

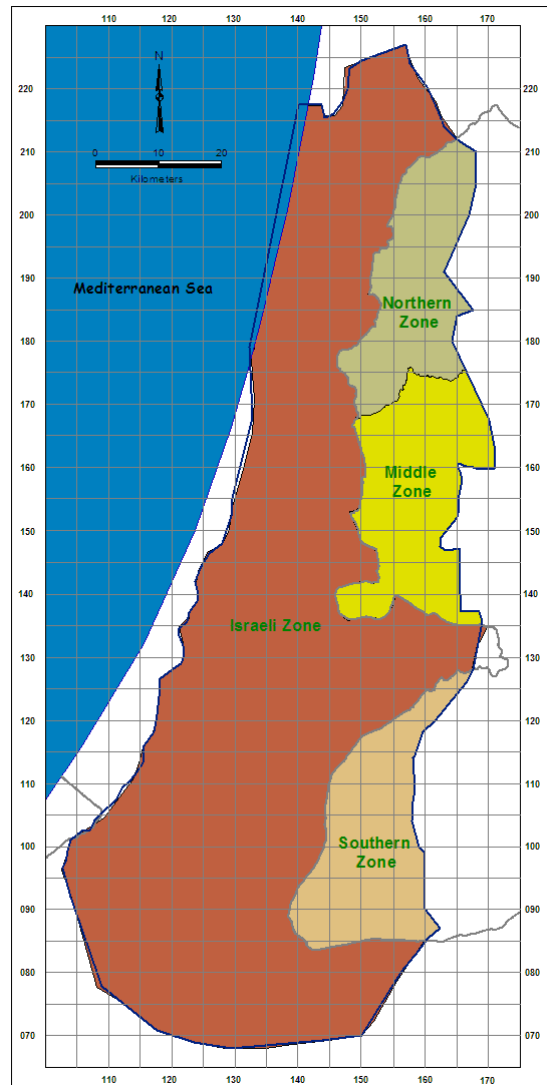


Assessment of Sustainable Yields of WAB

Muath Abu Sadah



Sustainable Yield of Palestinian Management Zones in WAB



Western Aquifer Basin is hydrogeologically a complex system due to:


- Confined/Unconfined Aquifer.
- Layered Aquifer
- Upper and Lower are connected in many places
- Shared aquifer

Therefore, Estimating the sustainable yield of WAB is mathematically very difficult.





Maximum Abstractions from Palestinian Management Zones in WAB

Aim:

-  To estimate the maximum possible abstractions in Palestinian management zones under different Israeli abstraction scenarios without creating adverse conditions in the whole Basin.

Calculations based on:

-  Rainfall scenario (1998-2025).
-  30 % of the saturation thickness as the maximum drawdown in the aquifer.

Calculations conducted by using the IMT (Iterative Method)



Maximum Abstractions from Palestinian Management Zones in WAB

- Under each Israeli abstraction scenario, three Palestinian (maximum) abstraction scenarios are tested.
- This tells us that the shaded in red box is the number of abstraction that we can generate from specific Palestinian Management Zone under the particular Israeli abstraction scenario without causing the basin to reach adverse conditions.

Scenario	Abstarction (Mcm)					
	Israeli Zone	Northern Zone	Middle Zone	Southern Zone	Palestinian Zones (Total)	WAB (Total)
Sc01	250	465	0.7	0.4	466.1	716.1
		19.9	490	0.4	510.3	760.3
		19.9	0.7	1.9	22.5	272.5
Sc02	317	385	0.7	0.4	386.1	703.1
		19.9	420	0.4	440.3	757.3
		19.9	0.7	1.8	22.4	339.4
Sc03	400	315	0.7	0.4	316.1	716.1
		19.9	315	0.4	335.3	735.3
		19.9	0.7	1.5	22.1	422.1
Sc04	500	230	0.7	0.4	231.1	731.1
		19.9	235	0.4	255.3	755.3
		19.9	0.7	1.4	21.8	521.8
Sc05	600	140	0.7	0.4	141.1	741.1
		19.9	138	0.4	158.3	758.3
		19.9	0.7	1.2	22	622
Sc06	700	54	0.7	0.4	55.1	755.1
		19.9	38	0.4	58.3	758.3
		19.9	0.7	1	21.6	721.6

19.9, 0.7, 0.4 & 317 Mcm are the average abstraction (1986-1998) for Northern, Middle, Southern and Israeli zones respectively.

Maximum Abstractions from Palestinian Management Zones in WAB

Results and Conclusions

Scenario	Abstarction (Mcm)					
	Israeli Zone	Northern Zone	Middle Zone	Southern Zone	Palestinian Zones (Total)	WAB (Total)
Sc01	250	19.9	0.7	1.9	22.5	272.5
Sc02	317	19.9	0.7	1.8	22.4	339.4
Sc03	400	19.9	0.7	1.5	22.1	422.1
Sc04	500	19.9	0.7	1.4	22	522
Sc05	600	19.9	0.7	1.2	21.8	621.8
Sc06	700	19.9	0.7	1	21.6	721.6

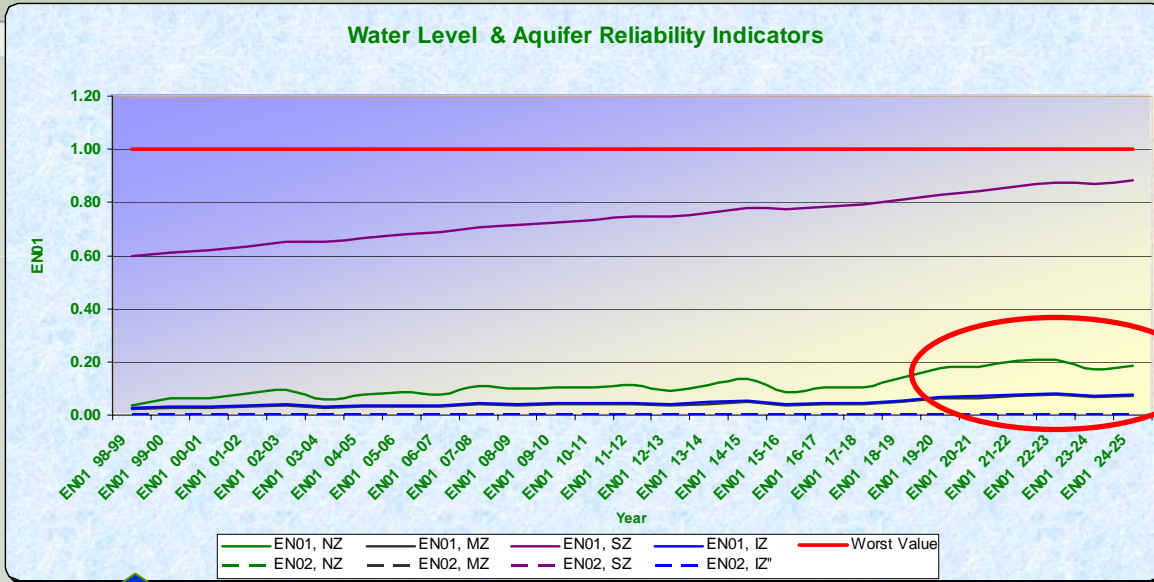
- ✚ The Palestinian management zone in the south is very limited in its recharge and productivity.
- ✚ The maximum abstraction from the southern zone did not increase more than 1.9 Mcm/yr whether regardless of abstraction scenarios in other zones
- ✚ This zone is not strong connected hydraulically with other zones
- ✚ The PWA is not advised to utilise the southern management zone of WAB beyond its current capacity (one or two wells only are recommended)

Maximum Abstractions from Palestinian Management Zones in WAB

- Water availability in middle zone is much greater than the northern zone, this does not mean that the ability to extract water is easier; development costs should be prepared and a tradeoff between cost of development & drilling and quantity of extracted water should be made for the two zones.

Scenario	Abstarction (Mcm)					WAB (Total)
	Israeli Zone	Northern Zone	Middle Zone	Southern Zone	Palestinian Zones (Total)	
Sc01	250	465	0.7	0.4	466.1	716.1
		19.9	490	0.4	510.3	760.3
Sc02	317	385	0.7	0.4	386.1	703.1
		19.9	420	0.4	440.3	757.3
Sc03	400	315	0.7	0.4	316.1	716.1
		19.9	315	0.4	335.3	735.3
Sc04	500	230	0.7	0.4	231.1	731.1
		19.9	235	0.4	255.3	755.3
Sc05	600	140	0.7	0.4	141.1	741.1
		19.9	138	0.4	158.3	758.3
Sc06	700	54	0.7	0.4	55.1	755.1
		19.9	38	0.4	58.3	758.3

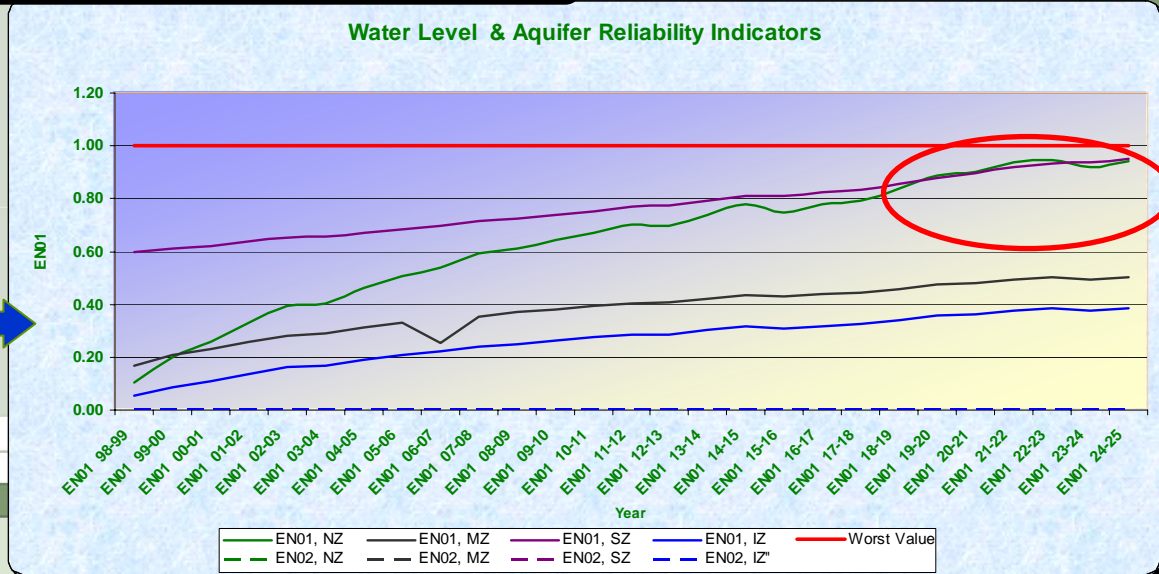
Maximum Abstractions from Palestinian Management Zones in WAB



However, The negative impacts of abstracting water from Israeli zone or Palestinian Middle zone are larger on the water levels of the Northern zone.

Abstractions (Mcm):
 NZ= 19.9
 MZ=0.7
 SZ=0.4
 IZ=317

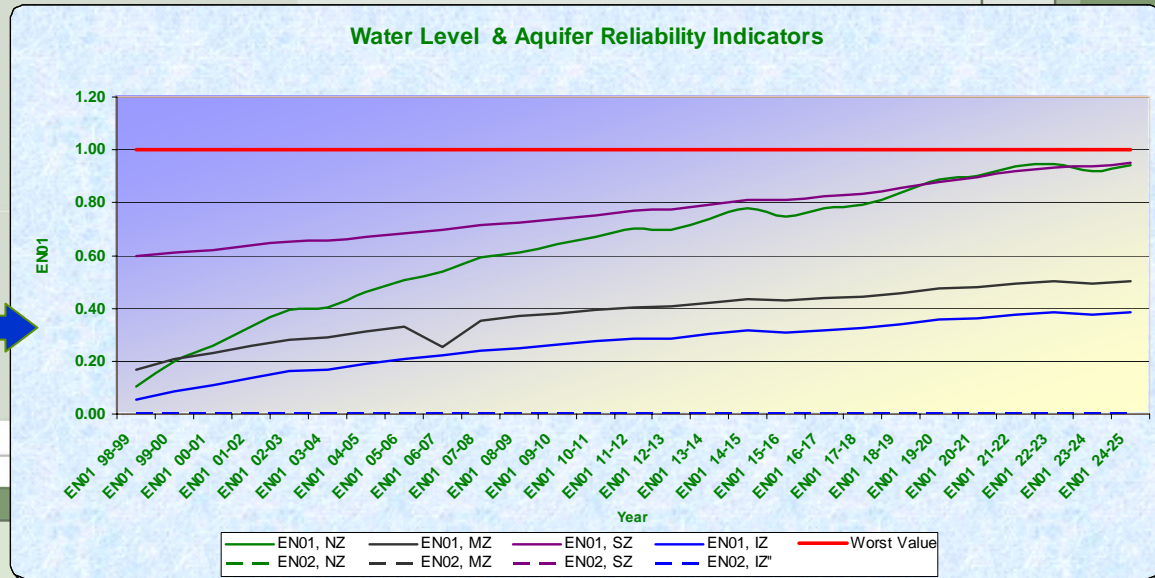
Abstractions (Mcm):
 NZ= 19.9
 MZ=315
 SZ=0.4
 IZ=400



Maximum Abstractions from Palestinian Management Zones in WAB

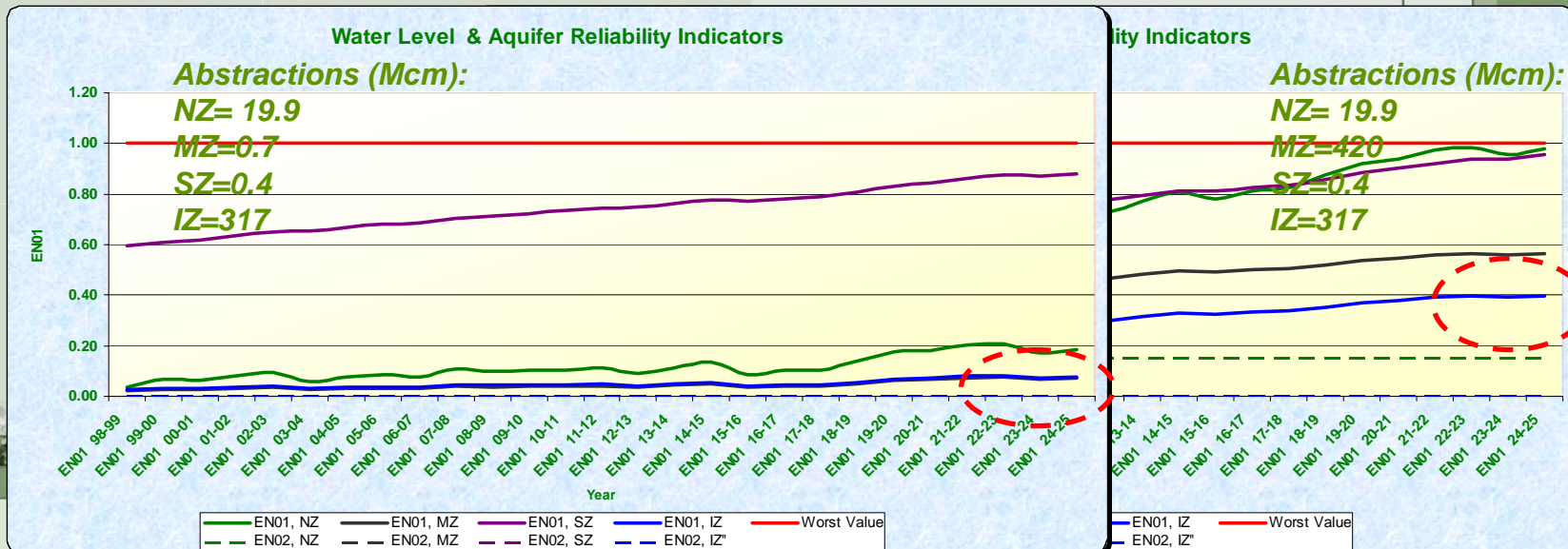
- + *Middle Zone and Northern Zone are strongly connected*
- + *Even we increased the abstraction in middle zone from 0.7 Mcm/yr to 315 Mcm/yr, the water levels of the middle zone deteriorates only to some extent while those of Northern Zone (even their abstraction remain low at 19.9 Mcm/yr) deteriorates to almost reach the worst condition.*

Abstractions (Mcm):
 NZ= 19.9
 MZ=315
 SZ=0.4
 IZ=400



Maximum Abstractions from Palestinian Management Zones in WAB

- ✚ It is shown that the Palestinians can abstract 420 Mcm/yr from middle zone without causing significant harm to the Israeli wells.
- ✚ In conclusion the Palestinian can abstract the difference between the Sustainable Yield of the basin (443 Mcm) and the current Israeli abstraction (317 Mcm), i.e. the Palestinian can now abstract 126 Mcm/yr from their management zones without causing any harm to any Israeli well.



Maximum Abstractions from Palestinian Management Zones in WAB

- ✚ *Technically, the Palestinians can abstract an equal amount of water to the Israelis'.*

Scenario	Abstarction (Mcm)		
	Israeli Zone	Palestinian Zones (Total)	WAB (Total)
Sc01	60	670	730
Sc02	250	510.3	760.3
Sc03	317	440.3	757.3
Sc04	400	335.3	735.3
Sc05	500	255.3	755.3
Sc06	600	158.3	758.3
Sc07	700	58.3	758.3




Calculations

Baseline (Year 1999)

- Northern Zone- Current Abstraction Year 1999

Existing Wells Abstraction Scenario - Northern Zone

Year 98-99 : 19.9	Year 07-08 : 19.9	Year 16-17 : 19.9
Year 99-00 : 19.9	Year 08-09 : 19.9	Year 17-18 : 19.9
Year 00-01 : 19.9	Year 09-10 : 19.9	Year 18-19 : 19.9
Year 01-02 : 19.9	Year 10-11 : 19.9	Year 19-20 : 19.9
Year 02-03 : 19.9	Year 11-12 : 19.9	Year 20-21 : 19.9
Year 03-04 : 19.9	Year 12-13 : 19.9	Year 21-22 : 19.9
Year 04-05 : 19.9	Year 13-14 : 19.9	Year 22-23 : 19.9
Year 05-06 : 19.9	Year 14-15 : 19.9	Year 23-24 : 19.9
Year 06-07 : 19.9	Year 15-16 : 19.9	Year 24-25 : 19.9



Set abstraction to : 19.9 Mcm

Increase abstraction by : 100 %

Unit: Mcm

Submit View Abstraction Chart Reset

Baseline (Year 1999)

- Middle Zone- Current Abstraction Year 1999

Existing Wells Abstraction Scenario -Middle Zone

Year 98-99 : 0.7	Year 07-08 : 0.7	Year 16-17 : 0.7
Year 99-00 : 0.7	Year 08-09 : 0.7	Year 17-18 : 0.7
Year 00-01 : 0.7	Year 09-10 : 0.7	Year 18-19 : 0.7
Year 01-02 : 0.7	Year 10-11 : 0.7	Year 19-20 : 0.7
Year 02-03 : 0.7	Year 11-12 : 0.7	Year 20-21 : 0.7
Year 03-04 : 0.7	Year 12-13 : 0.7	Year 21-22 : 0.7
Year 04-05 : 0.7	Year 13-14 : 0.7	Year 22-23 : 0.7
Year 05-06 : 0.7	Year 14-15 : 0.7	Year 23-24 : 0.7
Year 06-07 : 0.7	Year 15-16 : 0.7	Year 24-25 : 0.7



Set abstraction to : 0.7 Mcm

Increase abstraction by : 100 %

Submit

View Abstraction Chart

Reset

Unit: Mcm

Baseline (Year 1999)

- Southern Zone- Current Abstraction Year 1999

Existing Wells Abstraction Scenario - Southern Zone

Year 98-99 : 0.4	Year 07-08 : 0.4	Year 16-17 : 0.4
Year 99-00 : 0.4	Year 08-09 : 0.4	Year 17-18 : 0.4
Year 00-01 : 0.4	Year 09-10 : 0.4	Year 18-19 : 0.4
Year 01-02 : 0.4	Year 10-11 : 0.4	Year 19-20 : 0.4
Year 02-03 : 0.4	Year 11-12 : 0.4	Year 20-21 : 0.4
Year 03-04 : 0.4	Year 12-13 : 0.4	Year 21-22 : 0.4
Year 04-05 : 0.4	Year 13-14 : 0.4	Year 22-23 : 0.4
Year 05-06 : 0.4	Year 14-15 : 0.4	Year 23-24 : 0.4
Year 06-07 : 0.4	Year 15-16 : 0.4	Year 24-25 : 0.4



Set abstraction to : 0.4 Mcm

Increase abstraction by : 100 %

Submit

View Abstraction Chart

Reset

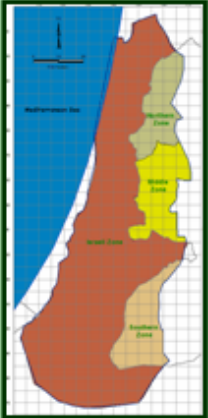
Unit: Mcm

Baseline (Year 1999)

- Israeli Zone- Current Abstraction Year 1999

Israeli Abstraction Scenario

Year 98-99 : 317	Year 07-08 : 317	Year 16-17 : 317
Year 99-00 : 317	Year 08-09 : 317	Year 17-18 : 317
Year 00-01 : 317	Year 09-10 : 317	Year 18-19 : 317
Year 01-02 : 317	Year 10-11 : 317	Year 19-20 : 317
Year 02-03 : 317	Year 11-12 : 317	Year 20-21 : 317
Year 03-04 : 317	Year 12-13 : 317	Year 21-22 : 317
Year 04-05 : 317	Year 13-14 : 317	Year 22-23 : 317
Year 05-06 : 317	Year 14-15 : 317	Year 23-24 : 317
Year 06-07 : 317	Year 15-16 : 317	Year 24-25 : 317



Set abstraction to : 317 Mcm

Increase abstraction by : 100 %

Unit: Mcm

Submit View Abstraction Chart Reset

Rainfall Scenario (1999-2025)

- Rainfall Accumulation

% From Average Recharge

Year 98-99 : 971	Year 07-08 : 404	Year 16-17 : 524
Year 99-00 : 502	Year 08-09 : 636	Year 17-18 : 598
Year 00-01 : 653	Year 09-10 : 576	Year 18-19 : 321
Year 01-02 : 516	Year 10-11 : 581	Year 19-20 : 237
Year 02-03 : 503	Year 11-12 : 538	Year 20-21 : 497
Year 03-04 : 827	Year 12-13 : 758	Year 21-22 : 337
Year 04-05 : 520	Year 13-14 : 461	Year 22-23 : 490
Year 05-06 : 556	Year 14-15 : 435	Year 23-24 : 765
Year 06-07 : 652	Year 15-16 : 827	Year 24-25 : 494

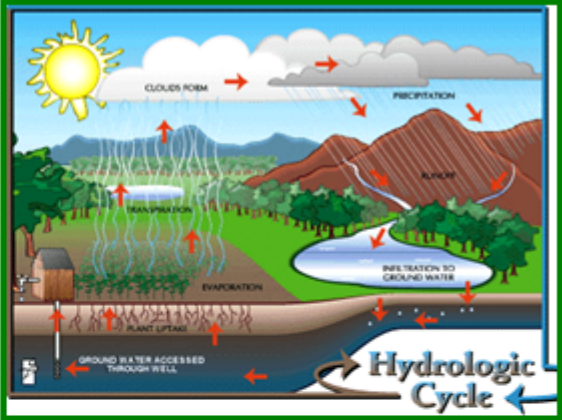
Unit: mm/yr

Multiply Rainfall by : 100 %

View Rainfall Time Series

View Recharge Time Series

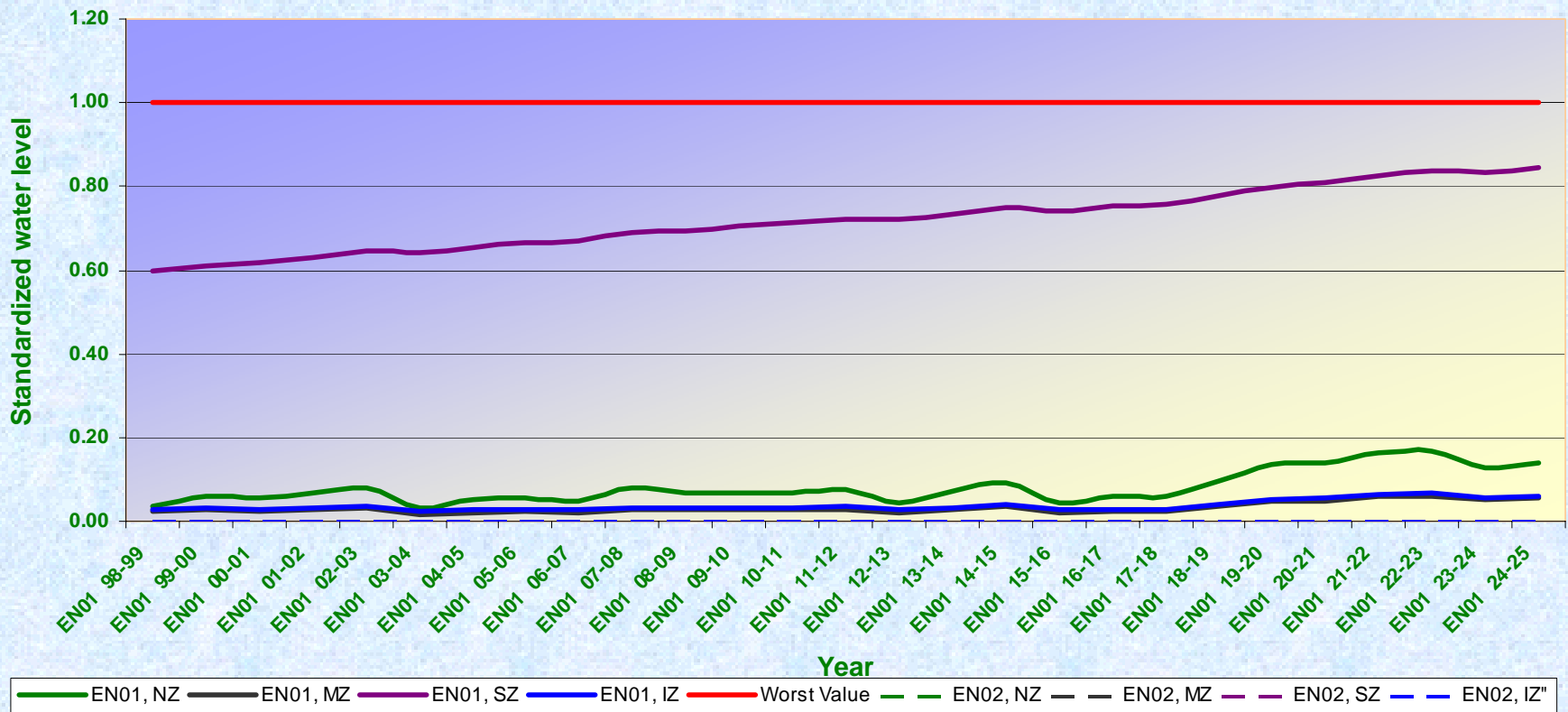
Save & Exit Exit without Save High Emission Low Emission



The diagram illustrates the hydrologic cycle with various processes labeled: CLOUDS FORM, PRECIPITATION, ALBINO, INFILTRATION TO GROUND WATER, EVAPORATION, PLANT UPTAKE, and GROUND WATER ACCESSED THROUGH WELL. It shows water moving between the atmosphere, land, and subsurface.

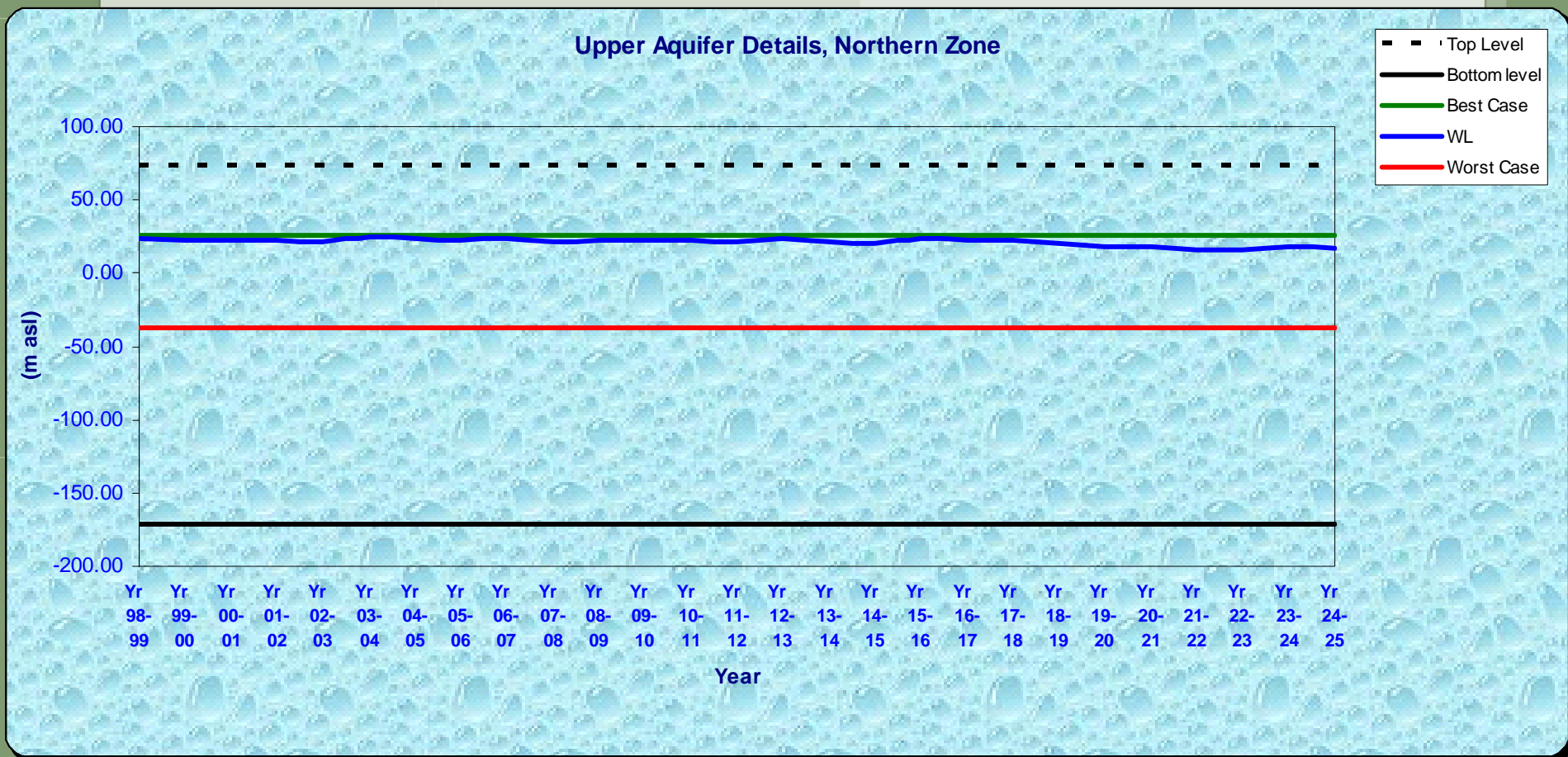
Baseline (Year 1999)

- Standardized Water Levels for the Four Management Zones



Baseline (Year 1999)

- Schematic diagram of Northern Zone.

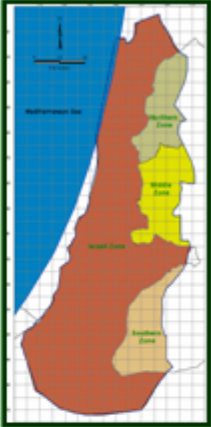


Scenario 1: ($Abst_{NZ} = 220 \text{ Mcm/Yr}$)

- Increase the abstraction of northern zone from 20 Mcm/yr to 220 Mcm/yr, while the other zones, the abstractions do not change.

Existing Wells Abstraction Scenario - Northern Zone

Year 98-99 : 220	Year 07-08 : 220	Year 16-17 : 220
Year 99-00 : 220	Year 08-09 : 220	Year 17-18 : 220
Year 00-01 : 220	Year 09-10 : 220	Year 18-19 : 220
Year 01-02 : 220	Year 10-11 : 220	Year 19-20 : 220
Year 02-03 : 220	Year 11-12 : 220	Year 20-21 : 220
Year 03-04 : 220	Year 12-13 : 220	Year 21-22 : 220
Year 04-05 : 220	Year 13-14 : 220	Year 22-23 : 220
Year 05-06 : 220	Year 14-15 : 220	Year 23-24 : 220
Year 06-07 : 220	Year 15-16 : 220	Year 24-25 : 220



Set abstraction to : 220 Mcm

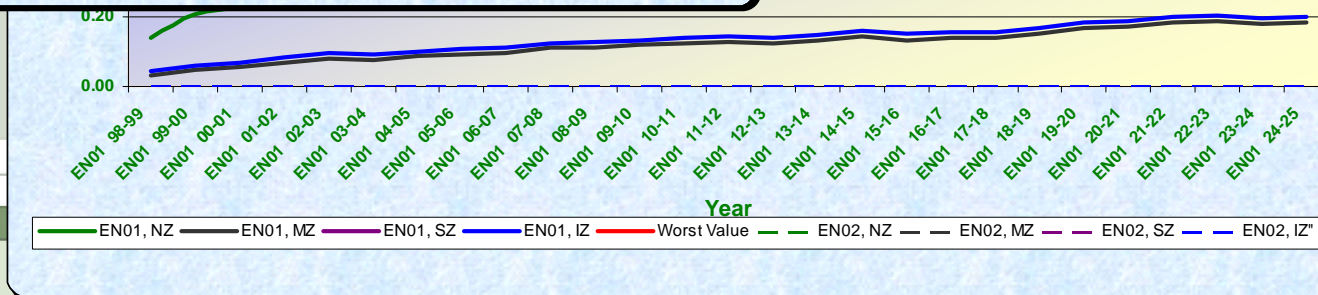
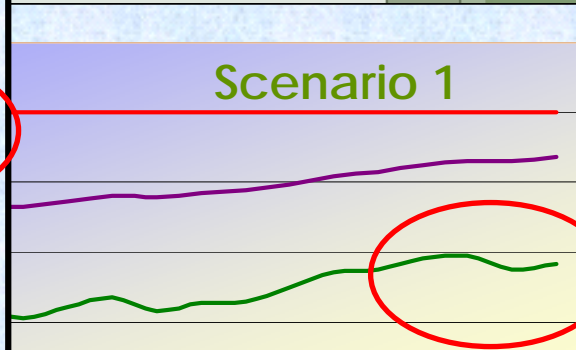
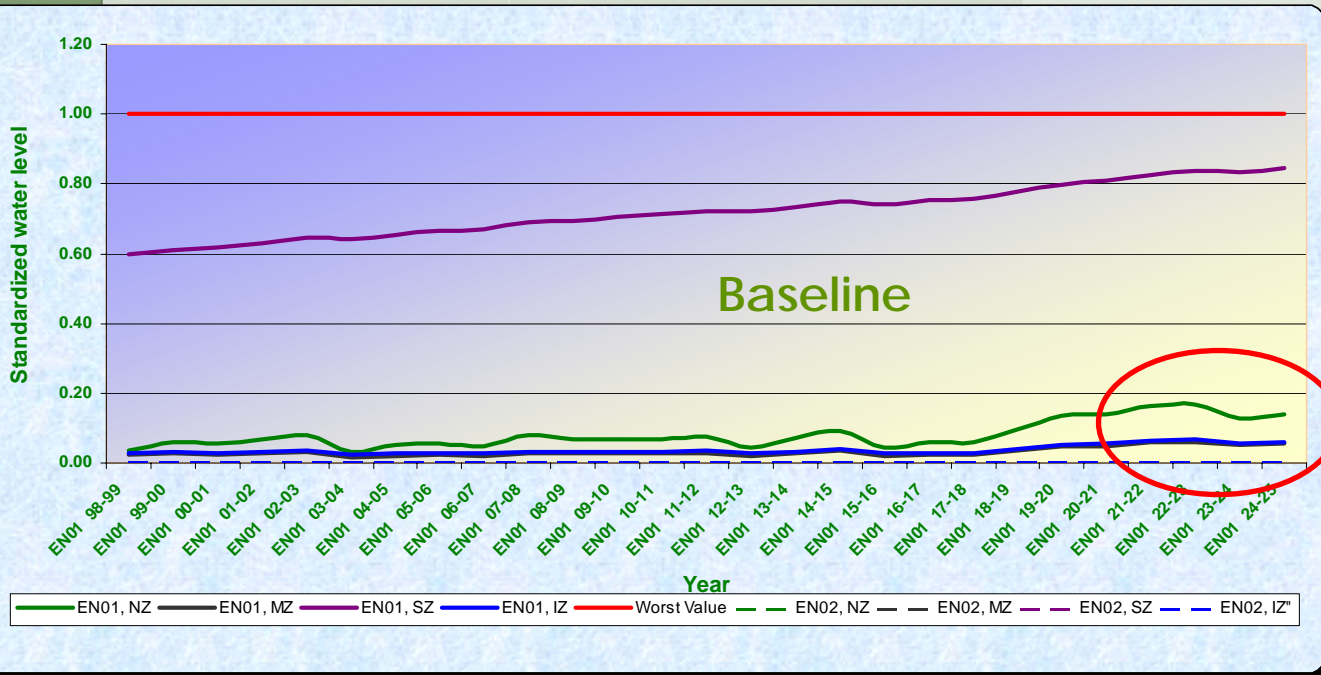
Increase abstraction by : 1106 %

Unit: Mcm

Submit View Abstraction Chart Reset

Scenario 1: ($Abst_{NZ} = 220 \text{ Mcm/Yr}$)

- Standardized water level:




Scenario 2: ($Abst_{NZ} = 500 \text{ Mcm/Yr}$)

- Increase the abstraction of northern zone to 500 Mcm/yr, while the other zones, the abstractions do not change.

Existing Wells Abstraction Scenario - Northern Zone

Year 98-99 : 500	Year 07-08 : 500	Year 16-17 : 500
Year 99-00 : 500	Year 08-09 : 500	Year 17-18 : 500
Year 00-01 : 500	Year 09-10 : 500	Year 18-19 : 500
Year 01-02 : 500	Year 10-11 : 500	Year 19-20 : 500
Year 02-03 : 500	Year 11-12 : 500	Year 20-21 : 500
Year 03-04 : 500	Year 12-13 : 500	Year 21-22 : 500
Year 04-05 : 500	Year 13-14 : 500	Year 22-23 : 500
Year 05-06 : 500	Year 14-15 : 500	Year 23-24 : 500
Year 06-07 : 500	Year 15-16 : 500	Year 24-25 : 500



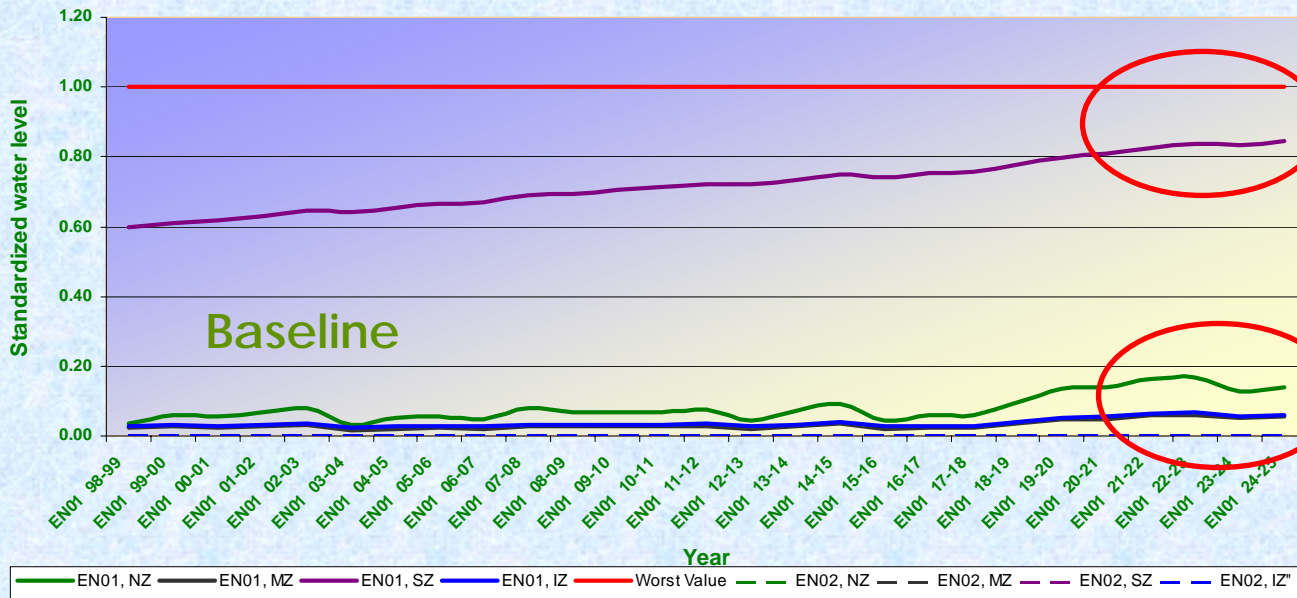
Set abstraction to : 500 Mcm

Increase abstraction by : 2513 %

Unit: Mcm

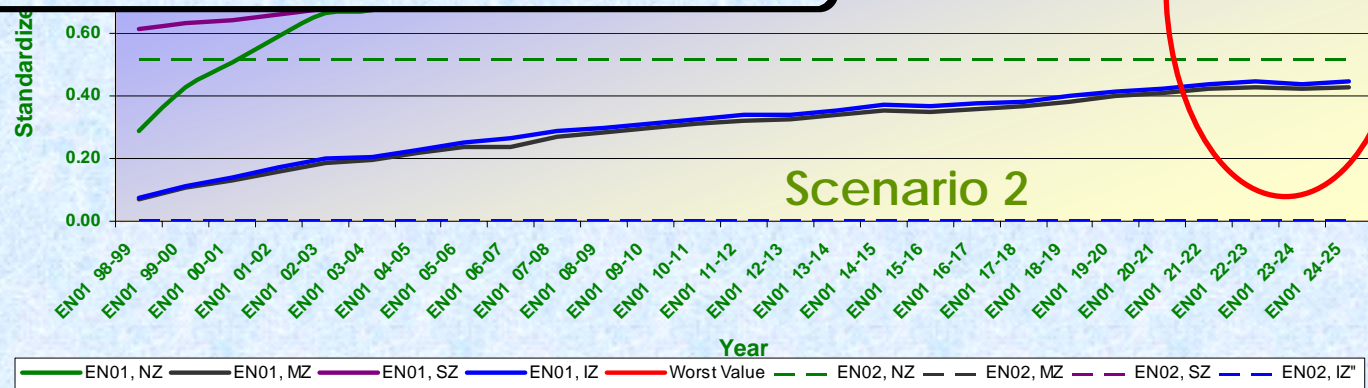
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Scenario 2: ($Abst_{NZ} = 500 \text{ Mcm/Yr}$)



Standardized water level

Scenario 2 is not sustainable

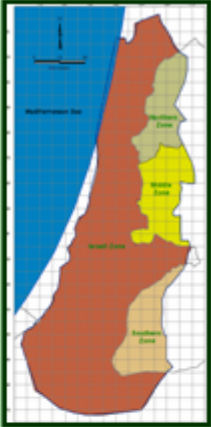


Scenario 3: ($Abst_{NZ} = 350 \text{ Mcm/Yr}$)

- Increase the abstraction of northern zone to 350 Mcm/yr, while the other zones, the abstractions do not change.

Existing Wells Abstraction Scenario - Northern Zone

Year 98-99 : 350	Year 07-08 : 350	Year 16-17 : 350
Year 99-00 : 350	Year 08-09 : 350	Year 17-18 : 350
Year 00-01 : 350	Year 09-10 : 350	Year 18-19 : 350
Year 01-02 : 350	Year 10-11 : 350	Year 19-20 : 350
Year 02-03 : 350	Year 11-12 : 350	Year 20-21 : 350
Year 03-04 : 350	Year 12-13 : 350	Year 21-22 : 350
Year 04-05 : 350	Year 13-14 : 350	Year 22-23 : 350
Year 05-06 : 350	Year 14-15 : 350	Year 23-24 : 350
Year 06-07 : 350	Year 15-16 : 350	Year 24-25 : 350



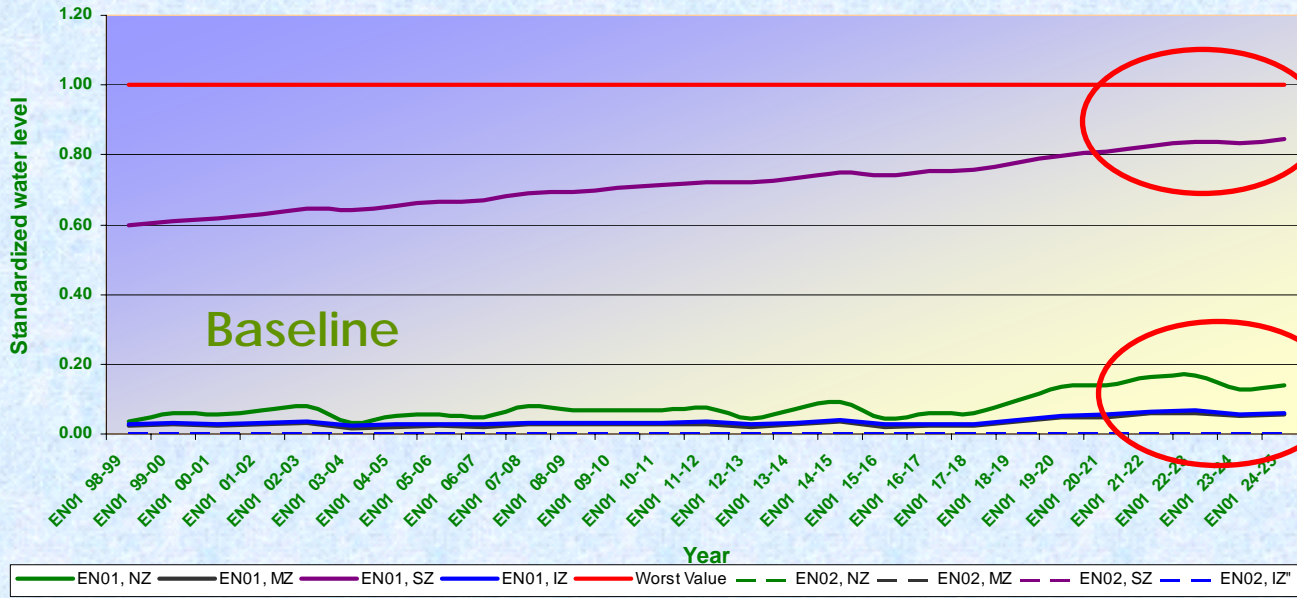
Set abstraction to : 350 Mcm

Increase abstraction by : 1759 %

Unit: Mcm

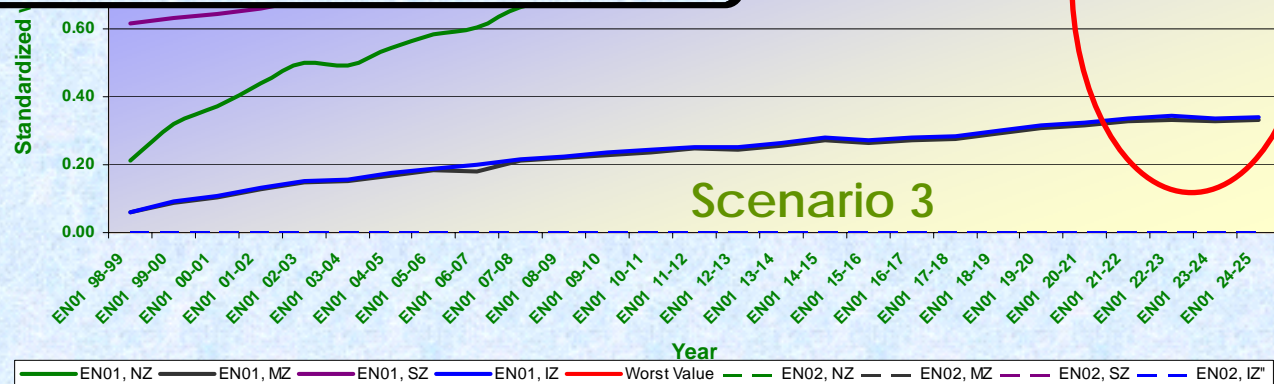
Submit View Abstraction Chart Reset

Scenario 3: ($Abst_{NZ} = 350 \text{ Mcm/Yr}$)



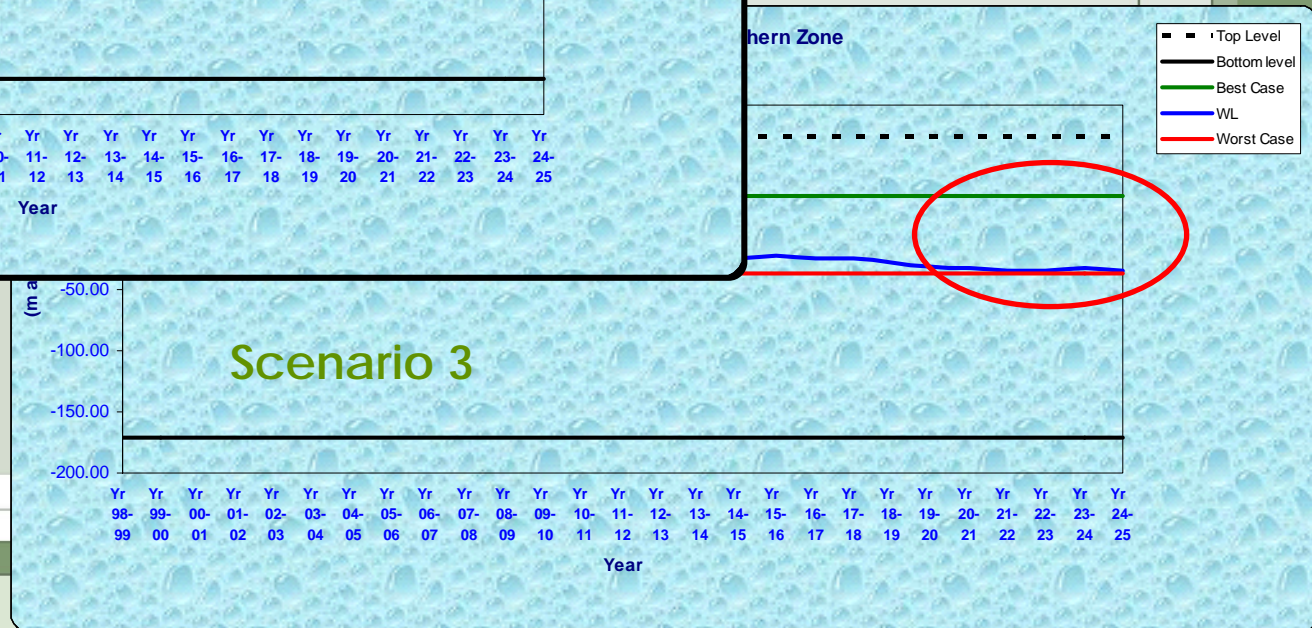
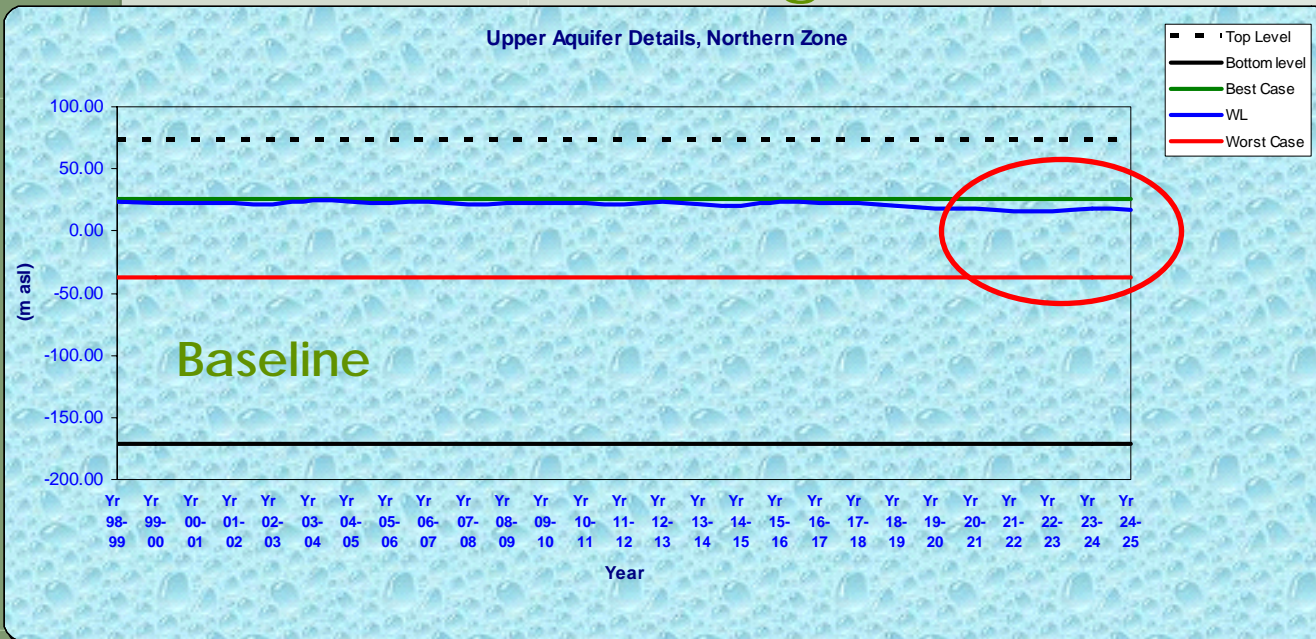
Standardized water level

Scenario 3 is sustainable



Scenario 3: ($Abst_{NZ} = 350 \text{ Mcm/Yr}$)

- Schematic diagram of Northern Zone.



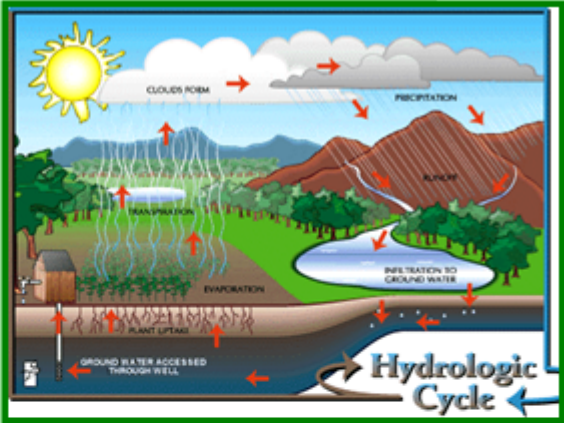
Scenario 4: Reduce the Rainfall by 25%

- Keeping the abstraction as scenario 3 (sustainable yield of northern zone [350 Mcm/yr])

% From Average Recharge

Year 98-99 : 728	Year 07-08 : 288	Year 16-17 : 371
Year 99-00 : 351	Year 08-09 : 454	Year 17-18 : 422
Year 00-01 : 466	Year 09-10 : 409	Year 18-19 : 230
Year 01-02 : 364	Year 10-11 : 407	Year 19-20 : 165
Year 02-03 : 360	Year 11-12 : 390	Year 20-21 : 351
Year 03-04 : 570	Year 12-13 : 529	Year 21-22 : 235
Year 04-05 : 369	Year 13-14 : 325	Year 22-23 : 353
Year 05-06 : 399	Year 14-15 : 311	Year 23-24 : 551
Year 06-07 : 462	Year 15-16 : 603	Year 24-25 : 344

Unit: mm/yr



View Rainfall Time Series

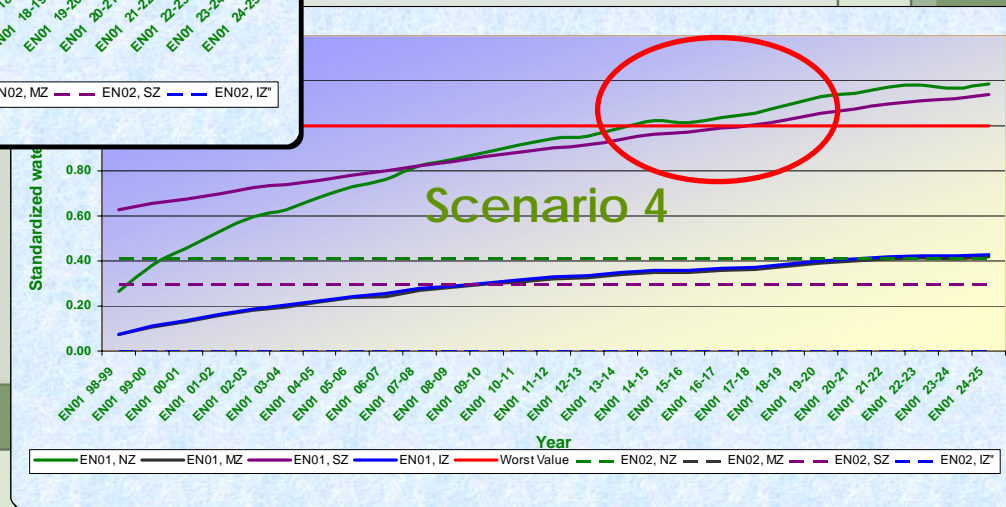
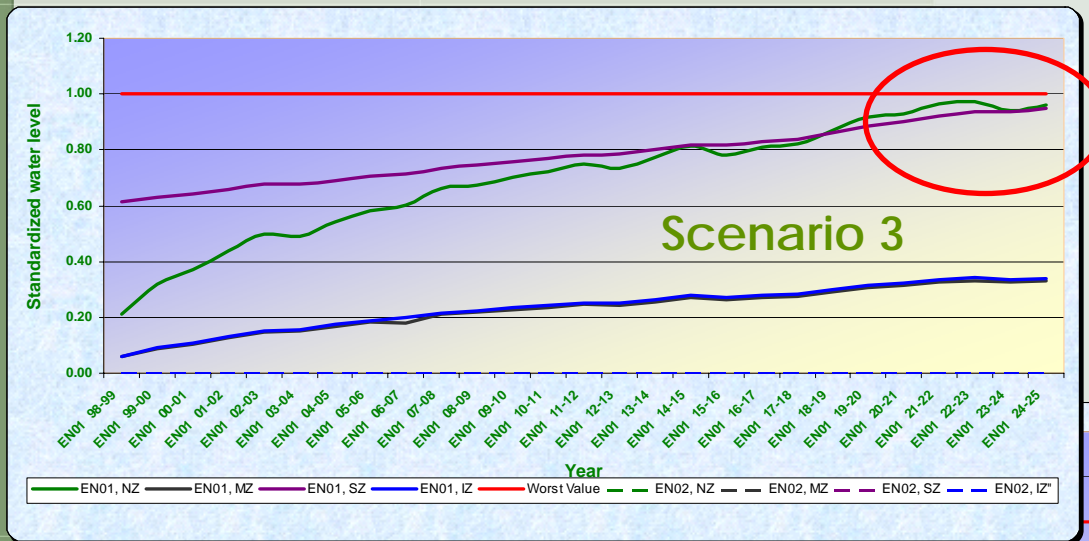
View Recharge Time Series

Multiply Rainfall by : 75 %

Save & Exit Exit without Save High Emission Low Emission

Scenario 4: Reduce the Rainfall by 25%

- Same abstractions but rainfall is reduced by 25%




Scenario 5:

- The same as scenario 4 with reducing the abstractions of northern zone to 250 Mcm/yr

Existing Wells Abstraction Scenario - Northern Zone

Year 98-99 : 250	Year 07-08 : 250	Year 16-17 : 250
Year 99-00 : 250	Year 08-09 : 250	Year 17-18 : 250
Year 00-01 : 250	Year 09-10 : 250	Year 18-19 : 250
Year 01-02 : 250	Year 10-11 : 250	Year 19-20 : 250
Year 02-03 : 250	Year 11-12 : 250	Year 20-21 : 250
Year 03-04 : 250	Year 12-13 : 250	Year 21-22 : 250
Year 04-05 : 250	Year 13-14 : 250	Year 22-23 : 250
Year 05-06 : 250	Year 14-15 : 250	Year 23-24 : 250
Year 06-07 : 250	Year 15-16 : 250	Year 24-25 : 250



Set abstraction to : 250 Mcm

Increase abstraction by : 1256 %

Unit: Mcm

Submit View Abstraction Chart Reset

Scenario 5:

- Under 25% reduction of rainfall, and decreasing the discharge of northern zone to 250, the northern zones is sustainable, but this situation will effect the southern zone. As an overall evaluation the WAB will not be sustainable under this conditions (i.e. abstraction must be reduced)

