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Strategic Water Reserve's effect on the water supply system in Abu Dhabi: A System Dynamics Approach

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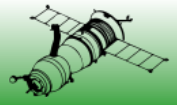
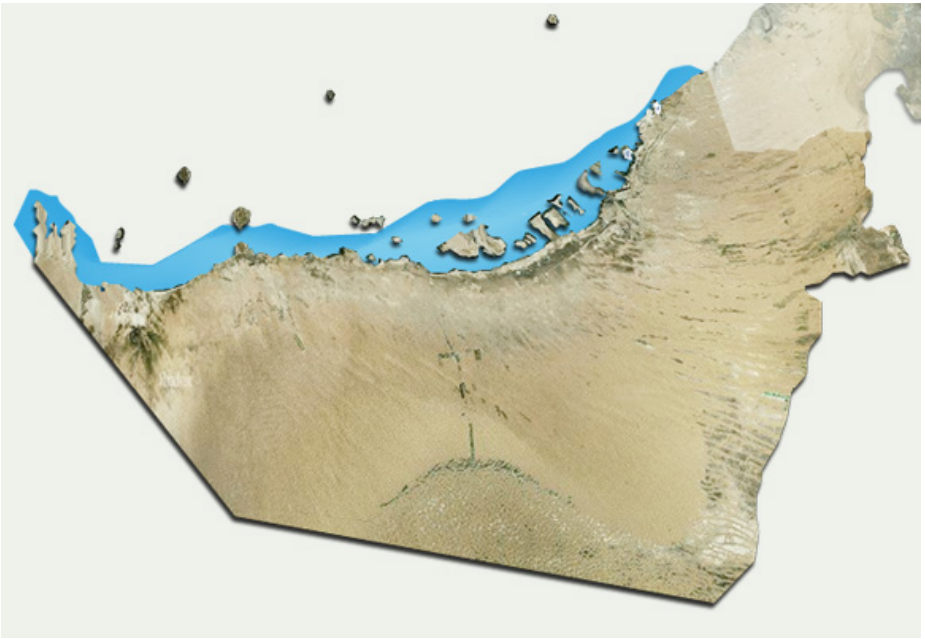



Background

- In Abu Dhabi the main source of water is groundwater
- The UAE lies in an arid area, thus Abu Dhabi has:
  - Low rainfall levels
  - Low annual groundwater recharge rate
- Non-conventional sources of water
  - Treated wastewater
  - Desalination
- 100% of the potable water comes from Desalinated water

Emirate of Abu Dhabi



Source: http://www.uaeim.ae

Desalination Concerns

Environmental concerns

- 30% of the total GHG emissions come from water & electricity production
- Discharged brine & cooling water raise both salinity & temperature of seawater endangering marine biodiversity

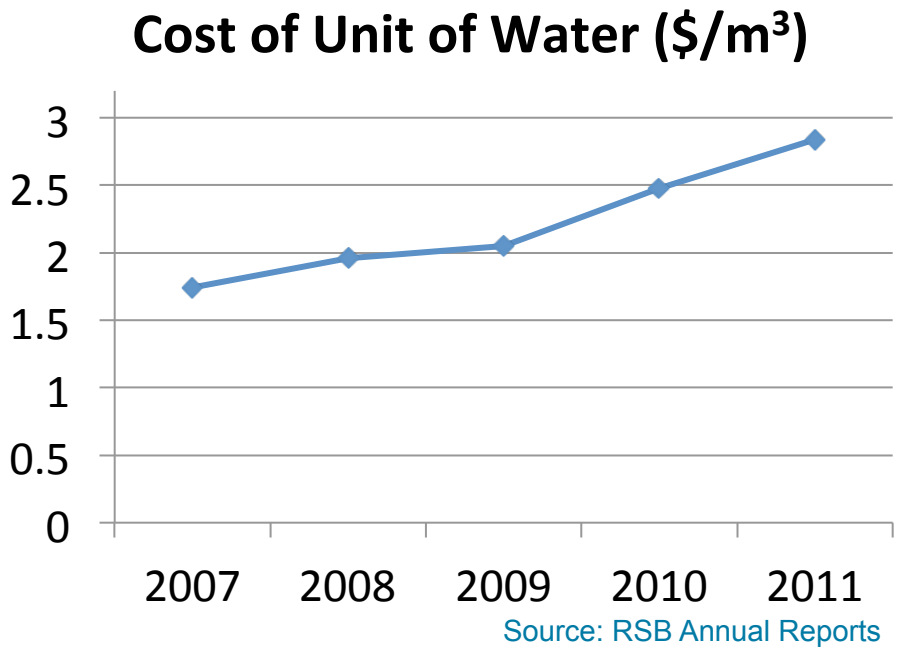
Bleached Coral

Source: scienceyoulove

Desalination Concerns

Economic concerns

- The cost of unit of water is increasing
- 51% of the fuel consumption goes to water & electricity production
- Vulnerability to breakdowns & pollution (oil spills & red tide)



Source: RSB Annual Reports

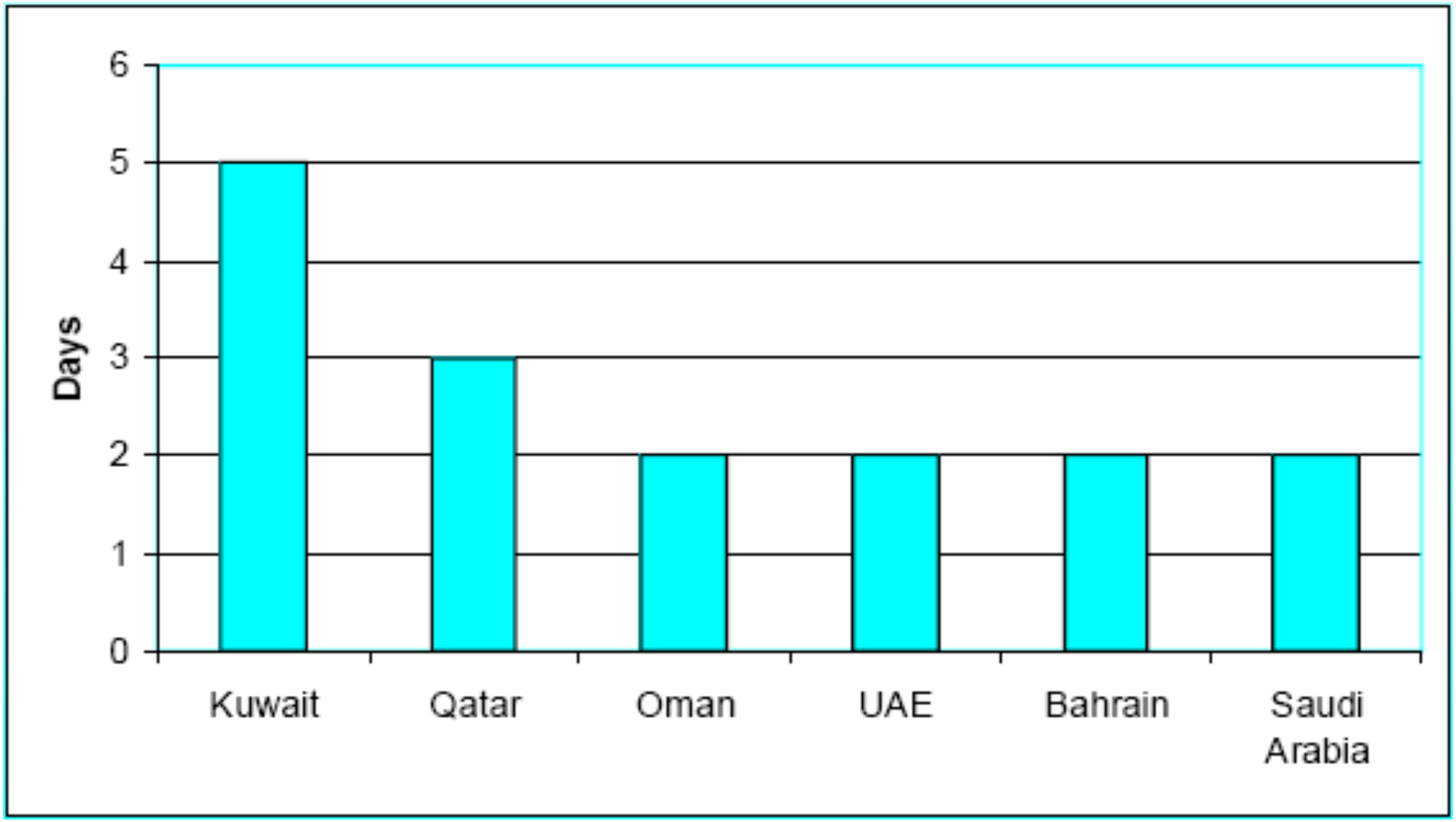
Red Tide

- Natural Disaster
- Harmful Algal Blooms (HAB's)
- 5000 kinds of phytoplankton
- Kills marine life
- Stop desalination plants

#	State	Year of Phenomenon	Kinds of perished marine animals
1	Sultanate of Oman (Salala)	1976	Fish
2	Kingdom of Bahrain and Kingdom of Saudi Arabia	1987	Mammals, Birds and Sea Star
3	Sultanate of Oman	1988	Fish and Marine Organisms
4	Kuwait	1999	Fish
5	Iran	1996	Fish
6	UAE	2000	Fish
7	UAE	2008	Fish
8	UAE	2009	Fish

Source: MOEW

Emergency Water Supply Capacity



Source: Menche, 2010

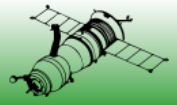
Water Reservoir

Sub-surface Aquifers

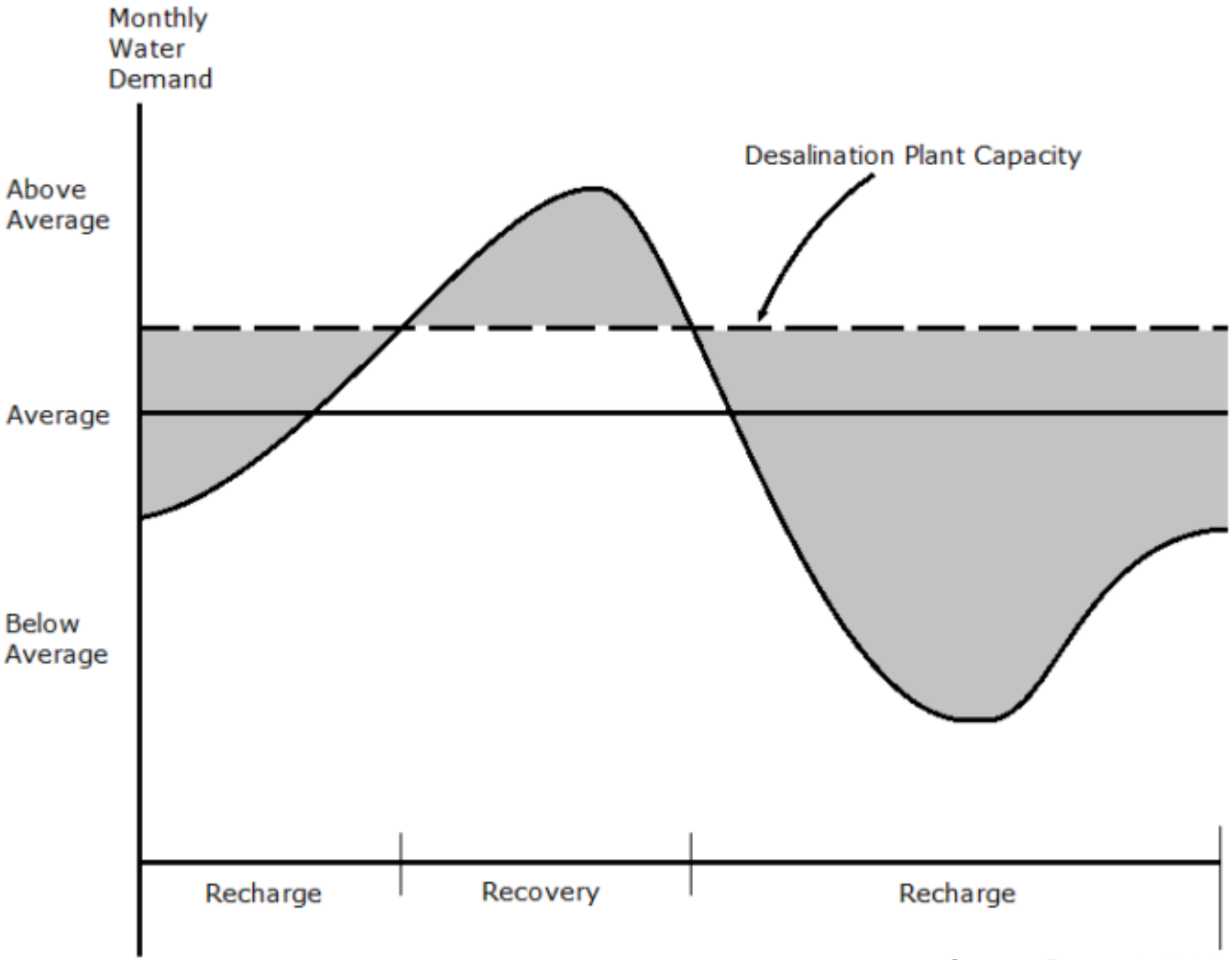
- Cheaper to build and maintain
- Requires smaller surface area with huge storage capacity
- Water quality doesn't change for thousands of years

Surface reservoirs

- Expensive to build
- Expensive to maintain and clean
- Water quality changes after two days of storage

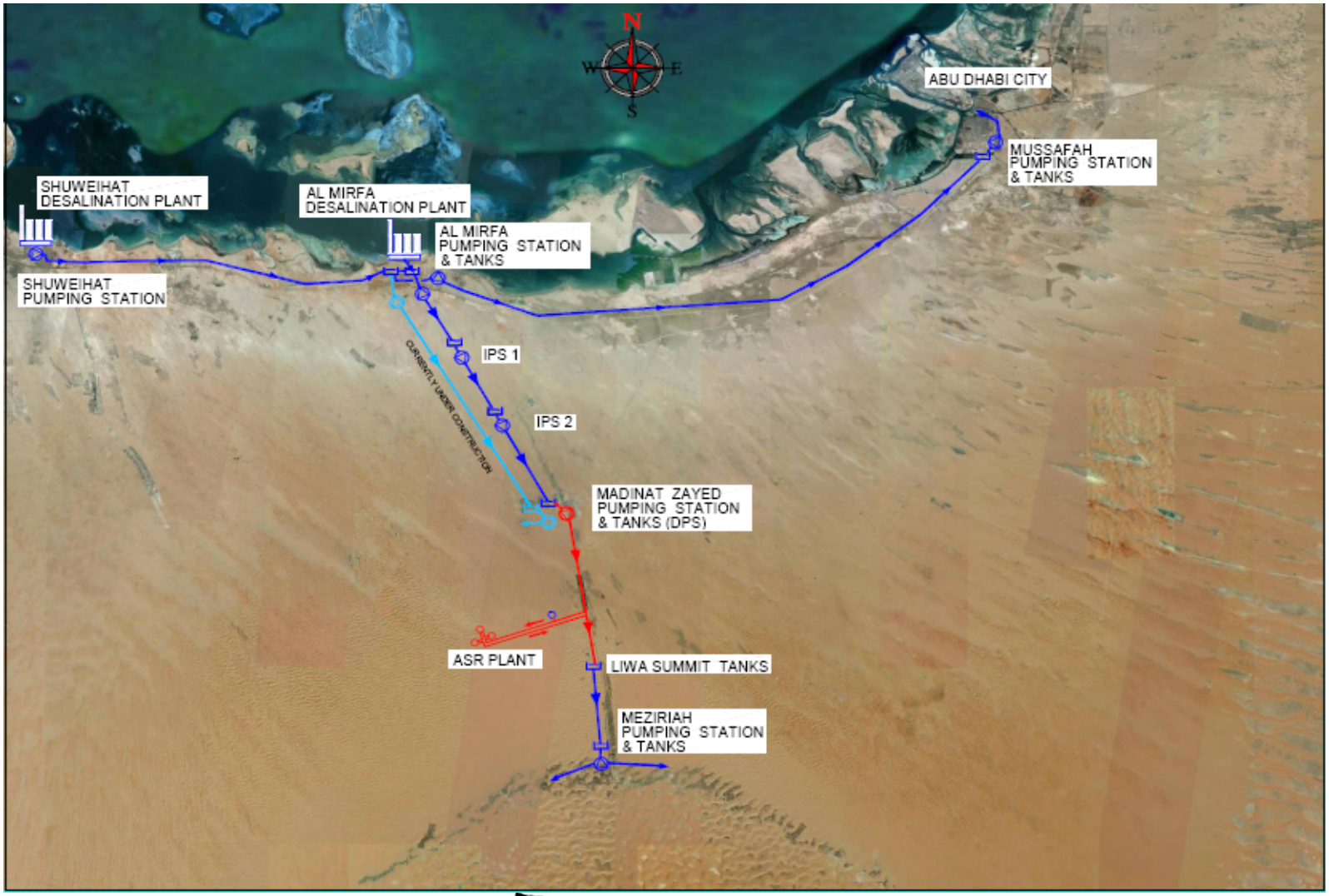

Aquifer Storage and Recovery



Source: Dawoud, 2011

Abu Dhabi Water & Electricity Authority and Environment Agency of Abu Dhabi led a project to use fresh groundwater aquifer as a strategic water reserve to store over-produced water from desalination plants in off-peak demand

Location of the Artificial Storage & Recovery Project



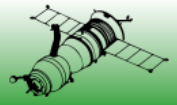
Source: Menche, 2010

Recovery Efficiency

- The Regulation & Supervision Bureau has set 500 ppm of total dissolved solids as a threshold for acceptable quality of supplied water

- Recovery Efficiency = total amount of recovered water / total amount of Stored water

- After running the pilot project:
  - Water quality 430 ppm: recovery efficiency 75 %
  - Water quality 485 ppm: recovery efficiency 85 %
  - Water quality 580 ppm: recovery efficiency 100 %
  - Water quality 725 ppm: recovery efficiency 120 %

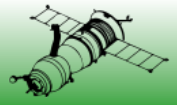

Strategic Water Reserve Plan

INPUT				
Recharge Rate			Duration	Total Volume
5.0 MIGD	0.21 MIGH		2 a	3,650 MIG
22,730 m³/d	947 m³/h	0.263 m³/s	24 months	16.6 Mio.m³

OUTPUT					Supply Rate
Recovery Rate			Duration	Total Volume	1 Mio. Residents
40.0 MIGD	1.67 MIGH		up to 90 d	3,600 MIG	40 IGD/cap.
181,844 m³/d	7,577 m³/h	2.105 m³/s	3 months	16.4 Mio.m³	182 litres/d/cap.

Recharge / Recovery Flow Volume Ratio:	1 : 8
Recharge / Recovery Time Ratio:	8 : 1

Source: Dawoud, 2011

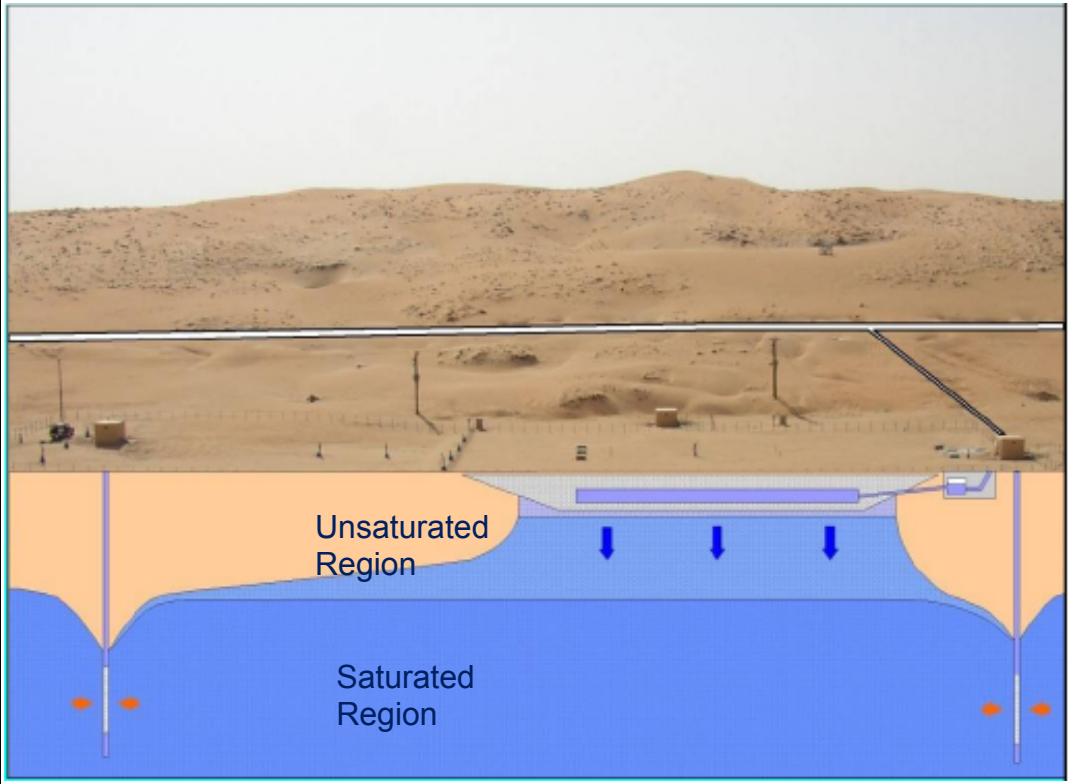

Study Plan

- Simulate the water supply system using System Dynamics and study the serviceability of the current desalination capacity in:
  - The baseline scenario
  - Static effect of ASR on the water supply system
  - The effect of ASR on the water supply system under uncertainties using multivariate simulation of demand seasonality and red tide incidents

Baseline scenario assumptions

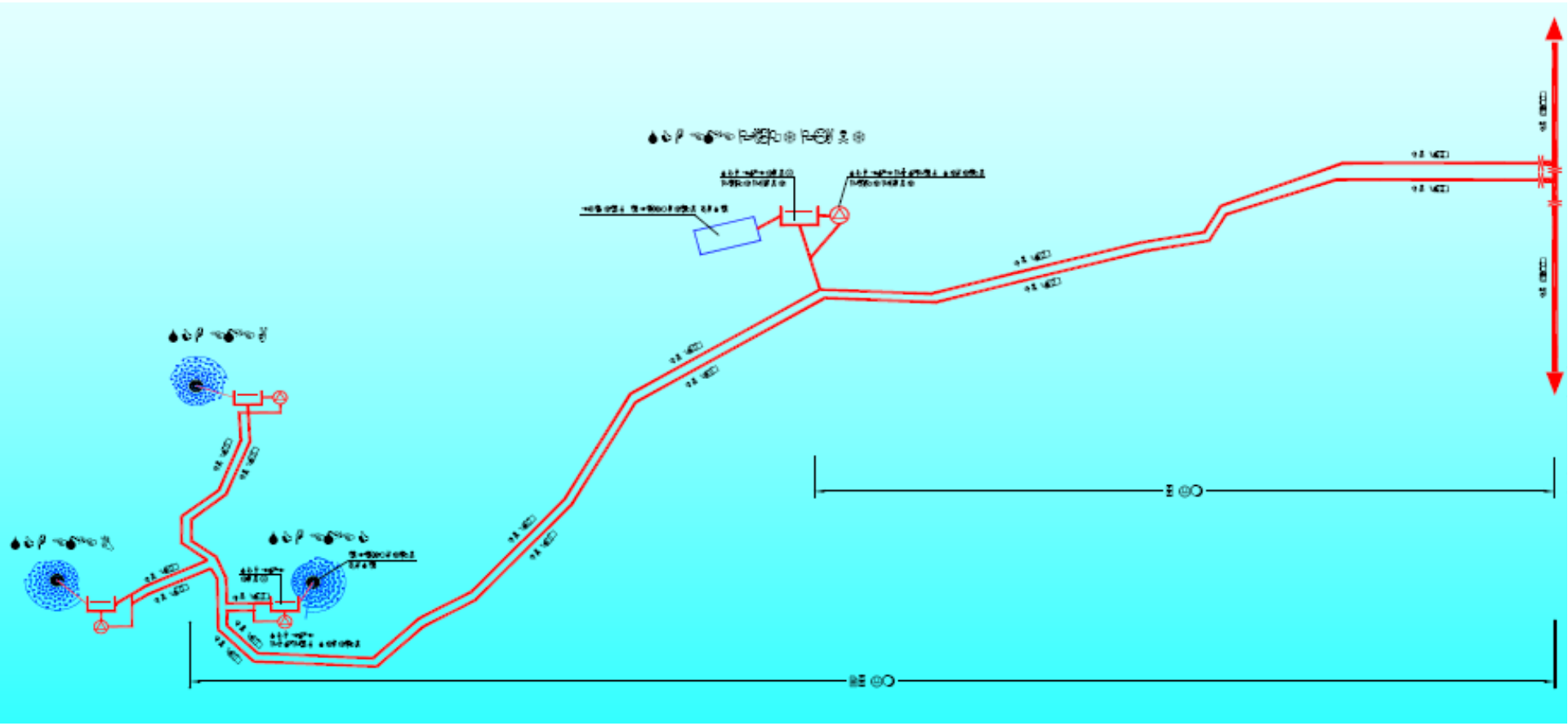
- The simulation is run from December 2010
- Demand is projected using a regression model
- The ASR Project will be built over three years and start at January 2014
- Population starts as 1,967,660 People (SCAD)
- Monthly Net Population Increase rate is 10,430 People/Month (Regression model)
- Recovery Efficiency is taken as 75%
- Number of Infiltration Basins Schemes is 3 schemes
- Number of Recovery Wells per scheme is 105 wells

Artificial Storage using Infiltration Basin



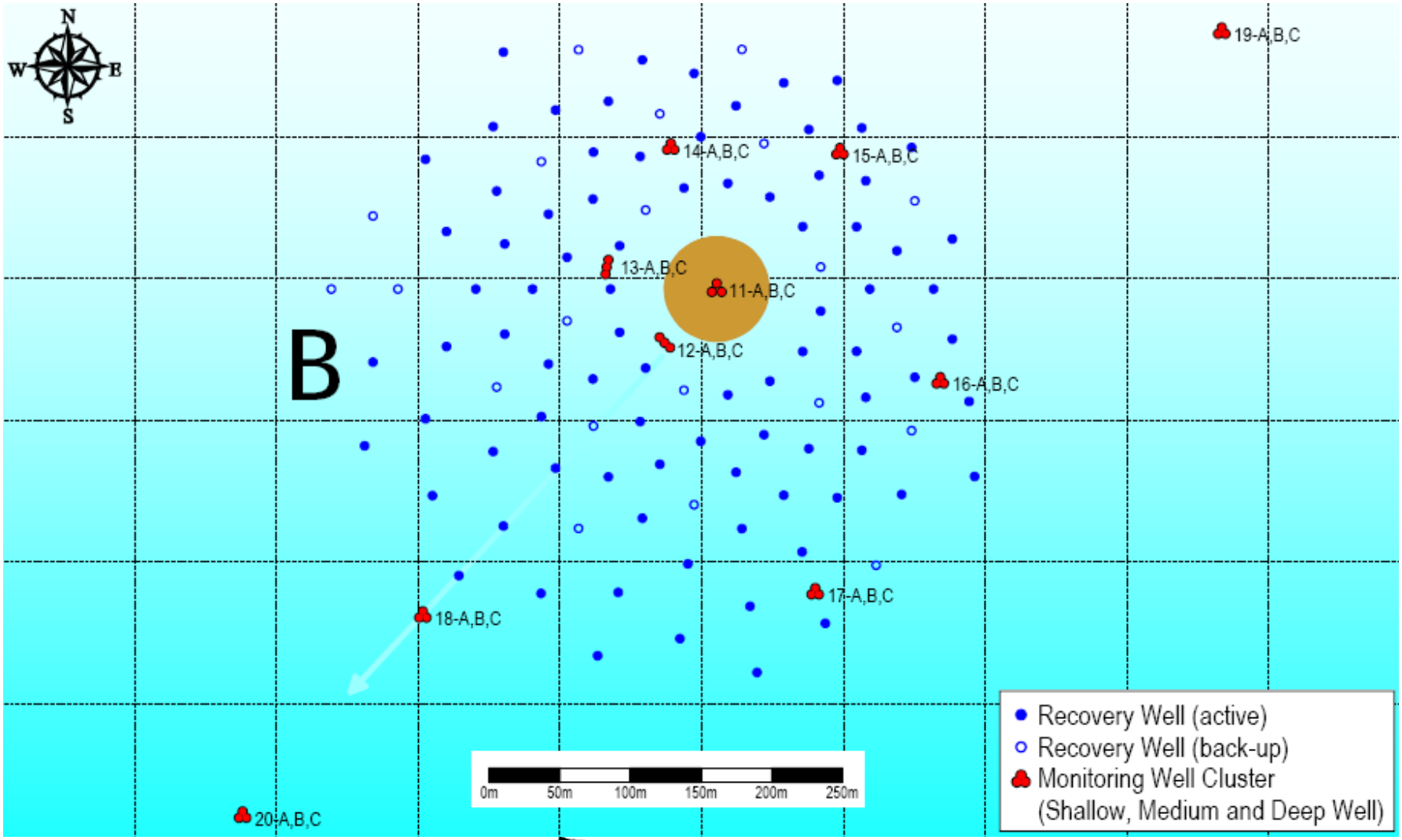
Source: Menche, 2010

Layout of the ASR Project



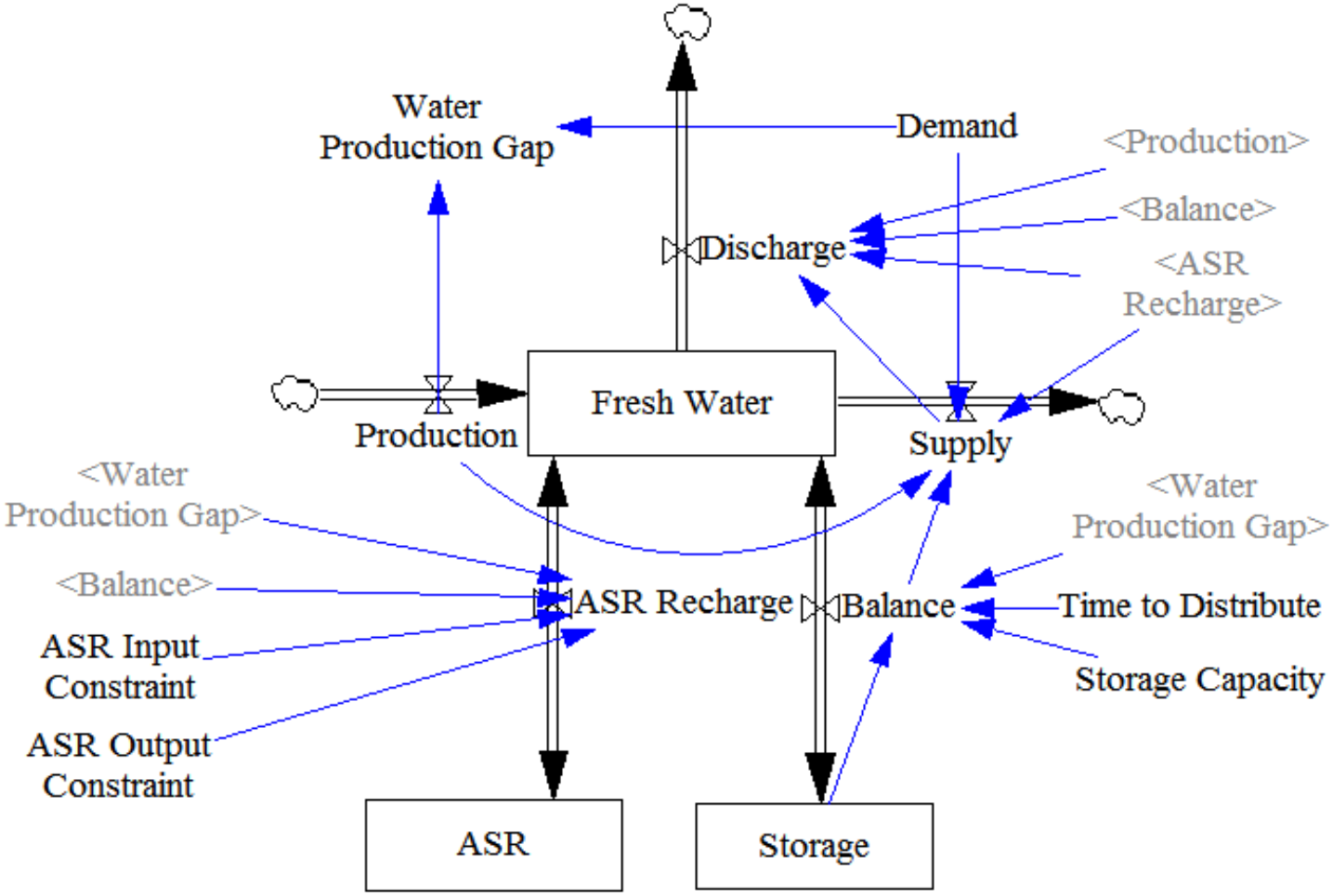
Source: Menche, 2010

Infiltration Basin Scheme

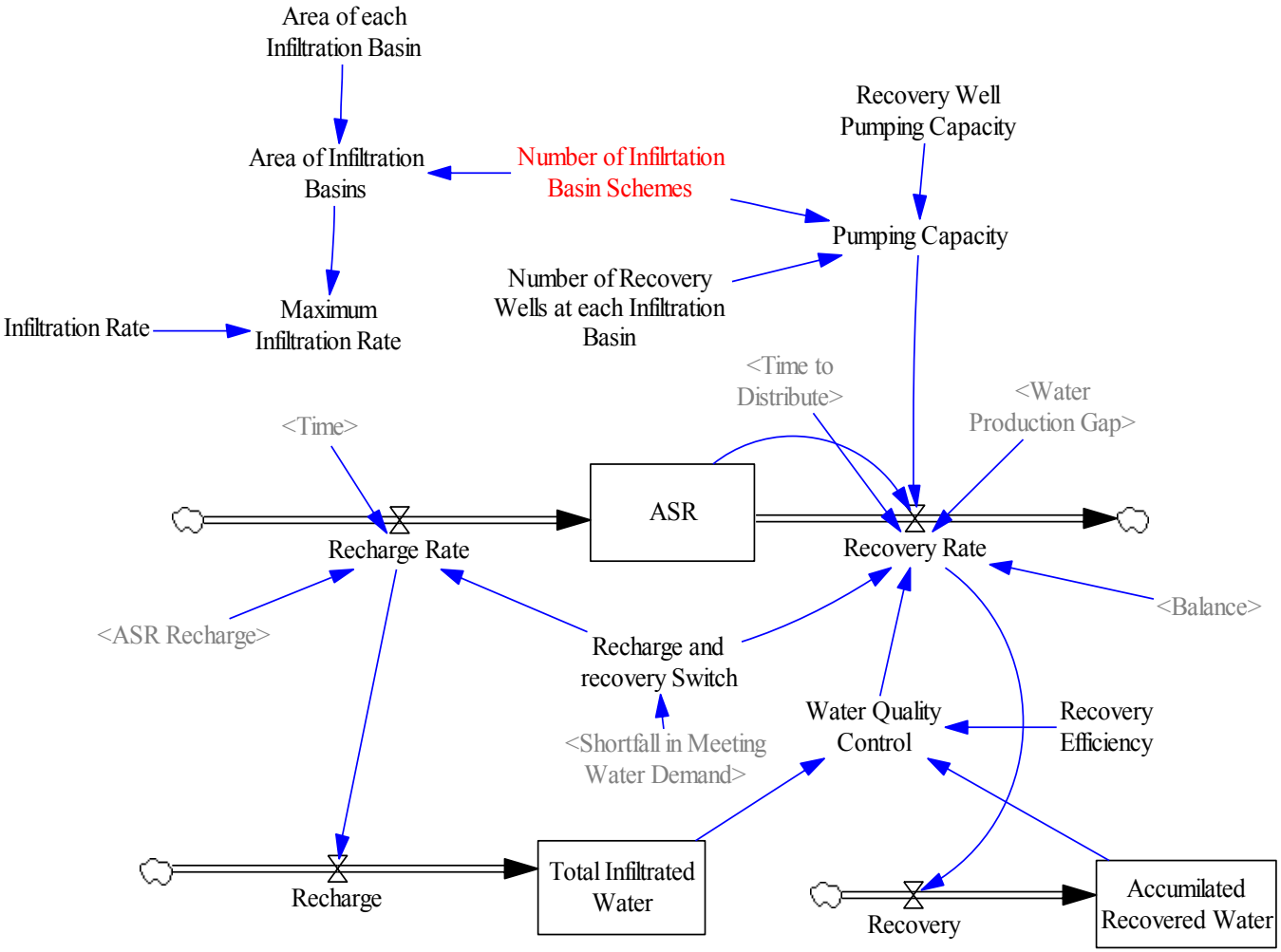


Source: Menche, 2010

Water Supply Model

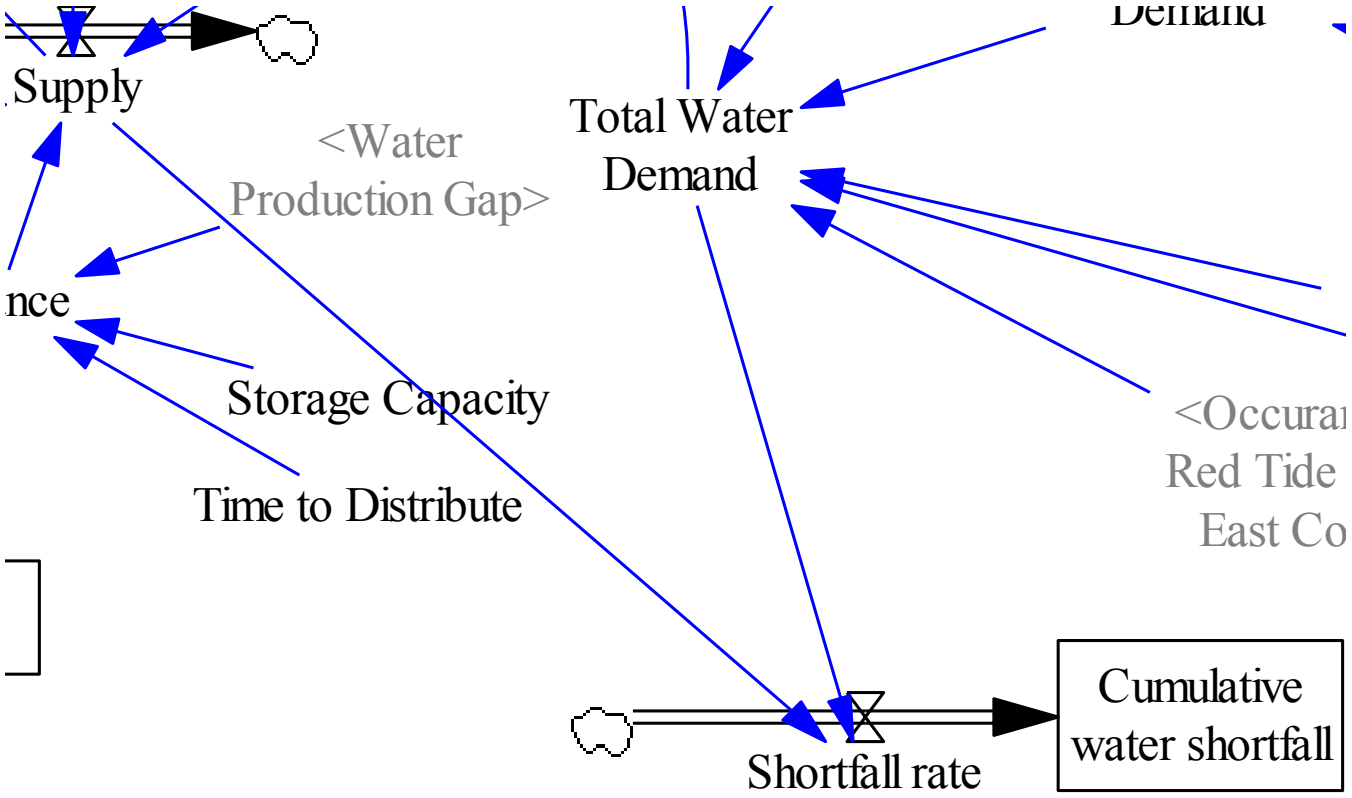


ASR SD Simulation



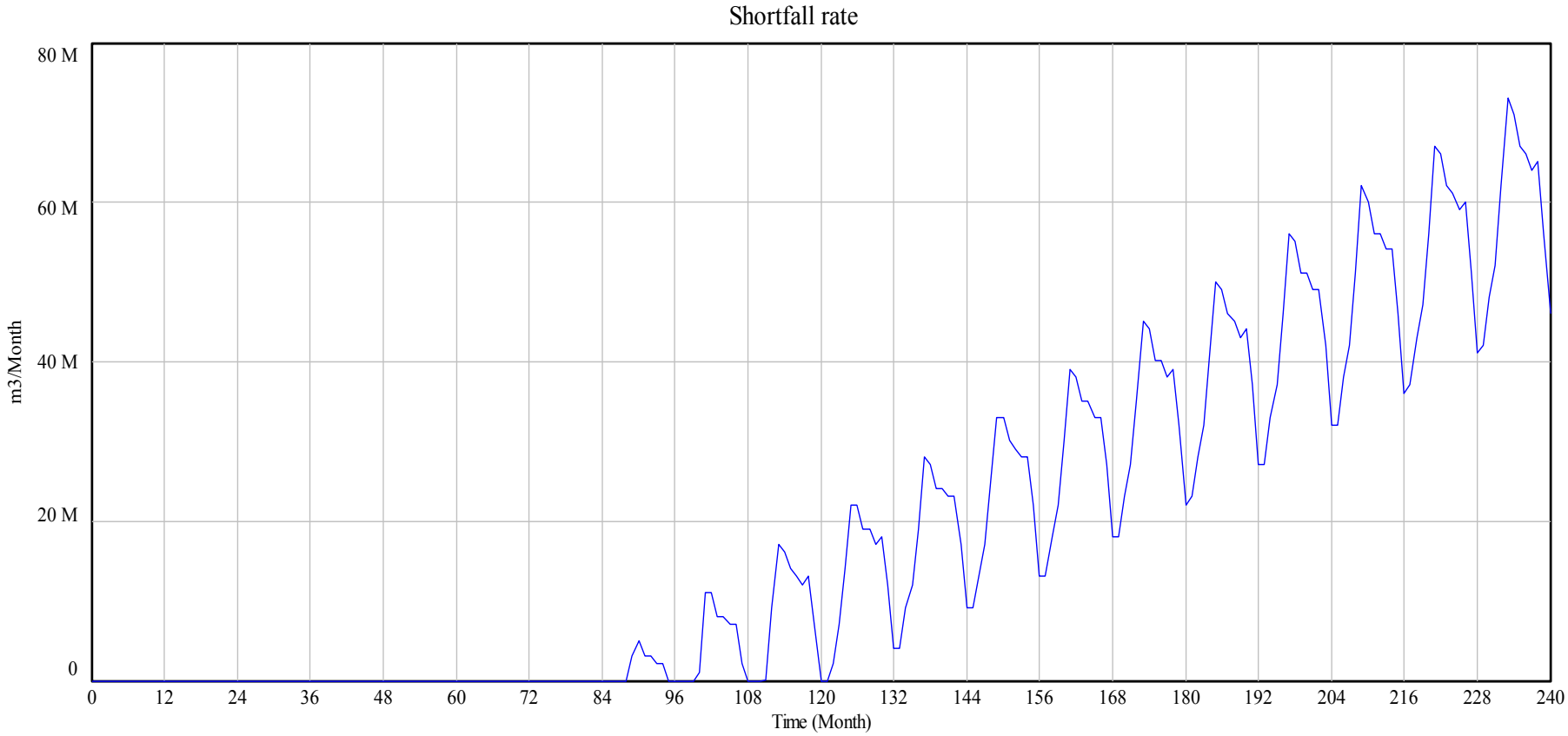
Water Shortfall

The time it takes to get the next shortfall is taken as measure to show the effect of having a Strategic Water Reserve enhancement to the water supply system



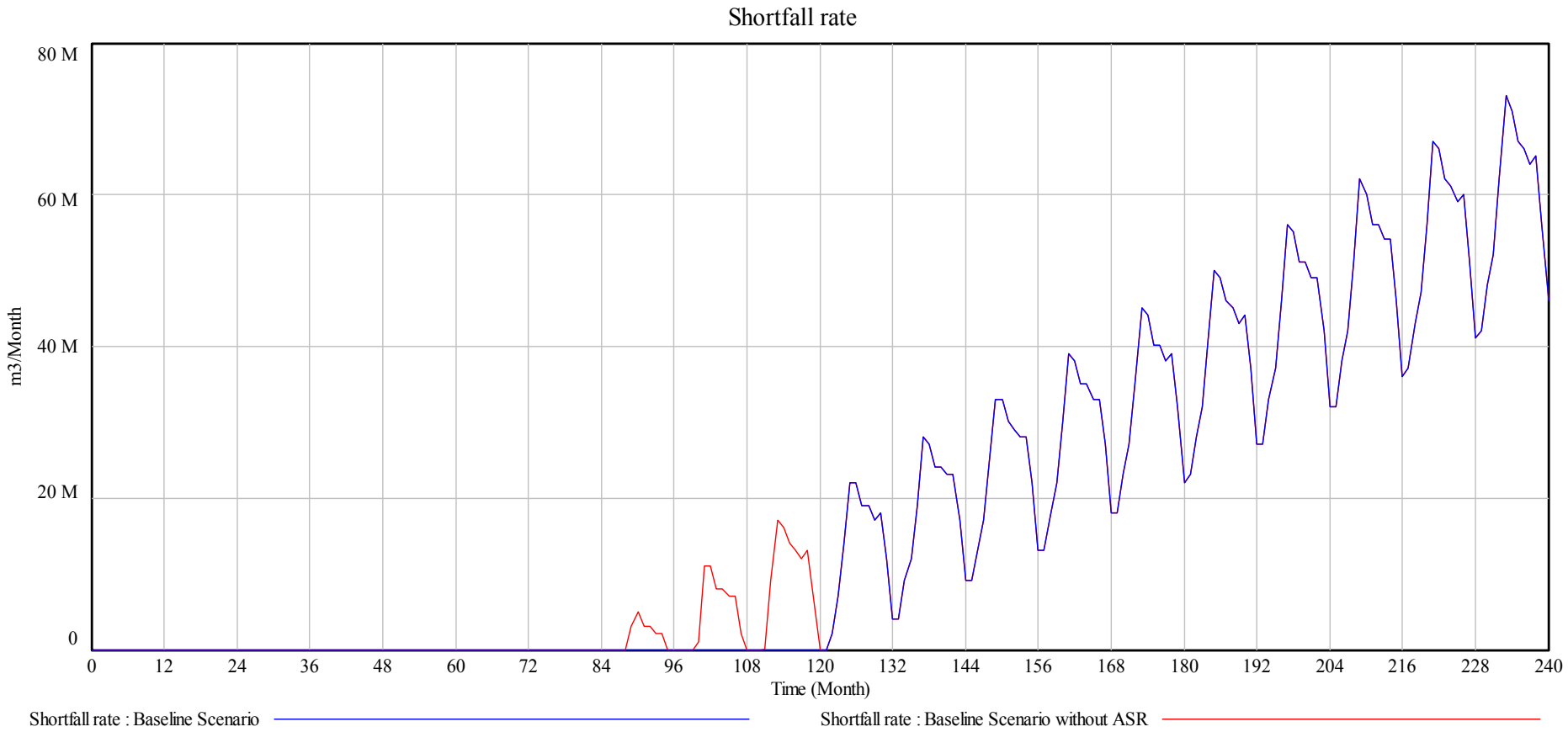
Baseline Scenario

With the current desalination capacity, Simulation shows that the first water shortfall appears after 7 years and 5 months

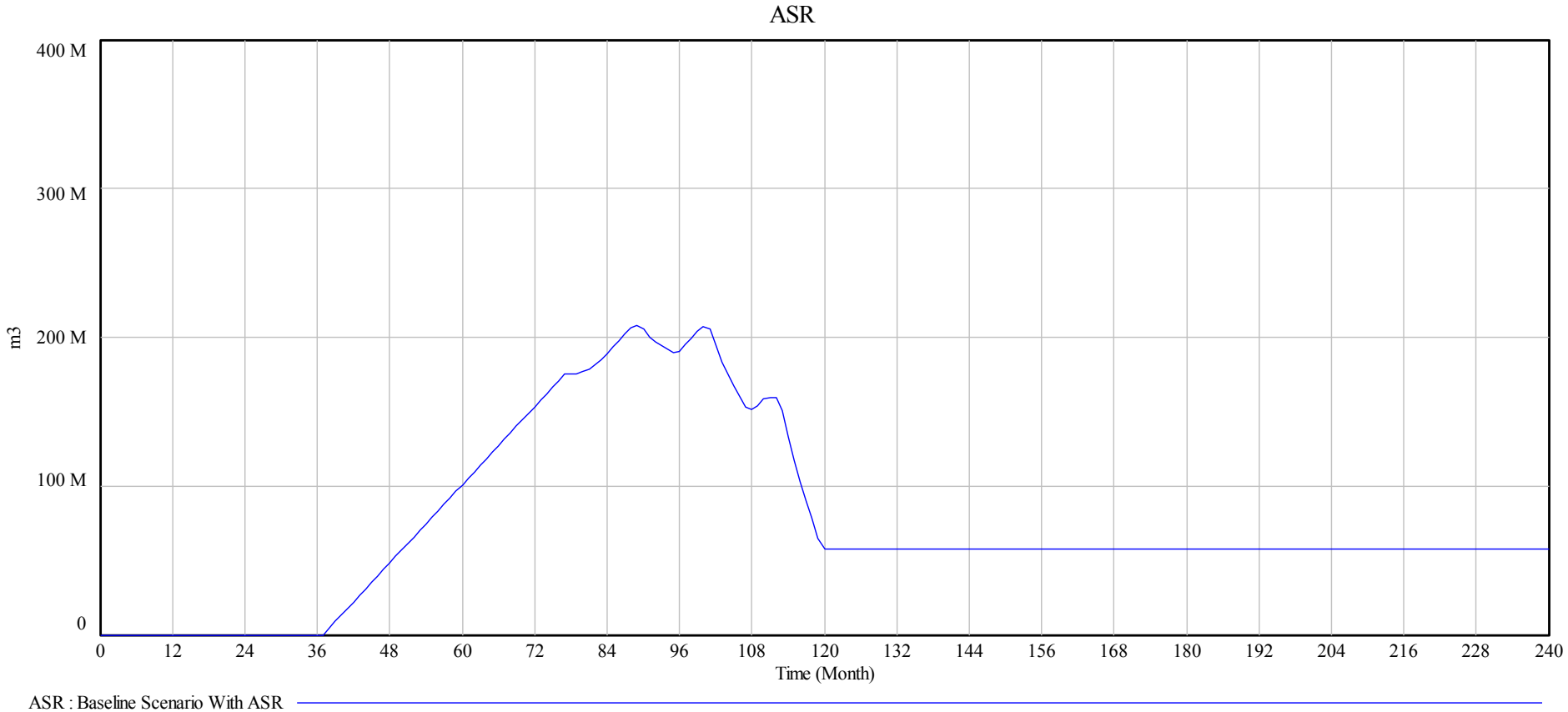


The effect of ASR on the water supply system

The ASR project can delay water shortfall by 2 years and 9 months

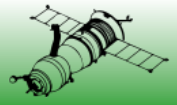


The aquifer stock

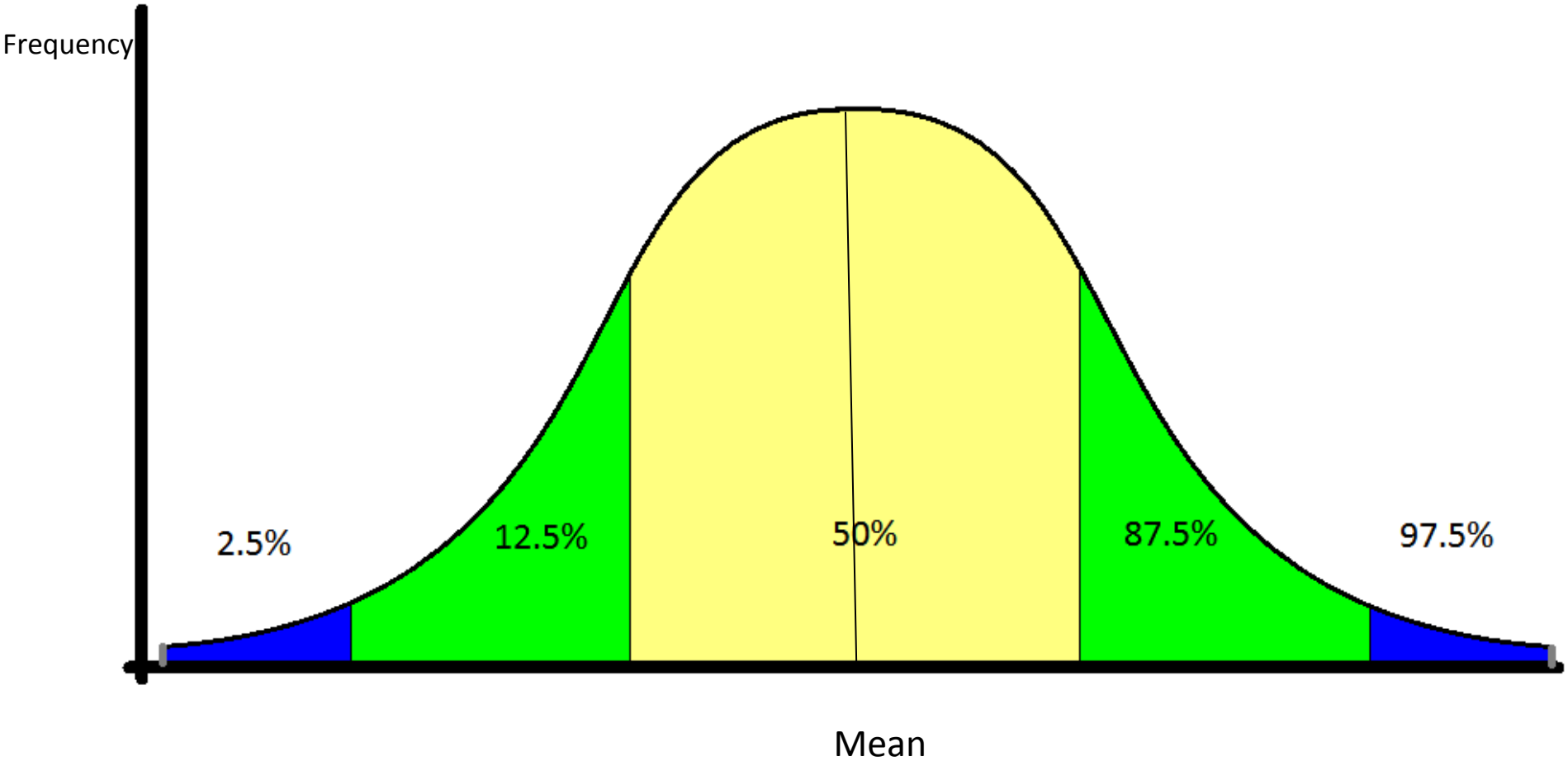


Uncertainties Risk Assessment Matrix

Uncertainty	Probability of Occurrence	Impact
Red Tide	15% (Anderson et al, 2012)	High on desalination plants - 40% of water production
Demand Seasonality	Random Beta(2,5)	Moderate on Demand

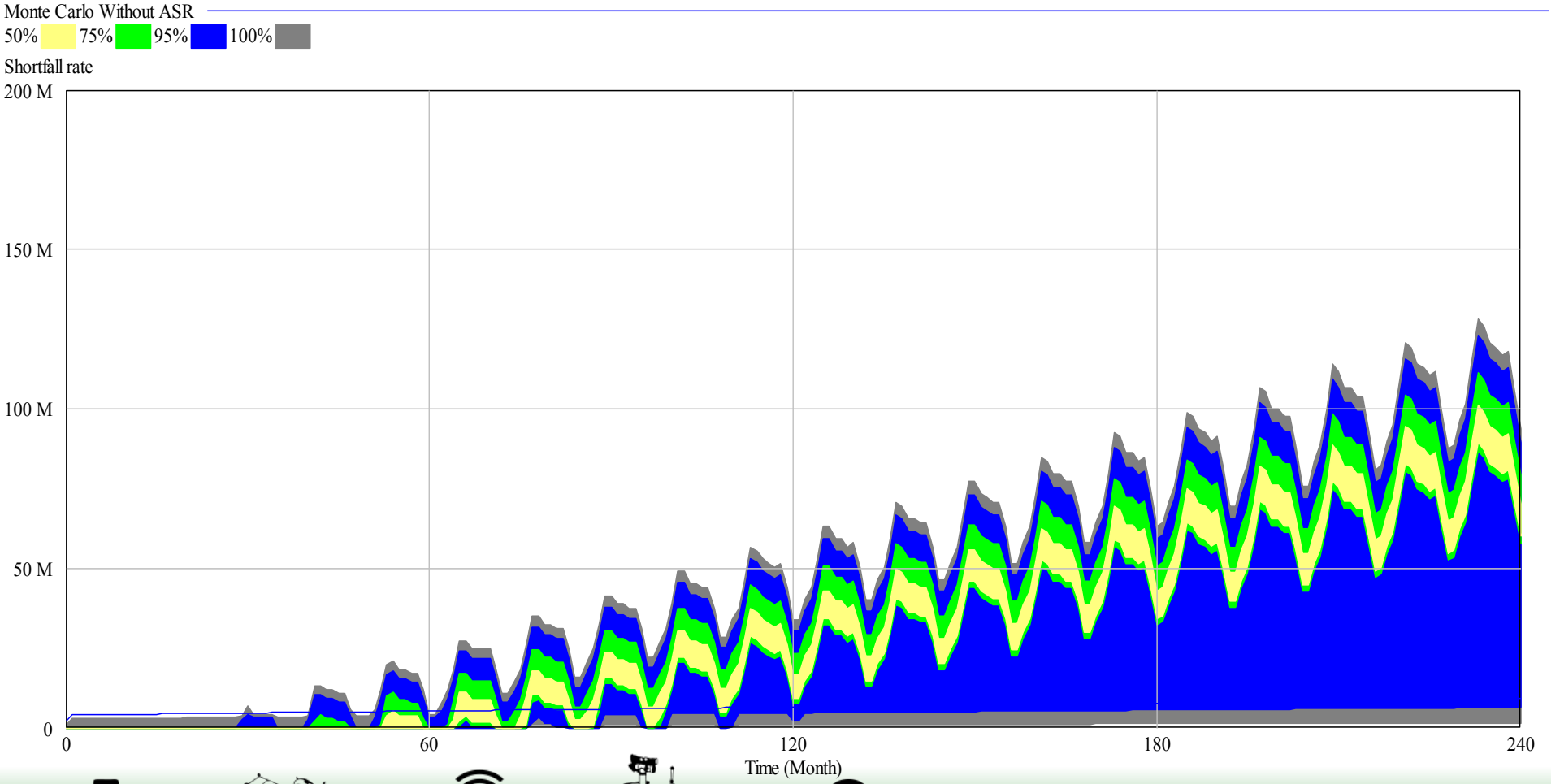




Simulation Result as a Distribution



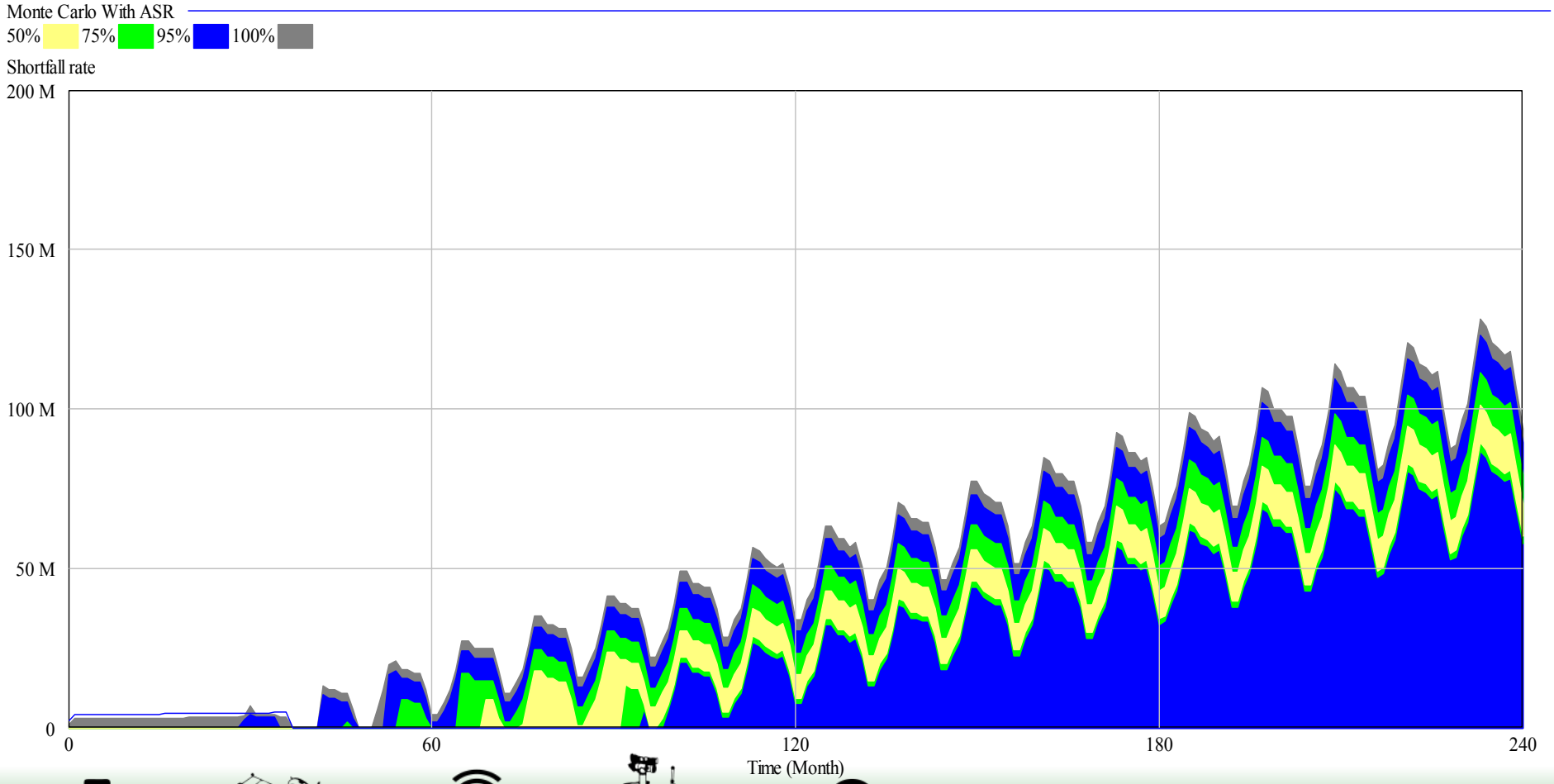
Baseline simulation under uncertainties

With 97.5% confidence level, the first water shortfall appears after 5 years and 5 months



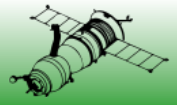
The effect of ASR on the water supply system under uncertainties

Monte Carlo simulation shows that, with the application of ASR, we are 97.5% confident that the water shortfall will be delayed by 30 months



Conclusion

- The ASR can extend the serviceability of the existing desalination capacity by 33 months
- Under uncertainties, Monte Carlo simulation shows that with 97.5% confidence the ASR can delay the appearance of the first water shortfall by 2.5 years


Questions time

THANK YOU