

WHI E-News Topics

2004 October Edition

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Waterloo Hydrogeologic, Inc. is a recognized leader in the development and application of environmental software and services.



Call for
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Product News

Official Release Notice!

HydroGeo Analyst - The Complete Groundwater & Borehole Data Management and Visualization Solution for Environmental Professionals!

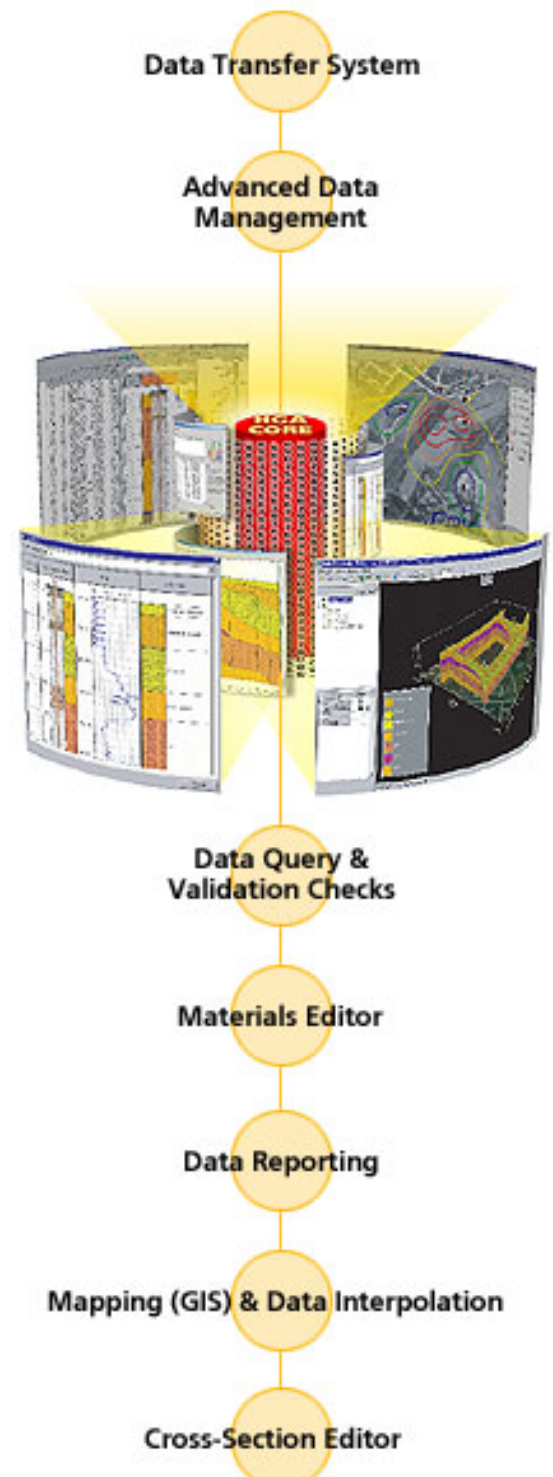
[HydroGeo Analyst](#), developed by Waterloo Hydrogeologic, Inc., represents the next generation in groundwater and borehole data management and visualization technology. HydroGeo Analyst integrates a complete range of easy-to-use analysis and reporting tools, with a powerful yet extremely flexible database technology - all wrapped into an innovative graphical user interface. With HydroGeo Analyst, you can expect the highest level of performance and a completely scalable solution to meet your project demands!

ALL-IN-ONE SOLUTION

HydroGeo Analyst offers a completely integrated solution without the need to export data to third party programs for analysis, visualization, and reporting. HydroGeo Analyst incorporates all the tools you need to import your data directly, and create professional reports. There is no need to purchase, learn, or maintain third-party products - HydroGeo Analyst has it all!

HydroGeo Analyst's suite of software tools include:

- [Project Wizard](#) (database creation, client management, etc.)
- [Data Transfer System](#) (validating and importing YOUR data)
- [Template Manager](#) (database tables, fields, templates, etc.)
- [Materials Specification Editor](#) (manages soil classifications)
- [Query Builder](#) (on-the-fly, map-ready data querying)
- [GIS Map Manager](#) (GIS mapping, contouring, gridding, etc.)
- [Cross-Section Editor](#) (geologic, hydrogeologic, model layers)



[HGA 3D-Explorer](#) (3D visualization and animation of data)

[Borehole Log Plotter](#) (design and plot borehole logs)

[Report Editor](#) (fully customizable reports)

Universal Data Transfer System:

HydroGeo Analyst has an extremely flexible and logical Universal Data Transfer System that simplifies and speeds up the challenging and time-consuming process of importing your data.

- ▶ Comprehensive importing of any data format, such as;
 - ▶ Text files (TXT, CSV, TAB, ASCII, etc.)
 - ▶ Microsoft Excel™ spreadsheets (XLS)
 - ▶ Microsoft Access™ databases (MDB)
 - ▶ Dbase Database Format (DBF)
 - ▶ Any other ODBC or OLEDB data sources
- ▶ On-the-fly unit and coordinate system conversions
- ▶ Seamless data validation and error checking during import
- ▶ [Click here for more information](#)

Query Builder:

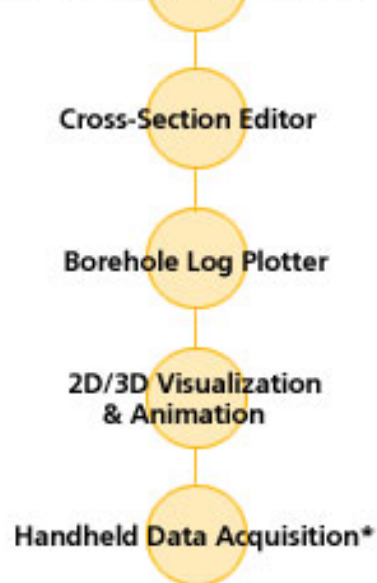
HydroGeo Analyst harnesses the power of 'Structured Query Language' (SQL) to help you access and interact with your data on-the-fly.

- ▶ Uses 'Structured Query Language' (SQL), the industry-standard!
- ▶ Quickly generate simple or complex data queries
- ▶ Display query results directly through the GIS Map Manager
- ▶ [Click here for more information](#)

GIS Map Manager:

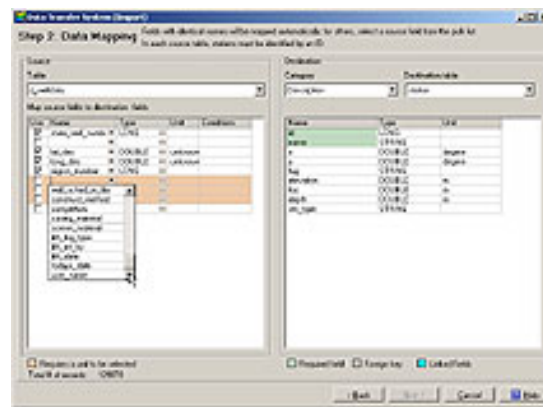
The GIS Map Manager is built on ESRI™ technology and is packed with an abundance of GIS mapping features that seamlessly connect your project maps with the HydroGeo Analyst database.

- ▶ Create map layers from station data and query results
- ▶ Import a vast array of basemap for your projects (BMP, DIB, BIL, BIP, BSQ, JPG, TIF, DXF, DWG, SHP, etc.)
- ▶ Create thematic maps from virtually any field in the database
- ▶ [Click here for more information](#)



*-Coming in 2005

**The Next Generation
in Environmental
Data Management
Technology!**



Flexible Data Transfer

Cross-Section Editor:

The Cross-Section Editor offers a complete set of interactive tools for developing geologic, hydrogeologic, and model layer cross-section interpretations.

- ▶ Digitize layers representing unique geologic formations or hydrogeologic properties
- ▶ Digitize interpreted model layers for use in Visual MODFLOW
- ▶ Add cross-section interpretations directly to your reports
- ▶ [Click here for more information](#)

Borehole Log Plotter:

The Borehole Log Plotter is a built-in borehole logging component developed with a full range of features that support the design and plotting of professional borehole logs and well construction details.

- ▶ Choose from pre-designed borehole log templates, or design custom borehole logs in minutes
- ▶ Robust import and export functionality for data exchange and presentation
- ▶ Automated data links reduce the need for user intervention!
- ▶ [Click here for more information](#)

HGA 3D-Explorer:

The HGA 3D-Explorer is a seamlessly integrated 3D visualization and animation tool designed for easy rendering of your well lithology, surfaces, and interpreted cross-sections.

- ▶ Display multiple cross-sections/fence diagrams, well locations with lithology, maps, contours, etc., all within the same 3D graphical environment
- ▶ View 3D cross-sections of geologic, hydrogeologic, or model layers
- ▶ Powerful import and export features for visualization of data, plus animation
- ▶ [Click here for more information](#)

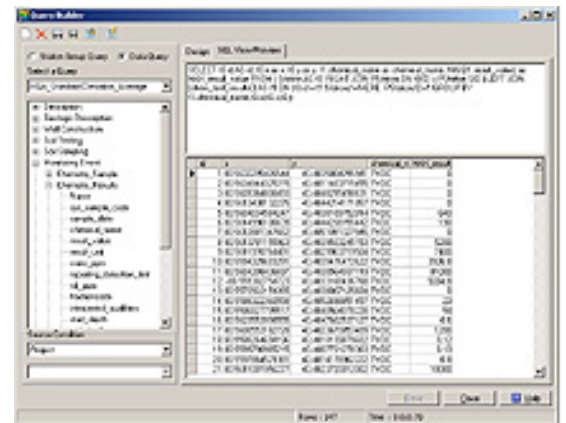
Report Editor:

The Report Editor assists users in generating professional reports directly from HydroGeo Analyst projects.

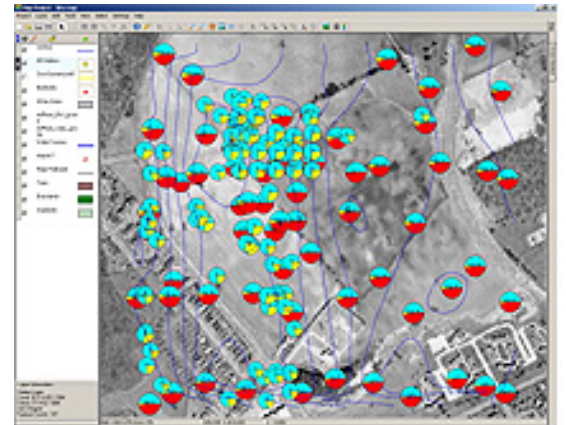
- ▶ Use pre-defined report templates, or create an unlimited number of custom report templates!
- ▶ Incorporate data values, time-series graphs, tables, logs, cross-sections, 3D views, maps, etc.
- ▶ Dynamic linking of reports to HGA data and components automates the report creation process
- ▶ [Click here for more information](#)

...PLUS SO MUCH MORE!

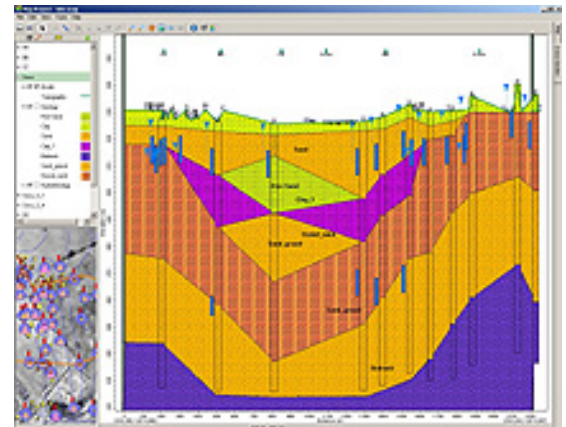
Check our [website](#) for further information on all of the Features and



Custom SQL Queries



High Impact Thematic Maps



Versatile Cross-Section Editor

Benefits of HydroGeo Analyst! Ask us about our multi-license discounts!

To learn more about HydroGeo Analyst, or to receive a Demonstration version of HydroGeo Analyst, please contact us today at 1-519-746-1798, or by email at sales@waterloohydrogeologic.com

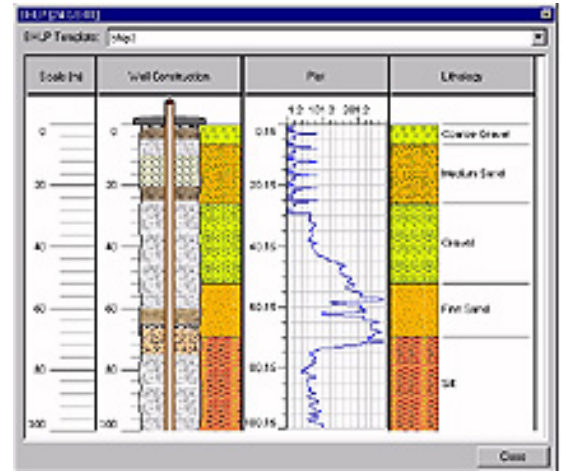
Introductory Price:
US\$ 2995 Single User

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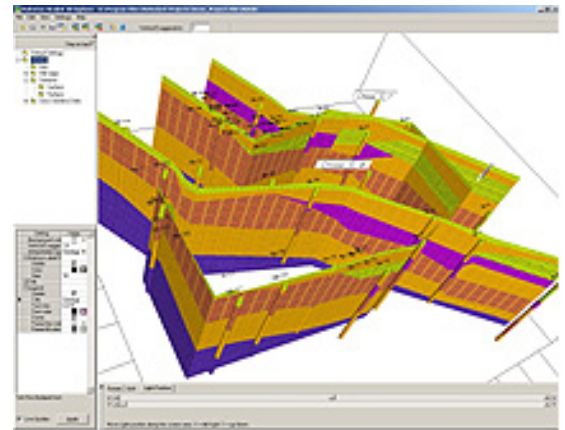
FREE DEMO

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Call us at 519-746-1798
Or order online

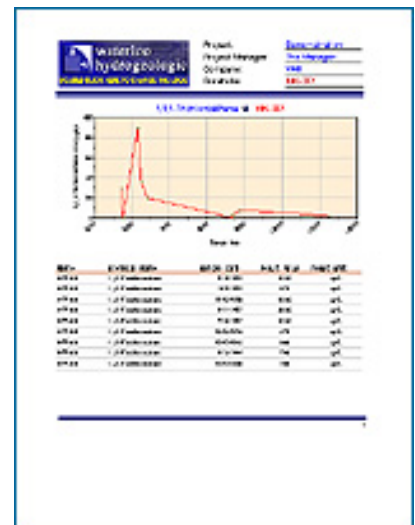
ORDER NOW



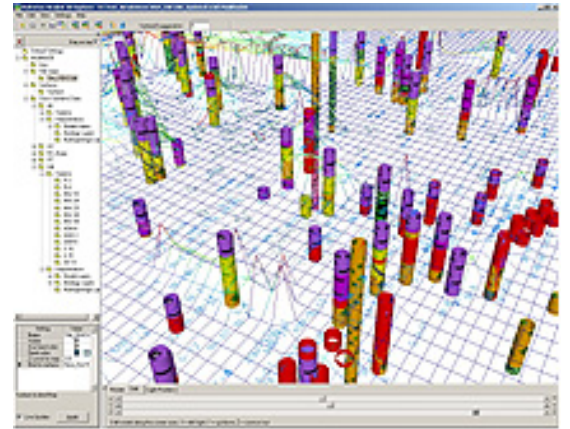
Borehole Log Plots



Stunning 3D Fence Diagrams



Professional Reports in Minutes



Interpolate & Grid Surfaces

For more information about **HydroGeo Analyst**, visit our website or contact us:
http://www.waterloohydrogeologic.com/software/Hydrogeo_Analyst/Hydrogeo_analyst_ov.htm

For more information about our software, please visit our website or contact us today:

Website: http://www.waterloohydrogeologic.com/software/software_main.htm

Email: sales@waterloohydrogeologic.com

Phone: (519) 746-1798



Consulting News

*Water Resources Data Management:
Data, Data Everywhere!*

In nearly all groundwater studies large quantities of data are generated. Waterloo Hydrogeologic's Consulting department is currently working with a water management group in the southern United States that has compiled nearly 100 years of water-taking information. WHI is using this data to develop a time-varying (transient) groundwater model for their jurisdiction. The model will be used as a tool to manage water resources throughout the water management area.

WHI's Geographic Information Systems (GIS) and data management experts frequently compile information from many different sources, allowing us to develop scientifically accurate solutions. Our philosophy is that the best approach is to use all of the available data.

Recently, WHI began offering data management warehousing services for groups that desire the piece of mind of having specialists safeguard and manage their valuable information. Data can be served up via web-based access systems, and can be updated or accessed remotely from any computer that can connect to the Internet. This keeps data available to Project Managers and project stakeholders at any time their business requires it.

For further details about our data management solutions, please visit our [website](#)

Waterloo Hydrogeologic Welcomes Lukas Calmbach

Waterloo Hydrogeologic, Inc. is excited to announce that Dr. Lukas Calmbach has joined our Consulting Services Team. As the original author of AquaChem, Dr. Calmbach has been working with Waterloo Hydrogeologic for the past 6 years. As a data management and geochemistry specialist, he will continue to apply these skills helping our consulting clients overcome information technology and data management challenges.

After completing his Doctoral studies (University of Lausanne) researching geochemistry of thermal waters, Lukas joined the Provincial Ministry of Environmental Protection in Basel, Switzerland. During his nine years with the Ministry, Lukas became the Team Leader of the Information Technology (IT) Department.

His expertise in IT, focused on environmental data management and geochemistry, are excellent compliments to WHI's software development, training, and consulting teams.

Lukas can be reached at:

lcalmbach@waterloohydrogeologic.com or at
(519) 746-1798, extension 245.



Proper data management is essential because it forms a base for every project!



Lukas Calmbach joined Waterloo Hydrogeologic on October 1, 2004



[Click here to get your copy today!](#)

For more information related to this topic, or if you would like more information about WHI's Consulting activities and capabilities, please visit our website or contact us today:

Website: www.waterloohydrogeologic.com/consulting/consulting_services.htm

Email: consulting@waterloohydrogeologic.com

Phone: (519) 746-1798



Training News

WHI's Line-Up of Environmental & Groundwater Modeling Courses!

The 2004 Waterloo Hydrogeologic Open Enrollment schedule has been set. In response to comments from groundwater professionals who have taken our Groundwater Modeling Courses in the past, and those who would like to attend courses in the future, WHI has combined the strengths of our previous Groundwater Modeling, Advanced Groundwater Modeling, and Model Calibration courses into one [Applied Groundwater Flow & Contaminant Transport Modeling](#) course. This course includes updated lecture material, as well as new hands-on laboratories to support the new course material. WHI has also created a new short course entitled [GIS Data Management for Groundwater Modelers](#), which teaches the theory and hands-on application of GIS data integration and interpolation to support groundwater modeling efforts, as well as 3-dimensional visualization of modeling results in both the Visual MODFLOW and GIS environments.

Click on the titles below and see which courses are appropriate for you!


- » [Applied Groundwater Flow & Contaminant Transport Modeling](#) - NEW
- » [Groundwater Contamination & Remediation](#) - UPDATED
- » [Finite Element Groundwater Modeling](#) - UPDATED
- » [Aquifer Test Analysis](#) - NEW
- » [Unsaturated Zone Modeling and Evaluation of Landfill Impacts](#) - UPDATED
- » [The Human Health Risk Assessment Course](#) - NEW
- » [Water Quality Data Management & Modeling](#) - UPDATED
- » [Regulatory Review of Hydrogeology Studies](#) - UPDATED
- » [GIS Data Management for Groundwater Modelers](#) - NEW

Who Can Benefit?

- » Experienced hydrogeologists with no prior groundwater modeling experience
- » Regulators who review modeling reports
- » Managers who want to understand what the modelers are doing
- » Experienced modelers who want to enhance their skills
- » Students who want to acquire new skills
- » Lawyers who want to understand some of the technical issues
- » Industry professionals who want to understand more about what their consultants are telling them

For further details on any of these courses, please visit our [website](#), or contact Miln Harvey, WHI Training Manager, at (519) 746-1798 x233.

Can't make one of our Open Enrollment Courses? Call us about our On-Site Custom courses designed to suit your specific needs!

Course Title	Dates/Locations
<p>APPLIED GROUNDWATER FLOW & CONTAMINANT TRANSPORT MODELING </p> <p>Theory and Hands-on Applications using MODFLOW-2000, MODPATH, MT3D & WinPEST</p> <p>Simple to complex applications of groundwater flow and contaminant transport models are covered in this 4-day hands-on course. Groundwater resource topics include model development and calibration to groundwater heads and flows, new well development, capture zone delineation, well interference, and stream impact investigations. Contaminant transport topics include model development and calibration to contaminant concentration, source area design, concentration boundary choice, solver comparison, and 3D visualization of flow and transport results. This course is ideally suited for hydrogeologists and modelers with some field investigation and modeling experience who wish to advance their modeling knowledge, and whose responsibilities include model development, review, planning, and project management.</p> <p>Course Objectives and Benefits</p> <ul style="list-style-type: none">» Apply Visual MODFLOW Pro to 3D groundwater flow and contaminant transport projects» Use MODFLOW-2000 to develop several groundwater flow models» Calibrate your groundwater models to observed field data» Use MODPATH particle tracking features to determine preferential flow paths and delineate capture zones» Use ZoneBudget to assess subregional water budgets within your groundwater model» Simulate 3D contaminant transport using RT3D, MT3DMS & MT3D99» Use WinPEST to improve model calibration and understand model uncertainty	<p>Santiago, Chile Oct 5 - 8, 2004</p> <p>Kraków, Poland Oct 11 - 14, 2004</p> <p>Tokyo, Japan Oct 26 - 29, 2004</p> <p>Rome, Italy Oct 26 - 29, 2004</p> <p>Sicily Nov 2 - 5, 2004</p> <p>Adelaide, Australia Nov 23 - 26, 2004</p> <p>Juarez, Mexico Nov 23 - 26, 2004</p> <p>Waterloo, Ontario Canada Feb 1 - 4, 2005</p> <p>Register Now</p>

CONTAMINATED SITE RISK ASSESSMENT AND GROUNDWATER MODELING



Transport Processes, Natural Attenuation and Risk Assessment

This course provides a more complete understanding of groundwater contamination and remediation, and the use of fate and transport models and risk assessment software for analysis. Topics that will be covered include contaminant source area characterization, the risk assessment process, the fundamentals of natural attenuation, and risk-based corrective action. This course is suited for groundwater modelers and risk assessors who wish to develop a better understanding of groundwater contamination and remediation, the risk assessment process, and the use of groundwater models to assess risk-based site-specific standards and contaminant remediation.

Course Objectives and Benefits

- » Define the Risk Assessment process and Risk-Based Corrective Action
- » Enhance your understanding of contaminant transport and natural attenuation processes
- » Detail how to quantify the potential risks of exposure to chemical contaminants
- » Link fate and transport models to risk-based decision making models
- » Quantitatively assess human health and ecological risk from environmental contaminants
- » Define site-specific target levels (SSTLs) for site clean-up goals

[Gent, Belgium](#)
[Oct 26 - 29, 2004](#)

[Register Now](#)

FINITE ELEMENT GROUNDWATER MODELING



Advanced Applications for Saturated/Unsaturated Flow & Transport, Density-Dependent Flow, and Heat Transport

Advanced applications of groundwater flow and contaminant transport models using the Finite Element method are covered in this 4-day hands-on course. This course provides a more complete understanding of the use and applicability of finite elements in groundwater modeling, and includes such topics as groundwater flow and transport modeling, principles of unsaturated flow, fracture flow modeling, thermal transport, and density-dependent flow modeling. This course is ideally suited for groundwater modelers who wish to advance their modeling knowledge, and apply finite elements-using FEFLOW- to more complex modeling designs.

Course Objectives and Benefits

- » Understand when to use finite-element vs. finite-difference modeling
- » Apply FEFLOW to 3D groundwater flow and contaminant transport problems
- » Simulate unsaturated zone flow using FEFLOW
- » Simulate density-driven groundwater flow (e.g. saltwater intrusion) using FEFLOW
- » Simulate fracture flow modeling using FEFLOW, and compare to a research case study

[Waterloo, Canada](#)
[Nov 2 - 5, 2004](#)

[Register Now](#)

- » Introduce the Interface Manager and the concept of model calibration to observed field data

THE HUMAN HEALTH RISK ASSESSMENT COURSE



Practical Approaches to Estimating Risk & Developing Site-Specific Target Levels

An introduction to the use of RISC Workbench for completing human health risk assessments is covered in this 2-day course of lectures and hands-on exercises. Topics that will be covered include hazard identification, exposure assessment, dose-response assessment, and risk characterization. Lectures and exercises will be presented in partnership with Lynn Spence, the developer of RISC Workbench. This course is suited for risk assessors who wish to develop a better understanding of the risk assessment process and the use of groundwater models and RISC Workbench software for completing a human-health risk assessment.

Course Benefits

- » Learn the fundamentals of accepted risk assessment protocols
- » Acquire lots of hands-on experience using the RISC Workbench software
- » Understand the practical aspects of conducting a risk assessment
- » Learn from an experienced risk assessment professional with worldwide experience

[Auckland, New Zealand](#)

[Nov 18 - 19, 2004](#)

[Register Now](#)

GIS DATA MANAGEMENT FOR GROUNDWATER MODELERS



Understanding Data Sources, Data Analysis and Visualization

This 3-day hands-on course presents an introduction to the management and analysis of groundwater data for Visual MODFLOW modelers. Topics include the data types used in groundwater models, the coordinate systems, datums and map projections in a GIS, the interpolation of data within the GIS (kriging, natural neighbor analysis, ...), the development of model layers (cross-sectional analysis of site hydrogeology) and parameter fields for groundwater model construction, and the import and export of different types of data from the GIS system to the groundwater model and back to the GIS system. Other topics that will be covered include 2-D and 3-D visualization of model input and model output. This course is ideally suited for groundwater modelers who wish to develop a comprehensive understanding of the sources of data that are used in groundwater models, the interpolation of this data for modeling, and the interchange of information between the groundwater model and the GIS system.

Course Objectives and Benefits

- » Understand the integration between the GIS system and Visual MODFLOW

[Waterloo, Canada](#)

[March 29 - April 1, 2005](#)

[Register Now](#)

- » Assess the applicability of MapInfo, Surfer and HydroAnalyst for developing a GIS
- » Use HydroGeo Analyst to develop model cross-sections and layer interfaces
- » Use HydroGeo Analyst to interpolate layer elevations and export them to Visual MODFLOW
- » Export Visual MODFLOW results to GIS and prepare report figures
- » Develop animation files of Visual MODFLOW results and insert them into client presentations

THE REMEDIATION COURSE



Princeton Groundwater's Remediation Course is the most comprehensive course on remediation available. Every aspect of this important subject is covered, from three-dimensional hydrogeochemical characterization, through practical details of all remediation technologies, to computer-simulated remedial alternatives such as Natural Attenuation, Pump & Treat, Funnel & Gate, Interceptor Trenches, and complete Hydraulic Containment using barriers and capping. The course also covers many essential topics, which are not found in any other courses or books. The Remediation Course uniquely integrates the topics of heterogeneous geohydrology, aquifer/source/plume characterization, remediation technologies/strategies/designs, and computer simulation software. The result is the premier course on remediation.

Course Objective

The objective of this course is to teach remediation from the key methodologies to collect hydrogeochemical data, through selecting and designing remediation systems based on geological and biological effects and air/water carriers. In addition, participants will use computers to simulate remediation hydrology, groundwater pathways, capture zones, mass transport, natural attenuation, and alternative remediation designs

Who Should Attend

The course is designed for groundwater geologists, engineers, hydrologists, and microbiologists working as project managers, regulators, or consultants to industry or government. Some technical background and experience in groundwater contamination problems is presumed.

[Oct. 4 - 8, 2004](#)
[Orlando, Florida](#)

[Register Now](#)

The NEW MODFLOW Course



The MODFLOW Course Theory & Hands-on Applications using MODFLOW-2000, MODPATH, MT3D & WinPEST

Course Description

The course begins with an introduction to the ground water modeling process, providing lectures and hands-on exercises in topics that range from data sources and evaluation, conceptual model development, numerical model implementation and model calibration and prediction. Presentations alternate between the theory behind each course topic and practical exercises to implement the concepts using Visual MODFLOW Pro. This course is a hands-on course. Attendees will spend 2 ½ days of the 4-day course using the computer to complete exercises.

New exercises have been developed to show the attributes of MODFLOW-2000, MODPATH, ZoneBudget, MT3D and RT3D, and how they can be used as part of a hydrogeologic modeling analysis.

The course then looks at automated parameter estimation using WinPEST to evaluate the quality of model calibration using error statistics to help decide when a model is calibrated. The course goes

beyond these introductory topics and provides advice on how to develop a model efficiently, and how to choose appropriate parameter distributions and boundary conditions to effectively represent the groundwater flow system that is being modeled.

[October 25-28, 2004 Princeton,
New Jersey](#)

[Register Now](#)

To register for this course you must be a member of the NGWA, if you are not please call NGWA Customer Service at 800.551.7379, or email customerservice@ngwa.org.



[For our full 2004 training schedule, click here!](#)



[To request your free 2004 Training Course Schedule Catalog, click here!](#)

For more information about our course offerings, visit our website or contact us today:

Website: www.waterloohydrogeologic.com/training/training.htm

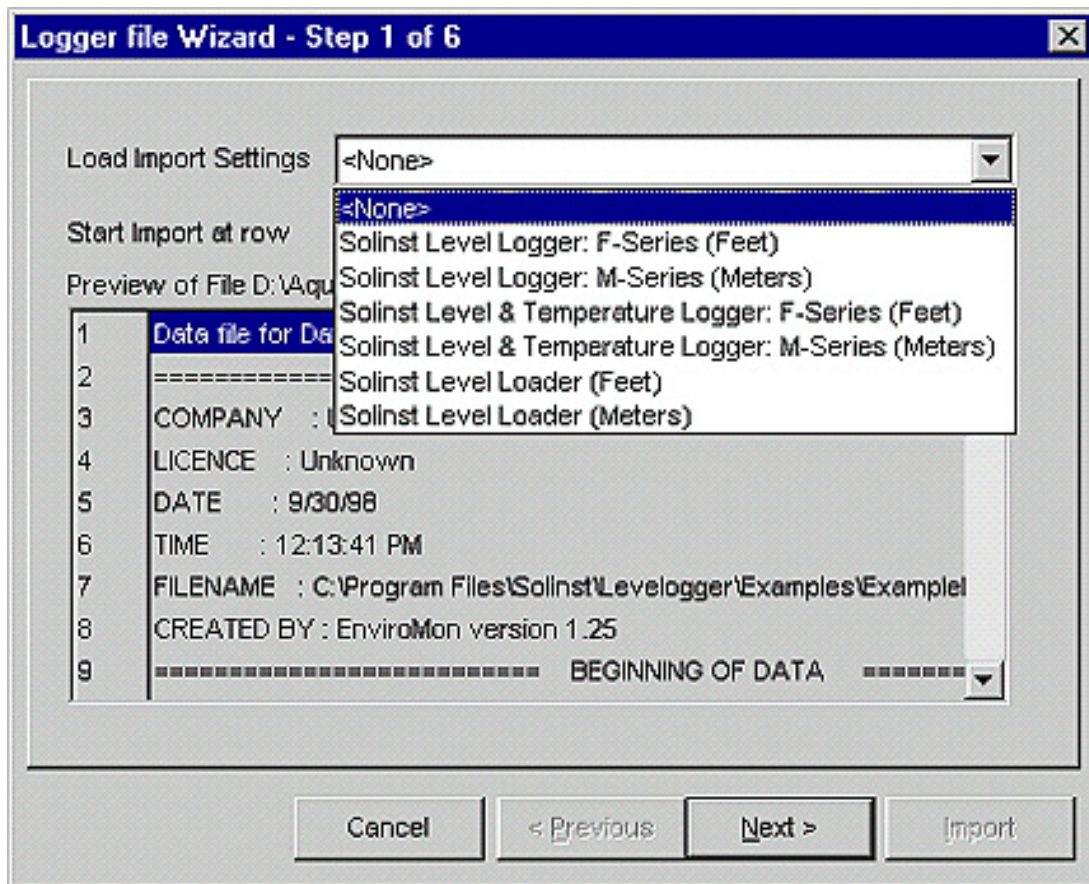
Email: training@waterloohydrogeologic.com

Phone: (519) 746-1798

Importing data logger files with *AquiferTest 3.5*

Data Loggers are often used in the field to record water level measurements observed during a pumping or slug test. Using [AquiferTest's](#) Data Logger wizard, you can transfer your data from your data logger files into the program in a matter of seconds! In addition, you can save the import settings for re-use at a later date, or select from one of the supported logger formats, including Solinst Level Loggers! This eliminates the task of manually specifying individual settings at each step - a tremendous time-saver when importing multiple datalogger files of the same format.

AquiferTest can import a data logger file in .txt, .asc, or Solinst .lev format, into your project. Load the data logger wizard (from the Data menu), and the first dialog will appear.



In Step 1, there is an option to load data logger import settings from a previous session. As mentioned, Solinst loggers are supported, including the following models:

- ▶ Solinst Level Logger F-Series
- ▶ Solinst Level Logger M-Series
- ▶ Solinst Level & Temperature: Logger F-Series
- ▶ Solinst Level & Temperature: Logger M-Series
- ▶ Solinst Level Loader (Feet)
- ▶ Solinst Level Loader (Meters)

Select the appropriate model from the list; if your logger is not listed here, then simply proceed with the import wizard,

define the necessary settings, then save the settings at the end of the import process (explained below).

By selecting a pre-defined import setting, the remaining tasks in the Wizard will be completed automatically, including the starting row, delimiter, date and time column and format, water level units and co-ordinate system. Simply press the [Next>] button to confirm that your file matches the pre-defined import settings in AquiferTest.

In the last step, specify which data values are imported. If the file contains many duplicate water levels (typical for a logger file), you will probably want to filter the data. You can filter the data by either "change in time" or "change in water level". From a practical point of view, importing duplicate datapoints is not useful in a conventional aquifer analysis. You should try to minimize the number of datapoints imported for each analysis, since the AquiferTest database and Automatic Fit slow down with higher numbers of datapoints.

Logger file Wizard - Step 6 of 6

Time at t=0

Date: 9/12/00 Time: 8:45:05 AM

Format: M/d/yy

Import

All Data

By change in time [s]

By change in Depth to WL [m]

0.01

Cancel < Previous Next > Import

At the end of the import routine, remember to Save the settings by clicking on the SAVE icon in the lower-left corner if you plan to re-use the import settings at a later date.

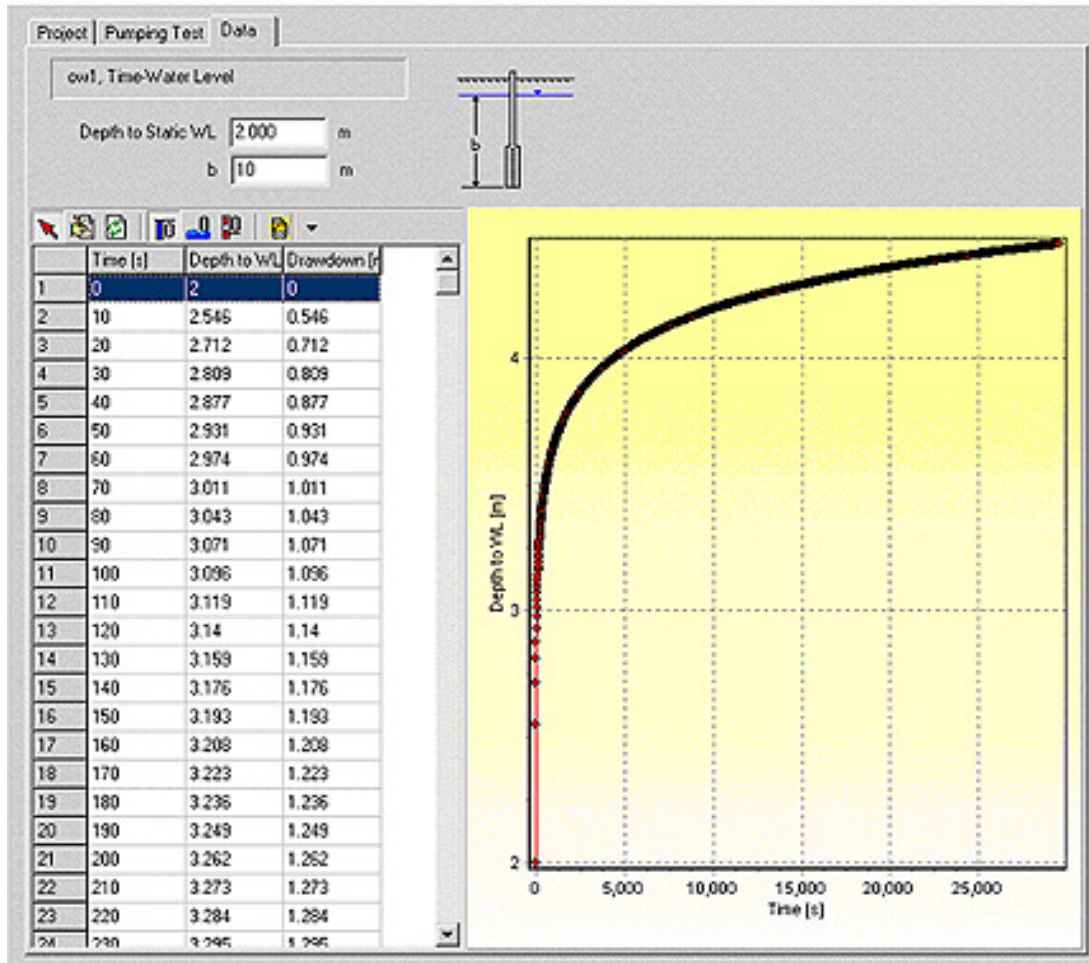
Save settings

Save current wizard settings as:

OK Cancel

Enter a name for the personalized settings, and click OK (My_Settings, for example). These settings can be recalled in the future and used for importing data sets in a similar format (see Logger File Wizard - Step 1).

To finish the import process, click Import and the datapoints will be imported into your project.



If you are interested in learning more about AquiferTest's capabilities, please browse to our [website](#), or contact our [Sales department](#).

For more information about this tip, contact us at:

Email: techsupport@waterloohydrogeologic.com

For more information about [AquiferTest](#), visit our website or contact us today:

Website: <http://www.waterloohydrogeologic.com>

Email: sales@waterloohydrogeologic.com

Phone: (519) 746-1798

[▲ TOP](#)

Contributions from E-News Subscribers

Contribution from E-News subscriber - Dr. Diana Allen

Waterloo Hydrogeologic, Inc. is always interested in hearing from our software users about their latest projects. Recently we spoke with Dr. Diana Allen, Chair of the Department of Earth Sciences at Simon Fraser University in Burnaby, British Columbia, Canada, who provided us with a copy of a published report addressing groundwater and climate change sensitivity analysis for the Grand Forks aquifer in southern British Columbia. Waterloo Hydrogeologic's [Visual MODFLOW](#) and [WHI UnSatSuite Plus](#) programs were used model groundwater flow, and estimate recharge, for the project. You can click on the link following the abstract and introduction for the complete report.

Dr. Allen commented:

"It may be worthwhile pointing out in the article that we have improved considerably on the methodologies used in that paper. Our final report to the Climate Change Action Fund, which details the new methodology and the results, is available on-line at the following site:"

<http://adaptation.nrcan.gc.ca/app/filerepository/E024419873CE482AA38E31E198E8CED8.pdf>

Abstract

The Grand Forks aquifer, located in south-central British Columbia, Canada was used as a case study area for modeling the sensitivity of an aquifer to changes in recharge and river stage consistent with projected climate-change scenarios for the region. Results suggest that variations in recharge to the aquifer under the different climate-change scenarios, modeled under steady-state conditions, have a much smaller impact on the groundwater system than changes in river-stage elevation of the Kettle and Granby Rivers, which flow through the valley. All simulations showed relatively small changes in the overall configuration of the water table and general direction of groundwater flow. High-recharge and low-recharge simulations resulted in approximately a +0.05 m increase and a -0.025 m decrease, respectively, in water-table elevations throughout the aquifer. Simulated changes in river-stage elevation, to reflect higher-than-peak-flow levels (by 20 and 50%), resulted in average changes in the water-table elevation of 2.72 and 3.45 m, respectively. Simulated changes in river-stage elevation, to reflect lower-than-baseflow levels (by 20 and 50%), resulted in average changes in the water-table elevation of -0.48 and -2.10 m, respectively. Current observed water-table elevations in the valley are consistent with an average river-stage elevation (between current baseflow and peak-flow stages).

Introduction

Evidence is mounting that we are in a period of climate change brought about by increasing atmospheric concentrations of greenhouse gases. Global mean temperatures have risen 0.3-0.6 °C since the late 19th century and global sea levels have risen between 10 and 25 cm (Intergovernmental Panel on Climate Change, IPCC 1995). The IPCC has reported that the expected global rise in temperature over the next century would probably be greater than observed in the last 10,000 years (IPCC 1995). As a direct consequence of warmer temperatures, the hydrologic cycle will undergo significant impact with accompanying changes in the rates of precipitation and evaporation (e.g., Loaiciga et al. 1996). Predictions include higher incidences of severe weather events, a higher likelihood of flooding, and more droughts (IPCC 1995).

In Canada, and particularly in British Columbia (BC), most research on the potential impacts of climate change to the hydrologic cycle has been directed at forecasting the potential impacts to surface water, specifically the links between glacier runoff and river discharge (e.g., Leith and Whitfield 1998; Whitfield and Taylor 1998). Relatively little research has been undertaken to determine the sensitivity of aquifers to changes in critical input parameters, such as precipitation and runoff, despite the fact that groundwater constitutes a significant proportion of freshwater supply in Canada. Internationally, only a few studies have been reported in the literature on the impacts of climate change (based on predictive scenarios) to groundwater resources (e.g., Vaccaro 1992; Loaiciga et al. 2000).

The purpose of this study was to assess the sensitivity and to identify potential impacts of climate change (based on projected scenarios) on groundwater in a surficial, unconfined aquifer at Grand Forks, BC, Canada. Grand Forks is located in south-central BC, 522 km east of Vancouver, along the Canada-United States border as shown in Fig. 1. The region is semiarid and, because residents rely on groundwater for both domestic and irrigation supply, it is essential that the

potential impacts of climate-change on the aquifer be identified for long-term water-management decisions.

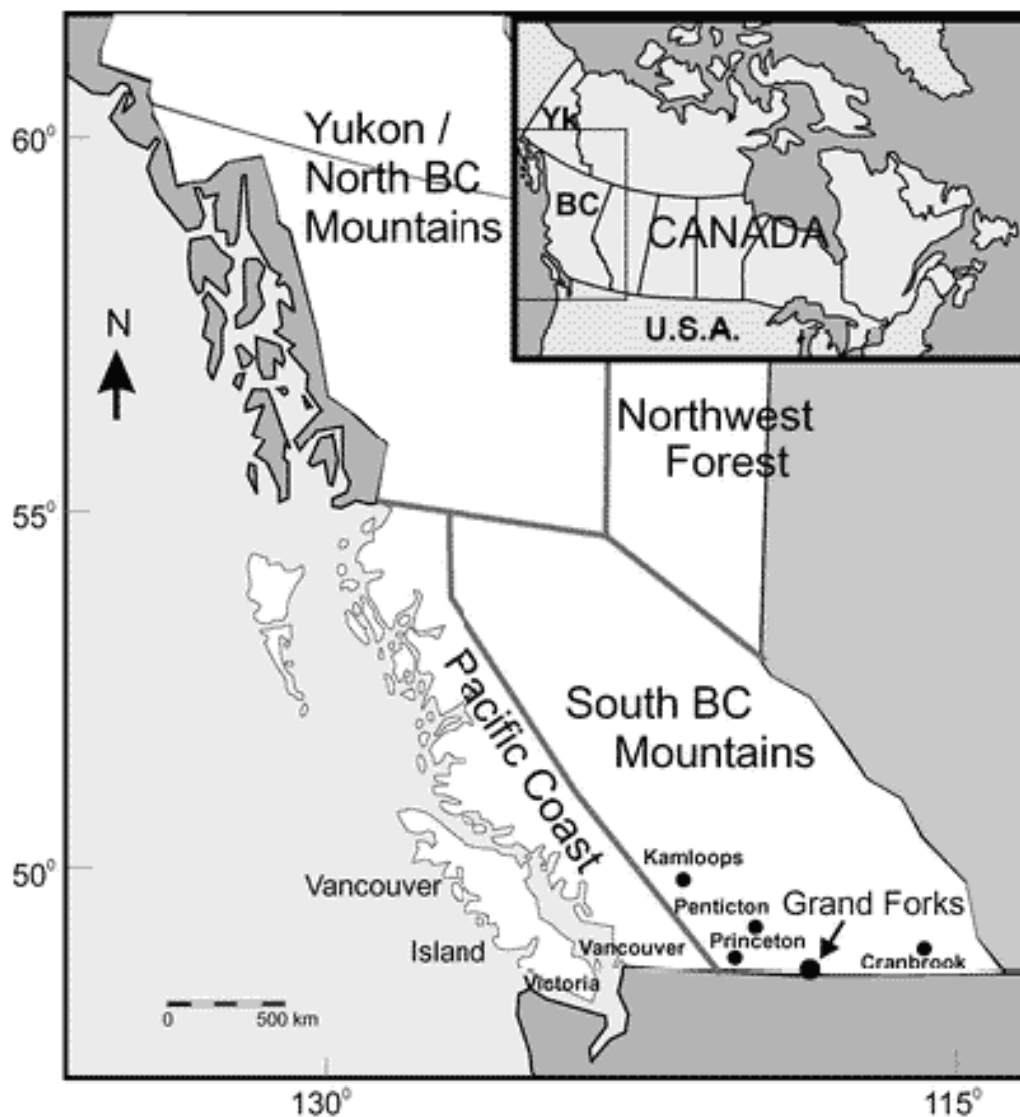


Fig. 1. Location of Grand Forks and other urban centers in southern British Columbia. Also shown are the Climate Region boundaries after Guillet and Skinner (1992)

This paper provides a brief literature review of climate change in BC, summarizes climate-change projections for the South BC Mountains climate region, describes a methodology and the results of simulations that were undertaken to estimate aquifer recharge under current conditions and various climate-change scenarios, and summarizes the results of a sensitivity analysis that was undertaken using Visual MODFLOW (Waterloo Hydrogeologic Inc., WHI 1997) to assess the potential impact of climate change on groundwater levels in the aquifer.

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