Development of regenerative water resources in semi-arid regions

Methods and processes – synopsis of a package solution

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This wonderful *falaj* is in *Wadi bani Khalid, Al Sharqiyah* Region.

Introduction

- Established methods of water supply in semi-arid regions:
  - Sources
  - Wells
  - Desalination plants of sea water

- Further used and not used potentials of regenerative water resources on the basis of seasonal rainfall events
  - Recharging of groundwater with different methods
  - Dams, usually overspill dams
  - **Subsurface storage** of precipitations from **defined catchment areas**


Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2010 GeoEye
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© 2010 Cnes/Spot Image
7.08 km
Google
Bildaufnahmedaten: 19. Mai 2009 - 15. Jun. 2009
23°55'04.49" N 56°59'11.68" E Höhe 81 m
Sichthöhe 24.69 km

Methodology

Catchment area

<u>1st step:</u> Selection of catchment areas, precipitation

- Definition of suitable catchment areas with satellite supported mapping
- Presentation of suitable regions of interest (ROI) with additionally high resolution satellite supported mapping
- Detailed measurements of precipitations in every regions of the catchment area
- Climate studies for long time prediction of precipitation


N
1156 m
© 2010 LeadDog Consulting
Image © 2010 GeoEye
©2009 Google
Bildaufnahmedaten: 19. Mrz. 2009 - 24. Mai 2009
23°01'03.06" N 57°35'01.10" E Höhe 1047 m
Sichthöhe 4.69 km

Methodology

Catchment area

<u>2st step:</u> Hydrology, hydrogeology

- Determination of hydrological runoff processes in the whole catchment area
- Hydrogeological characteristics for determination of possible losses by infiltration and evaporation
- Determination of really runoff in the stream network in the catchment area

Methodology

Catchment area

<u>3st step:</u> Measures of hydraulic engineering

- Determination of hydromechanical characteristics and the possible amount of sediment load in the catchment area
- Determination of hydraulic engineering measures to handle sediment load (for example gabions)
- Determination and dimensioning of intermediate dams (self-cleaning dams) and of secondary collection conduits
- Dimensioning of main dam (usually overspill dams)

Methodology

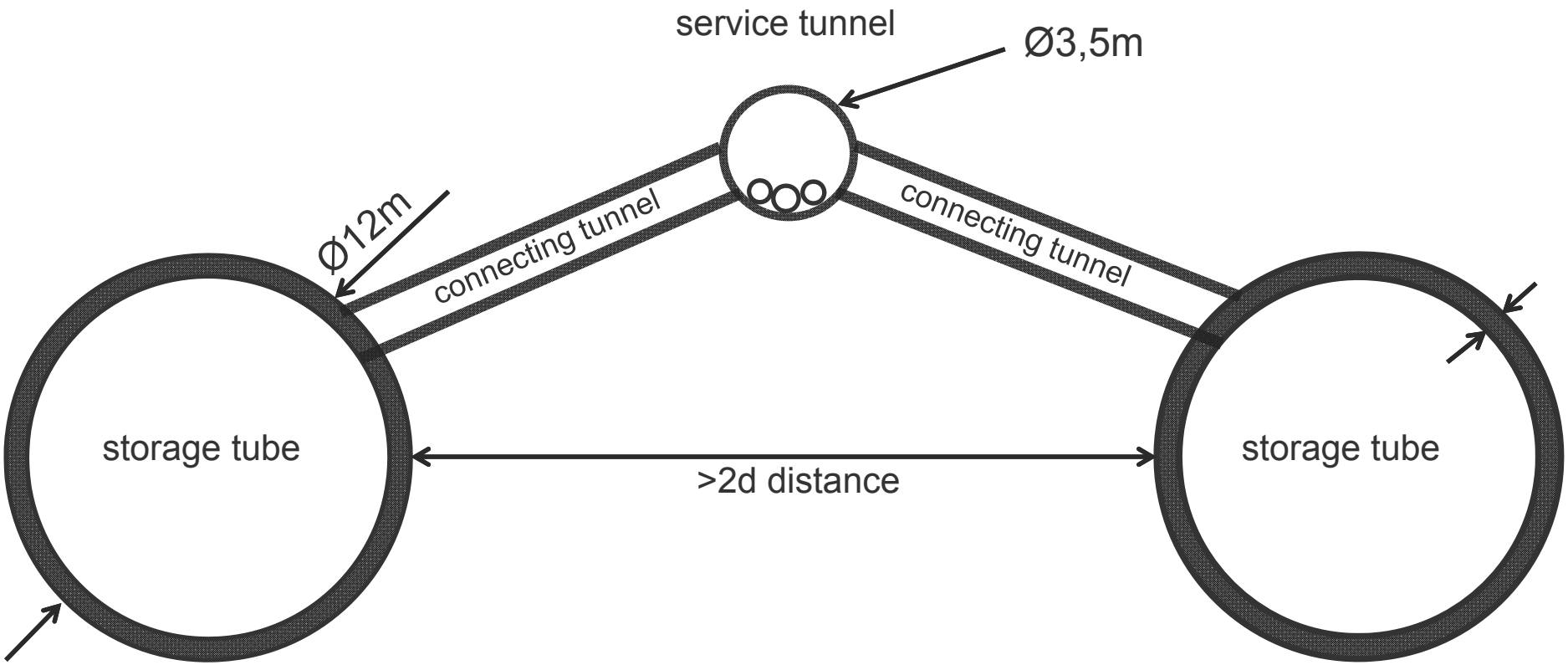
Construction of underground artificial galleries

<u>1st step:</u> Dimensioning of underground artificial galleries for water storage

- Determination of the regional amount of drinking water and other water uses
- Determination of possible water yield in the catchment area under consideration of climate studies
- Determination of the necessary capacity of die storage system in the worst case situation under consideration of possible long term influences
- Determination of the underground storage system on the basis of regional geological fact

  (blindtunnels, tunnels with perforation through a mountain massif)


1401 m
Image © 2013 DigitalGlobe
© 2013 Google
Google earth
Bildaufnahmedatum: 5/24/2009 23°01'01.85" N 57°34'50.75" O Höhe 964 m Sichthöhe 6.64 km


service tunnel
Ø3,5m
Ø12m
connecting tunnel
connecting tunnel
storage tube
storage tube
>2d distance

Methodology

Construction of underground artificial galleries

<u>2st step:</u> Using of new tunnelling technology

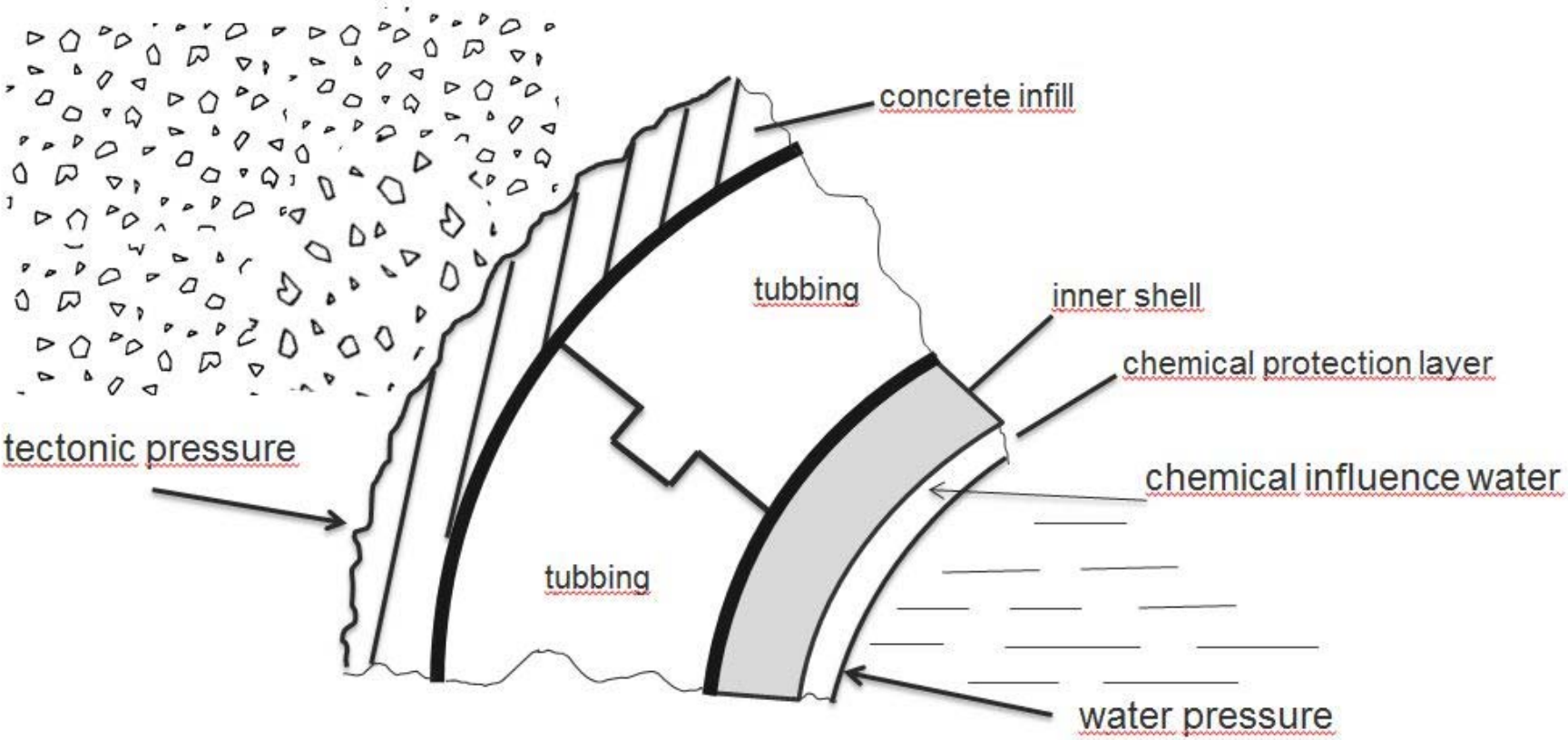
- Ideal positioning for the regional application of the tunnel boring machine (TBM)
- Exploration boring along the planned tunnel line to find out the geological and hydrogeological conditions
- Estimation of impacts on existing water supply systems (for example AFLAJ)
- Planning for a production plant to produce tubbings

Methodology

Construction of underground artificial galleries

3st step: Design of storage units

- Presentation of the construction of storage unit
- Estimation of tectonically influences to dimension the thickness of tubbings
- Dimensioning of the inside wall under consideration of statics calculations of the present hydraulic pressure also with possible tectonically influences
(for example earthquakes)



Design of storage units

Methodology

- Determination of water chemical influences to the building material by long term storage, for example of changing pH-values and/or ions in solution
  Solutions:

  Using of durable building materials for a long term guarantee for the substance of the building
  (for example: fiberglass, carbon grids)

  Coating of specific materials (with bactericide effects) on the inside wall for prevention of materials losses or changes of the water quality

Methodology

Construction of underground artificial galleries

<u>4st step:</u> Guarantee for operating ability and water quality

- Installation of water indicators and sensors for every storage unit
- Installation of a pumping system along the service tunnel:
  - for filling the storage units and for water supply
  - for pressure balance of every storage unit
- Installation of electrodes to produce bactericidal ions to prevent contaminations together with additional methods
- Automating of the whole storage system with IT-Solutions

Advantages/Disadvantages

Construction of underground water storage systems

Advantages

- Storage of defined volumes of water for a projectable water management
- Very small losses by evaporation, no losses by infiltration
- Clear reduction of contaminations
- High security to influences from outside
- Wide range for using in semi-arid regions, in special cases are 2-3 heavy rainfall events of at least 15 mm enough
- Regional decentralized applications are possible like combination over more catchment areas
- Supply in supra-regional water supply systems in the case of abundant runoff and vice versa

Advantages/Disadvantages

Disadvantages

- High costs for implementation

Cost-benefit-estimation (worst case)

<u>Example:</u> **Standardized storage unit**

Demand:	4000 inhabitants
Per head-demand:	110 litre water per day
Necessary storage capacity:	160.000 m^3 per year
Costs for implementation: (water intake, water storage, water treatment for users)	84 Mio. € +/- 2 Mio. € (87 Mio. $)
Period of amortization:	60 years

> 0,96 € (up to 1 $) per inhabitant and day

Conclusion

The package solution as well as components of the package solution can be individual applied for the following purposes:

- for compensation of already existing water shortages, especially in semi-arid regions
- as a balance to expected water deficits by climate change
- to bridging arid time windows, which are in many regions of the world presently make settlements almost impossible
- in developing, emerging and industrial countries, in which the water capacities demands for large storage capacity
- in tropical as well as in as in semi-tropic regions, in which drinking water is endangered through microbial, viral as well as organic contaminants

Conclusion

- in crisis regions, in which water shortage continuous conflict potential is
- in from natural disasters endangered regions
- to reduce results of heavy rainfall events as a positive companion effect, that in semi-arid regions can presently lead to flooding disasters as well as
- for agricultural application in regions until now unsuitable therefore, at least contributing to regional self-sufficiency

Day after