Updates to the Walla Walla Regional Hydrological Model (IWFM Model)

Knowledge gained from the Walla Walla Basin Shallow Aquifer Recharge Program

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March 7th, 2012

GSI Water Solutions, Inc.

Background Walla Walla Model

1. For my MS project the Oregon side of the Walla Walla Model. As part of my PhD work, expansion to current model. Now continue updating the model as a consultant.

2. Since March of last year I work for GSI Water solutions as a consultant to the WWBWC

3. GSI has been working very closely with the WWBWC updating our conceptual hydrogeological understanding of the basin.

The power of local knowledge

The Walla Walla basin has a very complex hydrogeological system. Modeling its water resources far away from the basin would lead to data interpretation errors.

Vs.

Vs.

What we know

Local experts

What we measure

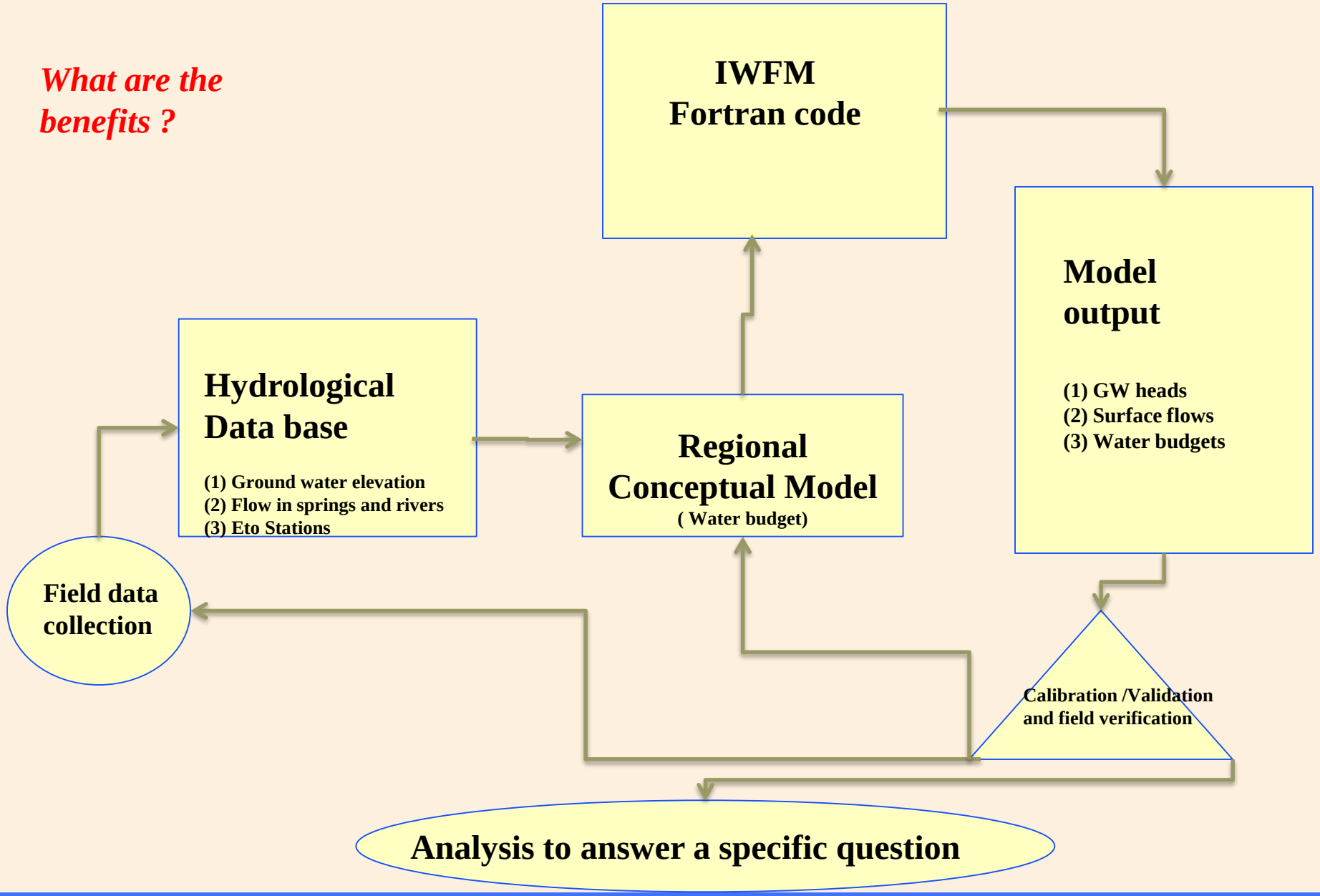
Reference Documentation

What we enter into the model

Data interpretation

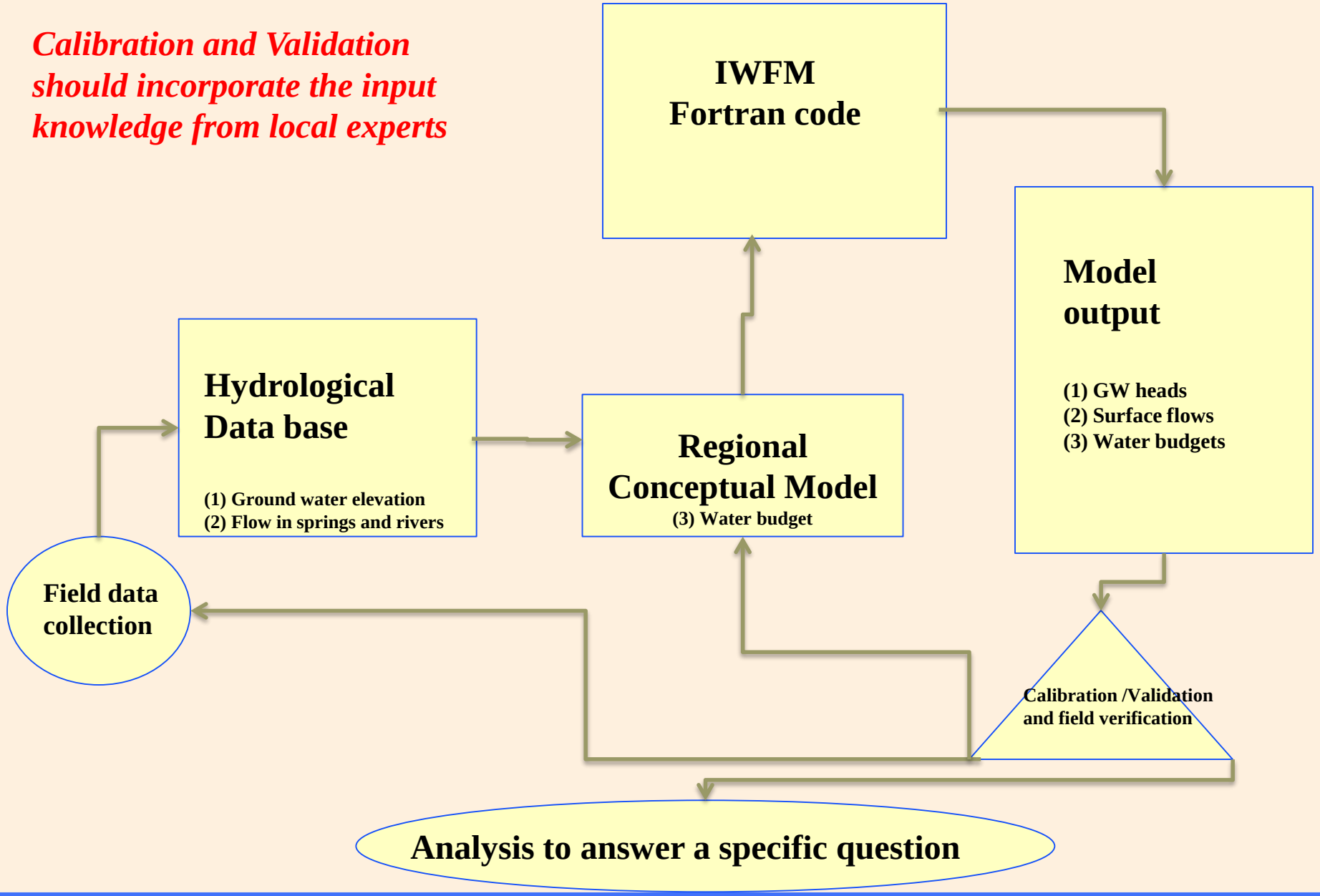
Regional Modeling Flow Chart

What are the benefits ?



Regional Modeling Flow Chart

Calibration and Validation should incorporate the input knowledge from local experts



Regional Modeling Flow Chart

Analysis to answer a specific question

Model objectives *uses of the model*

- **To make predictions about a groundwater system response to stresses . Example: (i.e. Effects of Aquifer Recharge, Lining irrigation canals, etc.)**
- **To understand the regional water resources (i.e. *water budgets)***
- **Direct and evaluate field data collections a new level of QA&QC**
- **As a tool to support decision. Future water demands, climate change etc.**

Model updates since Dec. 2010

- Model calibration and sensitivity analysis
- Model uncertainty analysis
- Model reviews and updates to surface waters
- Distribution of Hydraulic conductivity
- Transferring the model to the WWBWC

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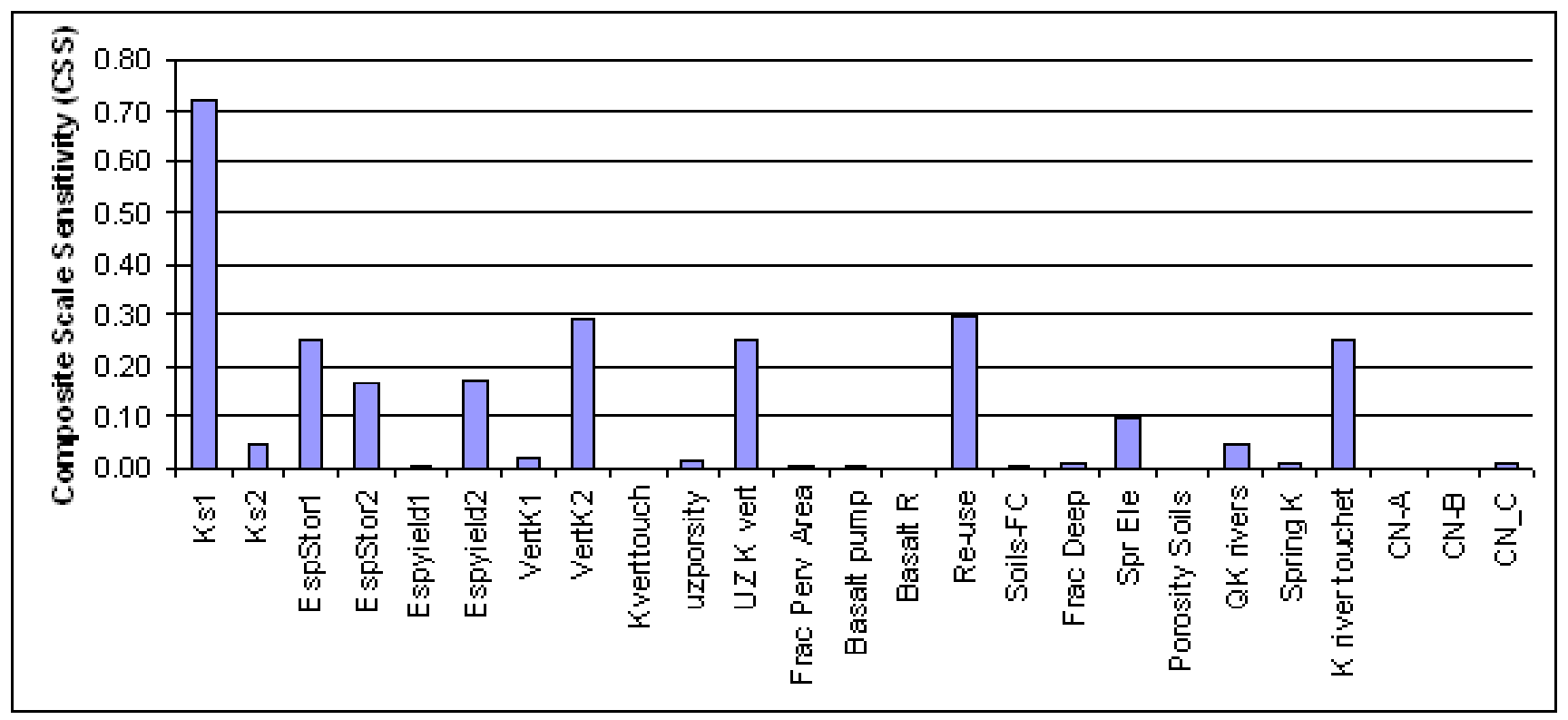
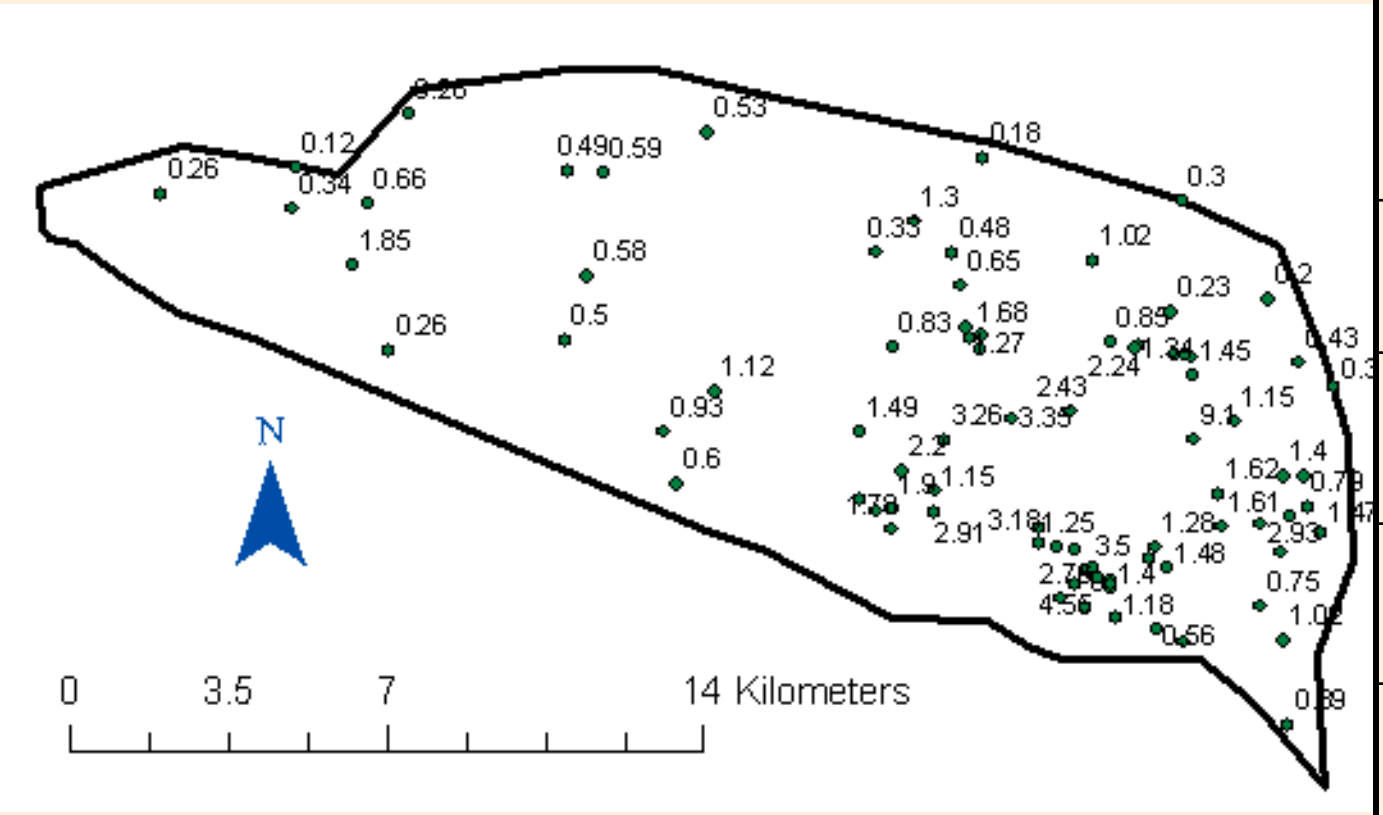
Composite Scale Sensitivities for 27 parameters GW & SW



In order to compare the sensitivities of different parameters, we need to use the same scale. Mary Hill (2007) proposes to use the following statistics

$$css = \sum_{1}^{NO} (dss^2 / NO)^{1/2}$$

Statistical Measurements of Overall Model Fit



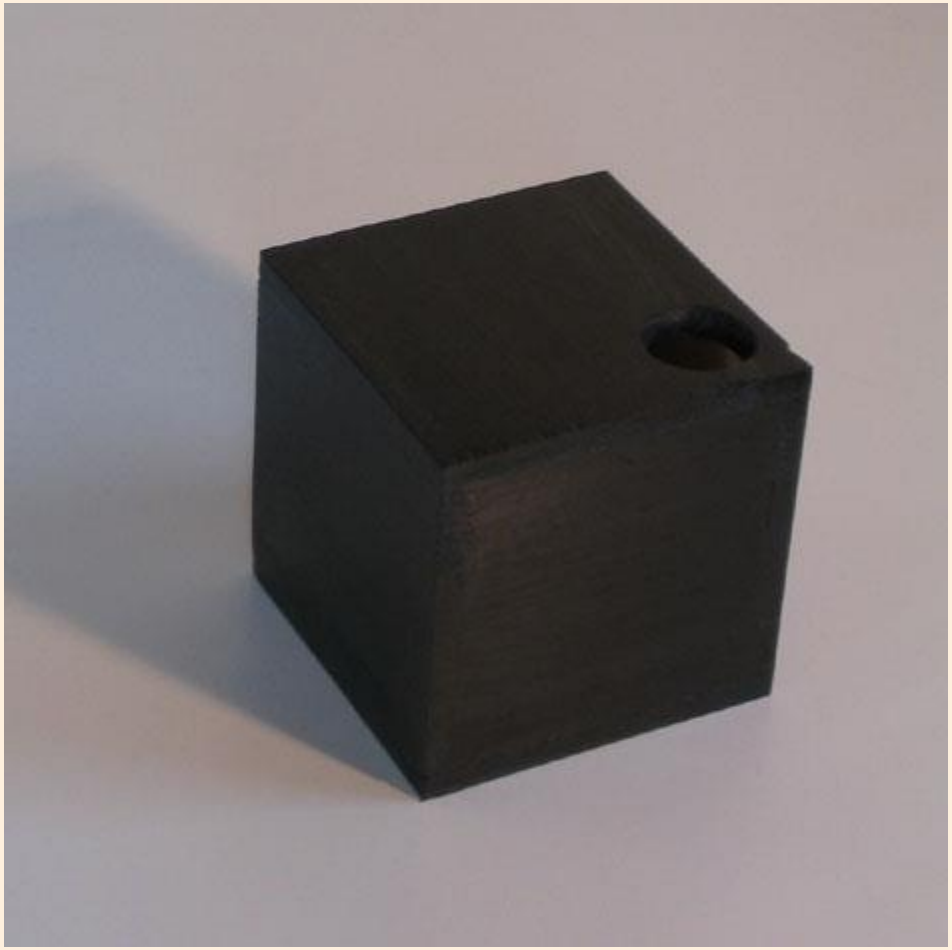
Sum of Squared Error	14,800
Obs. Wells	1,949
SD (GW only)	2.7 m
Nash (SWonly)	0.96
Weighted overall	140,000

GIS output map showing the SD at all wells without weights in the model area.

Uncertainty analysis

Range of possible input values

± %



Range of model results

%

The Watershed Model ("Black Box") runs with different input values

Results Uncertainty Analysis

1. Surface water inflows are the major source of uncertainty in the model. There is at least 30 % of uncertainty in the estimated inflows. They dominate the entire distribution of water resources in the basin.

2. Crop definition and crop rotation account for only 5 to 10% of model output uncertainty. The actual model doesn't account for crop rotation.

3. Since the model applies water per sub-region (7 areas in the model domain), the location and amount of individual surface water diversions doesn't incorporate a major model uncertainty. A Future IWFM version will account for element based pumping, water demand and applied water from diversions.

4. The uncertainty incorporated into the model by setting surface elevations with a USGS 10-m DEM was not evaluated. The standard error of the DEM is 15m. Surface elevations are critical for the estimation of flow in the springs

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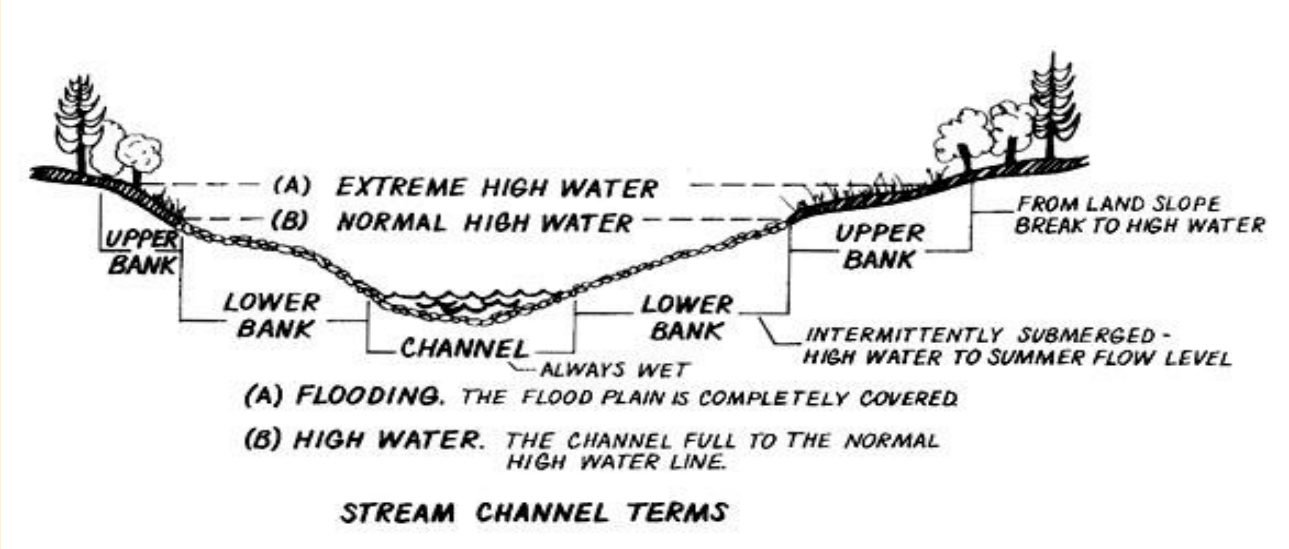
Model Updates

- Wetted Perimeter and Hydraulic conductivity



- Distributions of Hydraulic Conductivity

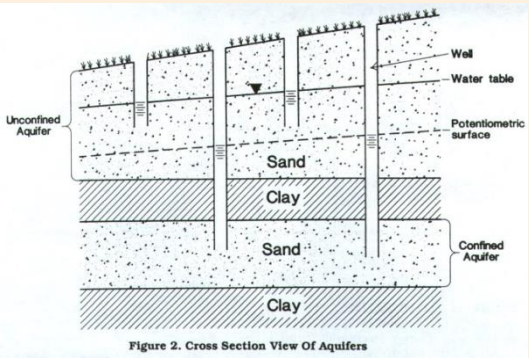
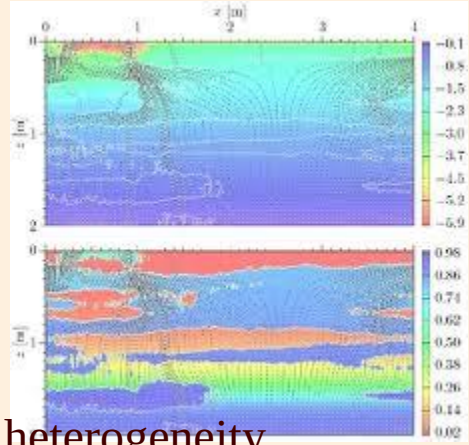
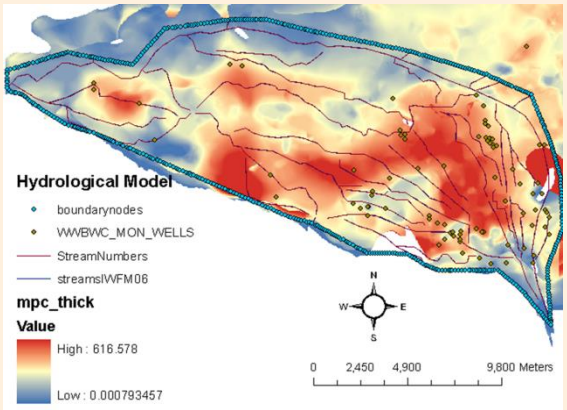


Figure 2. Cross Section View Of Aquifers





Picture examples to illustrate heterogeneity

Model Transfer from developers to the WWBWC

Objectives

- Local expert model review: identifies areas for model improvement and potential new information *post audit*
- Diminish cost as the WWBWC could update the model with new information collected
- Major independence of the WWBWC to use the model as a tool to support decision
- Promotes communication: Ensures the model final application for which it has been created

Illustration of technological transfer

Model Transfer from developers to the WWBWC

Challenges

- Complex model: Irrigation canals, pumping wells, land uses. IWFM doesn't have a user interface

- Requires a diverse set of skills hydrology, GIS, simulation modeling and statistics

- Budget of resources: Time consuming

Steep learning curve

Illustration of the WWBWC using the model

Example of the model scenarios reviewed

The WWBWC in the last hands-on training with the regional hydrological model has review the following scenarios:

- Include a new river segment
- Lining Irrigation canals
- Modify irrigation Point of diversions and Bypasses
- Include a new surface inflow
- Include a new artificial aquifer recharge basin.
- Include new crops and modify crop consumptions
- Include a new rain gauge

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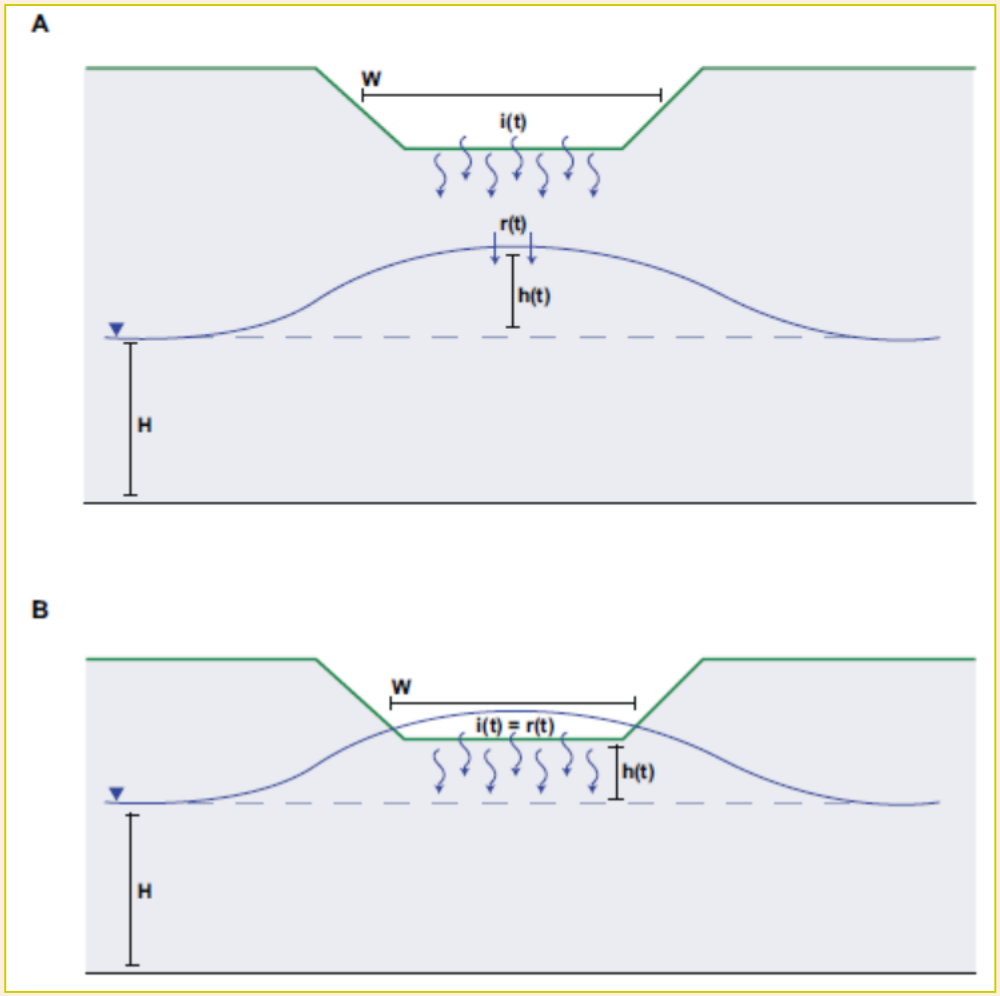
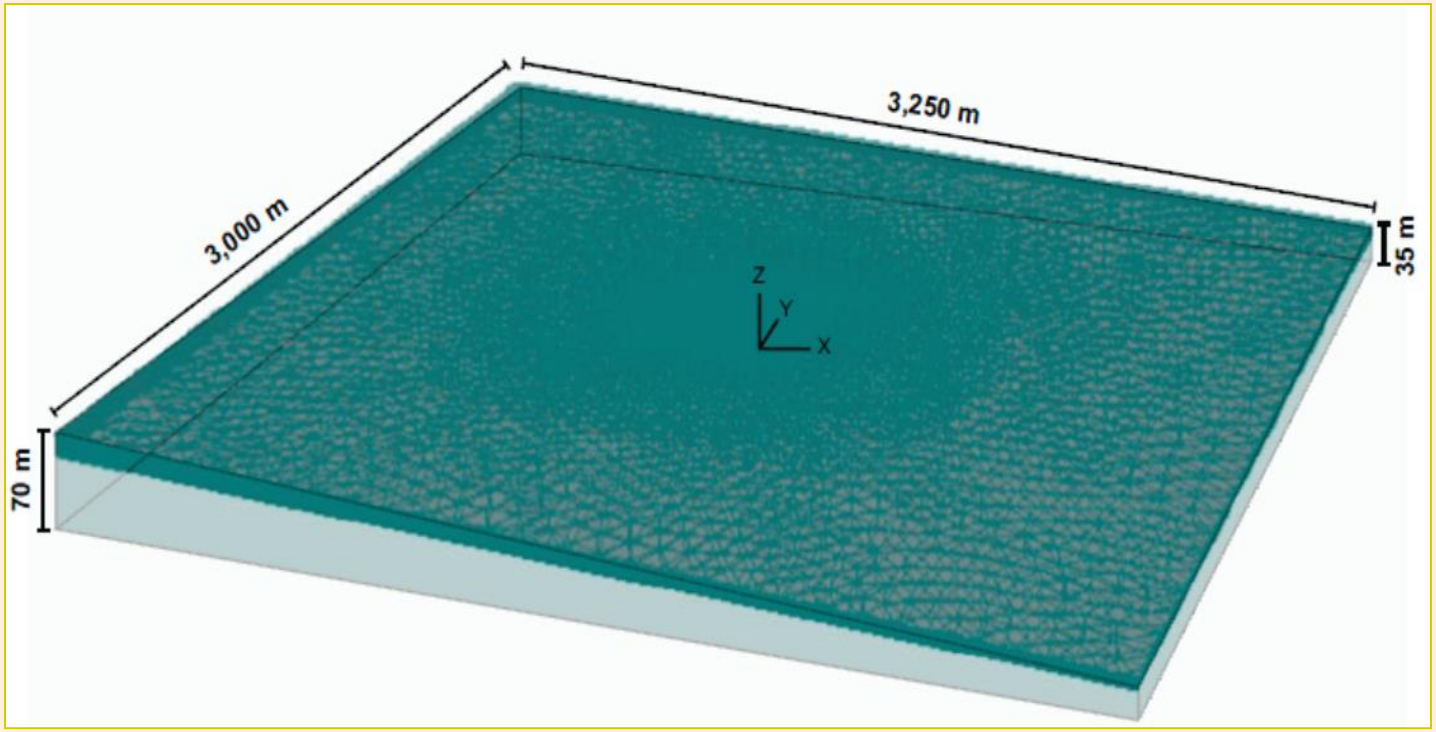
Shallow Aquifer Recharge



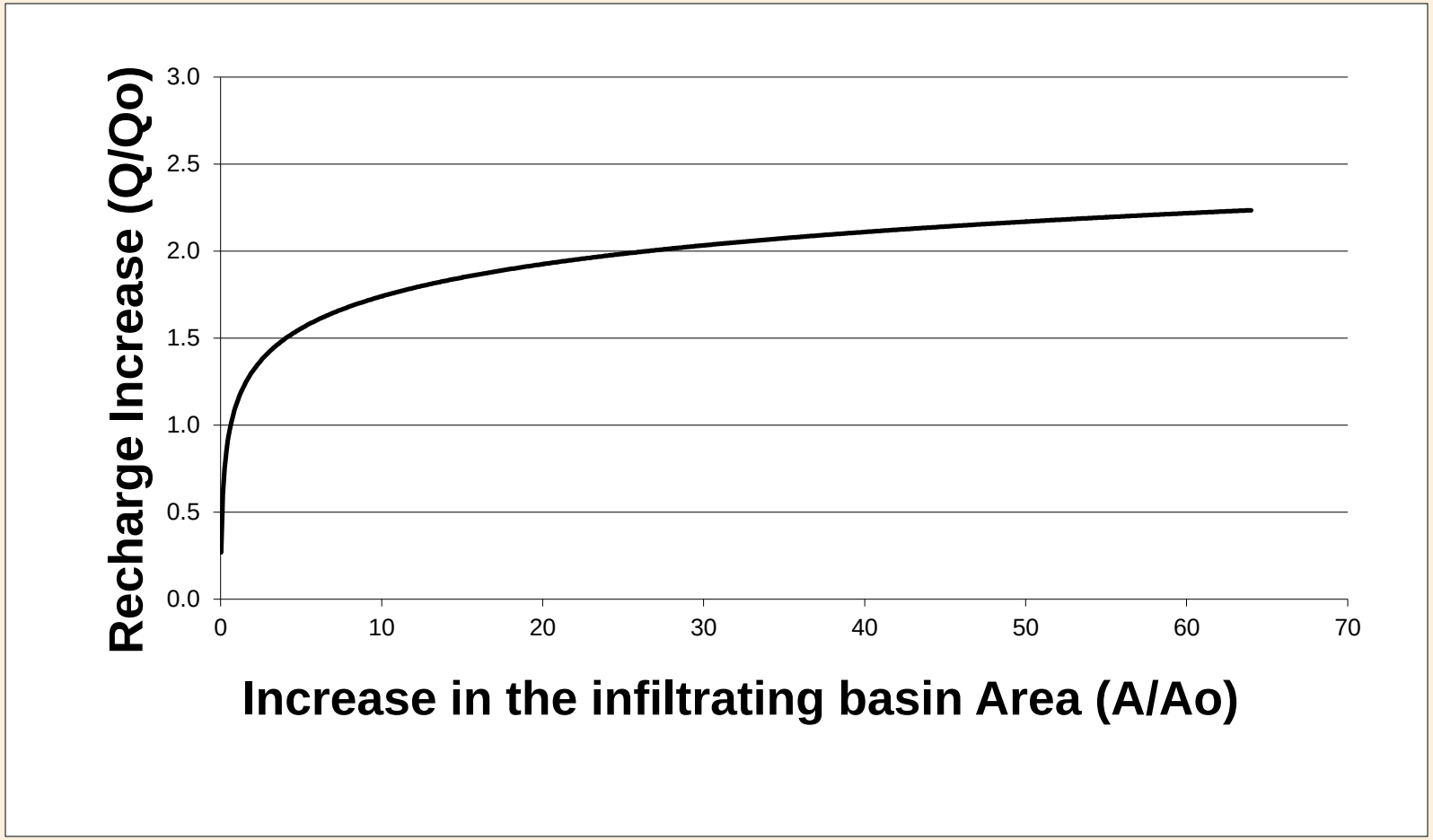
Difference between infiltration rate *i(t)* to recharge rate *r(t)*from (A) infiltrating basins where the groundwater mound doesn't reach the surface and , (B) infiltrating basins with a full hydraulic connection to the aquifer

Modeling of AR Basins



We developed models to estimate the growth of the groundwater mound. And estimate the rate of recharge from different infiltrating basin geometries

Effective Size of the Infiltrating Basins



Estimating recharge rates (Q) as the infiltrating basin increase relative to the original pilot test (A)

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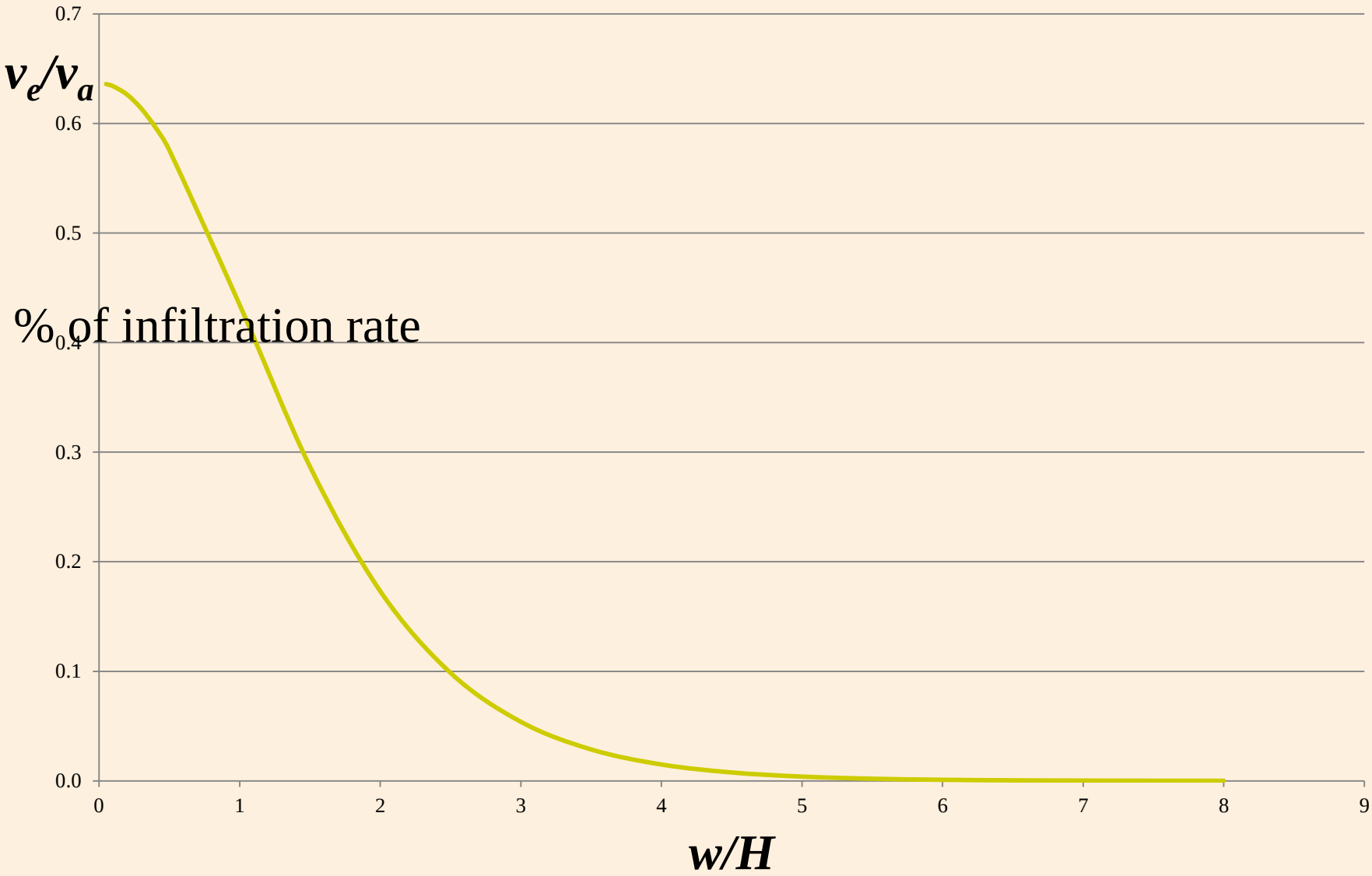
Infiltration rate at the center of the infiltrating basin



Increase in effective radius to aquifer thickness (dimensionless)

Future Work

- Continue with the evaluation of AR projects throughout the basin linking IWFM model and HYDRUS results
- Continue with model transfer and updating the IWFM-Model
- Revisit tracer test from the AR projects and the hydraulic response of the springs

Thank you for your time

Conceptual Model **Parsimony**

“Everything should be made as simple as possible, but not simpler.” Albert Einstein

Models should be as simplified as possible, yet they should retain enough complexity so that it adequately reproduces system behavior.

Ethics: Warn of the limitations of the model and that there may be a cheaper, more effective approach to some of the problems in the basin