

Report to Management: Groundwater Assessment Program Pilot Study



by
Charles F. Pitz, L.G., L.H.G.

Environmental Assessment Program
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For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600
Olympia, WA 98504-7600

E-mail: jlet461@ecy.wa.gov

Phone: (360) 407-6764

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Cover photo: Using an air-rotary drilling rig to install a groundwater monitoring well in Centralia, Washington.

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Abstract

Washington State citizens are recognizing the high value of the state's groundwater resources. Groundwater provides fresh water for our homes, industry, agriculture, and the natural environment. Groundwater, however, is a limited resource that is vulnerable to both contamination and overdraft. The long-term availability of a clean, reliable supply of groundwater will clearly be a key component of managing the state's complex water resource challenges, and ensuring a healthy environment and economy into the future.

Nearly two-thirds of state citizens already depend on groundwater as a safe drinking water source, and demand for additional groundwater withdrawals is expanding rapidly across the state with population growth and restrictions on further surface water withdrawals.

As an integral part of the hydrologic cycle, groundwater is also increasingly recognized for the important role it plays in influencing surface water flows and quality. Discharge from state groundwater aquifers sustains streamflow throughout the biologically critical low-flow season, and affects the habitat value of streams, lakes, wetlands, and estuaries across Washington.

Despite the significance of the resource to Washington citizens, there is currently no strategically organized, state-level program to monitor and assess larger-scale ambient groundwater conditions. The Washington State Department of Ecology (Ecology) monitoring and management efforts remain heavily focused on surface water resources. The limited information and understanding we have about the status, behavior, and availability of groundwater continues to hamper both state and local efforts to manage our water in a proactive, cost-effective manner.

From 2003 through 2005, Ecology's Environmental Assessment Program conducted a pilot test of a proposed state groundwater monitoring and assessment program to help address this important information need. This report summarizes the key lessons and recommendations from that effort.

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Introduction

Although unseen, groundwater is a vital natural resource for Washington State. The availability of a clean and plentiful supply of groundwater will exert a significant influence on the state's economic and environmental future.

Groundwater is a critical source of safe water supply for Washington State, and demand for groundwater is rising.

Groundwater is the source of drinking water for the majority of Washington's six million citizens, and currently supplies over one-quarter of the total freshwater demand in the state, including irrigation and industrial uses (Hutson et al., 2004). As the state's population expands in the coming years, much of the growth in water use will likely be supported by increases in groundwater withdrawals. In fact, each year approximately 7,000 new water supply wells are installed into state aquifers (Szymarek, 2006).

The rising demand for groundwater is, in part, a response to restrictions on new surface water withdrawals and storage reservoir projects, imposed in the effort to restore and protect aquatic habitats. Drought conditions, as well as long-term concerns about changes in regional climate and runoff patterns, have also driven interest in the use of aquifers to meet the state's water supply needs. Most recently, the state has been actively evaluating the potential for large-scale aquifer storage and recovery (ASR) systems to help mitigate declining streamflows and augment water supply during the dry season.

Groundwater is a fundamental component of the hydrologic cycle that can significantly influence surface water flow, water quality, and habitat value.

In addition to serving as a key source of water supply for human use, groundwater plays an important, if less-recognized, role in our state's environmental quality. Many recent studies have highlighted the principle that groundwater and surface water are, in reality, a single, interconnected resource. Discharge from state groundwater systems sustains stream and river baseflow during the biologically critical low-flow season, and is an important factor in maintaining the water quality and habitat value of streams, lakes, wetlands, and estuaries throughout Washington (Sinclair and Pitz, 1999; Winter et al., 1998; Alley et al., 1999).

The sizeable restoration and management investments the state makes in surface water systems will have limited success if we fail to recognize and account for the interconnection between groundwater and surface water. Watershed planning efforts, Total Maximum Daily Load (TMDL) studies, and water resource permitting decisions across the state have helped prompt a growing appreciation of the key role that groundwater plays in basin water budgets.

The quality of groundwater in state aquifers has been significantly impacted by overlying human activities, and groundwater remains at risk of further contamination.

Groundwater is vulnerable to both point and nonpoint sources of pollution, and it is difficult and costly to remediate groundwater once contamination occurs. As our primary drinking water resource, we need to ensure a groundwater supply that is free of pollutants that place human health and the environment at risk.

We know that humans have already had a significant impact on the quality of water in state aquifers. Recent studies have shown that large portions of important regional groundwater systems within the state (for example, the central Columbia Basin and Sumas-Blaine systems) currently fail to meet drinking water health criteria for nitrate due to widespread infiltration from overlying land-use activities (Frans, 2000; Cox and Kahle, 1999). Each year, water supply wells in the state are abandoned or deepened due to chemical contamination, and some public water system operators need to mix clean and contaminated water from well fields to meet Washington State drinking water standards (WDOH, 2006).

The quality of state groundwater remains under pressure from a variety of potential sources. These include accidental chemical spills, irrigation loss from large-scale agricultural and land application operations, seawater intrusion from overpumping, and ongoing contaminant releases from point sources such as landfills, industrial sites, and commercial facilities.

In addition, more than 700,000 household, municipal, and industrial on-site septic systems across the state currently discharge effluent to the subsurface (WDOH, 2007). To protect surface water habitats and enhance recharge, stormwater runoff from urban and suburban communities is increasingly directed to drywells and groundwater infiltration basins. And reclaimed wastewater from a growing number of municipal treatment plants is now returned to underlying aquifer systems (Cupps and Morris, 2005).

We normally assume that the soil column overlying aquifers will filter the complex mix of dissolved chemicals borne by water from such sources. In reality, we have limited knowledge of the *cumulative* effects of these inputs on the ambient¹ groundwater quality of the state. In spite of the susceptibility of aquifers to contamination, few of the one million state citizens using private wells for domestic supply have had a comprehensive test of the quality of their drinking water.

¹ The term “ambient” refers to large-scale or area-wide conditions (i.e., conditions not associated with a specific point source, facility, or property).

Overdraft of groundwater – and the associated declines in water levels, aquifer storage volumes, and downgradient surface flows – are ongoing concerns for the state.

As groundwater use expands, concern about the depletion of storage, as well as the related consequences to pumping costs, stream discharge, and riparian and wetland habitat quality, will grow.

In the Odessa area, for example, extraction of water for irrigation has already led to large declines in regional groundwater levels, essentially mining the water stored beneath the land surface (173-128A WAC, 1988). Rapid annual decreases in storage in aquifers providing municipal water supplies have also been experienced in communities such as Pullman and Vancouver (Lum, et al., 1990; McFarland and Morgan, 1996). Recent drought conditions have resulted in a number of citizens reporting dry domestic wells.

Aquifer depletion can be further complicated by reductions in the annual recharge that replenishes these systems. Deforestation, the expansion of impervious surfaces that accompanies land development, and changing regional climate patterns (with associated reductions in annual snowpack and increases in surface runoff) may all contribute to a decrease in recharge rate to state aquifers in the coming years.

The hydraulic interconnection between groundwater and surface water means that groundwater withdrawal for supply can also lead to cumulative reductions in natural discharge from aquifers (or even capture of surface water), contributing to declining flow in downgradient rivers and streams (Winter, et al., 1998; Morgan and Jones, 1996; Alley et al., 1999). In many areas, we lack site-specific knowledge about the timing, location, and degree of exchange between groundwater and surface water systems. This limits our ability to accurately correlate the effect of groundwater development on surface water conditions.

Despite the high value of groundwater and the stress on this resource, there is no systematic state program to monitor and assess larger-scale ambient groundwater conditions.

Effective environmental management depends on an accurate understanding of conditions in the field, and measurements collected by systematic, high-quality monitoring programs are essential to that understanding. With this purpose in mind, state ambient monitoring programs have been established in Washington for air, surface freshwater quality and flows, marine water and sediment quality, beach health, environmental toxins, stream biological health, and even invasive aquatic plants.

There is no state-level, strategically organized ambient monitoring program for groundwater.² This is despite the fact that from half to two-thirds of Washington's drinking water supply is currently derived from groundwater, and accelerating demand for additional water will be largely met by withdrawals from aquifer systems.

² The Washington State Department of Health does oversee routine monitoring of water quality of drinking water drawn from public water supply wells, but samples are normally collected at the point of use (for example, after treatment), and are not necessarily representative of ambient groundwater conditions.

Groundwater monitoring efforts are taking place in Washington. A variety of local, regional, state, and federal organizations (as well as private consultants) conduct groundwater studies and measurement (see Pitz, 2003, and www.ecy.wa.gov/programs/eap/groundwater/survey.html for detailed reviews). However, the work that is conducted is not well coordinated, and the monitoring results vary widely in quality, duration, and level of documentation. The data produced are often difficult to access, and there is no central repository for the information generated by the various groups conducting the work. Many of the monitoring efforts are conducted on an ad-hoc basis in response to an existing water resource problem, and are therefore often focused on a single parameter, measurement type, or facility.

Outside of the larger, better-funded communities, there remain areas of the state that still lack *baseline* information about basin-scale groundwater conditions, ambient character, and behavior. The absence of information continues to hamper the Washington State Department of Ecology's (Ecology) and local communities' ability to cost-effectively and proactively manage the groundwater resource.

Groundwater is a complex, large-scale, three-dimensional resource, with a high degree of spatial variability. Accurate groundwater monitoring can be difficult and costly. The long time-scales for groundwater recharge and transport in aquifer systems often require long periods of measurement record to reach definitive conclusions about changes in condition. However, the longer the state waits to initiate a comprehensive monitoring strategy for groundwater, the more difficult it will be to recognize and manage larger-scale, groundwater-related problems. As a *discretionary* responsibility of the state's lead water management agency, groundwater monitoring has not been a significant funding priority for Ecology. The attention paid to groundwater has not been equal to the value of the resource to state citizens.

Background of the Pilot Study

Concerned about the lack of a strategic approach to monitoring state groundwater conditions, managers from the Environmental Assessment Program (EAP, the primary monitoring and technical services branch of Ecology) requested an evaluation of how EAP could best help the state meet current and future information needs for the groundwater resource. In response to this request, Pitz (2003) reviewed groundwater monitoring efforts within Washington and developed a list of recommendations for managers' consideration. In addition to steps focused on mining existing data and improving coordination between organizations that collect groundwater information, Pitz proposed a technical approach for a state-level monitoring and assessment program.

After evaluating alternative program designs and interviewing a variety of stakeholders about their groundwater information needs, Pitz recommended that EAP conduct a series of basin to sub-basin scale groundwater monitoring studies. Instead of focusing solely on water quality conditions (the approach taken by many other states), the proposed studies would use a more comprehensive monitoring design. Monitoring would be conducted hand-in-hand with characterization of the study area hydrogeologic setting to facilitate data interpretation. The relatively small scale of the studies (in contrast to a statewide network) would require Ecology water programs to collaboratively prioritize the locations and order of the areas selected for study. Technical details of the proposed program were presented in Pitz (2003). Pitz recommended that Ecology run a pilot test of the approach to help refine the costs and feasibility of the proposal.

In October 2002, EAP received a \$100,000 start-up grant from the Region 10 office of the U.S. Environmental Protection Agency to help launch the pilot test, funded through Section 104(b)(3) of the Clean Water Act. With these funds in hand, EAP, with support from Ecology's Southwest Regional Office (SWRO) water management team, identified a high-priority study area that would benefit from baseline groundwater monitoring and characterization.

The pilot study focused on the surficial aquifer system underlying the Chehalis and Newaukum River valleys in Lewis and Thurston Counties of southwestern Washington. The area was originally suggested by a SWRO watershed lead. The suggestion was based, in part, on the fact that the Chehalis Basin Watershed Planning Partnership had recently identified reliable information about the local groundwater system as a high-priority data gap in their planning process. This need has been echoed by a number of the Ecology watershed leads interviewed over the past several years.

The pilot study was conducted during 2003-2005, and included the four key components of the proposed technical approach:

1. Study area hydrogeologic characterization to provide the physical context for interpreting the monitoring data.
2. Monitoring of ambient groundwater quality conditions.
3. Monitoring of ambient groundwater level conditions.
4. Monitoring of groundwater/surface water interactions.

The final technical report and map plates for the pilot study, *Washington State Groundwater Assessment Program: Hydrology and Quality of Groundwater in the Centralia-Chehalis Area Surficial Aquifer*, are available online at www.ecy.wa.gov/biblio/0503040.html (Pitz et al., 2005). This document is a good example of the type of information and report that would be generated by a continuing groundwater assessment program.

Pilot Study Resource Estimates

Table 1 summarizes project costs for the pilot study, including salaries, equipment, permitting fees, legal support, monitoring well installation, and laboratory costs. The total cost for the pilot project was approximately \$353,000.

The cost of the pilot study was comparatively low due to a number of factors, including the low staff classification and salary level of the project field lead, the lack of overnight travel costs, limited monitoring well installation costs, small size of the pilot study area, and the ability to depend heavily on existing EAP supplies and field equipment. The pilot study cost estimate does not include the time spent by project team members on the development of a new database that was created to manage the large amount of information generated during the project.

Table 1. Summary Pilot Project Costs for the 2003-05 Chehalis River Valley Study (Pitz et al., 2005)

Category	Cost	Comments
Salaries, benefits, indirect	\$262,791	Database development not included in salary cost for pilot study - not considered a recurrent project task
Equipment and fees	\$12,500	Project run using existing EAP field equipment, mostly consumables and fees
Laboratory services	\$67,240	Full lab price (includes lab base funding)
Monitoring well installation	\$8,800	2 monitoring wells
Travel	\$2,000	No overnight travel costs for the pilot study
Total	\$353,331	Project run over 2.5 years

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Pilot Study Lessons and Recommendations

With some modification, the characterization and monitoring approach used during the 2003-05 pilot study is judged to be a successful and cost effective method of assessing ambient groundwater conditions, and is recommended as the basic design for a more permanent state program. The approach (1) facilitates interpretation of the monitoring data collected, (2) synthesizes information that is useful to a wide audience both inside and outside of Ecology, and (3) generates data that is directly applicable to a variety of Ecology business needs. The monitoring and characterization work conducted during Groundwater Assessment Program (GAP) studies can be readily integrated with data collection efforts by other organizations. If consistently applied, the approach will provide credible, comparable, and unbiased groundwater information in high-priority areas of the state.

The technical approach tested during the pilot study is focused on collecting accurate field measurements at the basin or sub-basin scale. The approach is *not* intended to directly resolve specific water management problems faced by local communities (for example, water supply shortages). This does not lessen the value of the information gained from such a program. The basic descriptive information and measurements generated by studies using the proposed approach are fundamental requirements of all groundwater-related management solutions, and lay the groundwork and physical context for more focused studies. This includes providing information critical to the development and calibration of numerical groundwater flow models, a primary tool that will be used in the coming years to guide aquifer development in Washington.

Assuming a permanent groundwater assessment program will eventually be established within Ecology, the important lessons and recommendations generated as a result of the GAP pilot study are listed below:

Study area selection

- In the process of prioritizing and selecting future study areas, the likelihood for strong, on-the-ground interest and support from the local community (most importantly support from local government, water utilities, conservation districts, and health departments) should be the top ranking/selection criteria. More than other environmental media that Ecology surveys, groundwater monitoring studies depend heavily on access to locally-owned property and wells; if there is resistance on the part of the community to a study, the work is not likely to succeed. Hand-in-hand with local support, internal Ecology proponents for a study (for example, watershed leads with strong local ties, regional hydrogeologists with good working relationships with local permittees) are essential for facilitating access for study teams.
- To ensure the areas of greatest information need are addressed first, and to maximize the benefit of future studies to as many users as possible, study area selection should be a collaborative process between local communities and Ecology staff from EAP, Water Resources, Water Quality, and Shorelands and Environmental Assistance (SEA) Programs.

- Whenever possible, the timing of groundwater assessment and monitoring studies should be coordinated with, and preferably precede, other work Ecology is pursuing that could benefit from the study findings (for example, the development of a TMDL model).

Implementation

- In the future, GAP studies should be operated as a technical assistance service that Ecology provides to Washington communities, versus a government program that is imposed on citizens. The non-regulatory nature of the program should be emphasized to study area residents.
- There may be pressure on study teams to investigate issues outside the scope of the monitoring studies proposed. Project teams will need to accommodate the information needs and hydrogeologic setting unique to each individual study area. However, to control program costs and continue to complete studies on a reasonable schedule, it will be important to maintain the focus on the ultimate goals of the GAP (i.e., the measurement and description of current field conditions).
- The 2003-05 GAP pilot study covered an area of approximately 32 square miles. The project budget for the study allowed for the analysis of water quality in approximately 50 wells and 12 instream piezometers, in addition to water level measurements in approximately 100 wells. Assuming the money available for monitoring is a fixed cost during future studies, increasing the size of the study area will reduce the density of the monitoring information. In selecting future study areas, the regional water programs will need to work closely with EAP groundwater study teams to find the appropriate balance between the desired study area size versus the complexity of the study area hydrogeology, the study goals, and the project budget. In most cases, the monitoring approach is probably best suited to study areas no greater than 50 to 100 square miles in area.
- EAP hydrogeologists should work closely with the regional Ecology water program hydrogeologists during all future studies, drawing on their expertise in the local hydrogeologic conditions, and whenever possible recruiting their assistance during large field measurement events. Regional hydrogeologists could be particularly helpful in identifying and arranging access to local monitoring wells at facilities permitted or overseen by Ecology. Developing a regional interest in the study areas also increases the chances that ongoing monitoring will continue beyond the completion of the study.
- The scope of a study like the pilot project requires a broad variety of skills to complete successfully. The skills necessary are often beyond the ability of any single hydrogeologist. All future studies should be run using a multidisciplinary team of Ecology staff members, with differing expertise. This approach also provides opportunities for staff to learn skills outside of their primary area of experience.

- EAP should consider the possibility of entering into a cooperative agreement with the Washington State Department of Natural Resources, Division of Geology and Earth Resources, to access the division's expertise in geologic and stratigraphic mapping in support of groundwater characterization studies.
- To remain cost effective, the use of senior staff for routine field monitoring should be minimized. Study teams should be organized in a manner similar to the EAP field teams used for TMDL studies, with a junior scientist running the bulk of the field monitoring and data management tasks, and senior scientists working primarily on project management, well installation, data interpretation, and report writing.
- The skill level of the employee acting as the field lead was critical to the success of the pilot study. It is recommended that if a permanent GAP is established, field lead positions be classified no lower than the Hydrogeologist 1 level. The required education and experience for this class is better suited to the types of knowledge needed for such studies than the administrative intern or entry-level environmentalist class.
- Under the proposed monitoring design, large-scale seepage evaluations are a routine field task for each study. Depending on the size and complexity of the study area surface streams, study team hydrogeologists may often need technical support from EAP stream-hydrology staff to complete an evaluation (for example, conducting flow measurements on large, non-wadeable rivers). The ongoing need for this type of cross-program support within EAP should be accommodated during the annual EAP project planning effort.

Administration, policy issues, and program funding

- EAP managers should continue to actively pursue avenues to obtain a *long-term* funding source for a state groundwater monitoring program, including the funds necessary to sustain permanent trend monitoring stations after the completion of individual studies. Relying on short-term grants or other year-to-year funding sources is not an effective foundation for such a program.
- To help support an ongoing groundwater assessment program, EAP should consider opportunities for cost sharing with other Ecology programs or other agencies that may benefit from the information. One example could be for other interested state agencies to fund the analysis of water quality parameters of particular interest that are not routinely tested. This approach will need to be balanced with the reality that expanding the list of contaminants tested can reduce the willingness of well owners to participate in a study (for example, testing for pesticides in a community that is economically dependent on agriculture).
- The installation of instream piezometers is a fundamental field task of the proposed technical program, as well as many other recent EAP groundwater investigations. As currently written, state law requires that a licensed driller or engineer be present during piezometer installation. This requirement can significantly increase the cost and logistical complexity of groundwater studies. EAP managers should consider supporting a Legislative request to

amend the current law to add licensed hydrogeologists (per Chapter 18.220 RCW) to the list of persons legally allowed to install piezometers.

- If possible, master agreements should be negotiated with appropriate state-level permitting agencies to provide a programmatic waiver or general permit for piezometer installation (e.g., Washington State Department of Natural Resource's aquatic use permit, Washington Department of Fish and Wildlife's hydraulic project approval; Ecology's well drilling variance). Streamlining the permitting requirements for piezometer installation for each individual study would greatly reduce the level of effort typically required for such work.
- Groundwater studies that involve sampling drinking water supply wells can have significant public health repercussions and can result in extra time demands directly or indirectly related to public relations (for example, preparing press releases, conducting public meetings to present study results, coordinating with local and state health departments). EAP managers should anticipate this workload when developing the EAP Public Information Officer's annual work plan.
- Standard field and office operating procedures employed for groundwater assessment studies should be documented in a central manual for use by project study teams. Similarly, boilerplate language for quality assurance project plans should be developed to streamline the early stages of project planning. Standardized and documented techniques improve the credibility of the data collected and allow comparison of conditions from location to location.
- EAP should develop appropriate guidelines in anticipation of policy issues that might arise during future groundwater studies. For example, EAP should have in place an agreed-upon procedure for occasions when monitoring data collected from drinking water supply wells indicate that water quality is failing public health criteria, either for an individual well, or on an area-wide basis. Similarly, EAP should establish program policies for issues surrounding well-owner anonymity and data sharing.

Technical design

- The technical approach tested during the 2003-05 pilot study (Pitz et al., 2005) requires that the hydrogeologic setting of the study area be characterized in tandem with the monitoring program. While this characterization work can add considerably to the overall FTE and cost of a study, the effort also significantly increases the value of the monitoring measurements and final technical product. Presumably the cost of future projects could be significantly reduced in those study areas where aquifer characterization work has already occurred and the local hydrogeologic setting is well understood. Similarly, while the use of a more comprehensive monitoring design – with measurements of water levels, water quality, and groundwater/surface water interactions – raises the cost of each study, it also greatly extends the usefulness and cost benefit of the project to a variety of water managers within and outside of Ecology.
- Consideration should be given to expanding the basic list of water quality analytes evaluated during the pilot study. Additional constituents could include, for example, fecal coliform,

“diagnostic” parameters such as caffeine and stable isotopes, emerging contaminant classes such as pharmaceuticals, and additional toxins such as heavy metals, MTBE, or perchlorate. To offset an increase in project laboratory costs resulting from an expanded list of analytes, it is recommended that the frequency of monitoring events for water quality for all future studies be reduced from the original pilot study schedule to only two major sampling rounds for all wells and piezometers: once at the end of the wet season (May), and again at the end of the dry season (Oct). While the reduced sampling frequency does result in less temporal resolution on water quality changes over short timeframes, the proposed schedule is judged to be appropriate to the overall technical goals of the program.

- Future ambient monitoring and characterization studies should be used by EAP as a routine “proving ground” to test new groundwater field methodologies, with particular emphasis on expanding the use of automated data collection techniques to increase cost efficiency. Successful methods that do not significantly expand the scope of work should be adopted as a standard method for future program studies.
- The use of randomized statistical techniques should be explored for future studies when selecting wells for monitoring.

Data management

- The database developed during the pilot study will be a mission-critical tool for EAP hydrogeologists for future GAP projects and other large-scale EAP groundwater studies. A continuing effort should be made to maintain and enhance the initial version. A “user’s manual” should be developed documenting routine database tasks to aid users. EAP managers need to recognize that as the complexity and number of users of the database expands, the need for technical support from an EAP information technology specialist will grow. The need for assistance with database debugging, tools enhancement, and upsizing to a server-based version is anticipated in the future.
- Large amounts of project information, including field monitoring measurements, well construction details, and geologic interval data, are generated during GAP studies. EAP should standardize protocols for importing this data into Ecology’s Environmental Information Management (EIM) database. This effort will likely require ongoing assistance from EIM technical support staff.
- The new GAP database has significantly improved EAP hydrogeologist’s ability to areally map point monitoring data using geographic modeling software. Data interpretation and report map creation could be greatly enhanced by development of a 2-D and 3-D geologic cross-sectioning and visualization capability. EAP managers should fund the purchase of, and training in, appropriate visualization/modeling software for this purpose.
- A web page dedicated to the Groundwater Assessment Program (GAP) should be added to the existing EAP groundwater team website. This web page should be used to organize all reports generated by the GAP, and could serve as an online “atlas” of ambient groundwater conditions as studies are completed.

Long-term monitoring

- An important goal of the GAP program design is the establishment of long-term trend-monitoring stations for both groundwater quality and groundwater levels. Information collected during individual GAP studies can help to guide the selection of “index” well locations that are representative of broader-scale conditions. As proposed, this would be accomplished by obtaining local permission to drill (and have permanent access to) dedicated monitoring wells in each study area selected. This would gradually build, and add to, a network of wells in strategic locations of the state.

Efforts to gain permission to build such wells met with mixed success during the 2003-05 pilot study, and this will likely continue to be a difficult task in future studies. The high value of having access to long-term monitoring stations in representative locations suggests it is worth the effort to keep trying. Again, strong local support for studies will be a critical factor in accomplishing this goal. If the GAP is established, EAP managers will need to plan for the resources necessary to operate an ongoing trend monitoring program above and beyond the resources dedicated to individual studies.

- Ecology Water Resources Program hydrogeologists have been maintaining regional water-level monitoring networks for many years. Water level monitoring conducted during GAP studies should not be considered a replacement or substitute for these regional systems. Ideally, dedicated trend monitoring wells installed during GAP studies will be integrated into the appropriate regional Water Resources Program monitoring network for continued measurement after the completion of the study. Such wells should, whenever possible, be instrumented for the long-term with dedicated, recording pressure transducers.
- No equivalent regional monitoring for groundwater *quality* occurs within Ecology. In light of the more complex infrastructure requirements for defensible water quality sampling (for example, pumps, meters, laboratory services, quality assurance programs), future trend monitoring for groundwater quality will likely remain EAP’s responsibility.

EAP groundwater staff currently work on a number of important special studies in support of Ecology regulatory or permitting activities (for example, TMDL groundwater support studies). Unless a new, dedicated source of funding is established to launch the GAP proposal and hire additional staff, EAP and Ecology managers will need to balance the demands for such work with the resources necessary to carry an organized state groundwater monitoring program forward. Since the technical approach and field activities often overlap, one option is to simply redirect the bulk of current hydrogeologist staff time to a GAP structure, essentially changing how we do business while still meeting similar goals. Under this scenario, the demand for groundwater information to support important Ecology initiatives would be a key consideration when prioritizing and selecting future study areas.

EAP managers should also continue to balance GAP field monitoring efforts with some of the other priorities outlined by Pitz (2003) such as data mining efforts of valuable existing information. The establishment of a formalized groundwater assessment program would amplify the need for EAP to improve cooperation and data sharing with other Ecology and non-Ecology groups also collecting groundwater data.

Options and Costs for a Permanent EAP Groundwater Assessment Program

The 2003-05 pilot study in the Chehalis River Valley (Pitz et al., 2005) successfully demonstrated a technical approach that could be used as the framework for a permanent groundwater monitoring and characterization program for Ecology. Depending on the level of demand and resource commitment, a permanent program could be assembled using any number of study teams, simultaneously conducting monitoring studies in different parts of the state.

Similar to the pilot study, study teams would be organized around two senior hydrogeologists with differing expertise (with one serving as the project manager for the study), and a junior scientist managing the field monitoring program. To reduce costs, improve project logistics, and address significant regional differences in hydrogeology, study teams would be based in a regional or headquarters office. It is assumed that each study team could complete one study per biennium, although the specific project schedule would be dictated by the size and complexity of the study area. The pilot study technical report mentioned above provides an example of the type of product that would be generated by each study.

Tables 2A and 2B present the estimated costs, in present dollars, for two permanent program options:

- Option A: two study teams – one based in and dedicated to eastern Washington, and one based in and dedicated to western Washington.
- Option B: four study teams – one per Ecology region (Northwest, Southwest, Central, and Eastern).

Cost estimates include salary, equipment and fees, laboratory services, monitoring well installation³, and travel. The total estimated *biennial* cost for establishing a permanent groundwater monitoring program for Washington ranges from approximately \$1.1 to \$2.2 million. These estimates indicate an individual GAP study would have an average cost of approximately \$550,000 in present dollars. Actual study costs would be influenced by the size and hydrogeologic complexity of the study area, as well as the amount of existing information.

³ Monitoring well installation costs are strongly dependent on site conditions and hydrogeologic setting. As a result, estimates of the costs of this important aspect of a long-term program have a significant level of uncertainty.

Table 2A. **Option A** – Estimated Biennial Costs for a Permanent EAP Groundwater Assessment Program

Category	Estimated Cost (in present \$)	Comments
Salaries, Benefits, Indirect	\$803,000	Two GAP teams: one in western Washington (w/ program coordinator); one in eastern Washington
Equipment/Fees	\$60,000	Cost includes purchase of major field equipment and project consumables for 2 teams ⁴
Laboratory	\$160,000	Assumes reduction in frequency of monitoring from pilot, but expansion of analyte list - lab price includes lab base funding (2 projects)
Monitoring Well Installation	\$36,000	Assumes 4 monitoring wells per project (\$4500/well) ⁵
Travel	\$40,000	8 staff * 12 weeks travel * \$416/week/staff member
Total Estimated Biennial Cost	\$1,099,000	(~\$550K/year)

Table 2B. **Option B** – Estimated Biennial Costs for a Permanent EAP Groundwater Assessment Program

Category	Estimated Cost (in present \$)	Comments
Salaries, Benefits, Indirect	\$1,587,000	Four GAP teams: one per Ecology region – NWRO, SWRO, CRO, ERO (1 team hosts program coordinator)
Equipment/Fees	\$120,000	Cost includes purchase of major field equipment and project consumables for 4 teams ⁴
Laboratory	\$320,000	Assumes reduction in frequency of monitoring from pilot, but expansion of analyte list - lab price includes lab base funding (4 projects)
Monitoring Well Installation	\$72,000	Assumes 4 monitoring wells per project (\$4500/well) ⁵
Travel	\$80,000	16 staff * 12 weeks travel * \$416/week/staff member
Total Estimated Biennial Cost	\$2,179,000	(~\$1.09M/year)

⁴ Estimated cost represents a “startup” cost necessary to obtain new team equipment; ongoing cost would typically be lower.

⁵ Monitoring well installation costs are strongly site-dependent; estimate has significant uncertainty.

Summary

Groundwater is a vital natural resource for Washington State. Ensuring an adequate supply of clean groundwater will be critical for the state's economic and environmental future.

Groundwater not only serves as an important source of safe water supply for state citizens and industry, but also plays a key role in sustaining the flow and quality of our surface water systems. Demand for groundwater is rising in Washington, and so is demand for information about the resource. Unfortunately, state aquifers are already under stress, showing signs of both human impacts to groundwater quality, and the effects of overdraft.

Despite the high value of the resource, Washington has not, to date, established a systematic state program to monitor and assess ambient groundwater conditions. As the primary technical services branch of Ecology, the Environmental Assessment Program (EAP) has recently been investigating the idea of establishing such a program. A proposed technical framework for a state groundwater program was pilot tested in southwestern Washington during 2003-05. The cost estimates, benefits, and lessons learned from the pilot study have been used to guide the development of a proposal for a permanent program.

The proposal calls for the creation of between two to four assessment teams that would simultaneously conduct ambient groundwater monitoring and characterization studies in different parts of the state. Study areas would be selected collaboratively by staff from Ecology's regional water programs, interested local communities, and team hydrogeologists. Monitoring projects would be focused at the basin to sub-basin scale and would be completed in an average of two years.

Each study would include four key tasks:

1. Study area hydrogeologic characterization.
2. Monitoring of ambient groundwater quality conditions.
3. Monitoring of ambient groundwater level conditions.
4. Monitoring of groundwater/surface water interactions.

Data and technical reports from these studies would be assembled on a central website to provide a dynamic atlas of ambient groundwater conditions for the state. Monitoring wells installed as part of each study would be used for long-term trend monitoring. The total biennial cost to the state for operating the proposed program would range from \$1.1 to \$2.2 million.

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