



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

**Delineation of the Groundwater Catchment for  
Jeita Spring using Tracer Tests, Mapping of GW Vulnerability  
and Delineation of GW Protection Zones**

4<sup>th</sup> Beirut Water Week

February 20, 2013

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*Protection of Jeita Spring*



## Outline

- Project - Tasks
- Description of Project Area
- Project Activities related to Protection Zones
  - Delineation of GW Catchment
  - GW Vulnerability Map
  - GW Protection Zones



## Project Setup

### Duration

1st phase	2 years	July 2010 – June 2012
extension	1.5 years	July 2012 – December 2013

### Partners

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

### Cooperation between two German Development Aid Projects

- KfW Development Bank > Jeita wastewater project (GITEC)



## Planned Project Activities

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

- Geoscientific advice for wastewater projects (site selection, EIA, WW best practice guidelines, standard for wastewater reuse, EIA guideline WW)

### 2. Integration of water resources protection aspects into landuse planning

- Preparation of GW vulnerability maps;
- Inventory of GW hazards, risk assessment;
- Delineation of GW protection zones
- Support of implementation



## Planned Project Activities

### 3. Collection and use of monitoring data concerning quality and quantity of water resources

- **Monitoring network**
- Water balance
- WEAP model
- Advice to WEBML (optimal usage and protection)

### 4. Support of the partner institutions concerning the implementation of urgent protective measures

Proposal for an

- **improved capture of Jeita Spring;**
- **improved water conveyance system** from the Jeita Spring to the Dbaye treatment plant.



- Insufficient and inadequate **meteorological** stations/**data** (not heated > no snow data)
  - No **groundwater** monitoring > no water levels > no GW model
  - **Spring discharge** monitoring stations not adequately designed, maintained and monitored
  - **Surface water** gauging stations not adequately designed and maintained
- ▶ lack of funds and staff

### **Water resources assessment needs monitoring system for all water balance components**

- rainfall / snow
- spring discharge
- runoff (surface water)
- groundwater abstraction
- irrigation water use (return flow)
- domestic water use / losses (return flow)

- ▶ **no data > no correct water resources assessment**
- ▶ **wrong water resources assessment leads to wrong planning !**
- ▶ **failed investments in the water sector**





# Spring Monitoring

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



Labbane spring



Daraya tunnel



Kashkoush spring



Jeita spring

+ADCP

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

Telemetric data transfer

Jeita

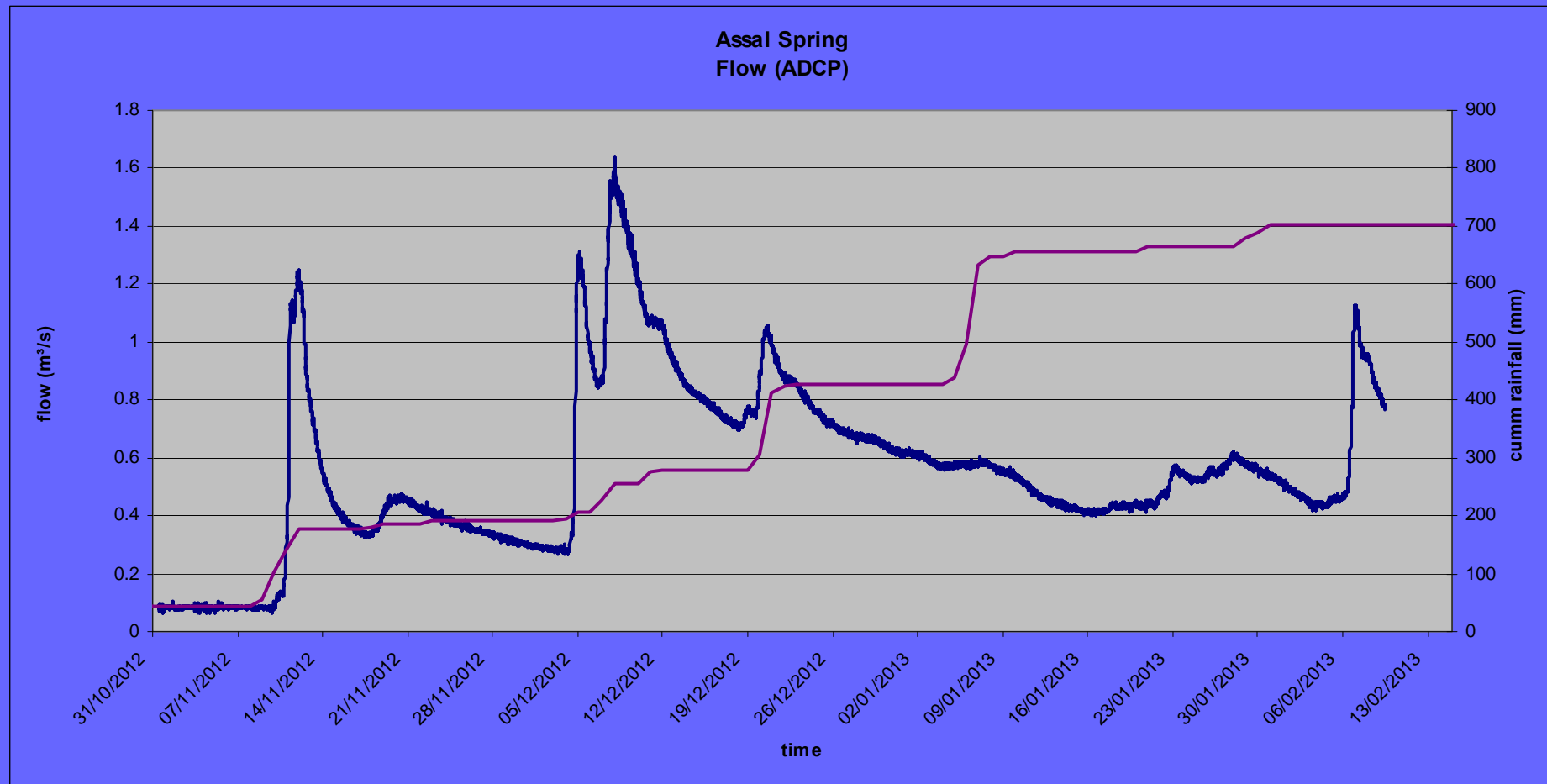


Assal spring

+ADCP

# Spring Monitoring

Assal – Monitoring by ADCP & multiparameter probe



ADCP : every **15 min**

multiparameter probe: every **20 min**



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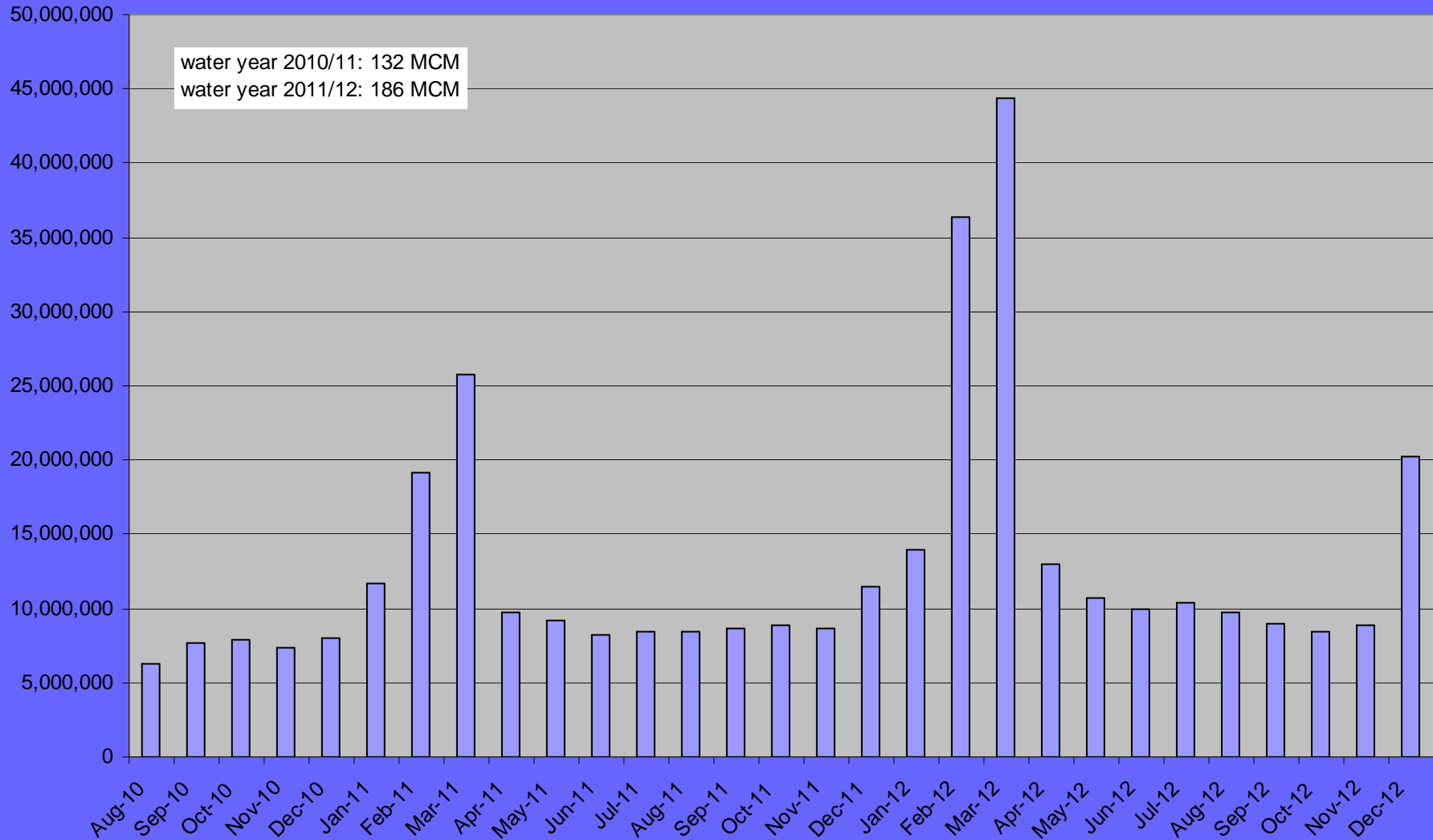




# Spring Monitoring

## Jeita – Monitoring by ADCP & multiparameter probe

### Monthly Discharge Jeita Spring



## Climate data

Installation of meteorological stations at

- Sheile
- Aajaltoun
- Kfar Debbiane
- Bakeesh
- Chabrouh dam





## Surface water data

Proposal for installation of streamflow gauging stations at

- Daraya (Nahr es Salib)
- Daraya (Nahr es Zirghaya)
- Jeita/Kashkoush (Nahr el Kalb)

LRA station 226 Daraya  
(Nahr es Salib + Nahr es Zirghaya)

Parshall flume weir Daraya (Nahr es Salib)

Unsuitable location and profile  
Highly turbid flow  
Difficult calibration  
No maintenance



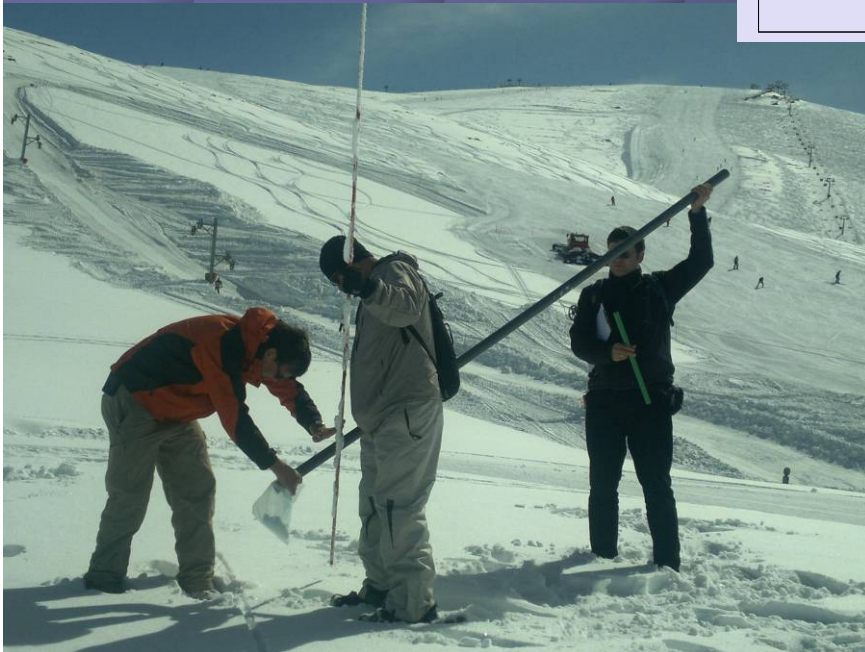
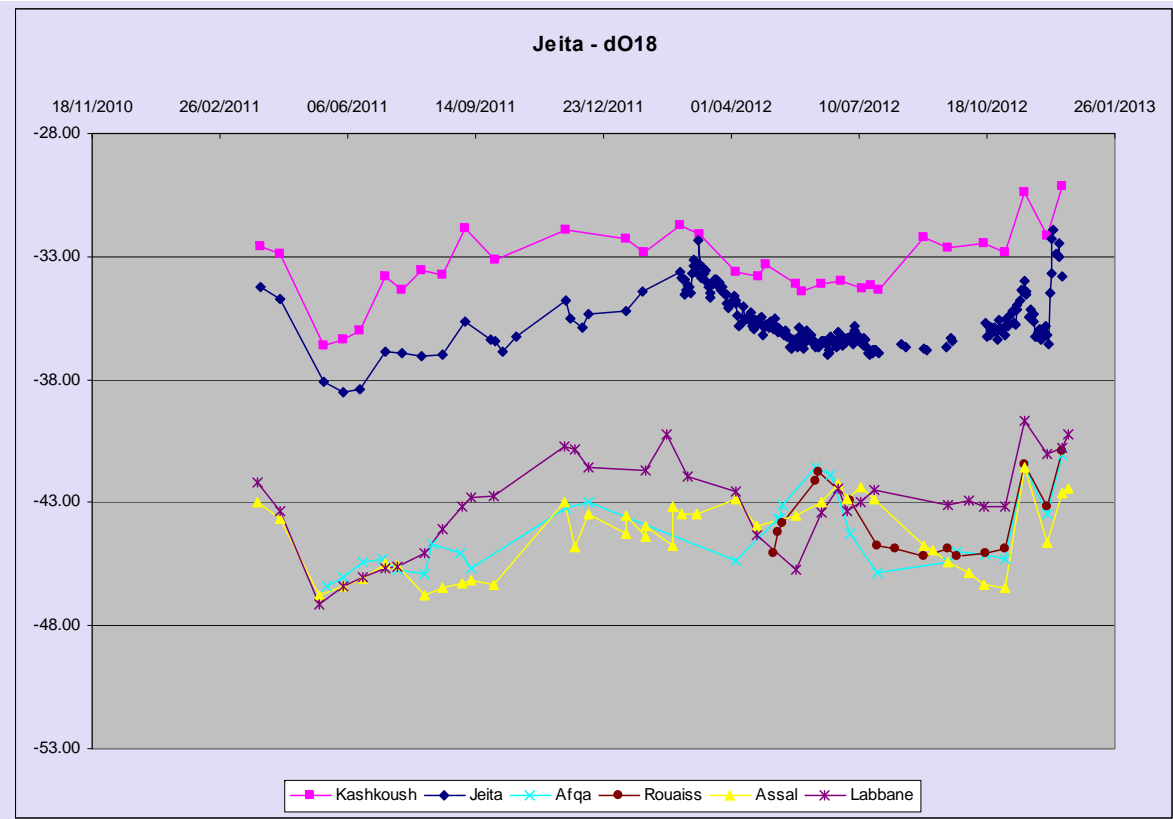


## Isotope data

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

### D/18O > 500 analyses

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



### D/18O

#### Springs Jurassic Aq (J4) :

- Jeita : daily
- Kashkoush : every 15 days

#### Springs Upper Cretaceous Aq (C4) :

- Assal, Labbane, Afqa, Rouaiss : 15 days
- Rainfall: Jeita, Sheile, Ajaltoun, Raifoun, Kfar Debbiane, Chabrouh : every 15 days
- Snow: integral & 10 cm depth intervals, 2 winter seas.

on of Jeita Spring

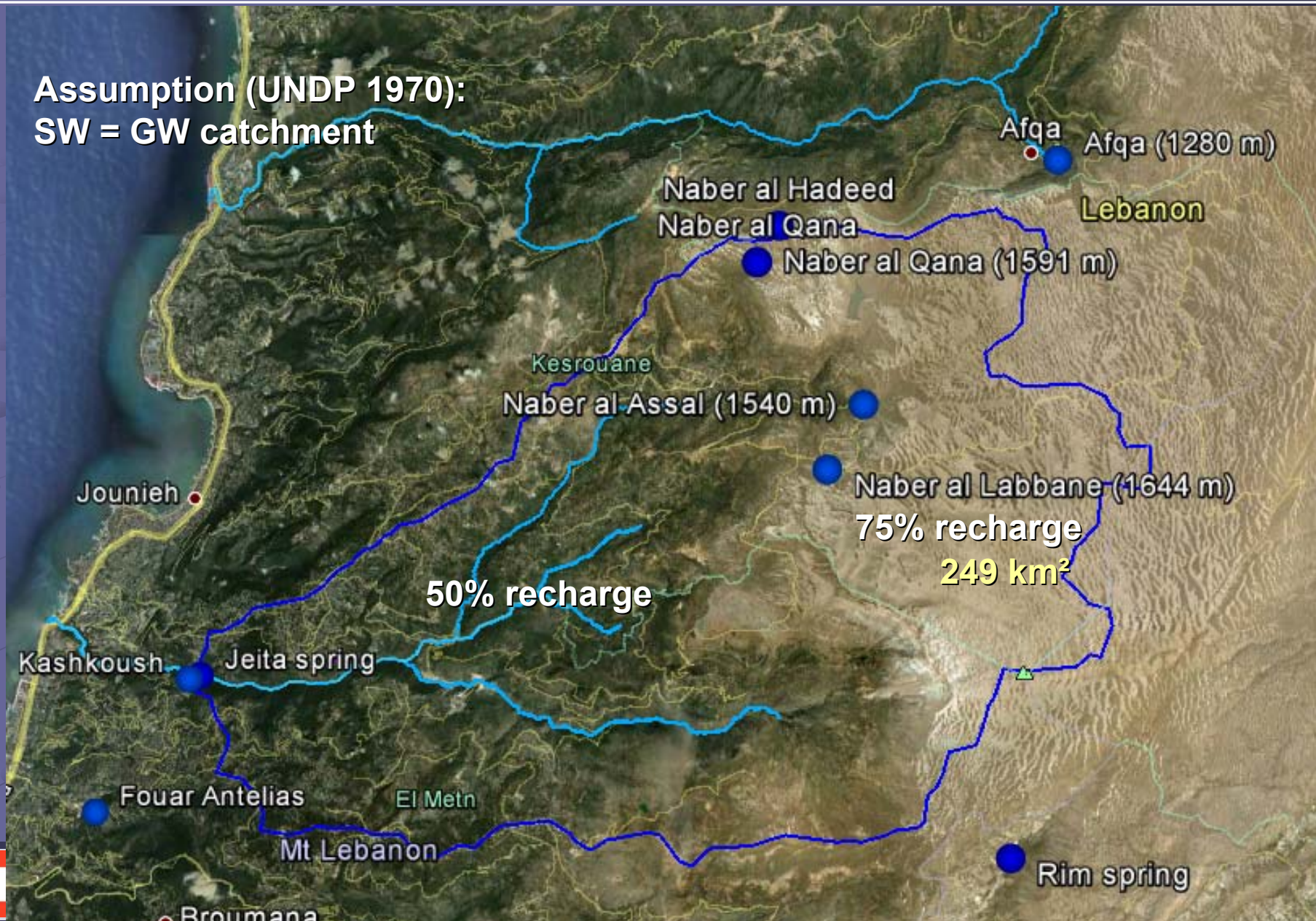




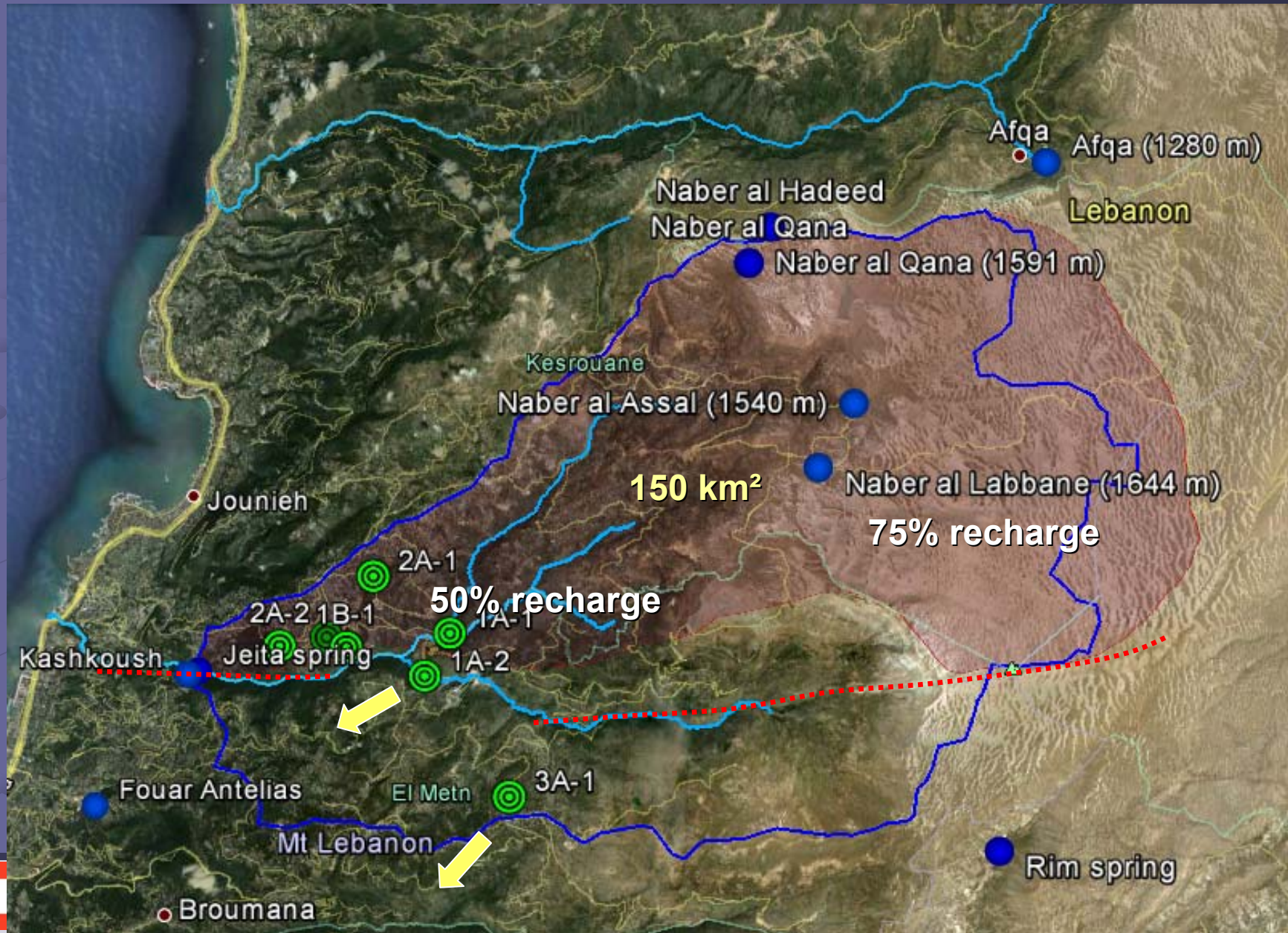
# Project Area = Groundwater Catchment

July 2010

Assumption (UNDP 1970):  
SW = GW catchment



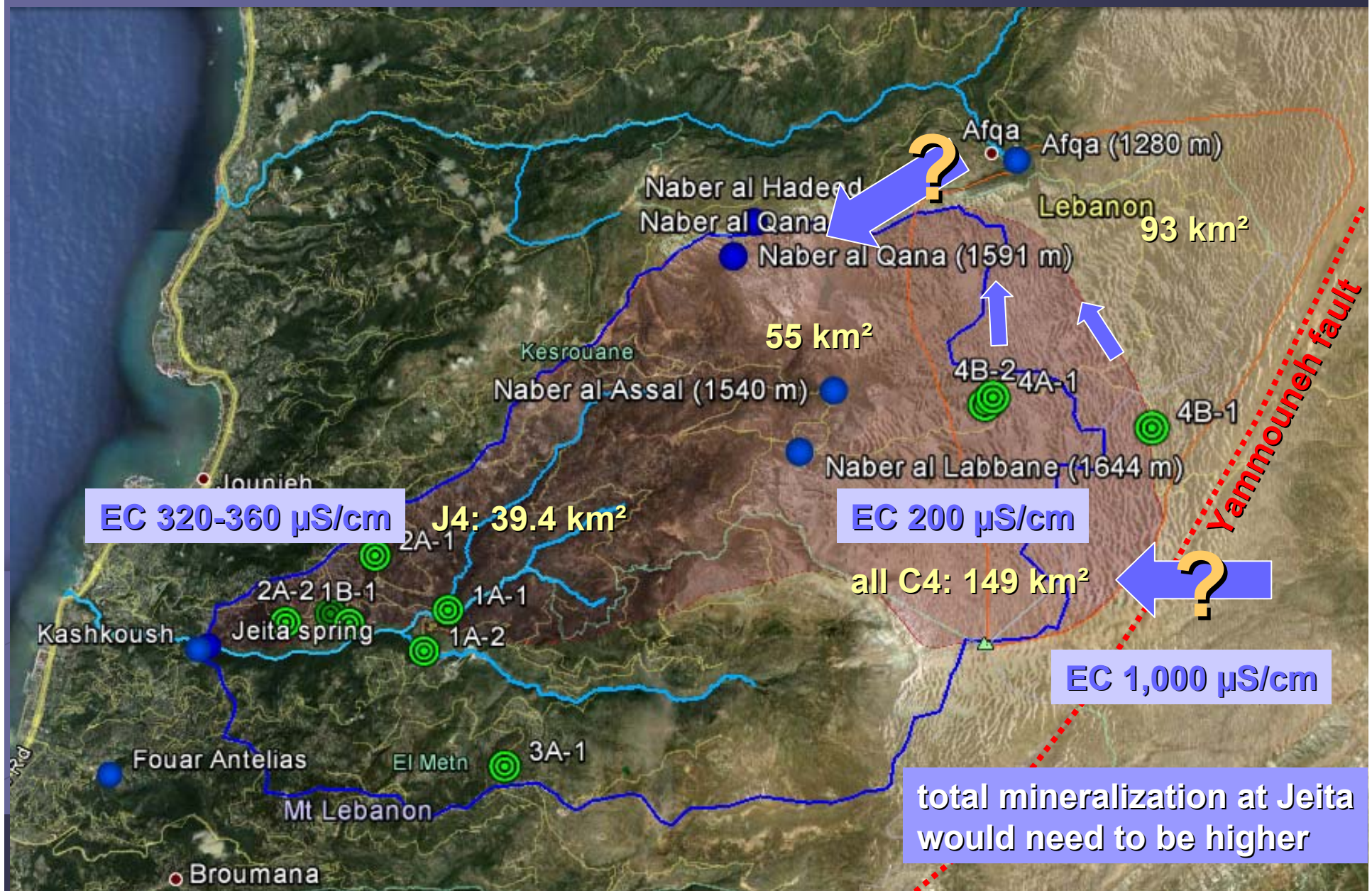






# Project Area

May 2011

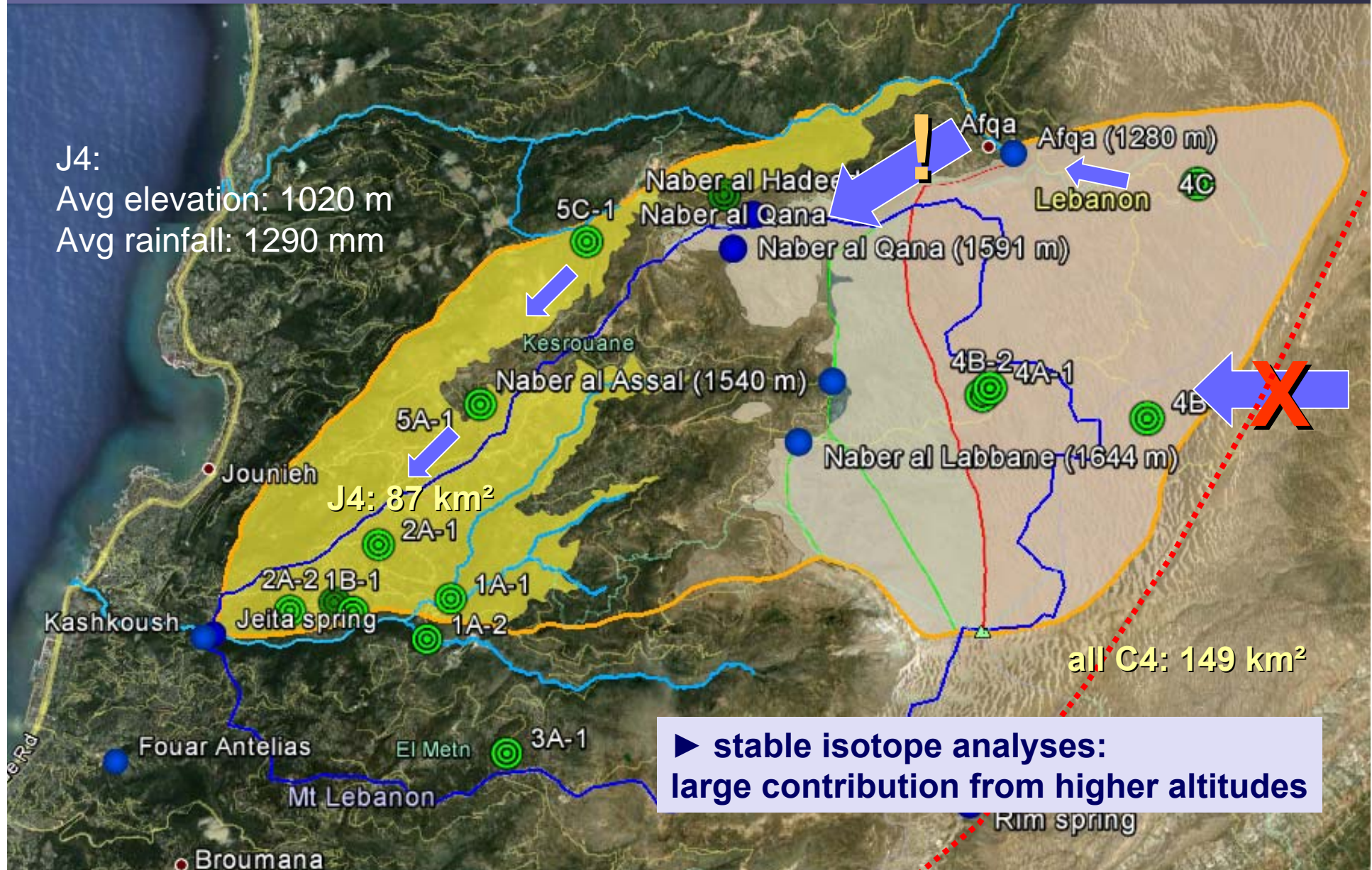


total mineralization at Jeita would need to be higher



# Project Area

September 2011 / April 2012



J4:  
Avg elevation: 1020 m  
Avg rainfall: 1290 mm

J4: 87 km<sup>2</sup>

all C4: 149 km<sup>2</sup>

► stable isotope analyses:  
large contribution from higher altitudes

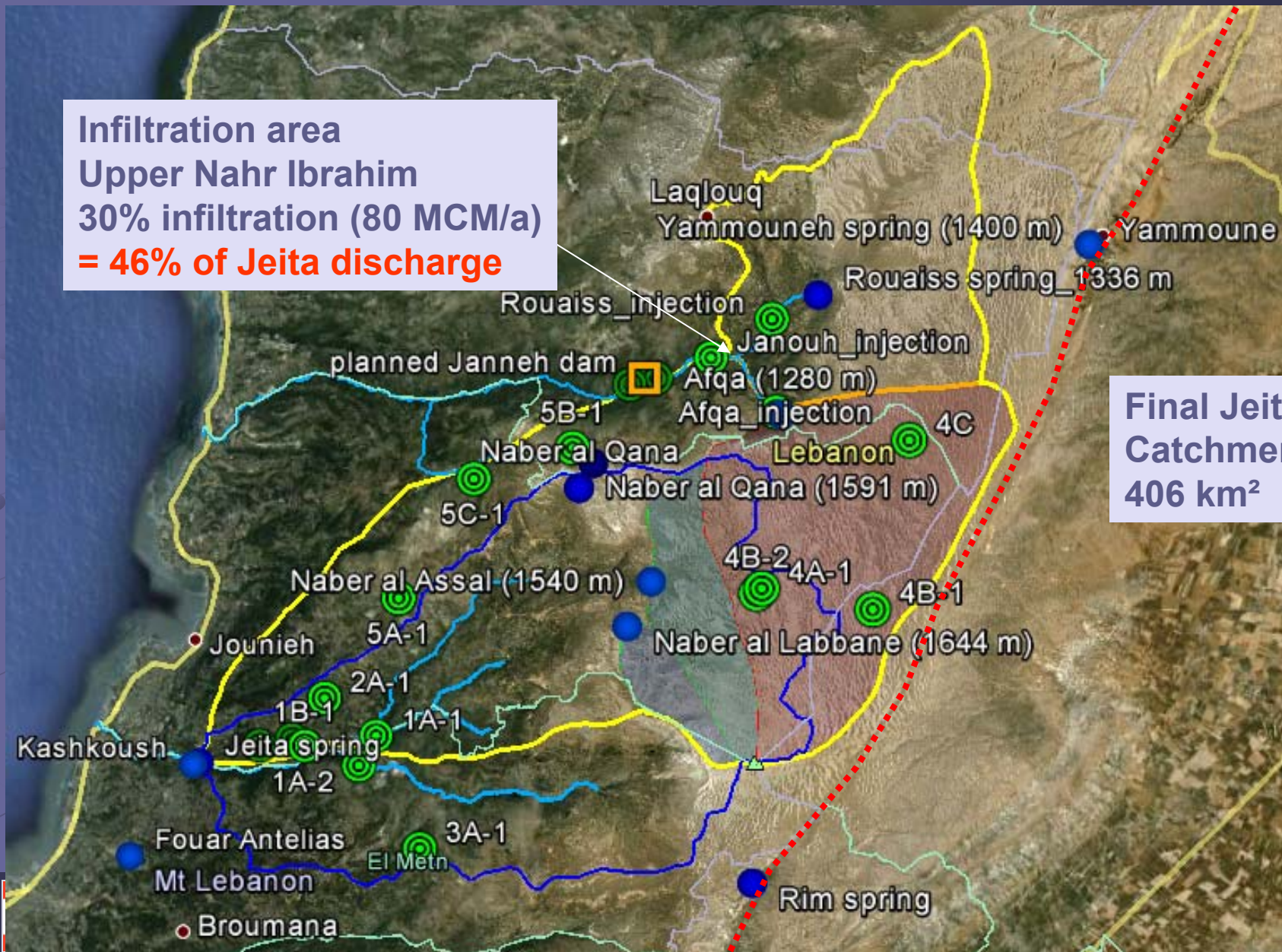


# Project Area

April / June 2012

Infiltration area  
Upper Nahr Ibrahim  
30% infiltration (80 MCM/a)  
**= 46% of Jeita discharge**

Final Jeita  
Catchment:  
406 km<sup>2</sup>





## Groundwater recharge

### Importance of Snow

**Cretaceous plateau (1,800 – 3,000 m asl):  
2-4 m snow (2012: up to 10 m and more)  
November – May**

**Very important for GW recharge (~ 86%)  
Snow is the lifeline of Lebanon**

**Climate change may lead to a significantly  
lower groundwater resources availability**

**Regional climatic scenarios predict less rainfall (15-30%),  
higher summer and winter temperatures (up to 5°C+)  
and thus less snow and runoff, more evaporation**



# Groundwater recharge

10/25/2007

- no major surface water runoff
- rapid infiltration into Cretaceous aquifer
- high GW recharge from snow melt

570 m)

Faraiya

Naber al Assal (1540 m)

Naber al Labbane (1644 m)

C4 limestone  
(upper aquifer)



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# Groundwater recharge

doline

GW recharge via dolines

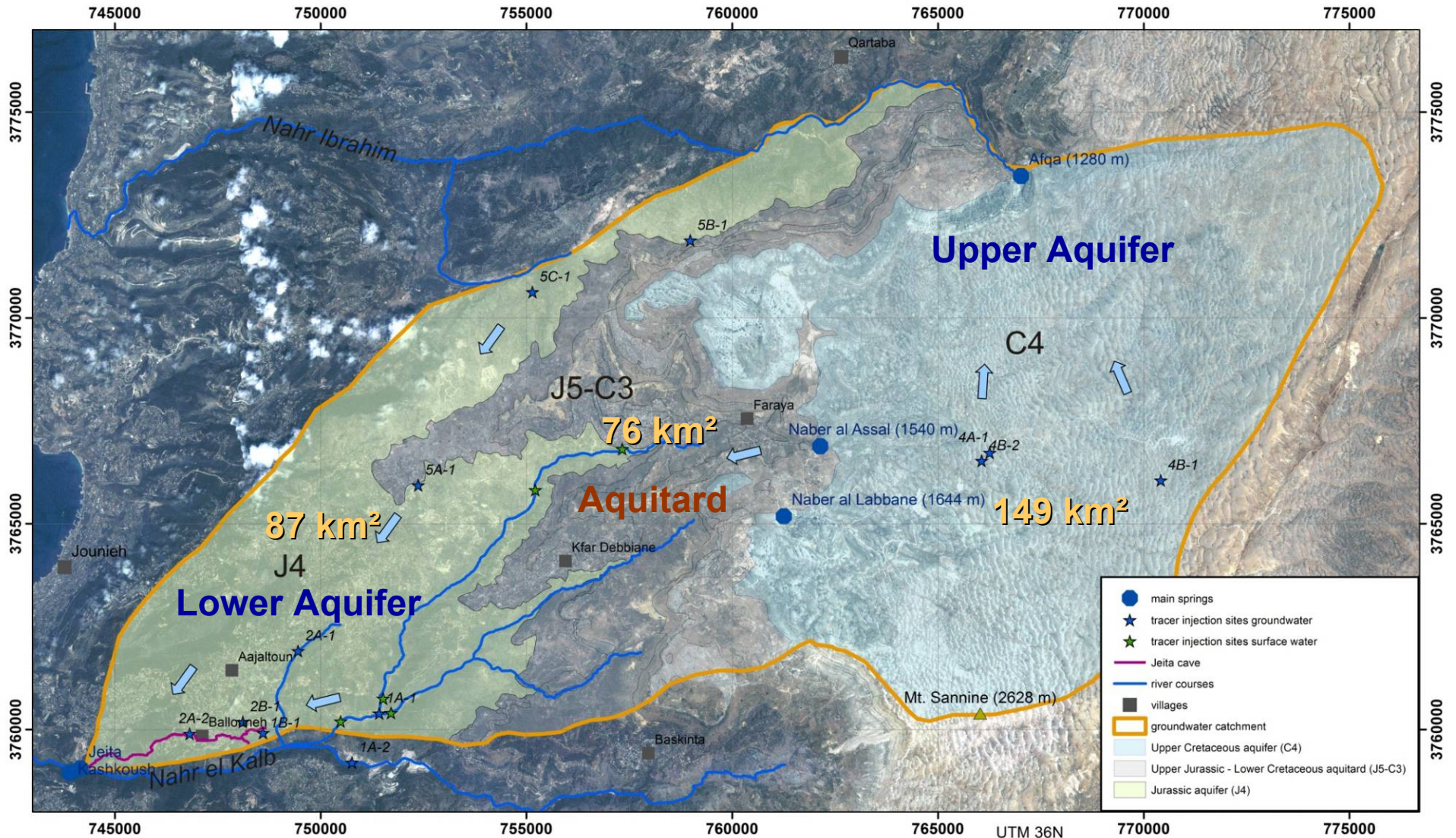
assumed GW recharge 86% in C4





# Groundwater System

New geological map prepared by BGR



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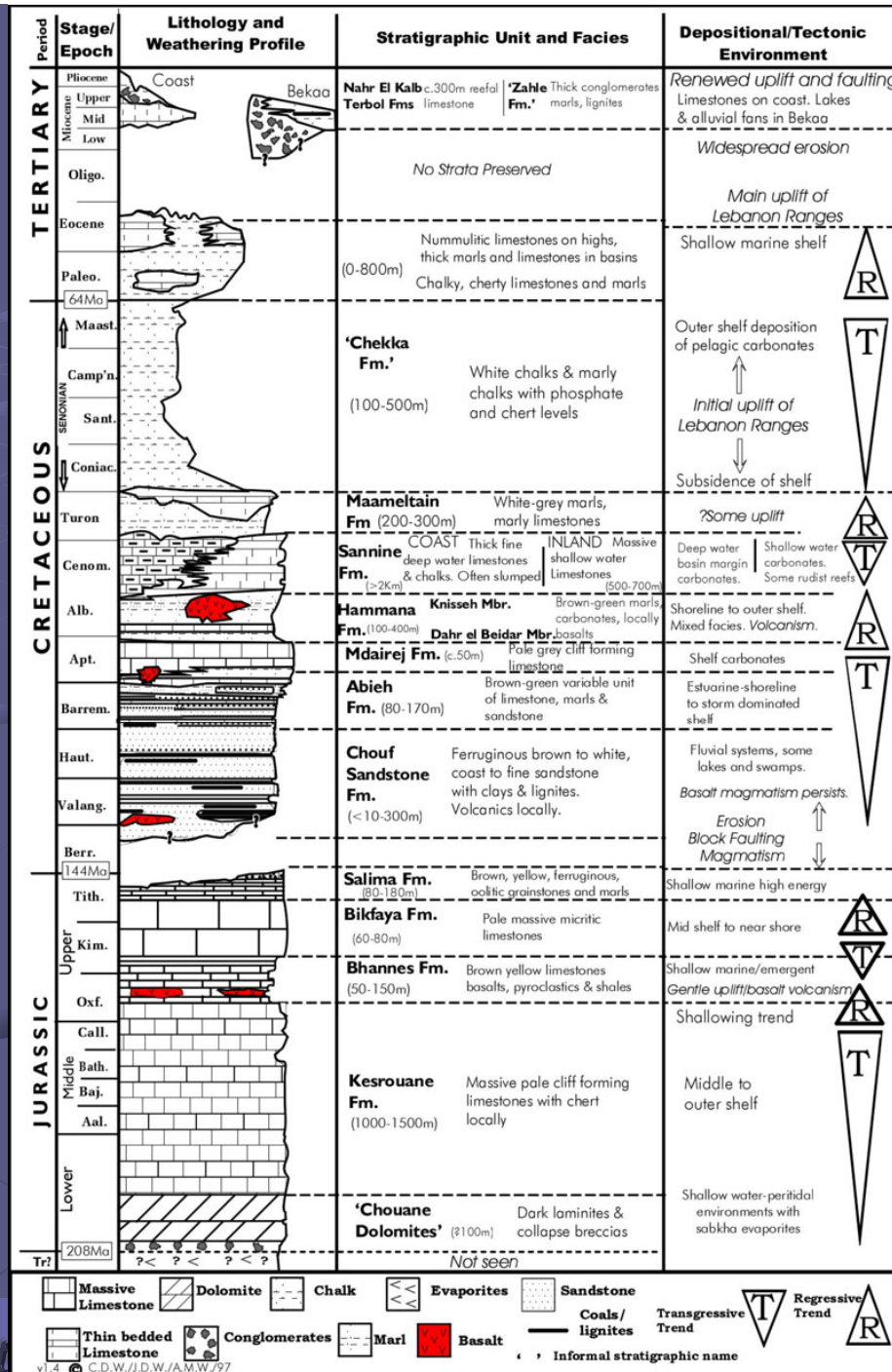


# Lithostratigraphy

Upper Aquifer up to 1000 m

Aquitard 500 - 800 m  
limited downward leakage

Lower Aquifer >1050 m



## Aquifers

- C4
- C3
- C2b
- C2a
- C1
- J7
- J6
- J5
- J4



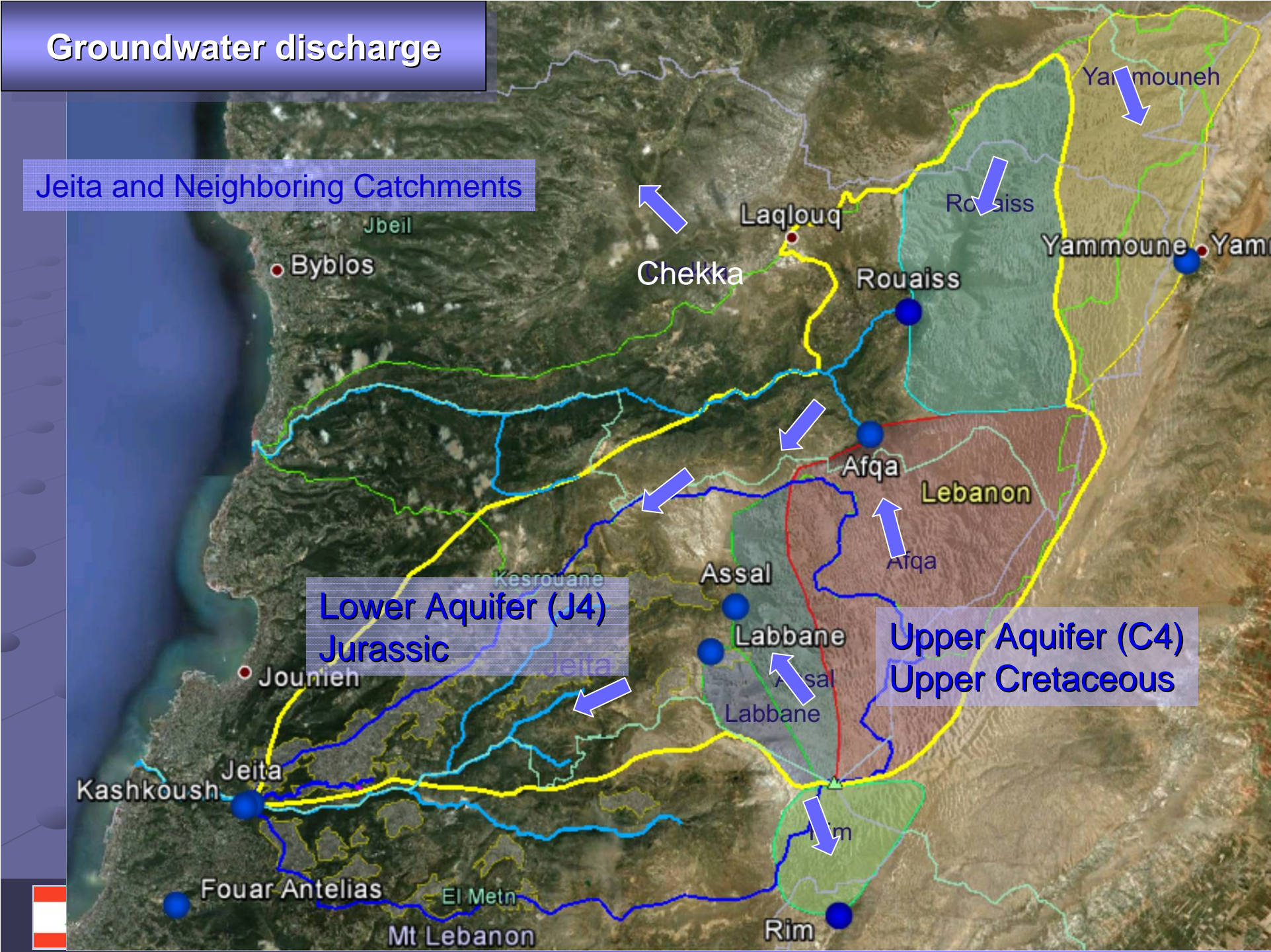
Prot

Source: C. D. Walley



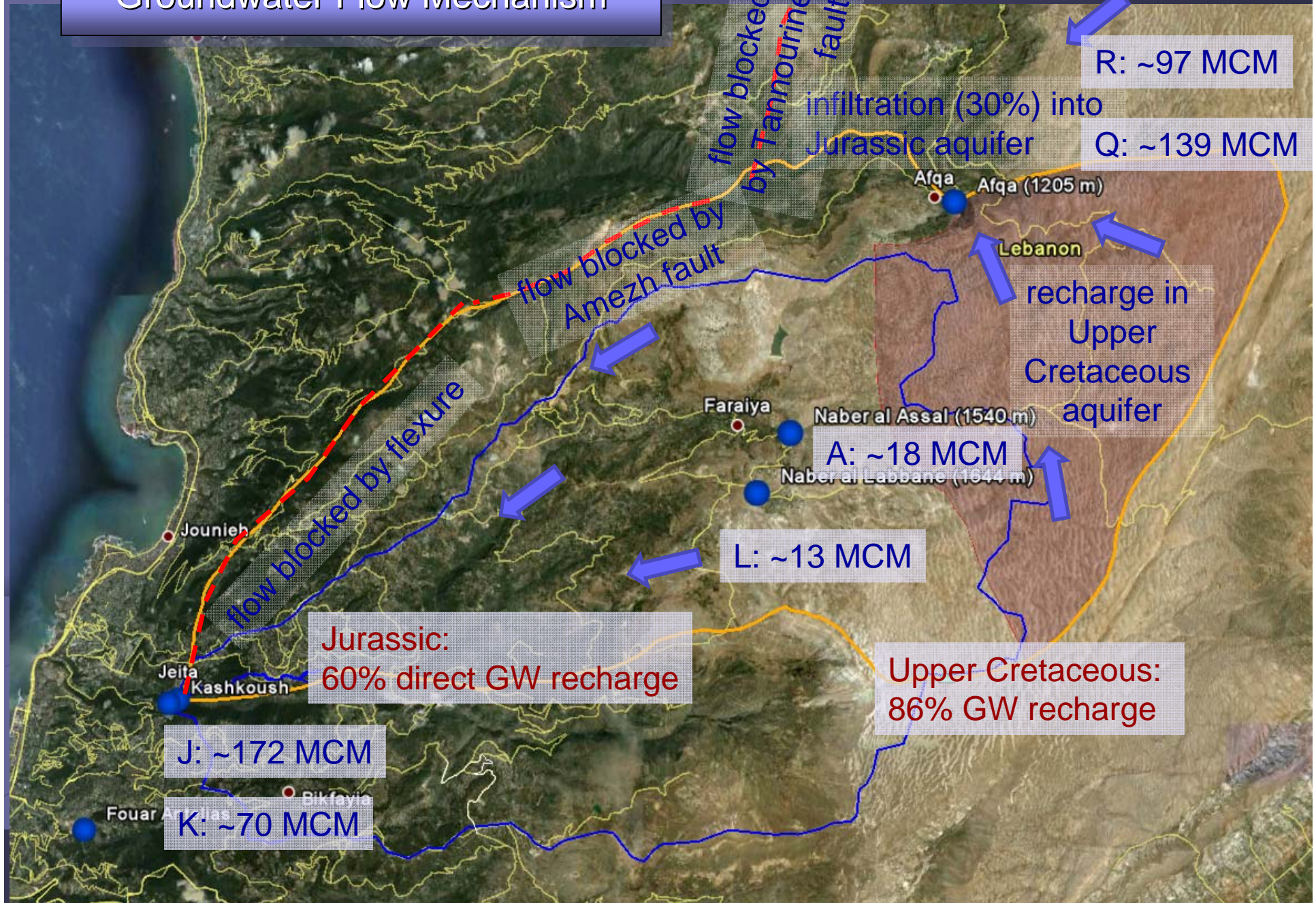
# Groundwater discharge

## Jeita and Neighboring Catchments





# Groundwater Flow Mechanism



R: ~97 MCM

infiltration (30%) into Jurassic aquifer  
Q: ~139 MCM

Lebanon  
recharge in Upper Cretaceous aquifer

A: ~18 MCM

Li: ~13 MCM

Jurassic:  
60% direct GW recharge

Upper Cretaceous:  
86% GW recharge

J: ~172 MCM

K: ~70 MCM

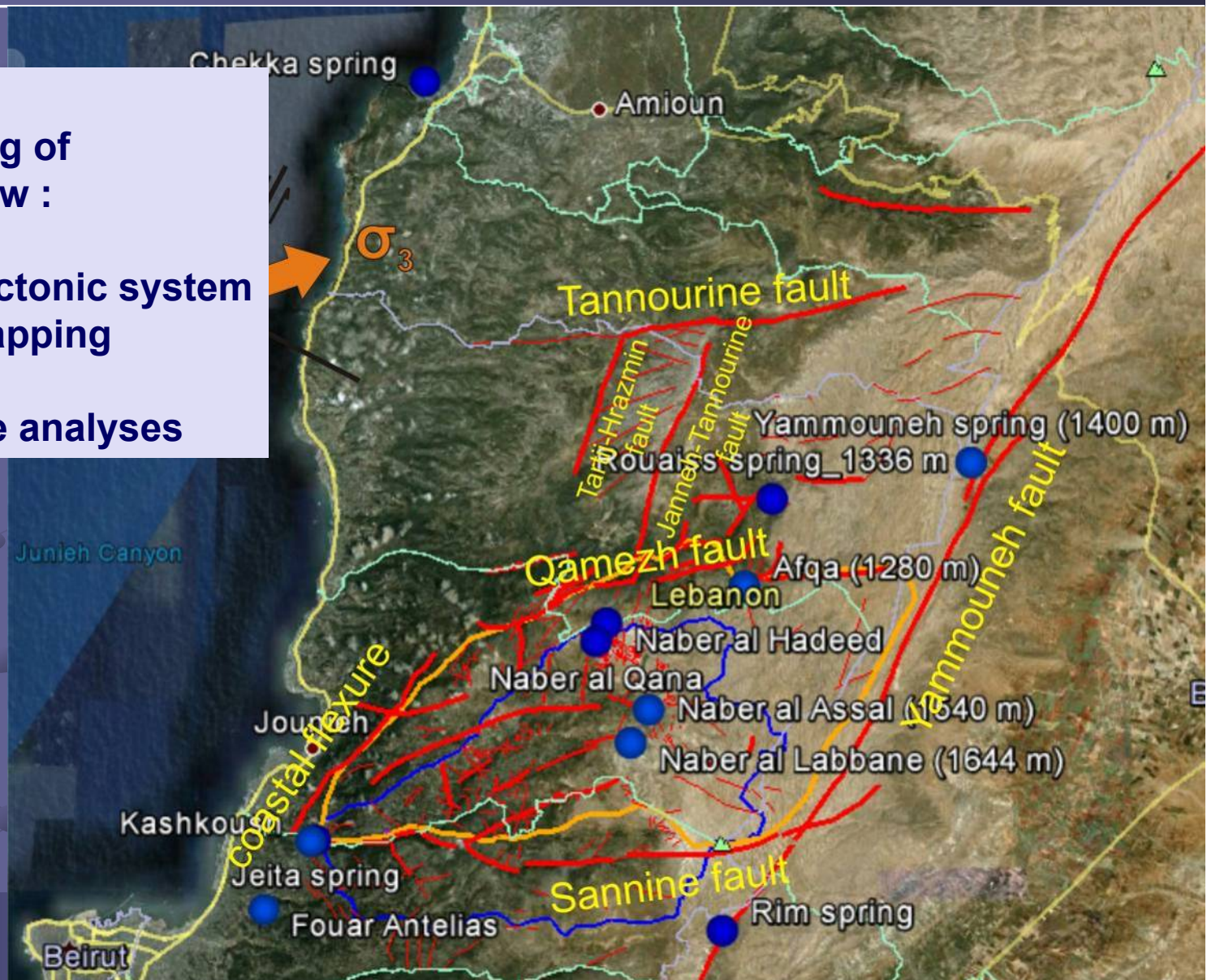


## Groundwater Flow

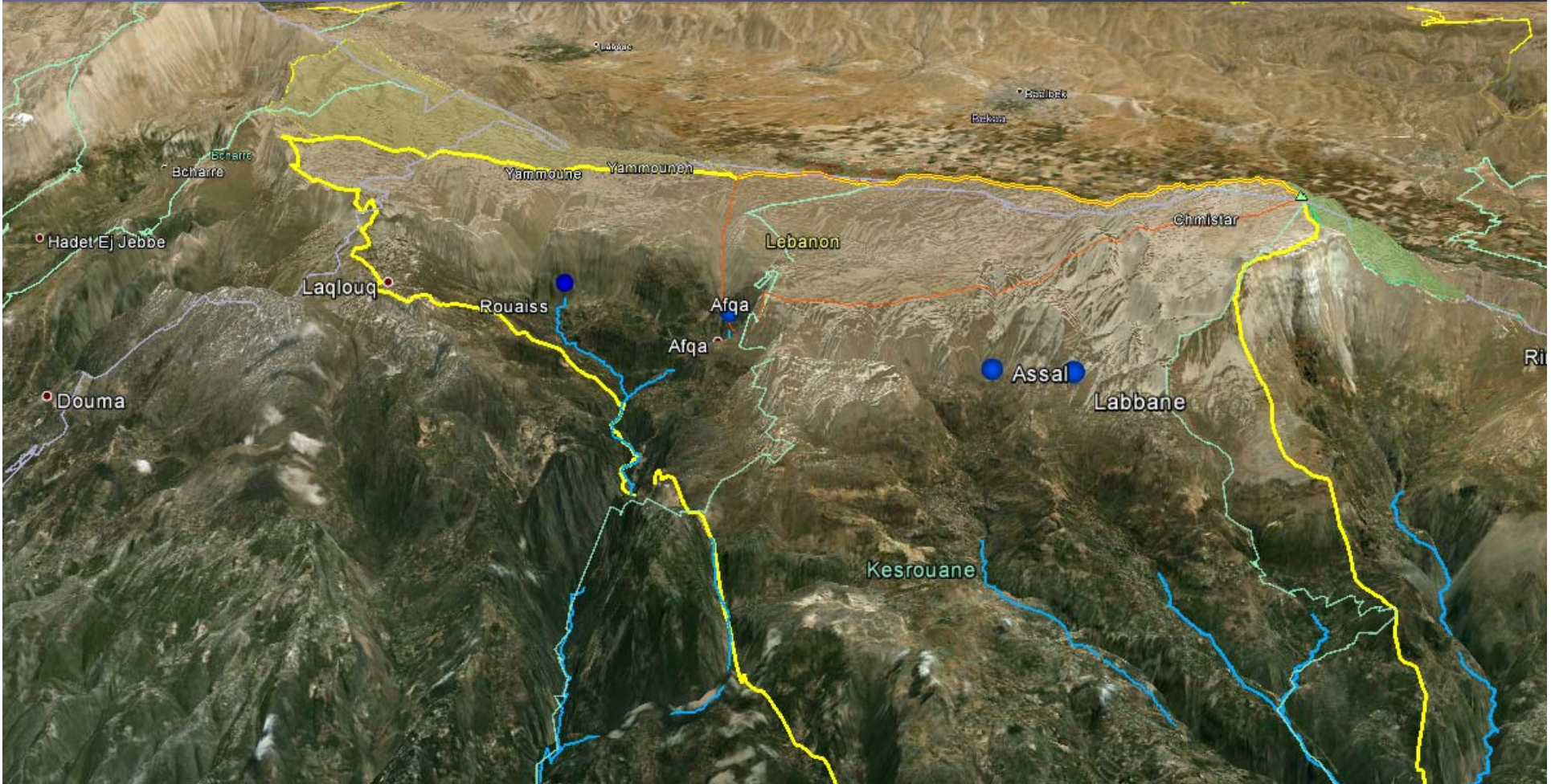
controlled by  
- structure (base) and  
- tectonics

key elements  
to understanding of  
groundwater flow :

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







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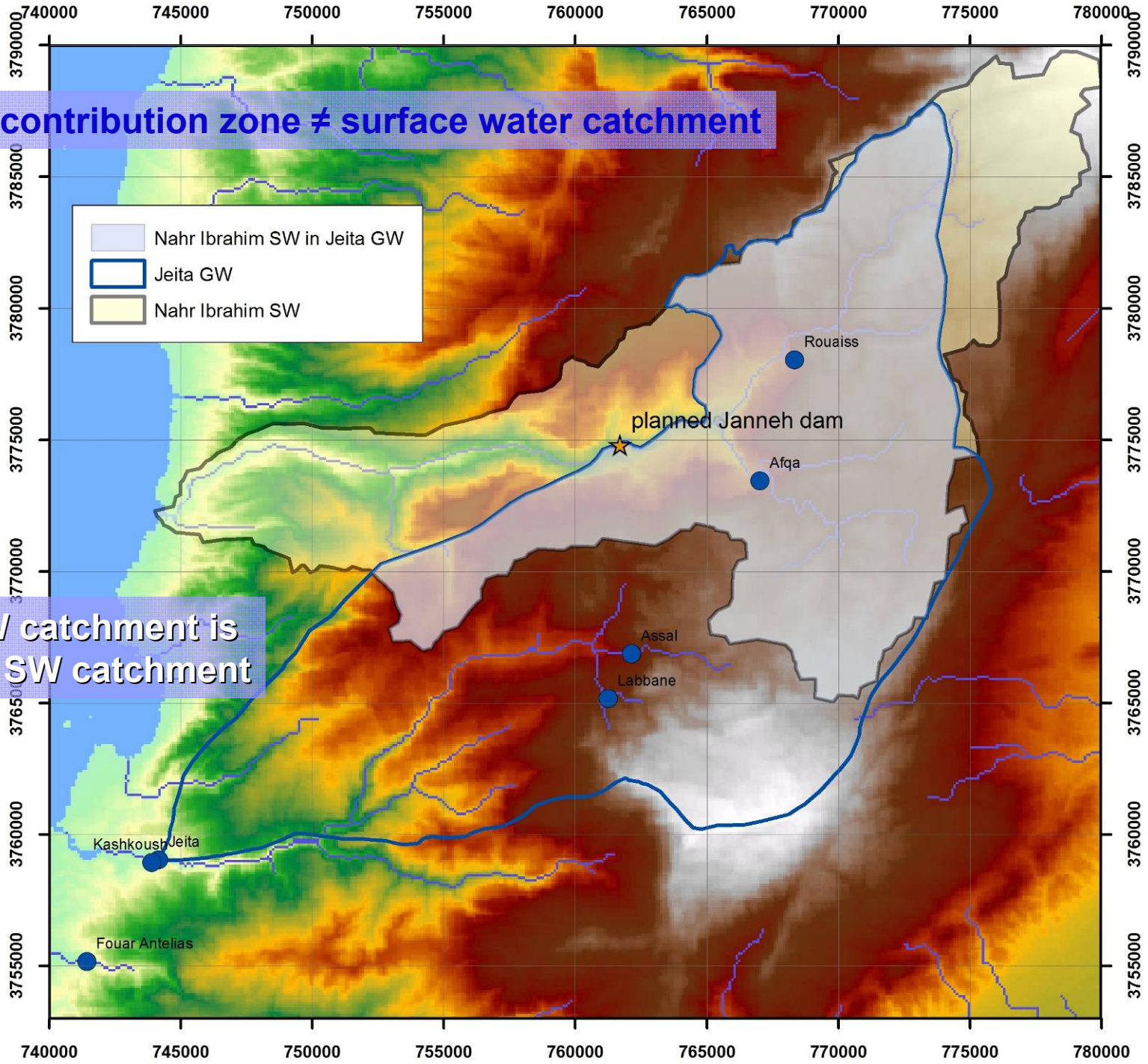




**Groundwater contribution zone  $\neq$  surface water catchment**



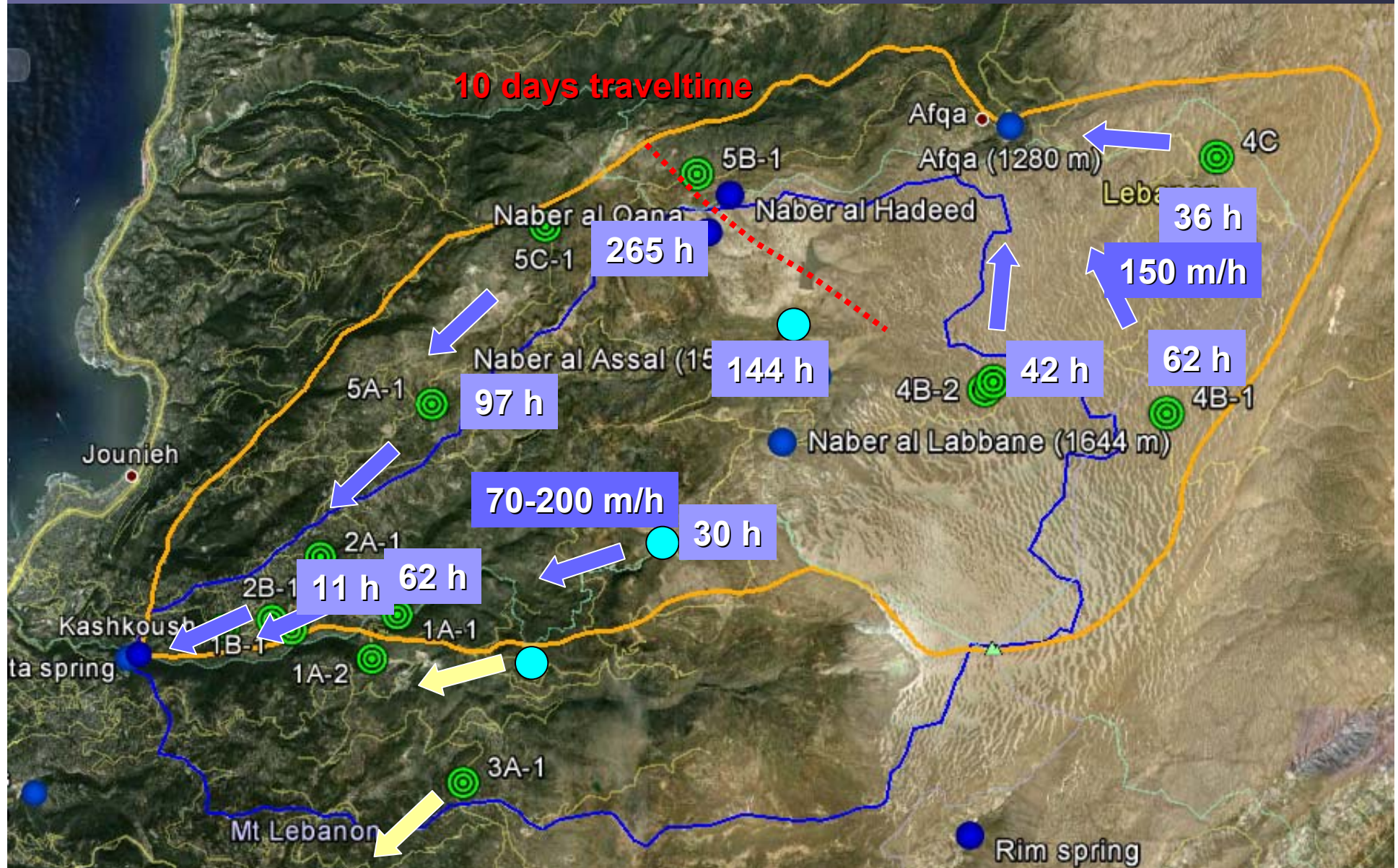
**50% of Jeita GW catchment is in Nahr Ibrahim GW catchment**





# Groundwater Flow

## Mean travel times

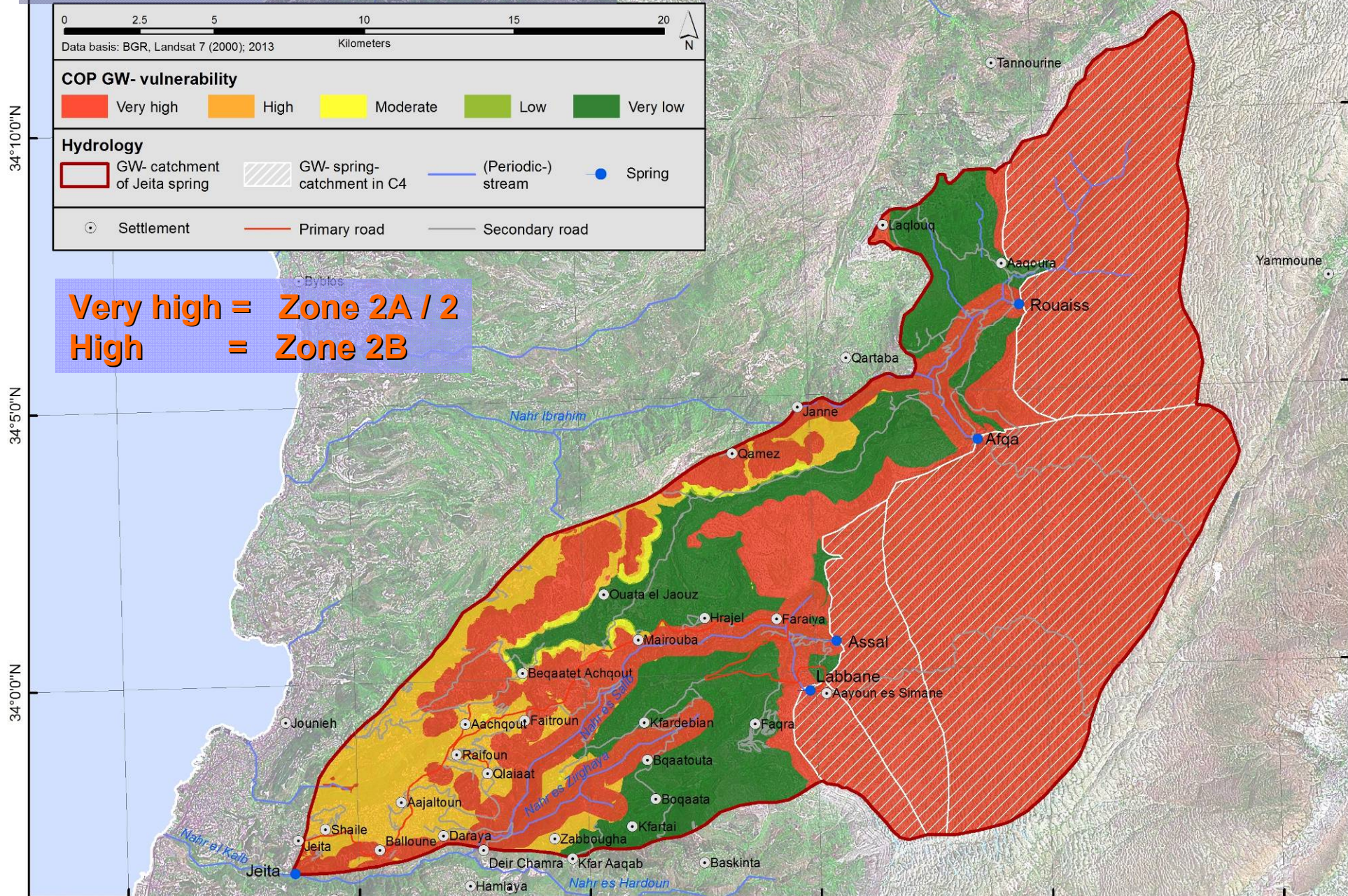




# Groundwater Protection Zones

# Groundwater Vulnerability COP Method (modified)

35°50'0"E



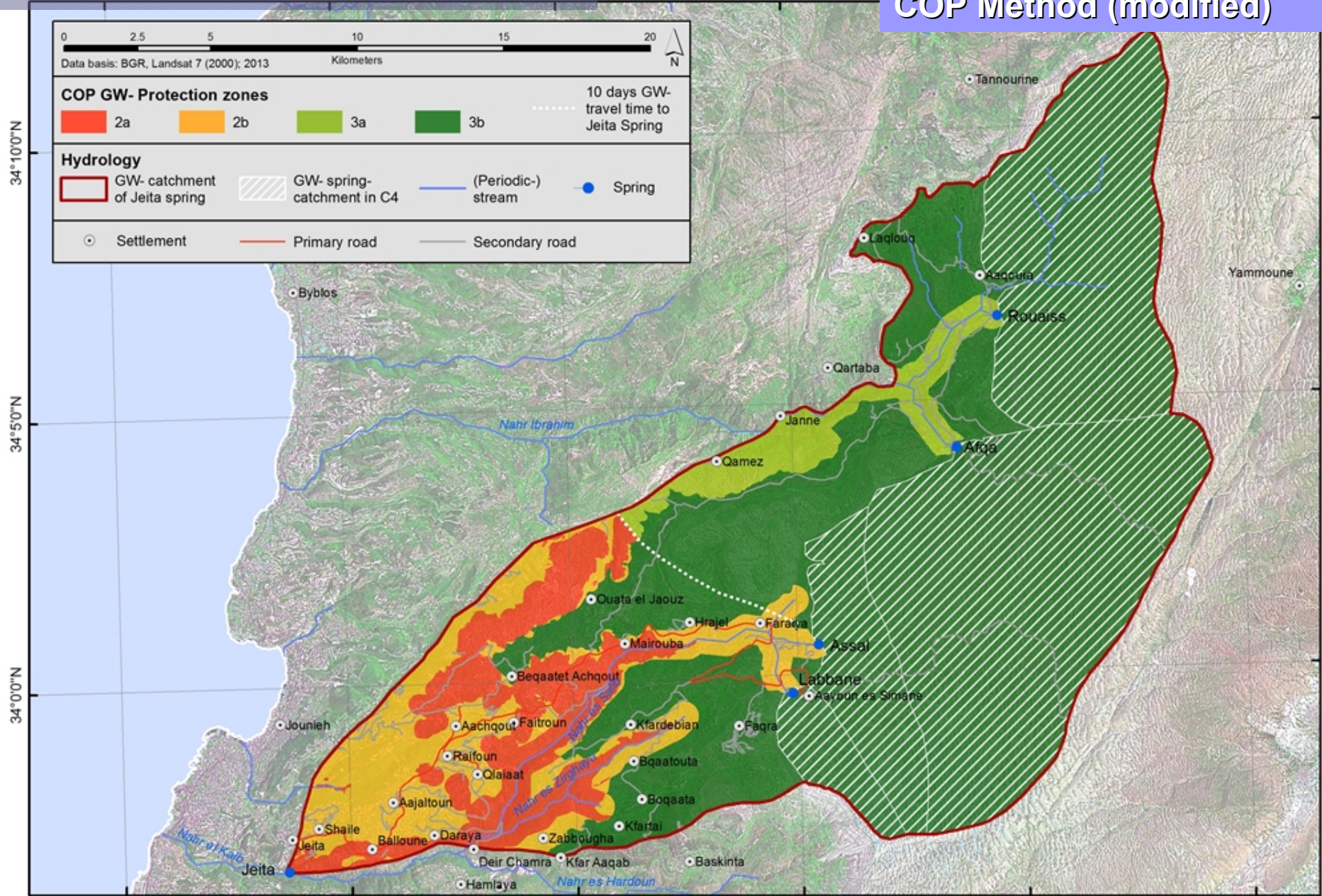
**Very high = Zone 2A / 2**  
**High = Zone 2B**



# Groundwater Protection Zones

for **Jeita Spring** based on Groundwater Vulnerability COP Method (modified)

35°50'0"E





# Groundwater Protection Zones

for Jeita, Afqa, Rouaiss, Assal and Labbane springs

35°50'0"E



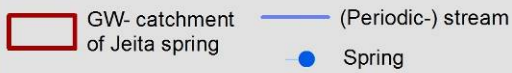
Data basis: BGR, Landsat 7 (2000); 2013

### COP GW- Protection zones

#### Jeita Spring



#### Hydrology



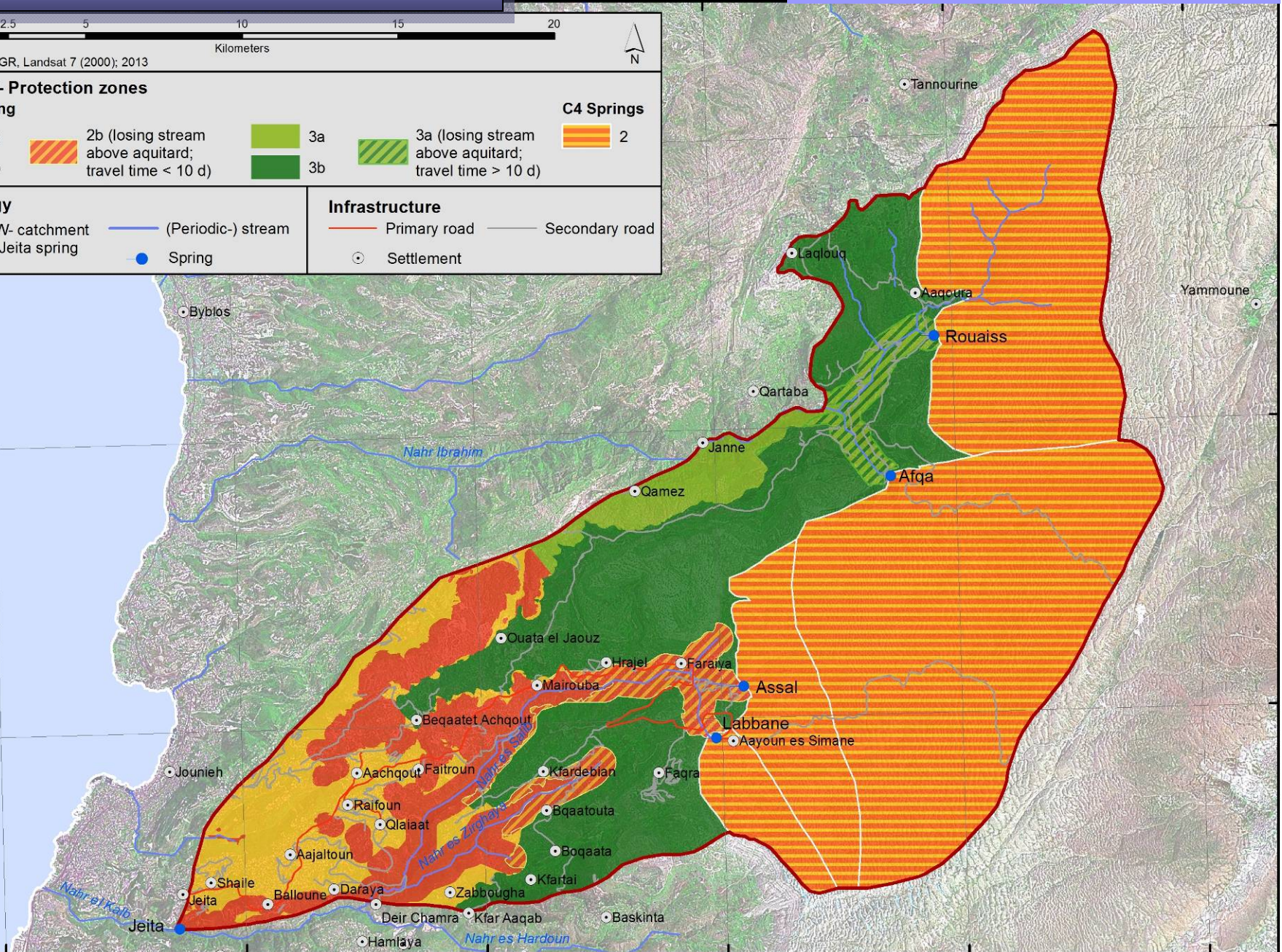
#### Infrastructure



34°10'0"N

34°5'0"N

34°0'0"N





*Thank you for your  
kind attention*

[www.bgr.bund.de/jeita](http://www.bgr.bund.de/jeita)

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