Wetbud – A Constructed Wetlands Design Tool

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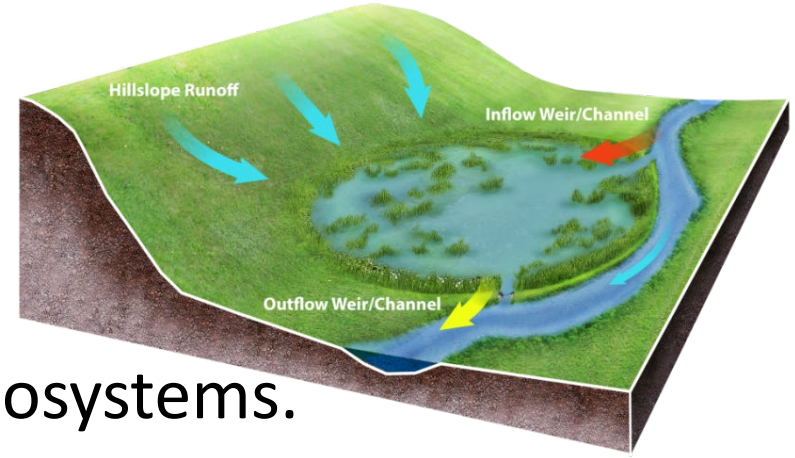
What is a Wetland?

- Diverse area where the presence of water for an extended time exerts a controlling influence on plant communities, soil properties, and animals.

What is a Wetland?

- Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Fish and Wildlife Service, 1979)
- A wetland is a land area that is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem.
- Wetlands play several roles in the environment:
  - Water purification, Flood control,
  - Carbon sink, Shoreline stability.
- Considered the most biologically diverse of all ecosystems.



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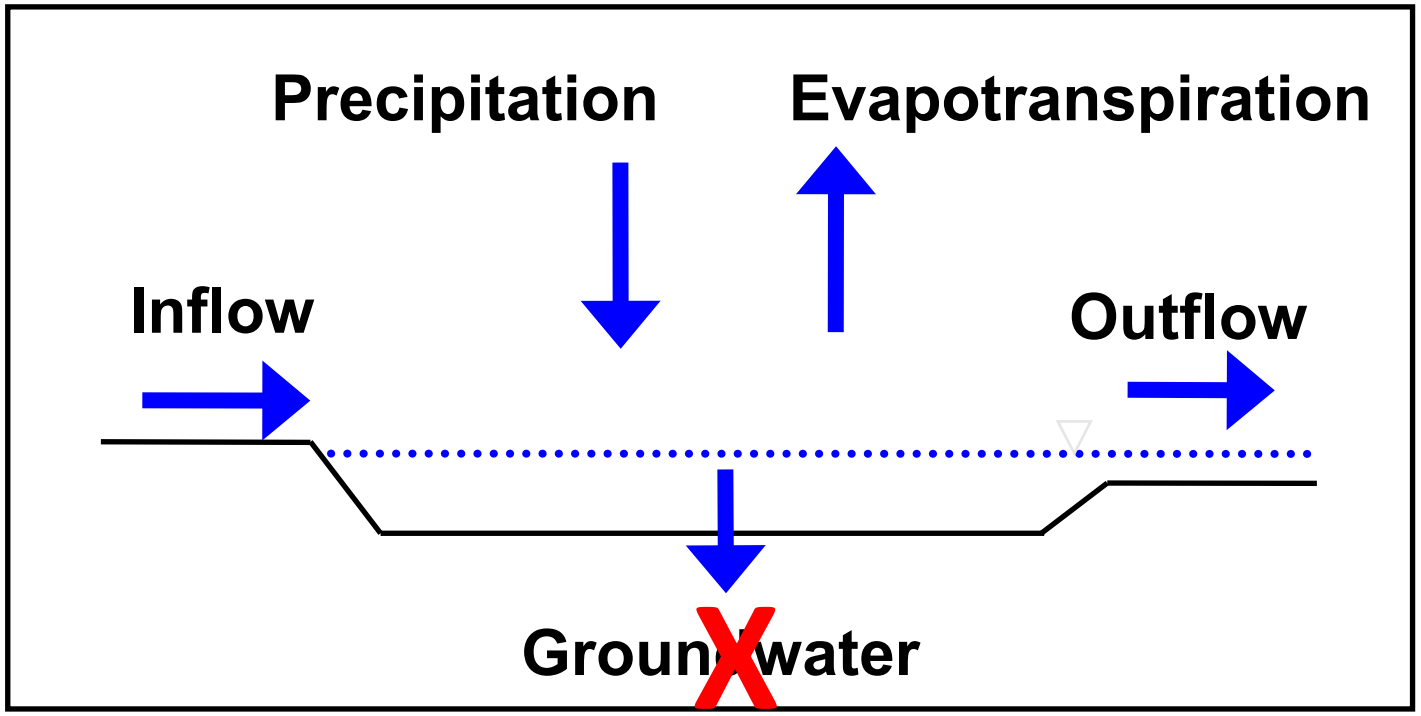
Why Wetbud (Created Wetland Water Budgeting)?

- We need to create wetlands for Mining and Civil Applications
- There are wide variation in water budgeting approaches among agencies and consultants
- Many agencies follow variations of the “Pierce Approach”

A “simple” way to create a mitigation wetland is to create a perched system

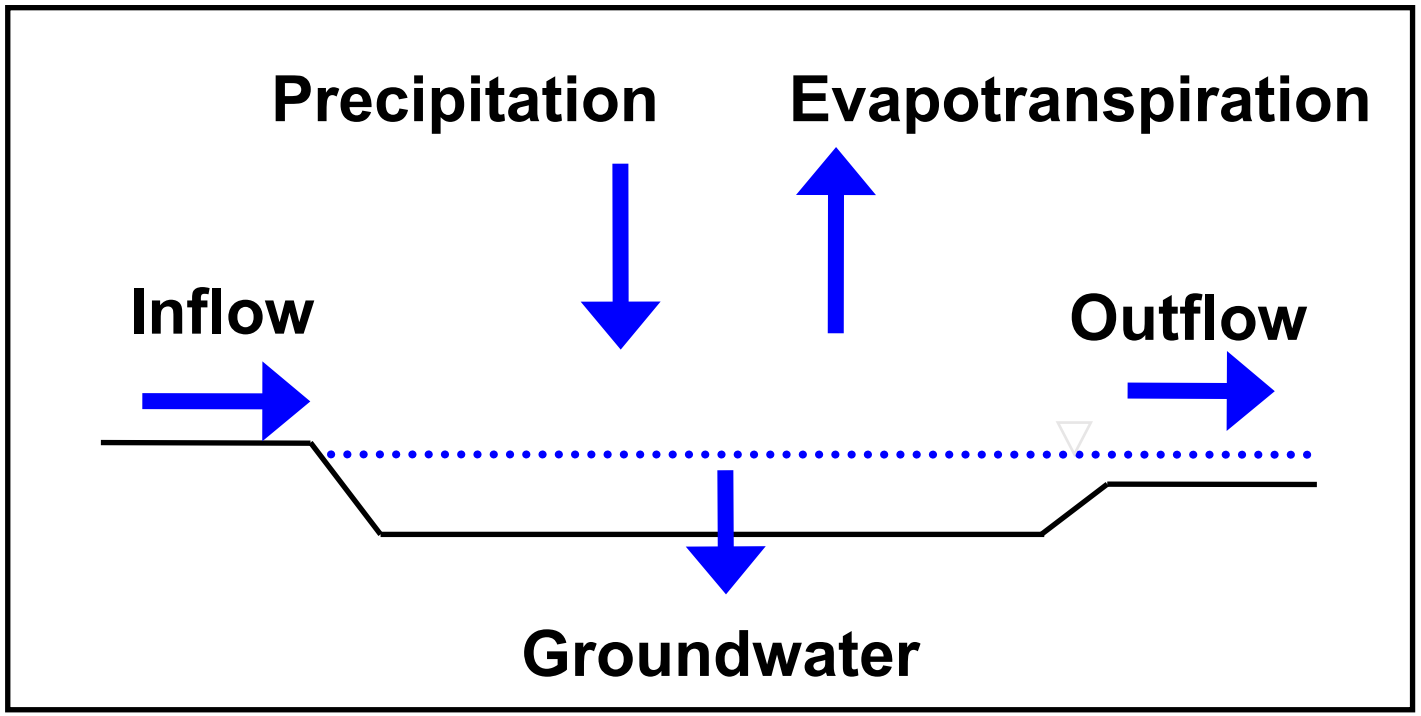
Can work on hilltops with low permeability compacted subsoils.



assume negligible

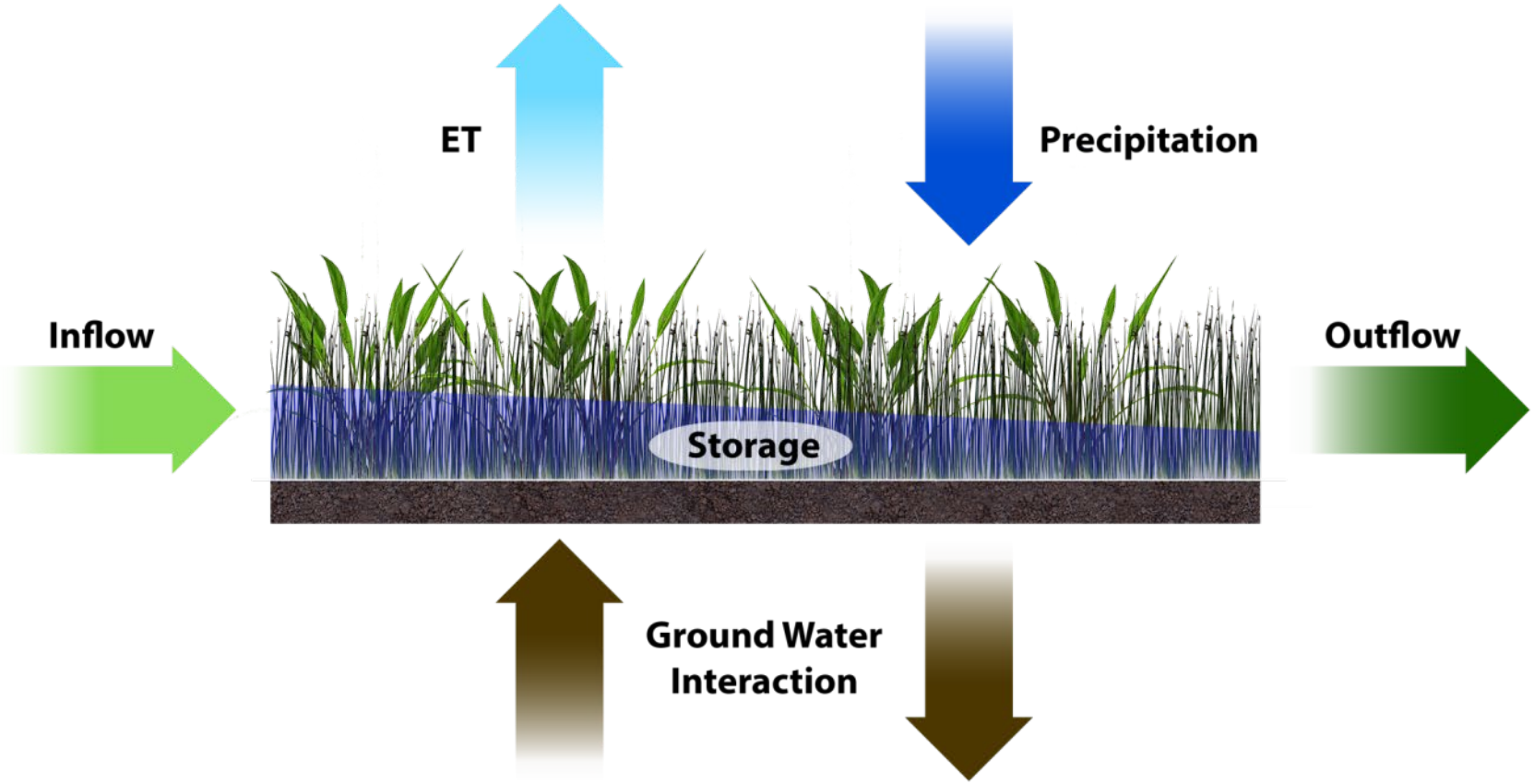
Role of Groundwater in Wetland design

- In most wetlands, groundwater can seep in and out in many places.
- If groundwater is ignored, the wetland can be “too wet.”



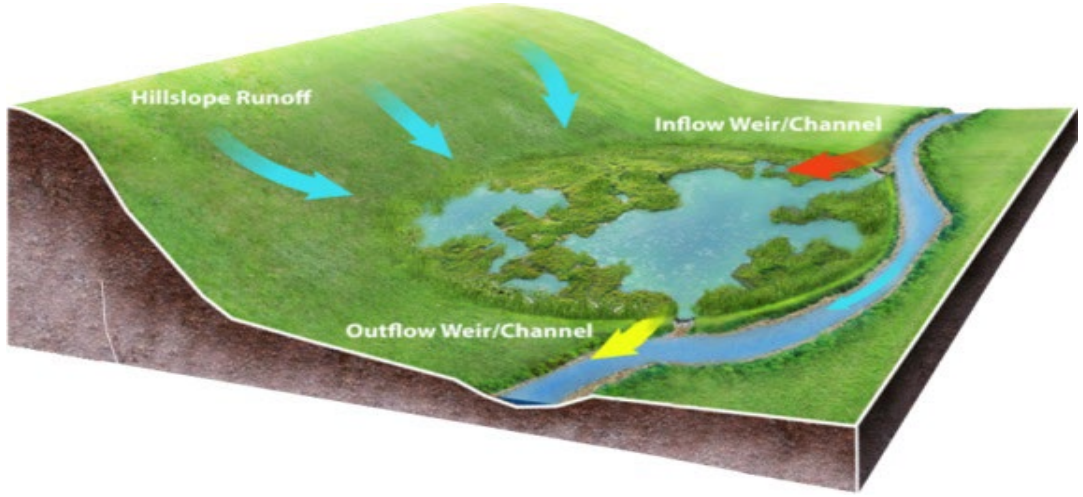
Water Inflows and Outflows

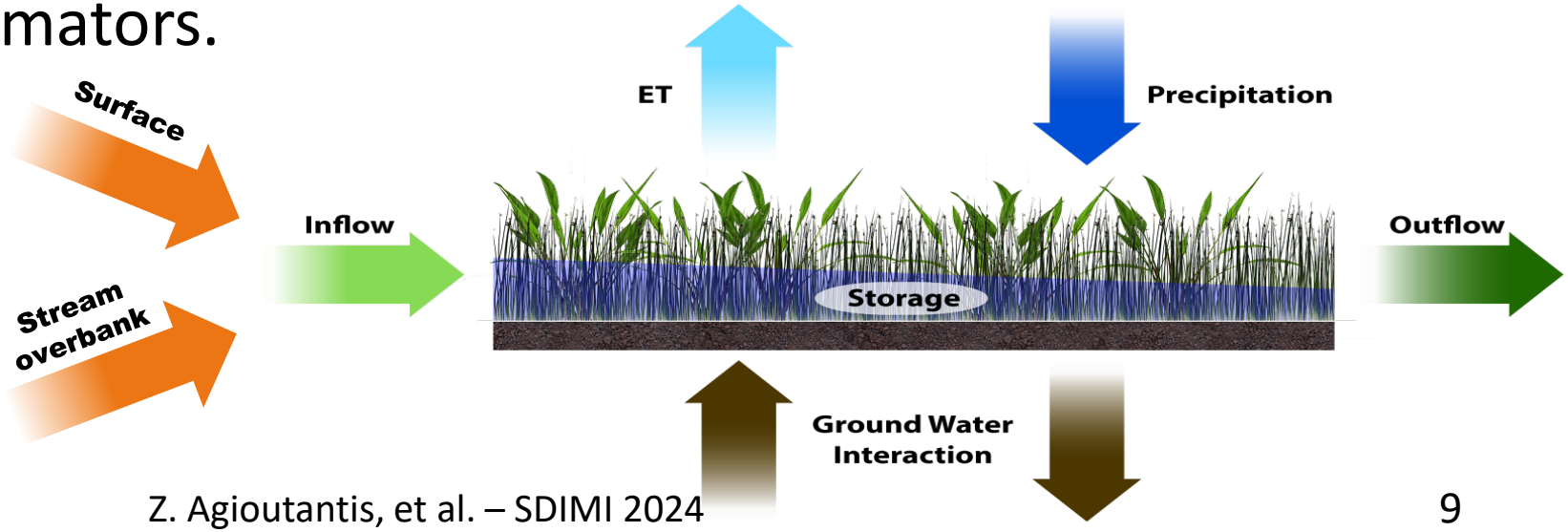
- Inflows can be due to groundwater seepage, runoff from the surrounding hillslopes, or flood flows from adjacent streams.



Water Budget Model Issues

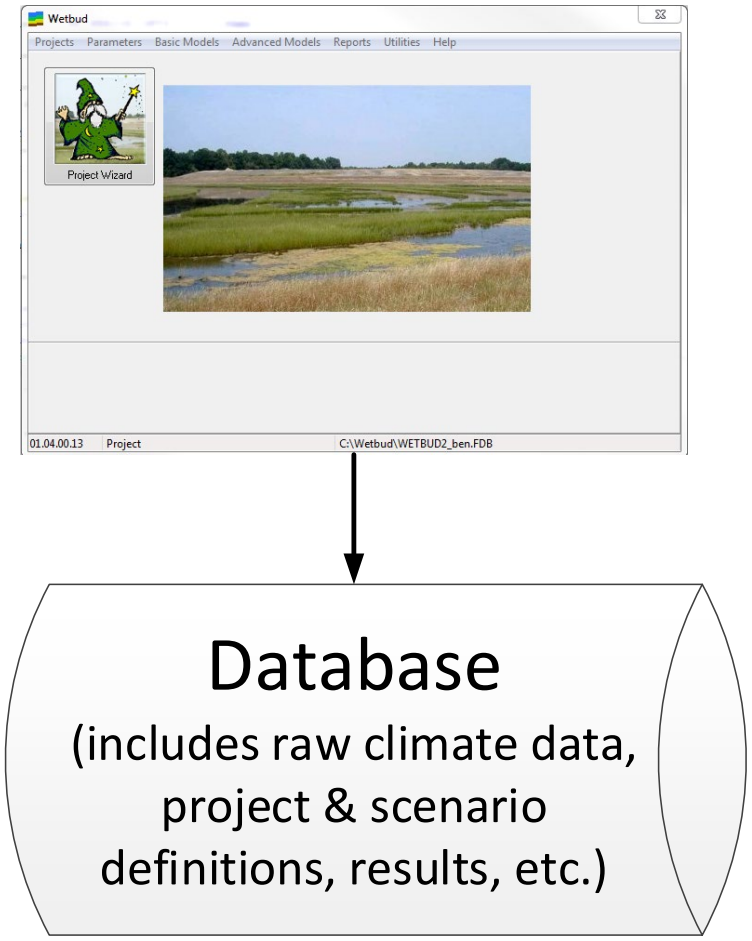
- Complex topography.
- Vegetative flow resistance.
- Groundwater inputs vs. data?
- Overbank flow contribution.
- Which precipitation data?
- Variations in ET estimators.





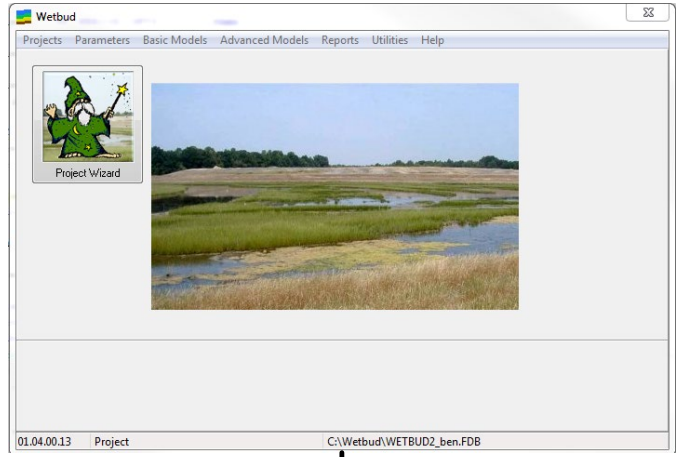
Wetbud Implementation Considerations (1/5)

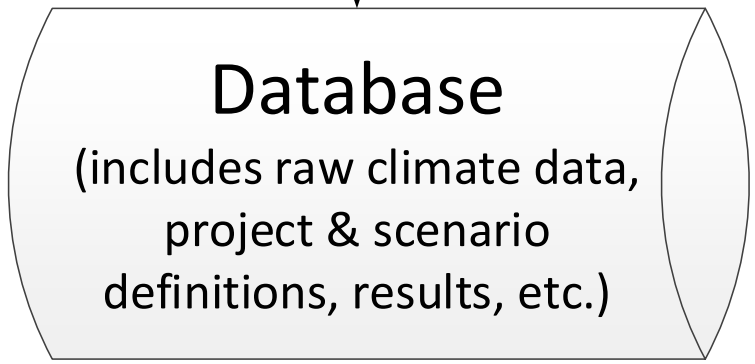
- Available for Windows™ Systems only (7, 8, 10, 11).
- Developed for collaborative (office) environment.
- Database driven application: Database stores input data and results.
- Features multiple projects and multiple scenarios per project.



Wetbud Implementation Considerations (2/5)

- Climate (precipitation, weather, solar) data can be imported automatically directly from NOAA, NRCS or other sites.
- Climate data can be imported manually for private weather stations.
- ET data can be calculated (Penman, Thornthwaite) or imported.





Wetbud Implementation Considerations (3/5)

- Climate data are reusable.
- Generated data based on climate data (e.g., ET) are also reusable.
- Climate data are tied to weather stations, i.e., by location.
- The most time-consuming part will be to get a “good” set of data.

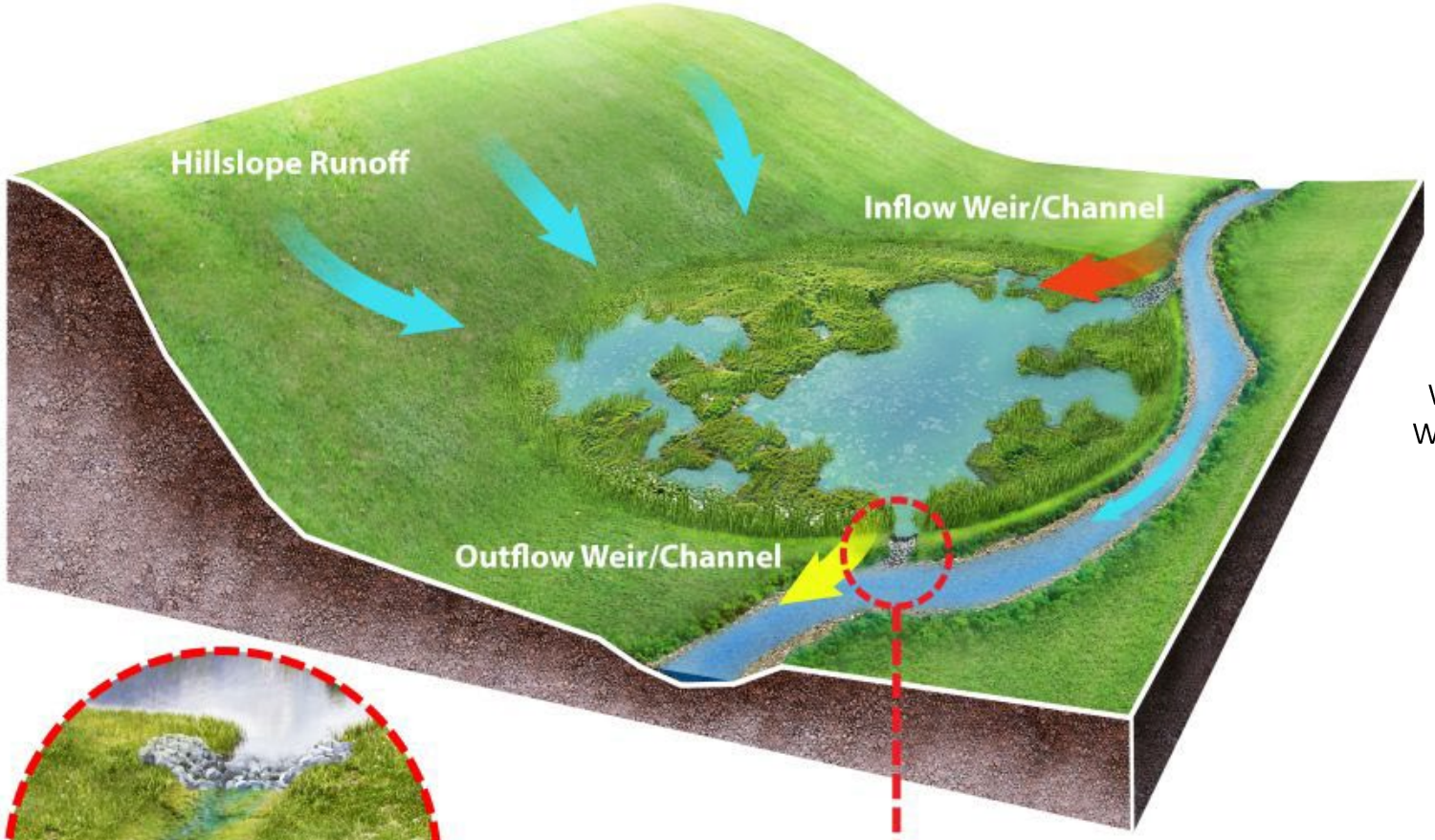
Wetbud Implementation Considerations (4/5)

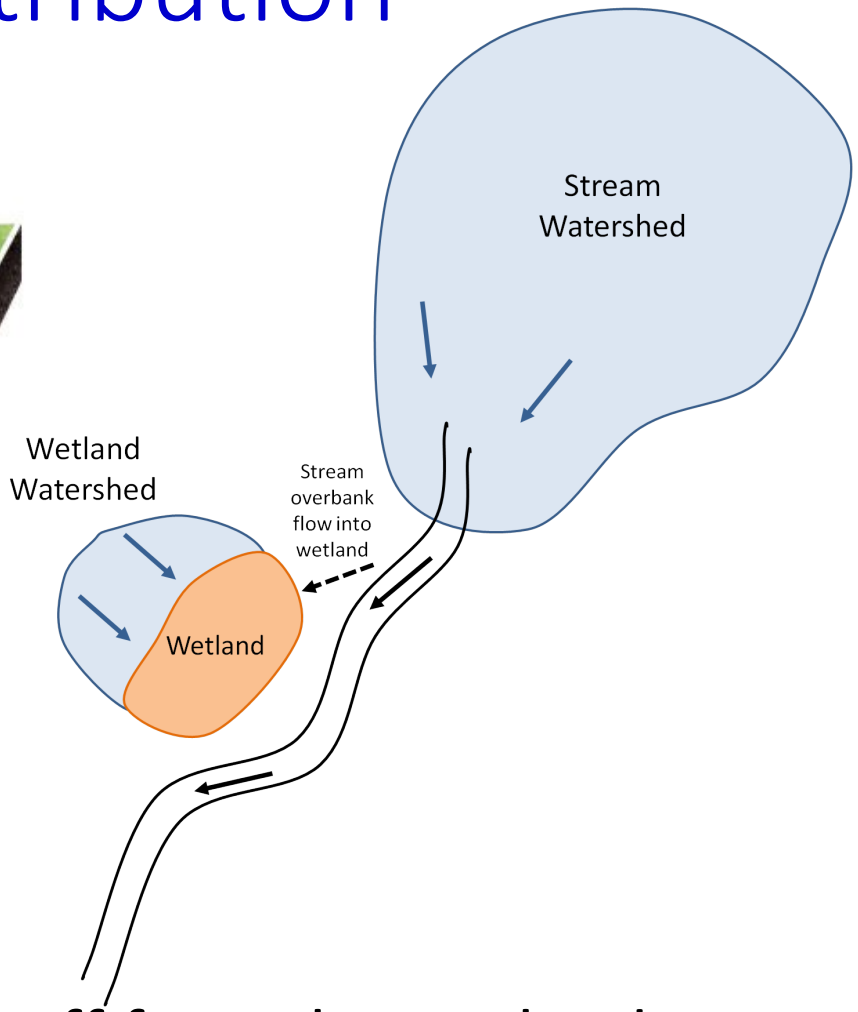
- The water budget is estimated for typical dry, normal, wet (DNW) year configurations for a given site.
  - Can be calculated using Wetbud's algorithm or input directly by the user.
- A procedure can be used to estimate groundwater flux from well measurements or historic data periods
- The contribution of surface water to the wetland water budget can be estimated. Procedures were developed to factor in stream and other contributions to the wetland.

Wetbud Implementation Considerations (5/5)

- Wetbud includes a **basic** and an **advanced** modelling approach.
- The basic models reflect mass balance calculations on a monthly and daily basis.
- The advanced models allow for full MODFLOW modeling of the wetland on any time step.

Basic Model: Surface Flow Contribution

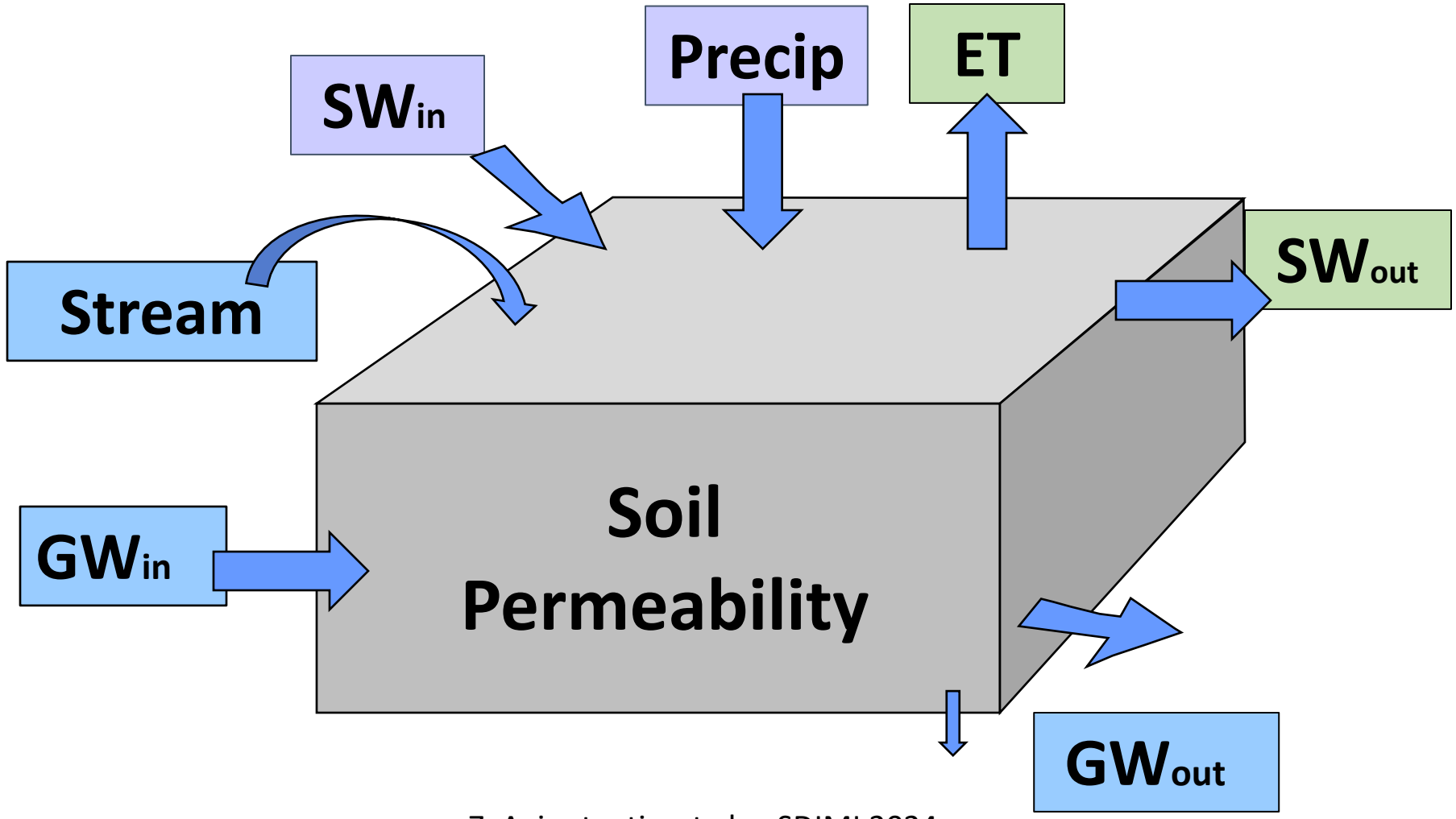




Surface water inflows can be runoff from the wetland watershed or overbank flows from an adjacent stream.

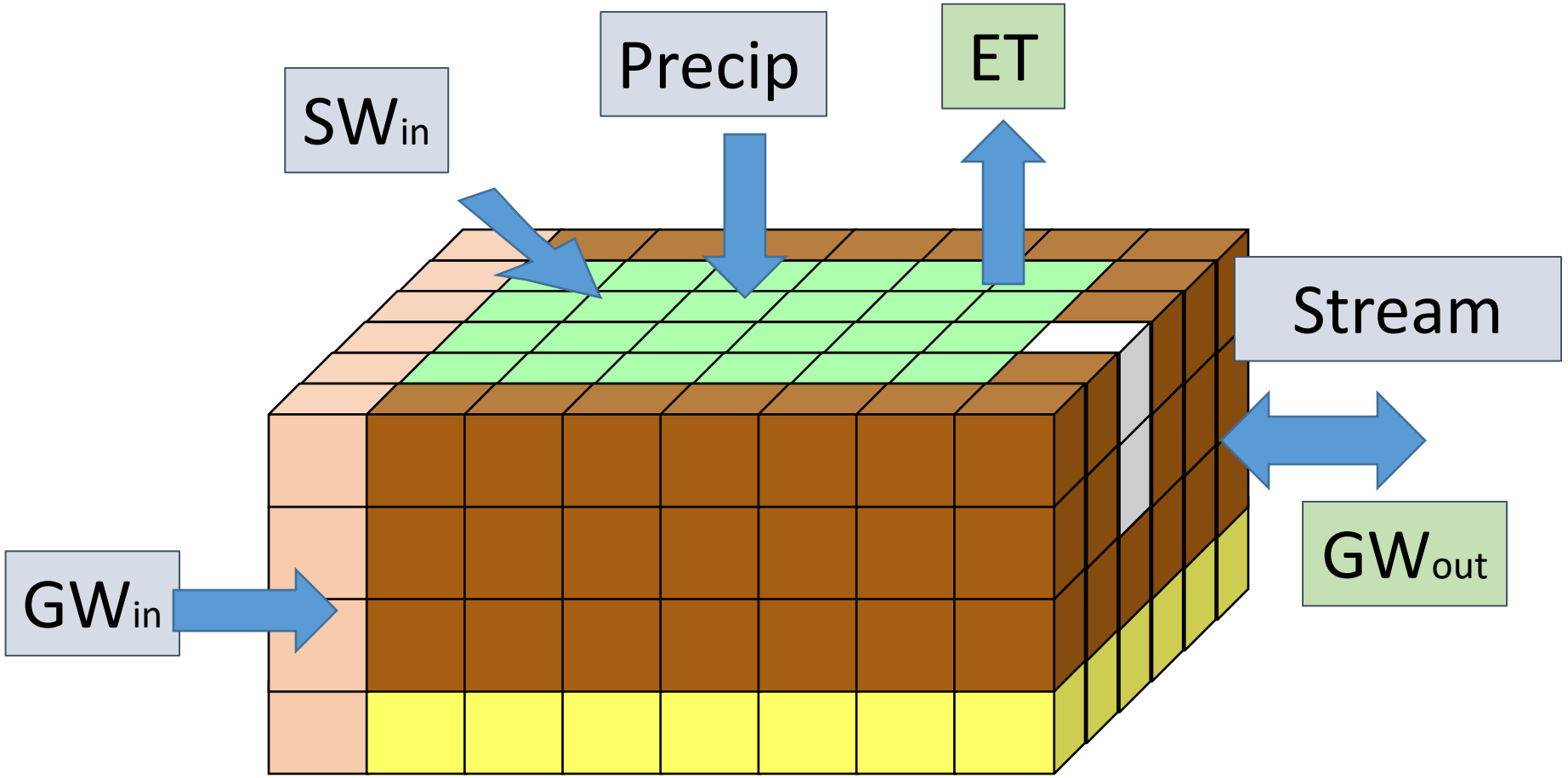
Figure designed by Dillon Conner.

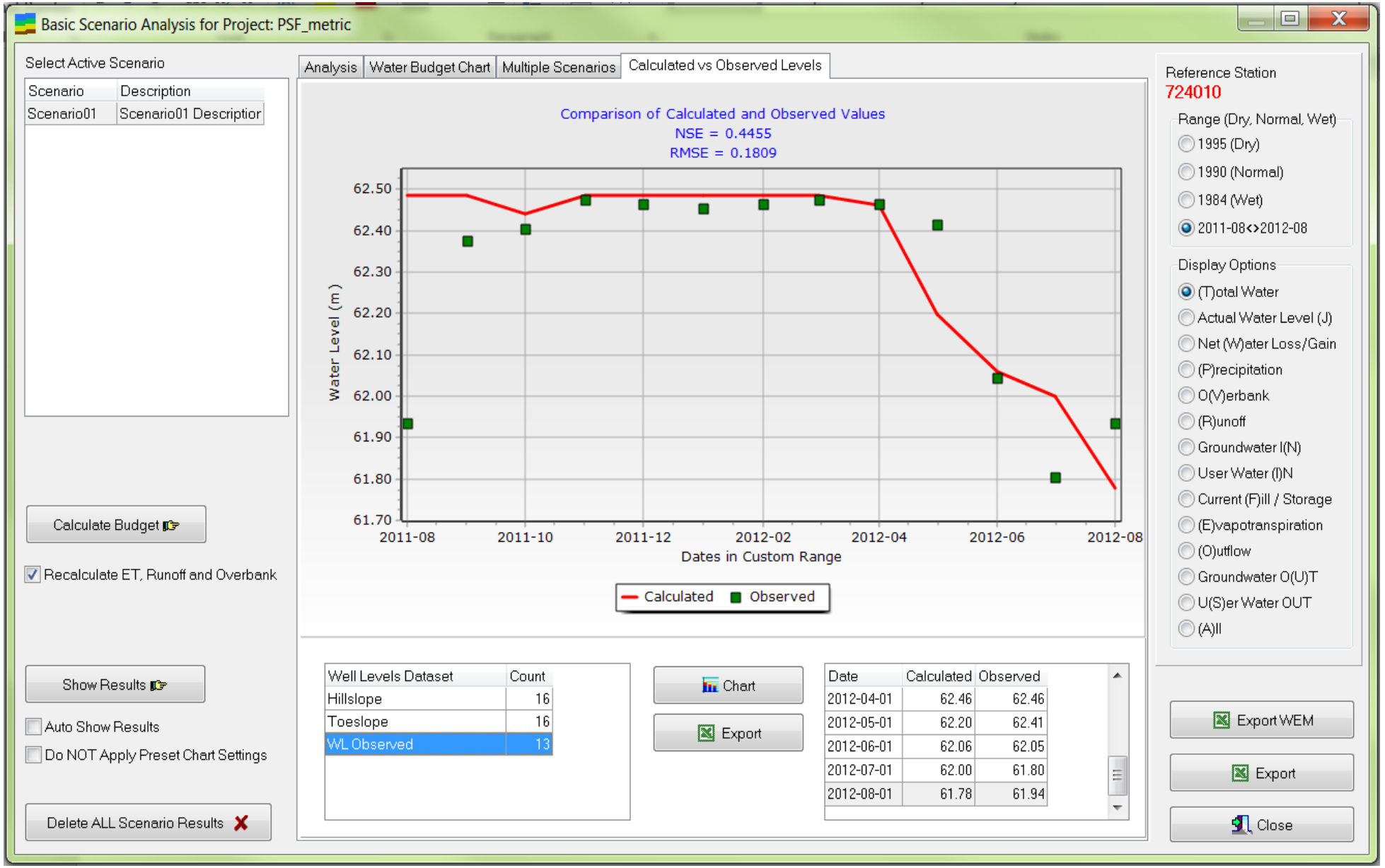
Wetbud Basic Models



Wetbud – Advanced Models

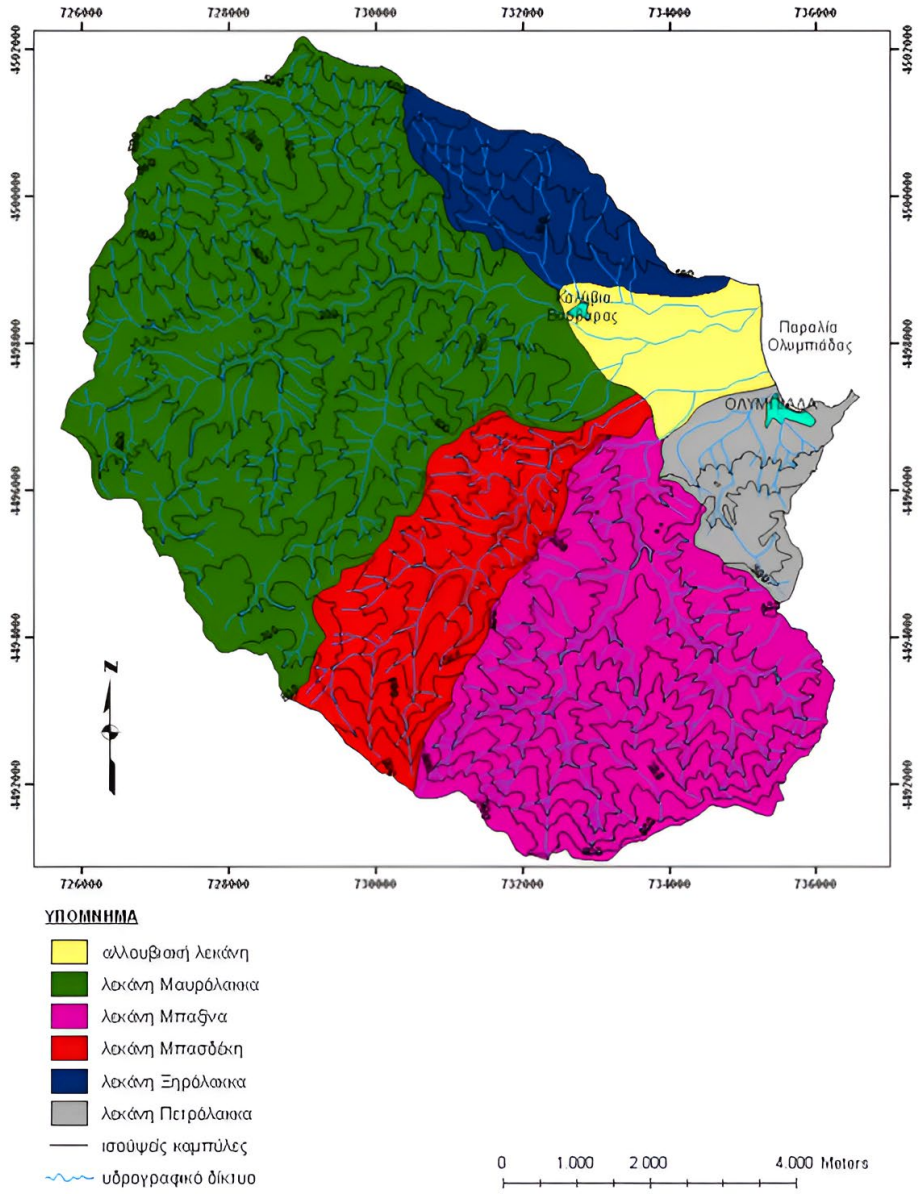
USGS MODFLOW Block Model




Basic Scenario Analysis for Project: PSF_metric
Select Active Scenario
Scenario
Description
Scenario01
Scenario01 Description
Analysis
Water Budget Chart
Multiple Scenarios
Calculated vs Observed Levels
Comparison of Calculated and Observed Values
NSE = 0.4455
RMSE = 0.1809
Water Level (m)
62.50
62.40
62.30
62.20
62.10
62.00
61.90
61.80
61.70
2011-08
2011-10
2011-12
2012-02
2012-04
2012-06
2012-08
Dates in Custom Range
Calculated
Observed
Reference Station
724010
Range (Dry, Normal, Wet)
1995 (Dry)
1990 (Normal)
1984 (Wet)
2011-08<>2012-08
Display Options
(T)otal Water
Actual Water Level (J)
Net (W)ater Loss/Gain
(P)recipitation
O(V)erbank
(R)unoff
Groundwater I(N)
User Water (I)N
Current (F)ill / Storage
(E)vapotranspiration
(O)utflow
Groundwater O(U)T
U(S)er Water OUT
(A)ll
Calculate Budget
Recalculate ET, Runoff and Overbank
Show Results
Auto Show Results
Do NOT Apply Preset Chart Settings
Delete ALL Scenario Results
Well Levels Dataset
Count
Hillslope
16
Toeslope
16
WL Observed
13
Chart
Export
Date
Calculated
Observed
2012-04-01
62.46
62.46
2012-05-01
62.20
62.41
2012-06-01
62.06
62.05
2012-07-01
62.00
61.80
2012-08-01
61.78
61.94
Export WEM
Export
Close

Recent Application in a Mining Scenario

- The project is related to a gold mining operation in Greece
- The objective is to use the wetland to treat mine waste water from the mineral processing plant
- Local weather data were collected and utilized
- Local hydrological and ground water data were also collected
- The hydrologic analysis was recently completed and will be presented as two engineering diploma theses at the Technical University of Crete in 2024.


726000
728000
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Παραλία Ολυμπιάδας
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λεκάνη Μπαξνα
λεκάνη Μπασδέκη
λεκάνη Ξηρόλακκα
λεκάνη Πετρόλακκα
ισοϋψείς καμπύλες
υδρογραφικό δίκτυο
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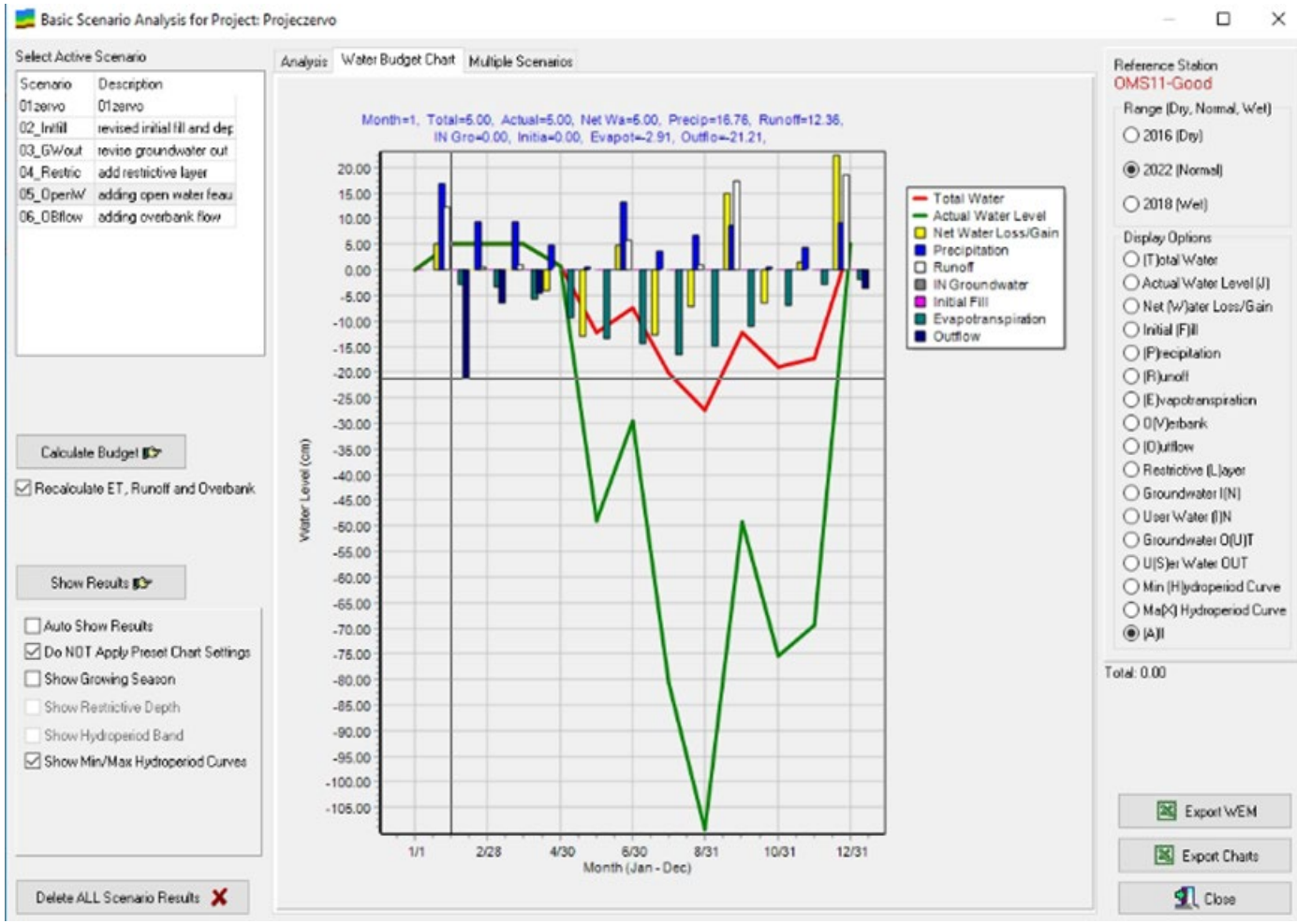
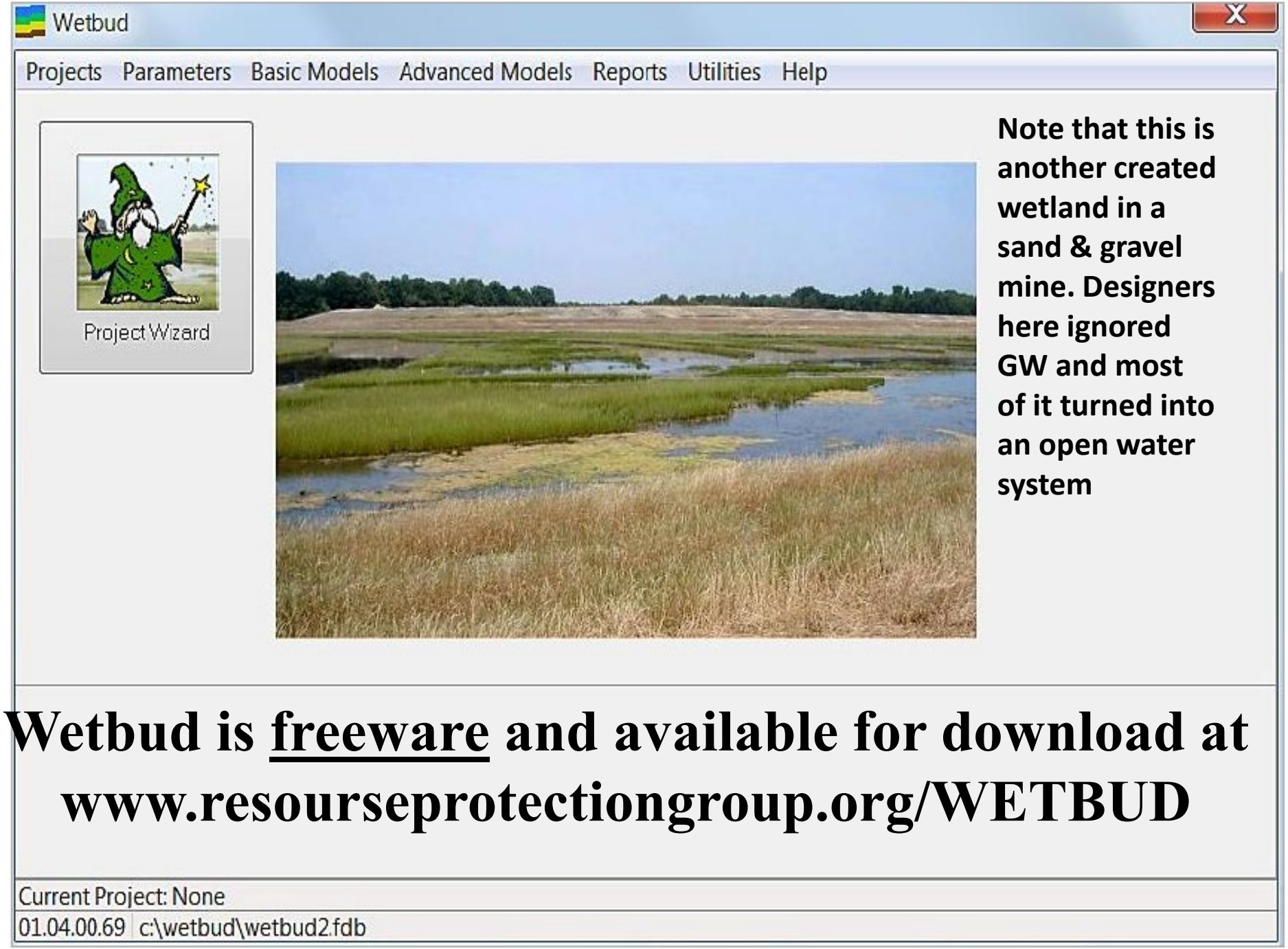
4.000 Meters


Basic Scenario Analysis for Project: Projeczervo
Select Active Scenario
Scenario
Description
01zervo
01zervo
02_Initfil
revised initial fill and dep
03_GWout
revise groundwater out
04_Restric
add restrictive layer
05_OpenW
adding open water feau
06_OBflow
adding overbank flow
Calculate Budget
Recalculate ET, Runoff and Overbank
Show Results
Auto Show Results
Do NOT Apply Preset Chart Settings
Show Growing Season
Show Restrictive Depth
Show Hydroperiod Band
Show Min/Max Hydroperiod Curves
Delete ALL Scenario Results
Analysis
Water Budget Chart
Multiple Scenarios
Month=1, Total=5.00, Actual=5.00, Net Wa=5.00, Precip=16.76, Runoff=12.36,
IN Gro=0.00, Initia=0.00, Evapot=-2.91, Outflo=-21.21,
Water Level (cm)
Month (Jan - Dec)
1/1
2/28
4/30
6/30
8/31
10/31
12/31
Total Water
Actual Water Level
Net Water Loss/Gain
Precipitation
Runoff
IN Groundwater
Initial Fill
Evapotranspiration
Outflow
Reference Station
OMS11-Good
Range (Dry, Normal, Wet)
2016 (Dry)
2022 (Normal)
2018 (Wet)
Display Options
Total: 0.00
Export WEM
Export Charts
Close



Note that this is another created wetland in a sand & gravel mine. Designers here ignored GW and most of it turned into an open water system

Wetbud is freeware and available for download at www.resourseprotectiongroup.org/WETBUD

Summary and Conclusions

- Wetland developers should consider using Wetbud to design successful mitigation wetlands for land reclamation projects associated with mining activities or mitigation for other land development projects.
- Wetbud streamlines the production of reliable water budgets for a wide variety of mitigation wetland settings.

Summary and Conclusions

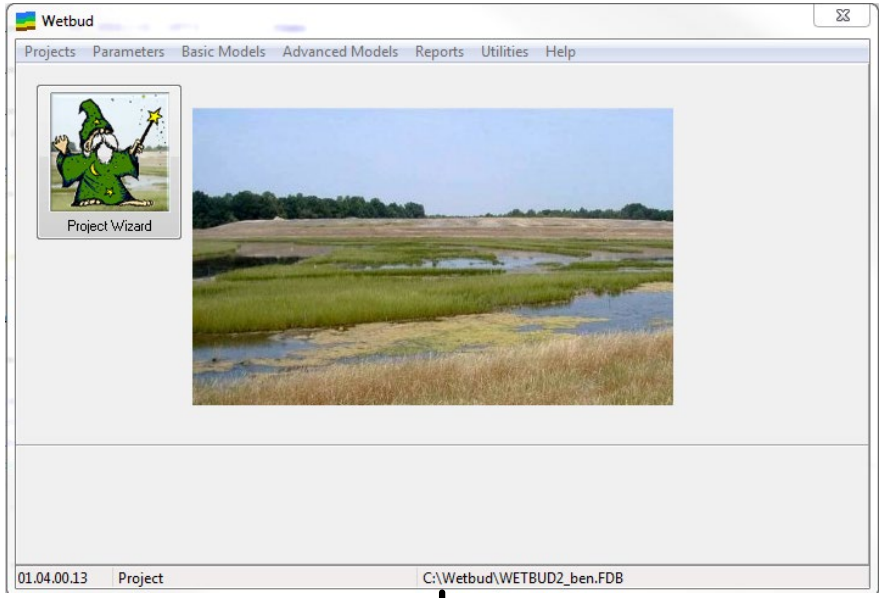
- Wetbud features a wizard for Basic Models. The wizard can set up a model in less than 15 minutes, for an area where climate data are already available.
- For more complicated settings, or for research purposes, users may employ the Advanced Scenario tools and create water budgets for sloping wetlands, or wetlands with variable topography, and dynamic sources and losses of water that can vary spatially and through time.

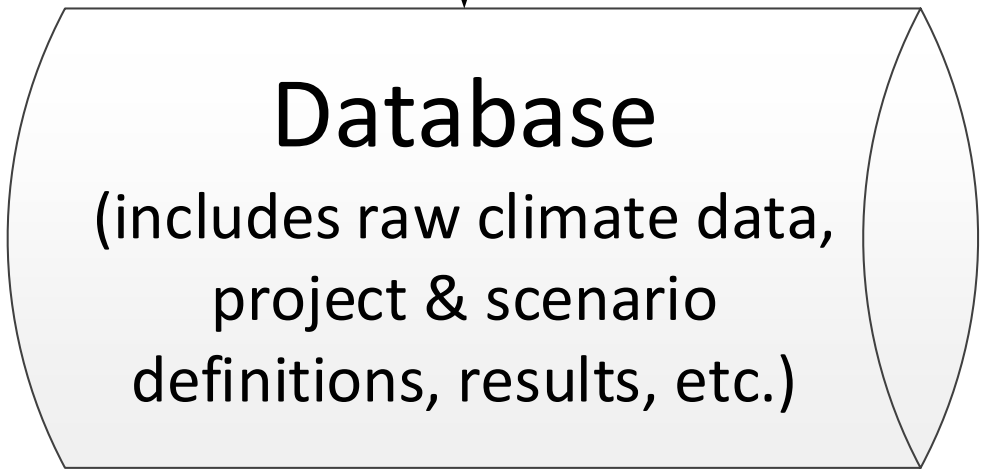
Acknowledgements

- This work was sponsored by Wetlands Studies and Solutions Inc. (WSSI), the Peterson Family Foundation and Resource Protection Group. The project started in 2008 and is still continuing today.

- The Wetbud package is available as freeware through this website: https://resourceprotectiongroup.org/wetbud/ --- or just google “Wetbud”
- Wetbud is still frequently updated. The install file will seamlessly update current installations.

Questions?


Wetbud
Projects
Parameters
Basic Models
Advanced Models
Reports
Utilities
Help
Project Wizard
01.04.00.13
Project
C:\Wetbud\WETBUD2_ben.FDB


Database
(includes raw climate data, project & scenario definitions, results, etc.)