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Coordination

Universität Karlsruhe (TH)
Forschungsuniversität • gegründet 1825

BGR Symposium – Coupling Sustainable Sanitation & Groundwater Protection

Integrated assessment of sanitation aspects and groundwater management at the Lower Jordan River

Dr. Leif Wolf, University of Karlsruhe, Germany

Dr. Bassim Abassi, Al-Balqua University, Jordan

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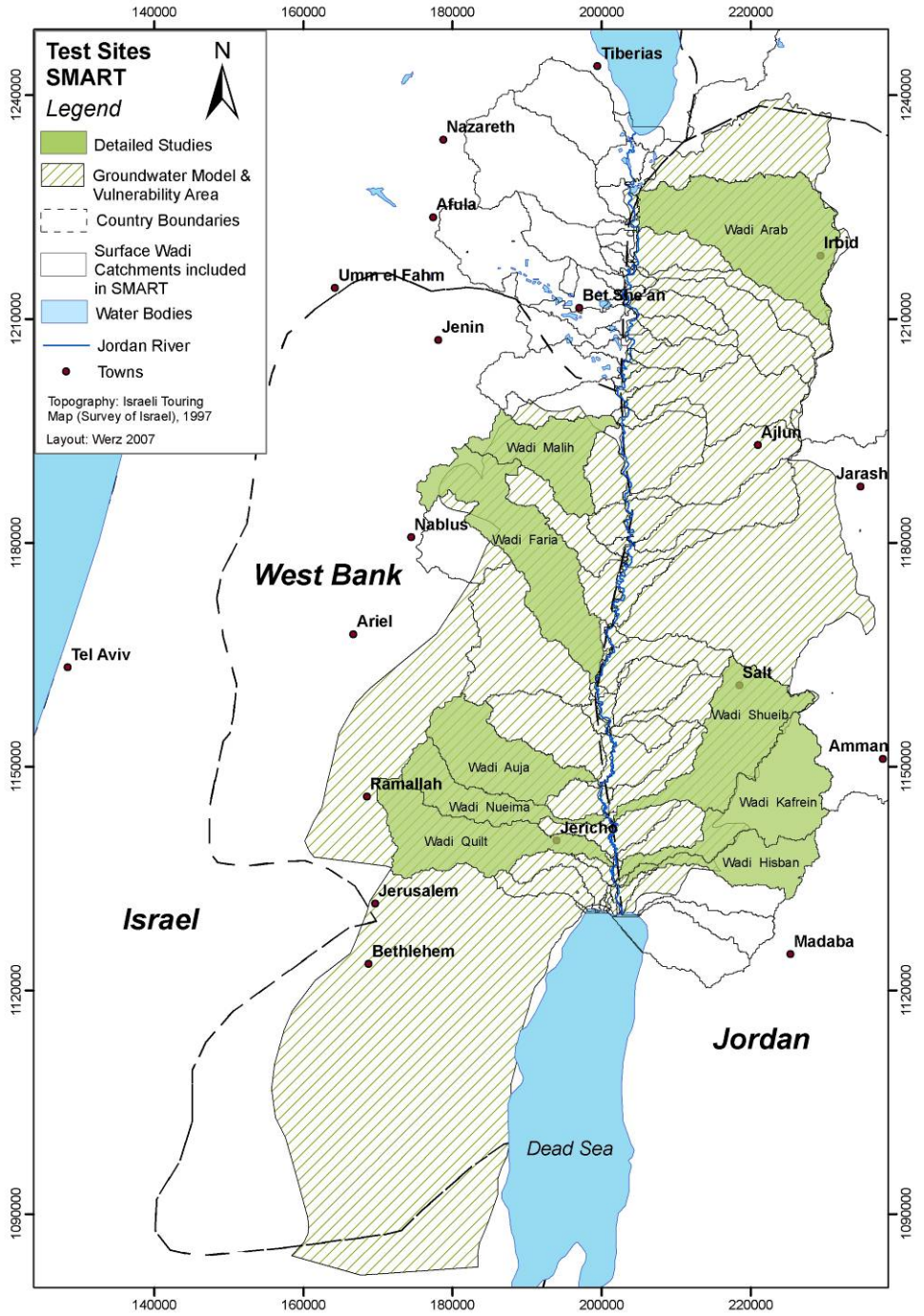
"Sustainable Management of Available Water Resources with Innovative Technologies in the Lower Jordan Valley"

- Implementation of IWRM requires multidisciplinary information.
- Implementation of IWRM must link land and water uses across the whole of a watershed catchment area or groundwater aquifer.
- IWRM must be extremely sensitive to national, political, cultural, and social conditions.
- Project ongoing, but example for intersectoral integration



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SMART Partners – A 21 partner network for peace & sustainable development

Germany University of Karlsruhe (Coordinator) University of Göttingen UFZ Environmental Research Cent. BDZ Centre for Decentralized Sewage Treatment ATB Environmental Technic University of Tuebingen Hans Huber AG, ÖKOTEK-Belzig, GmbH	**Israel** Water Commissioner, Tel Aviv Mekorot Co Ltd., Tel Aviv Tel Aviv University Ben Gurion University Environmental & Water Resources Engineering, Haifa
Jordan Ministry of Water and Irrigation Jordan University, Amman Al Balqa Applied University German-Jordan University ECO Consult	**Palestine** Palestine Water Authority Palestinian Hydrological Group Al Quds University

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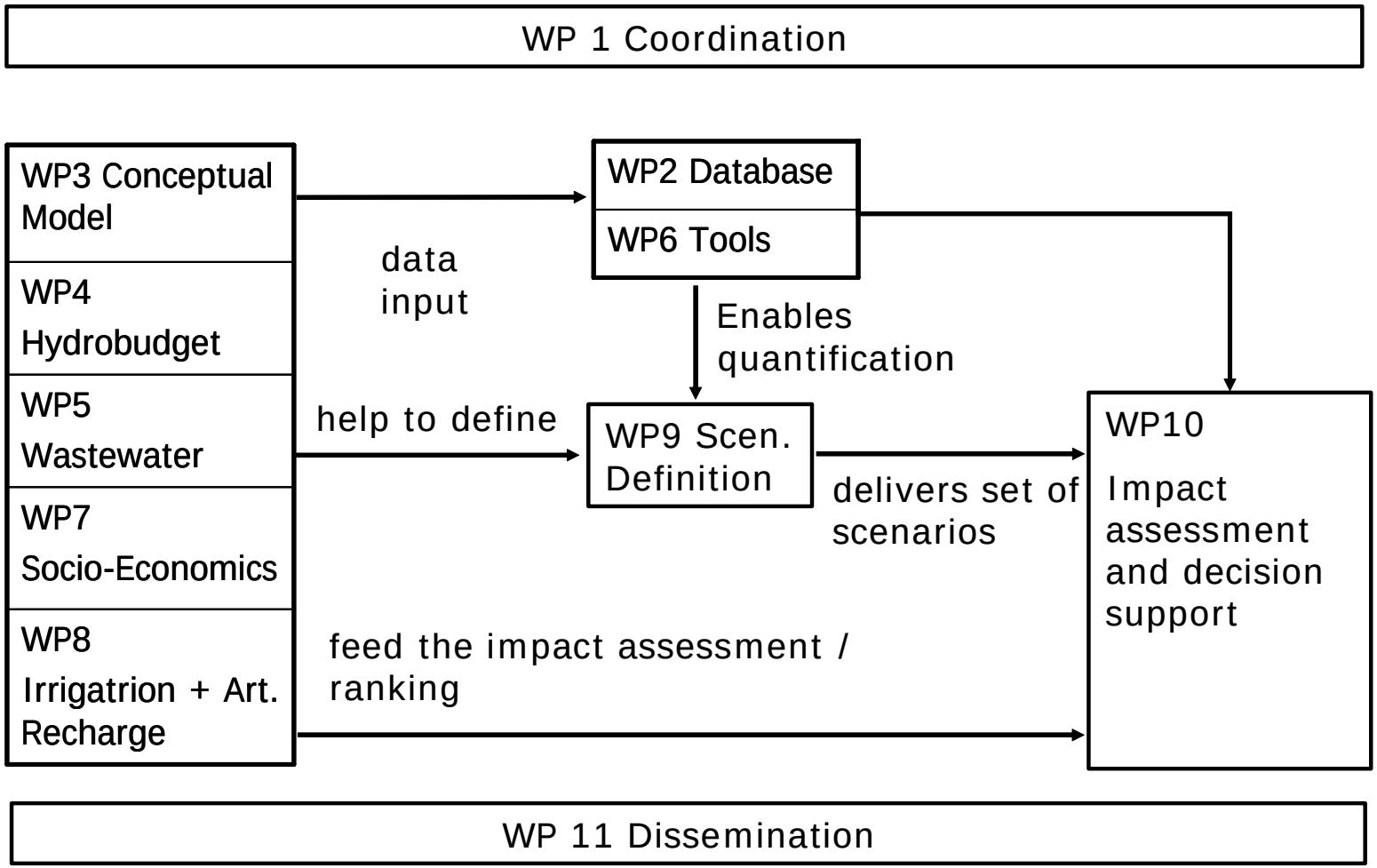
SMART Workpackage Structure



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The problem: Wastewater disposal systems in rural and many suburban areas

- Most cesspits are one or two chamber systems, constructed with brick or concrete
- Most are built to seep/ infiltrate into the soil or through fractured rocks (karstic rock)
- Very large annual seepage volume to groundwater
- Significant groundwater pollution and contaminated springs

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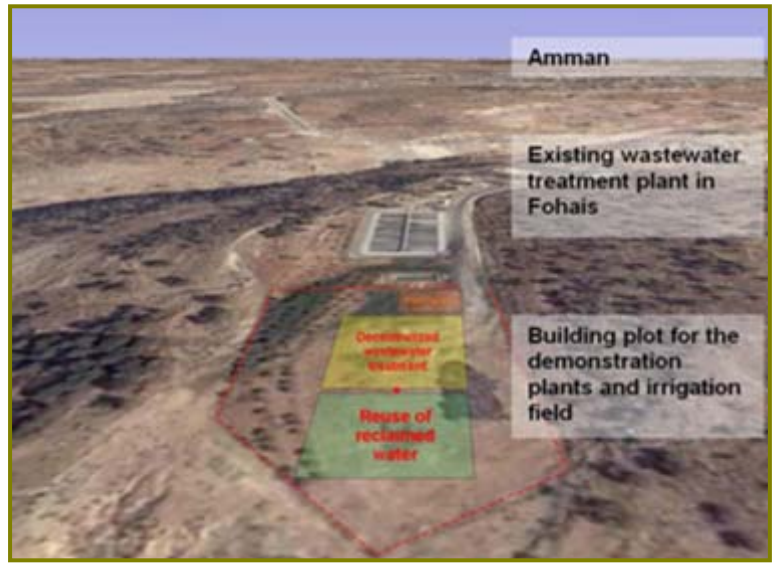
WP5: Demonstration and research site Wadi Fuheis

Technologies

- Sequencing Batch Reactor, SBR
- SBR with UV
- Planted/unplanted vertical flow soil filter (constructed wetland)
- Anaerobic reactor
- Sludge reed beds

Reuse options

- Home gardening
- Agriculture
- Landscaping
- High value crops
- Nursery



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Interviews with stakeholders and key professionals in three villages

Cost related questions:

- Disposal tanker frequency (0.7-7.0 times/per year)
- Cost sludge pumping (39-53 JD/tanker load)
- Construction cesspit (470-820 JD/cesspit)
- Household water consumption (3.2 -4.3 m^3/week per household)
- Monthly income of household (38% <200 JD/month)

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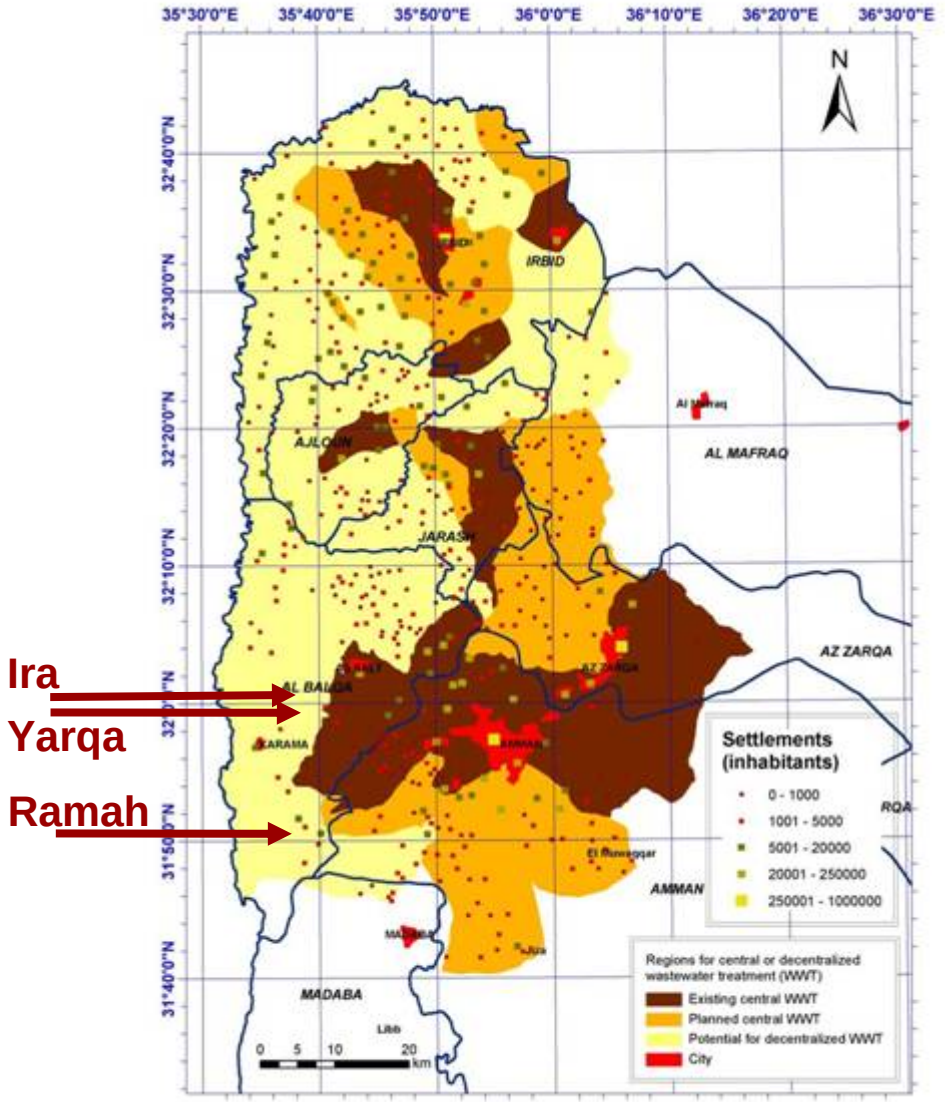
Sites Selection of potential villages (D 504)

In agreement with the Water Authority of Jordan, the villages of Ira, Yarqa and Ramah were proposd for the implementation of decentralized waste water management systems



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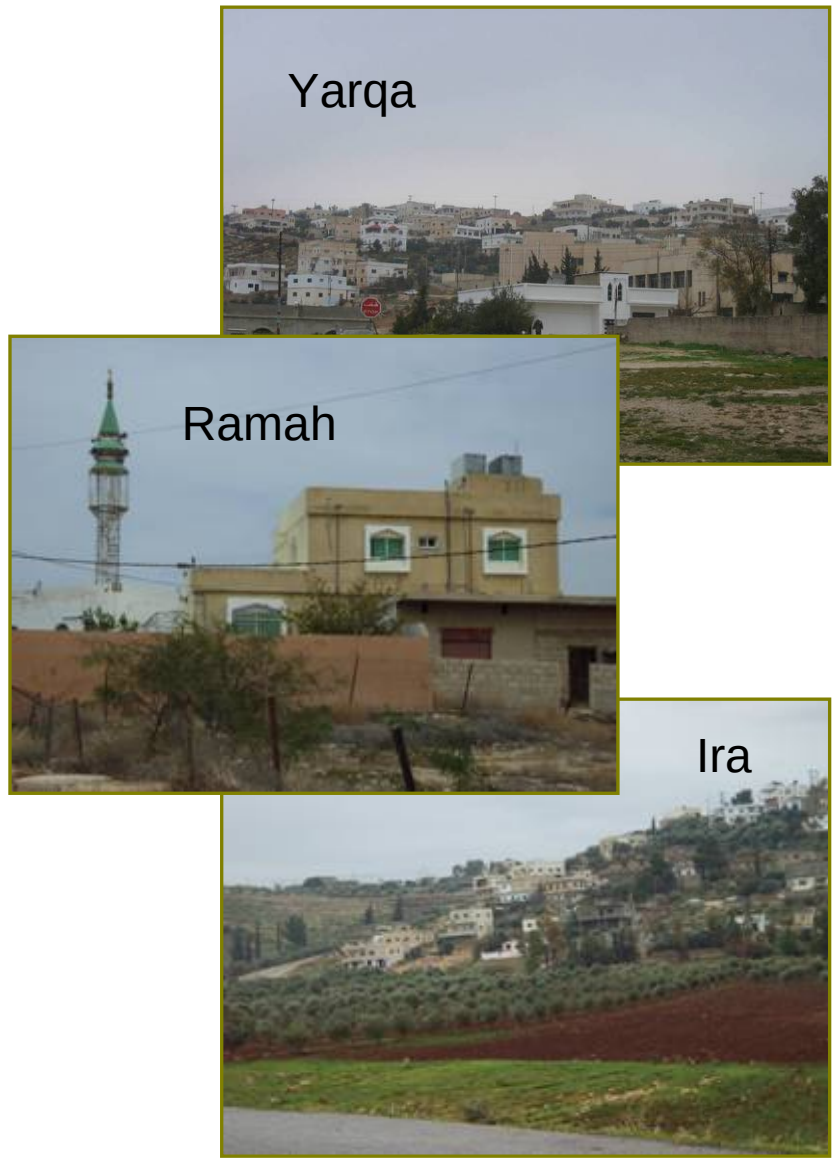
Operation and maintenance model (D 505)

The main objective is to develop feasible operation and financing models

- Status Quo I: Existing operating and financing models
- Status Quo II: Definition of scenarios and pre-selection of operating & financing models, interviews with stakeholders and decision makers
- Development of appropriate operating and financing models for the proposed sites (D504)



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Overall potential for decentralized wastewater treatment technologies

Tourism sector

- **Total treatment capacity to be installed** **0** pe
- **Annual need of new treatment capacity** **900** pe

Sub-Urban sector

- **Total treatment capacity to be installed** **912,474** pe
- **Annual need of new treatment capacity** **113.335** pe

Rural sector

- **Total treatment capacity to be installed** **523.549** pe
- **Annual need of new treatment capacity** **15.436** pe

Concentration on rural and suburban sector

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Prestudies for the implementation of decentralized wastewater treatment plants

- The main objective is to propose and describe sites in Jordan, feasible for future implementation of decentralized system solutions for wastewater management

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Perspective

Current situation

- The Jordanian government integrated decentralized wastewater treatment and reuse technologies in the National Water Master Plan
- The future plan of the Jordanian government is the privatization of the complete water sector within 5 years
- Considering this policy the government is open for the implementation of decentralized system solutions. (Private sector under financial participation of the Jordanian government and funding organizations)

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Perspective

Coordinated future activities of German players

Concerted action SMART II-module

Jordan government, Universities, BGR, GTZ, companies

- Implementation of Decentralized System Solutions
  - Where and why decentralized technologies?
- Specification of master plan for Decentralized Solutions
  - National regulations on Decentralized Solutions

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Joint analysis of wastewater drainage and groundwater quality

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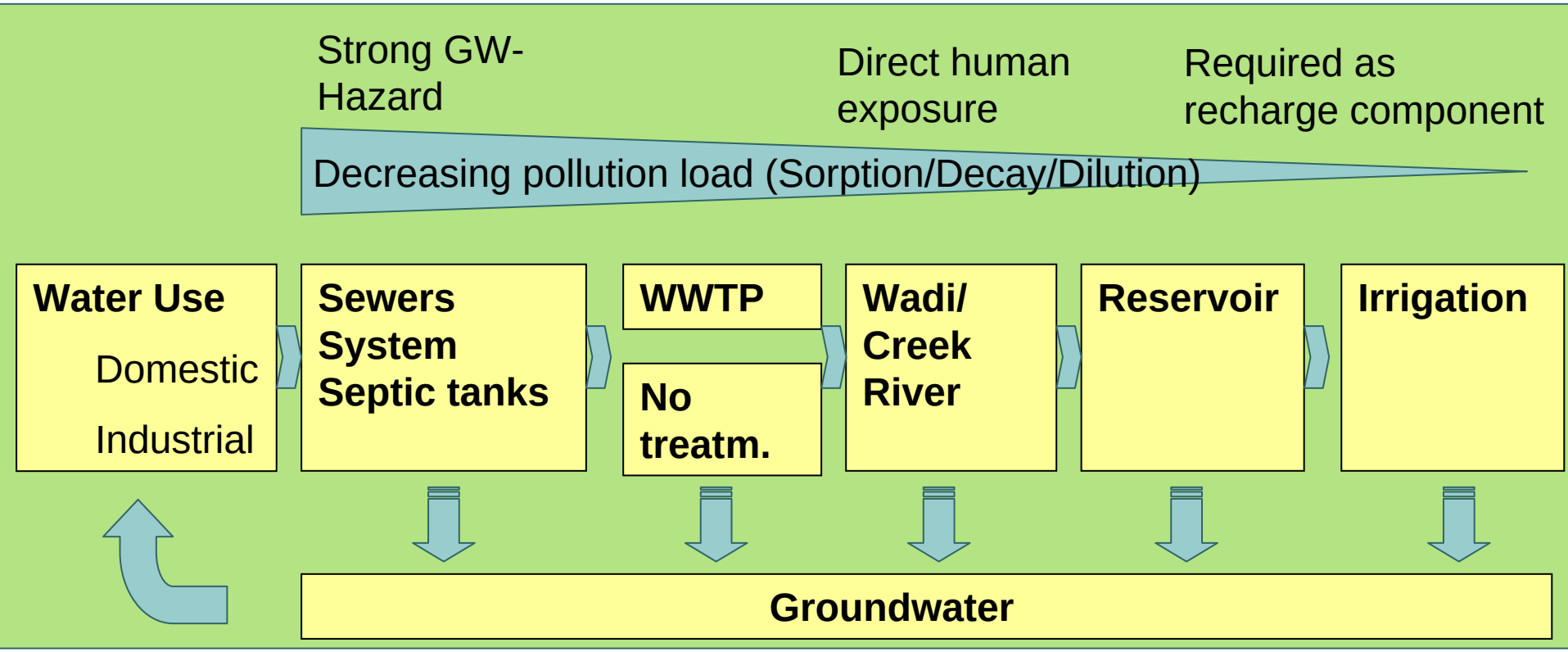
Sanitation & Groundwater protection

- Identifying critical control points to direct investments



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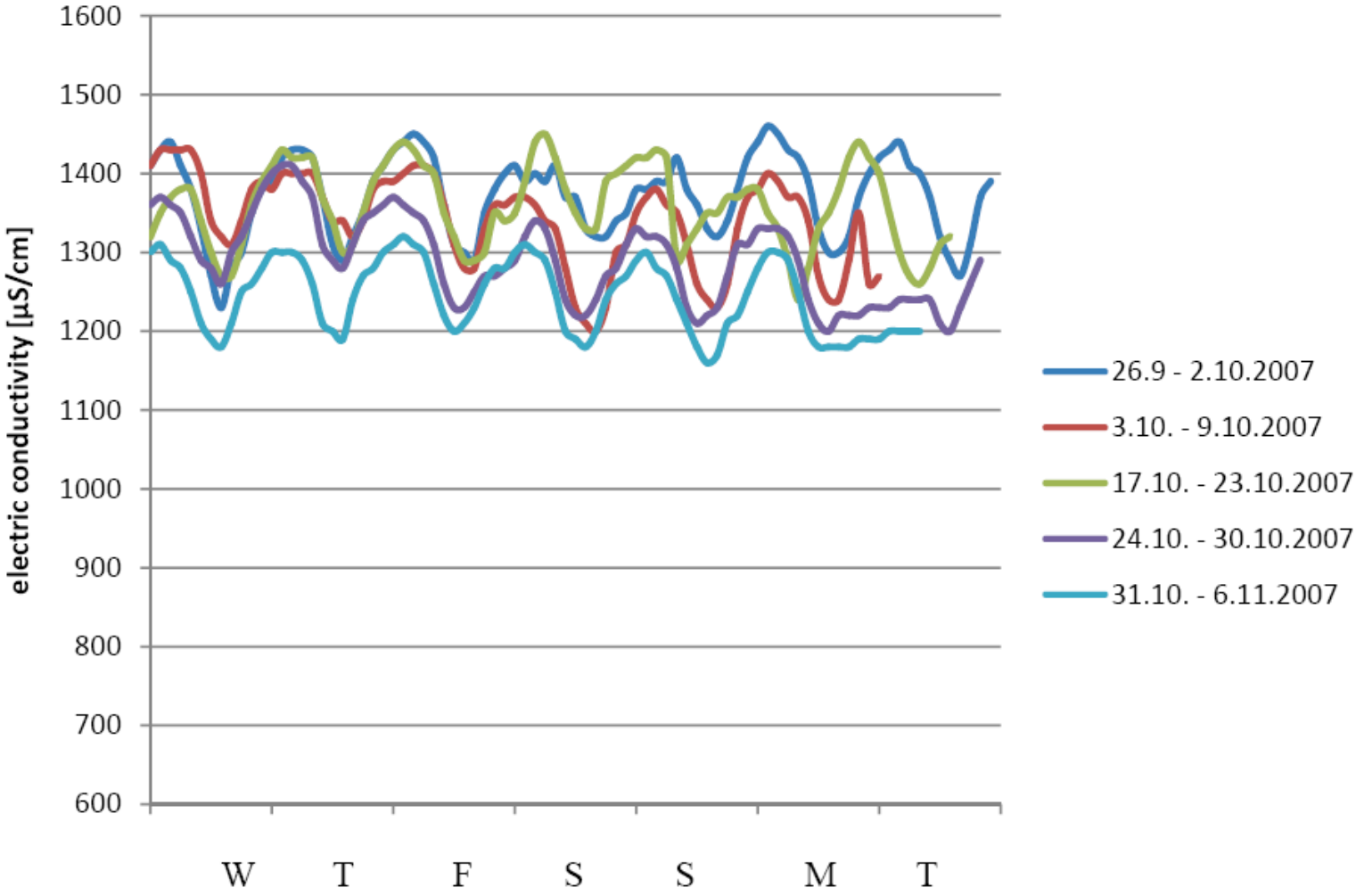
Quality variations in the baseflow reflecting wastewater influence



Mobile trace organics to show wastewater impact on groundwater (In cooperation with TZW)

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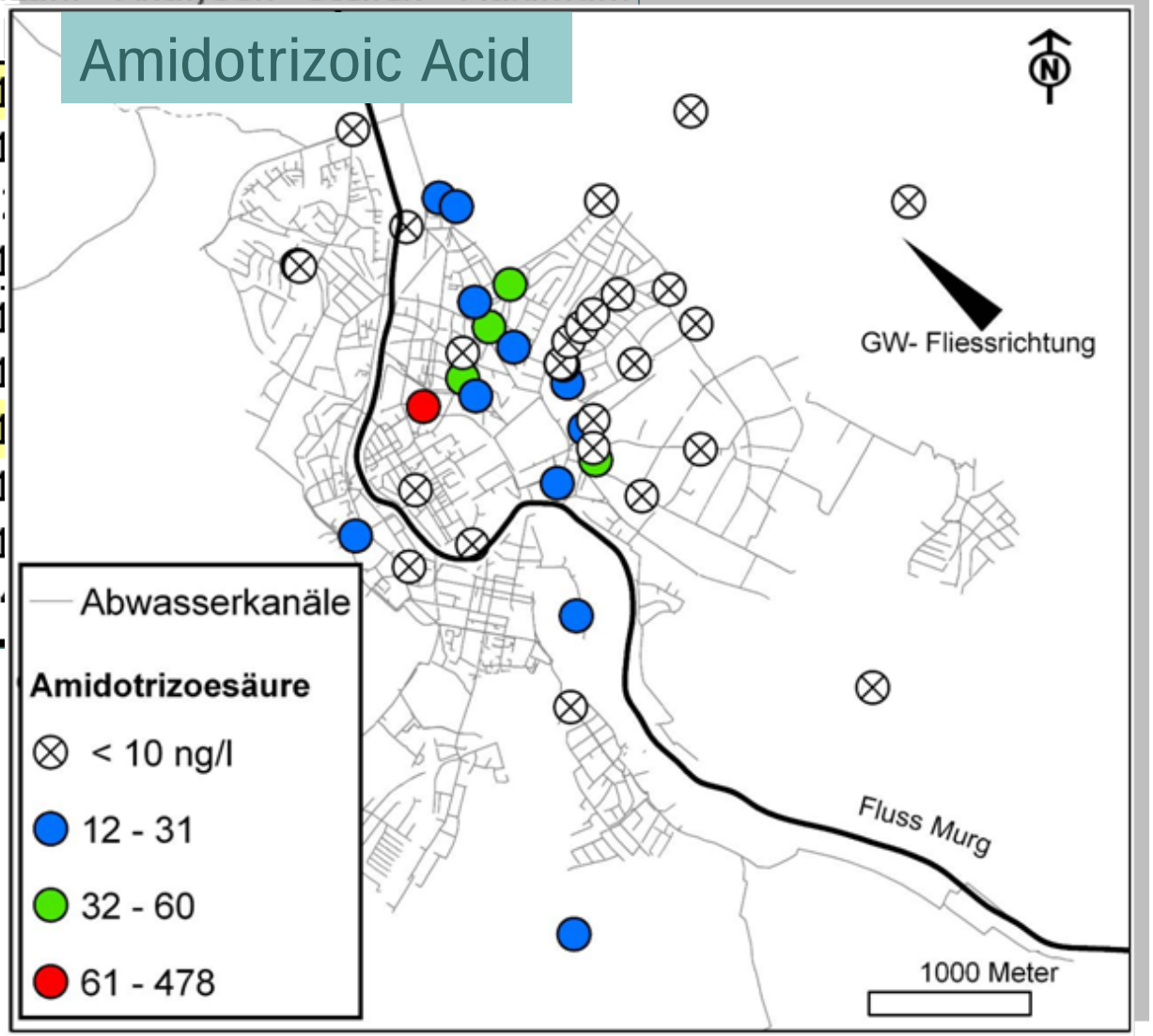
Substance	Groundwater 14 samples % positive	Surface Water 12 samples % positive	WWTP Effluent 4 samples % positive
Amidotrizoe Acid	79	50	25
Iopamidol	43	75	100
Iohexol	29	75	100
Carbamazepine	21	83	75
Gemfibrozil	14	83	75
Iomeprol	14	75	75
Iopromide	14	67	75
Bezafibrate	7	58	75
Phenacetin	0	0	0
Indomethacin	0	0	0
Diclofenac	0	42	50
Ibuprofen	0	42	50
Fenoprofen	0	0	0
Ketoprofen	0	0	0
Fenofibrate	0	0	25
Fenofibric Acid	0	0	0
Clofibric Acid	0	25	25
Pentoxifylline	0	0	0
Naproxen	0	17	25
Diazepam	0	8	50
Etofibrate	0	0	0
Iodipamide	0	0	0
Iopan Acid	0	0	0

Comparision:
Iodated X-ray contrast media in a German city

	Substanz	Proben-anzahl	Positive Analysen	Positive Mess-stellen	Maximum
ionisch	**Amidotrizoesäure**	1			
	Iothalaminsäure	1			
	Ioxalaginsäure				
	Ioxitalaminsäure	1			
nicht-ionisch	**Iopamidol**	1			
	Iopromid	1			
	Iomeprol	1			
	Iodipamid	1			
	Iohexol	1			
	Iotrolan				

Amidotrizoic Acid



- highly specific marker species
- concentrations in groundwater in the same range than sewage (in some wells)

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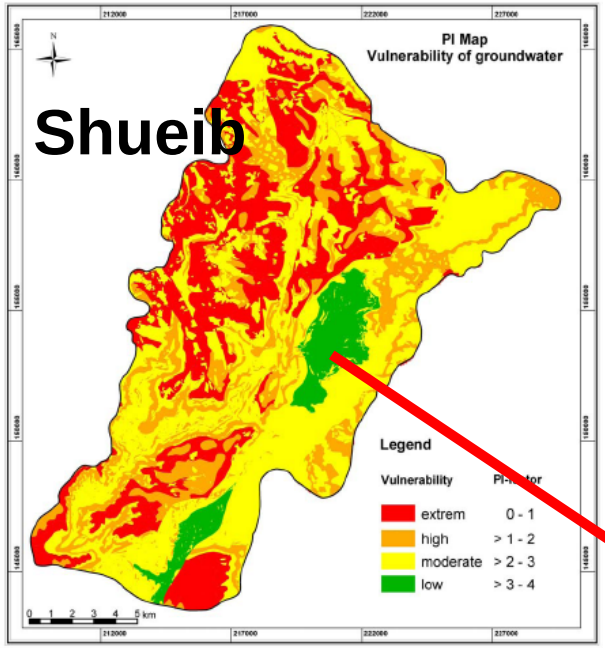
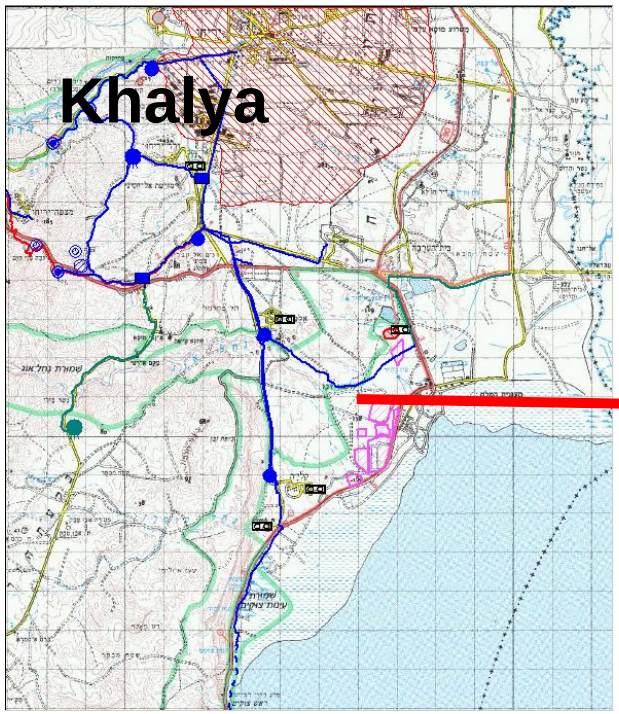
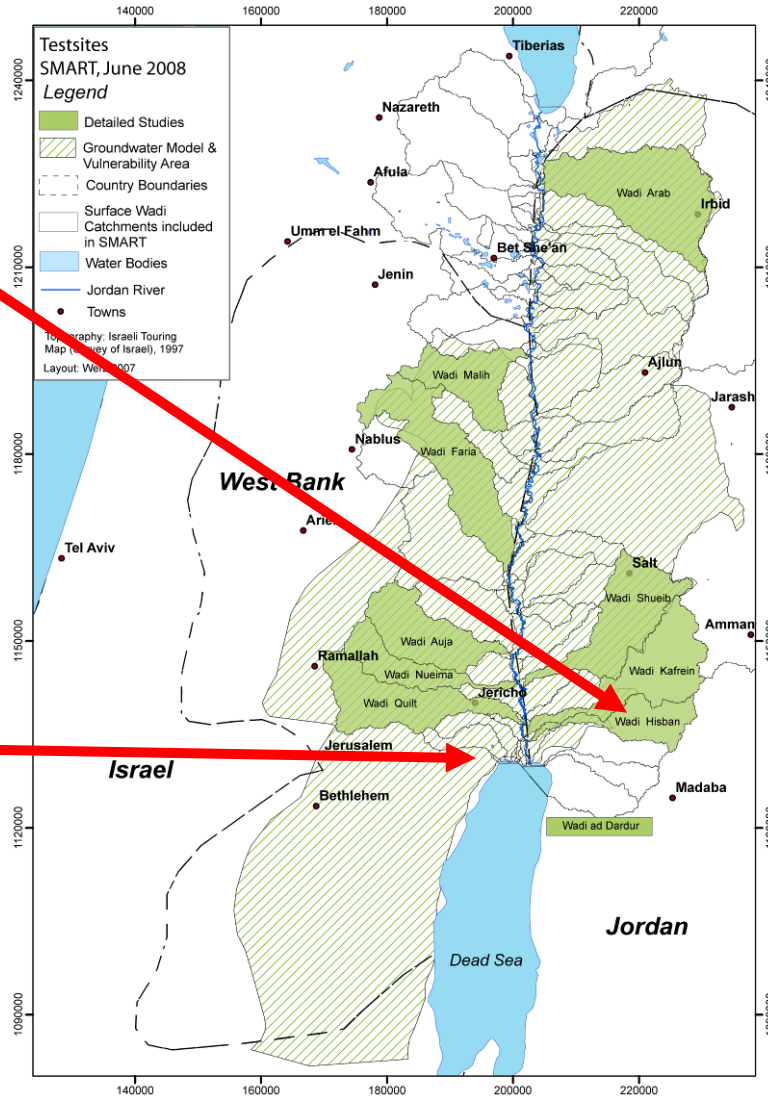
Related posters at the symposium

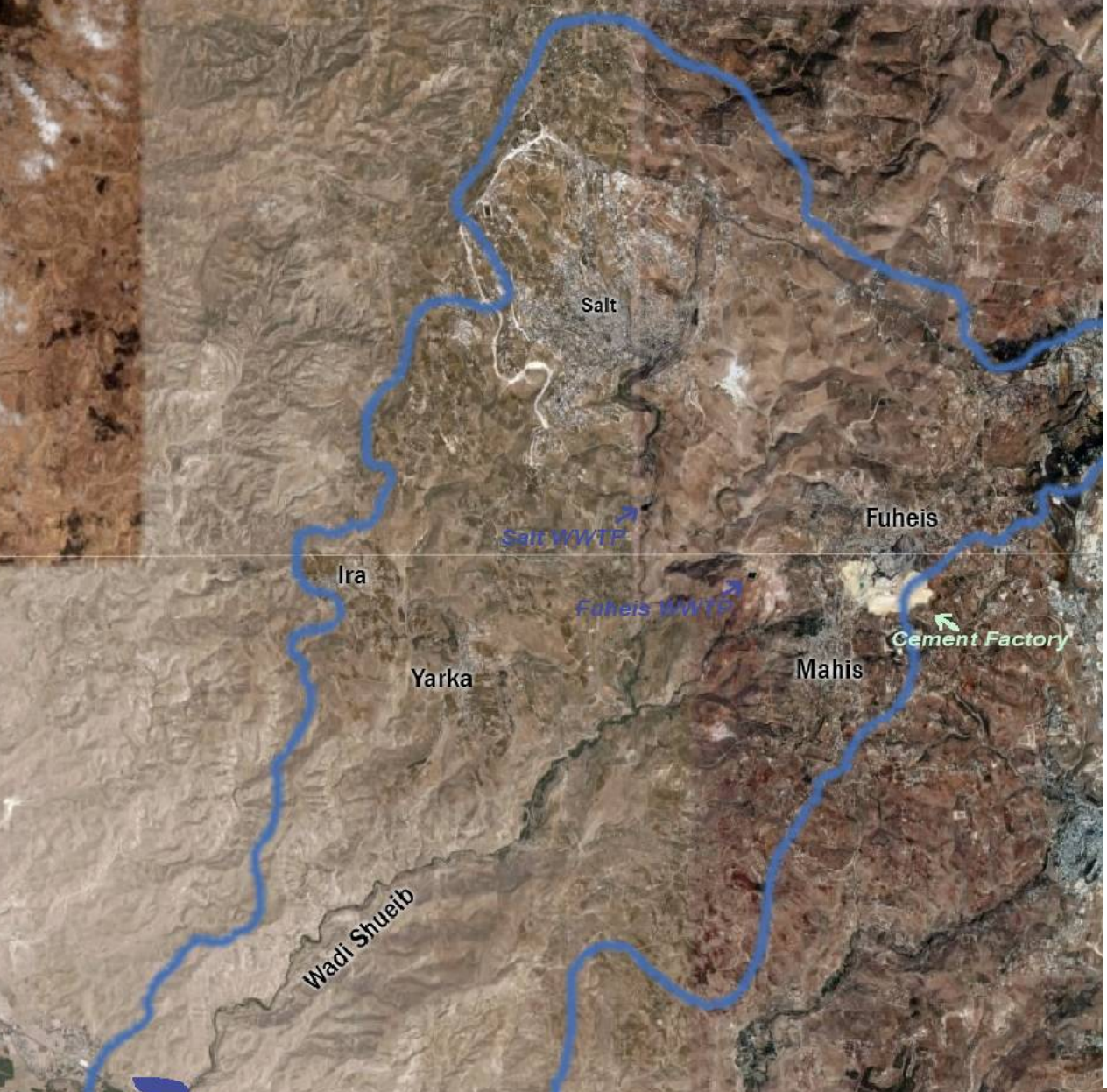
- TZW: Development of molecular tools to monitor virus elimination in waste water reuse
- TZW: Elimination of emerging pollutant in membrane bioreactors (MBR) and soil-aquifer-treatment (SAT)
- AGK: Managed aquifer recharge in Jordan: test sites, water quality monitoring and mapping of potential areas

DSS-Prototype Areas Wadi Shueib & Khalya









- Catchment size: ~200 km²
- Heigth difference: -200 bsl bis 1250 asl
- Lithology: Carbonates, Shales, Sandstones
- More than 21 Springs, partly used for drinking water supply
- 5 connected settlements
- 2 Wastewater treatment plants
- Population and uses concentrated in the upper part of the catchment
- Perennial baseflow
- Reservoir at the Wadi outlet stores winter flows for usage in downstream agriculture

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Issues in Wadi Shueib

- Pollution of spring Water indicated by high nitrate & ammonium concentrations (exceeding guidelines)
- Leaking sewerage network in the Salt area
- Several villages not connected to the sewer system
- Significant water imports necessary due to unused spring water
- High energy consumption of pumping process

Stakeholder Consultation MWI (different sectors, BGR, GTZ) on Wadi Shueib

Groundwater

Deterioration of GW-Quality (also springs)

Safe yield / declining water tables

Water protection zones

Vulnerabilty-infiltration factor…

Wastewater

Decentralized systems for the villages

Limited capacity of Salt treatment plant……

Cost-benefit analysis of decentralisied WWTP /Feasibility study

Water Supply

Reduce unaccounted for water

(impact on gw-recharge & baseflow ?)

Benefit

Economical

……

Institutional Arrangements / Laws

Overview/Revision of water rigths?

Social

Capacity building / Brain drain

Irrigation

Save production of fruit & vegetables (acc. to env. Ass.)

Adaptation to availability…& water rigths…

Vulnerability Maps

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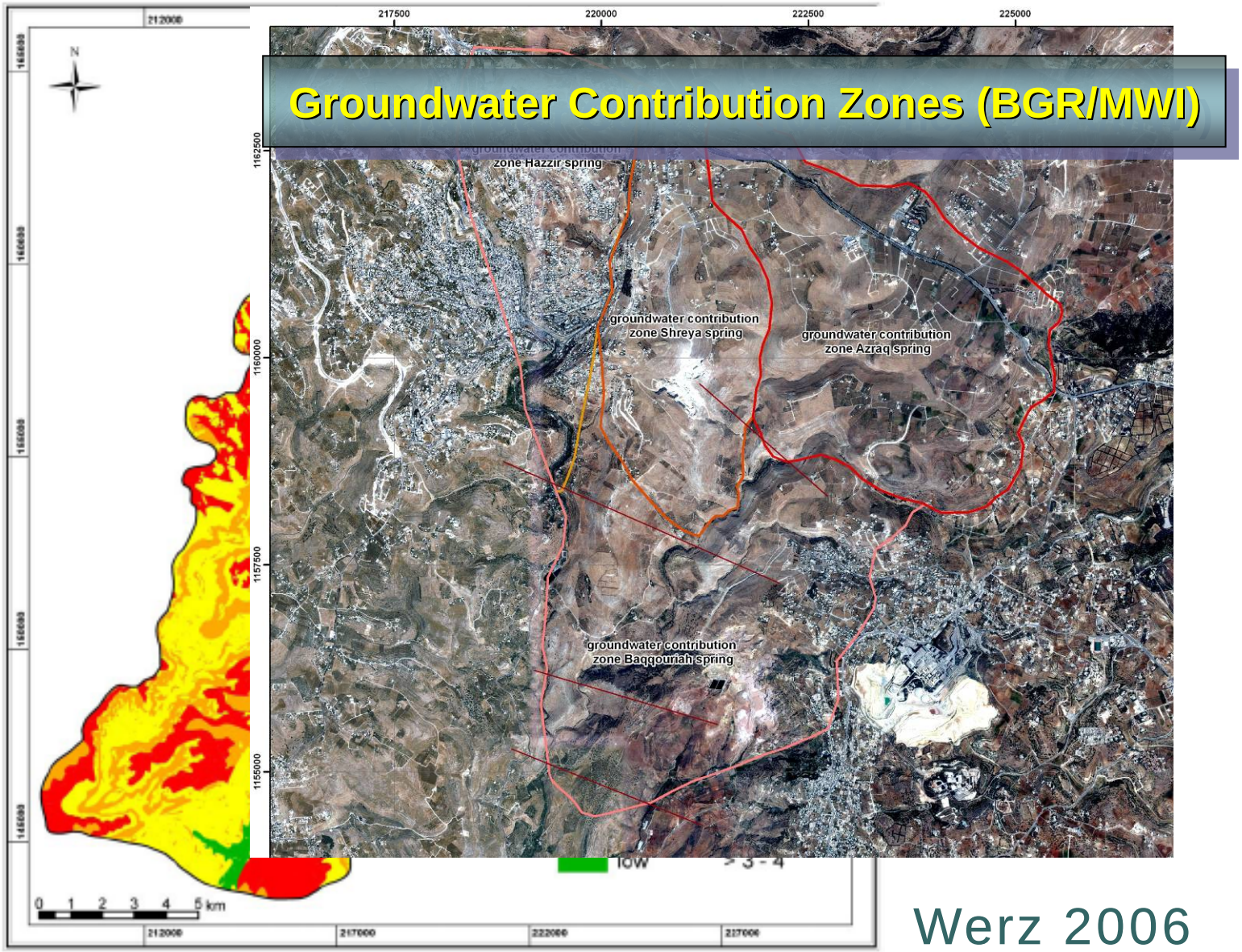

Werz 2006

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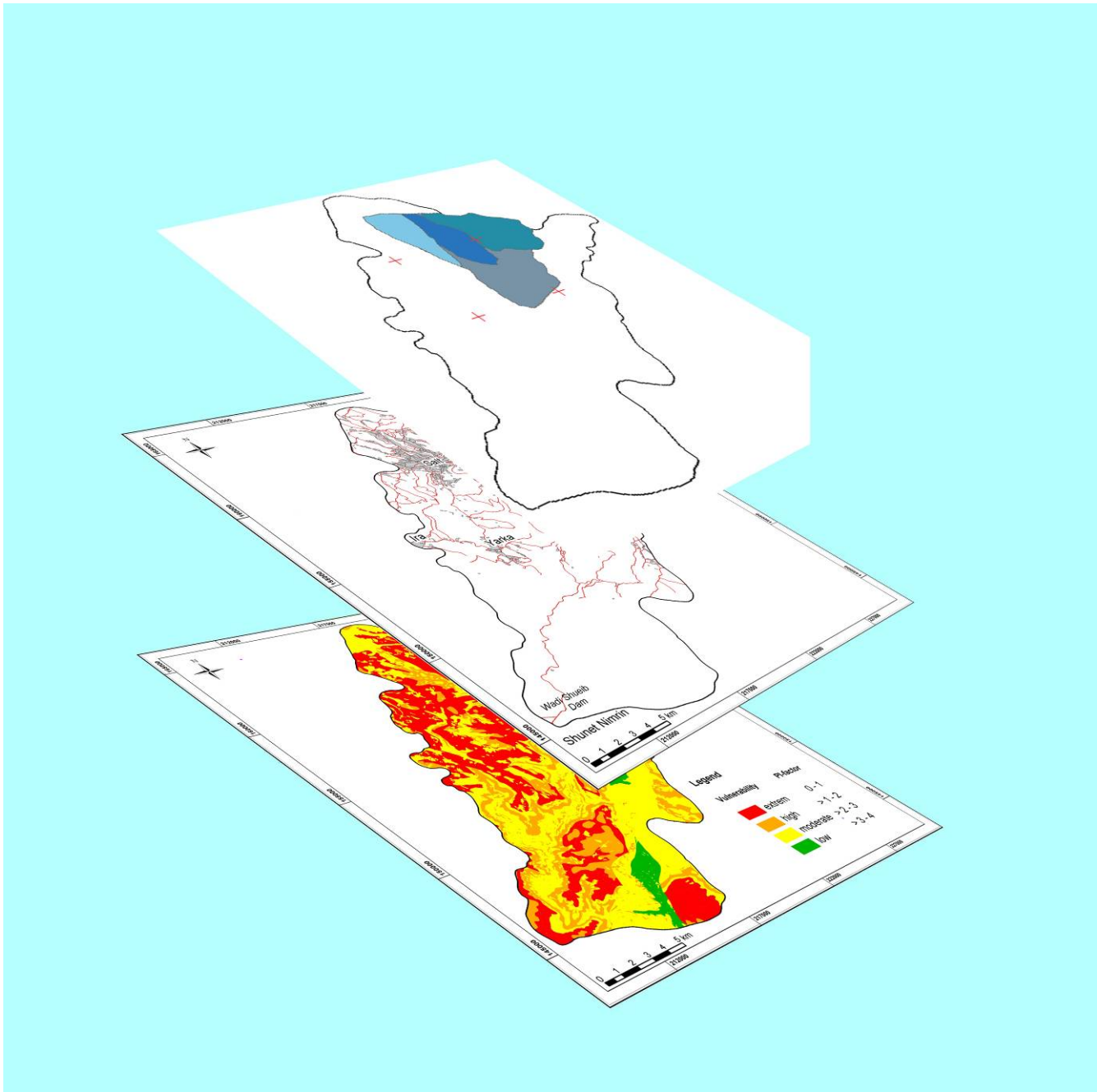

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Spring Protection Zones in Wadi Shueib

- Protection zones have been elaborated by the MWI in cooperation with BGR
- Protection of the entire spring catchment is impossible due to economical constraints
- The trade-off between protection and economic benefit needs to be assessed in more detail

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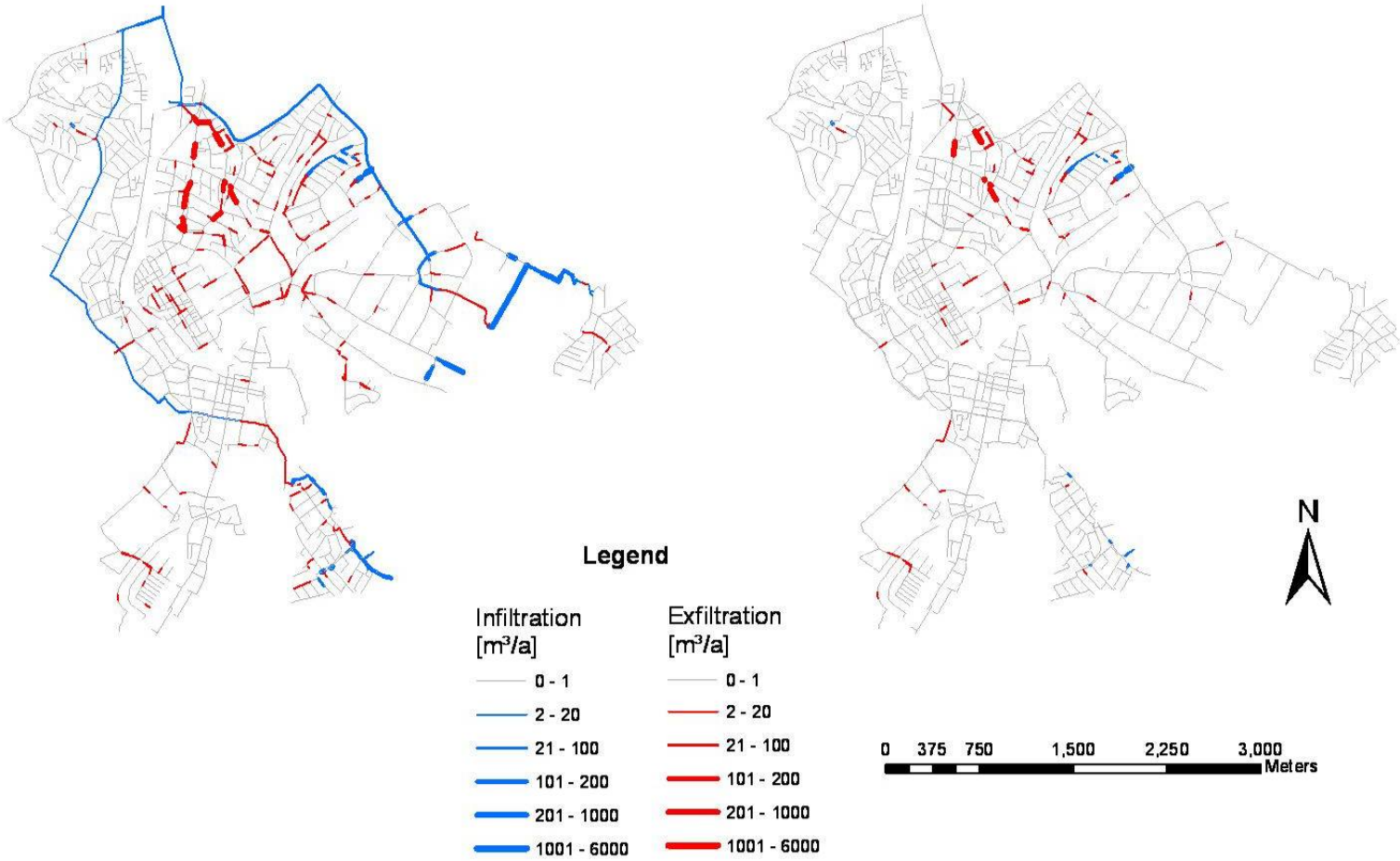
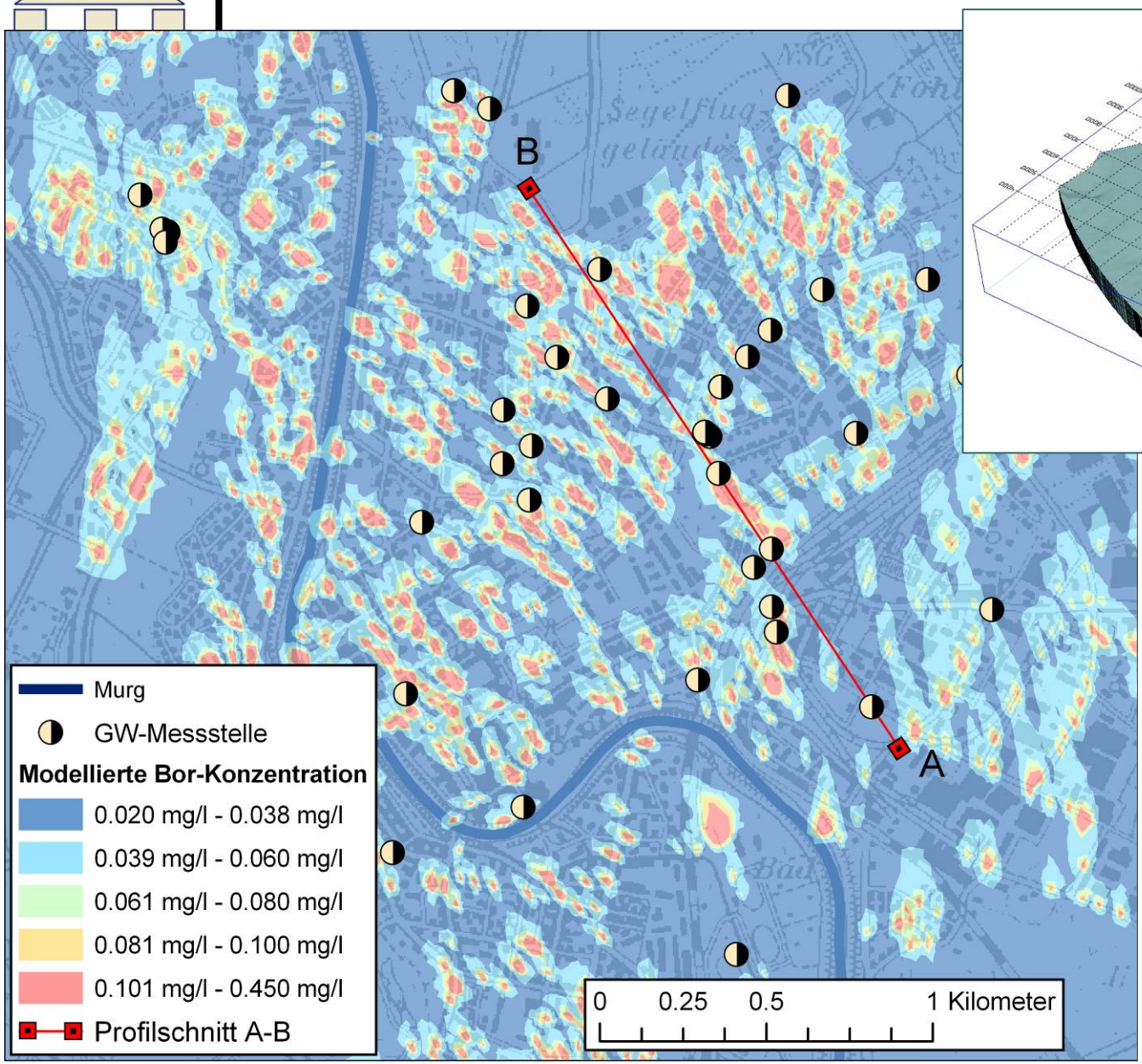
Example for assesing sewer leakage
In-/Exfiltration estimated with NEIMO software

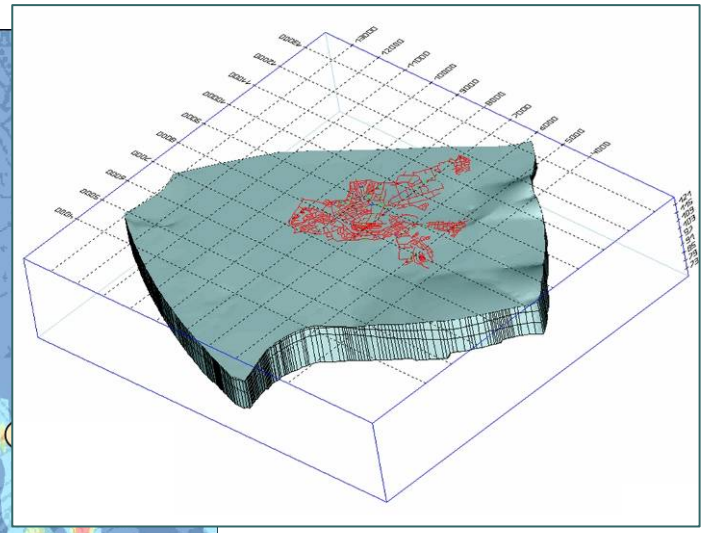


Before Rehabilitation

After Rehabilitation

Predicting impact of leaky sewers in groundwater





7 – Layers, steady state, 324180 Elements

5295 Leaks represented by 1216 contaminant sources.

20 % of the urban area exhibt elevated mass concentration compared to background

Schematic of SMART DSS

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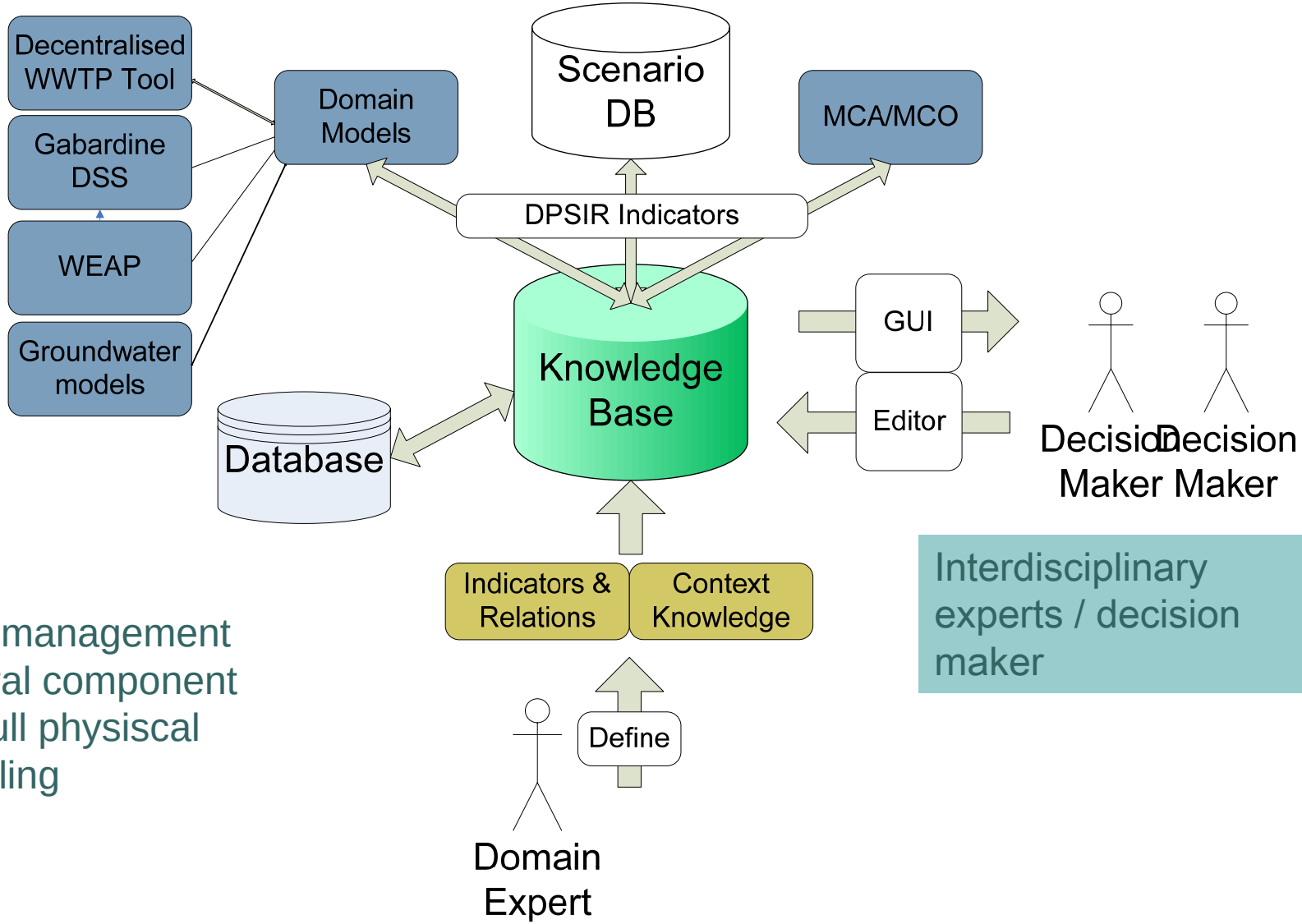

Knowledge management as the central component instead of full physiscal model coupling

Interdisciplinary experts / decision maker

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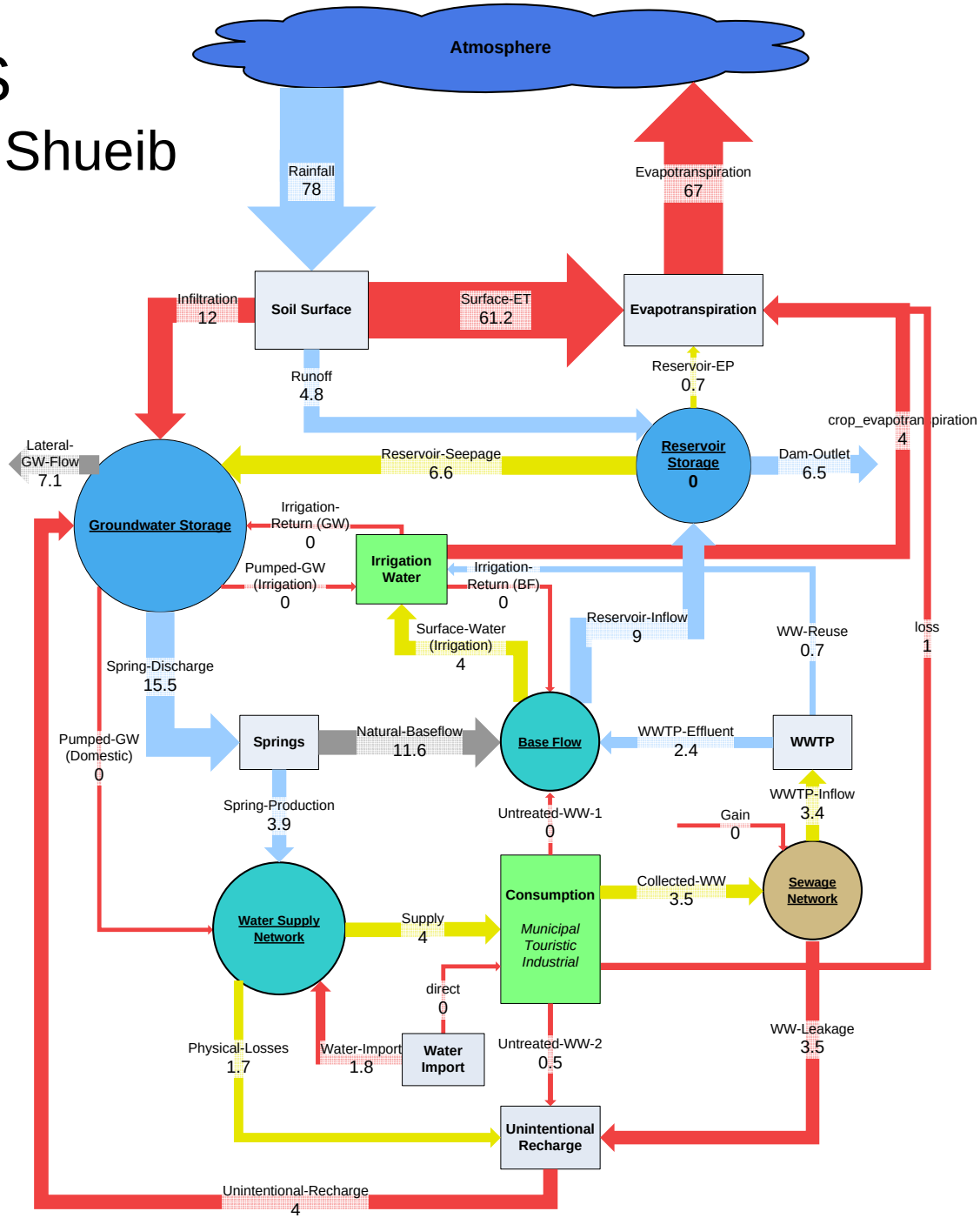
SMART-DSS
Example Wadi Shueib

Employing physically based, holistic water cycle diagrams to structure available knowledge

Width of the arrows indicates volume of flow

Color indicated uncertainty in quantification:

blue = fair,
red = uncertain,
grey = derived solely from the balance



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Decision support software for faster preparation of scenario comparions

Indicators	2004 AWY	Scenarios 2020				
	Reference	BAU	DWWT	Increase Sewer Coverage	GW Protection Zones	...
Implementation Costs	--	--	*Value*	*Value*	*Value*	
Total Costs of Municipal Water Supply	**0.7 JD/m³**	*Value*	*Value*	*Value*	*Value*	
Total Costs of Municipal Waste Water Treatment	**0.4 JD/m³**	*Value*	*Value*	*Value*	*Value*	
WW Collection Rate	**65%**	*61%*	*80%*	*79%*	*70%*	
Overabstraction index	*Value*	*Value*	*Value*	*Value*	*Value*	
Water Supply Deficit	**1.2 MCM/a**	*Value*	*Value*	*Value*	*Value*	
Water Quality	*Value*	*Value*	*Value*	*Value*	*Value*	
…						

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Scenarios defined for Wadi Shueib

- Baseline (continuation without change)
- Implementation of decentralized wastewater treatment plants / Link unconnected houses
- Sewer rehabilitation in Salt
- Enforced implementation of spring protection zone concepts
- Reduction of unaccounted for water in urban areas / water losses in agricultural areas

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Conclusions

- Excellent prospects for increasing decentralised wastewater treatment in Jordan, Demonstration projects in real villages along with financing models are required
- Better groundwater protection requires improved demonstration of groundwater protection benefits
- Cost-benefit analysis must include full environmental/health costs
- Knowledge management of integrated problem analysis is insufficient > Development of new systems
- Implementation priorities for sanitation infrastructure should be based on groundwater vulnerability and risk assessments
- Source identification can be aided by employing mobile organic trace substances > Next sampling programme

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THANK YOU FOR YOUR ATTENTION !

THANKS TO ALL SMART PARTNERS & Co-Workers

Ministry of Water & Irrigation Jordan,
BGR

www.iwrm-smart.org

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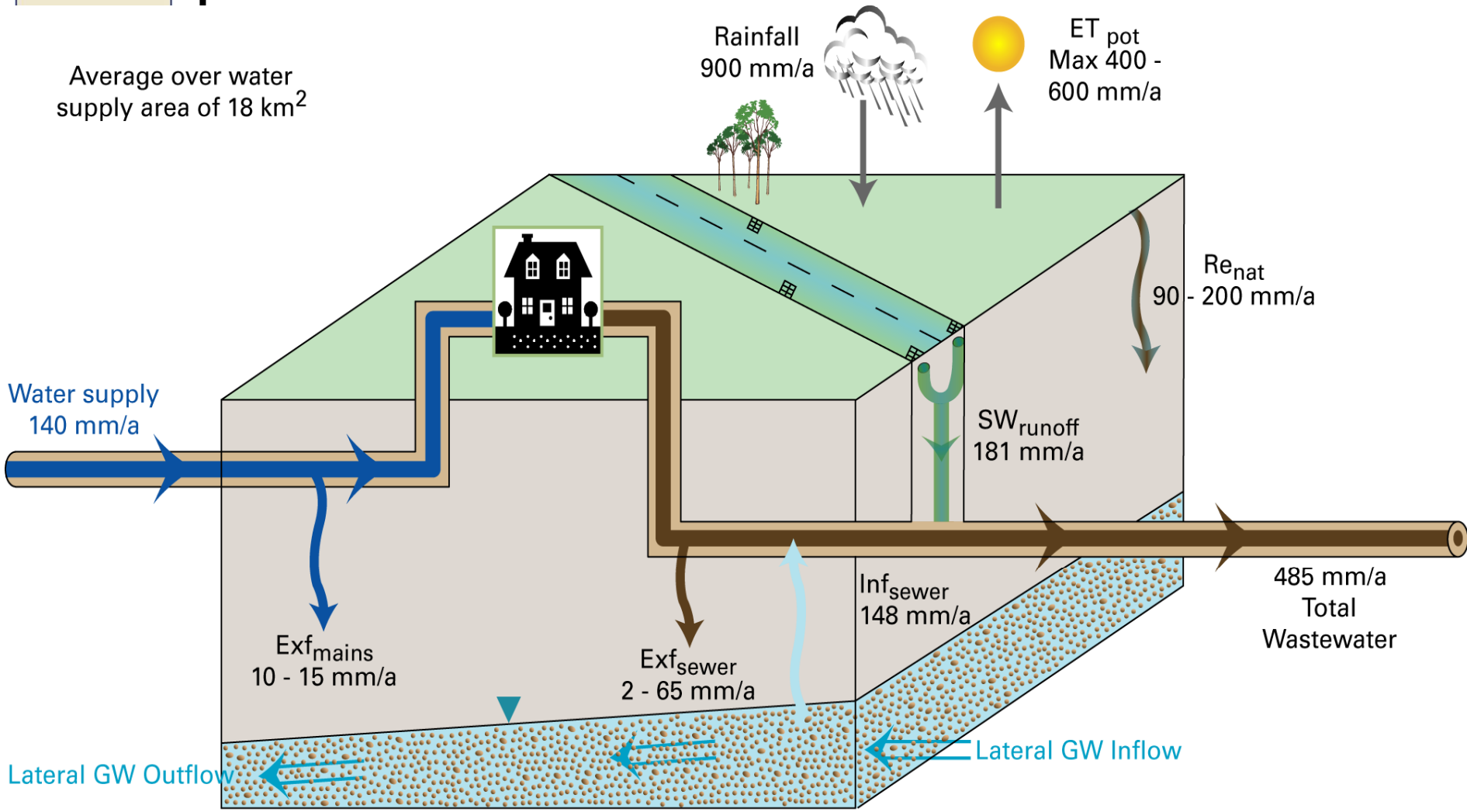
IWRM activities in Wadi Shueib

- Vulnerability Mapping (GIJP-SMART)
- Delineation of spring protection zones (MWI-BGR)
- OMS (Operations & Management Support)-Program (GTZ/KfW)
- Modelling of Groundwater recharge from Wadi Shueib dam (SMART)
- Demonstration plant for decentralised wastewater treatment (SMART)
- Feasibility Studies for decentralised wastewater treatment of the villages Ira and Yarqa (SMART)
- Preparation of holistic water balances including all water sources (surface water, runoff, wastewater, groundwater) (SMART)
- Stakeholder consultation and problem screening exercise according to the DPSIR concept (SMART)
- Organizing and classifying the available knowledge

Urban Water Balance Rastatt, Germany



Wolf et al (2006)

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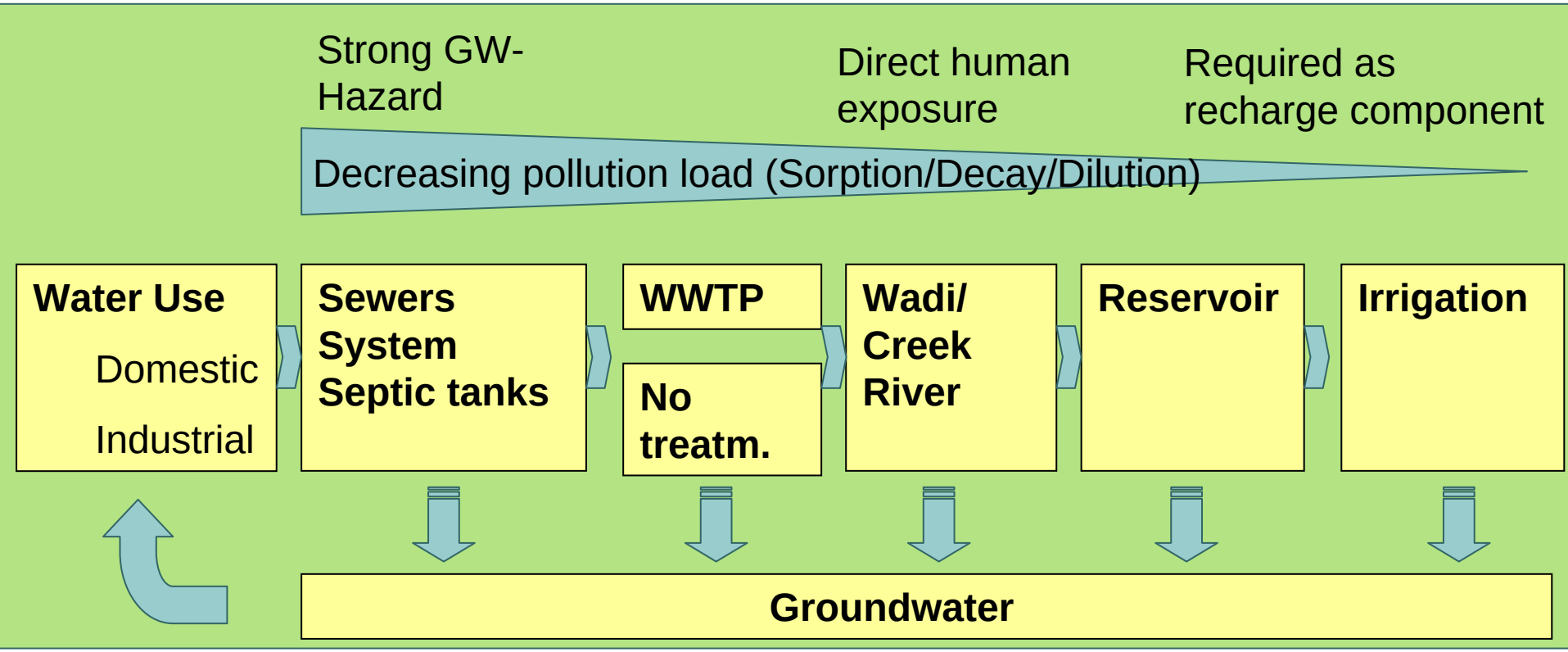
Water afteruse in Jordan Wadis

- Identifying critical control points to direct investments



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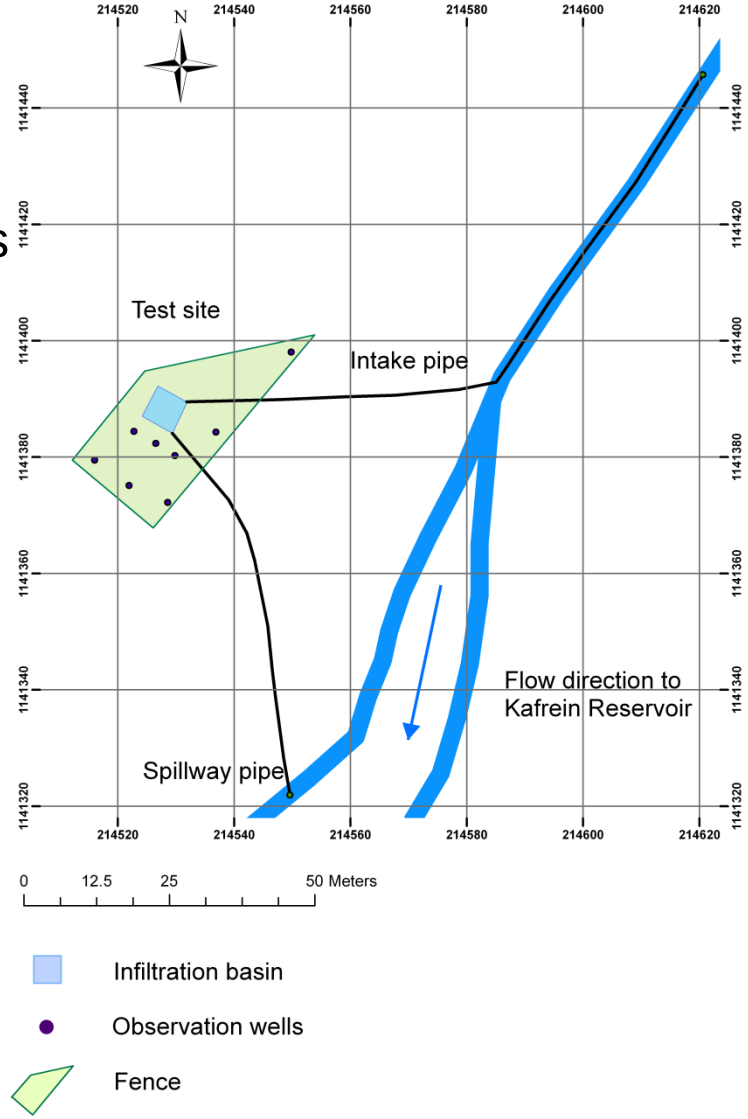
Artificial recharge test site Wadi Kafrein

- Activities:
  - Infiltration tests
  - Water sampling and analysis
  - Soil sampling and analysis
  - Measurement of the electric conductivity



Source: Zemann, 2008

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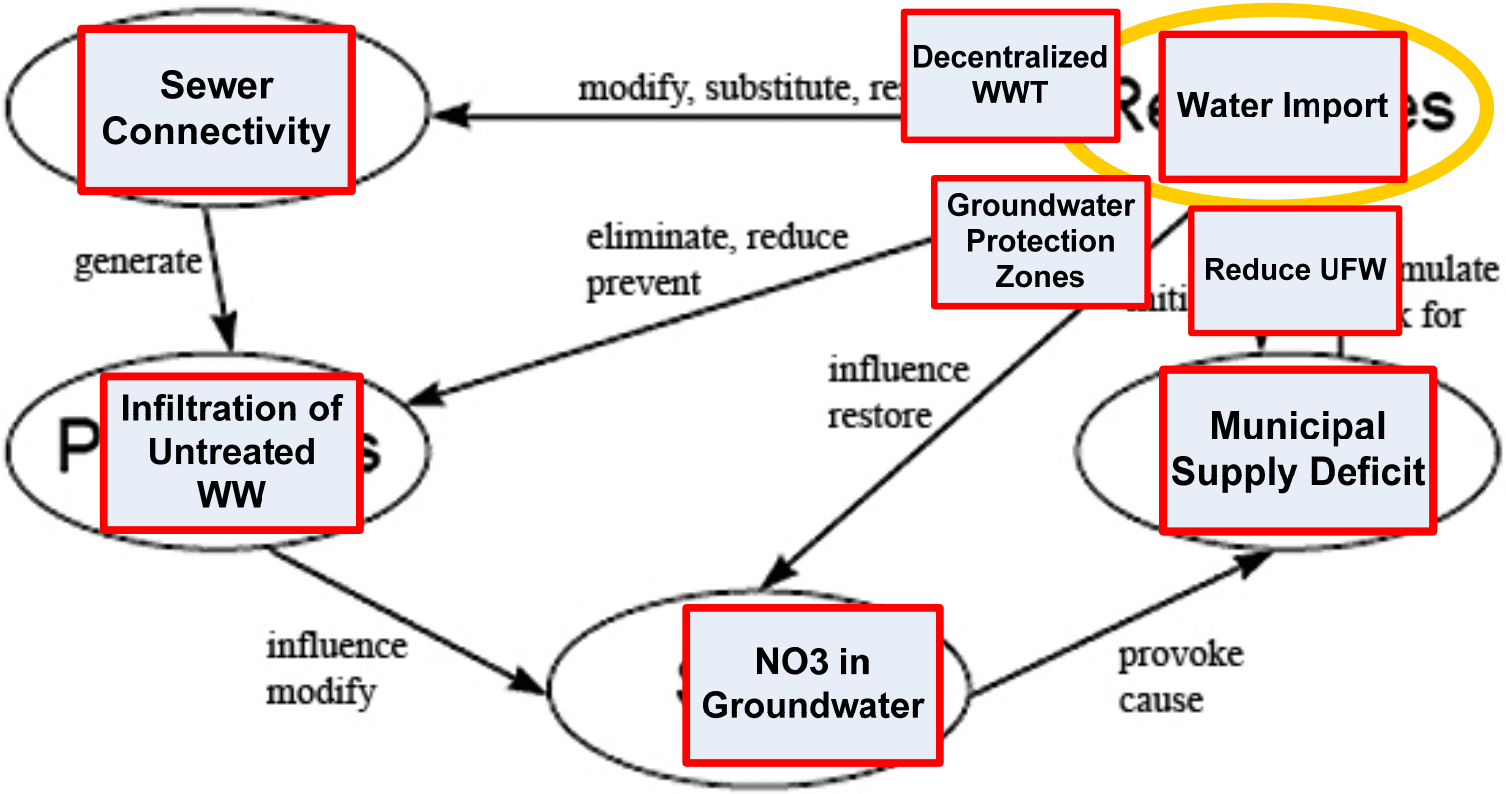
Using DPSIR models to describe integrated problems



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Cost/Benefit Analysis for scenarios

- Direct cost (e.g. construction of treatment plant, maintenance & operation, cost of incentives)
- Opportunity cost
- Environmental costs /Benefits / Environmental health costs
- Compensation costs

Risk Maps

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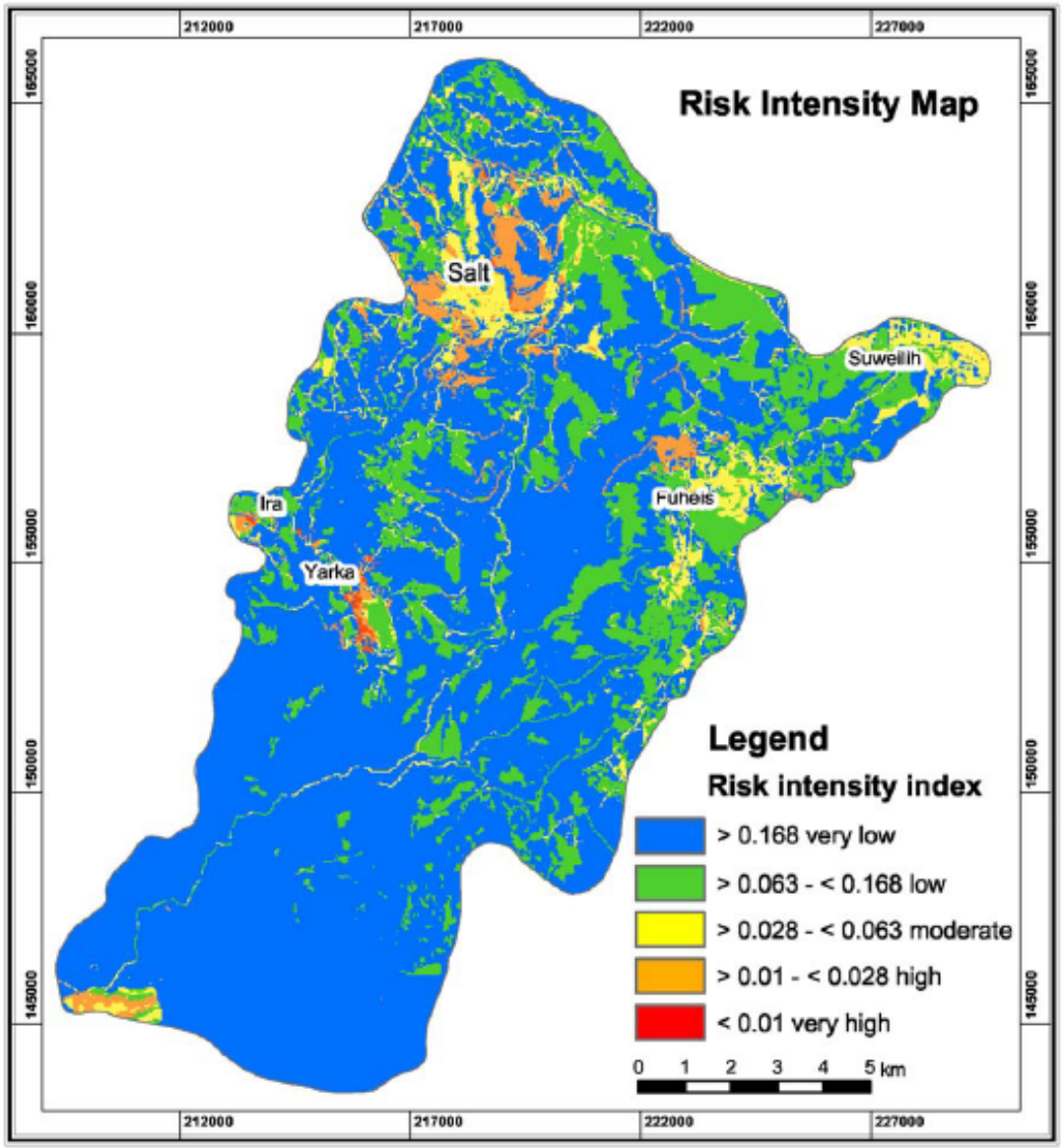

Fig. 9.2: Risk intensity map of the test area (Werz & Hötzl, 2005).

Werz 2006

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Overview of the Wadi Shueib

- Catchment size: ~200 km²
- Heigth difference: -200 bsl bis 1250 asl
- Lithology: Carbonates, Shales, Sandstones
- More than 21 Springs, partly used for drinking water supply
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Overview

- Scope & Aims of the SMART Project
- Pilots for decentralised wastewater treatment
- Socio-Economic concepts – Research on financing models

- Case study Wadi Shueib – Demonstration of links between Sanitation & Groundwater
  - Reports of stakeholder consultation in Jordan
- Groundwater vulnerability in Wadi Shueib
- A set of integrated scenarios in Wadi Shueib

> Project ongoing, but already an example how to organize the integrated approach

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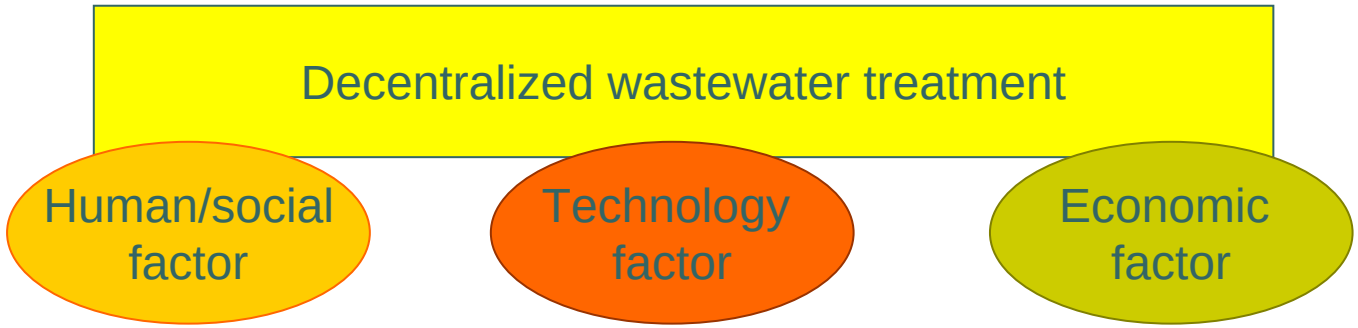
WP5:
The Methodology “Systemic approach”



Obstacles that might hinder the implementation

- Responsibilities
- Acceptance
- Awareness
- Legislation
- Institutional framework
- Old technologies
- Leakage
- Efficiency
- Hygienization
- Maintenance
- Environment
- spec. household income
- National finances
- Operating and financing
- Public health

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WP5: **Technologies - Managing Waste Water for Reuse "Subregion Jordan"**

Objectives

- The main objective is the adaptation of decentralized waste water treatment technologies to meet site specific demands
- Preparation of technology implementation within an integrated water management system

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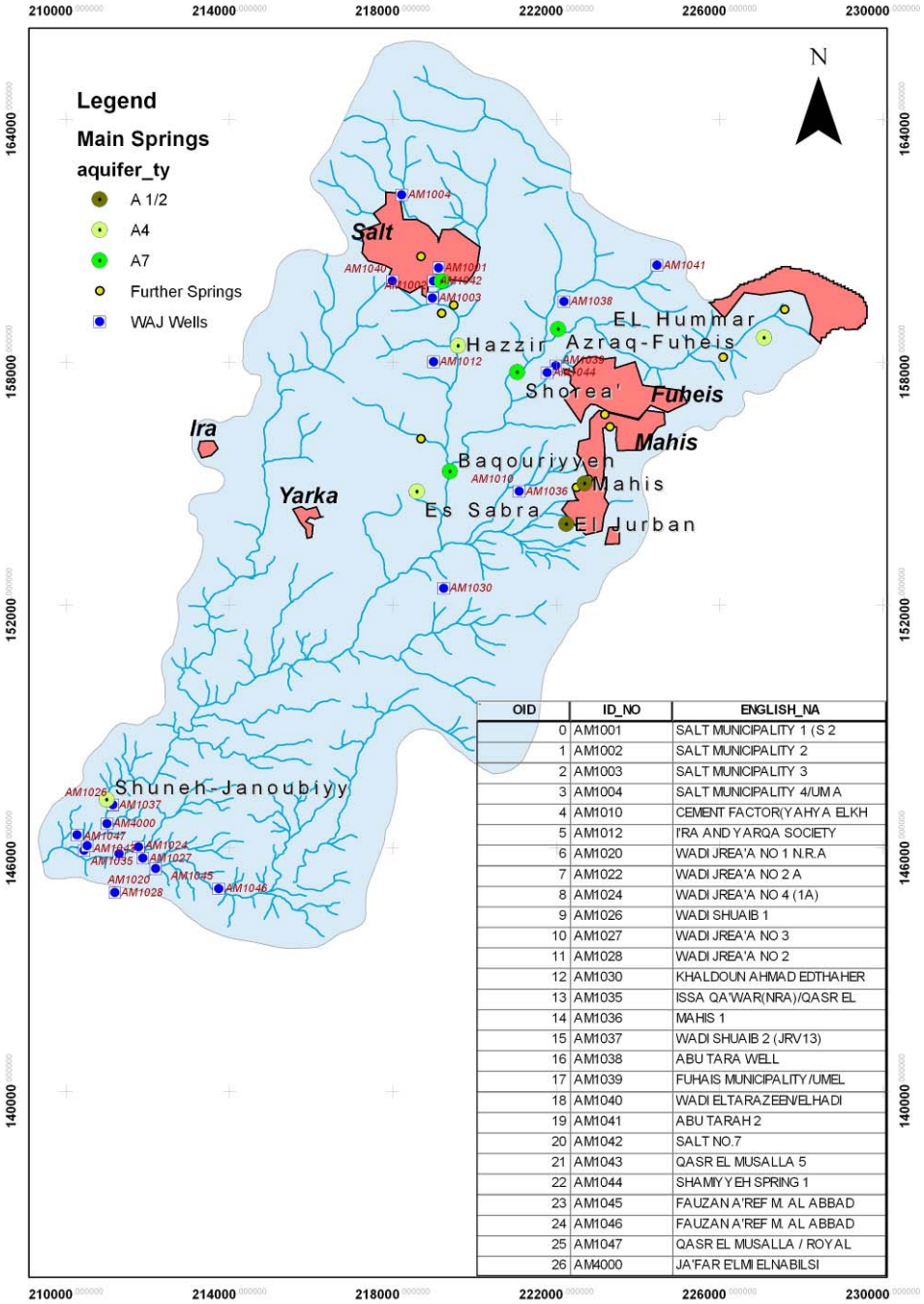

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1	AM1002	SALT MUNICIPALITY 2
2	AM1003	SALT MUNICIPALITY 3
3	AM1004	SALT MUNICIPALITY 4/UMA
4	AM1010	CEMENT FACTOR(YAHYA ELKH
5	AM1012	I'RA AND YARQA SOCIETY
6	AM1020	WADI JREA'A NO 1 N.R.A
7	AM1022	WADI JREA'A NO 2 A
8	AM1024	WADI JREA'A NO 4 (1A)
9	AM1026	WADI SHUAIB 1
10	AM1027	WADI JREA'A NO 3
11	AM1028	WADI JREA'A NO 2
12	AM1030	KHALDOUN AHMAD EDTHAHER
13	AM1035	ISSA QA'WAR(NRA)/QASR EL
14	AM1036	MAHIS 1
15	AM1037	WADI SHUAIB 2 (JRV13)
16	AM1038	ABU TARA WELL
17	AM1039	FUHAIS MUNICIPALITY/UMEL
18	AM1040	WADI ELTARAZEEN/ELHADI
19	AM1041	ABU TARAH 2
20	AM1042	SALT NO.7
21	AM1043	QASR EL MUSALLA 5
22	AM1044	SHAMIYYEH SPRING 1
23	AM1045	FAUZAN A'REF M. AL ABBAD
24	AM1046	FAUZAN A'REF M. AL ABBAD
25	AM1047	QASR EL MUSALLA / ROYAL
26	AM4000	JA'FAR E'LMI ELNABILSI

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Issues which are currently tackled by the consortium

- Costs [JD/m³] of the mricofiltration drinking water treatment plant in Shreija (Salt)?
- What are the costs [JD/m³] of the water coming from Deir Alla into the treatment plant in Shreija (consider especially pumping costs from-300 to 1000 m amsl)?
- What are the costs for rehabilitation of the sewer network in Salt? What are the costs for rehabilitating sewers only in vulnerable areas ?
- What are the cost for building decentralised wastewater treatment plants in Ira & Yarqa ?
- What are the costs for having a water treatment plant to remove the high nitrate concentration (80 mg/l) from the water of the Hazzir spring?
- What is the approximate water volume stored in the different aquifers in Wadi Shueib?

SMART

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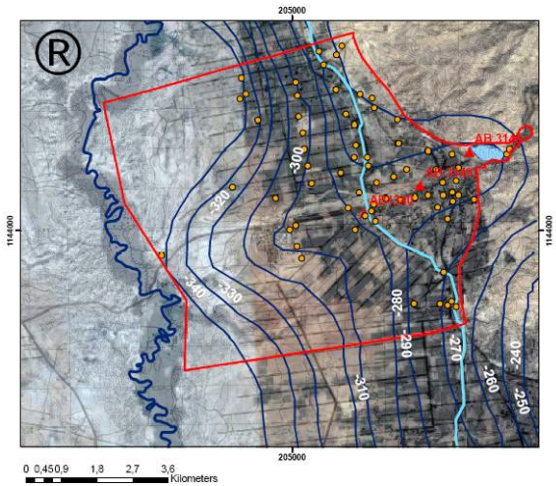
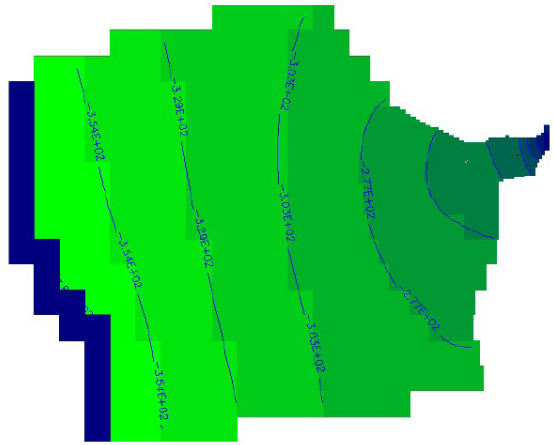
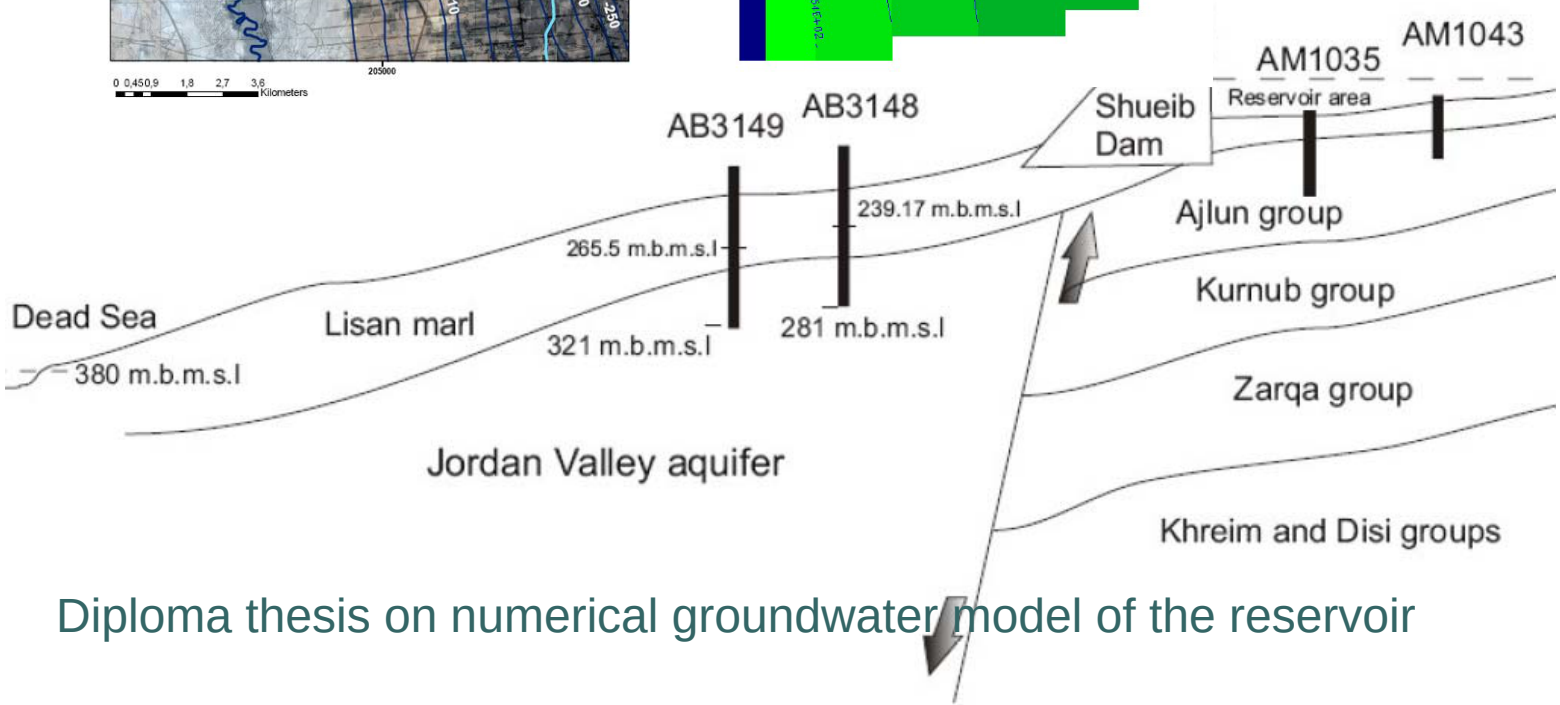
All water leaving the Wadi is collected in a reservoir and used for agriculture & artificial recharge







Diploma thesis on numerical groundwater model of the reservoir