Tenth Gulf Water Conference, *22-24 April 2012, Doha, Qatar*

Groundwater Management Optimization

by ALL_WATER_gw

New problem formulation & additional functionalities.

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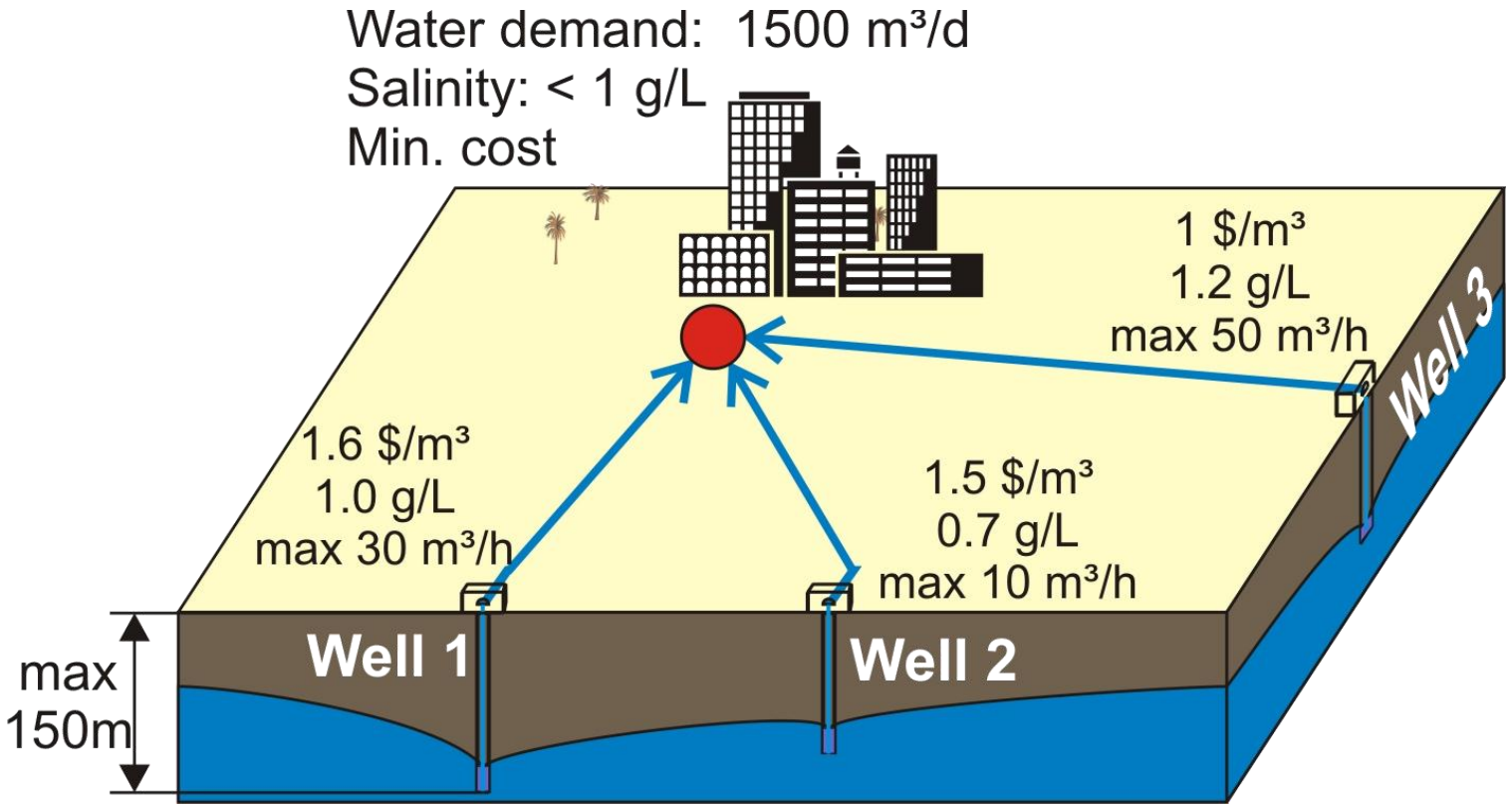
Outline

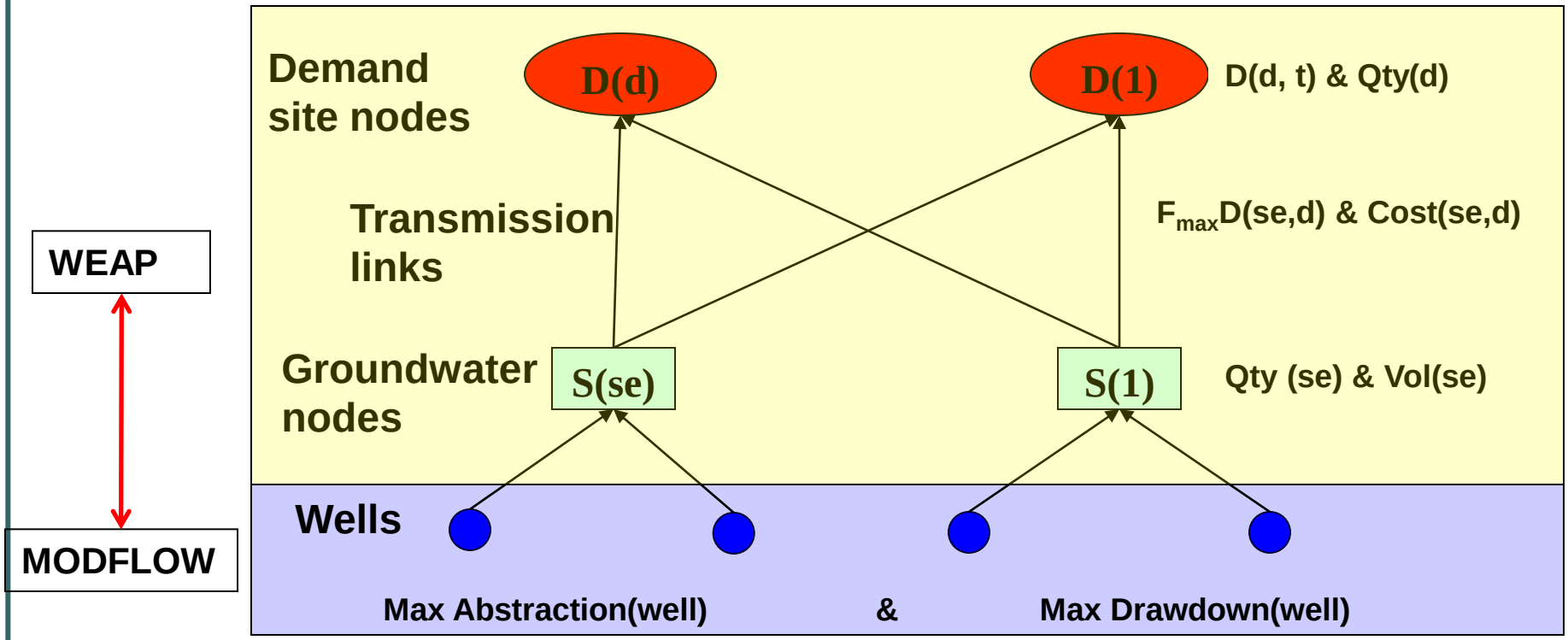
- **Problematic,**
- **General conceptual model and objective,**
- **Problem formulation and resolution methodology,**
- **ALL_WATER_gw presentation,**
- **Case study application.**

Problematic



How much water has to be taken from each well ?

General Conceptual Model



Objective

The main objective of this work was to develop a multi-objective optimization tool for groundwater management.

Problem formulation (1/4)

OBJECTIVES

Objective 1 :

Satisfy the water demands of the sites “d” at every time step “t”.

Objective 2 :

Minimize the maximal drawdown.

Problem formulation (2/4)

Objective 3 :

Minimize the unit cost of water.

Problem formulation (3/4)

CONSTRAINTS

1. Water supply from each groundwater node to any demand site must be lower than the maximal transmission link capacity.

2. Water abstraction from each well must be lower than the maximal acceptable value.

3. Water drawdown in each well cell must be lower than the maximal acceptable value.

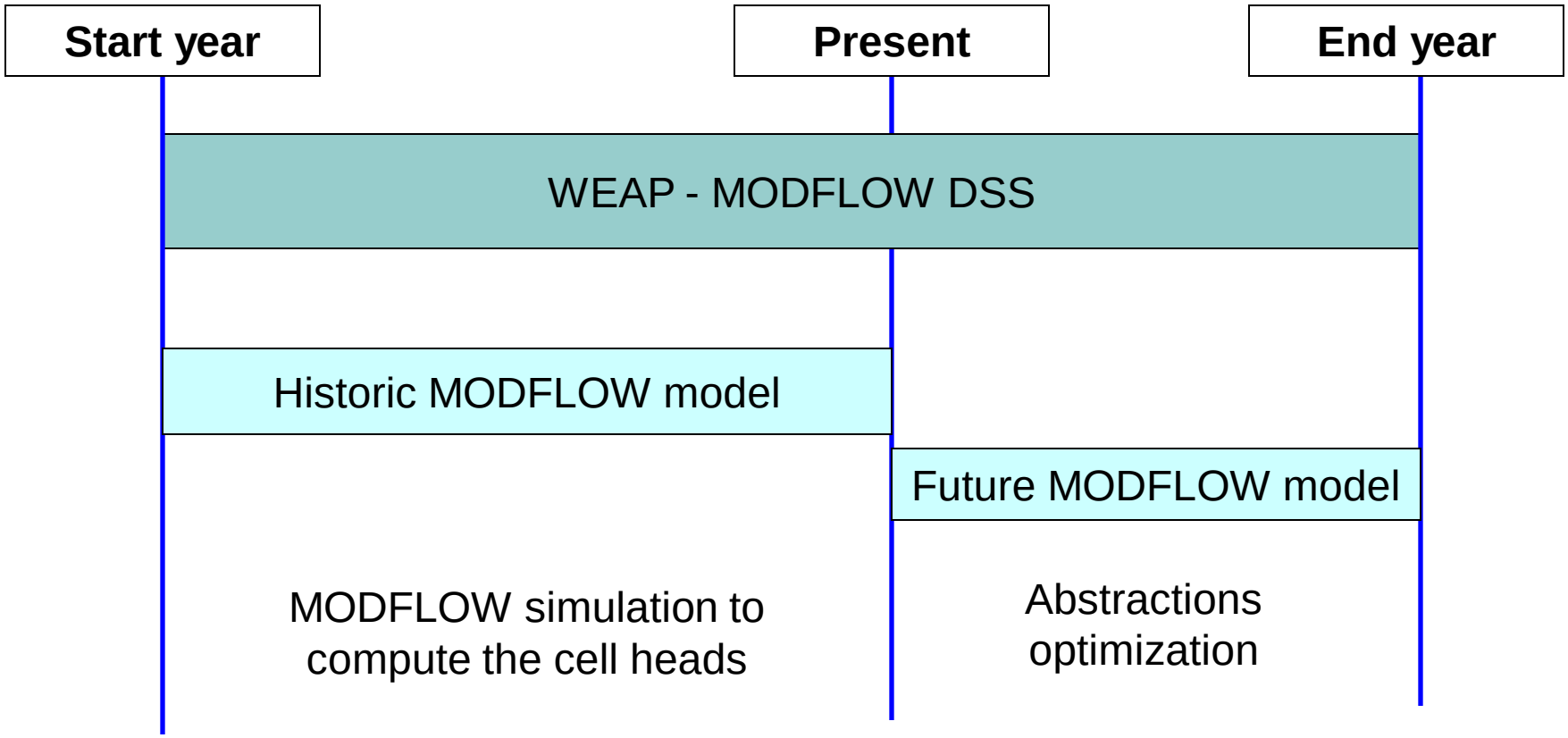
4. Water quality supplied to each of the demand sites must be lower than the maximal acceptable value.

Resolution methodology

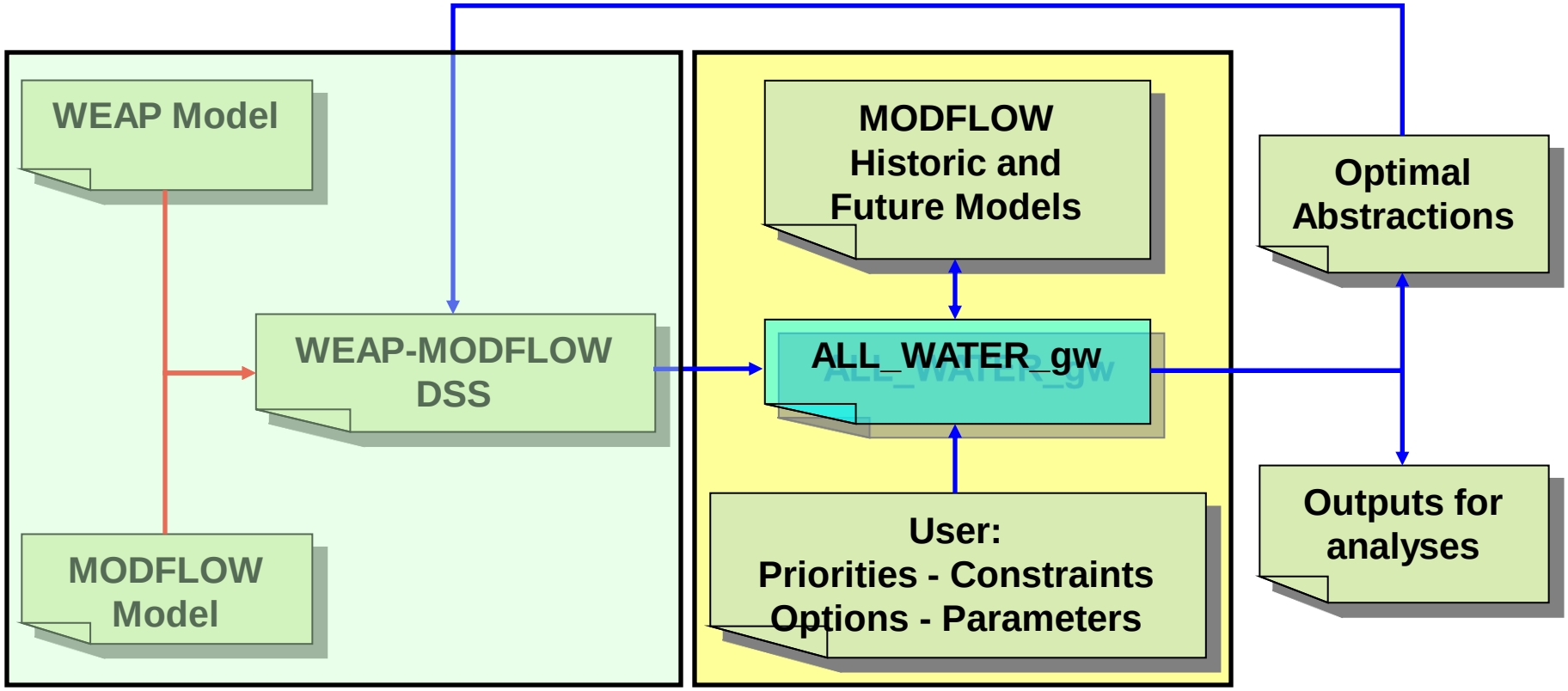
$$\begin{cases} Fitness\ 1 = \dfrac{p_1 \times f_{\mathrm{DS}} \times (1 + MaxEQty) + p_2 \times f_{DD} \times (1 + MaxEQag)}{p_1 + p_2} \\ Fitness\ 2 = f_c \end{cases}$$

1. Multi-objective Genetic Algorithm

2. PARETO optimality Concept


Start year
Present
End year
WEAP - MODFLOW DSS
Historic MODFLOW model
Future MODFLOW model
MODFLOW simulation to compute the cell heads
Abstractions optimization

ALL_WATER_gw in the Framework WEAP – MODFLOW DSS

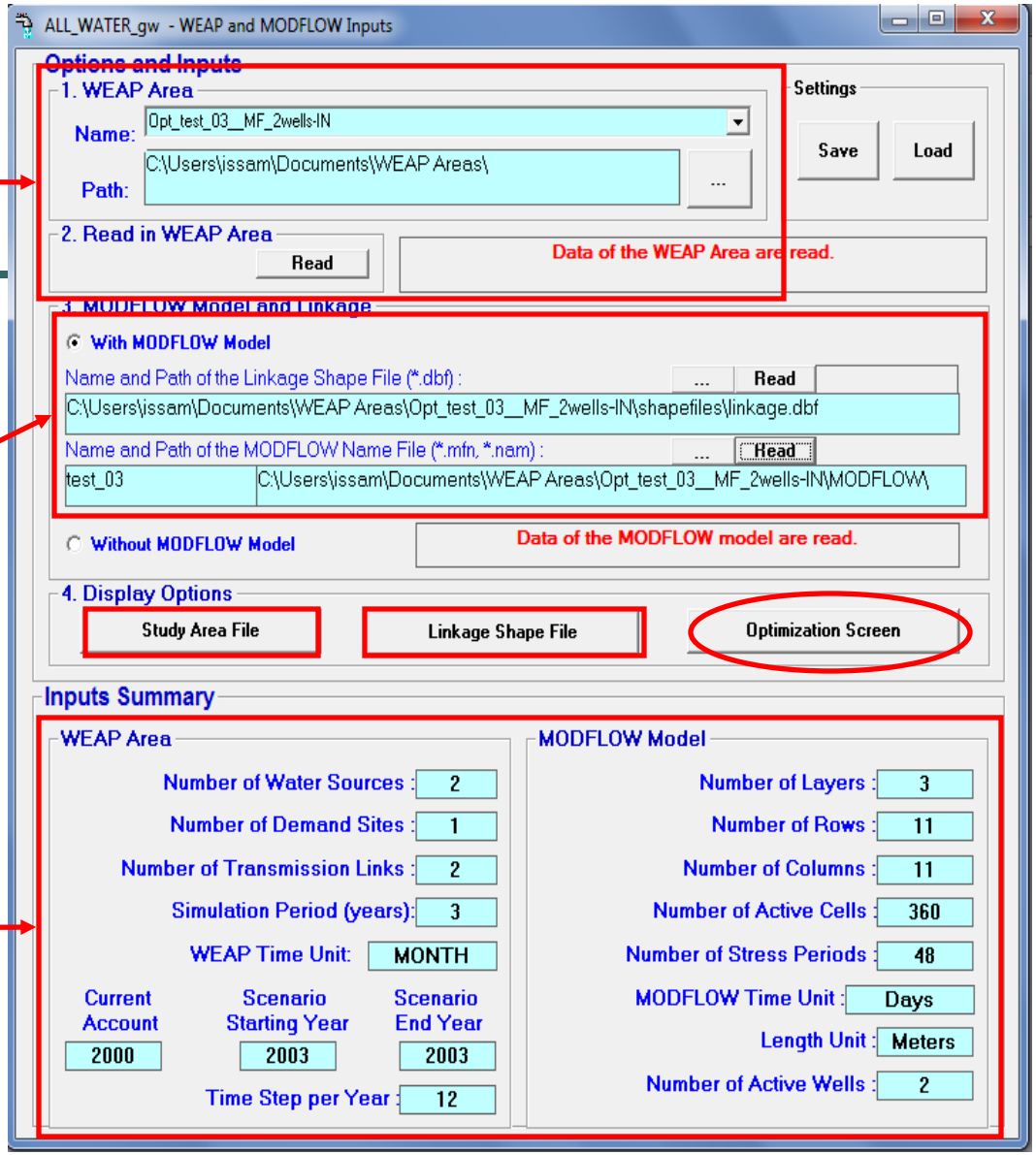


ALL_WATER_gw User interface

Read in the WEAP Area

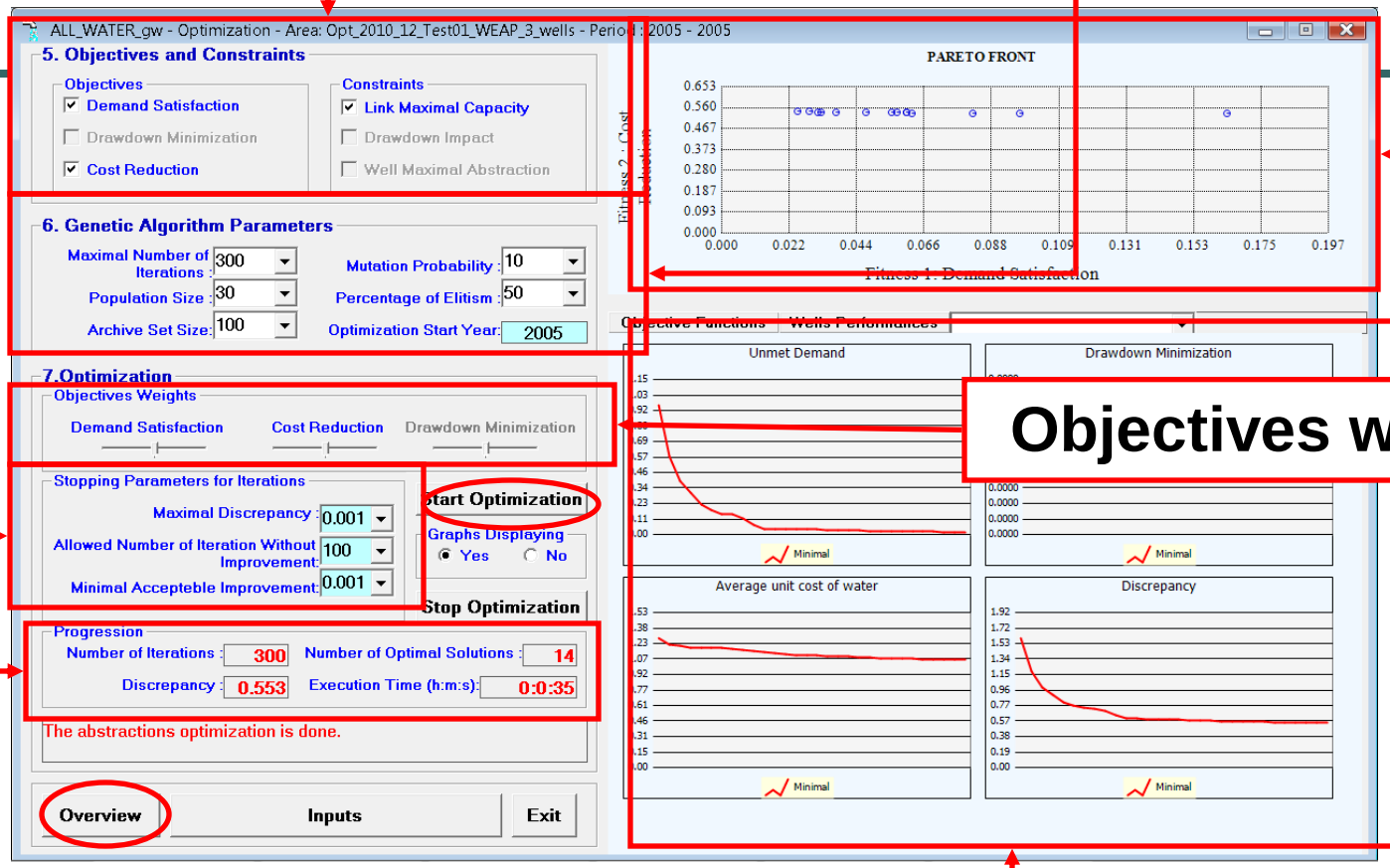
Read in the Linkage and the MODFLOW model

Summary of the inputs



Objectives and constraints

GA parameters

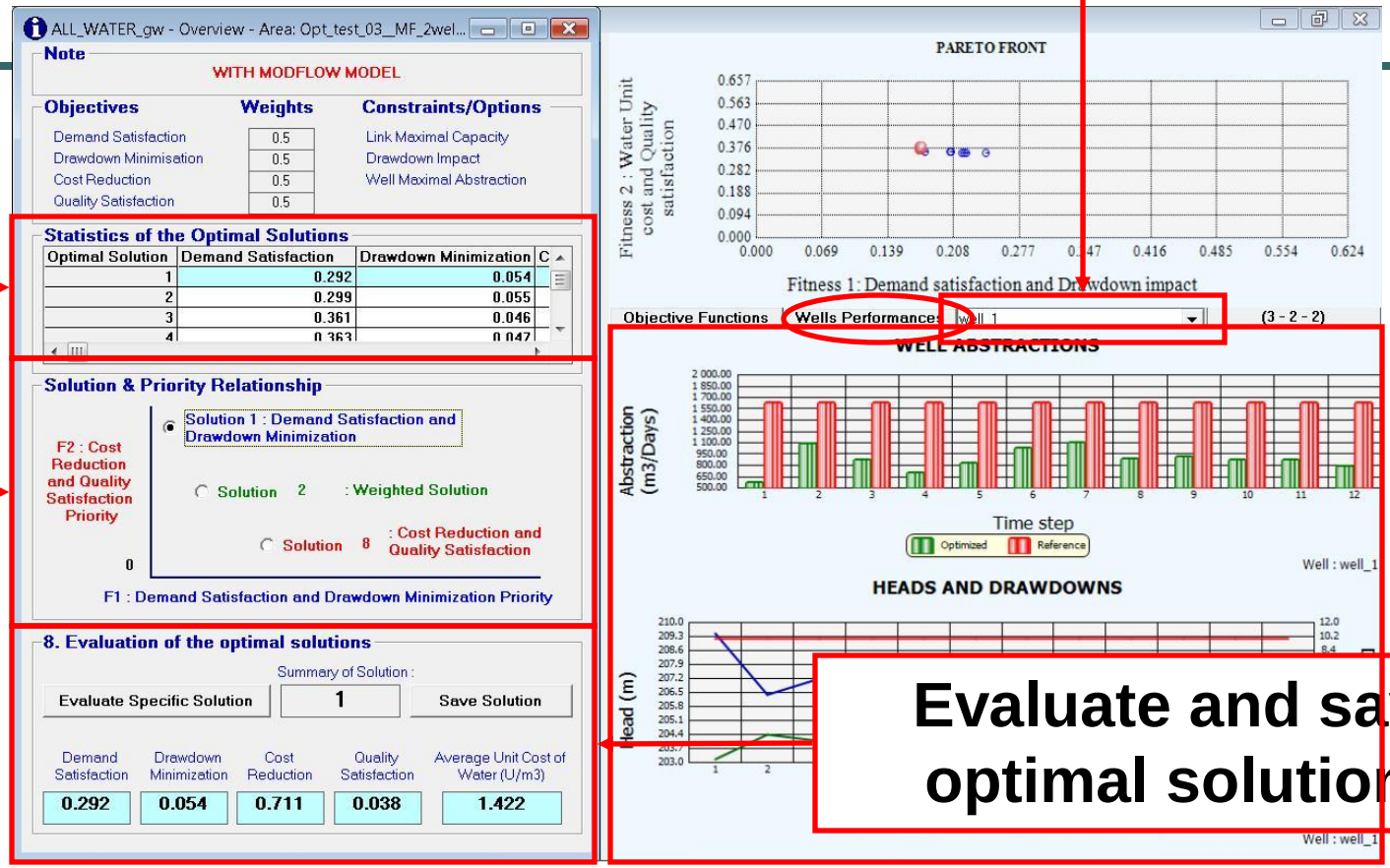


Objectives weights

Progression

Statistics of the optimal solutions

Choose a well

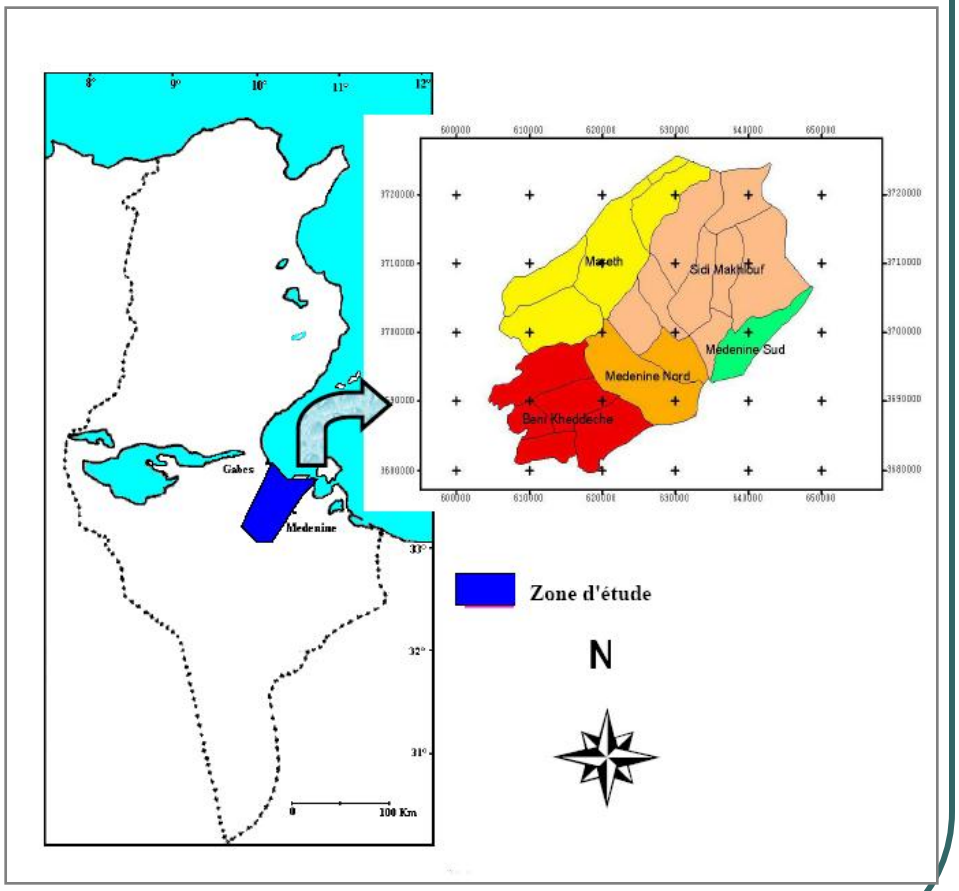


Evaluate and save optimal solutions

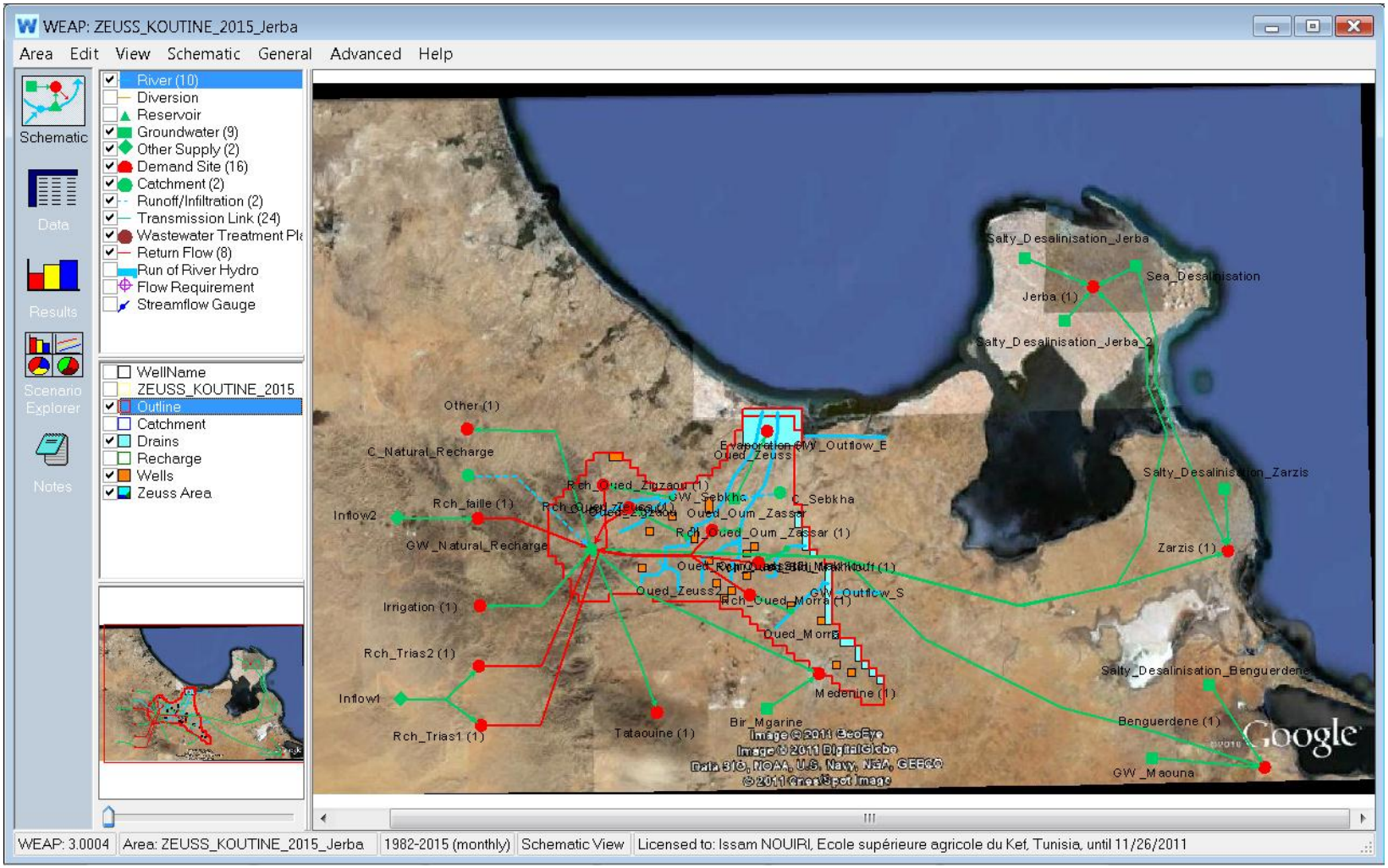
Proposed optimal solutions

Case study application

- 9 groundwater nodes,
- 16 demand sites,
- 24 Transmission links,
- Period: 1983 – 2015,
- Monthly time step,
- Optimization 2013-2015,



WEAP-MODFLOW model for Zeuss Koutine



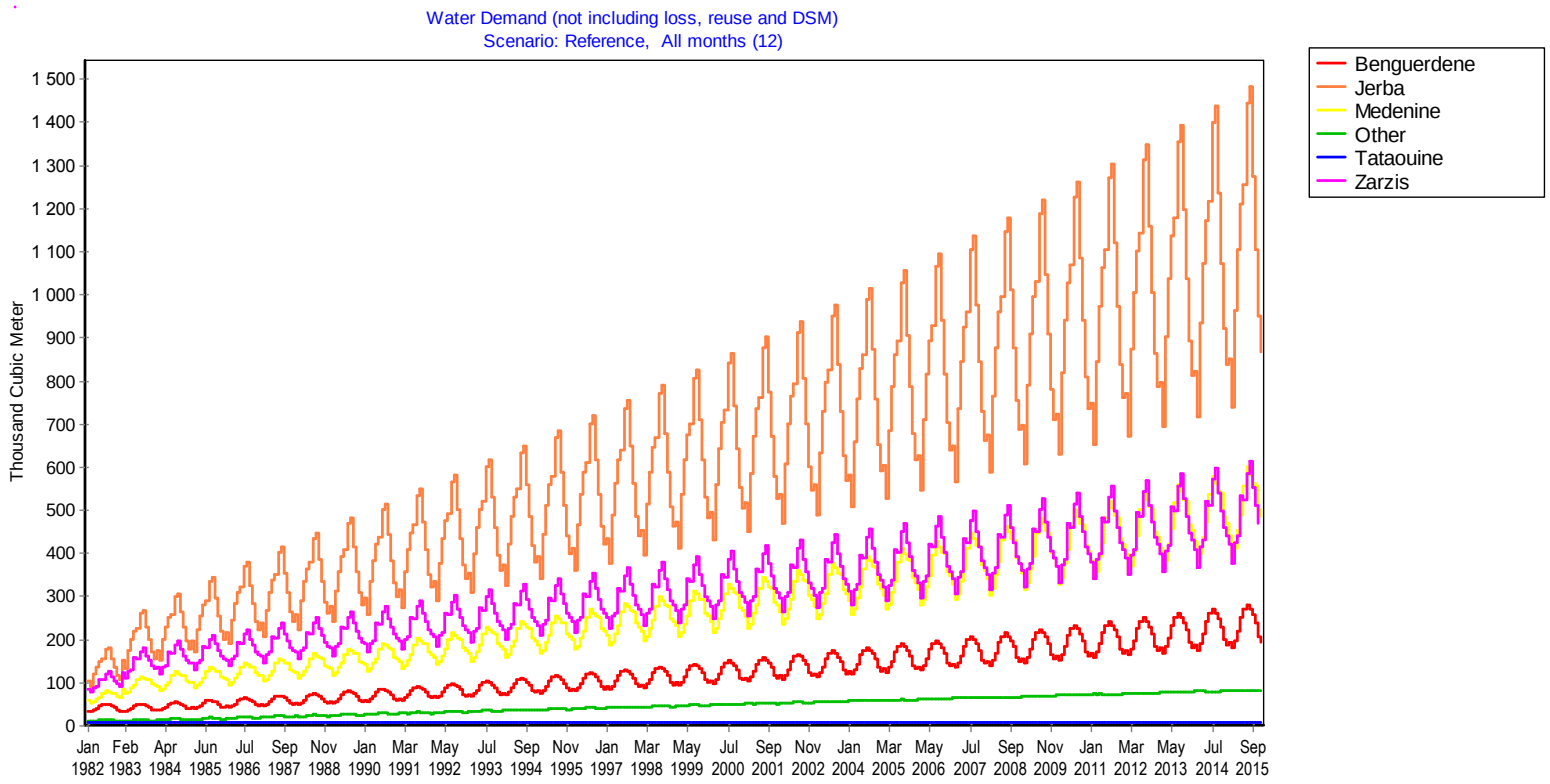
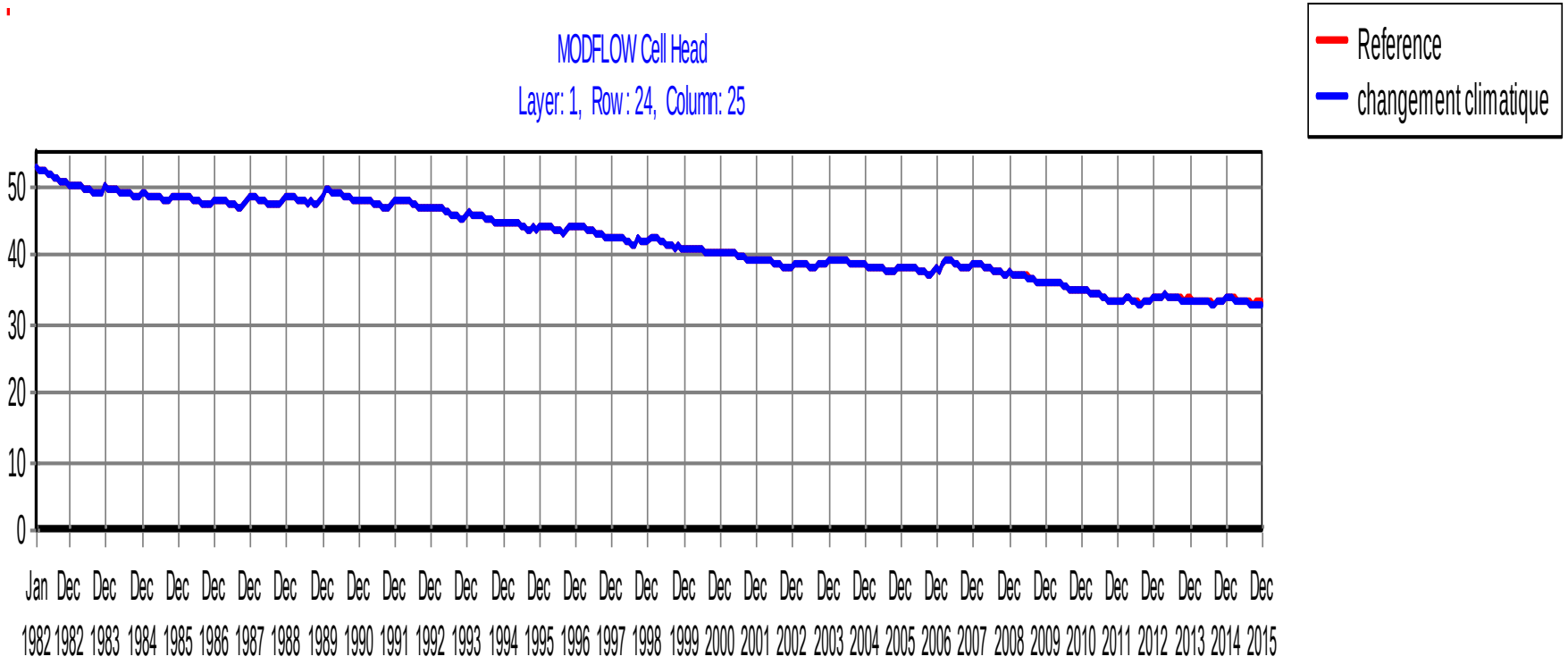
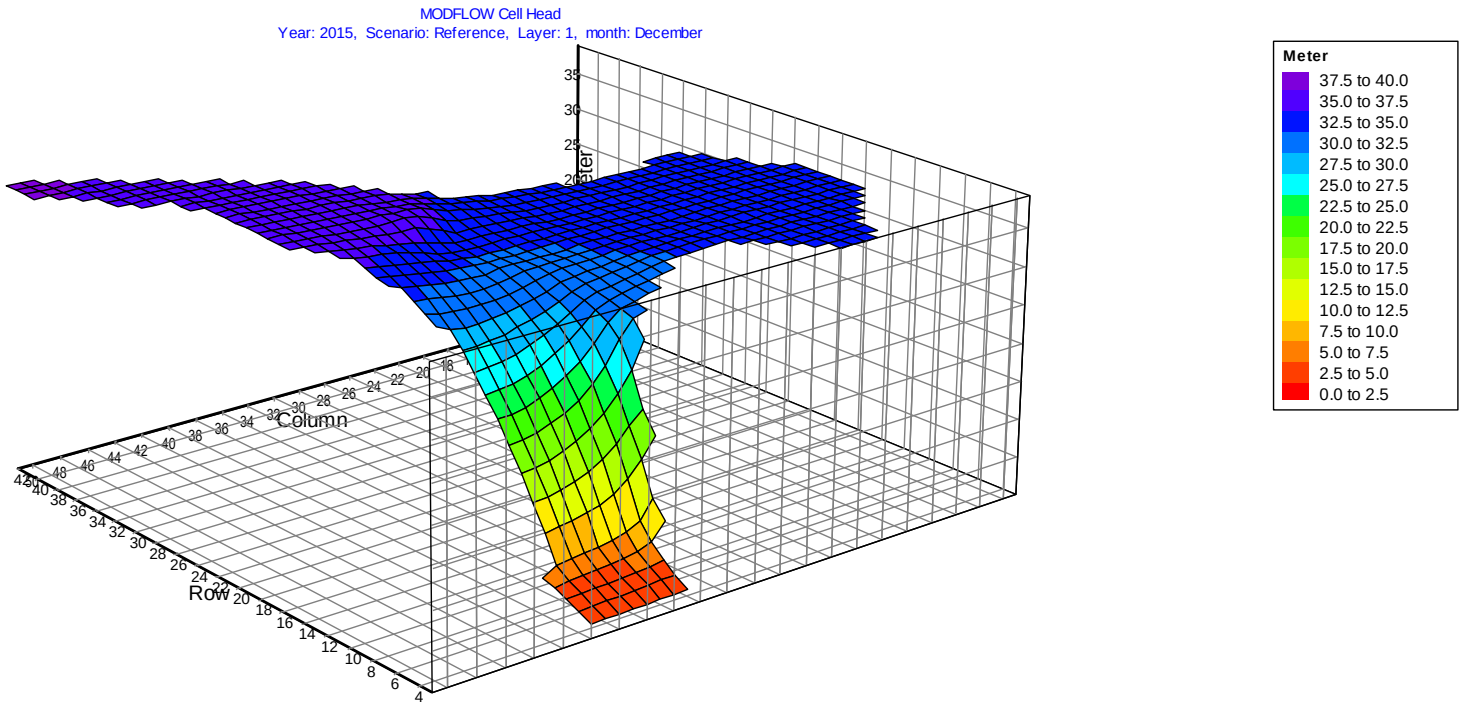


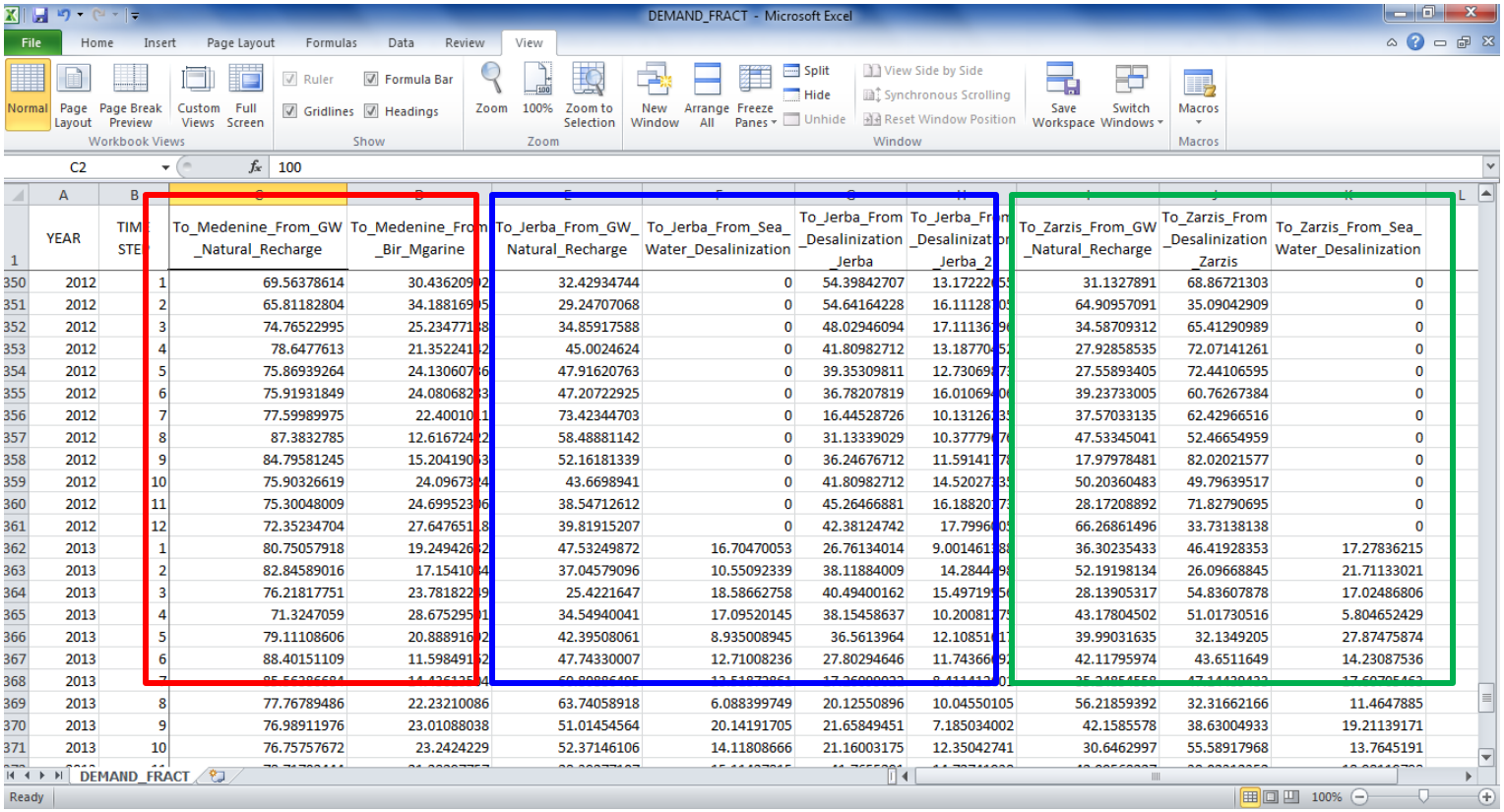
Figure . Monthly water demand for domestic and touristic demand sites nodes.

Simulation results




MODFLOW Cell Head
Year: 2015, Scenario: Reference, Layer: 1, month: December
Meter
Column
Row
Meter
37.5 to 40.0
35.0 to 37.5
32.5 to 35.0
30.0 to 32.5
27.5 to 30.0
25.0 to 27.5
22.5 to 25.0
20.0 to 22.5
17.5 to 20.0
15.0 to 17.5
12.5 to 15.0
10.0 to 12.5
7.5 to 10.0
5.0 to 7.5
2.5 to 5.0
0.0 to 2.5

Optimization results



	YEAR	TIME STEP	To_Medenine_From_GW_Natural_Recharge	To_Medenine_From_Bir_Mgarine	To_Jerba_From_GW_Natural_Recharge	To_Jerba_From_Sea_Water_Desalinization	To_Jerba_From_Desalinization_Jerba	To_Jerba_From_Desalinization_Jerba_2	To_Zarzis_From_GW_Natural_Recharge	To_Zarzis_From_Desalinization_Zarzis	To_Zarzis_From_Sea_Water_Desalinization
350	2012	1	69.56378614	30.43620942	32.42934744	0	54.39842707	13.17222653	31.1327891	68.86721303	0
351	2012	2	65.81182804	34.18816945	29.24707068	0	54.64164228	16.11128703	64.90957091	35.09042909	0
352	2012	3	74.76522995	25.23477148	34.85917588	0	48.02946094	17.11136196	34.58709312	65.41290989	0
353	2012	4	78.6477613	21.35224142	45.0024624	0	41.80982712	13.18770452	27.92858535	72.07141261	0
354	2012	5	75.86939264	24.13060736	47.91620763	0	39.35309811	12.73069473	27.55893405	72.44106595	0
355	2012	6	75.91931849	24.08068283	47.20722925	0	36.78207819	16.01069406	39.23733005	60.76267384	0
356	2012	7	77.59989975	22.40010011	73.42344703	0	16.44528726	10.13126133	37.57033135	62.42966516	0
357	2012	8	87.3832785	12.61672422	58.48881142	0	31.13339029	10.37779176	47.53345041	52.46654959	0
358	2012	9	84.79581245	15.20419043	52.16181339	0	36.24676712	11.59141178	17.97978481	82.02021577	0
359	2012	10	75.90326619	24.09673384	43.6698941	0	41.80982712	14.52027133	50.20360483	49.79639517	0
360	2012	11	75.30048009	24.69952396	38.54712612	0	45.26466881	16.18820173	28.17208892	71.82790695	0
361	2012	12	72.35234704	27.64765128	39.81915207	0	42.38124742	17.79960109	66.26861496	33.73138138	0
362	2013	1	80.75057918	19.24942642	47.53249872	16.70470053	26.76134014	9.001461188	36.30235433	46.41928353	17.27836215
363	2013	2	82.84589016	17.15410984	37.04579096	10.55092339	38.11884009	14.28444994	52.19198134	26.09668845	21.71133021
364	2013	3	76.21817751	23.78182249	25.4221647	18.58662758	40.49400162	15.49719156	28.13905317	54.83607878	17.02486806
365	2013	4	71.3247059	28.67529501	34.54940041	17.09520145	38.15458637	10.20081175	43.17804502	51.01730516	5.804652429
366	2013	5	79.11108606	20.88891692	42.39508061	8.935008945	36.5613964	12.10851017	39.99031635	32.1349205	27.87475874
367	2013	6	88.40151109	11.59849152	47.74330007	12.71008236	27.80294646	11.74366091	42.11795974	43.6511649	14.23087536
368	2013	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
369	2013	8	77.76789486	22.23210086	63.74058918	6.088399749	20.12550896	10.04550105	56.21859392	32.31662166	11.4647885
370	2013	9	76.98911976	23.01088038	51.01454564	20.14191705	21.65849451	7.185034002	42.1585578	38.63004933	19.21139171
371	2013	10	76.75757672	23.2424229	52.37146106	14.11808666	21.16003175	12.35042741	30.6462997	55.58917968	13.7645191

Figure. Overview of the “DEMAND_FRACT.csv” file produced by ***ALL_WATER_gw***.

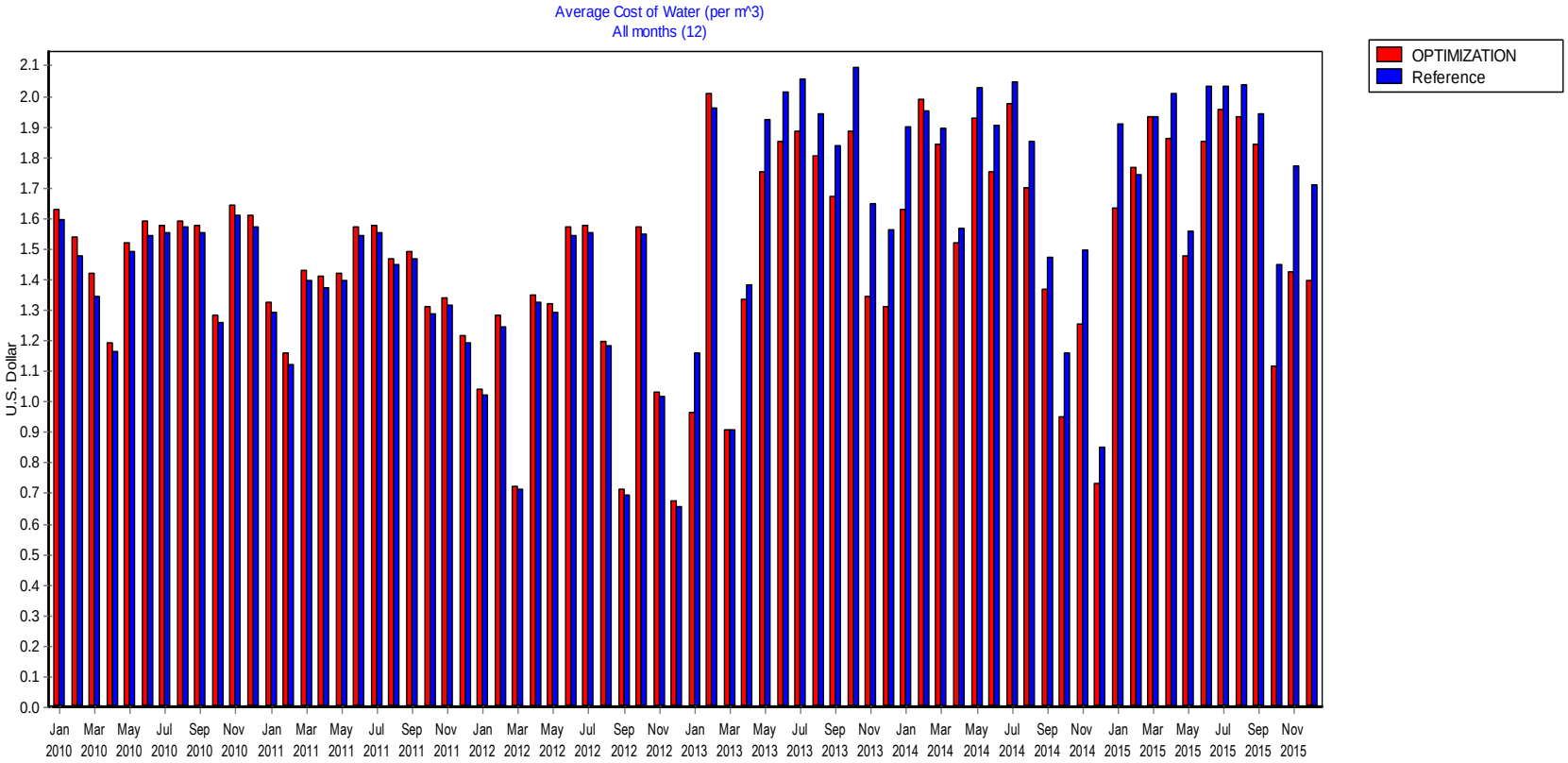
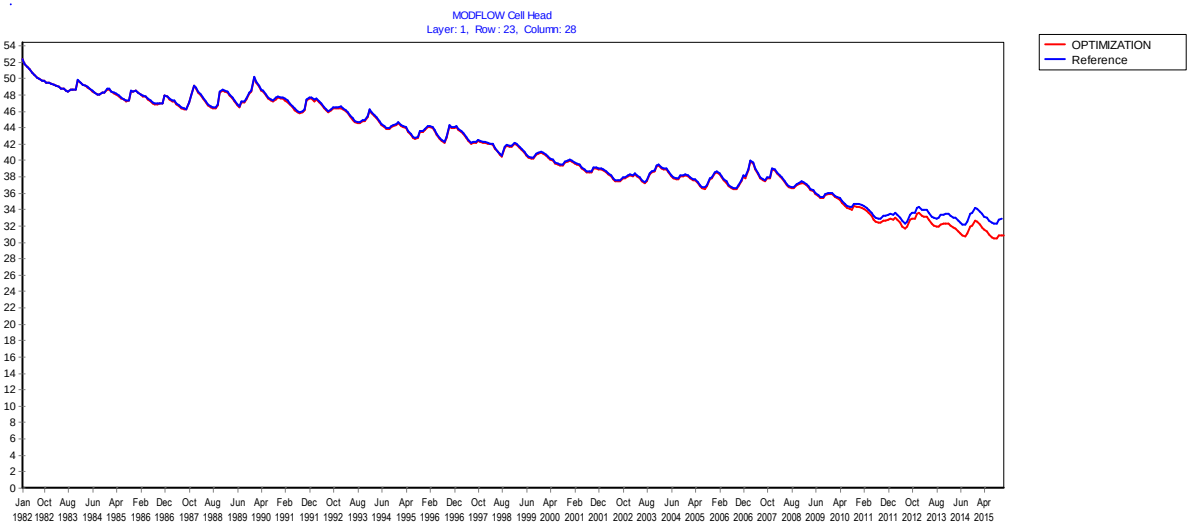


Figure. Optimized and Reference “Average Cost of Water” (KWh per m3).



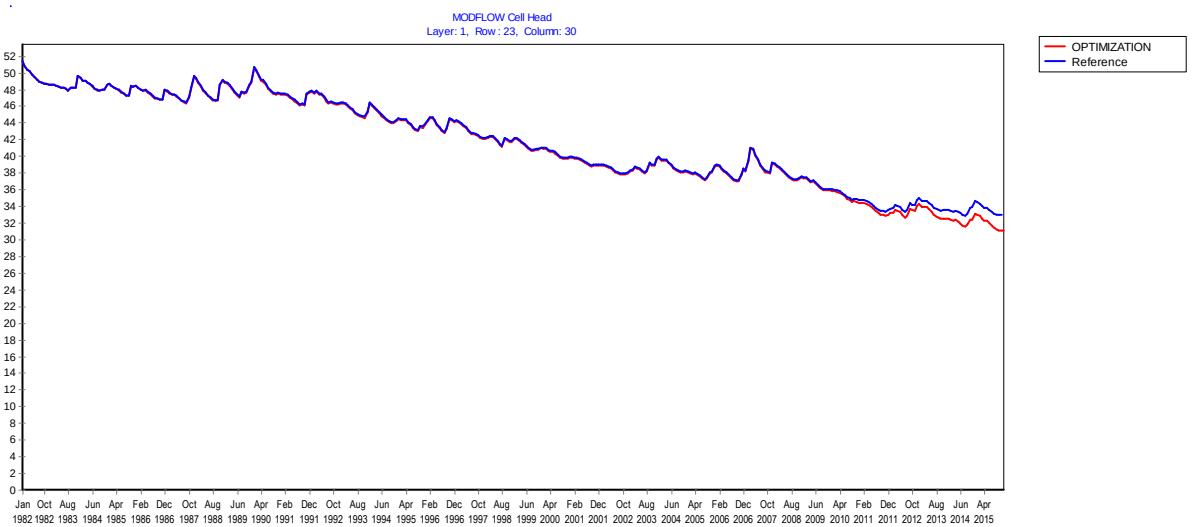


Figure. Optimized and Reference cells heads of two piezometers.

Summary & Conclusions

- ***ALL_WATER_gw*** can be used in the framework of WEAP-MODFLOW or as stand alone tool.
- It considers the main objectives and constraints for groundwater management,
- For real groundwater, it was able to identify optimal management solutions,
- ***ALL_WATER_gw*** is a free tool.

شكرا

Merci

Thank You

Danke schön