WEAP Water Evaluation and Planning System

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Overview

WEAP© is a microcomputer tool for integrated water resources planning. It provides a comprehensive, flexible and user-friendly framework for policy analysis. A growing number of water professionals are finding WEAP to be a useful addition to their toolbox of models, databases, spreadsheets and other software. This introduction summarizes WEAP's purpose, approach and structure. A detailed technical description is available in a separate publication, the WEAP User Guide.

Background

Many regions are facing formidable freshwater management challenges. Allocation of limited water resources, environmental quality and policies for sustainable water use are issues of increasing concern. Conventional supply-oriented simulation models are not always adequate. Over the last decade, an integrated approach to water development has emerged which places water supply projects in the context of demand-side issues, water quality and ecosystem preservation.

WEAP aims to incorporate these values into a practical tool for water resources planning. WEAP is distinguished by its integrated approach to simulating water systems and by its policy orientation. WEAP places the demand side of the equation—water use patterns, equipment efficiencies, re-use, prices and allocation—on an equal footing with the supply side—streamflow, groundwater, reservoirs and water transfers. WEAP is a laboratory for examining alternative water development and management strategies.

WEAP is comprehensive, straightforward and easy-to-use, and attempts to assist rather than substitute for the skilled planner. As a database, WEAP provides a system for maintaining water demand and supply information. As a forecasting tool, WEAP simulates water demand, supply, flows, and storage, and pollution generation, treatment and discharge. As a policy analysis tool, WEAP evaluates a full range of water development and management options, and takes account of multiple and competing uses of water systems.

WEAP Development

The Stockholm Environment Institute provided primary support for the development of WEAP. The Hydrologic Engineering Center of the US Army Corps of Engineers funded significant enhancements. A number of agencies, including the UN, World Bank,

USAID and the Global Infrastructure Fund of Japan have provided project support. WEAP has been applied in water assessments in the United States, Mexico, China, Central Asia, Africa, Egypt, Israel and India.

The WEAP Approach

Operating on the basic principle of water balance accounting, WEAP is applicable to municipal and agricultural systems, single subbasins or complex river systems. Moreover, WEAP can address an wide range of issues, *e.g.*, sectoral demand analyses, water conservation, water rights and allocation priorities, groundwater and streamflow simulations, reservoir operations, hydropower generation, pollution tracking, ecosystem requirements, and project benefit-cost analyses.

The analyst represents the system in terms of its various supply sources (*e.g.*, rivers, creeks, groundwater, reservoirs); withdrawal, transmission and wastewater treatment facilities; ecosystem requirements, water demands and pollution generation. The data structure and level of detail may be easily customized to meet the requirements of a particular analysis, and to reflect the limits imposed by restricted data.

WEAP applications generally include several steps. The study definition sets up the time frame, spatial boundary, system components and configuration of the problem. The current accounts provide a snapshot of actual water demand, pollution loads, resources and supplies for the system. Alternative sets of future assumptions are based on policies, costs and factors that affect demand, pollution, supply and hydrology. Scenarios are constructed consisting of alternative sets of assumptions or policies. Finally, the scenarios are evaluated with regard to water sufficiency, costs and benefits, compatibility with environmental targets, and sensitivity to uncertainty in key variables.

Scenarios

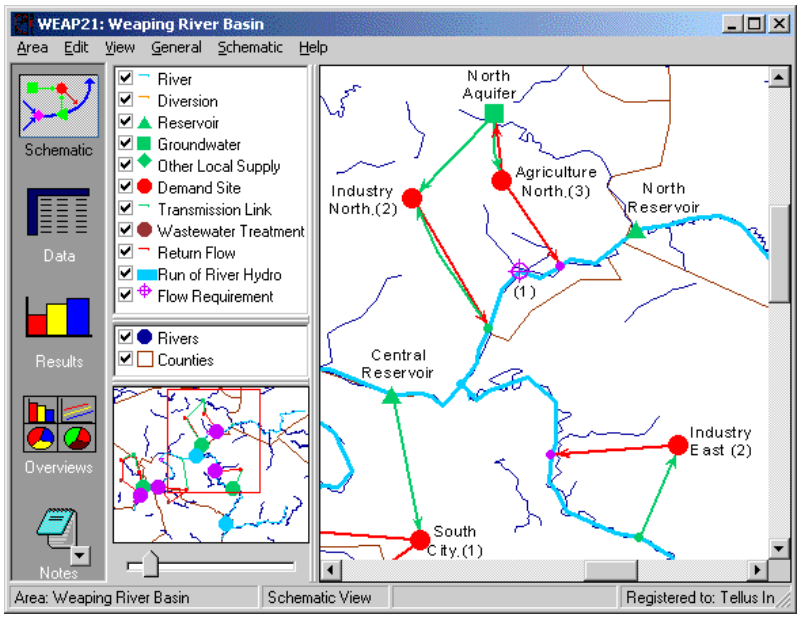
Scenario analysis is central to WEAP. Scenarios are used to explore the model with an enormous range of "what if" questions, such as:

- What if population growth and economic development patterns change?
- What if reservoir operating rules are altered?
- What if groundwater is more fully exploited?
- What if water conservation is introduced?
- What if ecosystem requirements are tightened?
- What if new sources of water pollution are added?
- What if a conjunctive use program is established to store excess surface water in underground aquifers?
- What if a water recycling program is implemented?
- What if a more efficient irrigation technique is implemented?
- What if the mix of agricultural crops changes?
- What if climate change alters demand and supplies?

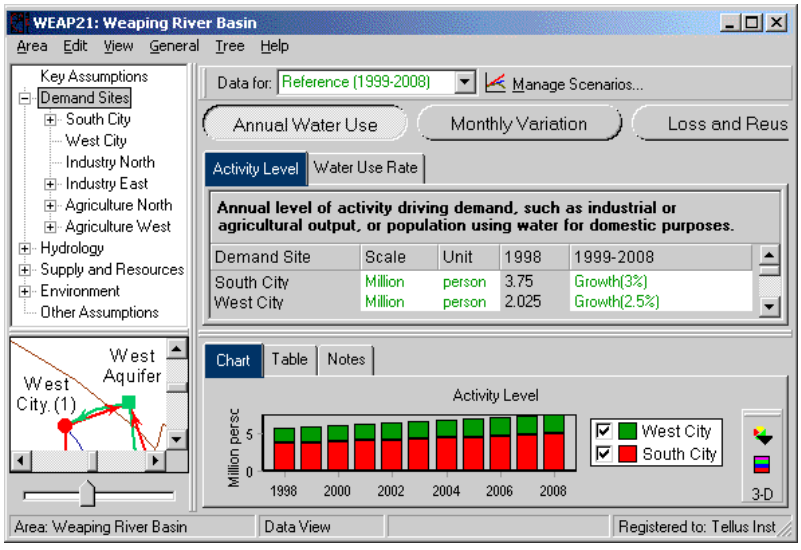
Program Structure

WEAP consists of five main views: Schematic, Data, Results, Overviews and Notes.

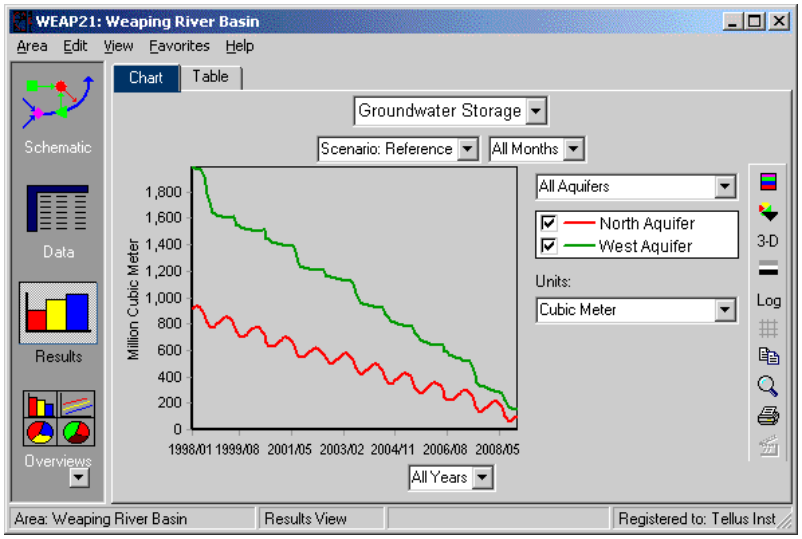
Schematic: GIS tools for configuring your system. Drag and drop to create and position. Add ArcView or other standard GIS vector or raster files as background layers. Instant access to data and results for any node.



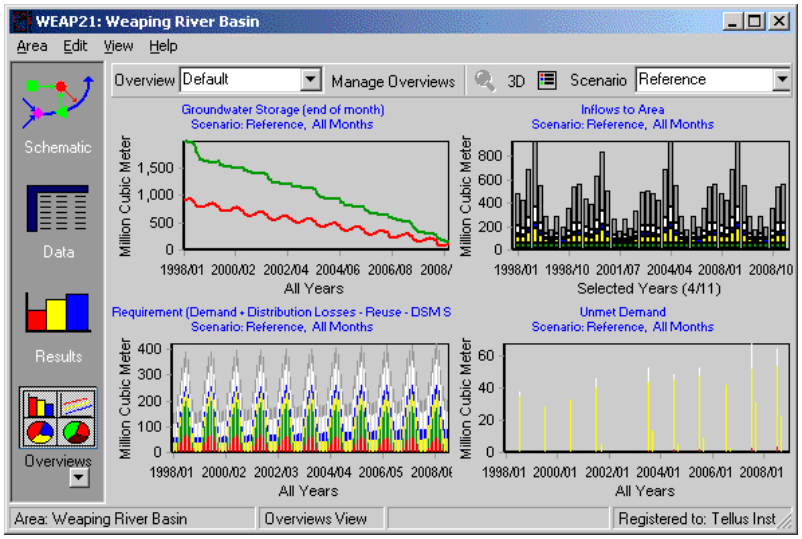
Data: Model building: create variables and relationships, enter assumptions and projections using mathematical expressions, dynamically link to Excel.



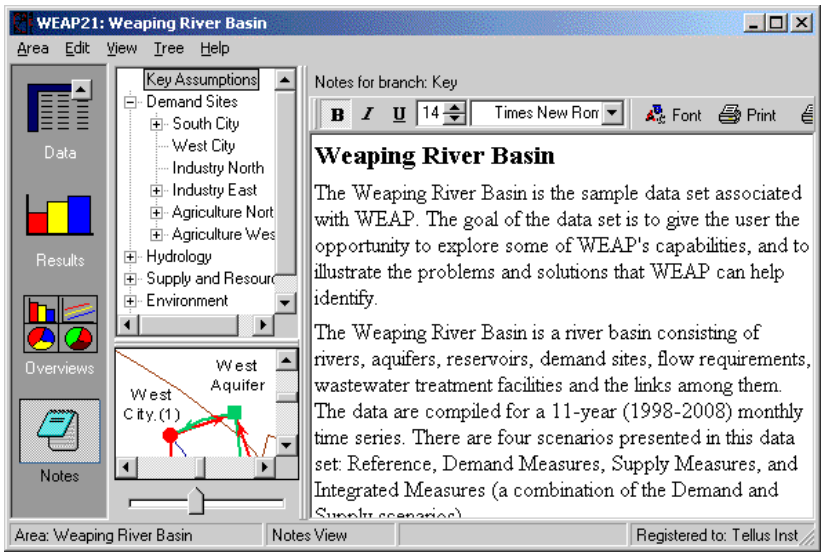
Results: Detailed and flexible display of all model outputs, both in graphical and tabular form.



Overviews: Design a bird's-eye view to highlight key indicators in your system.



Notes: Document your data and assumptions.



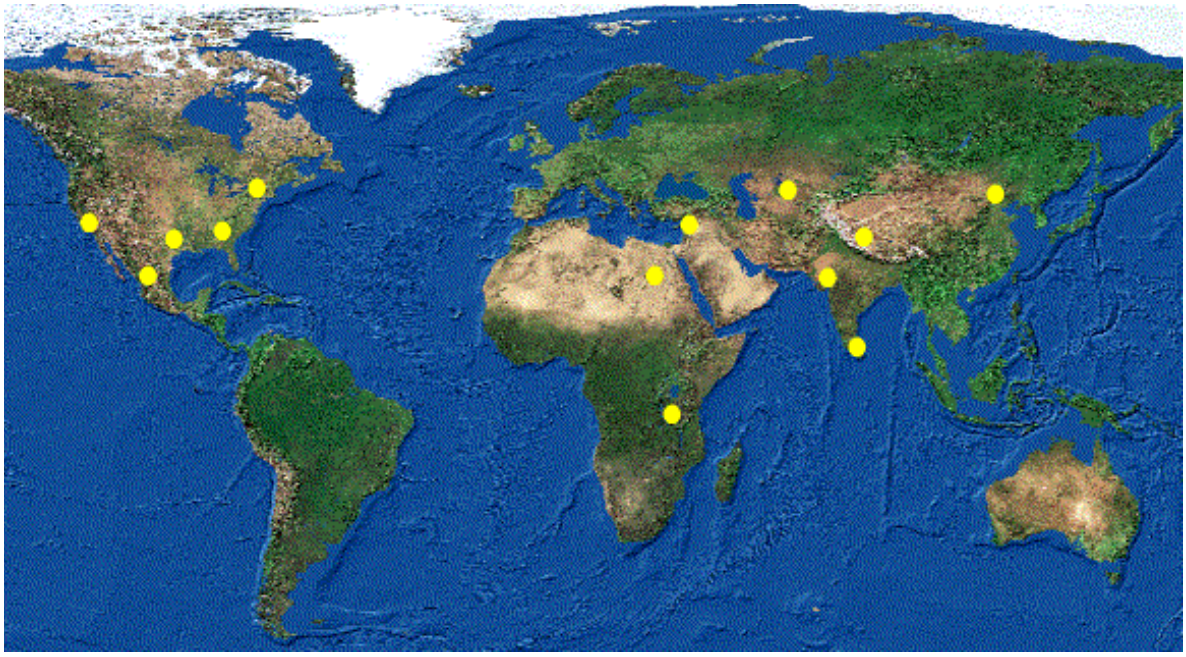
Ease of Use

An intuitive GIS-based graphical interface provides a simple yet powerful means for constructing, viewing and modifying the configuration—the user designs a schematic of the water system using the mouse to "drag and drop" system elements, which can all be overlaid on a map built from ArcView and other standard GIS and graphic files. Data for any component can be edited directly by clicking it on the schematic. The user may consult the context-sensitive help feature from anywhere in WEAP. Wizards, prompts and error messages provide advice throughout the program. With WEAP's highly flexible and comprehensive reporting system, the user may customize reports by selecting metric or English water units, years and format (*e.g.*, absolute levels, percent shares or growth rates). Specific report configurations can be saved as "favorites," which can be combined into "overviews"—bird's eye views of key system indicators. All tables can be exported directly into Excel. Model calculations run in minutes.

Highlights

- Integrated water resources planning system
- GIS-based, graphical drag and drop interface
- Model-building tool
- User-created variables and modeling equations
- Dynamic links to spreadsheets & other models
- Embedded linear program solves allocation equations
- Flexible and expandable data structures
- Powerful reporting system including graphs
- Context-sensitive help and User Guide
- Minimal requirements: runs under Windows 95/98/ 2000/NT on a Pentium computer with 32 MB RAM.

Selected Applications



- **Effects of Climate Change on Ecosystem Services in California**: WEAP used to identify and evaluate the likely impacts of climate change and other stressors on the provision of aquatic ecosystem services (e.g., water for agriculture, recreation, hydropower generation, water for municipal and industrial use, habitat function and health, biodiversity, water purification) in the San Francisco Bay Basin and Watershed. See http://www.eco-services.org/.

- **Beijing - Hebei Eco-Region Programme**: The project is designed to provide the basis for achieving co-operation on water-related issues, involving upstream stakeholders in 14 Counties of Hebei Province and downstream stakeholders in 6 counties in Beijing. We will be using WEAP to develop scenarios to support this effort.

- **Israeli/Palestinian Dialogue**: WEAP was used to represent alternative water development and allocation scenarios in a process involving both Israeli and Palestinian participants. Results used in a workshop in which government, academic and stakeholder representatives jointly explored alternatives for water sharing in the region.

- **Capacity Building in India and Nepal**: Four water development NGOs from India and Nepal trained in application of WEAP to evaluate water supply and conservation options in the diverse water conditions in their regions.

- **Water, Climate and Agriculture**: SEI-Boston worked with a team to model the links between climate change scenarios, hydrological responses, and agricultural productivity. WEAP was used to study existing and future water availability for agriculture in multiple river basins throughout the world.

- **Water Planning for the State of California**: Currently, all water resources within the state and any available imported water are utilized to their fullest extent by a large number of stakeholders. SEI-Boston was tasked by a coalition of Federal and State agencies and organizations to enhance and apply WEAP to assist California to achieve equitable and sustainable water allocation, and to bring an integrated approach to stakeholder dialogue.

- **Beijing Environmental Master Planning**: SEI-Boston developed the Beijing Environmental Master Plan Application System (BEMPAS) for the Beijing Municipal Environmental Planning Bureau. WEAP along with SEI-Boston's energy and solid waste planning models, were used as the core planning model for BEMPAS. Main tasks included consultation on Beijing's environmental planning needs, building an integrated assessment tool, and training.

- **Model Building for the Hydrologic Engineering Center**: The Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers contracted SEI-Boston for enhancements to WEAP for use in the U.S. An international leader in water modeling, the HEC has developed numerous water resources models since the 1960s, known as the HEC model series. The HEC models have been used throughout the world. WEAP was selected for its unique design philosophy stressing integration, flexibility, and the environment. HEC has used WEAP in water resources planning cases in the United States.

- **Supply Augmentation in Texas**: WEAP was used in a firm yield analysis Texas, which included an assessment of water supply augmentation through an inter-basin transfer. A WEAP based analysis determined how the existing and proposed supply options could be used together to maximize the system firm yield. By prioritizing the supply withdrawals between the two sources, the study predicted a ten percent increase in combined firm yield compared to original estimates which had simply added the two individual firm yields. As a result of this preliminary analysis, the region has moved forward to the design stage.

- **Integrated Assessment of the Apalachicola-Chattahoochee-Flint River Basin**: The entire Apalachicola-Chattahoochee-Flint River Basin was modeled in WEAP. The states of Alabama, Florida, and Georgia rely on the surface water and groundwater from the entire basin and conflicts are starting to emerge between upstream and downstream users. After training in WEAP, the team analyzed water use and allocation scenarios among the states to establish sustainable and equitable allocation of the regions water resources.

- **Water and Environment in the Rio San Juan**: WEAP was used in an integrated water resources assessment of the Rio San Juan basin in Mexico, including the industrial center of Monterey. The study included the development of a supply and demand balance for the watershed, and the identification of alternative water development strategies and their environmental implications. The analysis also estimated the true cost of water in the region, reflecting opportunity costs, marginal costs, and scarcity costs.

- **Strategies for Water Use in the Aral Sea Region:** SEI-Boston joined the Russian Institute of Geography in a major research project in the Aral Sea region. The Aral is shrinking, a result of intensive withdrawals from its two feed rivers, primarily for agricultural development. Regional impacts include severe ecological degradation and deterioration of public health. The WEAP system was applied to the two major rivers feeding the Aral. Scenarios of water demand and supply provided a framework for evaluating future conditions and policies for amelioration. This was the first comprehensive analysis of water accounts for the Aral region.