SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

SWIM-H2020 SM Regional Activities-Jordan

Presented by:

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WEAP Water Resource Management Model for the Amman-Zarqa Basin with a focus on groundwater over-abstraction

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Objectives of the WEAP Water Resources Management Models (WRMM) in the Amman-Zarqa Basin

Support the holistic water planning and drought mitigation in the AZ Basin by providing a support tool to the MWI and training staff to use and expand it

Objectives of the WEAP Water Resources Management Models (WRMM) in the Amman-Zarqa Basin

- Simulate the hydrological balance in the basin (for a better representation a link with the ArcSWAT model was implemented)
- Evaluate the balance between groundwater recharge and abstraction for the period 2001-2015
- Investigate the impact of the current practices (i.e. the actual groundwater abstraction) on the aquifer
- Quantify the groundwater over-abstraction
- Link the over-abstraction to specific water using sector (domestic, agricultural, industrial) and Governorates' water demand
- Feed data (over-abstraction / unmet demand) to calculate drought vulnerability indicators

Why WEAP Simulation has been selected:

WEAP

WEAP Capability as Decision Support Tool for:

1. Hydrological Simulation of GW Recharge in the Basin
2. Integration of Rainfall + Evapotranspiration Data
3. Using Rainfall-Runoff Modeling + Estimation of Flood flow
4. Calculations on the Stresses on GW-Abstraction using:
    1. Unmet Demands Parameter
    2. Actual GW-Water Supply vs. Natural GW Recharge
5. Capacity of integration of WEAP with other Hydrological Models like SWAT, MODFLOW, etc.
6. User-friendly, easily expandable

WEAP Conceptual Design

1. Modeling GW Recharge (Simulation)+Balancing Safe Yield

2. Considering Demands is the Actual GW Supply (Measured)

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1. Modeling GW Recharge (Simulation):

Catchment Area using Simplified Rainfall-Runoff Method

Enter the following

1. **Land-area of the catchment**
2. **Kc**
3. **Effective Precipitation**
4. **Rainfall Data**
5. **Reference Eto**

WEAP Conceptual Design

1. Modeling GW Recharge (Simulation)+Balancing Safe Yield
2. **Considering Demands is the Actual GW Supply (Measured)**

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2. Actual Supply as Demand (Measured):

Demand Node

Enter the following

1. **Monthly Data on GW-Abstraction**
2. **Monthly Variation**

Overview of WEAP Model in AZ-Basin (GW Over-Abstraction)

Aggregated Model

1 Catchment

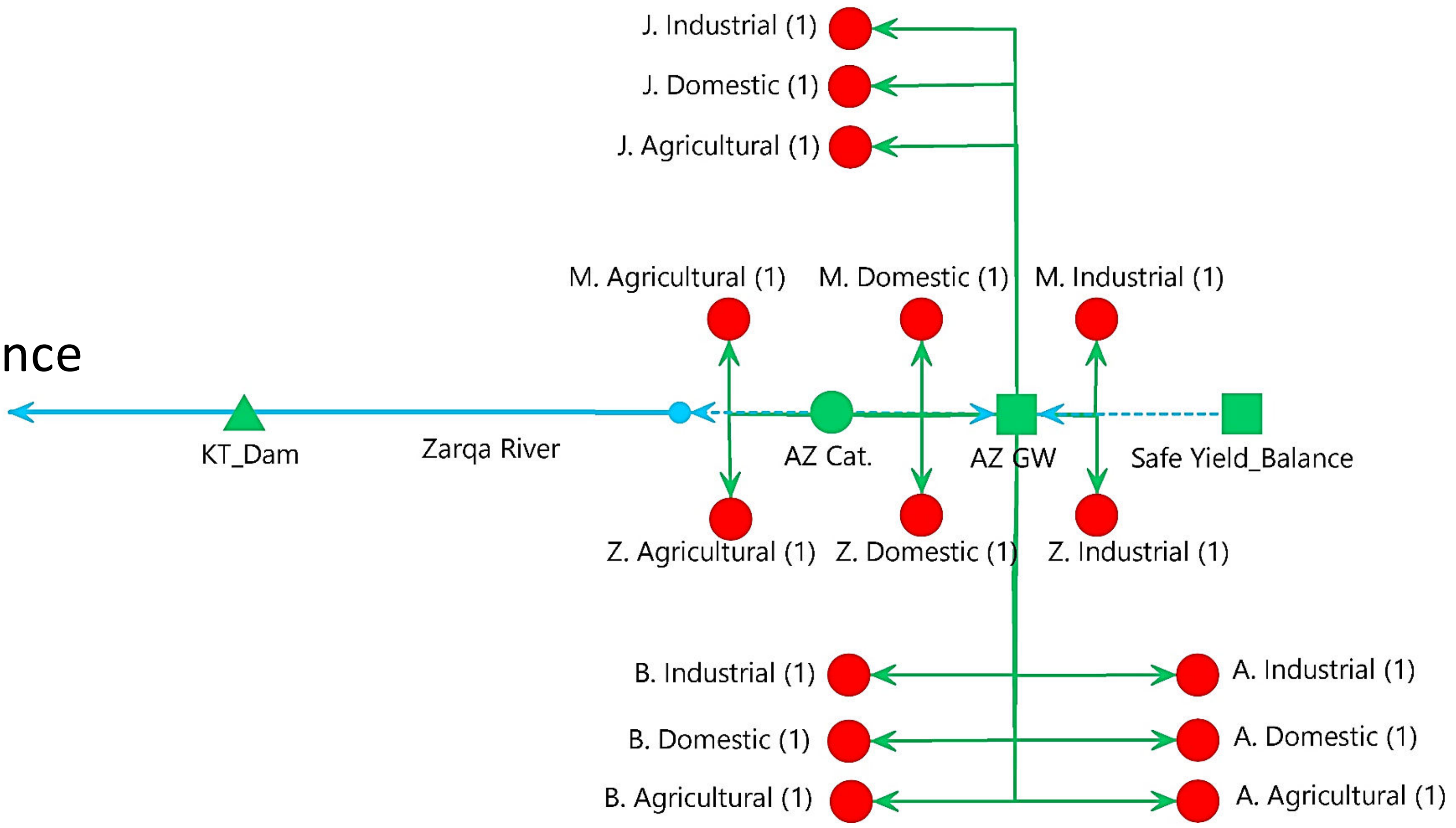
1 Groundwater

1 GW Safe-yield Balance

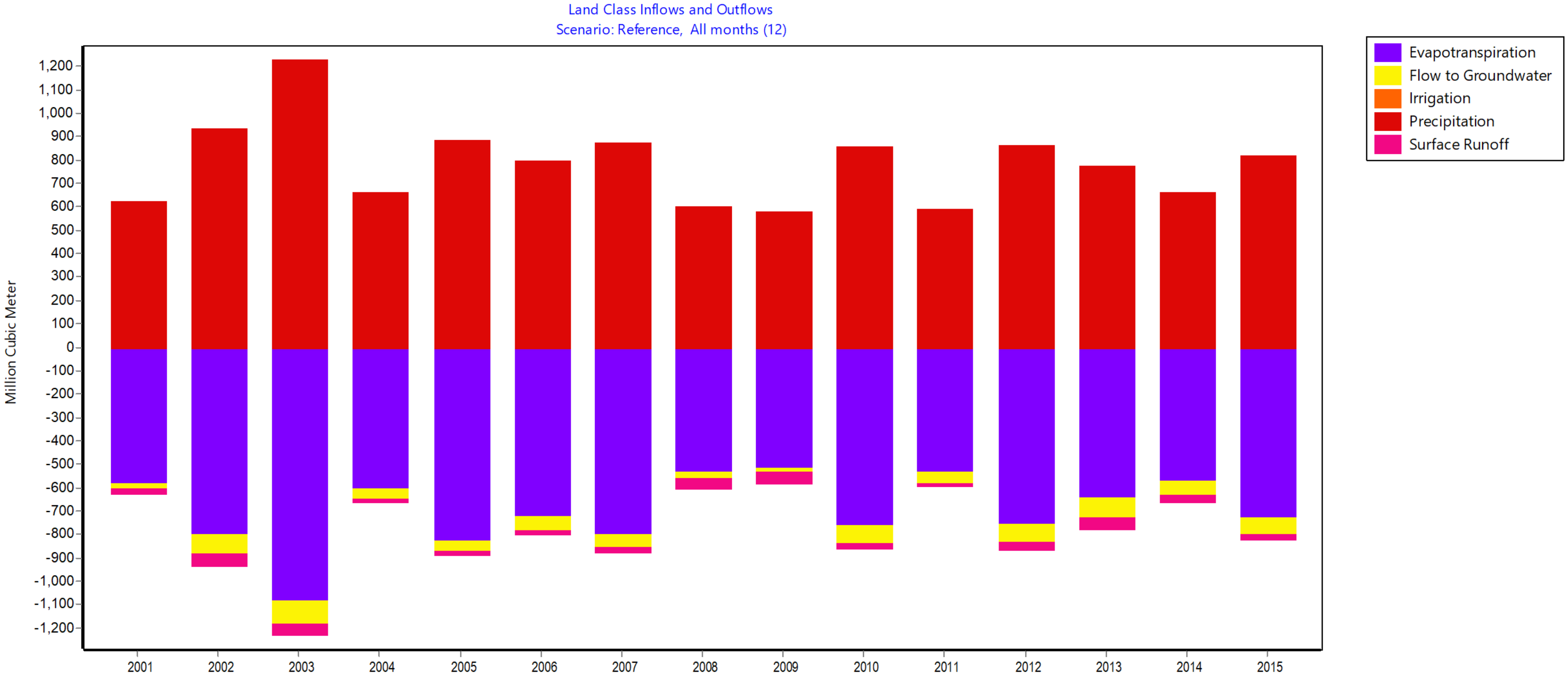
1 River

5 Regions

3 sectors



Model Results – Mass balance

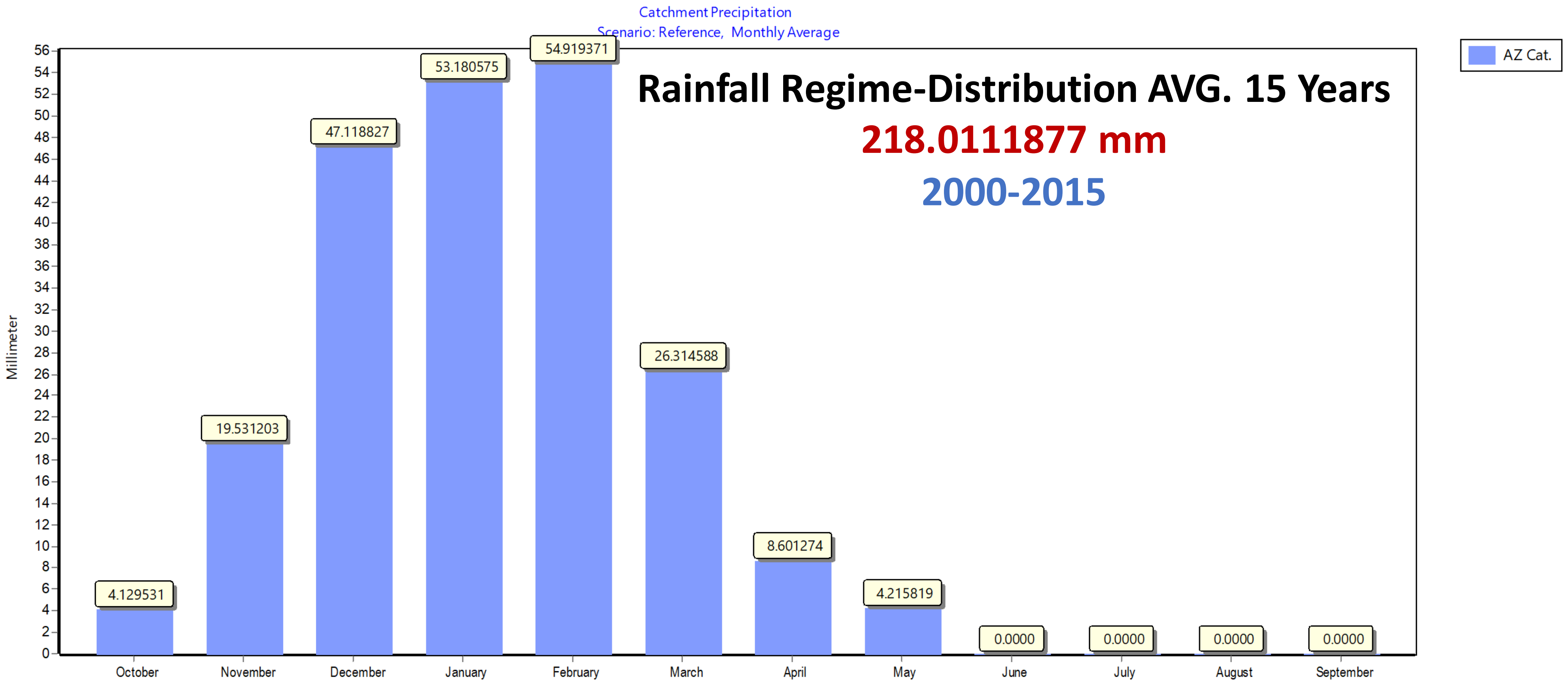


Model Results : Mass balance (in m3)

Period 2001-2015	Precipitation	Actual Evapotranspiration	Flow to Groundwater	Surface Runoff
Average	783,532,209	-696,366,493 (-89%)	-57,109,286 (-7%)	-30,056,431 (-4%)
Max	1,226,905,189 *(2003)*	-1,082,351,912 *(2003)*	-96,850,695 *(2003)*	-49,865,564 *(2002)*
Min	579,008,342 *(2009)*	-515,317,424 *(2009)*	-16,964,944 *(2009)*	-9,550,736 *(2011)*

Year	Precipitation	Actual Evapotranspiration	Flow to Groundwater	Surface Runoff
2001	625,626,778	-93%	-4%	-3%
2002	932,106,215	-86%	-9%	-5%
2003	1,226,905,189	-88%	-8%	-4%
2004	659,401,560	-91%	-7%	-2%
2005	887,530,260	-93%	-5%	-2%
2006	796,095,054	-91%	-7%	-2%
2007	876,721,234	-91%	-6%	-3%
2008	604,018,020	-88%	-4%	-8%
2009	579,008,341	-89%	-3%	-8%
2010	856,140,781	-89%	-9%	-2%
2011	589,551,598	-90%	-8%	-2%
2012	865,547,342	-87%	-8%	-4%
2013	774,931,441	-82%	-11%	-6%
2014	659,974,166	-86%	-9%	-5%
2015	819,425,162	-89%	-9%	-2%

1. Precipitation Data



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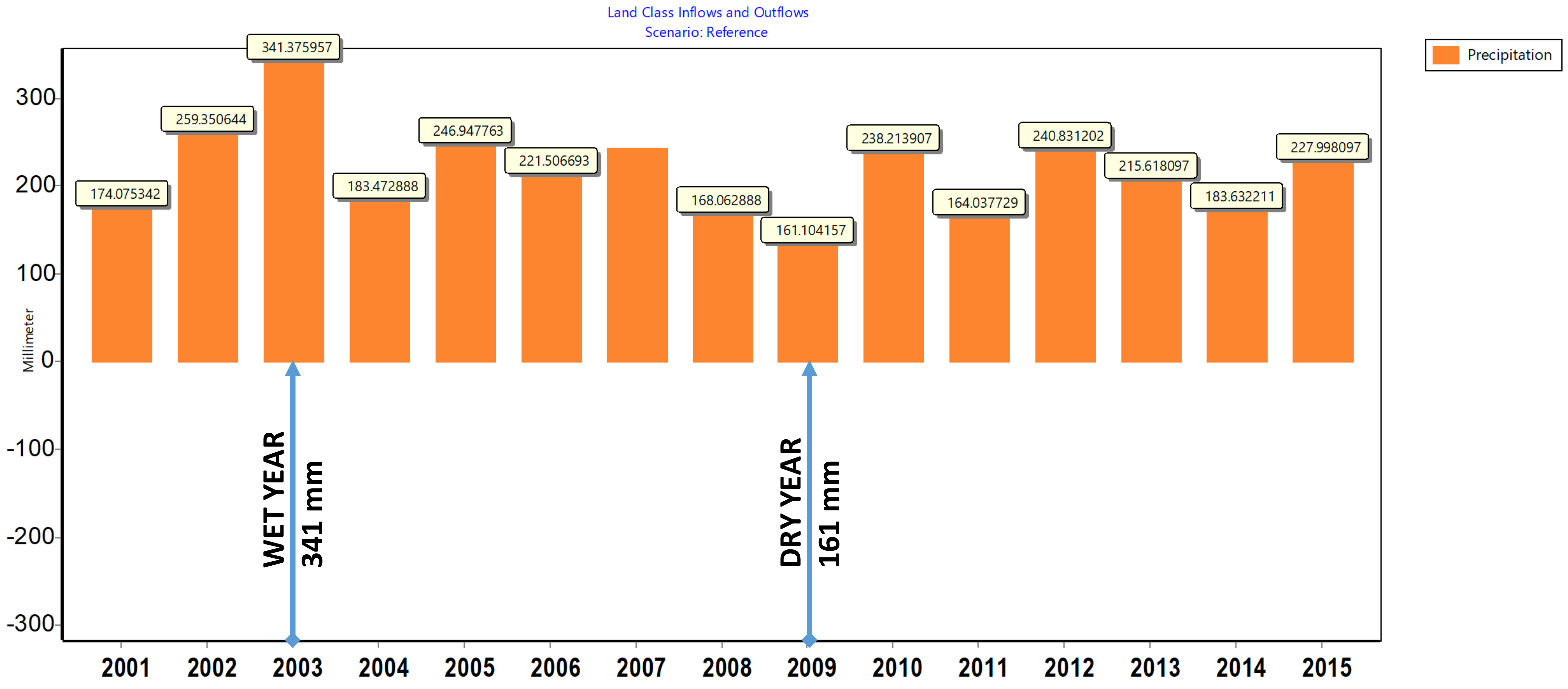
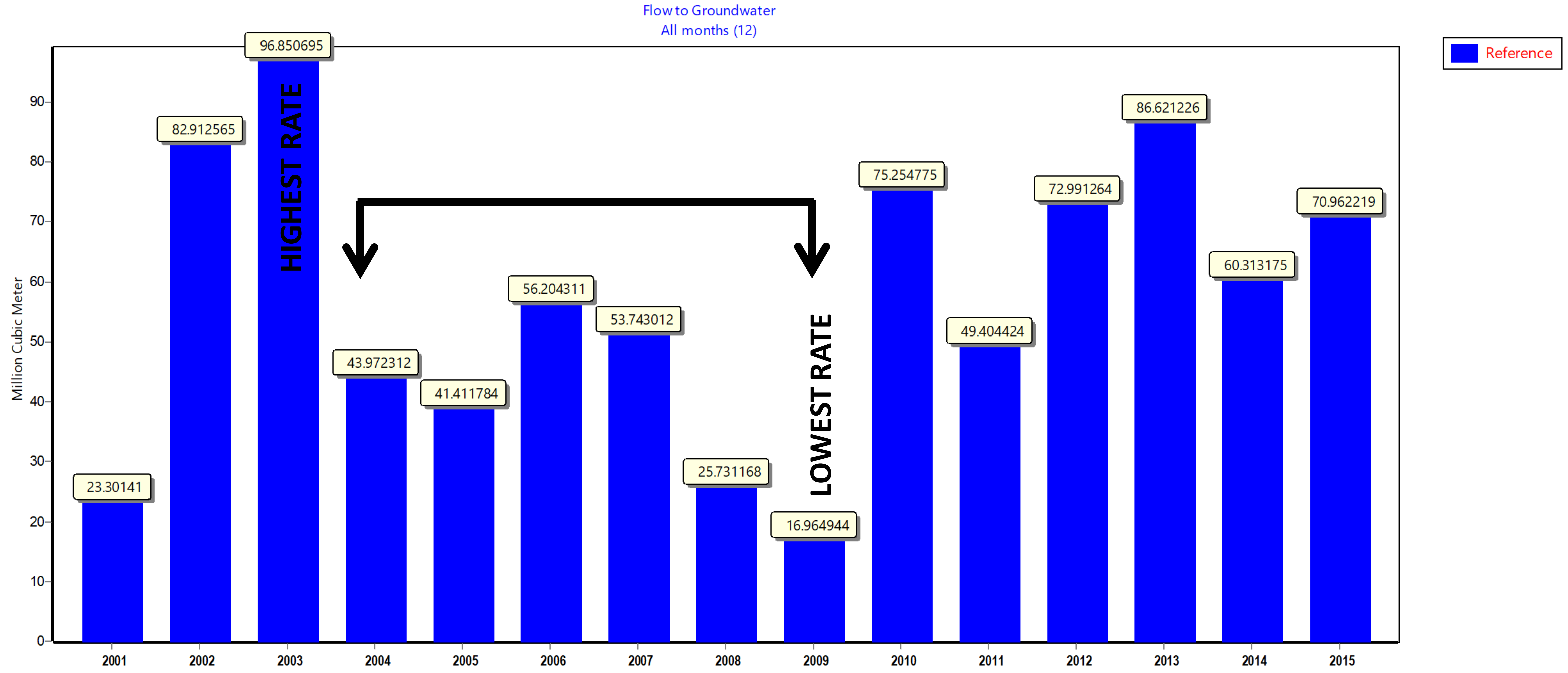
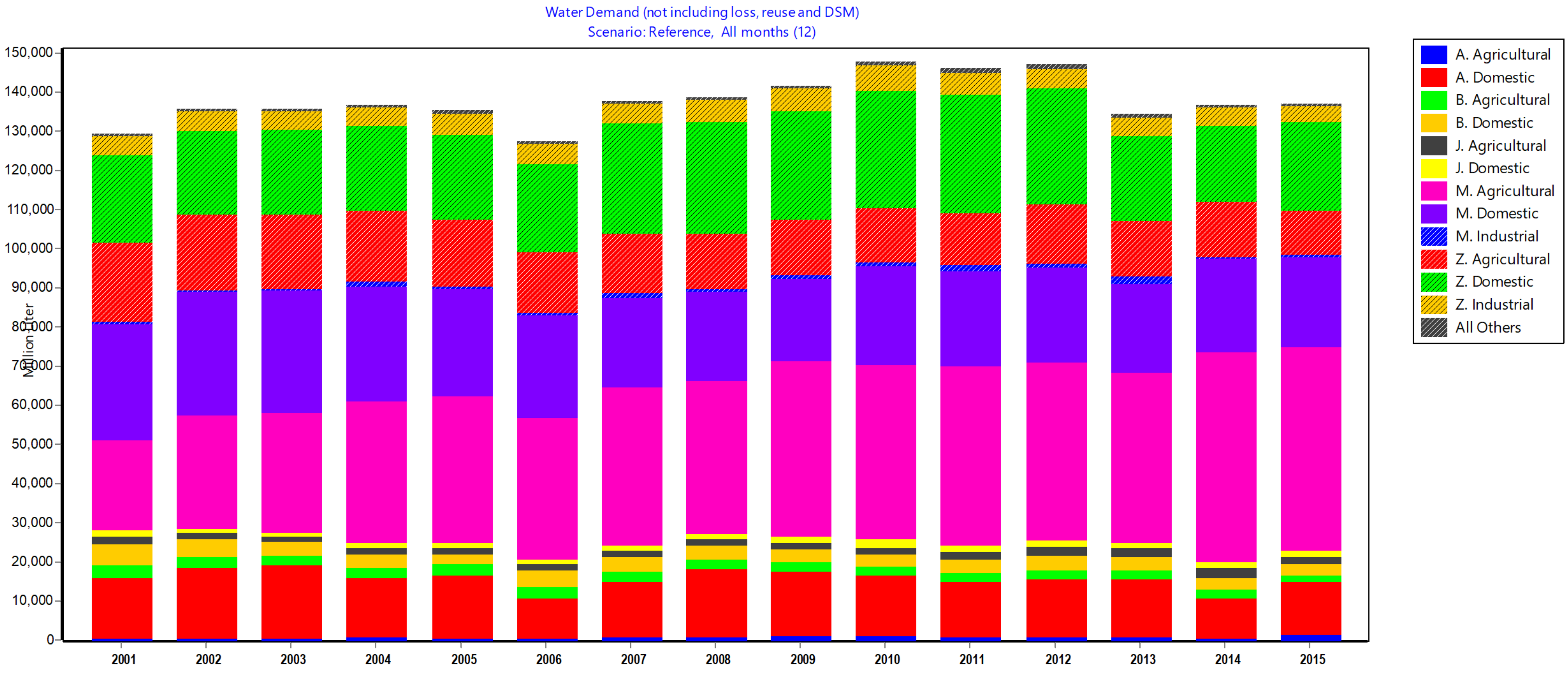


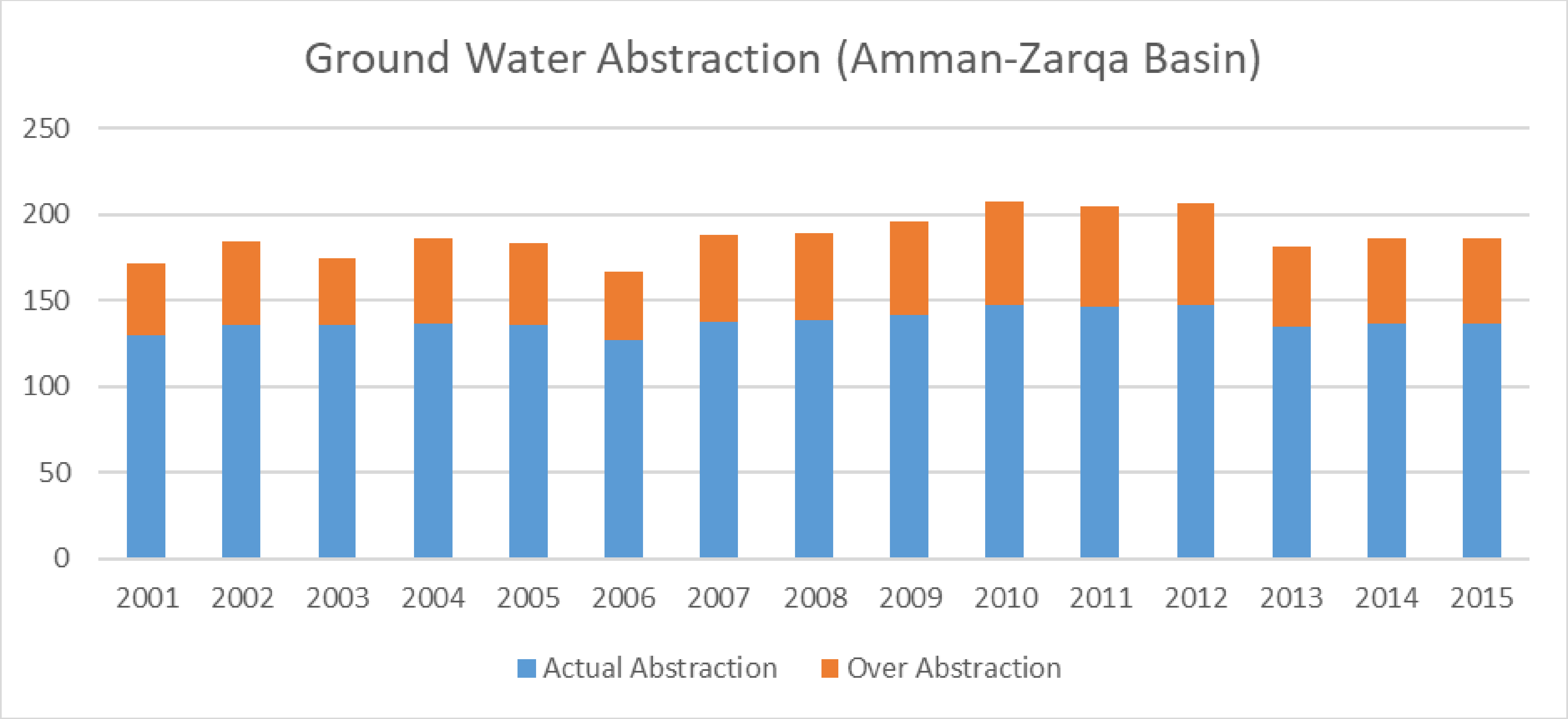
Natural Recharge (Groundwater) in MCM



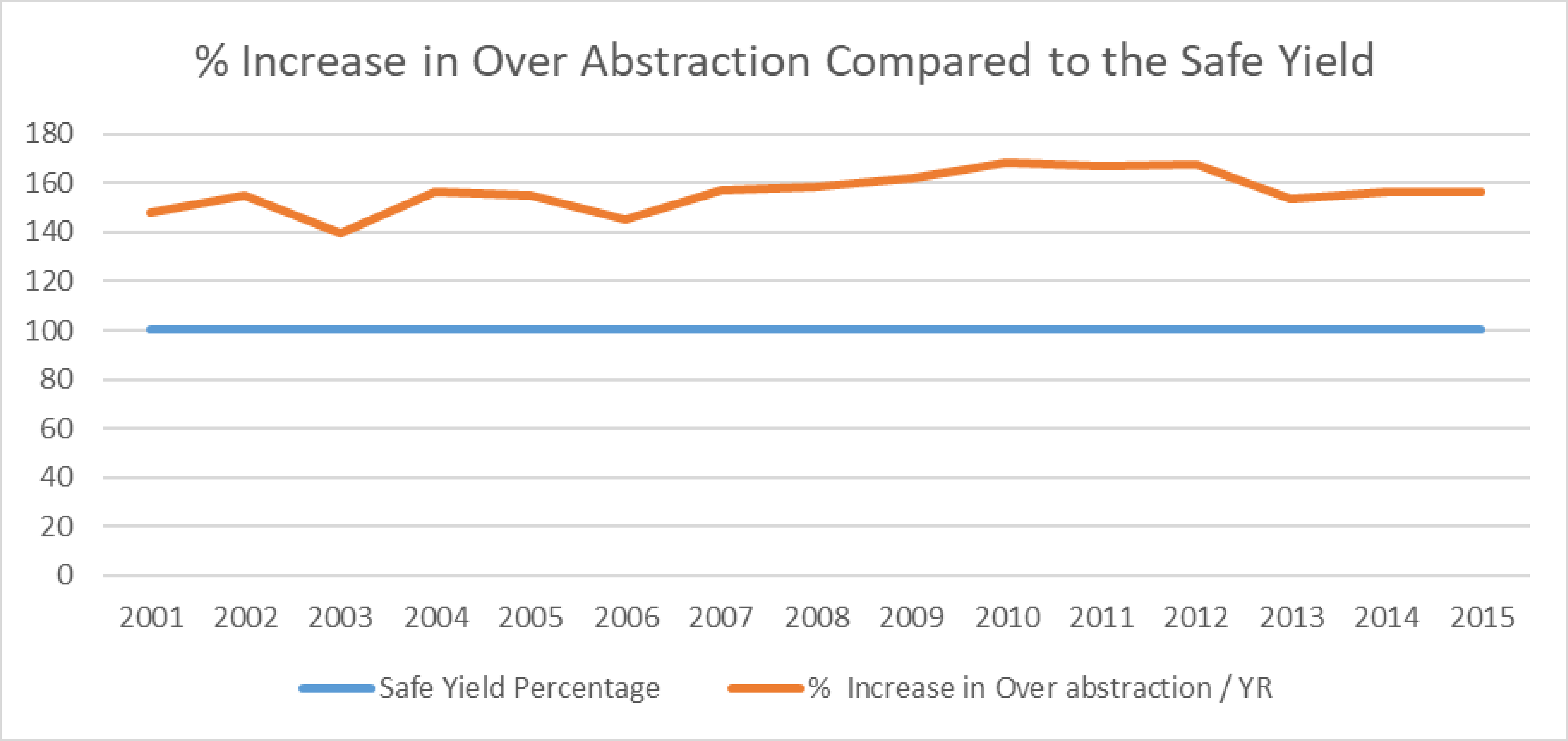
Groundwater Actual Abstraction (Demand)



Over Abstraction %



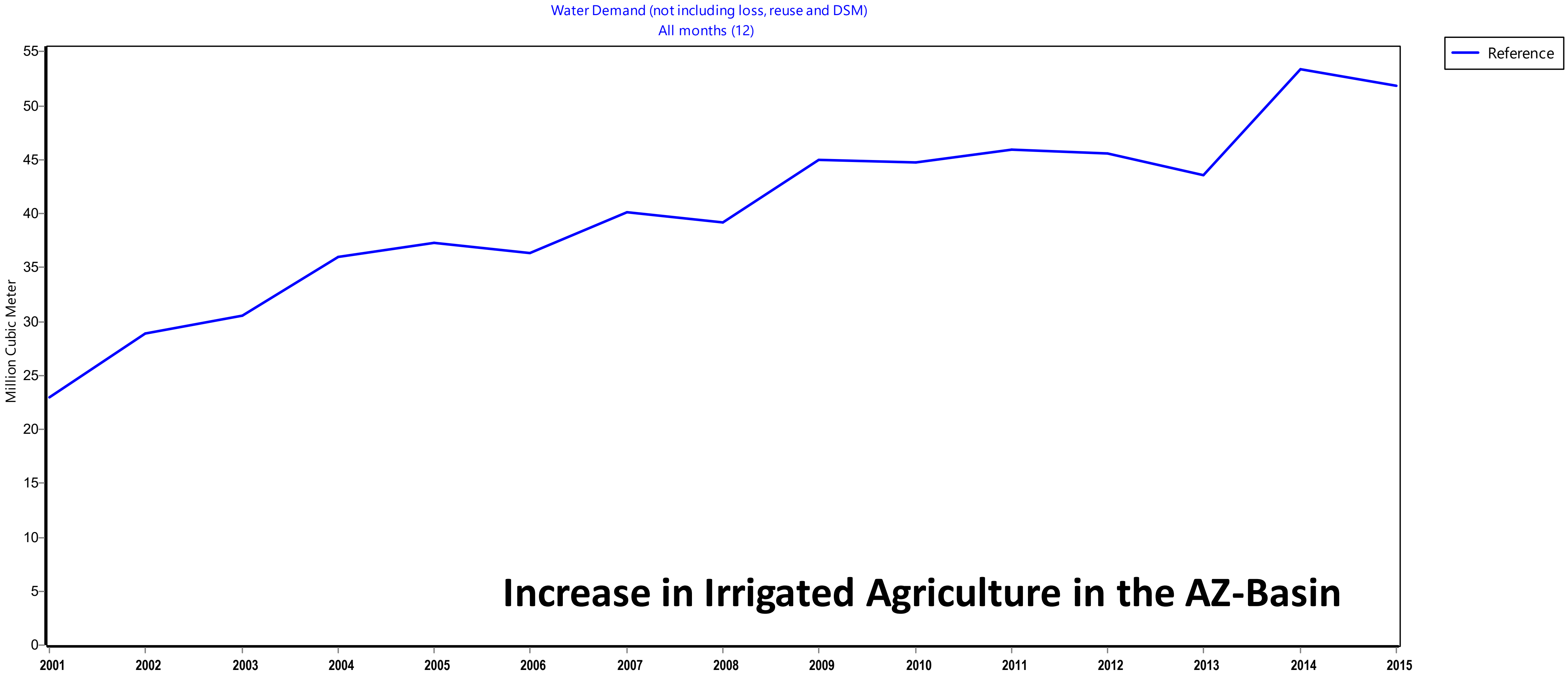
Over Abstraction %



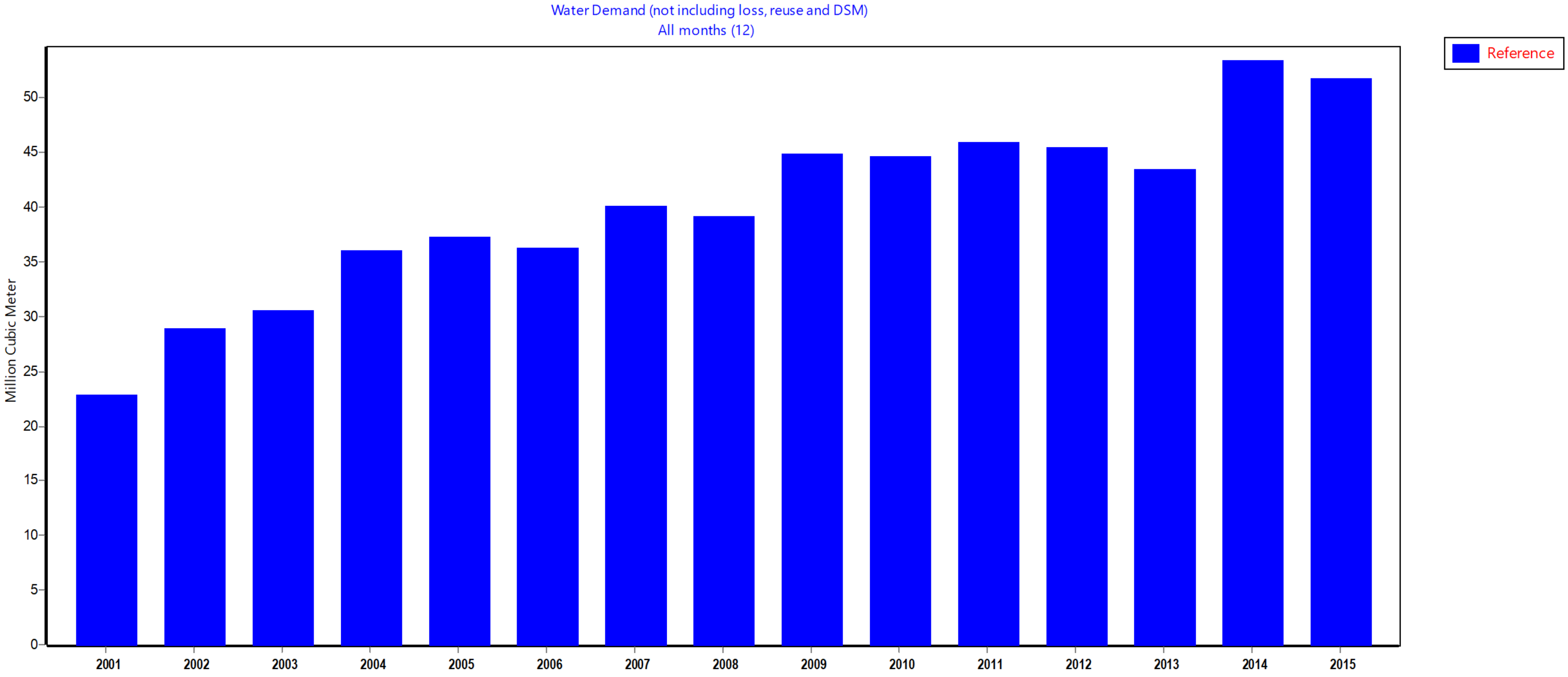
Over Abstraction %

Year	Actual Abstraction MCM	Unmet Demand(Over Abstraction) MCM	Safe Yield MCM	% Increase in Over abstraction / YR	Unmet Demand (Over-Abstraction) as % of Total demand
2001	129.37	41.87	87.50	147.85	32.4%
2002	135.68	48.18	87.50	155.06	35.5%
2003	135.82	38.32	97.50	139.30	28.2%
2004	136.79	49.29	87.50	156.33	36.0%
2005	135.26	47.76	87.50	154.58	35.3%
2006	127.27	39.77	87.50	145.46	31.3%
2007	137.60	50.10	87.50	157.25	36.4%
2008	138.47	50.97	87.50	158.25	36.8%
2009	141.53	54.03	87.50	161.75	38.2%
2010	147.49	59.99	87.50	168.56	40.7%
2011	145.88	58.38	87.50	166.72	40.0%
2012	146.83	59.33	87.50	167.80	40.4%
2013	134.35	46.85	87.50	153.55	34.9%
2014	136.72	49.22	87.50	156.25	36.0%
2015	137.05	49.55	87.50	156.63	36.2%
SUM	2,066.10	743.60	1,322.50		36.0%
Average	137.74	49.57	88.17		36.0%

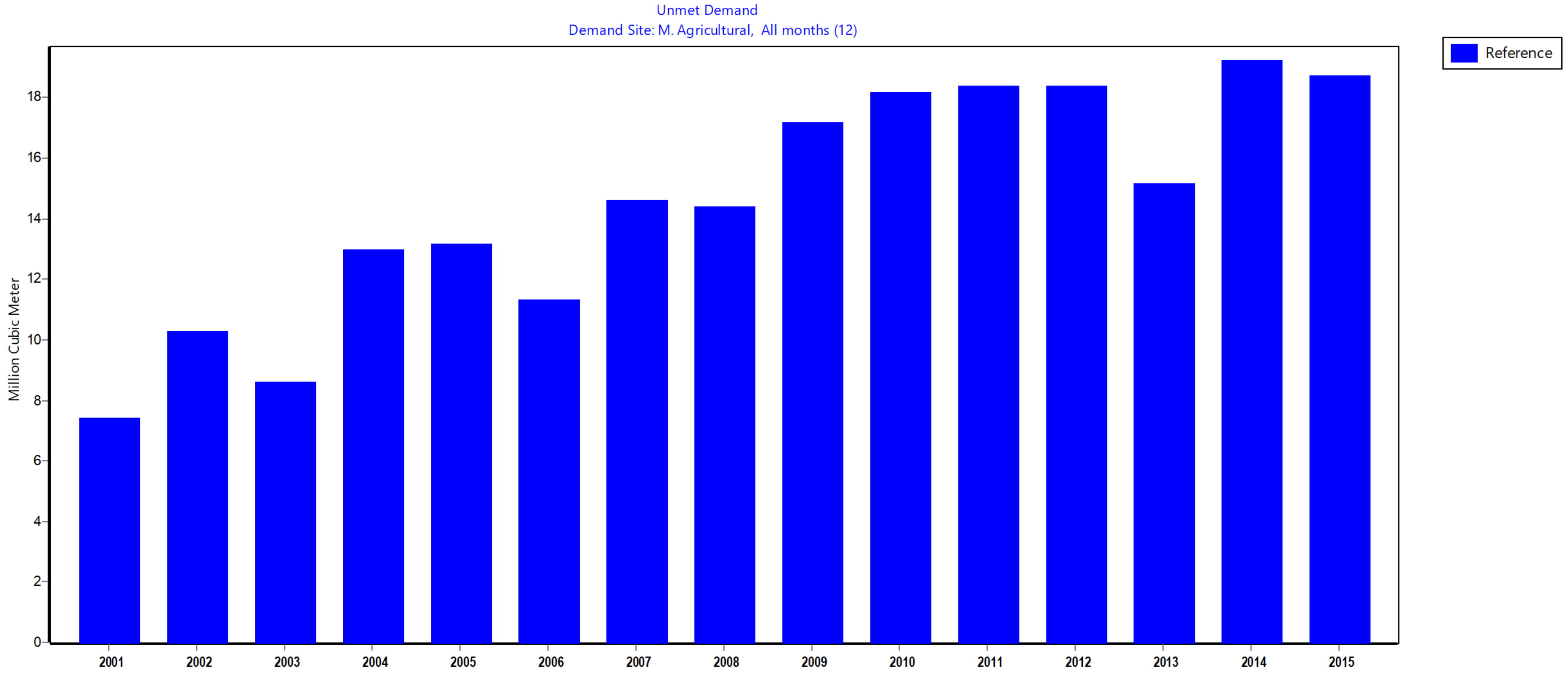
Evidences show Increasing Demand in Mafraq Agriculture



GW Abstraction for Mafraq Agriculture



GW Over Pumping



Conclusions

A. On the results

1. Over-abstraction in the AZ is significant and about 36% on an average annual basis)
2. There is an increase of GW-actual abstraction in the Irrigated Agriculture Sector in the Basin for the last 15 Years (Observed in Mafraq)
3. The level of Actual GW-Abstraction in the Basin is Constant over the last 15 Years (2001-2015)
4.

B. On the WEAP

1. usability of the WEAP model (is it fit for purpose?)

is it able to accurately represent the basin?

Are the data ok?

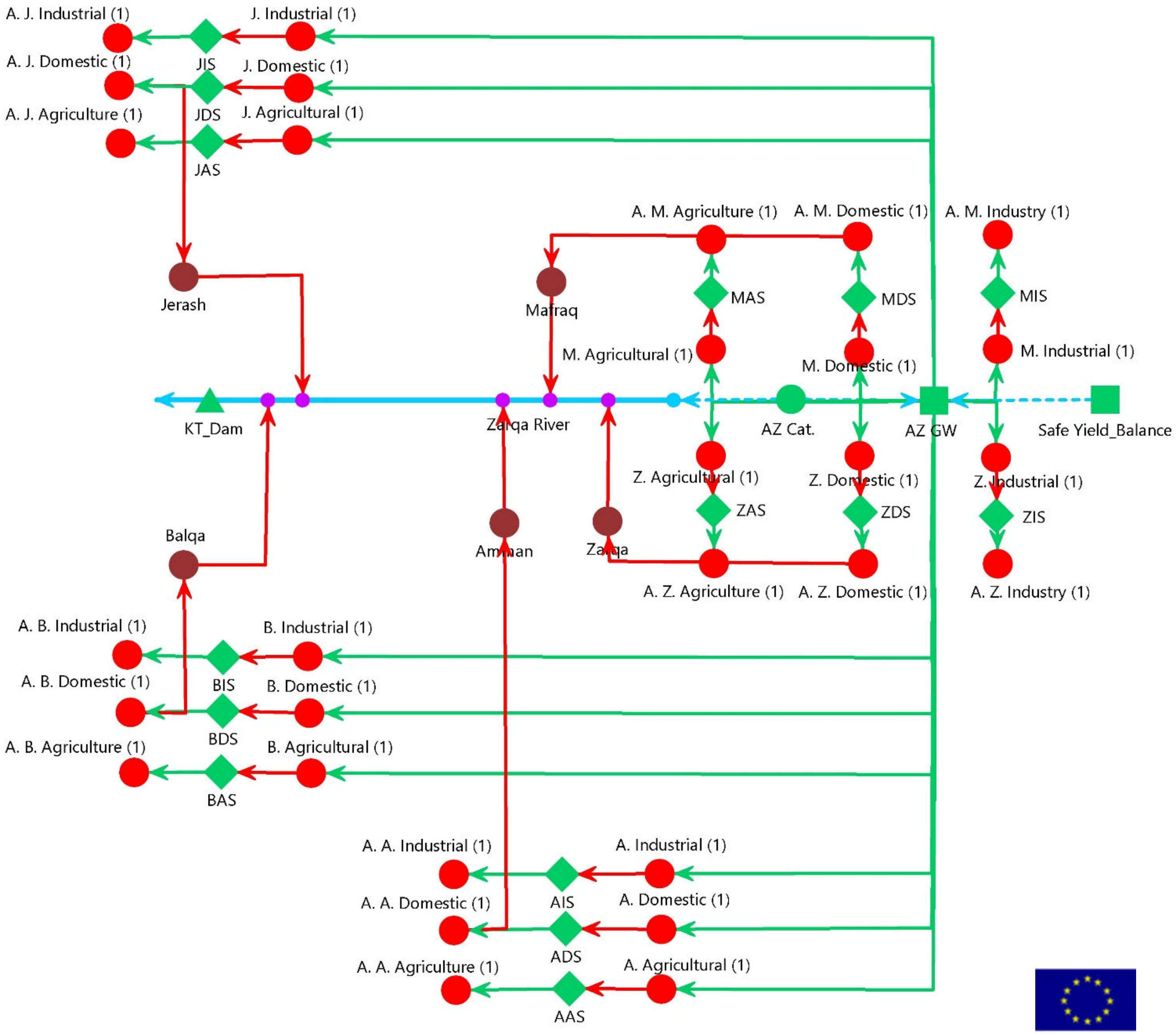
WEAP Model Limitations and Future Improvements

1. Integrating The Actual Demands with the GW Over-Abstraction Model
2. Disaggregation on the Catchment Analysis as to have 5 sub-catchment Simulation
3. Build a Link with MODFLOW/SWAT models at National-Wide Scale to have Better Data on the GW/SW-Mass Balance
4. Instead, Doing WEAP GW-Balance with other Basins in terms of Water Supply
5. Build a Long-Term Climatic Data for WEAP Simulation e.g. 30 Years

1. WEAP Model is not able to enhance the simulation Through Basin-Based together with the Administrative Boundaries
2. The WEAP Model <u>in our Case</u> is not Supply-Demand By Concept - - - It is a Hydrological Study of the Aquifer Behavior and Also Sector Analysis Tool
3.

General WEAP Schematic

Amman – Zarqa Basin WEAP Model



General WEAP Schematic

Amman – Zarqa Basin WEAP Model