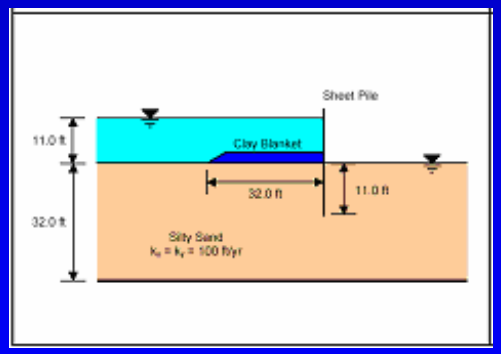
SEEP2D & GMS:

Simple Tools for Solving a Variety of Seepage Problems



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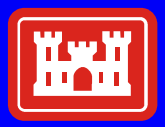
Earl Edris, ERDC-CHL

SEEP2D

- 2-D finite element seepage model
- Written by Fred Tracy, USACE-ERDC-ITL, published 1973
- Late 1970s – Dr. Tracy published groundbreaking work on visualization and pre- and post-processing for FEM models.
- Simple, mesh-based interface for SEEP2D first included in GMS v2.1, 1998.
- GMS v6.0 (2005) has a newly updated map-based interface

SEEP2D Applications

- Isotropic/anisotropic soil properties
- Confined/unconfined profile models
- Saturated/unsaturated flow for unconfined profile models
- Confined flow for plan (areal) models
- Flow simulation in the saturated and unsaturated zones
- Heterogeneous soil conditions
- Axisymmetric models such as flow from a well
- Drains



SEEP2D cannot simulate…

- Transient or time varying problems
- Unconfined plan (areal) models

Governing Equation

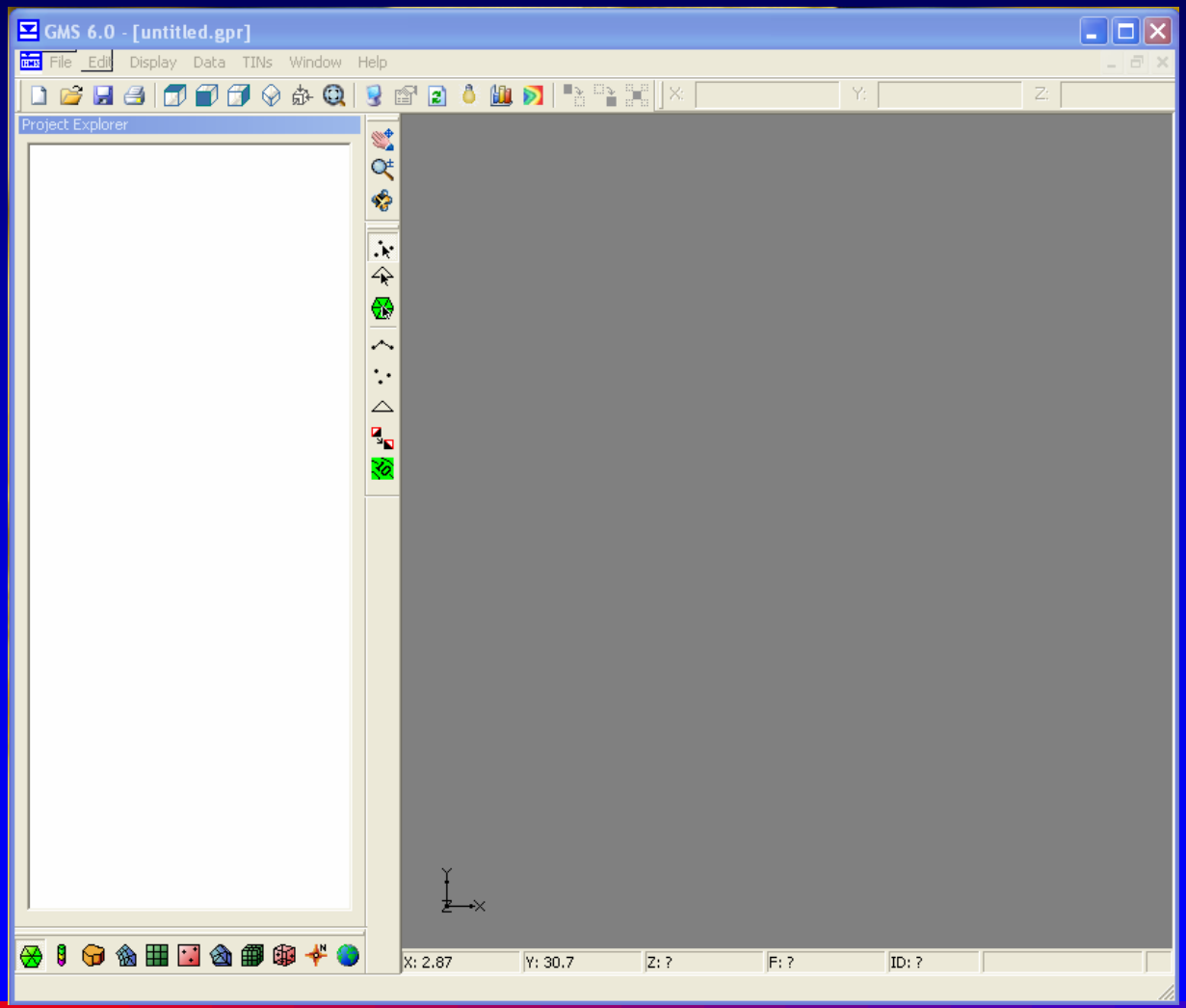
$$\nabla \bullet (K \bullet \nabla h) = 0$$

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}+K_{xy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}+K_{yx}\frac{\partial h}{\partial x}\right)=0$$

h=total head (elevation + pressure head)

K=hydraulic conductivity

Department of Defense Groundwater Modeling System (GMS)

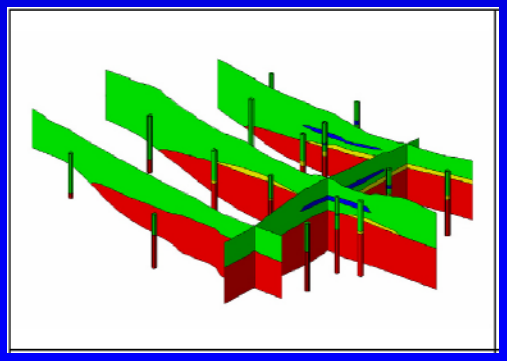


US Army Corps of Engineers

Engineer Research and Development Center

Groundwater Modeling System (GMS)

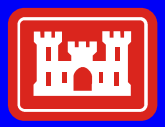
- 3D sub-surface characterization for groundwater modeling
- Supports 2D and 3D FEM, FDM, and analytic codes
- Incorporates advanced 3D post-processing visualization tools



- Supported Models
  - MODFLOW2000
  - MODPATH
  - FEMWATER
  - WASH123D
  - ADH
  - SEEP2D
  - ART3D
  - SEAM3D
  - MT3DMS
  - RT3D
  - UTCHEM
  - MODAEM

GMS Quick Facts

- First version released late 1994
- Current version is v6.0
- Developed by consortium of federal, academic & private concerns
- Graphical interface by EMRL at BYU
- Over 700 Fed Gov't users and thousands more in over 90 countries



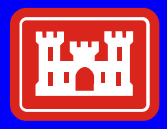
Obtaining GMS

- Employees of DoD, DoE, NRC, EPA and their on-site contractors can obtain free licenses for GMS at http://chl.erdc.usace.army.mil/gms.
- Groundwater Modeling Technical Support Center at ERDC handles GMS user support and training.
- Others can purchase licenses by contacting EMS-I at http://www.ems-i.com.

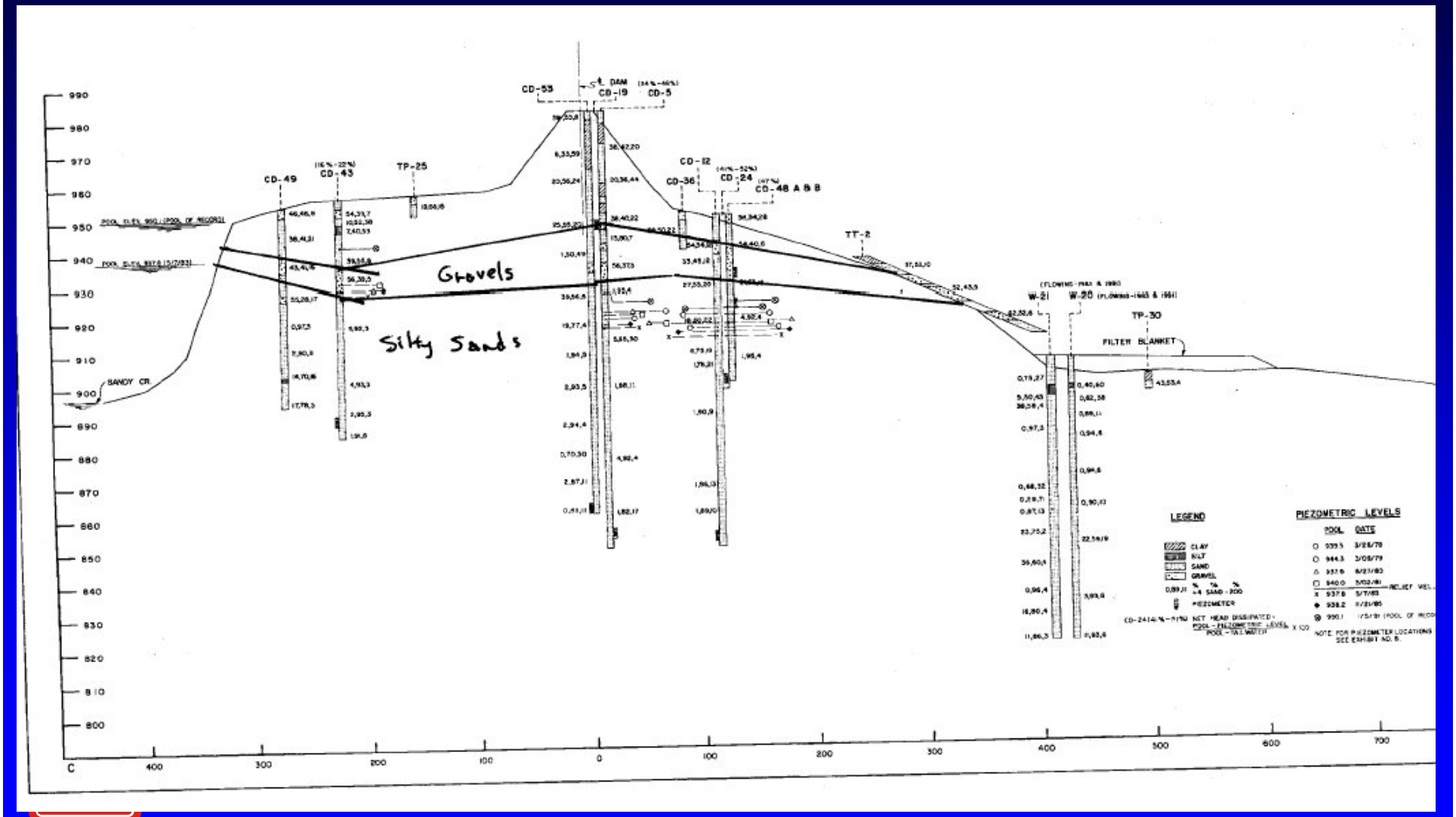
The GMS download comes with the SEEP2D executable and source code, two SEEP2D tutorials and the SEEP2D documentation.

Setting Up a SEEP2D Simulation in GMS

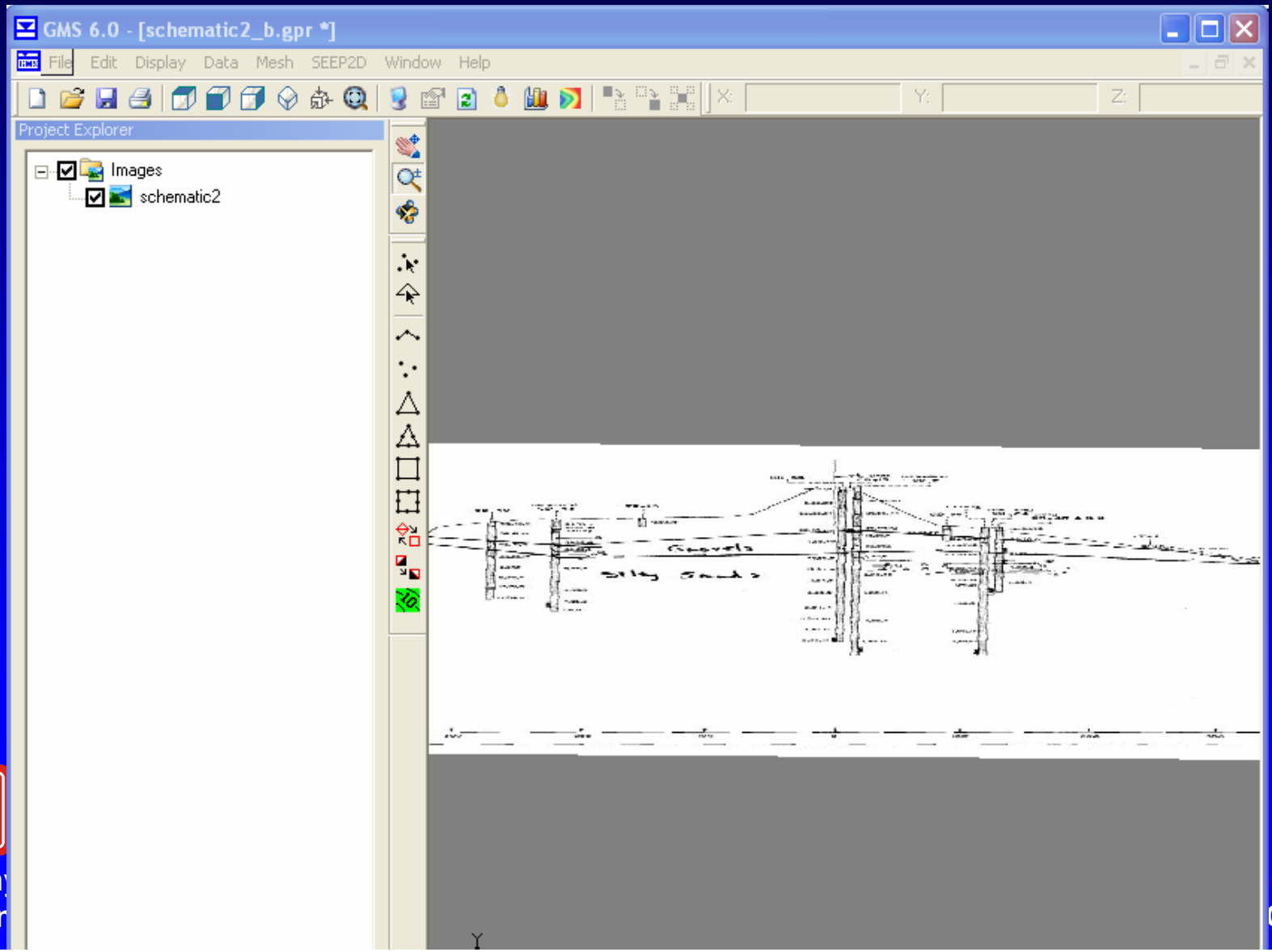
1. Set up Conceptual Model
   a) Set up domain
   b) Assign soil properties
   c) Redistribute vertices
   d) Assign boundary conditions
2. Build Computational Mesh
3. Map Boundary Conditions
4. Run
5. View Results



Sample Problem



Import Image



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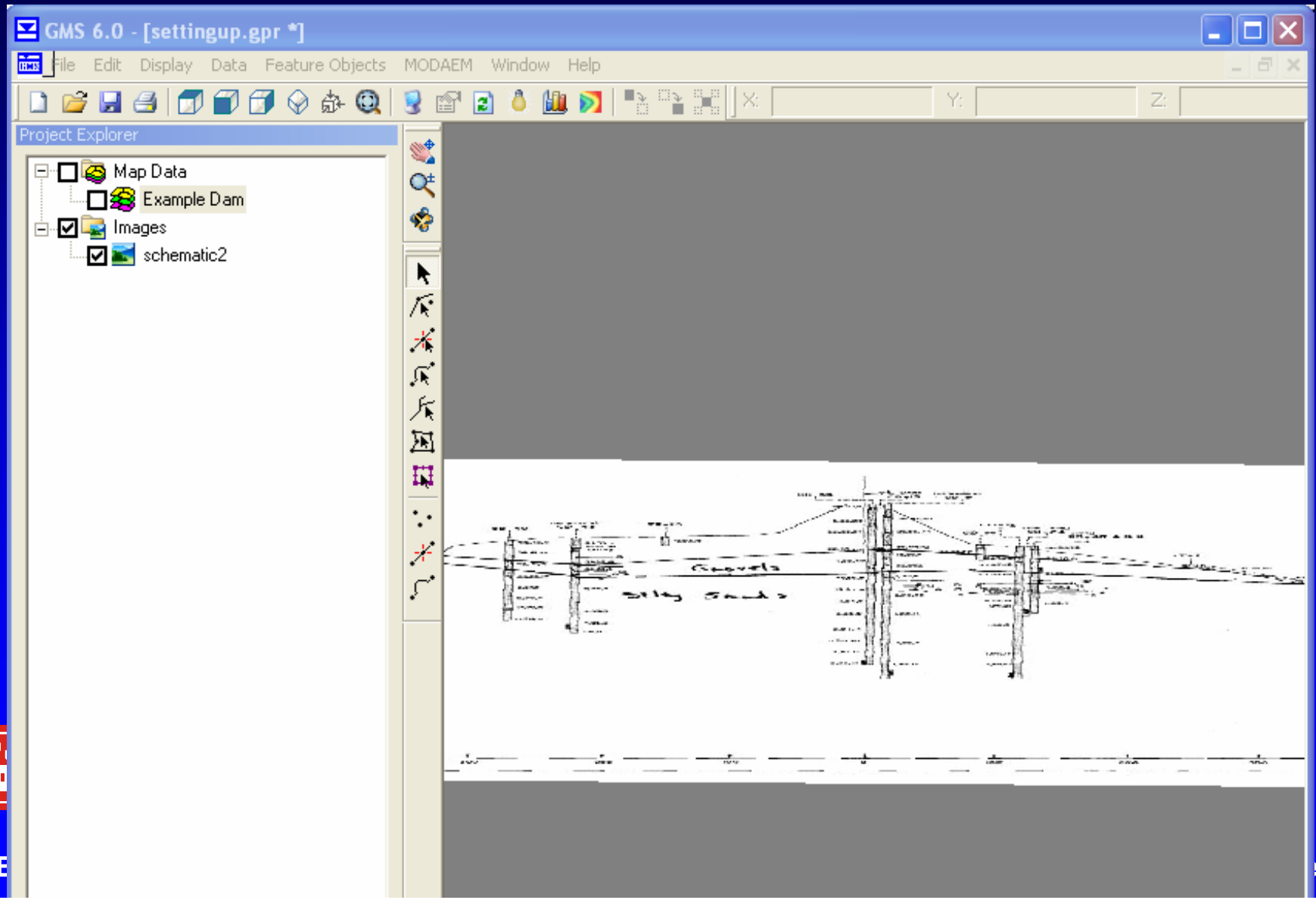
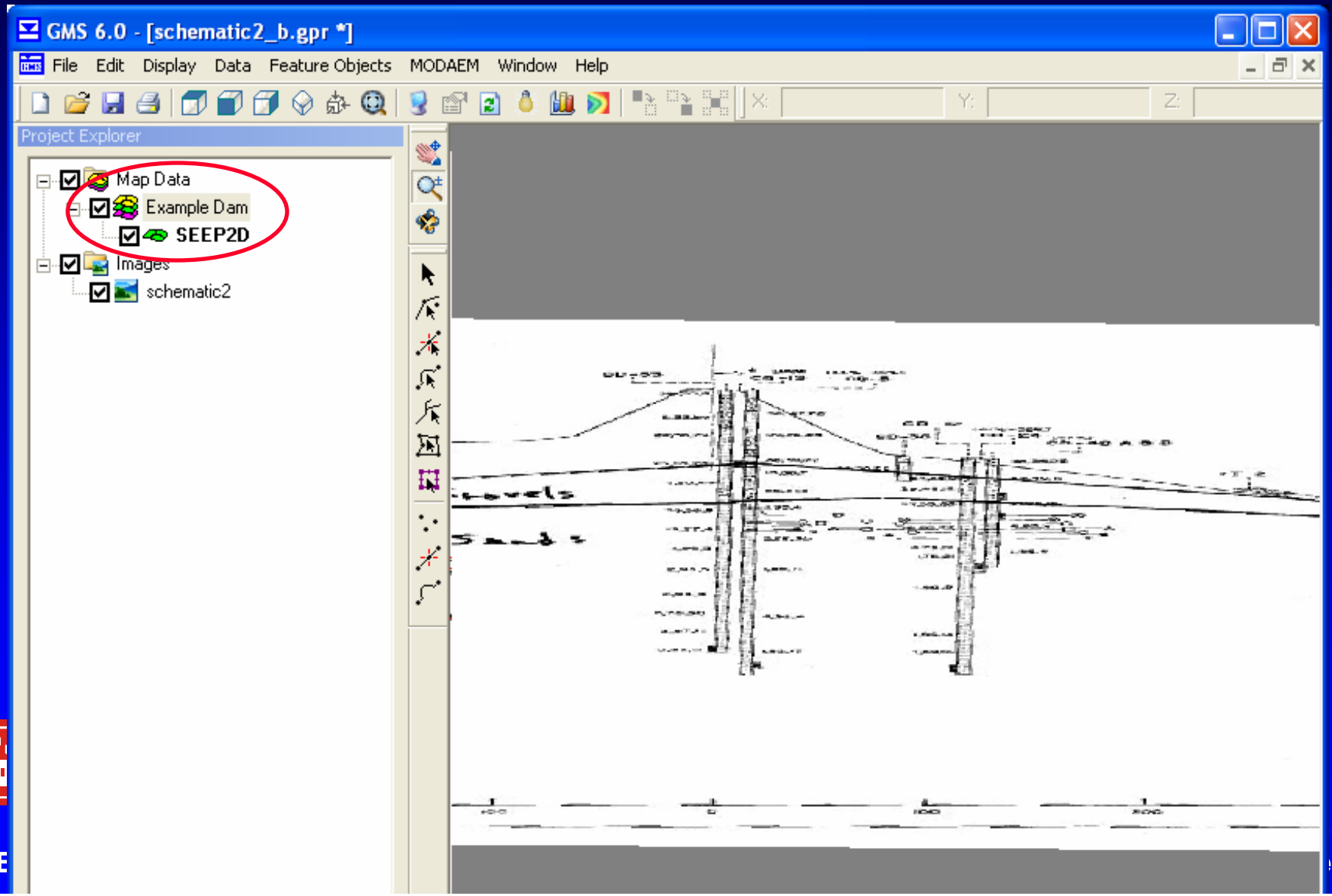
Create Conceptual Model



Create Coverage



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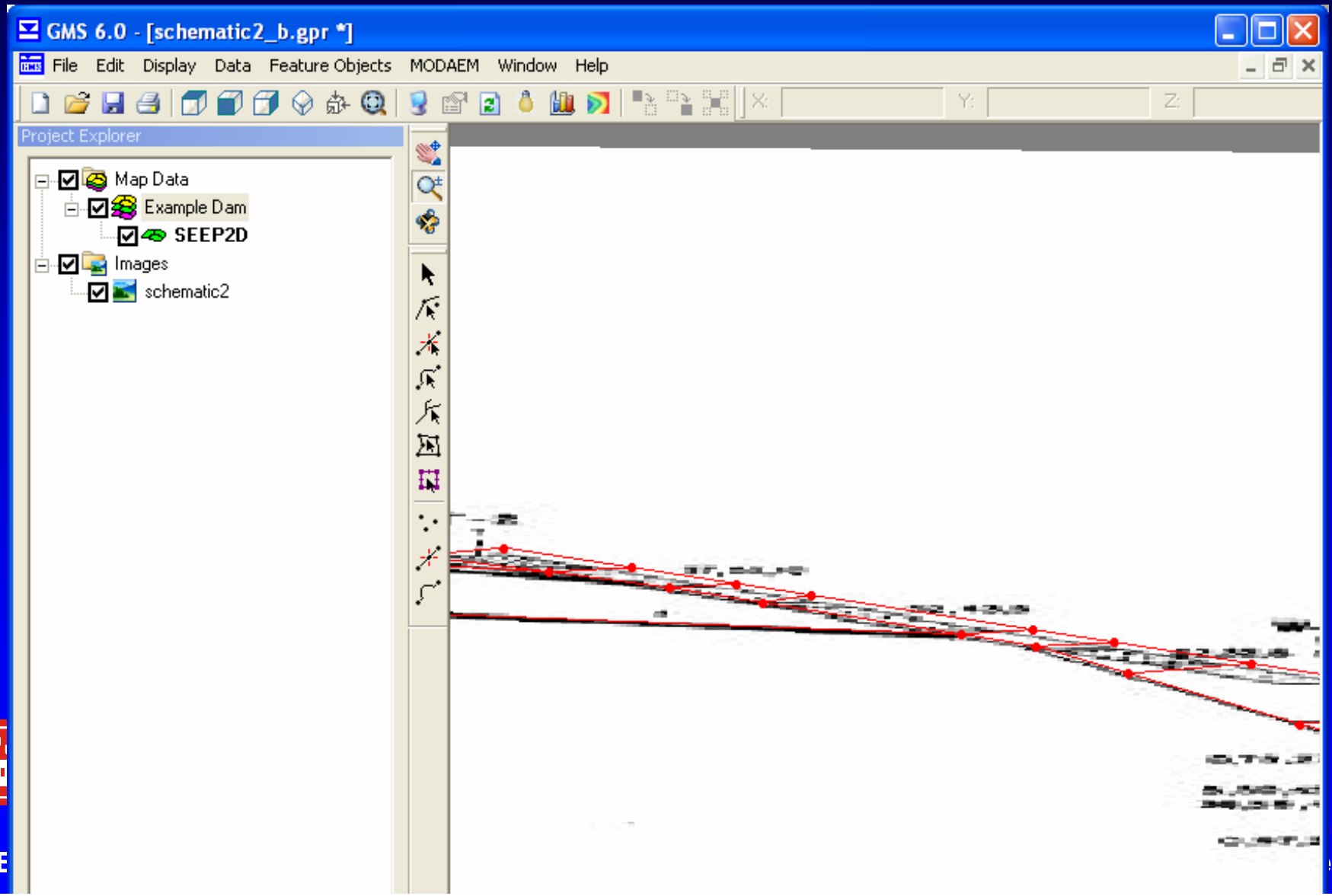
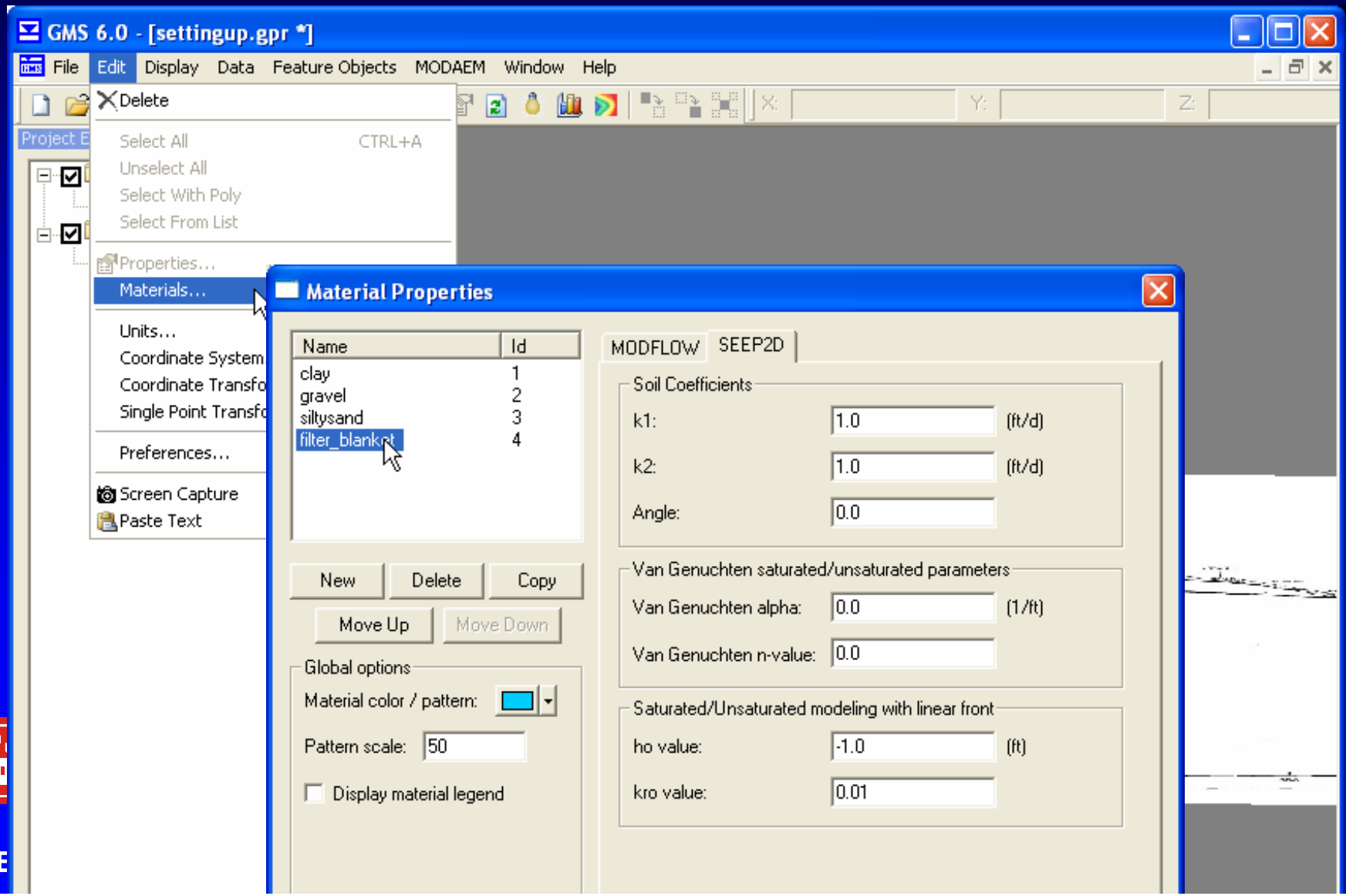
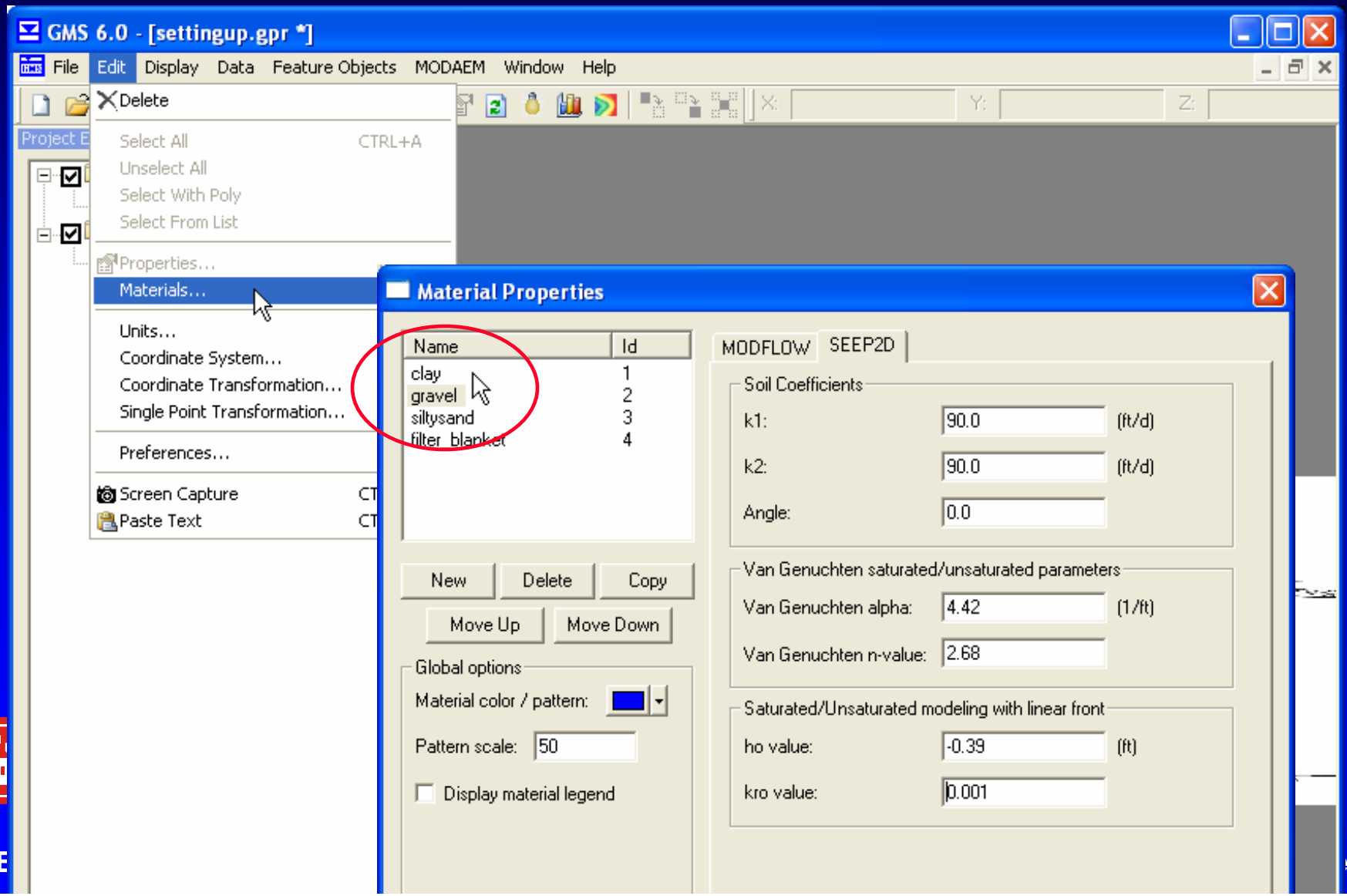
Set Up Domain



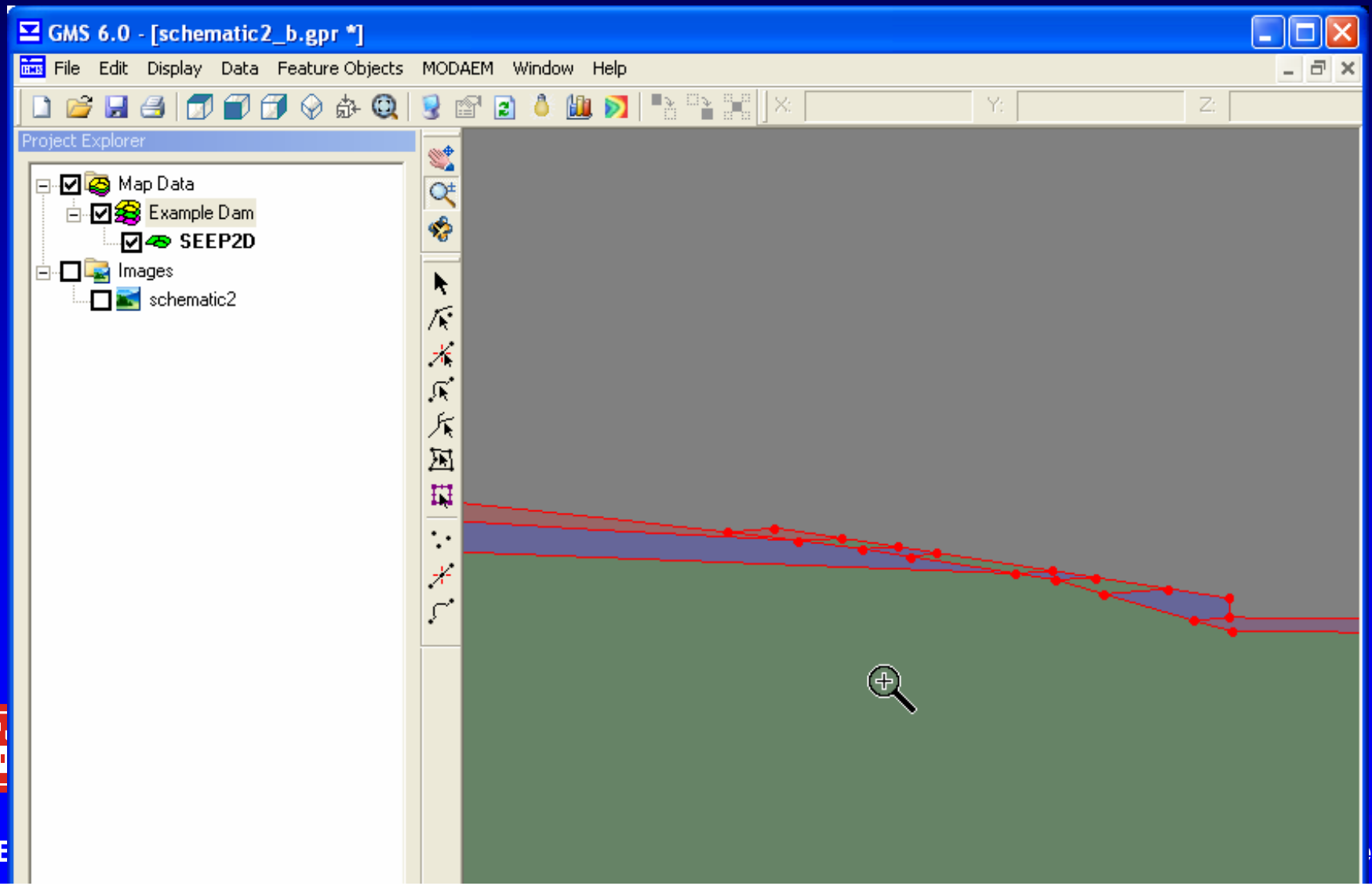
Create Material Types



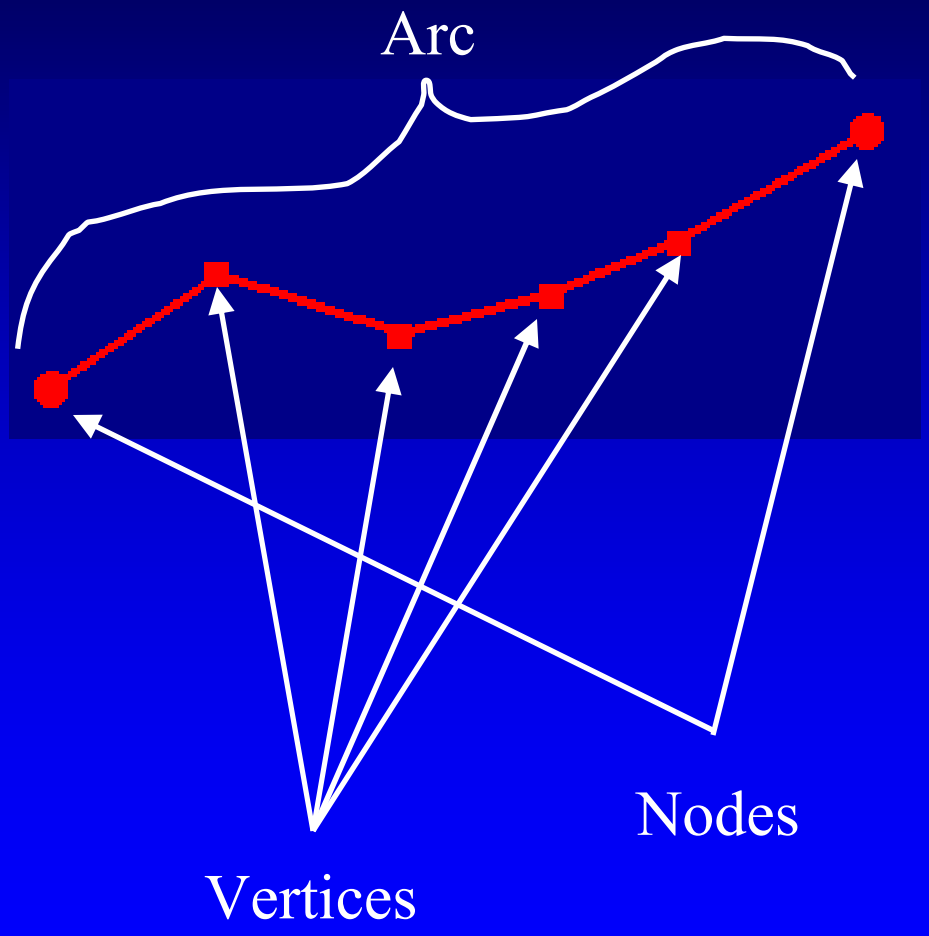
Assign Material Properties



Assign Materials to Polygons



Redistribute Vertices



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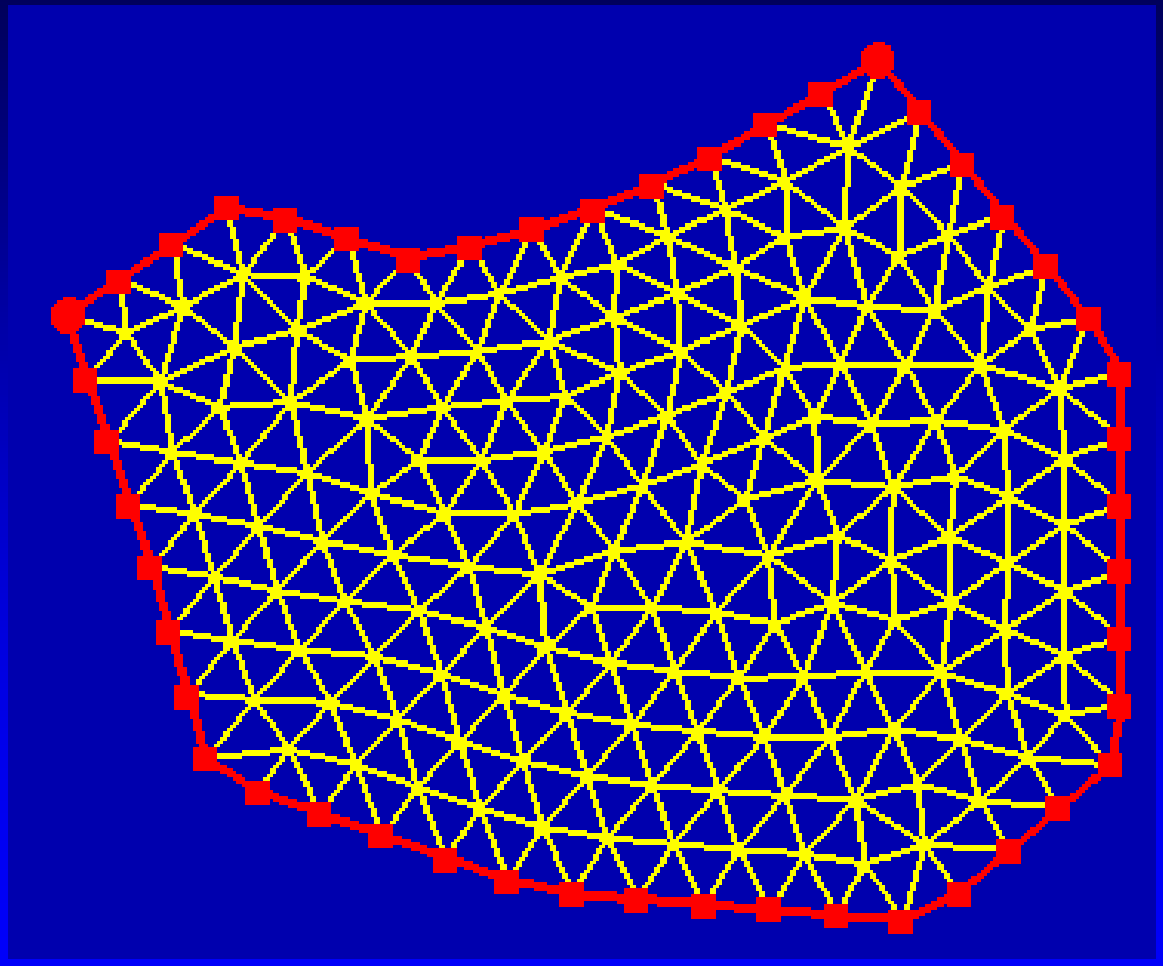
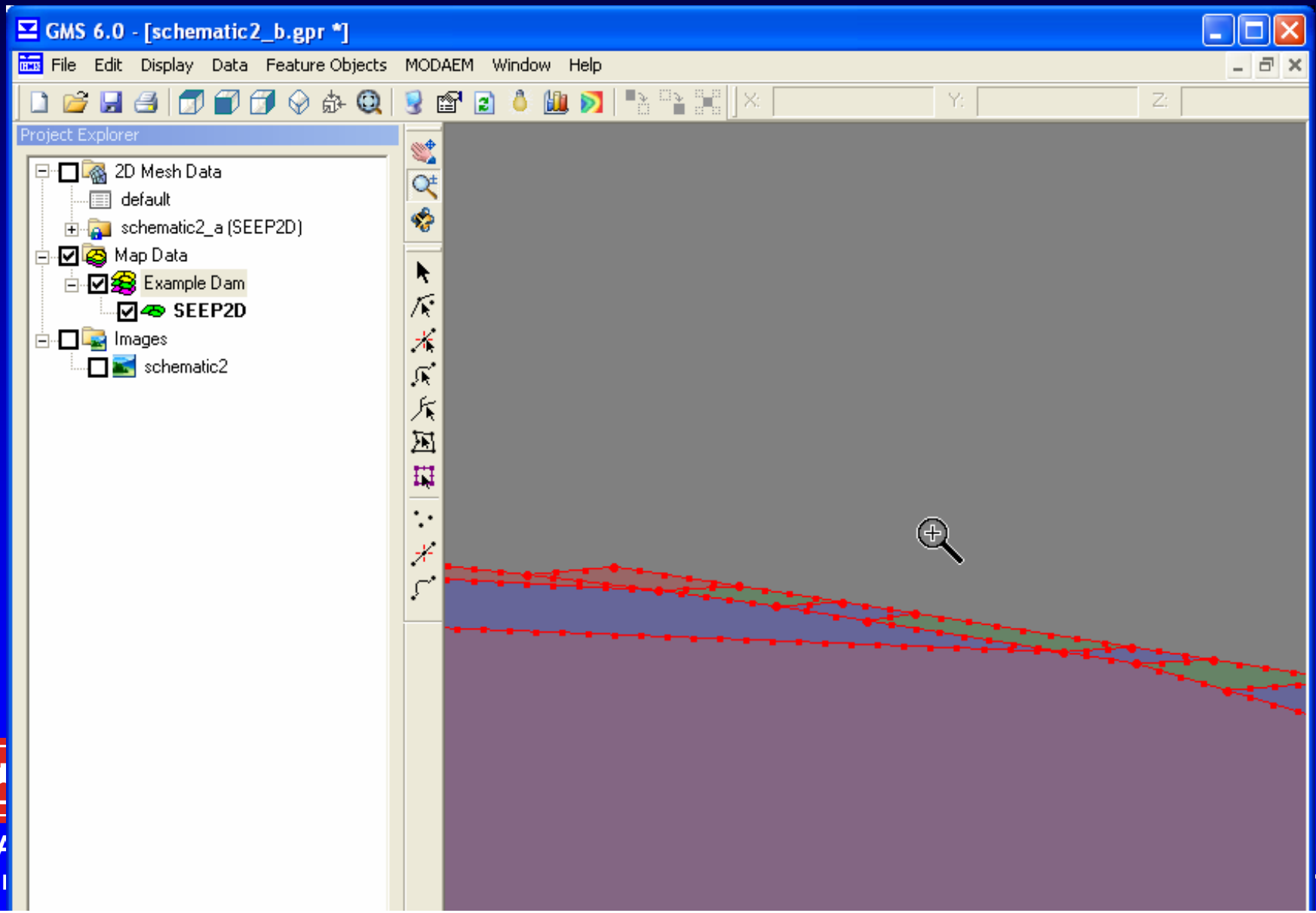


Redistribute Vertices



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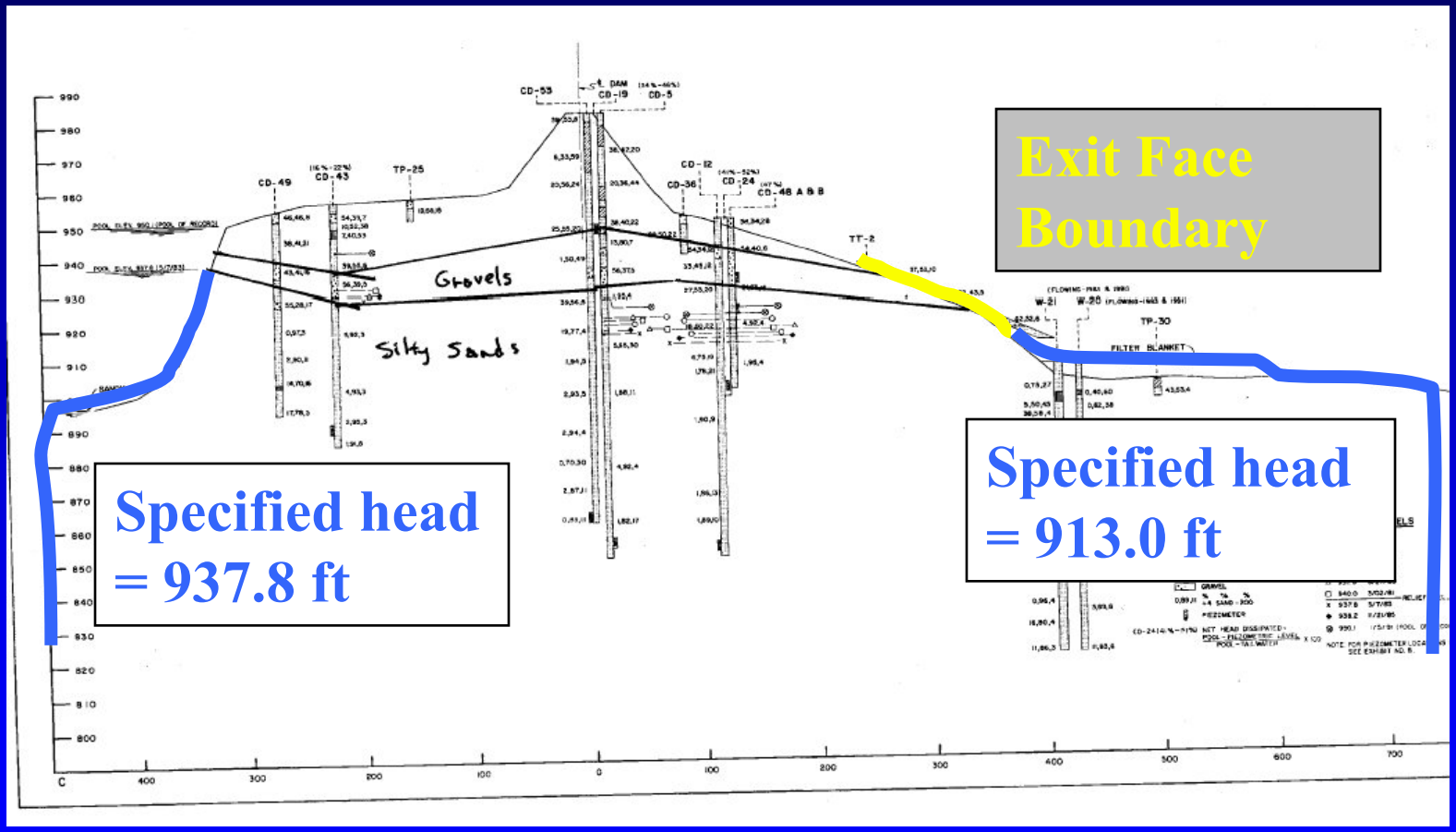
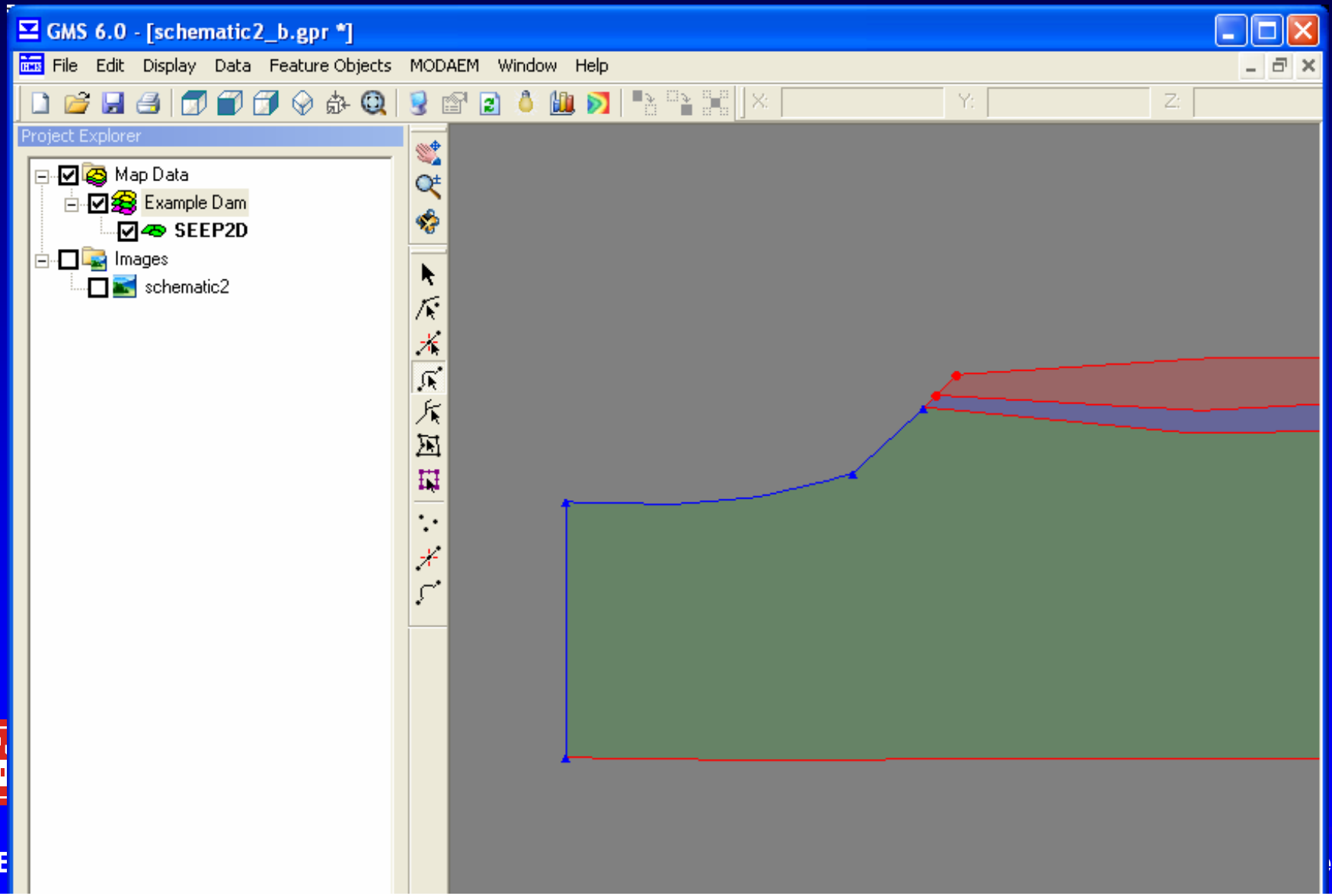
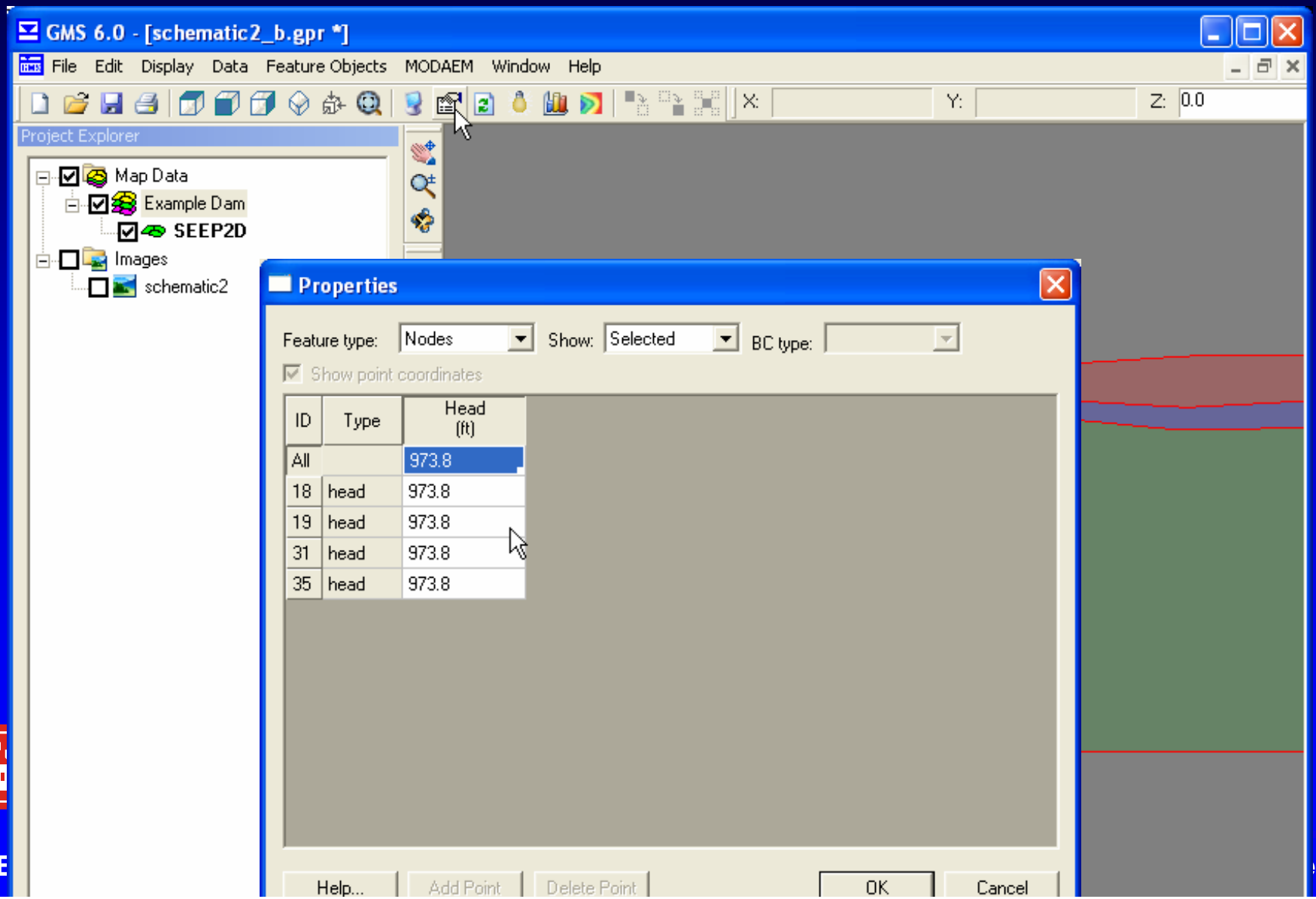
Assign Boundary Conditions



Assign Boundary Conditions



Assign Boundary Conditions



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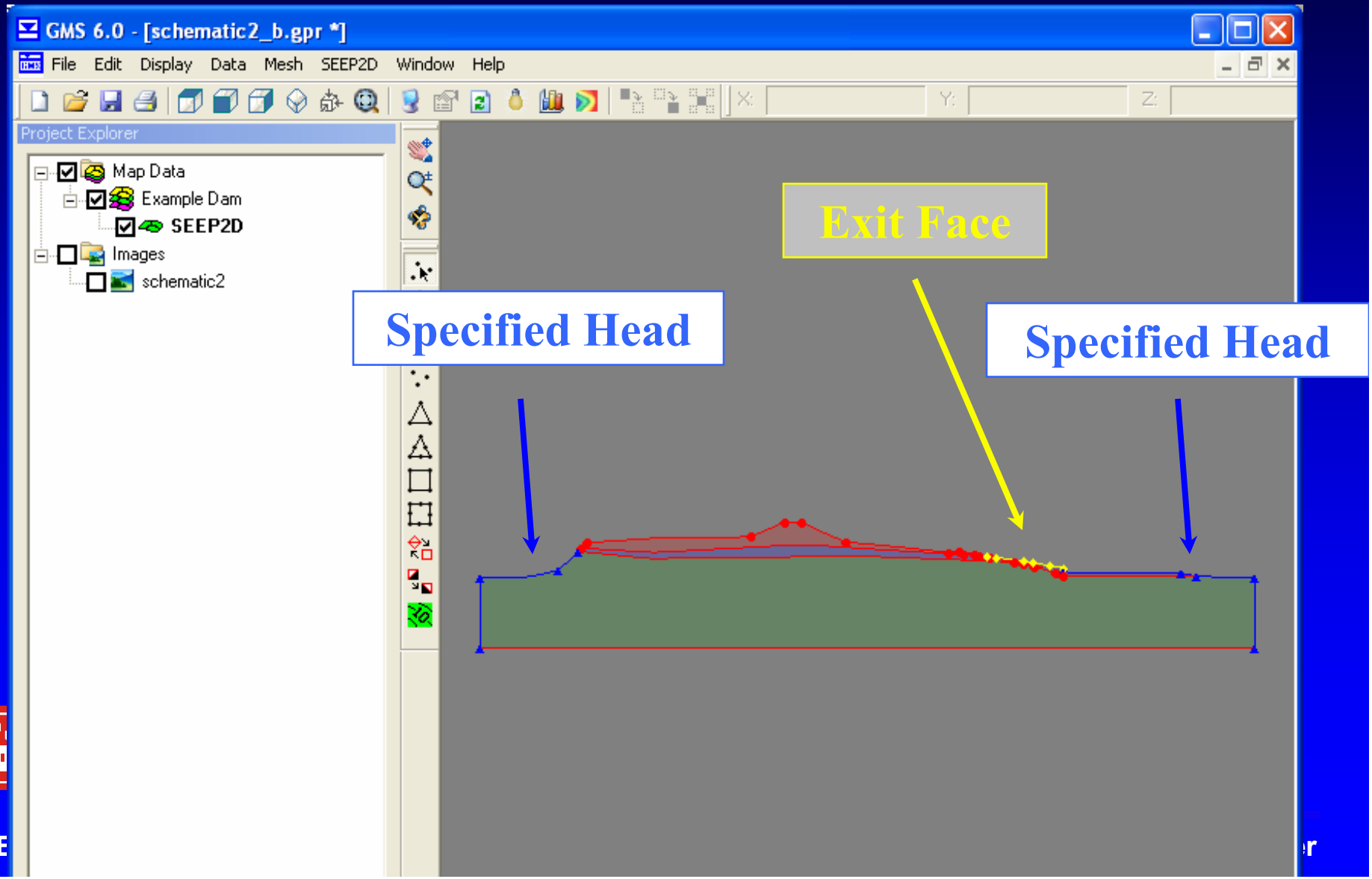
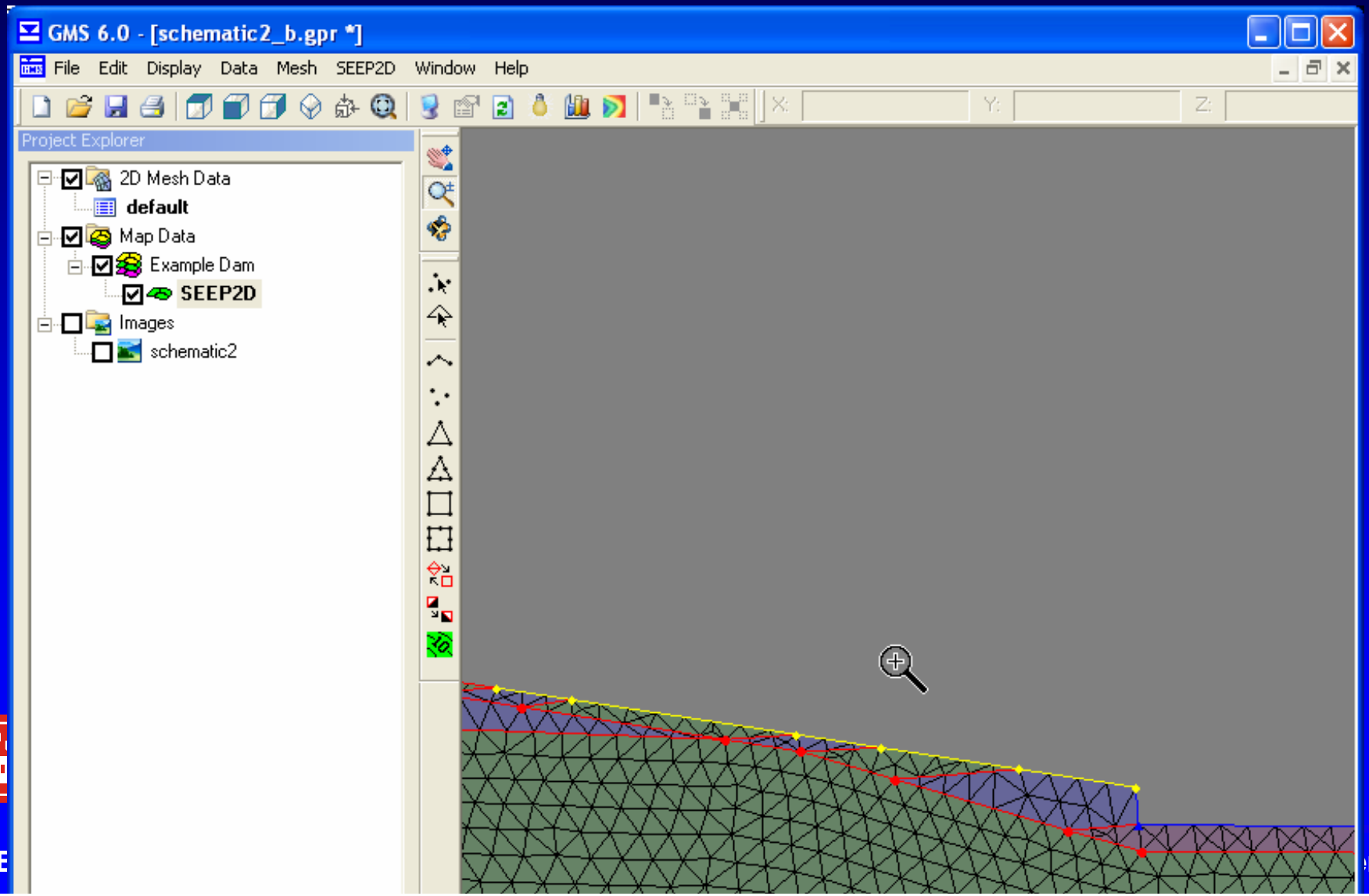


Build Computational Mesh



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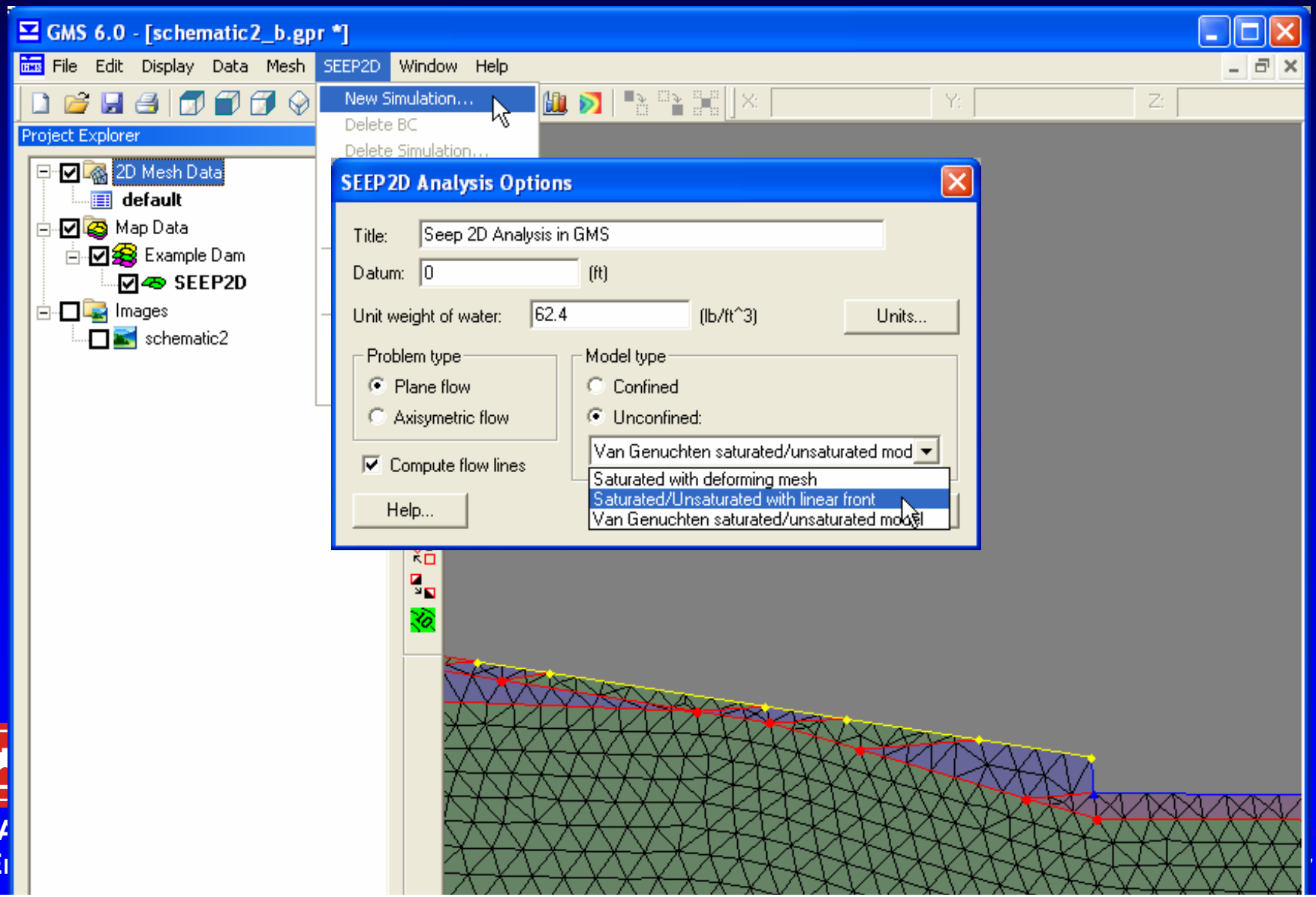
Initialize SEEP2D Simulation



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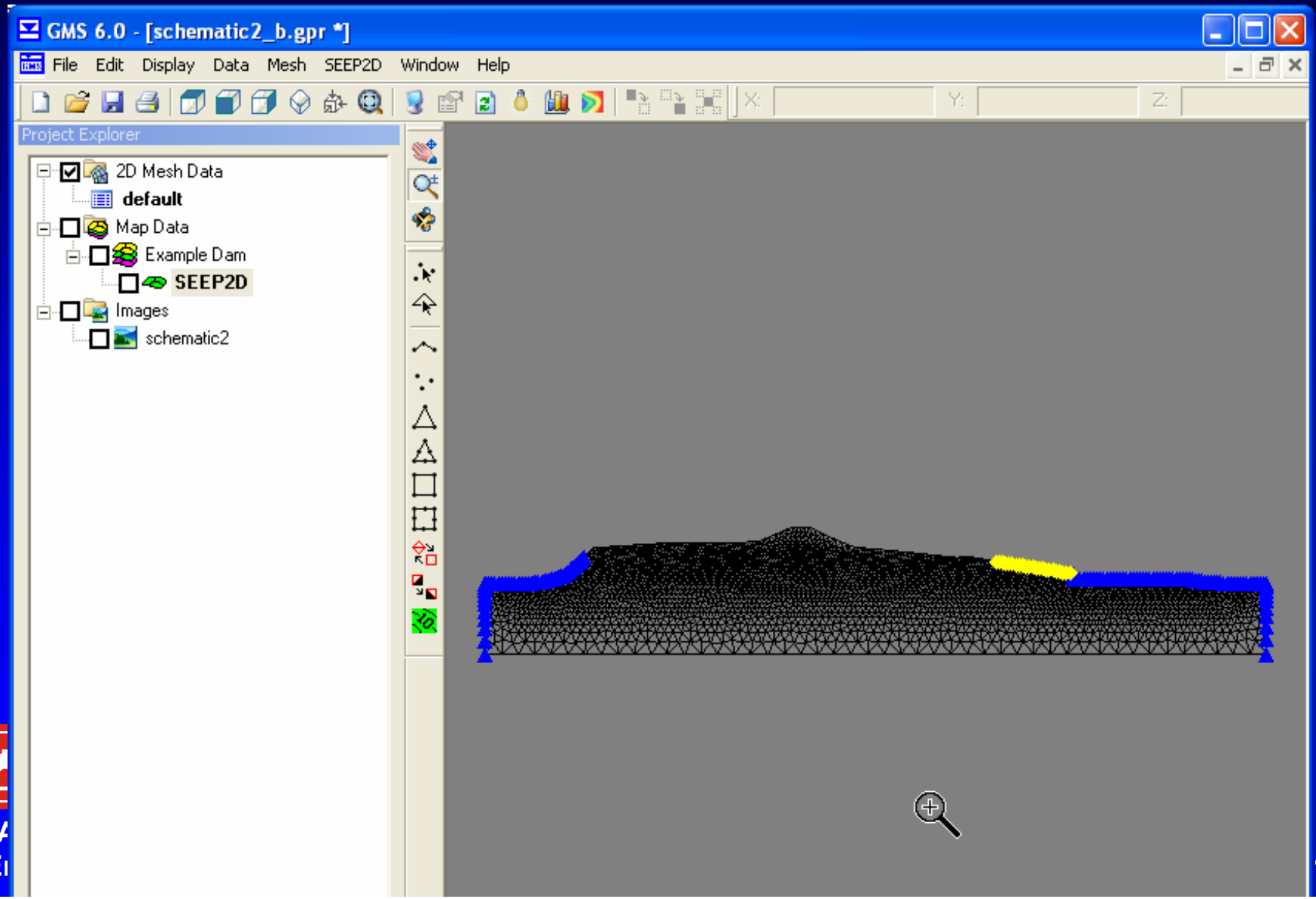
Map Boundary Conditions



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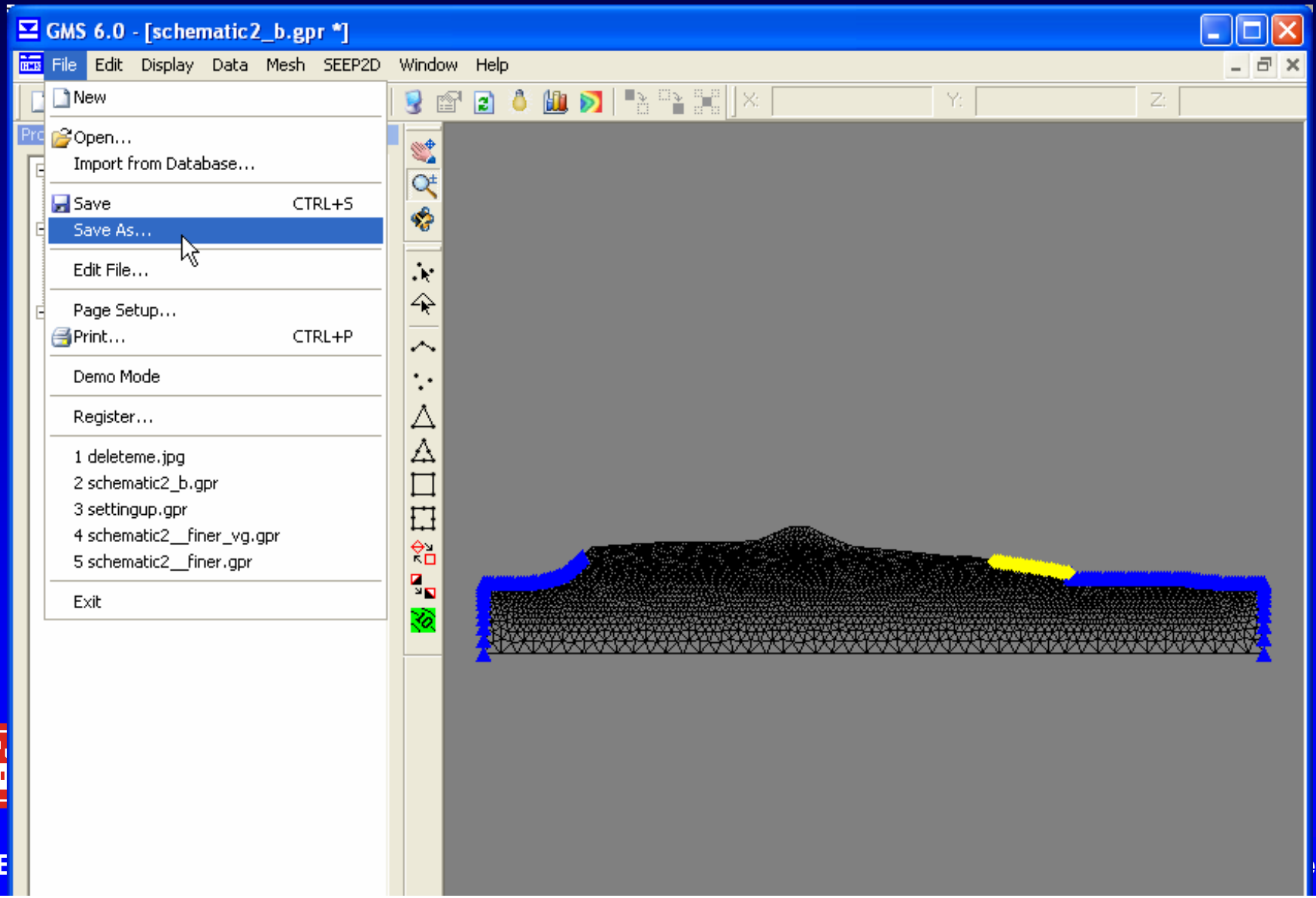
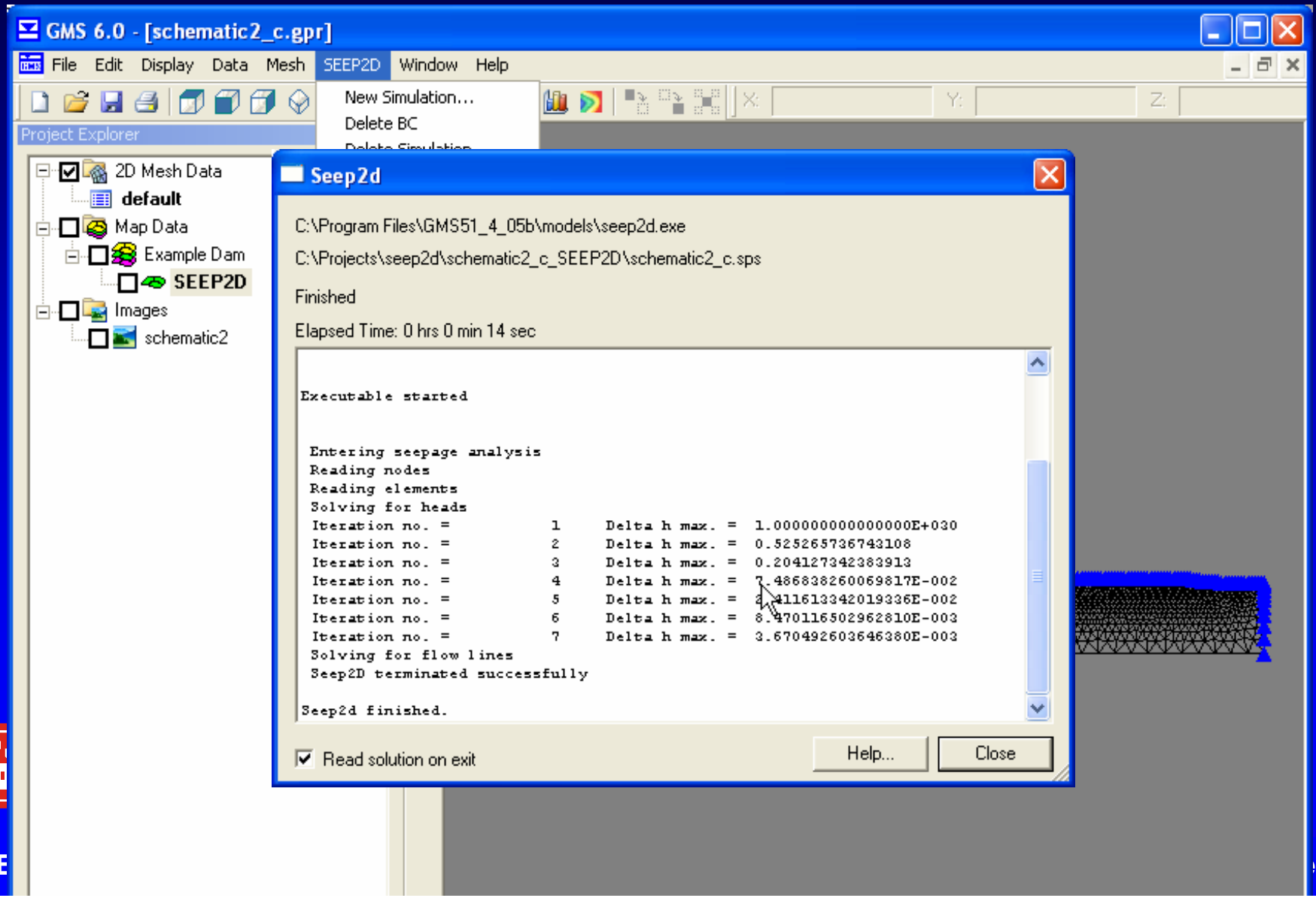
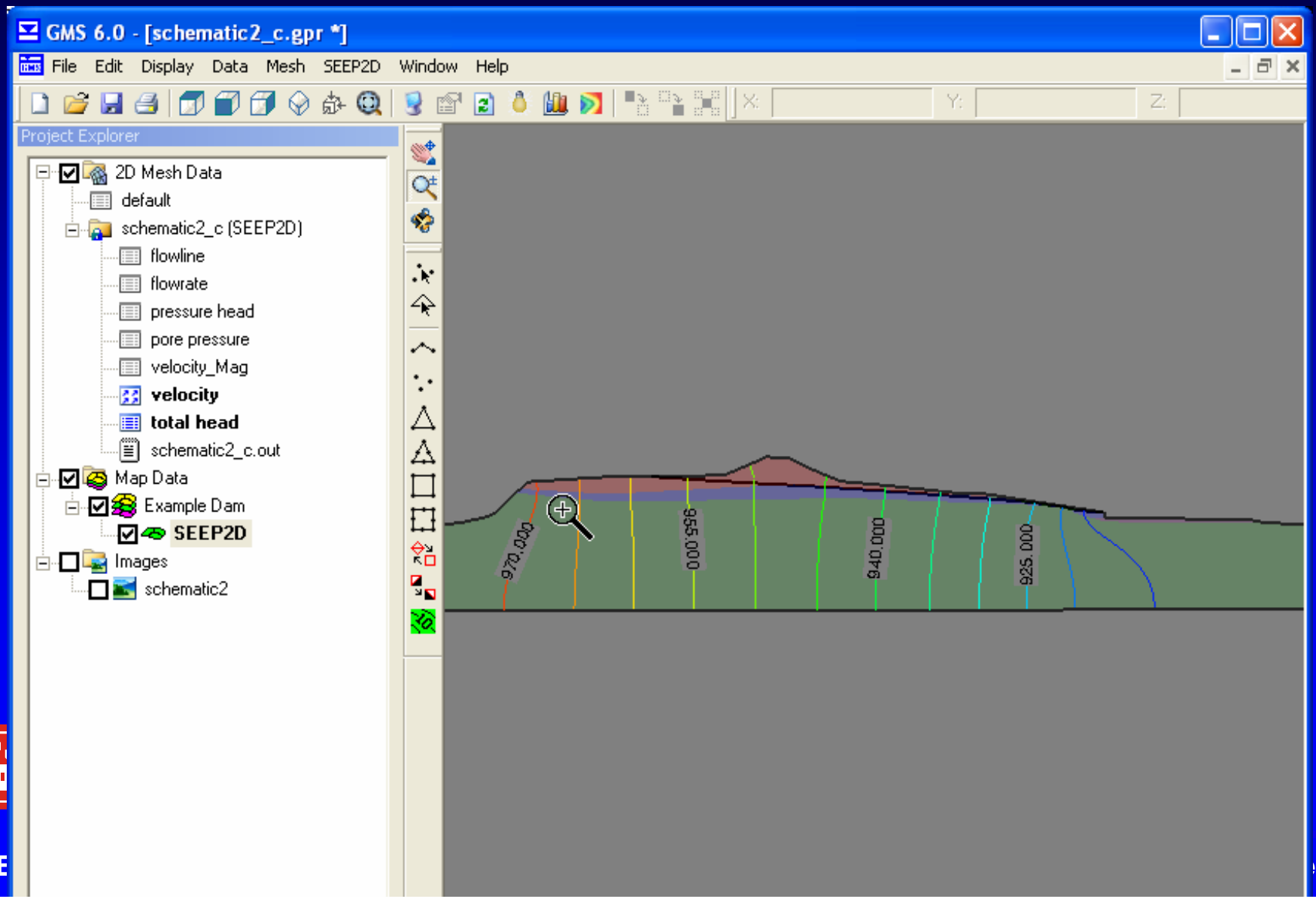
Save the Simulation



Run SEEP2D


GMS 6.0 - [schematic2_c.gpr]
File Edit Display Data Mesh SEEP2D Window Help
New Simulation...
Delete BC
Project Explorer
2D Mesh Data
default
Map Data
Example Dam
SEEP2D
Images
schematic2
Seep2d
C:\Program Files\GMS51_4_05b\models\seep2d.exe
C:\Projects\seep2d\schematic2_c_SEEP2D\schematic2_c.sps
Finished
Elapsed Time: 0 hrs 0 min 14 sec
Executable started
Entering seepage analysis
Reading nodes
Reading elements
Solving for heads
Iteration no. = 1 Delta h max. = 1.000000000000000E+030
Iteration no. = 2 Delta h max. = 0.525265736743108
Iteration no. = 3 Delta h max. = 0.204127342383913
Iteration no. = 4 Delta h max. = 7.486838260069817E-002
Iteration no. = 5 Delta h max. = 2.411613342019336E-002
Iteration no. = 6 Delta h max. = 8.470116502962810E-003
Iteration no. = 7 Delta h max. = 3.670492603646380E-003
Solving for flow lines
Seep2D terminated successfully
Seep2d finished.
Read solution on exit
Help...
Close

View Results



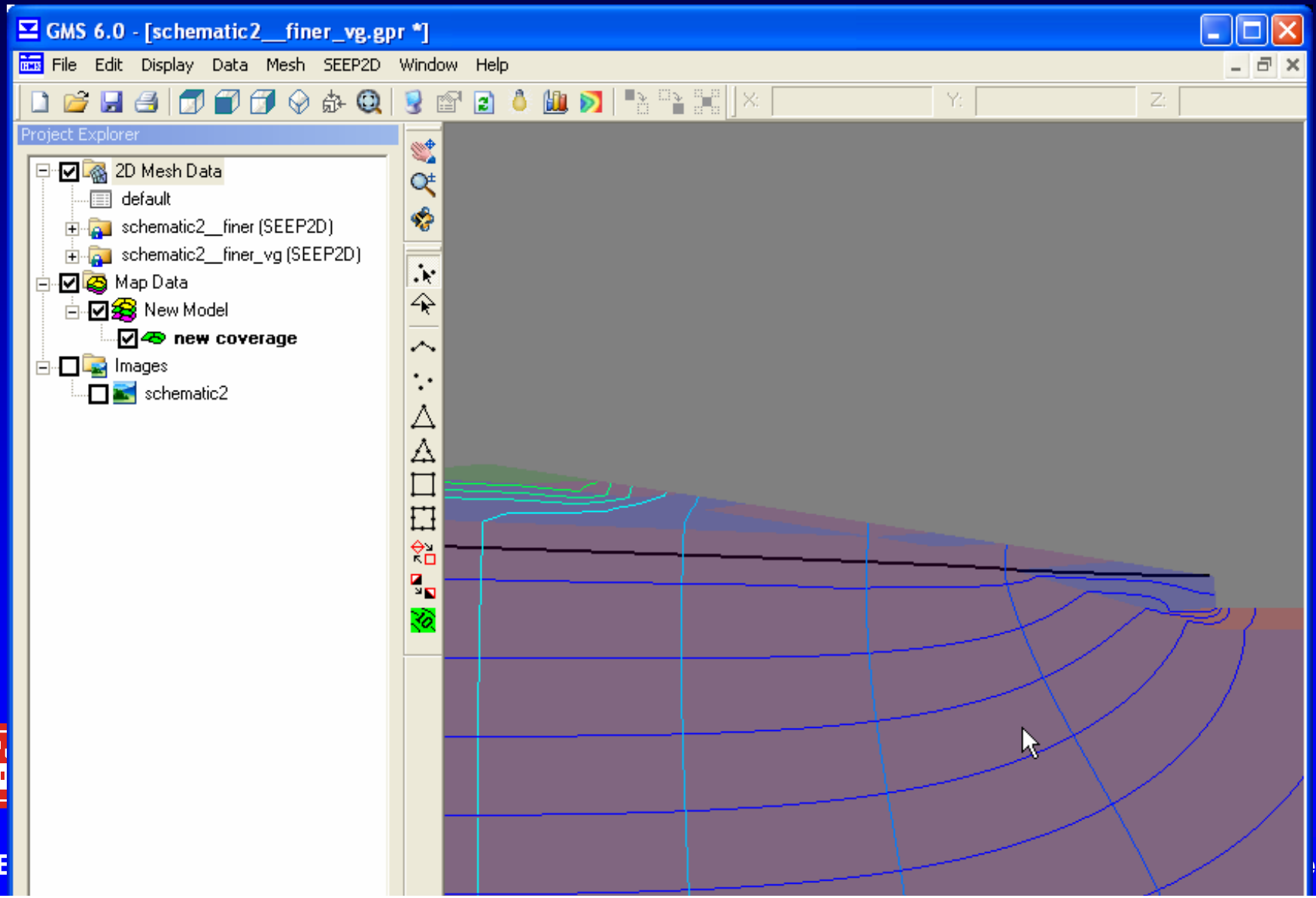
Conclusion

- SEEP2D is a fast, simple tool for seepage analysis.
- GMS provides a nice interface for setting up the problem and assigning boundary conditions.
- GMS also provides multiple options for viewing and analyzing the results.
- Best of all… SEEP2D and GMS are free for federal employees (DoD, DoE, EPA, NRC)

Issues to Consider:

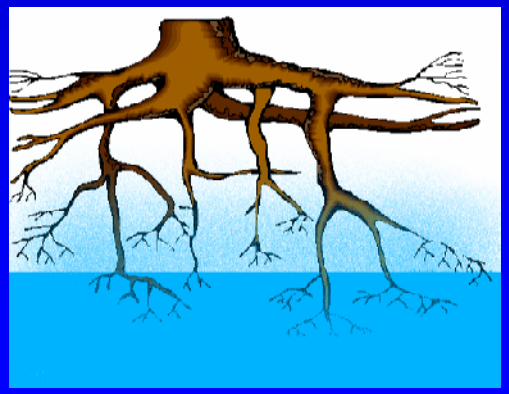
- Mesh resolution
- How to handle the unsaturated zone:
  - Linear Front
  - Van Genuchten parameters

Mesh Resolution



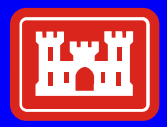
Unsaturated Zone Flow

- Conductivities are lower than the saturated value and can be tied to the pressure head.
- SEEP2D calculates K_r, relative conductivity, and uses the following equation to determine the conductivity at each node having a negative pressure head:
  - $K = K_{sat} * K_r$

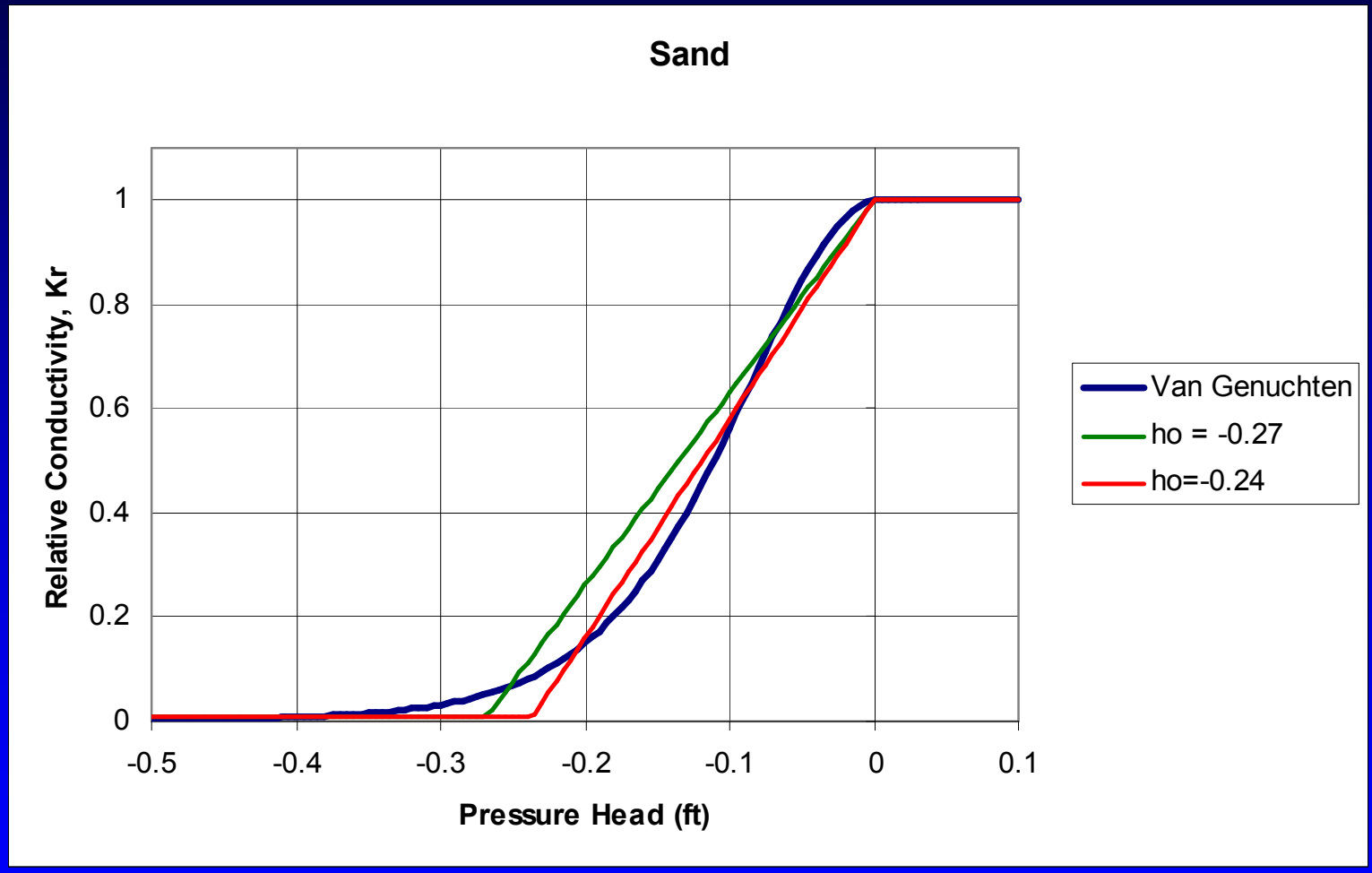


Unsaturated Zone Flow

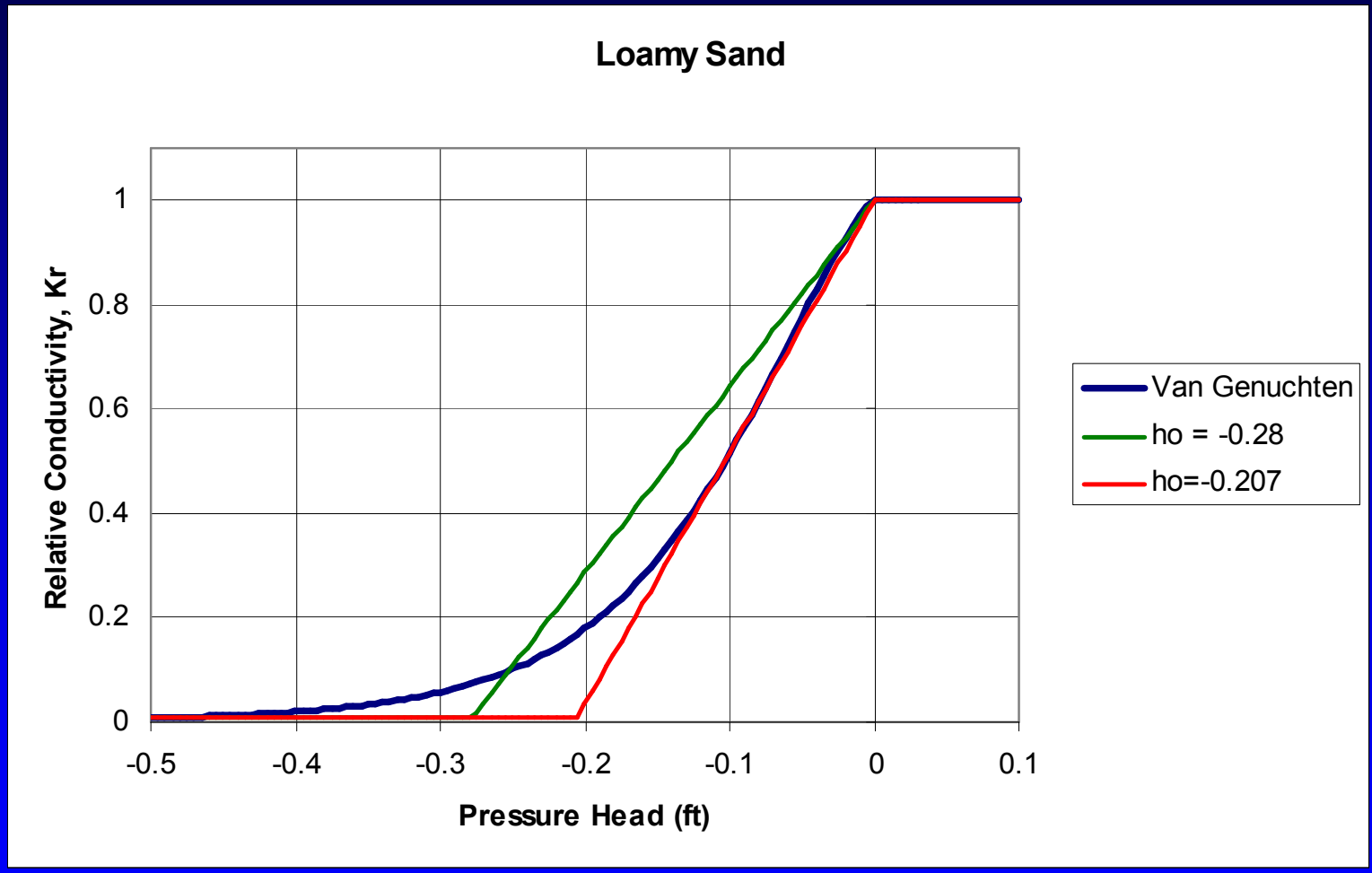
- Two ways to determine K_r:
  - Van Genuchten Parameters
    - User supplies α, n.
    - Estimated for several soil types in:
      - Carsel, F. F. and R. S. Parrish. 1988. Developing joint probability distributions of soil water retention characteristics. *Water Resources Research* 24, no. 5:755-69.
  - Linear Approximation
    - User supplies h_o, K_{ro}



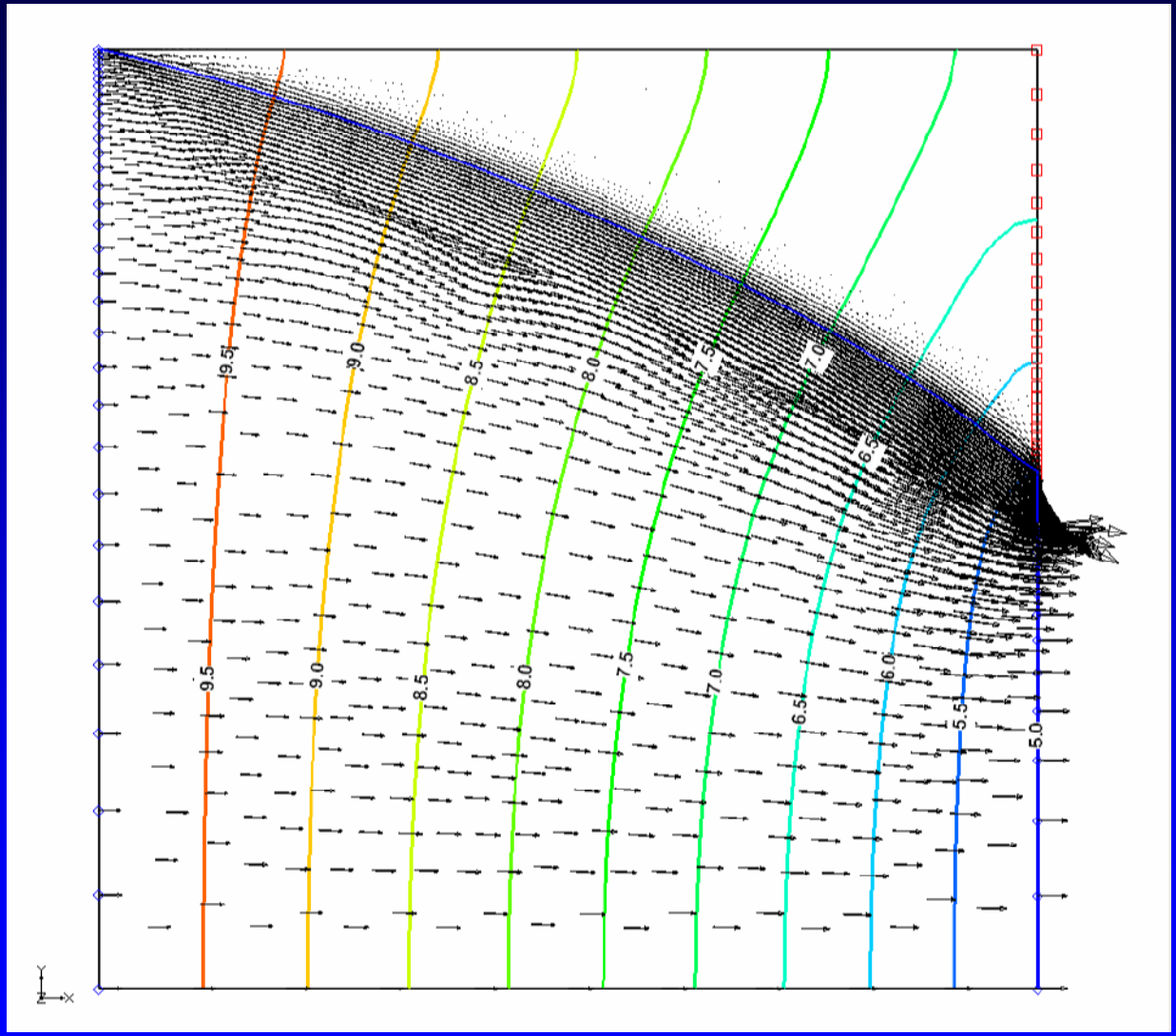
Unsaturated Zone Flow



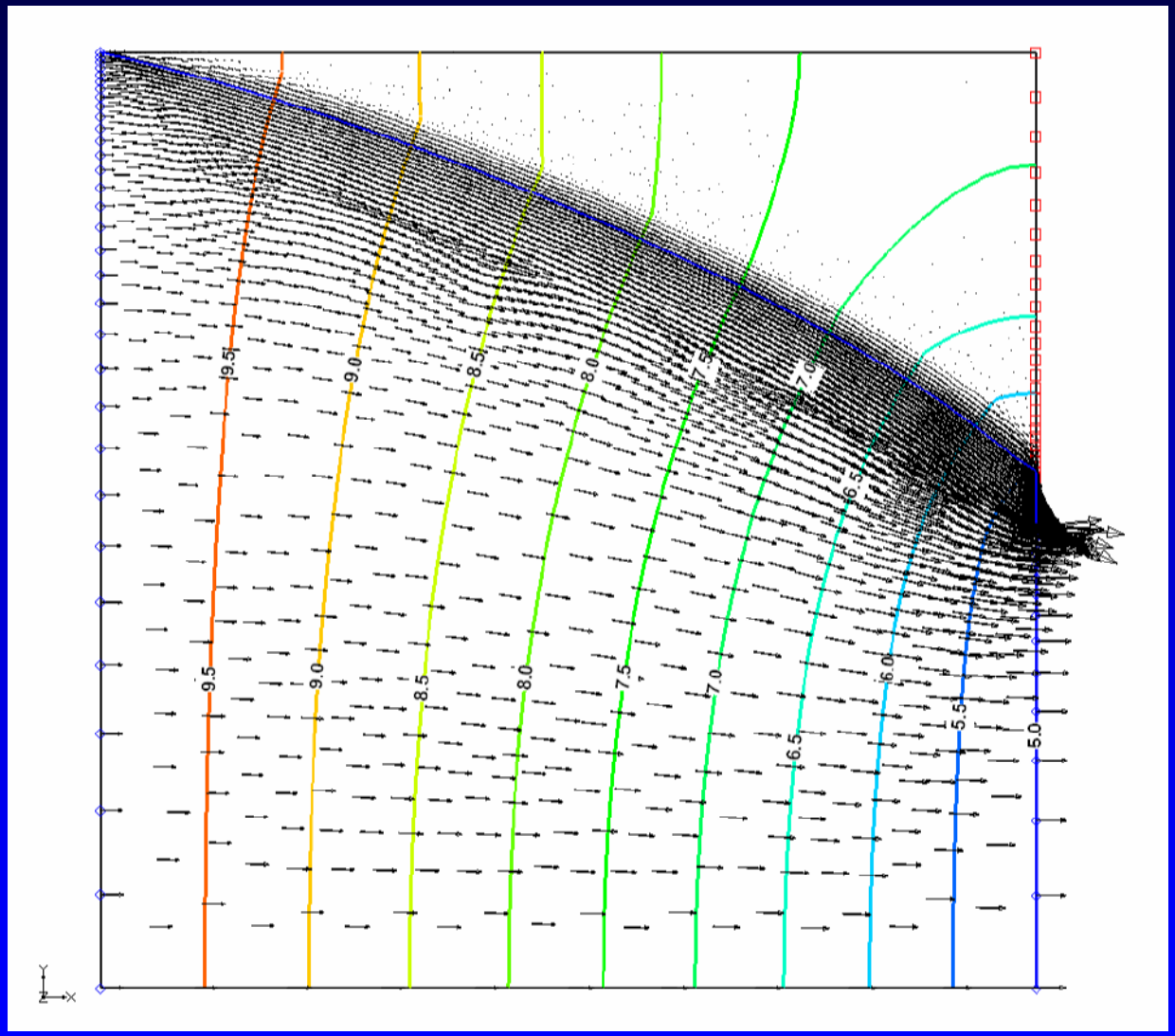
Unsaturated Zone Flow



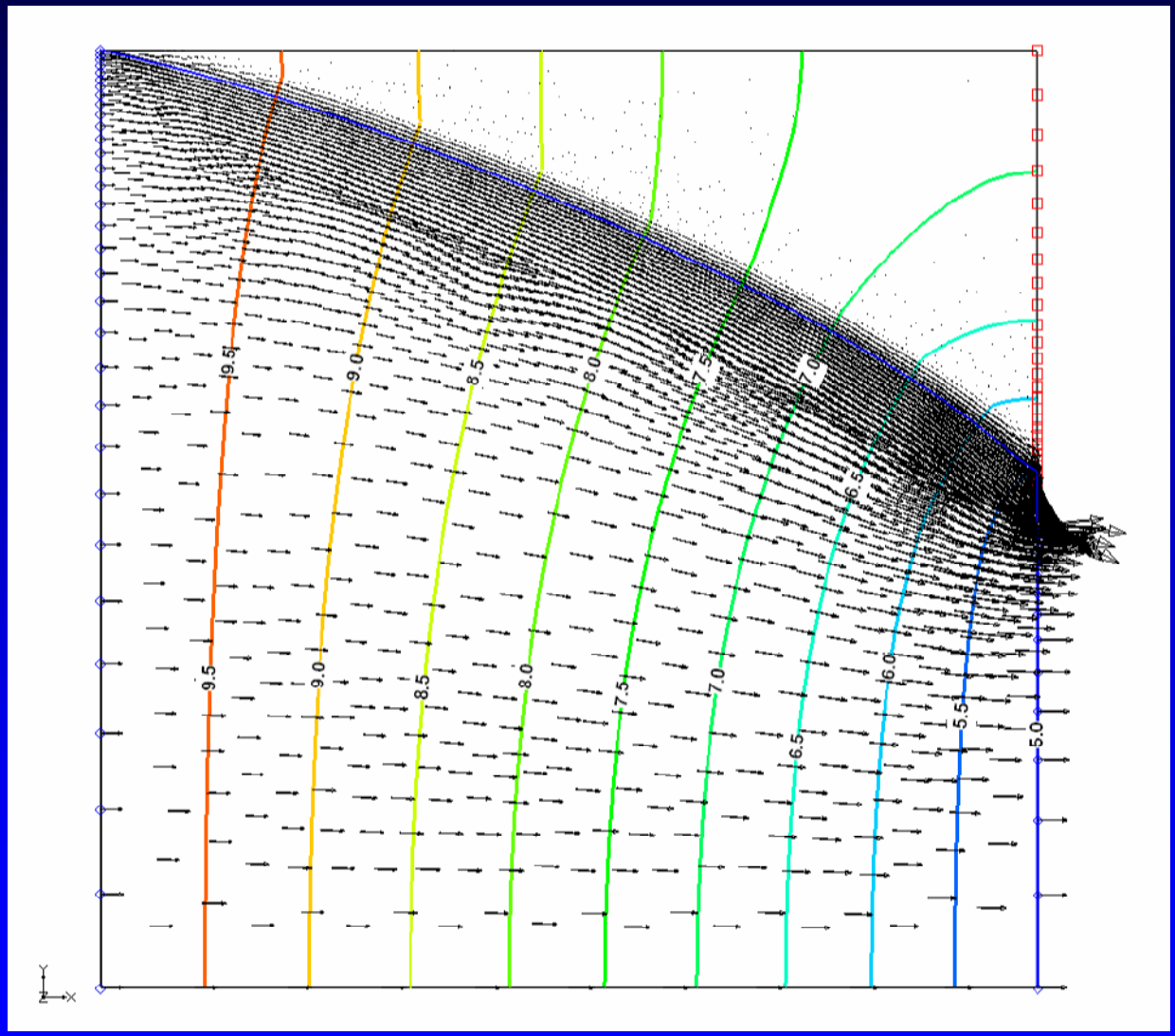
Loamy Sand – Van Genuchten



Loamy Sand – Linear, h_o=-0.28



Loamy Sand – Linear, h_o=-0.207



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Contact Information

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