

College of Graduate Studies



**Water Resource Management
Programme**

Assessing the Sustainability of the Municipal Wastewater Management System in the Kingdom of Bahrain

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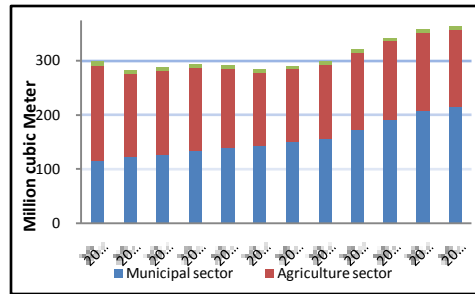
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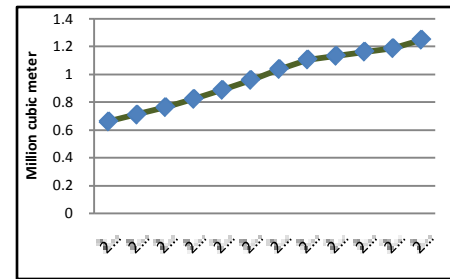


Introduction

- The Kingdom of Bahrain is classified as one of the world's most water-scarce country and is experiencing a large water demand due to population growth

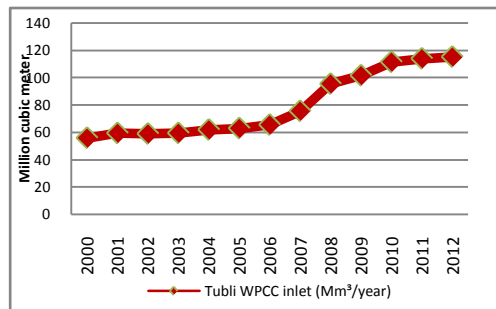


water consumption

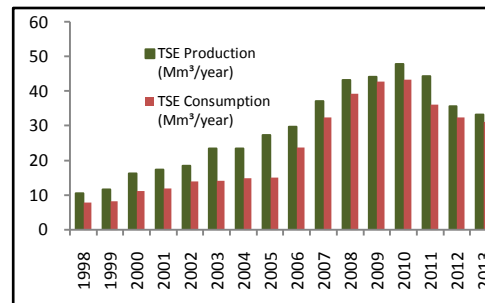


population

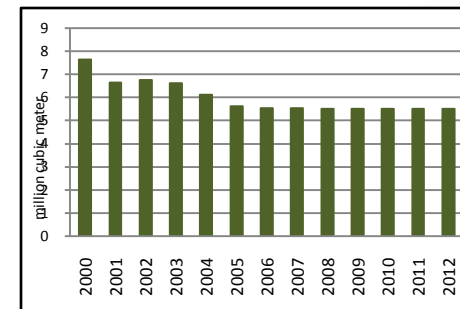
- Since the 1980s, Treated wastewater is used to supplement/replace groundwater in irrigation and landscaping in Bahrain



wastewater generation



TWW utilization



groundwater consumption



Research Objectives

The aim of this research is to assess and improve the efficiency and the sustainability of the wastewater management system in Bahrain; the specific objectives are

- **To develop a management model suitable for improving the existing wastewater management system in the kingdom**
- **Suggest ways to raise the efficiency of the wastewater sector management to enhance its sustainability**
- **Recommending strategic options to achieve the sustainability for wastewater sector in Bahrain**

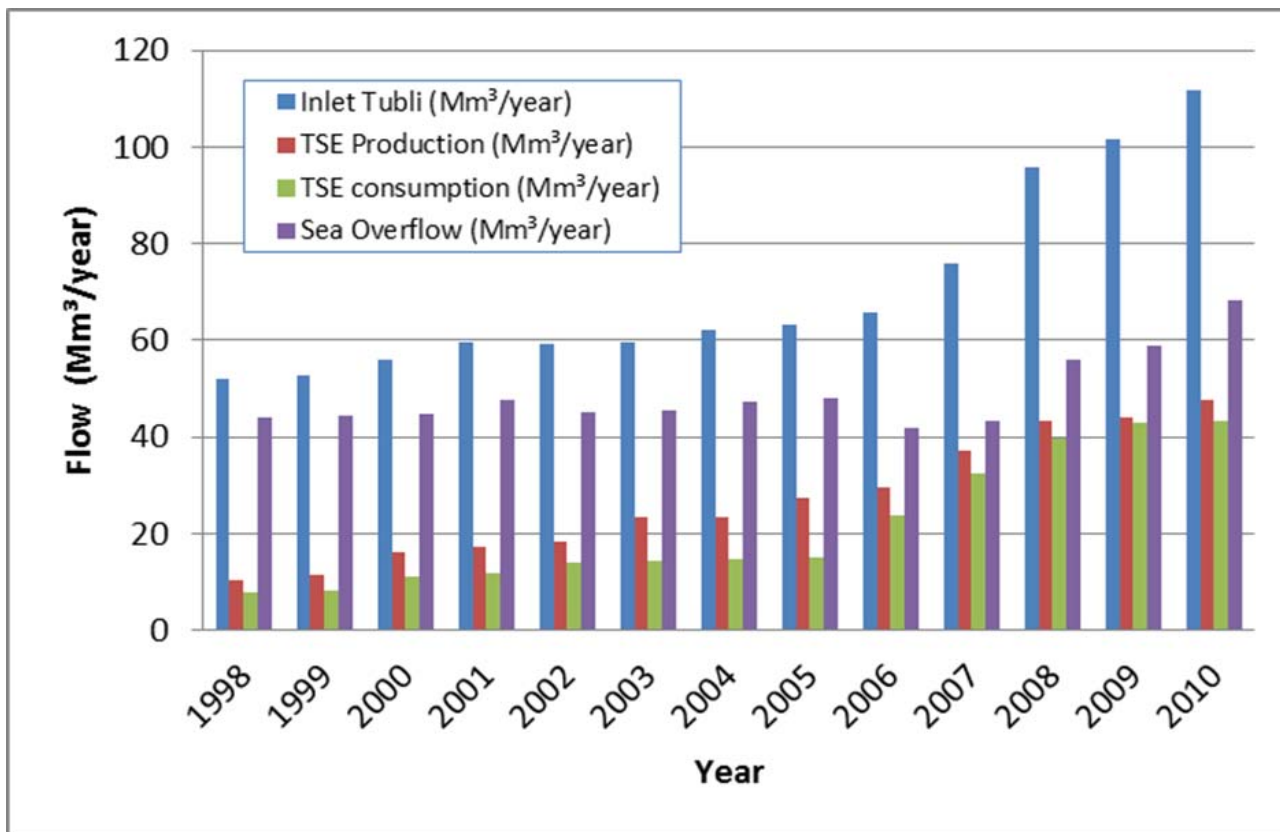


Research Methodology

- 1. Assess the current situation and determine the main problems in the wastewater sector**
- 2. Analyze the policies of wastewater resources management in the Kingdom of Bahrain**
- 3. Development of a dynamic model using WEAP software to represent the wastewater management system in Bahrain**
- 4. Determine the suitable options or scenarios for the wastewater management result in reduce the gap between supply and demand and assess their effectiveness in enhancing its sustainability**
- 5. Draw conclusions and recommend the most effective available strategic management options to achieve a high degree of sustainability in the wastewater sector in Bahrain**



Current Situations



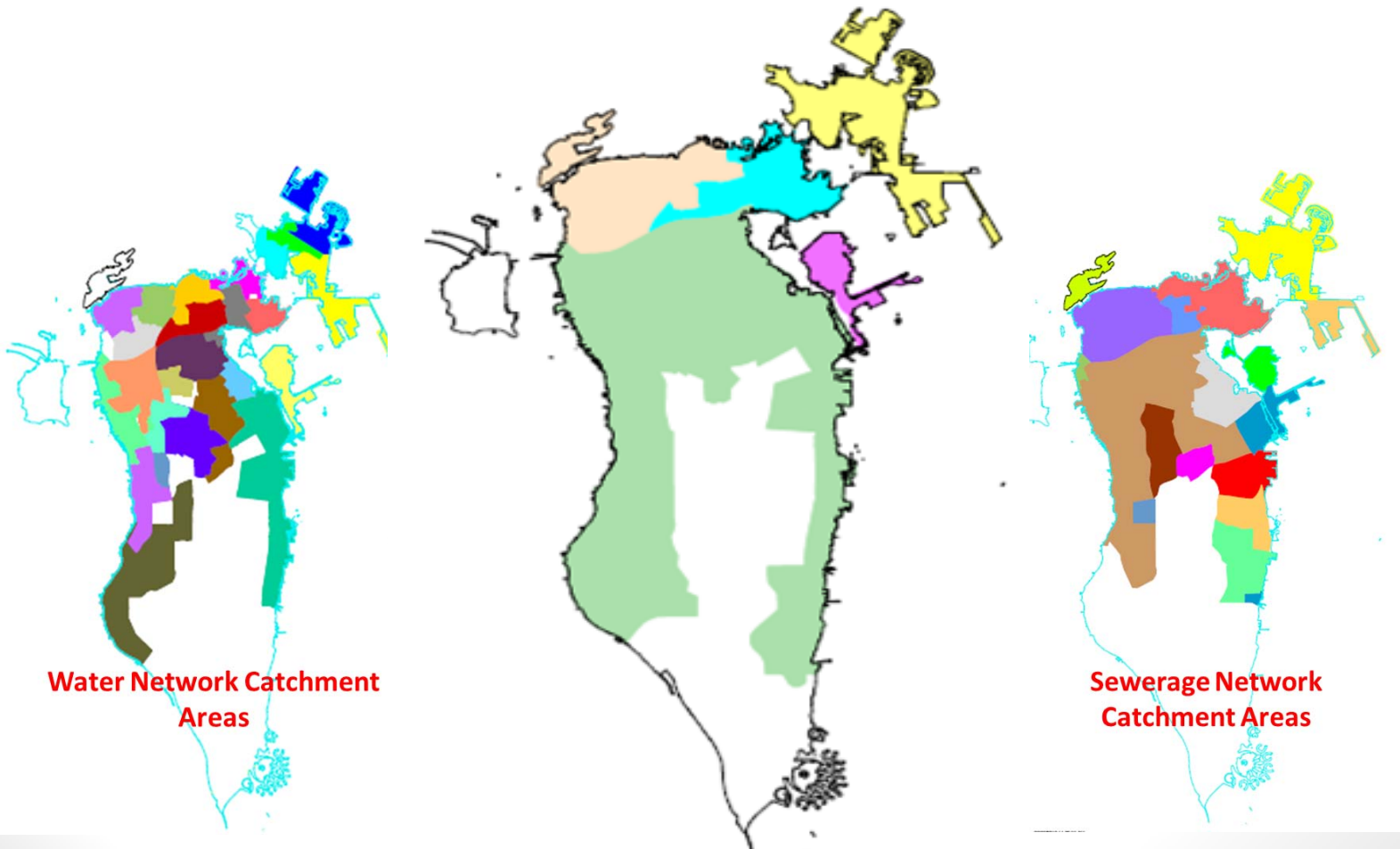


Issues and challenges

- **Centralized system**
- **Sludge carryover volumes**
- **Treated wastewater Quality deterioration**
- **Lack of Integrated Planning**
- **Aging condition of sewerage system**
- **Limited capacity of STPs**
- **Delay of implementing future plans**

Integrated water and wastewater sector system in Bahrain

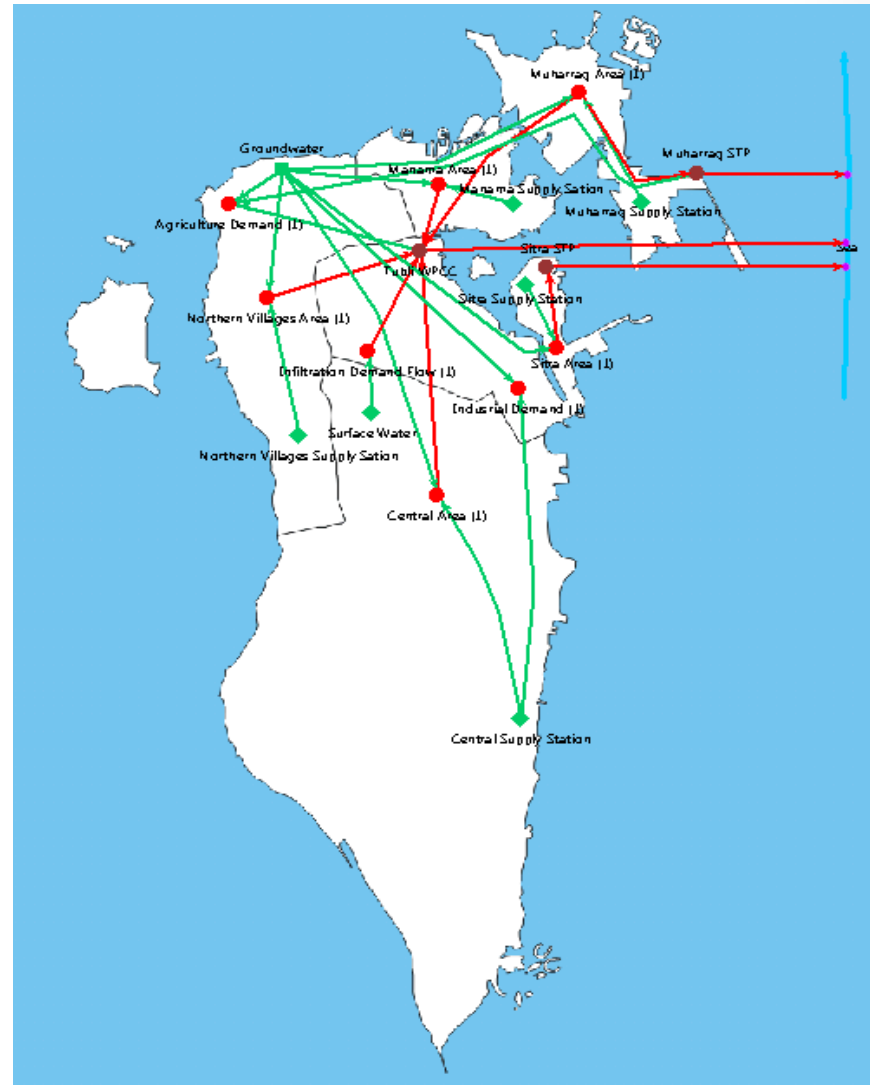
- The municipal water consumption and its generated wastewater inflow to the STPs are integrated in the model to five catchment areas



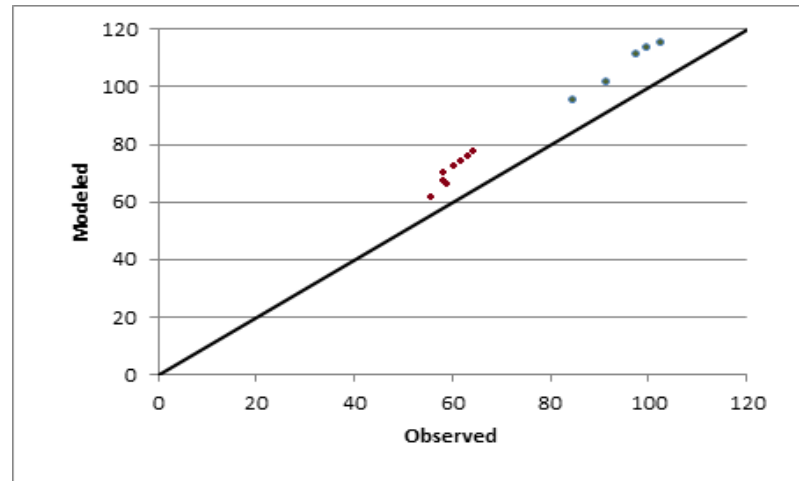
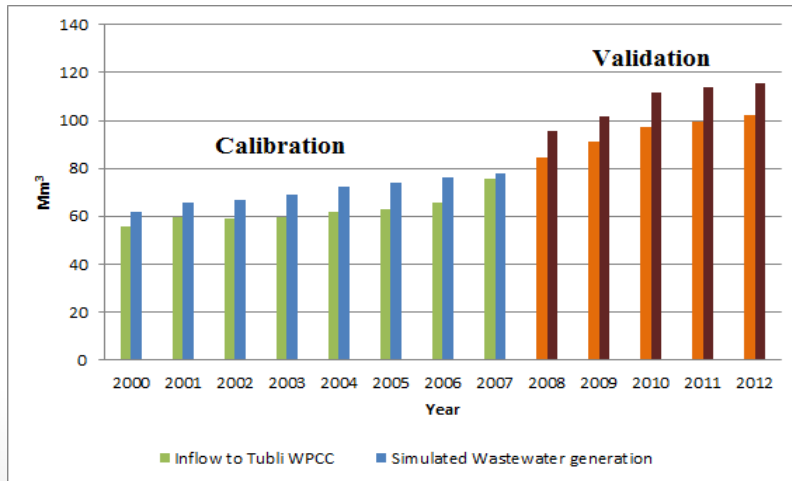
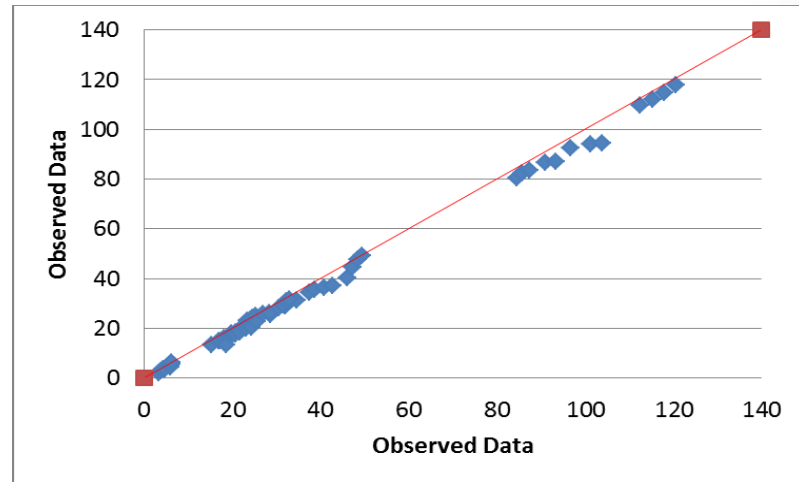
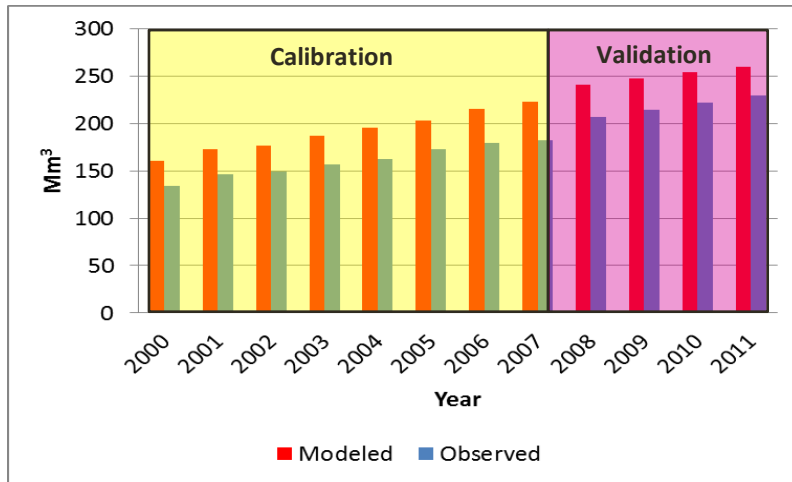
Modeling of water sector management system in Bahrain



- **Conceptual WEAP Model**



Model Calibration and Validation-Municipal water





Management Option Scenarios

- **Scenario 1** Accelerating the reduction rate of the Infiltration rate in the wastewater collection network
- **Scenario 2** Use of water saving devices in the municipal sector
- **Scenario 3** Use of modern irrigation techniques in the agricultural sector
- **Scenario 4** Reducing Infiltration rate in collection network and water saving devices in the municipal sector (Combination of Scenario 1 and 2)
- **Scenario 5** Reducing Infiltration rate in collection network, water saving devices in the municipal sector and use of modern irrigation techniques in the agricultural sector (Combination of Scenario 1, 2, and 3)



Financial analysis for all scenarios

Secondary and Tertiary treatment cost and carryover volume was used as indicator for all scenarios (wastewater secondary treatment at 0.164 US\$/m³ and tertiary treatment cost at 0.317 US\$/m³)

Scenario	Cumulative wastewater inflow volume in Mm ³ (2013 -2030)	Cumulative Treated wastewater volume in Mm ³ (2013 - 2030)	Cumulative treatment cost in Million US\$ (Secondary and Tertiary)	Cumulative carryover volume in Mm ³ (2013 -2030)	Cumulative Carryover cost in Million US\$ (Secondary)
Business as usual	2367.53	2263.68	1088.83*	79.77	13.08*
Scenario 1 Reduce infiltration rate	2293.35	2263.68	1088.83*	47.19	7.73*
Scenario 2 Use water saving device	2326.34	2263.68	1088.83*	41.20	6.76*
Scenario 3 Use modern irrigation	2367.53	1707.69	820.92*	562.51	92.25*
Scenario 4 Combination 1&2	2252.16	2263.68	1088.83*	5.76	0.94*
Scenario 5 Combination 1,2 &3	2293.29	1706.69	820.92*	474.12	77.76*

* Cost estimated based on Al Noaimi, 1993



Ground water and Environmental costs analysis for all scenarios

Total Suspended Solids (TSS) and Total Ammonia (NH₃) dumped to Tubli bay was used as environmental cost indicator for all scenarios

Scenario	Cumulative wastewater inflow volume in Mm ³	Cumulative Carryover volumes in Mm ³	Cumulative Carryover Financial cost in million US\$	Cumulative (TSS) for carryover (2013 -2030) @132.38mg/L (ton)	Cumulative (NH ₃) carryover (2013 -2030) @5.5mg/L (ton)	Ground water saving	TWW Quality
Business as usual scenario	2367.53	79.77	13.08*	10,55**	438**	+	+
Scenario 1	2293.35	47.19	7.73*	6,247**	259**	++	++
Scenario 2	2326.34	41.20	6.76*	5,454**	226**	++	++
Scenario 3	2367.53	562.51	92.25*	74,466**	3,093**	+++	+
Scenario 4	2252.16	5.76	0.94*	762**	31**	+++	+++
Scenario 5	2293.29	474.12	77.76*	62,764**	2,607**	+++	++

* Cost estimated based on Al Noaimi, 1993

** Base on the average yearly for 2012 for daily 24 hour sampler result (Tubli WPCCLaboratory).

(+) Low, (++) Mid., (+++) High



Conclusion

- **Reuse of treated wastewater will increase water availability. Therefore, treated wastewater reuse should be considered as a potential component and it can save significant amounts of groundwater**
- **Wastewater management system in Bahrain is facing many issues and challenges such as aging, capacity and condition of wastewater collection, treatment and reuse system**
- **Assessment of wastewater management system has indicated that is not sustainable as it is associated with high cost**
- **treated wastewater reuse outside agriculture might also be economically feasible, have more added value, and ecologically sustainable**
- **Reduction of infiltration rate in collection networks and installation of water saving devices in households will eliminate the carryover, reduces treatment and carryover cost, especially environmental impacts on Tubli Bay**



Recommendations

- **Integrated planning and management between wastewater sector and water supply sector**
- **Reducing infiltration in collection networks and fixing Water saving devices in households is the better option for sustainable wastewater management**
- **To study the visibility of using TWW in industrial processes such as (aggregate and sand washing, concrete curing, industrial cooling system, injection in oil well) that currently mostly use desalinated groundwater**
- **To study the option of aquifer recharge by surplus TWW this required detailed evaluation and investigation of hydro-geological conditions in selected areas of Bahrain**



Thank you