MANAGING INFORMATION ABOUT THE FAILURE OF DRINKING WATER SOURCES: IDENTIFYING A BASELINE FOR THE DEVELOPMENT OF THE NEXT GENERATION OF WATER MANAGEMENT INFORMATION SYSTEMS

John O'Looney

AUTHOR: Public Service Associate, Carl Vinson Institute of Government, University of Georgia, 201 N. Milledge Avenue, Athens, GA 30602.
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Abstract. A number of states have begun to develop sophisticated water reporting and management systems. The recent years of drought conditions in Georgia have brought greater attention to the need for adequate information about the condition of water resources. This paper reviews the participation and technical assistance experiences of Carl Vinson Institute of Government faculty in the Interagency Task Force on Georgia's Drought and outlines the key features and limitation of the information system that was developed. Features of a 'next generation' system that could contribute more effectively to water resource management in the state are identified.

KEY FEATURES OF THE WATER REPORTING SYSTEM

Managing a water resource will typically involve being able to track the level of the resource available and the degree to which the resource can meet the need of those who depend it. Management of drinking water supply would be relatively trivial were there only a few supply sources and providers. However, when the number of sources and suppliers reaches into the thousands (e.g., 5,000 registered drinking water sources in Georgia as well as thousands of unregistered wells), the need for an information system to identify and track changes in supply characteristics becomes paramount. In the summer of 2000, faculty from the Carl Vinson Institute of Government were charged by the Interagency Task Force on Georgia's Drought to develop such a system to assist in managing drought-related problems. As we proceeded to design such a system, we were forced to keep certain needs in mind. In particular we knew that because of the rapid movement of events, it would be necessary to develop a system that could:

- *Gather and provide information on thousands of water sources on a real-time basis.*

Even though most of Georgia's drinking water consumers are served by a moderate number of large public sector systems, the Task Force understood that multiple failures of small private systems (which tend to be based on older equipment and to have smaller maintenance budgets) could have a cascading impact on nearby systems that would be called upon to meet shortfalls. To address these design criteria, we developed an Internet-accessible information system that could be used by anyone (including small, private, well owners) to report a problem or potential problem with a water source. The system included records on the 5,000+ existing registered water sources but also allowed people to report a problem with other water sources, including agricultural sources that could potentially impact drinking water.

- *Provide some sort of rating of the potential for a failure incident.*

Although there are no sure-fire early warning predictors of water source failures, there are a number of indicators of that failure may be imminent. As these indicators differ depending on whether a water source is a well or surface water, we developed two problem-reporting forms, one for ground and one for surface water sources. The well water problem report asked questions related to whether:

- The water level is below pump level.
- The water level is below the lowest level the pump can be set.
- The well is pumping air.
- The well is pumping sand.
- The system cannot meet demand.
- There is oil in the distribution system.

By checking a box on the web form next to these questions, the report simultaneously inserted risk level data into an invisible input field. If more than one box was checked, additional risk points would be added. After the data were sent to the web server database, systems users could access information about state of the system as well as quickly view an aggregate risk level measure.

- *Provide information about the level of impact of any failure incident.*

The impact of a water source failure is not always clear. This is the case because consumers whose needs are provided for by large water supply systems are typically not dependent on any single water source. Rather, the water supplier in these cases can draw on multiple supply sources. The Water Reporting System was not fully able to provide adequate information about the level of possible impact of a failure incident because of a lack of current and accurate data on water availability, particularly with respect to ground water sources.

- *Help decision makers to quickly identify both immediate impacts and the possible secondary impacts of a failure incident*

What the Water Reporting System provides in this regard is a geographic display of current water sources experiencing problems and the level of their problems, e.g., severe problems marked by a red dot, while less server problems marked by a blue dot. (With additional data such as normal well capacity, it would be possible to also show (e.g., through the size of the dots) the expected level of impact were the water source to fail or be severely impaired.) Using this display and related data, water resource managers should be able to improve their reactions to water supply problems by examining the locations of water source problems in relation to:

  - Incident reports regarding nearby water sources.
  - The relationship between a water source and its re-supply conditions (e.g., what are the overall conditions in the watershed that would lead one to expect either a worsening or a lessening of the problem).
  - The historical pattern of conditions that might indicate that a water problem experienced at Source A is related to problems later experienced at Source B. (Note: While the Water Reporting System did not have historical data of this sort, it was designed to help produce such data over time.).

- *Be flexible enough to allow users to update whenever the conditions change (e.g., due to a renewal of supply or a change in well depth).*

Tracking water supply problems in real time is difficult because conditions change rapidly. That is, after a long rain, some of the problems that might have been reported yesterday may cease to exist. In other cases, what may have looked like a problem to a nonprofessional may not have in fact been one. To complicate matters further, when operators take measures to address a problem, they may take measures that are likely to solve the problem for a considerable amount of time, or they may take steps that only provide for a temporary solution to a problem. Because of these possibilities, we felt that it would be useful to both gather some summary information about the resolved state of the water source as well as to have detailed information about the history of a problem recorded. To accomplish this goal, we designed a report that allowed Department of Natural Resources field workers to summarize the degree to which they felt that the problem had been resolved or not. Specifically, they were asked to specify whether the problem had been substantially or somewhat improved due to measures taken, or whether the problem had been resolved fully or only partially due to the resumption of rainfall or natural water flow, or whether the resource had been taken off line.

- *Track local government conservation measures*

The Task Force spent some time wrestle with the trade-off between making the reporting form easy and quick to use and the desire to gather as much detailed information about local water conservation measures. The final reporting form design tended to favor ease of use in that it only asked about whether the system had put in place, state outdoor water restrictions, restrictions more strict than the state on outdoor use, a total ban on outdoor water use, or restrictions on new water hook-ups.

PROBLEMS AND ISSUES FOR THE FUTURE

Information systems that are open to wide use typically experience accuracy problems. We identified two such problems with the WRS: 1) The likely accuracy of reports from non-professionals. Because the Task Force was interested in getting broad feedback on the condition of water sources in the state, use of the system was not limited to water professionals. In fact, the desire for reports was widely advertised. Many of the potential reporters may not have known the technical details about the state of their water source(e.g., whether their well was pumping sand, air or oil). To address the possibility of uninformed reporter, we included a question about whether the reporter was a water system professional. This information was then used to sort the professional from the non-professional reports and to prioritize the follow-up monitoring. 2) the accuracy of the water source identification. This problem arose because the naming system for water sources in the state has not been codified. That is, while the state DNR has assigned each water source a unique identification number, it is not always the case that the local operators of this source know this number or can readily provide it at the time of a report. The solution to this problem was to take the geographic coordinates of each water source and use them to create a map. This map was then made interactive over the web such that users could identify their water source by its location on the map and click on the dot representing the water source to see the existing information about that water source such as its ID number.

THE NEXT GENERATION INFORMATION SYSTEM

Development of the Water Reporting System occurred in a crisis situation where immediate needs took precedent over any urge to design a system that would optimize our ability to manage water resources in their totality. In particular, this system was limited to identifying problems at the level of isolated drinking water sources. Yet, it is commonly recognized that water problems are systems problems, or ones that involves multiple concerns about quantity and quality, use and reuse, treatment and loss, and the potential for replenishment. Obviously, an information system that could help the state to better understand the current and future state of water resources would be of great benefit. As part of the development of the Water Reporting System, we attempted to look at what kinds of data that were available or not for possible use in a larger or more comprehensive system. At a minimum, for example, such a system would need to track data at numerous levels, including:

- State level (inflow, outflow, internal flow)
- Regional by River Basins and Sub-basins and Watersheds (rainfall, aquifers, surface water (70,150 stream miles)
- Local environmental conditions (e.g., slope, use and extent of riparian buffers, amount of impervious surface)
- Local Jurisdictions (related to water management policies)
- Water Systems (drinking, agricultural, industrial).
- Water Plants (drinking treatment, pre-discharge treatment)
- Water Sources
- Water Consumers

Obviously, even within this structure there will exist overlapping data items. For example, while most water systems will tend to exist within a single jurisdiction, there may be cases where one system serves multiple jurisdictions.

We identified a number of issues regarding the state's ability to move forward with a next generation information system, including:

Water Quantity Data from Treatment Plants

These data provide an important missing link between drinking water source supply, drinking water actually consumed, and water that is returned to what may be a water source for other consumers further down a river or stream. Currently, water treatment plants in Georgia are required to complete and file monthly reports on the amount of water treated, amounts of chemicals used in the treatment, and amount of water discharged. Unfortunately, these data are only available in a paper format and are stored at the regional level. Hence, they cannot be easily incorporated into a central data system or application. Additionally, because the data are not used beyond the purpose of having a record of water treatment activity, the accuracy of the reports may not be sufficient to incorporate into a water MIS.

Stream Flow Data

USGS provides a moderate amount of real time stream flow data that could potentially be incorporated into a water management system. However, the number of observation points is not likely to be sufficient to provide for analysis or early warning of water supply incidents.

Rain Fall Data

The University of Georgia's College of Agriculture hosts a large database containing current and historical data on rainfall amounts in areas across the state. Whether these data provide sufficiently accurate estimates of watershed-specific replenishment would need to be determined.

Water Quality Data

Measures of water quality that could provide the state with the ability to identify relationships between specific water events (e.g., heavy, light, or lack of rainfall; drought conditions; excess consumption conditions, etc.) and water quality represent the ideal in a water management information system. For the most part this level of data is not available. Moreover, the water quality data that do exist are collected by dozens of different agencies and organizations, including numerous cities, universities, federal agencies (USGS, U.S. Forest Service, Tennessee Valley Authority), and the water management departments of bordering states.[1]

Environmental Data: Environmental data include data on factors that might relate to both the flow of water and water quality. Some of these data such as land slope and soil type already exist in forms that make it possible to integrate them into more comprehensive analyses. Other important data will be available soon as part of a study being conducted at the University of Georgia's Institute of Ecology. This study will use high-resolution satellite and aerial photography to produce GIS-based data (or estimates of data) on vegetation amounts and type as well as data on impervious surfaces and other land-use related features. The availability of such data will make it possible to begin to relate water quantity, water flow rates, and water quality outcomes to specific combinations or patterns of environmental characteristics. These finding in turn could be used to identify the practices and remediation programs with the greatest potential to produce desired outcomes at the least cost. Such findings could help policy makers to put in place a more effective package of sanctions and incentives than currently exists.

Water Conservation Policy and Practice Data

Data on just how water is used and conserved in the state may represent the largest hole in the vision for a comprehensive water management information system. Currently, local and state governments put in place policy tools with only the hope that these tools are actually effective. The current policy tools, which include various bans or restrictions on outdoor watering, tend to be focused on emergency situations. Even for these policies very little is known about their relative effectiveness. However, there are numerous other policies (e.g., allowing or supporting the use of gray water or encouraging retention of storm water at the residential level, etc.) that need to be examined for their relative costs and effectiveness.

DATA MANAGEMENT ISSUES

Because of the diversity of data sources, ownership, accuracy, and level of motivation to provide data, the management of data resources will likely be crucial to any effort to develop an enterprise-level water management information system. In this regard, action will be needed in three areas:

1. *Administrative*: Data systems are difficult enough to create and use within a single agency. They become nearly impossible to develop and employ when their creation and maintenance require collaboration on the part of several agencies. In this regard, the state will likely need reforms related to the funding of data collection, the training of data collectors., the

[1] **USGS (U.S. Geological Survey (2000)**: Provides 14 real-time monitoring stations for suspended sediment. Approximately 80 sites for real-time flow monitoring. During the past 30 years, the U.S. Geological Survey (USGS) has operated two national stream water-quality networks the Hydrologic Benchmark Network (HBN) and the National Stream Quality Accounting Network (NASQAN). The water-quality data include a set of 63 physical, chemical, and biological properties. Unfortunately, Georgia site data are only available for 6-8 active sites at the present time, although historical data on additional sites are available for research purposes. **U.S. Army Corps of Engineers:** Gathering data on the Alabama-Coosa-Tallapoosa and Appalachicola-Chattahoochee-Flint basins. Also, the USACE is conducting a comprehensive study of the Savannah River basin. **DNR-EPD**: Water monitoring is conducted based on the classification of water uses. As such, different measures may be used for different classification such as water for recreational, drinking, or agricultural use. DNR-EPD has adopted 31 standards for the protection of aquatic life and 90 standards for the protection of human health (Georgia Department of Natural Resources (2000). Water quality data are gathered at approximately 100 core stations, while additional more intensive and detailed data collection is conducted periodically at basin-specific sites. Core station trend monitoring data are available on a monthly basis, while the agency's targeted monitoring of specific river basins is conducted on five year cycles. Adopt-A-Stream: This EPD sponsored program receives data gathered from volunteers that have been trained to provide 'quality assured' data on water in streams, rivers, and lakes. Volunteers provide chemical monitoring data on average once a month for approximately 200 sites. However, sites tend to be concentrated in area where there are active groups. They also provide about 30 biological monitoring data points once a season. In general, the Adopt-A-Stream is not integrated into other EPD systems.
Some of the water quality data collected by EPD is actually collected by USGS under a cooperative service contract. As such, there may be substantial overlap between these two data systems. Additionally, operators of water treatment plants report data to the EPD. While operators' water quality reporting is mandated, the actual water testing by plant operators is conducted on a self-monitoring basis.
Because of the successful lawsuit that has resulted in the state needing to address TMDLs on a shorter cycle than is likely to be the case for most states, Georgia will probably need to increase its data collection as part of showing that it is meeting the settlement requirements related to TMDLs.
In addition, environmental interest groups are also collecting and analyzing TMDLs as part of the lawsuit settlement process.

responsibility for oversight of data collection and management, and the availability of resources and incentives for maintaining such a system.

2. *Policy*: Administrative consolidation of responsibility for data collection, management, and use will only go so far. There will always be data that are collected and owned by agencies that are not directly accountable to the state agency put in charge of a water management information system (e.g., certified volunteers, research scientists, USGS, etc.). In this respect, policy can help fill in some of the gaps. For example, the state could develop policies that would set a standard for data quality, data formats and collection sites and intervals, as well as technical standards for data availability (e.g., on the Internet). Any agency or group that followed these standards could have their data incorporated into the official water management information system. A model for this type of policy development exists within the state geographic information system clearinghouse. The policies developed for this operation has enabled diverse providers and users of GIS data to share their products and services across departments, sectors, and interest areas.

3. *Technology*: By working with other groups to develop and use standards for data sharing, the state should be able to lower the on-going costs of a water management information system. As part of our development of the web-based Water Reporting System, we explored current inter-source data sharing capabilities within the framework of existing web-based data sources. In particular, we attempted to incorporate a relevant piece UGA College of Agriculture rainfall data into a water source problem report. This experiment essentially involved having the web master at the College insert a couple of lines of code into the existing rainfall data-reporting web page. These lines of code created a hidden HTML field with the data value of the rainfall on the day of the Water Reporting System report. Essentially, the web page used in reporting a water source problem included code that would simultaneously open the relevant web page with rainfall data, grab the figure, and incorporate it into the water source problem-reporting page as a field value. As a consequence, it was possible to store some important context information about a water source problem. While technology "work arounds" like this one can be developed, they are unlikely to represent a long-term solution to the problem of integrating relevant data from multiple and disparate sources. In the long run the development of common data formatting policies based on XML document and data standards will likely represent a more viable approach to this problem. USGS has already taken a number of steps in this direction already (Federal Geographic Data Committee, 2000). A similar and cooperative effort to develop and use of XML standards at the state level could enable, for example, any provider or user of information published in an XML standard on the web to employ and integrate data elements produced by other providers who use the same standards.

CONCLUSION

In comparison to the Water Reporting System, the next generation water MIS needs will have the advantage of being integrated with on-going reporting requirements and can therefore enhance its acceptability by offering short-cuts and easier reporting procedures than is currently the case with paper-based reporting. Additionally, this system can be designed to be seamless from the outside while integrating data from multiple sources on the inside. The key question as to the development of such a system is related to matching expenditures and benefits. That is, while the development of such a system would be in the general public interest, the cost of its development would typically fall on a single agency. Whether the unique benefits for such an agency justify the cost of the system will likely determine whether such a system is built in the near future.

SELECTED REFERENCES

Georgia Department of Natural Resources (2000). *Water Quality in Georgia 1998-1999*. Environmental Protection Division, Atlanta, Ga.

U.S. Geological Survey (2000). Review of Water Data available at: http://water.usgs.gov/data.html

Federal Georgraphic Data Committee. (2000) http://fgdc.gov/index.htmland http://www.fgdc.gov/metadata/metaxml.html