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

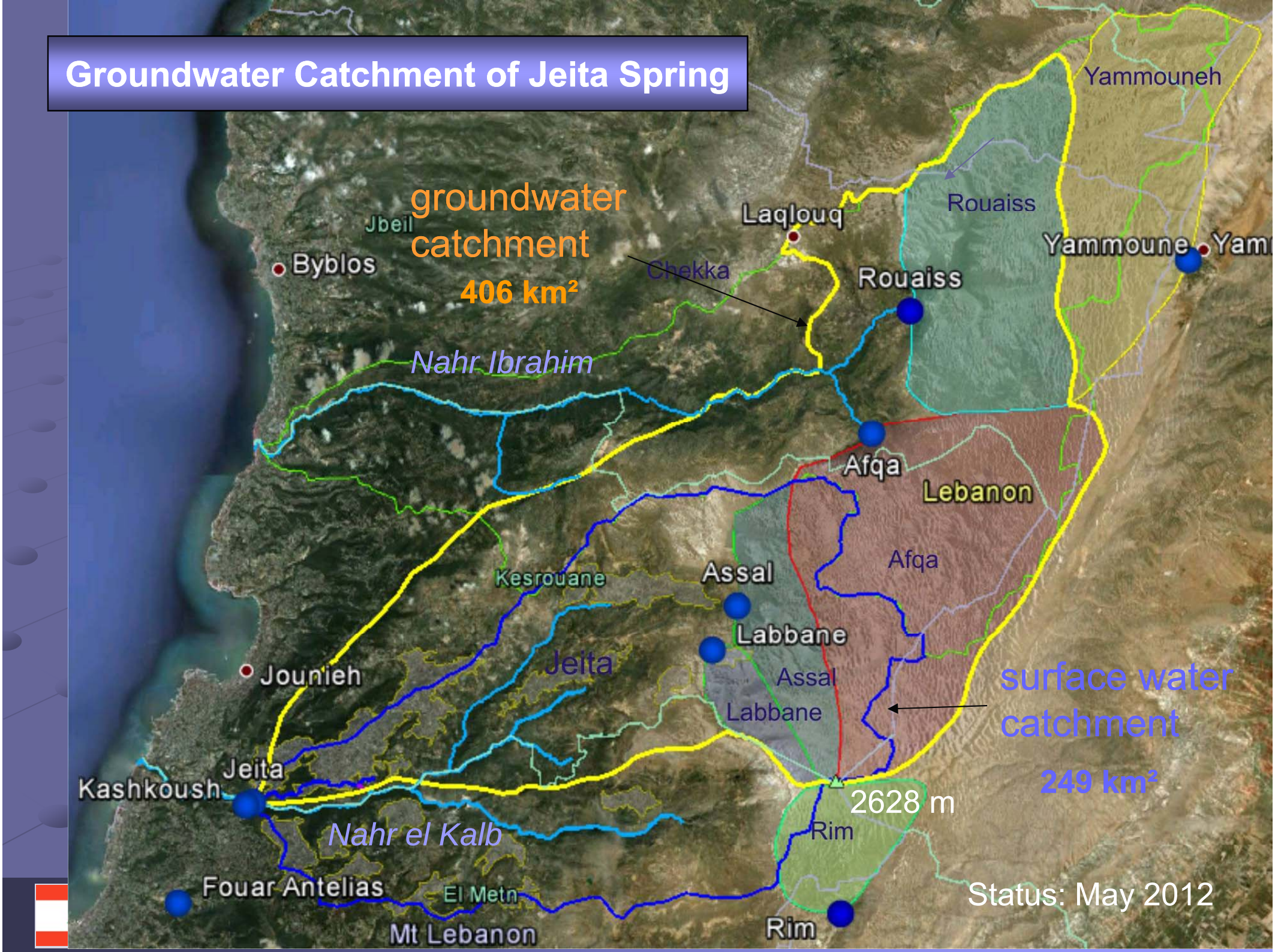
German-Lebanese Technical Cooperation Project

Public Awareness Campaign for Schools

Planning of the Mokhada Wastewater Treatment Facilities

BGR
September 2012

Dr. Armin Margane, BGR

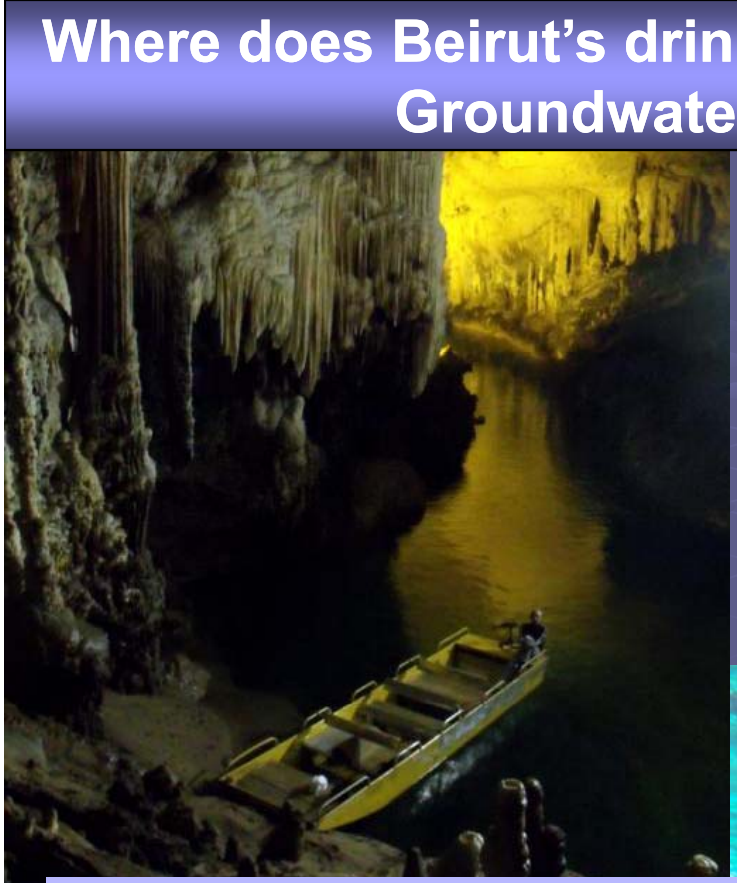

Groundwater Catchment of Jeita Spring
groundwater catchment
406 km²
surface water catchment
249 km²
Yammouneh
Rouaiss
Laqlouq
Jbeil
Byblos
Chekka
Rouaiss
Yammoune
Yam
Nahr Ibrahim
Afqa
Lebanon
Afqa
Kesrouane
Assal
Labbane
Jeita
Assal
Labbane
Jounieh
Jeita
Kashkoush
2628 m
Rim
Nahr el Kalb
Fouar Antelias
El Metn
Mt Lebanon
Rim
Status: May 2012

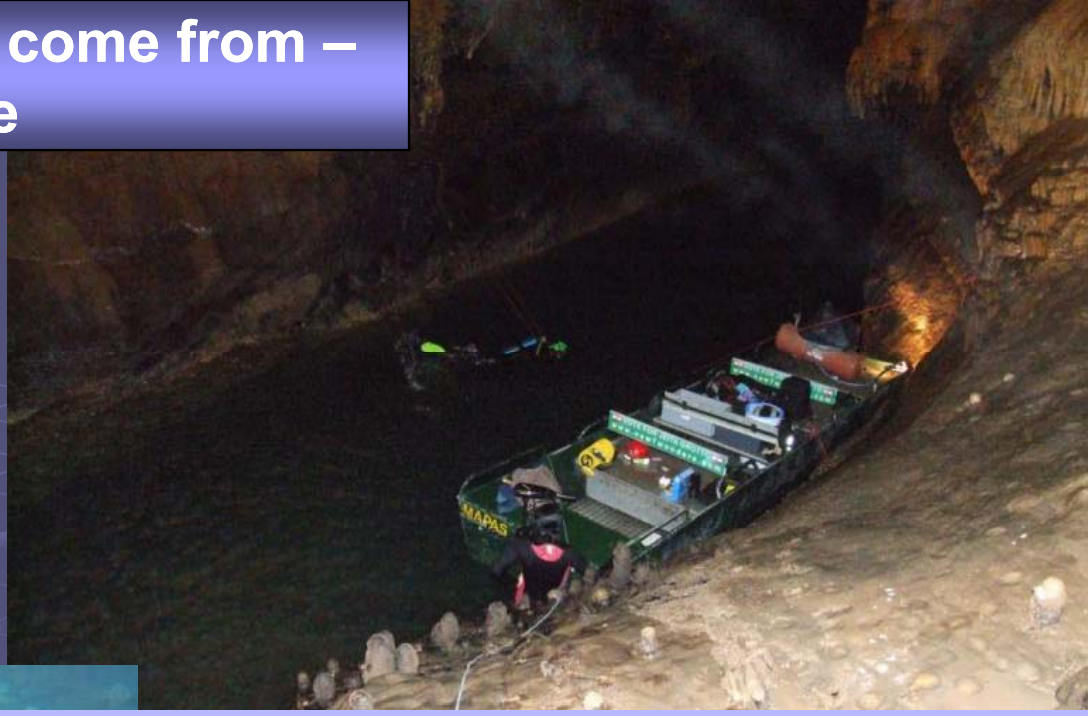
What is karst and how Groundwater is recharged

High karstification in Cretaceous limestone (Faqra)

The Jeita groundwater catchment consists mainly of limestone units which have been exposed since a long time so that they are highly karstified. Because of the high karstification, the planning of waste-water facilities needs geoscientific expertise.

Where does Beirut's drinking water come from – Groundwater discharge





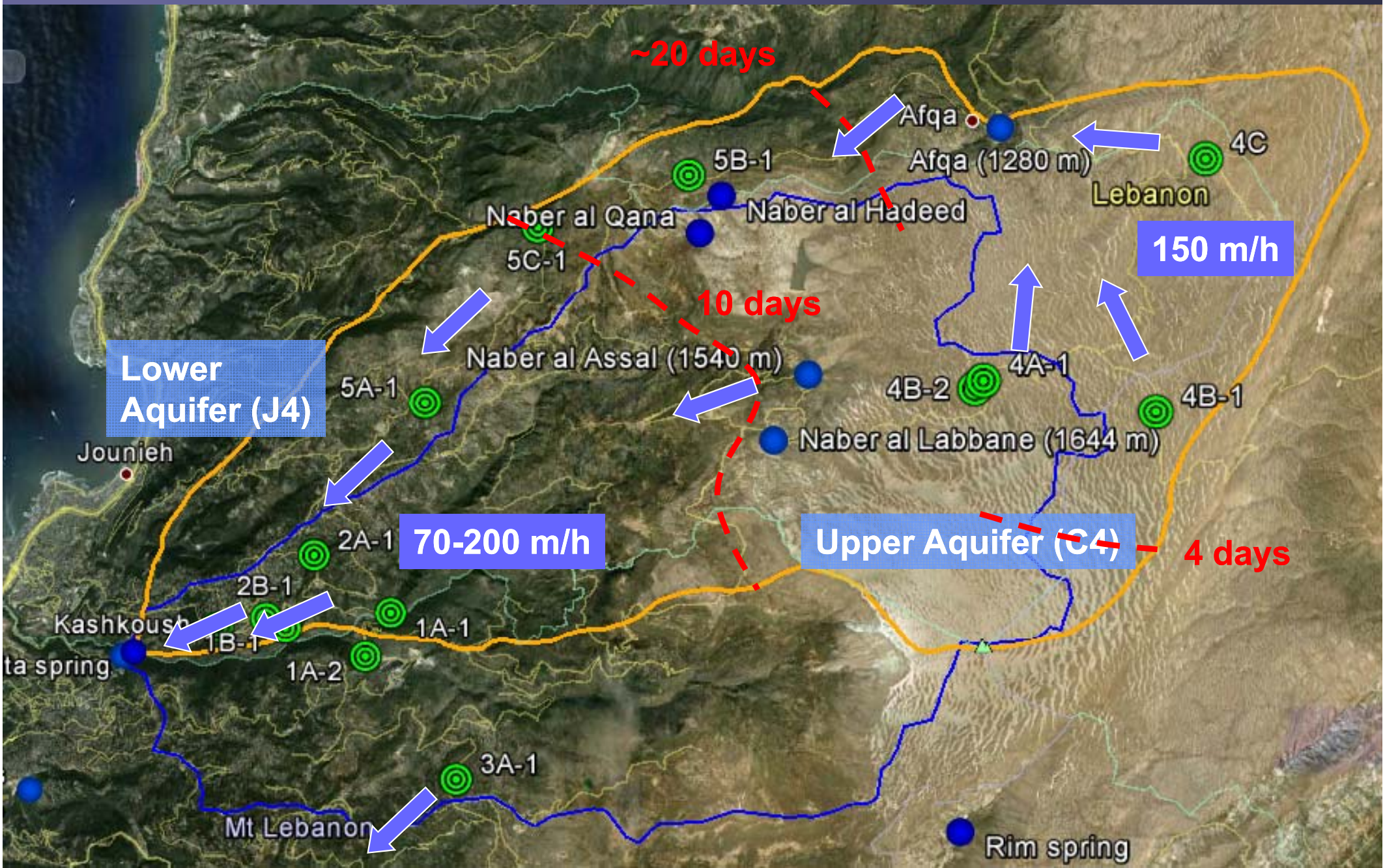
Jeita Spring
The main Source for Water Supply of Beirut

75 % of Beirut's water comes from Jeita

Awareness Movie „Beirut Waters“

Groundwater Flow

Mean travel times



Groundwater Protection Measures

There are five measures that need to be implemented in order to protect the groundwater resources used for drinking water supply against pollution:

- assess pollution risks and implement mitigation measures (e.g. abandon industrial sites or clean-up of contaminated sites)
- establish groundwater (and surface water) protection zones (landuse restrictions must be enforced)
- collect and treat wastwater generated in the GW catchment
- adopt landuse planning policies
- monitor water quality

► In karst areas it is important to find the appropriate location for wastewater treatment and effluent discharge

Contamination Risks from Wastewater

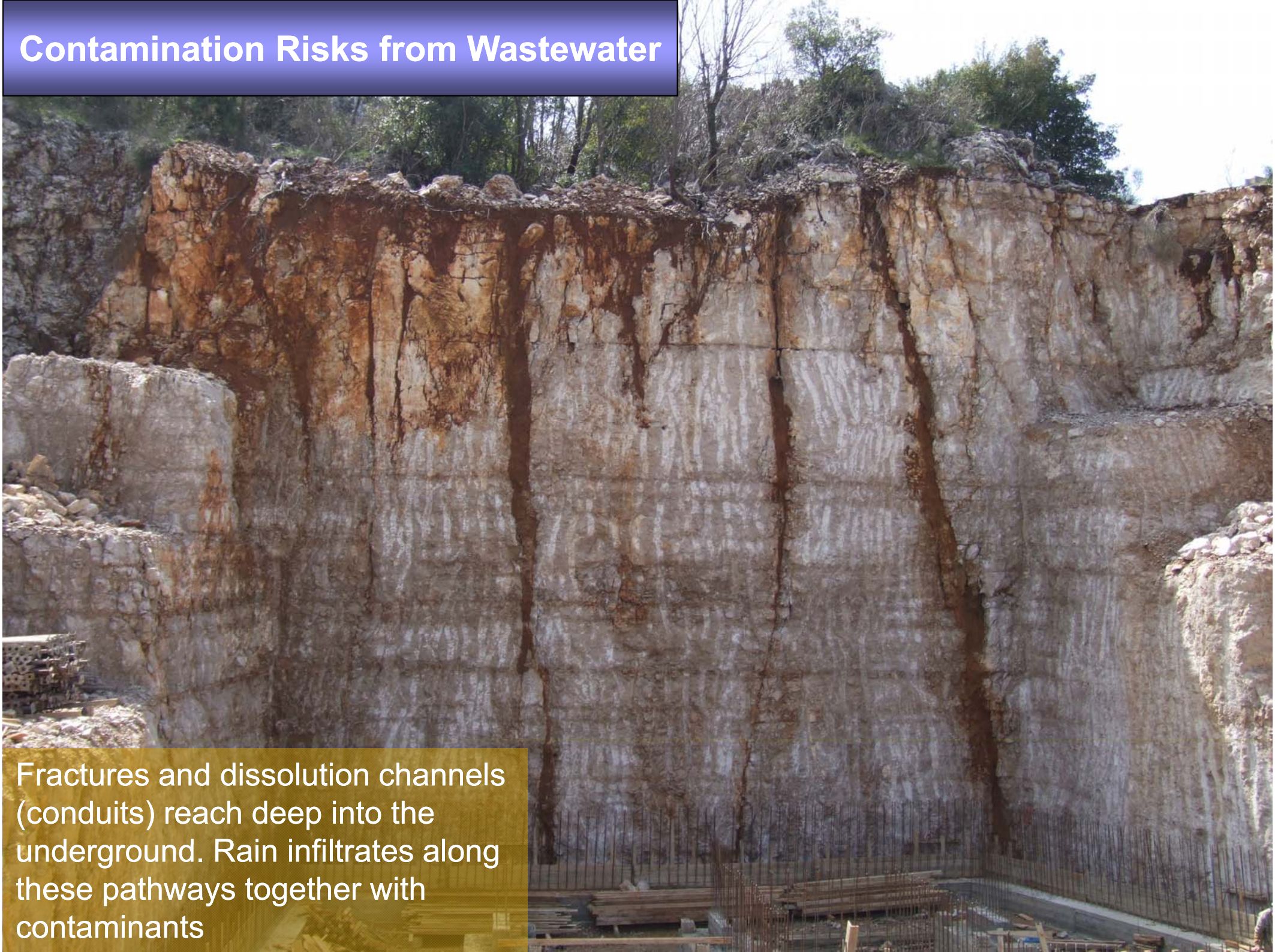
Currently wastewater is discharged
- **into injection wells**
- **into open cess pits or**
- **into nearby creeks/rivers/wadis**

residences with no wastewater collection and treatment

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

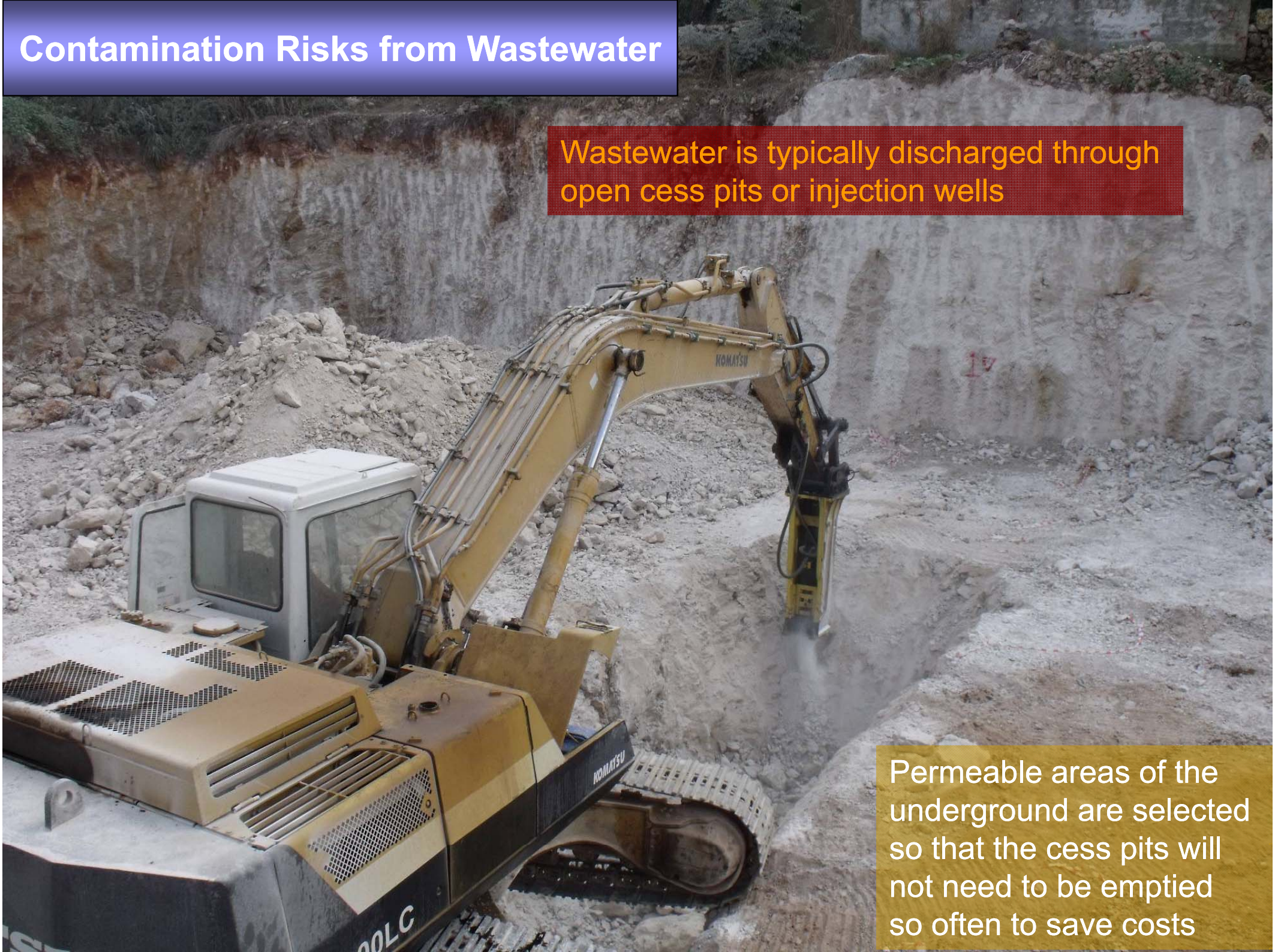
► microbiological contamination of Jeita spring

Contamination Risks from Wastewater



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

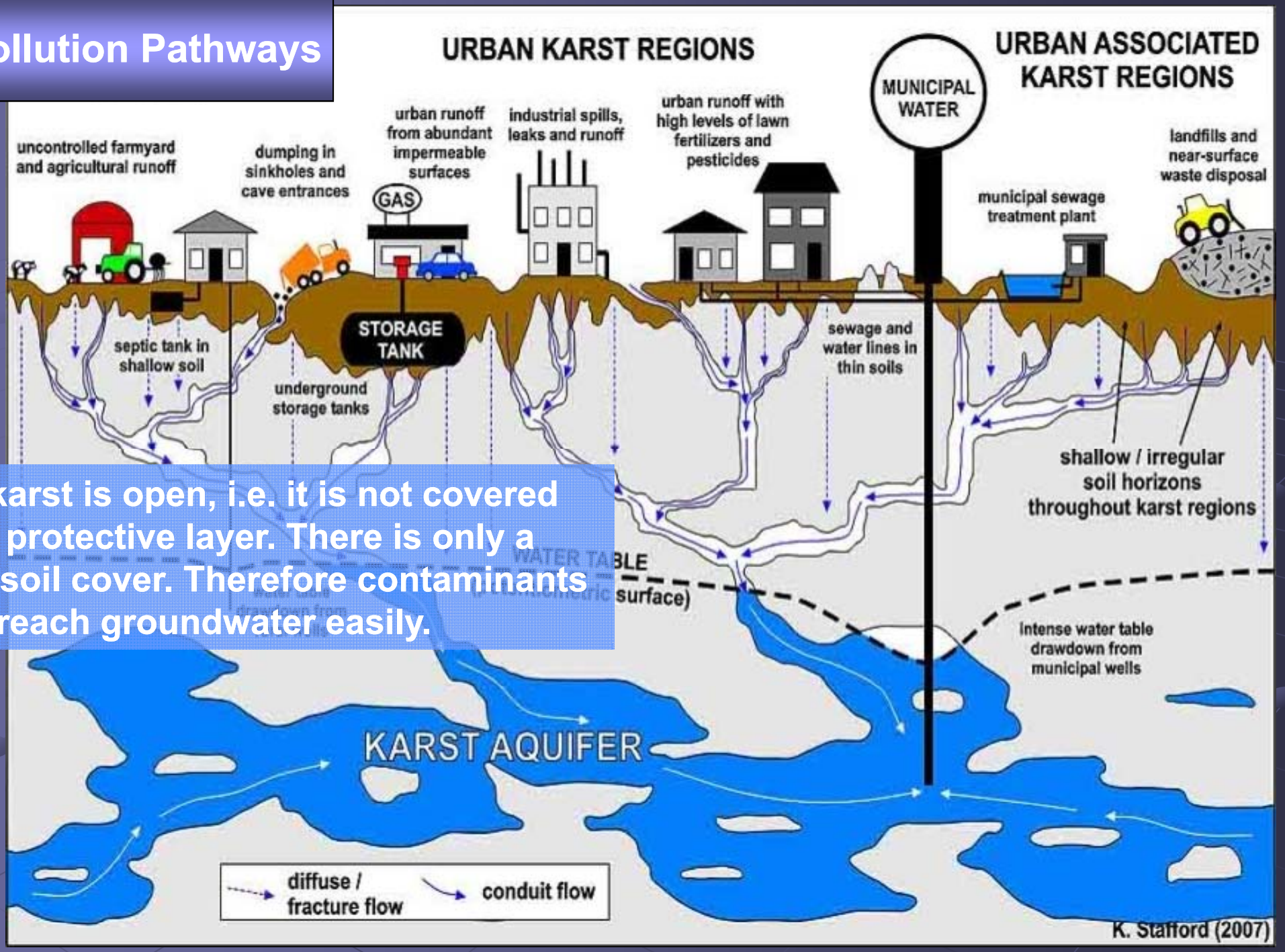
Contamination Risks from Wastewater



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 save costs

Pollution Pathways

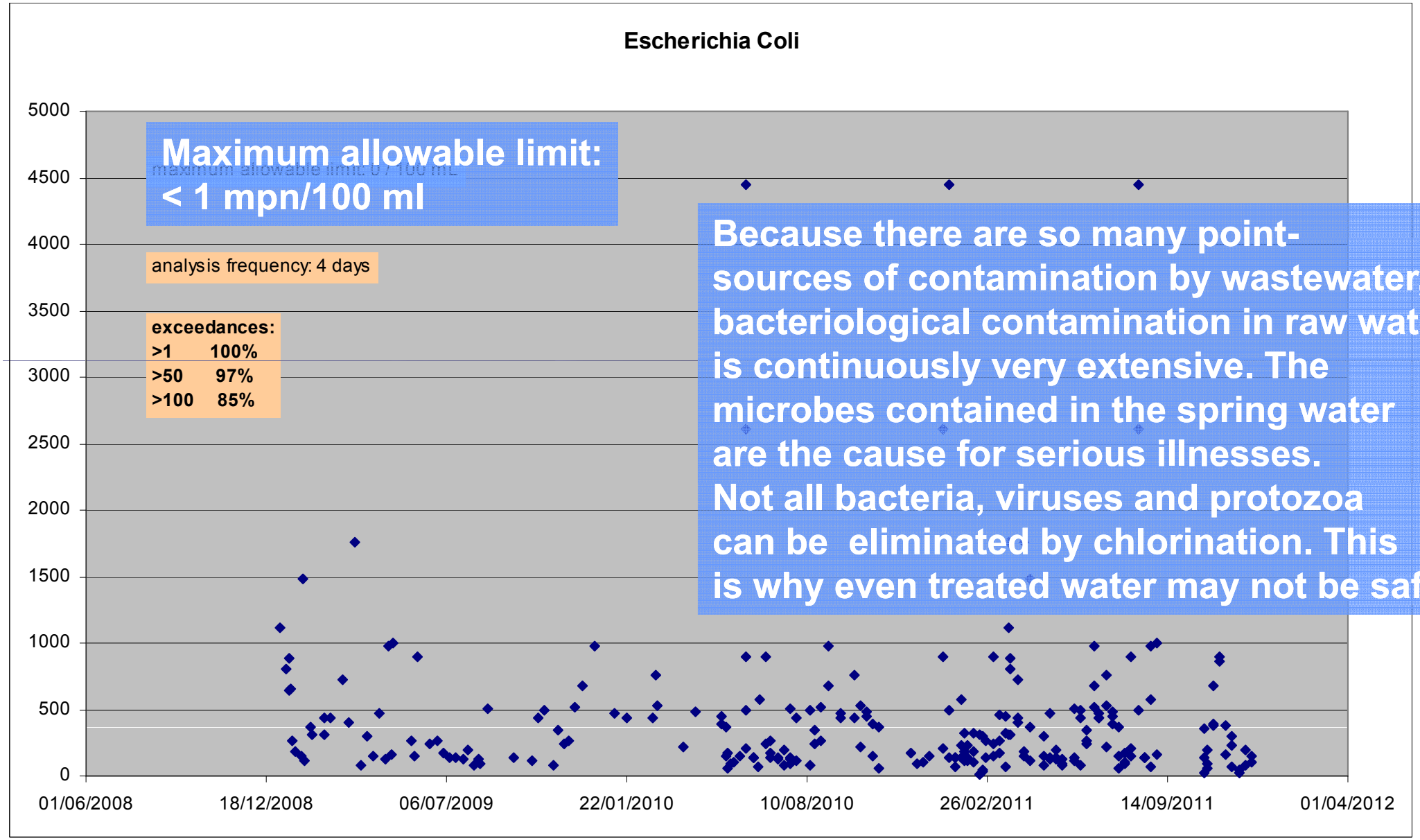


the karst is open, i.e. it is not covered by a protective layer. There is only a thin soil cover. Therefore contaminants can reach groundwater easily.

Health Effects

Dbayeh raw water (treatment plant)

High and continuous microbiological contamination



Health Effects

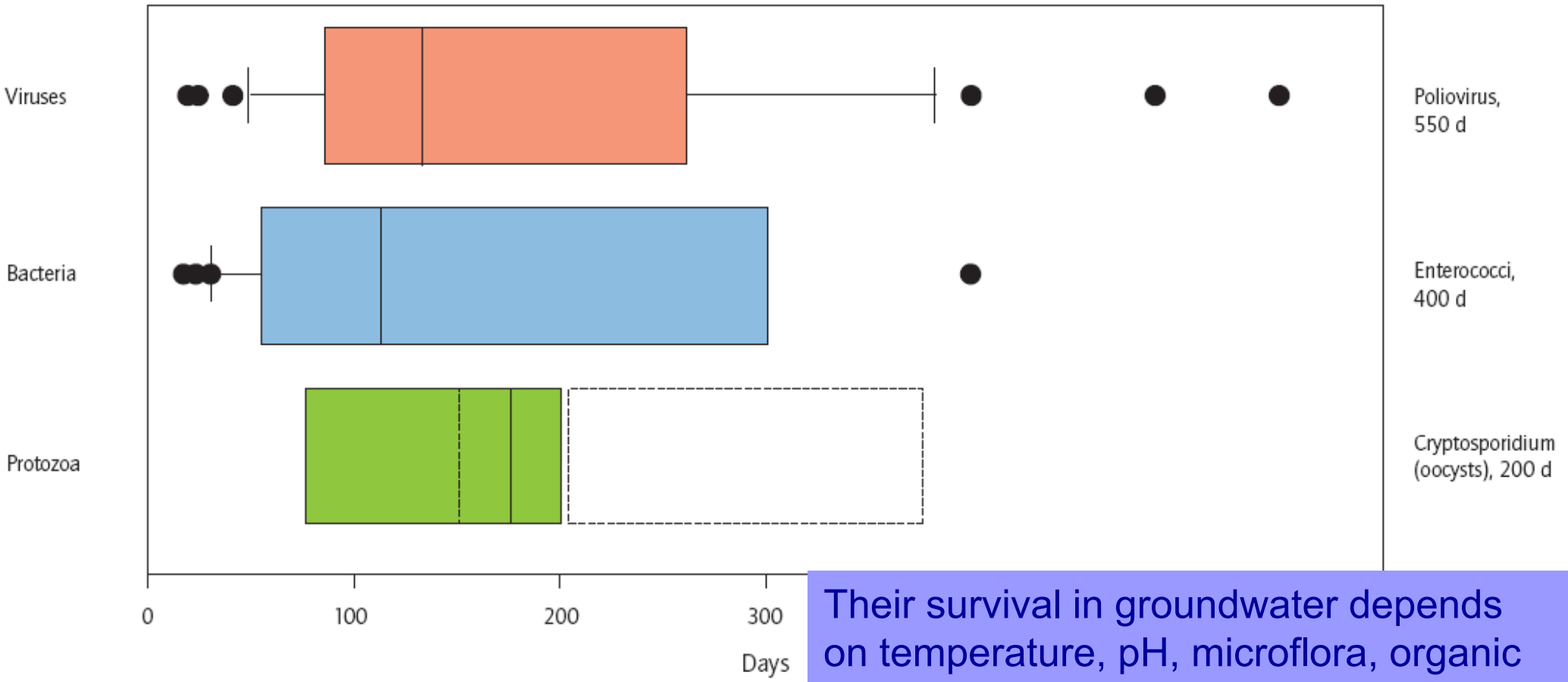
PATHOGEN	MAJOR DISEASES	SOURCES
Bacteria		
Escherichia coli	Gastroenteritis, Haemolytic Uraemic Syndrome (enterotoxic *E. coli*)	Human faeces
Salmonella spp.	Enterocolitis, endocarditis, meningitis, pericarditis, reactive arthritis, pneumonia	Human and animal faeces
Shigella spp.	Gastroenteritis, dysentery, 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



Krauss & Griebler (2011)

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.

Specific Problems concerning Wastewater Planning

Jeita Catchment

- Topography (WW must be pumped up at several locations; extremely high gradients)
- Electricity not available 24/7 (max 40%)
- 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, ... i.e. all new foreign donor funded investment in the wastewater sector will not use any of the preexisting collectors !
- Geology: geohazards and impacts on water must be considered:

  karst, tectonics, landslides, rock falls, earthquakes

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. what principally be done to cover a certain area with adequate collection and treatment facilities. The WMP proposes several individual wastewater schemes and gives a rough estimation of costs.
- An initial site investigation for the proposed wastewater treatment plants (WWTP) has to be conducted to determine their suitability (draft environmental impact assessment (EIA), especially on water resources). Based on this draft EIA the update 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 EIA for the scheme is prepared by the consultant and discussed with all stakeholders (public participation)
- The wastewater facilities are built and transferred to the agency operating it (WEBML)

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)

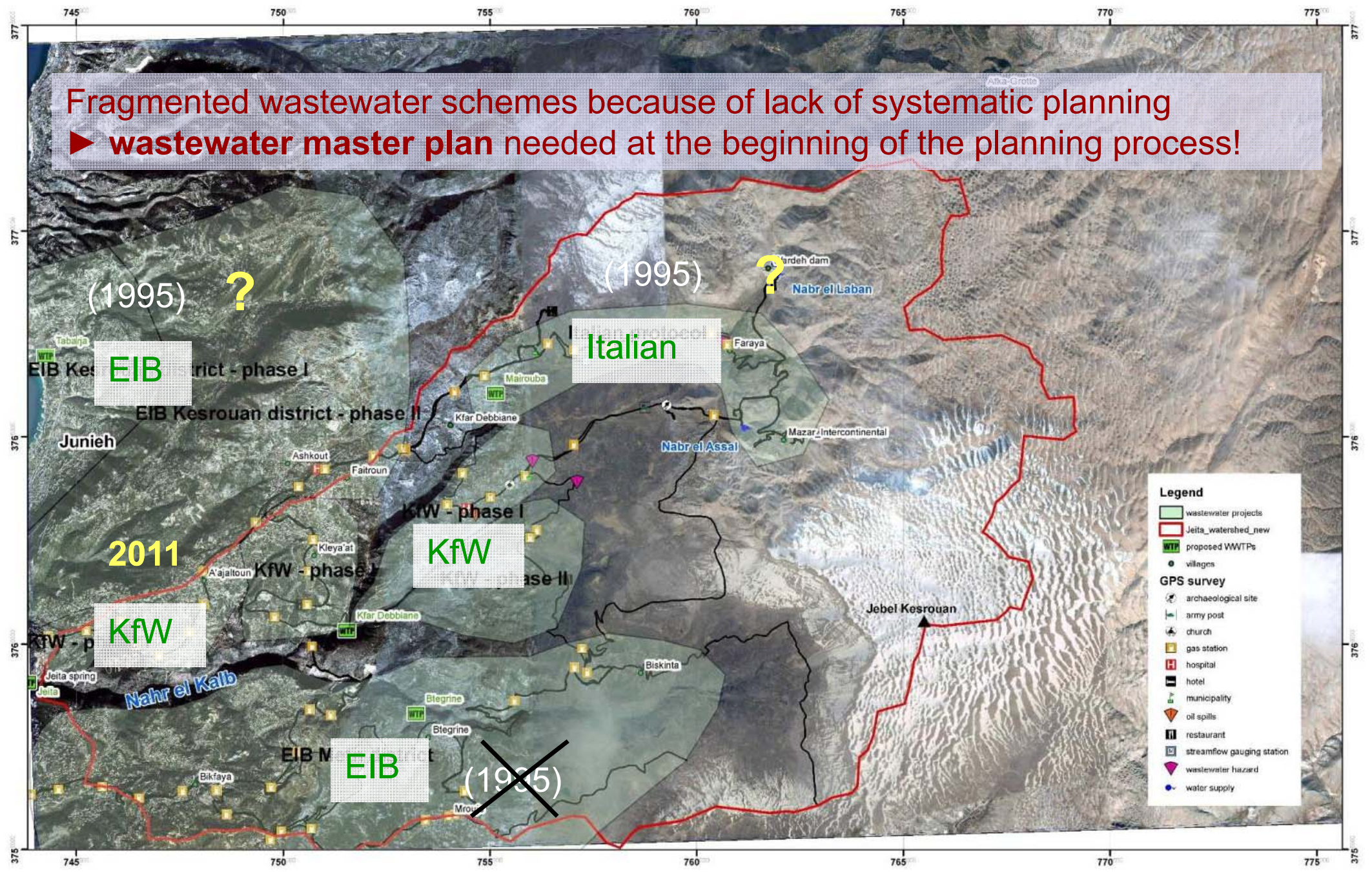
Sanitation Systems

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

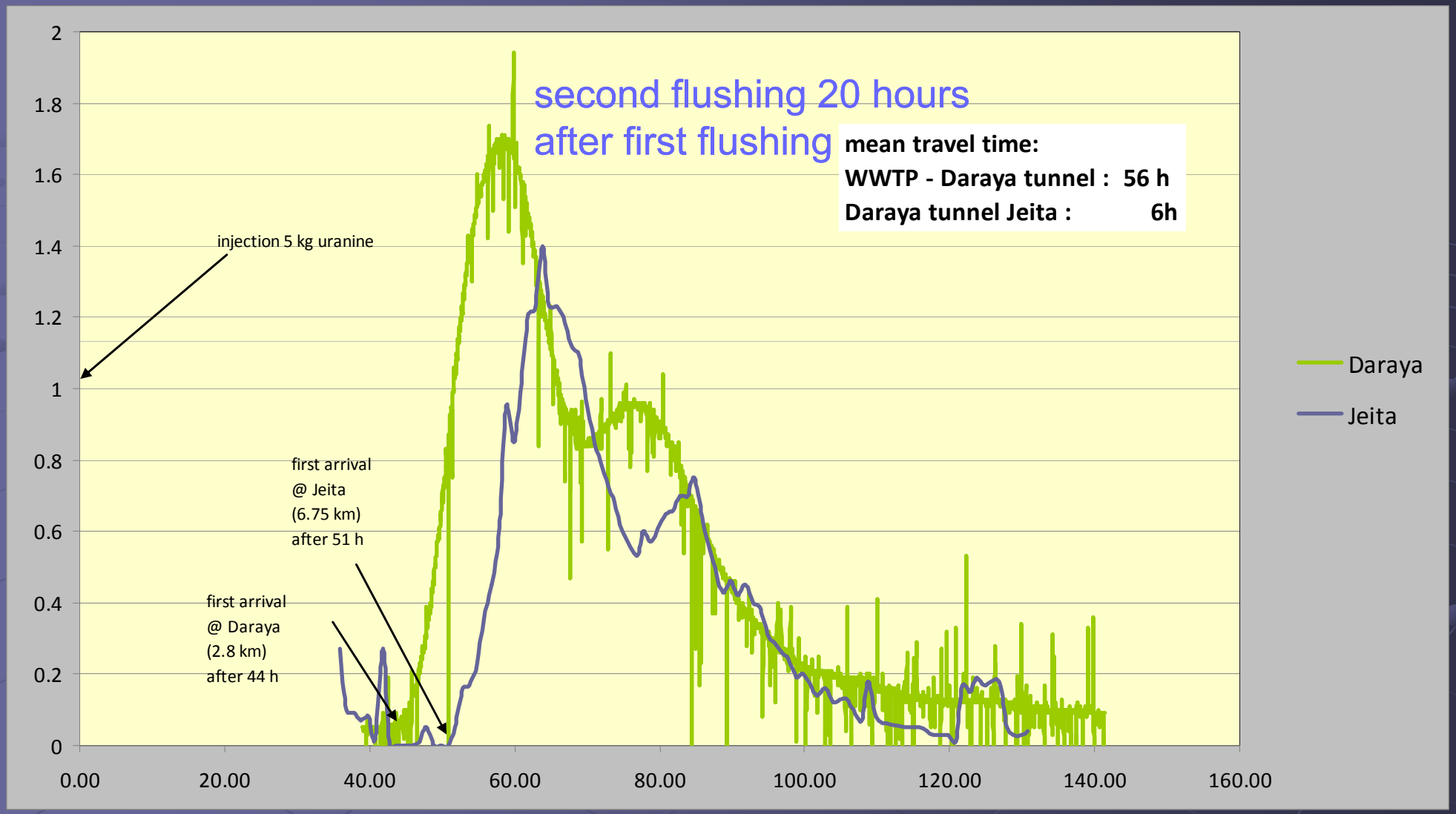
Wastewater Projects North of Beirut




Investigation of Proposed WWTP
WWTP site selection
Vertical flow
through unsaturated zone
~ 360 m
injection sites
land surface
560 m
monitoring sites
WWTP_Kfar-Debbiane (uranine)
5 kg
initially
proposed
WWTP
3.95 km
Daraya-tunnel
2.8 km
2.25 km
~200 m asl
Jeita-Grotto
Jeita (manual)
140 m asl
Abou_Mizane (amidorhodamine G)
5 kg
70 m asl
flow in saturated zone
6.75 km
land surface
540 m
Image © 2010 GeoEye
Image © 2010 DigitalGlobe
©2009 Google
2726 m

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

Planning of Wastewater Facilities

Site Selection

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						
WW indus						
planr /indu plan)						
popu						
planr						
mate appr						
existi mate						
chara inclu						
topo can b have to be wher follov						
land ?)						

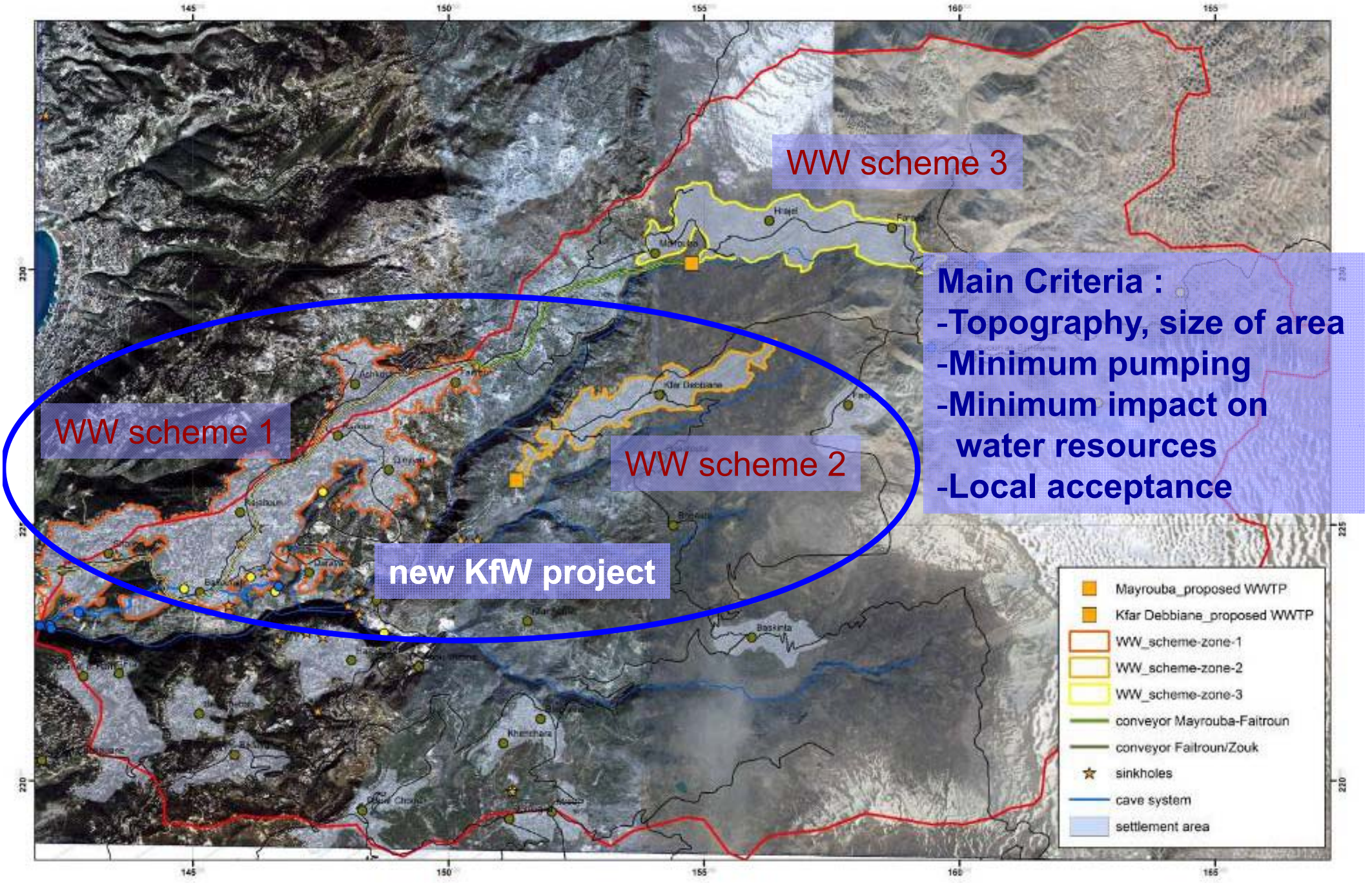
Criteria	Collector Lines	WWTP Location	WWTP Design	discharge Location	Remarks	Tasks / source
Geological and Hydrogeological Criteria						
geology (rock type, underground as a barrier, dip direction/angle)	xx	xx			if natural geological barrier is existing, it should be used	geological mapping
stability						
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

Proposed Wastewater Schemes

Centralized sanitation systems only



KfW Jeita Project

- BGR prepares EIA for all components of KfW
- wastewater scheme related to impact on water
- resources and impact from geohazards

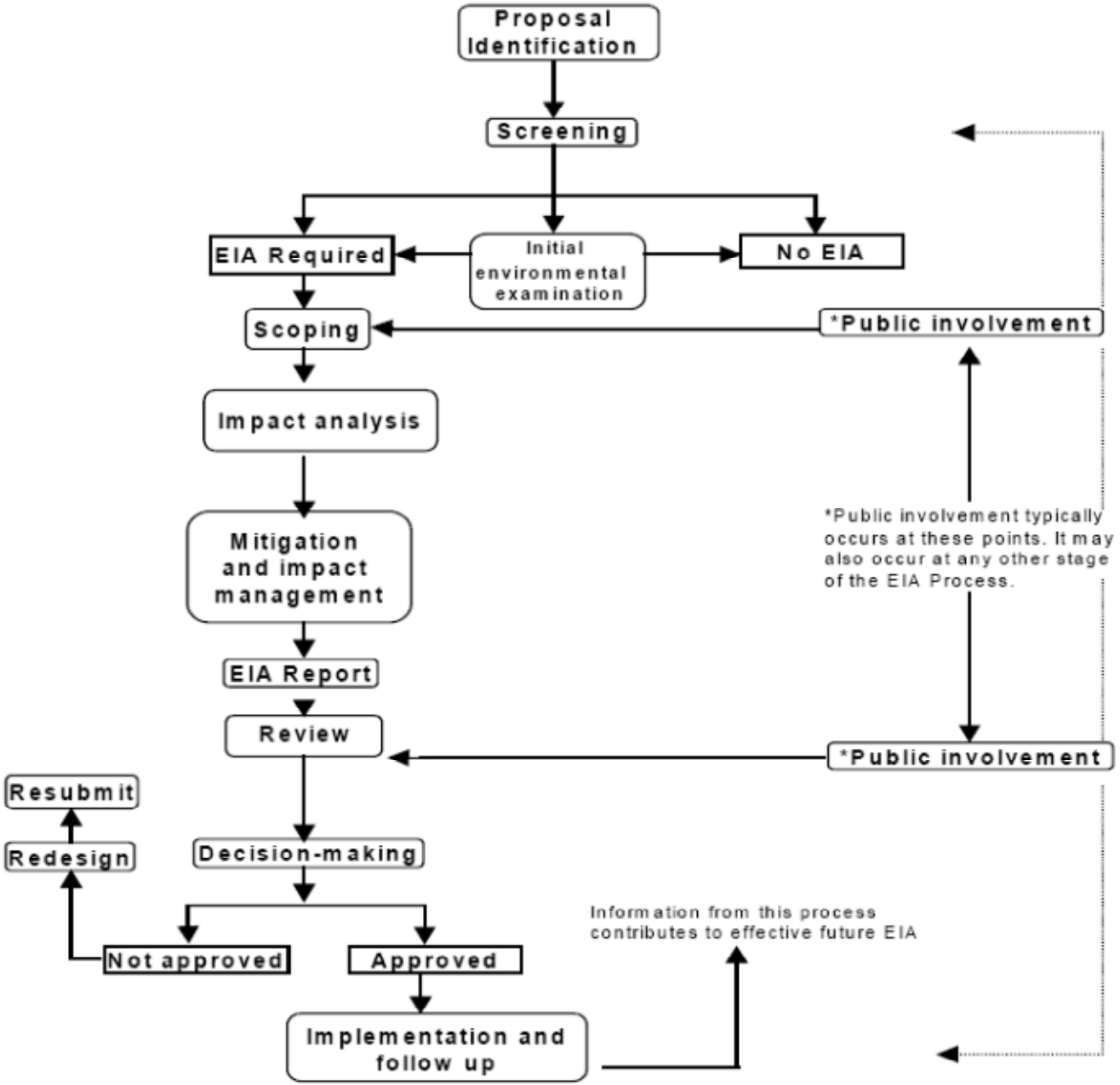
Serviced area
- (Zouk Mosbeh)
- Jeita
- (Sheile)
- Ballouneh
- Aajaltoun
- Daraya
- Kleyyat
- Kfar Debbiane

Phase I : 42,000 PE
Phase II: 85,000 PE

Guideline for Environmental Impact Assessment for Wastewater Facilities in Lebanon

EIA Procedure

Generalised EIA Process Flowchart



Stakeholder Participation

Possible forms of public participation

1	**Public meetings**	• open with no restriction as to who may attend
2	**Advisory panels**	• group of individuals chosen to represent stakeholders • meet periodically to assess work done/results obtained • advise on future works
3	**Public information centres**	• facility in an accessible location • contains information on the project • members of the public can visit, obtain information and express concerns
4	**Interviews**	• open-ended interviews with selected community representatives
5	**Questionnairs**	• a written, structured series of questions issued to local people assemble concerns/views/ideas
6	**Participatory Appraisal techniques**	• a systematic approach to appraisal based on group inquiry and analysis with multiple and varied inputs

BGR

Construction

Thank you for your kind attention

www.bgr.bund.de/jeita

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