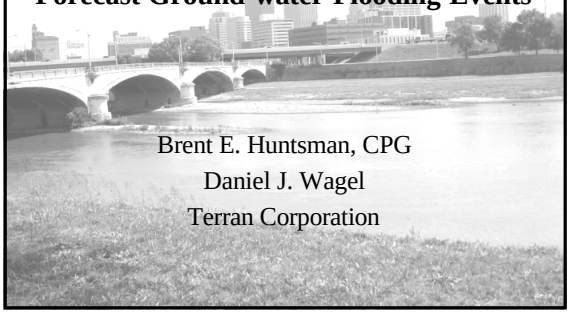
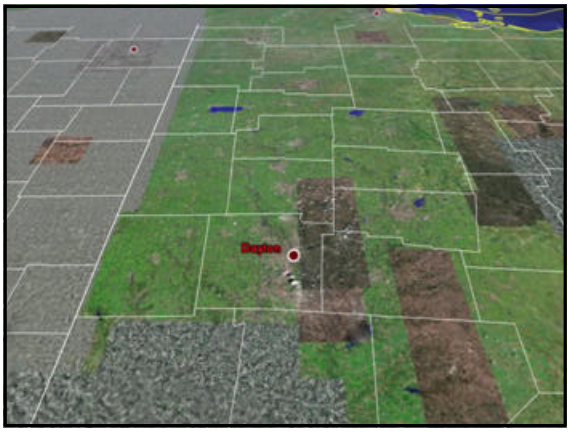
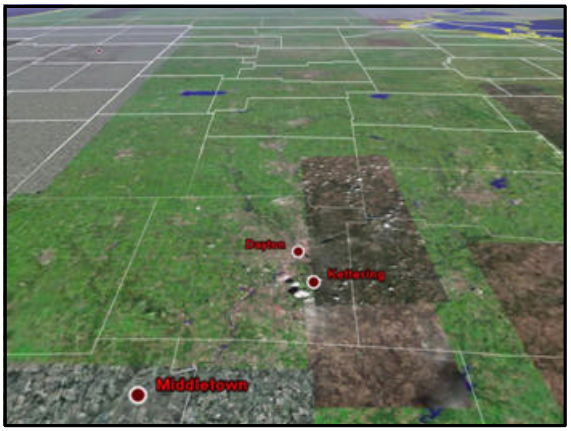
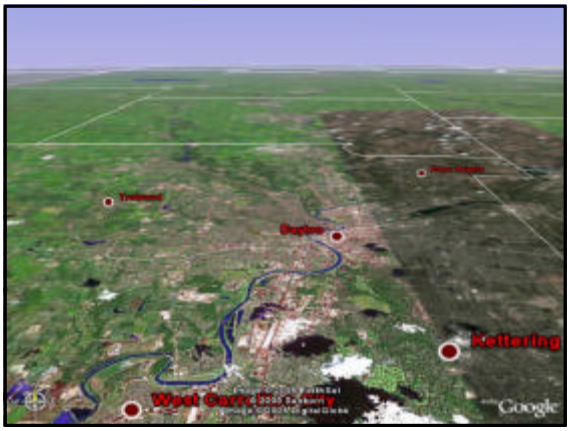
Development and Application of an Artificial Neural Network Model to Forecast Ground-water Flooding Events

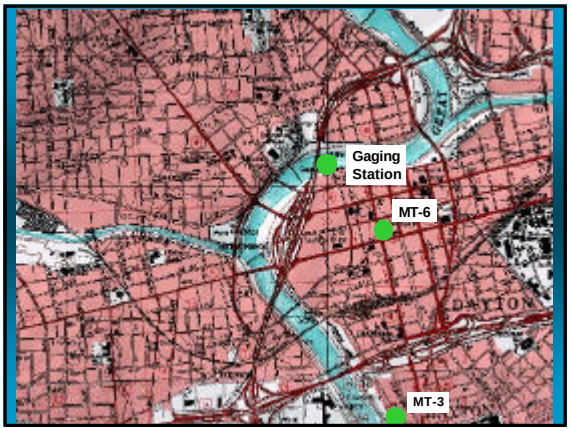


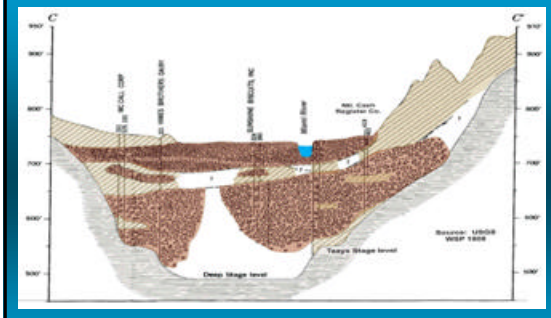
Brent E. Huntsman, CPG
Daniel J. Wagel
Terran Corporation











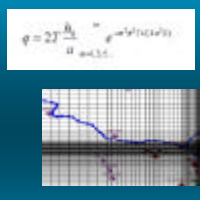
The Great Flood of 1913

Needs Statement

How can ground water levels in the downtown area of Dayton be accurately predicted to control subsurface dewatering systems ?

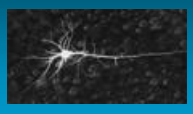
Modeling Approaches

- Analytical Models
  Example: Rorabaugh



- Numerical Models
  Example: MODFLOW

- Artificial Neural Networks
  Example: Your Brain



ANN Models

An information processing paradigm composed of many highly interconnected processing elements (neurons), configured for a specific application, working in unison to solve specific problems.

ANN models are trained, they learn and become experts for a specific problem.

Why Use ANN Models for Water Level Predictions ?

- Can use large, complex data sets
- Generalized decisions from imprecise data
- Learn by example, iteratively trained and retrained
- Complete hydrogeologic characterization of a site is not necessary

ANN Models – Basic Networks

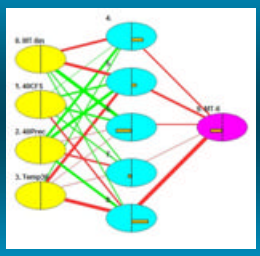
Hierarchical Layers

- Input Layer

  Long-term data records
- Hidden Layer (s)

  Processing & weight adjustments
- Output Layer

  Results from learned association



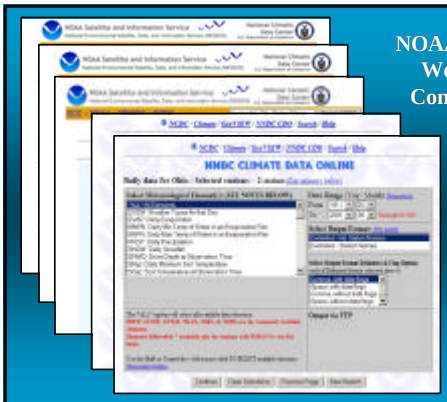
ANN Model Software

EasyNN-*plus* Version 7.0

- Backpropagation learning algorithm
- Training, validating & querying data sets
- CPU intensive

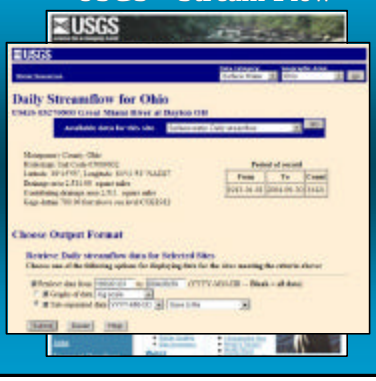
http://easynn.com

ODNR Groundwater Levels

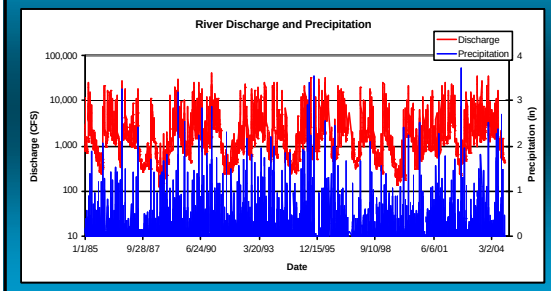


NOAA NCDC Weather Conditions

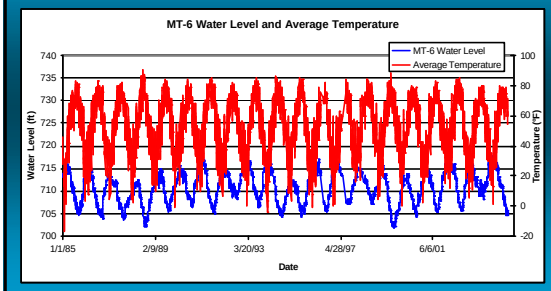
USGS – Stream Flow



River Discharge and Precipitation for 1985-2005

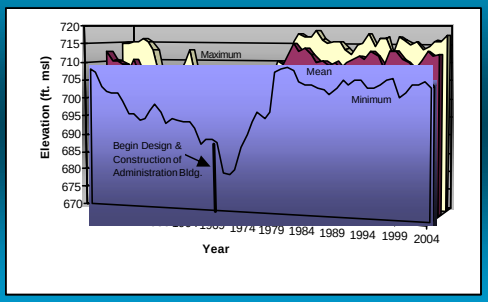


MT-6 Water Level and Average Temperature for 1985-2005

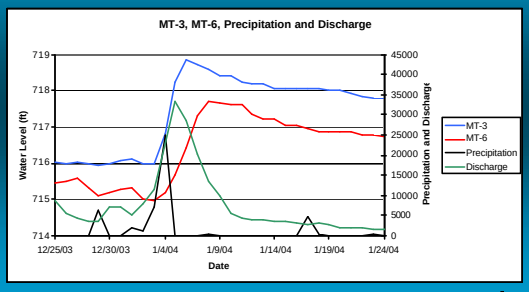


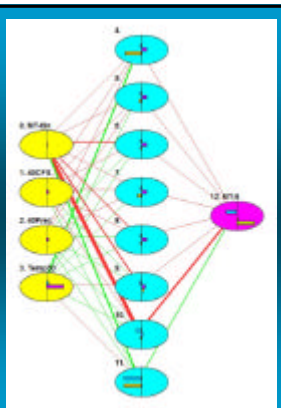
Groundwater Flooding in Dayton

Annual Groundwater Levels in Well MT-6



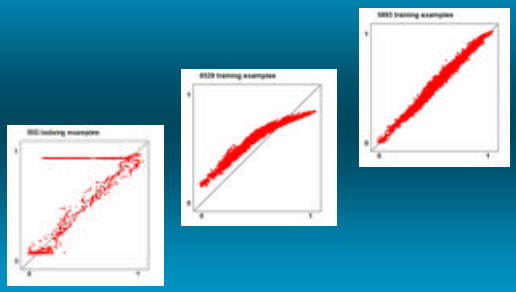
Flood Event Sequence



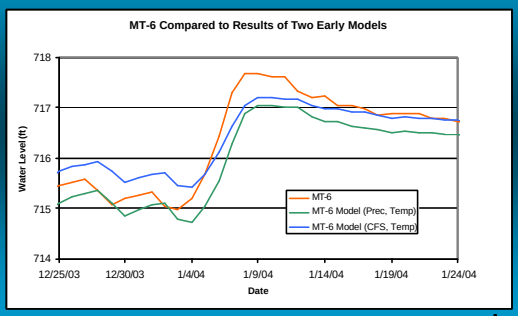


Graphical Representation of ANN Model

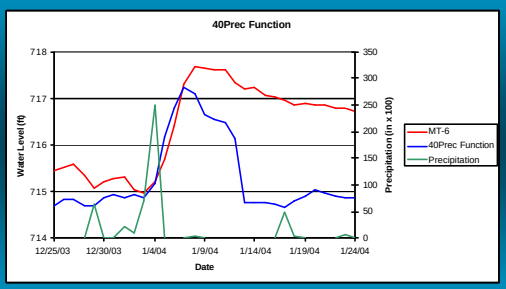
EasyNN Predictions



Results of Early MT-6 Models

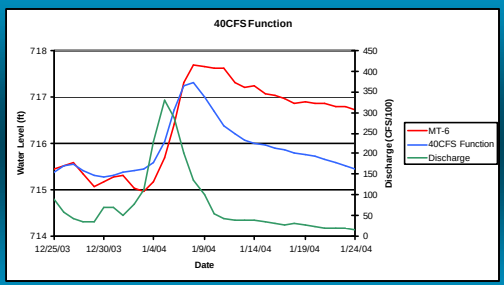


Construction of Precipitation Function



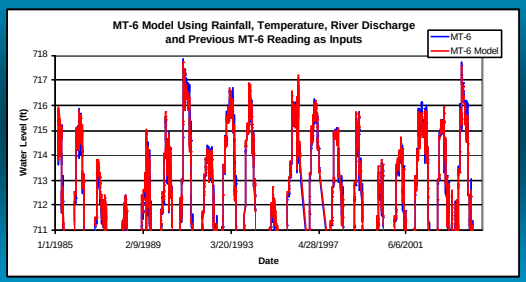
Distributes each precipitation event over a 40-day period.

Construction of Discharge Function

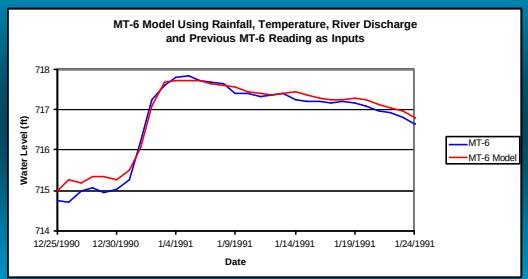


Distributes discharge over a 40-day period.

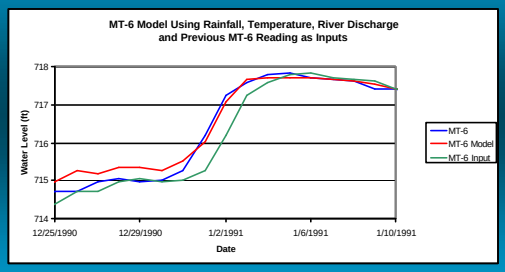
Model Results for Entire Period



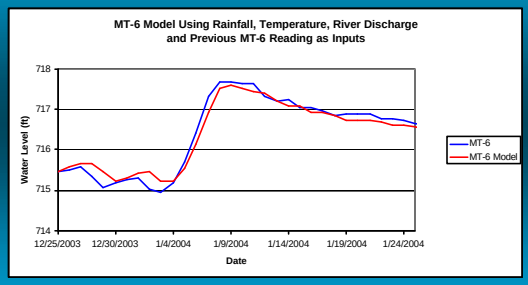
Detail of 1990-1991 Flood Event



Detail of 1990-1991 Flood Event



Detail of 2003-2004 Flood Event



Comparison of Water Levels In MT-6 and MT-3

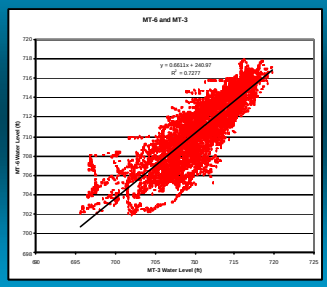
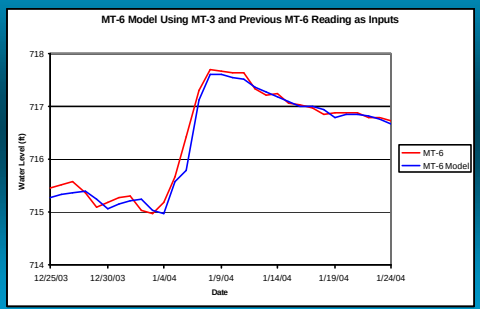
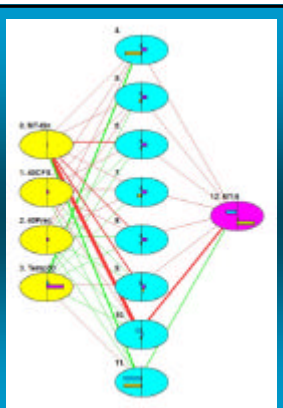


Diagram of MT-6 ANN Model Using MT-3 as an Input

MT-6 Model Using MT-3 as Input 2003-2004 Flood Event

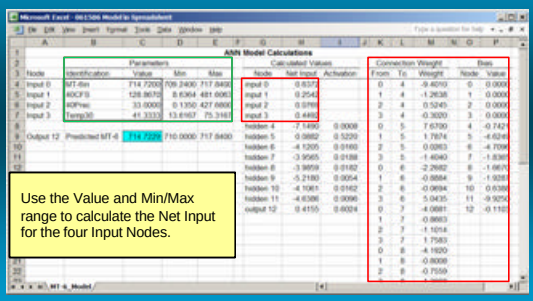




ANN Model Calculations can be Performed in a Spreadsheet

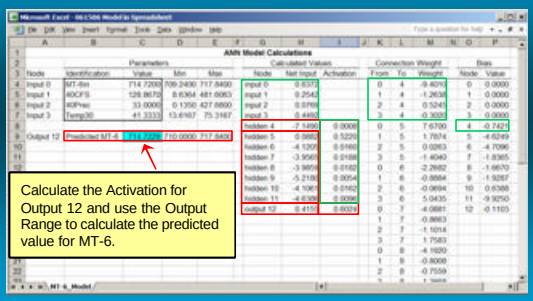
- 4 Input Nodes
- 8 Nodes in One Hidden Layer
- 1 Output Node

MT-6 Model Implemented In an Excel Spreadsheet



Use the Value and Min/Max range to calculate the Net Input for the four Input Nodes.

MT-6 Model Implemented In an Excel Spreadsheet



Calculate the Activation for Output 12 and use the Output Range to calculate the predicted value for MT-6.

Conclusions

- Ground water levels in a BVA during flood events were successfully predicted using ANN modeling techniques.
- ANN model predictive results were comparable using either hydrologic & climatological parameters or near-river ground water levels.
- By integrating numerical and ANN modeling techniques, a robust ground water level forecasting system and better aquifer characterization is achievable.