

OASIS: Florida's water-management expert system

By Gary Goforth

The South Florida Water Management District is developing a comprehensive decision-support program to aid in operation of its water-control structures. Called OASIS (Operations Assistant and Simulated Intelligence System), the program monitors and displays real-time hydrologic and meteorologic data and structure status, provides current and projected water-level readings, incorporates a versatile current and historic data-plotting package, and features an operations-advisor expert system. A prototype including 31 stations was completed last September. Full implementation of OASIS is scheduled for September 1988.

The district's physical system provides flood protection during the wet season (June through October) by storing water and discharging excess into the ocean. During the dry season (November through May), it draws water from storage. This strategy must incorporate environmental protection.

General operating guidelines for each water control structure were implemented into the system. These guidelines suggest appropriate gate levels and pumping conditions for specific objectives, including safely passing the design flood, supplying water demands during the dry season, preventing saltwater intrusion, providing discharge to Everglades National Park, and facilitating water movement during normal operations. There are also local operating policies that are derived from environmental considerations, development pressures, agricultural demands, and other socioeconomic concerns.

Communications with local users of the water supply/flood control system has given rise to an additional set of operating guidelines. For example, during the biannual growing seasons in the Everglades Agricultural Area (EAA), the district diverts water from appropriate storage reservoirs to local agricultural areas in anticipation of and in response to water-supply demands. However, the stormwater pumping capacity of the secondary canal system in EAA greatly exceeds the primary canals' conveyance capability. Hence, it is necessary to anticipate the pumping events in order to avert local flooding.

Water-level gauges provide the primary measure of hydrologic conditions. Hydrologic and meteorologic data are collected by field personnel, telephone-based units, and through the district's microwave telemetry network, which consists of over 650 electronic sensors at 44 major water control stations. Sensors at each station are automatically interrogated one to four times per hour during normal operations. Control room personnel can also interrogate sensors as frequently as once per minute. During severe weather conditions, requiring frequent data scans, up to 250,000 records per day of informa-

tion are processed by the telemetry network.

Factors that enter the decision process include canal water level, trends in the canal stage, local precipitation forecast, antecedent rainfall conditions, capabilities of water control structures, notices from district constituents, and other site-specific operating constraints. The extensive data-acquisition program maintained at the district provides the operations decision makers with sufficiently detailed information to evaluate these factors.

The district chose a Symbolics 3640 computer and Inference's Automated Reasoning Tool (ART) for the development of OASIS.

Consultants and knowledge engineers from Symbolics, Inference, McDonnell Douglas, NASA, A.D. Little, and the University of Florida commented on OASIS. They covered programming techniques, knowledge acquisition, knowledge representation, inter-computer communication, expert system verification, and other fundamental programming elements.

Consistent with other major applications of a new technology, a prototype was developed to evaluate the technical feasibility of the concept. It concentrated on the development of OASIS features for a subset of the district's water control stations and telemetry network. EAA, located between Lake Okeechobee and the water conservation areas, was chosen because of the variety and operational complexity of the stations present. In EAA are 31 stations, which encompass 83 sensors, over 50 water water-control gates, 29 pumps at eight pump stations, four major canals, and innumerable miles of secondary drainage canals.

Inference and the district developed OASIS jointly. District staff conducted the knowledge-acquisition interviews, formalized the knowledge representation, and established the intercomputer communications links. Inference provided the

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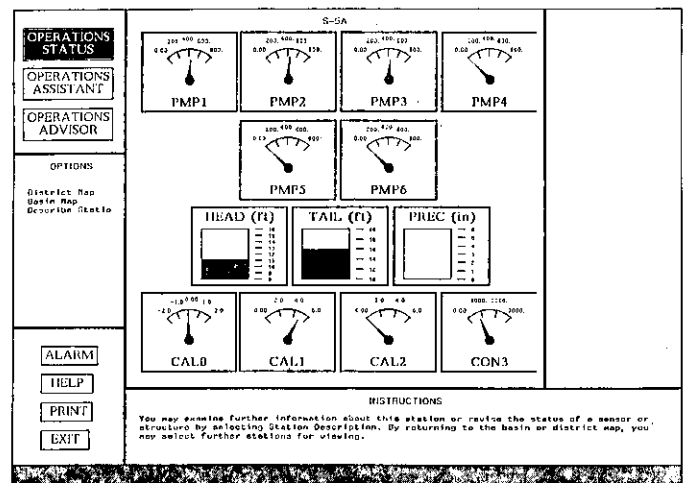


Figure . Operations Status Sensor Display Screen

OASIS water management

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functional framework, encoded district and basin maps, and designed the data storage formats. Many aspects of the program's functions were resolved cooperatively.

The OASIS prototype has four main elements:

- *Operations status* displays data in real-time.
- *Operations assistant* plots historic and current data.
- *Operations advisor* suggests structure operations. It considers relevant constraints of structure maintenance, environmental quality, legal, and other concurrent objectives.
- *Alarm status* provides a current summary of present and anticipated alarm conditions and includes suggestions for ameliorating the identified alarm conditions.

The prototype is executed through a highly interactive color graphics interface. A series of maps serves as the means to locate stations of interest, and screen menus are available to

select functions. Stations of interest, OASIS functions, and other requests are accessed by moving the cursor arrow to the appropriate location on the screen. Keyboard input is needed only to enter optional station information.

During fiscal year 1988, the prototype will undergo extensive internal and external review. The operations staff will verify the accuracy, consistency, and completeness of the expert system and other OASIS features. Computer hardware consultants will analyze the prototype on the basis of whether it uses the Symbolics computer to its full potential. Software engineer consultants will review the performance of the prototype, particularly its speed, data storage and retrieval, and overall coordination among different elements. It is anticipated that a significant number of other hydrologic basins will be added to the OASIS knowledge base in fiscal year 1988.