

**Texas A & M University and U.S. Bureau of Reclamation
Hydrologic Modeling Inventory
Model Description Form**

JUNE 18, 1999

1. Name of Model:

Object Watershed Link Simulation (OWLS)

2. Model Type:

Continuous precipitation runoff models, snowmelt runoff models, unsteady-flow flood routing models

3. Model Objective(s):

To physically and visually simulate the real time or short-term hydrological processes for small forested watersheds and to provide detailed information about watershed response to environmental changes.

4. Agency and Office:

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6. Model Structure or Mathematical Basis:

Please see the HMI web page: <http://www.usbr.gov/hmi>
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- (1) Type of basins: Mountainous Source Watershed (expandable to rural, agricultural watershed)**
- (2) Size of basins: in theory, no restriction**
- (3) Nature of simulation: physically-based, continuous, 3-D simulation**
- (4) Components of the hydrologic cycle represented: Precipitation (Rainfall and Snowfall), Solar Radiation, Air Temperature, Snow melting, Infiltration, Exfiltration, Evaporation, Interception, Detention storage, Overland flow, Micropore pipe flow, Ground water flow, Stream flow and related routing processes.**
- (5) The underlying hypotheses:**
 - i. Cells: No restrictions on the geometry and size of the simulation units (or cells) for the model. But all cell has to be plane. Cells with different geometry are simulated using a Equivalent Rectangle Approximation (ERA) method, which solved a 3-D hydrologic problem using a simple 1-D model.**
 - ii. Network of cells: A watershed is represented by a network of cells, which connected hydraulically via their boundary (edges). Water migrates from upper cells to the lower cells through their edges.**
 - iii. Network of edges: A automatic flow tracing model was built-in in the OWLS to generate a network of flow paths and basin boundary. These paths and boundary forms a network of edges and they partition the cells where their cross over. The network of flow path edges becomes the stream network which can expand or shrink as the result of the water balance.**
 - iv. Precipitation: Linear spatial interpolation to distribute observed precipitation data into different cells in the watershed**
 - v. Interception: Related to the physical property of the forest coverage, a mass balance equation is used for accounting the interception and evaporations.**
 - vi. Infiltration: Two considerations: <1> For soil surface infiltration, Modified Horton Infiltration Equation is used with consideration of soil moisture contain. <2> For macropore pipe infiltration, a linear equation with soil surface infiltration rate is used.**
 - vii. Exfiltration: Continuity equation was used in conjunction with macropore flow routing and ground water routing equations.**
 - viii. Detention storage: As the simulation results from mass balance equation from flow routing processes**
 - ix. Snowmelting: Modified Degree-day Model.**
 - x. Overland Flow: Nonlinear Kinematic Wave Scheme Finite-Difference Method.**

- xi. **Micropore Flow: Pipe-bundle Model derived from energy and continuity equation.**
- xii. **Ground Water Flow: Darcy's Law with continuity equation with unsaturated conductivity.**
- xiii. **Stream Flow: Tree structured segment and node stream network with flow routing by Manning's equation and continuity equation.**

7. Model Parameters:

There are 46 parameters in the OWLS model, including Canopy (1), Surface (6), Soil (11), Macropore (13), Stream (8), and 9 general parameters. 10 of them are most sensitive parameters to the OWLS model (see table below). As a physically based model, the number of parameters can be reduced or replaced by the field measured data.

Parameter	Description	Data Range
infiltration0Adjust	Dimensionless, adjust factor for maximum infiltration rate. For distributed model, different soils have different lab-tested maximum infiltration rates, the "infiltration0Adjust" parameter is a ratio to adjust all the soil maximum infiltration rates simultaneously to approximate the field condition. This parameter has great effect the proportion of water distribution among surface, soil and macropore system.	0.1 ~ 10.
infiltrationCAAdjust	Dimensionless, adjust factor for maximum infiltration rate. This parameter has great effect the proportion of water distribution among surface, soil and macropore system.	0.1 ~ 10.
surfaceMacroporeConstant	Dimensionless, adjust factor for amount of surface water directly drain into the soil macropore system. It is a proportion factor to the amount of soil infiltration. It has great effect to the peak flow and basically control the flow subdivision between surface flow and macropore pipe flow.	1 ~ 5.
soilMacroporeConst	Dimensionless, adjust factor for amount of soil water directly drain into the macropore system. It is a proportion factor to the amount of soil water depth, relative soil moisture content. It has great effect to the base flow and basically control the base flow subdivision between soil matrix flow and macropore pipe flow.	0 ~ 10 ⁻³
conductivityAdjust	Dimensionless, adjust factor for soil	1 ~ 1000

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Parameter	Description	Data Range
	conductivity rate. For distributed model, different soils have different lab-tested unsaturated conductivities, the "conductivityAdjust" parameter is a ratio to simultaneously adjust the hydraulic conductivities for all the soils to approximate the field condition. This parameter has great effect on the soil base flow.	
frictionCoeff	Dimensionless, the friction coefficient for macropore pipe system. It has great effect on the falling-limb of a peak flow hydrograph.	1 ~ 100
roughness	Dimensionless, the Manning's roughness for watershed surface. It has great effect on the peak timing and smoothness of the hydrograph.	0.1 ~ 1.0
Manning	Dimensionless, the Manning's roughness for channel segments. It has large effect on the peak timing and smoothness of the hydrograph.	0.05 ~ 0.5
SnowMelt_Df	m ^o C/hr, the degree-day snowmelt factor. It has great effect on the snowmelt-caused flow event, both peak and event period.	10 ⁻⁴ ~ 10 ⁻²

8. Spatial Scale Employed in the Model:

Unrestricted distributed cell geometry and size. Tested: <45 meters for the longest edge of a cell. But larger scale should be applicable as long as each cell is plane.

9. Temporal Scale Employed in the Model:

Continuous Simulation. Tested: 0.5hr, 1hr, 4hr, 12hr, 24hr. Length temporal scale will introduce timing offset to the simulation.

10. Input Data Requirements:

- (1) Required Data
 - i. DEM data
 - ii. Precipitation Data
 - iii. Geographical Coordinators
 - iv. Air Temperature Data
 - v. Soil Survey Data
- (2) Optional Data
 - i. Stream flow Data

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- ii. Soil Infiltration Data
- iii. Macropore Pipe Data
- iv. Channel Geometry Data
- (3) System Parameter Data
 - i. System Control Parameters
 - 1) Unit Usage
 - 2) Time Domain
 - 3) Output Unit Option
 - 4) File Name Definitions
 - 5) Switch Parameters
 - 6) Visualization Control
 - ii. System Model Parameters.

11. Computer Requirements:

- (1) Hardware Minimum: 486DX2 66 with 8MB RAM and 50 MB HDD
- (2) Software Minimum: Windows 3.1 for Workgroup and up. Tested in Windows 95, 98 and Windows NT.

12. Model Output:

- (1) Two-Dimensional Data
 - i. Stream Flow
 - ii. Water Storage
 - iii. Vertical Flux
 - iv. Soil Moisture Content
 - v. Temperature
 - vi. Conductivity
- (2) Three-Dimensional Data
 - i. Topographical Output
 - ii. Stream Segment
 - iii. Stream Network
 - iv. Watershed Cells, Boundary and Flowpath
- (3) Hydrologic Output
 - i. Flows for Stream Segments
 - ii. Water Storage for Watershed Cells.

13. Parameter Estimation / Model Calibration:

The OWLS model has default parameter set calibrated from an experimental watershed in Maine, USA. Some of the parameters have to be obtained from the field measurement. Some can be estimated from the physical equations. Others should be manually calibrated. The OWLS model provides a set of rules for manual calibration to the parameters. No automatic processing was developed at this point.

14. Model Testing and Verification:

The OWLS model has been testing to a pair of watersheds in Bear Brook Watershed of Maine. The watershed research is one the long-term project sponsored by US EPA (<http://www.umaine.edu/WaterResearch/linking.html>) .

15. Model Sensitivity:

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Infiltration, macropore and conductivity parameters are most sensitive factors to the OWLS model.

16. Model Reliability:

- (1) The model has been tested for good overall water balance. Leaking from numerical simulation has been prevented.
- (2) The model was calibrated in one watershed for a period of time and validated in another watershed and the same watershed for different period of time. Results are generally accurate as compared with the real observations.
- (3) The model was also tested for different cell structure and different temporal scale. All tests produced consistent results for the same period of time.

17. Model Application / Case Studies:

The OWLS model has been applied to simulate the dynamic hydrologic processes in the experimental watershed in Maine.

18. Documentation:

The model source code, executable, technical document and user manual in MS Word format are freely available through the internet site: <http://hydromodel.com>

19. Other Comments:

20. References:

(1). **Chen, Huaisheng. 1996. Object Watershed Link Simulation (OWLS). Ph.D. Dissertation, Oregon State University. U.S.A.**

(2). **H.Chen and R.Beschta. 1999. Dynamic Hydrologic Simulation of the Bear Brook Watershed in Maine (BBWM). Environmental Monitoring and Assessment 55:53-96, 1999**

(3). **H.Chen and R.Beschta. 1999. Dynamic Hydrologic Simulation of the Bear Brook Watershed in Maine (BBWM). THE BEAR BROOK WATERSHED IN MAINE: A Paired Watershed Experiment - The First Decade (1987-1997) Edt: Stephen A.Norton and Ivan J. Fernandez. P53-96, Kluwer Academic Publishers, 1999.**