

Dynamics of Groundwater Levels and Quality in ASR Systems

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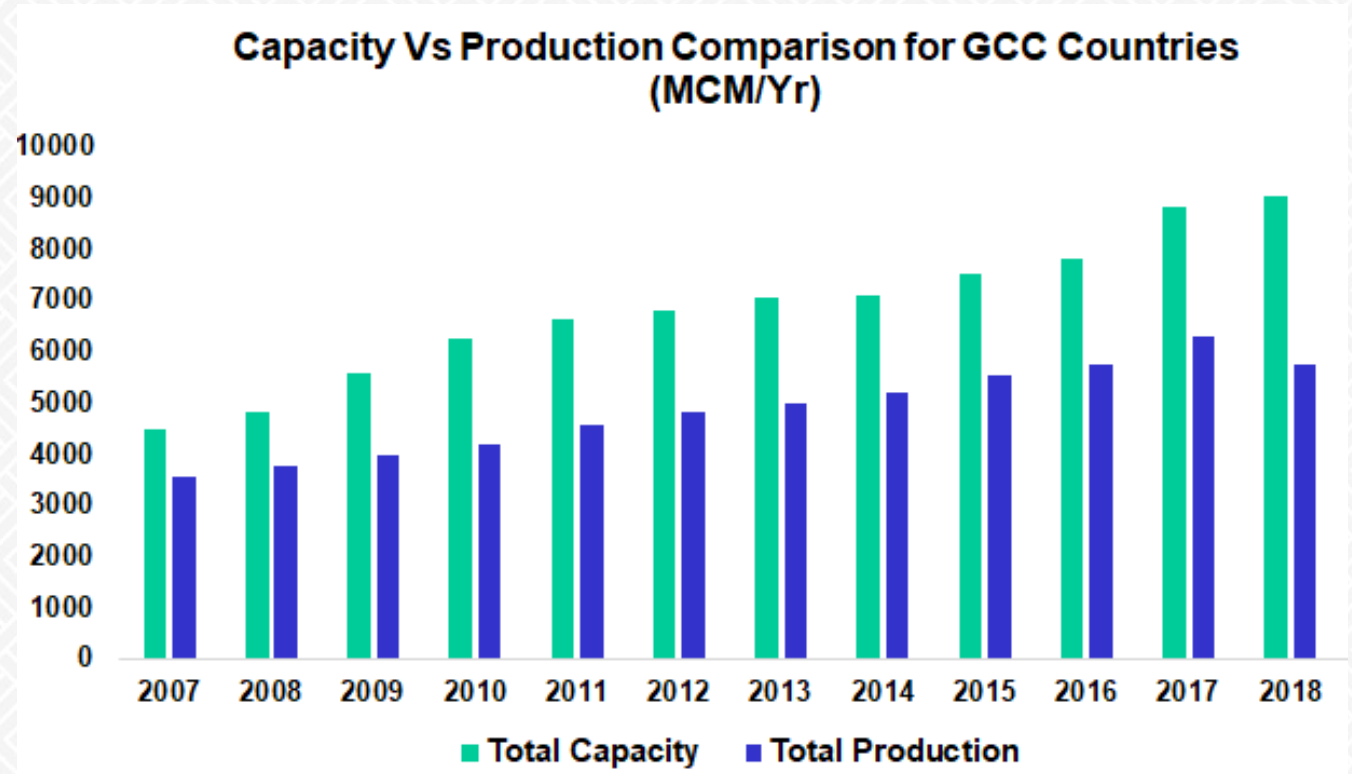
*Project Funded by Sharjah Electricity and Water Authority
(SEWA)*

March 17th, 2021

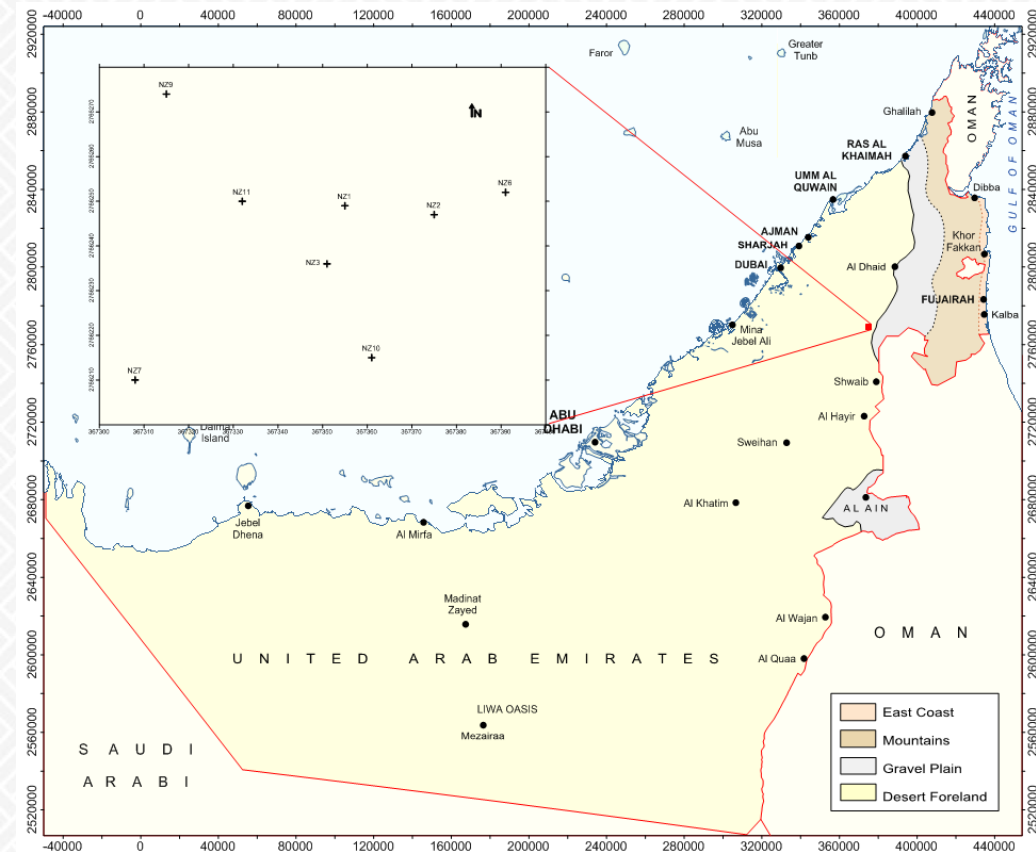


Desalination Capacity and Production in GCC

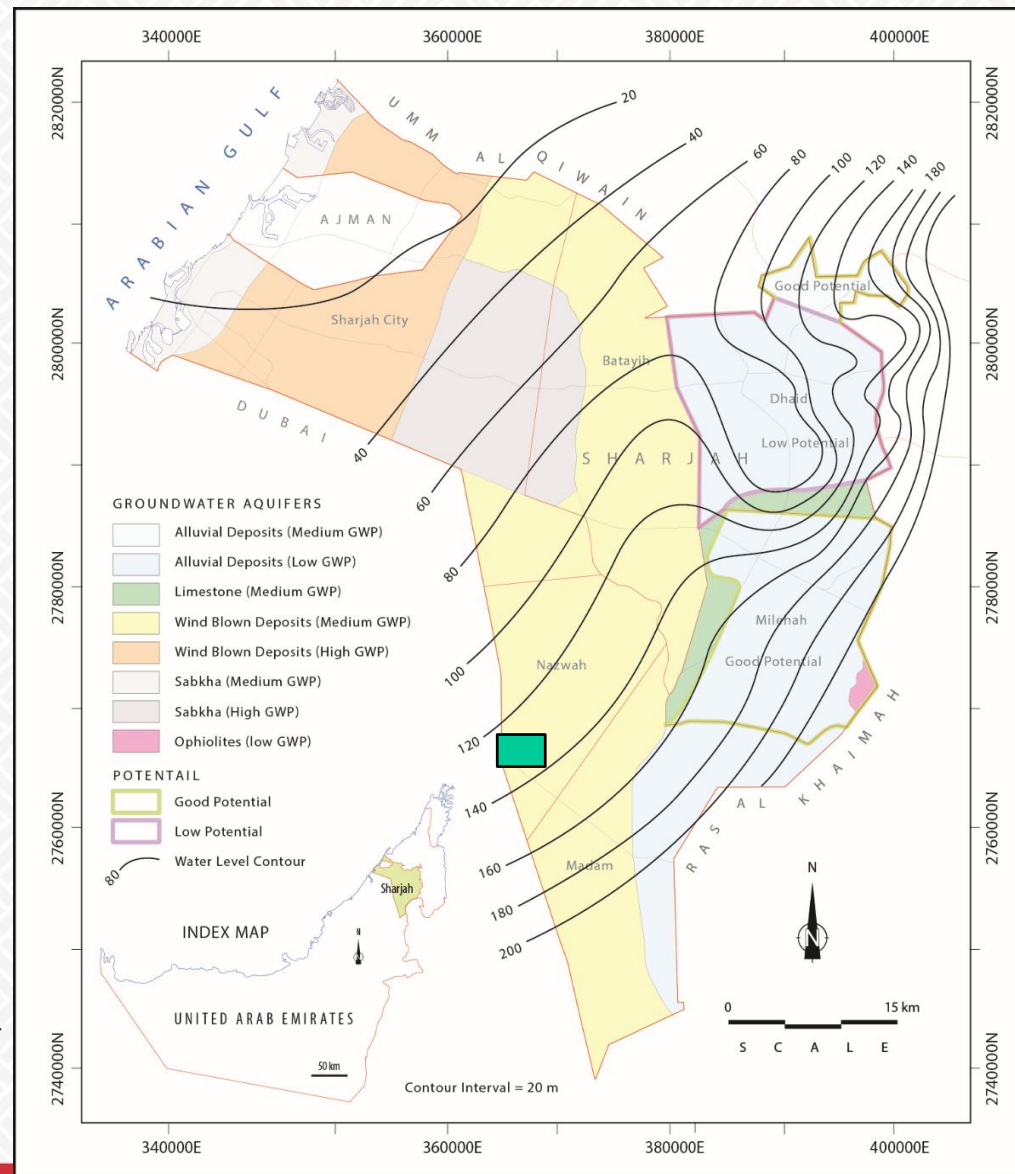
- ❑ Total capacity (2018) = 9.03 bm^3/year
- ❑ Total production (2018) = 5.75 bm^3/year
- ❑ The cost of desalination reduced significantly
- ❑ Electricity Generation
- ❑ Demand Fluctuation
- ❑ Development of Freshwater Strategic Reserves



ASR-System in Sharjah Emirate- Nazwah

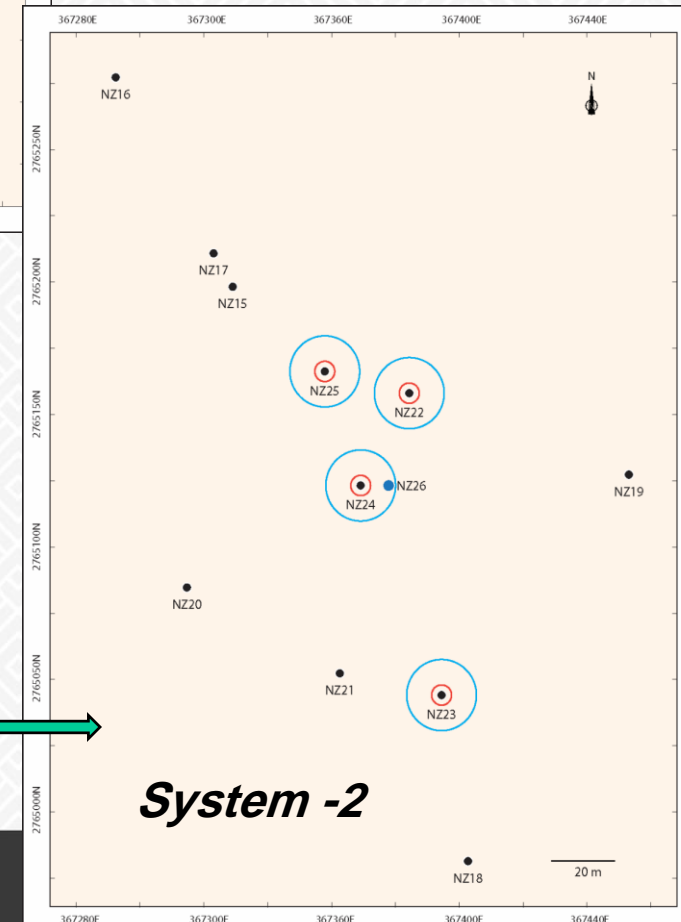
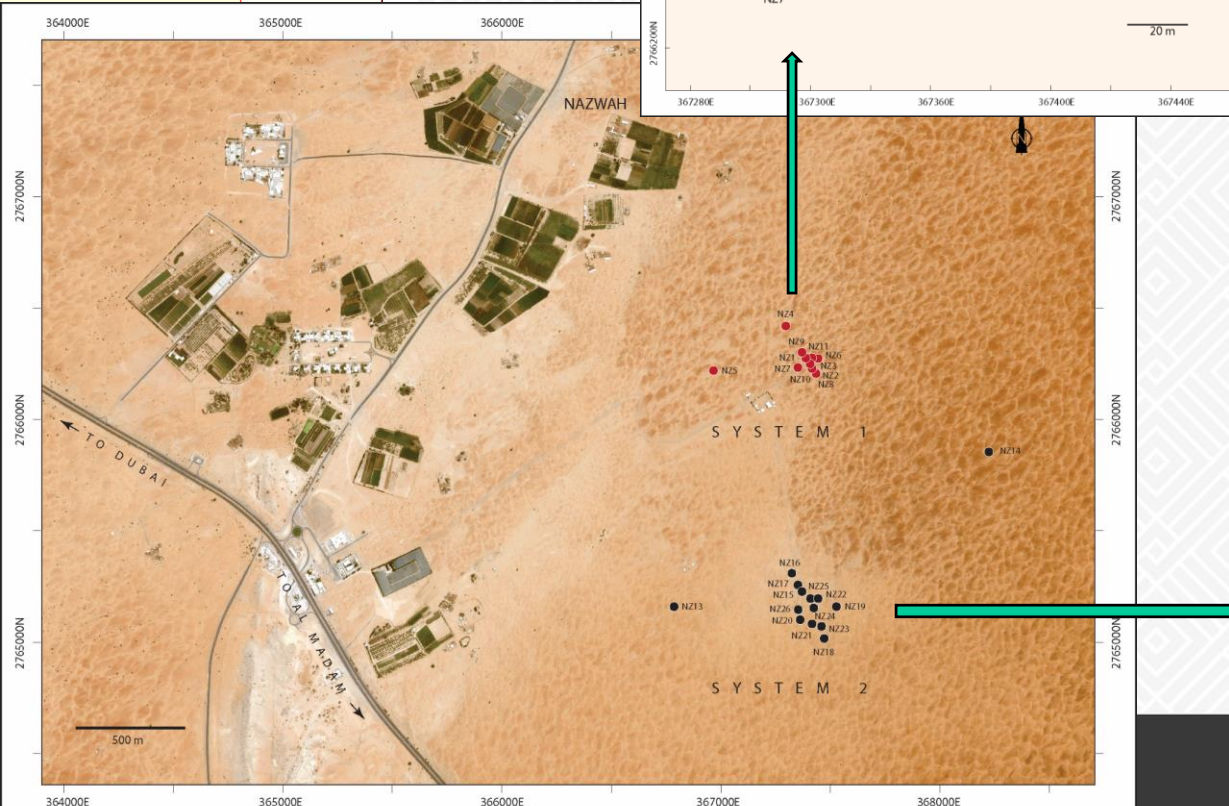
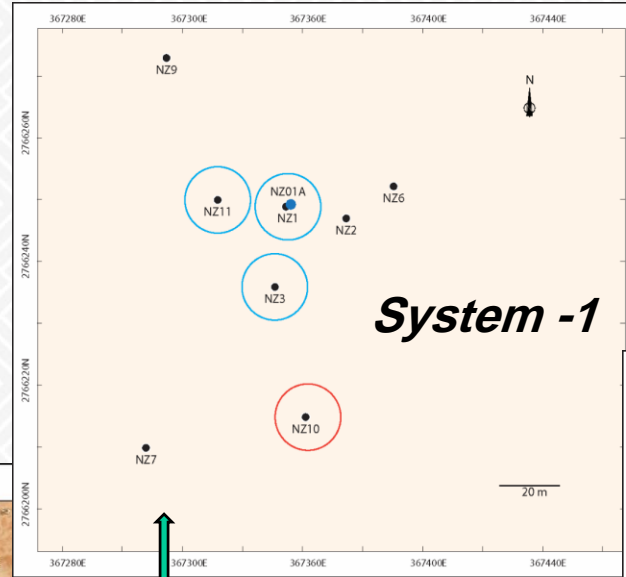
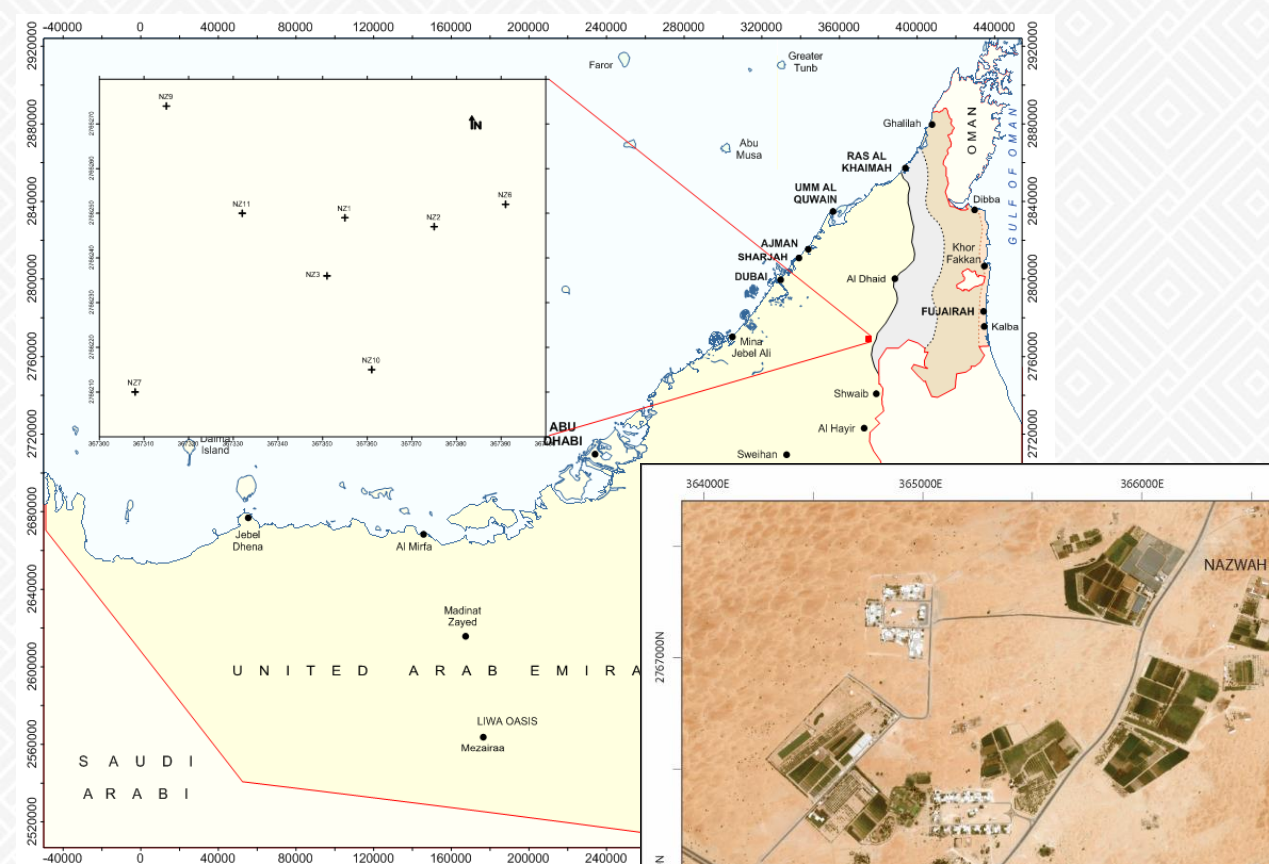


Location map



Hydrogeology map

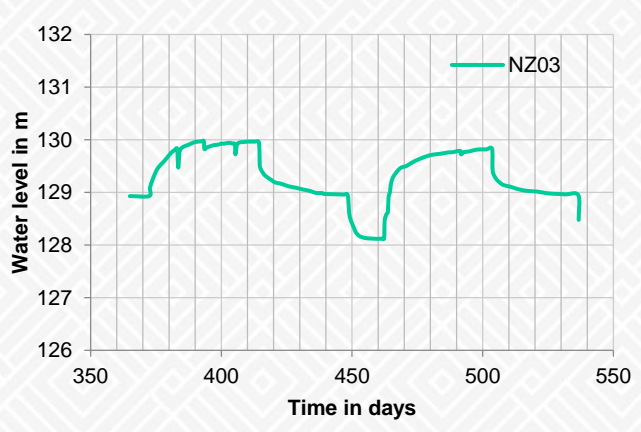
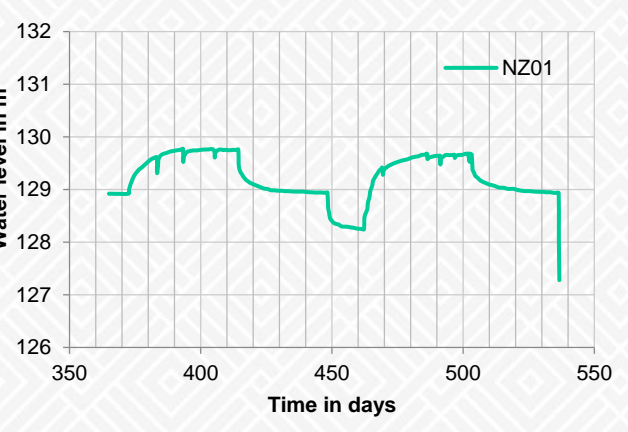
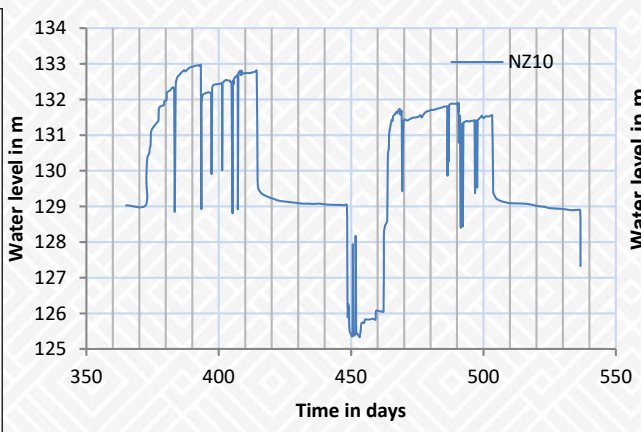
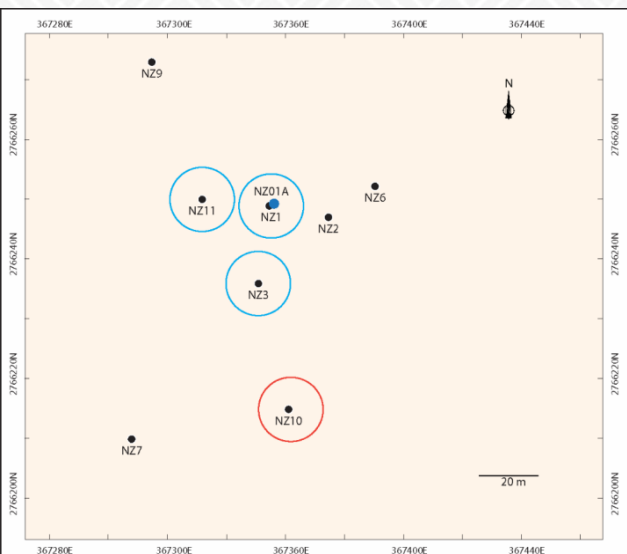
ASR-System in Sharjah Emirate- Nazwah



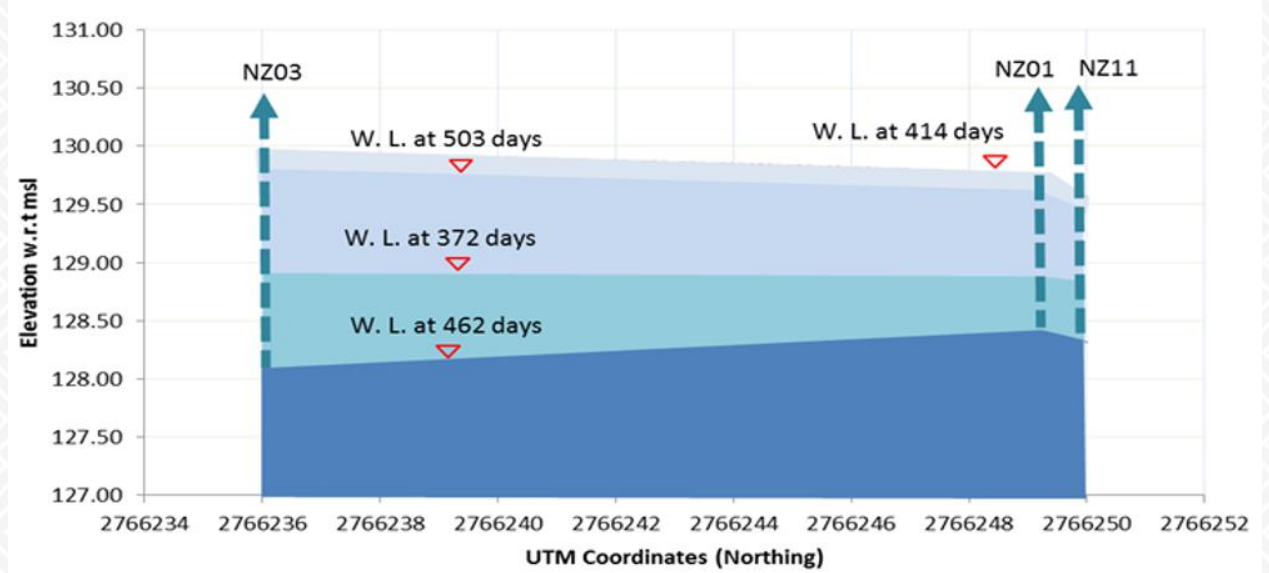
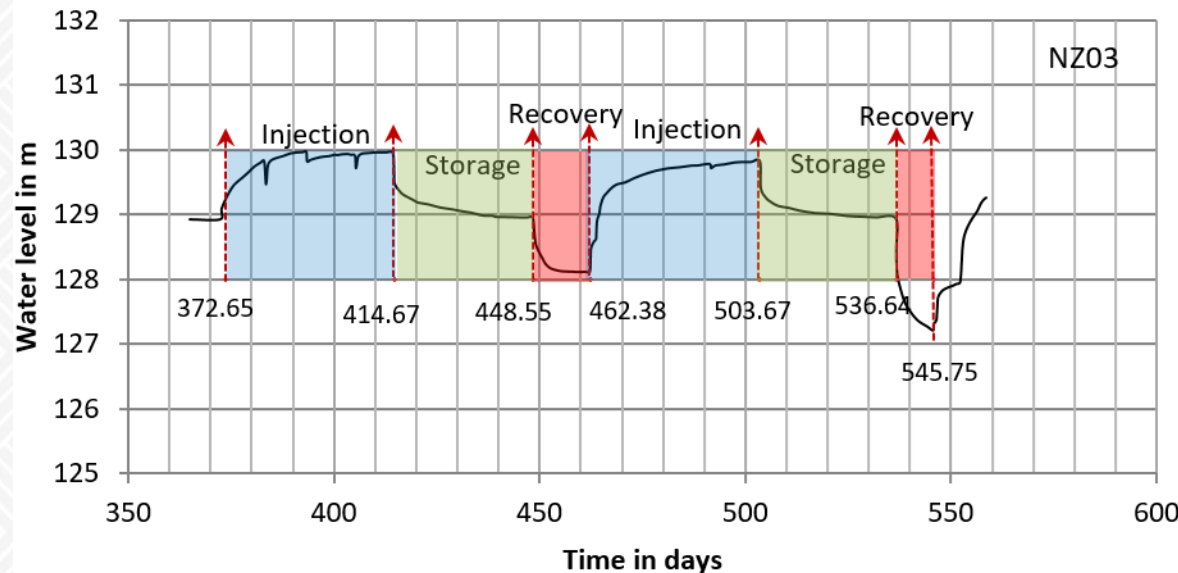
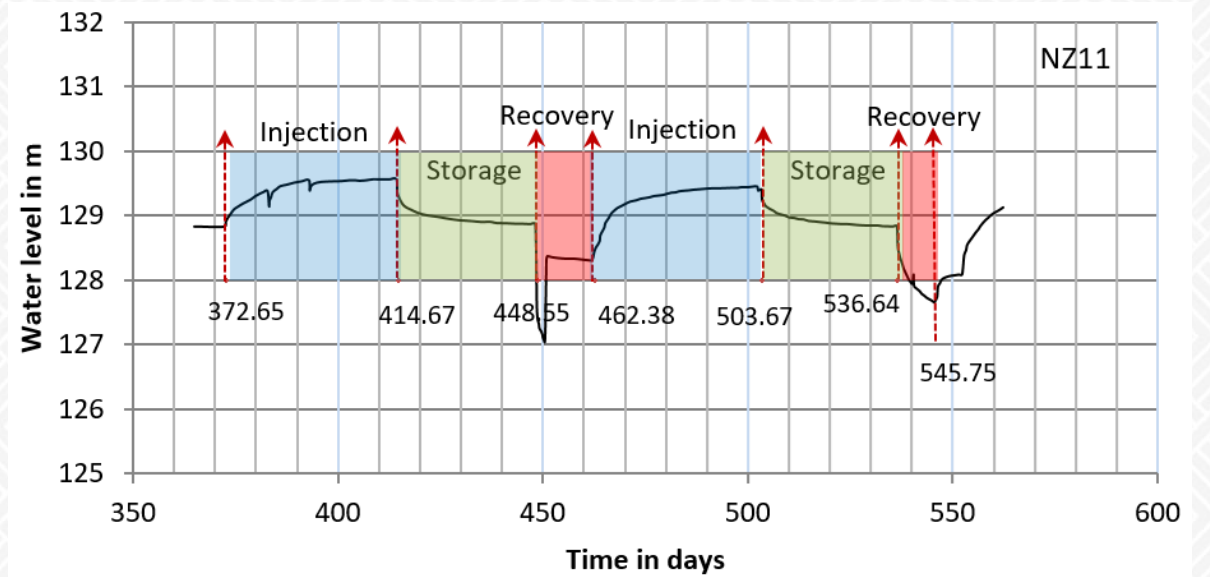
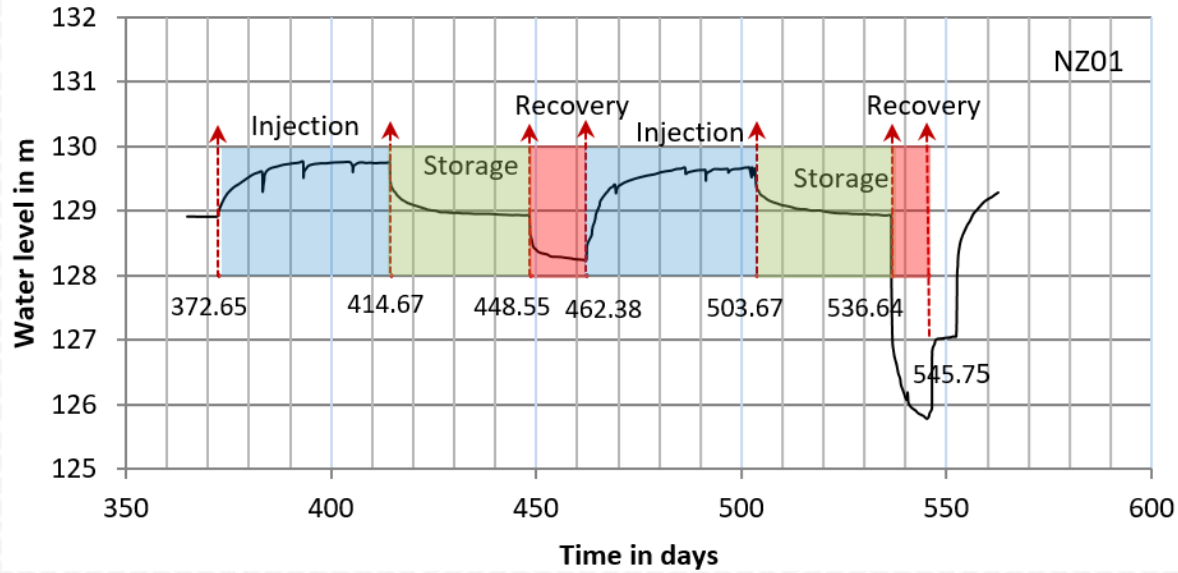
Operation Schedule and Water Level Measurements

Cycle	Active well	Injection/Recovery/Storage	Start Date	End Date	Pumping rate m ³ /day	Days	Total volume (m ³)
System-1							
Cycle-10	NZ1A, NZ10	Injection	18/10/2011	17/12/2011	727	60	43638
		Storage	17/12/2011	27/02/2012		72	
	NZ1, NZ1A, NZ10	Recovery	27/02/2012	27/04/2012	-625	60	37488
		Standby	27/04/2012	30/04/2012		3	
Cycle-11	NZ1A, NZ10	Injection	30/04/2012	08/06/2012	1038	39	40477
		Storage	08/06/2012	10/08/2012		63	
	NZ1, NZ1A, NZ10	Recovery	10/08/2012	10/10/2012	-625	61	38135
Cycle-12	NZ1A, NZ10	Injection	31/10/2012	27/11/2012	748	27	20215
		Storage	27/11/2012	27/11/2012		0	
	NZ1, NZ1A, NZ10	Recovery	27/11/2012	06/01/2013	-672	40	26883
Cycle-13	NZ1A, NZ10	Injection	04/03/2013	02/06/2013		57	44638

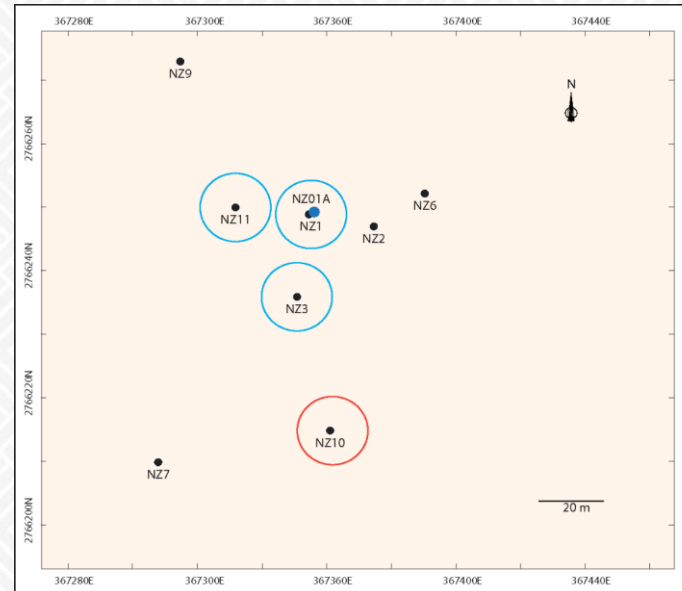
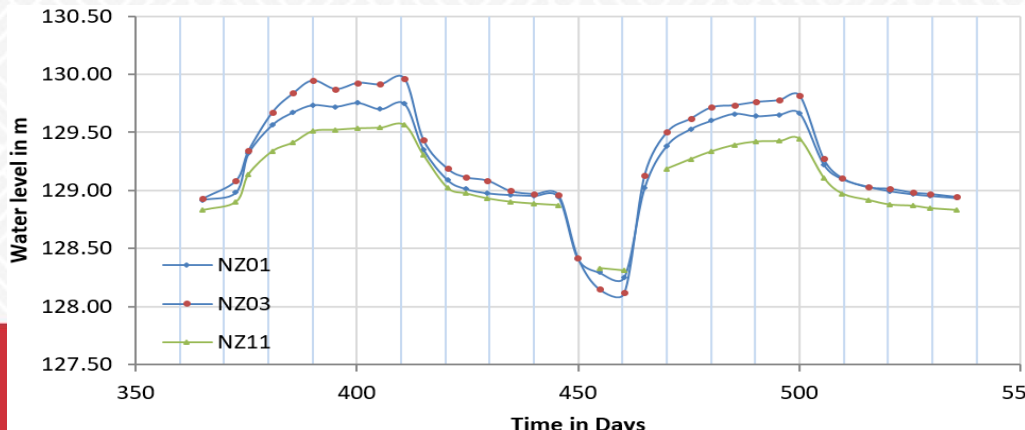
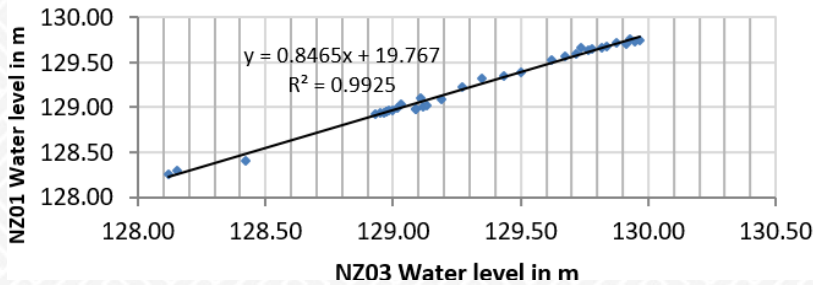
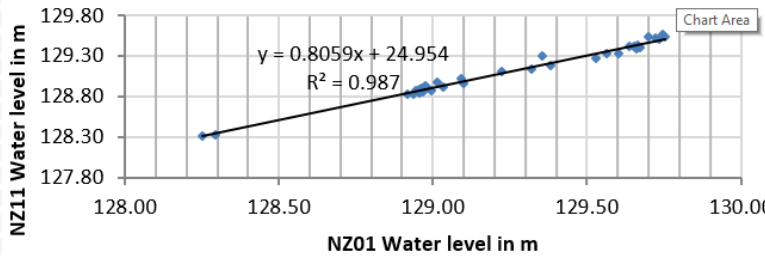
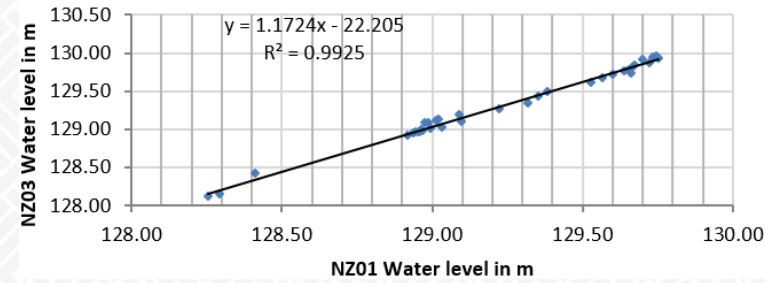
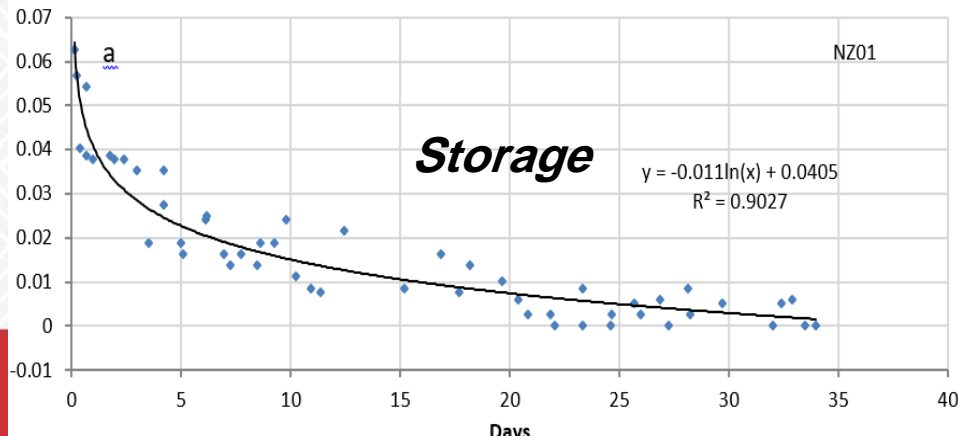
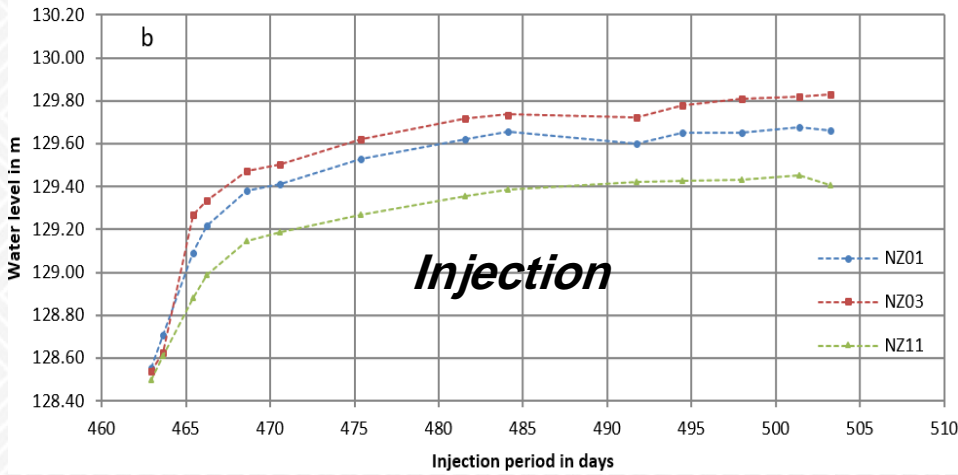
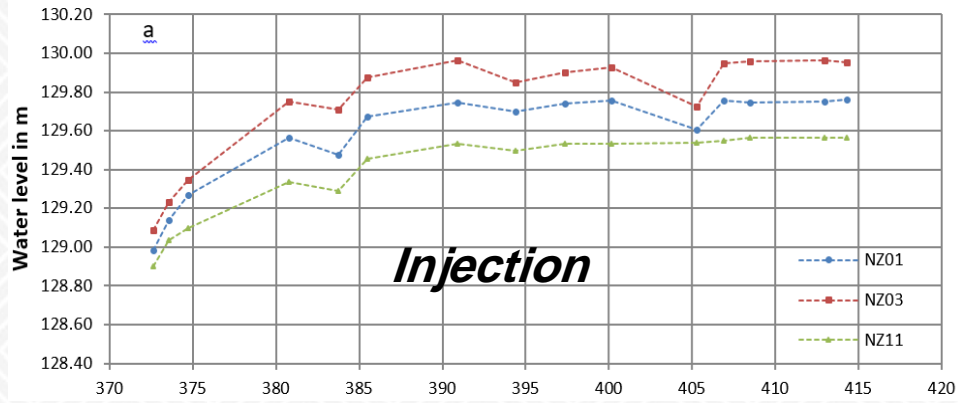
Cycle	Active well	Injection/Recovery/Storage	Start Date	End Date	Pumping rate m ³ /day	Days	Total volume (m ³)
System-2							
Cycle-5	NZ23, NZ24, NZ26	Injection	12/10/2010	22/03/2011	981	161	158998
		Storage	22/03/2011	31/05/2011		70	
	NZ23, 24, 25, 26	Recovery	31/05/2011	17/10/2011	-925	139	129488
		Standby	17/10/2011	22/10/2011		5	
Cycle-6	NZ23, NZ24, NZ26	Injection	22/10/2011	27/02/2012	1019	128	131432
		Storage	27/02/2012	12/06/2012		106	
	NZ23, 24, 25, 26	Recovery	12/06/2012	31/10/2012	-873	141	124034
		Standby	31/10/2012	05/11/2012		5	
Cycle-7	NZ23, NZ24, NZ26	Injection	05/11/2012	27/11/2012	823	22	18127
		Storage	27/11/2012	27/11/2012		0	
	NZ23, 24, 25, 26	Recovery	27/11/2012	31/12/2012	-808	34	27481
		Standby	31/12/2012	26/01/2013		26	



Analysis of Groundwater Levels



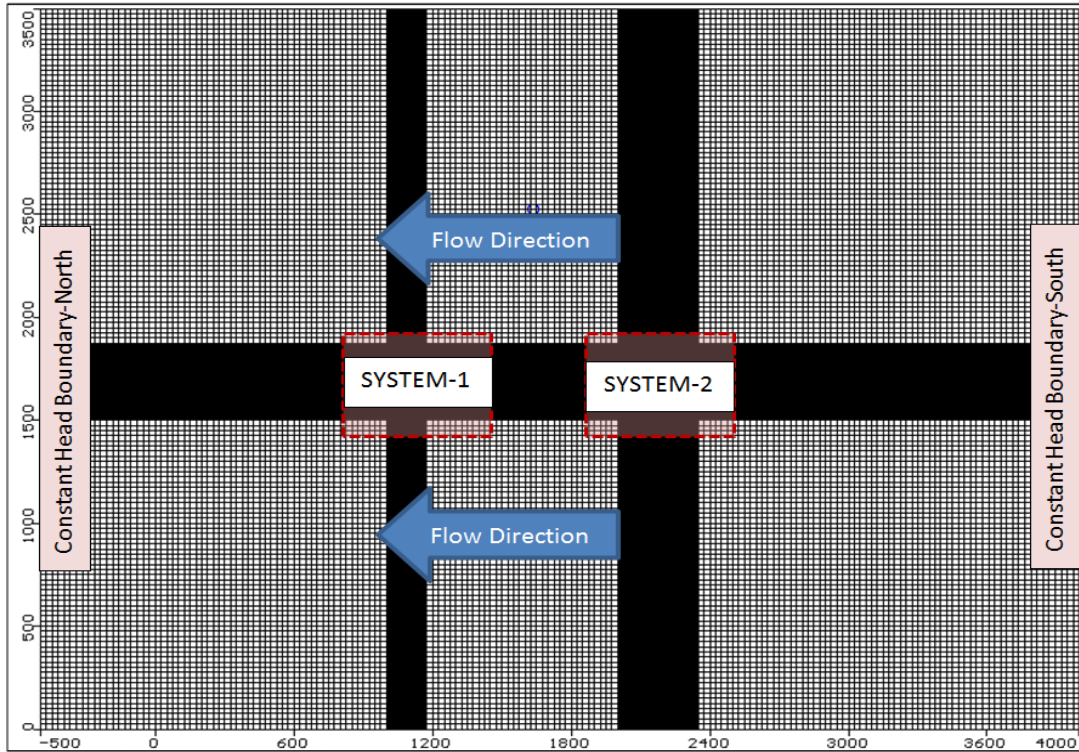
Analysis of Groundwater Levels



WL of NZ01 = 0.8465 x WL of NZ03 + 19.767

WL of NZ01 = 1.2247 x WL of NZ11 + 28.875

ASR Simulation – MODFLOW



Hydraulic Conductivity Inputs for Nazwa ASR Pilot System-1 Model*

Model Layer	Longitudinal Conductivity (K_x) [m/day]	Transversal Conductivity (K_y) [m/day]	Vertical Conductivity (K_z) [m/day]
Layer 1	38.88	3.888	0.389
Layer 2	3.888	0.389	0.039
Layer 3	0.389	0.039	0.0039

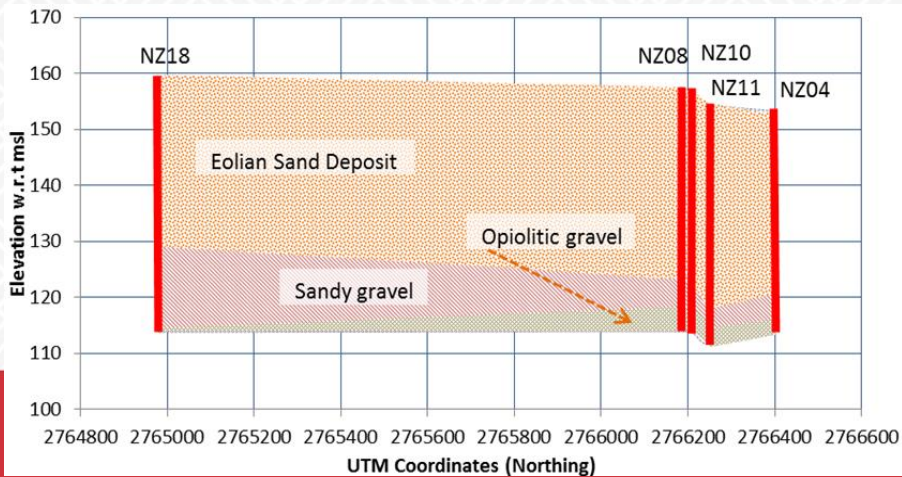
* After SEWA, Schlumberger 2009.

Aquifer parameters

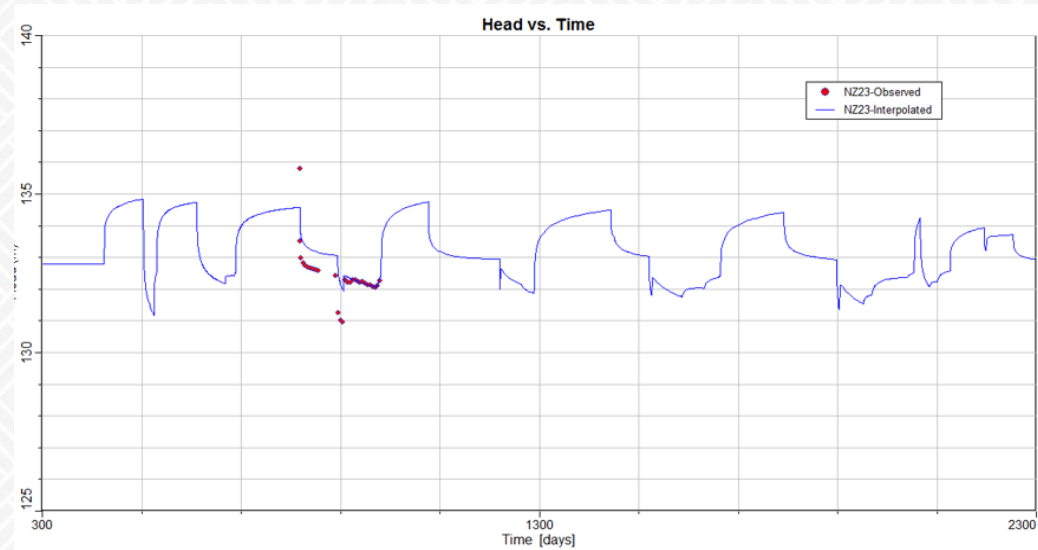
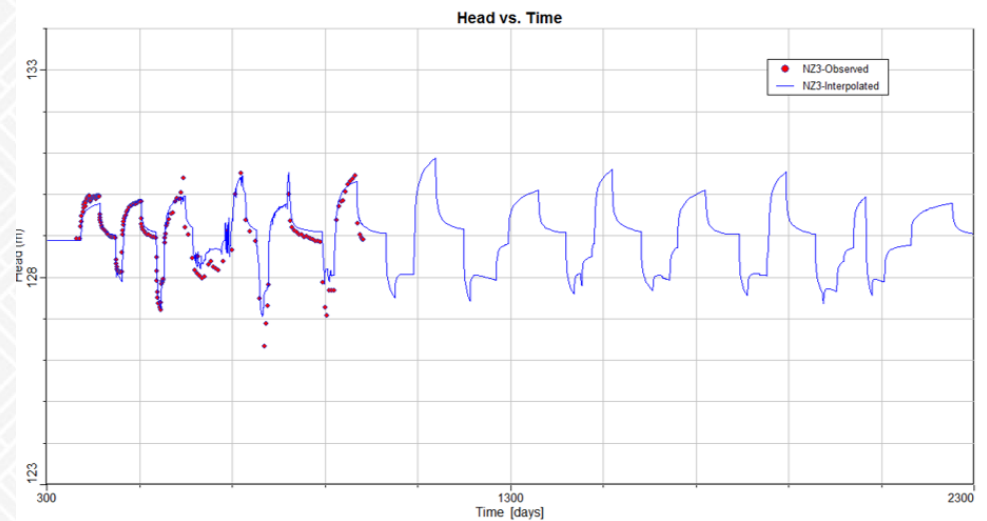
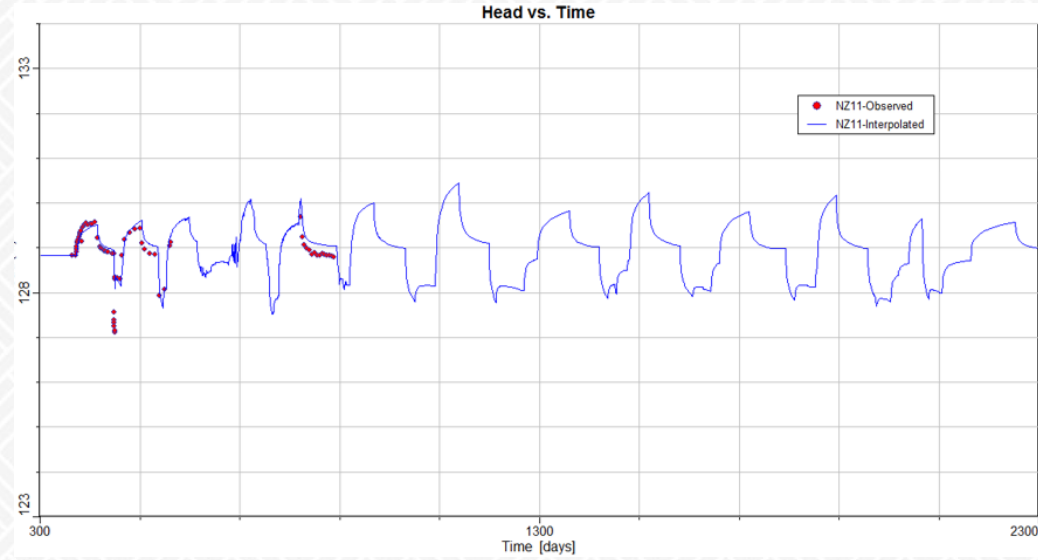
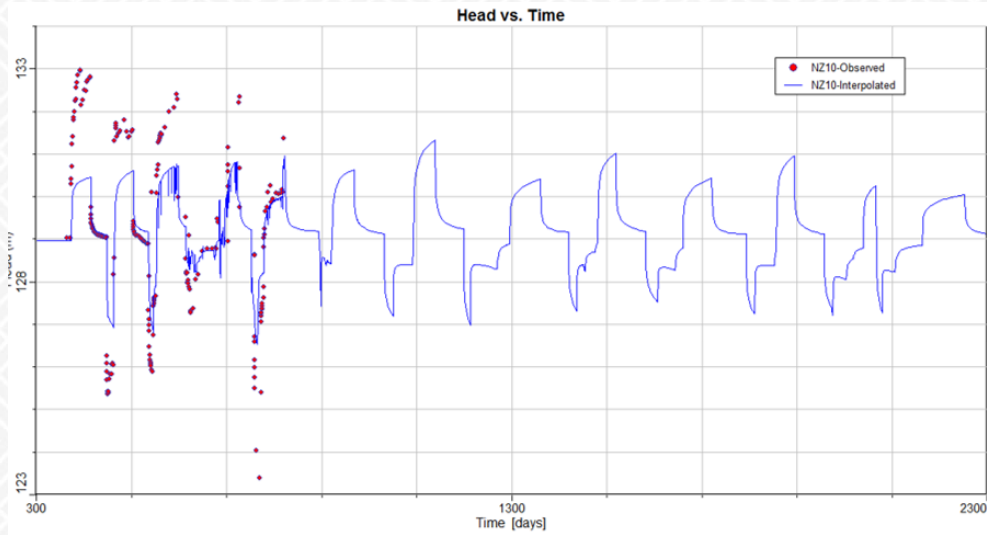
Parameter	Value
K_z/K_x anisotropy	0.01
K_z/K_y anisotropy	0.1
Total porosity	0.3
Effective porosity	0.23
Specific yield, S_y	0.15
Specific storage coefficient S_s	0.0035

Calibrated aquifer parameter

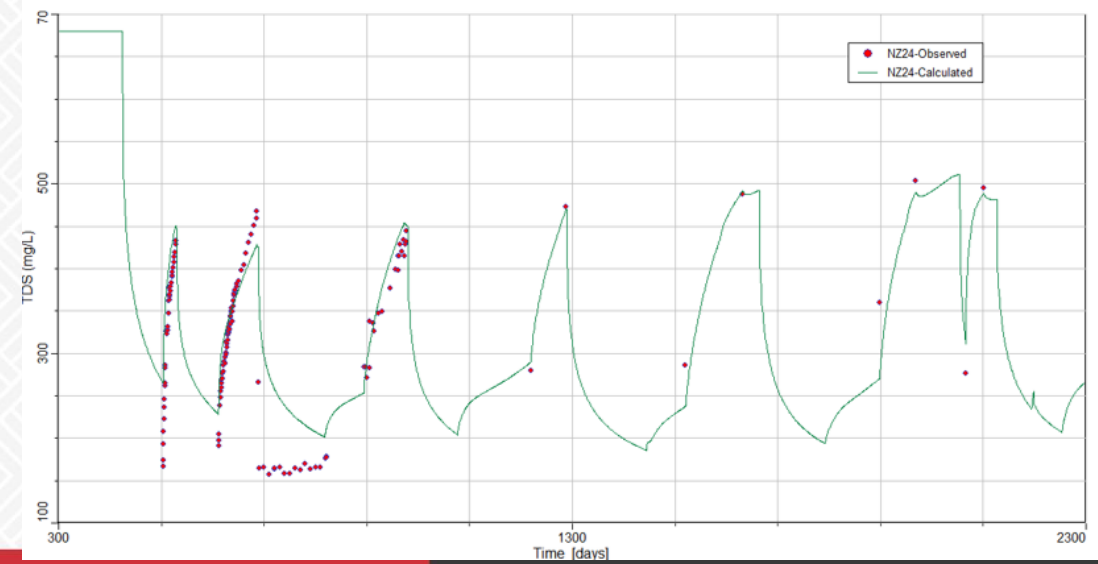
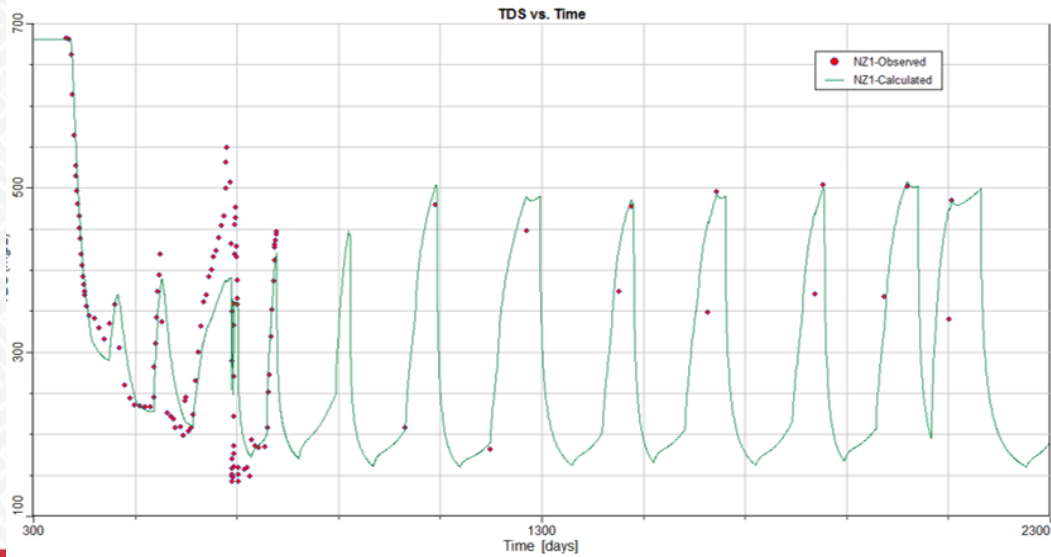
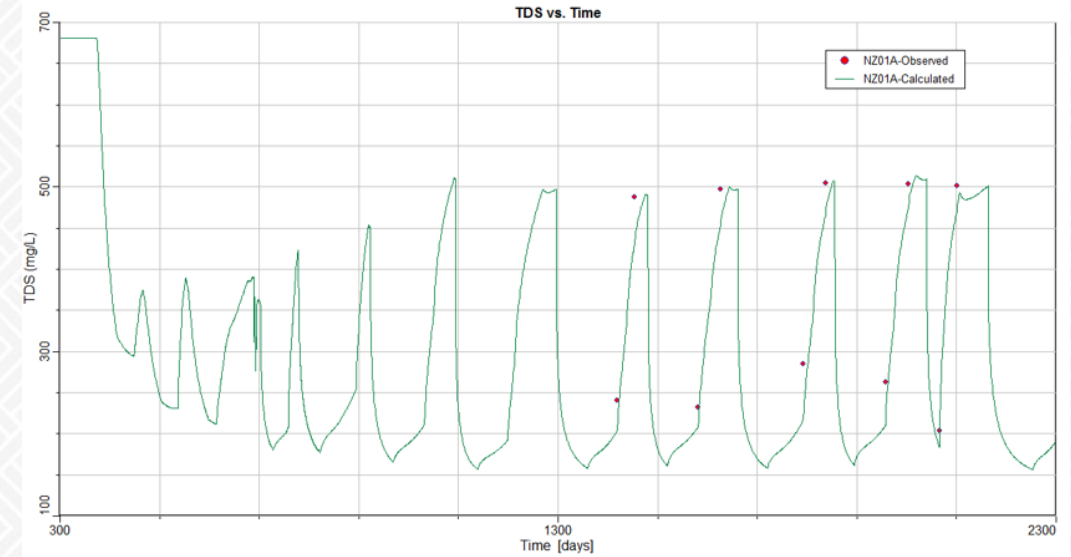
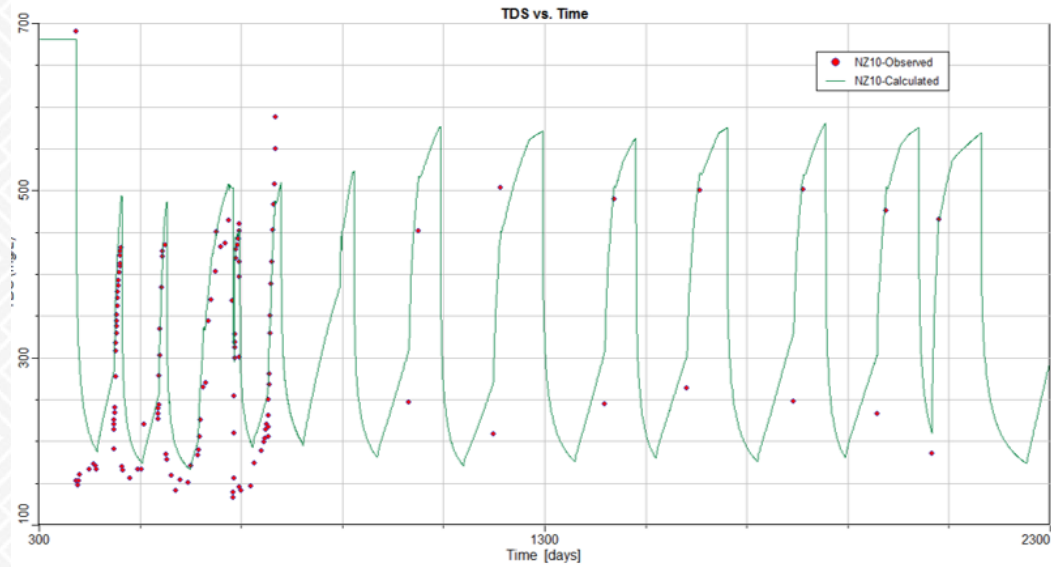
Parameter	Value
K_x/K_z anisotropy	0.01
K_y/K_z anisotropy	0.1
Total porosity	0.25
Effective porosity	0.15
Specific yield, S_y	0.1
Specific storage coefficient S_s	0.001 l/m
Constant Head boundary (South)	136.4m
Constant Head boundary (North)	124.9m



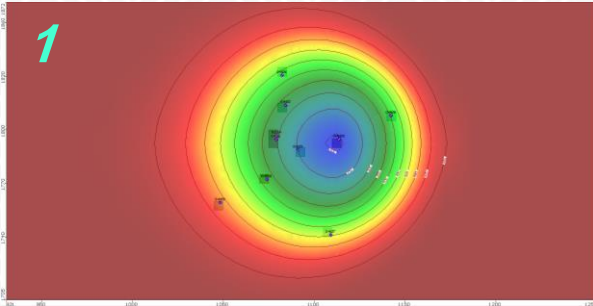
ASR Simulation – MODFLOW: Water Levels



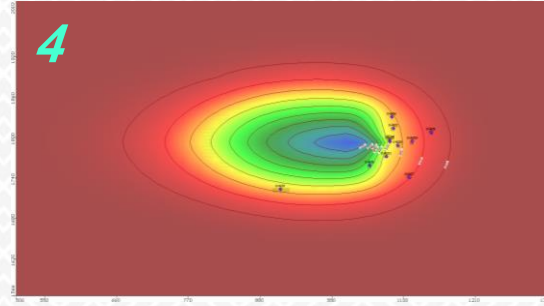
ASR Simulation – MODFLOW: Salinity



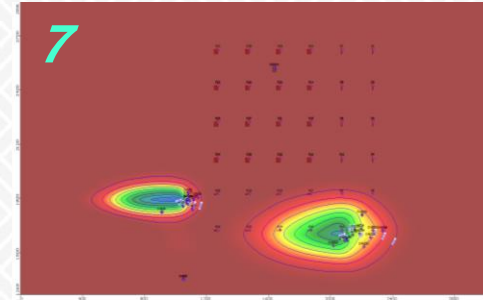
Plume development in single and multiple wells in ASR



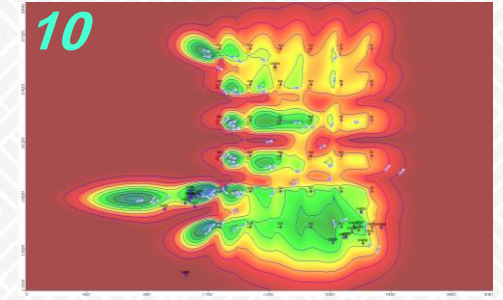
End of injection (1st cycle)



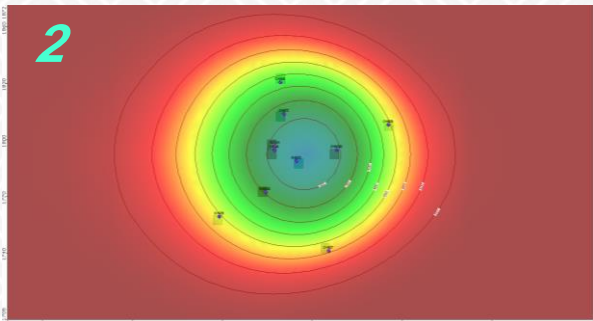
Operation day 1212



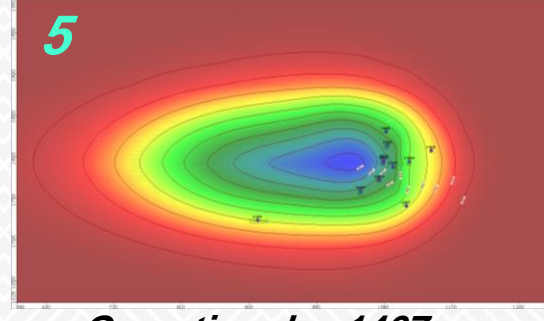
The two systems



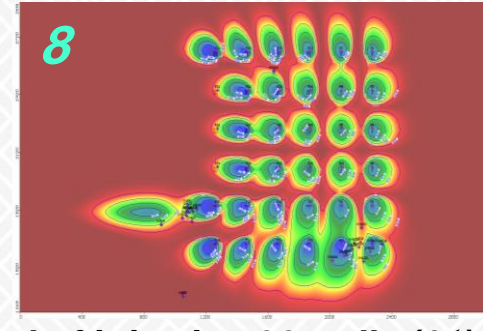
End of recovery 36 wells (1st)



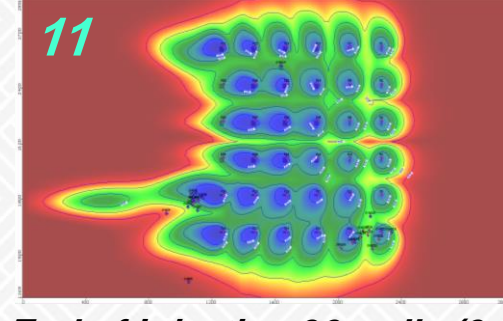
End of storage (1st cycle)



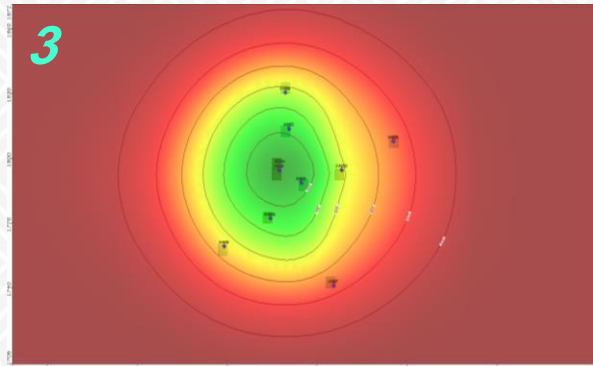
Operation day 1467



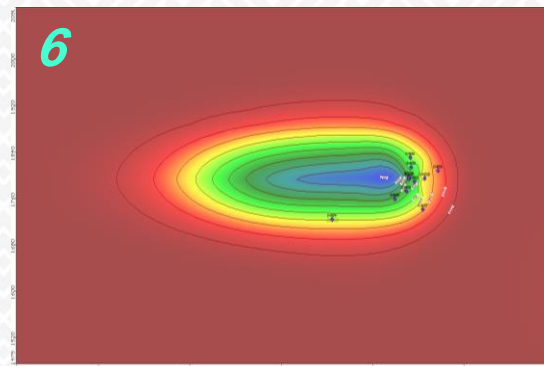
End of injection 36 wells (1st)



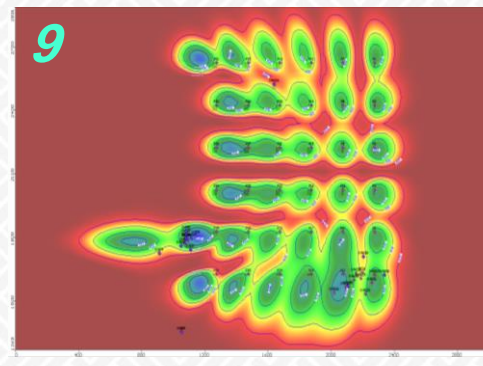
End of injection 36 wells (3rd)



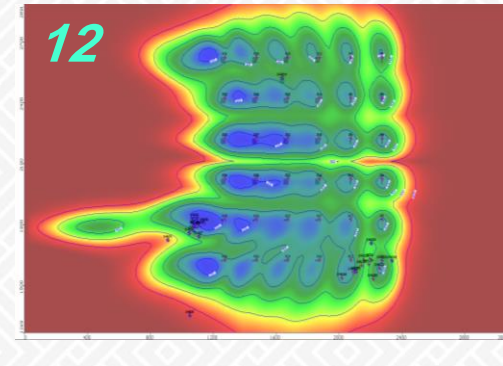
End of recovery (1st cycle)



Day 1602 (end of recovery cycle 9)

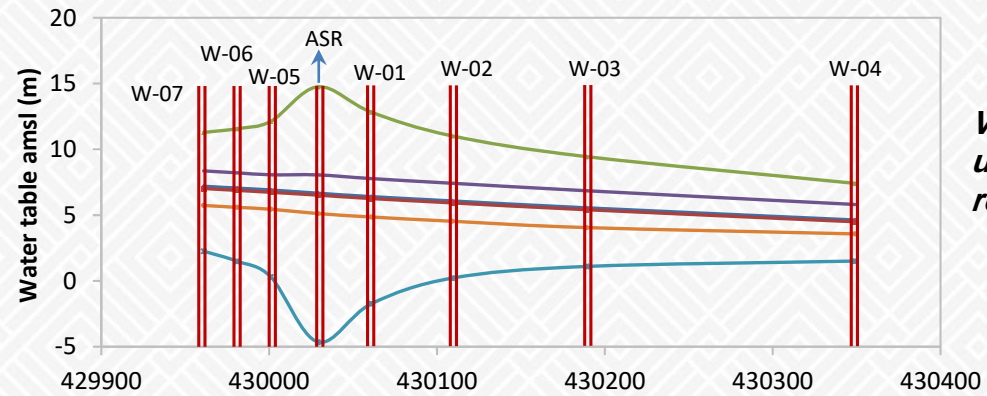
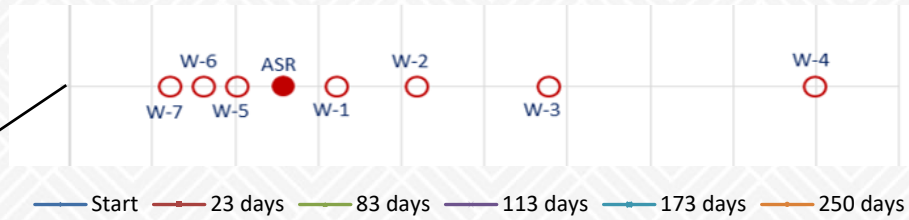
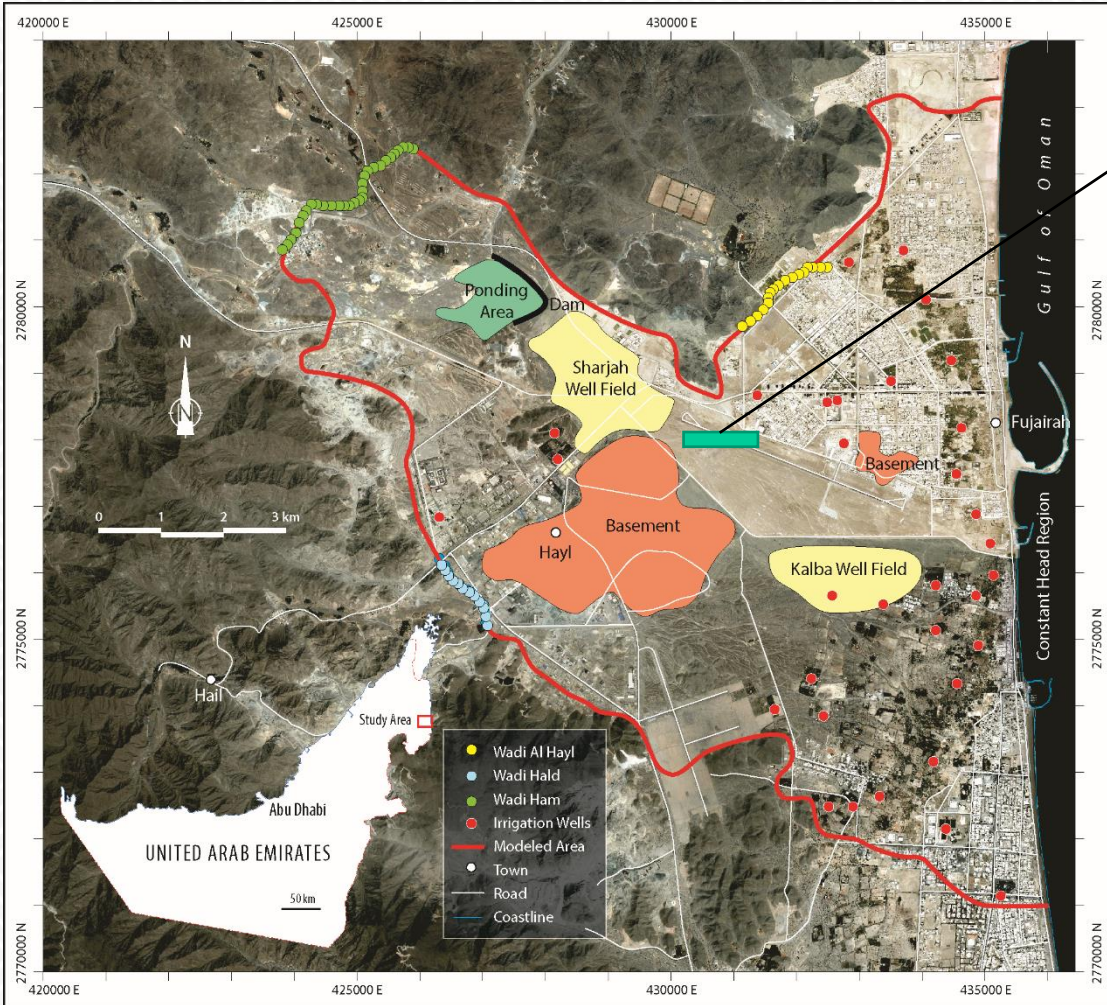


End of storage 36 wells (1st)

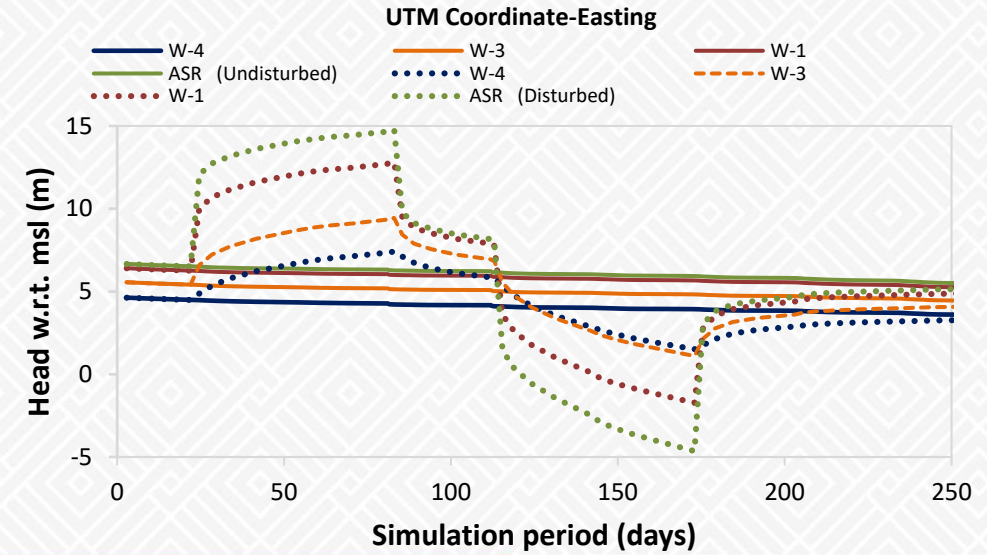


End of storage 36 wells (3rd)

Dynamics of Water Levels in ASR System



Variation of water levels under injection and recovery- Vertical view



Time variation of water levels under injection and recovery in ASR and other observation wells

Concluding Remarks

- **ASR systems provides a feasible option for storage of the excess of water and recovery during high demand .**
- **ASR projects can not be duplicated – each project has its own characteristics and operation parameters. The presented results are specific of the studied areas.**
- **Aquifer geological, hydrogeological and hydrochemical characteristics must be carefully Investigated.**
- **Variable density flow models would provide better simulation of ASR systems.**

Thank you

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