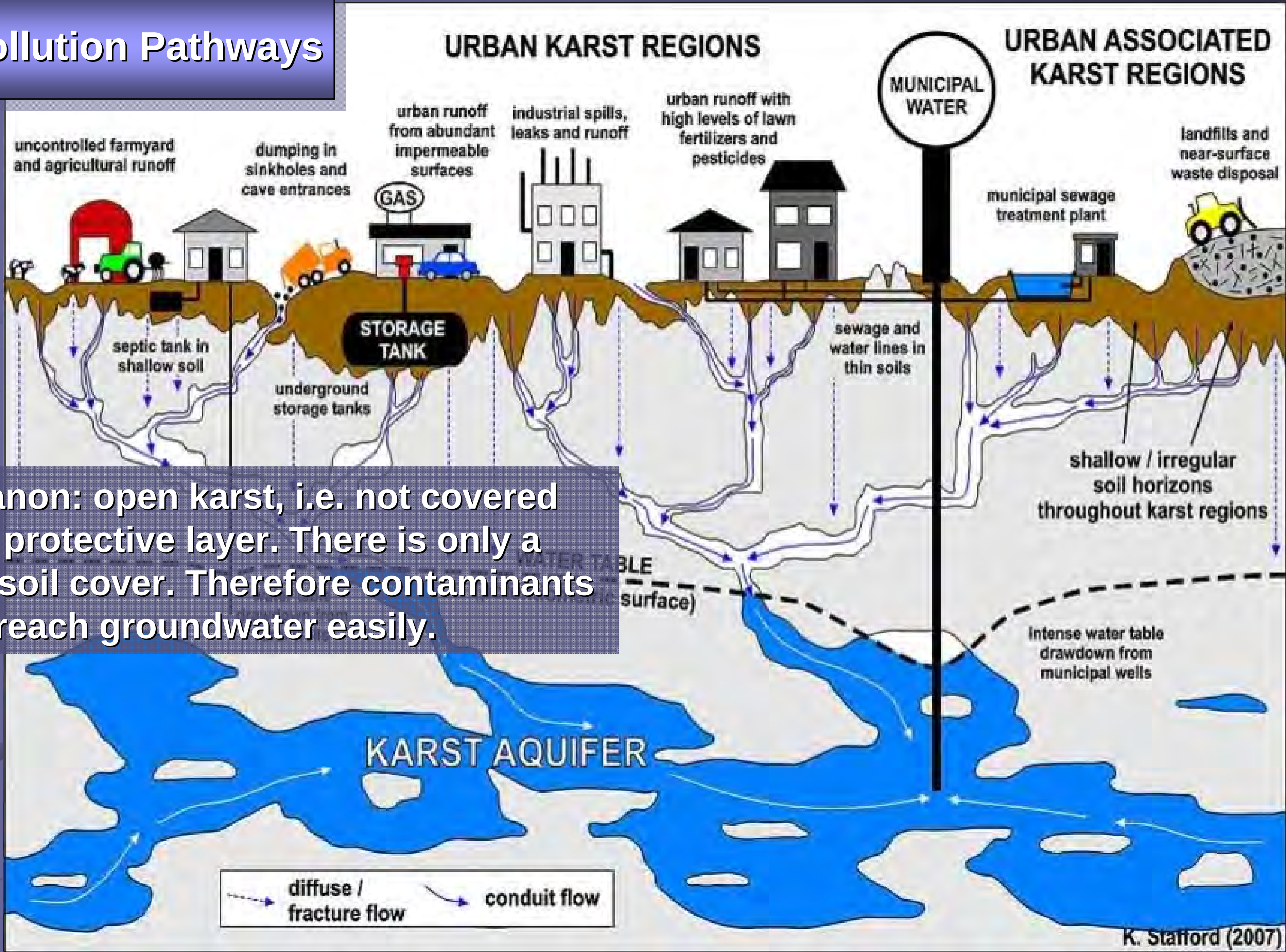
Before a decision is taken where to establish a Potentially Hazardous Site the envisaged site must be studied in more detail !

Because available data are often insufficient for detailed studies

Pollution Pathways

Fractures and dissolution channels (conduits) reach deep into the underground. Rain infiltrates along these pathways together with contaminants

Pollution Pathways



Lebanon: open karst, i.e. not covered by a protective layer. There is only a thin soil cover. Therefore contaminants can reach groundwater easily.

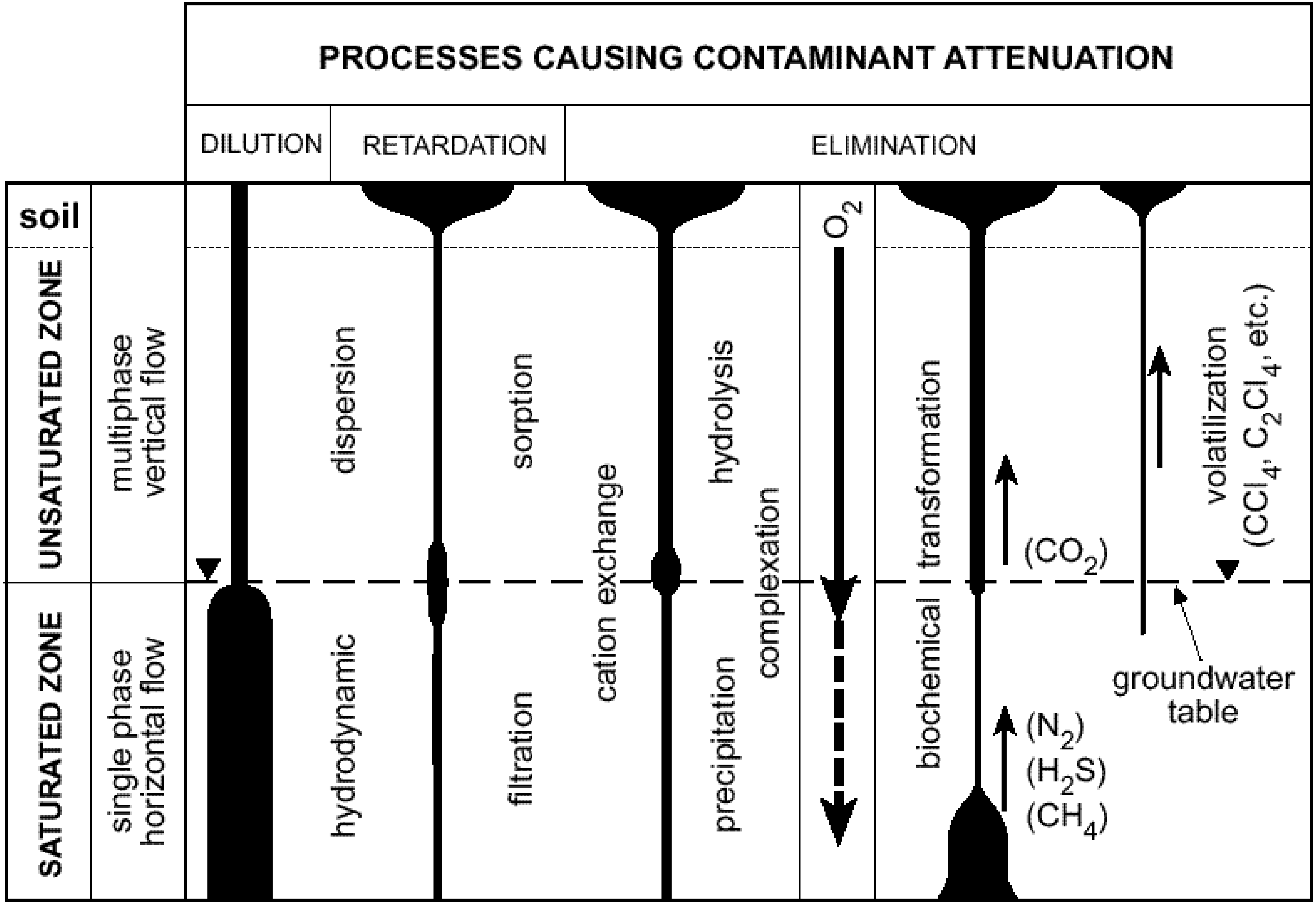
GW Vulnerability

Factors determining the protective effectiveness or filtering effect 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.

natural parameters influencing the solubility and chemical reactivity (temperature, pressure, etc.),

- dispersion/diffusion,
- chemical complexation, sorption and precipitation
- degradation (chemical/biological/radiological transformation, hydrolysis, etc.)



(line width indicates relative importance of process in corresponding zone)

MORRIS & FOSTER (2000)

Methods

➢**Hydrogeological Complex and Setting Methods (HCS)**
Simple Method for Large Areas (country-wide scale)

➢**Parametric System Methods** can be divided into :

- Matrix Systems,
- Rating Systems and
- Point Count System Models.

Rating Systems: many parameters with fixed ranges of ratings according to their variation in the area. The total rating is calculated by overlaying the ratings for the different parameters and then dividing the total rating into different levels of Vulnerability (e.g. GOD, PRZM, SAFE, GLA-/PI-Method, EPIK, **COP**).
Point Count System Models: (e.g. DRASTIC, SINTACS)

➢**Index Methods and Analogue Relations**

➢**Mathematical Models (Numerical Methods or Statistical Methods)**

Protective Effectiveness of the Soil Cover and the Unsaturated Zone

Parameter 1: S - effective field capacity of the soil (rating for ΣeFC in mm down to 1 m depth)
Parameter 2: W - percolation rate (groundwater recharge)
Parameter 3: R - rock type (consolidated/unconsolidated)
Parameter 4: T - thickness of soil and rock cover above the aquifer
Parameter 5: Q - bonus points for perched aquifer systems
Parameter 6: HP - bonus points for hydraulic pressure conditions (confined/artesian conditions)

Overall protective effectiveness (PT) is calculated using the formula:

PT = P1 + P2 + Q + HP

P1 - protective effectiveness of the soil cover: P1 = S * W
P2 - protective effectiveness of the unsaturated zone (sediments or hard rocks):

P2 = W * (R1*T1 + R2*T2 + ... + Rn*Tn).

C – concentration of flow,
O – overlying layers and
P – precipitation.

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

O-score
$O = O_S + O_L$; layer index = Σ (ly * m)

C-score
Scenario 1: swallow hole
$C = d_h * d_s * sv$
swallow hole (d_h),
distance to the sinking stream (d_s)
combined effects of slope and vegetation (sv)
Scenario 2: no swallow hole
C = sf * sv ; surface features (sf), and slope and vegetation (sv)

COP-Method

Parameters

P-score

$P = P_Q + P_I$; quantity of precipitation (P_Q) and intensity of precipitation (P_I)

P_Q - mean precipitation of a wet year
P_I - mean annual precipitation / mean number of rainy days per year

COP-Method

VIAS et al. (2002, 2006)

O FACTOR (Overlying layers)

[O_S] Soil

I

Clayey	> 30 % Clay
Silty	> 70 % Silt
Sandy	Sand > 70 % Clay ≤ 15 %
Loam	Rest

II

Thickness	Texture: Clayey	Silty	Loam	Sandy
> 1.0 m	5	4	3	2
0.5 - 1 m	4	3	2	1
< 0.5 m	3	2	1	0*

*: Also 0 when no soil is present

→ [O_S]

[O_L] Lithology

III

Lithology and fracturation	Value
Clays	1500
Silts	1200
Marls and non-fissured metapelites and igneous rocks	1000
Marly limestones	500
Fissured metapelites and igneous rocks	400
Cemented or non-fissured conglomerates and breccias	100
Sandstones	60
Scarcely cemented or fissured conglomerates and breccias	40
Sands and gravels	10
Permeable basalts	5
Fissured carbonated rocks	3
Karstic rocks	1

Thickness of each layer

V

Confined conditions (cn)	Value
Confined	2
Semi-confined	1.5
Non confined	1

(ly) (m) (cn)

Layer index = Σ (ly · m)

IV

Layer index	Value
(0 – 250]	1
(250 – 1000]	2
(1000 – 2500]	3
(2500 – 10000]	4
> 10000	5

Value Layer index · cn = [O_L]

O SCORE = [O_S] + [O_L]

VI

O SCORE	Protection value
1	Very low
2	Low
(2 – 4]	Moderate
(4 – 8]	High
(8 - 15]	Very high

→ **O MAP**

C FACTOR (Concentration of flow)

SCENARIO 1 — Swallow hole recharge area

Distance to swallow hole (dh)

VII

Distance to swallow hole in meters	Value	Distance to swallow hole in meters	Value
≤ 500	0	(3000 - 3500]	0.6
(500 - 1000]	0.1	(3500 - 4000]	0.7
(1000 - 1500]	0.2	(4000 - 4500]	0.8
(1500 - 2000]	0.3	(4500 - 5000]	0.9
(2000 - 2500]	0.4	> 5000	1.0
(2500 - 3000]	0.5		

Slope and Vegetation (sv)

IX

Slope	Vegetation	Value
≤ 8 %	-	1
(8 – 31]	Yes	0.95
	No	0.9
(31 – 76]	Yes	0.85
	No	0.8
> 76 %	-	0.75

Distance to sinking stream (ds)

VIII

Distance to sinking stream	Value
< 10 m	0
10 - 100 m	0.5
> 100 m	1*

Score c = dh · ds · sv

*: Also 1 when no sinking stream is present

SCENARIO 2 — Rest of the area

Surface features (sf)

X

Karstic features	Surface layers: Absence	Permeable	Impermeable
Developed karst	0.25	0.5	0.75
Scarcely developed or disolution features	0.5	0.75	1
Fissured karst	0.75	0.75	1
Absence of karstic features	1	1	1

Slope and Vegetation (sv)

XI

Slope	Vegetation	Value
≤ 8 %	-	0.75
(8 – 31]	Yes	0.8
	No	0.85
(31 – 76]	Yes	0.9
	No	0.95
> 76 %	-	1

Score c = (sf) · (sv)

XII

C SCORE	Reduction of protection
[0 – 0.2]	Very high
(0.2 – 0.4]	High
(0.4 – 0.6]	Moderate
(0.6 – 0.8]	Low
(0.8 - 1.0]	Very low

→ **C MAP**

P FACTOR (Precipitation)

[P_Q] Quantity

XIII

Rainfall * (mm/year)	Value
> 1600	0.4
(1200 - 1600]	0.3
(800 - 1200]	0.2
(400 - 800]	0.3
≤ 400	0.4

*: Average rainfall for wet years. Wet year ≥ $(0.15 \cdot \bar{x}) + \bar{x}$

[P_I] Intensity

$$\text{Intensity} = \frac{\text{P (mm/year)}}{\text{N° rainy days}}$$

XIV

Intensity (mm/day)	Value
≤ 10	0.6
(10 - 20]	0.4
> 20	0.2

P SCORE = [P_Q] + [P_I]

XV

P SCORE	Reduction of protection
0.4 - 0.5	Very high
0.6	High
0.7	Moderate
0.8	Low
0.9 - 1	Very low

→ **P MAP**

COP Index = C SCORE · O SCORE · P SCORE

XVI

Cop Index	Vulnerability classes
[0 - 0.5]	Very high
(0.5 - 1]	High
(1 - 2]	Moderate
(2 - 4]	Low
(4 - 15]	Very low

→ **COP Map**

COP-Method

O FACTOR (Overlying layers)

[O_S] Soil

II

Clayey	> 30% clay	
Silty	> 30% silt	
Sandy	Sand > 70%	Clay ≤ 15%
Loam	Rest	

[O_S]

		Texture			
		Clayey	Silty	Sandy	Loam
	+	3	2	1	0*
Thickness > 1 m	2	5	4	3	2
Thickness 0.5 - 1 m	1	4	3	2	1
Thickness < 0.5 m	0	3	2	1	0

* 0 when no soil is present

[O_L] Lithology

III

Lithology and fracturation	Value
Clays	1500
Silts	1200
Marls and non fissured	1000
matapellites and igneous rocks Marly limestones	500
Fissures metapelites and igneous rocks	400
Cemented or non fissured conglomerates and	100
Sandstones	60
Scarcely cemented or fissured conglomerates	40
Sands and gravels	10
Permeable basalts	5
Fissured carbonate rocks	3
Karstic rocks	1

UZ

V

Confined conditions (cn)	Value
Confined	2
Semi-confined	1.5
Non confined	1

(ly) (m) (cn)

Layer Index
(ly.m)

IV

Layer Index	Value
(0-250]	1
(250-1000]	2
(1000-2500]	3
(2500-10000]	4
>10000	5

Value Layer Index . cn
[O_L]

[O] Score

O SCORE= [O_L] + [O_S]

VI

O score	Protection value
1	Very low
2	Low
(2 - 4]	Moderate

C FACTOR (Concentration of flow)

Scenario 1 [C_1]: Swallow hole recharge area

Distance to swallow hole (dh)

VII

Distance to swallow hole (m)	Value	Distance to swallow hole (m)	Value
≤ 500	0	(300-350]	0.15
(50-100]	0.025	(350-400]	0.18
(100-150]	0.05	(400-450]	0.2
(150-200]	0.075	(450-500]	0.23
(200-250]	0.1	> 500	1
(250-300]	0.125		

Slope and Vegetation (sv)

IX

Slope	Vegetation	Value
≤ 8%	-	1
(8-31] %	Yes	0.95
	No	0.9
(31-76] %	Yes	0.85
	No	0.8
> 76%	-	0.75

C_1 SCORE = [dh] . [ds] . [sv]

VIII

Distance to sinking stream (ds)*	Value
< 10 m	0
10-100 m	0.2
100-500 m	0.5
> 500 m	1

*1 when no sinking stream is present

Scenario 2 [C_2]: Non-swallow hole recharge area

Surfaces features (sf)

X	Absence	Permeable	Imp
Dev. Karst	0.25	0.5	0.75
Scarcely developed or dissolution features	0.5	0.75	1
Fissured karst	0.75	0.75	1
Absence of karst features	1	1	1

Slope and Vegetation (sv)

XI

Slope	Vegetation	Value
≤ 8%	-	0.75
(8-31] %	Yes	0.8
	No	0.85
(31-76] %	Yes	0.9
	No	0.95
> 76%	-	1

C_2 SCORE = [sv] . [sf] . *[ds]*

(sf) (sv) (ds)

[C] Score

1) C_1 SCORE = [dh] . [ds] . [sv] **or** 2) C_2 SCORE = [sv] . [sf] . *[ds]*

XII

C score	Reduction of Protection
(0 - 0.2]	Very high
(0.2 - 0.4]	high
(0.4 - 0.6]	Moderate
(0.6 - 0.8]	Low
(0.8 - 1]	Very low

P FACTOR (Precipitation)

P_Q Quantity

XIII

Rainfall (mm/year)	Value
> 1600	0.4
(1200-1600]	0.3
(800-1200]	0.2
(400-800]	0.3
≤ 400	0.4

P_I Intensity

$$\textbf{Intensity} = \frac{\text{P (mm/year)}}{\text{N of rainy days}}$$

XIV

Intensity (mm/day)	Value
≤ 10	0.6
(10-20]	0.4
> 20	0.2

[P] Score

P SCORE = [P_Q] + [P_I]

XV

C score	Reduction of Protection
0.4-0.5	Very high
0.6	high
0.7	Moderate
0.8	Low
0.9-1	Very low

[COP] Score

COP Index = [C] . [O] . [P]

XVI

COP Index	Vulnerability classes
(0 - 0.5]	Very high
(0.5 - 1]	high
(0 - 2]	Moderate
(0 - 4]	Low
(0 - 15]	Very low

Modified by MARGANE & SCHULER (2013)

COP-Method

Modified

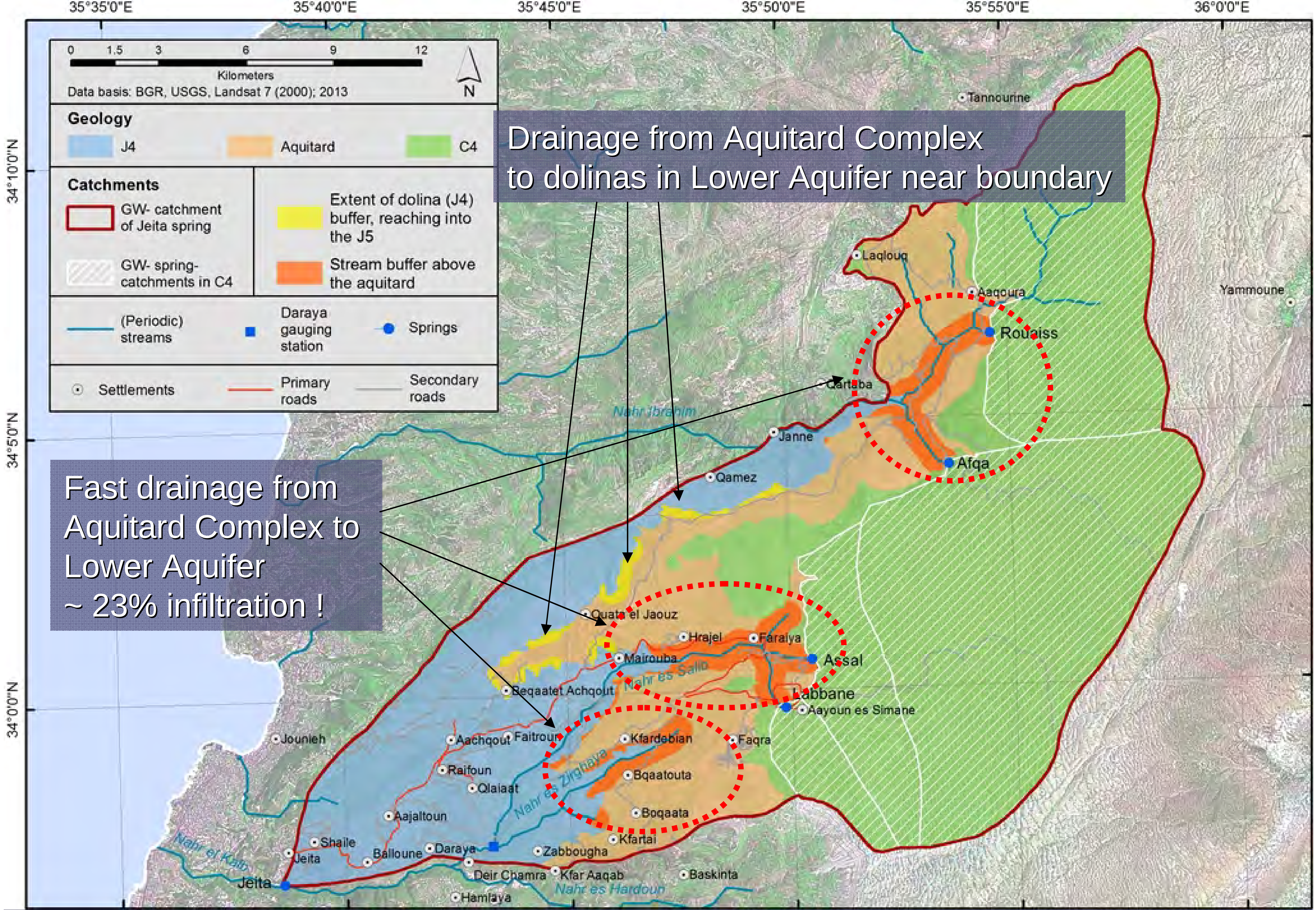
- distance to swallow holes (dh)
(reduced from 5,000 m to 500 m)
- integration of drainage from aquitards to swallow holes in aquifer
- integration of drainage from aquitards to sinking streams in aquifer
- distance to sinking streams
(increased from 100 m to 500 mdue to very steep valleys)
- sinking streams also integrated into scenario 2 (S-factor added)

S FACTOR (Concentration of flow)	
Exent of concentration towards gaining stream	
Distance to gaining stream (sg) XV	
Distance to gaining stream (m)	sg
≤ 500	0

S SCORE = [sg]

Data needed for COP GW vulnerability map

- Detailed geological structure (geological mapping) > similar to GLA method
- Soil properties (soil mapping) > similar to GLA method
- Characterization of GW flow (especially travel time: tracer tests, hydrochemical study, stable isotope analyses)
- Karst features (mapping) > modified by project
- detailed DEM, vegetation cover


35°35'0"E
35°40'0"E
35°45'0"E
35°50'0"E
35°55'0"E
36°0'0"E
34°10'0"N
34°5'0"N
34°0'0"N
0 1,5 3 6 9 12
Kilometers
N
Data basis: BGR, USGS, Landsat 7 (2000); 2013
Geology
J4
Aquitard
C4
Catchments
GW- catchment of Jeita spring
GW- spring-catchments in C4
Extent of dolina (J4) buffer, reaching into the J5
Stream buffer above the aquitard
(Periodic) streams
Daraya gauging station
Springs
Settlements
Primary roads
Secondary roads
Drainage from Aquitard Complex to dolinas in Lower Aquifer near boundary
Fast drainage from Aquitard Complex to Lower Aquifer ~ 23% infiltration !
Tannourine
Laqlouq
Aaqoura
Yammoune
Rouaiss
Qartaba
Janne
Afqa
Qamez
Nahr Ibrahim
Quatra el Jaouz
Hrajel
Faraiya
Mairouba
Assal
Nahr es Salib
Beqaatet Achqout
Labbane
Aayoun es Simane
Jounieh
Aachqout
Faitroun
Kfardebian
Faqra
Raifoun
Qlaiaat
Bqaatouta
Nahr es Zirghaya
Boqaata
Aajaltoun
Shaile
Jeita
Balloune
Daraya
Zabbougha
Kfartai
Nahr el Kalb
Deir Chamra
Kfar Aaqab
Baskinta
Nahr es Hardoun
Hamlaya

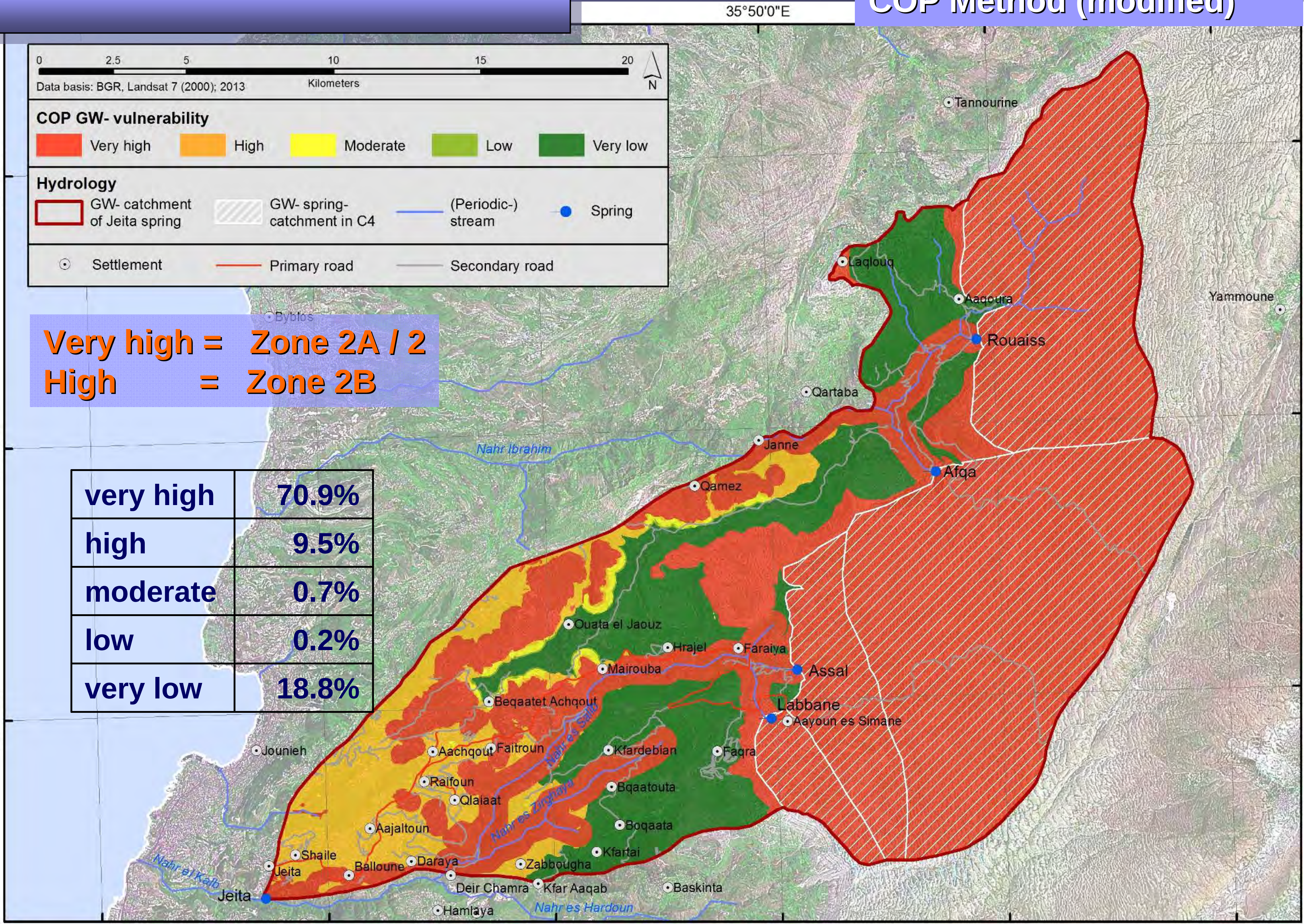
COP-Method

Data source

Type	Data	Source	Specificity
Raster	SRTM DEM (2000)	USGS, 2011	Corrected cell size 110 m; resampled to 10 m. Coverage: Lebanon
	Average monthly precipitation (1931/1960)	UNDP & FAO (1973), modified, according to MARGANE, et al. (in progr.)	Cell size: 10 m. Coverage: JEITA GW CATCHMENT
Shapefile	Boundaries of the sub-surface catchments of Afqa-, Assal-, Jeita-, Labbane- and Rouaiss spring	MARGANE et al. (in progr.)	Coverage: JSC
	Geology		
	Groundwater contour		
	Soil texture and thickness	RAAD et al. (2011)	
	Surface karst features	ABI RIZK & MARGANE (2011)	
	Landuse and landcover	SCHULER (2011)	
	Streams		
	Daily precipitation (1999-2010)	TUTIEMPO NETWORK, 2011	Beirut Airport

Groundwater Protection Zones

Groundwater Vulnerability COP Method (modified)



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

very high	70.9%
high	9.5%
moderate	0.7%
low	0.2%
very low	18.8%

Groundwater Protection Zones

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;

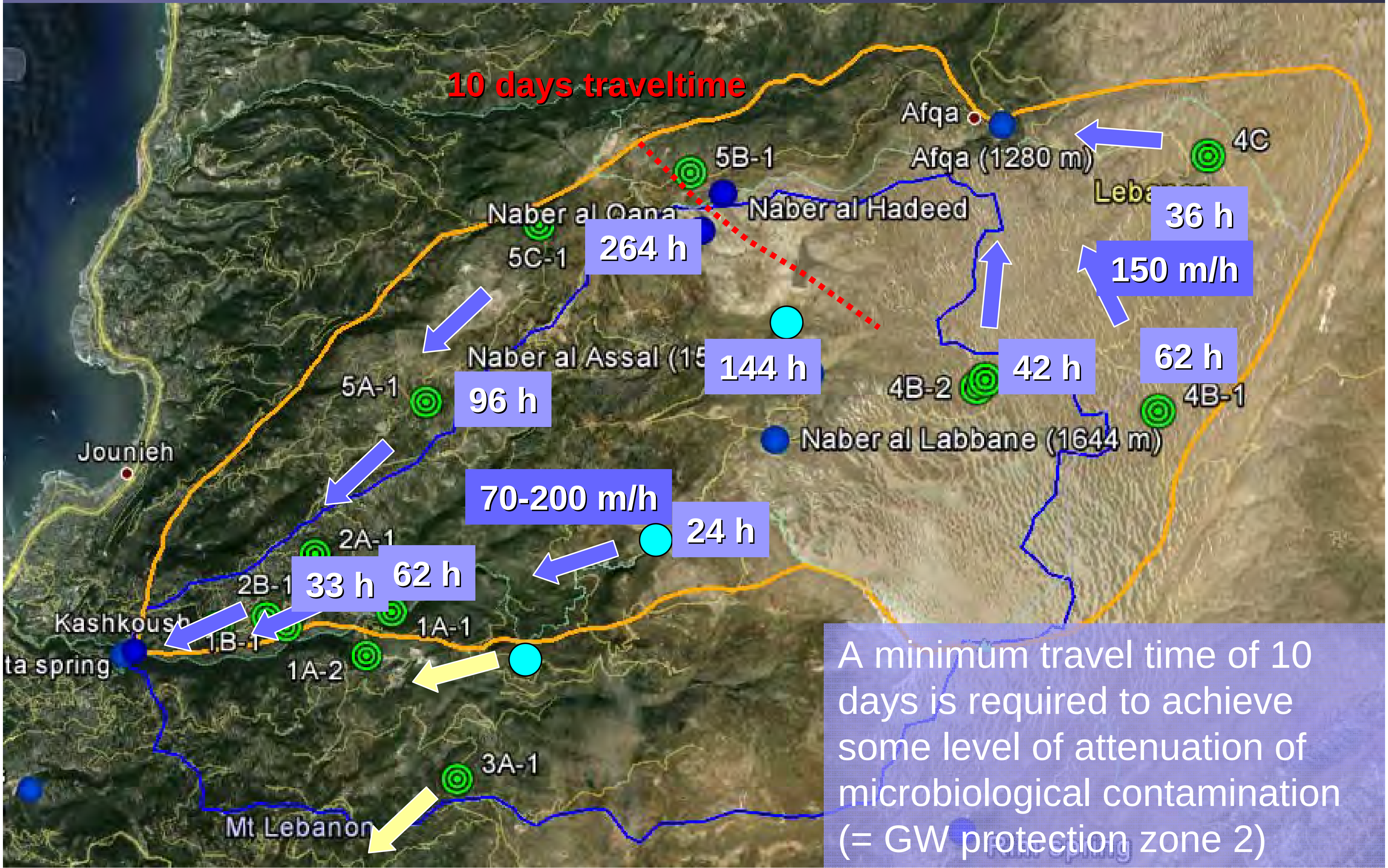
zone 2B: groundwater travel time < 10 days, high groundwater vulnerability;

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

zone 3B: all other parts of the groundwater catchment.

Groundwater Flow

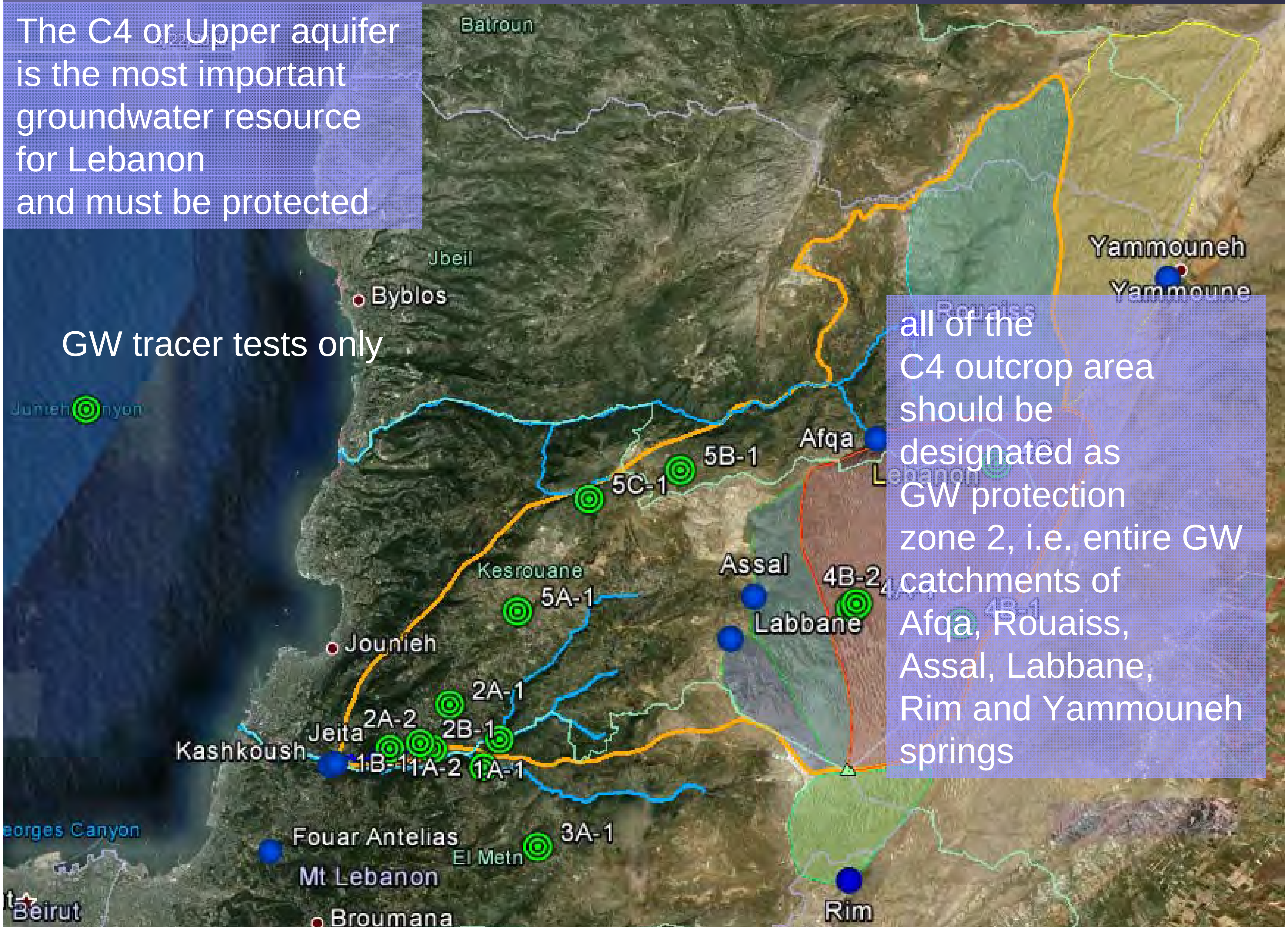
Mean travel times



A minimum travel time of 10 days is required to achieve some level of attenuation of microbiological contamination (= GW protection zone 2)

The C4 or Upper aquifer
is the most important
groundwater resource
for Lebanon
and must be protected

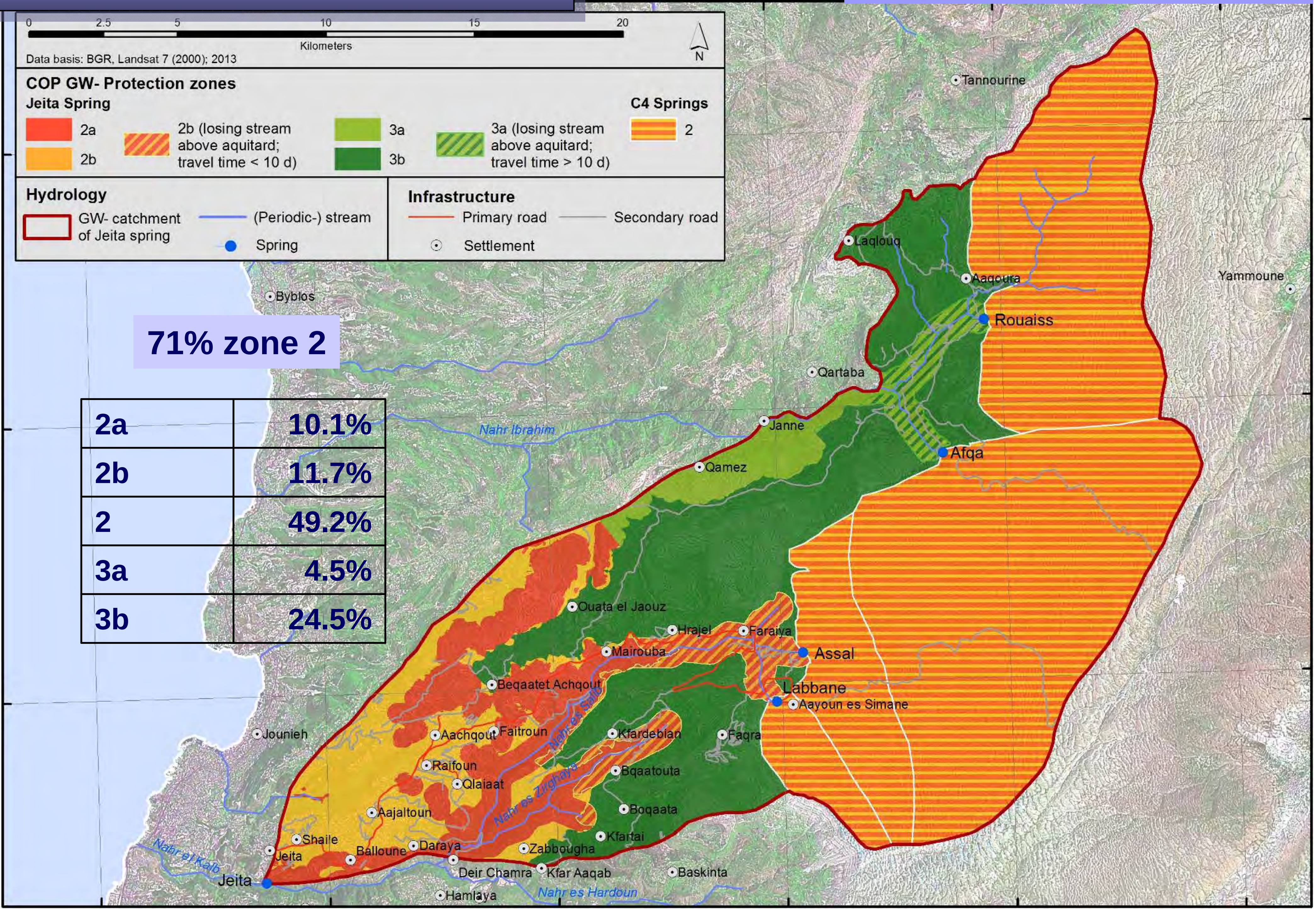
GW tracer tests only



all of the
C4 outcrop area
should be
designated as
GW protection
zone 2, i.e. entire GW
catchments of
Afqa, Rouaiss,
Assal, Labbane,
Rim and Yammouneh
springs

Groundwater Protection Zones

for Jeita, Afqa, Rouaiss, Assal and Labbane springs



71% zone 2

2a	10.1%
2b	11.7%
2	49.2%
3a	4.5%
3b	24.5%

Zone 1 comprises:

- the entire Jeita cave (approx. 5.8 km long)
- the water conveyor (canal and tunnel) from Jeita spring to the Dbayeh drinking water treatment plant
- the area over Jeita cave where the overlying rock thickness is less than 100 m or where faults can lead to a rapid infiltration

Any landuse by the water utility within zone 1 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)

Groundwater Protection Zones

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]

The following landuse activities shall **not be allowed in protection zone 3**:

- Waste disposals,
- Industrial sites of any type,
- Commercial businesses involving the use and/or storage of heavy metals, toxic or hazardous substances (e.g. pesticides),
- The establishment of new gas stations.

Groundwater Protection Zones

Jeita Spring

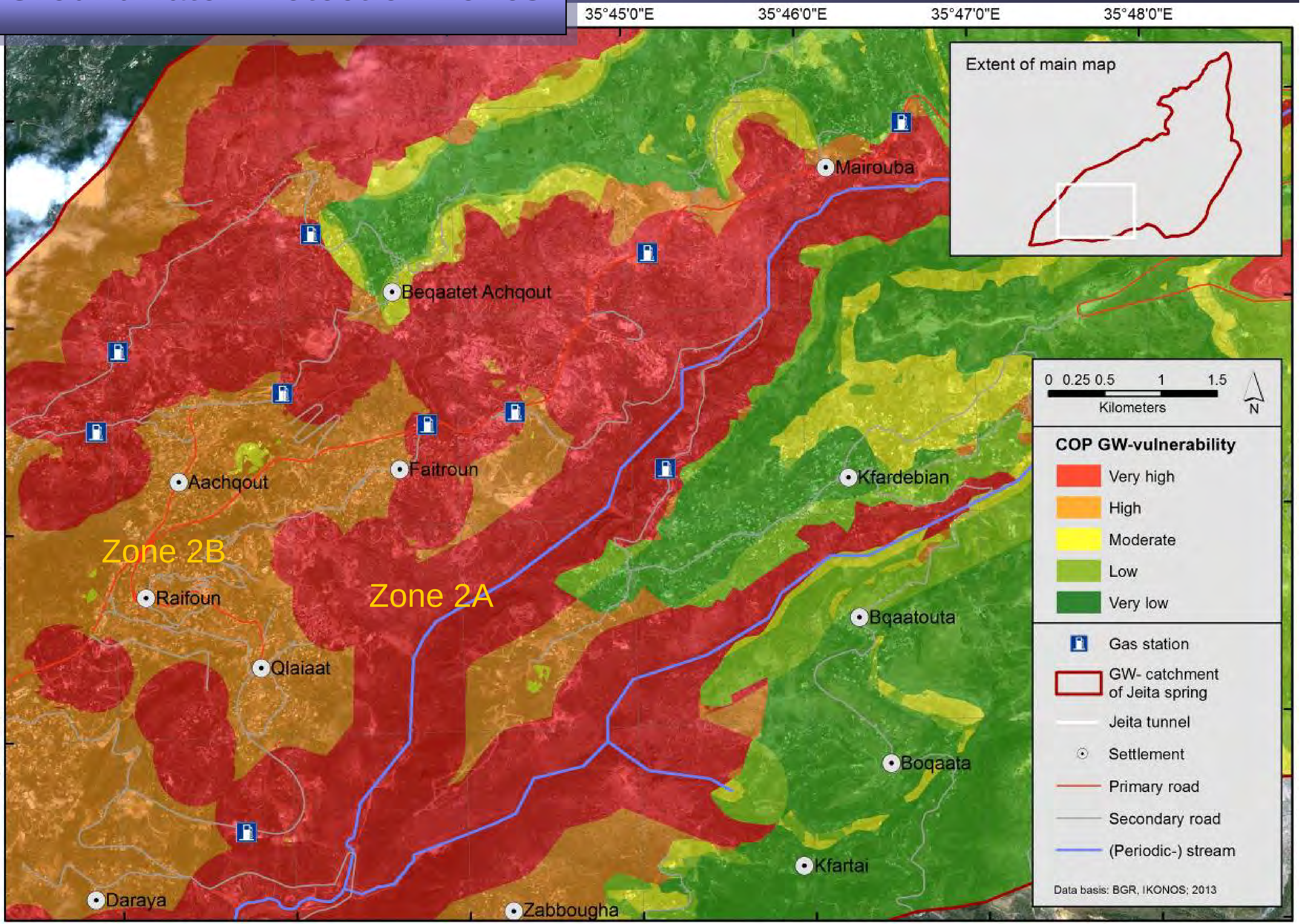
CIL group housing projects

gas stations

George Matta housing project
Aajaltoun Valley

Groundwater Protection Zones

Jeita Spring



Groundwater Protection Zones

Assal Spring

Protection Zone 1 for Assal Spring

Groundwater Protection Zones

Assal Spring

Modifications required in Protection Zone 1 for Assal Spring:
- fence needs to be extended
- stormwater drainage system at the road must be improved

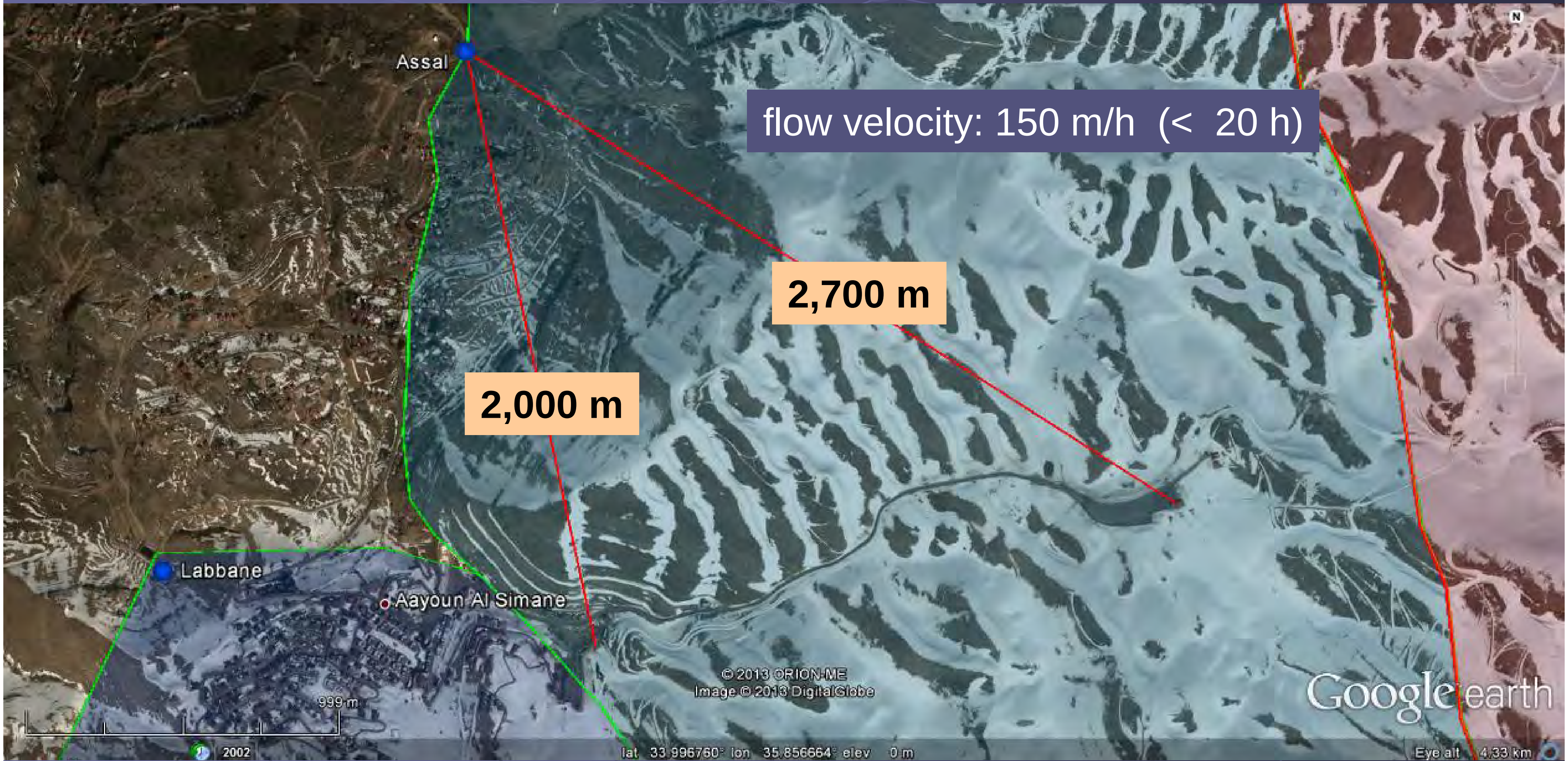
Protection Zone 2

The following landuse activities shall **not be allowed in protection zone 2**:
- Gas stations,
- Industrial sites,
- Commercial businesses (e.g. repair shops) using or storing hazardous substances,
- Storage of hazardous substances,
- Quarries, rock cutting facilities, brick factories,
- Dumping of waste,
- Animal farms,
- Agricultural farms,
- Slaughterhouses,
- Application of pesticides and chemical fertilizers.

Groundwater Protection Zones

Assal Spring

Distance from ski stations



Groundwater Protection Zones

Assal Spring

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.

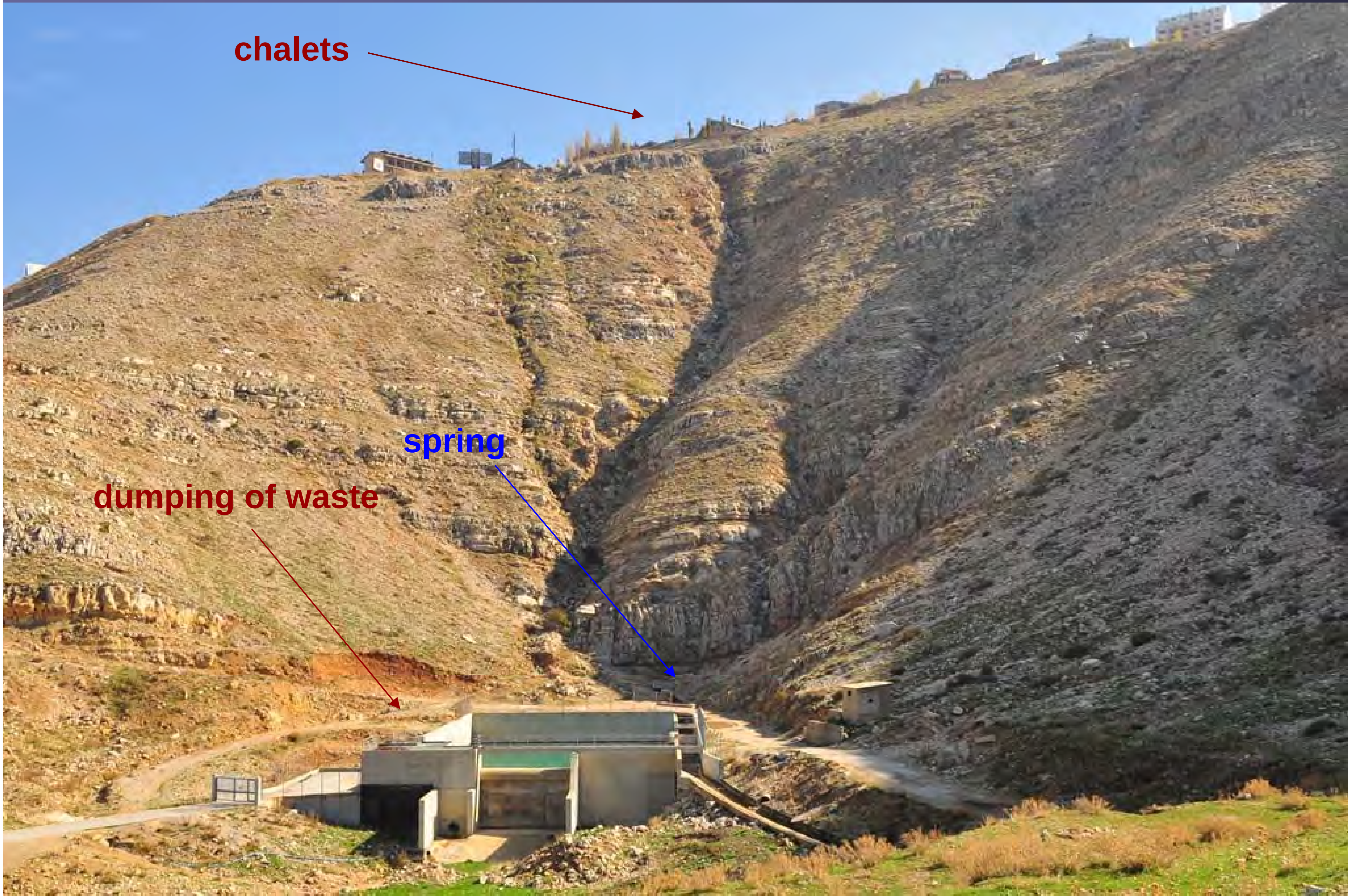
Groundwater Protection Zones

Groundwater Protection Zones

Labbane Spring

Groundwater Protection Zones

Labbane Spring



Groundwater Protection Zones

Reports for Project Component 2

Integration of Water Resources Protection Aspects into Landuse Planning

Technical Report 4: **Geological Map, Tectonics and Karstification** in the Groundwater Contribution Zone of Jeita Spring (September 2011) ✓

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

Technical Report 7: **Groundwater Vulnerability** in the Groundwater Catchment of Jeita Spring and **Delineation of Groundwater Protection Zones** Using the COP Method (September 2012; February 2013) ✓

www.bgr.bund.de/jeita

Reports for Project Component 2

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)

Reports for Project Component 2

Integration of Water Resources Protection Aspects into Landuse Planning

Special Reports 14: Guideline for Gas Stations - Recommendations from the Perspective of Groundwater Resources Protection (May 2012) ✓

Special Report 16: Hazards to Groundwater and Assessment of Pollution Risk in the Jeita Spring Catchment (September 2013) ✓

Special Report 19: Risk Estimation and Management Options of Existing Hazards to Jeita spring (September 2013) ✓

Advisory Service Document No. 5: Preliminary Assessment of the Most Critical Groundwater Hazards to Jeita Spring (June 2013) ✓

Thank you for your kind attention

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HASHEMITE KINGDOM OF JORDAN
Ministry of Water and Irrigation
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Amman

Federal Institute for Geosciences
and Natural Resources (BGR),
Hannover, Germany

Jordanian-German Technical Cooperation Project

Groundwater Resources Management (2002-2010)

GW Protection Zone Delineation in Jordan
Example Ain Rahoub & Hallabat Wellfield

Project Exchange Meeting Jordan - Lebanon
30 October 2013

تعاون
المملكة الاردنية الهاشمية
جمهورية ألمانيا الاتحادية

Dr. Armin Margane

Need for Protection of Water Resources

The scarce water resources of Jordan are heavily overexploited.

Groundwater resources abstractions exceed present-day groundwater recharge since the mid 1980s (groundwater deficit in 2007: 151 MCM). This has caused groundwater level declines of 1-2 m/a in most areas of Jordan.

With the expanding agricultural development since the 1970s and the growing industrial development since the 1990s the risks of ground and surface water pollution have grown.

The wastewater collection and treatment systems cover only the main urban centers. Bacteriological contamination of springs, wells and reservoirs is widespread.

The need for improved landuse management decisions, which take aspects of groundwater protection into consideration, was recognized in the mid 1990s but implementation is still insufficient.

Measures for Water Resources Protection

Implemented by
BGR-MWI projects

Groundwater

- **Groundwater Vulnerability Maps**
  introduced in 1996, 6 maps available:
  Irbid, South Amman, Qunayya spring, Karak-Lajjun, Corridor wellfield, Hallabat wellfield
- **Groundwater Protection Zones**
  introduced in 1999 (Pella spring); 8 protection zones established until 2010
- **Groundwater Protection By-Law and Guideline**
  proposal in 2002, guideline accepted in 2006

Surface Water

- **Surface Water Protection Zones (drinking water; ongoing project phase):**
  2 protection zones: Wadi Mujib dam, Wadi Wala dam)
- **Surface Water Protection Guideline** (proposed in 2007)

Hazards to Groundwater

- **Improved Licensing Decisions** (2005-10)
- **Raise Public Awareness** (since 2006)
- **Design Standards for Waste Disposal Sites, Sewage Treatment Plants, etc.**
  (future project phase)
- **Environmental Impact Assessments** (future)
- **Best Management Practice Guidelines** (agriculture, industry; future)

Implementing Groundwater and Surface Water Resources Protection Program in Jordan

- Requires an integrated approach, involving many ministries and other institutions
- Requires laws and regulations

- The Project prepared Guidelines for Groundwater (2002) and Surface Water (2007) Protection Zone Delineation
- **Higher Committee for Water Resources Protection** established to provide guidance and to coordinate all efforts
- Guideline accepted in July 2006 > must be amended for surface water

Zoning System

objective

Delineation of zones where certain landuses are not allowed

The dimensioning of the protection zones has to be done very carefully in order to balance the competing interests:
- as large as necessary for safeguarding the water supply,
- as small as possible for avoiding inadequate restrictions.

Accepted Jordanian Guideline

Zone I - Immediate Protection Zone
Protects the wells and their immediate environment from any contamination and interference. No access for the public allowed.

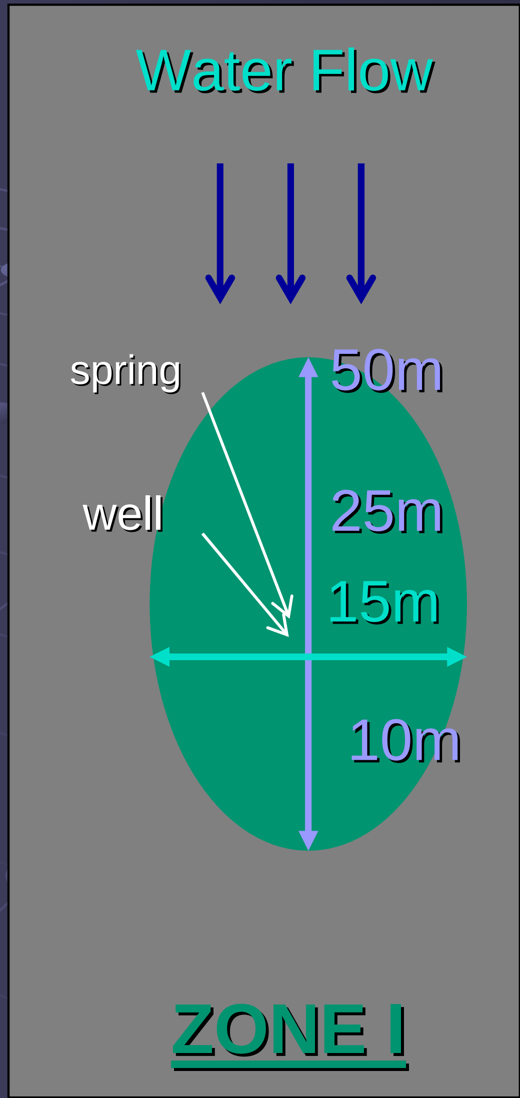
Zone II - Inner Protection Zone
Protection against pathogenic micro-biological constituents such as bacteria, viruses, parasites and worm eggs.

Zone III - Outer (Wider) Protection Zone
Protection from contamination affecting water over long distances such as contamination by chemicals which are non- or hardly degradable.

Groundwater Protection Zone Guideline

ZONE I - About 1 dunum around each water source (springs and wells, public or private)

- No activities allowed other than those needed for water abstraction
- For public supplies, WAJ will acquire the land and fence it (no public access)
- For private supplies, a similar land area should be protected



Groundwater Protection Zone Guideline

Zone II

Based on 50-days travel time (maximum up to 2 km upstream of well or spring)

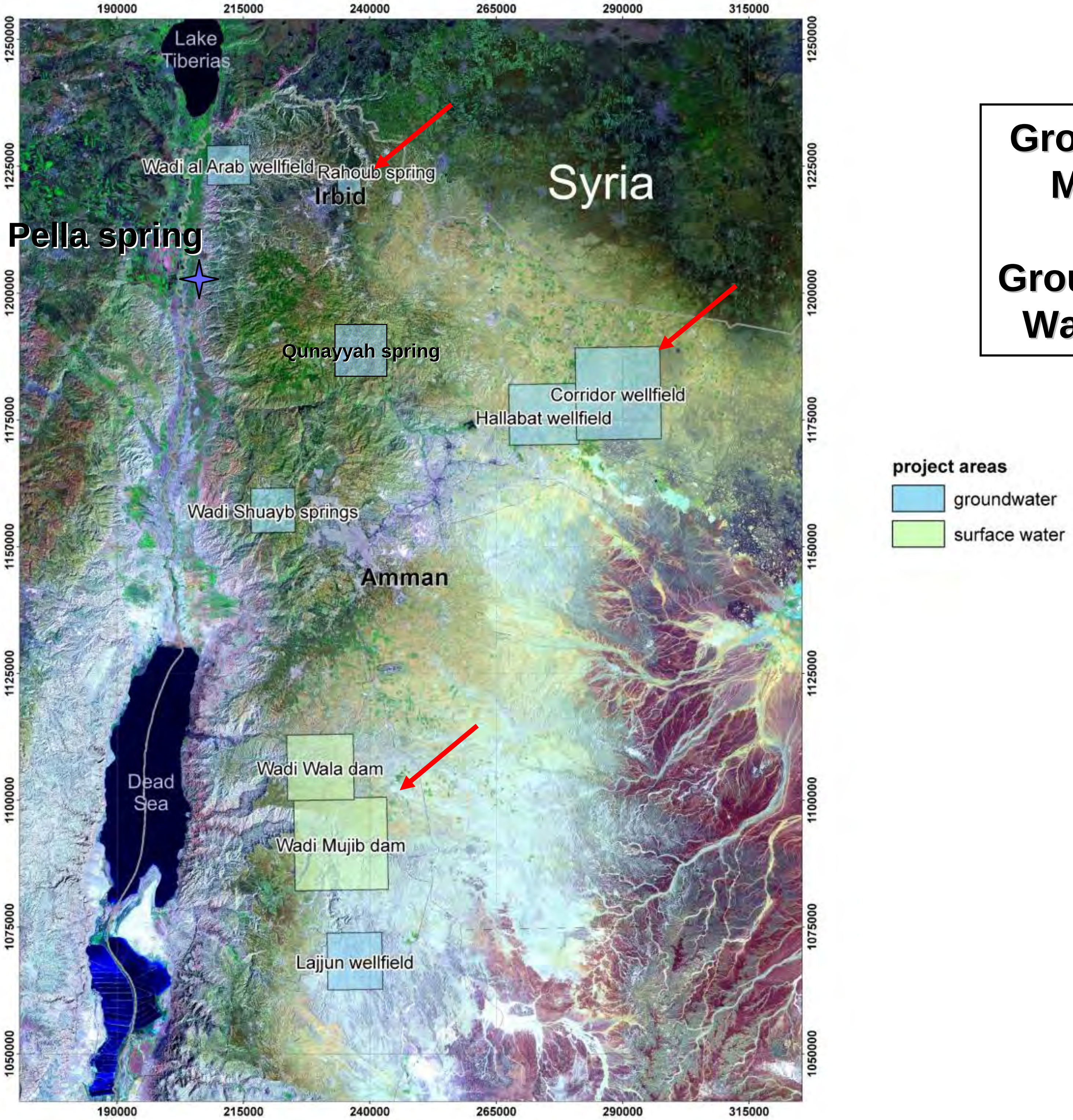
- Allowed activities (newly developed land)
  - Residential areas only with sewers or impermeable septic tanks
  - Organic farming (free of microbial health risks) – no application of pesticides allowed
- Allowed activities (already developed land)
  - Residential areas (high priority for wastewater systems)
  - Organic farming (free of microbial health risks) – no application of pesticides allowed
  - Other activities have to implement BMP's
- Activities in Zone II will be intensively monitored

Zone III

Protection of the entire groundwater catchment area.

All activities must employ sound environmental practices.

Groundwater Resources Management Project (2002-2010)
Groundwater and Surface Water Protection Zones



BGR

Groundwater Protection Zones

Completed:

- **Pella Spring** (Tabaqat Fahel, Jordan Valley; MARGANE et al., 1999) 8 MCM
- **Qunayyah Spring** (E of Jarash; HOBLER et al., 2004) 2.9 MCM
- **Wadi al Arab well field** (W of Irbid; HOBLER et al., 2006) 11.2 MCM
- **Rahoub Spring** (NE of Irbid; MARGANE et al., 2007) 0.2 MCM
- **Corridor well field** (E of Mafraq; BORGSTEDT et al., 2008) 8.1 MCM
- **Hallabat well field** (NE of Zarqa; MARGANE et al., 2009) 8 MCM
- **Wadi Shuayb springs** (S and E of Salt; MARGANE et al., 2009) 8 MCM
- **Lajjun, Qatrana, Sultani, Ghweir well fields**
  (E of Karak; MARGANE et al., 2010) 20 MCM

66.4 MCM

Delineation of Protection Zones

Facts needed

Descriptions of
- project area (topography, climate, population, landuse)
- geology
- surface water
- groundwater
- water quality (bacteriological contamination ?)
- contamination risks (hazards to groundwater)
- delineation of protection zones
- definition of landuse restrictions
- recommendations for landuse changes and implementation of protection zones

Delineation Report > discussed with implementing agencies > report issued
Currently all reports prepared by MWI (through BGR / USAID projects)

Protection Zone Delineation

3D view from NNE

Example Ain Rahoub

Flow velocity

Zone II is delineated using the distance over which groundwater travels within a time period of 50 days (the maximum survival time of bacteria in groundwater)

The maximum actual flow velocity v_{max} is calculated:

$$v_{max} \approx 2^* v_n$$

With:

v_n = hydraulic conductivity (K) * hydraulic gradient (I) / effective porosity (n_0)

$$v_n = 6 \text{ m/d} * 0.03/0.01 = 18 \text{ m/d}$$

$$v_{max} \approx 36 \text{ m/d}$$

In a porous aquifer, the distance covered in 50 days would therefore be :

50d * 36 m/d = 1,800 m

However, the Umm Rijam is a karst aquifer, where flow along individual flow paths may be considerably higher > therefore the maximum distance possible under the current Jordanian Guideline for Drinking Water Protection zone delineation of 2,000 m is proposed as boundary of groundwater protection zone II for the Ain Rahoub spring

Protection Zone Delineation

Required parameters

- Hydraulic conductivity (pumping tests)
- Hydraulic gradient (GW contour map)
- Effective porosity (estimated)

Maximum actual flow velocity: estimation

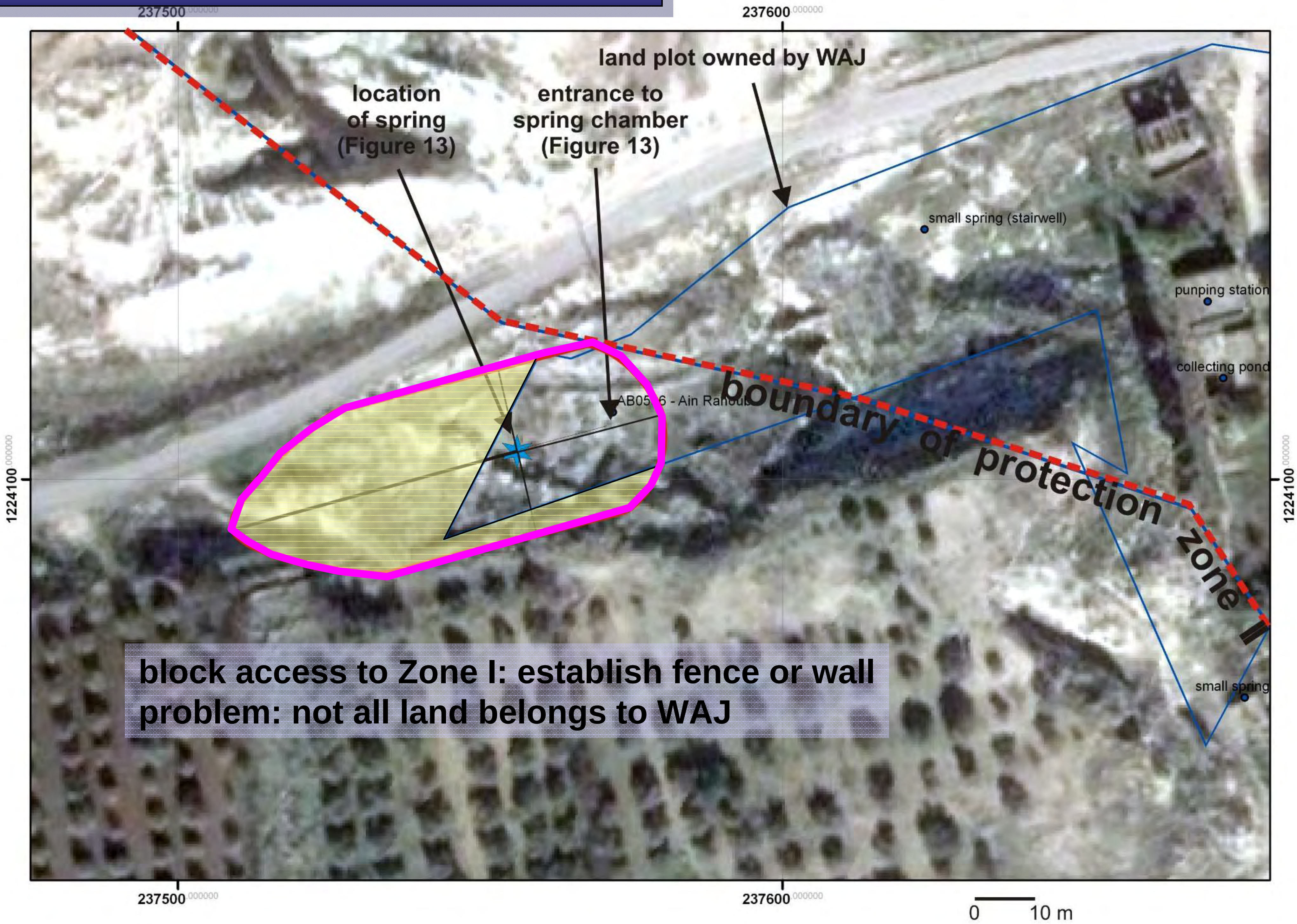
Assumed that aquifer behaves like a porous aquifer

► used data scarce and sometimes not reliable
► geological structure often not known in detail, i.e. GW catchment not reliably delineated

Ain Rahoub – Zone II

Ain Rahoub – Zone I

Protection Zone I – required actions



block access to Zone I: establish fence or wall
problem: not all land belongs to WAJ

Ain Rahoub – constructional changes

Ain Rahoub – constructional changes

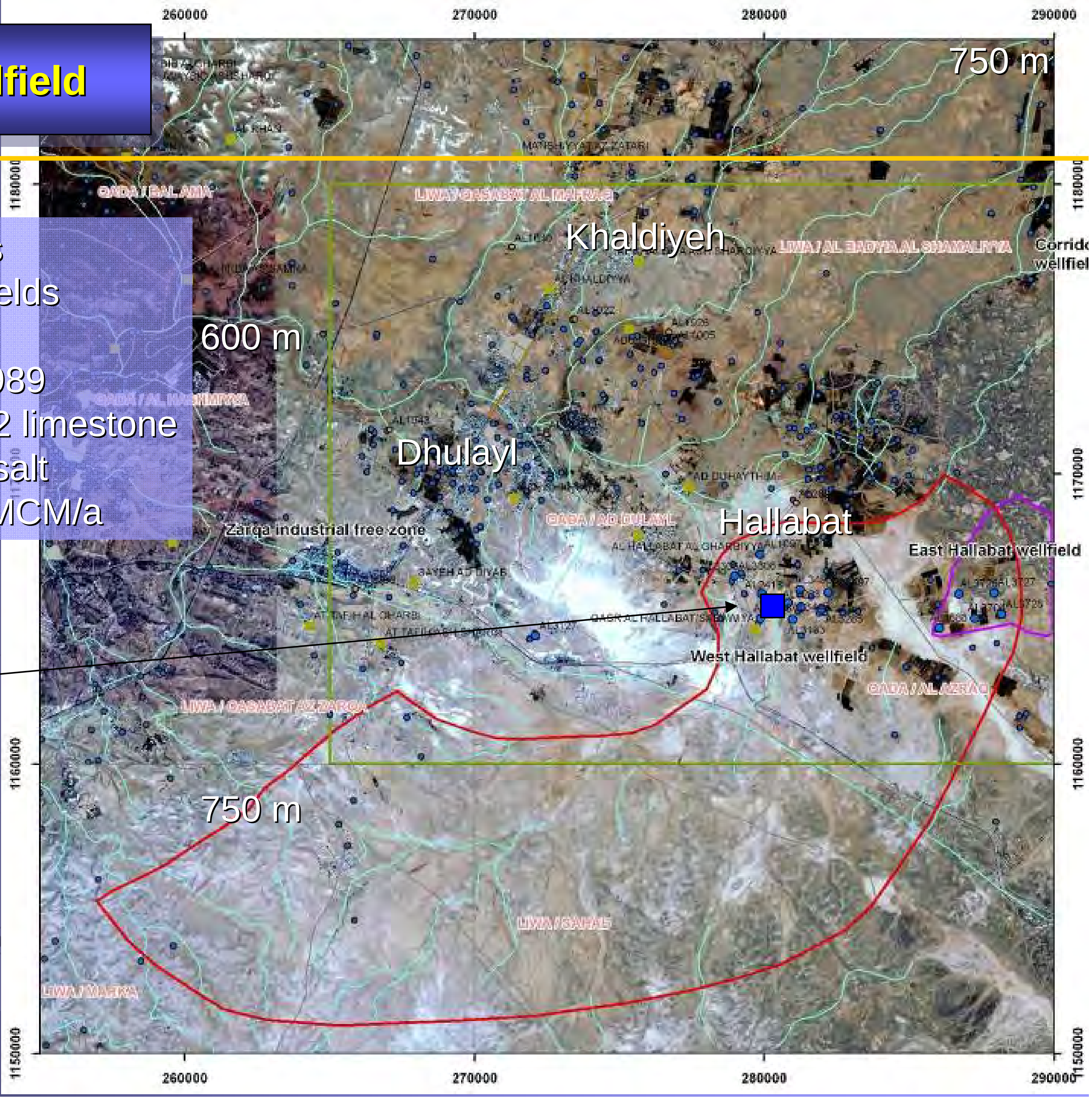
new tank

Ain Rahoub – constructional changes

Hallabat Wellfield

19 production wells
in 2 separate wellfields
1 pumping station
developed since 1989
main aquifer: A7/B2 limestone
second aquifer: basalt
Water supplied: 4 MCM/a

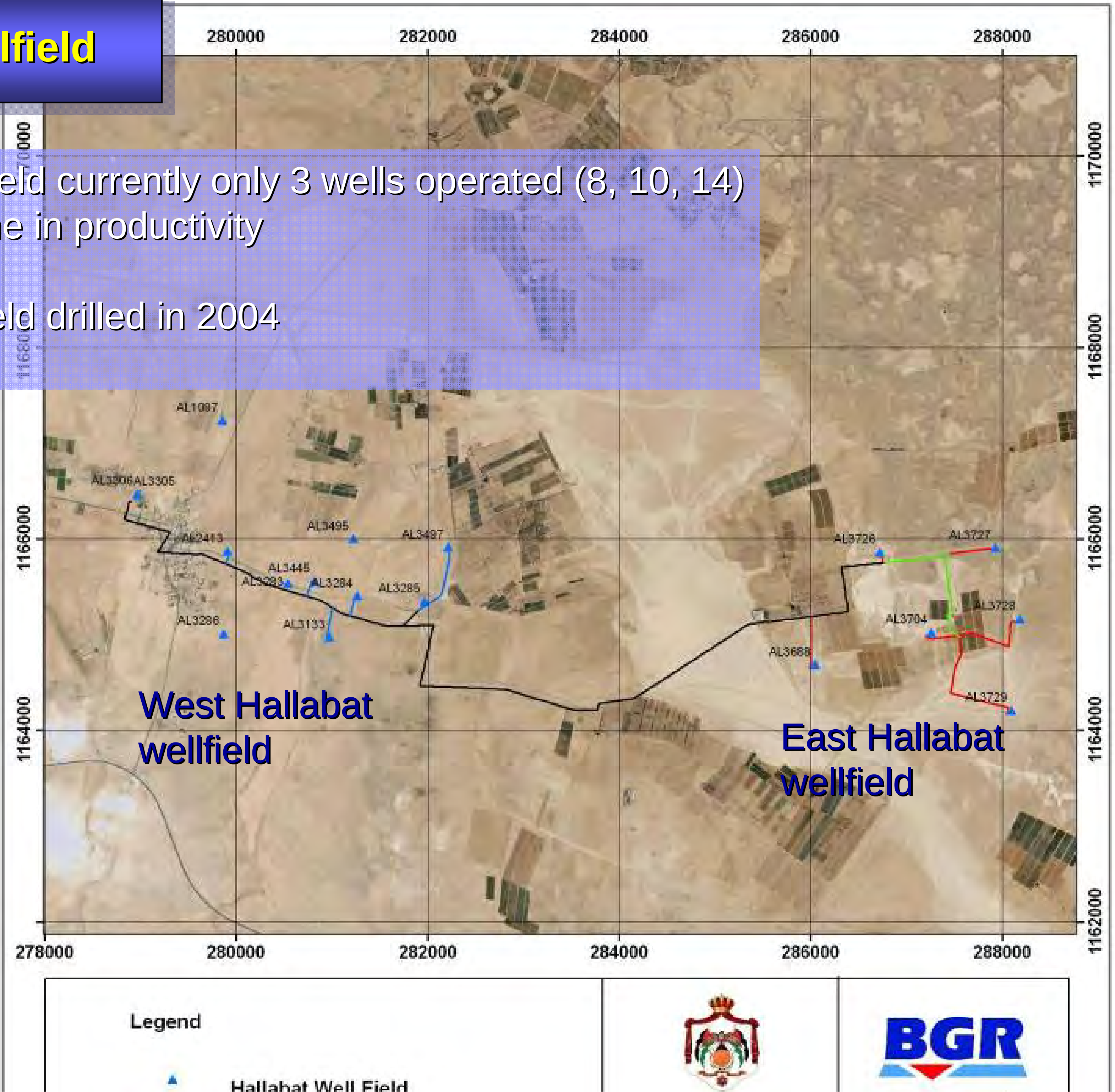
pumping station



Hallabat Wellfield

West Hallabat wellfield currently only 3 wells operated (8, 10, 14)
Due to strong decline in productivity

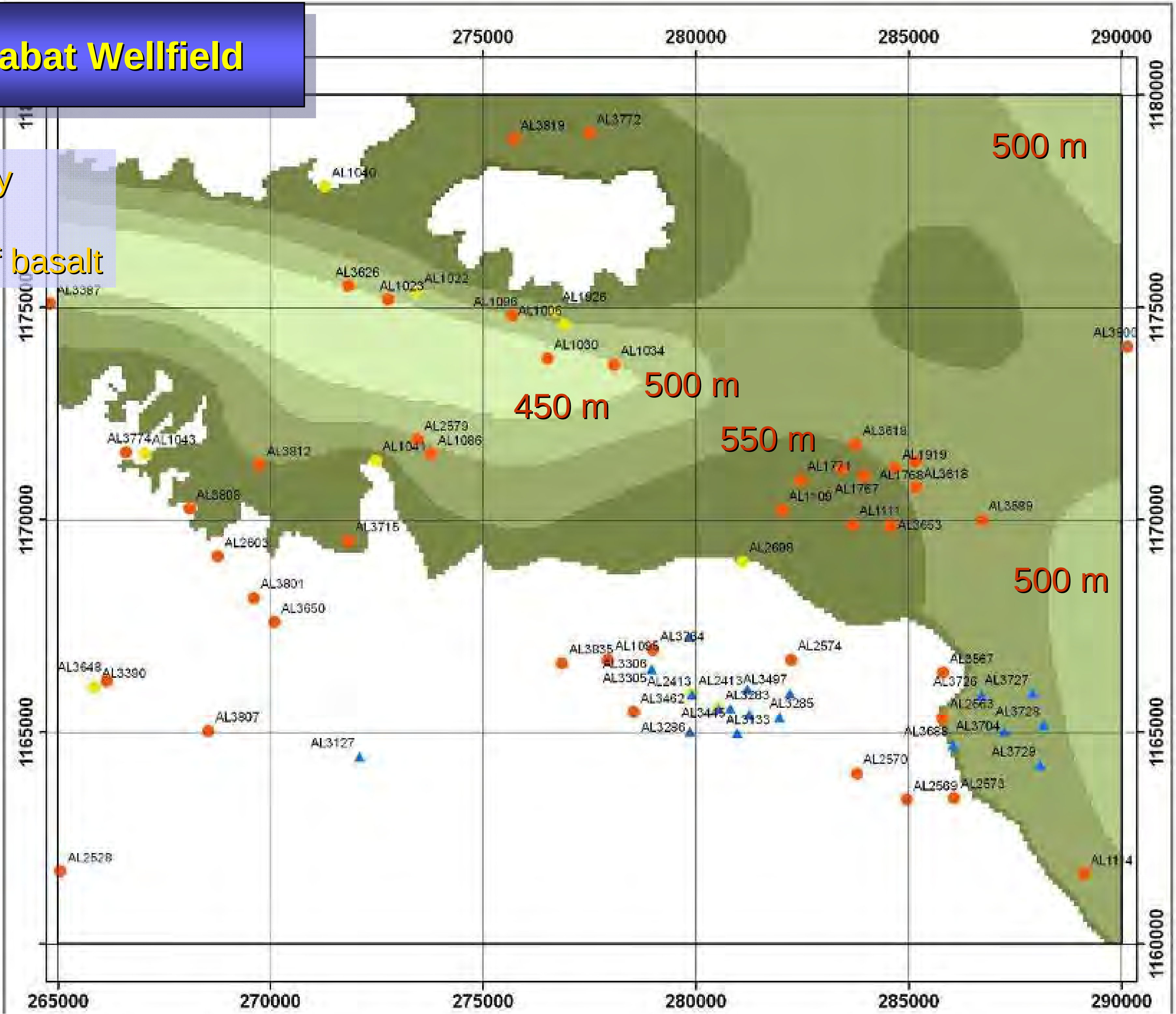
East Hallabat wellfield drilled in 2004



Hallabat Wellfield

Geology

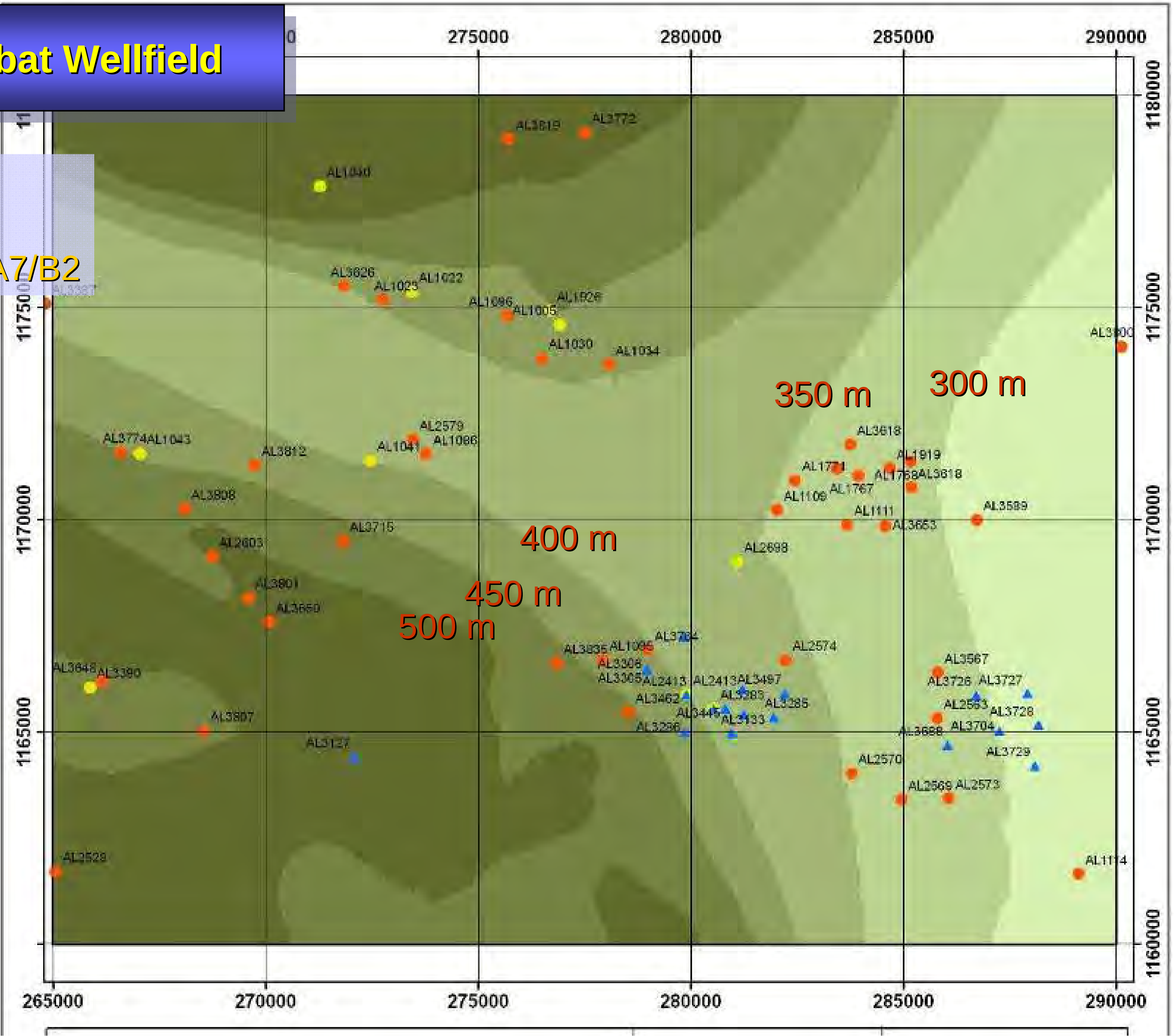
Base of basalt



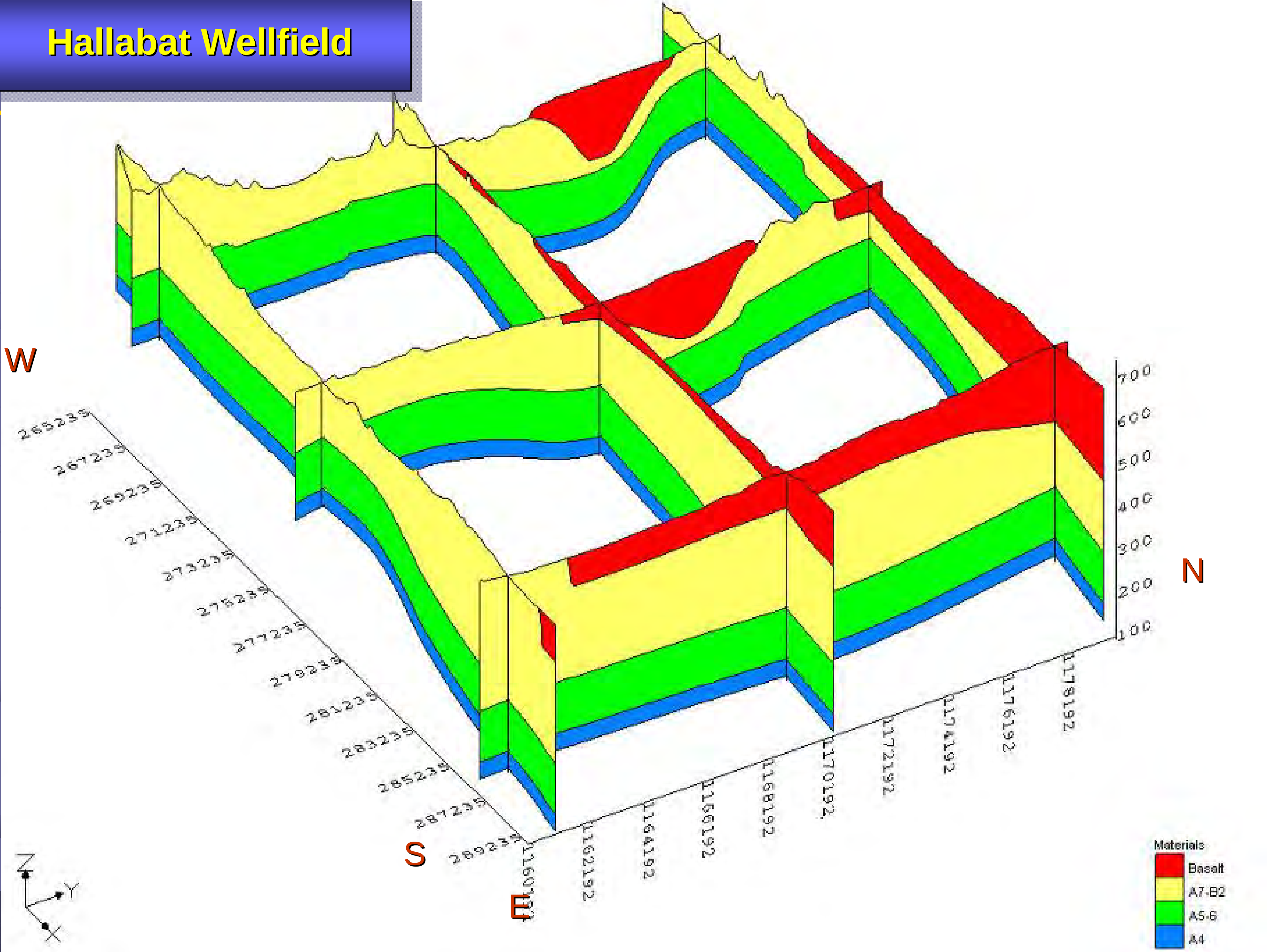
Hallabat Wellfield

Geology

Base of A7/B2

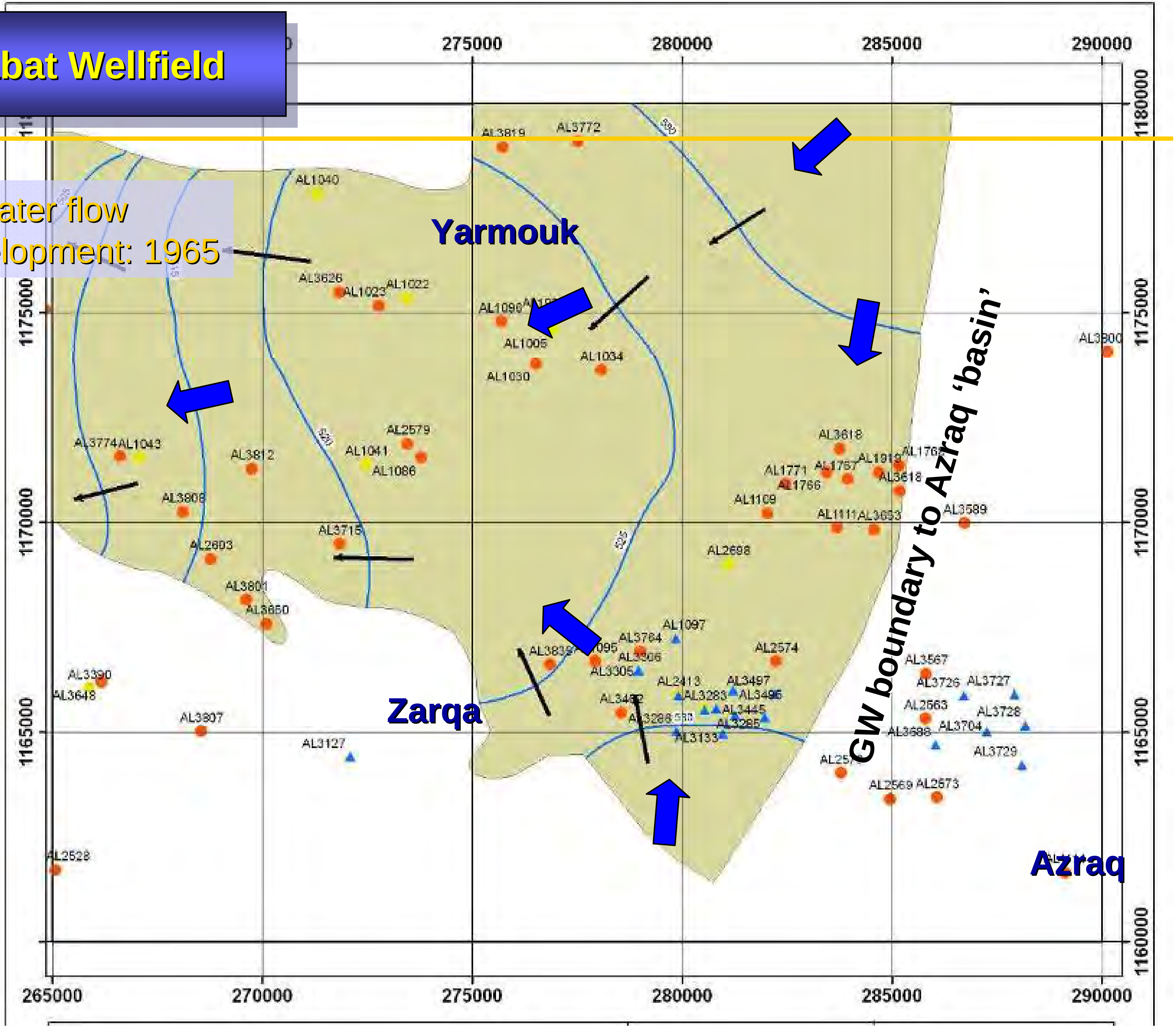


Hallabat Wellfield



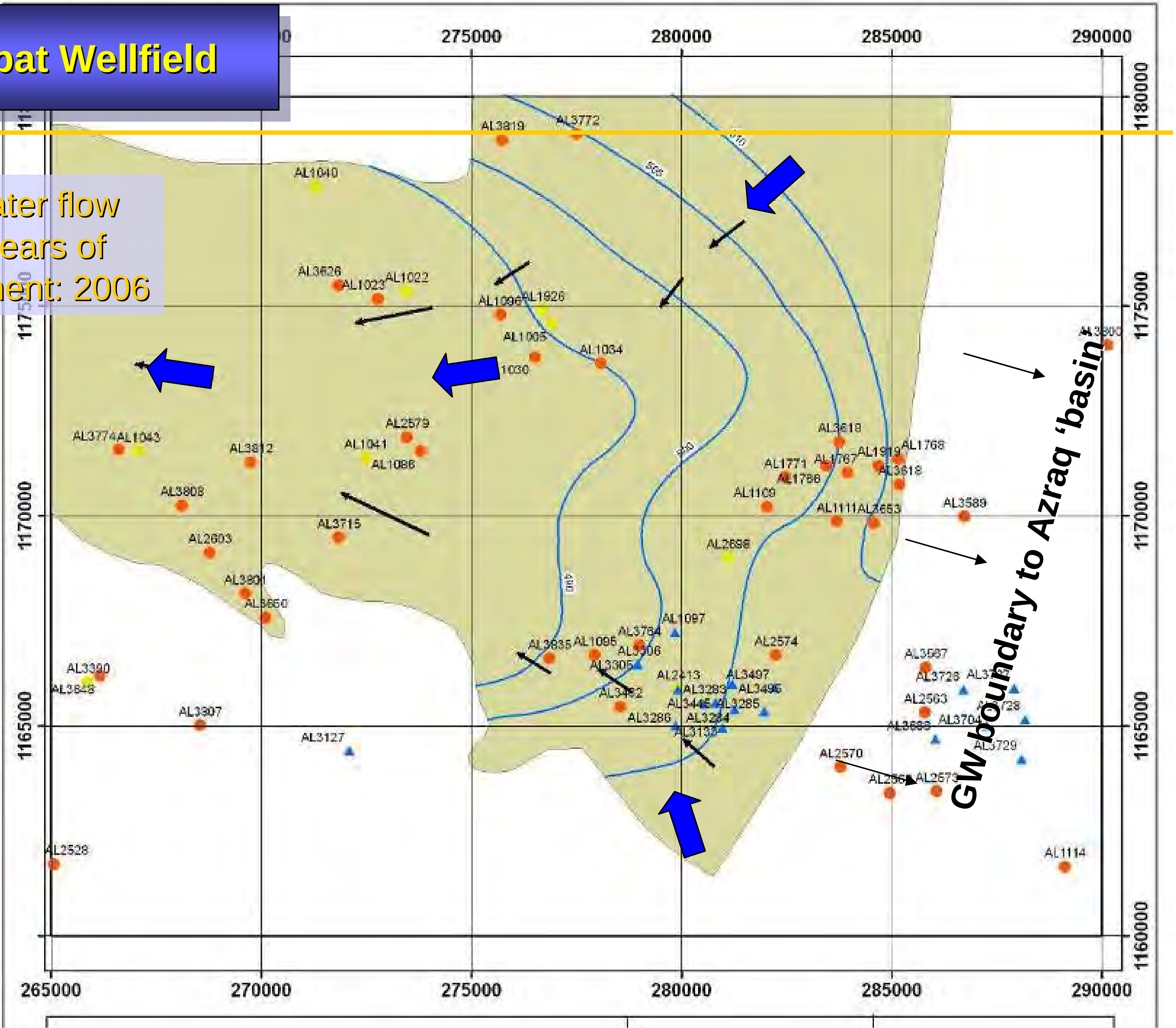
Hallabat Wellfield

groundwater flow
pre-development: 1965



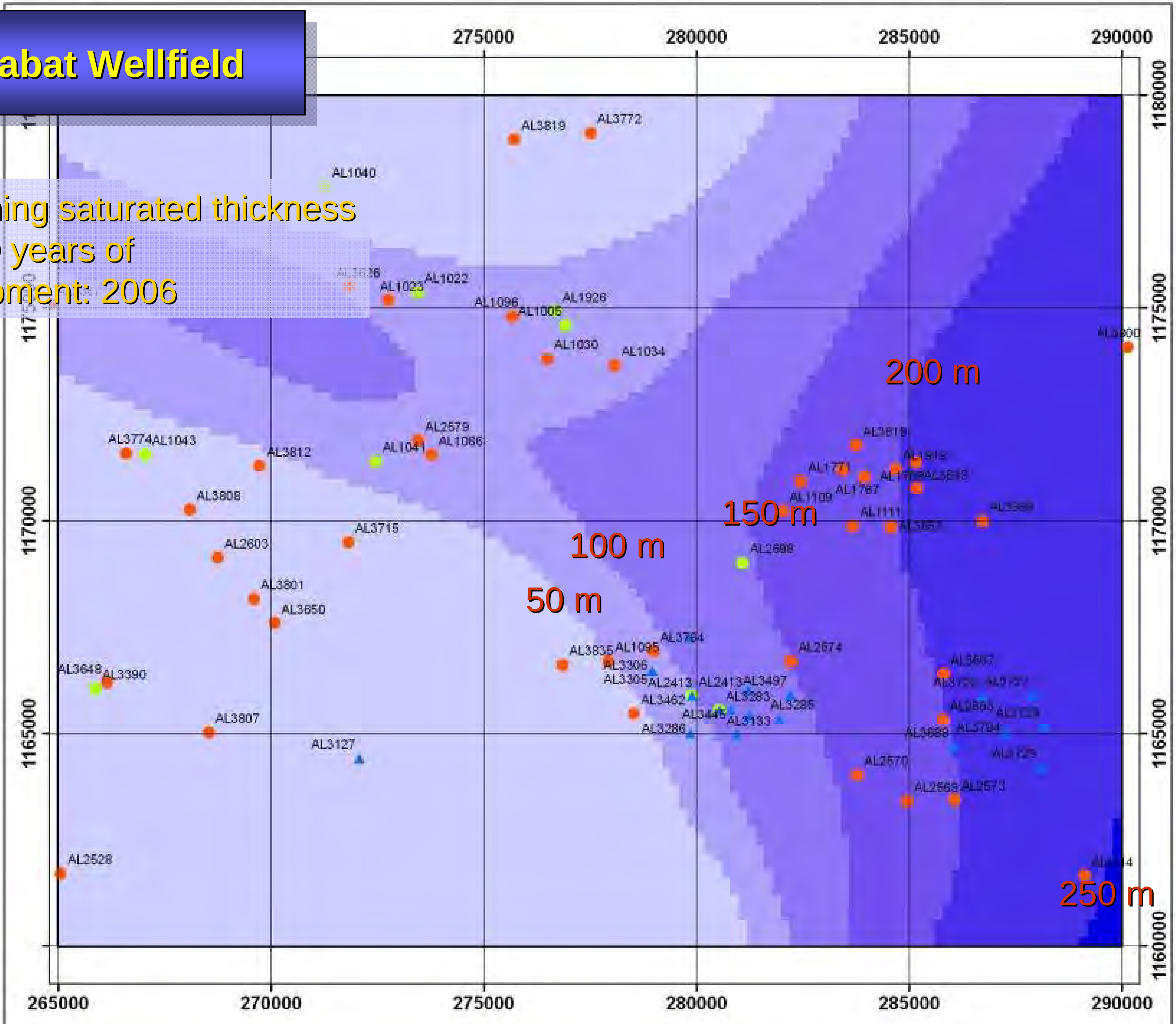
Hallabat Wellfield

groundwater flow after 40 years of development: 2006



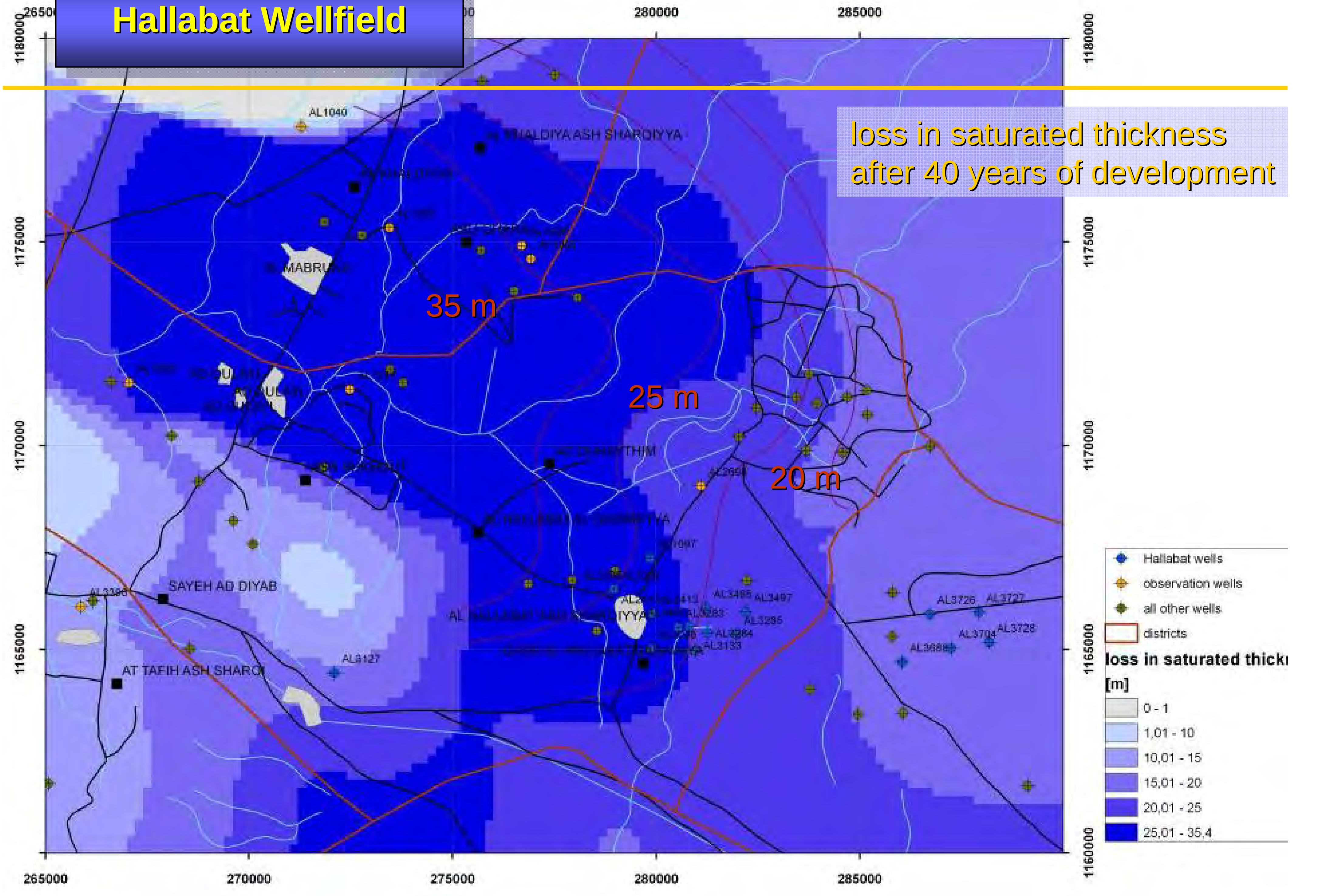
Hallabat Wellfield

Remaining saturated thickness after 40 years of development: 2006



Hallabat Wellfield

loss in saturated thickness
after 40 years of development



Hallabat Wellfield

storage loss over
40 years of
development

Start of development: 1965
41 years of abstraction
Storage loss: 655 MCM > 16 MCM/yr
loss in A7/B2: 415 MCM (effective porosity 5 %)
loss in basalt: 240 MCM (effective porosity 10 %)

Total estimated abstraction (1965-2006): 680 MCM

Storage loss in West Hallabat wellfield: 22-29 m
(close to limit of saturation)

Hallabat Wellfield

Moderate hydraulic permeability in basalt (0.2 - 31 m/d)
Transmissivity mostly around 100 m²/d

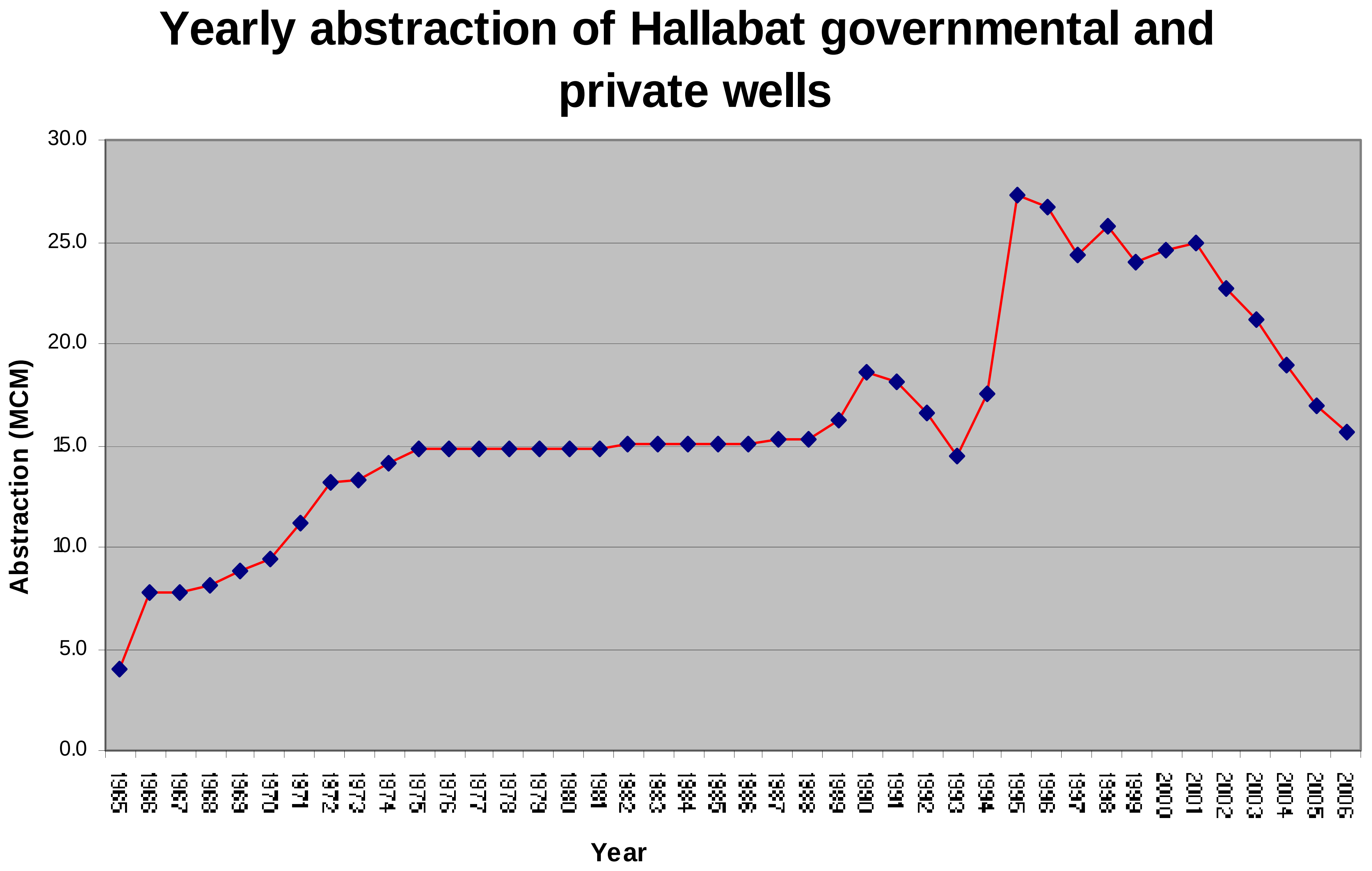
Moderate hydraulic permeability in A7/B2 (15 - 50 m/d)
Transmissivity mostly around 2,500 m²/d

Groundwater abstraction from Hallabat wellfield: ~ 4 MCM/a (1994-2007)
Total abstraction much higher:

	Yearly abstraction in 2007 (MCM)	Percentage of use in 2007 (%)	Overall abstraction from 1965 to 2006 (MCM)	Percentage of use from 1965 to 2006 (%)
Private	14.8	59.4	367	54
Governmental	10.1	40.6	313	46
Total	24.9	100	680	100

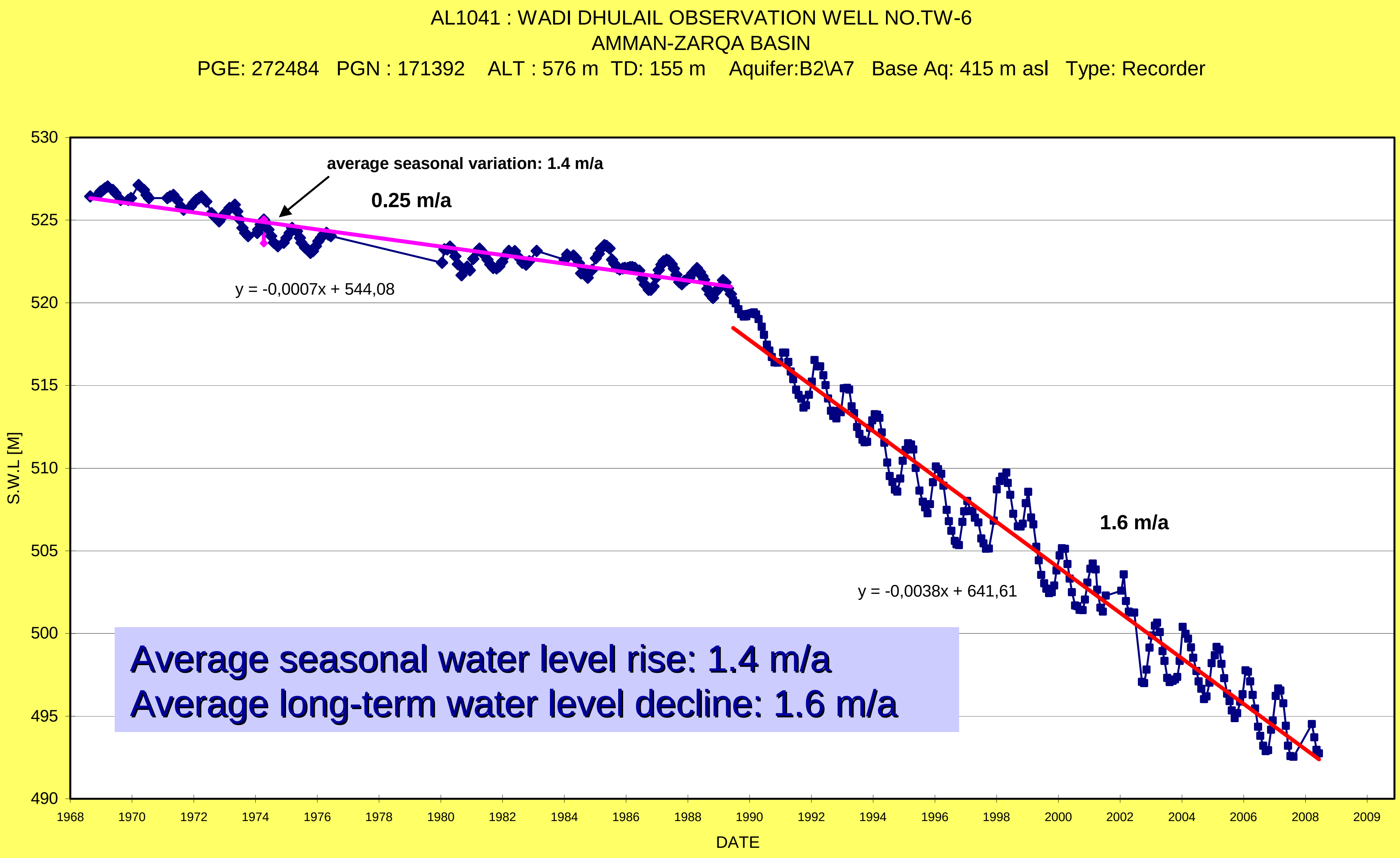
Hallabat Wellfield

groundwater abstraction



Hallabat Wellfield

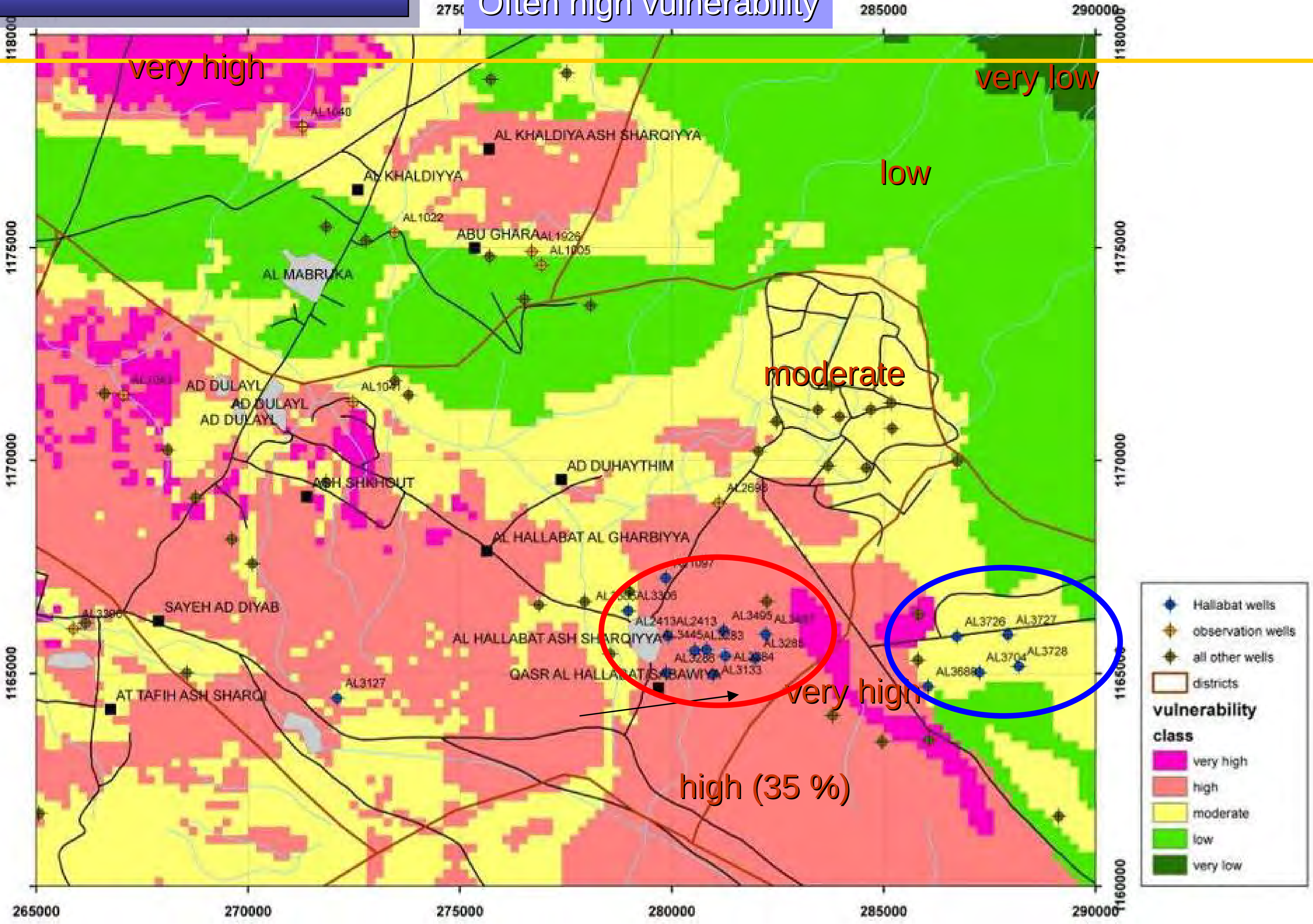
groundwater monitoring



Average seasonal water level rise: 1.4 m/a
Average long-term water level decline: 1.6 m/a

Hallabat Wellfield

Often high vulnerability



Hallabat Wellfield

Many hazards to groundwater:

- Cow farms
- Manure dump sites
- Olive/grape farms
- Fuel stations
- Chicken farms
- Factories
- Solid waste disposals
- Quarries
- Animal husbandries and agricultural farms (use of untreated organic fertilizer and pesticides)
- Open wells

Hallabat Wellfield

groundwater hazards

Cow farms near Dhulayl

Delineation of Protection Zones

Zone 2

Approximation of the maximum actual flow velocity v_{max}

$v_{max} \approx 2^* v_n$

Where v_n - mean pore water velocity

$v_n = K^*I/n_0$

K – hydraulic conductivity (20 m/d)
I – groundwater gradient (0.004)
n_0 – effective porosity (specific yield) (0.05)

distance covered in 50 days:

v_n = 20 m/d * 0.004/0.05 = 1.6 m/d
v_{max} ≈ 3.2 m/d

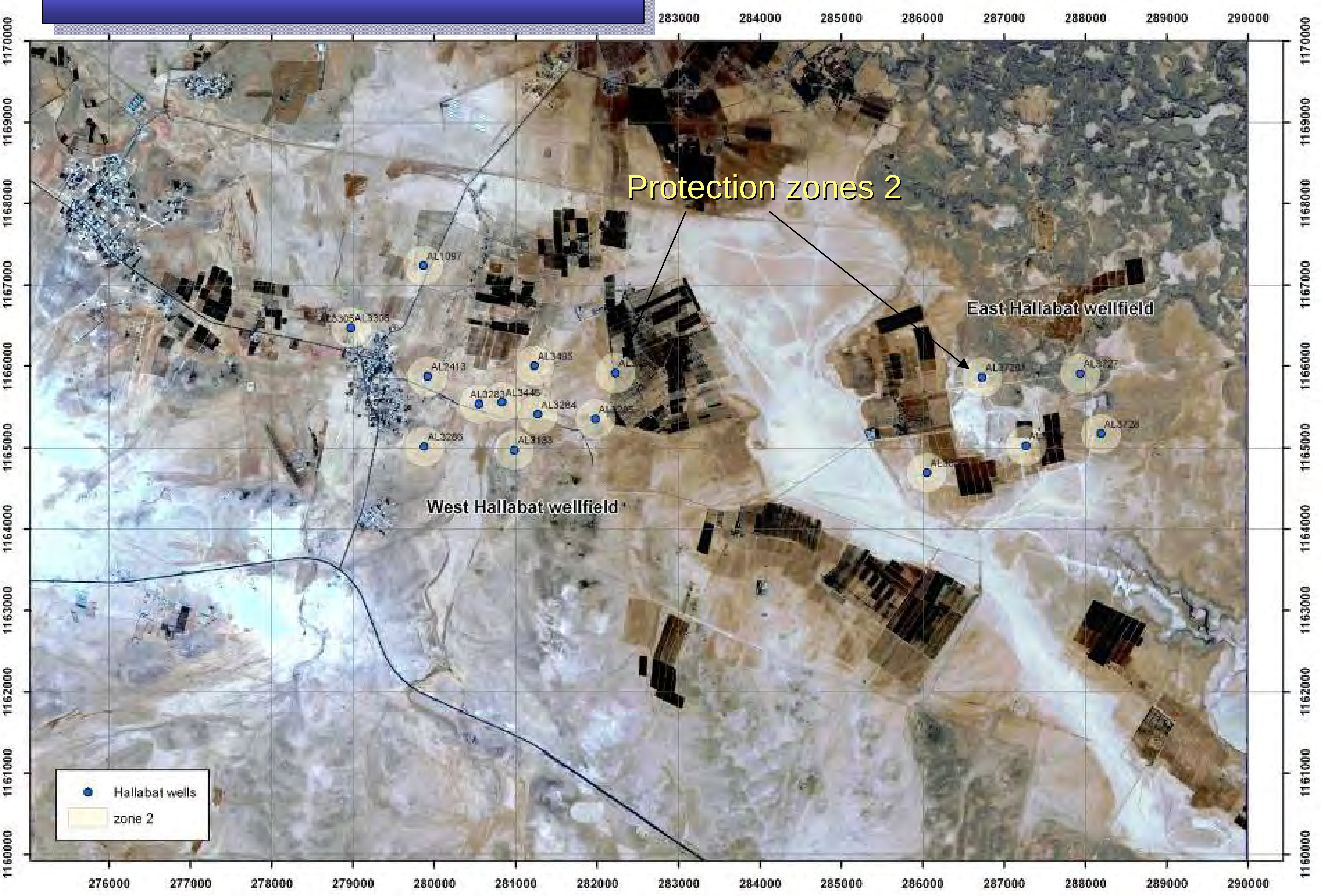
50d * 3.2 m/d = 160 m

Safety margin 50% (high uncertainty of data): 240 m

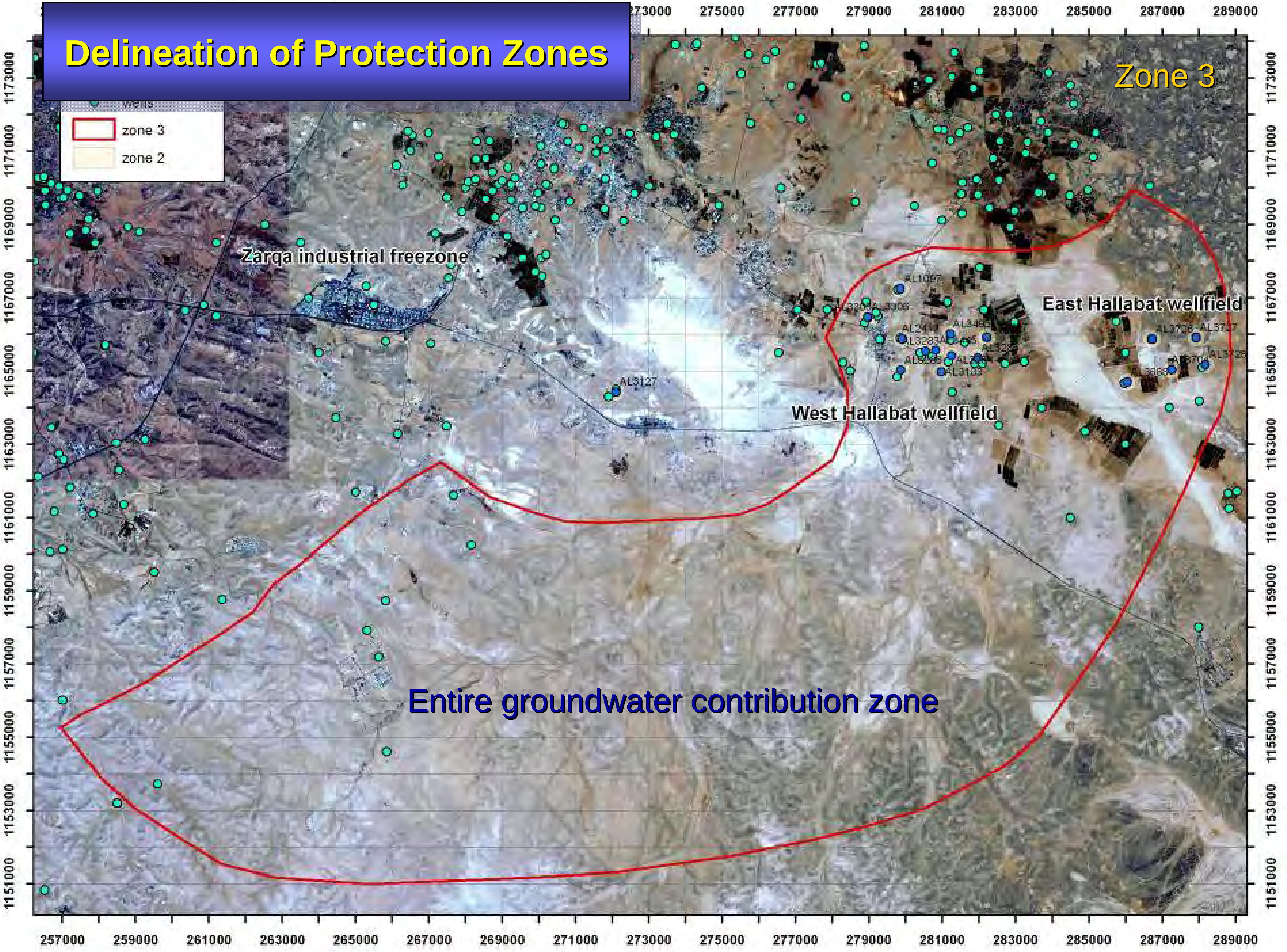
Zone 2 : circle with radius of 240 m

Delineation of Protection Zones

Zones 2



Delineation of Protection Zones



Required Actions

Zone 1

- Fence must be at a distance of 25 m in all directions from the well, i.e. additional land will have to be purchased by WAJ
- Some operator’s rooms are equipped with a cesspit > they have to be removed
- All wellheads have to be modified so that a) water cannot infiltrate during flooding and so that b) the well head is always closed
- It has to be explained to the local population that unauthorized access will not be tolerated any longer
- Signpost for protection zone 1 should be installed at least on two sides of the fence and should be visible from the distance
- To avoid vandalism of the pipe system, official watering places for animals should be installed

Required Actions

Zone 1

Required Actions

Zone 1

Generators should not be used in zones 1

Oil spills

Required Actions

Zone 1

insufficient protection of well head

Required Actions

Zone 1

Watering places for animals must be provided

Required Actions

Zone 2

Illegal dumping of wastewater must be banned

Signposts

Zone 1

Zone 2

Required Actions

Zone 2

With respect to agriculture, organic farming has to be applied. This needs to take into consideration that organic fertilizers, which are to be applied, such as animal manure, have to be free of bacteriological potentially harmful substances. To this end, such fertilizers need to be treated (dried or pasteurized) before application.

Pesticides are not allowed to be used in protection zones 2.

Special control/supervision of these zones has to be applied to ensure compliance with environmentally sound practices. Agricultural practices need to be controlled by the responsible authorities.

Required Actions

Zone 3

Manure and cadavers are dumped illegally at many places throughout the area, even directly in the villages (Figures 82, 83 and 84). For this reason it is advised to allow animal farming in protection zone 3 only if environmental-friendly operation is ensured. This would have to be strictly controlled.

A solution urgently needs to be found for the collection, treatment and disposal/reuse of the manure, which is currently illegally disposed of at scattered places throughout the area.

Option 1: extension of Corridor wellfield, especially in the northern part

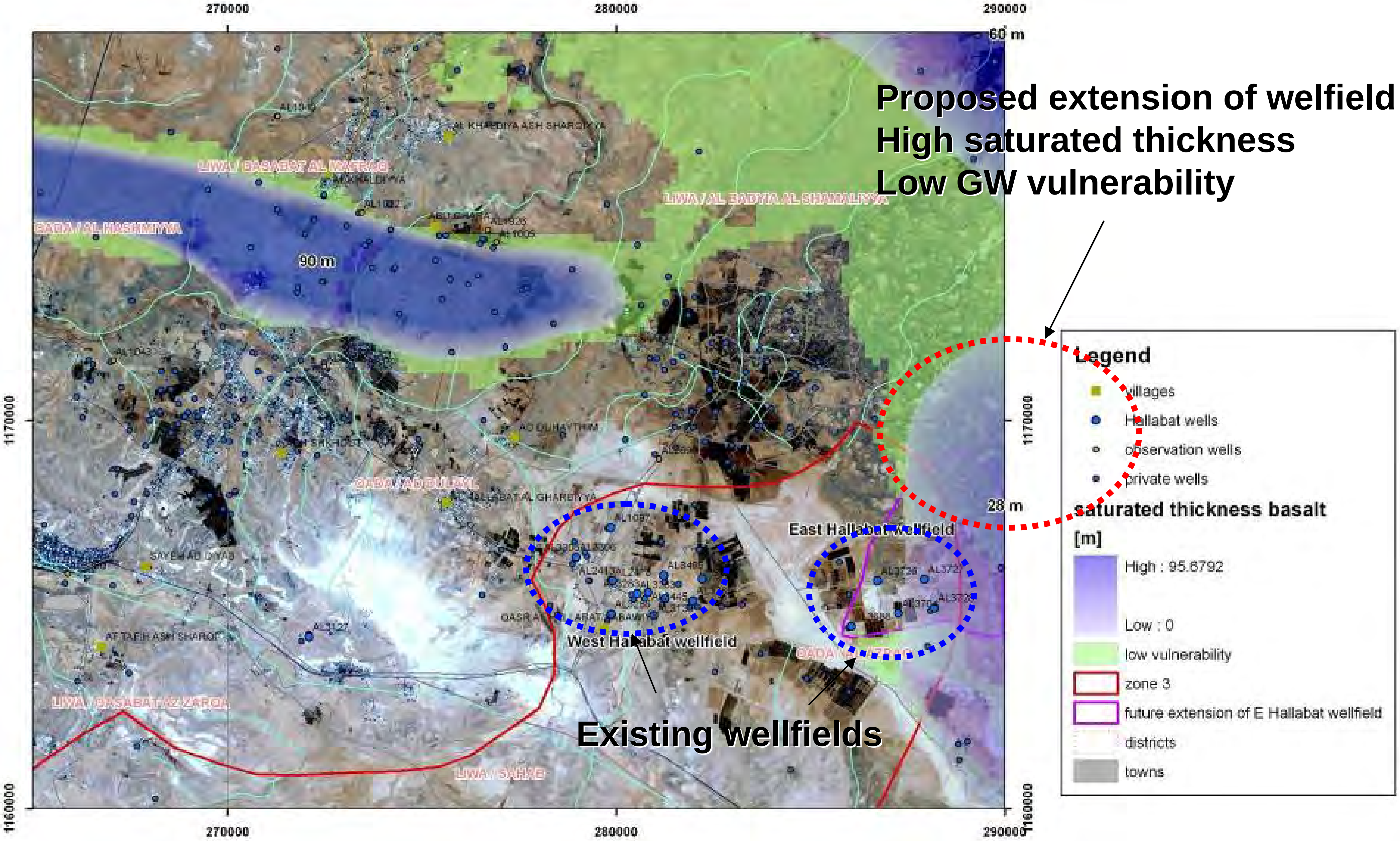
The exploitation of the Hallabat wellfield in the long-term is less promising than that of the Corridor wellfield.
Reasons:
- the saturated thickness, especially that of the basalt, is low
- the existing landuse provides a much better protection for the Corridor wellfield and it is therefore easier to maintain water quality standards

West Hallabat wellfield almost exhausted (near limit of saturation)

Option 2: extension of East Hallabat wellfield to the NE

Resources Management

Options



Groundwater Protection

problems

- ➢ Data inadequate for delineation (flow velocity; safety margin higher than necessary)
- ➢ Most water supply facilities in poor conditions (rehabilitation urgently needed for adequate protection)
- ➢ Protection of supply system (often vandalized; no access to water for bedouins)
- ➢ Control of proposed measures necessary (Environmental Rangers > need training)
- ➢ Awareness Campaigns for decision makers and local population necessary
- ➢ Water resources protection must be truly integrated into landuse planning process (design of wastewater projects, waste disposal sites, industrial sites)

Surface Water Protection Zones

protected drinking water sources

Completed:

- Wadi Mujib Dam (N of Karak; MARGANE et al., 2008) 16.6 MCM
- Wadi Wala Dam (S of Madaba; MARGANE et al., 2009) 9.3 MCM

25.9 MCM

GWRM Project	
Groundwater Protection Zones	66.4 MCM
Surface Water Protection Zones	25.9 MCM
Total	92.3 MCM
Drinking Water Supply (2007)	284.0 MCM
Percentage under Protection through GWRM Project	33 %

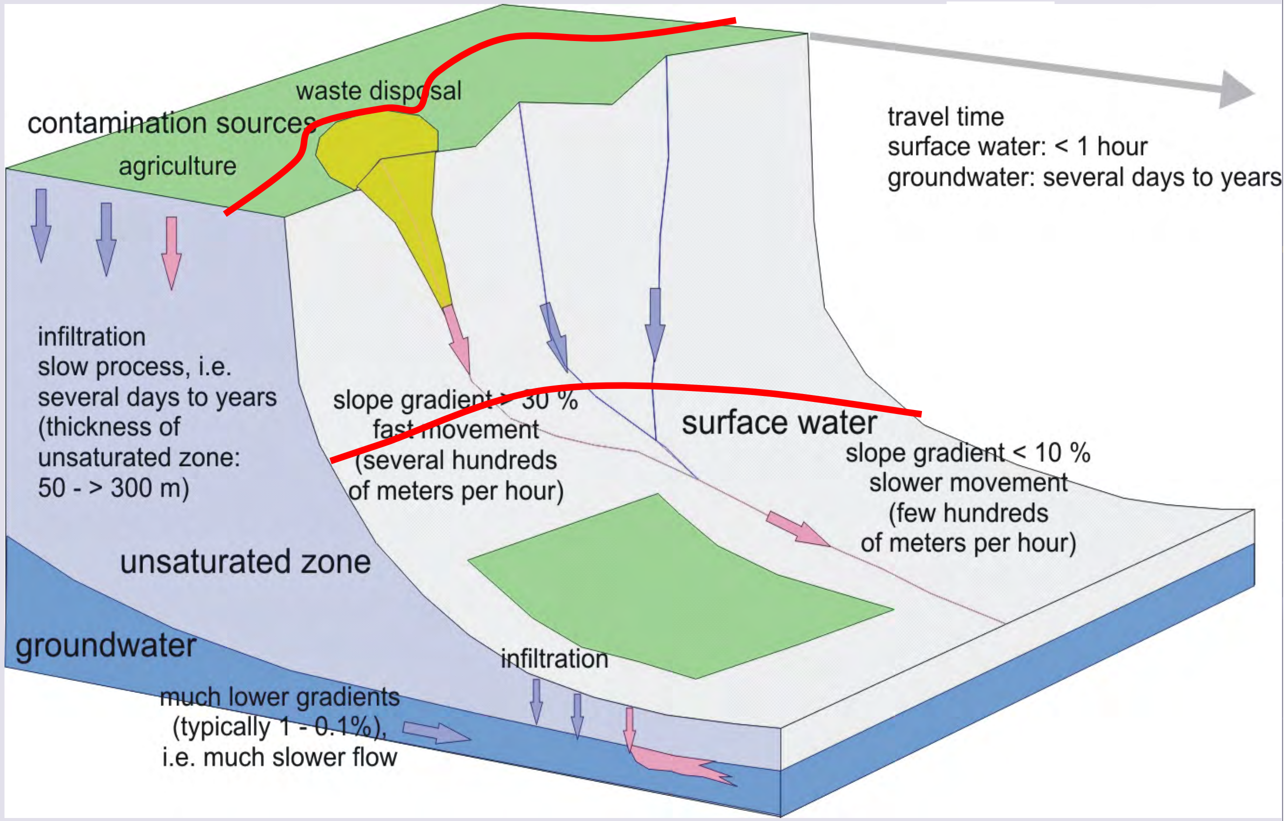
Surface Water – Dams

Future Zoning System

Under the typical conditions in Jordan the time-of-travel in surface water is very short
➢ large protection areas

A compromise must be reached so that landuse restrictions are still acceptable

Time of Travel (TOT) in Surface Water and Groundwater



Groundwater has much longer travel times than surface water. Therefore surface water is much more vulnerable to contamination and the protection of surface waters is much more difficult than that of groundwater

Most critical factors in Jordan:

in the Surface Water Path:
- high slope gradients
- low vegetation cover

in the Groundwater Path:
- level of karstification, fracturing

result in relatively fast movement in surface water and groundwater

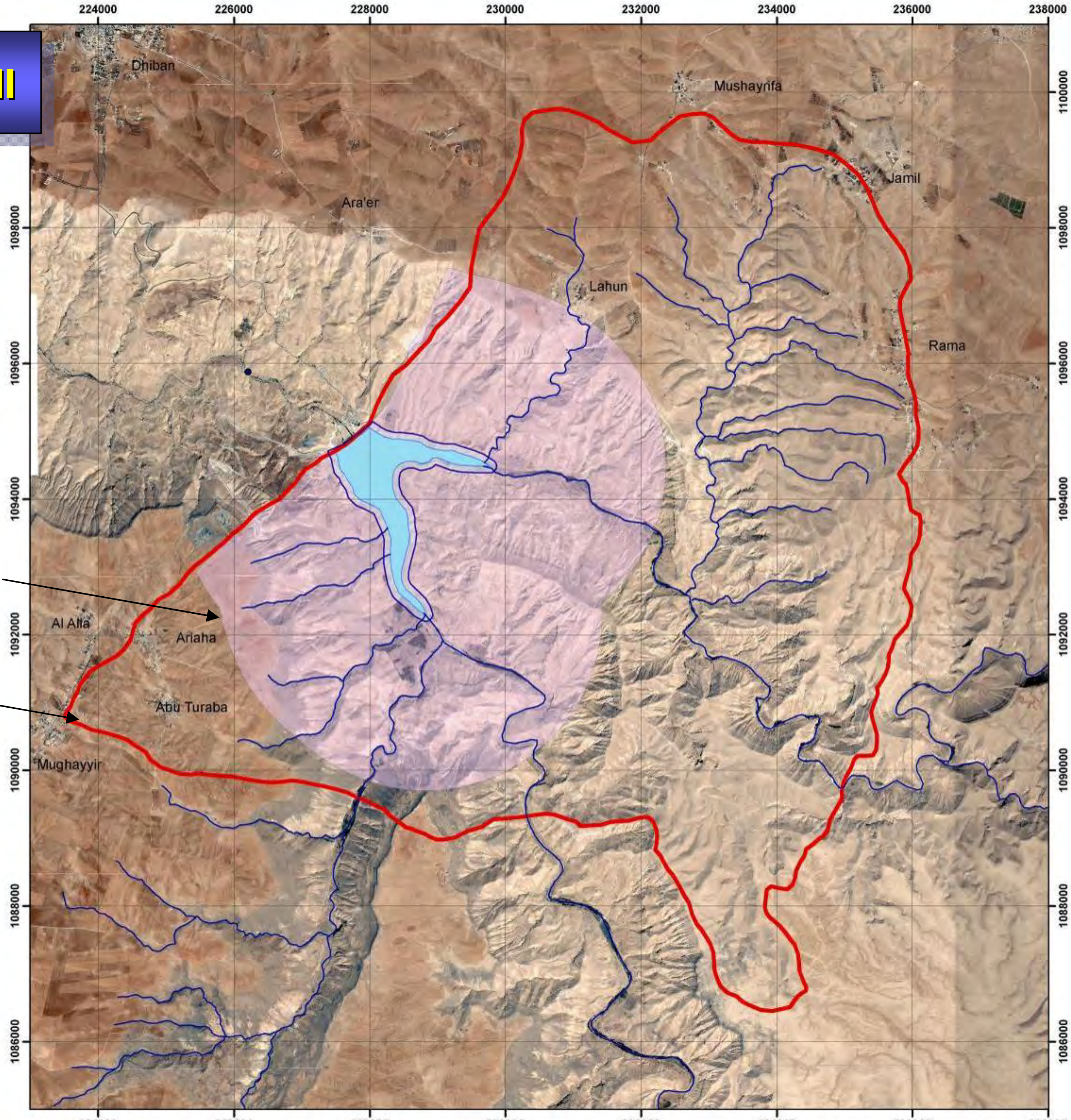
Future Zoning System

Zone I: buffer zone of 100 m around a reservoir, measured from the highest possible water level.
Zone II: buffer zone of 500 m around the dam, measured from the highest possible water level, if slope within this zone is below 2°. If the slope exceeds 2° at a distance of 500 m, zone II will reach to where the slope becomes less than 2°. In the upstream area, zone II will reach until a distance of a maximum of 5 km following the course of the main wadis discharging into zone I. Zone II will also encompass a buffer zone of 100 m to each side from the center of the main wadis discharging into zone I until a distance of 15 km, measured from the highest possible water level, following the course of the main wadis.

Protection Zone II

33 km²
existing guideline

amended guideline
91 km²



Thank you for your kind attention

Technical Cooperation Project

Groundwater Resources Management

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Amman

التعاون الألماني
DEUTSCHE ZUSAMMENARBEIT

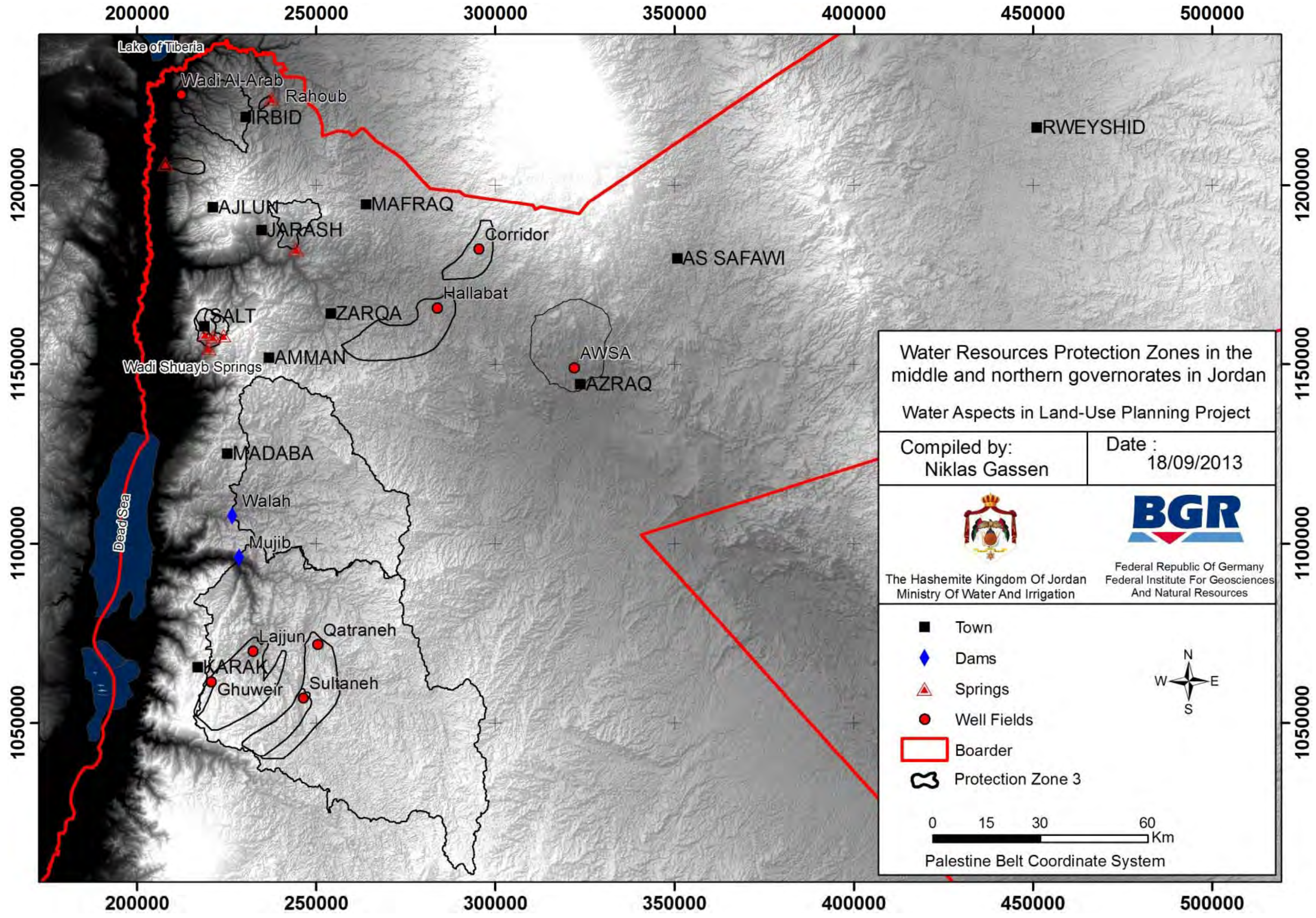
Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany

Jordanian-German Technical Cooperation Project

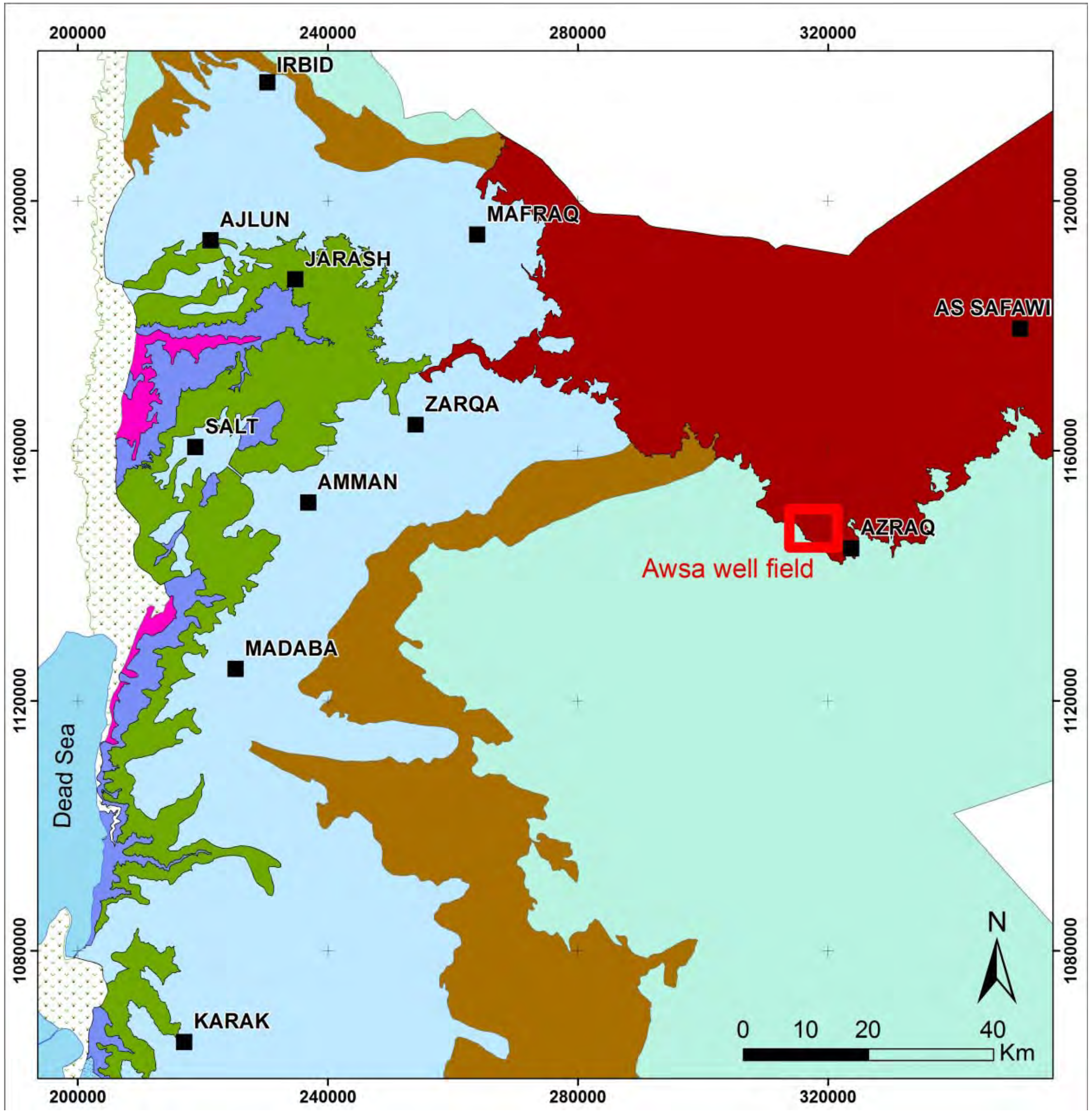
Delineation of Groundwater Protection Zones in AWSA and Hidan well field

Niklas Gassen, BGR

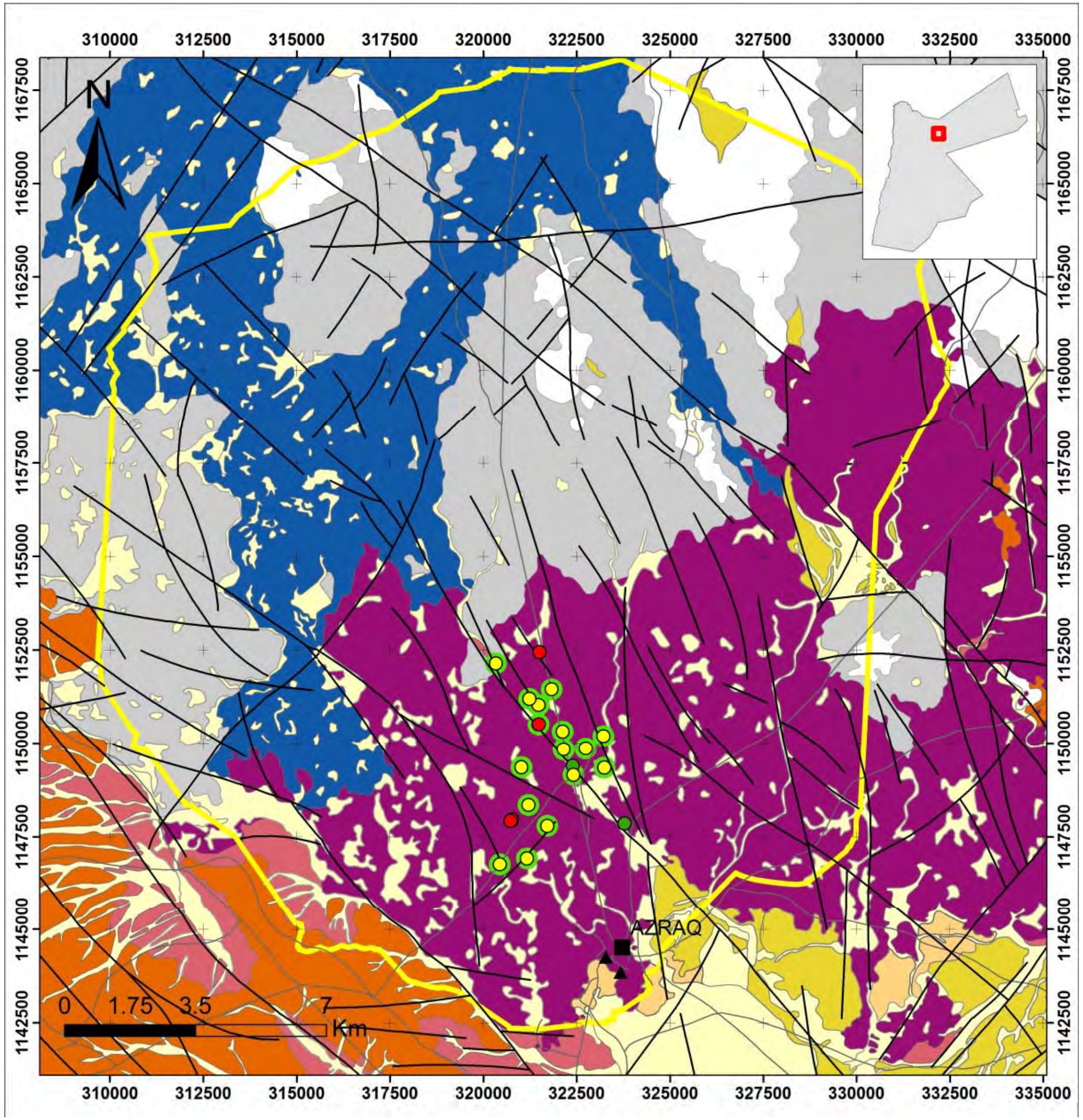
Water Protection Zones in Northern Jordan

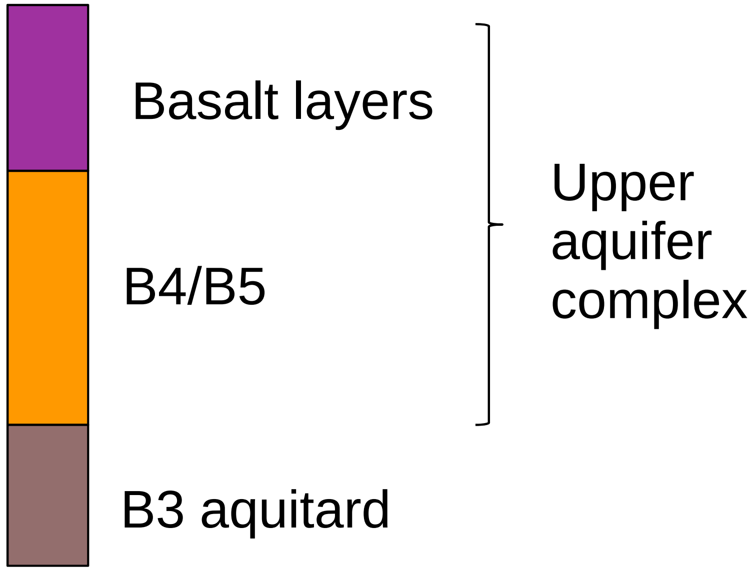


Awsa well field

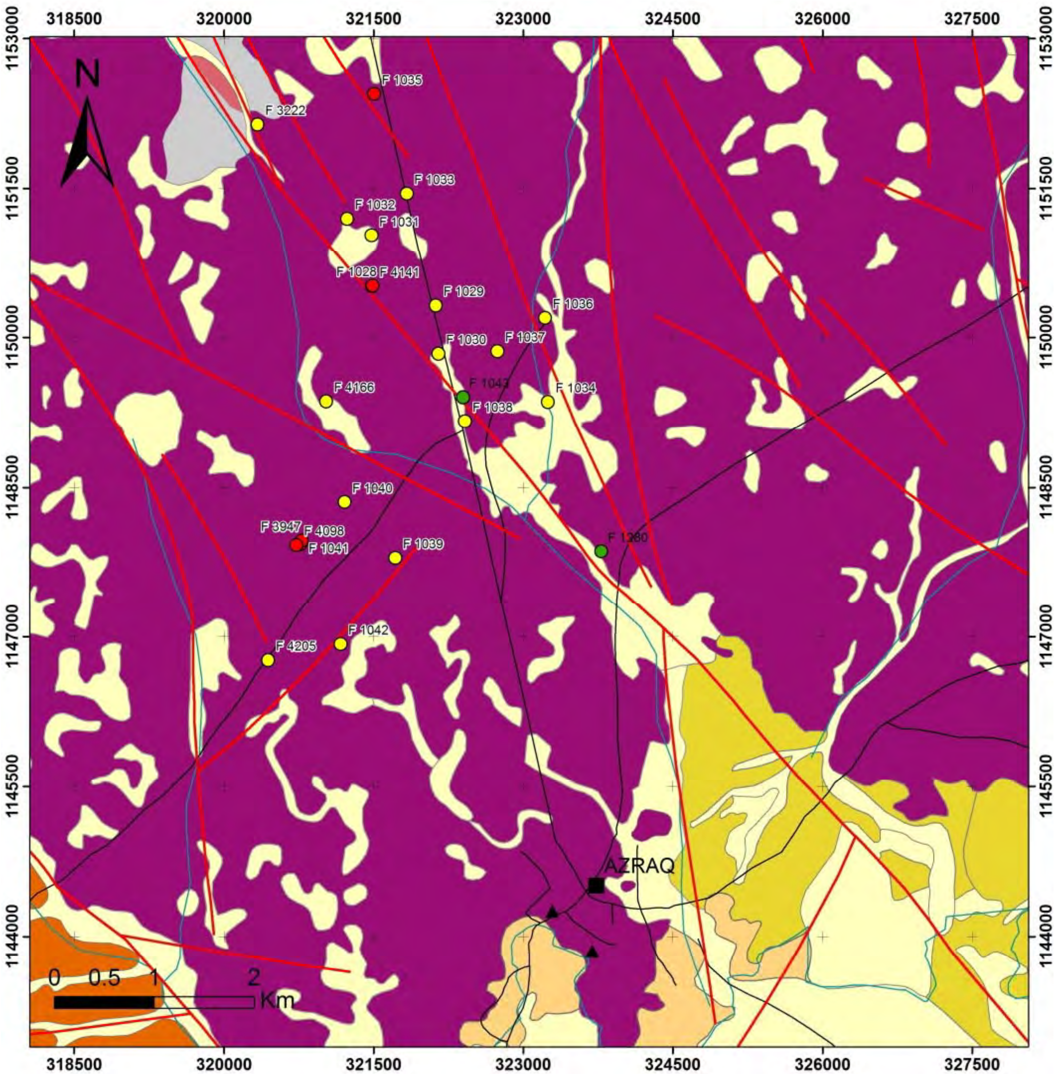


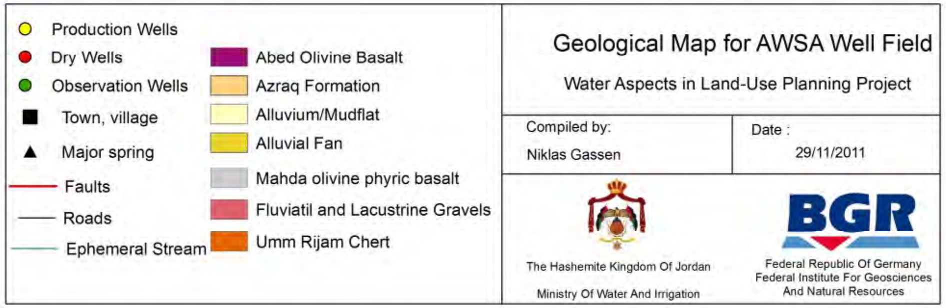
Awsa Well Field





Awsa well field



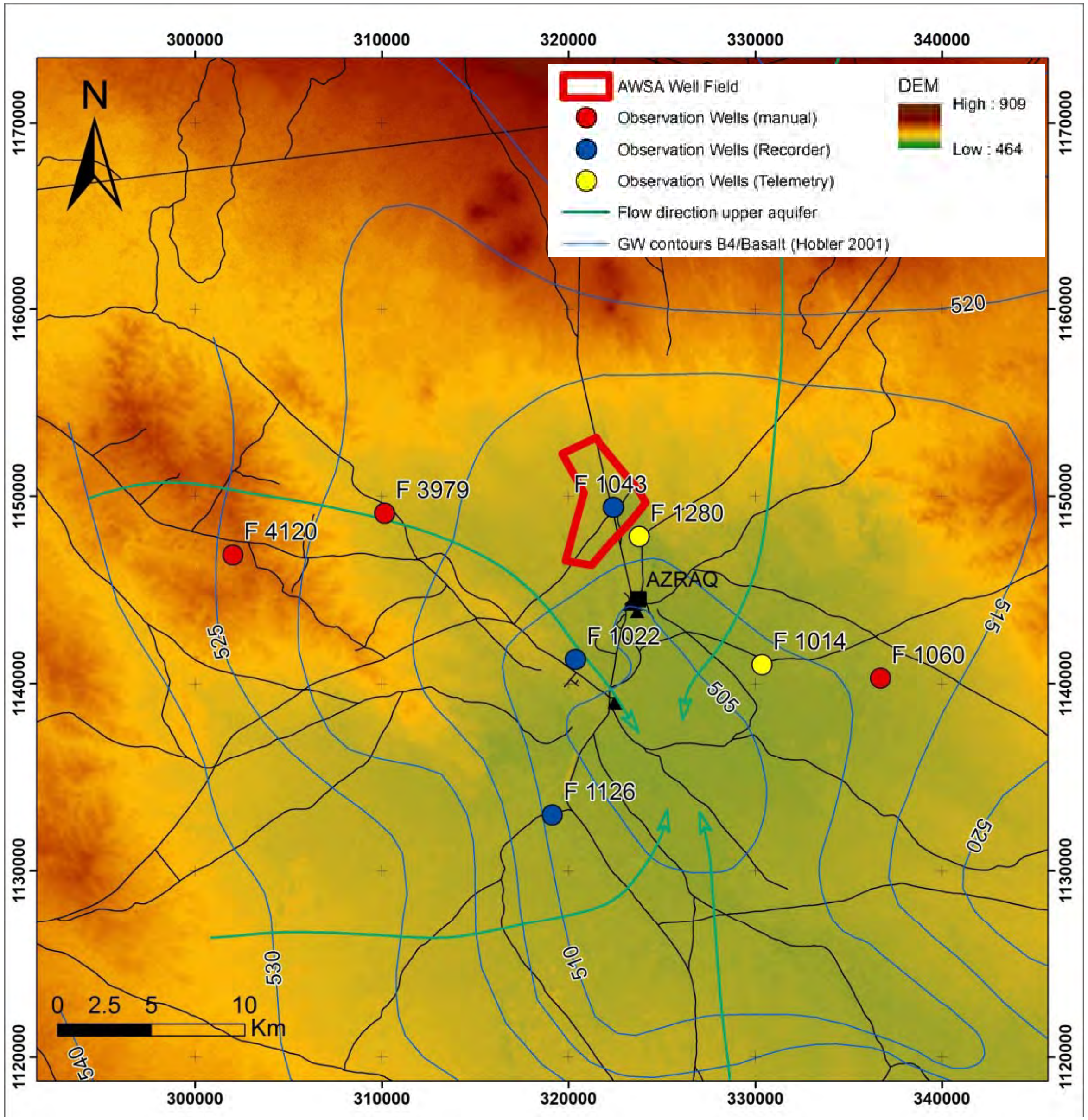


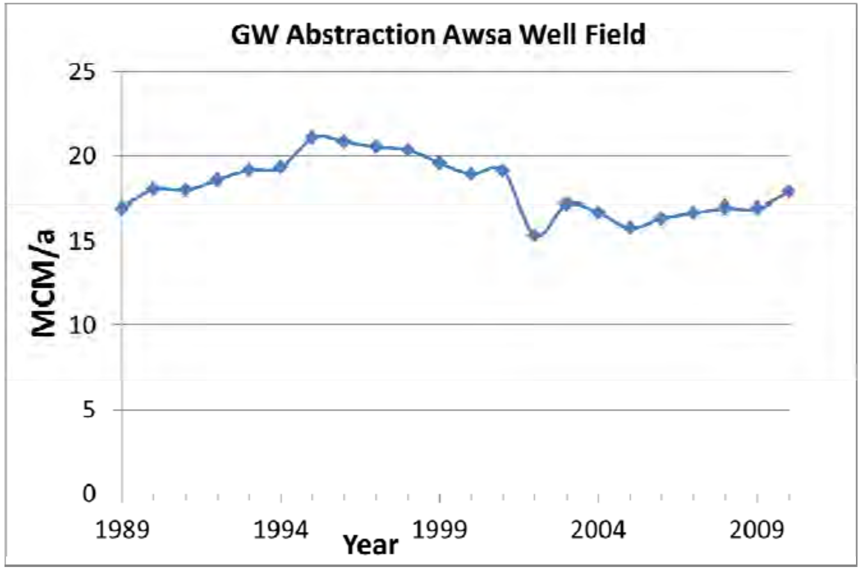
15 Production Wells
5 Abandoned Wells
2 Observation Wells

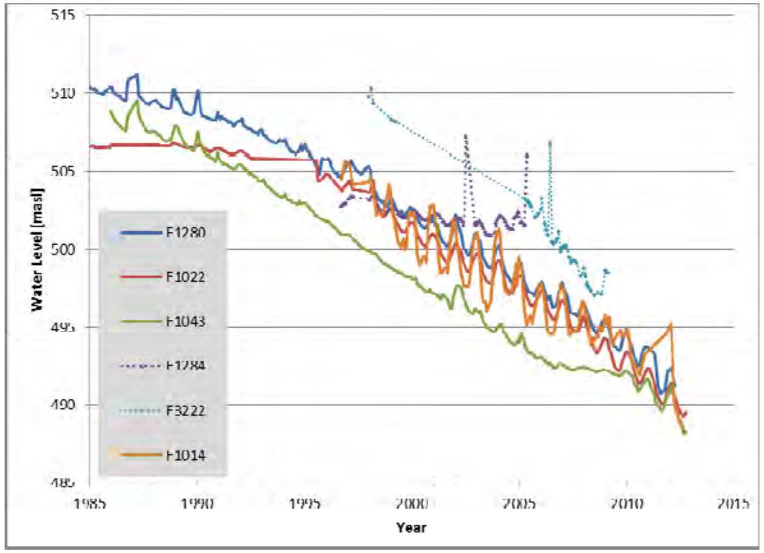
Well depth up to 220 m

Abstraction from the upper aquifer complex

Awsa well field







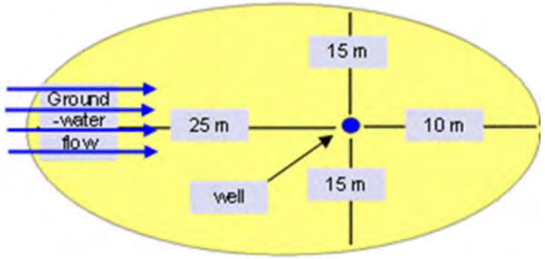
Restrictions in Protection Zone 1

Zone 1:
In this area, only activities needed for the water abstraction are allowed. All installations required for the operation of the well have to be constructed downstream of the well.

BGR

How do we delineate Protection Zones?

Zone 1: Fixed distances

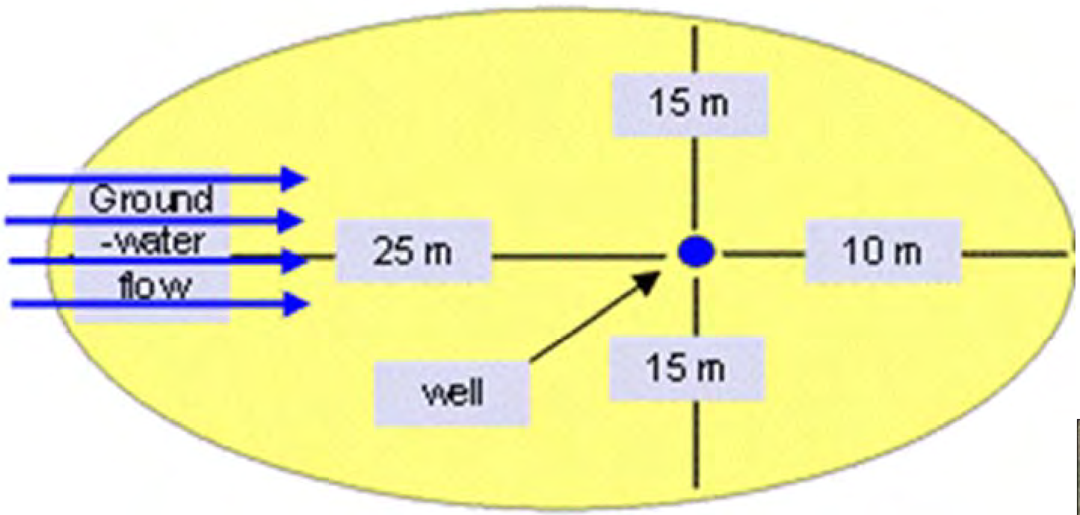


Zone 2: Determine 50 day line by

- estimation of groundwater velocity
- Numerical groundwater model
- Tracer tests

Zone 3: Surface water catchment / Groundwater recharge area

Delineation of Protection Zone 1



Delineation of Protection Zone 1

ID: F 1038

Name: AWSA 11

PBN: 1149139	PBE: 322425
Altitude (m .a.s.l): 517	Total Depth (m): 61
Aquifer: BA	Yield: 200
Conductivity [m/d]:	Transmissivity (m2/hr): 29290

Protection Zone 1:

Legend:

Actual PZ 1

Optimal PZ 1

remarks

Wellhead and Gates: Remarks

- The gate is open.
- Many parts of the fence are destroyed.
- There is an opening on the well head to inter the electricity cable.
- There is a shallow wide bit inside PZ 1.
- There is some dump near the well head.
- There is no PZ 1 sign.

Recommendations for PZ1:

- In order to implement PZ1, the fence should be fixed or replaced.
- The inproper installation of the cables allow direct access to the casing. This should be properly installed.

Delineation of Protection Zone 2

Estimation of maximum actual flow velocity:

$V_{max} = 2 * v_n$

$$v_n = K * I / N_0$$

K: hydraulic conductivity = 31.6 m/d
I: GW gradient = 0.001
N_0: effective Porosity = 5 %

$V_{max} = 2 * (31.6*0.001/0.05) = 1.264$ m/d

50 day line: $V_{max} * 50 = 63.2$ m

This formula fails here due to the low groundwater gradient.
Effects of the depression cone are much more important

Delineation of Protection Zone 2

For hydraulic gradients < 0.001 the cylinder formula should be applied:

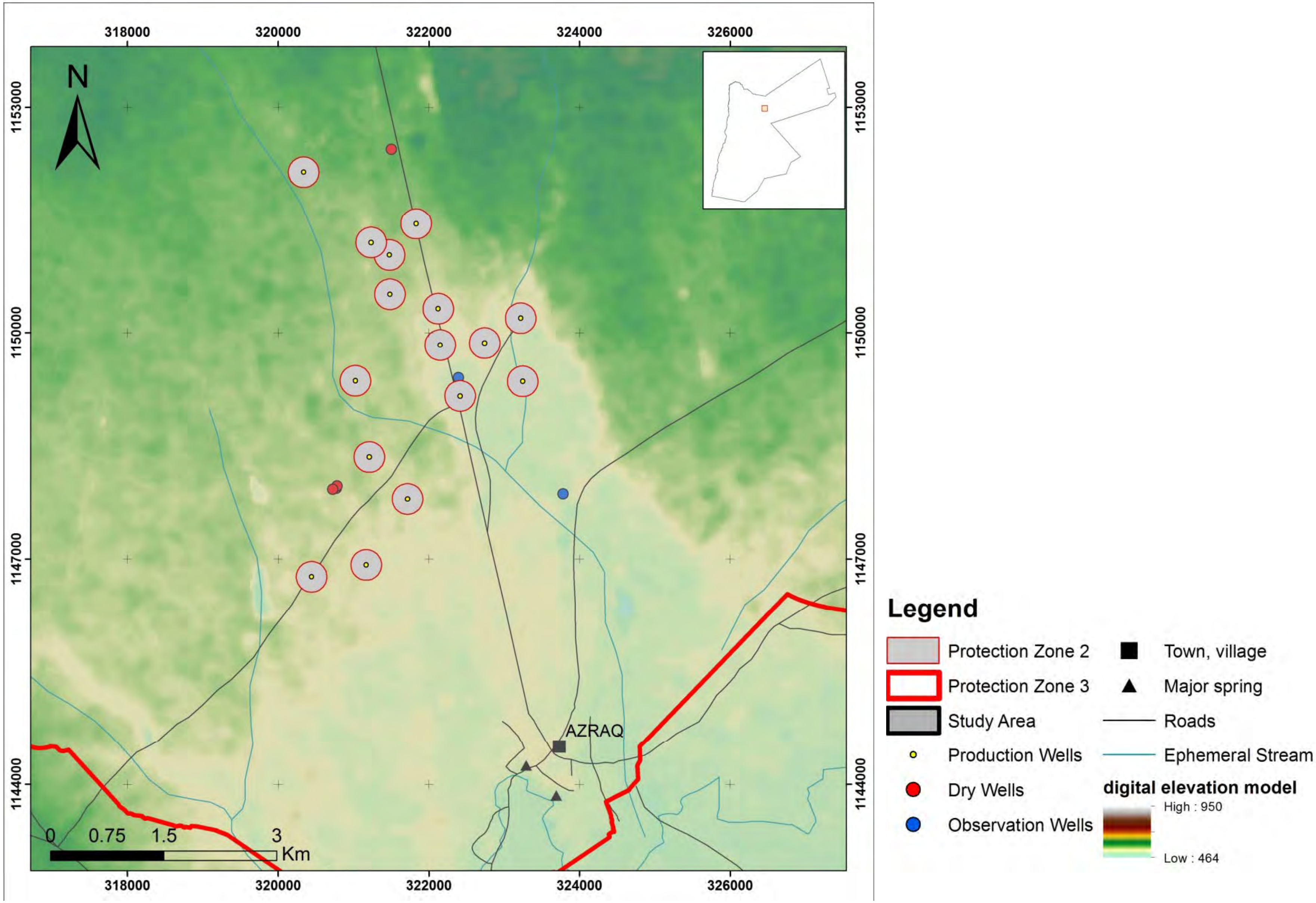
$$x_{50} = \sqrt{\frac{Q_{50}}{\pi * b * N_0}}$$

With
X_{50} = Distance of the 50 day Isochrone [m]
Q_{50} = Abstraction within 50 days [m³] = 62 l/s (maximum abstraction rate) = 267840 m³/50d
b = saturated thickness of the aquifer = 200 m
N_0 = effective porosity = 0.05

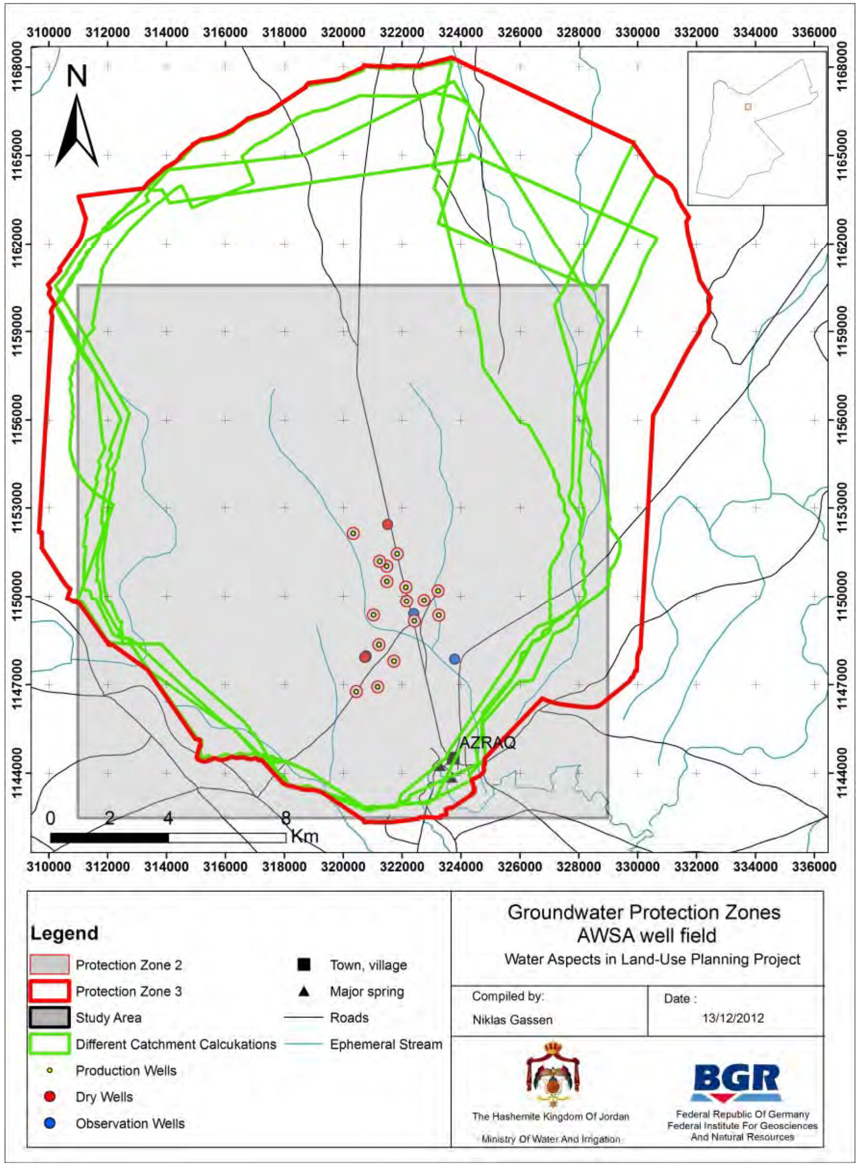
$$x_{50} = 92.3m$$

Safety Factor of 2: 185 m

Delineation of Protection Zone 2



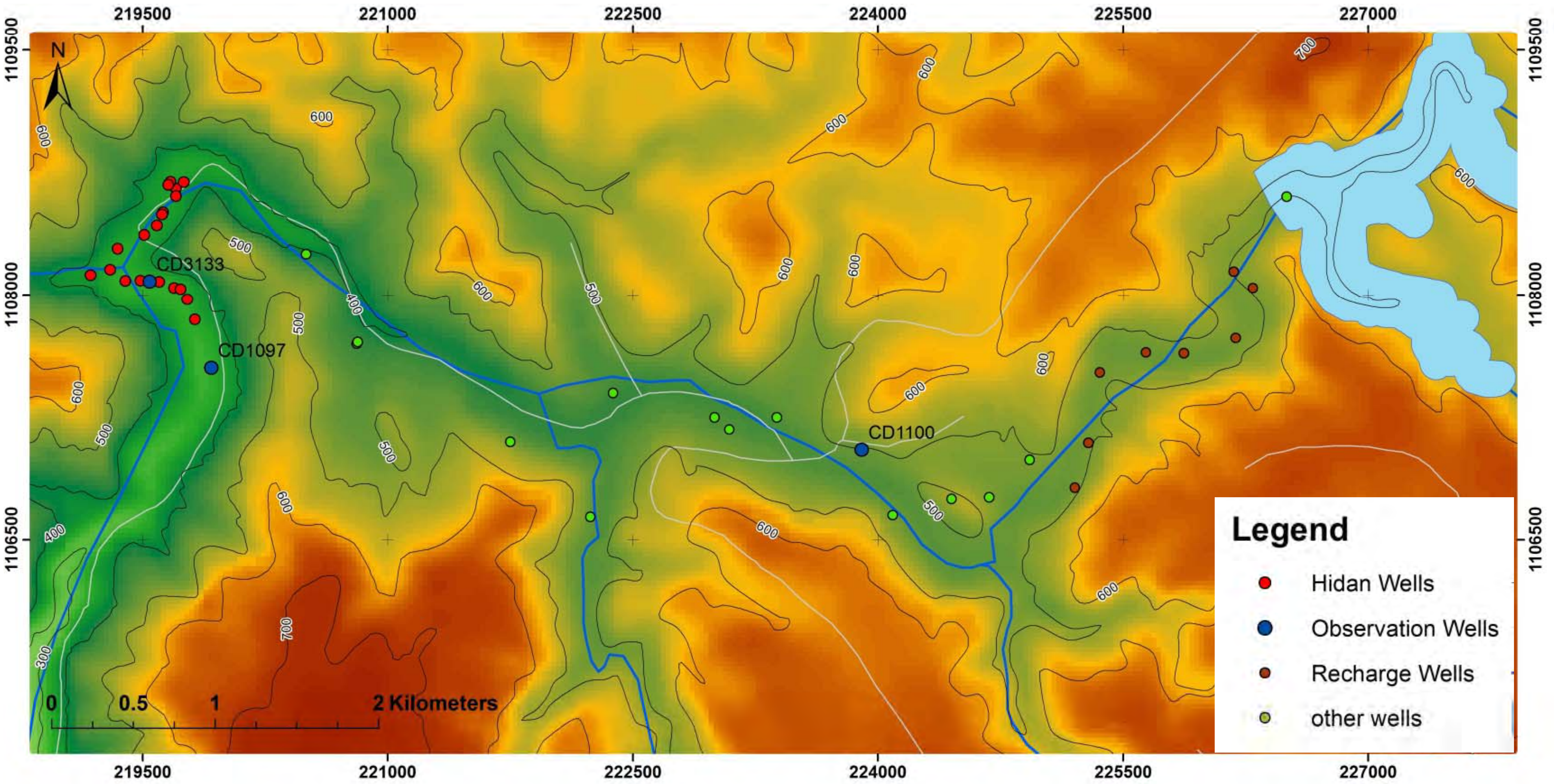
Delineation of Protection Zone 3



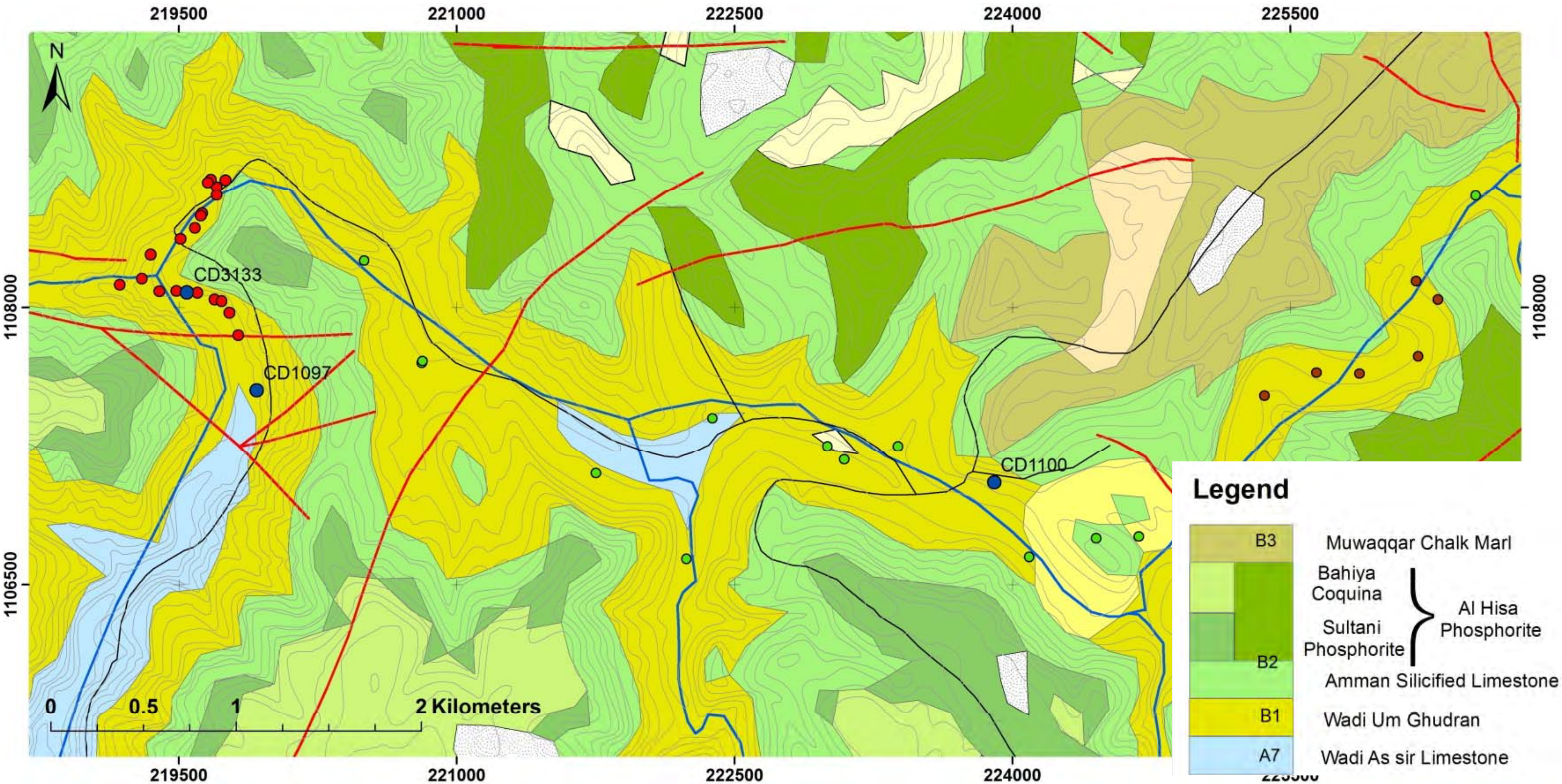
Calculate catchment of each cell
by using Modpath

Combine the catchments of the cells to
one shape file

Hidan Well Field: Topography

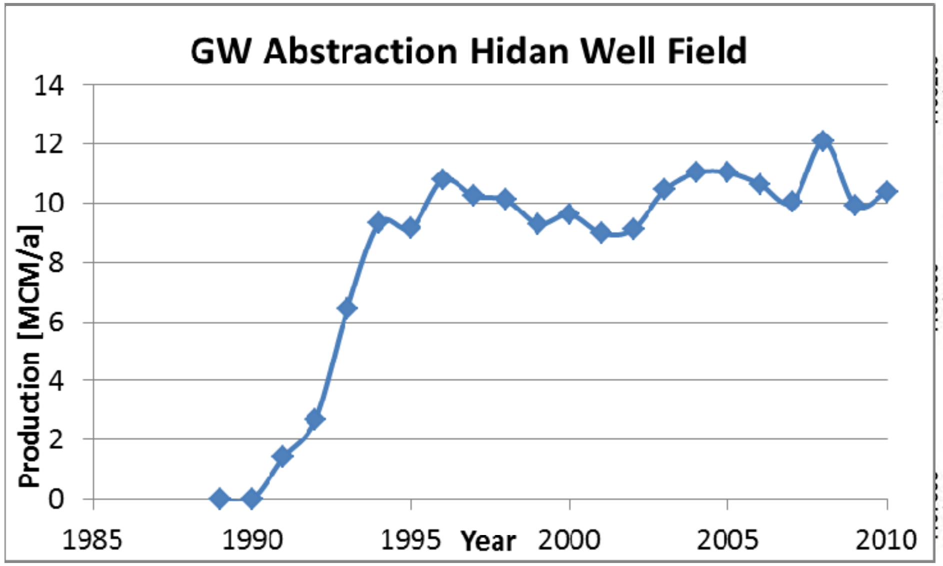


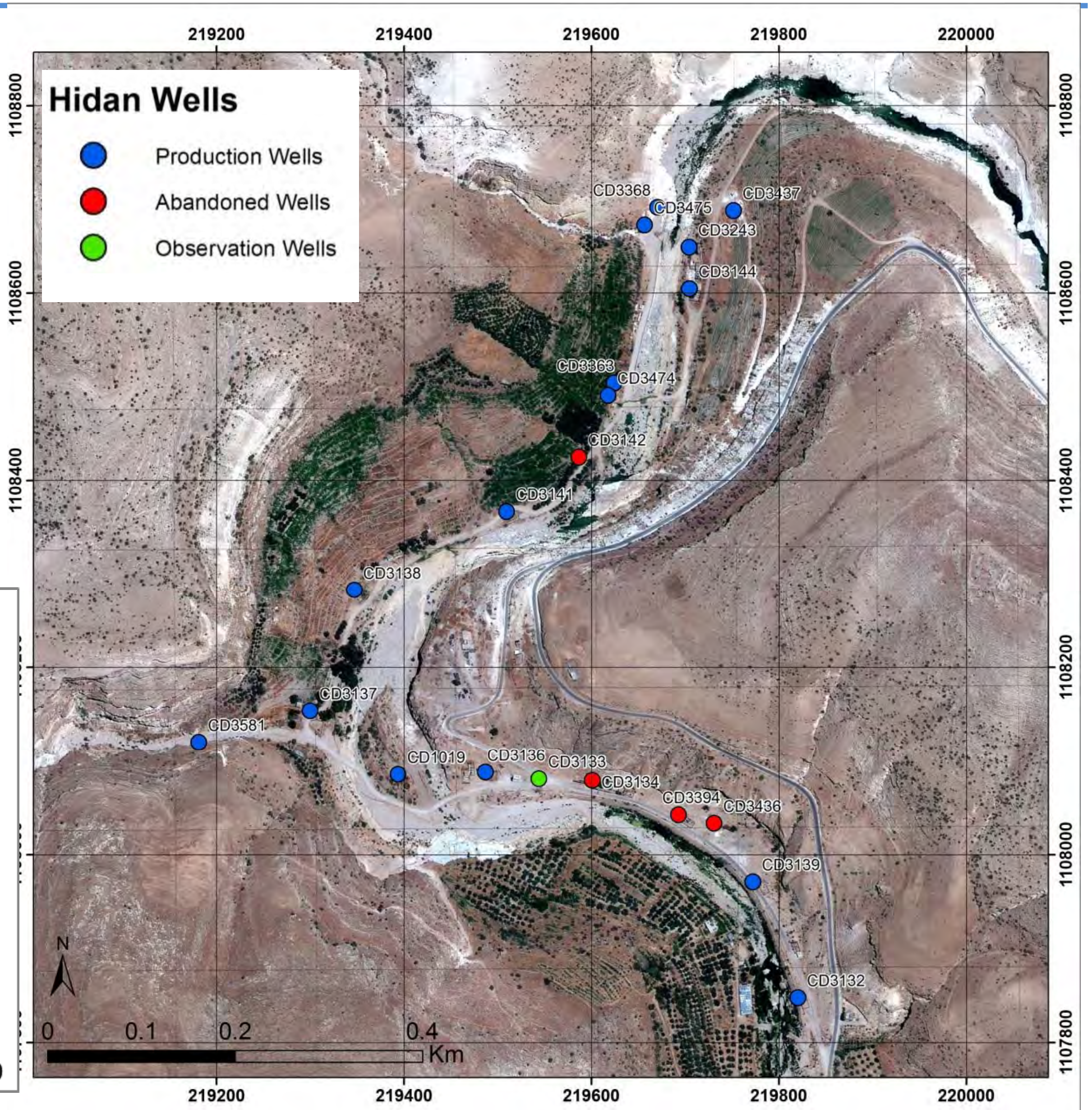
Hidan Well Field: Geology

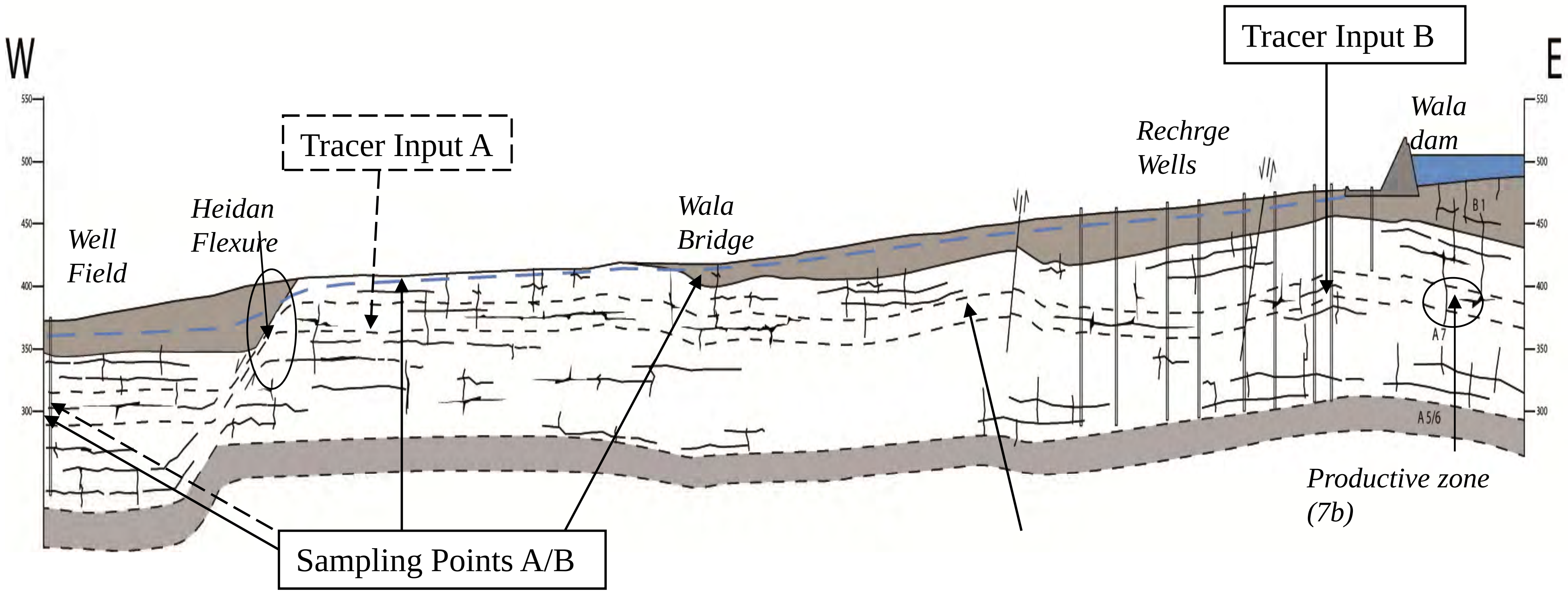


Hidan Well Field

- 15 Production wells from A7 Aquifer
- Well depth 30 -160m.
- 4 abandoned wells, not backfilled
- 2 Observation wells



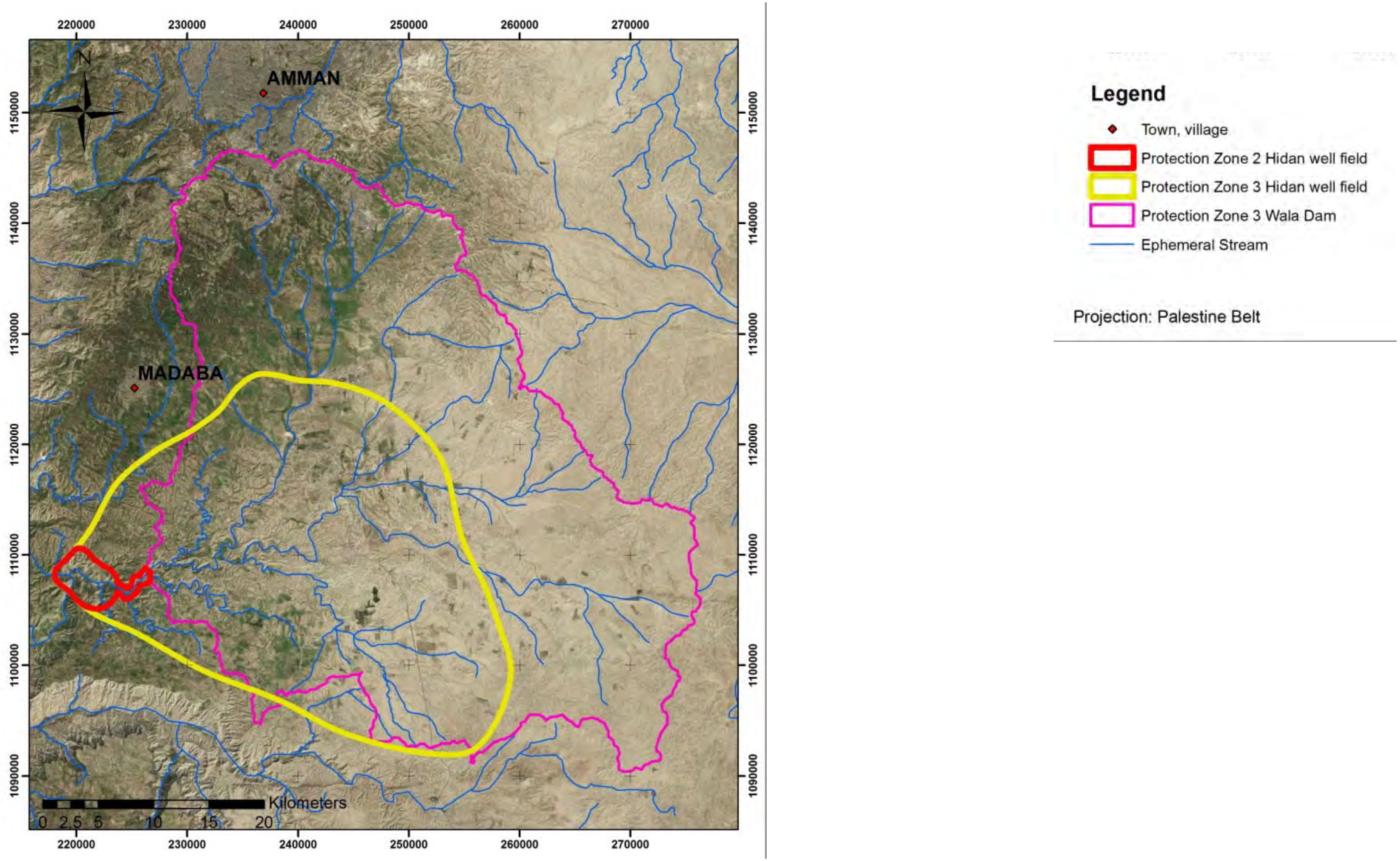



W
E
Tracer Input A
Tracer Input B
Well
Field
Heidan
Flexure
Wala
Bridge
Rechrge
Wells
Wala
dam
B 1
A 7
A 5/6
Productive zone
(7b)
Sampling Points A/B

NaCl Tracer

Protection Zone 2

Protection Zone 3



Shukran!

Federal Republic of Germany
Federal Institute for Geosciences
and Natural Resources

التعاون الألماني
DEUTSCHE ZUSAMMENARBEIT

The Hashemite Kingdom of Jordan
Ministry of Water and Irrigation

Jordanian-German Technical Cooperation Project

Water Aspects in Land-Use Planning

Cooperation With Rangers Department

Mohammad ALHYARI

Introduction

- Environmental Police Department was established on 15th June 2006 according to a directive of His Majesty King Abdullah II
- On 15th December 2008 it became the Royal Department for Environment Protection (RDEP)
- Executive arm of the Ministry of Environment (MoE), but administratively a unit of the Public Security Directorate (PSD).
- Operating in coordination and cooperation with nine strategic partners consisting of governmental institutions and environmental conservation organizations

الادارة الملكية لحماية البيئة

RANGERS

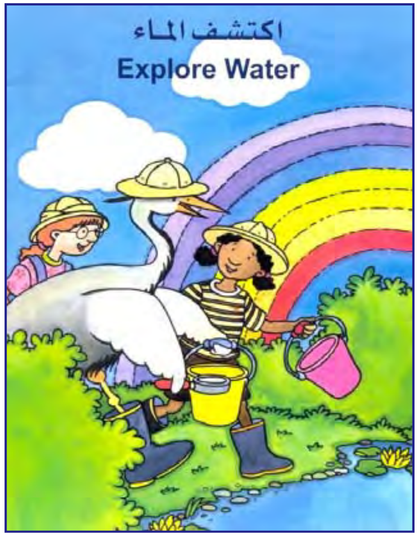
The Royal Department for Environment Protection

- <u>German-Jordanian Technical Cooperation:</u>

  Since 2009. Rangers department was linked to the Project *Water Aspects in Land Use Planning* conducted by the *Federal Institute for Geosciences and Natural Resources (BGR)* and the *Ministry of Water and Irrigation (MWI)*

Cooperation with Rangers

- Based on the initiative of Ministry of Water and Irrigation and BGR the rangers created a Water Resources Protection Team in their headquarter.
- The Rangers are trained regularly on GPS and GIS with support from Ministry of Water and Irrigation and BGR.
- The Rangers produce and distribute educational material for schools about water and environment protection – input is given by BGR/GIZ.
- Rangers support events/workshops of the BGR/MWI-project with their presence and speeches.
- A Memorandum of Understanding between Rangers and MWI has been achieved lately for a better cooperation between both institutions.



Water Resource Protection Team

- Acting as an extension team to the 18 branches in the whole Kingdom (training and follow-up).
- Processing and updating information obtained from field officers, own field surveys and from other institutions
- Identification of hazard sites within the protection areas (remote sensing and field inspections)

Water Resource Protection Team

- Since 2011 the WRP team is systematically analysing all reports collected and filed in the Rangers HQ control room. Any suspicions case involving dumping of hazardous substances has to be geo-referenced by GPS coordinates

- Violations concerning water production facilities are also documented and information is forwarded to the responsible authorities

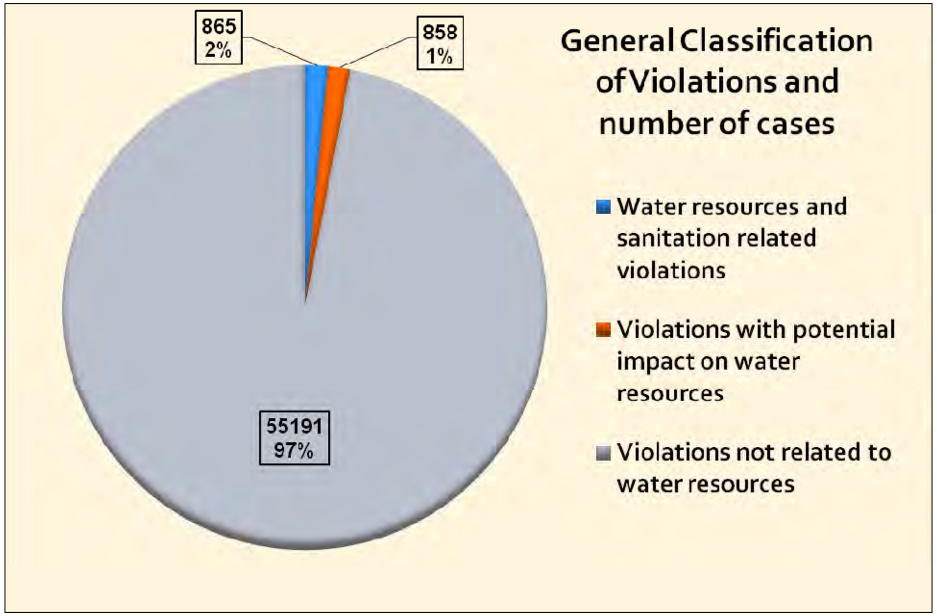
The Rule of the Rangers in Water Resources Protection

- The Rangers are supporting the implementation of the regulations in water protection zones through patrolling and participation in environmental awareness campaigns

- Particularly they are involved in the Water Aspects in Land Use Planning Project of MWI and BGR

Results and Conclusions

- Rangers apply acquired tools and knowledge to support WALUP
- Number of reported cases increased
- Incidents concerning water resources are geo-referenced and documented in Rangers statistics
- BGR ,MWI and Rangers are sharing data and information (e.g. in WPZ delineation, campaigns, law enforcement)



BGR

Federal Republic of Germany
Federal Institute for Geosciences
and Natural Resources

التعاون الألماني
DEUTSCHE ZUSAMMENARBEIT

The Hashemite Kingdom of Jordan
Ministry of Water and Irrigation

Thank You For Your Attention

Jordanian-German Technical Cooperation Project
Water Aspects in Land-Use Planning
Ministry of Water and Irrigation
P.O. Box 2412
Amman 11183

Phone + 962 6 5685257

Mohammad ALHYARI
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Protection of jeita spring

Presented by : Zeina yaacoub - Environmental specialist
Ministry of environment – Lebanon

Implementation of the GW protection zone

- Commitment from the ministry of environment.
- Ministerial decision for landuse restrictions.
- All departments should be informed.
- Elaboration of adequate GIS map.
- Imposing severe environmental conditions on existing industries.
- refusing new industrial permitting license in vulnerable zone.

Shortcoming for the implementation

- Awareness of stakeholder (land owner).
- Awareness of citizen.
- Presence of many industries, gas station, feedlots, slaughterhouses not respecting environmental conditions imposed by the Moe.
- Overlapping of competence among the ministries.
- Decisions for accepting or refusing permitting license are not always unanimous (contradictions in opinions).

Better control of proposed landuse restrictions

- Environmental police : draft law
- Direct involvement of the local authorities.
- Sufficient staff to monitor all activities contributing to the environmental deterioration (GW contamination in particular).
- Educating the population and potential polluters about the advantages of changing behavior to ensure wellbeing in terms of benefit from good natural resources.

Amendment of legal framework

- Decree 8633(date: 2012): improvement in the environmental legislations.
- Requesting EIA and IEE for several activities.

↓

- Integration of many aspects: chemical-physical-biological-social and economic environment.

↓

- Protection of water resources, GW, ecosystem, archeological sites,…

Amendment of legal framework

- Some permitting license decisions can be changed in court (based on laws, decrees and ministerial decisions).
- Polluter –pays principle is applied in court and the polluter pays to repair the damage and to change the behavior.
- Many environmental claims are win in court.
- Recent achievement: draft law for the designation of environmental judge dedicated to discuss the environmental claims only.

Law 444/2002

- Environmental protection and natural resources management.
- Surface and GW protection.

Decisions 8/1 and 52/1

- Environmental limit value for wastewater discharge into the sea, surface water and the sewer.

Amendment of legal framework

- Reviewing of existing legislations and new regulations are needed.
- No policy will be successful without the enforcement of existing laws.
- Needs for creating a committee comprising staff assigned by the relevant institutions to discuss all requests and decide to give a license or not.
- Landuse classification should include hydrogeological issue.

Thank You

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E-mail : Z.Yaacoub@moe.gov.lb
Website : www.moe.gov.lb

Council for Development and Reconstruction (CDR)
Ministry of Energy and Water (MoEW)
Water Establishment Beirut and Mount Lebanon (WEBML)

Federal Institute for Geosciences
and Natural Resources (BGR),
Hannover, Germany

German-Lebanese Technical Cooperation Project

Protection of Jeita Spring

Use of Stable Isotope Analyses and Environmental Tracers to characterize GW Recharge and Flow Mechanism in the Jeita Catchment

Project Exchange Meeting Jordan - Lebanon

31 October 2013

Dr. Armin Margane, BGR

Means of Charcterization of Groundwater Flow in a Karst System

Groundwater infiltrates into the underground (recharge)

- direct recharge (at the place where it rains) or
- indirect recharge (along the surface water flow path)

e.g. in the river bed (Jeita catchment: 23% of SW flow) or depressions

Mount Lebanon: mainly karstified limestone (dissolution by carbonic acid)

groundwater moves along fractures, faults, dissolution channels (conduits)

- high flow velocities (70-200 m/h; up to 2000 m/h in large conduits !)
- high water level fluctuations (dry/wet season)

How to determine groundwater flow directions/velocities, groundwater contribution zone ?

► tracer tests

► geochemical data (and environmental tracers)

► isotope data (oxygen 18, deuterium, tritium)

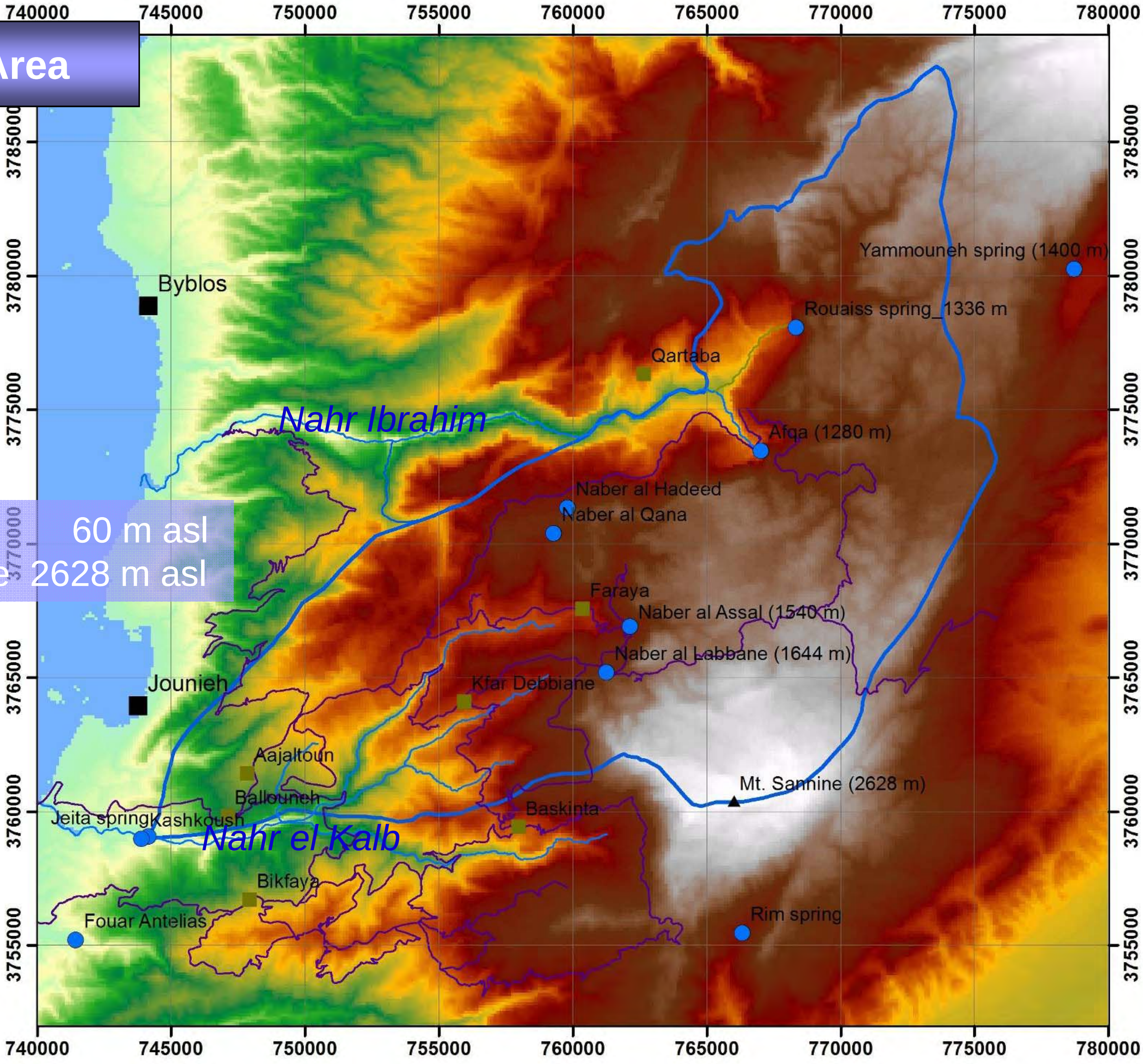
Purpose of Stable Isotope Studies

- study the groundwater recharge mechanism
- study evaporation effects
- determine the mean elevation of a groundwater catchment
- determine the mean residence time of groundwater.

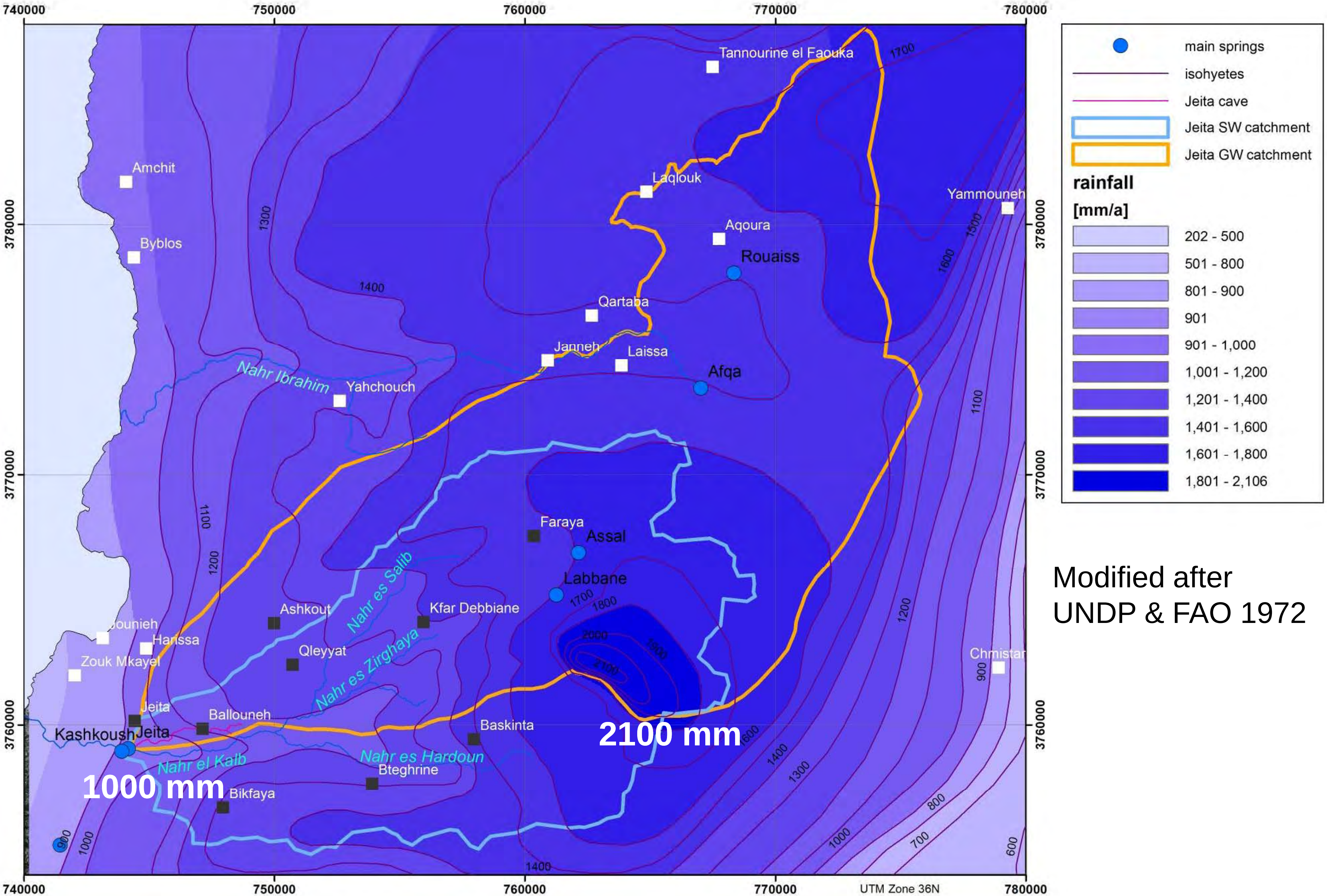
Project Area

DEM

Min: Jeita spring 60 m asl
Max: Mt. Sannine 2628 m asl



Rainfall Distribution

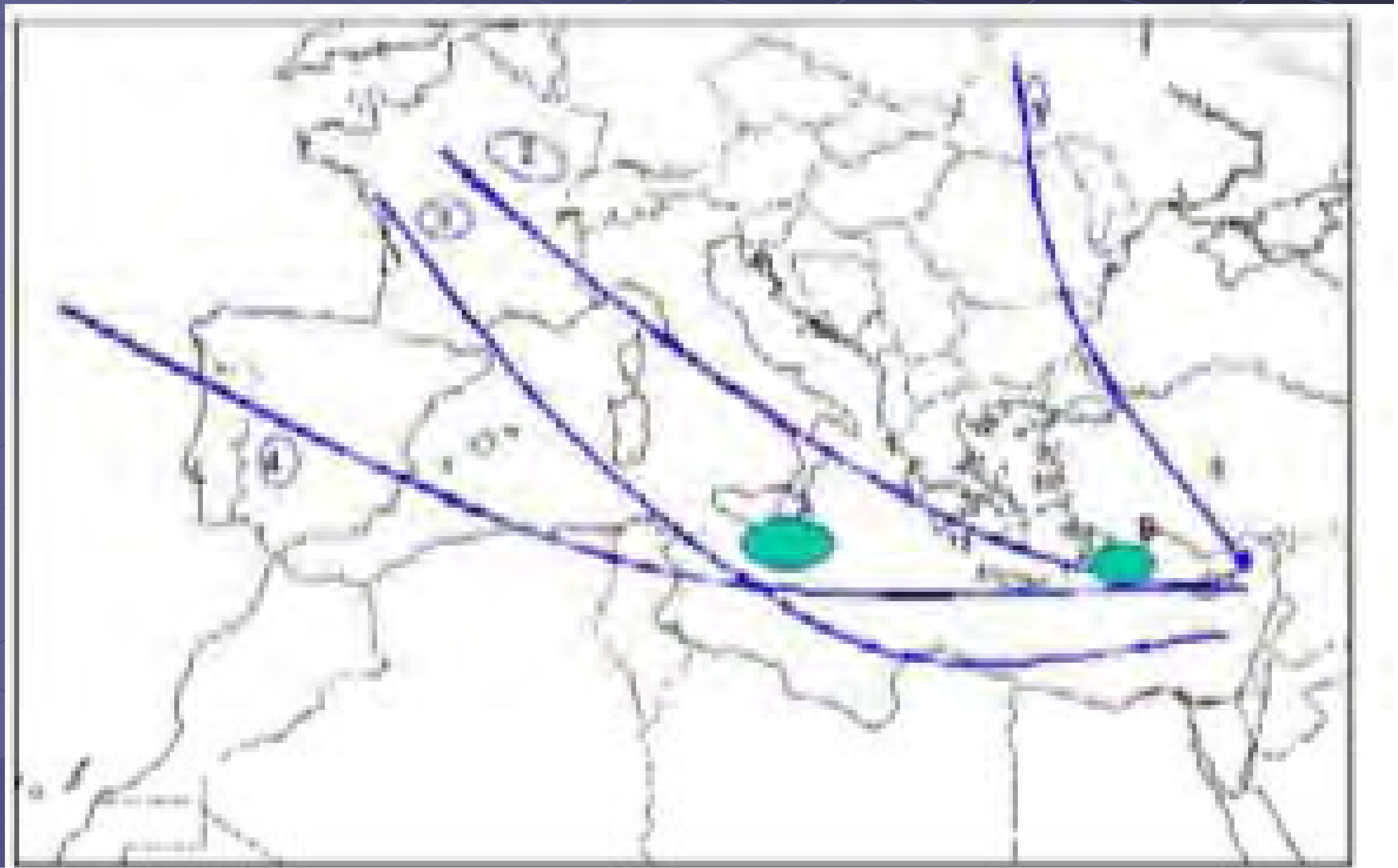


Modified after UNDP & FAO 1972

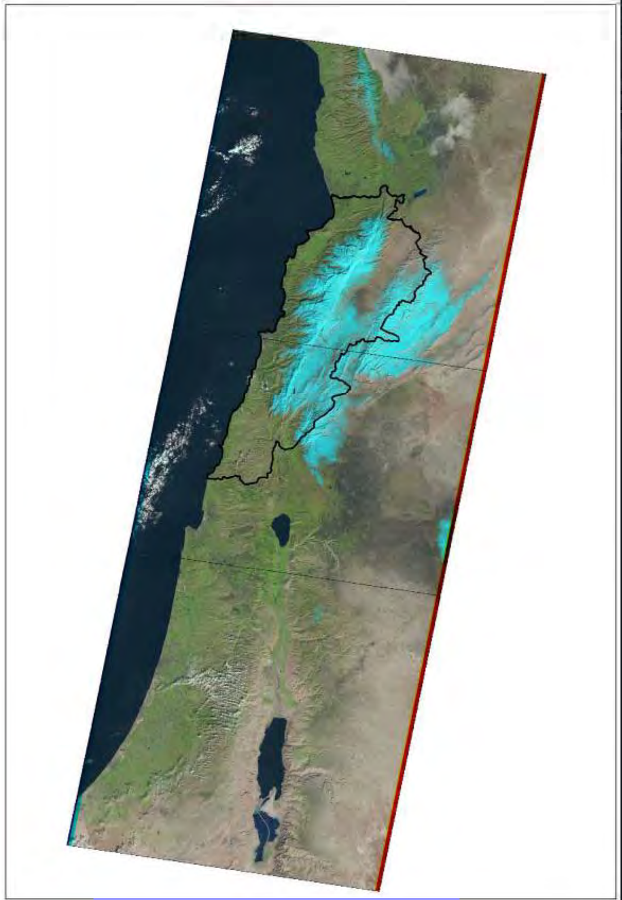
Rainfall Provenience

rainfall in the eastern Mediterranean is strongly influenced by the Cyprus Low, which forms when cold air masses from Europe approach the region from the NW. Moving over the warm Mediterranean waters they gain moisture and become unstable, forming cyclones

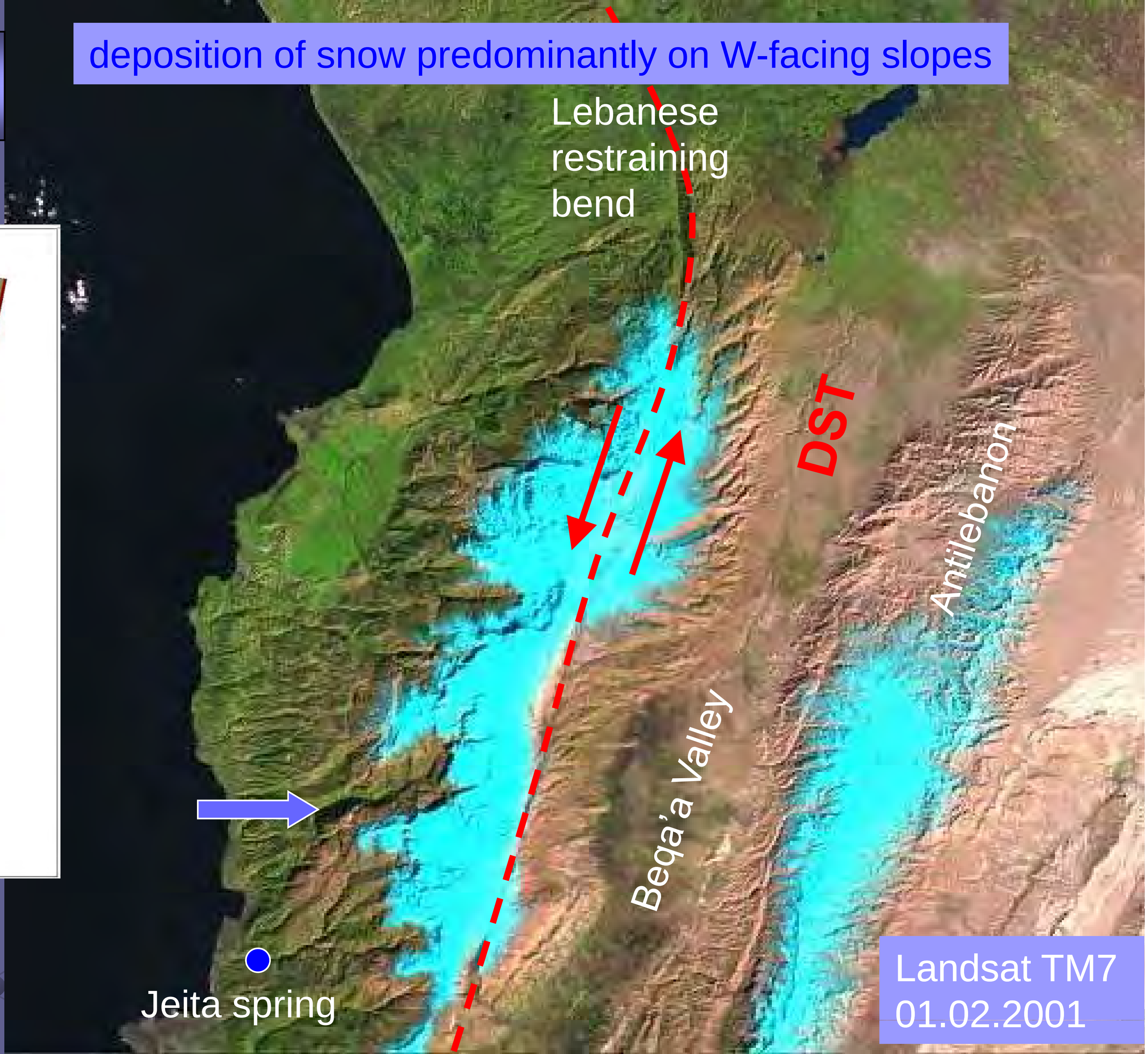
Common trajectories (based on AOUAD-RIZK et al., 2005)



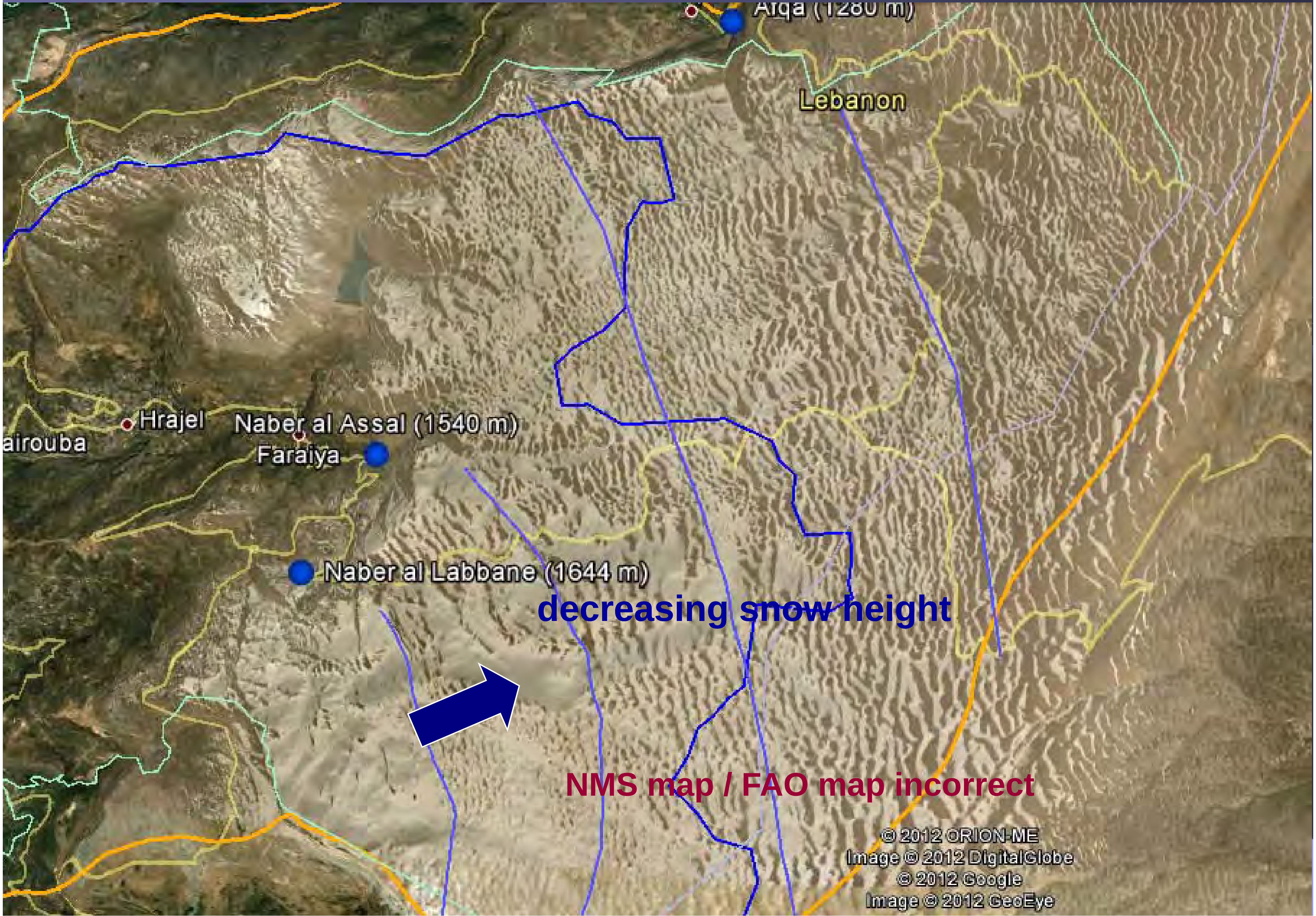
Snow Cover



Landsat TM7
19.01.2002

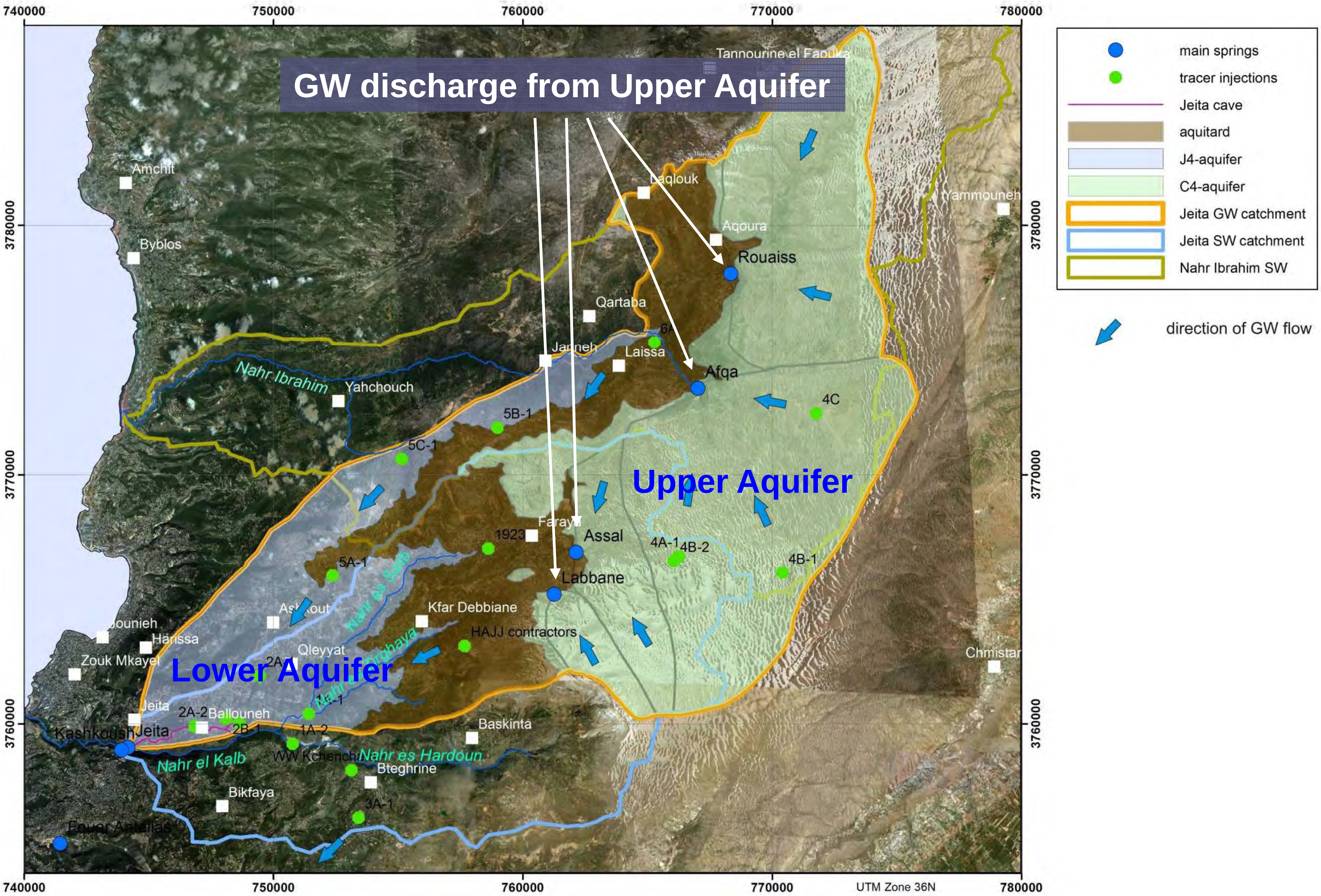


Landsat TM7
01.02.2001

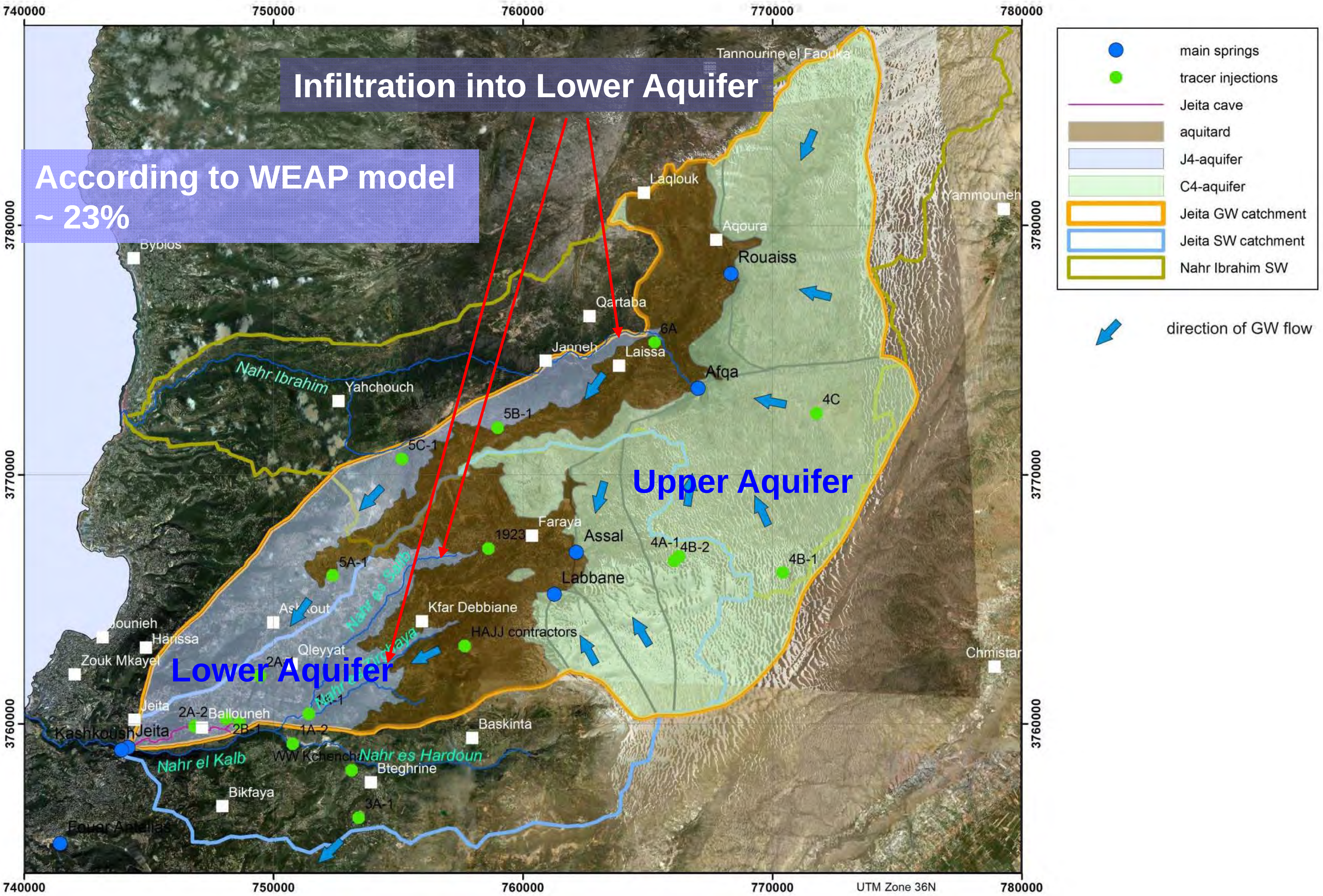

Afqa (1280 m)
Lebanon
Hrajel
airouba
Naber al Assal (1540 m)
Faraiya
Naber al Labbane (1644 m)
decreasing snow height
NMS map / FAO map incorrect
© 2012 ORION-ME
Image © 2012 DigitalGlobe
© 2012 Google
Image © 2012 GeoEye


Currently not possible to determine **S**now **W**ater **E**quivalent
Predominantly western winds

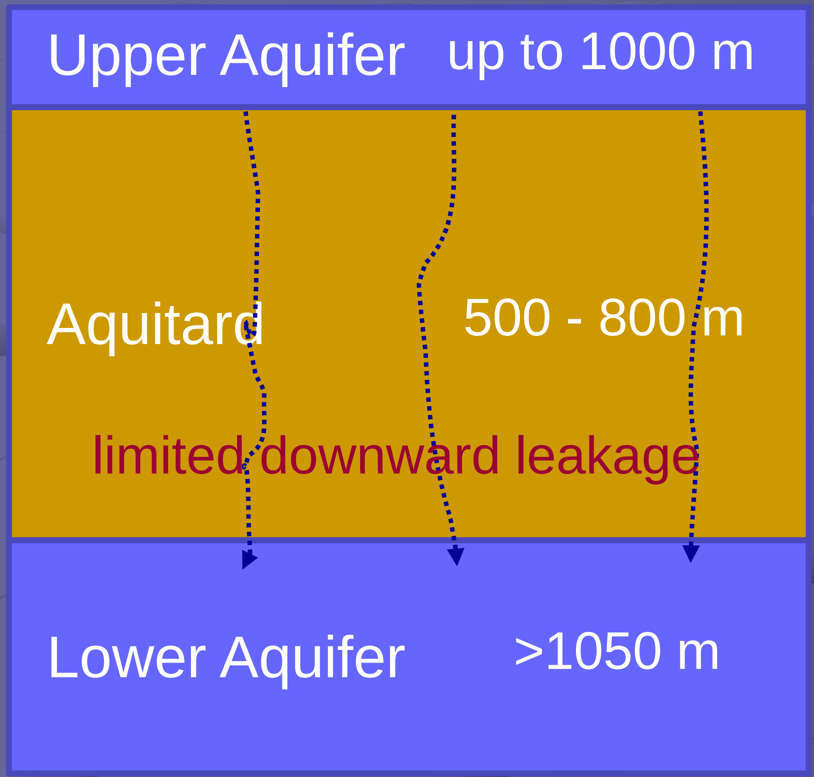
Groundwater System

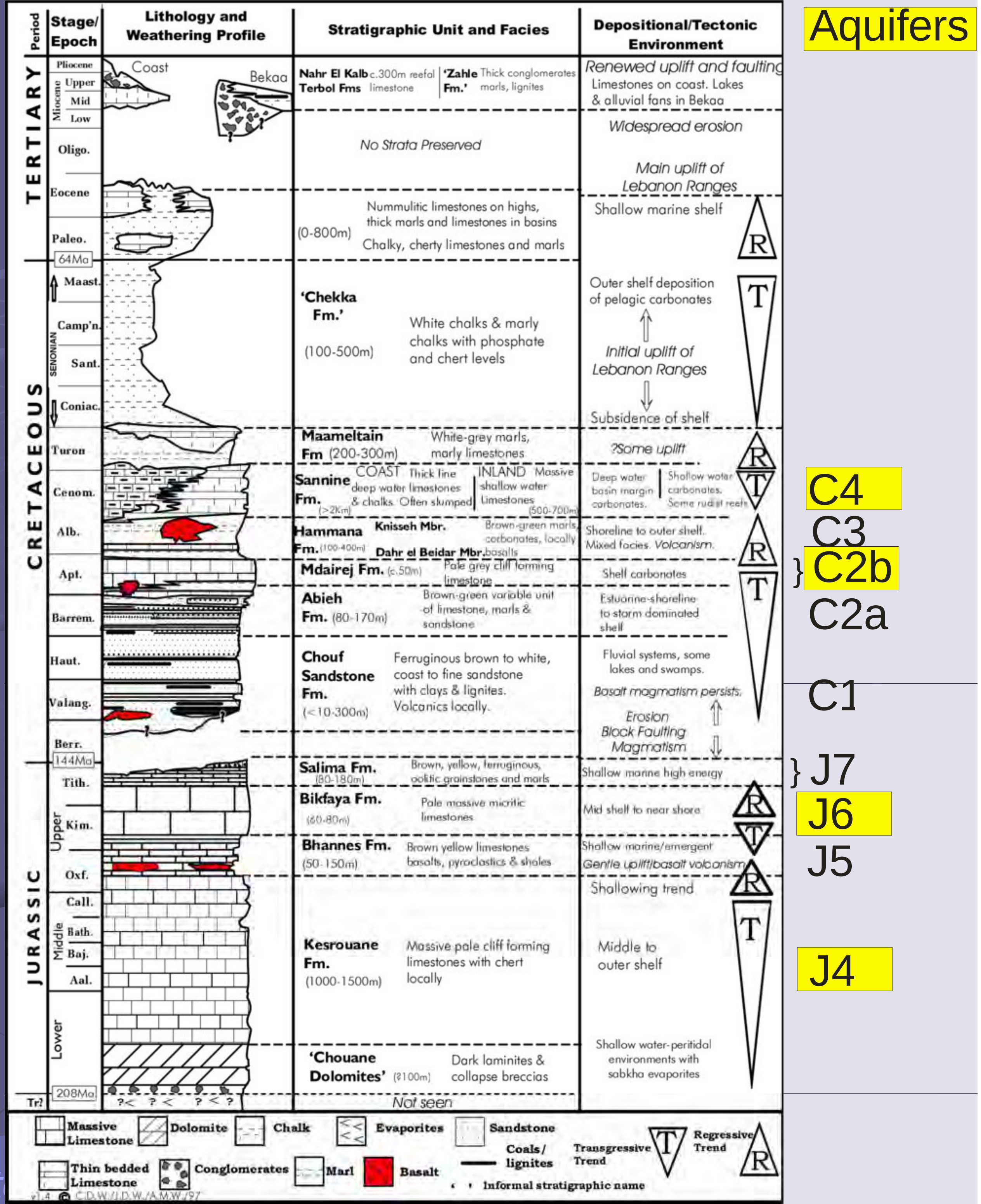


Groundwater System



Lithostratigraphy





Source: C. D. Walley

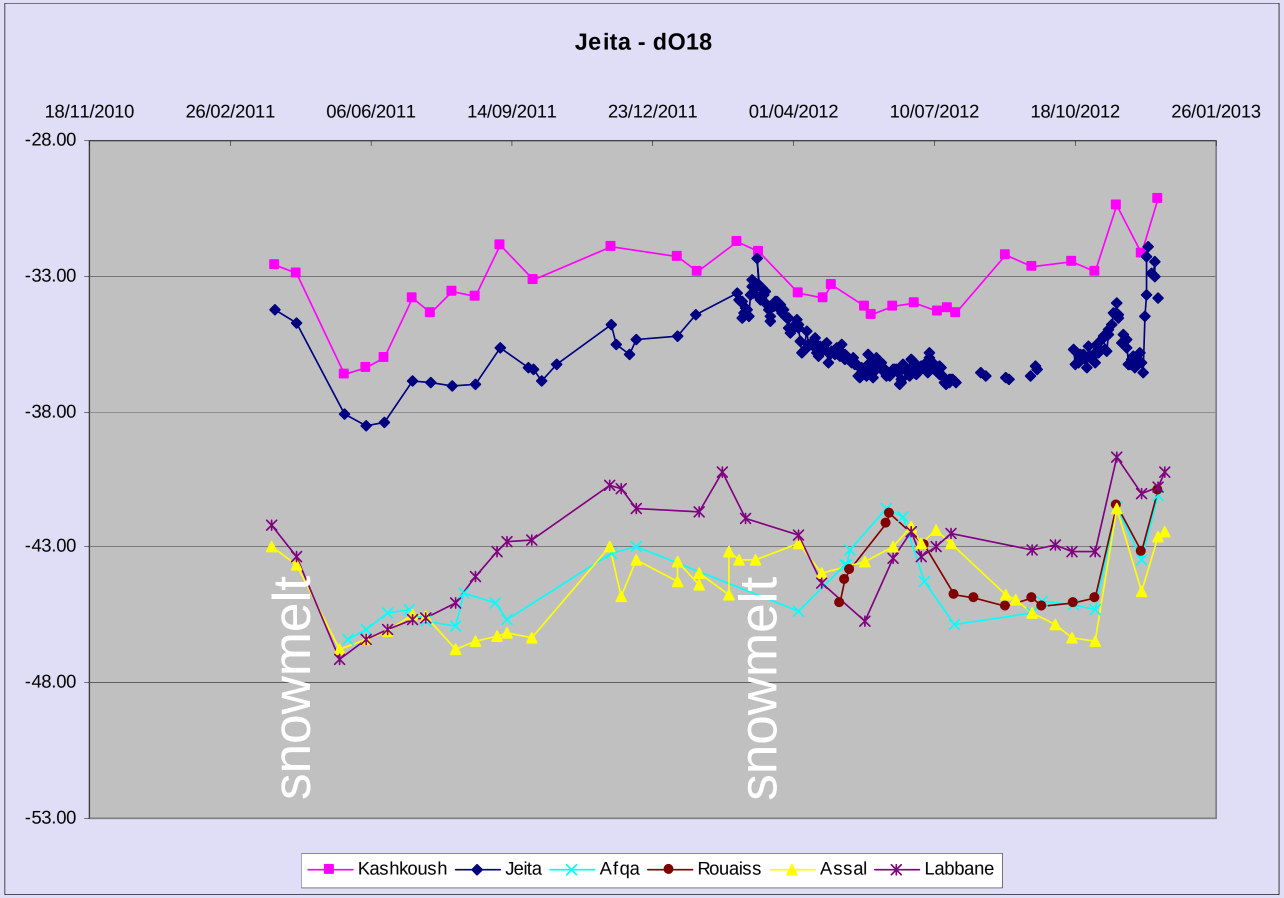
Prot

Isotope data

- deuterium/oxygen-18
- tritium/helium
- CFC (chlorofluorocarbon)

D/18O > 700 analyses

- 6 springs
- rainfall – 6 stations @ diff elev.
- snow sampling campaigns



D/^{18}O
Springs Jurassic Aq (J4) :
- Jeita : daily
- Kashkoush : every 15 days

Springs Upper Createaceous Aq (C4) :
- Assal, Labbane, Afqa, Rouaiss : 15 days

Rainfall: Jeita, Sheile, Aajaltoun, Raifoun, Kfar Debbiane, Chabrouh : every 15 days
Snow: integral & 10 cm depth intervals, 2 winter seas.

BGR

Stable Isotope Sampling

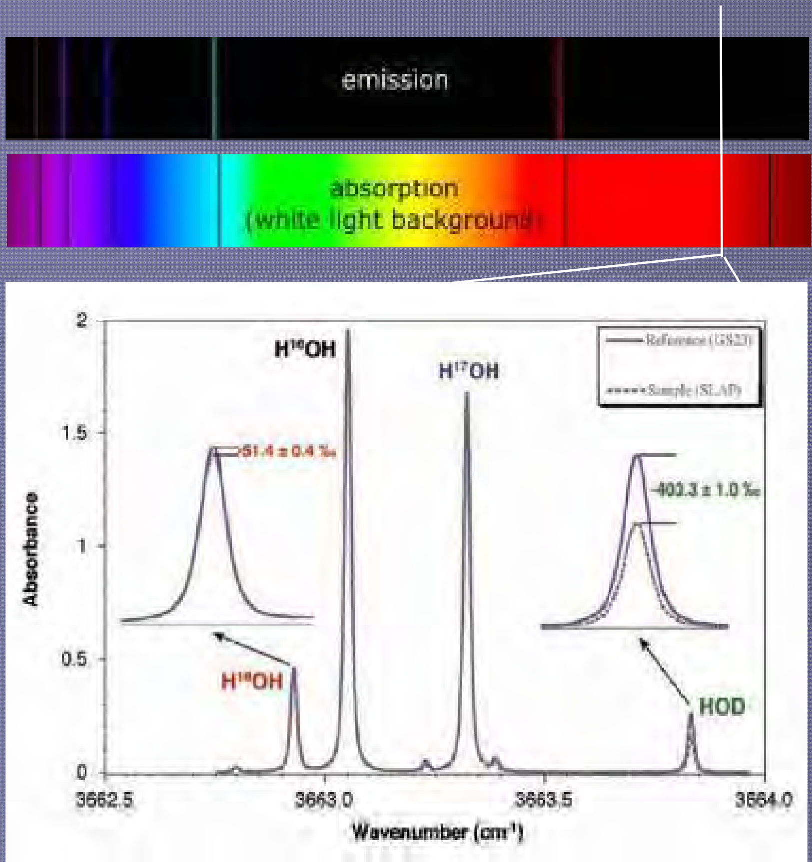
- **Springs** (every 2 weeks): Afqa, Rouaiss, Assal, Labbane, Jeita (daily), Kashkoush;

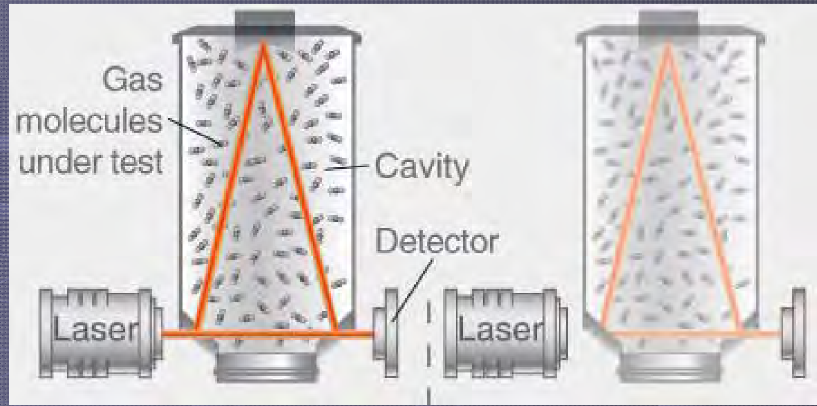
- **Rainfall** (every 10-15 days): 6 stable isotope rainfall sampling stations: Jeita Grotto restaurant (92 m), Sheile reservoir (471 m), Aajaltoun AIS (821 m), Raifoun BGR office (1036 m), Kfar Debbiane municipality (1307 m), Chabrouh dam treatment plant (1591 m);

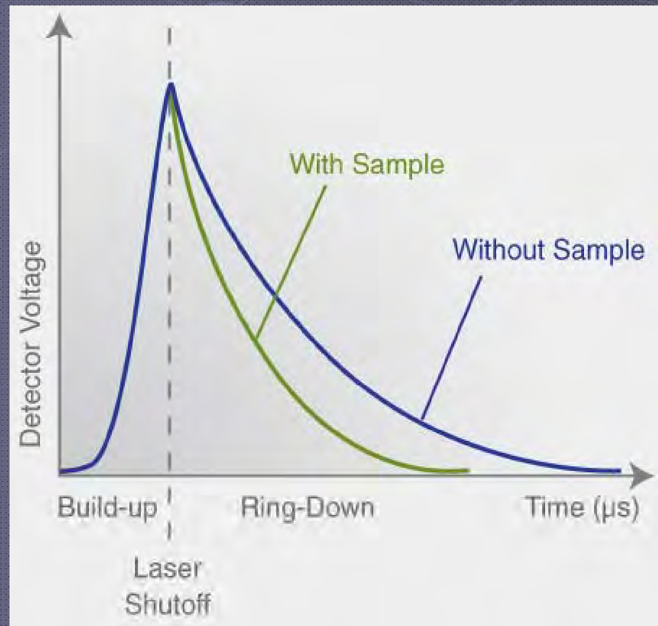
- **Snow** (10 cm depth intervals and integral samples): approx. 20 sites during 2 sampling campaigns (February 2012, February 2013).

BGR Stable Isotope Lab (Dr. Paul Koeniger)

Picarro Laser „Cavity Ring Down Spectroscopy“







standard deviation:
0.2‰ - 0.8‰
$\delta^{18}O$ - $\delta^{2}H$

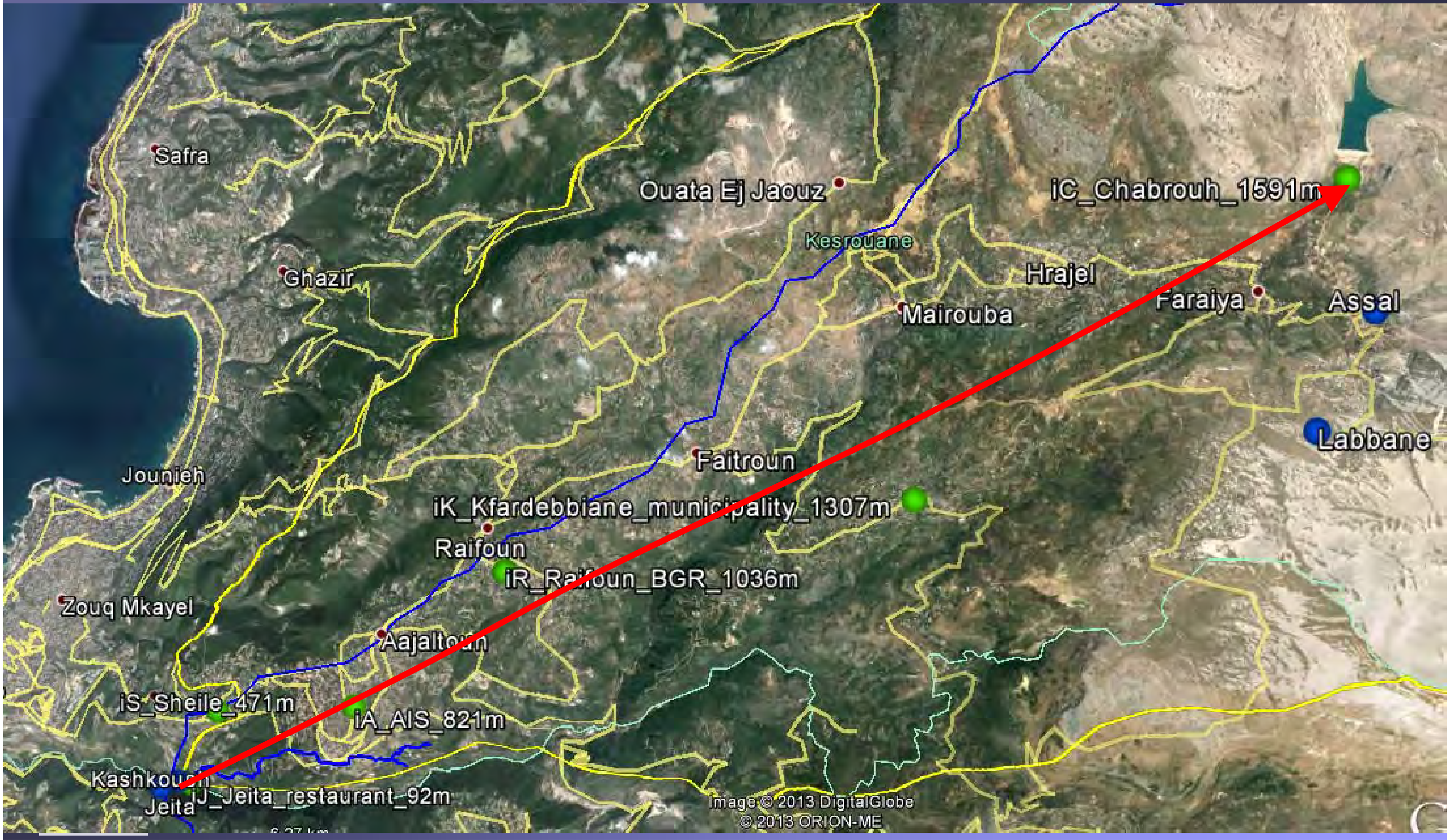
Stable isotope rainfall samplers

Raifoun (BGR office)

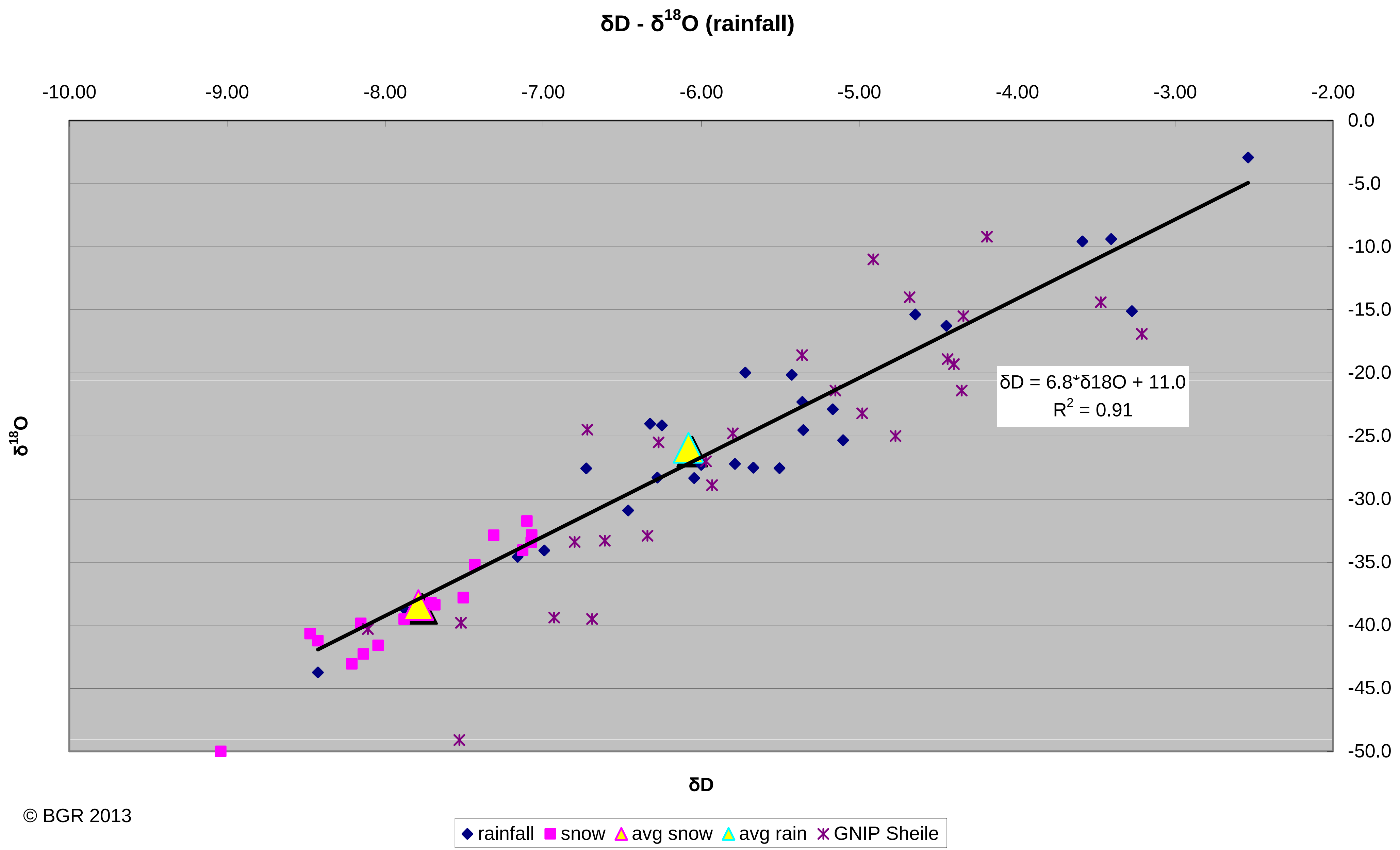
AIS school

Charbouh dam

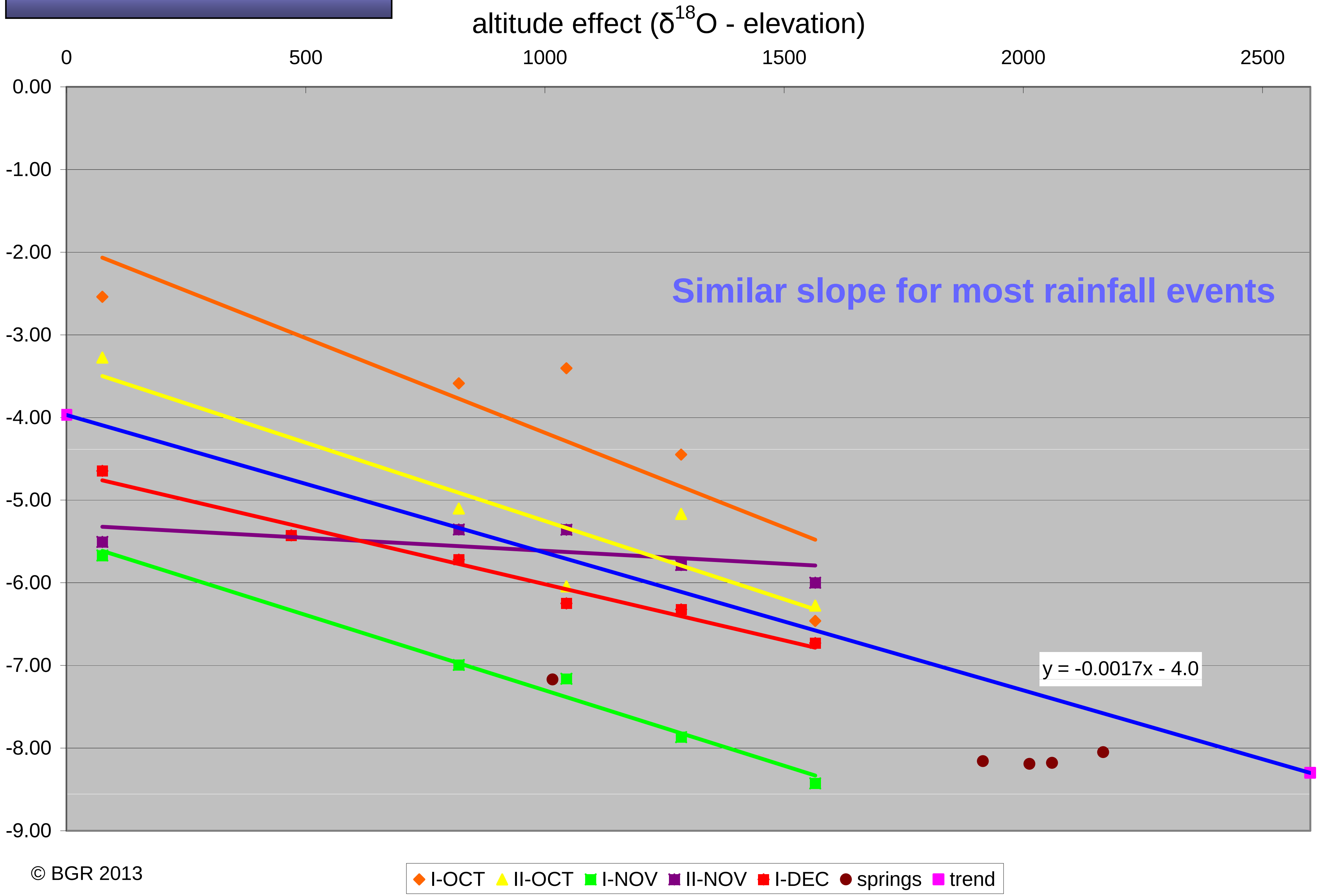
Stable isotope rainfall samplers



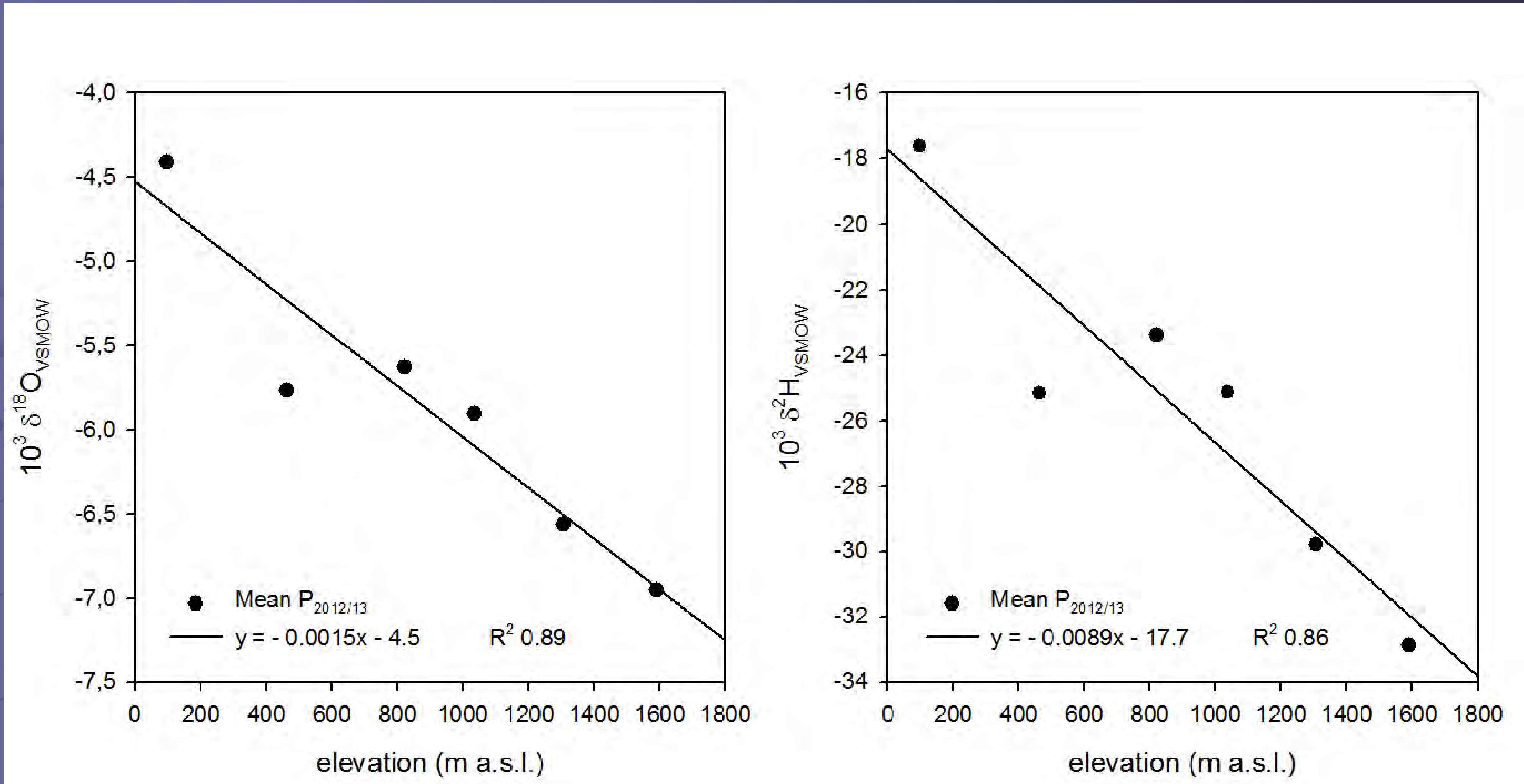
Rainfall Sampling



Rainfall Sampling



Spring Sampling



δ18O = -0.0015*elevation - 4.5

δ2H = -0.0089*elevation - 17.7

Rainfall Sampling

BGR stable isotope composition of rainfall samples (MARGANE et al., 2013)
October - May 2013 (LWML) :
$\delta^2H = 6.7*\delta^{18}O + 13.6$ R2 0.97 n=41

BGR average composition, weighted by rainfall amount :

δ18O: -5.87‰,
δ2H: -25.7‰
DE : 21‰

correlation of $\delta^{18}O$ and δ^2H with elevation :

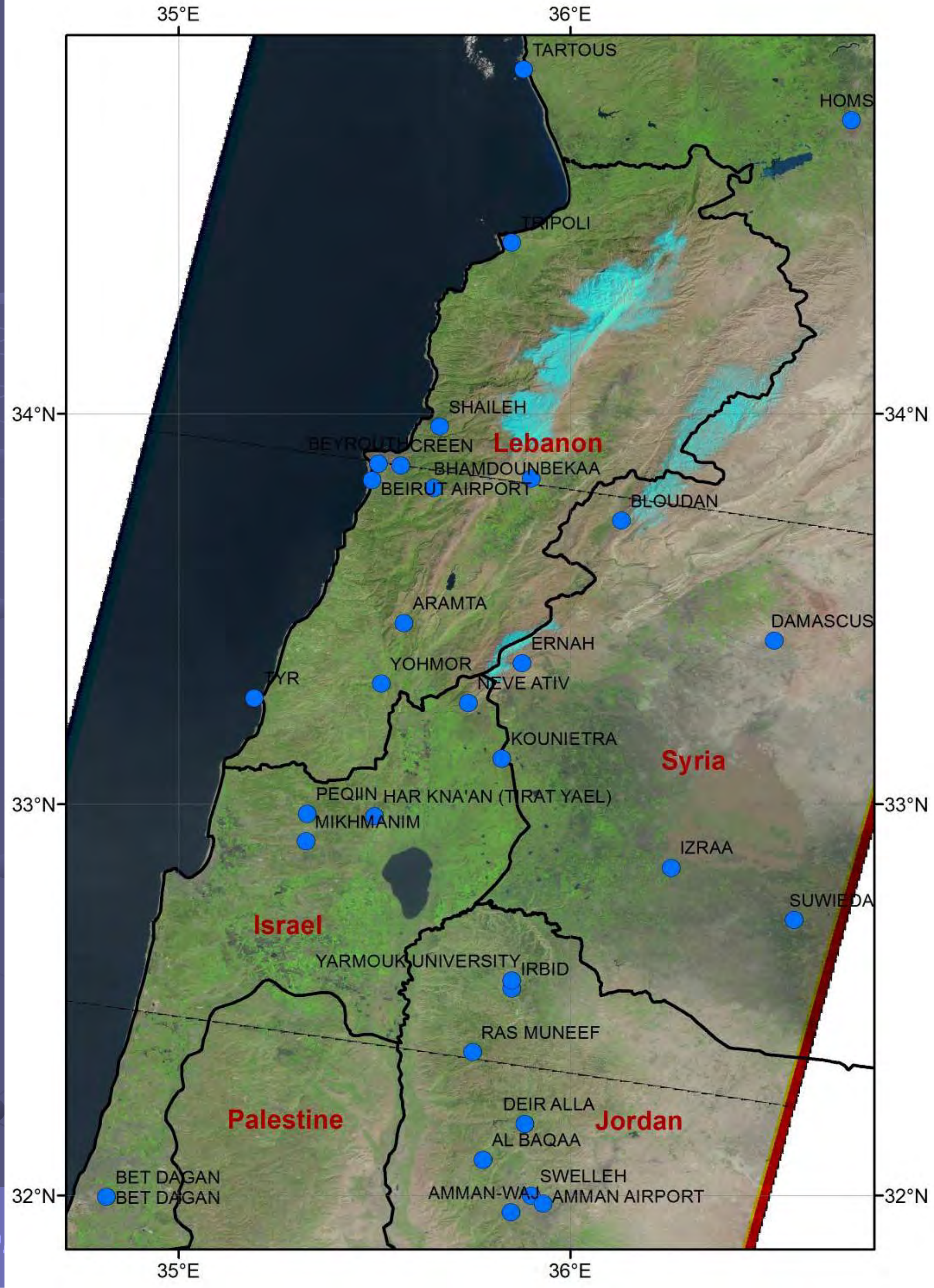
$\delta^{18}O = -0.0015*elevation - 4.5$
$\delta^2H = -0.0089*elevation - 17.7$

Rainfall Sampling

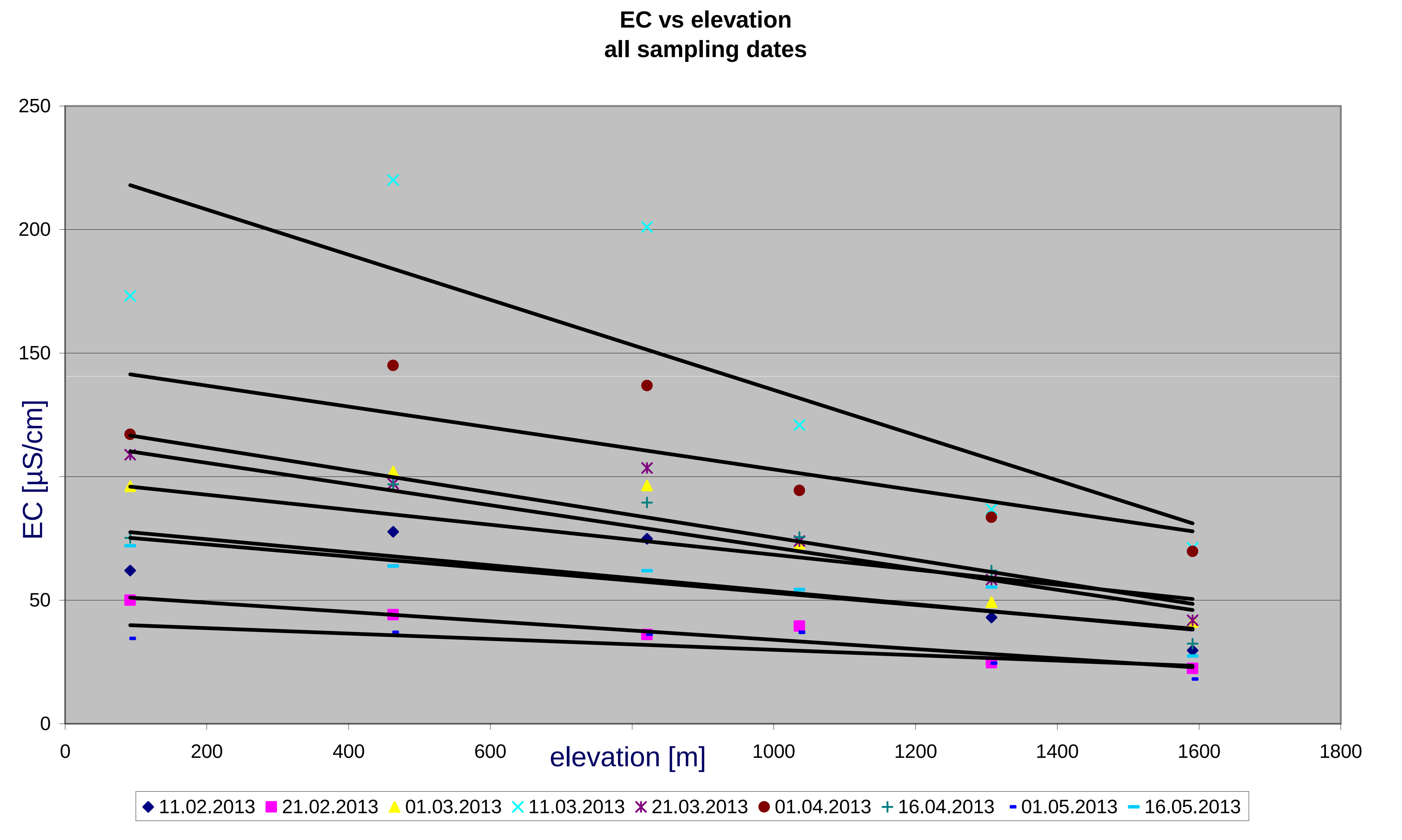
Regional Comparison

GNIP stations
(Global Network of Isotopes
in Precipitation)
www-naweb.iaea.org/napc/ih/
IHS_ resources_isohis.html

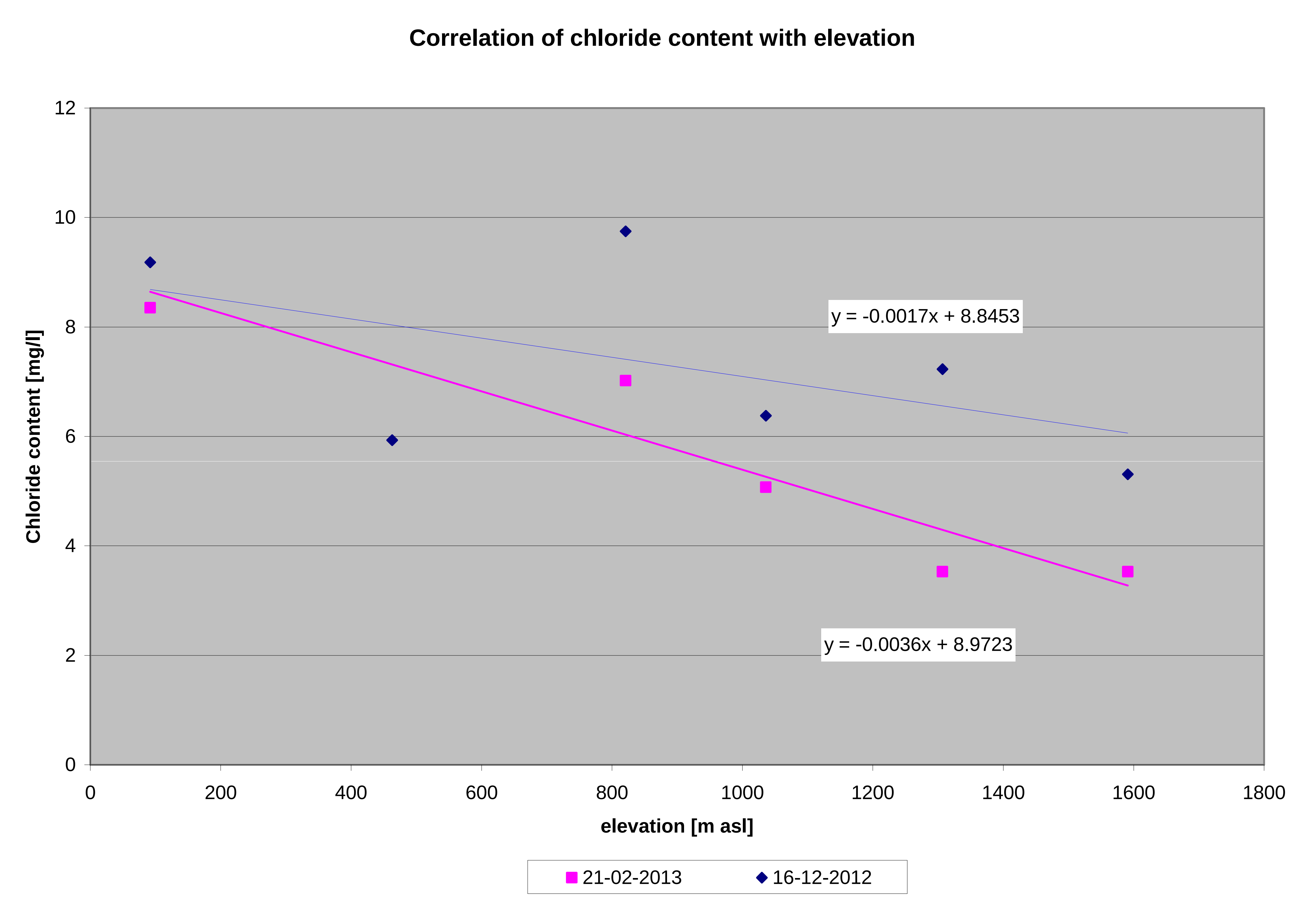
Israel : 1350 ^{18}O samples
Syria : 151 ^{18}O samples
Lebanon : 155 ^{18}O samples
Jordan : 569 ^{18}O samples



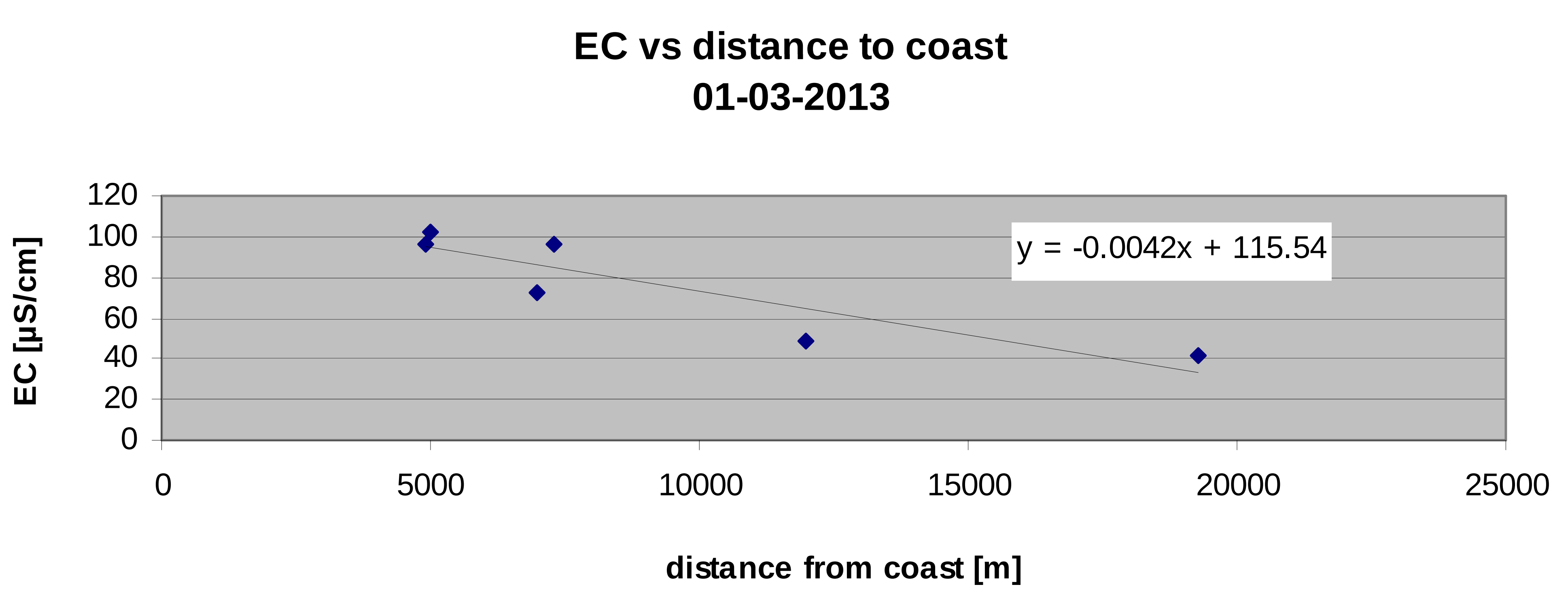
Chloride Content in Rainfall

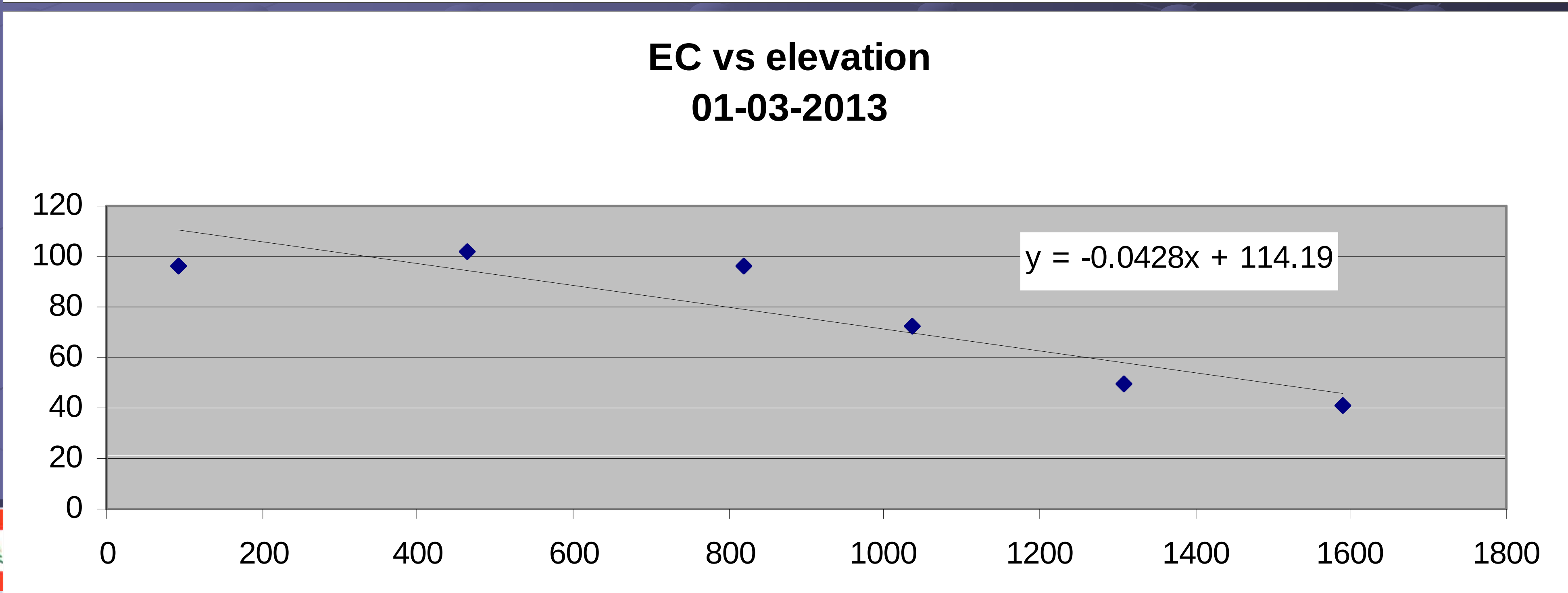


Chloride Content in Rainfall



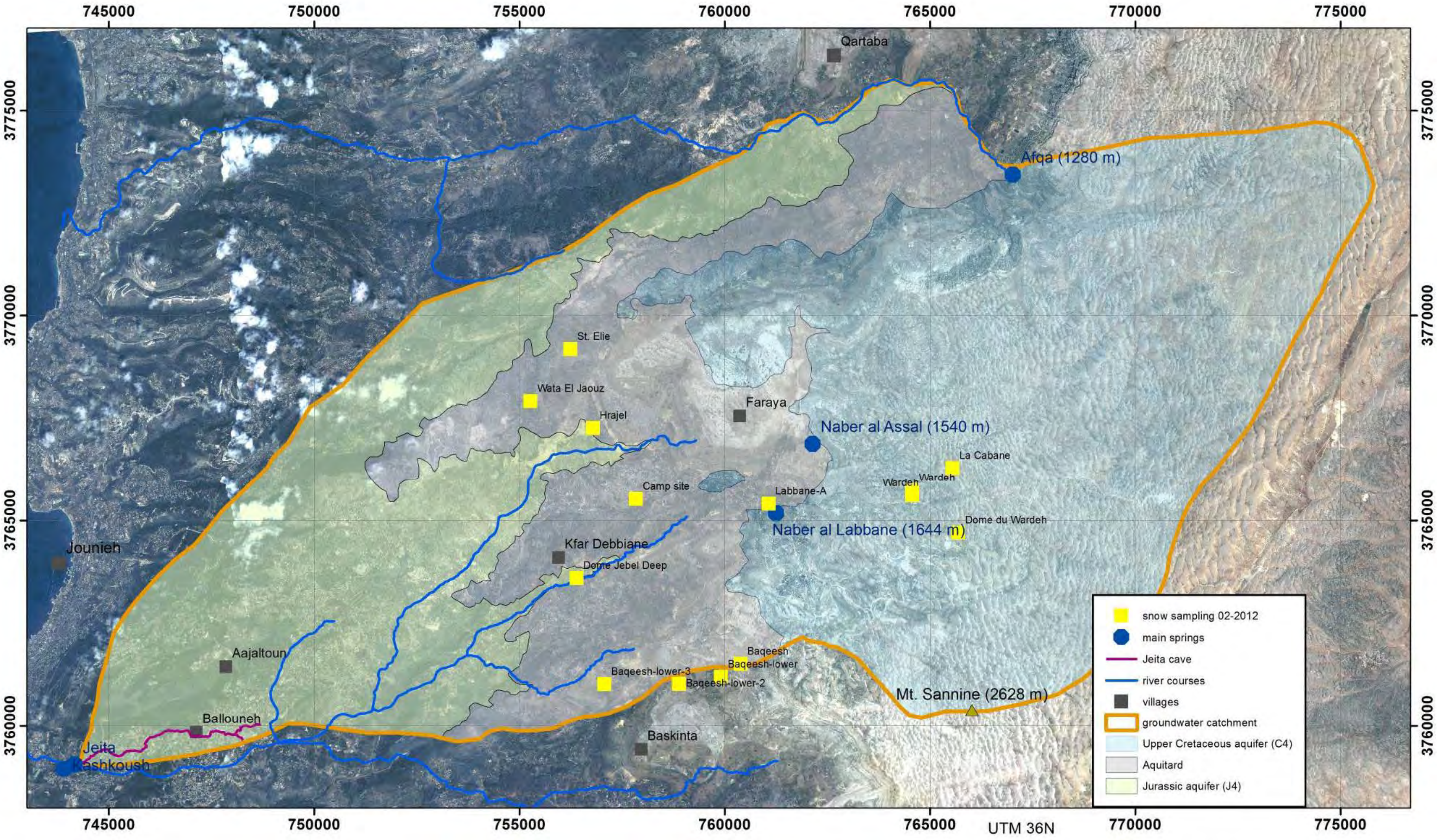
Chloride Content in Rainfall





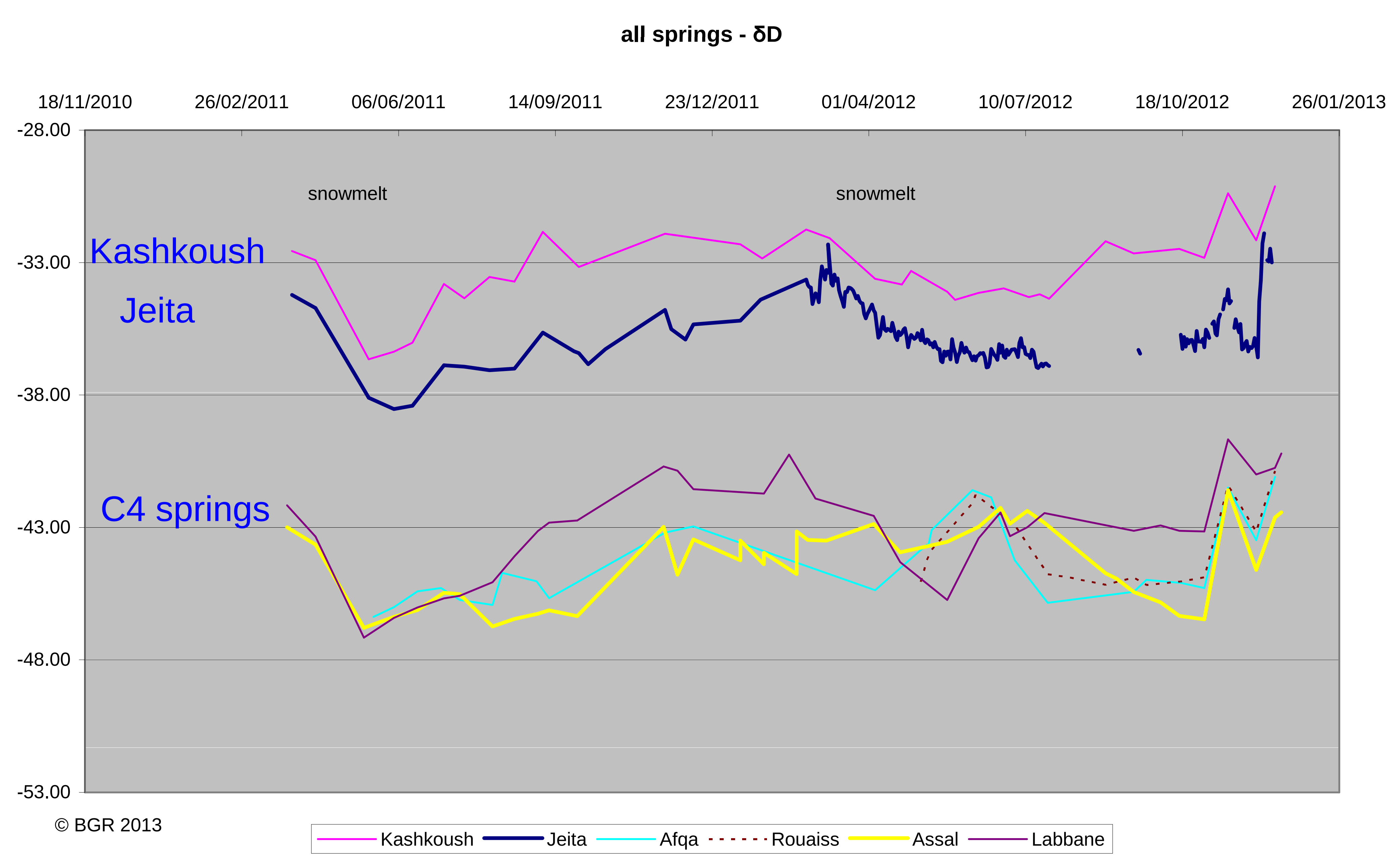
Snow sampling at different elevations (February 2012, February 2013)

a) entire snow column
b) 10 cm intervals

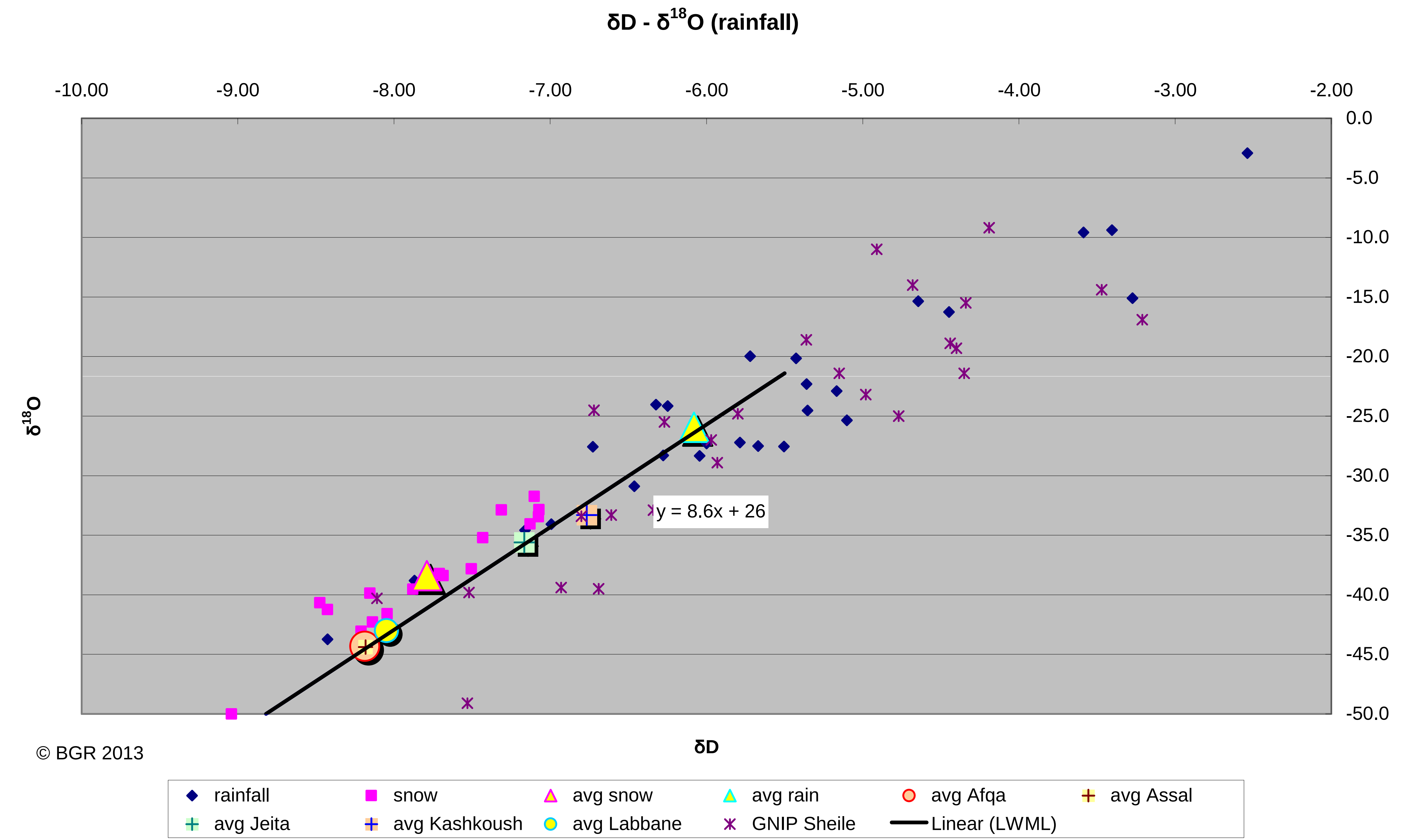


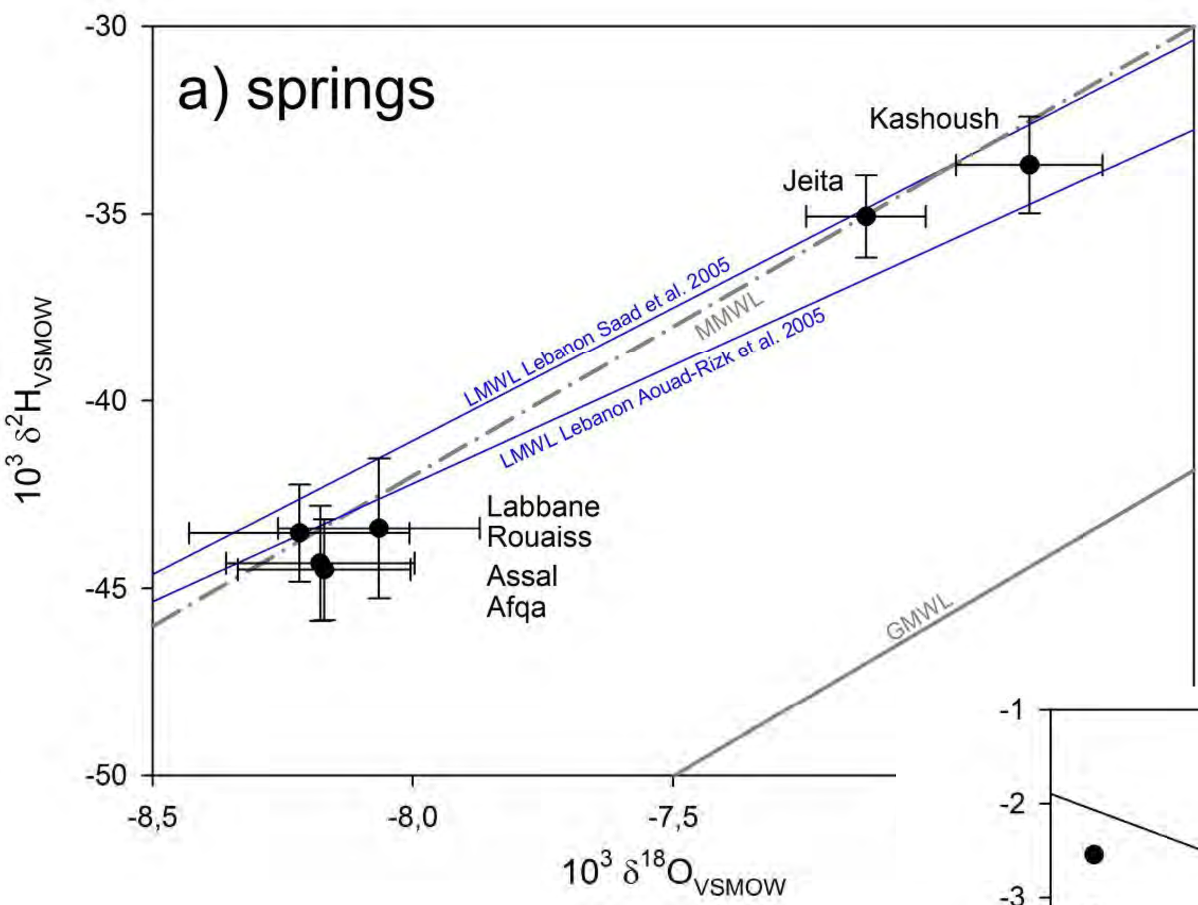



Spring Sampling

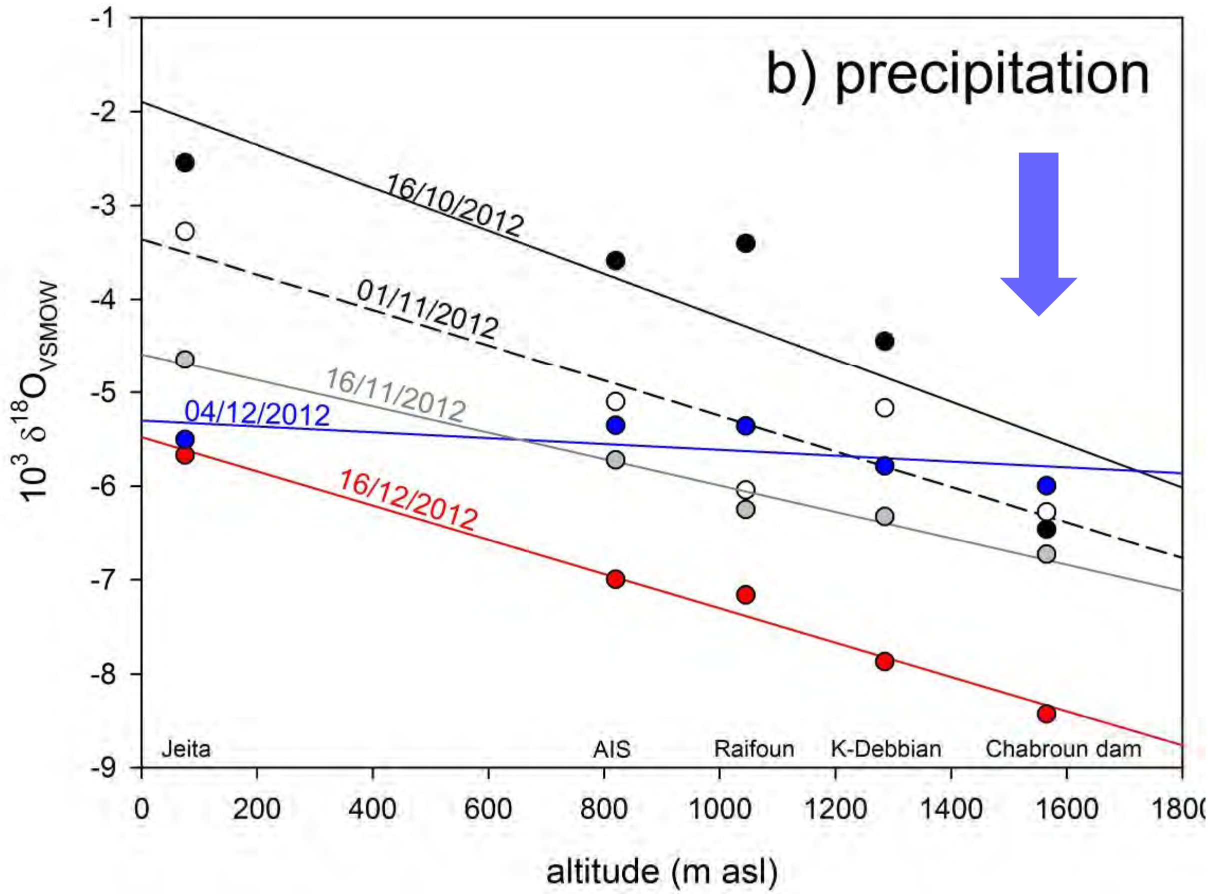


Spring Sampling





decrease in heavy isotopes with increasing elevation composition different for every storm event



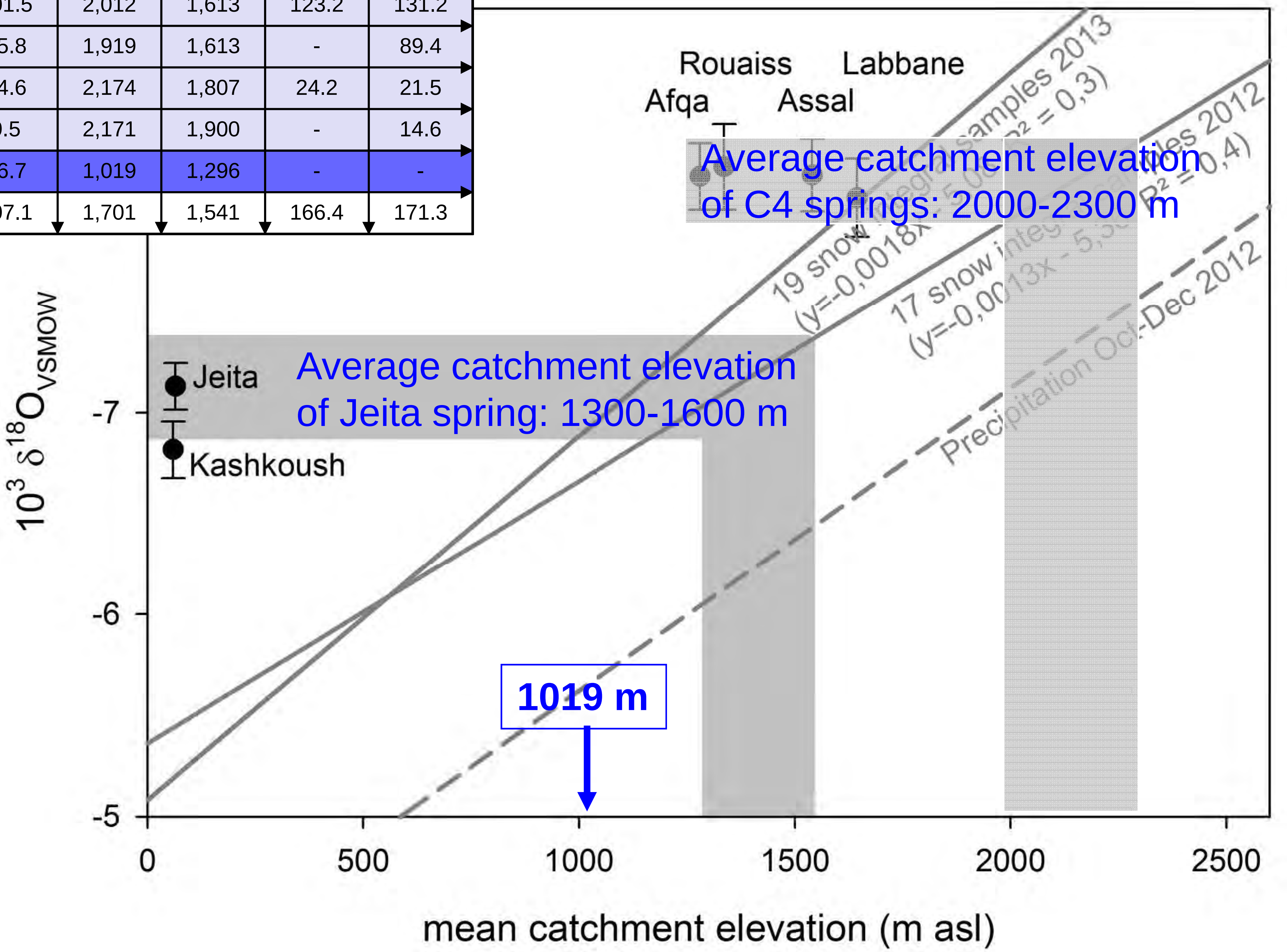
average composition of springs

Avg catchment elevation:

Afqa	2012 m
Rouaiss	1919 m
Assal	2174 m
Labbane	2171 m
Jeita (J4)	1019 m
Jeita (all)	1629 m

Isotope data

GW Catchment	Aquifer	Size [km²]	Mean Elevation [m]	Mean Rainfall [mm/a]	Mean Discharge Measured [MCM/a]	Mean Discharge WEAP model [MCM/a]
Afqa	C4	101.5	2,012	1,613	123.2	131.2
Rouaiss	C4	65.8	1,919	1,613	-	89.4
Assal	C4	14.6	2,174	1,807	24.2	21.5
Labbane	C4	9.5	2,171	1,900	-	14.6
Jeita	J4	86.7	1,019	1,296	-	-
Jeita	C4+J4	307.1	1,701	1,541	166.4	171.3



Spring Sampling

- Pronounced seasonal variation of $\delta^{18}O$ and $\delta^{2}H$ with fast response to snowmelt
- Significant difference between Jeita/Kashkoush and C4 springs
- Response of C4 springs fits with catchment elevation
- Difference in composition between Jeita and Kashkoush spring points to lower average catchment elevation of Kashkoush spring
- Jeita spring must be fed by contribution from higher elevations (more than 30%)

Other Environmental Tracers

Special Report No. 15
(GEYER & DOUMMAR, 2013)

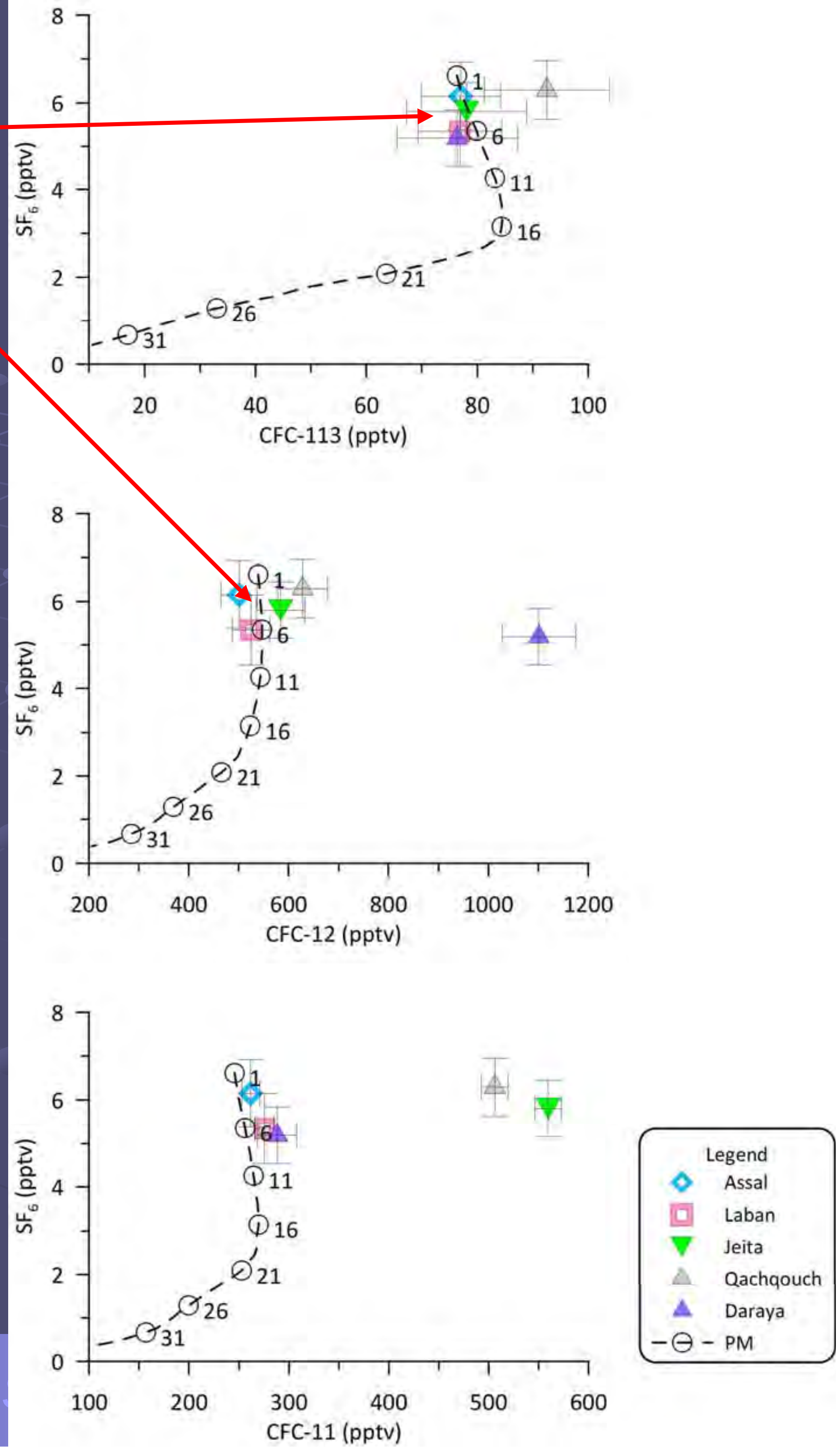
Helium - Tritium
Chlorofluorocarbons (CFC) and SF6 samples from
Jeita, Daraya (Jeita siphon terminale), Assal, Labbane and Kashkoush springs

Groundwater dating using CFC-11 (CCl3F), CFC-12 (CCl2F2) and CFC-113 (CFCl2CClF2)
- historic amounts in the atmosphere over the past 50 years (were reconstructed)
- solubilities in water
- concentrations in air and water
(USGS: pubs.usgs.gov/fs/ FS-134-99/)

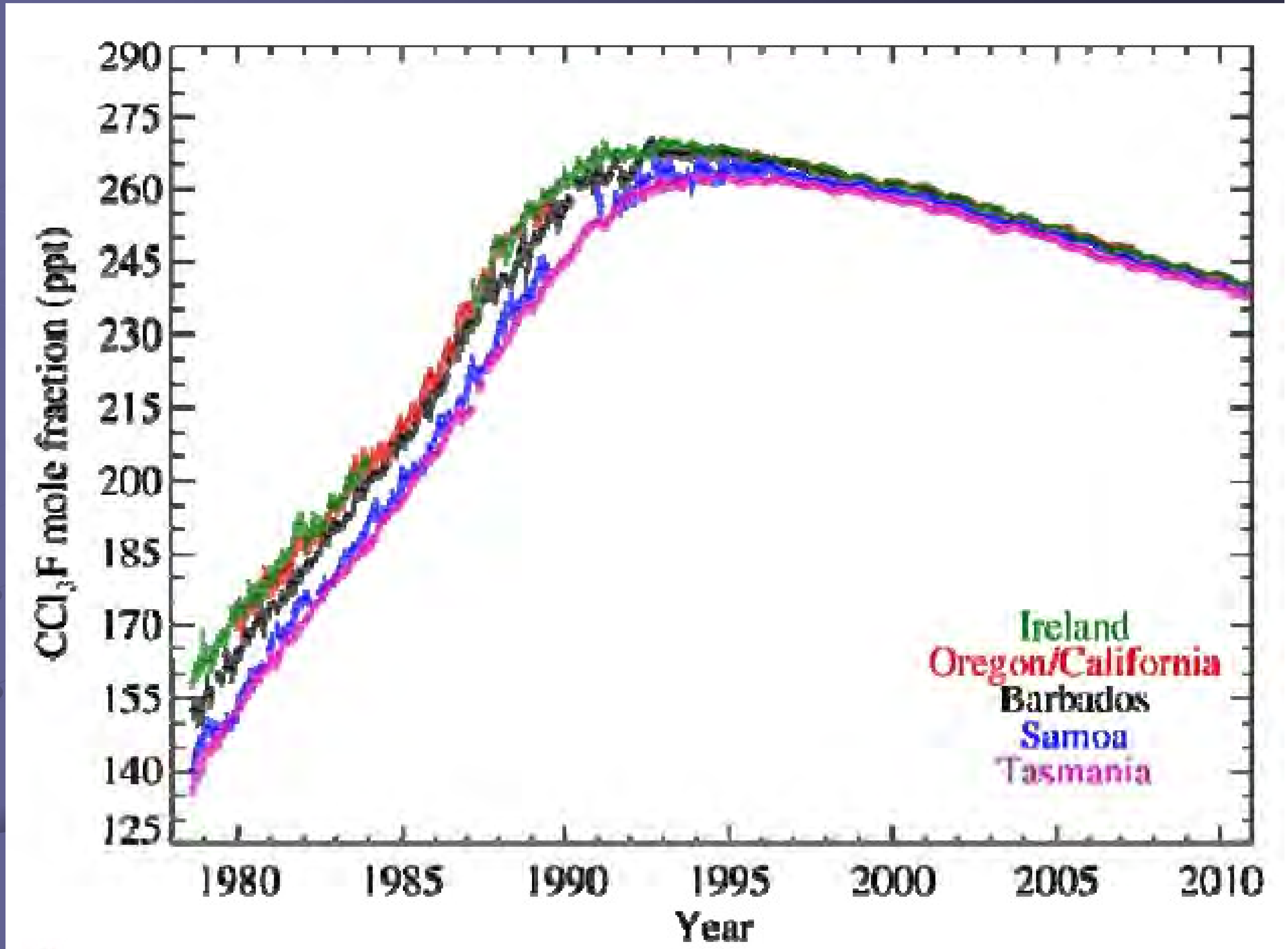
Measurements using gas chromatography with electron-capture-detector

Evaluation using piston-flow conspt after Maloszewski & Zuber (2002)

Age: 1 – 6 years


SF6 (pptv)
CFC-113 (pptv)
CFC-12 (pptv)
CFC-11 (pptv)
1
6
11
16
21
26
31
Legend
Assal
Laban
Jeita
Qachqouch
Daraya
PM

CFC-11



source: www.agage.eas.gatech.edu

Helium – Tritium method (Sültenfuß et al., 2009)
Determination of concentration in water of
Helium (^3He, ^4He) and Neon (^{20}Ne, ^{22}Ne)
> determined by sector mass spectrometer

Gas samples taken in copper pipe (40 ml)
Tritium (^3H) taken in 500 ml glass bottles

Radioactive decay of Tritium in groundwater leads to accumulation of $^3He_{(trit)}$ in GW.

$$\frac{^3H}{^3He_{trit}age} = \frac{T_{1/2}}{ln2} ln\left(1 + \frac{^3He_{trit}}{^3H}\right)$$

Location	Date	Tritium	Helium-3	Helium-4	Helium/ Tritium Age
		TU	ccSTP kg^{-1}	ccSTP kg^{-1}	Years
Jeita	17.09.2010	3,03 ±0,31	6.65E-11	4.85E-05	0,9
Daraya tunnel	17.09.2010	3,00 ±0,18	6.85E-11	4.97E-05	1,6
Labbane	18.09.2010	3,26 ±1,32	5.82E-11	4.20E-05	1,7
Assal	18.09.2010	3,27 ±0,23	5.81E-11	4.24E-05	1,5
Kashkoush	19.09.2010	2,99 ±0,24	6.91E-11	5.03E-05	0,9

Sampling equipment

Thank you for your kind attention

www.bgr.bund.de/jeita

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armin.margane@bgr.de +961 70 398027

HASHEMITE KINGDOM OF JORDAN
Ministry of Water and Irrigation
(MWI)
Amman

Federal Institute for Geosciences
and Natural Resources (BGR),
Hannover, Germany

Jordanian-German Technical Cooperation Project

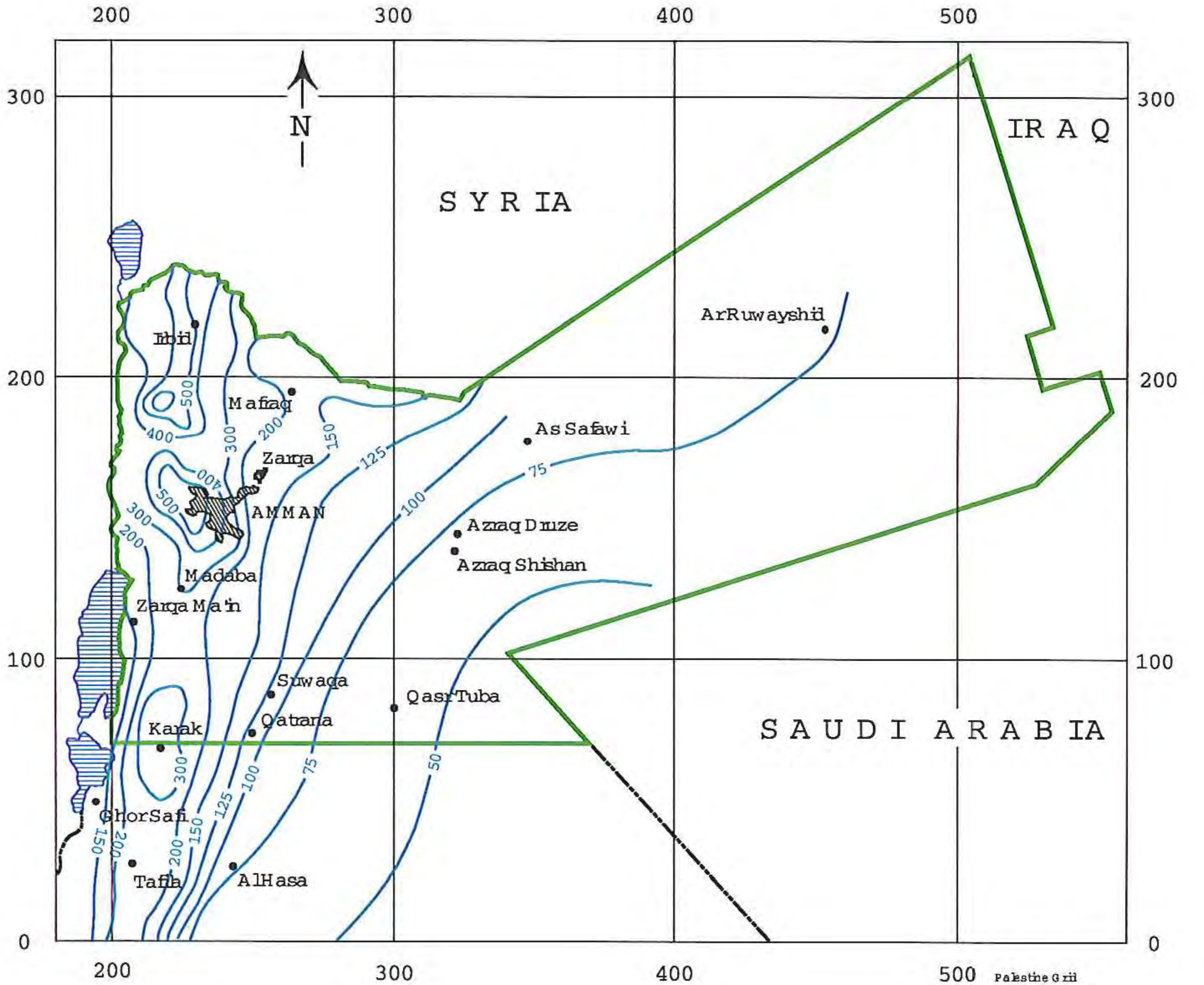
Groundwater Resources Management (2002-2010)

GW Recharge Assessment / Water Balance

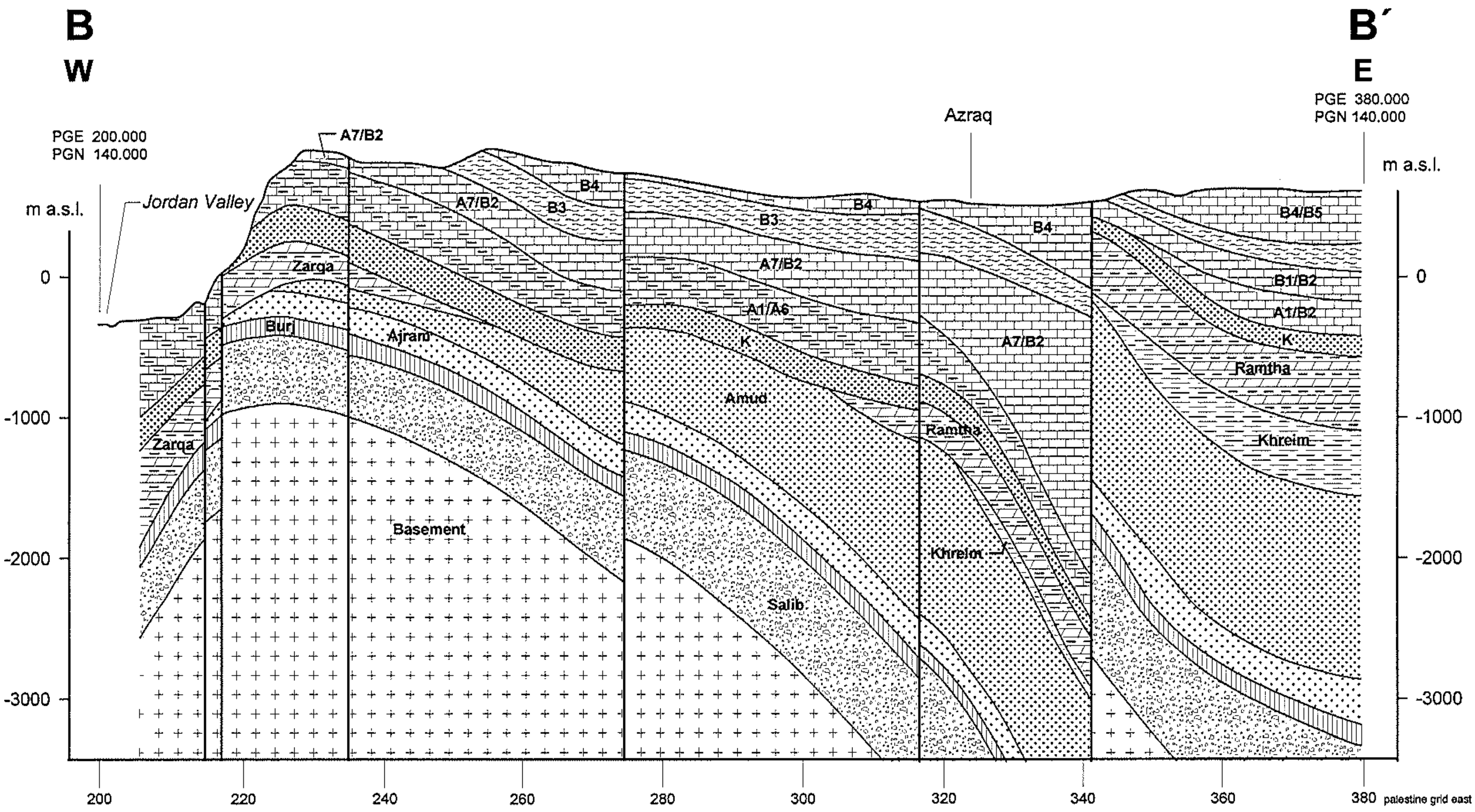
Project Exchange Meeting Jordan - Lebanon
31 October 2013

تعاون
المملكة الاردنية الهاشمية
جمهورية ألمانيا الاتحادية

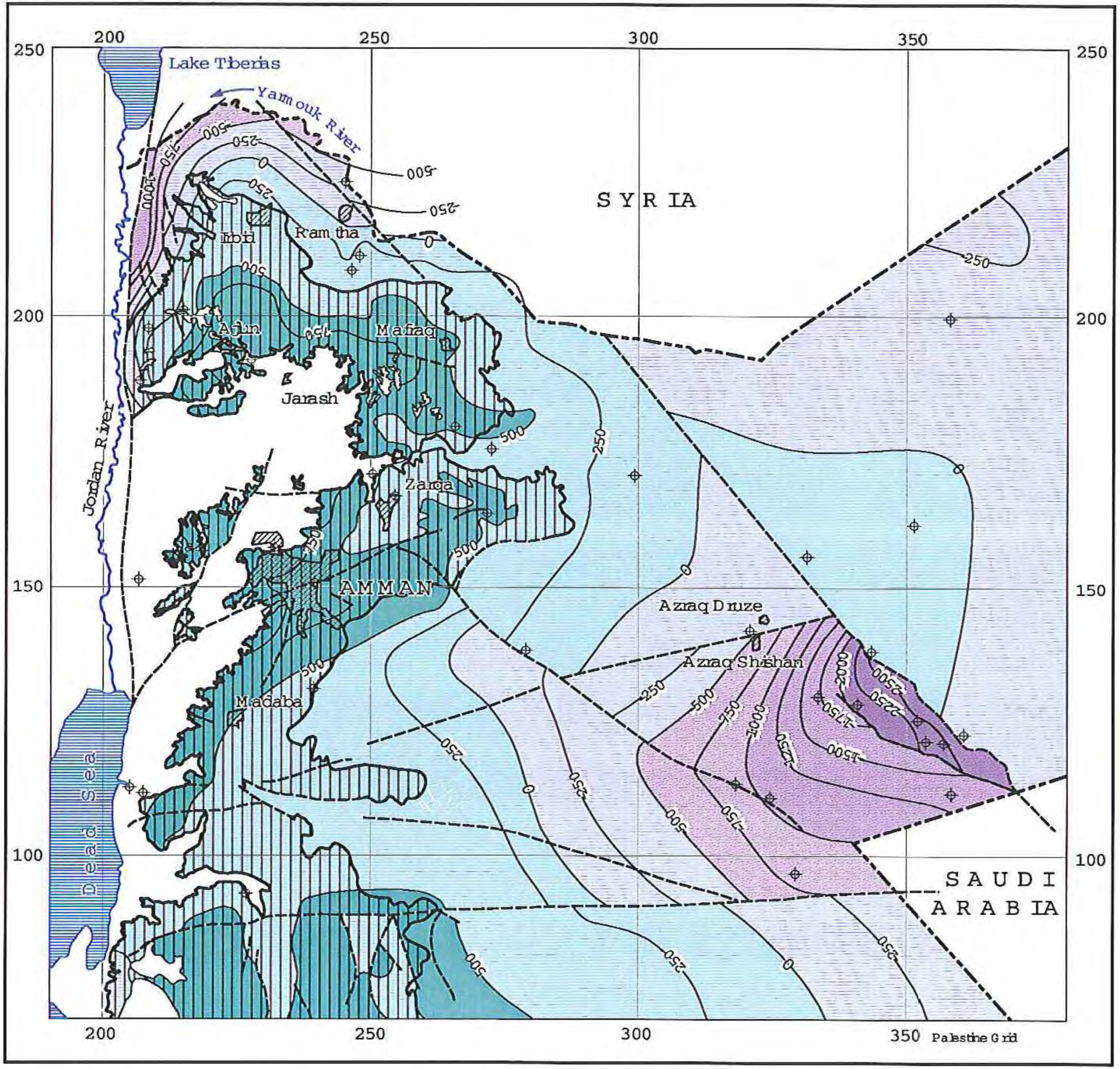
Dr. Armin Margane



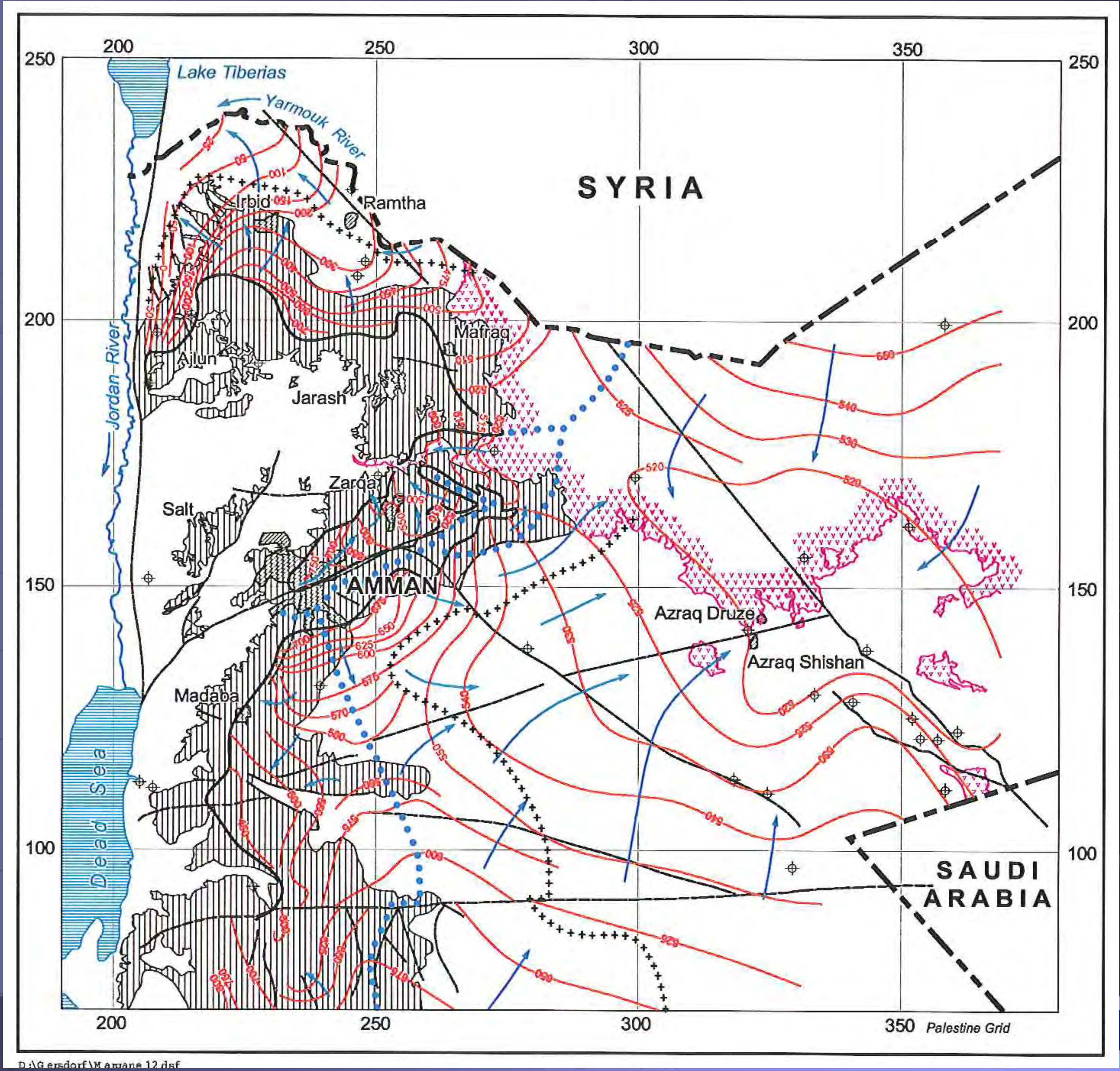
N
SYRIA
IRAQ
SAUDI ARABIA
Irbid
Mafraq
Zarqa
AMMAN
Madaba
Zarqa Ma'in
As Safawi
Ar Ruwayshid
Azraq Druze
Azraq Shishan
Suwaqa
Qasr Tuba
Qatrana
Karak
Ghor Safi
Tafila
Al Hasa
500
400
300
200
150
125
100
75
50
200
300
400
500
100
0
Palestine Grid



B
W
B´
E
PGE 380.000
PGN 140.000
PGE 200.000
PGN 140.000
Azraq
A7/B2
Jordan Valley
m a.s.l.
m a.s.l.
B4
B3
A7/B2
B4/B5
B1/B2
A1/B2
K
Ramtha
Khreim
A1/A6
Amud
Zarqa
Burj
Ajram
Basement
Salib
Khreim
Ramtha
0
-1000
-2000
-3000
200
220
240
260
280
300
320
340
360
380
palestine grid east



Lake Tiberias
Yarmouk River
SYRIA
Irbid
Ramtha
Ajlun
Mafraq
Jarash
Jordan River
Zarqa
AMMAN
Azraq Druze
Azraq Shishan
Madaba
Dead Sea
SAUDI ARABIA
Palestine Grid



Lake Tiberias
Yarmouk River
Jordan River
Dead Sea
SYRIA
SAUDI ARABIA
Irbid
Ramtha
Mafraq
Ajlun
Jarash
Zarqa
Salt
AMMAN
Madaba
Azraq Druze
Azraq Shishan
200
250
300
350
150
100
Palestine Grid
BGR
D:\Gersdorf\Mamane 12.dsf

The recharge conditions in northern Jordan vary considerably within short distances.

Important factors which influence the recharge mechanisms include the:

- Topographical gradient,
- Precipitation distribution,
- Run-off character (ponding, etc.),
- Agricultural activities (land preparation, irrigation, etc.),
- Water courses (influent or effluent conditions),
- Soil (texture, thickness, rooting depth, etc.),
- Flow mechanism in the unsaturated zone.

Recharge is defined as:

Recharge = precipitation - runoff - actual evapotranspiration $\pm$ changes in storage.

GW Recharge can be determined by:

- Direct measurement (by lysimeters)
- Water balances (soil moisture budget, river channel water balance, water budget, water table rise, spring flow, flow-net analysis)
- Darcian approach (flow of water in the unsaturated zone)
- Tracer techniques (chloride balance, D - ^{18}O relationship)

GW Recharge estimation based on chloride mass balance:

On the basis of the relation between chloride content in groundwater and rainfall, SEILER & ALMOMANI (1994) calculated a recharge rate of 3.3 % (using an average rainfall of 87 mm/a, a chloride ratio of 1.5 / 45 mg/l and a recharge area of 12,710 km^2 as input data). The high variability of chloride contents in recent rainwater makes this type of calculation problematic. Further, the chloride content of present-day rainwater might differ considerably from water recharged thousands of years ago (ESCWA/BGR 1996; M. GEYH).

GW Recharge estimation based on GW monitoring (water level fluctuations):

$$R = (\delta s + \sum Q_A * \delta t + V_D) / A * \delta t$$

R	: total recharge
δs	: volume of water stored between lowest and highest water table position
Q_A	: groundwater abstraction from production wells
δt	: time interval between low and high water table positions
A	: area
V_D	: volume of water discharged to springs, seeps in riverbeds etc.

The change in storage (δs) is calculated as:

Change in storage = specific yield * head difference

Disadvantage: influenced by pumping pattern for irrigation
Example Somaya wellfield (N-Jordan)

GW Recharge estimation based on spring discharge measurements:

- Defined catchment
- Acurate spring discharge
- Acurate rainfall

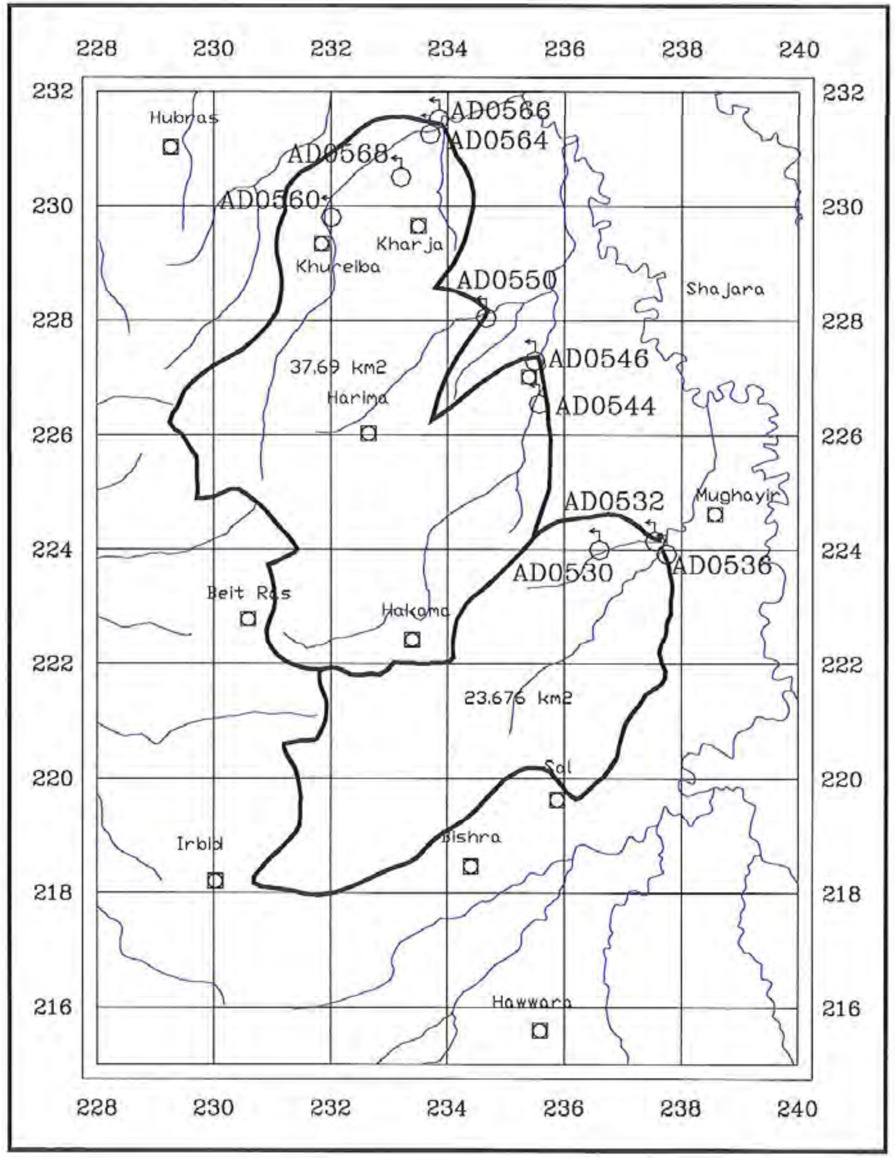
Example: North Jordan B4 springs

the springs AD0530, AD0532 and AD0536 (grouped as AD-2 in Vol. 1, Part 2 of the project reports; BGR & WAJ 1996), recharge has been estimated as follows:

Spring discharge:	0.527 MCM
Well abstraction:	0.0 MCM
Catchment area:	23.676 km^2
Total rainfall:	9.0 MCM (nearest rainfall station AD0009)
Recharge:	**5.9 %** of the rainfall volume.

For the springs AD0544, AD0546, AD0550, AD0560, AD0564, AD0566 and AD0568 (grouped as AD-4 and AD-5 in Vol. 1, Part 2) recharge has been estimated as follows:

Spring discharge:	0.724 MCM
Well abstraction:	0.0 MCM
Catchment area:	37.69 km^2
Total rainfall:	16.2 MCM (nearest rainfall station AD0009)
Recharge:	**4.5%** of the rainfall volume.



GW Recharge estimation based on flow net analysis:

- Acurate GW contours
- Acurate hydraulic conductivity

$$Q = K * I * A$$

Q	: groundwater flow
K	: hydraulic conductivity
I	: gradient
A	: area

Area	Method	Recharge [%]	Reference
Northern Riftside Catchment Area	Climatic balance	14.4	WAJ (1989)
Northern Riftside Catchment Area	Spring flow	Up to 25 (30% in wet years)	This report
Azraq Basin	Water balance	2.9 (0.8 – 6 %)	R. TA'ANY (1996)
Amman-Zarqa Basin	Storm-by-storm analysis (US Soil Conservation Service)	14	WAJ (1989)
Salt (springs AM-1, AM-2)	Spring flow	18.4	This report
Wadi Juheira (springs CD-5)	Spring flow	6-8	This report)
Udruh	Water level fluctuations	(up to ~30% in very wet years)	This report

Table 1: Goundwater Recharge Rates of the A7/B2 Aquifer

Historic GW recharge estimates

- Vierhuff (National Master Plan 1977): 462 MCM/a (6.4% of rainfall)
- WAJ (BILBEISI, 1992): 275 MCM/a (4%)
- BGR (North Jordan Project, 2001): 280 MCM/a

Pre-development baseflow: 380 MCM/a but large share of discharge coming from more humid time periods (last glacial period)

- GIZ NWMP 2004: 395 MCM, also used in BGR GW-Model

In most cases, baseflow measurements are only available for a limited number of years and not for all wadis. It is therefore fairly difficult to estimate the amounts of pre-development and present-day baseflow. In many wadis, baseflow is measured only randomly (sometimes only every 3 months). Since the calculated baseflow varies considerably from year to year, the margin of error may be as high as 20 %.

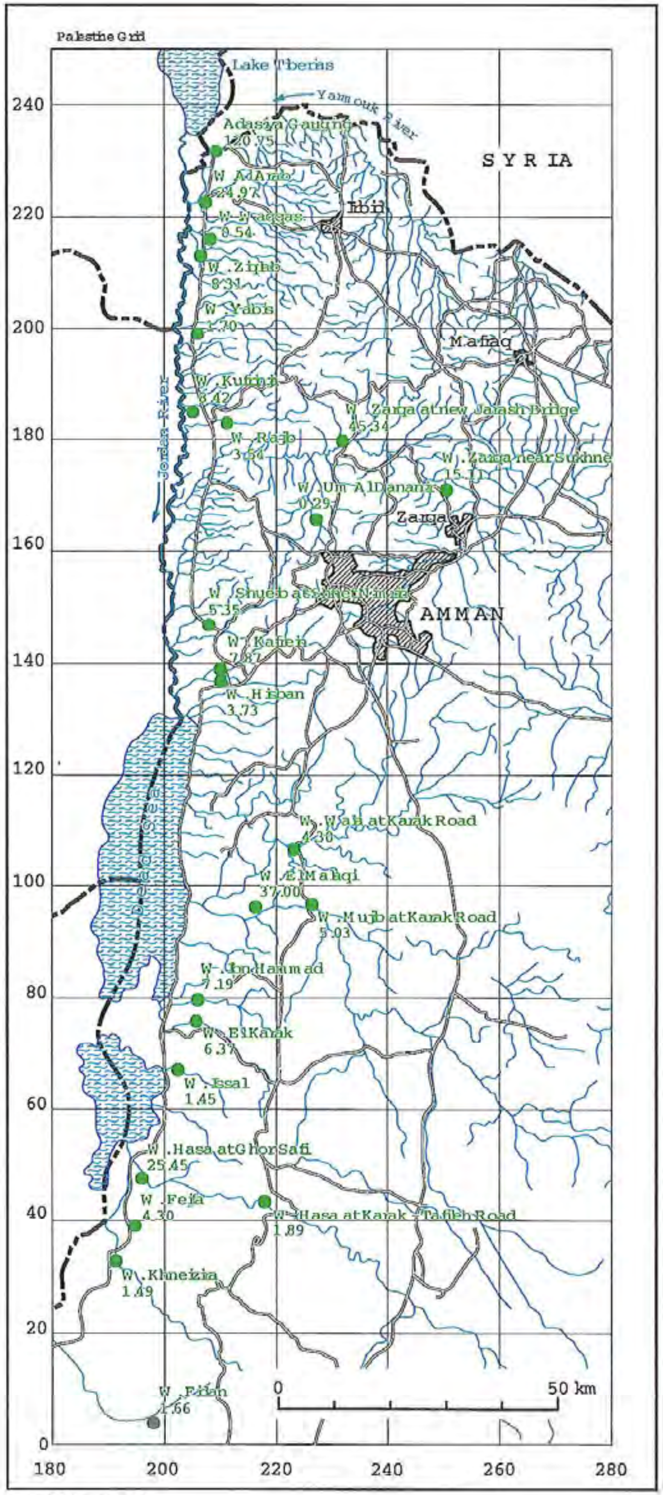
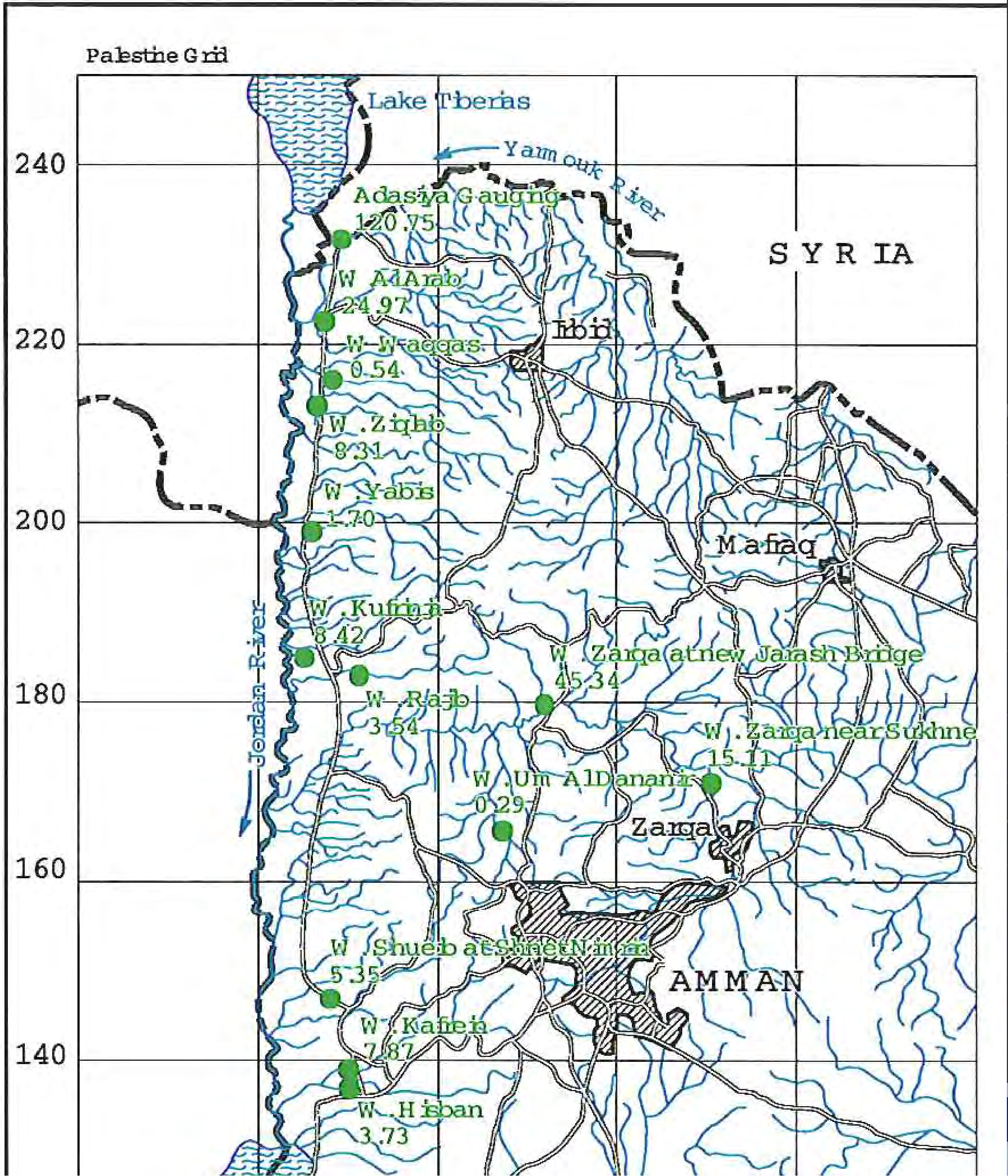


Fig. 20: Baseflow in Northern and Central Jordan



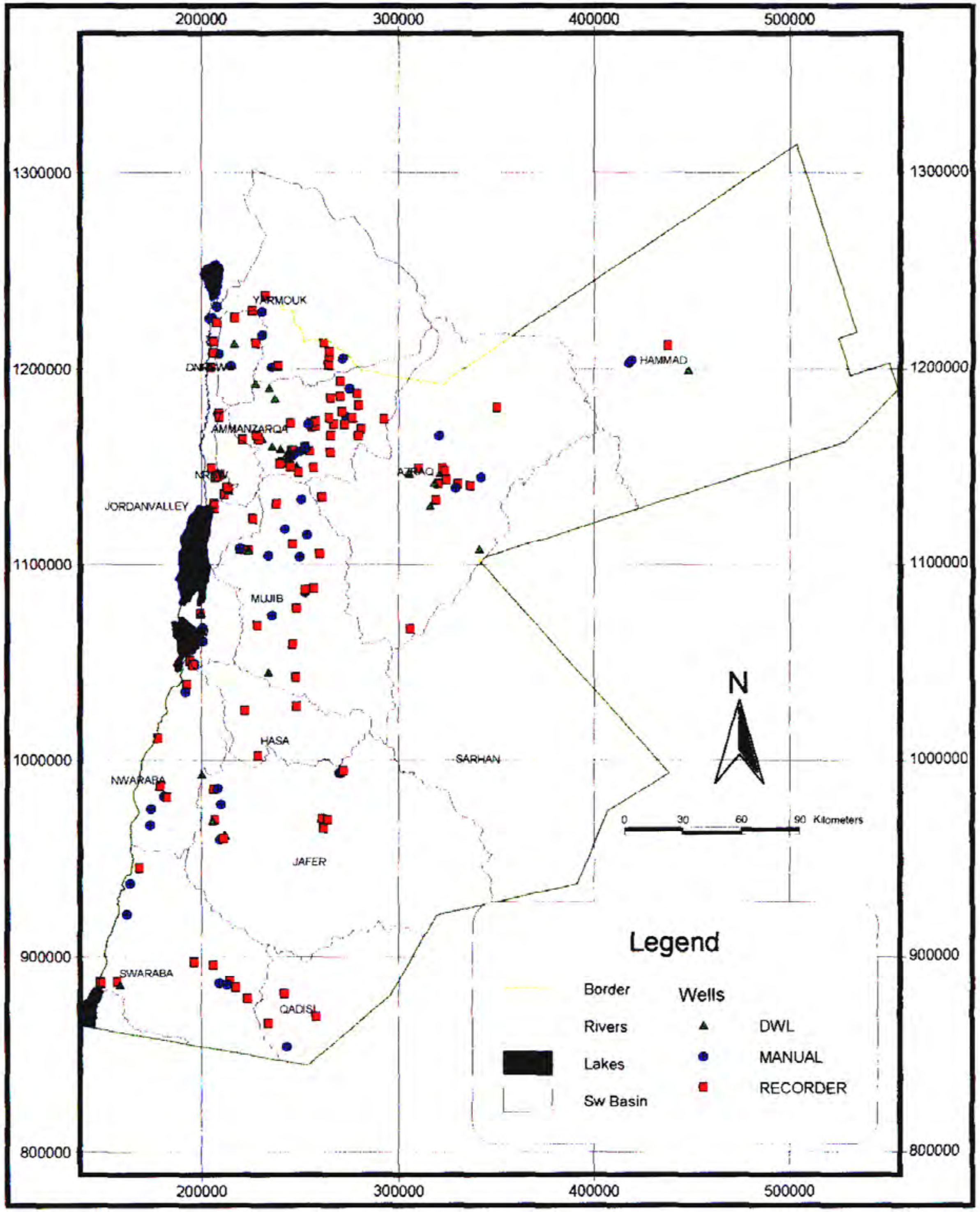
Palestine Grid
Lake Tiberias
Yarmouk River
Adasiya Gauging
120.75
SYRIA
W. Al Arab
24.97
Irbid
W. Waqqas
0.54
W. Ziglab
8.31
W. Yabis
1.70
Mafraq
W. Kufrinja
8.42
Jordan River
W. Zarqa at new Jarash Bridge
45.34
W. Rajib
3.54
W. Zarqa near Sukhne
15.11
W. Um Al Dananir
0.29
Zarqa
W. Shueib at Shnet Nimrin
5.35
AMMAN
W. Kafrein
7.87
W. Hisban
3.73
240
220
200
180
160
140

Area	Name	Period	Recorded Baseflow	Unrecorded Baseflow	Total Baseflow Pre-development	Total Baseflow Today (estimated)	Spring Discharge Average 1983/84-1992/93
AB	Jordan Valley	1982-89	0.5	35	35.5	25.0	27.4
AD	Yarmouk (from Jordan only)	1963-81	40.0		40.0	35.0	17.0
Ä	Wadi al Arab	1973-88	25.0		25.0	0.0	9.2
AF	Wadi Ziqlab	1963-80	8.3		8.3	6.0	0.1
AG	Wadi Jirim (included in AB)	-	-		0.0	0.0	-
AH	Wadi al Yabis	1981-92	1.7	3.8	5.5	1.5	5.5
AJ	Waki Kufrinja	1970-88	5.9	1.7	7.6	5.0	7.6
AK	Wadi Rajeeb	1981-93	3.5		3.5	3.5	1.0
AL	Seil Zarqa [4]	1985-93	45.3		27.2	15.0	27.2
AM	Wadi Shuayb	1981-93	5.4	5.9	11.3	8.0	11.3
AN	Wadi Kafrein	1985-93	7.9	3.8	11.7	8.0	11.7
AP	Wadi Hisban	1982-93	3.7	1.0	4.7	3.5	4.7
CA	Dead Sea Side Catchments [1]	1978-93	8.6	39.7	48.3	40.0	48.3
CD	Wadi Mujib	1964-78	37.0	20	57.0	50.0	16.8
CE	Wadi al Kerak	1978-93	6.4	1.4	7.8	6.0	7.8
CF	Wadi al Hasa	1963-81	25.5		25.5	20.0	3.7
DA	Wadi Umruq	1978-93	0.4	2.5	2.9	2.0	2.9
DB	Wadi Feifa	1978-93	4.3	2.4	6.7	5.0	6.7
DC	Khneizira	1978-93	1.5		1.5	1.5	2.2
DE	Wadi Fidan	1978-93	1.6		1.6	1.5	0.2
EA	Wadi Tlah			0.8	0.8	0.8	0.8
G	Wadi Jurdhna	1963-82	46.3		46.3	40.0	
N-Jordan			**165.7**	**86.4**	**232.9**	**155.5**	**163.3**
Total A+C			**224.7**	**112.3**	**318.9**	**226.5**	**199.2**
Total Jordan			**278.8**	**118.0**	**378.7**	**277.3**	**212.0**

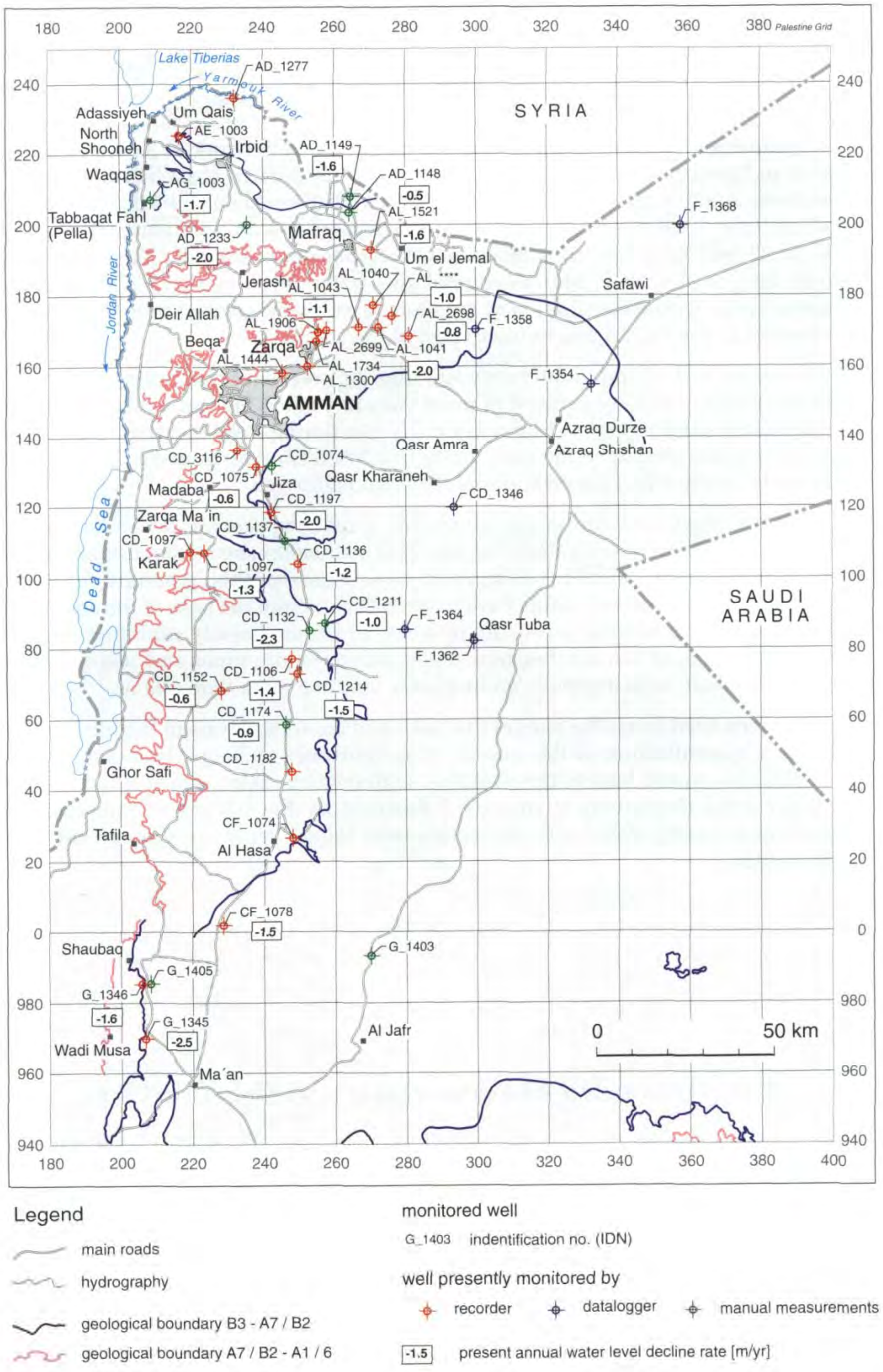
Safe Yield by Groundwater Basins

Basin	Safe Yield (MCM)
Jordan Valley	21
Yarmouk	40
Northern Rift Side Wadis	8
Southern rift side wadis	7
Amman-Zarqa	87.5
Dead Sea	7.4
Mujib	32.8
Wadi Hasa	12.8
Northern Wadi Araba	4
Southern Wadi Araba	6
Southern Desert	<1
Jafr	6
Azraq	30
Sirhan	5
Hammad	8
Total	**276**

GW Monitoring



GW Monitoring
Water Level Decline



Thank you for your kind attention

Technical Cooperation Project
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www.bgr.bund.de/jordan2002-9

Development Cooperation
Hashemite Kingdom of Jordan
Federal Republic of Germany

German-Jordanian Programme
"Management of Water Resources"
Telemetry Water Resources Observation Network

Hussein Hamdan, GIZ

Eng. Ali Subah, MWI

Hashem Alnaser, MWI

Background

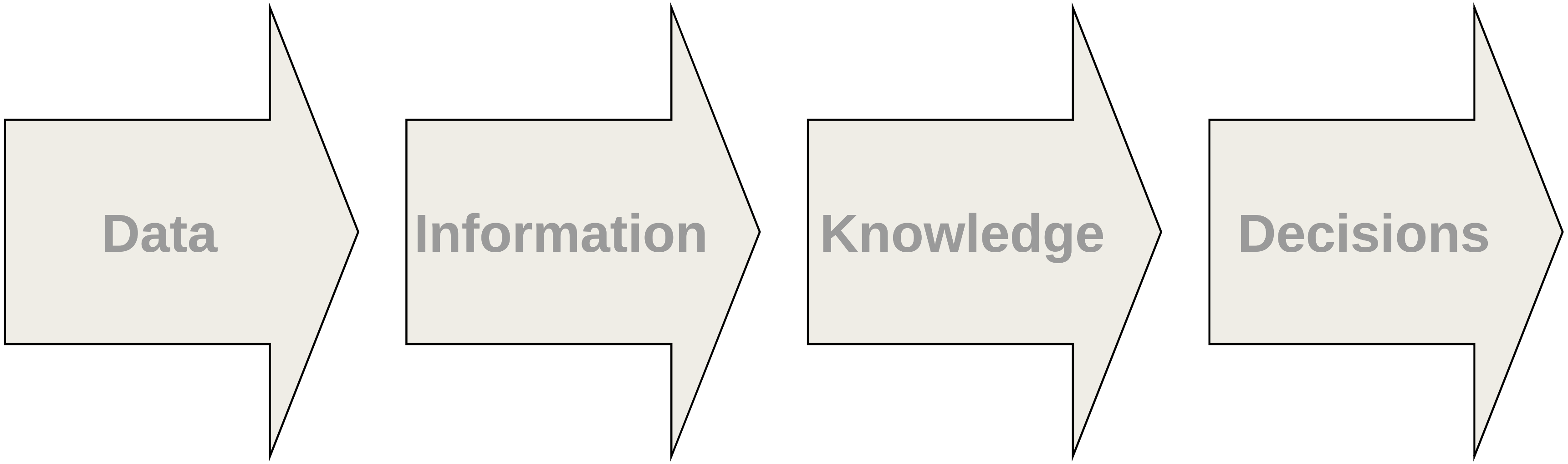
- Hydro-meteorological data is **essential** for planning, design and implementation of all water related activities (improved resilience in case of extreme weather events)

- Continuous hydro-meteorological measurements of good quality are necessary for climate records in the long term

- “the existing climatic and water resources monitoring in the country is facing permanent problems in operation, slow modernization of equipment and reducing of the monitoring network”

Second National Communication of Jordan to the UNFCCC, 2009

Background



Telemetric

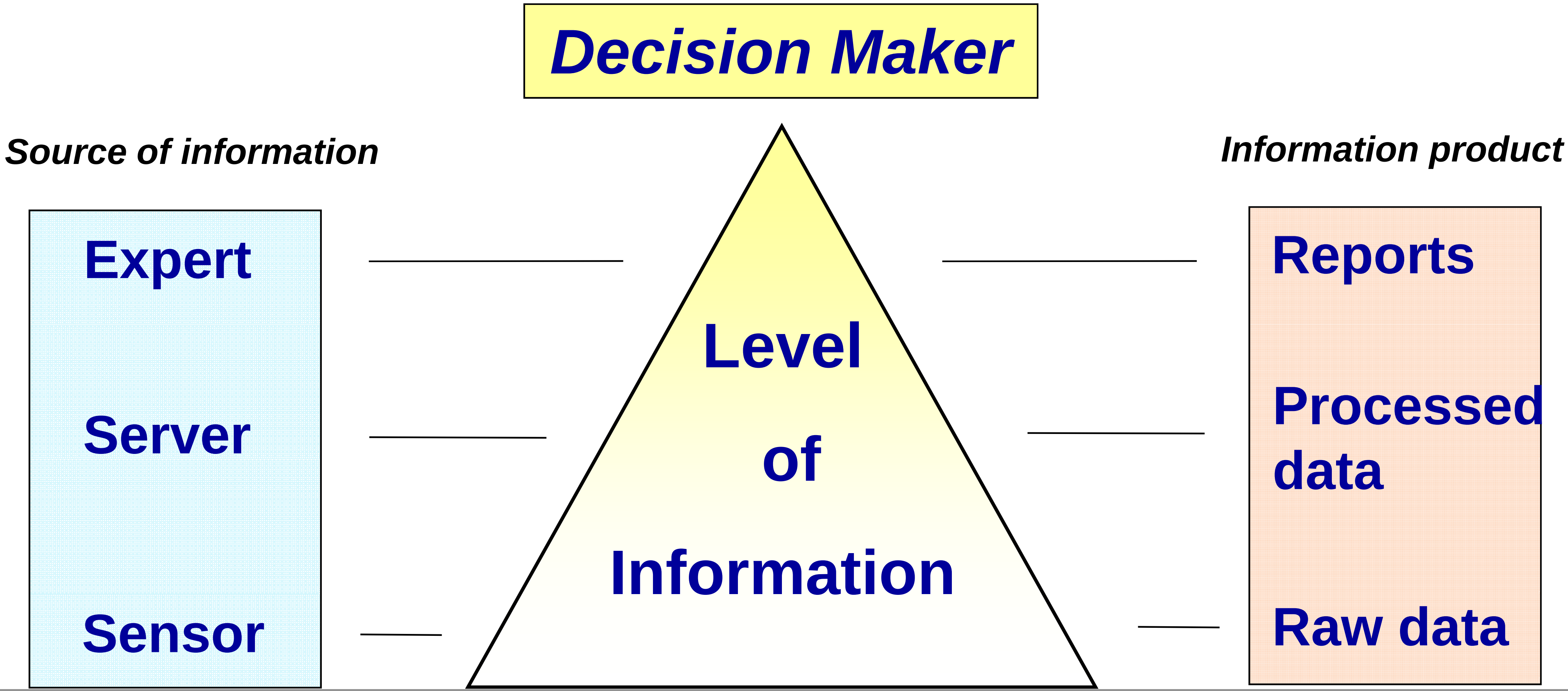
- *giz* has been approached by *MWI* on helping to develop a concept for an implementation of a National Water Resources Observation Programme (**NaWaROP**).

- As an important base element for future water sector management, *MWI* has decided to include a modern Telemetric Water Resources Observation Network facilitating sound data acquisition (**TeWaRON**)

Concept development for NaWaROP

- **The Concept consists of the following elements:**
  - Recommendations for the build-up of TeWaRON
  - Requirements for an effective operation of TeWaRON
  - Stepwise implementation schedule
  - Proposals for outsourcing of responsibilities & Establishment of corresponding administrative structures
  - Identification of information products for the Reporting
  - Cost estimation – Level of Effort

Basic characteristics of information aggregation to be achieved by NaWaROP



Benefit

NaWaROP

Capability to obtain profound knowledge of available amounts, quality and protection of Jordan's water resources being the foundation for effective decision making.

- Hydro administrative framework in support of **Good Water Governance**
- Provide legally **actionable** administrative conditions
- Establish empowerment of **hydro-administrative decision making**
- Establish and safeguard updating of official data on National Water Resources

Benefit

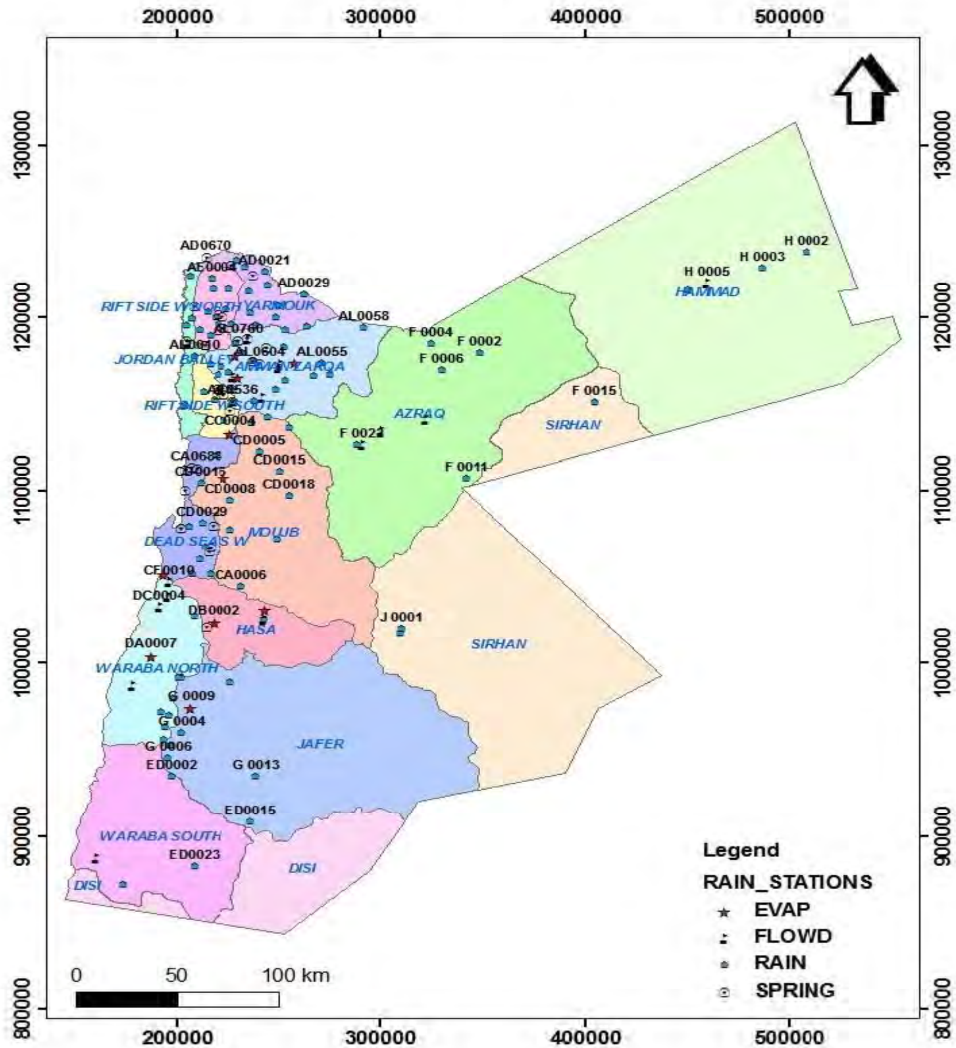
TeWaRON

provides a reliable scientific basis for

- Identification and assessment of available water resources
- Scenario Analysis – “what if” questions
- Hydro-environmental Impact Assessment
- **Integrated / associated / Spatial planning**
- Climate Impact Assessment

Telemetric Water Resources Observation Network (TeWaRON)

- Telemetric monitoring for
- Surface water
- Ground water
- Meteorological stations


200000
300000
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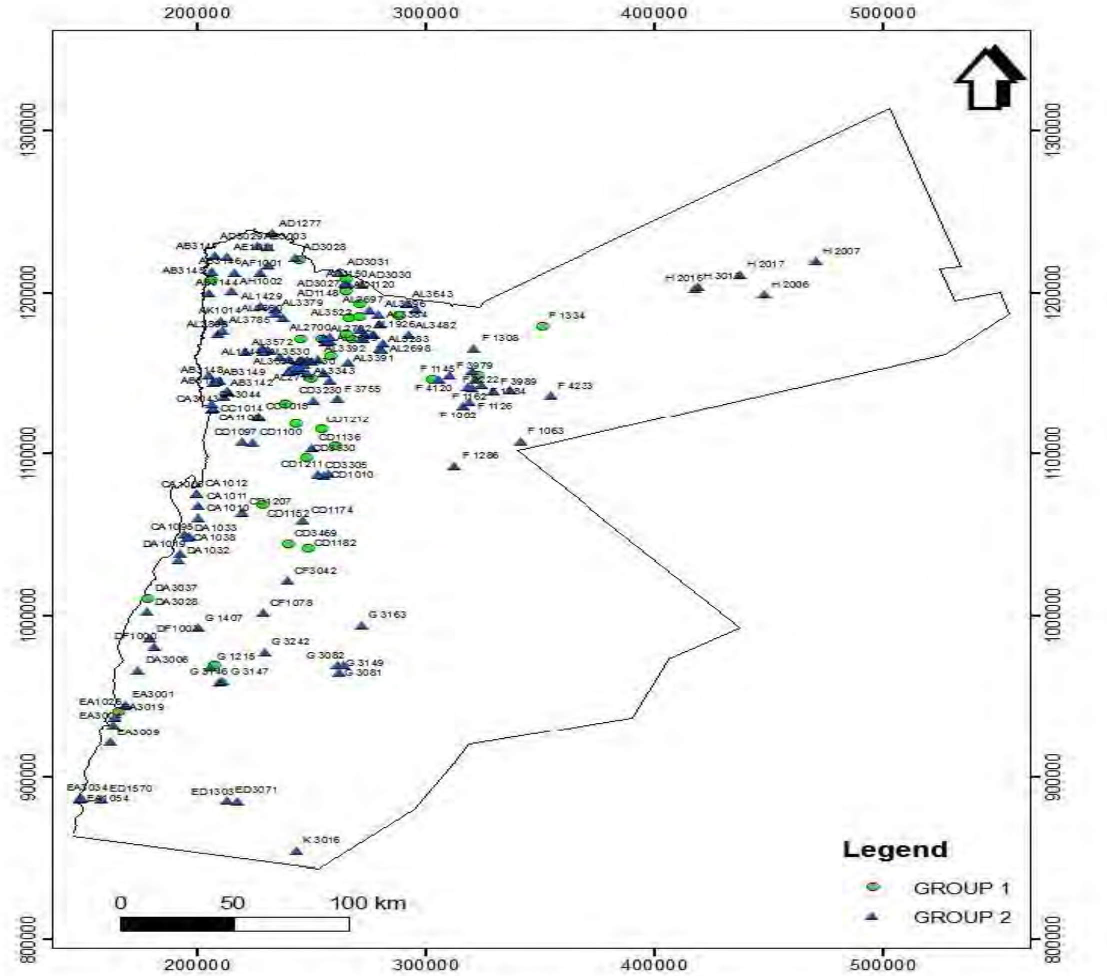
1000000
900000
800000
H 0002
H 0003
H 0005
HAMMAD
AD0670
AD0021
AE0004
AD0029
RIFT SIDE W NORTH YARMOUK
AL0058
F 0004
F 0002
F 0006
AL0055
JORDAN VALLEY
AMMAN ZARQA
RIFT SIDE W SOUTH
F 0015
AZRAQ
SIRHAN
F 0022
CD0005
CD0015
F 0011
CD0008
CD0018
CD0029
DEAD SEA S W
MOJIB
CA0006
DB0002
HASA
J 0001
SIRHAN
DA0007
WARABA NORTH
G 0009
G 0004
G 0006
ED0002
G 0013
JAFER
ED0015
WARABA SOUTH
ED0023
DISI
DISI
Legend
RAIN_STATIONS
EVAP
FLOWD
RAIN
SPRING
0
50
100 km


200000
300000
400000
500000
1300000
1200000
1100000
1000000
900000
800000
H 2007
H 2017
H 2006
F 1334
F 1308
F 4233
F 1063
F 1286
G 3163
K 3016
0
50
100 km
Legend
GROUP 1
GROUP 2

Telemetry-Stations

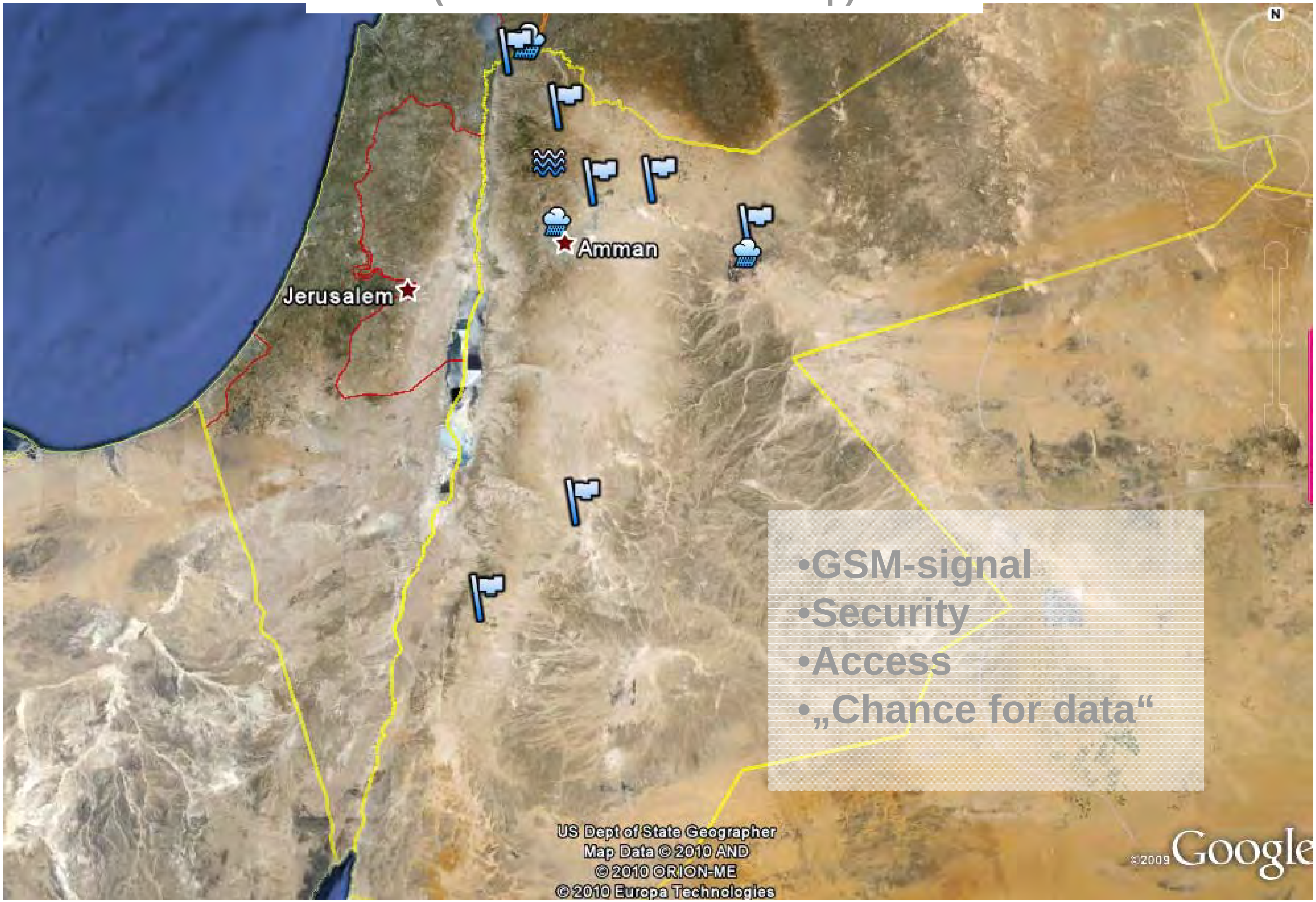
DPP	***TeWaRON1***	***BGR/ESC WA***	***TeWaRON2***	***TeWaRON 3***	***TeWaRON 4***
2010	2010	2011	2011/12	2012 (Tendering)	2013
GIZ	MWI	BGR/ESC WA	MWI	MWI	MWI
SEBA	SEBA	OTT	Campbell	Campbell	Sutron
7xGW 2xMet 1xRain 1x Discharge	8xGW 2xDischarg e 6xMet	11xGW 1xMet	15xGW 5xMet 15xPrec	15xGW 5xMet 10xRain	15xGW 10xRain
11 stations	16 stations	12 stations	35 stations	30 stations	25
Total= 104					

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Ministry of Water & Irrigation
وزارة المياه والري

PPP-Stations

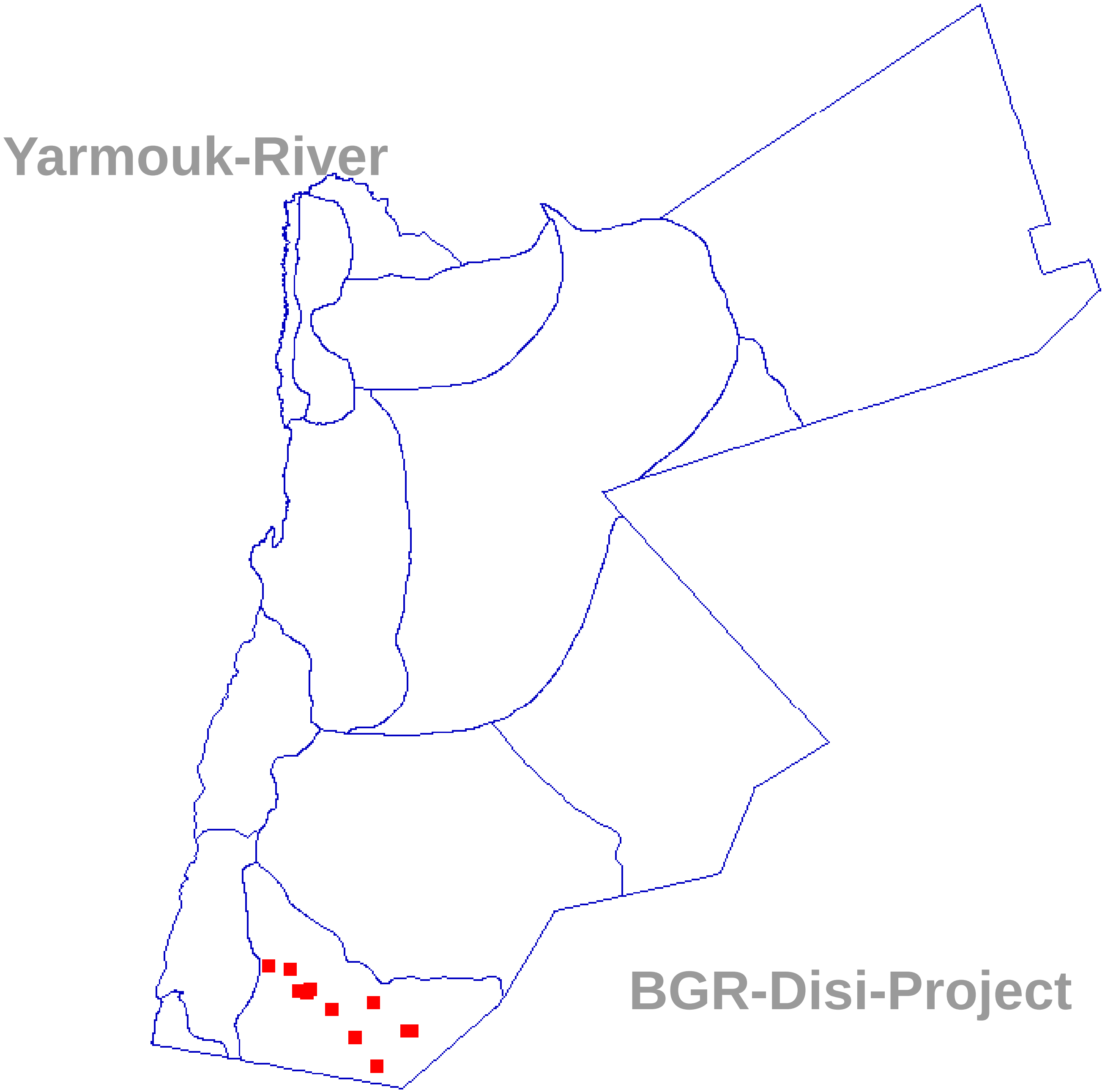
(Public Private Partnership)



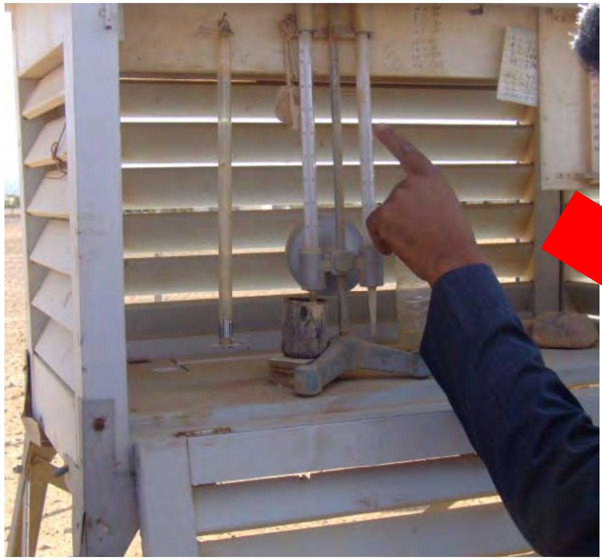
- GSM-signal
- Security
- Access
- „Chance for data“

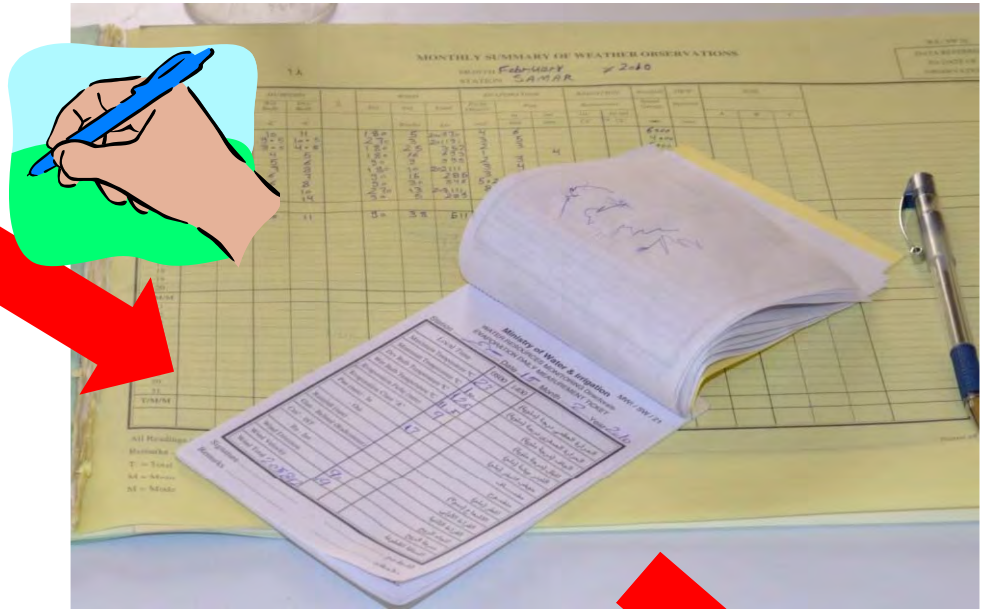
PPP-stations (blue) & MWI-stations (red)

Other Projects



Meteorological stations





- Rainfall
- Temperature
- Radiation
- Wind direction & velocity
- Evaporation

Wadi stations (base & flood flow)

- Base flow

- Flood flow
  Cable way

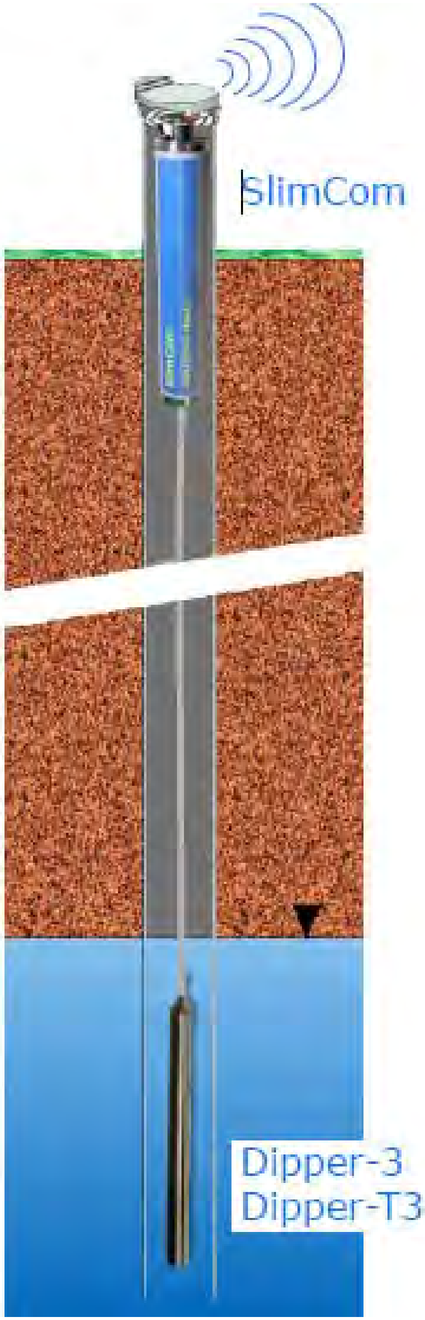
Ground Water Stations

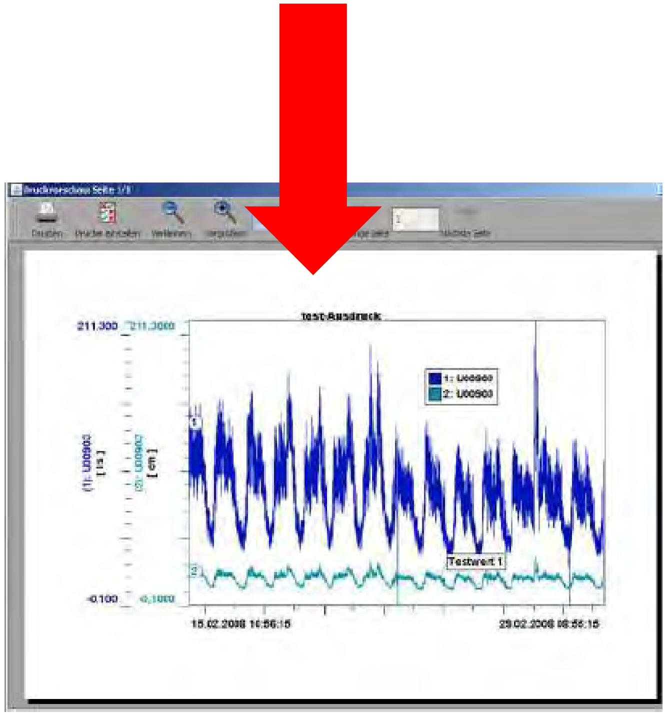
- Water level

Data transfer from monitoring station

Telemetric monitoring

Ground water stations

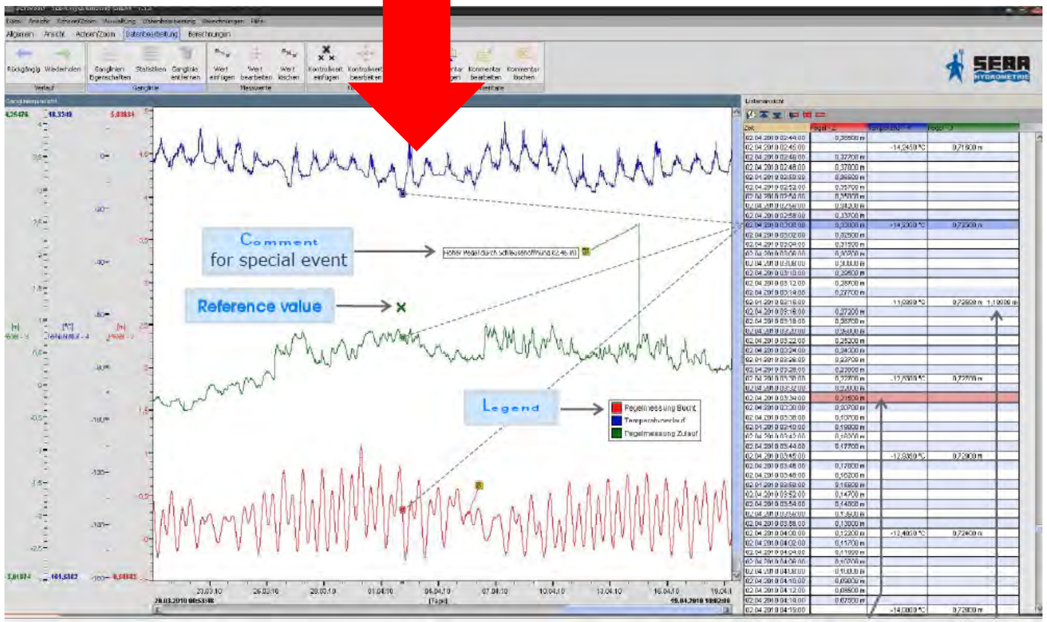




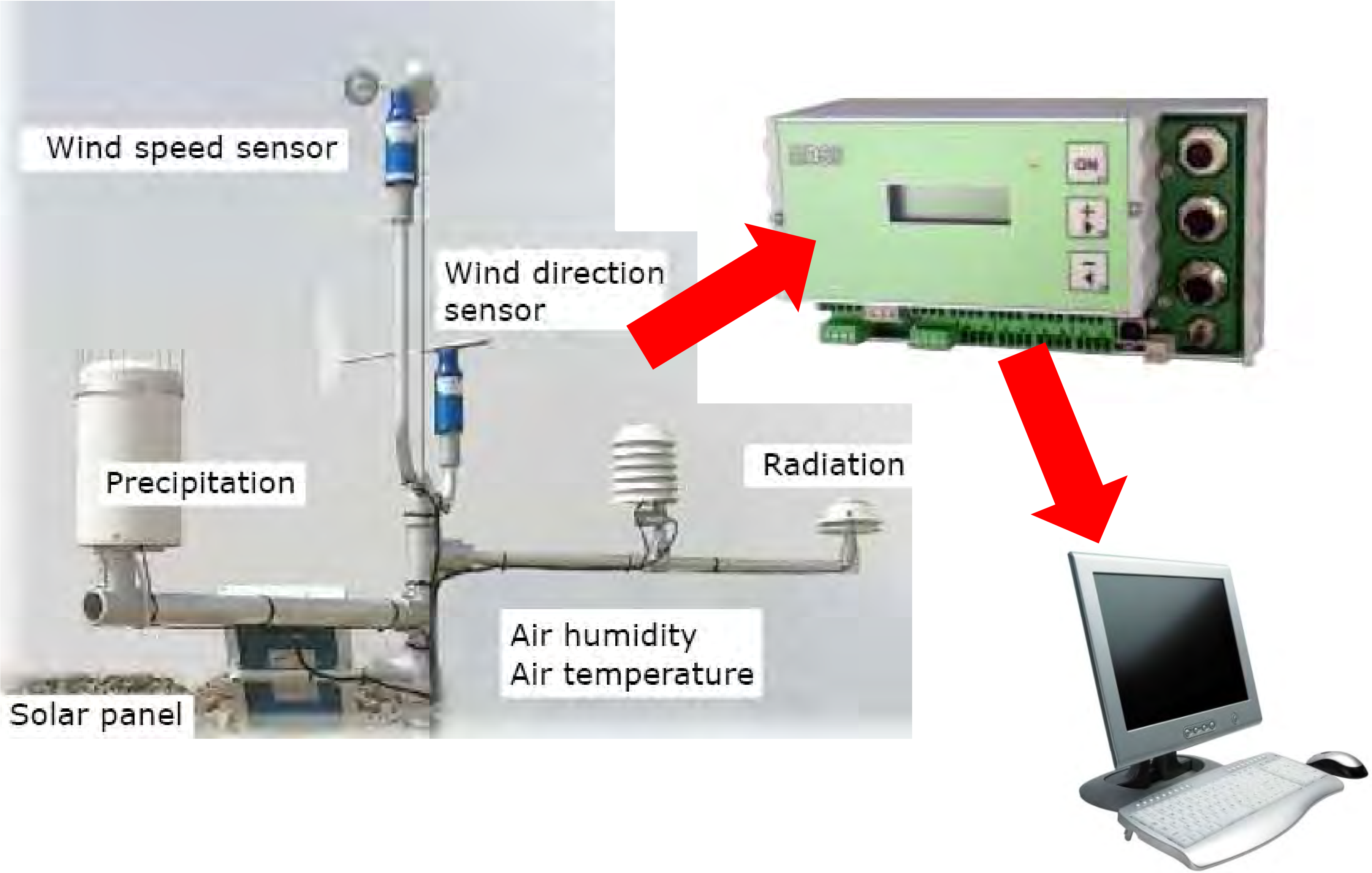
water level
temperature
conductivity
pH
nitrate …

Surface Water

radar sensor for contact free water level measurement



Meteorological stations



Data Transfer

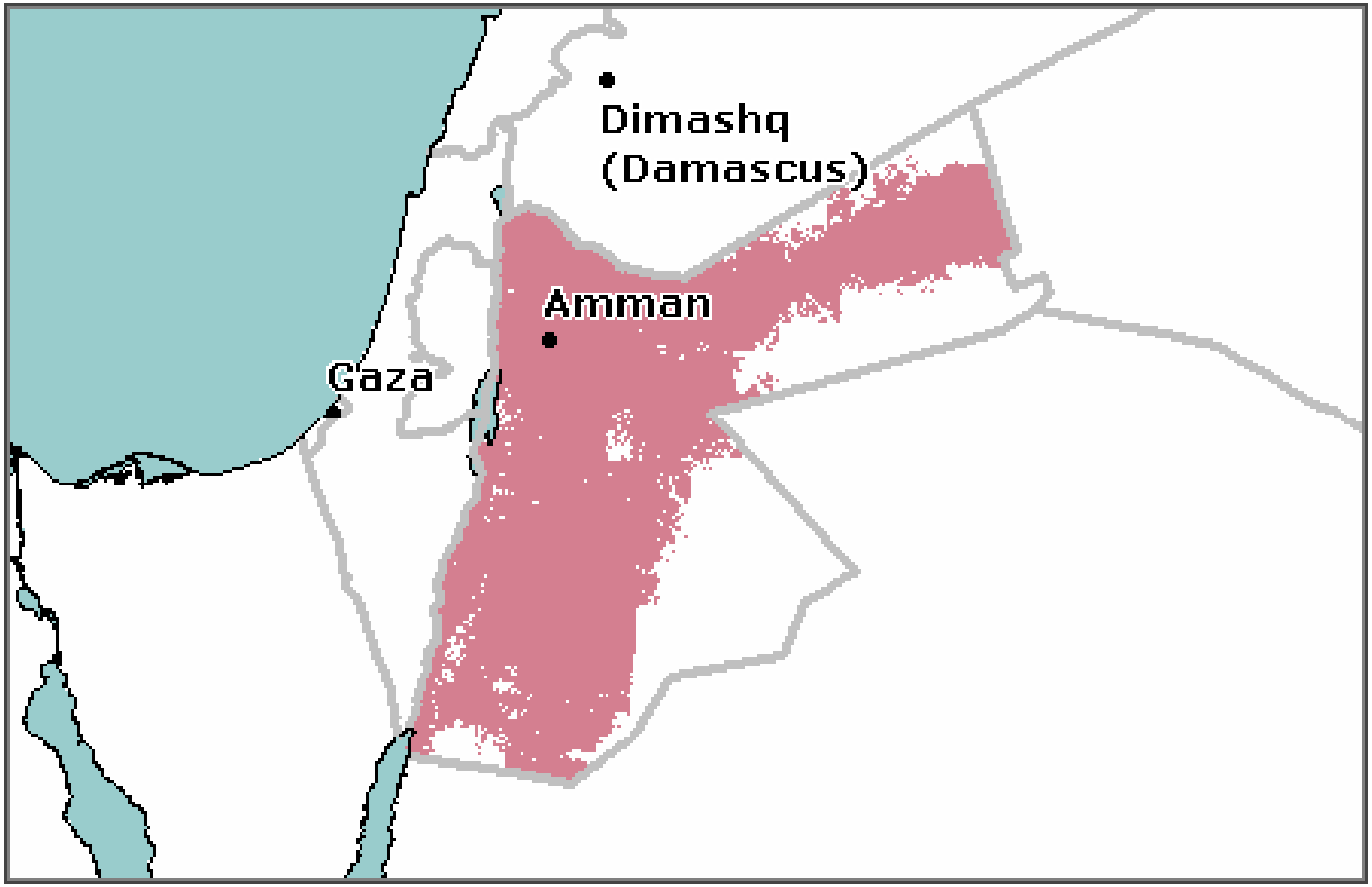
Data transmission:

- ➢ Transfer data from field
- ➢ Communication with the stations in the field

via

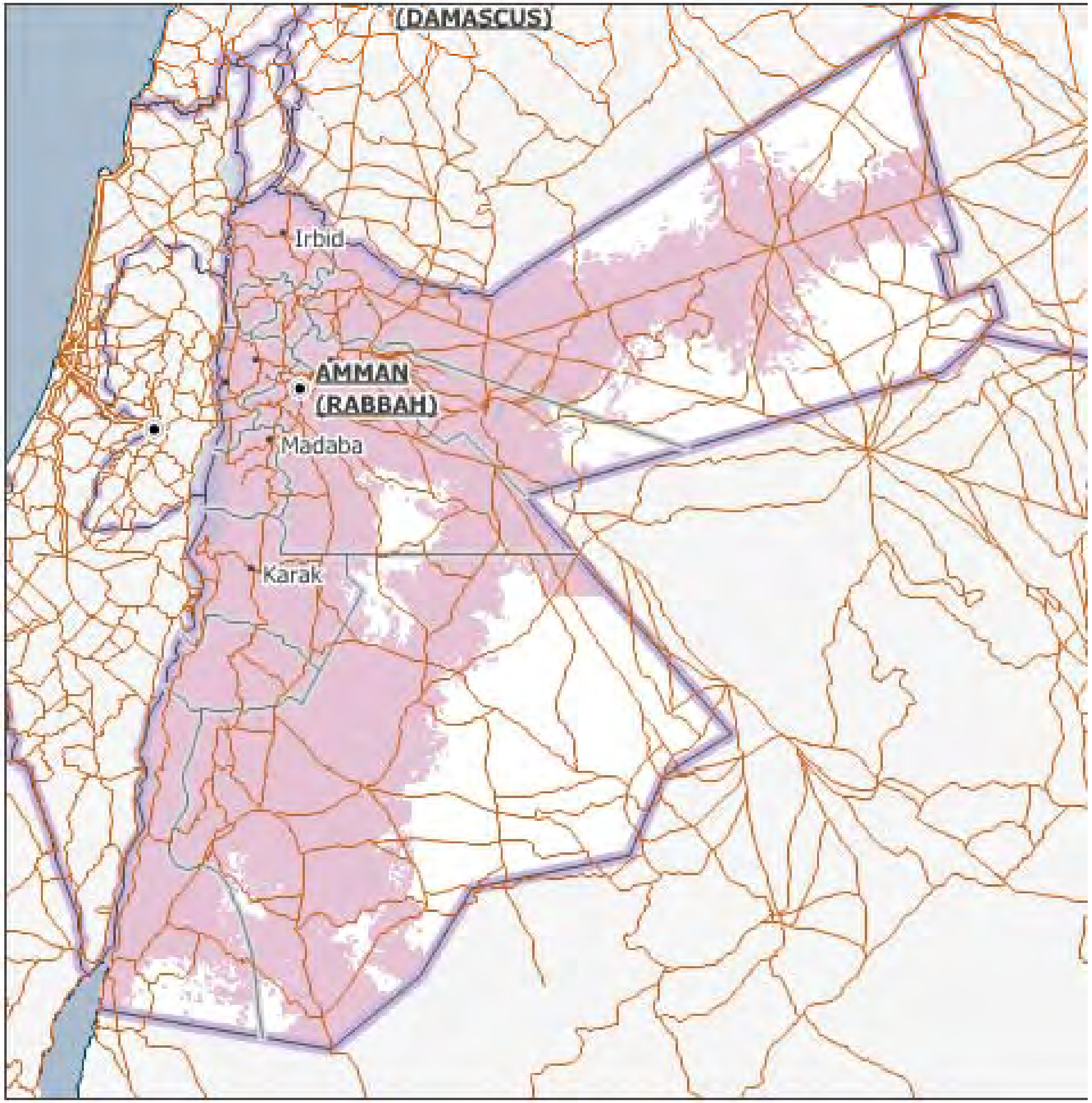
- Analogue/digital telephone (land)-line
- GSM (Global System for Mobile Communication)
- GPRS (General Packet Radio Service)
- Radio modem
- Satellite
- Mixed network

Zain coverage area



bad signal especially in the wadis and remote area

Orange coverage area



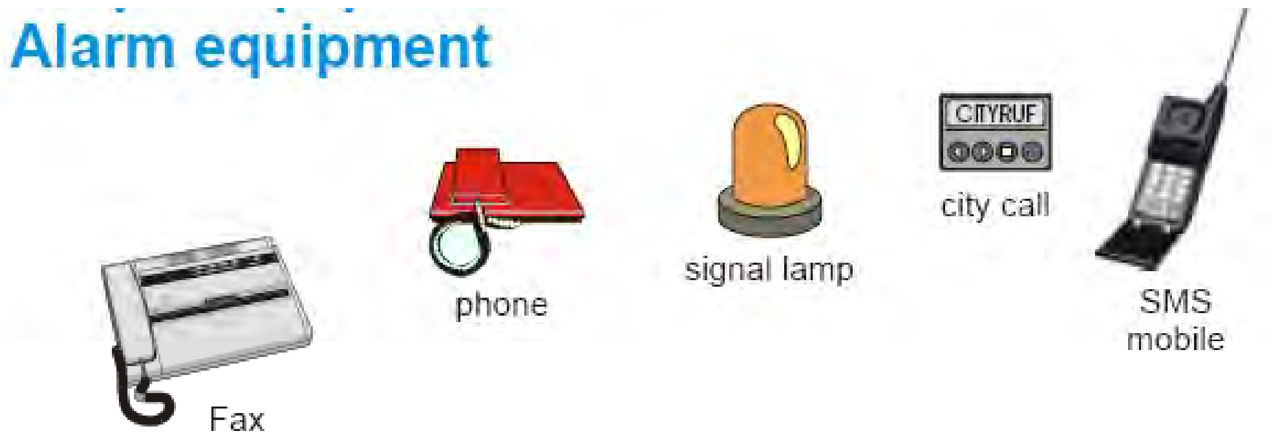
Maps: © 2009 GSM Association, Europa Technologies Ltd.

Application: © 2010 Europa Technologies Ltd. www.coveragemaps.com

Advantages of telemetric monitoring

Advantages of telemetric monitoring

- Reliable data (prevention of typing errors)
- Online status control (battery etc.)
- Alarm in cases of instrumental malfunction (SMS, phone call, etc.)
- Automatic data visualization and validation possible



Next Steps

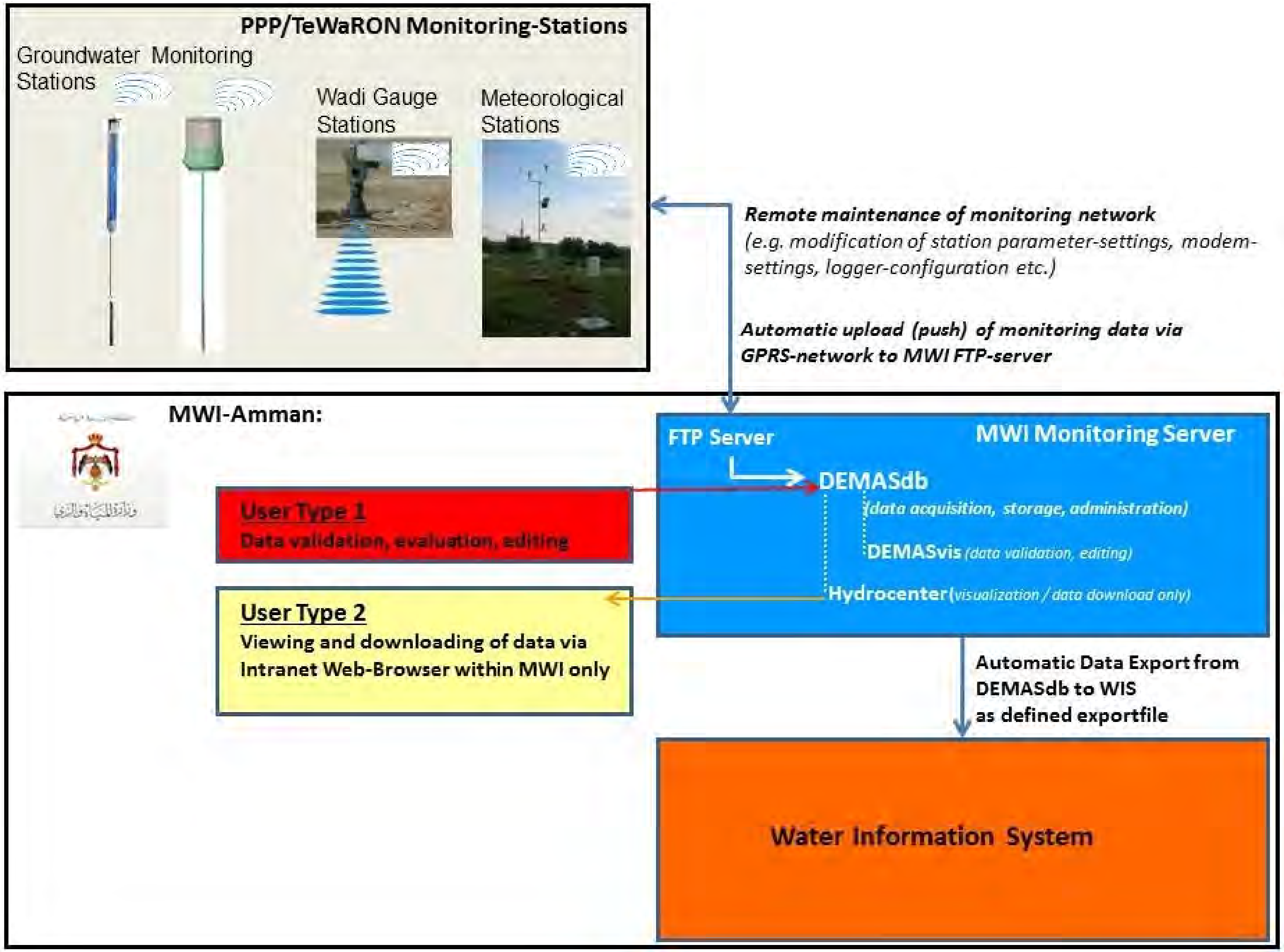
- Fund from KFW 6.4 Million Euro
- Measurement stations:
  - Enlargement of the hydro-meteorological measurement system through the erection of new measurement stations
  - Extension of existing measurement stations with a telemetric component
  - Improvement of the hydro-meteorological measurement system through the measurement of water quality parameters (possibly also at production wells of the Water Authority of Jordan WAJ)
  - Rehabilitation of existing measurement stations
  - Improvement of the measurement system of the Jordan Valley Authority JVA

Next Steps

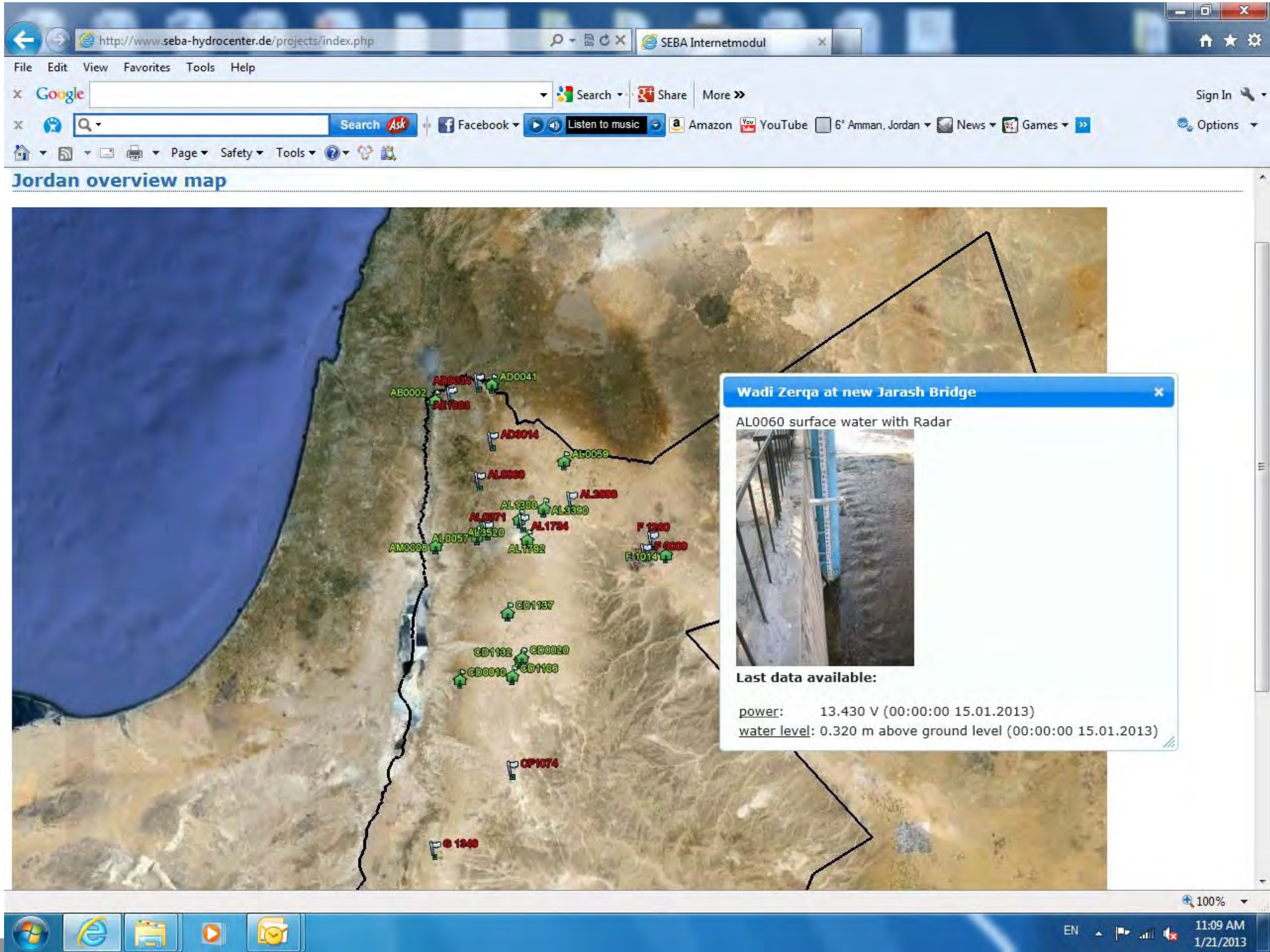
- Computer-based data system
  - Improvement / new setup of the central database (Water Information System WIS)
  - Optimised interfaces between the WIS and other water-related information systems
  - Improvement of the system to control the quality of the measured data
  - Improvement of the possibility to analyse the data and to provide these data and analysis to the decision level and interested public (e. g. via internet)
- Training of the staff

3. Monitoring Data Management- Integration

- **FTP-server**
- **DEMASdb (Data Management)**
- **DEMASvis (Visualization)**
- **Hydrocenter (web-module)**



Web Based Application



- Results and Lessons learnt
  - <u>Protection-Concept of Monitoring Network</u>
  - **Groundwater Monitoring Stations - one station loss**
  - minor damages at 2 stations by vandalism;
  antennas inserted into metal protection housing.
  - **Rainfall Station - no station loss**
  - **Meteorological Stations - no station loss**
  - **Wadi Gauge Station - one station loss**
- **- network very stable; good connectivity throughout the country**
  - change of providers within an area: from Orange to Zain (Station Awsa 2/Ballila 2)
  - **Groundwater Stations: 2 x data push per day**
  - **Meteorological- /Rainfall-/Wadi Gauge-Station: 12 x data push per day**
  - **No Data Loss – High Data Integrity**
  - **Low Running Costs for GPRS-Data transfer (< 3 JD / month / station**

Security on Monitoring Networks

- **Group 1: Stations without Solar Panel**
- Experiences and important criteria for the selection of save station locations:
- **Re-using existing protection housing!** Why?
- No more public attention of existing station
- No visible changes of station for state-of-the-art equipment, no attention!
  Avoid attraction! (e.g. no solar panels)

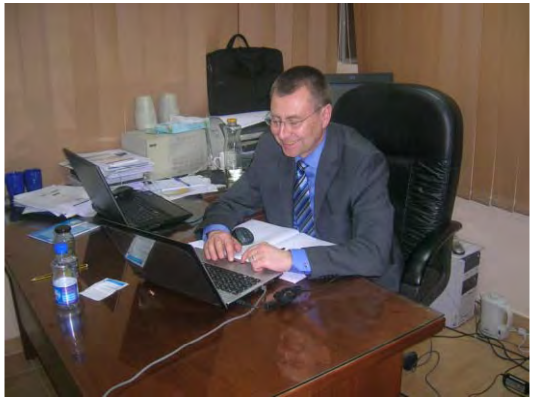
Security on Monitoring Networks

- **Group 2: Stations with Solar Panel**
- Experiences and important criteria for the selection of save station locations:
- b) Installation of equipment (logger, power supply, modem, antenna, alt. solar panel) **outside on top of well/ on open ground.**
  - Station shall be located in **protected area only**.
- People of the vicinity shall be officially informed about the measuring device and the general benefit of the project for the region/country.
- Let the people become part of the program through an awareness campaign!




- **Knowledge Transfer/Capacity Building**
  - **Regular in-house (MWI) training for MWI-monitoring specialists on installed monitoring systems incl. logger /modem programming, sensor calibration.**
  - **Regular field trainings for standard SOP, O&M-procedures.**
  - **Intense knowledge transfer for MWI – IT section on data management software DEMAS modules (DEMASdb, DEMASvis, SEBA Config) and intranet-web based Hydrocenter**


Jordan



http://www.seba-hydrocenter.de/projects

Thank you for your attention!

شكراً لحسن إهتمامكم !

Council for Development and Reconstruction (CDR)
Ministry of Energy and Water (MoEW)
Water Establishment Beirut and Mount Lebanon (WEBML)

Federal Institute for Geosciences
and Natural Resources (BGR),
Hannover, Germany

German-Lebanese Technical Cooperation Project

The WEAP model of the Jeita GW catchment

current status - climate change scenario - water use options

BGR Project Exchange Meeting Lebanon/Jordan

Aqaba, 1st of November 2013

Philip Schuler MSc, BGR

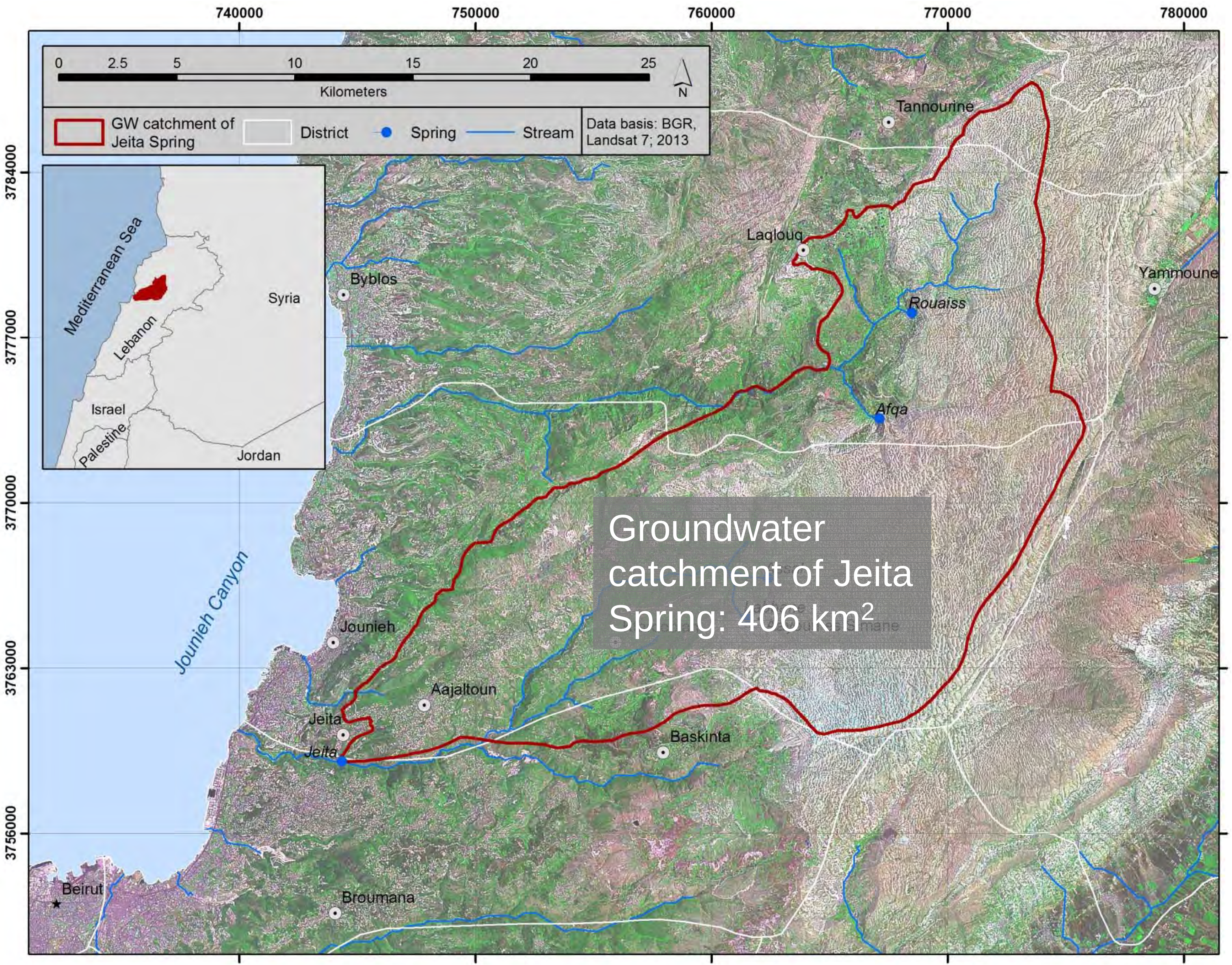
Outline

I. Introduction
II. Study area
III. Problem statement
IV. Objectives of the model
V. WEAP model
VI. Results
  - Water Balance
  - MAR Option
  - Climate Change Scenario
VII. Conclusion

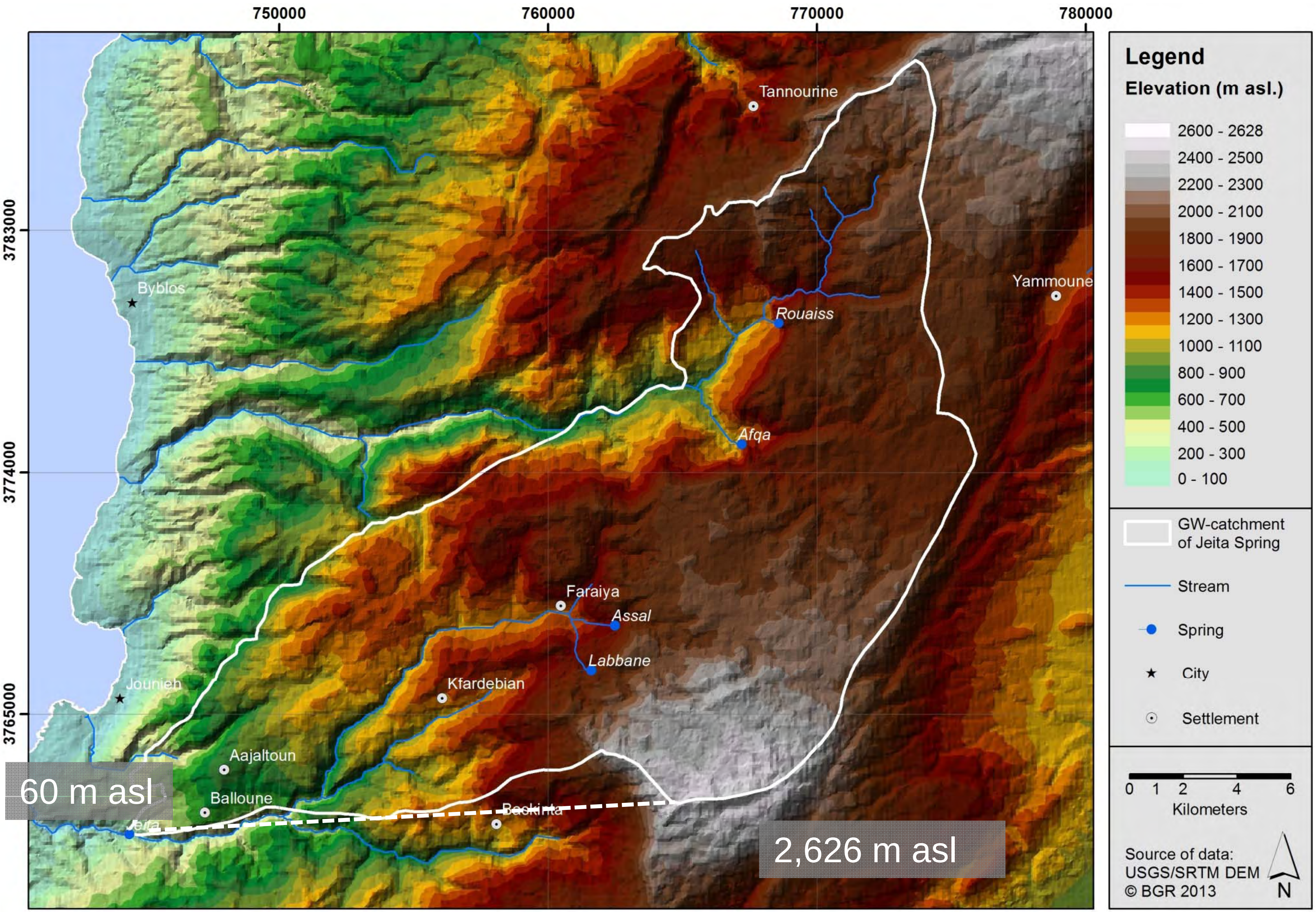
I. Introduction

- Jeita Spring provides approx. 75% of Beirut's drinking water
- Karst spring
- Seasonal variation of discharge
- Excess of water between OCT & APR
- Water shortage between AUG & OCT
- National Water Sector Strategy (03/2012):
  - Incentive on supply management:
  - "*Maximize the potential of surface water resources*"
  - "*Fulfill deficits through groundwater/surface water storage*"
  - "*promote artificial recharge*"
- Weak data availability and reliability

II. Study area

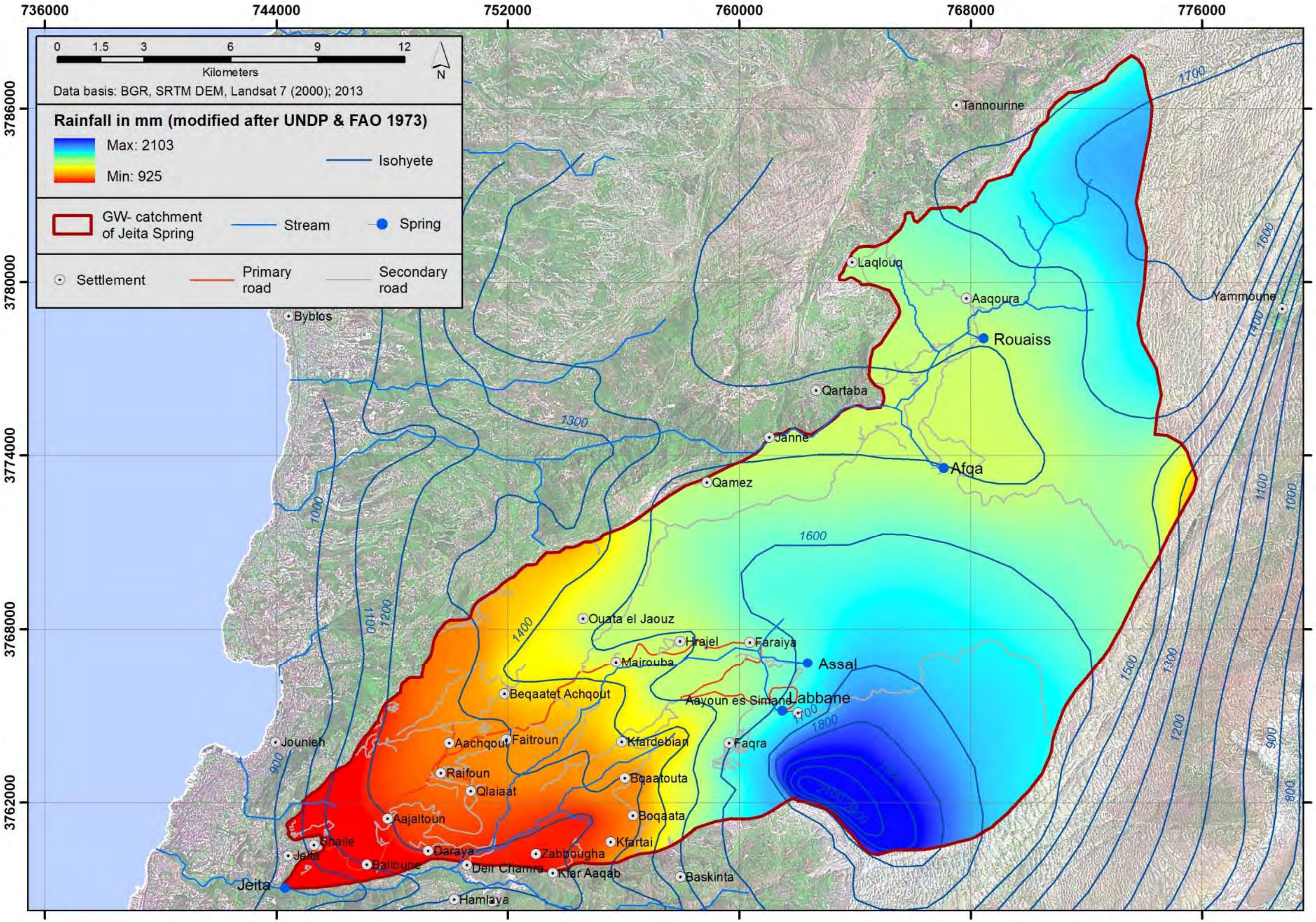


II. Study area



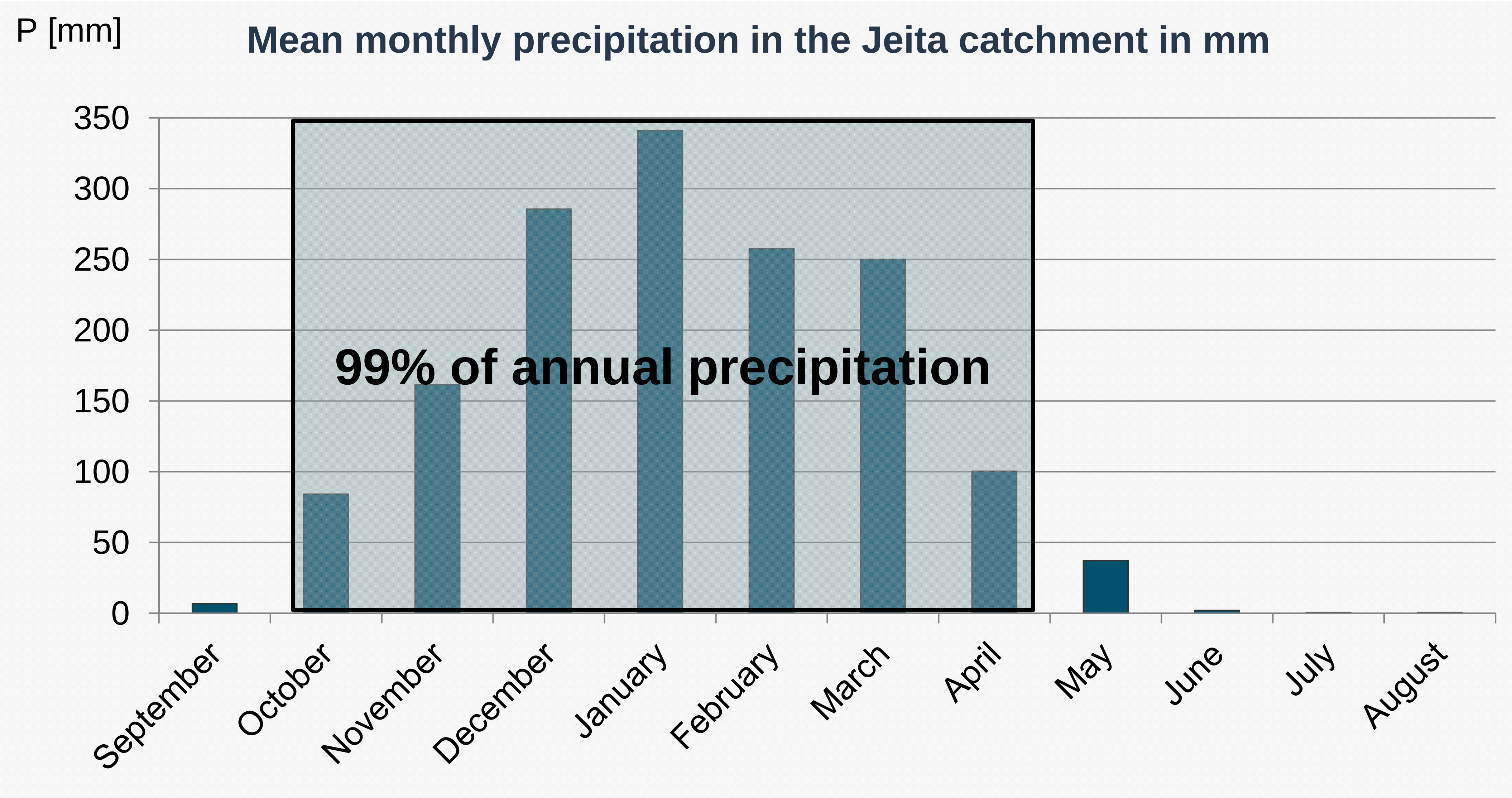
II. Study area

- **High spatial variability of precipitation**



II. Study area

- **High temporal variability of precipitation**



II. Study area

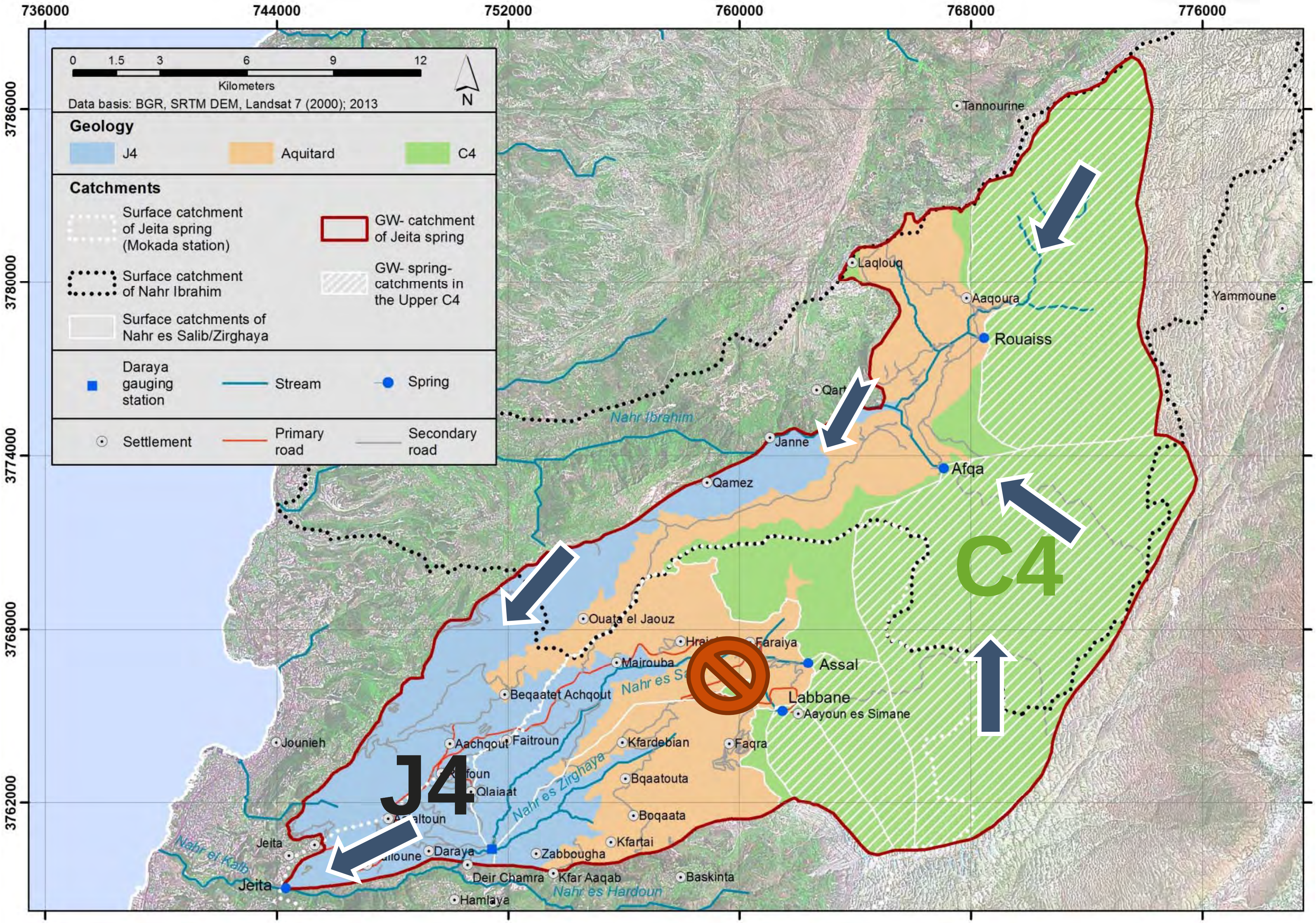
- **High karstification of the Jurassic (J4) and Cretaceous (C4)**

C4 plateau

J4 in Nahr Ibrahim Valley

II. Study area

- **High karstification of the Jurassic (J4) and Cretaceous (C4)**



II. Study area

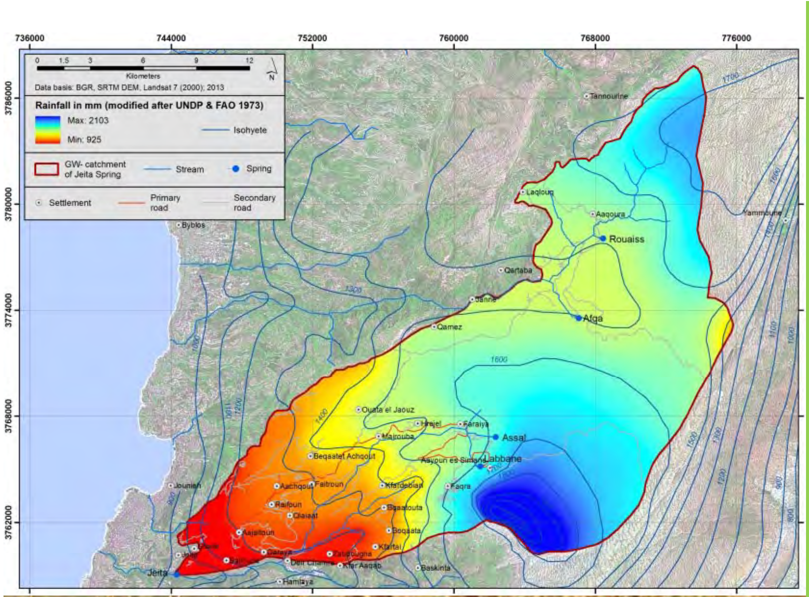
- **Water Resources Availability**

- Mainly available at springs (Upper Aquifer [C4] and Lower Aquifer [J4])
  - Depth to groundwater: often > 500 m → high pumping costs
- High fluctuation in groundwater system (no monitoring yet): probably > 200 m
- C4 Springs (Afqa, Rouaiss, Assal, Labbane):
  - high flow peaks in March - June
- Jeita (Lower Aquifer (J4) + surface water infiltration from Upper Aquifer (C4):
  - high flow peaks in January – March (earlier)
- Difficult to store groundwater of C4 or J4 in dams

  → few suitable locations because of high level of karstification
  - [outcrop area of aquitard too small to build storage dams, weak stability]
- Groundwater discharging from C4 springs can be used to sustain Lower Aquifer → MAR dams

III. Problem statement

- **Quantity of Jeita discharge influenced by:**



Climate

Ecosystem

Agriculture

Domestic

III. Problem statement

- **Seasonal variation of discharge of Jeita Spring**

Available resources for supply management*

?

***Demand management poorly developed in Lebanon**

III. Problem statement

- Poor demand management
- Weak data availability and reliability:
  - Precipitation data
  - No GW observation wells
  - Spring discharge measurements
  - Surface runoff stations in poor conditions
- Reliability of current water resources planning???
- Water planning of the MoEW, CDR & WE fragmented and no clear structure to see:
  - Future scenarios?
  - WEAP officially used by MoEW, but in practice?

Effectiveness of supply management ?

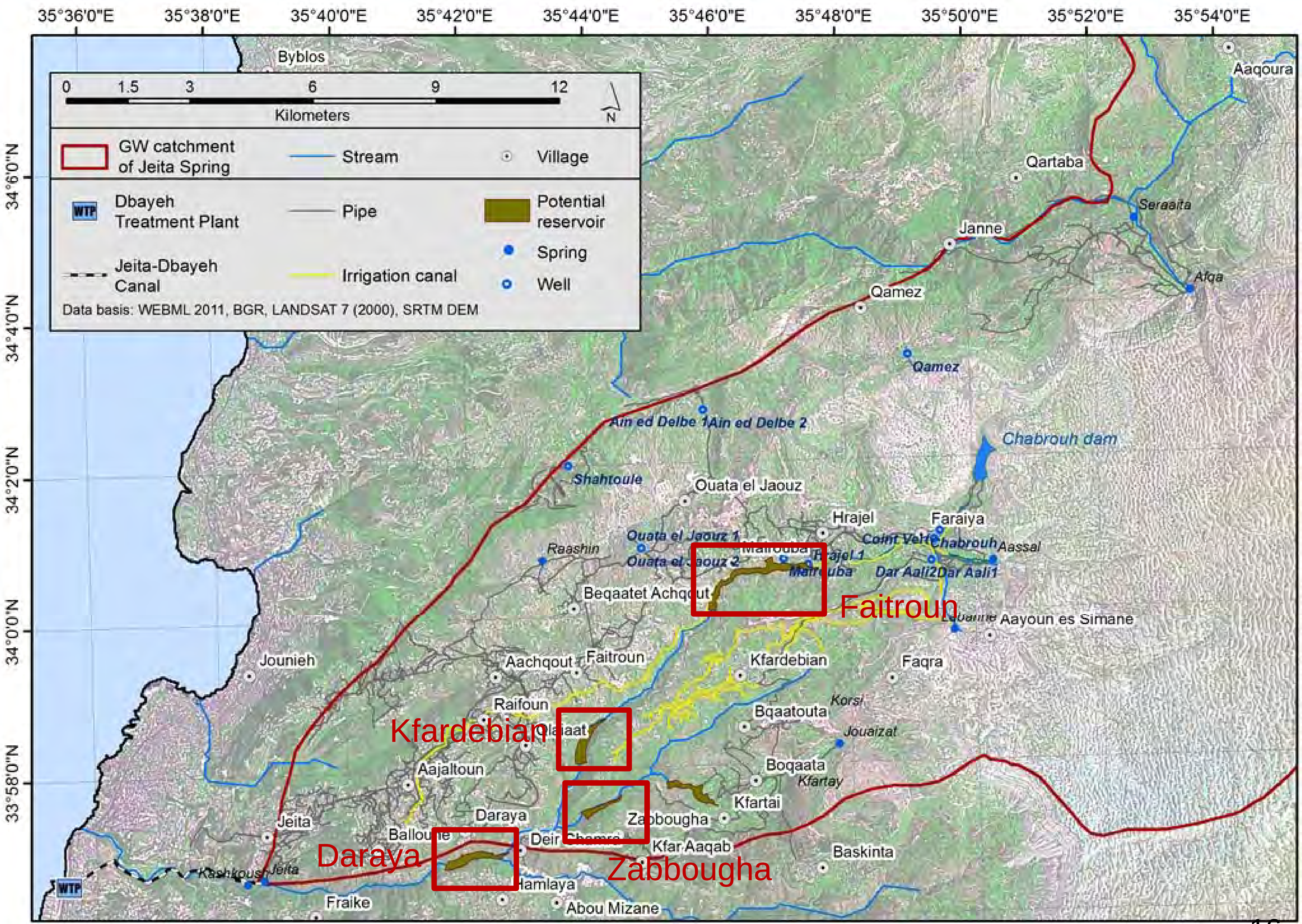
IV. Objectives of the model

- Hydrological balance on a monthly basis
- Assessment of hydrological components:
    - Rainfall
    - Evapotranspiration
    - Surface runoff
    - GW recharge
- Domestic & agricultural demand
- Origin of Jeita's groundwater
- Future scenarios: e.g. Climate Change
- Water management options: MAR

IV. Objectives of the model

- **MAR Dams**

Dam names	Elevation [m asl]	Dam crest [m]	Storage [MCM]	Surface area [m²]	Catchment [km²]	Rainfall [mm/a]	Rain volume [MCM/a]
Kfardebian	720	100	7.3	224.7	91.0	1,565	142.4
Faitroun	1,115	65	6.6	460.0	80.1	1,596	127.8
Boqaata	900	80	4.1	198.0	16.8	1,442	24.2
Baskinta	1,035	100	6.0	157.7	28.5	1,659	47.4
Zabbougha	635	100	3.0	105.0	46.9	1,454	68.2
Daraya	320	100	9.0	235.2	222.0	1,494	331.7

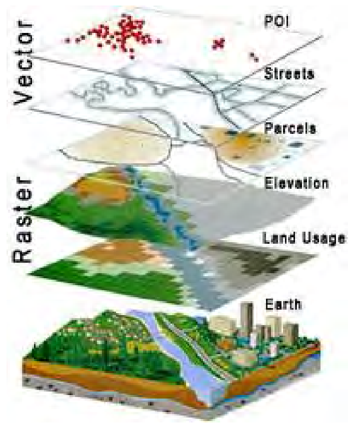

35°36'0"E
35°38'0"E
35°40'0"E
35°42'0"E
35°44'0"E
35°46'0"E
35°48'0"E
35°50'0"E
35°52'0"E
35°54'0"E
34°6'0"N
34°4'0"N
34°2'0"N
34°0'0"N
33°58'0"N
0 1.5 3 6 9 12
Kilometers
N
GW catchment of Jeita Spring
Stream
Village
Dbayeh Treatment Plant
Pipe
Potential reservoir
Spring
Jeita-Dbayeh Canal
Irrigation canal
Well
Data basis: WEBML 2011, BGR, LANDSAT 7 (2000), SRTM DEM
Byblos
Aaqoura
Qartaba
Seraaita
Janne
Afqa
Qamez
Ain ed Delbe 1
Ain ed Delbe 2
Chabrouh dam
Shahtoule
Ouata el Jaouz
Hrajel
Faraiya
Ouata el Jaouz 1
Chabrouh
Aassal
Raashin
Ouata el Jaouz 2
Hrajel 1
Dar Aali2
Dar Aali1
Beqaatet Achqout
Faitroun
Aayoun es Simane
Jounieh
Aachqout
Faitroun
Kfardebian
Faqra
Raifoun
Korsi
Bqaatouta
Kfardebian
Jouaizat
Aajaltoun
Boqaata
Kfartay
Kfartai
Daraya
Jeita
Baskinta
Kfar Aaqab
Daraya
Zabbougha
Kashkoush
Jeita
WTP
Fraike
Hamlaya
Abou Mizane

V. WEAP Model

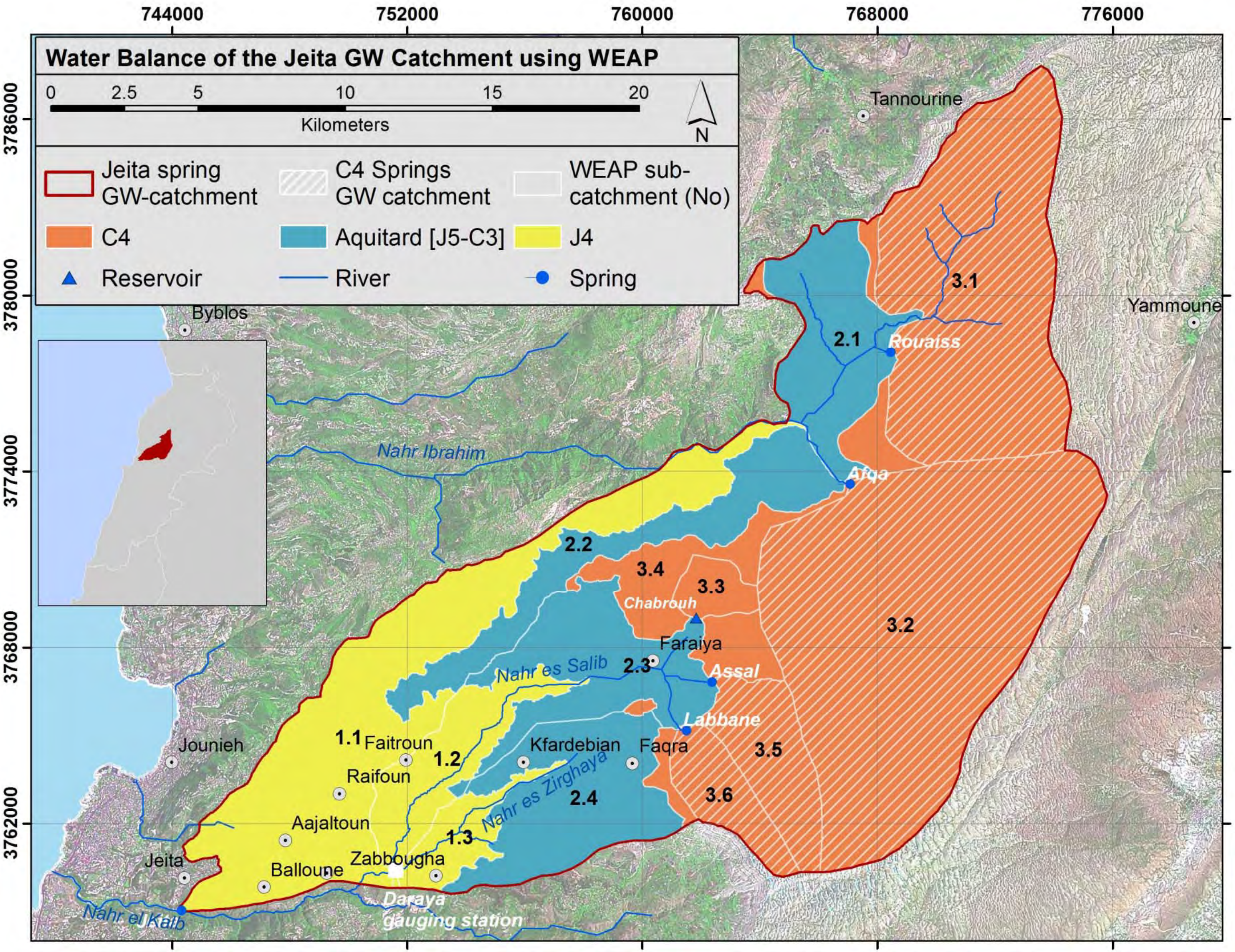
- Water Evaluation and Planning
- Non-commercial software
- Developed by the Stockholm Environment Institute
- Used within the MENA region:
    - Jordan, Morocco, Tunisia, Palestine, Syria
- Conceptual in- & output model
- Modeling of hydrological budget
    - time step: daily to annual
- Natural and anthropogenic supply and demand
- Scenario development

V. WEAP Model

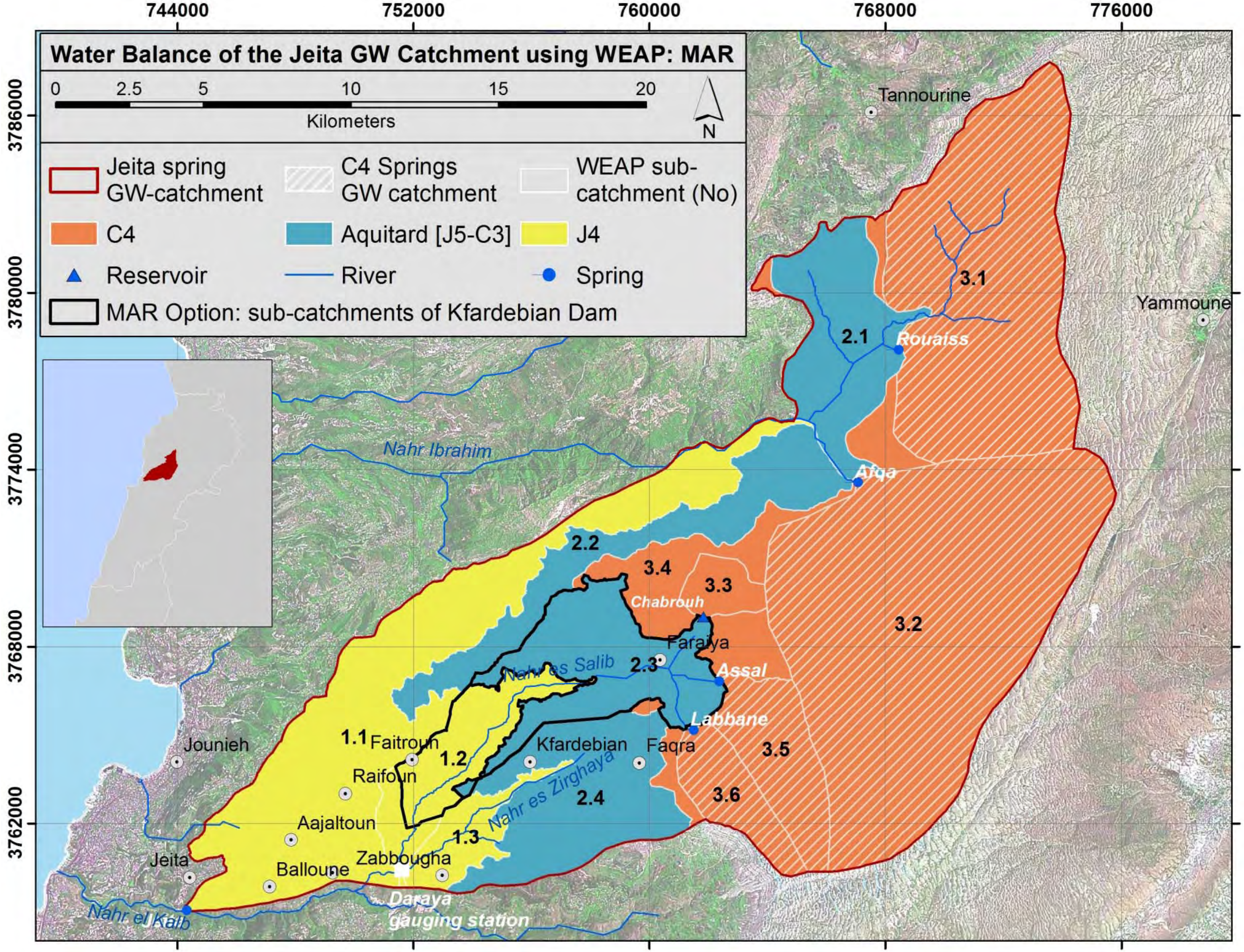
- Model 1: static
- Model 2: flexible
- Discretization
- Sub-division into 13 sub-catchments:
  I. Geology
  II. Surface runoff
  III. Spring- & reservoir catchments
- Reflect spatial variability:
  - Topography
  - Hydrogeology: Aquifer /Aquitard
  - Precipitation
  - Temperature & evapotranspiration
  - GW recharge



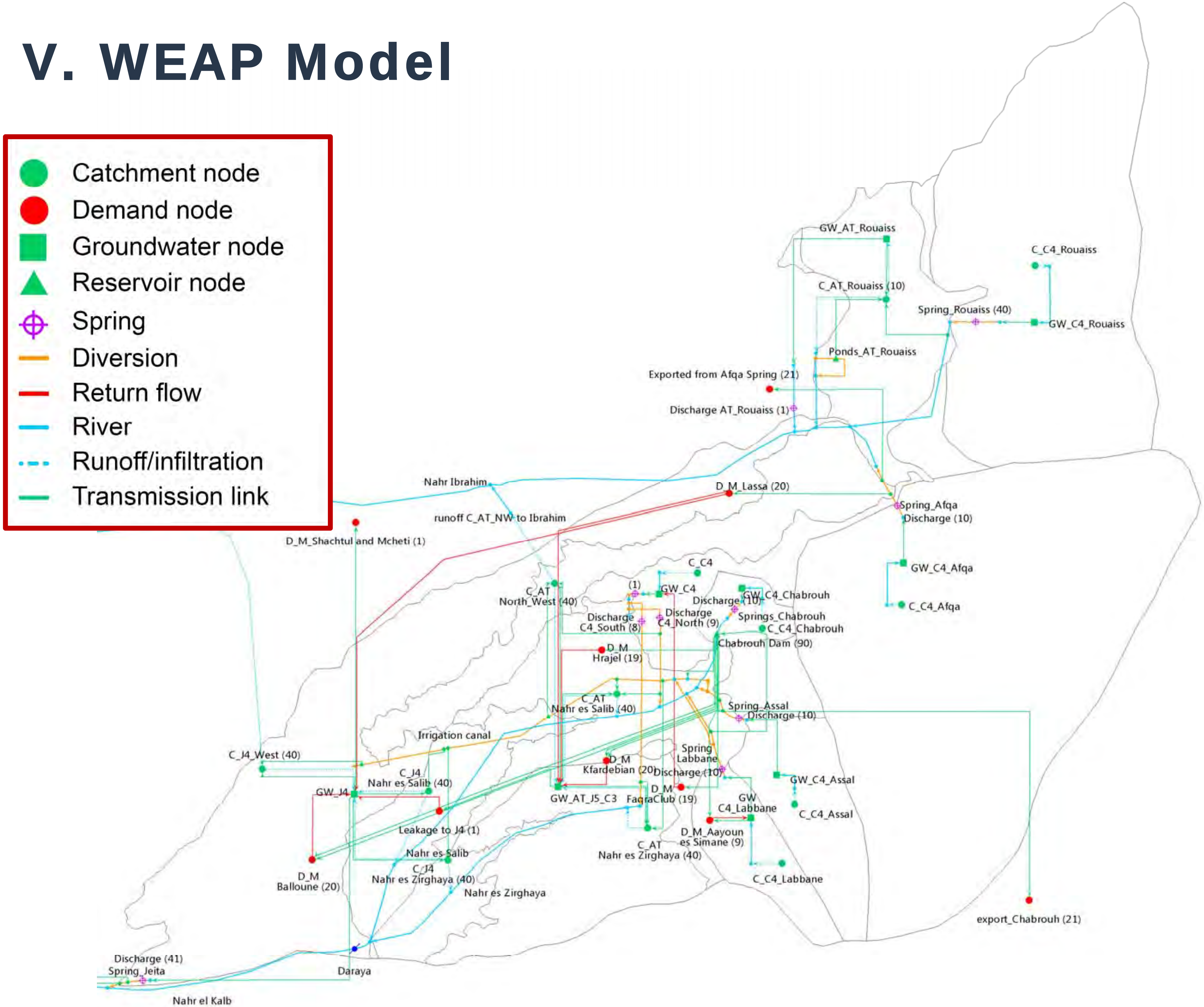
V. WEAP Model


Water Balance of the Jeita GW Catchment using WEAP
0 2.5 5 10 15 20
Kilometers
N
Jeita spring GW-catchment
C4 Springs GW catchment
WEAP sub-catchment (No)
C4
Aquitard [J5-C3]
J4
Reservoir
River
Spring
744000
752000
760000
768000
776000
3786000
3780000
3774000
3768000
3762000
Tannourine
Yammoune
Byblos
Rouaiss
Afqa
Nahr Ibrahim
Chabrouh
Faraiya
Assal
Labbane
Nahr es Salib
Kfardebian
Faqra
Nahr es Zirghaya
Jounieh
Faitroun
Raifoun
Aajaltoun
Zabbougha
Balloune
Jeita
Daraya gauging station
Nahr el Kalb
1.1
1.2
1.3
2.1
2.2
2.3
2.4
3.1
3.2
3.3
3.4
3.5
3.6

V. WEAP Model – incl. Kfardebian Dam



V. WEAP Model


Catchment node
Demand node
Groundwater node
Reservoir node
Spring
Diversion
Return flow
River
Runoff/infiltration
Transmission link
GW_AT_Rouaiss
C_C4_Rouaiss
C_AT_Rouaiss (10)
Spring_Rouaiss (40)
GW_C4_Rouaiss
Ponds_AT_Rouaiss
Exported from Afqa Spring (21)
Discharge AT_Rouaiss (1)
Nahr Ibrahim
D_M_Lassa (20)
Spring_Afqa
Discharge (10)
runoff C_AT_NW to Ibrahim
D_M_Shachtul and Mcheti (1)
GW_C4_Afqa
C_C4_Afqa
C_C4
C_AT
North_West (40)
(1)
GW_C4
Discharge (10)
GW_C4_Chabrouh
Discharge
C4_South (8)
Discharge
C4_North (9)
Springs_Chabrouh
C_C4_Chabrouh
Chabrouh Dam (90)
D_M
Hrajel (19)
C_AT
Nahr es Salib (40)
Spring_Assal
Discharge (10)
Irrigation canal
C_J4_West (40)
Spring
Labbane
D_M
Kfardebian (20)
Discharge (10)
C_J4
Nahr es Salib (40)
GW_J4
D_M
GW_AT_J5_C3
FaqraClub (19)
GW
C4_Labbane
GW_C4_Assal
C_C4_Assal
Leakage to J4 (1)
D_M_Aayoun
es Simane (9)
C_AT
Nahr es Zirghaya (40)
Nahr es Salib
C_J4
Nahr es Zirghaya (40)
D_M
Balloune (20)
Nahr es Zirghaya
C_C4_Labbane
export_Chabrouh (21)
Discharge (41)
Spring_Jeita
Daraya
Nahr el Kalb

V. WEAP Model

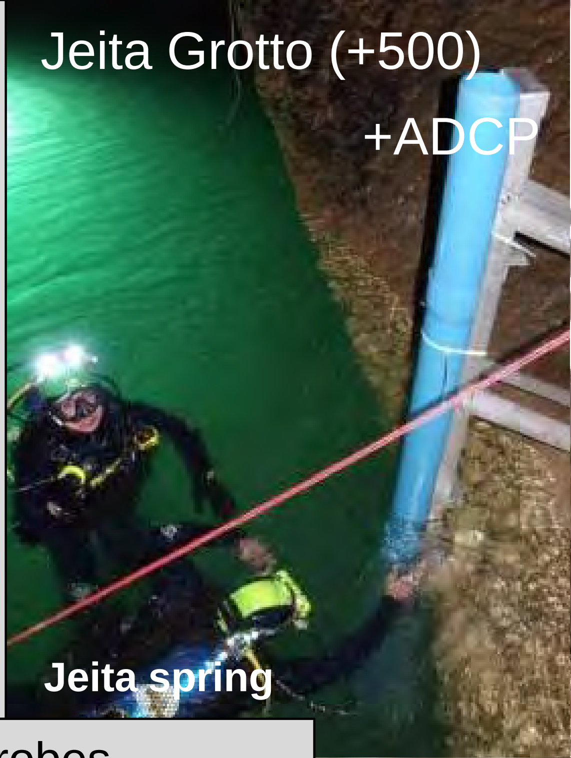
	Data		Unit	Period	Source
Atmosphere	Precipitation (P)	Total P	mm	1931-1960	ATLAS CLIMATIQUE DU LIBAN (1977)
		Distribution in space	-	-	UNDP & FAO (1973)
	Temperatures (t)		°C	1974/1975	TUTIEMPO
	Reference evapotranspiration (ET_0)		mm	-	FAO, CLIMWAT
	Humidity		%	1974/1975	TUTIEMPO
	Wind		m/s	-	-
	Melting point		°C	-	-
	Freezing point		°C	-	-

Geosphere

Surface runoff	Nahr el Kalb at Daraya	MCM/m	1967/1968- 1973/1974	LRA
Spring discharge	Afqa	MCM/m	2000/2001-2009/2010	LRA
	Assal	MCM/m	1968/1969-1972/1973	LRA
	Labbane	MCM/m	1971/1972-1972/1973 and 2002/2003-2008/2009	LRA
	Jeita	MCM/m	1966/1967-1970/1972	UNDP (1972)
	Rouaiss	MCM/m	2000/2001-2010/2011	LRA
Crop coefficient (k_c)	Apples		-	Allen et al. (1998)
	Tomatoes		-	Allen et al. (1998)
	Sealed		-	-
	Scarce vegetation		-	-
	Woodland		-	-
	Ponds & lakes		-	BGR Project
Landuse & landcover		m^2	2007	Schuler (2011)
k-values		-		BGR Project
Rate of GW-recharge	Aquitard	% of total P		BGR Project
	C4	% of total P		BGR Project
	J4	% of total P		BGR Project
Irrigation efficiency		%		BGR Project
Soil water capacity	Scarce vegetation	mm		
	Sealed	mm		
	Woodland	mm		
Consumption rate		%	-	BGR Project
Population records		-	2011	GITEC(2011); Schuler (2011)
Chabrouh dam Volume		MCM/m	2010-2011	Water Establishment Beirut Mount Lebanon

Multiparameter probes parameters:
Water level
Temperature
EC
pH
ORP
DO
(ammonium)
(ISE)

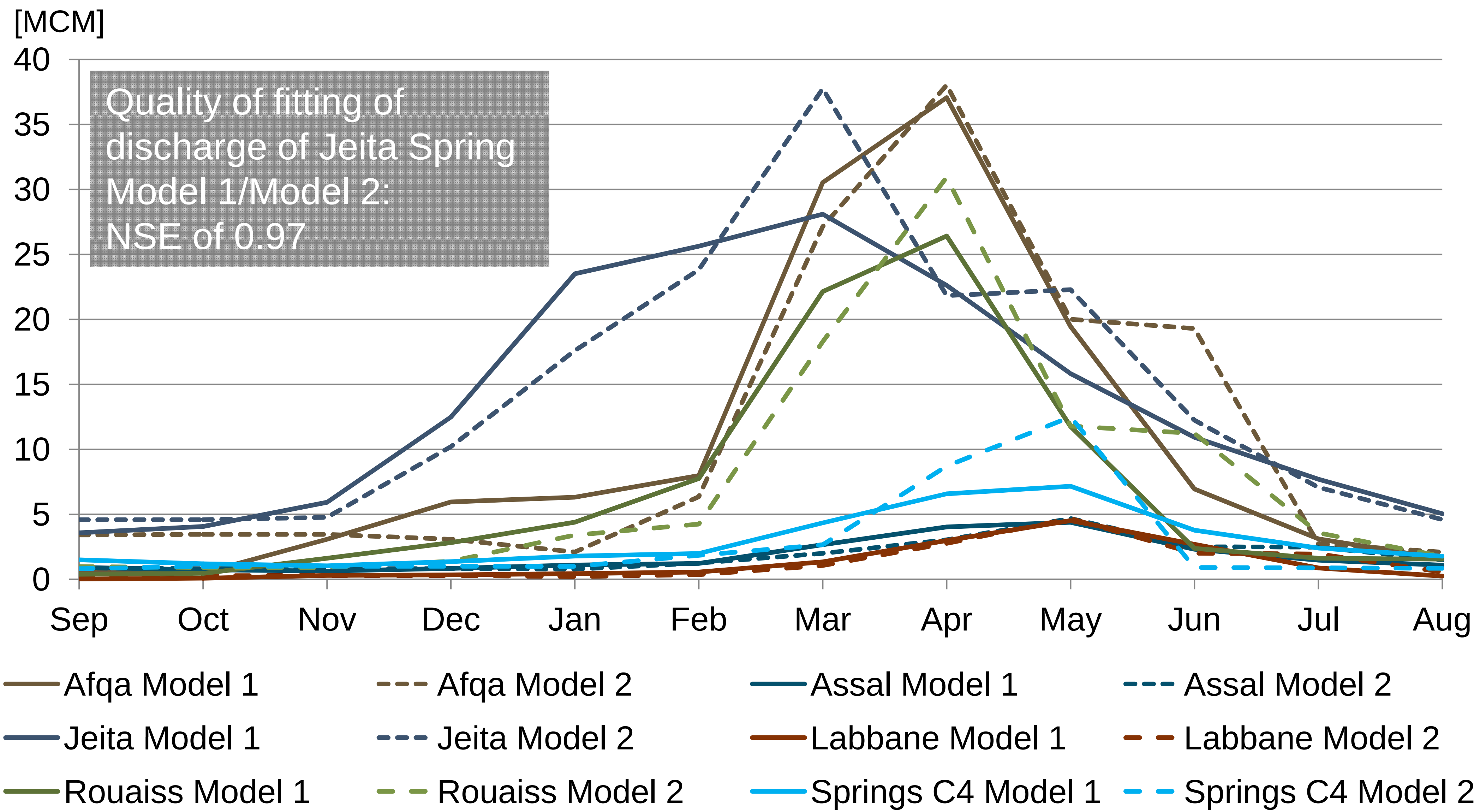
Telemetric data transfer



- multiparameter probes
- gauging stations (weir, ADCPs)
- direct discharge measurement (> 300 dilution tests)

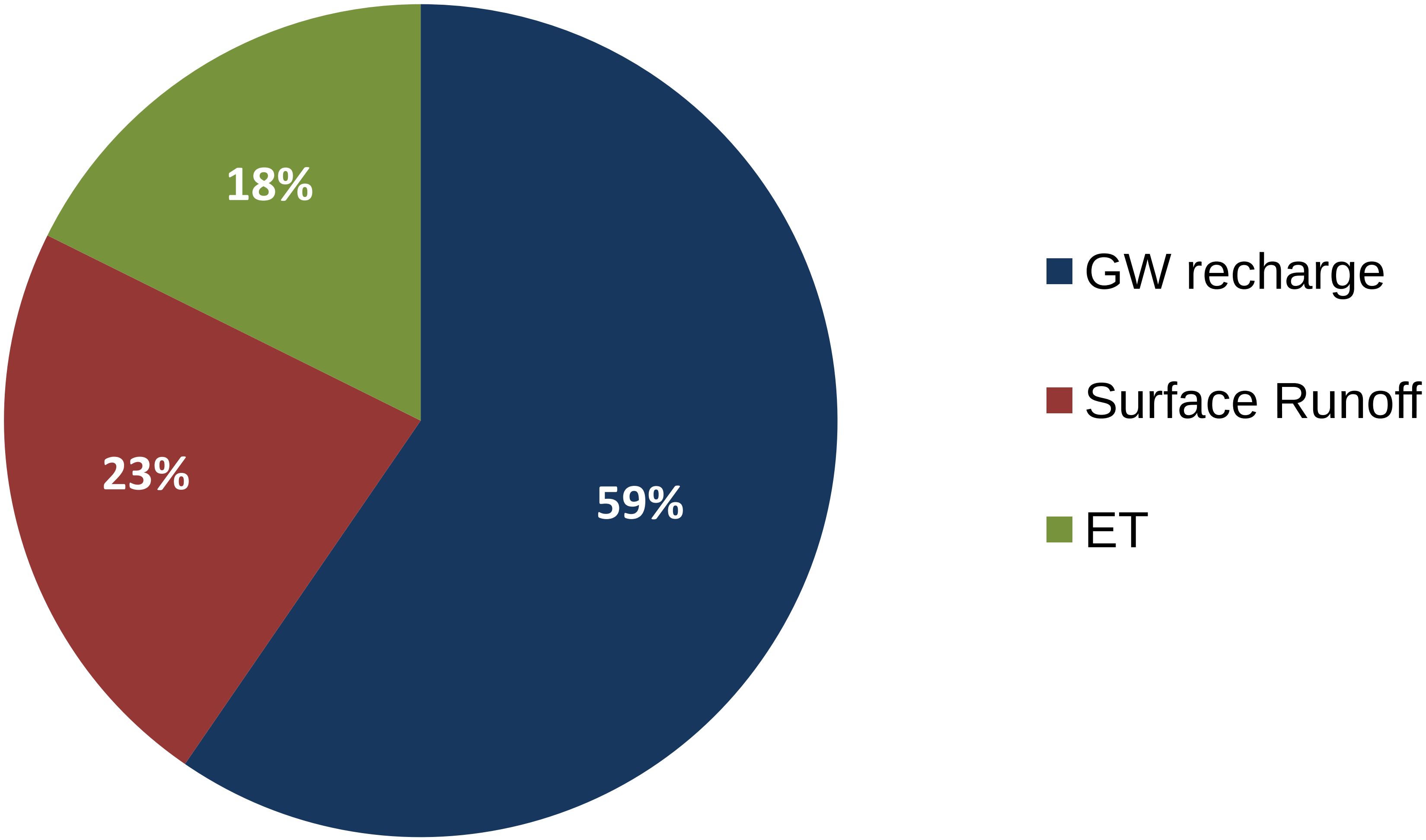
VI. Results: Water Balance

Monthly spring discharges in MCM

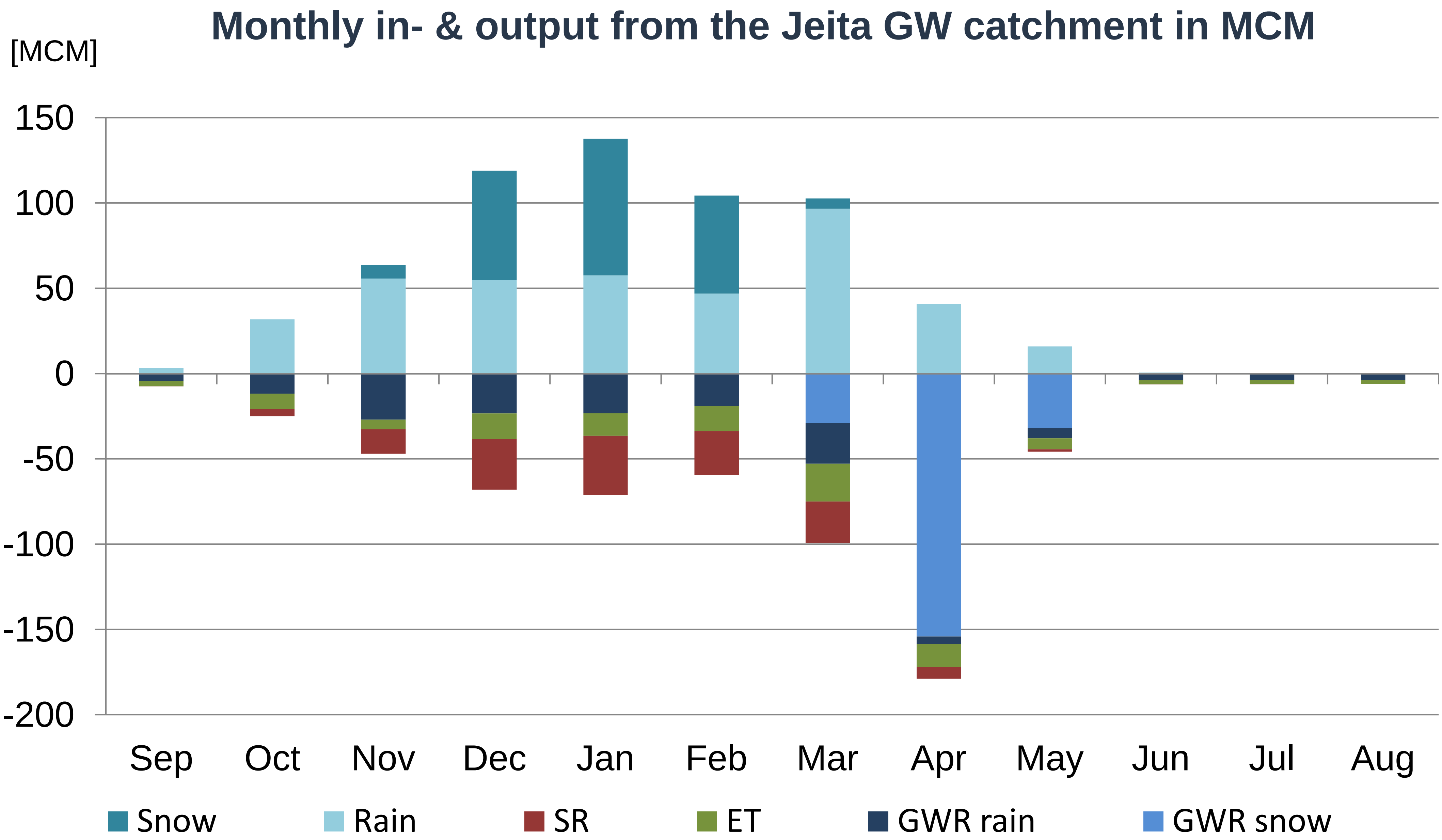


VI. Results: Water Balance

Total annual precipitation of 619 MCM leads to:

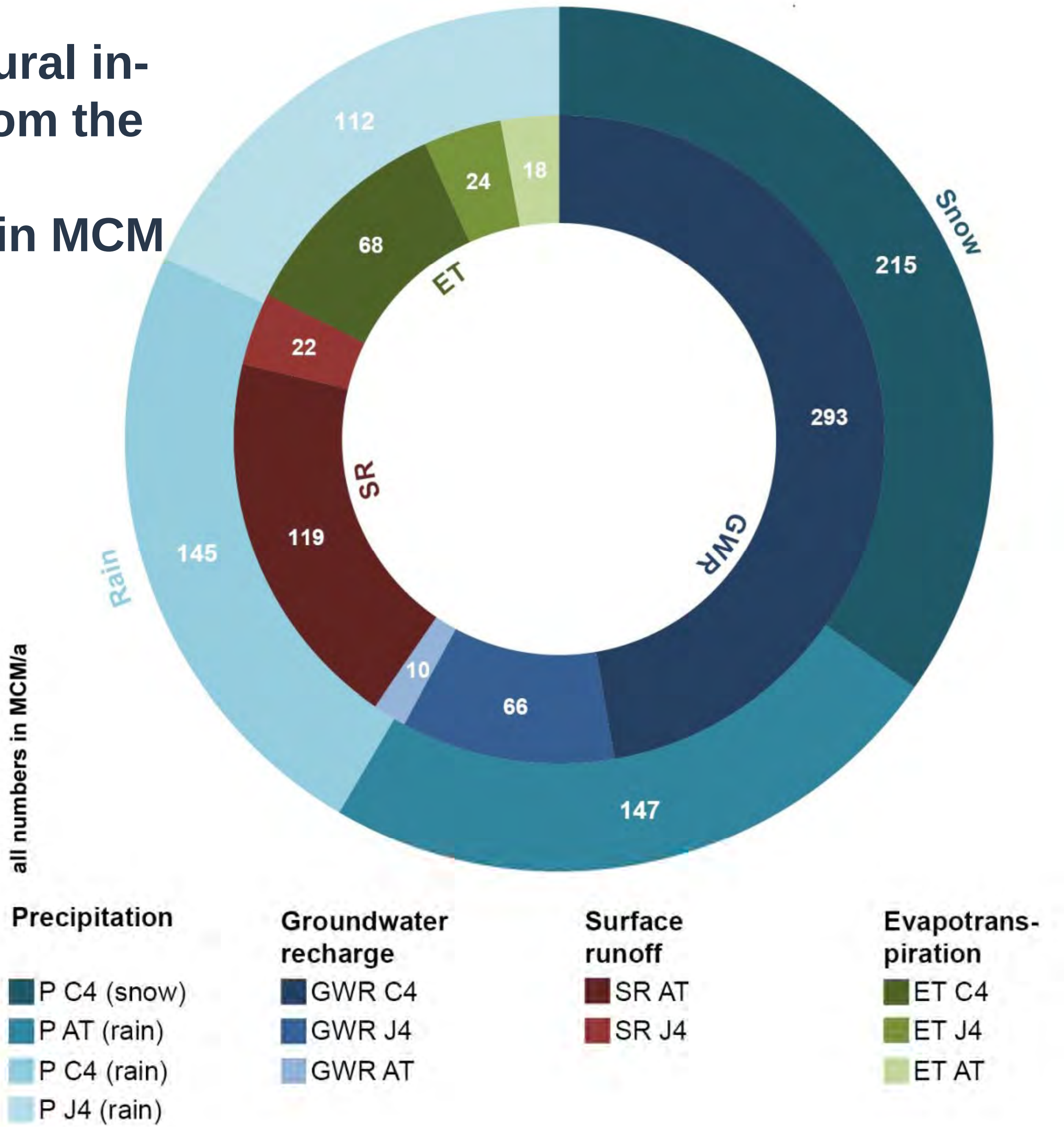


VI. Results: Water Balance



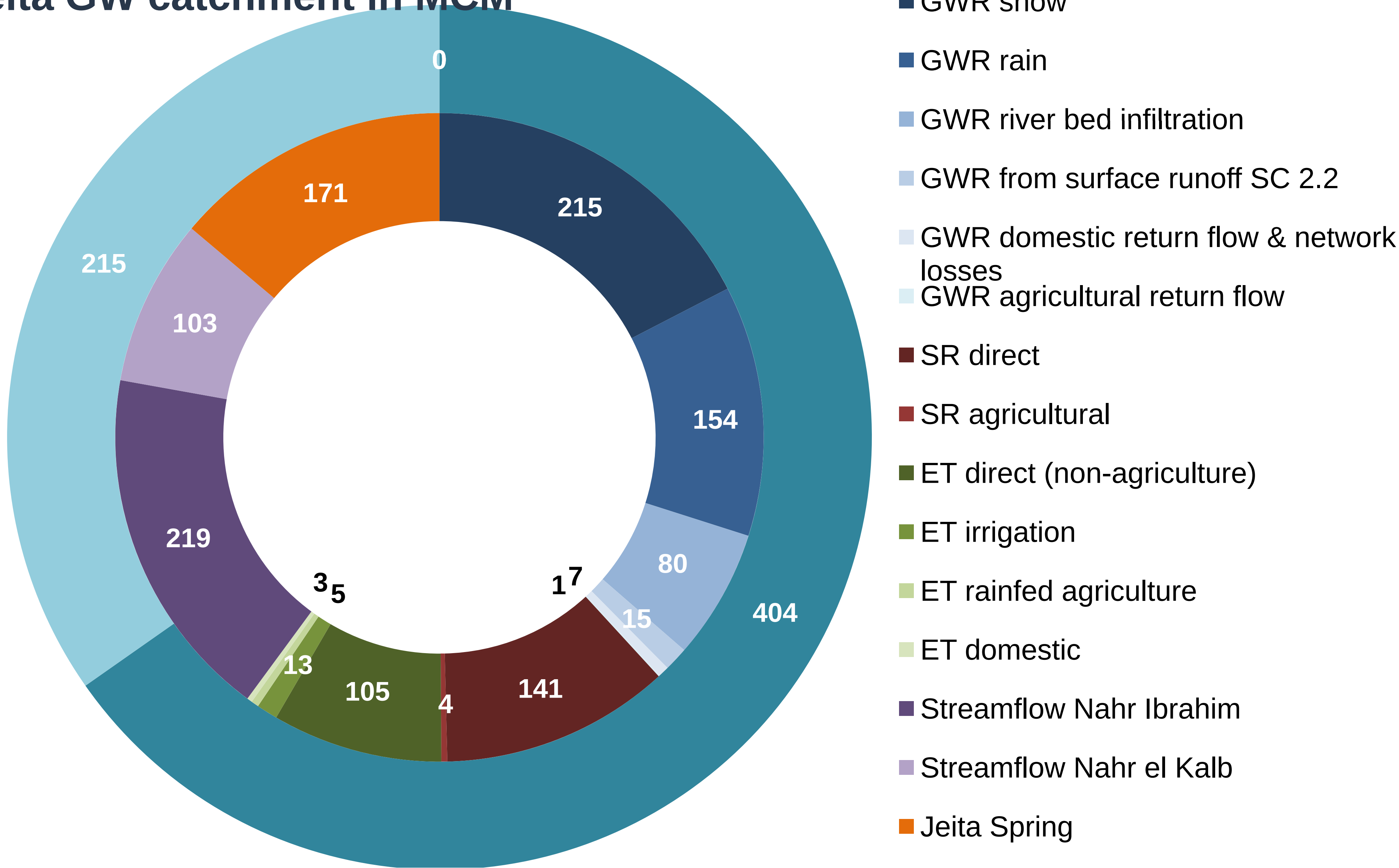
VI. Results: Water Balance

Annual natural in- & output from the Jeita GW catchment in MCM

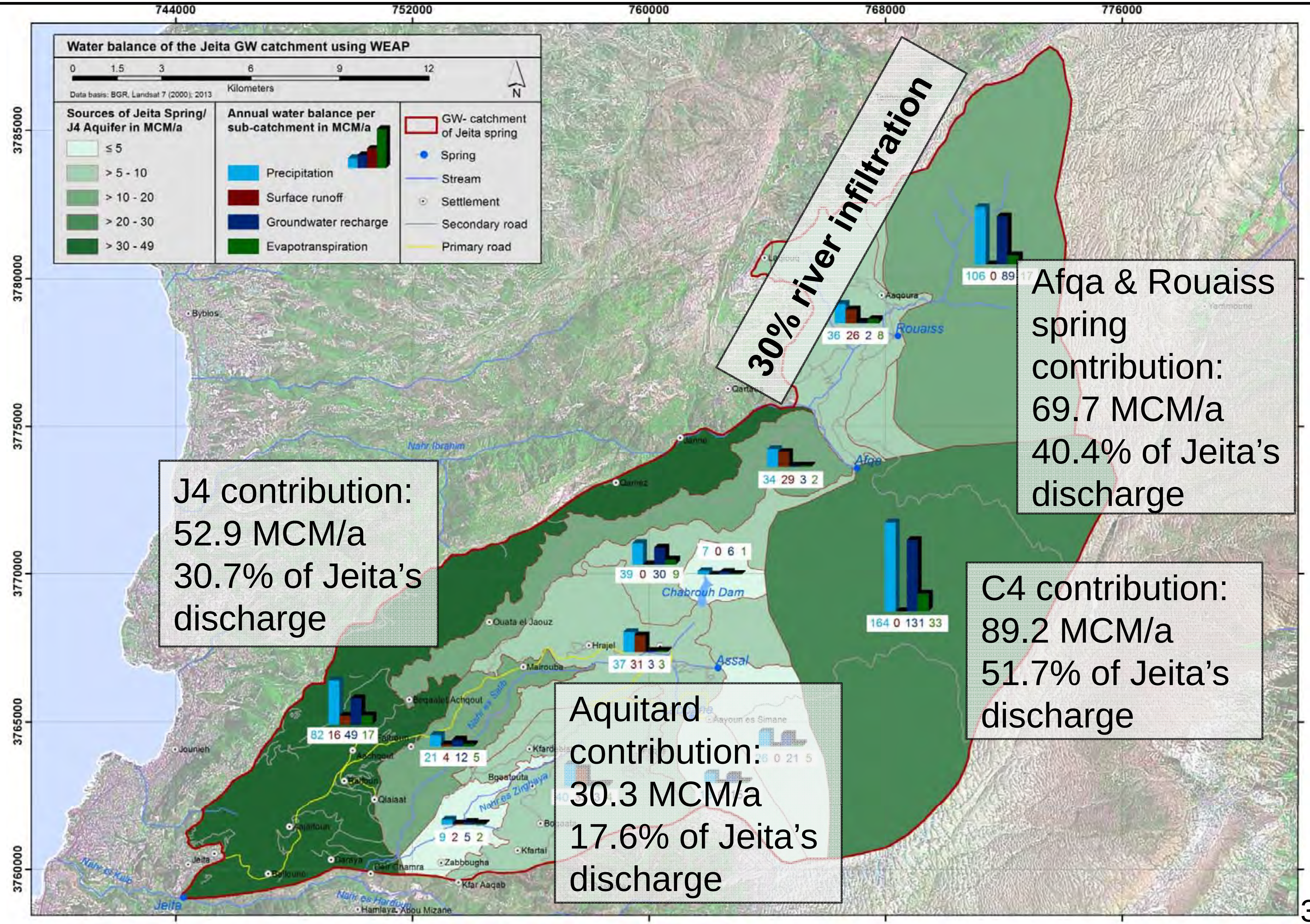


VI. Results: Water Balance

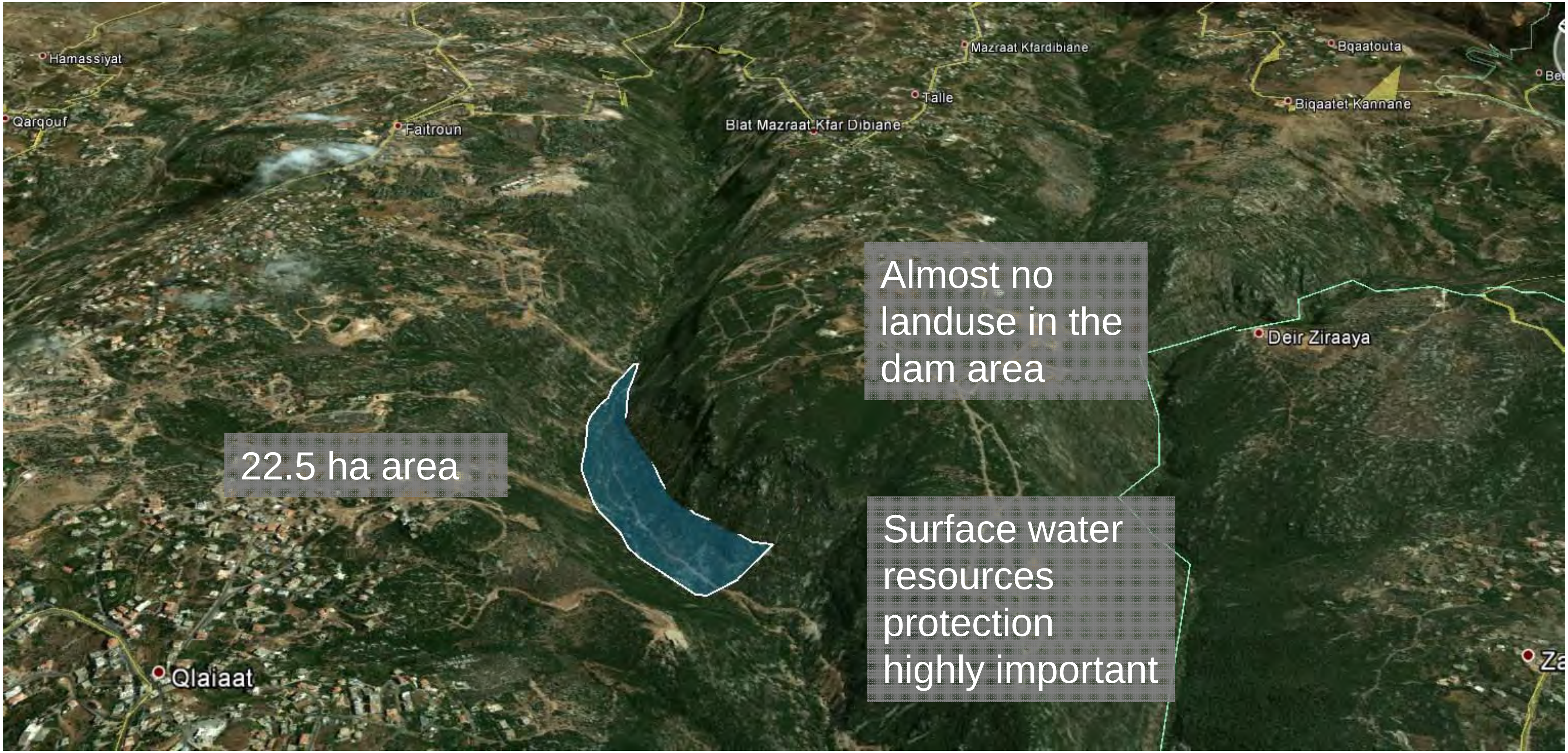
Annual anthropogenic in- & output from the Jeita GW catchment in MCM



VI. Results: Water Balance



VI. Results: MAR Option

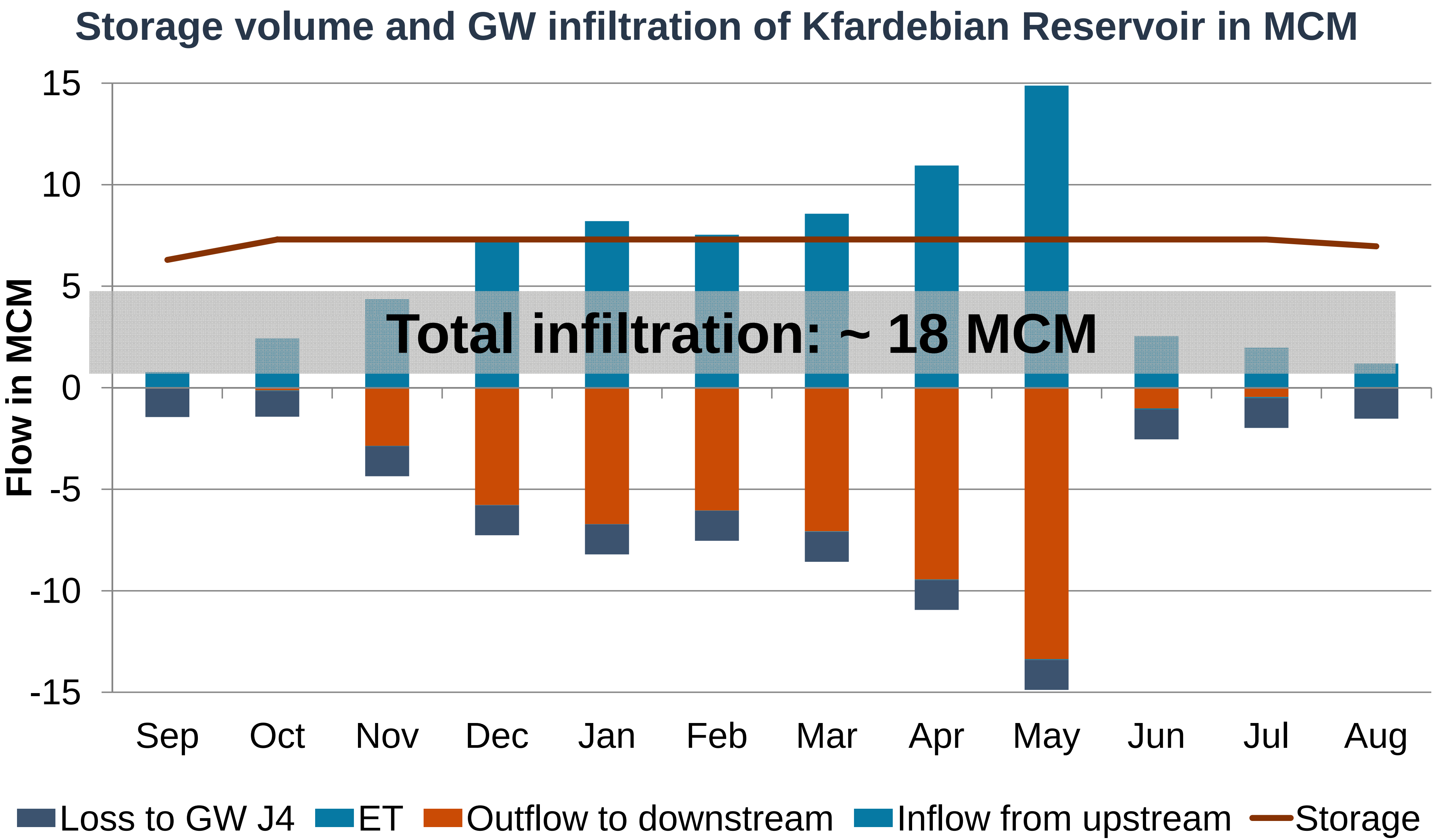


Almost no landuse in the dam area

22.5 ha area

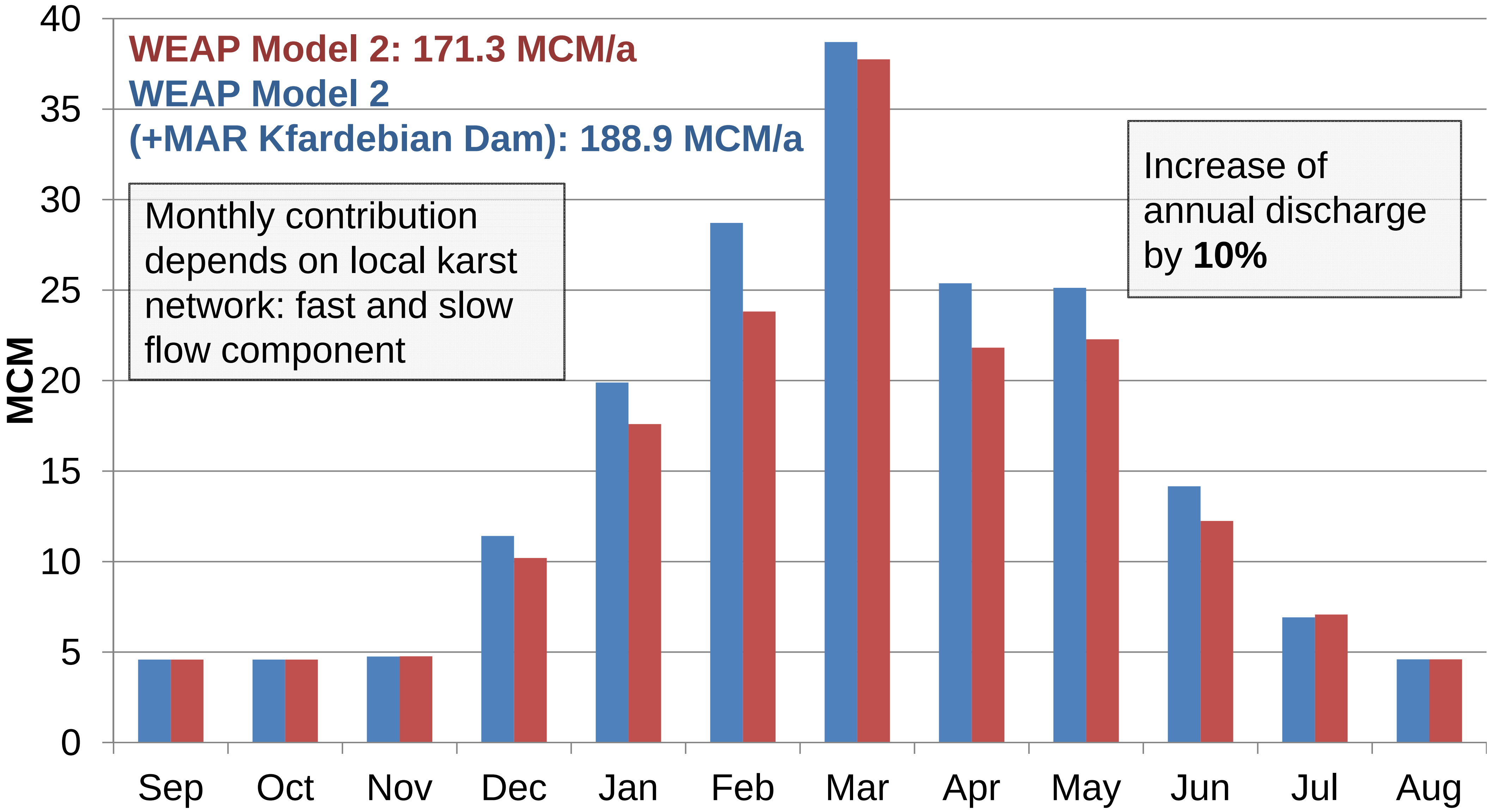
Surface water resources protection highly important

VI. Results: MAR Option



VI. Results: MAR Option

Discharge of Jeita Spring of Model 2.0: +/- Kfardebian Dam in MCM



VI. Results: Climate Change Scenario

- Modeling period: 2010 to 2040
- Based on the A1B scenario (*)
  - *Most commonly used*
  - *Based on: Beirut, Cedars, Dahr el Baidar and Zahleh*

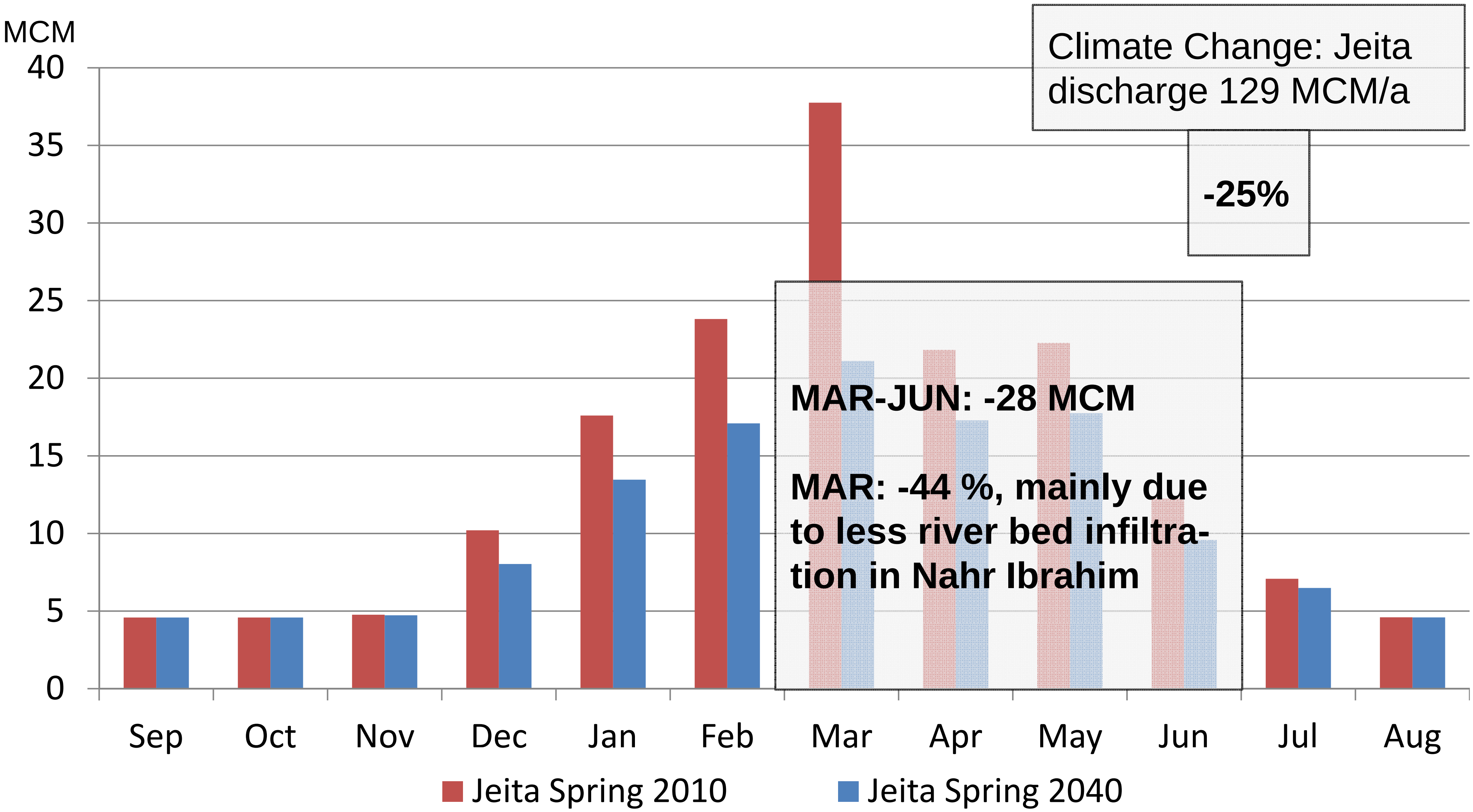
- Selected forecasts until 2040:

Precipitation (%)		Temperature(°C)		k_c	
Summer	Winter	Summer	Winter	Summer	Winter
-15	-20	+2	+1.75	+4.4	+3.1

(*) MINISTRY OF ENVIRONMENT (MoE) (2011): Lebanon's Second National Communication to the UNFCCC. Republic of Lebanon, Ministry of Environment, 191 p.; Beirut/Lebanon.

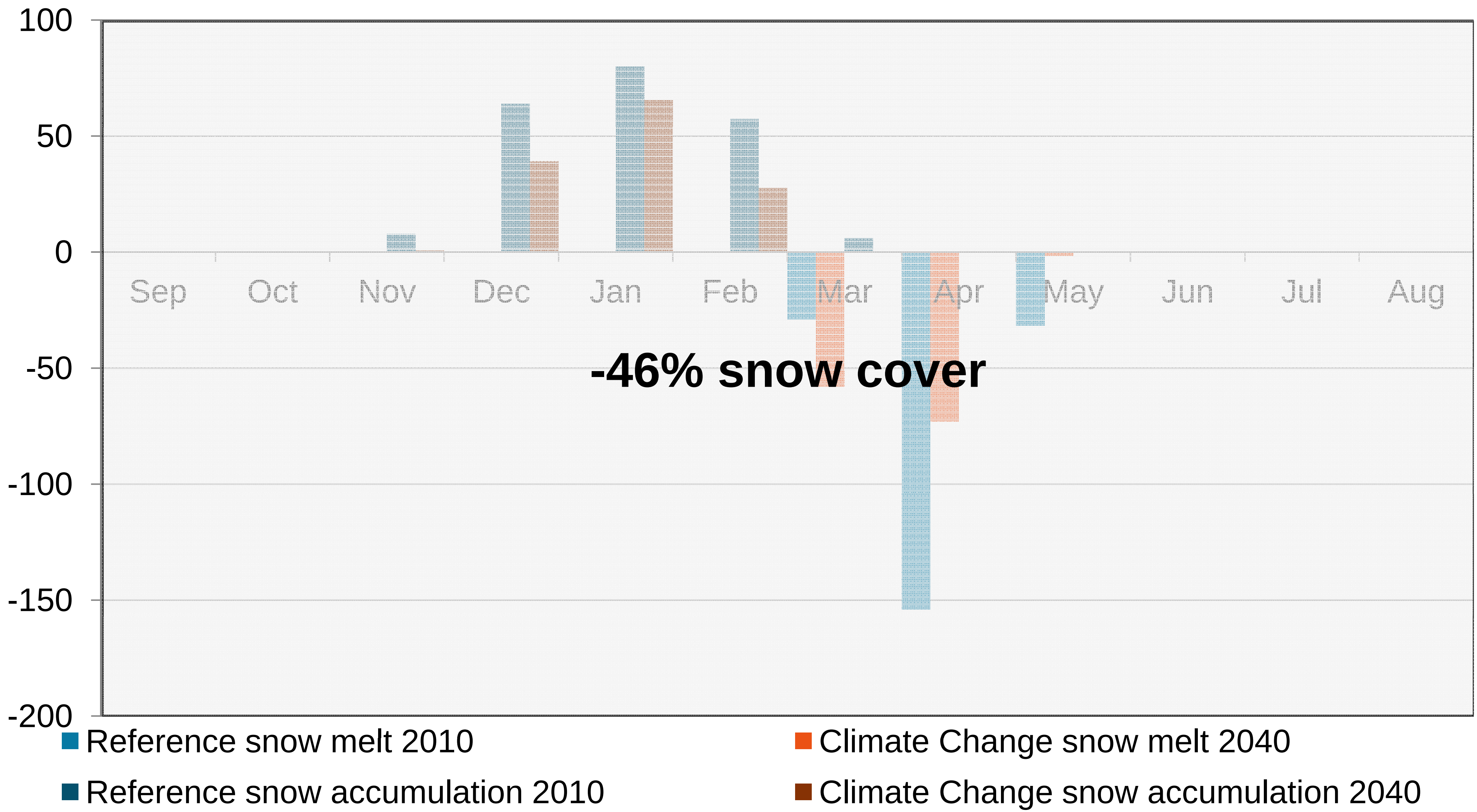
VI. Results: Climate Change Scenario

Discharge of Jeita Spring: Reference vs. Climate Change Scenario in MCM



VI. Results: Climate Change Scenario

Snow cover on the C4: Reference vs. Climate Change Scenario in m



VII. Conclusion

- Technical cooperation offers a solid base for hydrological modeling: improved access to data & knowledge

  → **field studies important!**
- Approx. 40% of Jeita's annual discharge comes from the C4
- Approx. 28% of Jeita's annual discharge comes from Afqa and Rouaiss Spring
- Large quantities of water resources are unused: 141 MCM direct runoff per year
- Potential for MAR: Increasing discharge at Jeita Spring

  → however, uncertainty about fast flow/ slow flow component
- According to A1B Scenario:

  - *snow cover will be reduced by 46%*

  - *discharge of Jeita will decrease by 25% in 2040*

VIII. Discussion

- WEAP outside donor activities: is WEAP used by the Ministry?
    - If YES, how?
        - Scenarios
        - Water allocation/supply
        - Demand management
        - Coupling with MODFLOW
        - Monitoring
    - If NOT, why?
- In which context WEAP results are applied in water management?
    - Water resources planning
    - Justification of investments

VIII. Discussion

- What are challenges in the usage of WEAP results?
  - Reliability
  - Complexity/simplicity of results
- Is there inter-ministerial or inter-institutional cooperation in applying/using WEAP?
  - Ministry of Agriculture – Ministry of Water
  - Water Authority/Establishment – Ministry of Water

Report available:
http://www.bgr.bund.de/EN/Themen/Wasser/Projekte/laufend/TZ/Libanon/

شكراً & Thank You!

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Project exchange meeting in Jordan and Lebanon
30 OCT - 01 NOV, Aqaba - Jordan

The Role of Decision Support Systems in Integrated Water Resources Management –Lebanon

Abbas Fayad, MSE
Environment Water Resources Expert
Ministry of Energy and Water - Lebanon

Outline

- **Water Dilemma**
  - **Water: A manageable limited resource**
- **Climate and Water**
  - Precipitation, Evapotranspiration, Soil moisture, Runoff and river discharge, Groundwater recharge
  - Patterns of large-scale variability
- **Linking Climate, Hydrology and Water Resources: Impacts and Responses**
- **IWRM Progress in Lebanon**
- **IWRM Conceptual Framework**
- **Implementation of a Hydrologic and Water Resources Model as a DSS for IWRM**
  - From data to information
    - Future water availability
    - Water demand
    - Water stress
- **Where We Stand from a Complete IWRM?**

Water Dilemma
Quantity/Quality

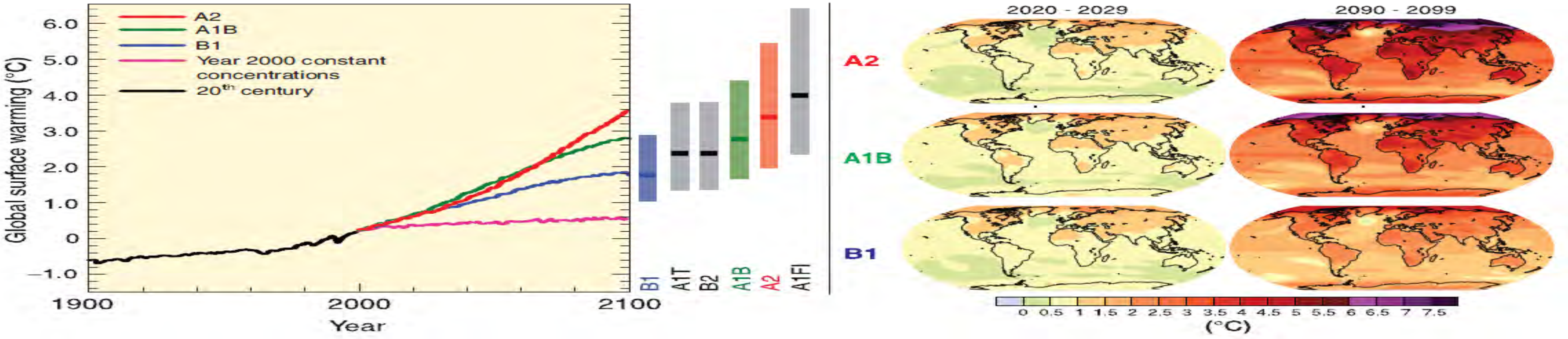
- Water scarcity is believed to be one of the main problems currently facing the country
  - Limited water resources
  - Increased pressure on the water sources
    - Increased supply requirements by all sectors
- Socio-economic development putting increased pressure on resources
  - population growth; increased economic activities & urbanization trends
    - Increased water demands, and
    - Amplified competition between user
- Increasing pollution of water resources (contributing to water scarcity)
  - Associated to increased human, industrial processes, sand agricultural activities

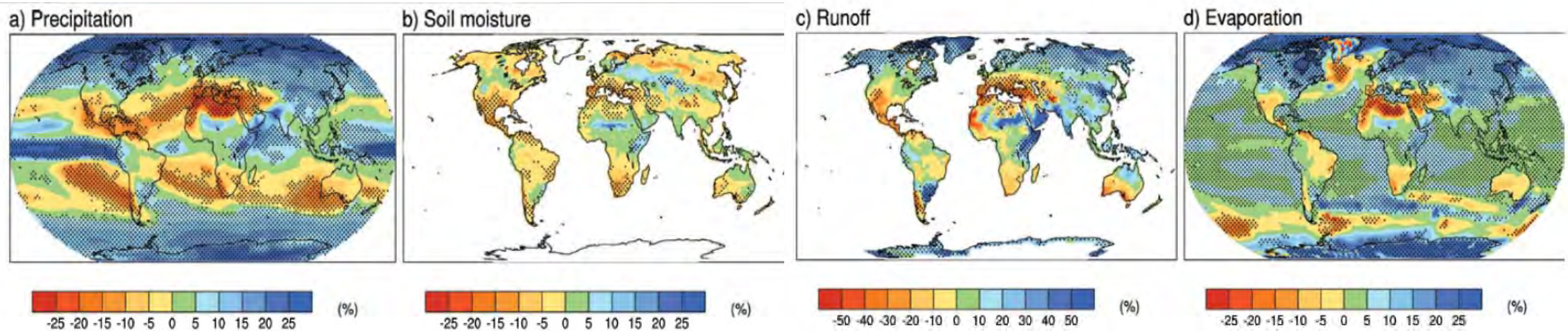
Water Dilemma

Institutional & Management Limitations

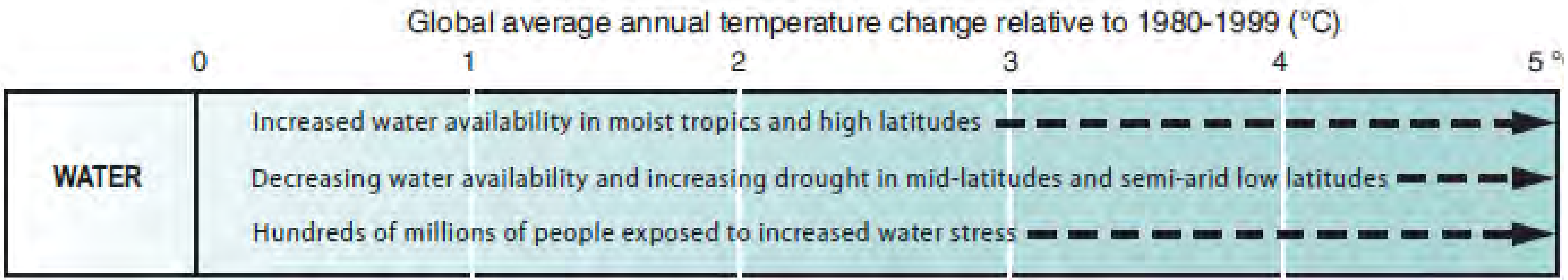
- Studies have fallen short of linking hydrologic modeling to water resources management and the assessment of climate change
- Lack of a comprehensive hydrologic and water resources management system at the national scale:
  - Inaccessibility to hydrological and meteorological data
  - Absence of integrated hydrological-water resources models
  - Fragmented and outdated information regarding water budget and water resources use in Lebanon
- Disorganized water governance
  - Limited governance, legislative, and institutional capacities
  - Inadequacy in the development of management and planning practices

Projected changes in climate as they relate to water





Atmosphere-Ocean General Circulation Model projections *for the period 2080–2099 relative to 1980–1999*



Source: IPCC *WGI Figure 10.12* & IPCC WGI 10.4, 10.8 (Figures 10.28, 10.29)

Effects and possible impacts of climate on water (Mediterranean and Semi-Arid Regions)

- ***Shifts in precipitation patterns***
  - changes in water availability and other related phenomena (e.g., groundwater recharge, evapotranspiration)
  - interannual precipitation variability and seasonal shifts in streamflow
- ***Reduced water availability***
  - decreased flows due to longer and more frequent dry seasons;
  - reduction of stored water in reservoirs fed with seasonal rivers (due to decreased precipitation);
- ***Reductions in groundwater levels***
  - low water availability will lead to groundwater over-exploitation
  - groundwater over-exploitation may lead in some cases to water quality deterioration.
- **Increased evapotranspiration** as a result of increased temperatures,
  - lengthening of the growing season and increased irrigation water usage;
- **Increased water supplying cost** (all water uses)

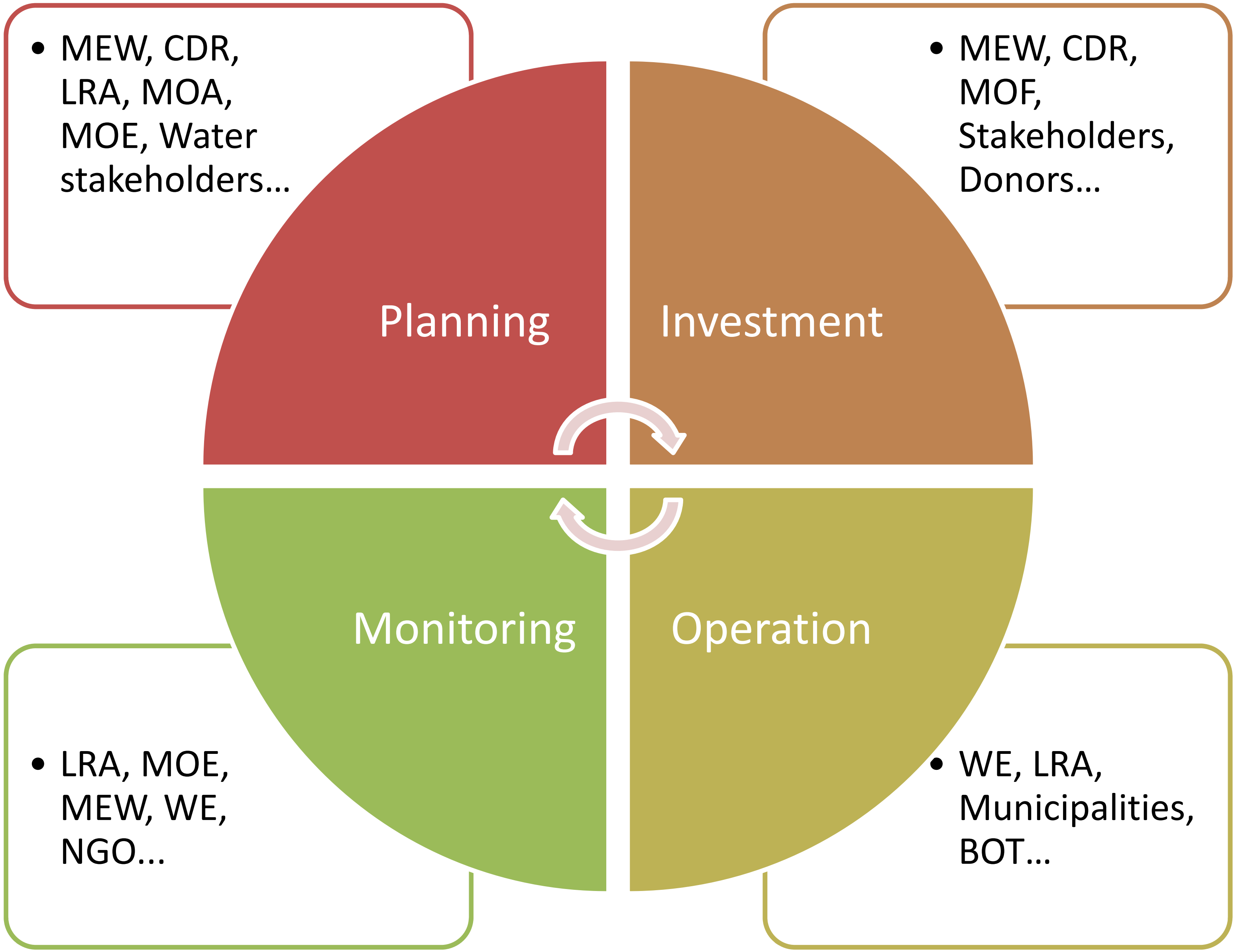
WATER

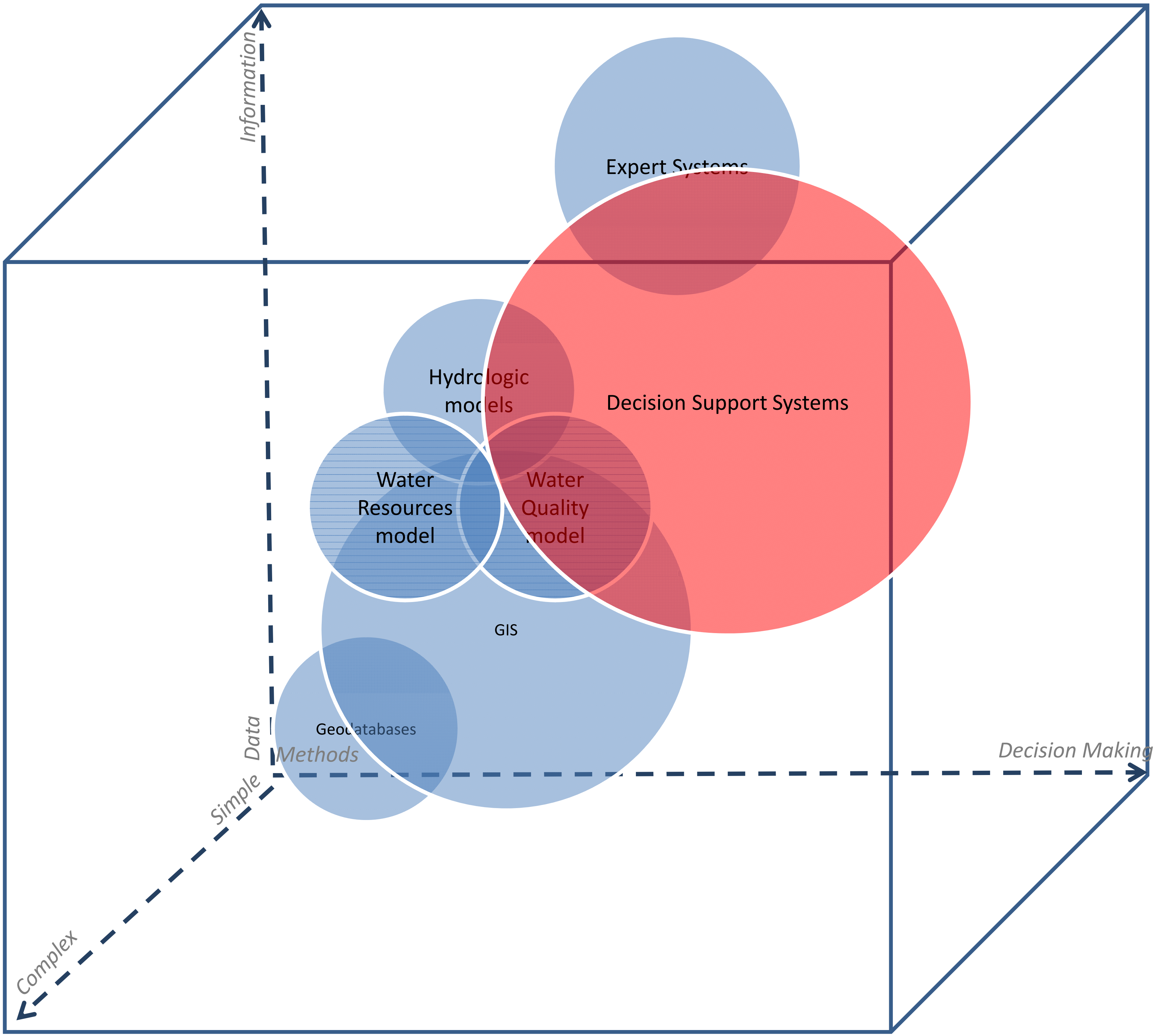
Vulnerability; Adaptation; Mitigation; Sustainable Management and Development

IWRM Progress in Lebanon (MEW Perspective)

- IWRM concepts and approaches have been introduced in Lebanon in the late 90s and have inspired:
  - Gathering **political will** and support for IWRM and the planning process;
  - **A framework for broad stakeholder participation** is being created;
- Revision of water Legislation (2000)
- Preparation of the National 10-year Strategy Plan for the Water Sector by GDHER / MEW (2000-2009)
- Preparation of the National Water Sector Strategy (NWSS) aligns with IWRM principles (approved March 2012)
- MED EUWI Country Policy Dialogue on IWRM in Lebanon (Phase I - concluded in 2009; Phase II (2010 - ongoing)
- The Water Code - a cooperation programme between the Lebanese and the French Government
  - Aims to tackle within a comprehensive and integrated framework governance, institutional and management issues and recommends provisions for the implementation of sustainable management of water resources;
  - The Water Code has been submitted to the Council of Ministers for approval.

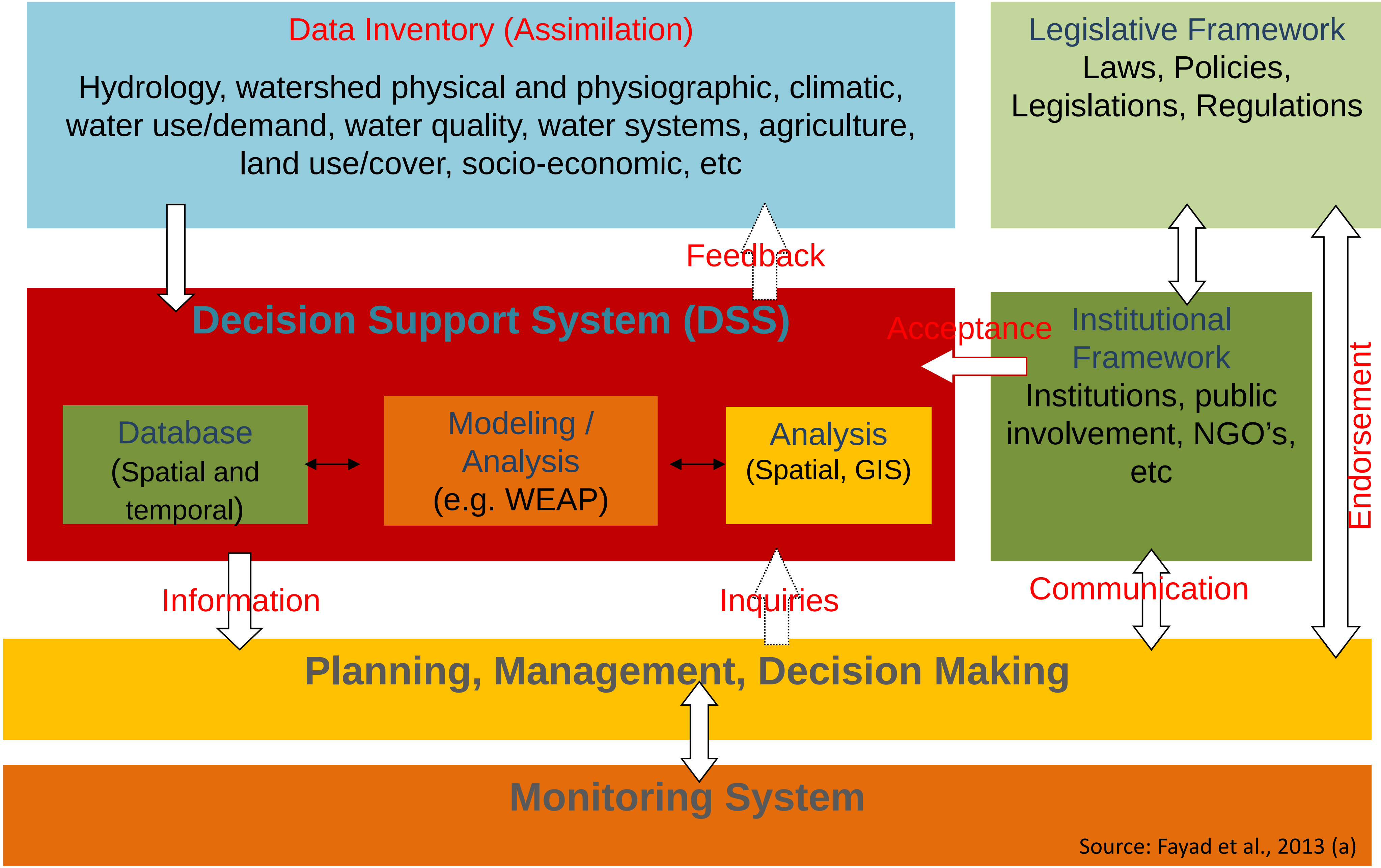
IWRM Directives





Information
Expert Systems
Decision Support Systems
Hydrologic models
Water Resources model
Water Quality model
GIS
Geodatabases
Data
Methods
Decision Making
Simple
Complex

IWRM Conceptual Framework (LEBANON)

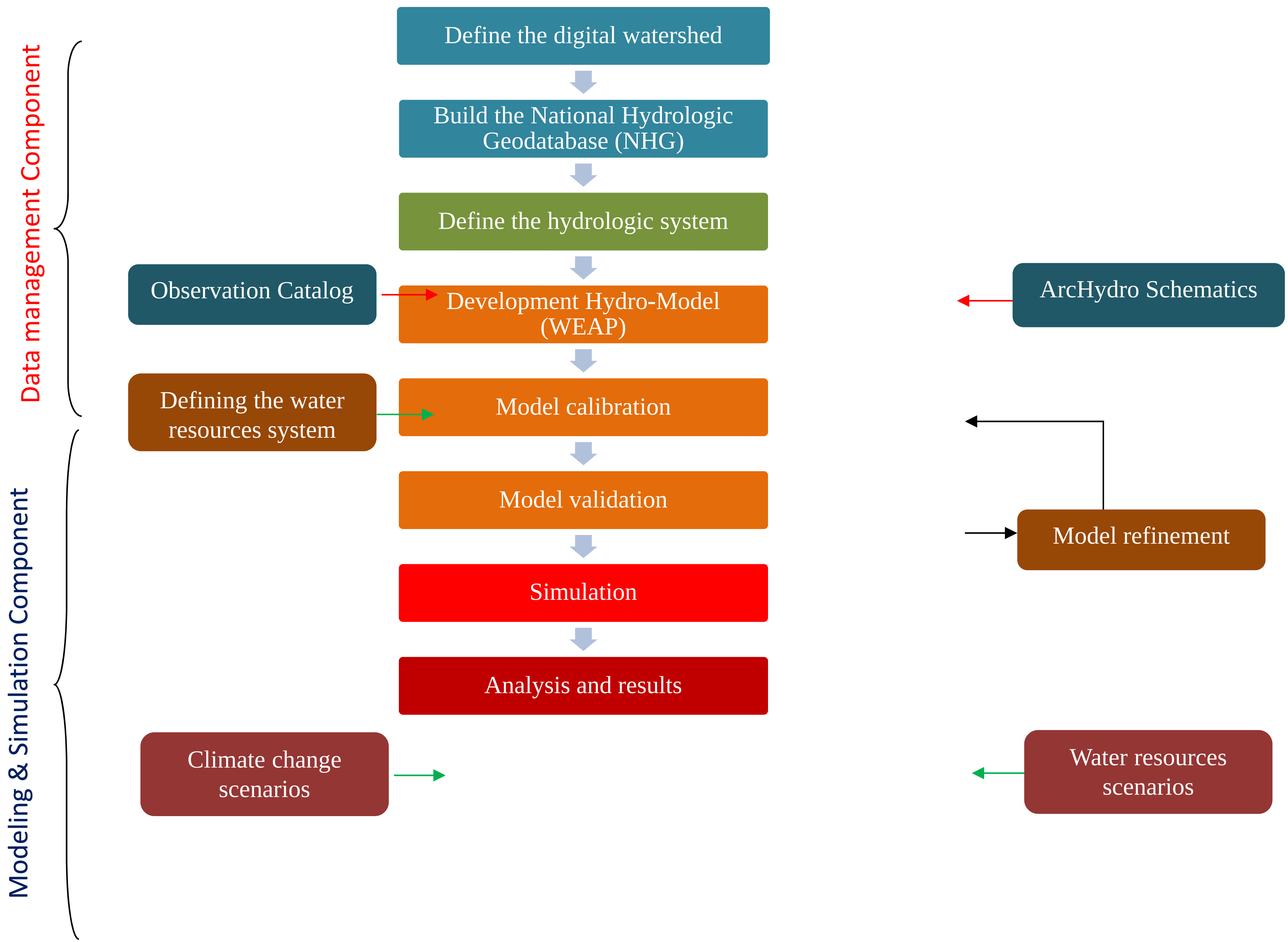


Source: Fayad et al., 2013 (a)

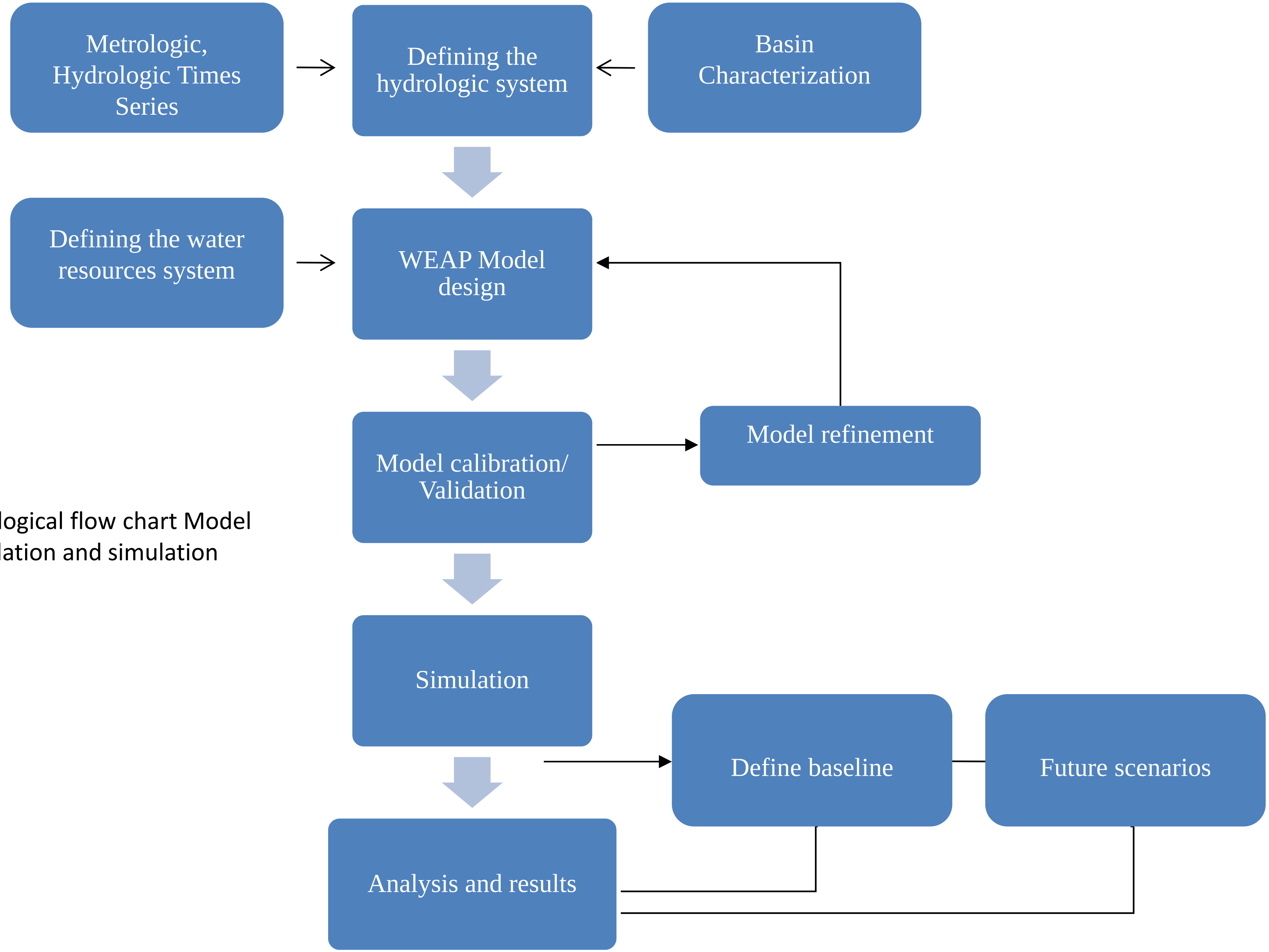
National Hydrologic and Water Data Inventory (NHWDI)

- Four types of data formats were recognized as part of the NHWDI:
- Spatial data derived from existing maps (e.g. soil, land cover, geology, and hydrogeology)
  - used to define the watershed physical and physiographic characteristics (including land use/cover, soil groups, DEM, drainage networks, rivers and streams, etc);
- Temporal hydrologic and climatologic data including observation from gauging river and meteorological stations
  - Available as time series data (including river flow/discharge, temperature precipitation, humidity, evaporation, etc);
- Water resources, socio economic data and census
- Supplementing spatial data (i.e. attribute data)
  - additional information on the spatial hydrologic data (e.g. hydrologic characteristics of soil units and hydrogeologic parameters of aquifers).
  - Available either in reports or tabulated data.

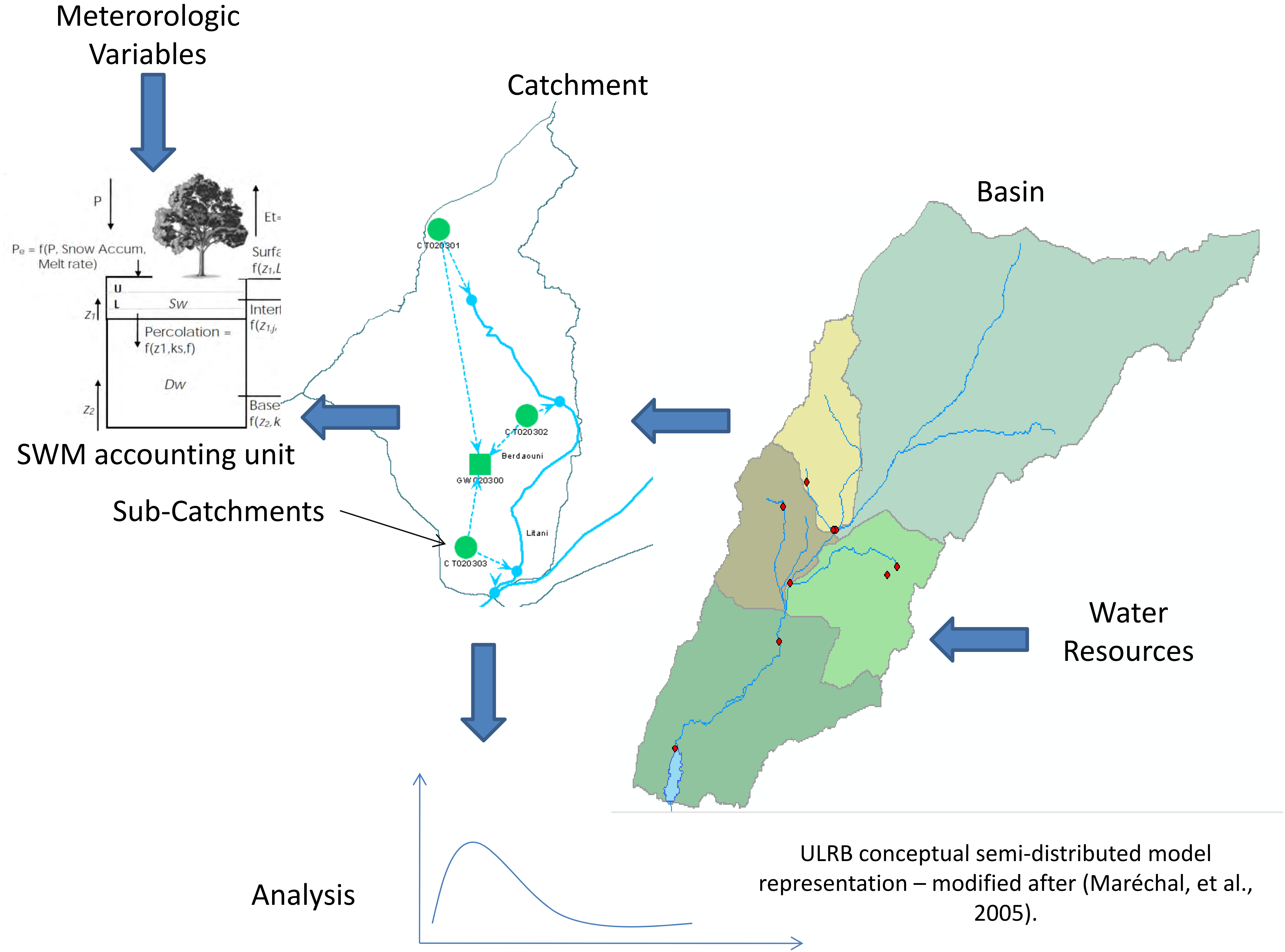
National DSS Framework



Development of an integrated hydrologic-water resources model



Methodological flow chart Model formulation and simulation



ULRB conceptual semi-distributed model representation – modified after (Maréchal, et al., 2005).

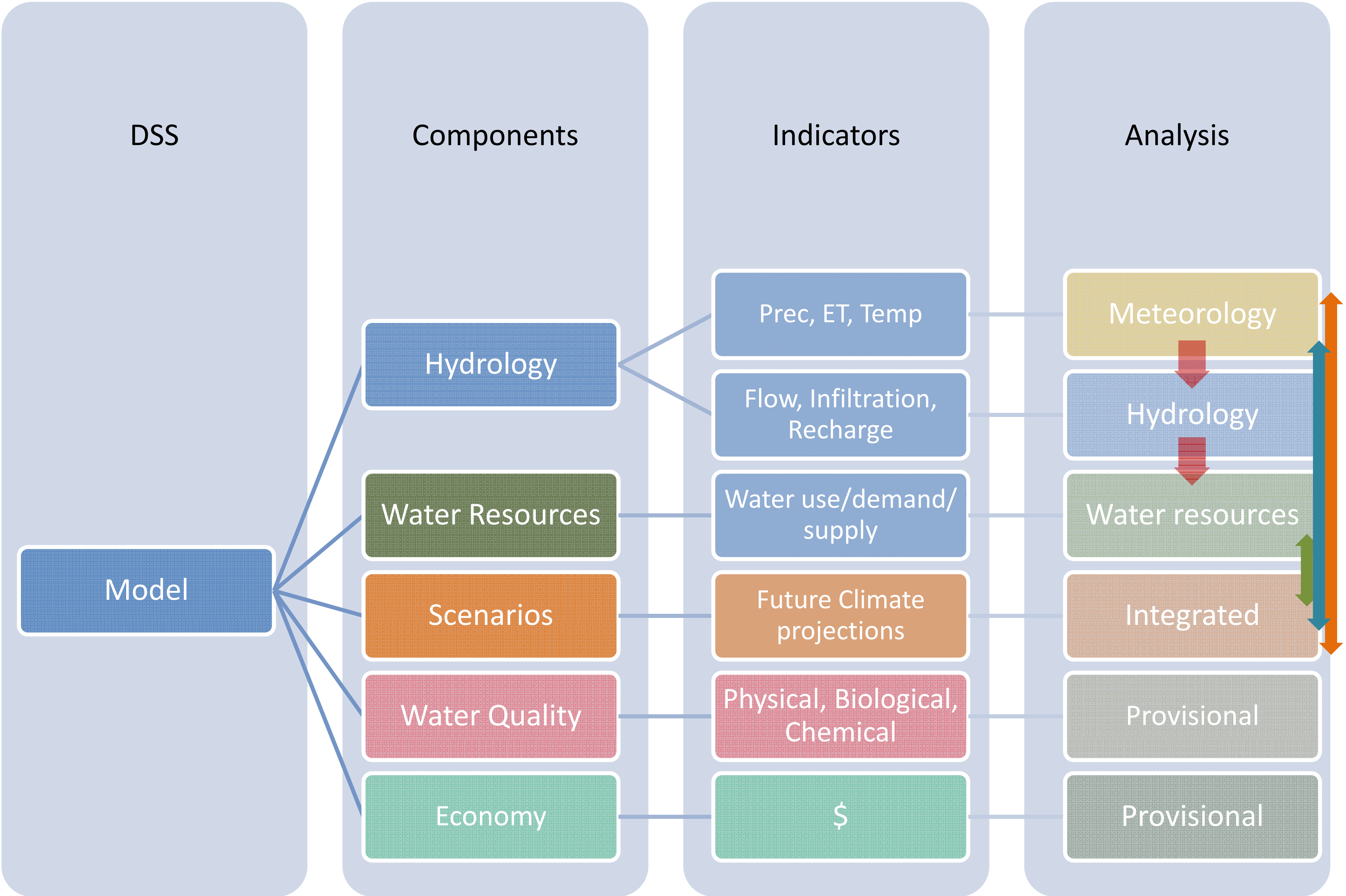
Model Characteristics

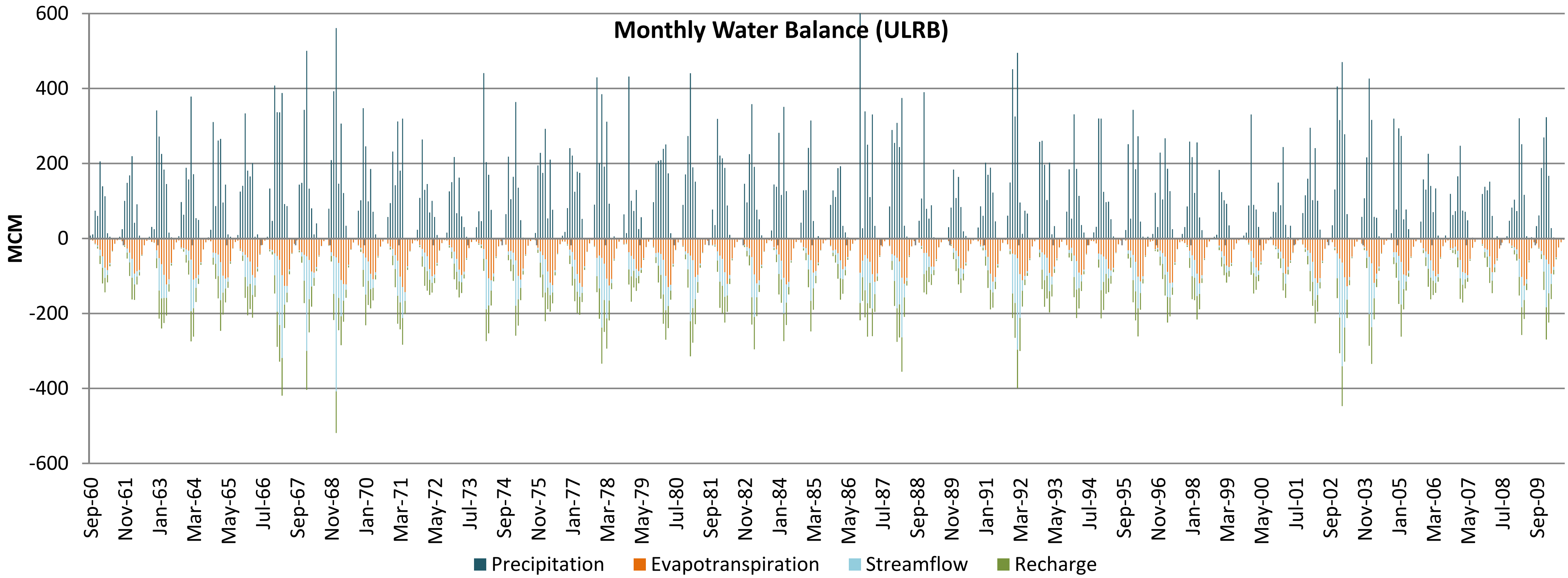
Parameter	Units	Ref	Scale	Format*	Sign**
Watershed physical characteristics					
Watershed area	sq km	Catchment	1/20k	SD	H
Rivers, streams	Variable	Catchment	1/20K	SD	H
Lakes	Volume	Catchment	1/20K	SD	M
Watershed physiographic characteristics					
Kc	-	Land class	1/50K	SD	H
RRF	-	Soil Unit/ Topo	1/200K	SD	H
PFD	-	Land Use/ Topo	1/50K	SD	M
Water capacity (surface/deep)	cm	Soil Unit	1/200K	SD & AD	H
Soil conductivity (surface/deep)	mm/month	Catchment	1/200K	SD & AD	H
Ground water					
Aquifer capacity	MCM	Hydrogeology	1/200K	SD & AD	M
Aquifer conductivity	mm/month	Hydrogeology	1/200K	SD & AD	H
Aquifer depth	m	Hydrogeology	1/200K	SD & AD	H
Climate/ Hydrology					
Precipitation	mm/month	Catchment	NA	TS	H
ET	mm/month	Catchment	NA	TS	M
Evaporation	mm/month	Catchment	NA	TS	M
Temperature	C	Catchment	NA	TS	H
Wind speed	m/s	Catchment	NA	TS	L
Humidity	%	Catchment	NA	TS	L
Flow	cm/s	Gauge	NA	TS	H
Water Use					
Crop water requirement, Urban…	cm/ha, cm/cap	demand zone	NA	SD, AD & TS	H
Waste water treatment plants	Capacity, operation	Water dataset	NA	AD	M
Lake, dams	Capacity, operation	Water dataset	NA	AD & TS	H
Supply network	Capacity, operation	Water dataset	NA	AD	H

* SD = Spatial GIS data; AD = GIS attribute data; and TS = Time series data

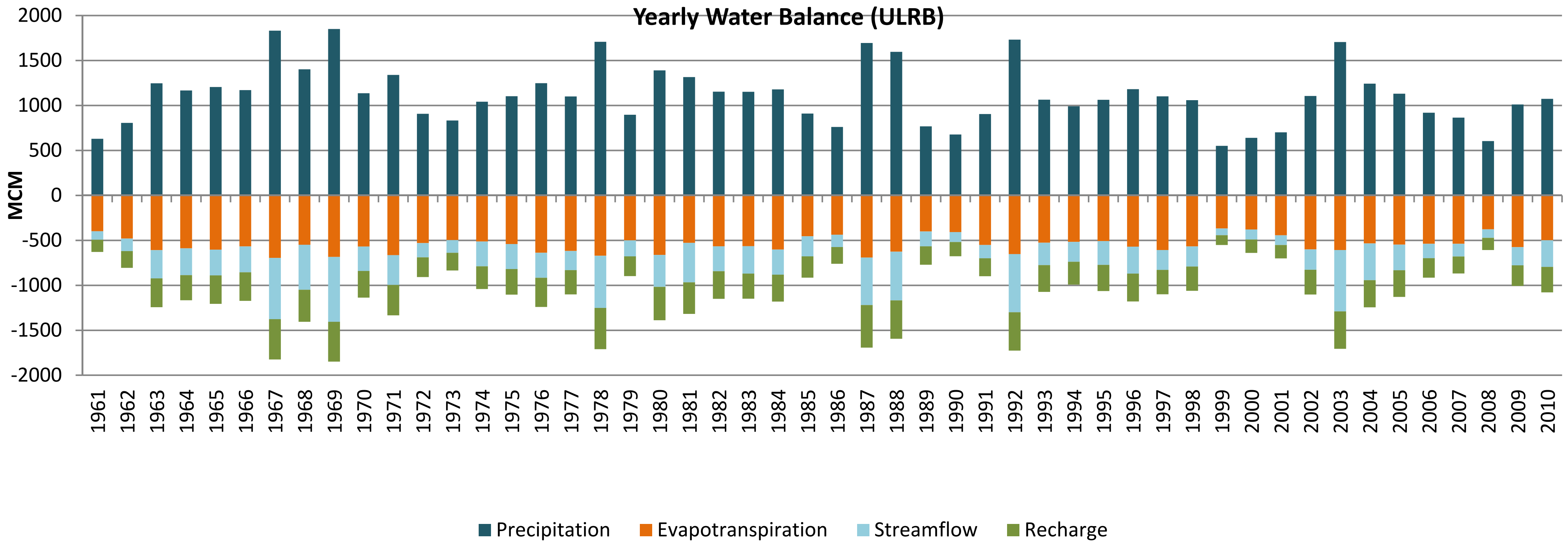
** Significance: H = High; M = Moderate; L = Low

From Data to Information





Monthly Water Balance (ULRB)
MCM
600
400
200
0
-200
-400
-600
Sep-60
Nov-61
Jan-63
Mar-64
May-65
Jul-66
Sep-67
Nov-68
Jan-70
Mar-71
May-72
Jul-73
Sep-74
Nov-75
Jan-77
Mar-78
May-79
Jul-80
Sep-81
Nov-82
Jan-84
Mar-85
May-86
Jul-87
Sep-88
Nov-89
Jan-91
Mar-92
May-93
Jul-94
Sep-95
Nov-96
Jan-98
Mar-99
May-00
Jul-01
Sep-02
Nov-03
Jan-05
Mar-06
May-07
Jul-08
Sep-09
Precipitation
Evapotranspiration
Streamflow
Recharge



Yearly Water Balance (ULRB)
MCM
2000
1500
1000
500
0
-500
-1000
-1500
-2000
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
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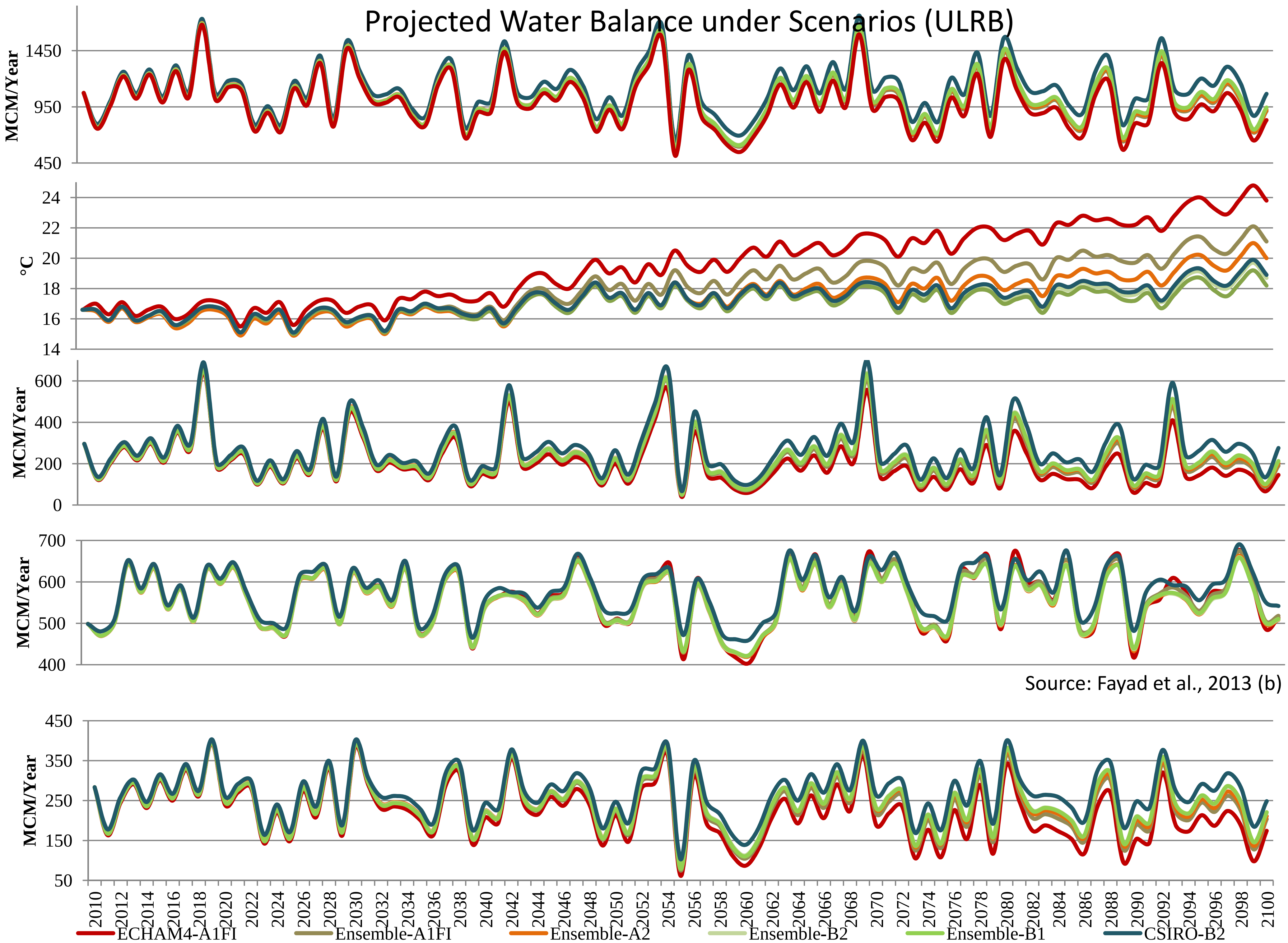
Precipitation
Evapotranspiration
Streamflow
Recharge



Comparison of the projected yearly (a) precipitation, (b) temperature, (c) streamflow, (d) evapotranspiration, and (e) recharge under scenarios

Projected hydrological changes

(average 2001-2010 vs. 2091-2100)

Projected hydrological changes	Vulnerability/Implications of hydrological changes	Occurrence †	Impact‡
Reduced surface runoff	Reduced extractable water supply for irrigation and other purposes (e.g. agriculture, irrigation)	Very likely	----/0
Changes in seasonal river flow patterns	Reduced extractable water supply for irrigation and other purposes (e.g. agriculture)	Unlikely	-/0
Reduced groundwater recharge	Reduced spring discharger and extractable water supply for all water sectors (i.e. domestic and agriculture)	Likely	---/0
Increased evapotranspiration	Reduced water in soils (drier soils)	Very likely	--/0

† Occurrence probabilities over the 24 different scenarios (where >90% (Very likely), >66% (Likely), and <33% (Unlikely)

‡ Magnitude of change between the simulated (average 2091-2100) and the observed average over the time period between 2001 and 2010. Each sign indicates a ±10% change. The impact represents the range of changes over the 24 different scenarios.

Source: Fayad et al., 2013 (c)

Main driving forces and variables (Lebanon)

Systems	Driving forces	Main Variables
Climate System	Climate change	Precipitation, temperature, etc
Hydrologic System	Climate change	Flow, groundwater storage, recharge, and evapotranspiration
Socio-economic system	Demographic change	Population growth, lifestyle (i.e. water consumption)
	Economic development	Agriculture, schemed irrigation, industrial development
	Technological innovation	Improved irrigation efficiency, improved water use efficiency, wastewater treatment, pollution control
Management system	Management framework	Water infrastructure, reservoir operation, water transfer
	Legislative and regulatory framework	Water allocation, water quota, water policies, water pricing

Source: Fayad et al., 2013 (c) - adopted from literature (IPCC, 2007b; Dong et al., 2013).

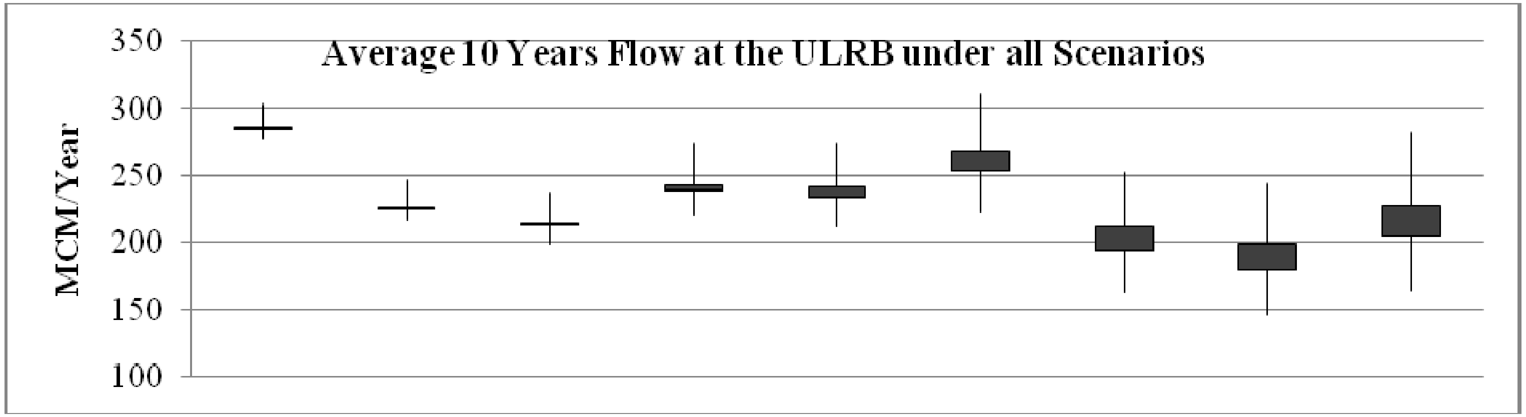
Evaluation of Alternatives

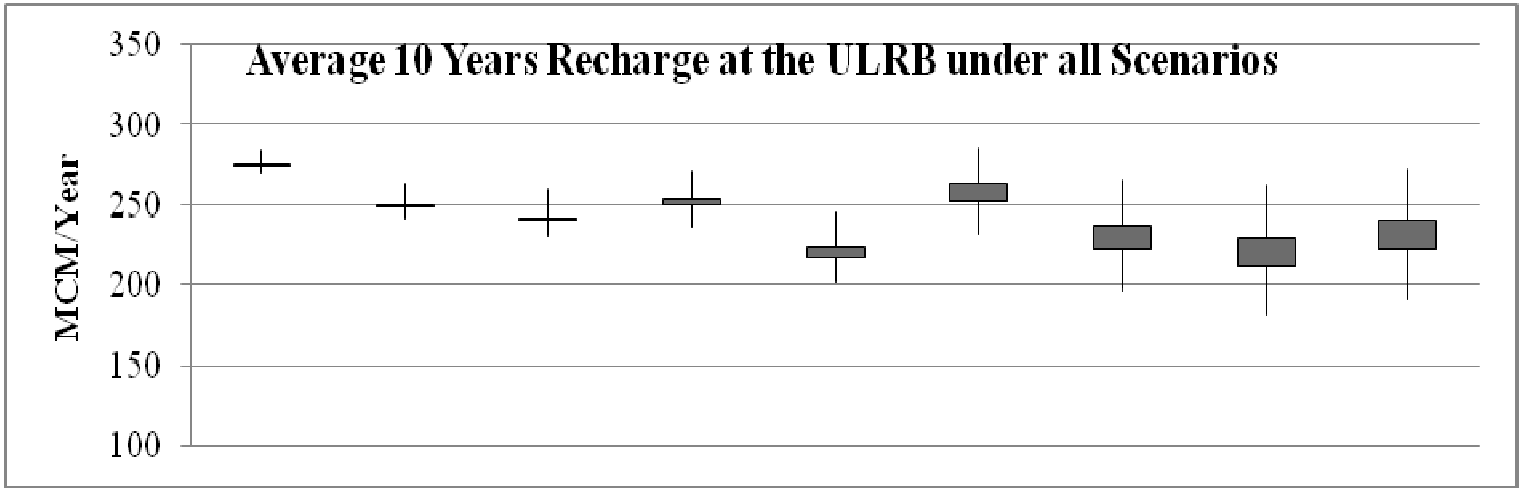
- Answer questions related to
  - Water quantity
    - How to decrease water deficiency in specific areas ?
    - Increase water use efficiency for urban consumption?
    - Increase water efficiency in agricultural practices?
    - Decrease water shortage during summer and dry periods?
  - Water quality (Provisional)
    - Quantify point source and non-point sources pollution? waste water impacts
    - Quantify urban, industrial waste water impacts?
    - How to increase water quality for urban and agricultural supply?

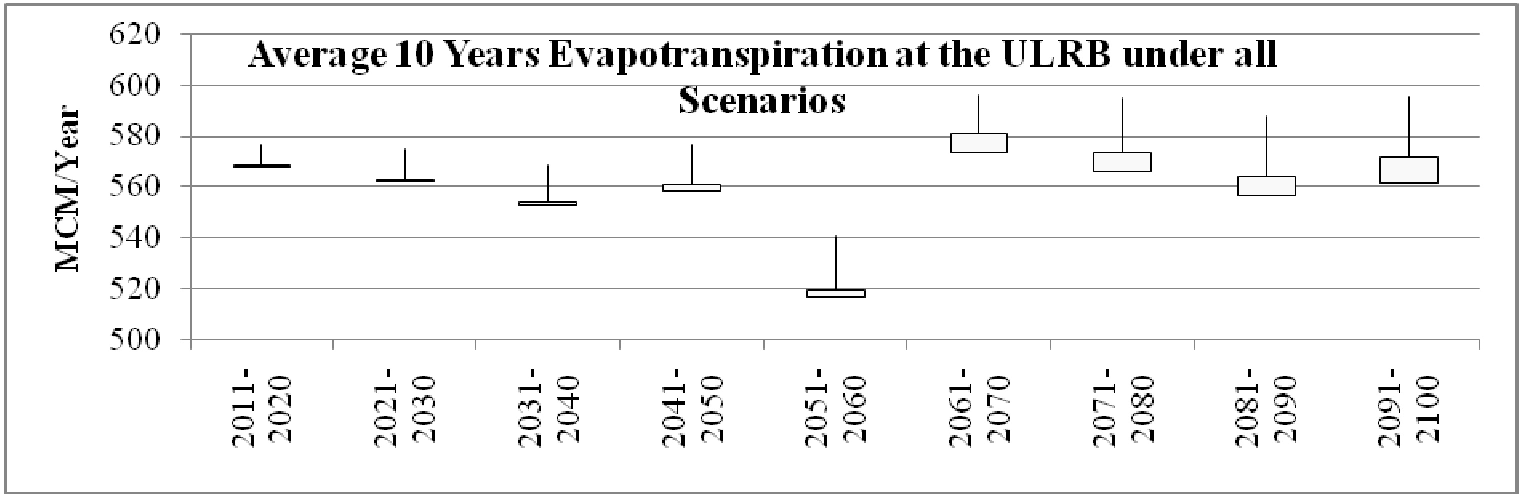
Evaluation of Adaptation Measures

- Interventions to increase water quantity
  – Construction of structural features
  – Change in management practices
- Interventions to increase water quality
  – Environmental protection
  – Change in management practices
- Intervention by using regulations and policies

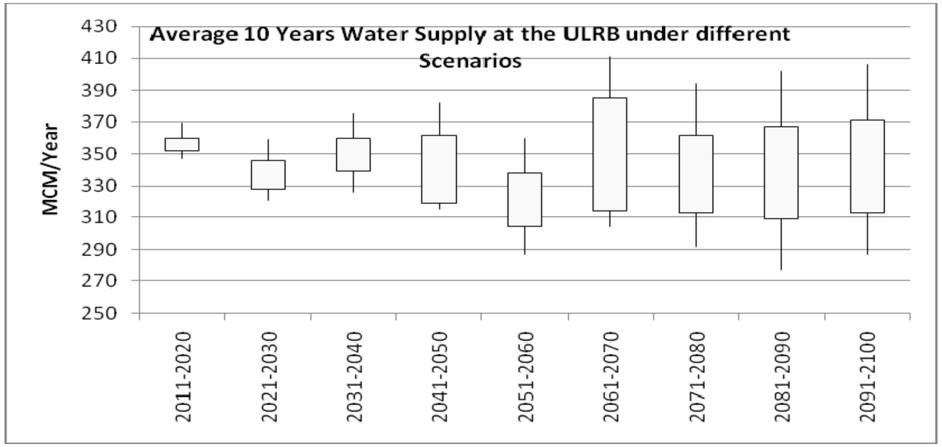
Indicators

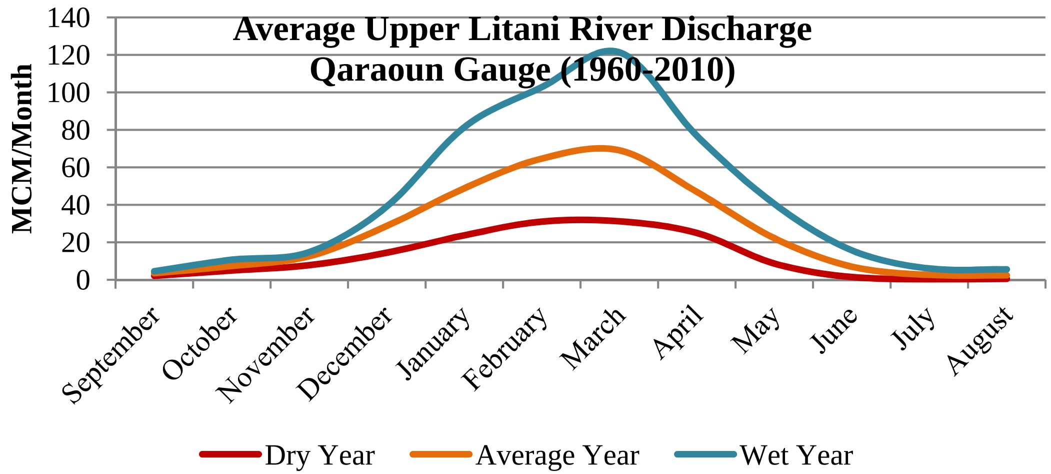

Average 10 Years Flow at the ULRB under all Scenarios
MCM/Year
350
300
250
200
150
100

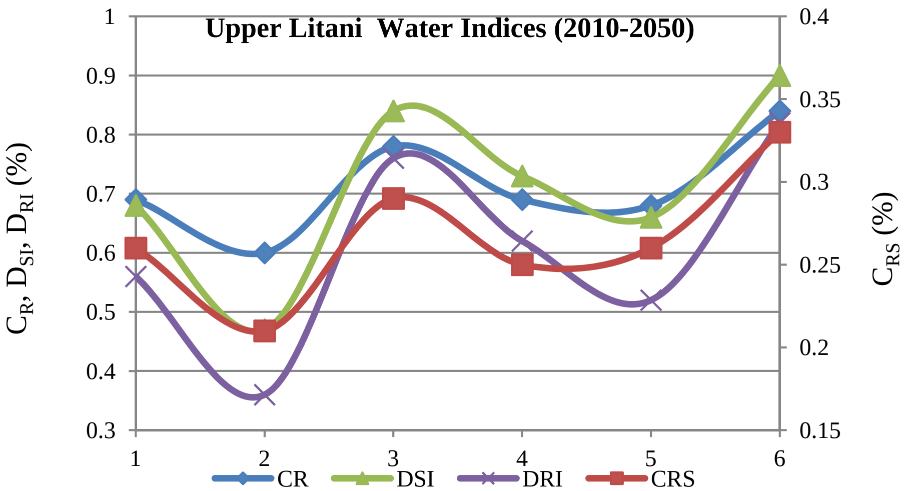

Average 10 Years Recharge at the ULRB under all Scenarios
MCM/Year
350
300
250
200
150
100

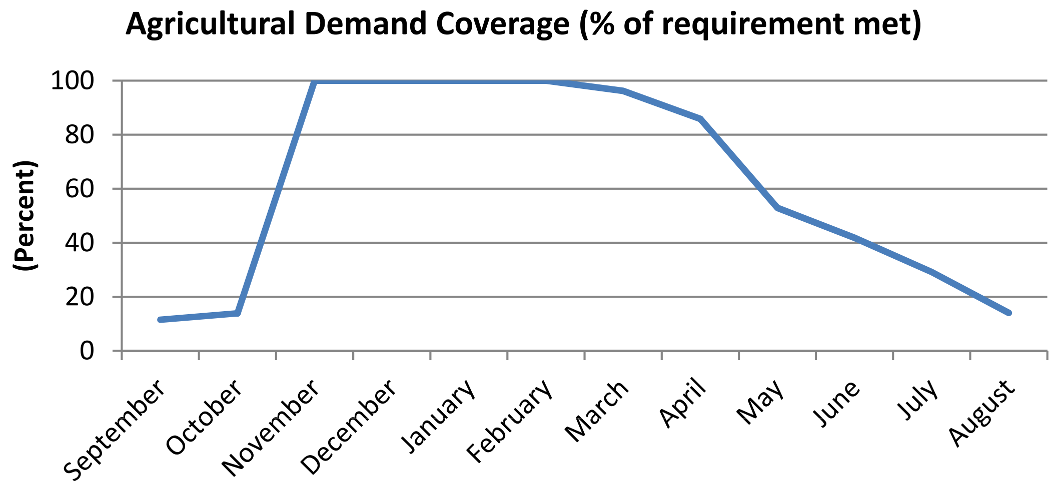

Average 10 Years Evapotranspiration at the ULRB under all Scenarios
MCM/Year
620
600
580
560
540
520
500
2011-2020
2021-2030
2031-2040
2041-2050
2051-2060
2061-2070
2071-2080
2081-2090
2091-2100

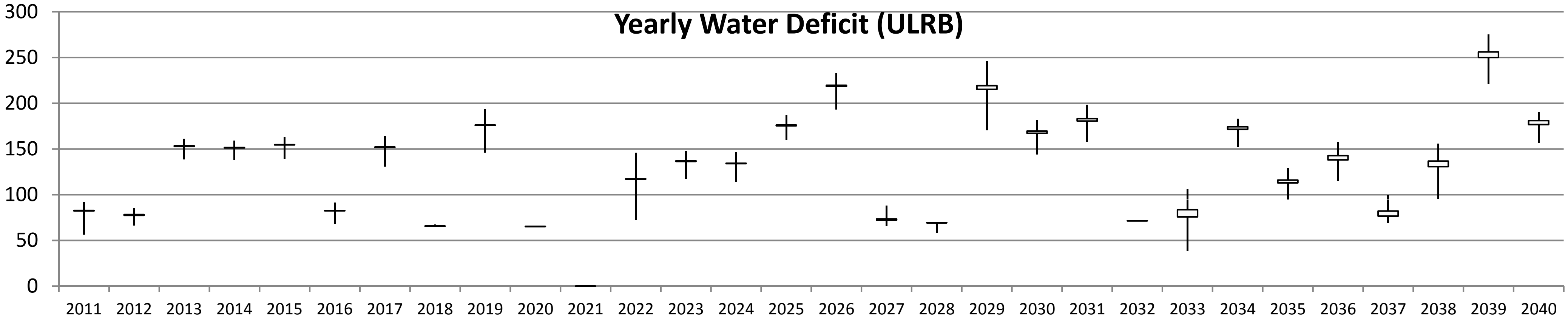
Indicators (2)











Where we stand from a complete IWRM?

- Development of a comprehensive national water database
- for surface water:
  - mapping of the location and boundaries of water resources (e.g. watersheds, rivers, streams, wells, etc);
  - Assessing climate and hydrologic variables;
  - Detection of baseline conditions for surface water resource (i.e. hydrologic cycle)
- For groundwater:
  - Mapping of the location and boundaries of groundwater resources (i.e. geologic, and hydrogeological analysis);
  - Detection of baseline conditions for ground water resource
- Scenario analysis
  - Water resource management, operations, and planning
  - Climate variability and change analysis
  - **Stakeholder consultations / water users contribution**

Completed   Ongoing / Partially completed   Planned

Where we stand from a complete IWRM? (2)

- **Identification of direct stresses**
  - e.g. water shortage, pollution
- **Identification of indirect impacts**
  - e.g. human health, overexploitation of resources, degradation of ecosystems
- **Recognizing of long-term potential impacts**
  - e.g. cultural deterioration, land degradation, loss of biodiversity
- **Identification of major drivers**
  - Natural (e.g. Climate change/Variability, drought); Man-made (e.g. pollution); Social; Capital…
- **Evaluation of alternatives**
- **Evaluation of adaptation Measures**

Completed Ongoing / Partially completed Planned

Where we stand from a complete IWRM? (3)

- Preparation of a summary of significant pressures and impact related to human activity on the status of surface water and groundwater including:
  - estimation of pressures on the quantitative status of water including abstractions,
  - analysis of other impacts related to human activities on the water system;
  - estimation of point source and diffuse pollution,
- Preparation of a socio-economic analysis of water use

Completed Ongoing / Partially completed Planned

Where we stand from a complete IWRM? (4)

- Definition of the main environmental objectives
- Preparation of key potential programs and measures
  - achieve adequate management of water resources (both quantitatively and qualitatively)
- Development of a management plan

Completed Ongoing / Partially completed Planned

THANK YOU…

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Decision Support System WEAP

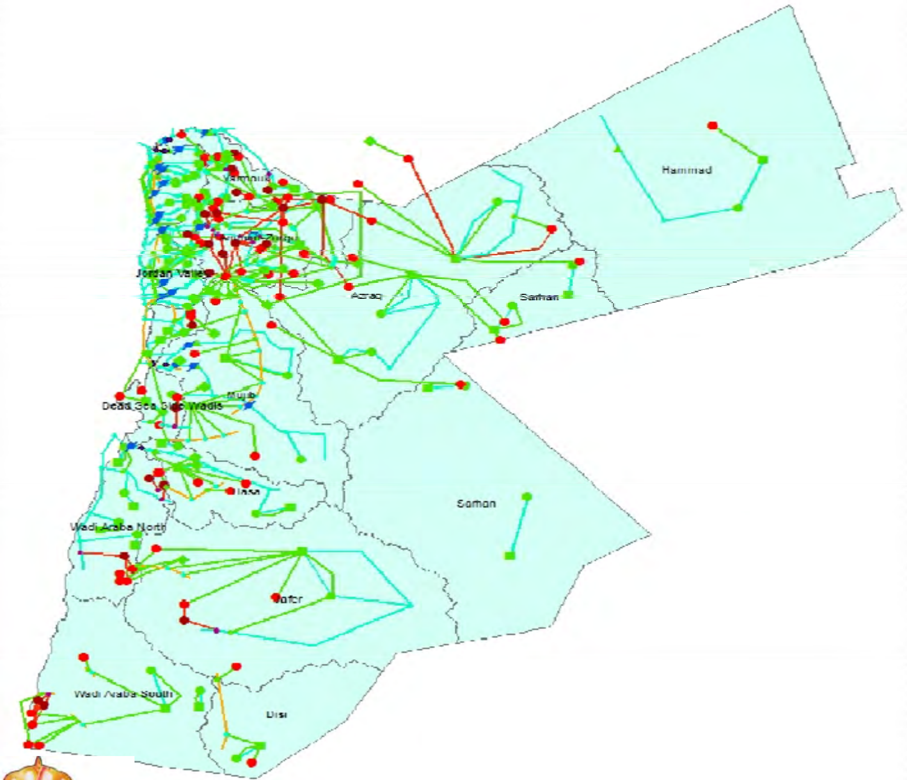
Ministry of Water & Irrigation
National Water Master Plan Directorate
Eng.Ali Brezat

WEAP

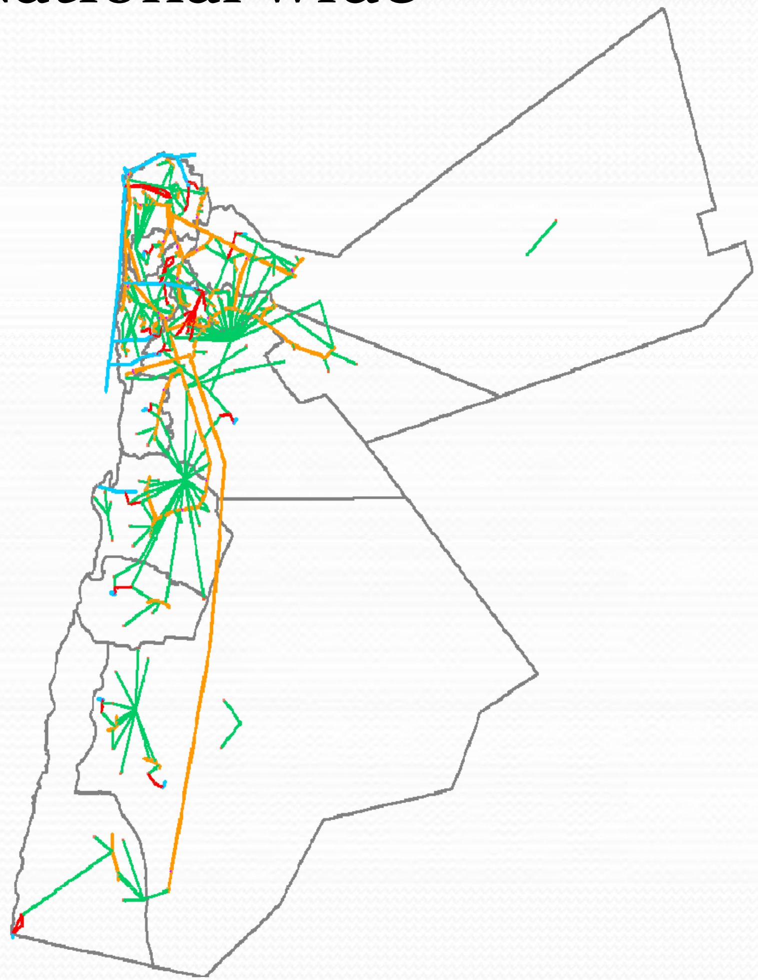
Implementation of decision support tools for water resources allocation and transfer for Jordan, based on the valid National Water Master Plan (NWMP) and the current data of the Ministry's Water Information System (WIS).

There are tow mode of WEAP Modules in Jordan

Basins Module



National wide



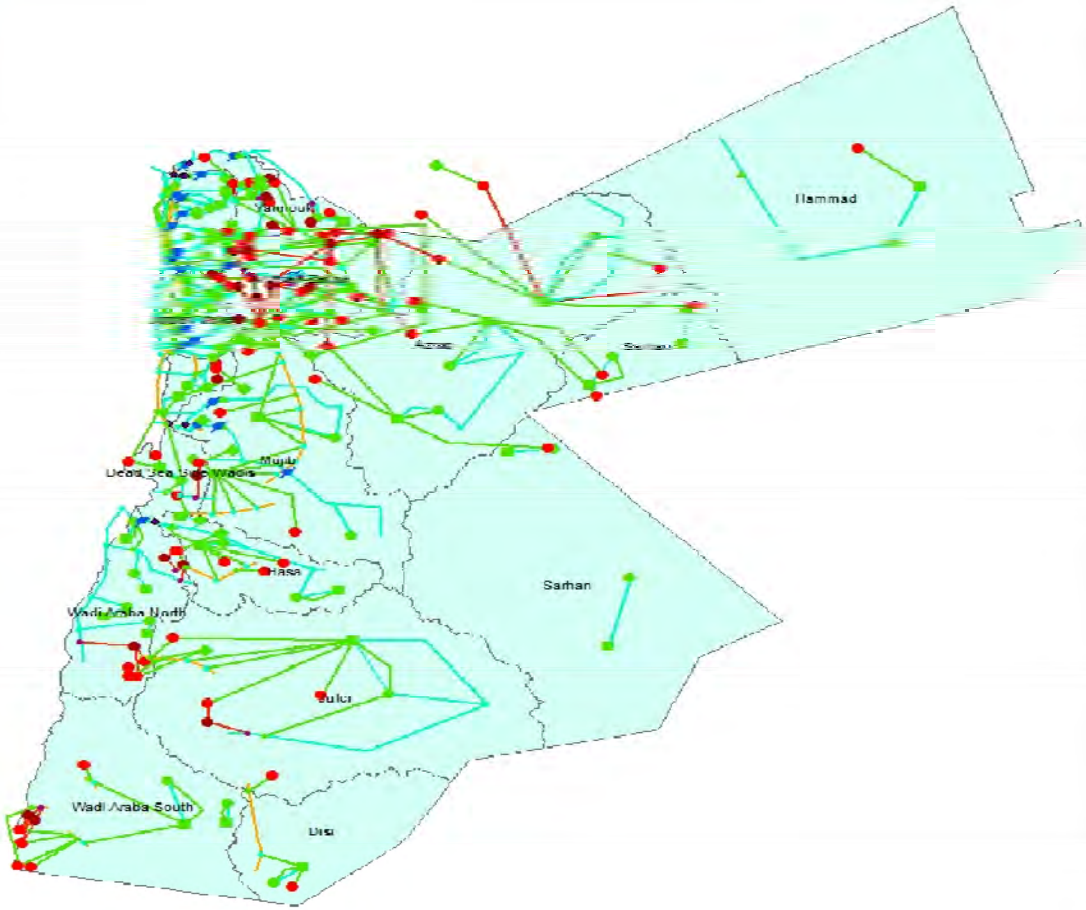
Basins Module

- 13 surface water basin models

- Input Data (2000 to 2012)

    - National Water Strategy
    - WIS data
    - WAJ and JVA

- All the Modules run tell 2030



Basins Module

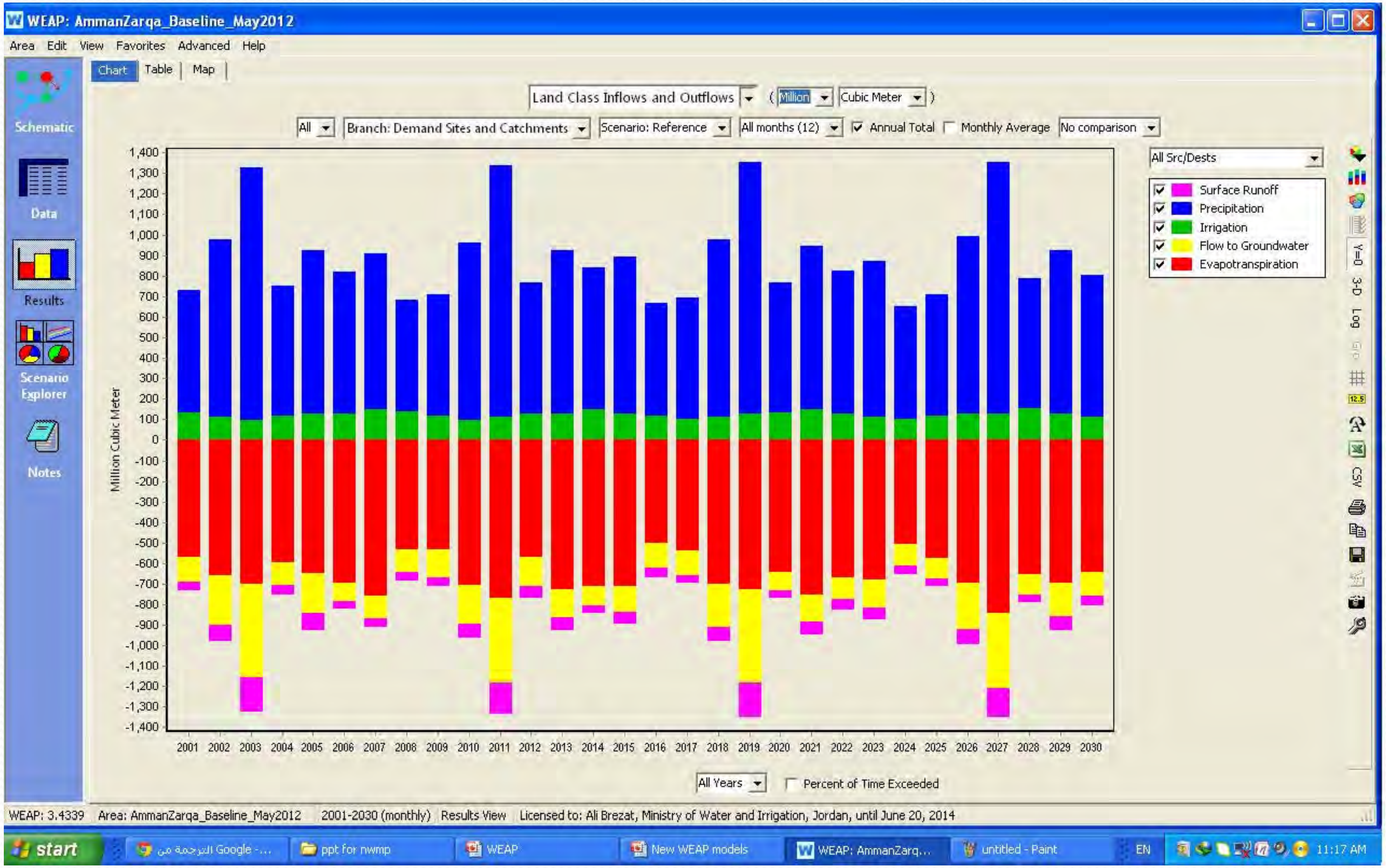
Demand Types:

- Domestic
- Agricultural
- Industry
- Tourism

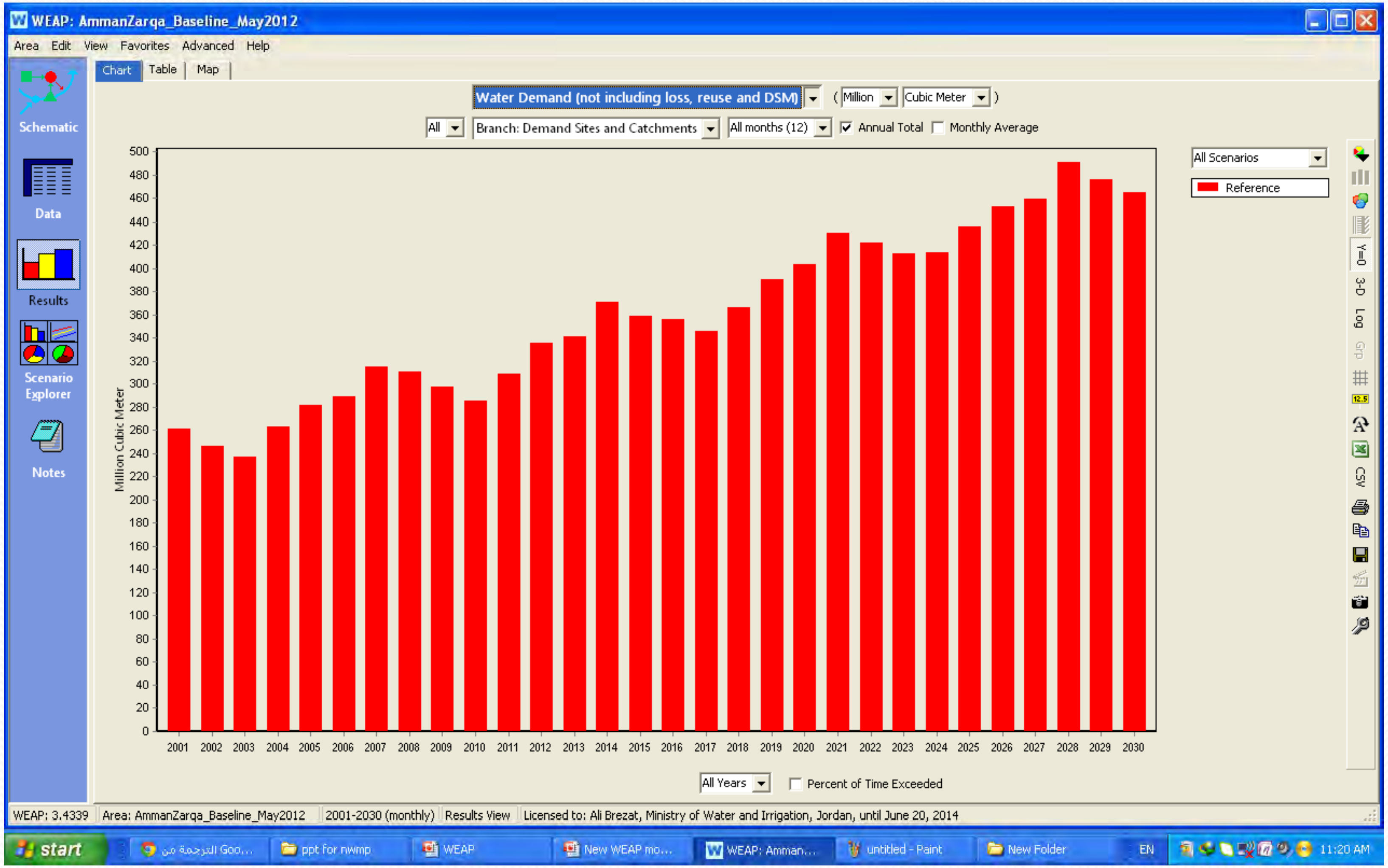
Input Data:

- Population
- Growth Rate
- Monthly demand
- Climate Data
- Non Revenue Water

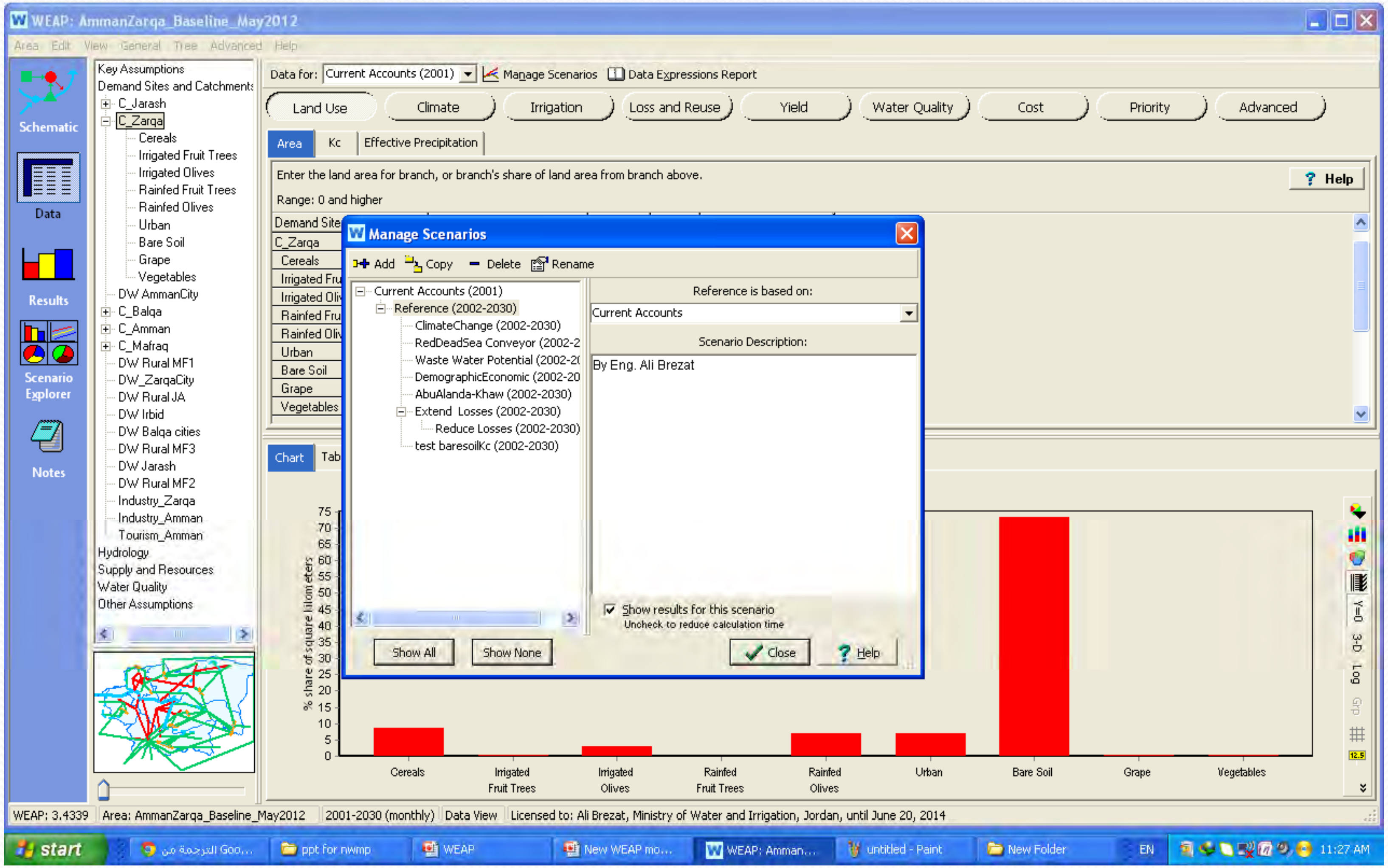
Land Class Inflow and Out Flow for Amman Zarqa Basin



Water Demand In Amman Zarqa Basin



Applied Scenarios

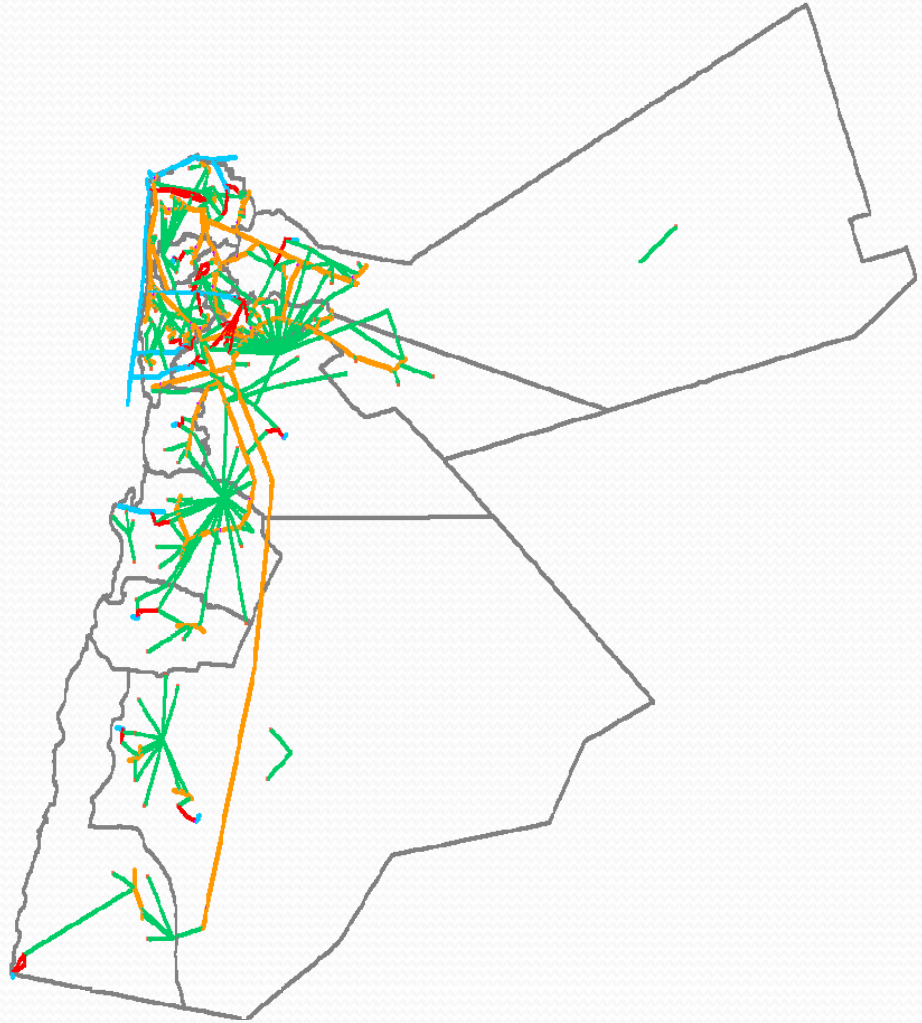


National Wide WEAP Schematic

- 90 Demand Sites

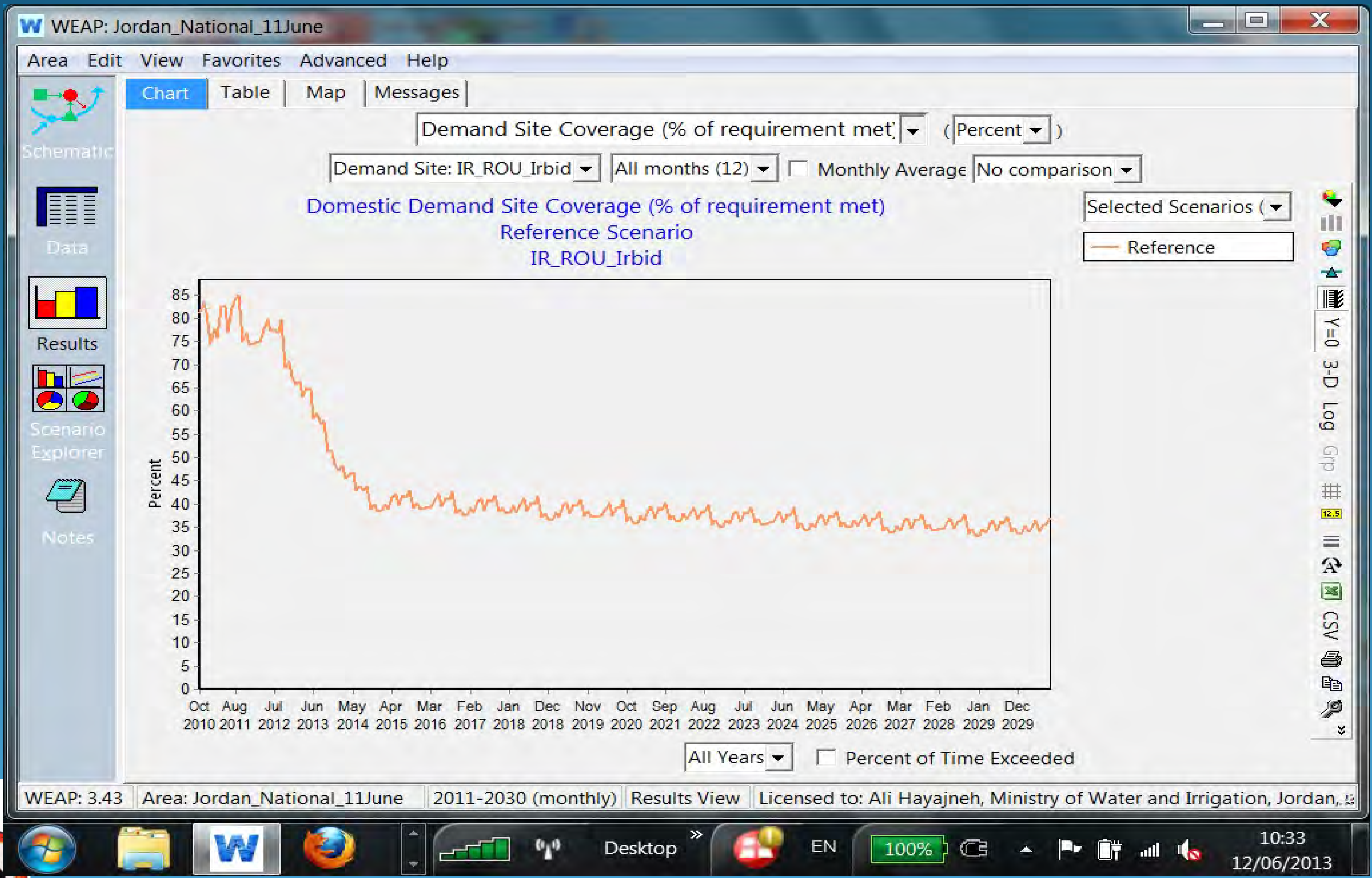
❑Private Households
❑Commercial
❑Tourism
❑Industry
❑Agriculture
❑Syrian Refugees

- 20 GW-Nodes
- 200+ Transmission Links
- 50+ Diversions
- 27 Waste Water TP

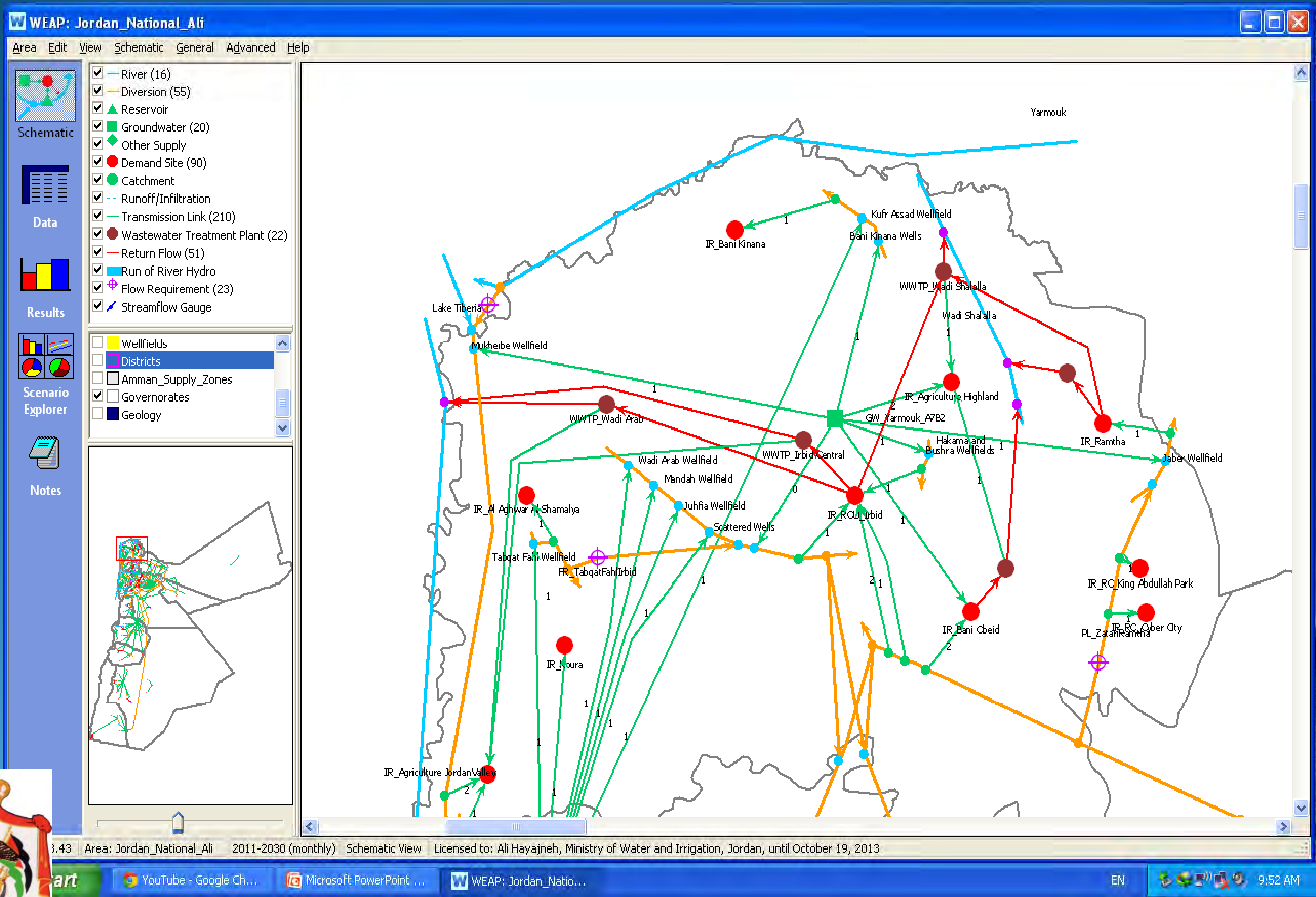


Unmet demand for the northern governorates (Irbid, Jerah and Ajloun)

Demand site coverage for Irbid ROU



WEAP schematic in Irbed Gov

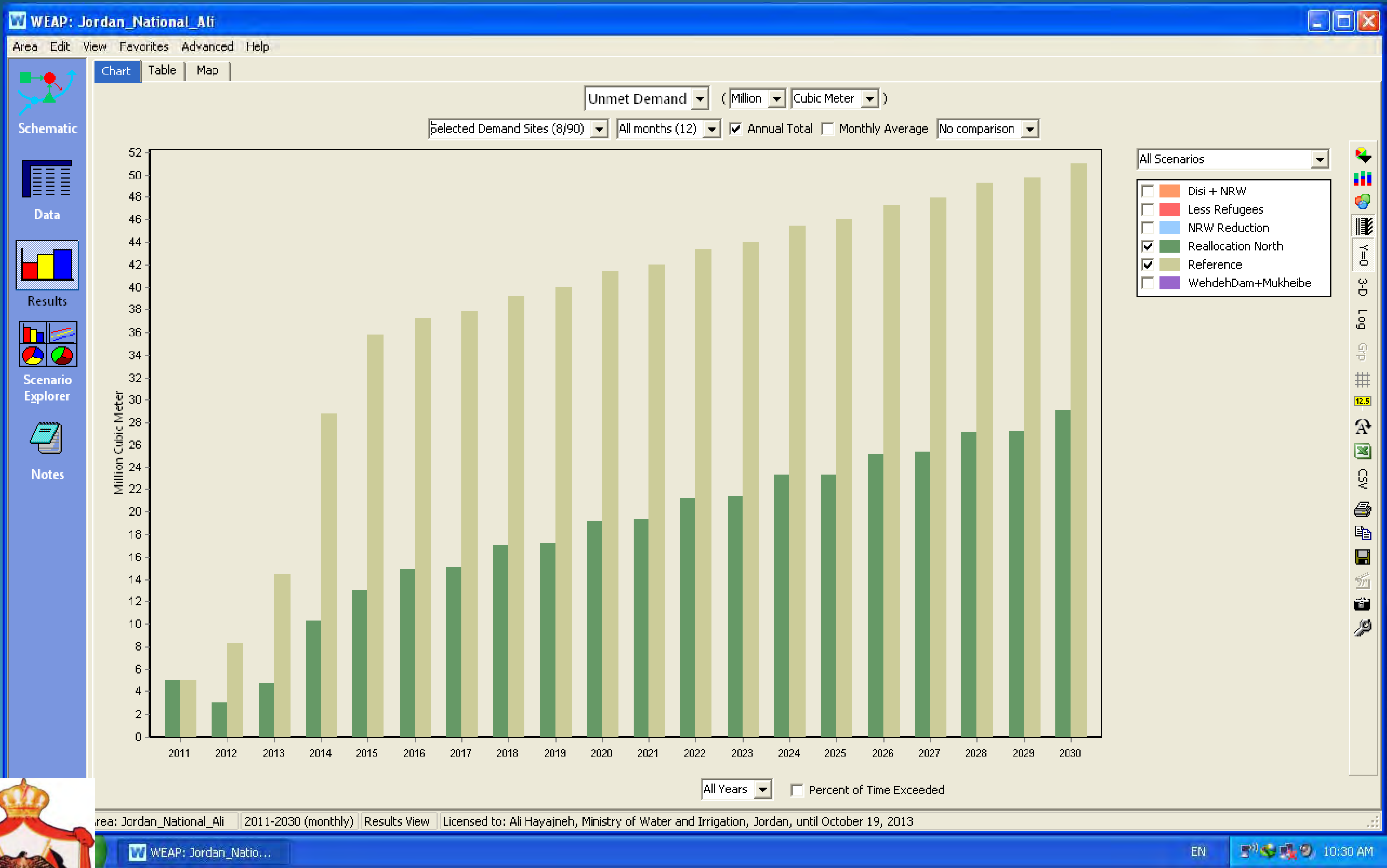


Strategy „reallocation Irbed“:

- Redirect water from the Mukheibe to drinking water Irbid (20 MCM)

- Increase the capacity of the WWTP Central Irbid (72% capacity) and Wadi Arab (49% capacity) to the max and transfer it to the Jordan Valley to replace the water from Mukheibe Wells.

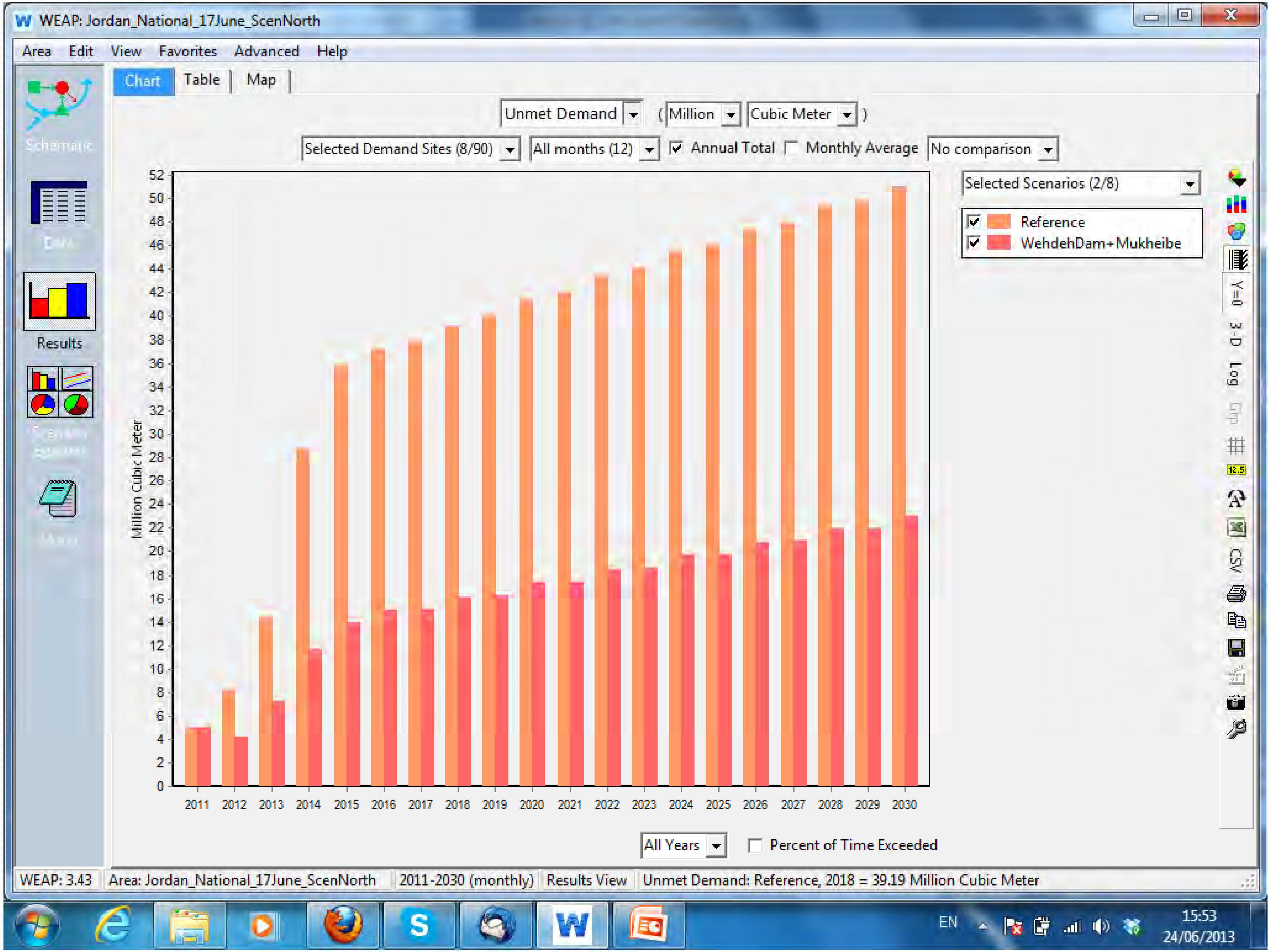
Unmet demand after reallocation



Scenario „Wehde + Muhkeibe“:

- Sent (~25 MCM) of water from Muheibe to Irbid.
- Compensate the needed water for agriculture JV using the water from the Wehde Dam (~ 1.0 MCM per month) and from Wadi Arab Dam (1 MCM per month)

Unmet demand Irbid ROU, senario „Wehde + Muhkeibe“:



Thanks for your attention

Points of discussion

- Is WEAP more suitable for water resources assessments and management than GW modules?
- Do we have adequate data for what we want to achieve with the WEAP modules?
- Is WEAP truly used as a management tool ? What is missing ?

WEAP Approach:

- WEAP is a software application for integrated water resource management.
- Developed by Stockholm Environmental Institute (SEI) in 1989, license free..
- WEAP consist of a water balance database, a simulation generation tool and a policy analysis tool.
- Answers questions of changing demands and resources
- WEAP is module structured and can be link to various other scientific models.

Council for Development and Reconstruction (CDR)
Ministry of Energy and Water (MoEW)
Water Establishment Beirut and Mount Lebanon (WEBML)

Federal Institute for Geosciences
and Natural Resources (BGR),
Hannover, Germany

German-Lebanese Technical Cooperation Project

Protection of Jeita Spring

Geoscientific Advice for Planning in the Wastewater Sector in Lebanon

Project Exchange Meeting Jordan - Lebanon
30 October 2013

Dr. Armin Margane, BGR

Outline

- Background of the Project - Tasks
- Description of Project Area
- Project Activities related to
  - Component 1 (Wastewater Sector)
  - Component 2 (GW Protection Zones, Awareness)
  - Component 3 (Monitoring Quantity/Quality, Balance)
  - Component 4 (Improved Jeita Spring Capture) and Conveyor)

Project Activities

Goal: *Major Risks for the Drinking Water Supply in the Greater Beirut Area are reduced by implementing measures to protect the groundwater contribution zone of the Jeita Spring from pollution*.

1. **Integration of water resources protection aspects into the investment planning and implementation process in the wastewater sector (geoscientific advice in wastewater sector)**
2. **Integration of water resources protection aspects into landuse planning (delineation of GW protection zones)**
3. **Collection and use of monitoring data concerning quality and quantity of water resources**
4. **Support of the partner institutions concerning the implementation of urgent protective measures**

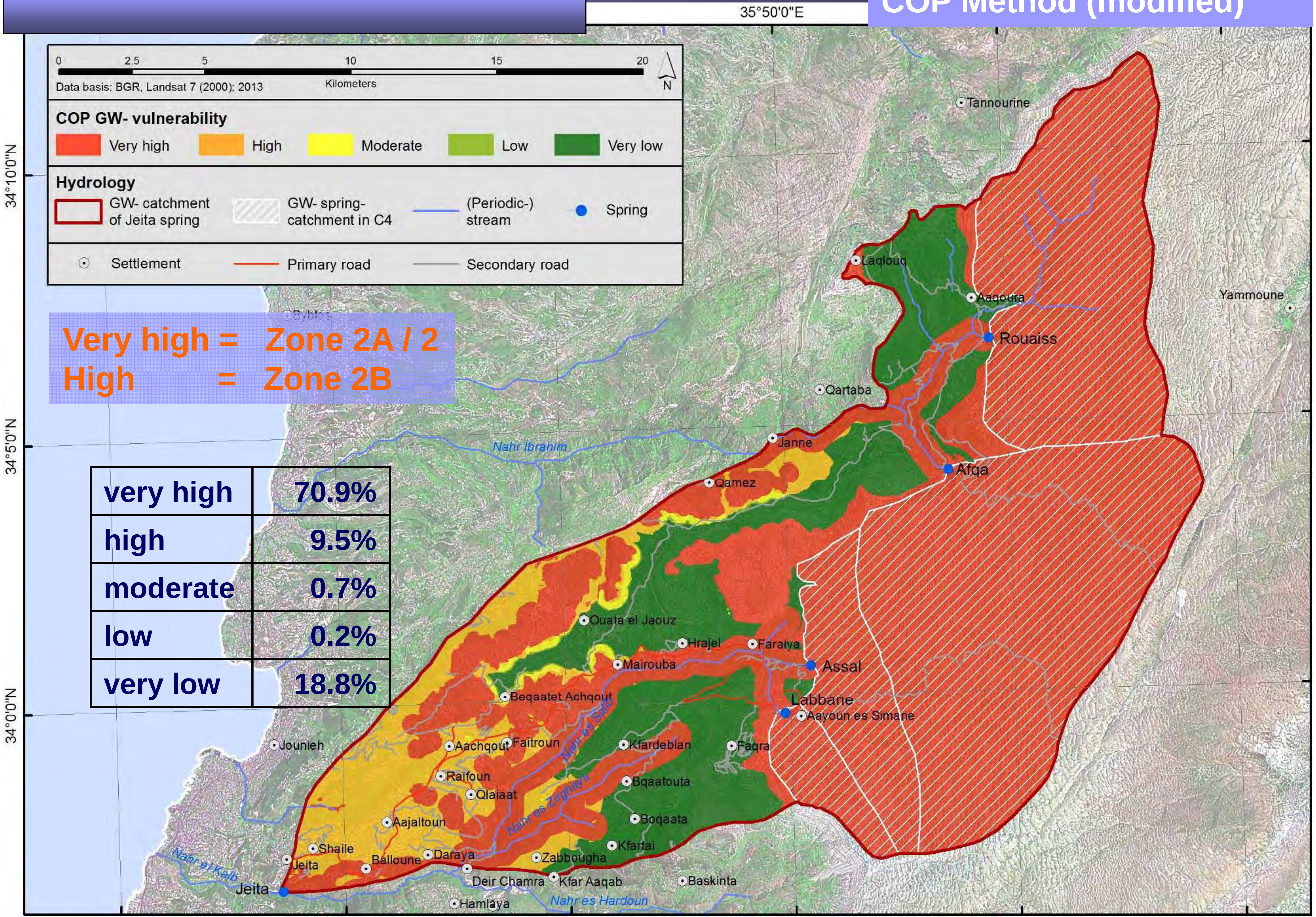
Planned Project Activities

1. **Integration of water resources protection aspects into the investment planning and implementation process in the wastewater sector**

- Support of CDR and other institutions concerning the prioritization of wastewater projects as well as the design and site selection for WWTPs, collector lines and effluent discharge locations; ✓
- Support of CDR concerning the preparation of EIAs for wastewater projects, with regards to their impact on the water resources;
- Preparation of best practice guidelines for the implementation of wastewater projects with special consideration of the aspect of ground and surface water protection. ✓

Groundwater Protection Zones

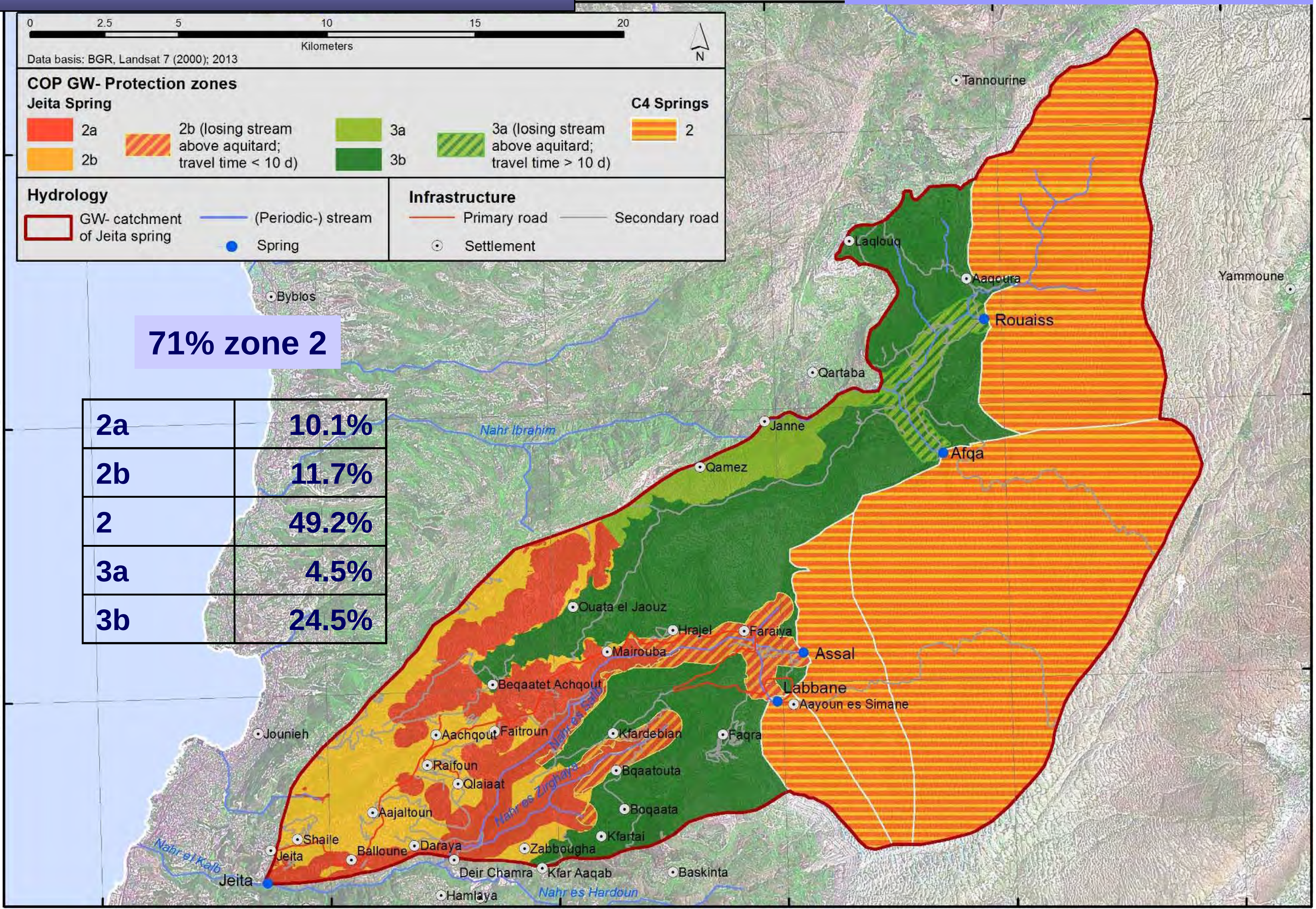
Groundwater Vulnerability COP Method (modified)



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

very high	70.9%
high	9.5%
moderate	0.7%
low	0.2%
very low	18.8%

Groundwater Protection Zones for Jeita, Afqa, Rouaiss, Assal and Labbane springs



71% zone 2

2a	10.1%
2b	11.7%
2	49.2%
3a	4.5%
3b	24.5%

Contamination Risks from Wastewater

Currently wastewater is discharged
- **into injection wells**
- **into open cess pits or**
- **into nearby creeks/rivers/wadis**

residences with no wastewater collection and treatment

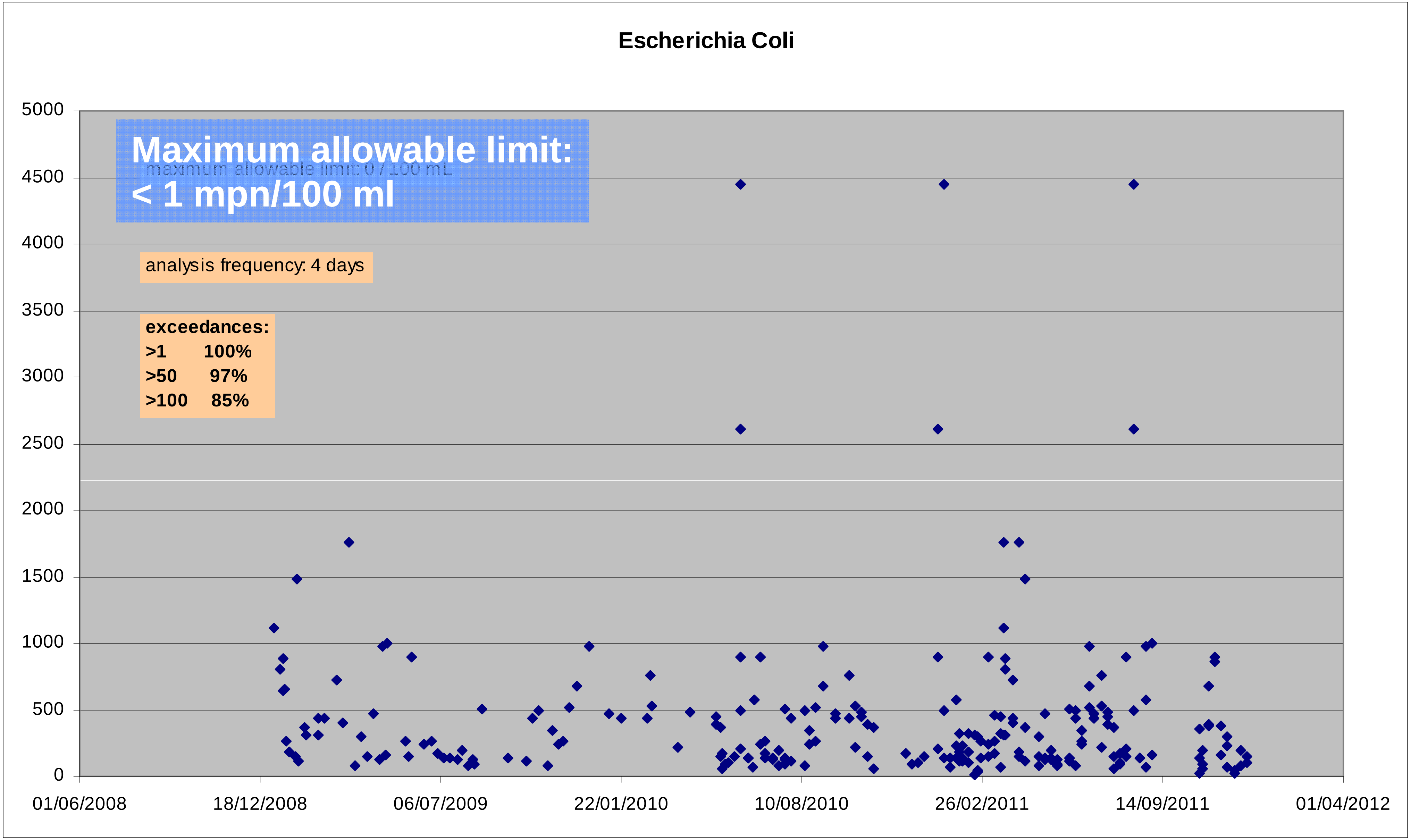
Infiltration of untreated wastewater into highly karstified Jurassic limestone (Faitroun)

► microbiological contamination of Jeita spring


Wastewater is typically „discharged“ through open cess pits or injection wells
Permeable areas of the underground are selected so that the cess pits will not need to be emptied so often to avoid costs

Dbayeh raw water (treatment plant)

High and continuous microbiological contamination



Health Effects

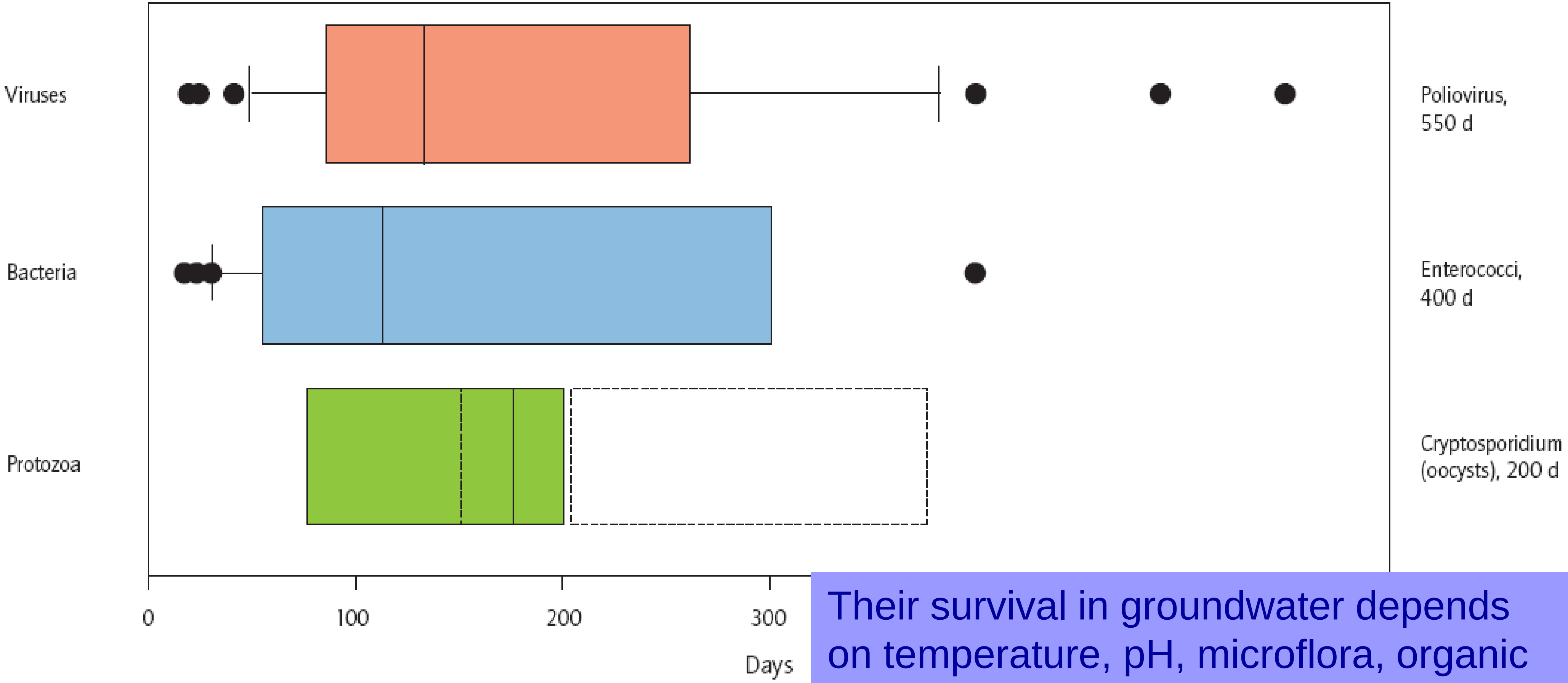
PATHOGEN	MAJOR DISEASES	SOURCES
Bacteria		
Escherichia coli	Gastroenteritis, Haemolytic Uraemic Syndrome (enterotoxic *E. coli*)	Human faeces
Salmonella spp.	Enterocolitis, endocarditis, meningitis, pericarditis, reactive arthritis, pneumonia	Human and animal faeces
Shigella spp	Gastroenteritis, dysentery, reactive arthritis	Human faeces
Campylobacter jejuni	Gastroenteritis, Guillain-Barré syndrome	Human and animal faeces
Yersinia spp.	Diarrhoea, reactive arthritis	Human and animal faeces
Vibrio cholerae	Cholera	Human faeces and freshwater zooplankton
Legionella spp.	Pneumonia (Legionnaires' disease)	Thermally enriched water
Pseudomonas aeruginosa	Pneumonia, urinary tract infections, bacteremia	Soil and water
Mycobacterium spp.	Pulmonary disease, skin and soft tissue disease	Soil and water
Protozoa		
Cryptosporidium parvum	Cryptosporidiosis (gastroenteritis)	Water, human and other mammal faeces
Giardia lamblia	Giardiasis (chronic gastroenteritis)	Water and animal faeces
Entamoeba histolytica	Dysentery	
Acanthamoeba spp.	Encephalitis, Keratitis	
Naegleria fowleri	Meningoencephalitis	
Toxoplasma gondii	(congenital) Toxoplasmosis (Encephalitis)	

Numerous bacteria, viruses and protozoa are contained in groundwater. Many of them are related to human activities.

Krauss & Griebler (2011)

Health Effects

Survival times of pathogens in groundwater



Their survival in groundwater depends on temperature, pH, microflora, organic carbon content, presence of cations (adsorption). Low temperatures support a long persistence. At typical groundwater temperatures of ≤ 15°C viruses may survive and stay infectious for several hundred days.

Krauss & Griebler (2011)

Specific Problems concerning Wastewater Treatment

Jeita Catchment

- Topography (WW must be pumped up at several locations; extremely high gradients)
- Electricity not available 24/7 (max 25%)
- Large spacing between residential areas (often only up to 70 % of a village can be serviced by a wastewater scheme)
- Households cannot be forced to connect to WW collector lines
- Municipalities have begun to construct WW collector lines without coordinating with the responsible agencies (aim: divert WW out of the village)
- Their concept, material, etc. does not fit with KfW's/EIBs concept, material, ...

- Geo-risks: karst (sinkholes), tectonics, landslides, rock slides, earthquakes, flooding

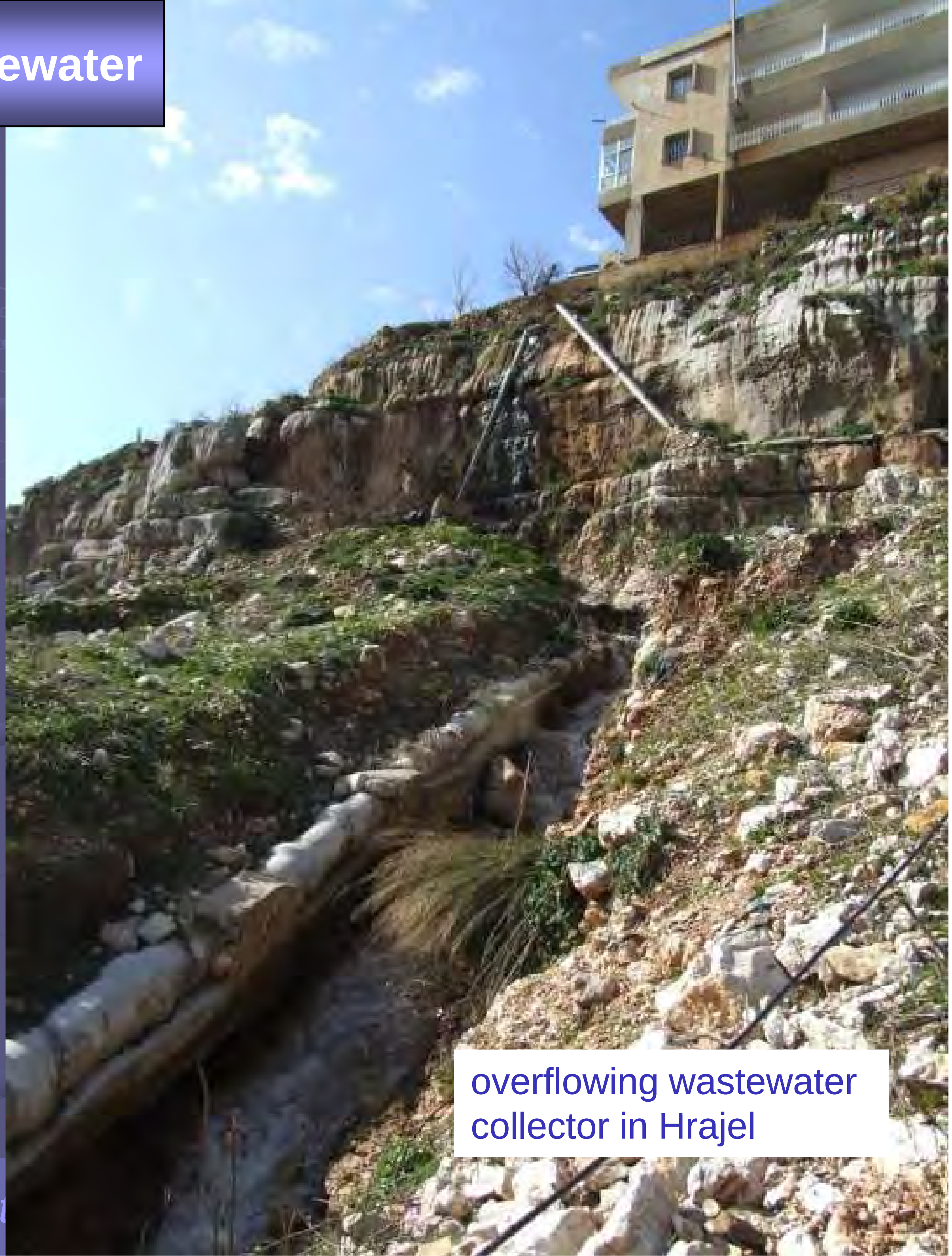
► wastewater master plan is urgently needed

Contamination Risks from Wastewater

Currently wastewater is discharged
- into injection wells
- into open cess pits or
- into nearby creeks/rivers/wadis

Some municipalities have started constructing their own wastewater collector lines. These may not fit with those to be established by foreign donor projects in the area (concept, material, diameters, etc.).

► existing network must be removed



overflowing wastewater collector in Hrajel

Wastewater Planning

Implementation Procedure (how it should be)

In order to establish a wastewater scheme (collection & treatment),

- a Wastewater Master Plan (WMP) has to be developed. This WMP defines the target for a specific planning horizon (e.g. 25 years), i.e. wha incipally be done to cover a certain area with adequate collection and tr acilities. The WMP proposes several individual wastewater schemes es a rough estimation of costs.

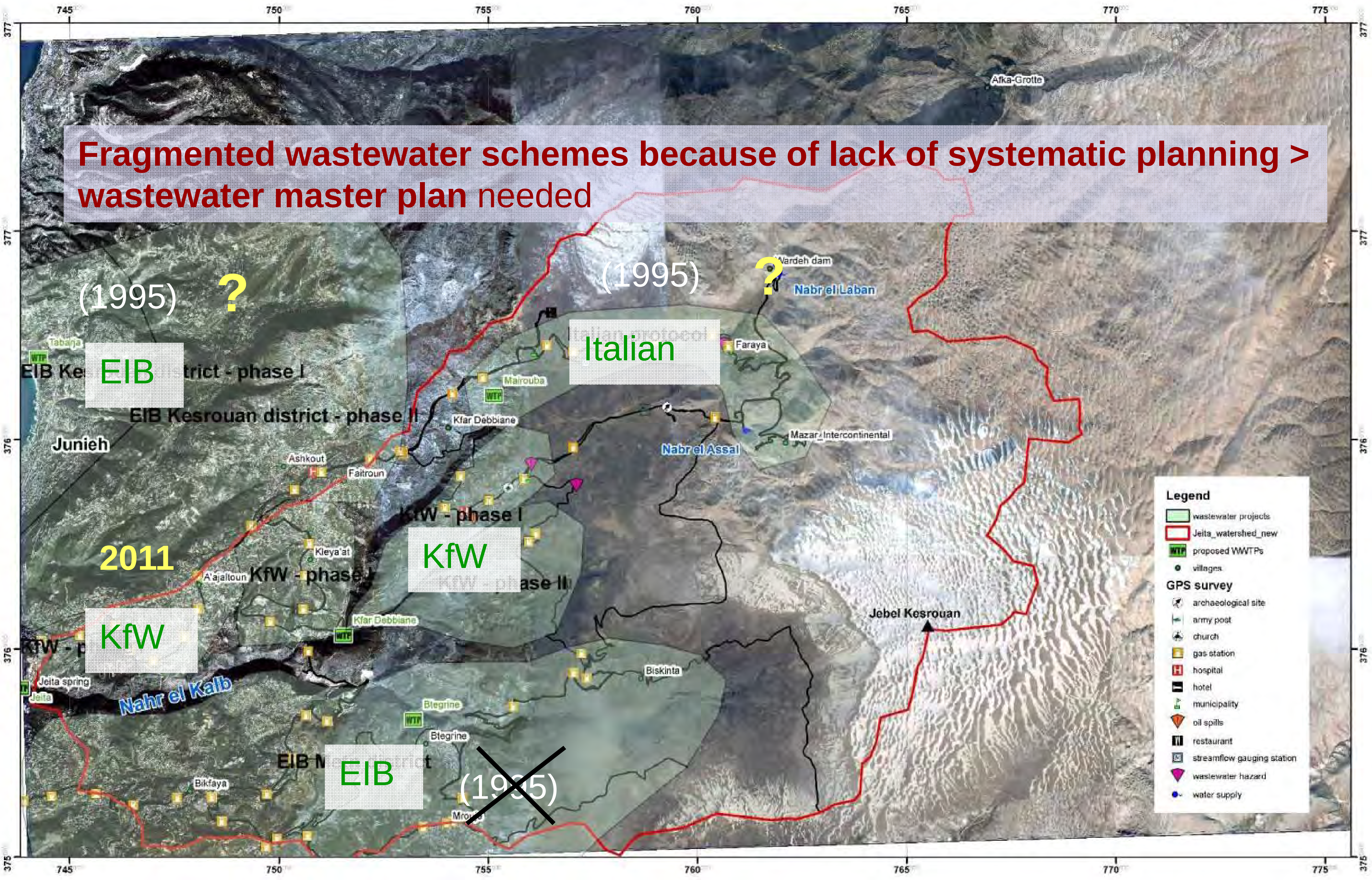
- An initial site investigation for the proposed wastewater treat nts (WWTP) has to be conducted to determine their suitability (draft environm act assessment (EIA), especially on water resources). Based on this draft EI ate of the WMP is done.

- The agencies responsible for planning in the wastewater sector (here: CDR, MoEW), according to the available funds, define which wastewater schemes will be implemented, what are the exact boundaries of these schemes and what is the time line for implementation.
- The municipalities involved in the proposed wastewater schemes have to agree to the planned wastewater facilities.
- Tender documents are prepared and a consultant is contracted to build the wastewater scheme.
- The detailed site investigation/planning & EIA for the scheme are prepared by the consultant and discussed with all stakeholders (public participation)
- The wastewater facilities are built and transferred to the agency operating it (WEBML)

Wastewater Projects North of Beirut

Project Component 1 : Wastewater

Fragmented wastewater schemes because of lack of systematic planning > wastewater master plan needed



Site Selection for Wastewater Facilities

criteria catalogue

- General criteria
- Geological/hydrogeological criteria ← BGR
- Financial criteria

ANNEX 1: Criteria for Site Selection and Design of Wastewater Facilities in Lebanon

Criteria	Collector Lines	WWTP Location	WWTP Design	discharge Location	Remarks	Tasks / source
General Criteria						
number of inhabitants to be serviced (capa…	xxx	xxx	xxx		financial feasibility	municipalities
WW… indus…						
planr… /indu… plan)						
popu…						
planr…						
mate… appr…						
existi… mate…						
chara… inclu…						
topog… can b… have… to be… wher… follov… land… ?)						

Criteria	Collector Lines	WWTP Location	WWTP Design	discharge Location	Remarks	Tasks / source
Geological and Hydrogeological Criteria						
geology (rock type, underground as a barrier, dip direction/angle)	xx	xx			if natural geological barrier is existing, it should be used	geological mapping
stability…						
landslic… effect						
tectoni…						
earthqu… affect t…						
ground… velociti…						
thickne… velocity…						
infiltrati…						
karst fe…						
risk of… becom…						
distanc… (used f…						
risk of f…						

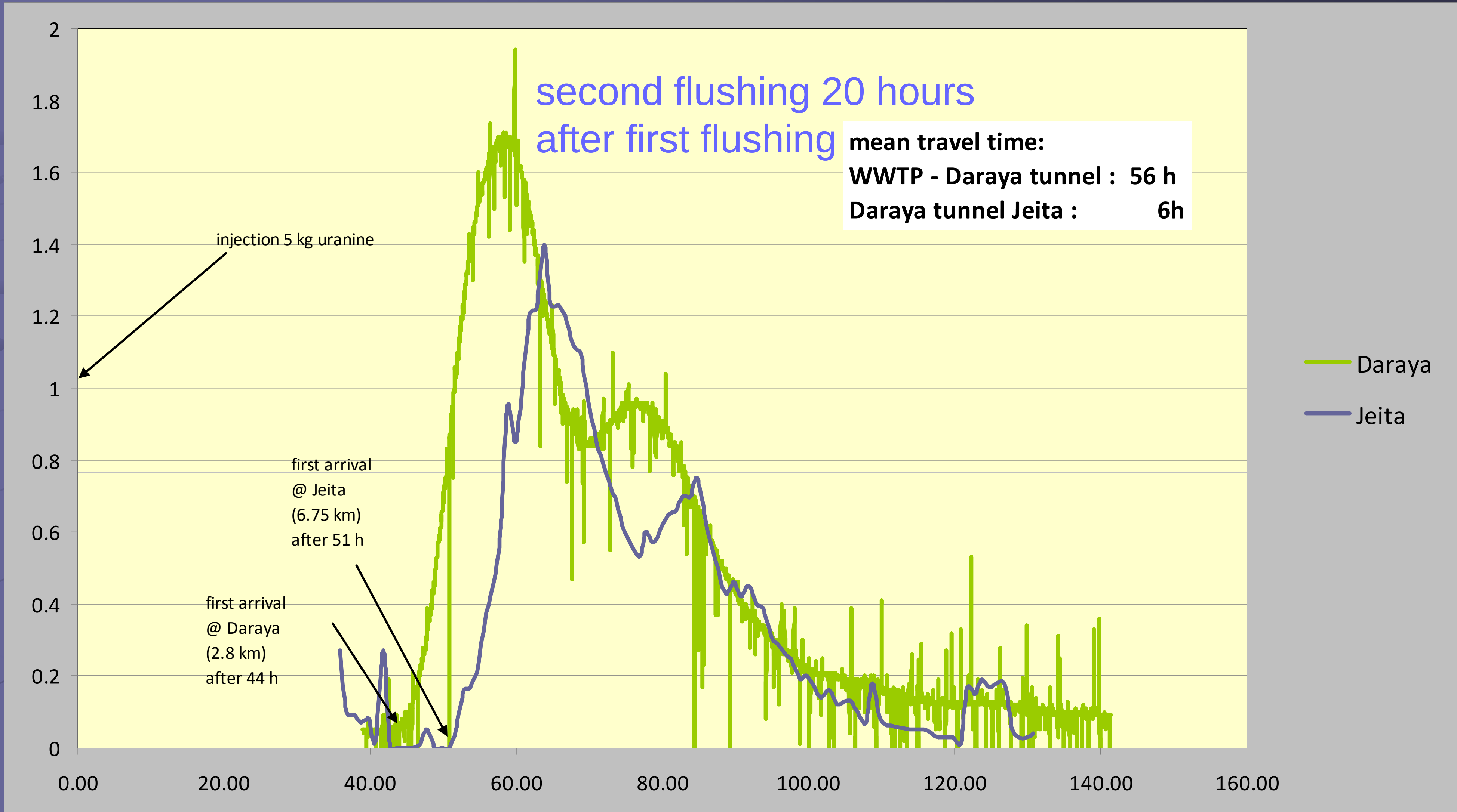
Criteria	Collector Lines	WWTP Location	WWTP Design	discharge Location	Remarks	Tasks / source
Cost related Criteria						
method of treatment (primary / secondary / tertiary)			xxx	xxx	can existing regulations / guidelines for effluent (reuse) quality be maintained at all times ?	
reliability of treatment			xxx	xxx		
storage capacity (bypass in case of overload ?)		xx	xx	xx	must be large enough to guarantee that bypassing untreated WW will not be necessary	
possibility / need for treated WW reuse		xx	xxx	xxx	discharge location must be high enough to use as little energy as possible for reuse	
sludge management / reuse of (treated) sludge for agriculture		xx	xx	xx	can existing regulations / guidelines for quality of (organic) fertilizer be maintained at all times ?	analysis of sludge content; determine sites for sludge application; determine treatment of sludge and related feasibility
costs for primary collector lines						
costs for secondary collector lines						
costs for household connections						
costs for WWTP construction						
costs for effluent discharge pipeline / canal						
overall costs for construction (available funds)					including equipment, laboratory and staff for continuous monitoring of treated WW quality	
annual costs for maintenance and operation (available budget)					including continuous monitoring of treated WW quality and sludge mgmt.	

xxxx - killing arguments, xxx - very important arguments, xx - important arguments, x - less important arguments

Investigation of Proposed WWTP

Investigation of Proposed WWTP

Results Tracer Test 1A



Consequence: KfW requests BGR to prepare proposal of alternative locations

Project Activities

Result

Tracer arrival in Jeita after only 62 h leaves not enough time for attenuation of pollution (die-off of bacteria/viruses/protozoa min. 10 days)
In case of by-passing of untreated wastewater (WW) at wastewater treatment plant (WWTP) a direct and concentrated pollution would occur at Jeita

Consequence

WWTPs should not be located in Nahr el Kalb Valley upstream of spring
► centralized treatment at/near coast, downstream of Jeita spring

Sanitation Systems

Centralized sanitation systems

- Collection of all wastewater from an area (groundwater catchment) and transfer to a central location mostly downstream of this area for treatment
- Treatment at a central wastewater treatment plant (WWTP) and discharge of treated effluent downstream of WWTP

Wastewater treatment Plant (WWTP) Kiel/Germany 380,000 PE (PE-person equivalent)

Sanitation Systems

Decentralized sanitation systems

- Collection of wastewater from individual households, small areas or parts of the catchment and treatment at different locations (small, less sophisticated treatment plants)

Decentralized treatment system for a single house

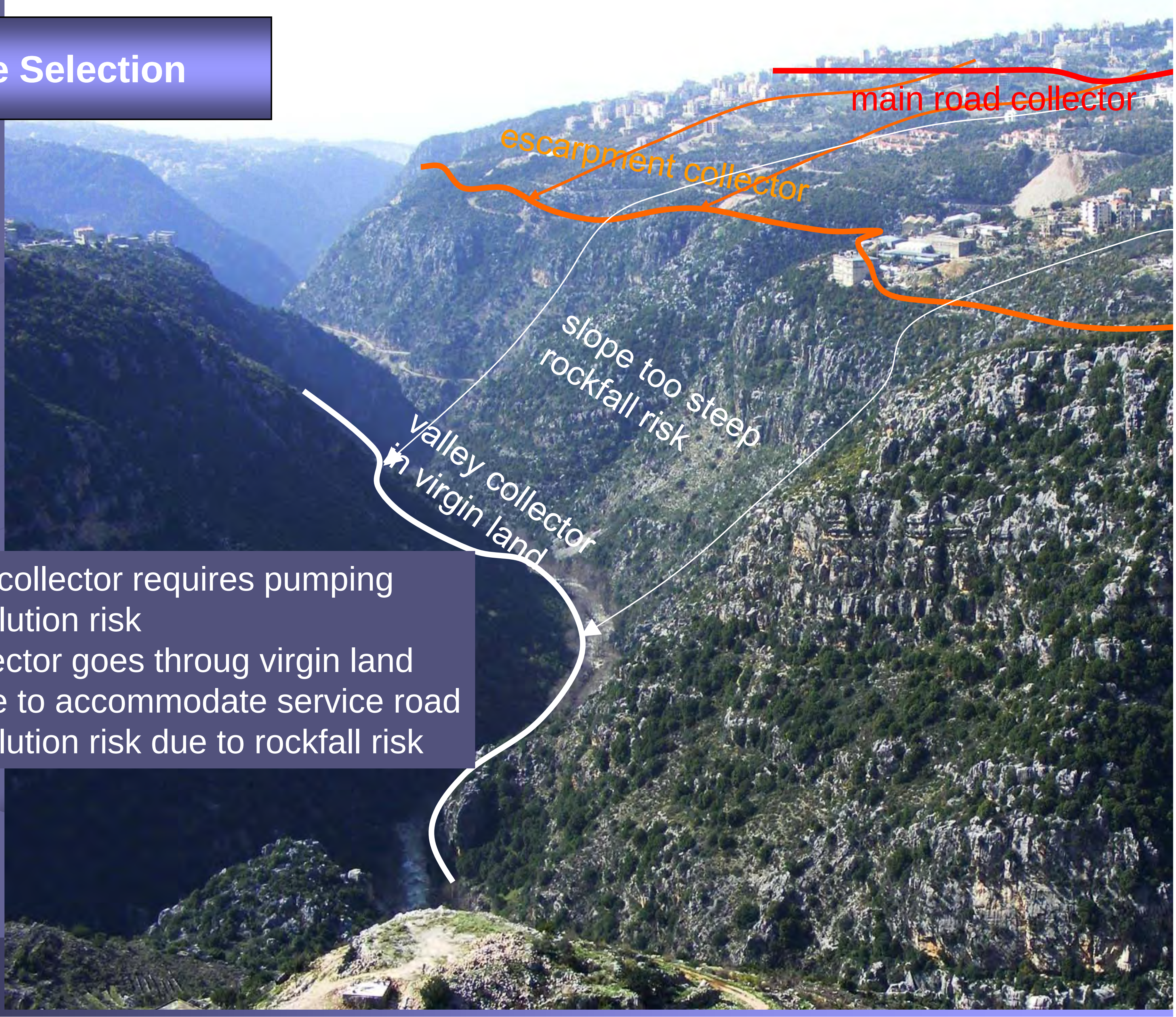
Site Selection

Treatment plant:
Centralized approach:
Because of impact on water resources the treatment location must be outside (downstream) of the GW catchment of drinking water resources
Also the potential impact by geohazards (flooding, active faults, landslides, rockfalls, cave collapse, etc.) must be low.

Collector line:
- should collect most wastewater to reduce groundwater pollution
- must avoid pumpage (pollution risk if not operated)
- cannot be along river (too steep, no possibility for maintenance road)

► only possibility: along escarpment

Site Selection



Main road collector requires pumping
► high pollution risk
Valley collector goes throug virgin land
► no place to accommodate service road
► high pollution risk due to rockfall risk

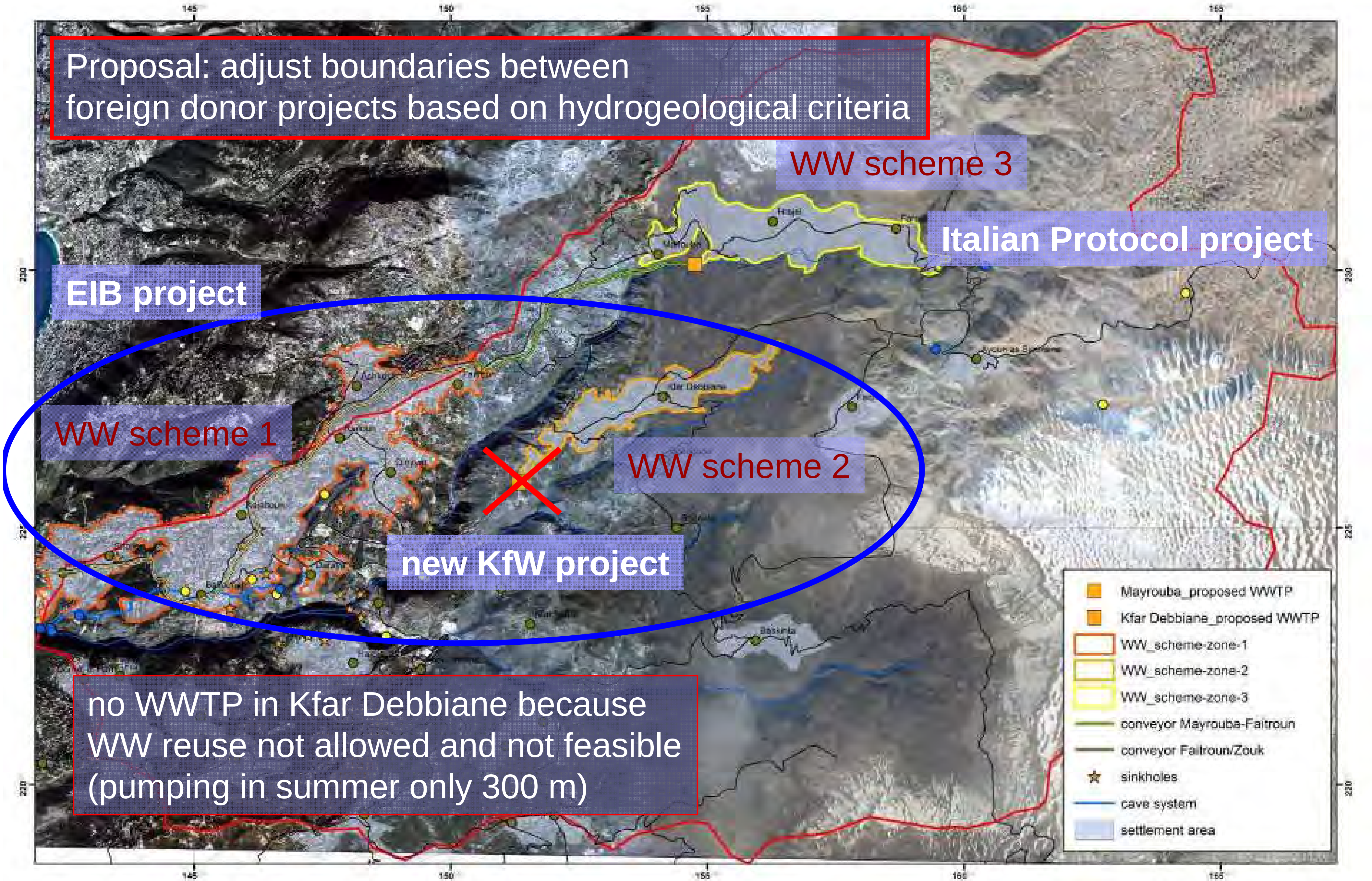
Site Selection

Valley collector not feasible
& environmental objection

Protect

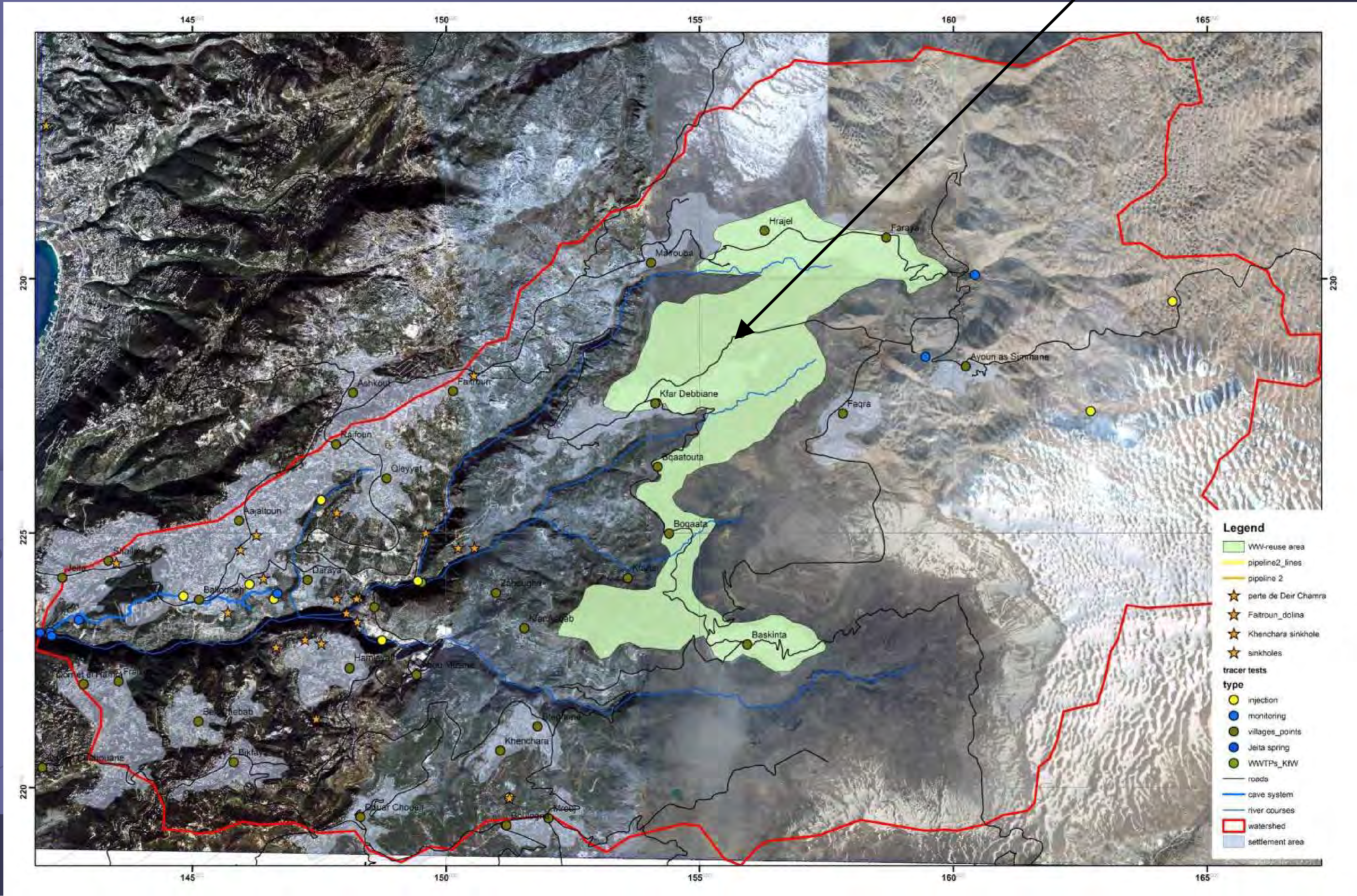
Proposed Wastewater Schemes

January 2011



Proposed Wastewater Schemes

Proposed area for
treated wastewater reuse



Planning of WW schemes

Ranking of Alternatives for WW schemes based on Water Resources Protection Aspects

Alternative	Rank	Main Advantages/Disadvantages
Principally acceptable solutions		
B4b*	1	Lowest pollution risk because no Jeita WWTP – Mokhada bridge collector/conveyor would be required but poor feasibility prospects for coast WWTP
B4a*	2	
A2b	3	Special protective measures in protection zone 2 necessary for escarpment collector and Jeita WWTP – Mokhada bridge conveyor/collector
A2a	4	Special protective measures in protection zone 2 necessary for Jeita WWTP – Mokhada bridge conveyor/collector
A1b	5	Uncertain reuse concept for Kfar Debbiane
A1a	6	
B2b	7	High costs for relatively small Jeita WWTP, poor feasibility prospects for coast WWTP
B1b	8	
B2a	9	
B1a	10	
Objected solutions		
A3a		The Daraya WWTP would be located in open karst where sinkholes are reported which are probably connected with Jeita cave. Discharge of treated effluent under these conditions is problematic.
A3b		
B3a		
B3b		

KfW Jeita Project

Serviced area
- S Jeita
- (S Sheile)
- Ballouneh
- Aajaltoun
- Daraya
- Kfar Debbiane
- S Zouk Mosbeh

Phase I : 45,000 PE
Phase II: 92,000 PE

EIAs for Wastewater Facilities

Proposed EIA Guideline for WW Facilities:

- Standard outline
- Integration of all relevant geoscientific aspects
    - impacts on water resources
    - impacts from geohazards (tectonic movements, earthquakes, landslides, rock falls, rock collapse structures, soil liquefaction, soil stability, flooding)

► Technical Report No. 3

Potential negative impacts on the quality of water resources must be considered separately for all individual components of a proposed wastewater facility or scheme (collector lines, treatment plant, effluent discharge location) and mitigation measures must be proposed for each of those

Proposed Standard Outline of EIA for WW Facilities

Guideline for Environmental Impact Assessment for Wastewater Facilities in Lebanon

BGR contribution

BGR

Impact on Water Resources

Impacts on water resources might be caused by :

- inadequate site selection
- inadequate design (methods, technology, capacities, diameters, etc.)
- inadequate materials
- mistakes during installation/construction
- mistakes during operation (e.g. inadequate maintenance, monitoring, etc.)
- impacts of geohazards

Impact of Geohazards

- tectonic movements
- earthquakes
- landslides
- rockfalls
- rock collapse structures (e.g. dolines)
- land subsidence
- soil liquefaction (instable soil)
- flooding

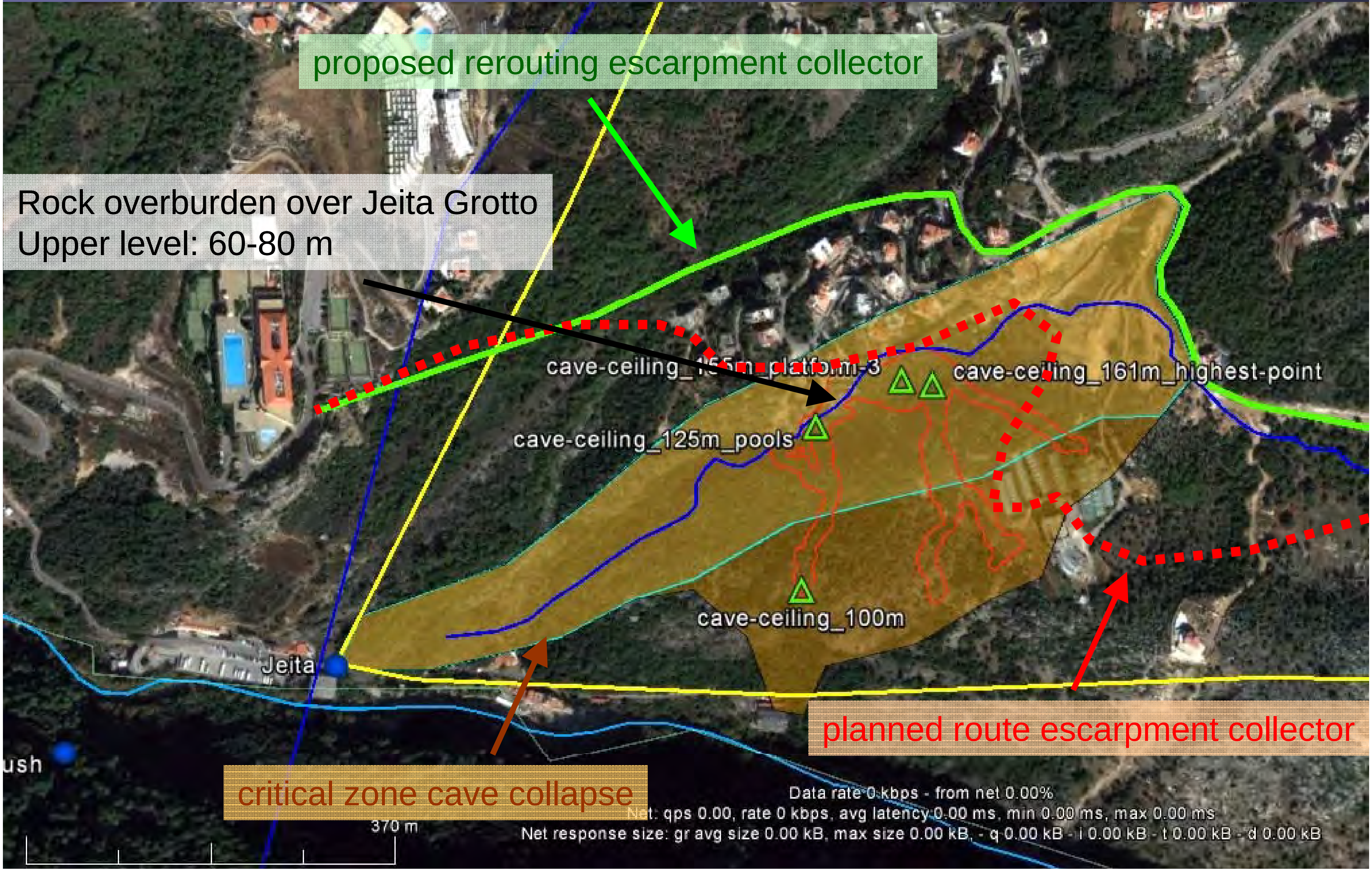
EIA for JSPP project

BGR prepares **EIA** for all components of KfW wastewater scheme related to impact on water resources and impact from geohazards (collector line, WWTP site, effluent discharge site)

Geo-risks:
- flooding
- landslides
- rock falls
- land subsidence
- cave collapse
- sinkhole formation
- earthquakes

EIA for JSPP project

detailed geological mapping at WWTP and collector line


proposed rerouting escarpment collector
Rock overburden over Jeita Grotto
Upper level: 60-80 m
cave-ceiling_161m_highest-point
cave-ceiling_125m_pools
cave-ceiling_100m
Jeita
planned route escarpment collector
critical zone cave collapse
370 m
Data rate 0 kbps - from net 0.00%
Net: qps 0.00, rate 0 kbps, avg latency 0.00 ms, min 0.00 ms, max 0.00 ms
Net response size: gr avg size 0.00 kB, max size 0.00 kB, - q 0.00 kB - i 0.00 kB - t 0.00 kB - d 0.00 kB

EIA for JSPP project

groundwater protection zones

Best Management Practice Guideline

The guideline gives recommendations on the potential impact on water resources with regards to:

- site selection and design process for wastewater treatment plants, collector lines and effluent discharge points
- selection of the optimal treatment method
- criteria for treated wastewater reuse
- criteria for sludge management
- proposal for monitoring of the treated wastewater effluent, sludge quality and effects of wastewater reuse and sludge application

► **Technical Report No. 2**

Proposed Standard for Treated WW Reuse

Recommendations:

• Treated industrial wastewater and treated domestic wastewater containing a large share (> 10%) of industrial or commercial wastewater, should not be reused for irrigation.

• Domestic wastewater reuse classes should be based on health concerns, hydrogeological criteria and soil characteristics of the area.
Groundwater vulnerability maps should be used to decide where reuse can be allowed.

• The concept for treated wastewater reuse must be agreed upon with the potential users before the planning of a wastewater facility. Treated wastewater will often have to be pumped to the irrigation area so that treatment for reuse in agriculture will be significantly more costly.

• Public awareness for farmers is needed in order to provide an agricultural production which is safe for human consumption. Moreover the safety of farm workers and local population around farms needs to be taken into consideration.

Proposed Standard for Treated WW Reuse

continued

Recommendations:

• Monitoring of treated wastewater quality is very important in order to provide that no pollution will occur. Monitoring will require a massive increase in laboratory capacities, which needs to be planned for now.

- where to monitor
- what to monitor
- how often to monitor

• The government agency responsible for the operation of the treatment plant should also be responsible for the monitoring of treated wastewater reuse. All impacts of treated domestic wastewater reuse for irrigation on soil, groundwater and humans have to be monitored regularly.

► **Special Report No. 4**

Reports for Project Component 1

Integration of Water Resources Protection Aspects into the Investment Planning and Implementation Process in the Wastewater Sector

Technical Report 1: Site Selection for Wastewater Facilities in the Nahr el Kalb Catchment (January 2011) ✓

Technical Report 2: Best Management Practice Guideline for Wastewater Facilites in Karstic Areas of Lebanon (March 2011) ✓

Technical Report 3: Guideline for Environmental Impact Assessments related to Wastewater Facilities (draft) ✓

Special Report 4: Proposed National Standard for Treated Domestic Wastewater Reuse for Irrigation ✓

www.bgr.bund.de/jeita

Reports for Project Component 1

Reports prepared with GITEC

GITEC & BGR: Regional Sewage Plan (October 2011) ✓

LibanConsult & BGR: Environmental Impact Assessment for the Proposed CDR/KfW Wastewater Scheme in the Lower Nahr el Kalb Catchment (October 2013) ✓

www.bgr.bund.de/jeita

Thank you for your kind attention

www.bgr.bund.de/jeita

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