$H = W \left[ \frac{k_2}{k_1} \left( q' - 1 \right) \left( \frac{q'}{k_2} \frac{x^2}{W^2} \right) \right]^{1/2}$

$z_{\text{max}} = \sqrt{h_t^2 + \frac{q' h_{\text{my}} t}{2S_y}} - h_i$

Organizing Committee
Eileen Poeter, IGWMC, Colorado School of Mines
Chunmiao Zheng, University of Alabama
Mary Hill, U.S. Geological Survey
John Doherty, Watermark Computing, Australia

September 16-19, 2003

INTERNATIONAL GROUND WATER MODELING CENTER (IGWMC)
COLORADO SCHOOL OF MINES
Proceedings of MODFLOW and MORE 2003: Understanding through Modeling

Featured Presentations

List of Featured Presentations

The Limit of Advection-Dispersion Theory
Chunmiao Zheng, Gaisheng Liu, Steven Gorelick

Modeling the Impact of Land Use on Surface Water and Groundwater Quality: Transport of Road Salt in The Grand Traverse Bay Watershed, Michigan
David Hyndman, David Boutt, Karen Wayland, Bryan Pijanowski, David Long

Development and Application of Bioremediation Models - Present Status and Future Challenges
T. Prabhakar Clement

Multi-Scale Conjunctive Modeling of Surface and Subsurface Flow
Sorab Pandav

Scientific Support for Groundwater Management Decisions through Coupled Models
David Steward

Judging Amy’s Flow Model or Assessing Model Credibility
William Woessner

Complexity
J. Jaime Gómez-Hernández

The Practical Use of Simplicity in Developing Ground-Water Models
Marv Hill

Assessing Pollution Risk for Potential New Wells in Urban Areas Using a GIS Landuse Database Linked to Groundwater Modelling
David Lerner, Ruth Davison, Nigel Tait, Janet Whittaker

Reducing Expectations and Raising Integrity in Environmental Modelling
John Doherty

Modeling Atmosphere-Induced Pressure Fluctuations and Chemical Vapor Transport in a Heterogeneous Fractured Vadose Zone
John McCray, W. Downs, R.W. Falta, L.T. Housley

The HYDRUS-PHREEQC Multicomponent Transport Model for Variably-Saturated Porous Media: Code Verification and Application
Diederik Jacques, Jirka Simunek, Dirk Mallants, Rien van Genuchten

Calibration of the Renewed and Extended Groundwater Model of the Amsterdam Dune Area Using Many Different Situations Simultaneously
Theo Olsthoorn, Pierre Kamps

Testing and Improving Conceptualization of Geohydrologic Systems through Flow Modeling
Donald Sweetkind, Claudia Faunt, Joan Blainey

Challenging MODFLOW
Mary Anderson, Randall Hunt

Opportunities and Challenges in Research on Ground-water Modeling
Frank Schwartz, G. Allen, Y.C. Fang, M. Ibaraki
SECTION 1
MODFLOW-2000, Latest Developments and Related Issues
Session Chairs: Mary Hill, Michael McDonald, Arlen Harbaugh
MODFLOW-ANI: A Fully 2-D Anisotropy Package for MODFLOW
Bennie Minnema, J.R. Valstar, A. Lourens, M. de Jonge
Model-Layer Variable-Direction Horizontal Anisotropy (LVDA) Capability in MODFLOW-2000
Evan Anderman, Kenneth Kipp, Mary Hill, Johan Valstar, Roseanna Neupauer
Improved Water Table Dynamics In Block-Centered Finite-Difference Flow Models
Tom Clemo
MODGRID, Simultaneous Solving of Different Groundwater Flow Models at Various Scales; An Application to the Groundwater Model of the Amsterdam Dune Water Area
Frans Schaars, Pierre Kamps, Jan Hoogendoorn, Kees Maas
Local Grid Refinement Methods For MODFLOW: The Good, the Bad, and the Ugly
Steffen Mehl, Mary Hill
Predicting the Impacts of Shallow Saline Groundwater on Vegetation Health: A MODFLOW 2000 Module for Alternating ET and Recharge
Rebecca Doble, Glen Walker, Ian Jolly, Craig Simmons
Coupling a Pipe-network to MODFLOW to Predict the Evolution of Karst Aquifers
Steffen Birk, Sebastian Bauer, Rudolf Liedl, Martin Sauter
Effects of Simulating Multi-node Wells on Model Calibration, Interpretation, and Prediction Results
Keith Halford, Randall Hanson
Application of the Multi-Node Well Package to the Simulation of Regional-Aquifer Systems In the Santa Clara Valley, California
Randall Hanson, Z. Li, C. Faunt
MODFLOW Equipped with a New Method for the Accurate Simulation of Axisymmetric Flow
Nozar Samani, Mazda Kompani-Zare, David Barry
Automated Management of Discontinuous Hydrogeologic Layers in MODFLOW Models
Jerry Shi, Michael Gefell, Franklin Schwartz
New Subsidence Package for MODFLOW-2000
Stanley Leake, Jörn Hoffmann, D. L. Galloway, Alicia M. Wilson
The Sea Water Intrusion (SWI) Package for MODFLOW
Mark Bakker, Frans Schaars
Detailed Evaluation of Particle Tracking in Hydrogeologic Units
Evan Anderman, Mary Hill
Inversion of Borehole Flowmeter Measurements Considering Well Screen Clogging and Skin
Tom Clemo, Warren Barrash
An Alternative Approach for Assigning Well Rates in a Block-Centered Finite-Difference Grid
Adán Pinales, Arturo Keer, Francisco Espinosa, Luisa Manzanares, Gerónimo Llerar, Adolfo Chávez

SECTION 2
Connections to MODFLOW for Simulating Processes Not Included in MODFLOW
Session Chairs: Michael McDonald, Arlen Harbaugh
Limitations of MODFLOW Velocity Field as the Basis for Groundwater Pollution Modeling and an Alternative Approach to Solve these Problems
M. Ghulam Rabbani
Dave Romero, Thomas Maddock

OpenMI: Harmonizing Water Management Through an Open Modeling Interface
Douglas Graham, P.J.A. Gijsbers, Jan Børge Gregersen

SECTION 3
Surface-Water/Ground-Water Interaction Modeling

Session Chairs: Frank Schwartz, Mary Anderson, William Woessner, John Doherty

Surface/Subsurface Modeling of Western Orange and Seminole Counties of Florida
Walter Jones, Sorab Panday, Sarah Frost, Brian McGurk

MODFLOW-WHT: A Fully-Coupled, MODFLOW-based, Surface-Subsurface Watershed Model
R. Brad Thoms, Rick Johnson

Incorporating Surface-Water/Groundwater Interaction in a Texas Central Gulf Coast Water-Demand-Forecasting Flow Model
Gilbert Barth

Grid-Independent, Graph-Based Approach for Supporting the Streamflow-Routing Package in Visual MODFLOW
Serguei Chmakov, Patrick Delaney

A Kinematic Wave Solution for Simulating Unsaturated Flow Beneath Streams Using MODFLOW
Richard Niswonger, David Prudic

Upgrading of Non-Linear Drainage Systems in MODFLOW Models by the Use of Extremely Detailed Elevation Data
Martina Kulper, Chris te Stroet

Estimating Induced Infiltration and Cross-River Flow From Numerical Modeling
Matthew Gamache, Robert Schreiber, Willis Weight

Simulation of Water Exchange Across a Gently Sloping Lakebed, South Lake Tahoe, California
Jon Fenske, Makrom Shatila

Simulation of Fully-Coupled Surface and Subsurface Hydrologic Processes in Irrigated Agriculture
George Matanga, Claire Jacquemin, Don DeMarco

A Groundwater Flow Model of the Trifa Aquifer in Morocco
El Houcynne El Idrysy, Florimond De Smedt

Simulation of Groundwater and Conjunctive Irrigation in Florida
Joseph Hughes, Ke Feng,

The Integrated Northern Tampa Bay, Florida Model: Conceptualization, Construction, and Calibration
Greg Ruskauff, P. Tara, E. Houssenipour

Flow Model of an Industrial Site in Pori, W-Finland-a Simple Approximation of a Complex Drainage System
Jussi Leveinen, Petri Lintinen

An Application of MODNET to the C-4 Canal Basin in the Miami Metropolitan Area
Mark Wilsnack, K. D. Konyha

Surface Water – Groundwater Interaction in a Central Texas Aquifer
David O'Rourke

Regional Modeling of Groundwater Flow in the Oak Ridges Moraine Area of Southern Ontario
E.J. Wexler, S. Holyst, D. Kassenaar, R. Gerber

Modeling River Aquifer Interactions and Geologic Heterogeneity In an Alluvial Fan System – Implications for River Flow Restoration
Jan Fleckenstein, Rich Niswonger, Graham Fogg
Effects of Potential Climate Change on Lake Levels and Capture Zones
Rahul John, Tina Pint, Mary Anderson, Randy Hunt

Stream-Groundwater Interactions: The Influence of Aquifer Heterogeneity and Stream Meandering on 2-D and 3-D Hyporhelic Exchange Flows
Jorge Eurico Matos, Claire Welty, Aaron Packman

A MODFLOW Package For Riparian Evapotranspiration
Kathryn Baird, Thomas Maddock

SECTION 4
Contaminant Transport Modeling
Session Chairs: Chunmiao Zheng, T. Prabhakar Clement, Suzanne Paschke, David Hyndman

Positive Solution of Two-dimensional Solute Transport in Aquifers
Paulo Herrera, Albert Valocchi

The Problem of Small Negative Concentrations in Variable Density Transport Modeling and Two Test Results with MOCALIF
Frieder Haefner, Siegrun Boy

Regional-Scale Modeling of Nitrate Contamination of Ground Water in Agriculture-Dominated Watersheds
Mohammad Almasri, Jagath Kaluarachchi

Emulating Contaminant Sources: Perspectives on the Benefits of Using Telescopic Mesh Refinement Techniques
Shawn Leppert, Steve Lynn

PCGEOFIM – A Finite Volume Model for More?
Mike Müller, Dietrich Sames, Holger Mansel

Modelling of Diffusion-Limited Retardation of Contaminants in Hydraulically and Hydrogeochemically Heterogeneous Aquifers Using a Sedimentological Facies Approach
Thomas Ptak, Rudolf Liedl

Stochastic Modeling of Colloid-Facilitated Contaminant Transport in Heterogeneous Porous Media
Ahmed Hassan, Hesham Bekhit

Evaluation of Simulated Forced-gradient Tracer Tests in Heterogeneous Aquifers: Different Test Types Yield Different Longitudinal Dispersivity Estimates
Claire Tiedeman, Paul Hsieh

Simulated Transport of Iodine-129 In the Snake River Plain Aquifer at and near the Idaho National Engineering and Environmental Laboratory: Preliminary Results
Gordon Rattray, Daniel Ackerman

Geochemical Transport Modeling of Water Quality Changes During Managed Artificial Recharge
Henning Prommer, Janek Greskowiak, Pieter Stuyfzand, Chittaranjan Ray

ART3D: An Analytical Model for Predicting 3-Dimensional Reactive Transport
Cristhian Quezada, Clarissa M. Hansen, T. Prabhakar Clement, Norman L. Jones, Kang-Kun Lee

Reactive Transport of U(VI) In Groundwater
John Phillippi, Tirtha Gautam, Prabhakar Clement, Melissa McIndoe, Mark Barnett, Eric Roden

Modelling of TCE Reactive Transport In a Partly Fe0 Filled Fracture:Conceptual Model and Lumped Parameter Approach
Zuansi Cai, Neil R. Thomson, Sascha Oswald, Ryan Wilson, David N. Lemer

Modelling Reactive Transport In Conduit-Continuum Hybrid Systems
Sabine Spiessl, Martin Sauter, Henning Prommer, Tobias Licha, Chunmiao Zheng

Multicomponent Simulation of Biodegradation Applying Locally Adaptive Remeshing and Parallel Processing
Ian Watson, P. Bastian, R.S. Crouch, S.E.Oswald,
Modeling Natural Attenuation of BTEX and Chlorinated Ethenes in a Landfill Leachate Plume
Geoff Thyne, Margaret Dodds, John McCray

Reactive Transport Modeling of Mineral Fouling in Permeable Reactive Barriers
Lin Li, Elizabeth Mergener, Craig Benson

Nitrogen Transformation and Transport Model in Saturated Soils: Model Formulation and Field Application
Mee-Sun Lee, Kang-Kun Lee, T. Prabhakar Clement, David Hamilton

Constraining Ground Water Model Calibration Using Geological Information
Steven Young, Dave Barton, Trevor Budge

Comparison of Analytical and Numerical Models for the Advection-Dispersion Equation: Mass Balance Errors in Analytical Solutions from Incorrect Application of the Retardation Factor
Todd Umstot

Upscaling Adsorption
J. Jaime Gómez Hernández, Jianlin Fu

Evaluation of Estimation Errors of Partitioning Tracer Tests for Source Zones with DNAPL Pools
Elena Moreno-Barbero, Tissa Illangasekare

SECTION 5
Typical Problems Encountered in Modeling and Their Solutions
Session Chairs: David Steward, Rien van Genuchten

Combining Vertically Integrated Flows and Three-Dimensional Flows in Regional Groundwater Modeling
Otto Strack, Randal Barnes

Obtaining a Steady-State Solution with Elliptic and Parabolic Ground-Water Flow Equations under Dewatering Conditions: Experiences with a Basin Model
Richard Naff, Edward Banta, James McCord

The Benefits of Object-Oriented Modeling Demonstrated through the Development of a Regional Groundwater Model
Andrew Spink, C.R. Jackson, A.G. Hughes, P.J. Hulme

Algebraic Multigrid (AMG) for Ground Water Flow and Oil Reservoir Simulation
Klaus Stüben, Patrick Delaney, Serguei Chmakov

An Investigation of Numerical Grid Effects in Automated Calibration
George Zyvoloski

Reconciling Recharge and Discharge in a Regional Flow Model
Daniel Feinstein, David Saad, David Hart, Kurt Zeiler

MODELS GONE BAD— Common Modeling Problems and How to Solve Them
Eve Kuniansky, Wesley Danskin

Groundwater Flow and Transport Simulations: A Comparative Study of Two Independent Model Conceptualizations
Wayne Woldt, Ram Marahatta

Multimodel Inference Based on Kullback-Leibler Information
David Anderson

Generation of Time-Independent “Structural Groundwater Heads” to Be Used as Observations in the Calibration of Steady-State Groundwater Models
J. Lebbink, H.L.M. Rolf

TimML, A Free, Multi-Aquifer, Analytic Element Model
Mark Bakker

Multi-Aquifer Modeling of Shallow Flow in the Middle Coastal Plain of North Carolina
Stephen Kraemer
**SECTION 6**

**Code Testing / Performance and Case Studies**

Session Chairs: Arlen Harbaugh, Sorab Panday

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerical Modeling of a Multiple-Well Pumping Test Using a Locally Refined, Object-Oriented Regional Groundwater Model</td>
<td>Christopher Jackson, A.G. Hughes, M.M. Mansour, A.E.F. Spink, J.P. Bloomfield, J. Riches, M.A. Jones</td>
</tr>
<tr>
<td>Application of MODFLOW to a Proposed Open Pit Mine in Northern Alberta</td>
<td>Brent Mooder</td>
</tr>
<tr>
<td>A Field-Scale Application of the Integrated Hydrologic Model</td>
<td>Alaa Aly, Mark Ross, Jeff Geurink, Zia Hosseinipour</td>
</tr>
<tr>
<td>The Carlsbad Area Groundwater Model: Validation and Model Insights Into Long-Term Hydrologic Behavior</td>
<td>Peggy Barroll, G. Ruskauff, D. Jordan</td>
</tr>
<tr>
<td>Simulating Underground Mine Inflows and Dewatering with MODFLOW-SURFACT</td>
<td>David Hay, Jeff Wright, Jason Rose</td>
</tr>
<tr>
<td>Using MODFLOW to Estimate Tree-Uptake Rate for Hydraulic Control at a Phytoremediation Site In Charleston, South Carolina</td>
<td>Bruce Campbell, James Landmeyer</td>
</tr>
<tr>
<td>Comparison of Three Numerical Models for Chain-Decay Transport Simulation at a Closed AFB in Texas</td>
<td>Ming-Shu Tsou, Kan Tu, Jan Kool, Christopher Neville, Steven Young</td>
</tr>
<tr>
<td>Modeling Multiple Screen Wells under Highly Variable Water Table Conditions</td>
<td>Quentin Moore, David Hay</td>
</tr>
<tr>
<td>Water-Rock Interaction and Groundwater Flow of The Upper Floridan Aquifer In Bay County and Surrounding Areas, Florida</td>
<td>Jeremy McCartha, Ming-Kuo Lee</td>
</tr>
</tbody>
</table>

**INDEX - Division between Volume I and Volume II**

**SECTION 7**

**Modeling & Social Issues (Policy Development, Conflict Resolution, Teaching)**

Session Chairs: Mary Anderson, William Woessner

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Role of Hand-Calculations in Groundwater Flow Modeling</td>
<td>Henk Haitjema</td>
</tr>
<tr>
<td>The Use of Flow Modelling to Assess the Impact of Agricultural Control Measures on Abstracted Groundwater Quality</td>
<td>Ann Williams, John Barker, Martyn Silgram, Majdi Mansour, Ilka Neumann, Andrew Hughes</td>
</tr>
<tr>
<td>Using Response Function Concepts to Model Groundwater Management Scenarios</td>
<td>David Scott</td>
</tr>
<tr>
<td>Groundwater Management Study In a Sedimentary Aquifer In Northeast Brazil</td>
<td>Michael Kohnke, Nilson Guiguer, Daniel Gomes</td>
</tr>
<tr>
<td>Development of a Shared Vision Groundwater Flow Model for the Former Guadalupe Oil Field</td>
<td>Eric Nichols, David Peterson, Don Eley</td>
</tr>
<tr>
<td>Understanding Integrated Processes through Groundwater Models and GIS Technology</td>
<td>David Steward, Eric Bernard</td>
</tr>
</tbody>
</table>