2001 Report to the Legislature

Artificial Storage and Recovery of Ground Water

Progress Report

December 2001

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INTRODUCTION

During its 2000 session, the Washington State Legislature extended the Department of Ecology's authority to issue reservoir permits under the state surface water code to cover projects designed to store water in underground geological formations for future recovery and use. Previously, Ecology only had authority to issue permits for typical surface water reservoirs.

The measure, Engrossed Second Substitute House Bill 2867, E2SHB-2867 (see **Appendix A** for full bill text), defines these types of water storage projects as "artificial storage and recovery", or "aquifer storage and recovery" (ASR) projects as they are commonly called. Under E2SHB-2867, Ecology is required to provide a report to the Legislature by December 31, 2001, outlining its standards for review and mitigation and the status of any applications that have been filed for such projects. This report is submitted in fulfillment of that statutory requirement.

BACKGROUND

Aquifer storage and recovery projects have been legally possible in the state of Washington since the first days of the state ground water code, Ch. 90.44 RCW, which was enacted in 1945. Early ASR projects came about more by accident than by design, particularly when irrigation districts realized that they were, in effect, recharging water table aquifers through canal leakage. The districts recognized the value of the stored water and sought ways to access that water.

Groundwater management sub-areas

The process developed, and outlined in RCW 90.44.130, allows Ecology to control withdrawals of ground water through the creation of ground water management sub-areas. Ground water management sub-areas, designed for distinct bodies of ground water, can be created either by the agency directly or by petition from local entities.

Prior to the formal designation of a sub-area, Ecology is required to publish notice of its intention and make findings of fact on the designation and any objections.

Within 90 days after a ground water management sub-area is designated, anyone claiming ownership of artificially-stored ground waters must file a declaration, including providing evidence that no water withdrawn is public ground water. If necessary, a claimant may apply for an extension after 90 days. Claimants to artificially-stored ground water subsequent to designation can file similar declarations within three years and, if necessary, apply for extensions of up to two years. Those withdrawing artificially-stored ground water must file similar declarations within 90 days following the earliest withdrawal.

Because the process for declaring ground water management sub-areas was relatively cumbersome and not well suited to meet their needs, ASR proponents approached the 2000 Legislature to propose an alternative process. The new process was created by E2SHB-2867.

The New Process

The process created by the new ASR legislation expands the definition of "reservoir" to include "any naturally occurring underground geological formation where water is collected and stored for subsequent use as part of an underground artificial storage and recovery project." A person wishing to use any water stored in a reservoir must file an application for a secondary permit and

provide evidence that an agreement exists with the owners of the reservoir to secure enough water for the secondary permit. Ecology can now issue permits for the storage of water in "natural underground formations" by means of injection, surface spreading and infiltration, or other Ecology-approved methods, as part of an ASR project.

A proposed ASR project would have to meet standards for review and mitigation established by Ecology rule. Those elements to be addressed include:

- Aquifer vulnerability and hydraulic continuity.
- Potential impairment of existing water rights.
- Geotechnical impacts and aquifer boundaries and characteristics.
- Chemical compatibility of surface and ground waters.
- Recharge and recovery treatment requirements.
- System operation.
- Water rights and ownership of water stored for recovery.
- Environmental impacts.

Analysis of each proposed ASR project and geological formation must be conducted through studies initiated by the applicant. The studies will then be reviewed by Ecology. Certain types of projects are exempted from the new law, including operational and seepage losses from irrigation projects, irrigation return flows, water artificially stored as part of irrigation district projects, reclaimed water, or artificially stored water that may be claimed when a groundwater sub-area is established. Existing law governing the issuance of permits to appropriate or withdraw waters remains unchanged.

IMPLEMENTATION OF THE LEGISLATION

Shortly after the legislation took effect, Ecology convened a technical advisory group to determine how best to implement the new legislation. The group included membership from a broad spectrum of interests such as water utilities, local governments, consultants, academics, and state, local, and tribal agencies.

Between July 2000 and January 2001, the advisory group held six meetings. Topics included:

- Background information on the history of artificial storage of ground water in Washington.
- General Washington water law.
- The water-right permitting process.
- Specific legal issues pertaining to ASR projects.

Committee members working on various ASR projects also presented information about their particular projects, which range in size from small projects intended to serve the needs of a single business to large ones that could potentially constitute a major source of water for one or more regional water suppliers.

The advisory committee had completed a draft of the regulation, which was being circulated for review and comment in January 2001, just as Washington entered the state's second-worst drought in recorded history. Therefore, work on the rule was suspended so Ecology staff could work on drought-related issues. The 2001 drought declaration expired on December 31, 2001, so Ecology is resuming work on the ASR regulation.

Framework

In considering the standards to be met by ASR projects, the advisory group agreed that four different aspects should be analyzed prior to permitting:

- **Hydrogeologic** — how water will be stored underground in a reservoir and be available for later recovery and how that operation would affect the area where the recharge and storage will be developed.
- **Operational** — how the project will be operated and over what time cycle.
- **Environmental** — potential effects a proposed project might have on environmental conditions in the vicinity.
- **Legal** — how other water right holders and water users might be affected by a specific project.

The **hydrogeologic analysis** is the primary analysis to be conducted in conjunction with a proposed ASR project. It would, at least initially, include the development of a conceptual hydrogeologic model that identifies the general geological and hydrogeological conditions in the area where the project is proposed. This would include identifying such features as the geologic materials and their thicknesses, structural information such as faults, fractures, or synclines, and other relevant information that would help to describe the general geologic setting in the vicinity of the project. General ground water information should be part of this analysis as well, including such elements as the water bearing units and their hydraulic properties, the general ground water flow system, and any ground water boundaries. The size of a proposed ASR project will have a bearing on the level of detail needed and the amount of investigation required to ascertain its feasibility. Larger and more complex projects may well require considerably more study, including the development of sophisticated computer models as part of the analysis.

The **operational analysis** would describe how the project, once completed, would function. This analysis would include the major elements of the project operation such as the means of recharge (e.g. injection well or spreading basin), the location, number, and capacity of proposed recharge facilities, the source water quality and the means of treatment and disinfection of the source and recovered waters, the timing of both the recharge operations and the use of the stored water, and the rates of recharge and recovery.

The **environmental analysis** would describe probable and potential environmental effects that might result from the ASR project. Possible effects identified in the conceptual model would be considered and assessed, including changes to local water bodies such as wetlands and springs, changes to water levels and water quality in nearby wells, changes in slope stability, and possible subsidence or ground heave. Some of this analysis could be conducted through compliance with the State Environmental Policy Act (SEPA) as part of completing an environmental checklist or preparing an environmental impact statement. The size of the project will have a bearing on the level of review necessary under SEPA.

The **legal analysis** would identify and assess the significance of any potential legal issues associated with a proposed project. This would include identification of any wells completed in the aquifer and water rights connected with them. It would also address any changes necessary to the ASR proponent's water rights to cover the project, including changes to water rights for the source waters, and any legal issues associated with the proposed recharge area, in terms of land use activities, land ownership, and possible adverse environmental effects.

Monitoring plan

A key component of the framework outlined above is the implementation of an appropriately-designed and scaled monitoring plan. A well-designed plan should identify any elements that need additional analysis. The design of a monitoring plan needs to be carefully tailored for each specific project to ensure the appropriate factors are evaluated. The monitoring plan should also provide an early-warning mechanism to detect adverse impacts to the physical, chemical, or biological environments that were not predicted by the conceptual model. The advisory group even discussed making the results of the monitoring plan available to the public as a way to demonstrate compliance with the applicable regulations and reduce concerns about project effects.

Phased approach

Central to the framework identified above is the notion of a phased approach to the necessary investigations, moving from the general to the specific as needed. As shown in **Appendix B**, the scale and scope of potential ASR projects varies greatly. While some are sufficiently large and complex enough to warrant thorough investigation from the start, similar expectations for a smaller project might render it infeasible. Therefore, advisory group members agreed that some form of phased approach made the most sense for all projects. A proponent of a project could conduct preliminary studies and, based on the results of those studies, work with Ecology to determine the need for more detailed investigations. This would also allow the proponent to then make an informed decision about the likely viability of the project.

A phased approach will also help identify possible problems before they pose a threat to the project, other parties, or the environment. Even the most sophisticated analytical techniques can still fail to identify or predict potential problems. The phased approach methodically expands the need for investigations if any problems are found. Finally, because the largest proposed ASR projects will take a long time to complete, this approach will allow necessary investigations to be conducted over time, rather than placing an unmanageable burden on proponents at the start.

ISSUES IDENTIFIED

Changes of purpose of use

Most ASR projects already are operating under one or more water rights, so new water rights are usually not an issue. However, the question arose about whether storage needed to be added as a new purpose of use for the source waters if it was not part of the original water right. This could have posed a serious difficulty since it would have required changes to existing rights. If those rights were inchoate surface water rights, as was the case with some of the proposed projects, adding storage as a purpose of use would not be allowed under current state law (RCW 90.03.380).

The Attorney General's office subsequently advised Ecology that, in itself, storage is not a purpose of use of water. Rather it is merely a means to provide water for the true purposes of use identified in the secondary permit. Therefore, in applying for a reservoir permit under RCW 90.03.370, there would be no need to change the purpose of use of the water to add storage.

Preliminary vs. temporary permits

ASR projects usually require a significant amount of testing to determine their feasibility. Generally, this can be accomplished over a relatively short period of time for smaller projects but

larger projects may require years before the full operational capacity of the project can be completely evaluated. Ecology normally authorizes the necessary drilling and testing that needs to take place to determine the feasibility of a new water project through the issuance of a preliminary permit. A preliminary permit requires the applicant to make "such surveys, investigations, studies, and progress reports as the department deems necessary."

The difficulty arises because a preliminary permit is normally issued for a period of three years or less, and can only be extended to a maximum of five years and then only with the approval of the governor. Failure to comply with the conditions of the preliminary permit and the application upon which it is based results in the automatic cancellation of the application. Given the longer time frames necessary to evaluate the viability of some ASR projects, the relatively short duration of a preliminary permit really is an inappropriate and inadequate tool for authorizing the initial investigations.

Presently, the interim solution is to allow initial testing and evaluation of proposed projects to be undertaken under temporary permits, as was done for the city of Seattle's Highline well field. However, the use of temporary permits is only appropriate for projects where the water rights to the source waters are secured and available.

Single line for new applications and reservoir permits

Applications for ASR projects, which require reservoir and secondary permits, must go into the same line as applications for new water right permits. This is probably a vestige of the early days of the water code, when new rights were needed for virtually all new water projects, including storage projects. Applications for new permits must be investigated to answer questions about use and availability of water and effects on other rights and the public interest, often a time-consuming process. In most cases, ASR projects have already secured the necessary water rights for their source waters and simply need to have the storage and recovery elements of the projects evaluated through the permitting process. Some projects could be moved forward in the permitting line if they met the criteria identified in Ch. 173-152 WAC, the *Hillis* rule, but many projects will not meet those criteria. The obvious solution would be the creation of a third line for such ASR projects.

Introduction of disinfection byproducts

Most of the ASR projects proposed thus far are for public water systems and would use treated drinking water as their source waters. However, some of the byproducts of disinfection exceed the state ground water quality standards, Ch. 173-200 WAC. Chlorine, which is the standard method of drinking water disinfection, can react with organic materials that occur in ground water to produce carcinogenic chemicals. While any long-term health and environmental effects from the introduction of those byproducts are extremely unlikely, their removal would be quite costly. Nonetheless, their introduction into the ground water system runs contrary to the antidegradation policy of the ground water quality standards.

Some of the options that were considered to address this problem included the use of alternative points of compliance for determining compliance with ground water standards, possible alteration of the standards to allow any disinfection byproducts to only meet Maximum Contaminant Levels, or the application of the "overriding consideration of the public interest" and "all known, available, and reasonable methods of prevention, control, and treatment" provisions of the water quality standards. The technical advisory group has yet to agree on the

most appropriate option to pursue. Fortunately, public water systems are beginning to make the transition to different methods of disinfection, so the problem will gradually cease to exist.

The natural discharge of stored waters

Some advisory group members expressed interest in using ASR projects to augment late-season streamflows by allowing stored water to naturally discharge to a stream, rather than actually withdrawing the water for that purpose. Currently, none of the projects under consideration in Washington would be for this purpose.

Projects of this type are normally referred to as "artificial recharge" projects and are specifically authorized in several western states. However, Washington law presently makes no provisions for such projects. Advisory group members differed regarding whether such projects would, or should, be possible under the new statute. At this point, the issue is undecided, although the prevalent view is that if the Legislature would like to endorse such projects, some change to the statute should probably be considered.

Priority dates

State-issued water rights are assigned a priority date when the application is filed. Applications for ASR permits can only be filed after the effective date of E2SHB-2867. Thus, permits for ASR projects would be junior to most other water rights. In some instances, ASR projects would be junior to established instream flows. There is concern that an ASR project subject to an established instream flow could not operate when flows were not being met. This could, conceivably, prevent the use of the project at a time when it would be most valuable. This potential exists despite the strong chance that the rights for the source waters for ASR projects may be senior to those established instream flows. Advisory group members were uncertain about the likelihood of subjecting ASR projects to instream flows, but the issue remains unresolved.

CONCLUSIONS

ASR has been demonstrated to be a successful way of augmenting water supplies in areas where it is technically and economically feasible. As such, ASR can help address future water supply needs in Washington. ASR projects can vary significantly in terms of size and purpose. The key to making ASR successful in Washington is to provide a program for authorizing ASR projects that provides the necessary flexibility to accommodate the different types of projects while simultaneously assuring the health and safety of the public and the state's environment are adequately protected.

As the technical advisory group discovered, there are several legal and technical obstacles that need to be resolved before the potential of ASR projects will fully be realized in Washington State. Nonetheless, work on possible ASR projects needs to continue, particularly as Washington confronts the dilemma of how to accommodate the future water needs of its population and industry.

FOR MORE INFORMATION

If you have questions or would like further information about aquifer storage and recovery in Washington, please contact Doug McChesney at (360) 407-6647 (e-mail: mcc461@ecy.wa.gov).

APPENDIX A

ENGROSSED SECOND SUBSTITUTE HOUSE BILL 2867

CERTIFICATION OF ENROLLMENT

ENGROSSED SECOND SUBSTITUTE HOUSE BILL 2867

Chapter 98, Laws of 2000

56th Legislature
2000 Regular Session

UNDERGROUND WATER STORAGE

EFFECTIVE DATE: 6/8/00

Passed by the House March 6, 2000
Yeas 98 Nays 0

CLYDE BALLARD
Speaker of the House of Representatives

FRANK CHOPP
Speaker of the House of Representatives

Passed by the Senate March 1, 2000
Yeas 46 Nays 0

BRAD OWEN
President of the Senate

Approved March 24, 2000

GARY LOCKE
Governor of the State of Washington

CERTIFICATE

We, Timothy A. Martin and Cynthia Zehnder, Co-Chief Clerks of the House of Representatives of the State of Washington, do hereby certify that the attached is **ENGROSSED SECOND SUBSTITUTE HOUSE BILL 2867** as passed by the House of Representatives and the Senate on the dates hereon set forth.

CYNTHIA ZEHNDER
Chief Clerk

TIMOTHY A. MARTIN
Chief Clerk

FILED

March 24, 2000 - 2:49 p.m.

Secretary of State
State of Washington

ENGROSSED SECOND SUBSTITUTE HOUSE BILL 2867

Passed Legislature - 2000 Regular Session

AS AMENDED BY THE SENATE

State of Washington 56th Legislature 2000 Regular Session

By House Committee on Agriculture & Ecology (originally sponsored by Representatives Linville, G. Chandler, Miloscia, Mitchell, Koster and Cooper)

Read first time 02/07/2000. Referred to Committee on .

AN ACT Relating to underground water storage; amending RCW 90.44.035 and 90.03.370; and adding a new section to chapter 90.44 RCW.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF WASHINGTON:

NEW SECTION. **Sec. 1.** A new section is added to chapter 90.44 RCW to read as follows:

The legislature recognizes the importance of sound water management. In an effort to promote new and innovative methods of water storage, the legislature authorizes the department of ecology to issue reservoir permits that enable an entity to artificially store and recover water in any underground geological formation, which qualifies as a reservoir under RCW 90.03.370.

Sec. 2. RCW 90.44.035 and 1987 c 109 s 107 are each amended to read as follows:

For purposes of this chapter:

(1) "Department" means the department of ecology;

(2) "Director" means the director of ecology;

(3) "Ground waters" means all waters that exist beneath the land surface or beneath the bed of any stream, lake or reservoir, or other body of surface water within the boundaries of this state, whatever may be the geological formation or structure in which such water stands or flows, percolates or otherwise moves. There is a recognized distinction between natural ground water and artificially stored ground water;

(4) "Natural ground water" means water that exists in underground storage owing wholly to natural processes; ((~~and~~))

(5) "Artificially stored ground water" means water that is made available in underground storage artificially, either intentionally, or incidentally to irrigation and that otherwise would have been dissipated by natural ((~~waste~~)) processes; and

(6) "Underground artificial storage and recovery project" means any project in which it is intended to artificially store water in the ground through injection, surface spreading and infiltration, or other department-approved method, and to make subsequent use of the stored water. However, (a) this subsection does not apply to irrigation return flow, or to operational and seepage losses that occur during the irrigation of land, or to water that is artificially stored due to the construction, operation, or maintenance of an irrigation district project, or to projects involving water reclaimed in accordance with chapter 90.46 RCW; and (b) RCW 90.44.130 applies to those instances of claimed artificial recharge occurring due to the construction, operation, or maintenance of an irrigation district project or operational and seepage losses that occur during the irrigation of land, as well as other forms of claimed artificial recharge already existing at the time a ground water subarea is established.

Sec. 3. RCW 90.03.370 and 1987 c 109 s 93 are each amended to read as follows:

(1) All applications for reservoir permits shall be subject to the provisions of RCW 90.03.250 through 90.03.320. But the party or parties proposing to apply to a beneficial use the water stored in any such reservoir shall also file an application for a permit, to be known as the secondary permit, which shall be in compliance with the provisions of RCW 90.03.250 through 90.03.320. Such secondary application shall refer to such reservoir as its source of water

supply and shall show documentary evidence that an agreement has been entered into with the owners of the reservoir for a permanent and sufficient interest in said reservoir to impound enough water for the purposes set forth in said application. When the beneficial use has been completed and perfected under the secondary permit, the department shall take the proof of the water users under such permit and the final certificate of appropriation shall refer to both the ditch and works described in the secondary permit and the reservoir described in the primary permit.

(2)(a) For the purposes of this section, "reservoir" includes, in addition to any surface reservoir, any naturally occurring underground geological formation where water is collected and stored for subsequent use as part of an underground artificial storage and recovery project. To qualify for issuance of a reservoir permit an underground geological formation must meet standards for review and mitigation of adverse impacts identified, for the following issues:

(i) Aquifer vulnerability and hydraulic continuity;

(ii) Potential impairment of existing water rights;

(iii) Geotechnical impacts and aquifer boundaries and characteristics;

(iv) Chemical compatibility of surface waters and ground water;

(v) Recharge and recovery treatment requirements;

(vi) System operation;

(vii) Water rights and ownership of water stored for recovery; and

(viii) Environmental impacts.

(b) Standards for review and standards for mitigation of adverse impacts for an underground artificial storage and recovery project shall be established by the department by rule. Notwithstanding the provisions of RCW 90.03.250 through 90.03.320, analysis of each underground artificial storage and recovery project and each underground geological formation for which an applicant seeks the status of a reservoir shall be through applicant-initiated studies reviewed by the department.

(3) For the purposes of this section, "underground artificial storage and recovery project" means any project in which it is intended to artificially store water in the ground through injection, surface spreading and infiltration, or other department-approved method, and to make subsequent use of the stored water. However, (a)

this subsection does not apply to irrigation return flow, or to operational and seepage losses that occur during the irrigation of land, or to water that is artificially stored due to the construction, operation, or maintenance of an irrigation district project, or to projects involving water reclaimed in accordance with chapter 90.46 RCW; and (b) RCW 90.44.130 applies to those instances of claimed artificial recharge occurring due to the construction, operation, or maintenance of an irrigation district project or operational and seepage losses that occur during the irrigation of land, as well as other forms of claimed artificial recharge already existing at the time a ground water subarea is established.

(4) Nothing in this act changes the requirements of existing law governing issuance of permits to appropriate or withdraw the waters of the state.

(5) The department shall report to the legislature by December 31, 2001, on the standards for review and standards for mitigation developed under subsection (3) of this section and on the status of any applications that have been filed with the department for underground artificial storage and recovery projects by that date.

Passed the House March 6, 2000.
Passed the Senate March 1, 2000.
Approved by the Governor March 24, 2000.
Filed in Office of Secretary of State March 24, 2000.

Appendix B
Summary of major ASR projects in Washington

Compiled from submitted material by Doug McChesney.

Appendix B: Summary of major ASR projects in Washington

Cities of Kennewick and Richland

Together, the cities of Kennewick and Richland are evaluating the feasibility of ASR as part of an overall water resources plan to meet future water supply needs. Part of the plan would use Richland's existing Willowbrook well, which has mostly been used as an emergency backup when the city's primary water sources have experienced elevated temperatures.

Groundwater from the Willowbrook well contains hydrogen sulfide and methane that cause taste and odor problems. Due to these water quality conditions, Kennewick and Richland would like to determine whether ASR can improve well water quality and allow the cities to use the well more often without customer complaints.

Under the ASR proposal, Columbia River water from the cities' treatment plants would be recharged into the Wanapum Basalt aquifer using the Willowbrook well. The length of the storage period as well as the percentage of recharged water recovered would vary, depending on the hydraulic properties of the aquifer, the physical and chemical changes to the water during storage, and the length of demand.

The overall objective would be to design a reliable system to maximize the recovery of recharge water while providing consistent water quality to the municipalities' customers. Development of the Richland ASR appears to be feasible, based on an evaluation of new and existing information, provided the Willowbrook well:

- Is completed in a moderately transmissive portion of a basalt aquifer that cannot impact surface water.
- Meets state well construction standards and is equipped with a pump that can be easily modified for ASR operations.
- Is connected with the city of Richland distribution system so recharge water can be easily conveyed to the well.
- Does not seriously affect the few major users of groundwater from the basalt aquifer in the vicinity of the well.

However, there are also some factors that need to be addressed before the Richland ASR can move forward. These include:

- Groundwater temperatures need to be reduced sufficiently.
- Detectable levels of methane and hydrogen sulfide need to be low enough.
- The presence of disinfection by-products in the recharge water, sometimes at levels higher than current state water quality (anti-degradation) standards, needs to be addressed.

Permitting status — The feasibility study was just completed and the cities have yet to submit any applications for reservoir and secondary permits.

Lakehaven Utility District

The Lakehaven Utility District, located in Federal Way, has one operational ASR well that has been used as a pilot since 1991. The district is planning additional ASR wells as part of their Optimization of Aquifer Storage for Increase Supply (OASIS) project. The Federal Way area, like nearly all Western Washington, receives most of its precipitation between October and April when water demand is relatively low. The OASIS project is intended to operate seasonally, storing excess winter water from either ground or surface water sources and making it available between May and September when customer demand is at its peak and regional precipitation at its lowest.

Currently, the district's source water comes from the Redondo-Milton Channel aquifer which lies above the Mirror Lake storage aquifer. The shallower aquifer provides natural recharge to the storage aquifer and is more susceptible to variations in seasonal precipitation. During wet years, excess water from the channel aquifer recharges the storage aquifer. In drier years, the channel aquifer is supplemented with water from the Mirror Lake aquifer.

In the future, excess winter surface water will be available as recharge to the storage aquifer, allowing the storage aquifer to supplement high and higher summer demands both locally and regionally. The source of the winter recharge water would come primarily from the Green and Cedar rivers.

The Mirror Lake aquifer has an estimated usable storage volume of 29,000 acre-feet. It consists primarily of coarse sand and gravels with aquitards above and below the aquifer. Wells have been screened from approximately 100 feet above sea level to about 200 below sea level with an average screen length of around 60 feet. The raw water quality meets both primary and secondary drinking-water standards.

There are currently three wells in the storage aquifer. Two wells provide recovery while the third is a duel-purpose recharge and production well. In the future, as many as 27 wells are contemplated. Past operational tests, using groundwater as the source water, have not included pre- or post-treatment. However, if surface water is used, it is expected that pre- and post-treatment will be required.

Permitting status — No action has yet been taken on the district's application. Lakehaven Utility District applied to Ecology for reservoir and secondary permits shortly after E2SHB-2867 became law, primarily to secure a place in the permitting line. The district continues testing for the project.

Small-scale ASR in Redmond

An electronics firm in the city of Redmond is constructing a data facility designed to withstand and remain in operation after a major earthquake. As part of its requirements, the facility will need a reliable source of emergency cooling water at a maximum sustained rate of 175 gallons per minute until its normal connection with the city of Redmond can be re-established. The maximum design stored volume for a 50-day supply is approximately 10 million gallons.

The firm is evaluating the feasibility of using a small-scale ASR system to provide a reliable supply of emergency cooling water for the facility. ASR is being considered for the following reasons:

- Well technology has been shown to be reliable in large-magnitude earthquakes, particularly if a facility's power and piping are designed for the event.
- The likelihood of obtaining a new groundwater right in the known aquifers is low due to the over-appropriation and potential surface water-ground water interconnection issues in the area.
- The availability of an existing water right for purchase is uncertain and appears to be unlikely.

Even though ASR is envisioned as primarily for emergency supply, an annual operational cycle is proposed for the system to provide the following benefits:

- Annual exercise of the system to ensure operational reliability.
- Use of the ASR system for facility cooling water during peak usage times in the summer to provide relief to the regional water supply.
- Replenishment of the stored water "bubble" after migration during storage periods.

The key feasibility factors to be addressed in 2002 include obtaining a commitment on the part of water purveyors to provide source water for the facility and for ASR injection, determining the permitting requirements for the project, and drilling a test well to verify the presence of a separate deeper aquifer that can accommodate the desired ASR system.

Permitting status — As the summary indicates, this project is still in its early stages of development. Project proponents have not submitted any applications to Ecology at this time.

Seattle Public Utilities

During the 1980s, the Seattle Water Department, now called Seattle Public Utilities, developed and put the Highline well field in service. The well field consists of three production wells capable of delivering a total of 10 million gallons per day. The well field has two basic uses:

- A peaking source that could be started in July and run for up to four months.
- An emergency supply.

In the early 1990s, Seattle Public Utilities received a grant from the U.S. Bureau of Reclamation to study artificial recharge as a means to enhance its Highline well field productivity. Artificial recharge of the aquifer with treated drinking water from the utility's Cedar River source was found to be feasible.

Two production wells are configured so water can be dropped by gravity down the space between the well casing and the pump column and out through the well screen into the aquifer. The ASR study found that artificial recharge in the Highline well field will not increase production capacity significantly above the current 10 million gallons per day. However, its use following heavy pumping of the well field will hasten the return of the aquifer to pre-pumping conditions. Seattle utility operators currently favor the use of its Cedar and South Fork Tolt

surface water sources, so the Highline well field has been used only sparingly in recent years and augmentation of the natural recharge to the aquifer has not been needed. Even so, it is considered a viable technique that should be "on call" for future well field operations.

Permitting status: Seattle has operated its Highline well field ASR project for several years under a series of temporary permits issued by Ecology. In 2001, Ecology sought to update the permitting status of the project but was advised by counsel to ensure that Seattle complied with the terms and conditions of the new legislation before proceeding.

City of Walla Walla

The city of Walla Walla's ASR program, implemented in 1999, is the lynchpin for the city's long-term water supply planning efforts. The program has shown that recharged water can replenish portions of the region's deep basalt aquifers. In addition to seeing aquifer water levels rise, the program has also sparked a dialogue with other deep basalt water-right holders in the area regarding regional planning for groundwater use.

Walla Walla's ASR program may also prove a key tool in the city's fire fighting arsenal. Recently, the U.S. Forest Service notified the city that the 36-square mile Mill Creek Watershed is at risk for a catastrophic fire because of the buildup of combustible materials. Should a catastrophic fire erupt in the watershed, turbidity levels in Mill Creek would rise above state and federal standards. Since the city is served by an unfiltered water supply, Walla Walla would no longer be able to divert Mill Creek water for a substantial period of time. An aggressive ASR program would provide the resources and ability to counter the loss of surface water supplies with stored ASR reserves.

Currently Walla Walla's single ASR well has the capability of recharging 150-200 million gallons per year. In 2002, the city hopes to bring another ASR well on line. If the rules are finalized by that time and no new water right is required, the city would like to drill a new well which would replace the need for a large, expensive above-grade storage tank needed to supplement low pressures during the summer.

An expanded ASR program in Walla Walla will also likely have another benefit for the community and the environment. During the 2001 drought, the city was approached by the National Marine Fisheries Service to participate in an experiment to increase survivability of Endangered Species Act-listed steelhead in Mill Creek. The city voluntarily returned a portion of its appropriated surface water flow to Mill Creek and offset this loss by pumping back the balance into the distribution system using its ASR water.

Permitting status: Walla Walla has conducted the pilot test of its ASR project under a water right issued by the state of Oregon. The city intends to eventually operate its ASR project under an inchoate Washington water right permit. However, because the actual diversion of water under that permit would take place within the state of Oregon, some legal issues need to be resolved before that water right permit can be used. To date, Walla Walla has not submitted any applications for reservoir or secondary permits to Ecology.

City of Yakima

The city of Yakima commissioned a pilot test to determine the feasibility of an ASR project in the Ahtanum-Moxee sub-basin in the central part of the Yakima Basin. A pilot test conducted during the fall and winter of 2000-01 indicates that a full-scale ASR program would be both hydrogeologically and operationally feasible.

The primary source of the ASR water is the city's Naches River Rowe Hill Water Treatment Plant. The recharge well was the city's Kissel well, which is screened between 876 and 1,163 feet below ground surface, in the Lower and Middle Members of the Upper Ellensburg Formation.

Recharge to the Kissel well was conducted for 25 days at a rate of approximately 1,200 gallons per minute. A total of 45.2 million gallons was recharged. After a storage period of 55 days, recovery was conducted at a constant pumping rate of approximately 2,000 gallons per minute for 30 days. A total of 89.7 million gallons was withdrawn as part of the test, the additional amount withdrawn to ensure that there were no residual disinfection by-products. Additional water was removed during post-pilot test step tests. Water for the pilot test was delivered through the existing municipal water supply system of the city of Yakima. The distribution system operated without disruption of public service.

Recharge activities resulted in an estimated sustained rise of about six feet in the water levels of the Ellensburg Formation at the Kissel well for the two-month storage period.

Water quality monitoring indicated compliance with state drinking water standards. Although disinfection by-product concentrations did increase temporarily during storage before decreasing, they remained well below drinking water standards at all times. Based on the results of tracer analyses, it is estimated that approximately 70 percent of the water recharged to the aquifer was recovered. The remainder of the water presumably remained in the aquifer and contributed to the net storage of the hydrologic system.

A full-scale ASR program using the city of Yakima's available infrastructure is also operationally feasible. However, to increase the capacity of the groundwater supply system, additional wells would have to be installed. The permitting of these withdrawals should be easier if they are operated as part of an ASR program. Key regulatory components include:

- How ASR operations using chlorinated potable water containing disinfection by-products will be addressed under water quality standards for groundwater.
- The means of quantifying the permitted amount of water that may be recovered following recharge.

Permitting status — While Yakima and its consultant have engaged in discussions with Ecology, the city has yet to submit applications for reservoir and secondary permits. Ecology did issue the city temporary permits to conduct the pilot test.