Oxbow Incentivized Managed Aquifer Recharge Project

Application for WaterSMART Grant

Funding Opportunity Announcement No. BOR-DO-19-F003

Funding Group 1

Drought Response Program

Submitted To: Bureau of Reclamation
Financial Assistance Support Section
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Oxbow Incentivized Managed Aquifer Recharge Project

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Oxbow Incentivized Managed Aquifer Recharge Project

1.0 Executive Summary

This application is made on March 25, 2019 by Snake River Valley Irrigation District (SRVID), Basalt, Idaho, in Bingham County. The Oxbow Incentivized Managed Aquifer Recharge Project is located in Sec. 31 T 1N R 37E, B.M. within the boundaries of the Snake River Irrigation District (SRVID). This project proposes to make possible the delivery of 20 cubic feet per second of water from a SRVID canal to a site that is ideal for recharge to the Eastern Snake Plain Aquifer. In this way drought resiliency is improved by (1) storing water in the regional aquifer and (2) enabling groundwater recharge of flows from the Oxbow wastewater treatment plant by providing needed mixing water. In both ways the project enhances drought resilience in an area prone to drought where crops require irrigation water to survive. This recharge is made possible because the aquifer in this area is not hydraulically connected to the Snake River but rather flows northwesterly under the river at a depth of 60-80 feet below ground surface.

The proposed system improvements identified in this BOR-DO-19-F003 grant application not only are necessary in satisfying irrigation needs in the described area, but are part of a broader water management effort that allows storage "space" in the aquifer to be used as though it were an extension of the surface reservoir system. The SRVID holds federal storage contracts in Jackson Lake, Palisades and American Falls Reservoirs. Water supplies for the project include natural flow, storage and class A wastewater from the adjacent Oxbow treatment plant owned and operated by the Eastern Idaho Regional Wastewater Treatment Authority (EIRWWA). SRVID holds a 200 cfs recharge water permit. In addition to diverting water under this permit, the SRVID board has the opportunity to transport waste water from the City of Idaho Falls that has been comingled with flows in the Snake River. This project will all be contained within the service area of the SRVID and the grant is requested to assist with (1) the construction of a new lateral head gate, (2) the replacement of deteriorated and undersized supply piping, (3) installation of telemetered measurement of flows in the pipe, (4) the excavation of material from the pond areas to increase capacity for incentivized managed aquifer recharge (IMAR), (5) modeling of recharge, and (6) monitoring of recharge water via a series of monitor wells. The excavated materials will be used to construct a berm to expand and define the IMAR site. This drought resilience grant in the amount of $299,910 will provide 47 percent of project funding and will be used for installation of 3,150 feet of a 36 inch diameter pipe and part of the project management and oversight. In-kind efforts and cash provided by the other cooperators will provide $343,300 for 53 percent of the project costs. Construction is anticipated to start in October, 2019 and be completed no later than May, 2020. The estimated pay-back time for this project is less than two years, and the project is expected to provide water for the Eastern Snake Plain Aquifer each year in the foreseeable future. This project is not located on a federal facility.

2.0 Background Data

The distribution system of the SRVID will be used to bring Snake River water to the Oxbow IMAR site. There are four water supplies for the purposes identified for the development of this site.

1. SRVID recognizes that their allocation of stored water can be adversely impacted by flood control operations of Reclamation in the event that flood control operations impact reservoir storage. Because 97% of the basin water supply resides in the Eastern Snake Plain Aquifer (ESPA), efforts to extend surface reservoir space will make more usable storage available for beneficial uses. By using the aquifer as a temporary extension of the Snake River reservoir system essential conjunctive water management processes can be initiated as a proof of concept. The extension of the reservoir system has been enabled by patent-pending processes developed by RDC™.

2. SRVID has a 200 cfs recharge permit that will be used to supply water to fill the recharge associated with this site. This includes ARUs currently owned, or to soon be acquired by, SRVID, City of Blackfoot, City of Shelley, the Eastern Snake Plain Aquifer Recharge, Inc. (ESPAR), Eastern Idaho Regional Wastewater Authority (EIRWWA) and the City of Idaho Falls.

3. SRVID wishes, at times, to move a portion of its carried over surface storage to ARU storage to protect this water asset from loss during flood control operations. The history of storage water delivery in the Upper Snake River reservoir system demonstrates that the delivery of surface storage from ARU aquifer storage could occur seamlessly from a water delivery standpoint and not be inconsistent with principles of state water law.

4. The City of Idaho Falls desires to use IMAR as the vehicle for recovering water that has been discharged to the river from their upstream sewage treatment facility. SRVID has agreed to transport this water to the ESPAR Oxbow site where it will be recharged and then through the ESPAR accounting system, made available for reuse by the city. It is anticipated that EIRWWA will also want to recharge directly at this site to not only capture water wasted from its Oxbow Sewage Treatment Plant but to reduce the phosphorous load associated with its current discharges back to the river. Phosphorous returned to the river is harmful due to algal growth. Phosphorous recharged to the groundwater has not been deemed to be harmful by the Idaho Department of Environmental Quality due to substrate attenuation and mixing.

5. The current IMAR site being established and developed is contained within a 60 acre tract of land located in Section 31 of TWP 1 N RGE 37 E, B.M. The average depth to groundwater below this site is 60-80 feet. The groundwater gradient in the area is to the northwest. The soil in the area is thin with highly permeable sands and gravels extending to the zone of saturation. Percolation tests indicate that flows recharged to groundwater at the site, if properly managed, can exceed 50 cfs continually. The limitation in delivery capacity is seen as the limitation of the SRVID to supply water to this site and maintain its obligation to meet summer irrigation demands. It appears realistic to recharge 20 cubic feet per second (cfs) to this site for 300 days per year, yielding an annual recharge of 12,000 acre-feet of IMAR that could be moved to ARUs each year, given the variety of sources of water for recharge, described below. This pipe might also be used to provide irrigation water during the summer if the existing pipeline is removed. For the past several years the irrigation flow has been less that 1 cfs, but it could increase to 2 cfs during some portions of the year.

ESPAR is organized as a canal company for groundwater supplies and is established to manage IMAR sites, fill and maintain the various classes of ARUs and distribute storage allocated to ARUs to the appropriate place of use. This distribution system is highly dependent upon electronic data acquisition, data bases and real-time communications. Consequently, instrumentation is an important component of the budget for this IMAR site. Observation wells and groundwater monitoring equipment are an important aspect of the project.

It is anticipated that there will be times when irrigation water will be delivered to the recharge site for the production of certain crops. Some of these crops will occur in cooperation with Ducks Unlimited to provide spring feeding areas for puddle ducks.

3.0 Location

The project is located in eastern Idaho, just west of the town of Shelley, along the Snake River. As depicted in Figure 1, and with larger scale in Figure 2, the project consists of a pipeline that will convey greatly increased flows (20 cfs) from a canal to the east to a recharge area to the west, to enable water to be stored underground thus increasing drought resiliency in the Eastern Snake Plain Aquifer.

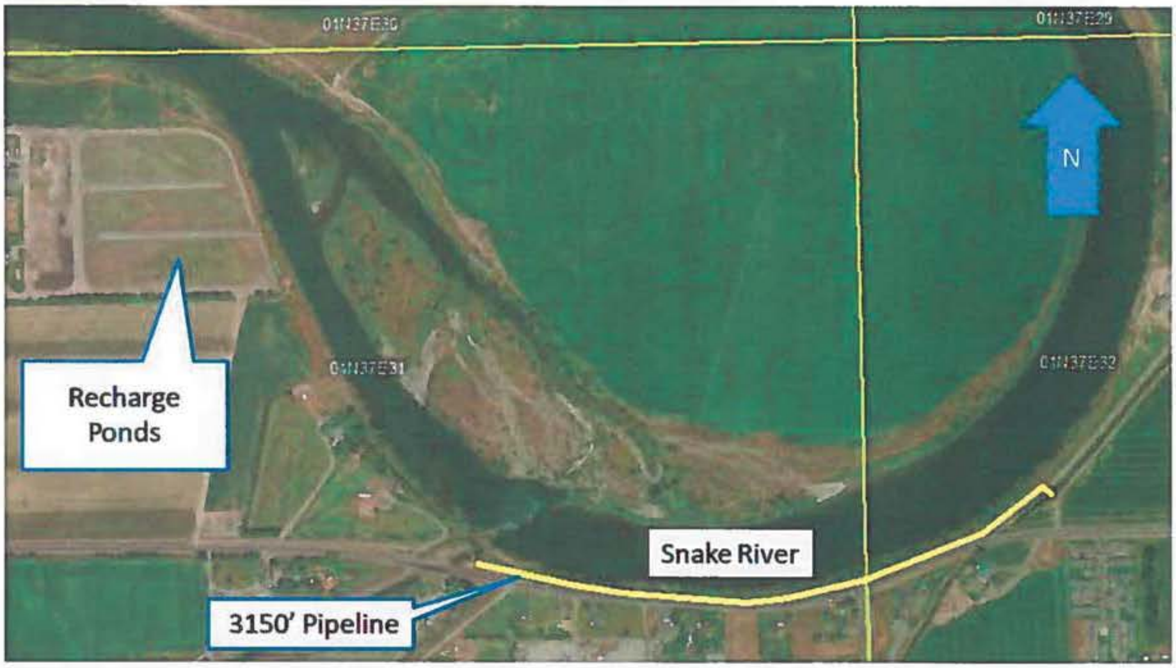

Figure 1. General Location of the Project.

Figure 2. Location of Pipeline

4.0 Project

4.1 Description

The described project is located in Bingham County, Idaho at an approximate elevation of 4,630 feet above mean sea level in a high desert environment that characterizes the eastern Snake River Plain. The area receives, on average, 13 inches of precipitation each year which mostly is accounted for in the average 69 inches of snow the area receives during the winter months. Irrigation and irrigation projects are responsible for much of the economic development that has occurred in the area since Shelley was first established in 1904. The Snake River Valley Irrigation District (SRVID) was established two years later and incorporates approximately 21,000 irrigated acres of land in Bingham County. SRVID holds water rights that predate Idaho Statehood. These water rights have been cut by the Snake River Watermaster late in the irrigation season when drought conditions resulted in insufficient natural stream flow to fill April 6, 1889 water rights. The later priority rights of SRVID are cut more frequently. Consequently, SRVID holds space-holder contracts with the Bureau of Reclamation for 91,467 acre feet of storage space, which is more or less evenly divided between Jackson Lake, American Falls and Palisades reservoirs. The project area is located within the boundaries of the SRVID. Using the RDC™ protocols ESPAR could make available ARU storage to SRVID patrons who are currently able to pump ground water. Drought resiliency is developed through expanded storage supplies or more security in filling space in Reclamation reservoirs.

In addition to the improved water supplies this project will provide for ARU owners, another project result of recharging the effluent from the Oxbow treatment facility will allow EIRWWA to avoid the installation of additional equipment for reducing phosphorous loading in the Snake River. It has been estimated that this avoided cost could save as much as $3 million for the residents or Bingham County, Ammon, and Shelley.

This project will all be contained within the service area of the SRVID and the grant is requested to assist with (1) the construction of a new lateral head gate, (2) the replacement of deteriorated and undersized supply piping, (3) installation of telemetered measurement of flows in the pipe, (4) the excavation of material from the pond areas to increase capacity for incentivized managed aquifer recharge (IMAR), (5) modeling of recharge, and (6) monitoring of recharge water via a series of monitor wells. The excavated materials will be used to construct a berm to expand and define the IMAR site. This drought resilience grant in the amount of $299,910 will provide 47 percent of project funding and will be used for installation of 3,150 feet of a 36 inch diameter pipe and part of the project management and oversight. In-kind efforts and cash provided by the other cooperators will provide $343,300 for 53 percent of the project costs. The estimated pay-back time for this project is less than two years, and the project is expected to provide water for the Eastern Snake Plain Aquifer each year in the foreseeable future.

4.2 Benefits

Under this FOA, Reclamation will fund projects that will build resiliency to drought. This project addresses many of the elements identified in the BoR guidance for this offering, including the following.

- Increasing the reliability of water supplies.
- Improving water management.

The proposed project will improve resiliency by improving the ability of water managers to continue to deliver water during a drought. This proposed project would decrease vulnerabilities and costs of drought by giving water managers flexibility in times of low water supply. In addition, the proposed project is beyond routine water management activities or activities required by state law for conservation and efficiency. The proposed resiliency project also helps avoid the need for emergency response actions, such as water hauling programs and temporary infrastructure during drought situations.

Projects funded under this FOA have ongoing benefits to build long-term resilience to drought, and also address an immediate drought concern.

This project is supported by an existing drought planning effort, as clarified in the drought plan information in Section 11 of this proposal. Specific ways in which this project is responsive to this funding opportunity are detailed as follows:

Task A—Increasing the Reliability of Water Supplies through Infrastructure Improvements

Investments in infrastructure can improve resiliency to drought conditions by increasing water management flexibility and providing alternative sources of water supply. For example, this project provides for the construction of a new surface conveyance system components—including a headgate and major delivery pipes. Also, the aquifer recharge facilities can support water banking in wet years for use in dry years and sustainable conjunctive use programs.

This project includes the following:

- **System modifications or improvements.**— This project will increase flexibility of water conveyance and deliveries, facilitating access to water supplies in times of drought, including:

  - Constructing a new conveyance system to increase flexibility to deliver water, to facilitate voluntary water marketing via ARUs.

- **Storing water and/or recharging groundwater supplies.**—This project enables the capture or storage of additional water supplies that can be made available during drought, including:

  - Developing or expanding small-scale surface water storage facilities for aquifer storage of surface water supplies.

  - Installing recharge ponds to increase recharge of surplus, inactive, or reclaimed water. Recharged water can serve multiple purposes such as sustainable conjunctive use in times of drought.

- **Developing alternative sources of water supply including water treatment.**— This project stores underground water supplies to build resiliency to the impacts of drought, including constructing an opportunity to save underground effluent from a municipal wastewater facility.

Task B – Projects to Improve Water Management through Decision Support Tools, Modeling, and Measurement

Task B projects are intended to help provide entities with water use information and tools to monitor the onset of drought, detect different levels of drought that may trigger certain drought mitigation and response actions, and to identify potential strategies to address drought. Task B projects also include the development of tools that facilitate water marketing between willing buyers and sellers to redistribute water supplies to meet other existing needs or uses (e.g., agricultural, municipal, or dedication to in-stream flows). This project includes activities such as:

- **Developing water management and modeling tools to help communities evaluate options and implement strategies to address drought.**

- This project includes an operational modeling to assess recharged flows relative to the recharge of water from the EIRWWA treatment facility. EIRWWA will potentially be providing up to 3 cfs for recharge when mixed with water from SRVID.

- This project includes an assessment of water quality with respect to the total dissolved solids from the plant as mixed with water from the Snake River.

- This project includes installation of real time flow measuring equipment to track the amount of water recharged to the aquifer.

4.3 Milestones

This project has the following discreet milestones and schedule:

Task No.	Task	Schedule	Funded By
1	Secure funding acquisition and initiate project.	Mar 19 - Sep 19	ESPAR
2	Secure any needed approvals from Bingham County and the State of Idaho (none have yet been identified as SRVID already has a right of way for this	Jun 19 - Sep 19	ESPAR, BoR
3	Contract for work projects.	Jun 19 - Sep 19	ESPAR, BoR
4	Survey pipe location.	Aug 19 - Sep 19	City of Shelley
5	Construct a new lateral head gate.	Nov 19 - Dec 19	SRVID
6	Replace deteriorated and undersized supply piping.	Oct 19 - Dec 19	BoR
7	Re-landscape.	Apr 20 - May 20	City of Shelley
8	Install telemetered measurement of flows in the pipe.	Feb 20 - Mar 20	ESPAR
9	Excavate material from the pond areas.	Oct 19 - Mar 20	City of Shelley
10	Model recharge.	Jul 18 - May 20	EIRWWA
11	Drill and equip monitoring wells at recharge site.	Jul 18 - May 20	EIRWWA
12	Complete project reporting and	Apr 20 - May 20	ESPAR, BoR
13	During the coming years – measure the amount of water recharged to the groundwater.	Apr 20 into the future	ESPAR

Table 1. Milestones and Schedule for the Oxbow Incentivized Managed Aquifer Project

5.0 Performance Measures

The performance of the Oxbow IMAR Project will be measured by the acre-feet of recharge water conveyed by the new pipe annually. This quantity will be measured by continuously recording measuring device and reported in ESPAR's annual recharge report. We estimate the annual recharge conveyed through the pipe will be in the range of 10,000 – 14,000 acre-feet during non-drought water years.

6.0 Evaluation Criteria

6.1 Project Benefits

6.1.1 How will the project build long-term resilience to drought?

During good water years this project is designed to convey over 10,000 acre-feet of water from the surface system into the Eastern Snake Plain Aquifer, thus storing water in good years to be available during drought years. This water will be available for use by water users in the ESPA during drought years.

6.1.2 How many years will the project continue to provide benefits? The design life for this project is at least 50 years. It is gravity flow so maintenance requirements are minimal.

6.1.3 Will the project make additional water supplies available? Yes. Water stored in the aquifer will be made available during times of need, measured and accounted through ARUs, defined above.

6.1.4 If so, what is the estimated quantity of additional supply the project will provide and how was this estimate calculated? The many sources of supply can be tapped to keep the recharge going at a rate of 20 cfs for 300 days per year in all but the driest years.

6.1.5 What percentage of the total water supply does the additional water supply represent? How was this estimate calculated? The total surface water storage in the Upper Snake system is over 4 MAF. While this project is small relative to the total annual supply of about 10MAF, it is highly cost effective for the flows proposed to be recharged.

6.1.6 Provide a brief qualitative description of the degree/significance of the benefits associated with the additional water supplies. Recharge of 12KAF can provide a supplemental supply for thousands of irrigated acres or for municipal needs of around 10,000 people. This will be an important source of supply for the growing cities in eastern Idaho.

6.1.7 Will the project improve the management of water supplies? For example, will the project increase efficiency, increase operational flexibility, or facilitate water marketing (e.g., improve the ability to deliver water during drought or access other sources of supply)? This project can serve as an additional water storage facility for the Minidoka Project irrigation users.

6.1.8 If so, how will the project increase efficiency or operational flexibility? The project enables Minidoka Project irrigation users to store excess water in good years and utilize it when needed in drought years.

6.1.9 What is the estimated quantity of water that will be better managed as a result of this project? How was this estimate calculated? An achievable amount of recharge under this project is 10,000 acre-feet per year during non-drought years. As shown below, during the past 20 years, 7 years have been declared drought years. In general, then, the average annual amount recharges at this site is anticipated to be in the range of 7,000 acre-feet.

6.1.10 How will the project increase efficiency or operational flexibility? The project provides the district an opportunity to store water that could be utilized by the district or put into accounts of others holding ARUs.

6.1.11 What percentage of the total water supply does the water better managed represent? How was this estimate calculated? If the total water supply in the Upper Snake Basin is around 10MAF, and the average amount of water recharged by this system is in the range of 7KAF, this project alone would enable recharge of 0.7 percent of the total basin supply. The amount of recharge proposed in this project is significant given the cost for new surface water storage to be from $1,000 to $2,500 per acre-foot, with an annual likelihood of fill in the range of 70 percent.

6.1.12 Provide a brief qualitative description of the degree/significance of anticipated water management benefits. The proposed project provides the district and others with the ability to store water in the aquifer which can be called upon during droughts.

6.1.13 Will the project make new information available to water managers? If so, what is that information and how will it improve water management? This project may encourage other irrigation entities to evaluate similar projects to improve management options and supply reliability.

6.1.14 Will the project have benefits to fish, wildlife, or the environment? If so, please describe those benefits. Since the district would be storing water in the aquifer primarily during good water years, there would be little impact. However, the project would make possible an alternative to flooding certain lands in the spring to provide habitat for waterfowl. Ducks Unlimited, active in Idaho, has visited and encouraged groundwater recharge sites with this management in mind.

6.1.15 Wells. What is the estimated capacity of the new well(s), and how was the estimate calculated? The only wells in this project are monitoring wells, to be used to model the project site for ground water rights.

6.1.16 New Water Marketing Tool or Program.

How does the new tool or program increase the flexibility of acquiring water on the open market? The use of ARUs to track and assign benefits of IMAR is new since 2014. This technique has already been used successfully to provide recharge credit to individuals, cities and a ground water district. Additional entities are now looking to ARUs to help satisfy water demands.

6.1.17 What is the scope of water users and uses that will benefit? The scope is unlimited. It is now being used in the ESPA and is being considered for implementation in other basins in ID, OR, WA and NM.

6.1.18 Are there any legal issues pertaining to water marketing that could hinder project implementation (e.g., restrictions under Reclamation or state law or contracts, or individual project authorities). None are anticipated.

6.1.19 Metering/Water Measurement Projects. To what extent are the methods tested/proven? This project will include a telemetered meter for flows within the diversion pipeline, for continuous tracking of water recharged to the groundwater. Currently there are numerous aquifer storage and recovery projects on Idaho's Snake Plain Aquifer.

6.2 Drought Planning and Preparedness.

6.2.1 Attach a copy of the applicable drought plan, or sections of the plan, as an appendix to your application. See Section 10 below and Appendix E.

6.2.2 Explain how the applicable plan addresses drought. Proposals that reference plans clearly intended to prepare for and address drought will receive more points under this criterion. This proposal specifically addresses drought by enabling delivery of water to an aquifer recharge site. The recharged water can be banked in the aquifer during times of plenty and used during times of scarcity via credits established by ARUs.

6.2.3 Explain whether the drought plan was developed with input from multiple stakeholders. Was the drought plan developed through a collaborative process? Yes. The Idaho Drought Plan was developed under the auspices of the Idaho Water Resource Board, with input from various sectors of the water use community. The Eastern Snake Plain Aquifer Comprehensive Aquifer Manage Plan addresses drought via a process that incorporated the views on individual water users, developers, municipalities and the irrigation community in a comprehensive manner.

6.2.4 Does the drought plan include consideration of change impacts to water resources or drought? Describe how your proposed drought resiliency project is supported by and existing drought plan. Yes, as described in Section 10 and Appendix E, one of the needs of drought planning is climate change, whereby snowpack is melting sooner and is providing less storage for use during the irrigation season.

6.2.5 Does the drought plan identify the proposed project as a potential mitigation or response action? Ground water recharge is specifically mentioned as a drought mitigation action. This project enables groundwater recharge by moving water from a distribution canal to a groundwater recharge site.

6.2.6 Does the proposed project implement a goal or need identified in the drought plan? Yes, the goal in the plan is to enhance groundwater recharge, which is the focus of this plan.

6.2.7 Describe how the proposed project is prioritized in the referenced drought plan? Eastern Idaho has many opportunities for groundwater recharge. The objective is to convey surface water supplies to locations there groundwater recharge can occur. One unique aspect of this site is although it is near the Snake River, the regional groundwater table is not connected to the river, flowing some 60-80 feet below the river in a northwesterly direction. This is the reason why Idaho's Department of Environmental Quality will contemplate allowing recharge of the flows from the Oxbow Wastewater Treatment Plant – such recharged water is not connected to the river.

6.3 Severity of Actual or potential Drought Impacts to be addressed by the Project.

6.3.1 What are the ongoing or potential drought impacts to specific sectors in the project area if no action is taken (e.g., impacts to agriculture, environment, hydropower, recreation and tourism, forestry), and how severe are those impacts? Bingham County has experienced seven years of drought in the last twenty that were severe enough to justify an emergency declaration. In recent years the snowpacks have been more plentiful but historical records are full of cycles of wetter and dryer years. This project assists with the opportunity to recharge water that otherwise would flow out of Idaho and into the Pacific Ocean, saving it for future use in Idaho.

6.3.2 Whether there are public health concerns or social concerns associated with current or potential drought conditions (e.g., water quality concerns including past or potential violations of drinking water standards, increased risk of wildfire, or past or potential shortages of drinking water supplies? There are essentially no significant impacts from the proposed project. Water will be stored only when it is available under Idaho water law.

6.3.3 Does the community have another water source available to them if their water service is interrupted?). The project will not impact community water availability. Water would be stored only when it is available.

6.3.4 Whether there are ongoing or potential environmental impacts (e.g., impacts to endangered, threatened or candidate species or habitat). Recharge of this water is not anticipated to have any impacts on any species. The project is located on private land and other previously disturbed land. Aquifer recharge is permitted by the Idaho Department of Water Resources.

6.3.5 Whether there are ongoing, past or potential, local, or economic losses associated with current drought conditions (e.g., business, agriculture, reduced real estate values). Yes, great losses occur during periods of drought, prompting Bingham County to issue drought declarations in seven of the past 20 years. See Appendix E for the 2013 declaration.

6.3.6 Whether there are other drought-related impacts not identified above (e.g., tensions over water that could result in a water-related crisis or conflict). The conflict between surface water and groundwater users was settled in a landmark 2014 agreement that emphasizes the benefit of groundwater recharge. Selected pages of this document are included in Appendix E.

6.3.7 Describe existing or potential drought conditions in the project area. See Section 10 and Appendix E.

6.3.8 Is the project in an area that is currently suffering from drought or which has recently suffered from drought? Please describe existing or recent drought conditions, including when and the period of time that the area has experienced drought conditions (please provide supporting documentation, [e.g., Drought Monitor, droughtmonitor.unl.edu]). See Section 10 and Appendix E.

6.3.9 Describe any projected increases to the severity or duration of drought in the project area resulting from climate change. Provide support for your response (e.g., reference a recent climate change analysis, if available) Yes, as described in Section 10 and Appendix E, one of the needs of drought planning is climate change, whereby snowpack is melting sooner and is providing less storage for use during the irrigation season. Climate change could increase the probability of drought in southern Idaho.

6.4 Project Implementation

6.4.1 Describe the implementation plan of the proposed project. Please include an estimated project schedule that shows the stages and duration of the proposed work, including major tasks, milestones, and dates. See Table 1 at Section 4.3.

6.4.2 Describe any permits that will be required, along with the process for obtaining such permits. None are known at this time as the participants in the project are permitting authorities. This aspect will be double-checked before the project proceeds.

6.4.3 Identify and describe any engineering or design work performed specifically in support of the proposed project. Survey will be conducted as part of the project.

6.4.4 Describe any new policies or administrative actions required to implement the project. None.

6.5 Nexus to Reclamation

6.5.1 Describe how the environmental compliance estimate was developed. Has the compliance costs been discussed with the local Reclamation office? None are known, but SRVID has contacts with the Upper Snake Field Office which has staff that can provide assistance.

6.5.2 Will the project benefit any tribe(s)? No.

6.5.3 Does the applicant receive Reclamation project water? The applicant receives supplemental Reclamation storage.

6.5.4 Is the project on Reclamation project lands or involving Reclamation facilities? No Reclamation lands or facilities are involved with this project.

6.5.5 Is the project in the same basin as a Reclamation project or activity? Yes.

6.5.6 Will the proposed work contribute water to a basin where a Reclamation project is located? Yes.

6.6 **Department of the interior Priorities -- *Modernizing our infrastructure***

6.6.1 Support the White House Public/Private Initiative to modernize U.S. infrastructure. Yes, this project modernizes by installing a new pipeline.

6.6.2 Remove impediments to infrastructure development and facilitate private sector efforts to construct infrastructure projects serving American needs. This project does not remove impediments but it demonstrates that any potential impediments can be overcome via public private partnerships.

6.6.3 Prioritize DOI infrastructure needs to highlight Construction of infrastructure, cyclical maintenance, and deferred maintenance. This infrastructure project fits squarely within the U.S. objectives to improve facilities.

7.0 Project Budget

7.1 Funding Plan

Funding for this project is proposed to be a combination of funding from the Bureau of Reclamation Drought Response Funding, matched by project development by (1) the proponent, Snake River Valley Irrigation District, (2) the City of Shelley, (3) EIRWWA, and (4) ESPAR. The BoR is being asked to provide about 47% of the funding. See Table 1 in Section 4.3 for an allocation of funding assignments. Those with matching funding roles have submitted letters of support. See Appendix C – Letters of Support.

7.2 Budget Proposal

See the following three tables, numbers 2 – 4, for identification of the parts to be paid by the parties, buttressed by letters of support from each of the parties as provides in the appendices.

BUDGET ITEM DESCRIPTION	COMPUTATION $/Unit	Quantity	Quantity Type	TOTAL COST	
Supplies and Materials					
Purchase and Install 3150 Feet of 36" Pipe – BOR	50	3150	36"	$	281,610.00
Contractual/Construction					
Headgate Installation – SRVID	20000	1	Install	$	20,000.00
Install Monitoring Wells – EIRWWA	20000	4	Each	$	90,000.00
Modeling – EIRWWA	Since July	Project	Project	$	100,000.00
Instrument Observation Wells – EIRWWA	4000	4	Each	$	9,600.00
Telemetered Flow Measuring Device For Pipe – ESPAR	10000	1	Each	$	10,000.00
Excavation – City of Shelley	20	4600	Yard	$	92,000.00
Survey by City of Shelley	5000	1	Each	$	5,000.00
Restore Landscaping – City of Shelley	10000	1	Each	$	10,000.00
Project Management, Environmental Compliance and Construction Oversight – BOR Funding Portion	183	100	Hourly	$	18,300.00
Project Management, Environmental Compliance and Construction Oversight – ESPAR Funding Portion	67	100	Hourly	$	6,700.00
TOTAL DIRECT COSTS				**$**	**643,210.00**
Indirect Costs					
N/A				$	
TOTAL ESTIMATED PROJECT COSTS				**$**	**643,210.00**

Table 2. Total Project Cost Table

FUNDING SOURCES	AMOUNT
Non-Federal Entities	
City of Shelley	$ 107,000.00
Snake River Valley ID	$ 20,000.00
EIRWWA	$ 199,600.00
ESPAR	$ 16,700.00
Non-Federal Subtotal	**$ 343,300.00**
Other Federal Entities	None
REQUESTED RECLAMATION FUNDING	**$ 299,910.00**

Table 2. Summary of Non-Federal and Federal Funding Sources

SOURCE	AMOUNT
Costs to be reimbursed with the requested Federal funding	$ 299,910.00
Costs to be paid by the applicant	$ 20,000.00
Value of third party contributions	$ 323,300.00
TOTAL PROJECT COST	**$ 643,210.00**

Table 3. Total Project Costs

7.3 Budget Narrative

The BOR funding will be used to pay for a central element of the project, the installation of the 36" pipe from the delivery canal to the splitter head box, and for some of the project administrative/management costs. This will enable diversion of about 20 cubic feet per second of flow from the canal to the recharge area, thus providing an annual recharge capability of 10,000 to 14,000 acre-feet during a 300 day season, excluding times of severe freezing.

The matching funds come from a variety of sources, as depicted in Table 1 on page 8. This table provides the tasks, the timing and the funding source of each element. Additional narrative would be redundant to this summary.

8.0 Environmental and Cultural Resources Compliance

It is anticipated that environmental and cultural clearances will be obtained through a categorical exclusion approved by the Bureau of Reclamation. The entire pipeline project will be conducted on land owned either by the City of Shelley or privately where there is an existing lease for water conveyance. Recharge activities will be conducted on land owned by the City of Shelley, EIRWWA, or privately with a lease agreement for recharge. There are no known compliance issues, although the project will thoroughly double-check this aspect prior to initiation.

9.0 Required Permits or Approvals

Because the property in the project is either owned by one of the proponents or covered via private lease, no additional permits or approvals are anticipated to be needed for this project. There are no known required permits or approvals, although the project will thoroughly double-check this aspect prior to initiation.

10.0 Existing Drought Contingency Plan

In Southeastern Idaho there is very little dry land farming due to lack of rainfall. The vast majority of crops are irrigated using water from surface systems or groundwater. During good water years water flows from the basin down the Snake River in excess. During drought years water supplies are insufficient, leading to the construction of surface water reservoirs that store more than 4 million acre-feet.

Due to the prevalence and serious impact of drought in the project area, planning for drought has been conducted at the state level, the basin level, and the county level as described below.

10.1 State Level Planning

State of Idaho drought planning activities are guided by the Idaho Drought Plan, a 103 page document found at https://idwr.idaho.gov/files/water-data/Idaho-Drought-Plan.pdf, and depicted in Figure 3 below.

IDAHO DROUGHT PLAN

with

FEDERAL WATER-RELATED DROUGHT RESPONSE PROGRAMS

Idaho Department of Water Resources
Planning and Technical Services Division
Boise, Idaho

Figure 3. Idaho Drought Plan

This plan has proven to be durable and is activated early in the year as forecasts identify potential drought situations. Due to its length, only the cover sheets and index are provided in Appendix E.

10.2 **Basin Level Planning**

The Idaho Water Resource Board (IWRB) spent several years to conduct a thorough, basinwide evaluation of groundwater planning, known as the Eastern Snake Plain Aquifer Comprehensive aquifer Management Plan (ESPA CAMP). The IWRB website depiction of this process is shown as Figure 4 below.

Figure 4. Idaho Water Resource Board Comprehensive Aquifer Management Plan

Aquifer Recharge is central to this plan. It is mentioned 34 times in the plan. As an example the following excerpt is from the plan:

> Page 4: "The long-term objective of the Plan is to incrementally achieve a net ESPA water budget change of 600 thousand acre-feet (kaf) annually. It is projected that this hydrologic goal can be achieved by the year 2030 through Implementation of a mix of management actions including, but not limited to, aquifer recharge, ground-to-surface water conversions, and demand reduction strategies. The Plan sets forth actions which stabilize and improve spring flows, aquifer levels, and river flows across the Eastern Snake Plain.

In addition the plan references the anticipated impact of climate change, as follows:

> Page 8: "In addition, proactive management of water supplies will help address variability in climatic conditions, including drought. The expected changes in the water budget, resulting from implementation of the management plan, should provide flexibility for future water management.

10.3 **Aquifer Recovery Agreement**

Concerns about the decline of the Eastern Snake Plain Aquifer came to a head between surface water and groundwater users in the spring of 2015. Long-term impacts of drought and pumping, and increases of water flowing out of the basin, had led to a serious water call by the downstream senior surface water rights on the junior groundwater right throughout the basin. The resulting discussions led to the development of a Settlement Agreement between the parties. The germane first two pages of this agreement are provided in Appendix E. Note that on page 2, item 3, part a, item ii states in part:

> Each Ground Water and Irrigation District with members pumping from the ESPA shall be responsible for reducing their proportionate share of the total annual ground water reduction or in conducting an equivalent private recharge activity.

The groundwater recharge enabled via this application will aid water users in the ESPA by providing some of the recharge contemplated in this agreement. In this way, this project is directly related to reducing the impacts of drought on the water users and on the aquifer.

10.4 **County Level Planning**

Drought has a huge impact at the county level. The prevalence of drought in this area is confirmed by the issuance of seven drought declarations by Bingham County in the past 20 years, shown in Table 4 below. A sample drought declaration, the one issued in 2013, is included in Appendix E.

County/Area	Date Declared
Bingham County	June 17, 2013
Bingham County	June 29, 2007
Bingham County	April 15, 2005
Bingham County	May 25, 2004
Bingham County	April 29, 2003
Bingham County	May 23, 2002
Bingham County	May 15, 2001

Table 4. Years when Bingham County Issued Drought Declarations

Implementation of the Oxbow Incentivized Aquifer Management Project would help alleviate drought conditions in Bingham County by providing an average long-term recharge opportunity of 7,000 acre-feet, a significant volume over time. This recharge is especially important for the groundwater pumpers in Bingham County, who generally have the most junior water rights and are thus most susceptible to curtailment during period of drought.

Thus the Oxbow Incentivized Aquifer Management Project directly addresses drought and climate challenges at the state, basin and local levels.

12.0 Unique Entity Identifier and System for Award Management

DUNS Number is 028720977. SAMS entity identifier has been requested and will be reported when it is secured.

Appendices

Appendix A -- Federal Forms

- SF424
- SF-424C
- SF- 424D

Appendix B -- Official Resolution from Snake River Valley Irrigation District

- Resolution dated March 19, 2019

Appendix C -- Letters of Support

- Eastern Idaho Regional Wastewater Authority
- City of Shelley (2 Letters)
- Eastern Snake Plain Aquifer Recharge, Inc.
- American Falls Aberdeen Ground Water Management Area
- Bingham County

Appendix D – Bids

- BTC Contractors, LLC.

Appendix E – Drought Documents

- Selected parts of Idaho Drought Plan.
- Selected parts of Eastern Snake Plain Aquifer Comprehensive Aquifer Plan
- Selected parts of Surface Water Coalition – Idaho Ground Water Appropriators, Inc. 2015 Agreement
- Order Declaring Drought Emergency in Bingham County

Appendix A -- Federal Forms

Appendix B -- Official Resolution from Snake River Valley Irrigation District

Resolution of the Board of Directors

Snake River Valley Irrigation District

Whereas, The Snake River Valley Irrigation District (SRVID) is organized and exists under the laws of the State of Idaho for the purposes of distributing water for the benefit of the patrons of the district, and;

Whereas, the lands identified in the ESPAR managed aquifer recharge (MAR) site are within the service area of the SRVID and are assessed for the water distribution services of the district, and;

Whereas, the board of directors of SRVID are interested in the benefits the proposed Oxbow site can provide to the patrons of the district, and;

Whereas, the board of directors of SRVID agrees to sponsor this project including submitting a request for funding to the U.S. Bureau of Reclamation and the installation of a headgate to supply water to the 36" pipeline proposed in the request, and:

Whereas, the board of directors of SRVID agrees to work with Reclamation to meet established deadlines for entering into a grant or cooperative agreement.

Now Be It Resolved, by the SRVID board of directors that they have by resolution agreed to be a participant in and the applicant of **Funding Opportunity BOR-DO-19-F003**.

Signed and included as a minute entry in the actions of the SRVID Board.

Ren Christensen ______________________ 3.19.19

Ren Christensen Date

Chairman, Snake River Valley Irrigation District Board

Gary Dial, Board Member

Dale Jensen, Board Member

Appendix C -- Letters of Support

Letter of Support and Commitment from EIRWWA

March 21, 2019

U.S. Bureau of Reclamation
Attn: Ms. Julie J. Hendricks
PO Box 25007, MS 84-27814
Denver, CO 80225

RE: Letter of Support and Commitment, Application for WaterSMART Grant BOR-DO-19-F003, Drought Response Program, Submitted by Snake River Valley Irrigation District

Dear Ms. Hendricks:

I am writing as the Chairman of the Eastern Idaho Regional Wastewater Authority (EIRWWA) to express both support for and commitment to the project identified in WaterSMART Grant BOR-DO-19-F003, Drought Response Program, submitted by Snake River Valley Irrigation District.

EIRWWA is responsible for treating wastewater in a major region of eastern Idaho, including the cities of Shelley and Ammon as well as unincorporated areas of Bingham and Bonneville Counties. These areas have limited water supplies due to the demands of downstream senior water rights, and drought very much accentuates these limitations. For example, Bingham County issued drought declarations in seven of the years during the period 2001 – 2013.

EIRWWA has an opportunity to participate in a groundwater recharge program that would enable large amounts of water to be stored in the Eastern Snake Plain Aquifer to be available for inevitable future periods of drought. This recharge will enable continued use of existing municipal supplies and provide for additional uses that our communities require to remain healthy and vital. In addition participation in this recharge project will enable us to save our "Class A" water in the aquifer rather than to place it in the river where during many periods, today for example, the water will flow out of Idaho largely unused. An added benefit is to reduce our treatment costs for the removal of phosphorous, using natural processes rather than expensive post-treatment equipment.

For these reasons EIRWWA strongly supports the project proposed by the Snake River Valley Irrigation District (SRVID), which will enable delivery of Snake River water to our site for mixing with our outflow. In addition to this support, EIRWWA pledges cost share for work conducted to enable this recharge to happen, including expenses paid since July of 2018 for the following:

- Modeling of the groundwater system, at a cost of $100,000.00 RSC
- Drilling of four monitoring wells at a cost of $90,000.00 RSC
- Instrumentation of the four monitoring wells at an anticipated cost of $~~16,000~~. RSC 9600.00

EIRWWA stands ready to assist the SRVID to bring this drought mitigation project to fruition. The grant funds provided by the Bureau of Reclamation will result in millions of dollars of benefits to the area served by our agency.

Sincerely,
Roger S Christensen
Chairman

City of Shelley
Celebrating our 100th Anniversary
101 South Emerson Street Shelley, Idaho 83274 (208) 357-3390
City Web Site www.ci.shelley.id.us

MAYOR
Stacy Pascoe

COUNCIL
Earl Beattie
Jeff Kelley
Kim Westergard
Adam French

OFFICERS
Sandy Gaydusek
City Clerk/Treasurer

Rod Mohler
Police Chief

Justin Johnson
Public Works Dir.

Mikel Anderson
Recreation Director

Forsgren Engineering
City Engineer

B.J. Driscoll
City Attorney

March 14, 2019

Ms. Julie J. Hendircks
P. O. Box 250007, MS 84-27814
Denver, CO. 80225

RE: Application for WaterSMART Grant
BOR-DO-19-003
Drought Response Program

Dear Ms. Hendricks:

I am writing as the Mayor of the City of Shelley to lend city support for the WaterSMART Grant application the Snake River Valley Irrigation District has applied for in anticipation of future drought events.

Drought can be defined as a period when the amount of allocated storage in a basin is inadequate to meet the demand for supplemental water. Storage in the past has been limited to the water retained in surface reservoirs and Reclamation has created most of the surface storage space in the western U.S.A. There can be no doubt that as populations grow and water supplies become increasingly less dependable, the solution lies in storing recoverable water in aquifers.

With the advent of "Aquifer Recharge Units" (ARUs™) true conjunctive water management appears to be with in the grasp of states and ultimately, those needing supplemental water supplies. The Snake River Valley Irrigation District is seeking a grant to aid in the construction of the first fully ARU™ based aquifer storage project. This project benefits not only the patrons of the irrigation district but will also provide a long-term vehicle for removing phosphorous from the reaches downstream from Shelley. These benefits accrue through recharging class "A" effluent from the Eastern Idaho Regional Waste Water Authority (EIRWWA) plant instead of discharging it to the river. These benefits alone represent several million dollars in savings to the residents of Bingham County, Ammon, and Shelley.

Because of the many beneficiaries within and outside of the SRVID boundaries, Shelley certainly encourages the review team for this application to grant the requested funds to the applicant. In doing so these funds will facilitate multi-million dollars in benefits that will arise from the completion of the Oxbow Managed Recharge project.

Very truly yours,

Stacy Pascoe, Mayor

City of Shelley

Celebrating our 100th Anniversary

101 South Emerson Street Shelley, Idaho 83274 (208) 357-3390

City Web Site www.ci.shelley.id.us

MAYOR
Stacy Pascoe

COUNCIL
Earl Beattie
Jeff Kelley
Kim Westergard
Adam French

OFFICERS
Sandy Gaydusek
City Clerk/Treasurer

Rod Mohler
Police Chief

Justin Johnson
Public Works Dir.

Mikel Anderson
Recreation Director

Forsgren Engineering
City Engineer

B.J. Driscoll
City Attorney

Letter of Support and Commitment from the City of Shelley

March 21, 2019

U.S. Bureau of Reclamation
Attn: Ms. Julie J. Hendricks
PO box 25007, MS 84-27814
Denver, CO 80225

RE: Letter of Support and Commitment, Application for WaterSMART Grant BOR-DO-19-F003, Drought Response Program, Submitted by the Snake River Valley Irrigation District

Dear Ms. Hendricks:

I am writing as Councilman for the City of Shelley to express support and commitment to the project identified in WaterSMART Grant BOR-DO-19-F003, Drought Response Program, submitted by Snake River Valley Irrigation District.

The City of Shelley has an opportunity to participate in a groundwater recharge program that would enable large amounts of water to be stored in the Easter Snake Plain Aquifer to be available for inevitable future periods of drought. This recharge will enable continued use of existing municipal supplies and provide for additional use that our city requires to remain health and vital. In addition participation in their recharge project will enable us to save our water in the aquifer rather than to place it in the river where during many periods, today for example, the water will flow out of Idaho largely unused.

For these reasons the City of Shelley strongly supports the project proposed by the Snake River Valley Irrigation District (SRVID), which will enable delivery of Snake River water to our site. In addition to this support, the City of Shelley pledges cost share for work conducted to enable this recharge to happen:

Removal of irrigation equipment and reinstallation of equipment and re-landscaping:

Equipment: $ 95,200

Labor:	
5 laborers	\$100,195
Total commitment	\$195,395

The City of Shelley stands ready to assist the SRVID to bring this drought mitigation project to fruition. The grant funds provided by the Bureau of Reclamation will result in millions of dollars of benefits to the area served by our city and other agencies.

Sincerely,

Jeff Kelley
City of Shelley Council

EASTERN SNAKE PLAIN AQUIFER RECHARGE, INC.
PO Box 8, 144 S. Main Street
Aberdeen, ID 83210-0008
208-397-8407

March 21, 2019

U.S. Bureau of Reclamation
Attn: Ms. Julie J. Hendricks
PO Box 25007, MS 84-27814
Denver, CO 80225

RE: Letter of Support and Commitment, Application for WaterSMART Grant BOR-DO-19-F003, Drought Response Program, Submitted by Snake River Valley Irrigation District

Dear Ms. Hendricks:

I am writing as the President of Eastern Snake Plain Aquifer Recharge, Inc. (ESPAR), a private non-profit corporation that provides supplemental groundwater supplies to its shareholders in the Eastern Snake Plain Aquifer. ESPAR desires to express both support for and commitment to the project identified in WaterSMART Grant BOR-DO-19-F003, Drought Response Program, submitted by Snake River Valley Irrigation District.

The objective of this BOR Program – to increase drought resiliency, is closely aligned with the objective of ESPAR – to provide supplemental groundwater during times of shortage. Thus, ESPAR strongly supports the project proposed by the Snake River Valley Irrigation District (SRVID), which will enable delivery of Snake River water to be recharged to the Eastern Snake Plain Aquifer. Accordingly we pledge our support of the project and our commitment to invest $16,700 in the project as indicated in the SRVID proposal.

ESPAR stands ready to assist the SRVID to bring this drought mitigation project to fruition. The grant funds provided by the Bureau of Reclamation will greatly aid in the development of infrastructure that will result in millions of dollars of benefits to the area served by our shareholders.

Sincerely,

Marc Elliott

Marc S. Elliott
President

American Falls Aberdeen Ground Water District
505 N Oregon Trail
American Falls, ID 83211

March 21, 2019

U.S. Bureau of Reclamation
Attn: Ms. Julie J. Hendricks
PO Box 25007, MS 84-27814
Denver, CO 80225

RE: Letter of Support, Application for WaterSMART Grant BOR-DO-19-F003, Drought Response Program, Submitted by Snake River Valley Irrigation District

Dear Ms. Hendricks:

I am writing as the Chairman of the American Falls Aberdeen Ground Water District (AFAGWD), a groundwater organization formed pursuant to Idaho Code Title 42 Chapter 52 for the benefit of its member groundwater users. AFAGWD desires to express our support for the project identified in WaterSMART Grant BOR-DO-19-F003, Drought Response Program, submitted by Snake River Valley Irrigation District (SRVID).

The objective of this BOR Program – to increase drought resiliency, is closely aligned with the objective of AFAGWD – to protect the interests of its member users. AFAGWD is a shareholder in Eastern Snake Plain Aquifer Recharge, Inc., which we understanding is also providing a letter of support for this grant request.

Our members are particularly vulnerable to the impacts of drought, and to forestall those impacts we actively encourage managed aquifer recharge (MAR) throughout the Eastern Snake Plain Aquifer, to serve as a hedge against potential curtailments of diversion by our members. The project envisioned by SRVID is particularly helpful as it will enable MAR activities during times of plenty – protecting against the impacts of drought.

AFAGWD stands ready to assist the SRVID to bring this drought mitigation project to fruition. The grant funds provided by the Bureau of Reclamation will greatly aid in the development of infrastructure that will result in millions of dollars of benefits to the aquifer served by our members.

Sincerely,

Nic Behrend
Chairman

BINGHAM COUNTY COMMISSIONERS

Whitney Manwaring, Chairman
Mark R. Bair
Jessica L. Lewis

Caren Hawkes, Commission Clerk
501 N. Maple #204
Blackfoot, ID 83221
Phone: 782-3013
Fax: 785-4131

March 25, 2019

U.S. Bureau of Reclamation

Attn: Ms. Julie J. Hendricks

RE: Letter of Support for WaterSMART Grant BOR-DO-19-F003, Drought Response Program, by the Snake River Valley Irrigation District.

Dear Ms. Hendricks:

I am writing to affirm the support of the Bingham County Commission for the Snake River Valley Irrigation District's application for a project identified in WaterSMART Grant BOR-DO-19-F003.

This project lies within Bingham County and will benefit the largest industry in Bingham County, agriculture. Bingham County declared a drought emergency seven times between 2001 and 2013, and we anticipate similar cycles in our future. The first farmers hurt by drought in the county are the groundwater pumpers, who have the most junior rights to use water. In fact, the Bingham County groundwater pumpers are currently operating under an agreement where they have had to reduce the groundwater pumping in order to help the levels of the aquifer recover.

Groundwater recharge is very beneficial for our farmers in several ways. It helps them recover the aquifer levels to ensure that the next time there is a drought there will be sufficient water for them to continue in business. It will also help them in meeting current commitments to reduce their impacts on the aquifer.

Recharge planned in this project will be especially beneficial because it will provide the Eastern Idaho Regional Wastewater Authority (EIRWWA) with additional water they need to mix with effluent from the treatment plant in order to use it for recharge. Because of the year-round nature of water from this plant, recharge to the aquifer will be larger and more consistent than in other recharge projects. It also benefits areas of our county served by EIRWWA.

Bingham County relies not only on direct agricultural impacts, but also on the many jobs that value added packing and processing provides. Without sufficient water for irrigation, our whole county would be severely impacted during periods of drought. For these reasons, we support the goals and implementation of this project.

Sincerely,

Whitney Manwaring

Whitney Manwaring, Chairman

Mark R. Bair

Mark R. Bair, Commissioner

Jessica Lewis

Jessica L. Lewis, Commissioner

Appendix D -- Bids

BTC Contractors, LLC.
744 E 1100N
Shelley, ID 83274
208-808-7283

Proposal

Proposal Date: 2/19/2019
Proposal #: 203
Project:

Bill To:
RDC

Description	Est. Hours/Qty.	Rate	Total
Irrigation ditch removal and new installation of new 36" hdpe pipe , approx. 3150 lf of pipe			
Removal of old system and regrading, bedding and installation of 36" HDPE pipe, remove and replace approx. 3150 lf of pipe, 1 manhole and 4 air vents	1	281,610.00	281,610.00
to go to 48" pipe would be an additional $126,000.00			
asphalt to replace walk path if necessary , approx. 2100 lf x 8' wide may be effected-16800sf - approx. $41,000 with prep for pitrun and 4" of 3\4 road base and 2" of asphalt this is price for asphalt if worst case, but it is hard to tell how much would or could be effected, but it could only be about 30% of this distance			

Total $281,610.00

Appendix E – Drought Documents

IDAHO DROUGHT PLAN

with

FEDERAL WATER-RELATED DROUGHT RESPONSE PROGRAMS

Idaho Department of Water Resources
Planning and Technical Services Division
Boise, Idaho

Revised

May 2001

Costs associated with this publication are available from the
Idaho Department of Water Resources
In accordance with Section 60-202, Idaho Code

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Comprehensive Aquifer Management Plan

ADOPTED BY **Idaho Water Resource Board**

JANUARY 2009

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1.0 EXECUTIVE SUMMARY

The ESPA region produces approximately 21 percent of all goods and services within the State of Idaho resulting in an estimated value of $10 billion annually. Water is the critical element for this productivity.

The Plan establishes a long-term program for managing water supply and demand in the ESPA through a phased approach to implementation, together with an adaptive management process to allow for adjustments or changes in management techniques as implementation proceeds. Due to the inherent complexities in the management and responses of the river and aquifer to water budget changes, a very deliberate choice was made to incrementally implement the various mechanisms proposed in this Plan. The long-term objective of the Plan is to incrementally achieve a net ESPA water budget change of 600 thousand acre-feet (kaf) annually. It is projected that this hydrologic goal can be achieved by the year 2030 through implementation of a mix of management actions including, but not limited to, aquifer recharge, ground-to-surface water conversions, and demand reduction strategies. The Plan sets forth actions which stabilize and improve spring flows, aquifer levels, and river flows across the Eastern Snake Plain.

The goal of the Plan is to:
"Sustain the economic viability and social and environmental health of the Eastern Snake Plain by adaptively managing a balance between water use and supplies."

The objectives of the Plan are to:
1. Increase predictability for water users by managing for a reliable supply.
2. Create alternatives to administrative curtailment.
3. Manage overall demand for water within the Eastern Snake Plain.
4. Increase recharge to the aquifer.
5. Reduce withdrawals from the aquifer.

Immediate implementation of the Plan is necessary to achieve the stated goal and objectives.

The Plan approaches the 600 kaf target in phases. The Plan Phase I (1-10 years) hydrologic target is a water budget change between 200 kaf and 300 kaf. Phase I includes site-specific implementation actions based on the anticipated hydrologic effect of those actions, as outlined in Section 3.2.1. The water budget adjustment mechanisms include:

- A. Ground water to surface water conversions.
- B. Managed aquifer recharge.
- C. Demand reduction, including:
  1. Surface water conservation.
  2. Crop mix modification in the Aberdeen/ Bingham groundwater district.
  3. Buyouts, buy-downs, and/or subordination agreements.
  4. Rotating fallowing, dry-year lease agreements, and Conservation Reserve Enhancement Program (CREP) enhancements.
- D. Pilot weather modification program.
- E. Minimizing loss of incidental recharge.

To ensure that the valuable input of stakeholders continues during the implementation of Phase I and the design and implementation of subsequent phases, this Plan establishes an Implementation Committee. This committee will provide recommendations to the Board concerning Phase I implementation, assessment of Phase I effectiveness, definition of subsequent phases, and coordination of activities necessary for implementation. This committee will also evaluate the effectiveness and viability of continuing Plan implementation during Phase I. The Implementation Committee will include representation, at a minimum, from all interest groups currently represented on the ESPA Advisory Committee.

Settlement Agreement Entered into June 30, 2015 between participating members of the Surface Water Coalition[1] and Participating members of the Idaho Ground Water Appropriators, Inc.[2]

In settlement of litigation involving the distribution of water to the members of the Surface Water Coalition, the parties agree as follows:

1. **Objectives.**
   a. Mitigate for material injury to senior surface water rights that rely upon natural flow in the Near Blackfoot to Milner reaches to provide part of the water supply for the senior surface water rights.
   b. Provide "safe harbor" from curtailment to members of ground water districts and irrigation districts that divert ground water from the Eastern Snake Plain Aquifer (ESPA) for the term of the Settlement Agreement and other ground water users that agree to the terms of this Settlement Agreement.
   c. Minimize economic impact on individual water users and the state economy arising from water supply shortages.
   d. Increase reliability and enforcement of water use, measurement, and reporting across the Eastern Snake Plain.
   e. Increase compliance with all elements and conditions of all water rights and increase enforcement when there is not compliance.
   f. Develop an adaptive groundwater management plan to stabilize and enhance ESPA levels to meet existing water right needs.

---

[1] The Surface Water Coalition members ("SWC") are A&B Irrigation District (A&B), American Falls Reservoir District No. 2 (AFRD2), Burley Irrigation District (BID), Milner Irrigation District (Milner), Minidoka Irrigation District (MID), North Side Canal Company (NSCC), and Twin Falls Canal Company (TFCC). The acronym "SWC" in the Settlement Agreement is used for convenience to refer to all members of the Surface Water Coalition who are the actual parties to this Settlement Agreement.

[2] The Idaho Ground Water Appropriators, Inc. ("IGWA") are Aberdeen-American Falls Ground Water District, Bingham Ground Water District, Bonneville-Jefferson Ground Water District, Carey Valley Ground Water District, Jefferson Clark Ground Water District, Madison Ground Water District, Magic Valley Ground Water District, North Snake Ground Water District, Southwest Irrigation District, and Fremont-Madison Irrigation District, Anheuser-Busch, United Water, Glambia Cheese, City of Blackfoot, City of American Falls, City of Jerome, City of Rupert, City of Heyburn, City of Paul, City of Chubbuck, and City of Hazelton. The acronym "IGWA" in the Settlement Agreement is used for convenience to refer to all members of the Idaho Ground Water Appropriators, Inc. who are the actual parties to this Settlement Agreement.

2. **Near Term Practices.**
   a. For 2015 IGWA on behalf of its member districts will acquire a minimum of 110,000 ac-ft for assignment as described below:
      i. 75,000 ac-ft of private leased storage water shall be delivered to SWC;
      ii. 15,000 ac-ft of additional private leased storage water shall be delivered to SWC within 21 days following the date of allocation;
      iii. 20,000 ac-ft of common pool water shall be obtained by IGWA through a TFCC application to the common pool and delivered to SWC within 21 days following the date of allocation; and
      iv. Secure as much additional water as possible to be dedicated to on-going conversion projects at a cost not to exceed $1.1 million, the cost of which will be paid for by IGWA and/or the converting members.
   b. The parties stipulate the director rescind the April 16 As-Applied Order and stay the April 16 3rd Amended Methodology Order, and preserve all pending rights and proceedings.
   c. "Part a" above shall satisfy all 2015 "in-season" mitigation obligations to the SWC.
   d. This Settlement Agreement is conditional upon approval and submission by the respective boards of the Idaho Ground Water Appropriators, Inc. ("IGWA") and the Surface Water Coalition ("SWC") to the Director by August 1.
   e. If the Settlement Agreement is not approved and submitted by August 1 the methodology order shall be reinstated and implemented for the remainder of the irrigation season.
   f. Parties will work to identify and pass legislative changes needed to support the objectives of this Settlement Agreement, including, development of legislation memorializing conditions of the ESPA, obligations of the parties, and ground water level goal and benchmarks identified herein.

3. **Long Term Practices, Commencing 2016.**
   a. *Consumptive Use Volume Reduction.*
      i. Total ground water diversion shall be reduced by 240,000 ac-ft annually.
      ii. Each Ground Water and Irrigation District with members pumping from the ESPA shall be responsible for reducing their proportionate share of the total annual ground water reduction or in conducting an equivalent private recharge activity. Private recharge activities cannot rely on the Water District 01 common Rental Pool or credits acquired from third parties, unless otherwise agreed to by the parties.
   b. *Annual storage water delivery.*
      i. IGWA will provide 50,000 ac-ft of storage water through private lease(s) of water from the Upper Snake Reservoir system, delivered to SWC 21 days after the date of allocation, for use to the extent needed to meet irrigation

BEFORE THE DEPARTMENT OF WATER RESOURCES

OF THE STATE OF IDAHO

IN THE MATTER OF A DECLARATION OF DROUGHT EMERGENCY FOR BINGHAM COUNTY	))))	**ORDER DECLARING** **DROUGHT EMERGENCY**

WHEREAS, the Board of County Commissioners for Bingham County has requested that the Governor and the Director of the Idaho Department of Water Resources declare a drought emergency for Bingham County to allow administrative actions to lessen the severe impacts of drought conditions in the county; and

WHEREAS, a portion of Bingham County is included within and relies upon water supplies from the Blackfoot River drainage and a portion of the county is included within and relies upon water supplies from the Upper Snake River basin; and

WHEREAS, snow water equivalent (SWE) levels as of May 1 for the Upper Snake River drainage were above 90 percent of average but snow packs melted out several weeks early and stream flow volumes for the Snake River near Bingham County from June through September are forecasted to be only about 69 percent of normal; and

WHEREAS, SWE levels in the Blackfoot River Basin were only 76 percent and 43 percent of normal on April 1 and May 1 respectively, and stream flow volumes in the drainage are forecasted to be about 53 percent of normal; and

WHEREAS, the United States Drought Monitor Index shows Bingham County included within that portion of Eastern Idaho classified as moderate drought, and given that the drier than normal conditions within Bingham County may result in tighter water supplies; and

WHEREAS, section 42-222A, Idaho Code, provides that upon declaration of a drought emergency for an area designated by the Director of the Department of Water Resources ("Director") and approved by the Governor, the Director is authorized to allow temporary changes in the point of diversion, the place of use, and the purpose of use for valid existing water rights and temporary exchanges of water rights when the Director determines that such changes can be accomplished in accordance with the provisions of section 42-222A, Idaho Code; and

NOW, THEREFORE, IT IS HEREBY ORDERED that pursuant to the authority of the Director provided in section 42-222A, Idaho Code, a drought emergency for purposes of section 42-222A, Idaho Code, is hereby declared for Bingham County, Idaho.

IT IS FURTHER HEREBY ORDERED that pursuant to this declared drought emergency and the provisions of section 42-222A, Idaho Code, the following procedures and requirements shall apply to the filing, processing, and approval of any application for a temporary change to an existing water right within Bingham County during the pendency of this declared drought emergency:

1. An application for a temporary change to an existing water right shall be made upon forms provided by the department and shall be accompanied by an application fee of fifty dollars ($50.00) per application.

2. The Director is not required to publish notice of the proposed change pursuant to the provisions of section 42-211, 42-222(1) or 42-240, Idaho Code, and is not required to make findings as provided in said sections. A temporary change may be approved upon completion of the application form, payment of the filing fee, and a determination by the Director that the proposed change can be properly administered and there is no information that the change will injure any other water right. If the right to be changed is administered by a watermaster within a water district, the Director shall obtain and consider the recommendations of the watermaster before approving the temporary change application.

3. All temporary changes approved pursuant to the provisions of this order shall expire on the date shown in the approval which shall not be later than December 31, 2013, and thereafter, the water right shall revert to the point of diversion and place of use existing prior to the temporary change. Nothing herein shall be construed as approval to authorize construction of a new well as a new point of diversion or to alter a stream channel.

4. The recipient of an approved temporary change issued pursuant to this order shall assume all risk of curtailment or mitigation should the diversion and use of water under the temporary change cause injury to other water rights or result in an enlargement in use of the original right.

5. Temporary changes shall only be approved for the purpose of providing a replacement water supply to lands or other uses that normally have a full water supply, except for the drought condition. Temporary changes may not be approved to provide water for new development or to allow expansion of the use of water under existing water rights. If the right to use the water is represented by shares of stock in a corporation, or if the diversion works or delivery system for such right is owned or managed by an irrigation district, no change in point of diversion, place or nature of use of such water shall be made or allowed without the written consent of such corporation or irrigation district.

6. Any applicant for a temporary change who is aggrieved by a denial of the Director for a temporary change pursuant to this order and the provisions of section 42-222A, Idaho Code, may request a hearing pursuant to section 42-1701A(3), Idaho

Code, and may seek judicial review of the final order of the Director pursuant to the provisions of section 42-1701A(4), Idaho Code.

IT IS FURTHER HEREBY ORDERED that this order is effective upon approval of the Governor and expires on December 31, 2013, unless extended or terminated by order of the Director.

DATED this 28th day of June, 2013.

Gary Spackman

GARY SPACKMAN
Interim Director

APPROVED this 1 day of ~~June~~ July CLO, 2013.

C. L. "Butch" Otter

C. L. "BUTCH" OTTER
Governor

BINGHAM COUNTY
RESOLUTION NO. 2013-16

A RESOLUTION DECLARING BINGHAM COUNTY A DISASTER AREA

WHEREAS, there is a threat to life and property in Bingham County as the result of an apparent severe water shortage and;

WHEREAS, the area in Bingham County is affected, and;

WHEREAS, many residents of the County will be affected by such a shortage to a degree that may cause loss of crops and thereby create extreme financial hardship on said residents, and;

WHEREAS, Section §46-1011, Idaho Code, authorizes the Commissioners of the County of Bingham, Idaho to declare a local disaster emergency to authorize the furnishings of aid and assistance, there under;

NOW THEREFORE, be it resolved and declared by the Bingham County Board of Commissioners, as follows:

1. A disaster emergency is hereby declared to exist within Bingham County created by a severe water shortage creating an imminent threat to property, public utilities, (etc.).
2. These conditions require the activation of the response and recovery aspects of all applicable local disaster emergency plans; and
3. Such disaster may require State emergency assistance to supplement local efforts to protect, rehabilitate, and replace public property as well as to provide a coordinated multi-agency effort to mitigate, avert, and lessen the threat and impact of the disaster.

ADOPTED unanimously in open special session this 17th day of June, 2013.

BOARD OF COUNTY COMMISSIONERS

By: A. Ladd Carter
A. Ladd Carter, Chairman

ATTEST:

Sara J. Staub
Sara J. Staub
Bingham County Clerk

Whitney Manwaring
Whitney Manwaring, Commissioner

Mark R. Bair
Mark R. Bair, Commissioner

BOARD OF COUNTY COMMISSIONERS
BINGHAM COUNTY
IDAHO

Incorporating Recharge Limitations into the Prioritization of Aquifer Recharge Sites Based on Hydrologic Benefits Using

ESPAM2.1

by

Michael McVay, P.E., P.G.

Idaho Department of Water Resources

November 2015

Executive Summary

This report, *Incorporating Recharge Limitations into the Prioritization of Aquifer Recharge Sites Based on Hydrologic Benefits Using ESPAM2.1*, uses the Enhanced Snake Plain Aquifer Model version 2.1 to assess the relative effectiveness of recharge at each of 19 sites in reaching Idaho's aquifer stabilization goals. A previous modeling report prioritizes the recharge sites and provides the Idaho Water Resources Board with a range of considerations related to seven general objectives, but does not identify the primary objective for State-sponsored managed recharge.

Increasing aquifer storage is the only objective that is aquifer-wide in scope and fully aligned with the overarching ESPA Comprehensive Aquifer Management Plan goal of improving the water budget for the entire aquifer. Successfully increasing long-term aquifer storage will raise aquifer water levels, increase spring discharge, and bolster river flow throughout the aquifer/river system. For these reasons, increasing aquifer storage has been identified as the most generally useful criterion for comparing recharge sites and for optimizing recharge efforts. In short, increasing aquifer storage is the primary objective for State-sponsored recharge.

The analyses presented herein build upon previous prioritization efforts by incorporating legal and policy guidelines to the Managed Recharge Program as well as site-specific limitations to recharge. State policy limits the volume of water that can be recharge in the ESPA to a long-term average of 250,000 acre-feet annually and State law dictates that the State's recharge right must be in priority for State-sponsored recharge to occur.

The Milner Zero Minimum Flow Policy effectively divides the Snake River into two separate rivers by allowing zero flow in the Snake River at Milner Dam. Although water users below Milner Dam cannot influence water use upstream of the dam, there are established minimum flows downstream at Swan Falls Dam which the State is obligated to maintain. The State Water Plan directs that the ESPA be managed as part of the Snake River system, and that the system be managed to maintain the minimum flows at Murphy. Therefore, the success of State-sponsored managed recharge is contingent on bolstering the flows at Murphy.

There are generally four limitations to the monthly volume of recharge at a site:

1. Water Availability – Water availability is delimited by water rights and the flows past Milner and Minidoka dams. Because the flow at Milner Dam can be brought to zero to fulfill beneficial uses upstream, any natural flow past Milner Dam is available for recharge. Given that the State's recharge right is in priority, the flow past Milner can be used for recharge downstream of Minidoka Dam. Recharge upstream of Minidoka Dam is complicated by reservoir fill water rights, physical reservoir fill, and the unsubordinated USBR hydropower rights at Minidoka Dam. The USBR hydropower rights of 2,700 cfs affect managed recharge in two ways: 1) the hydropower rights are senior to the State's recharge rights, and 2) the hydropower rights are used to indicate the likelihood of physical reservoir fill. Therefore, flow in excess of 2,700 cfs at Minidoka are available for recharge upstream, but care must be taken to ensure that assumed minimum stream flows are maintained upstream of American Falls Reservoir. Water is only considered available for recharge if the State's recharge water right is in priority at the POD during the period of recharge.

2. Diversion Limitations – Diversion limitations are generally related to the size of diversion, transmission, and recharge structures; therefore, it may be possible to engineer increased diversion capacity. The diversion limitations used in this study have been developed from historic recharge activities.

3. Infiltration Limitations – Infiltration limitations are generally related to surface and subsurface geologic materials, infrastructure available at the recharge site, and the volume of water that can be delivered to the site. The infiltration limitations used in this study have been developed using a combination of published values, model-derived values, and interviews with facility managers. It may be possible to engineer increased infiltration capacity if recharge infrastructure or diversion capacity is the limiting factor.

4. Shallow Groundwater Limitations – Shallow groundwater effectively limits the space between the water table and land surface and can hinder recharge efforts by causing infrastructure damage or allowing rapid return to surface water. Limitations due to shallow groundwater have been determined using ESPAM2.1. Due to the analysis methodology and regional nature of the model, it is recommended that a hydrogeologic or engineering investigation be conducted for proposed recharge at rates greater than the shallow groundwater limitation of the site. Shallow groundwater is generally related to regional hydrogeological conditions; therefore, it is likely not possible to engineer solutions to these conditions in regards to managed recharge.

Multiple modeling scenarios have been run to evaluate the effectiveness of recharge to increase aquifer storage. Results of the modeling scenarios indicate that there are three elements to recharge that impact a site's ability to increase aquifer storage:

1. Location of the recharge site. Distance from connected reaches of the South Fork, Henry's Fork, and Snake River governs the retention of recharge in the aquifer (or how quickly water returns to the rivers). Geologic materials control how easily water infiltrates. Aquifer heterogeneities affect the distribution of recharge impacts and influence where the benefits are realized.

2. The volume of water recharged. The volume of water recharged at a site necessarily impacts how effectively aquifer storage is increased.

3. Recharge frequency. Recharge frequency is important for the development of aquifer storage. Higher recharge frequency means that more water can be recharged over time. Higher recharge frequency also means that less time passes between recharge events, during which stored water to returns to the river without replenishment by recharge. The combination of increased recharge and shorter inter-recharge periods results in the development of aquifer storage over time.

The results of the modeling and analyses indicate that water availability for recharge is most consistent at sites that divert water downstream of Minidoka Dam. Reservoir fill, water-right priority, and assumed minimum stream flows reduce availability in the upstream direction.

In general, sites located along the Henry's Fork and sites located on the main stem Snake River downstream of Minidoka Dam have the highest aquifer retention rates, while sites located along the South Fork and main stem Snake River upstream of Minidoka Dam have the lowest aquifer retention rates.

Based on modeling that considers both the site-specific recharge limitations and water availability, Northside canal system is the site with the greatest ability to benefit aquifer storage, followed closely by the Milepost 31 recharge site. The United canal system and Jensen's Grove sites provide the least benefit to aquifer storage.

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Introduction

The Eastern Snake Plain Aquifer (ESPA) is the largest aquifer in Idaho (Figure 1), and storage within the aquifer has been steadily declining since the 1950's (Figure 2). The State of Idaho (State) has determined that aquifer stabilization and recovery are the primary objectives for managed recharge, and the legislature has allocated funds to support the Managed Recharge Program (HB 547, 2014). This study uses the Enhanced Snake Plain Aquifer Model version 2.1 (ESPAM2.1) to assess the relative effectiveness in reaching aquifer stabilization goals via recharge at each of 19 sites located throughout the ESPA. The analyses presented herein build upon the prioritization efforts outlined in *Prioritization of Aquifer Recharge Sites Based on Hydrologic Benefits Revised Using ESPAM2.1* (Prioritization Report; McVay, 2015) by incorporating site-specific limitations to recharge such as water availability, diversion rate, infiltration rate, and shallow groundwater. A cursory discussion of regional ESPA hydrogeology is included to provide context to the modeling results.

The prioritizations developed in this study are not intended to preclude recharge at any site, nor do they imply a priority in monthly or annual recharge activities. Rather, this study is intended to provide understanding of the important factors governing recharge impacts so the State can develop a managed recharge program that best meets the goals of aquifer stabilization and recovery. This study illustrates the benefits and drawbacks of recharge at each site, and is intended to assist with prioritizing investment decisions and maximizing the effectiveness of recharge efforts.

Selection of Managed Recharge Sites

Potential recharge sites analyzed in this report are limited to those that were identified in the Prioritization Report (Figures 3-6). Site selection was based, in part, on the ability and willingness of the irrigation entities that operate the sites to participate in managed recharge. Managed recharge sites are defined in this report as any natural or man-made feature or location such as a basin, pond, pit, well, or canal that can accept surface water and allow it to infiltrate to the regional aquifer. Recharge sites evaluated in this project include: 1) Egin Lakes (Fremont-Madison Irrigation District), 2) Canals east of the Henry's Fork in Fremont-Madison Irrigation District, 3) Canals west of the Henry's Fork in Fremont-Madison Irrigation District, 4) Great Feeder area canals, 5) New Sweden Irrigation District, 6) Idaho Irrigation District, 7) Snake River Valley Irrigation District, 8) Peoples Canal Company, 9) Riverside Canal Company, 10) United Canal Company, 11) Jensen's Grove, 12) Aberdeen-Springfield Canal, 13) Hilton Spill on Aberdeen-Springfield Canal, 14) the Lake Walcott recharge site, 15) Southwest Irrigation District, 16) American Falls Reservoir District #2 main canal (Milner-Gooding Canal), 17) Shoshone recharge site filled from Milner-Gooding Canal, 18) Mile Post 31 recharge site filled from Milner-Gooding Canal, and 19) Northside Canal Company including Wilson Lake. Locations of the model cells used to represent the recharge sites are shown in Figures 2 through 5. Hydrologic effectiveness of recharge is evaluated with ESPAM2.1 using objectives developed for the Idaho Water Resource Board (IWRB) in the Prioritization Report.

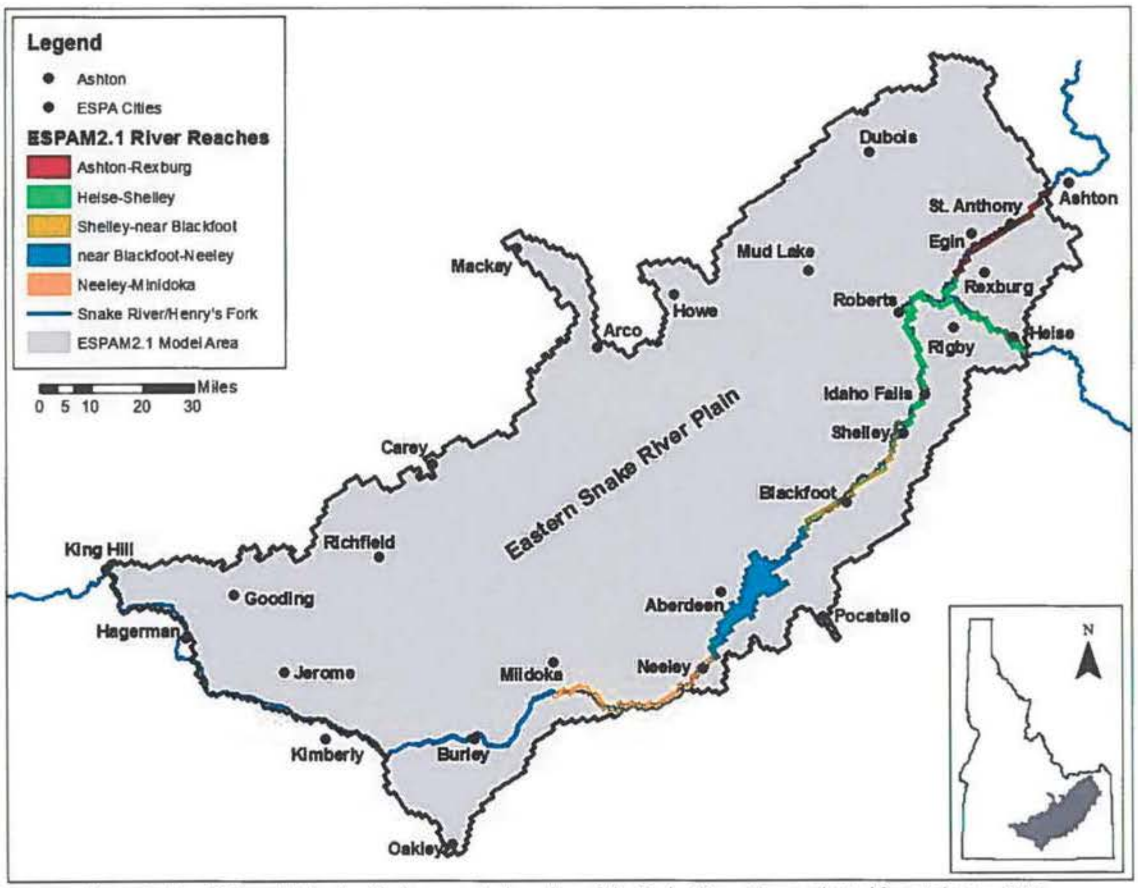

Figure 1. The ESPA and six hydraulically connected reaches of the Snake River. Figure adapted from Johnson, 2012.

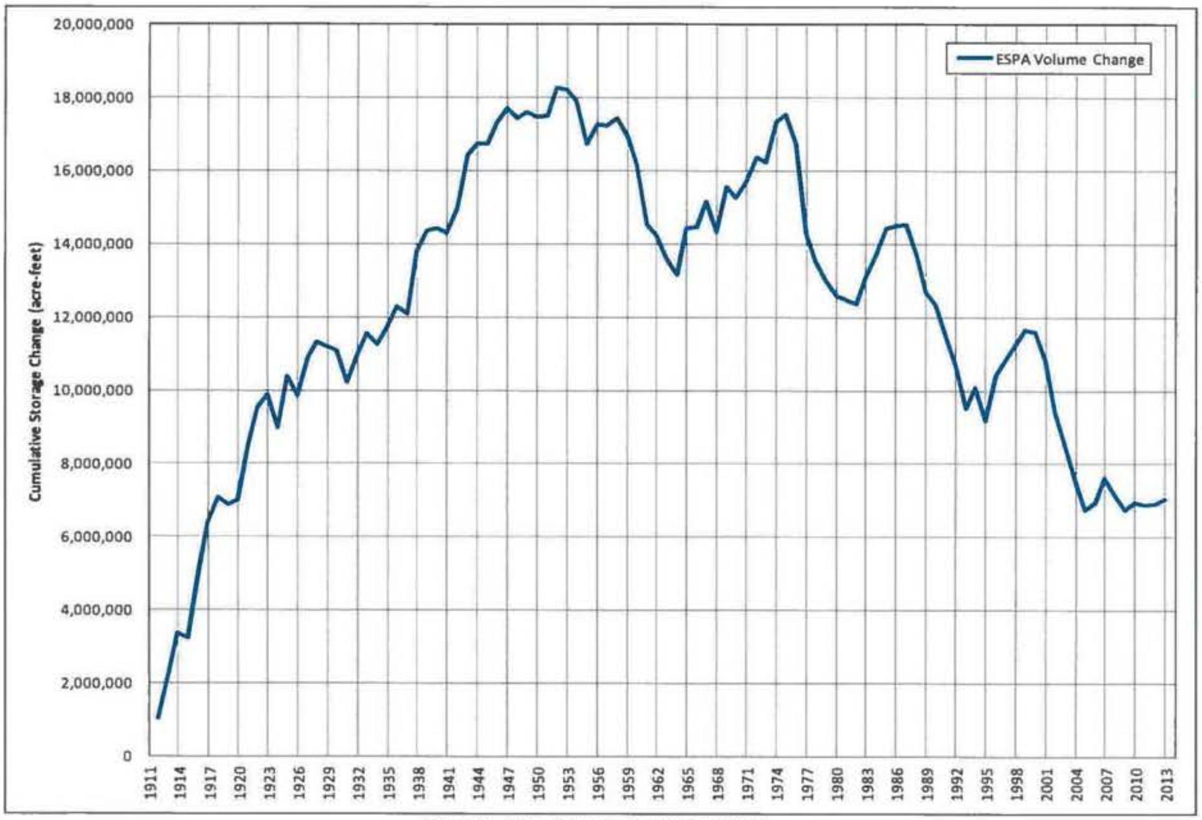

Figure 2. ESPA storage changes over time.

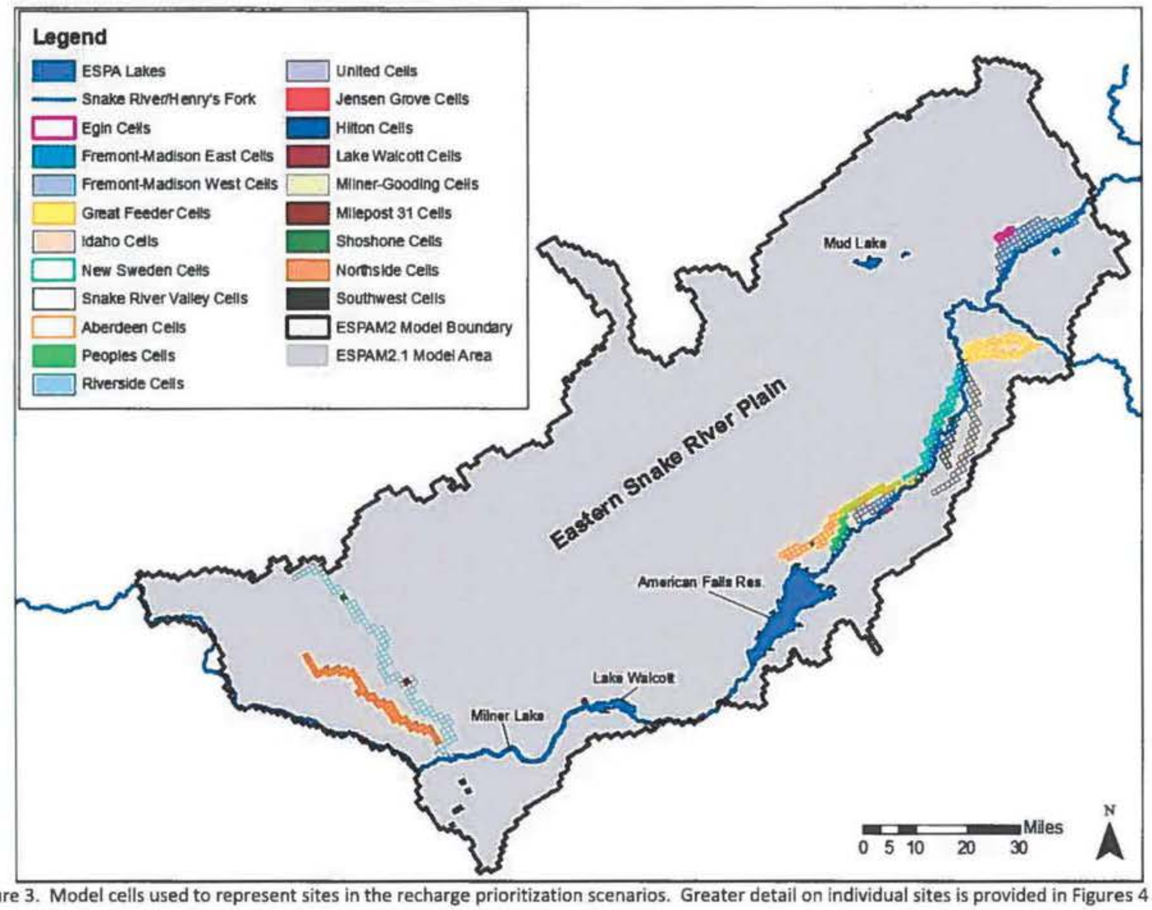

Figure 3. Model cells used to represent sites in the recharge prioritization scenarios. Greater detail on individual sites is provided in Figures 4 – 6.

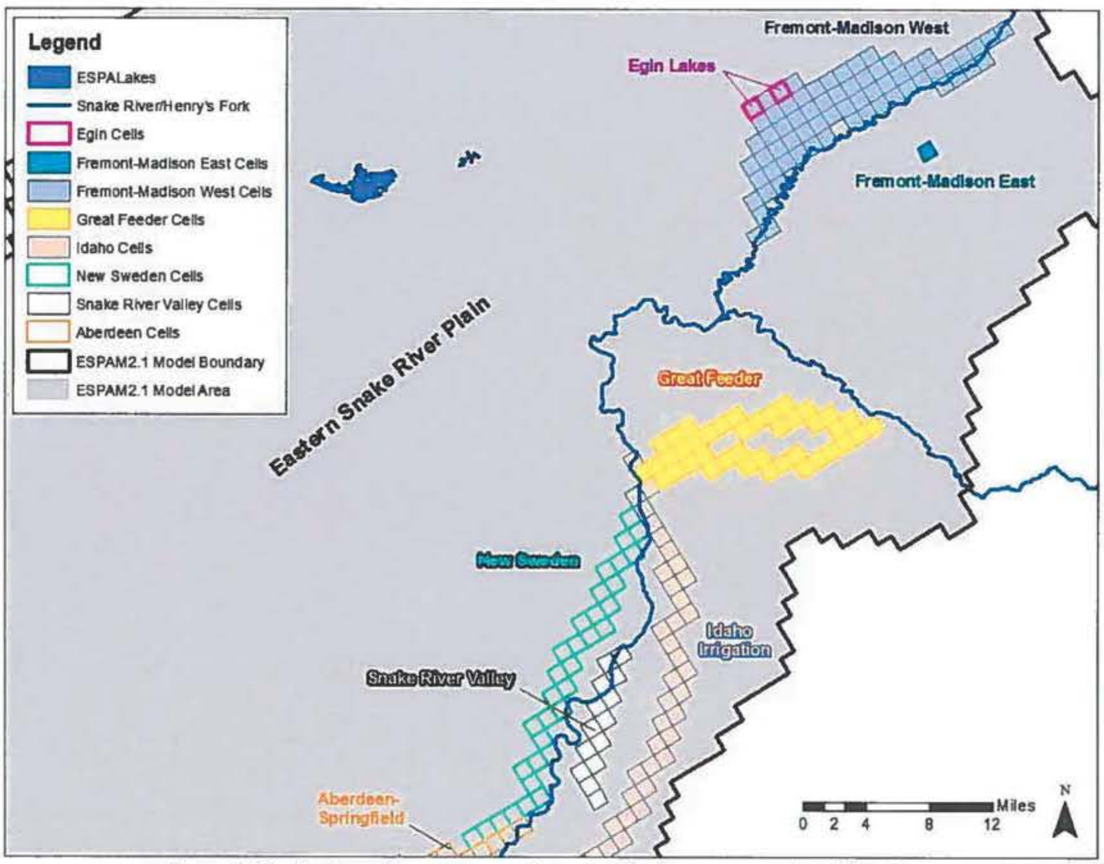

Figure 4. Model cells used to represent recharge sites for the eastern portion of the ESPA.

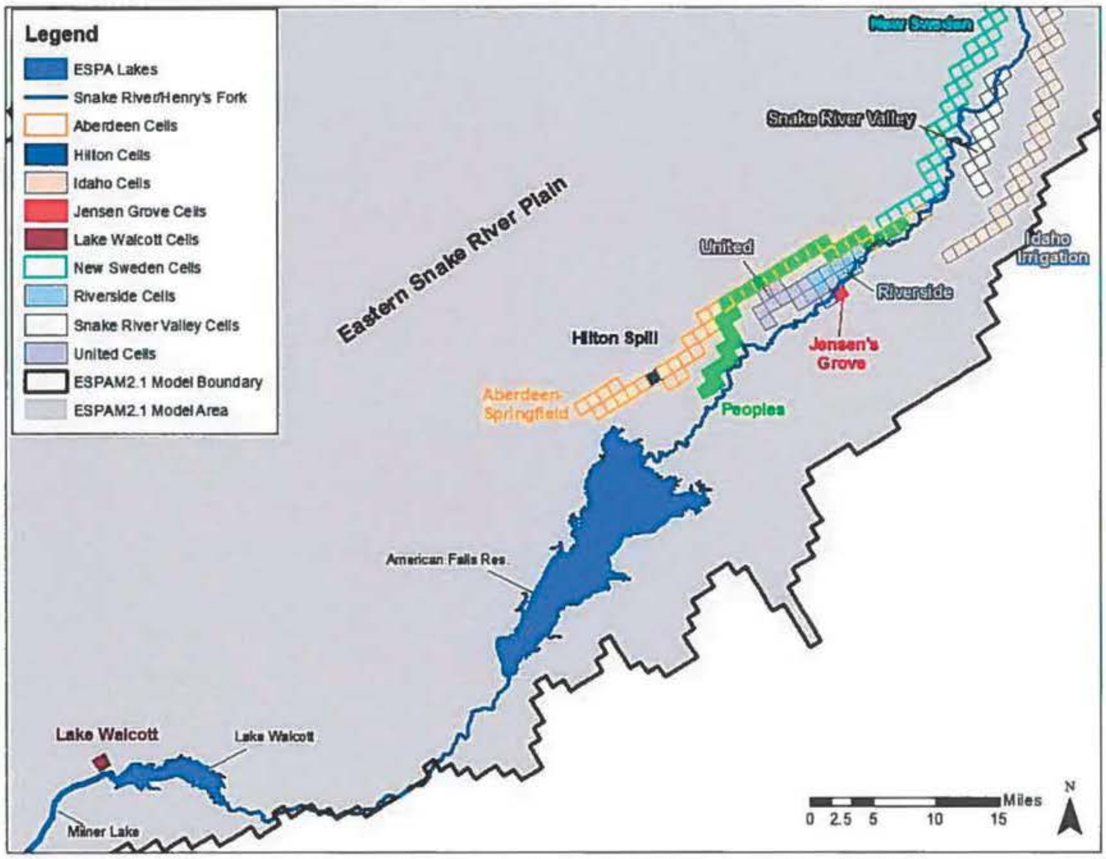

Figure 5. Model cells used to represent recharge sites for the central portion of the ESPA.

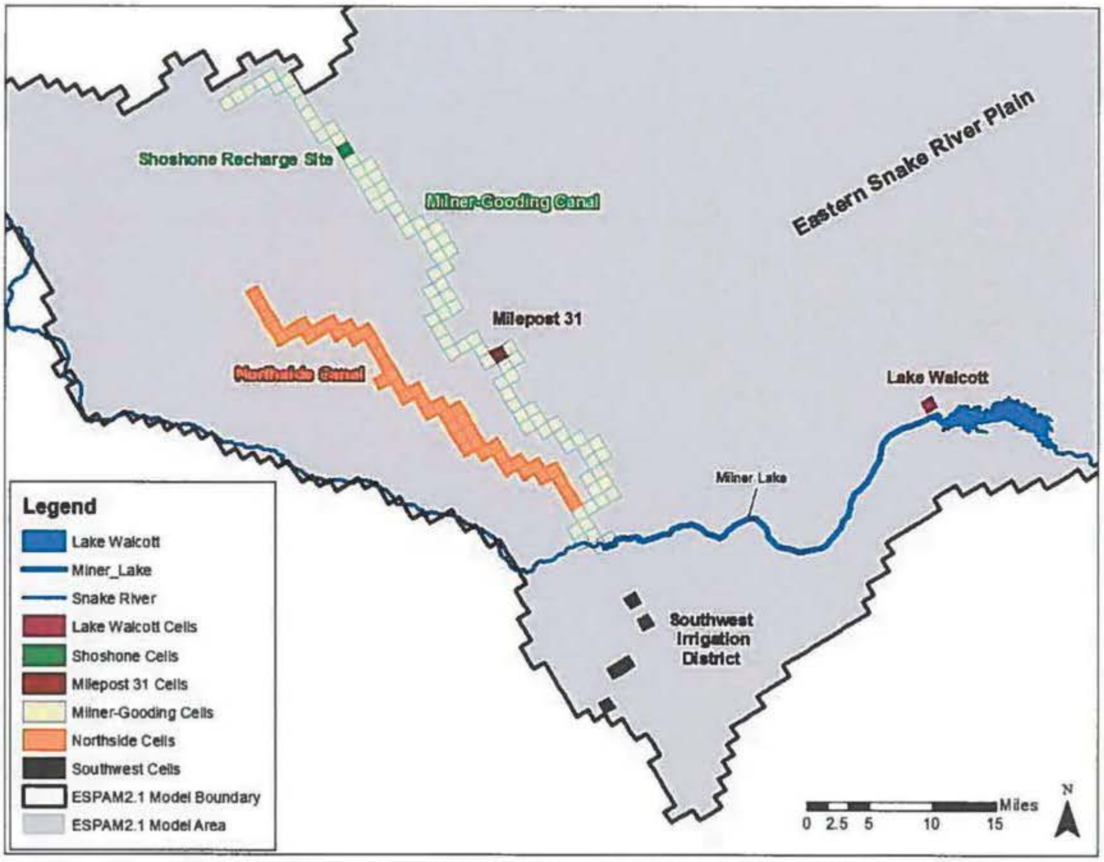

Figure 6. Model cells used to represent recharge sites for the western portion of the ESPA.

Hydrogeologic Setting

In order to fully understand the modeled impacts due to recharge, it is important to view recharge in the context of the hydrogeologic setting. The hydrogeologic setting not only influences site characteristics (e.g soil type, soil depth, depth to groundwater, and infiltration rate), but also controls the timing and spatial distribution of recharge impacts.

Geologic Framework

The surface of the Eastern Snake River Plain (ESRP) consists primarily of volcanic rocks – predominantly basalt. Most areas are covered by a veneer of windblown or fluvial sediments that vary in thickness from zero to tens of feet (IDWR, 2013). The most significant sediment deposits occur near the margins of the plain (Figure 7).

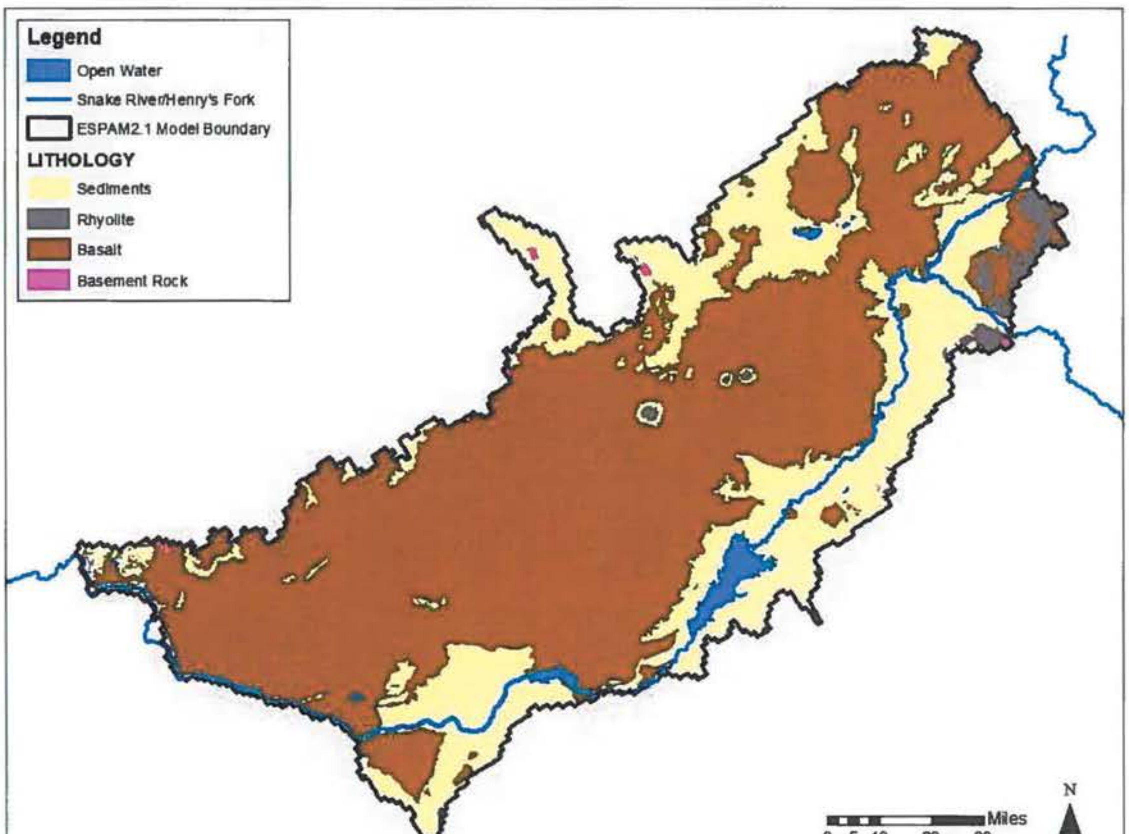

Figure 7. Generalized lithology map of the ESPAM2.1 model area.

The ESPA is composed of a series of relatively thin basalt flows and interbedded sediments, with flows ranging in thickness from a few feet to tens of feet. Individual flows typically have rubble zones at the top and bottom with flow interiors that generally are more massive. The flow interiors contain vertical fractures that form columnar basalt in some locations (Garabedian, 1992). The collective thickness of basalt flows is estimated to exceed several thousand feet in places (Whitehead, 1986). More detailed descriptions of the geology of the ESPA are provided by Anderson (1991), Whitehead (1986), and Kuntz and others (1992).

Hydrogeology

The ESPA is a highly productive aquifer comprising fractured basalt flows and interbedded sediments. Although the collective thickness of the basalt may be in excess of several thousand feet in places, the most productive portion of the aquifer is thought to be limited to the upper several hundred feet of saturated thickness (Robertson, 1974; Mann, 1986; Garabedian, 1992; de Sonneville, 1974; Lindholm and others, 1980; Cosgrove and others, 1999).

Most of the groundwater flow in the aquifer is through highly-permeable rubble zones located at the tops and bottoms of the individual basalt flows. Water-table elevation contours indicate that groundwater enters the aquifer from around the margins, the flow direction is generally parallel to the axis of the plain from northeast to southwest, and the aquifer primarily discharges via springs and reach gains in the Kimberly-to-King Hill and Blackfoot-to-Neeley reaches of the Snake River (Figure 8; Figure 1).

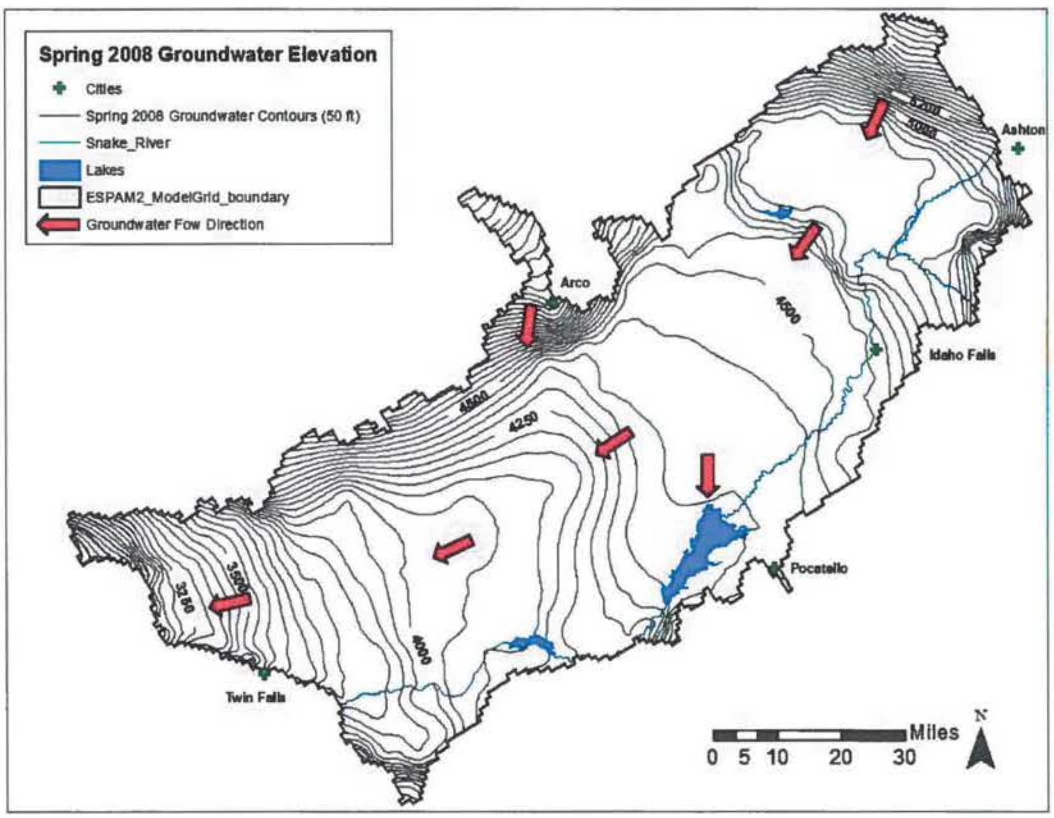

Figure 8. Water-table elevation map, spring 2008.

Managed recharge induces a stress that deforms the regional groundwater gradient; therefore, impacts due to managed recharge do not follow the regional gradient, but instead progress radially from the point of recharge until encountering hydrogeologic controls (Asano, 1985).

In the ESPA, the hydrogeologic controls that influence the progression and distribution of recharge impacts throughout the aquifer are:

1) Aquifer Boundaries: Aquifer boundaries represent the limits of the ESPA. Modeled recharge impacts do not progress beyond these boundaries (no-flow boundaries). Instead, modeled aquifer-storage impacts (expressed as water-level changes) are "reflected" back into the aquifer, which results in greater water-level changes than if the area of impact did not encounter any no-flow boundaries. The ESPA aquifer boundaries are illustrated by the black outline in Figure 9.

2) Hydraulically connected reaches of the Snake River: Hydraulic connection with the aquifer occurs with all springs and when aquifer water levels are above the bottom of a riverbed. Spring discharge and river gains/losses vary with aquifer water levels where the river and aquifer are hydraulically connected. River losses occur at rates that are unaffected by aquifer water-level changes at locations where groundwater and surface water are disconnected.

   Increase in aquifer storage is reduced as the area-of-impact encounters hydraulically connected reaches or springs. Additionally, groundwater levels near the hydraulically connected surface-water features areas experience muted increases in response to recharge. This dampening of aquifer-related impacts occurs because additional recharge water exits the aquifer as increased river gains (or decreased river losses) and spring discharge along the connected reaches instead of increasing aquifer storage.

   Hydraulic connection between the aquifer and Snake River occurs along portions of the Ashton-to-Rexburg, Heise-to-Shelley, Shelley-to-near Blackfoot, near Blackfoot-to-Neeley, and Neeley-to-Minidoka reaches. Hydraulic connection with the ESPA is strongest along the upper segments of the near Blackfoot-to-Neeley and the Heise-to-Shelley reaches, and the dampening effect on modeled recharge impacts are more pronounced in these locations. Hydraulically connected reaches of the Snake River are illustrated by green (annually losing reach) and orange (annually gaining reach) circles in Figure 9.

   The Snake River is perched above the regional aquifer system between the communities of Roberts and Shelley, and between the community of Minidoka and Milner Dam (Figure 8; IDWR, 2013). Perched reaches are not hydraulically connected to the aquifer, and lose water to the aquifer at rates that are independent of aquifer water levels. Modeled recharge impacts expand without regard to these reaches.

3) Springs: Springs occur where the water table intersects land surface and represent aquifer discharge locations that are above the elevation of the river. Discharge from springs is dependent on aquifer water levels; therefore, the flow from springs fluctuates with aquifer head. As discussed above, modeled recharge impacts to aquifer storage are dampened due to interaction between recharge-

induced water-level changes and spring discharge. Springs areas are illustrated by blue arrows in Figure 9.

4) Aquifer Heterogeneity: Non-uniform (heterogeneous) aquifer properties will cause the impacts of recharge on aquifer-storage to vary with distance and direction from the recharge site. The aquifer properties of transmissivity and storage coefficient are discussed in the following section, *Model-derived Aquifer Properties*.

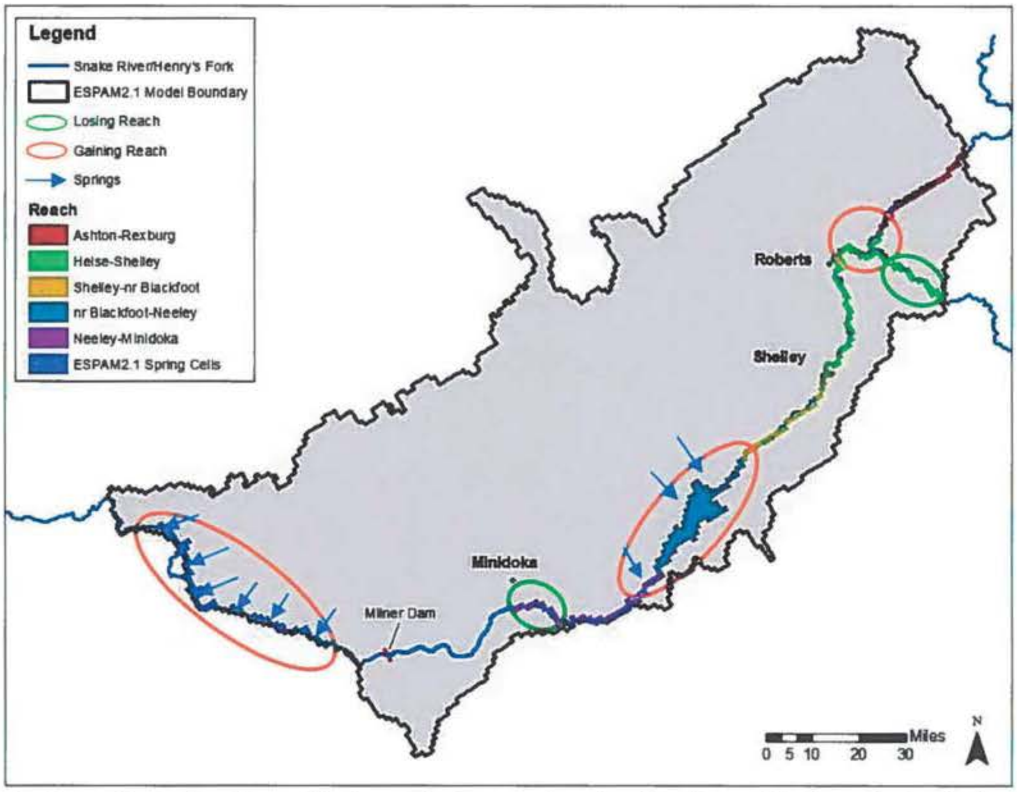

Figure 9. Approximate locations of hydrogeologic controls related to the aquifer boundaries, hydraulically connected reaches of the Snake River, and springs.

Model-derived Aquifer Properties

Calibrating a groundwater model involves relating all of the known aquifer-stress parameters (canal and perched river seepage, excess irrigation seepage, tributary underflow, evapotranspiration, and well pumping) to all measured observations (water levels, irrigation return flows, Snake River gains/losses, and spring discharge) using the governing mathematical equations for groundwater flow. Calibrating a groundwater model consists of repeatedly running the model while adjusting input parameter values until the differences between the modeled results and measured observations are sufficiently minimized. Values for the aquifer properties of transmissivity and storage are generated as a result of the ESPAM2.1 calibration process, and these properties influence the propagation and distribution of aquifer-storage impacts throughout the aquifer.

Transmissivity

Transmissivity is a measure of the ease with which water flows though an aquifer. If the aquifer is homogeneous, recharge impacts will expand radially until encountering one of the hydrogeologic controls listed above. However, aquifer non-uniformity will cause recharge induced water-level changes to preferentially follow high transmissivity zones.

The Great Rift and Mud Lake barriers are two zones of relatively low transmissivity that are important influences on the distribution of managed recharge impacts. Despite the informal moniker, these areas are not barriers to flow, but rather low-transmissivity zones that retard the flow of groundwater and hinder the progression of water-level changes due to recharge. The Great Rift low-transmissivity zone extends from north to south-southwest in the middle of the plain, and is the result of a volcanic rift zone. The Mud Lake low-transmissivity zone extends from west-northwest to east-southeast across the eastern third of plain, and is the result of thick sediment deposits. Transmissivity differences are illustrated in Figure 10.

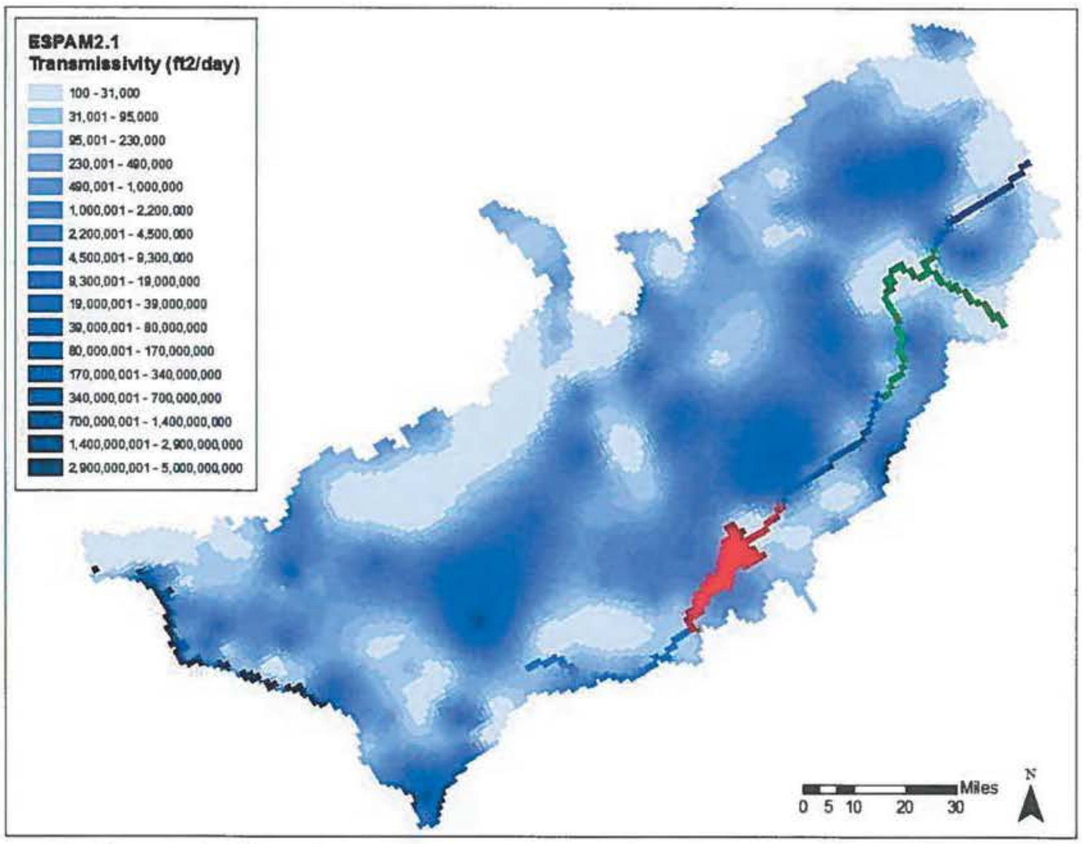

Figure 10. Distribution of calibrated ESPAM2.1 transmissivity values illustrating the Great Rift and Mud Lake low transmissivity zones.

Aquifer Storage Coefficient

The aquifer storage coefficient describes the amount of water that can be held in or released from an aquifer. In terms of recharge, it is defined as the volume of water that results a unit water-level rise over a unit area (Fetter, 1994). This means that areas with relatively large storage coefficient values require greater recharge volumes to induce water-level changes similar to those in areas characterized by smaller storage coefficient values. Therefore, recharge induced water-level changes expand more slowly in areas with large storage coefficient values than in areas with smaller storage coefficient values. The ESPAM2.1 storage-coefficient distribution is illustrated in Figure 11.

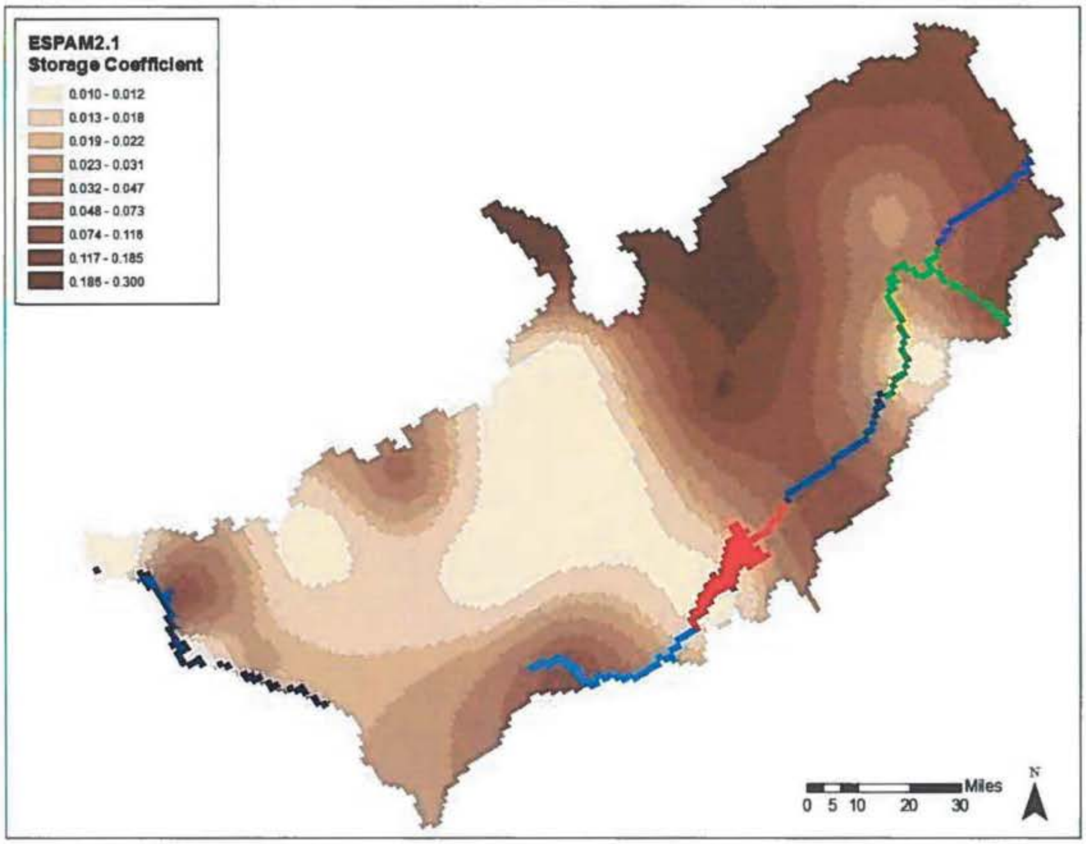

Figure 11. Distribution of calibrated ESPAM2.1 storage coefficient values.

Because water-level changes are a function of both transmissivity and storage coefficient (for a given recharge volume), the distribution of recharge induced water-level changes is dependent on the distribution of both aquifer transmissivity and aquifer storage.

State-sponsored managed recharge

The goals of the ESPA Managed Recharge Program must be defined in order to evaluate the relative effectiveness of the various recharge sites. The current ESPA Managed Recharge Program is founded on the ESPA Comprehensive Aquifer Management Plan (CAMP). The ESPA CAMP is a long-term program that directs IWRB efforts for managing water supply, and aims to stabilize and improve spring flows, river flows, and aquifer water levels across the ESRP (IWRB, 2009a). The ESPA CAMP was adopted by the IWRB in 2008 and by the Idaho Legislature in 2009 as an effort to decrease water-user conflict and reduce the need for litigious or administrative solutions (IDWR, 2015). Through stabilization of the ESPA aquifer/river system, CAMP looks to increase the predictability of water resources, and in turn, sustain the economic viability of the region. State-sponsored managed recharge is one of the mechanisms identified in the ESPA CAMP to achieve stabilization of the ESPA aquifer/river system.

Previous modeling to prioritize managed recharge sites

The Prioritization Report provides the IWRB with a range of considerations for prioritizing recharge by evaluating recharge at 19 sites relative to the following objectives and assessment criteria:

1) Augmenting flow in springs below Milner Dam in the near term.
    a. Percent of a single, one-month recharge volume which appears as reach gains below Milner Dam within three years.
    b. Percent of a continuous recharge rate which appears as additional spring discharge below Milner Dam after one year.

2) Augmenting flow in springs below Milner Dam in the long term.
    a. Percent of a single, one-month recharge volume which appears as reach gains below Milner Dam between 3 and 30 years.
    b. Percent of a continuous recharge rate which persists in springs below Milner Dam three years after recharge ceases.

3) Augmenting summer flows of the Snake River above Minidoka Dam and in the Henry's Fork.
    a. Percent of recurring March recharge which appears as reach gains above Minidoka Dam from July through September in the 30^{th} year of recharge.

4) Augmenting winter flows of the Snake River above Minidoka Dam and in the Henry's Fork.
    a. Percent of recurring March recharge which appears as reach gains above Minidoka Dam from November through February in the 30^{th} year of recharge.

5) Increasing flow in the Snake River above Minidoka Dam and in the Henry's Fork during extended drought.
    a. Percent of a single, one-month recharge volume which appears as reach gains above Minidoka Dam between 3 and 30 years after the recharge activity.

6) Increasing aquifer water levels in the A & B Irrigation District area.
    a. Average water-level change in four model cells in the A & B area after 10 years of continuous recharge at 100,000 acre-feet/year.

7) Increasing aquifer storage (and water levels) throughout the ESPA.
    a. Percent of a single, one-month recharge volume retained in aquifer storage 10 years after the recharge event.
    b. Average water-level change in the ESPA after 10 years of continuous recharge.

An important conclusion from the Prioritization Report is that no single site provides the greatest recharge benefit for all seven objectives. In other words, the best site for recharge depends on the objective of recharge.

Of the seven objectives that were evaluated, six are concerned with increased water availability at specific locations. Only objective seven (increased ESPA storage) is aquifer-wide in scope. As such, it is the only objective that is fully aligned with the overarching ESPA CAMP goal of improving the water budget for the entire aquifer (IWRB, 2009a). Moreover, it is accordant with the other six objectives and it does not prioritize one objective at the expense of another. Also, it is the least restrictive objective in terms of recharge limitations. For these reasons, increasing aquifer storage has been selected as the most generally useful criterion for comparing recharge sites and for optimizing recharge efforts.

Aquifer water levels are an expression of aquifer storage (IDWR, 2013) and ESPA discharge is dependent on aquifer water levels (Kjelstrom, 1986). Therefore, discharge from the aquifer increases as storage in the aquifer increases (Cosgrove et. al., 2005; Figure 12).

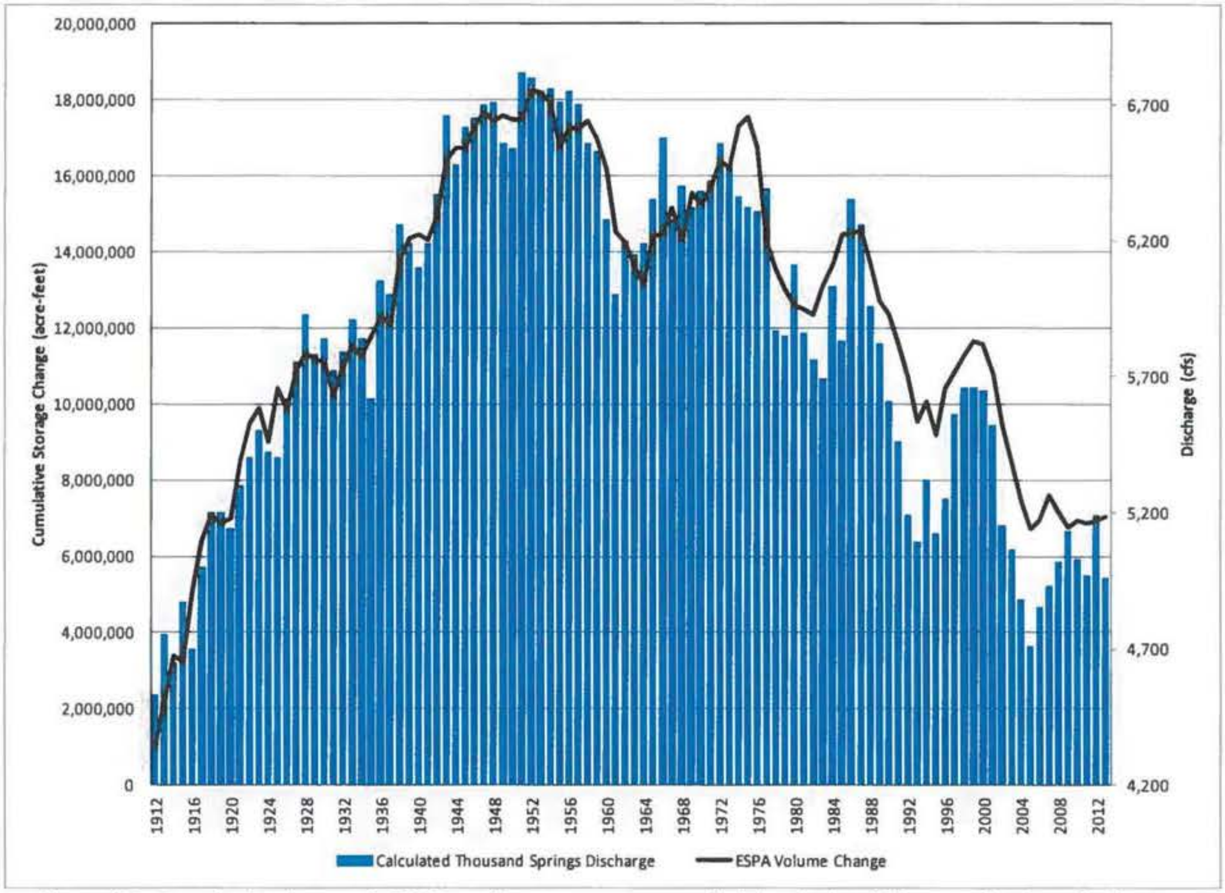

Figure 12. Cumulative changes in ESPA aquifer storage compared with calculated Thousand Springs discharge.

If managed aquifer recharge successfully increases long-term aquifer storage, aquifer-wide water levels will increase, and spring discharge and river flow throughout the aquifer/river system will be bolstered. This point is illustrated by comparing aquifer storage impacts to long-term discharge both below Milner Dam and above Minidoka Dam, as determined in the Prioritization Report (Tables 1a and 1b).

Table 1a. Long-term aquifer storage and discharge below Milner Dam.

Recharge Site	2A[1]	7A[3]
Southwest	31%	26%
Lake Walcott	21%	25%
Milner-Gooding	19%	17%
Milepost 31	19%	18%
Northside	18%	16%
Shoshone	16%	16%
Hilton Spill	3%	11%
Aberdeen-Springfield	3%	11%
Riverside	3%	10%
People's	3%	10%
United	3%	11%
Jensen's Grove	2%	9%
New Sweden	2%	11%
Snake River Valley	2%	10%
Idaho	2%	9%
Great Feeder	1%	9%
Egin Lakes	1%	36%
Fremont-Madison West	1%	26%
Fremont-Madison East	1%	22%

Table 1b. Long-term aquifer storage and discharge above Minidoka Dam.

Recharge Site	5[2]	7A[3]
Egin Lakes	65%	36%
Fremont-Madison West	50%	26%
Fremont-Madison East	45%	22%
Lake Walcott	41%	25%
Southwest	39%	26%
Milepost 31	28%	18%
Milner-Gooding	27%	17%
New Sweden	27%	11%
Shoshone	26%	16%
Hilton Spill	25%	11%
Aberdeen-Springfield	25%	11%
United	25%	11%
Great Feeder	25%	9%
Snake River Valley	24%	10%
Northside	24%	16%
Riverside	24%	10%
Idaho	24%	9%
People's	23%	10%
Jensen's Grove	21%	9%

[1]Criterion 2A: Percent of a single, one-month recharge volume discharged Below Milner 3 – 30 years after recharge.
[2]Criterion 5: Percent of a single, one-month recharge volume discharged Above Minidoka 3 – 30 years after recharge.
[3]Criterion 7A: Percent of single, one-month recharge volume retained in aquifer storage 10 years after recharge.
*Note: Blue highlight indicates recharge sites with a 10-year storage-retention value greater than 15%.

The State has determined that aquifer stabilization and recovery are the primary objectives for water-resource management, and the legislature has allocated funds for the purpose of replenishing aquifer storage (HB 547, 2014). The most efficient way to achieve aquifer stabilization is by prioritizing recharge sites with relatively high aquifer retention. Therefore, the primary goal for State-sponsored recharge is necessarily the maximization of aquifer storage.

Due to limitations in water availability and recharge resources, it is important to focus recharge efforts at locations most beneficial to the primary goal of stabilizing the ESPA. However, the success of managed recharge in the ESPA will be dependent on coordinated efforts at many locations.

State Water Law and Policy that guide State-sponsored recharge

The dedicated pursuit of aquifer-storage enhancements through the implementation of managed recharge is a reasonable strategy for stabilizing and recovering the ESPA. However, recharge must be conducted in accordance with Idaho State law and State policy.

Policy 1I of the 2012 Idaho State Water Plan provides that "[a]quifer recharge should be promoted and encouraged, consistent with state law" (IWRB, 2012). The State Water Plan also recognizes that managed recharge of the ESPA is in the public interest.

The 2012 State Water Plan (Plan) states that the "minimum stream flows provide the management framework for the optimum development of the water resources of the Snake River Basin." The Plan reaffirms that the flow of the Snake River may be reduced to zero cfs and that the minimum flow at the Murphy Gage would be 3,900 cfs from 4/1 through 10/31 and 5,600 cfs from 11/1 through 3/31. By reaffirming the Milner Zero Flow Policy, the Plan recognizes that the ground water discharge from the Thousand Springs during portions of low-water years is the primary source of water for maintaining the Murphy minimum flow. Accordingly, Policy 4D of the Plan provides that "[t]he Eastern Snake Plain Aquifer and the Snake River below Milner Dam should be conjunctively managed to provide a sustainable water supply for all existing and future beneficial uses within and downstream of the ESPA. Policy 4B calls for implementation of "a sustainable aquifer recharge program" as one of the measures to sustain the ground water levels in the ESPA (IWRB, 2012).

The State Water Plan also reaffirms the 2009 ESPA Comprehensive Aquifer Management Plan (ESPA CAMP). The ESPA CAMP identifies recharge as a mechanism for stabilizing the aquifer, and establishes a long-term hydrologic target for managed aquifer recharge from 150,000 to 250,000 acre feet on an average annual basis. The Phase 1 (through 2018) CAMP recharge target is to conduct recharge at an average of 100,000 acre-feet annually (IWRB, 2009a). Legislative approval is required if the IWRB proposes to increase the 100,000 acre-foot limit by more than 75,000 before January 1, 2019 (IWRB, 2009b; IDWR, 2015). After January 1, 2019, the CAMP recharge target is raised to an average of 250,000 acre-feet annually.

The Murphy minimum flows are an important consideration for recharge because Snake River flows at Murphy have been declining, and a shortfall in the minimum average daily flow occurred briefly during 2015 (Figure 13).

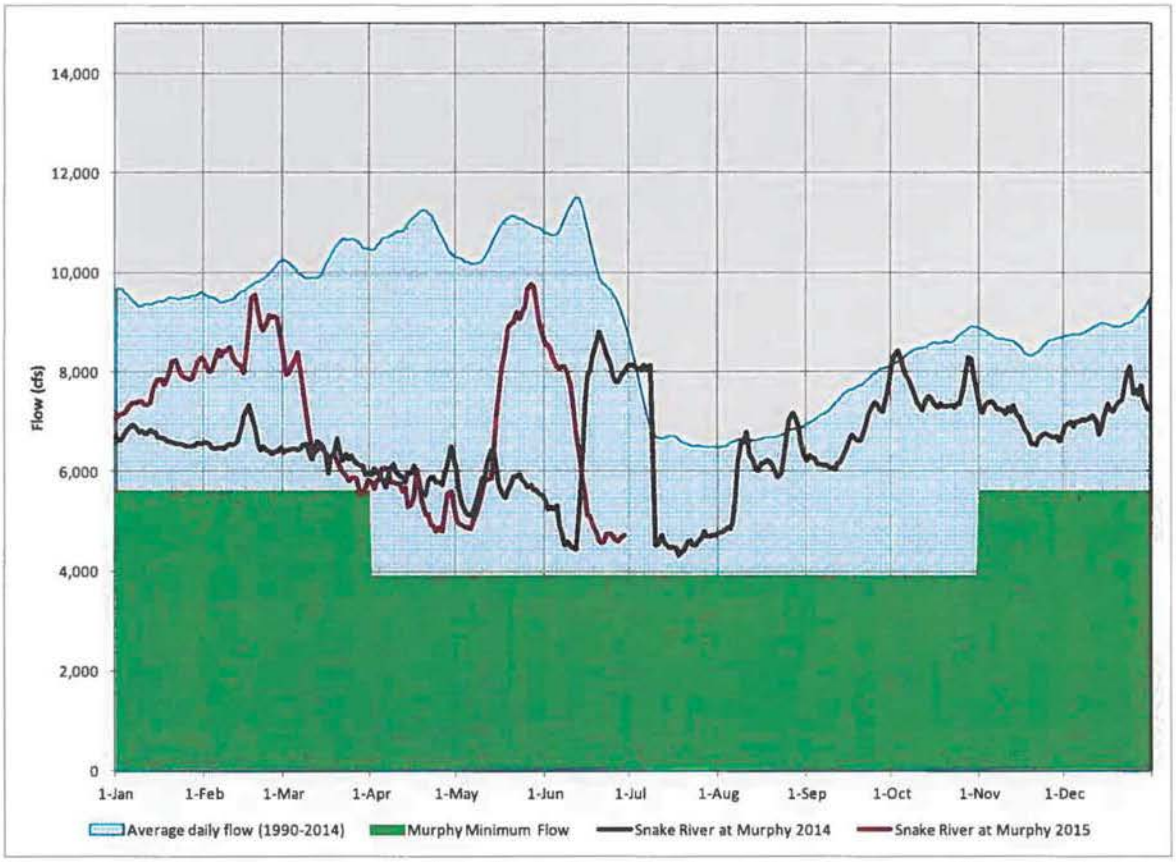

Figure 13. Seven-day average of average daily flow in the Snake River at the Murphy gage illustrating declining river flow in relation to the established minimum flows.

The State Water Plan also reaffirmed the Two-Rivers Policy, whereby the separation of water administration at Milner Dam precludes downstream calls for water above Milner. As contemplated by the Two-Rivers Policy, all flows that would otherwise pass Milner Dam are available for recharge above Milner Dam. These flows are a critical source of recharge water for the State.

Because the majority of the flow in the Snake River at Murphy is ESPA spring discharge that occurs between Kimberly and King Hill (Figure 12; Table 2; Appendix A), protecting the minimum flow water rights at Murphy requires management of the ESPA in a way that supports spring discharge along the Kimberly-to-King Hill reach of the Snake River (i.e., below Milner Dam).

Table 2. Percentage of Murphy flows due to ESPA spring discharge.

Month	Snake River at Murphy 2014[1] (cfs)	ESPA Spring Discharge 2014 (cfs)	ESPA Springs (% of Murphy Flow)
January	6,650	5,648	85%
February	6,518	5,594	86%
March	6,383	5,494	86%
April	5,913	5,441	92%
May	5,673	5,400	95%
June	4,479	5,526	123%
July	4,509	5,634	125%
August	6,183	5,918	96%
September	6,545	6,109	93%
October	7,518	6,044	80%
November	7,033	5,818	83%
December	7,206	5,724	79%

[1]Flow-augmentation releases have been subtracted from Murphy flow values to calculate June and July percentages.

Using the flows passing Milner Dam to for managed recharge to increase aquifer storage is an effective way to increase long-term, year-round spring discharge (Tables 1a and 1b). In this way, recharging to produce long-term benefits to flow at Murphy is consistent with the States recharge goal of increasing aquifer storage.

Limitations to Managed Recharge

Some recharge sites have higher recharge capacities than others. Limitations to recharge need to be understood before an effective managed recharge program can be developed. Limitations to managed recharge include:

1) Availability of surface water,
2) Rate of diversion to a recharge site (diversion capacity),
3) Rate of infiltration at a recharge site (infiltration capacity), and
4) Depth-to-groundwater at or near a recharge site (vadose-zone capacity).

Sources of information regarding recharge limitations come from several sources including: hydrogeologic studies, water-right exams, personal communications with canal managers, calibrated ESPAM2.1 parameters, and ESPAM2.1 modeling results. While many of these limitations are estimates, they are reasonable approximations that serve to help the IWRB prioritize recharge activities and develop a comprehensive managed-recharge plan.

Surface-Water Availability

The magnitude, location, and timing of surplus Snake River flow limit the amount of recharge that can take place. Surplus flow is natural flow (i.e., water not released from storage) at the point-of-diversion (POD) that is in excess of the water necessary to satisfy all in-priority water rights. Limitations to *surface-water availability* generally involve physical realities such as precipitation and reservoir storage, as well as other constraints.

In simplest terms, surface-water availability for recharge is a function of precipitation. However, in the ESPA aquifer/river system, water availability for recharge is complicated by considerations such as:

1. Water rights – The water diverted for recharge must be associated with a water right that is in priority both at the POD and during the entire period of recharge. The most senior IWRB recharge water right has a priority date of 1980, which is junior to the 1903 Minidoka (Lake Walcott), 1916 Milner, and 1921 American Falls reservoir-fill water rights, as well as the 1909/1912 unsubordinated Minidoka Dam hydropower water rights.

2. IWRB policy – The IWRB has adopted resolutions limiting recharge to the use of natural flow to avoid placing additional burden on the storage supplies above Milner Dam (IWRB, 2014). Furthermore, the IWRB has adhered to a policy that recharge should not interfere with or prevent the capture of water in the federal reservoir system (Weaver, 2012). This policy creates uncertainty as to the timing, location, and magnitude of recharge. The U.S. Bureau of Reclamation's (USBR) unsubordinated hydropower water rights at Minidoka help resolve uncertainty of the timing, location, and magnitude of recharge above Minidoka Dam. The unsubordinated Minidoka hydropower rights serve as visible and transparent indicators of whether recharge will interfere with physically filling the reservoir system. Flows in excess of 2,700 cfs at Minidoka indicate that the USBR is confident the reservoir system will physically fill, and

the diversion of water for recharge is unlikely to intercept water that could otherwise be captured in the reservoir system. Flows of less than 2,700 cfs at Minidoka indicate that the USBR is still physically filling the reservoir system, and the diversion of water for recharge upstream of the Minidoka Dam would have the potential of intercepting water that would otherwise be captured in the reservoir system (Weaver, 2012).

Determination of Water Availability for Recharge

Application of the Milner Zero Flow Policy means that only water passing Milner Dam can be considered surplus to upstream beneficial use – regardless of where the diversion occurs (IDWR, 1999). Furthermore, the Snake River flows through a canyon downstream of Milner Dam, and there is no infrastructure to divert river water onto the ESRP below the dam. Therefore, the natural flow passing Milner Dam represents the total volume of water that could be used for managed recharge if there were adequate infrastructure and administrative considerations in place to divert the water. The median 1980-2012 natural flow at Milner Dam is 964,097 acre-feet annually, which demonstrates that there is physically enough natural flow to meet the ESPA CAMP long-term recharge targets (Figure 14).

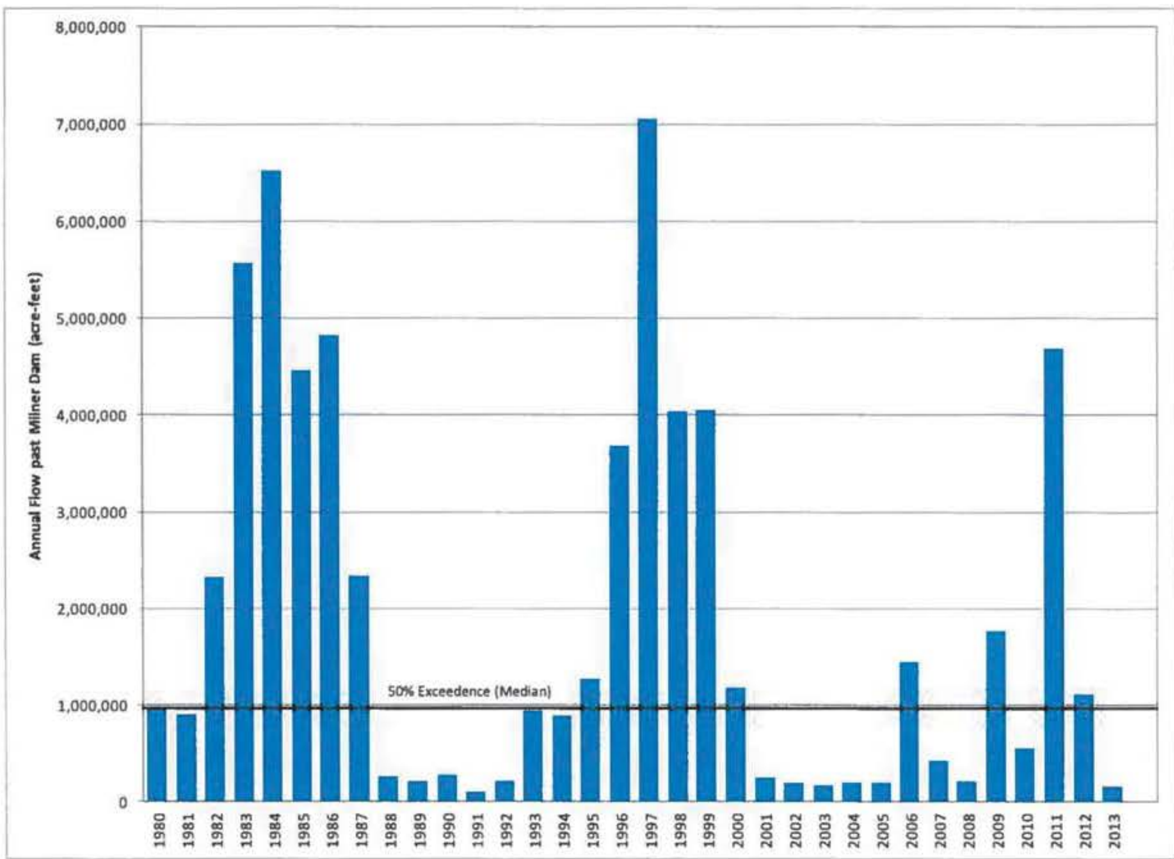

Figure 14. Annual volume of natural flow passing Milner Dam.

The median is used (instead of the mean) to describe the water availability data because it represents the skewed nature of the data more appropriately than does the mean. More extensive discussions of the water-availability data and the use of descriptive statistics are included in Appendix B.

The amount of natural flow available for recharge at a site is an important consideration for the prioritization of State recharge investment, and historic Snake River flow data is the most objective way of quantifying recharge water availability.

The determination of historic water availability is dependent on the flow at the Minidoka and Milner dams. The flow passing Milner Dam represents the total amount of water available for recharge, and the flow past Minidoka Dam serves as an indicator of the likelihood that recharge upstream of the dam will interfere with reservoir fill. Water availability is calculated using the following steps:

1. Subtract storage-release water from all minimum-flow gages used to determine water availability.
    a. Storage releases for uses such as flow augmentation for fish propagation released upstream of a recharge POD are not available for recharge.
2. Examine flow at Milner Dam (USGS 13088000 SNAKE RIVER GAGING STATION AT MILNER ID; Figure 15).
    a. If there is no flow past Milner Dam, no water is available for ESPA recharge.
    b. If there is flow past Milner Dam, recharge can take place between Minidoka Dam and Milner Dam at a rate that is less than or equal to, the flow past Milner Dam (Figure 15).
3. Assess if the State's recharge water rights are in priority at recharge PODs located between Minidoka and Milner dams.
    a. If the rights are not in priority, no recharge can take place.
4. Examine flow at Minidoka Dam (USGS 13081500 SNAKE RIVER NR MINIDOKA ID; Figure 15).
    a. Given that there is flow past Milner Dam, recharge can take place upstream of Minidoka if flow past Minidoka Dam is greater than 2,700 cfs. The 2,700 cfs is based on the USBR unsubordinated hydropower water rights.
    b. Recharge can take place between American Falls Dam and Minidoka Dam at a rate equal to the flow past Minidoka, less 2,700 cfs (Figure 15).
5. Assess if the State's recharge water rights are in priority at recharge PODs located upstream of Minidoka Dam.
    a. If the right is not in priority, no recharge can take place.
6. Examine flow at recharge PODs upstream of American Falls Dam.
    a. Because operation of the reservoir system may allow for flow in excess of 2,700 cfs at Minidoka while upstream flows are relatively low, it is important to also look at flow in the Snake River at the recharge PODs. Flows at Blackfoot, Heise, and St. Anthony are used as proxies for PODs that divert from the main stem Snake River above American Falls Dam, the South Fork Snake River (South Fork), and the Henry's Fork Snake River (Henry's Fork), respectively (Figure 15).

b. Given that the unsubordinated USBR hydropower rights are satisfied, the volume of water available for recharge upstream of American Falls Dam is limited to the smaller of either the spills past Minidoka Dam (less 2,700 cfs), or the flow in the Snake River at the recharge POD (less an assumed minimum flow).
c. Downstream limitations are applied upstream. For example, if there is not enough flow at Blackfoot to perform recharge on a given date, recharge is not permissible on the Henry's Fork or South Fork on that date.

7. Calculate recharge water availability on a daily basis at each POD.
   a. Sum to monthly and annual volumes for analysis.

A flow-chart illustrating the steps for determining water availability is located in Appendix C.

Because of the efforts required to conduct recharge activities, it has been assumed that the act of recharge does not occur if the calculated available flow is less than 10 cfs, or if water is available for less than four consecutive days (Hoekema, 2015).

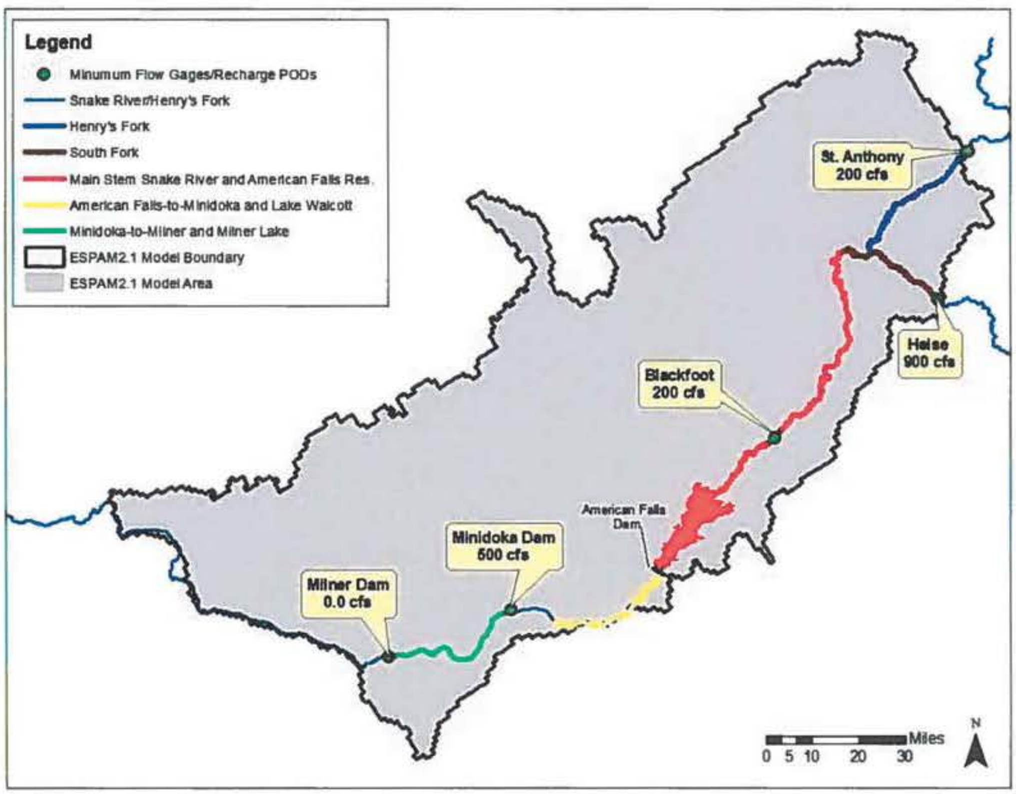

Figure 15. Locations of the minimum stream flow gages/recharge POD proxies.

These steps represent the process for determining historic water availability at each site in order to inform State recharge investment decisions. Because it is not known how much recharge will actually occur at each site, upstream recharge diversions have not been deducted from the availability at downstream sites. Calculation of real-time water availability for conducting recharge uses a similar, but iterative approach that may require adjustment of recharge diversions due to upstream recharge activities.

The minimum stream flows used in the calculation of water availability are based on Idaho Code, USBR operations, and professional judgment regarding sustainable low flows (Table 3).

Table 3. Assumed minimum stream flows for determining the availability of water for recharge.

Stream Gage	Assumed Minimum Flow (cfs)	Comments
St. Anthony (USGS 13046000)	200	Based on discussions with local water managers.
Heise (USGS 13037500)	900	Based on USBR hydropower operations.
Blackfoot (USGS 13062500)	200	Based on historic low flow.
Minidoka (USGS 13081500)	2,700	Based on USBR hydropower rights.
Milner (USGS 13088000)	0	Milner zero minimum flow policy.

The assumed minimum flows were chosen so as not to interfere with existing in-stream beneficial uses, and may not be appropriate at all times for meeting river ecosystem needs. Ecosystem-maintenance flow recommendations are discussed more thoroughly in IDWR (1999) and IDFG (2014).

Using the methodology described above, the annual recharge water availability at the minimum flow locations are illustrated in Figure 16 and Appendix B. It is important to reiterate that flows have been corrected for storage releases and reach gains.

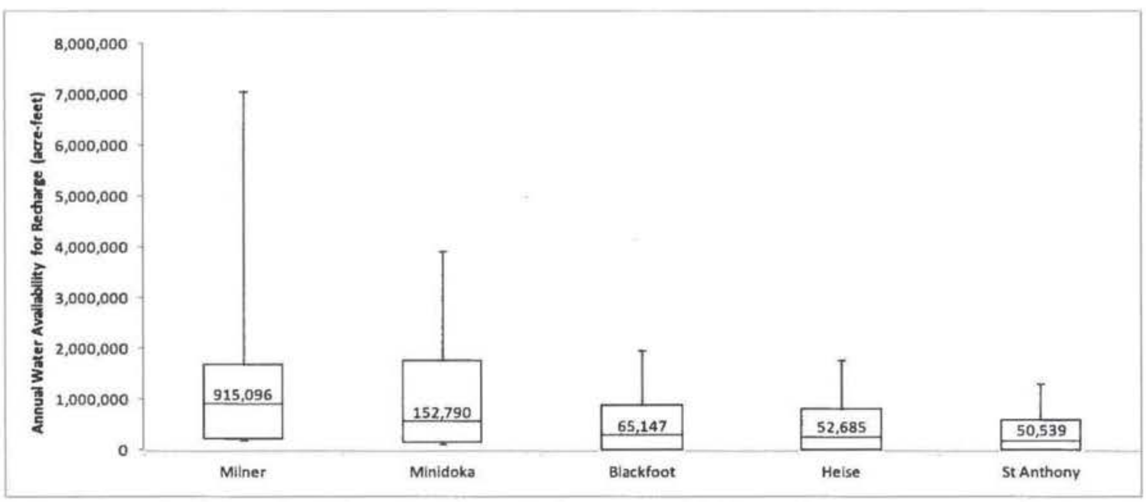

Figure 16. Box-and-whisker plots illustrating the annual water availability at the minimum streamflow locations.

The whiskers in Figure 16 represent the maximum and minimum volumes available for recharge during the analysis period, and the top and bottom box borders represent the 75[th] and 25[th] percentiles, respectively. The median volumes are labeled within the boxes.

The amount of water available for recharge downstream is significantly larger than upstream for three reasons:

1. Reservoir fill is a priority. The State has committed to prioritizing reservoir fill over recharge, and water upstream of Minidoka Dam must go to reservoir fill before it becomes available for recharge. Sites located downstream of Minidoka Dam are downstream of the combined federal reservoir system.

2. There is a constant source of water for recharge between the Minidoka and Milner dams. USBR operations provide a minimum of 500 cfs of flow past Minidoka Dam during the non-irrigation season which is available for recharge due to the Milner Zero Flow Policy.

3. Water availability at each location has been calculated independently from the other locations. Because the water availability at each location has been calculated as though no other recharge takes place, the total volume of water available for recharge is less than the sum of the water availability at all of the sites.

Monthly Water Availability

Although the median value of natural flow passing Milner Dam is greater than the annual volume necessary to meet recharge diversion objectives, the amount of recharge that can take place at any site will change over the course of a year depending on the interplay between overall water-supply conditions, reservoir fill, and water-right priorities. Therefore, it is important to look at monthly recharge-water availability at the minimum flow locations in order to determine when recharge is likely to occur during the year (Figures 17 – 21; Table 4).

Monthly water availability is affected by seasonal water use and water-right priorities related to reservoir fill and irrigation. The irrigation season is considered to be April 1 through October 31 in this study.

Monthly Water Availability: Minidoka Dam-to-Milner Dam

Due to the Milner Zero Flow Policy, the historic water availability at Milner Dam represents the total volume of water that may have been available for recharge in the ESPA aquifer/river system. The flow past Milner Dam also represents the maximum volume of water that was available for recharge between the Minidoka and Milner dams, with the assumption that no upstream recharge takes place. Figure 17 illustrates the monthly water availability at Milner Dam.

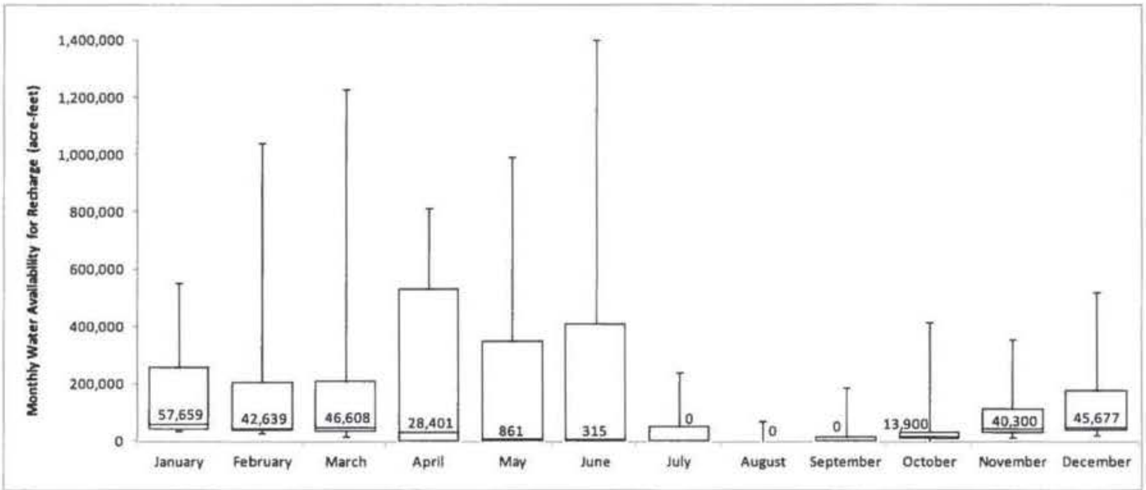

Figure 17. Monthly volumes of water available for recharge at Milner Dam.

The whiskers in Figure 17 represent the maximum and minimum volumes available for recharge during the analysis period, and the top and bottom box borders represent the 75th and 25th percentiles, respectively. The median volumes are labeled. The lack of a box indicates that no water is available in August at least 75% of the time.

Water availability for recharge is greatest during the non-irrigation season at locations between the Minidoka and Milner dams. The USBR tries to maintain a minimum of 500 cfs past Minidoka Dam during the non-irrigation season to meet river ecology needs immediately downstream of Minidoka Dam. This flow continues past Milner Dam, and is therefore available for recharge along this reach. Because the Milner Policy allows for zero flow past Milner Dam, recharge of at least 500 cfs is possible between the Minidoka and Milner dams for the entire non-irrigation season.

Significant volumes of water are also available during both early and late irrigation season months (April, May, and October). Diversions for beneficial use typically bring flows past Milner Dam to zero during the heart of the irrigation season, and virtually no water is available for recharge in June, July, August, or September in most years.

Monthly Water Availability: American Falls Dam-to-Minidoka Dam

The flow at Minidoka signals when recharge can be accomplished upstream while recharge is in priority and without interfering with reservoir fill. The historic water availability at Minidoka represents the total volume of water that may have been available for recharge above Minidoka Dam because any flow over 2,700 cfs is considered surplus to reservoir fill. The flow past Minidoka Dam also represents the maximum volume of water that was available for recharge between the American Falls and Minidoka dams, with the assumption that no upstream recharge takes place. Figure 18 illustrates the monthly water availability at Minidoka.

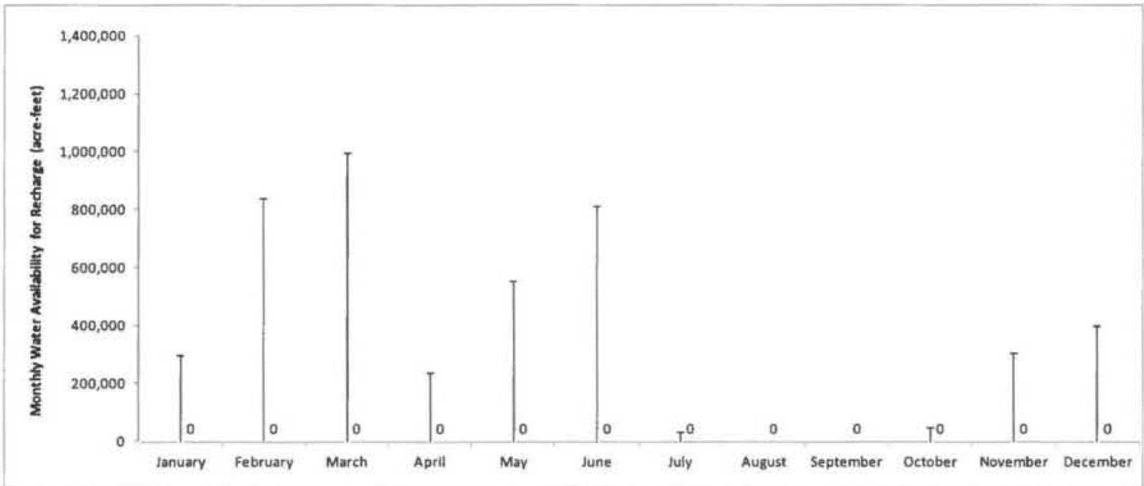

Figure 18. Monthly volumes of water available for recharge at Minidoka.

The whiskers in Figure 18 represent the maximum volumes available for recharge during the analysis period. The median volumes are labeled. The lack of a box indicates that no water is available during any month at least 75% of the time.

Because of water-right priorities, irrigation practices, and reservoir-fill precedence, water is rarely available for recharge from July through October at locations between the American Falls and Minidoka dams. Recharge water is most available November through June. However, the State's recharge water right is typically only in priority during high-flow years, resulting in a few years with very large volumes of water for recharge interspersed with many years with little or no supply.

Monthly Water Availability: Roberts-to-Aberdeen

The historic water availability at Blackfoot represents the total volume of water that may have been available for recharge at Blackfoot, and serves to represent the water-availability conditions for recharge at those sites that divert from the main stem Snake River between the communities of Roberts and Aberdeen, with the assumption that no upstream recharge takes place. Figure 19 illustrates the monthly water availability at Blackfoot.

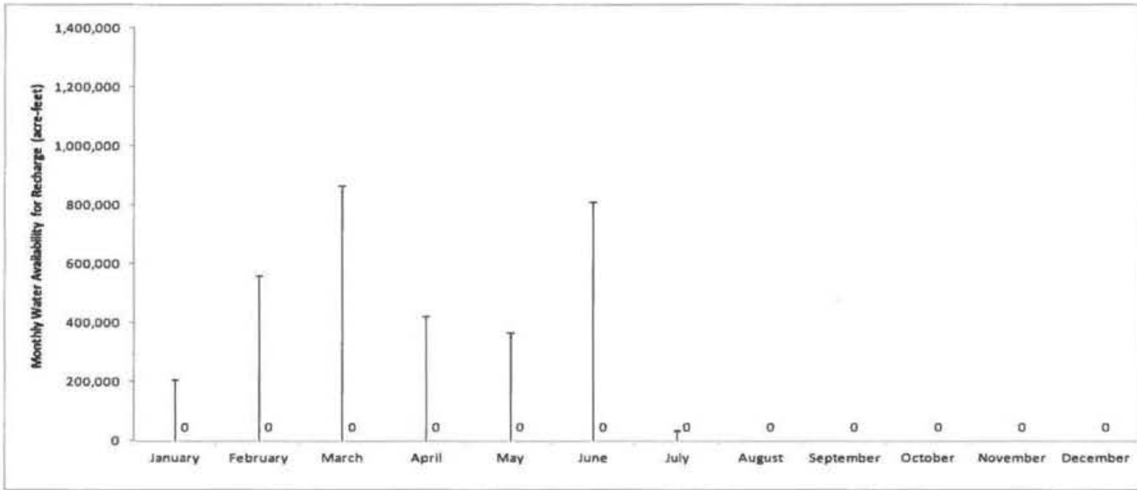

Figure 19. Monthly volumes of water available for recharge at Blackfoot.

The whiskers in Figure 19 represent the maximum volumes available for recharge during the analysis period. The median volumes are labeled. The lack of a box indicates that no water is available during any month at least 75% of the time.

Because of irrigation practices and reservoir-fill precedence, water is rarely available for recharge from July through December at locations between the Henry's Fork/South Fork confluence and American Falls Dam. Recharge water is most available from January through June. However, the State's recharge water right is typically only in priority during high-flow years, resulting in a few years with very large volumes of water for recharge interspersed with many years with little or no supply.

Monthly Water Availability: South Fork

The historic water availability at Heise represents the total volume of water that may have been available for recharge at Heise, and serves to represent the water-availability conditions for recharge on the South Fork upstream of the confluence of the Henry's Fork and South Fork. Figure 20 illustrates the monthly water availability at Heise.

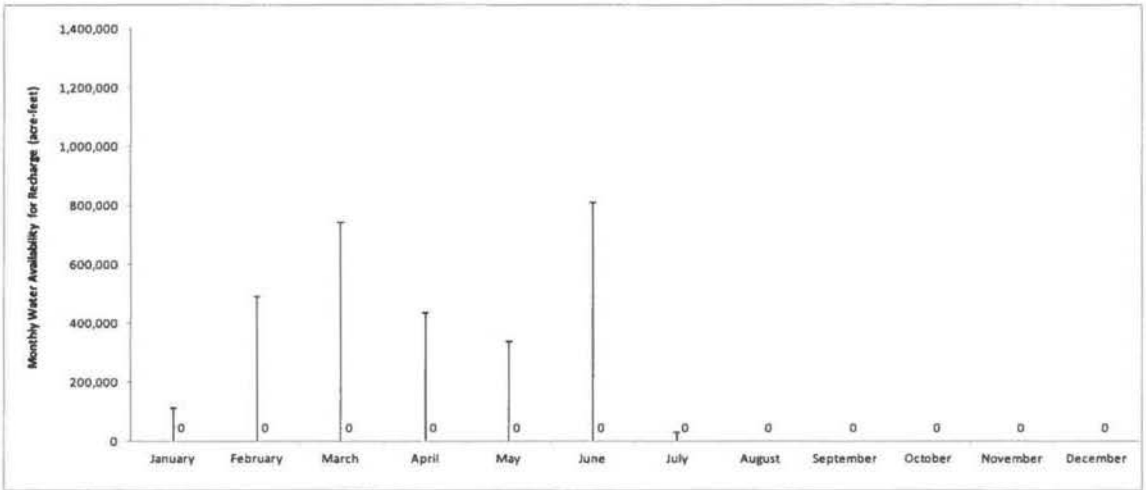

Figure 20. Monthly volumes of water available for recharge at Heise.

The whiskers in Figure 20 represent the maximum volumes available for recharge during the analysis period. The median volumes are labeled. The lack of a box indicates that no water is available during any month at least 75% of the time.

Because of irrigation practices and reservoir-fill precedence, water is rarely available for recharge from July through December at locations on the South Fork. Recharge water is most available from January through June. However, the State's recharge water right is typically only in priority during high-flow years, resulting in a few years with very large volumes of water for recharge interspersed with many years with little or no supply.

Monthly Water Availability: Henry's Fork

The historic water availability at St. Anthony represents the total volume of water that may have been available for recharge at St. Anthony, and serves to represent the water-availability conditions for recharge on the Henry's Fork upstream of the confluence of the Henry's Fork and South Fork. Figure 21 illustrates the monthly water availability at St. Anthony.

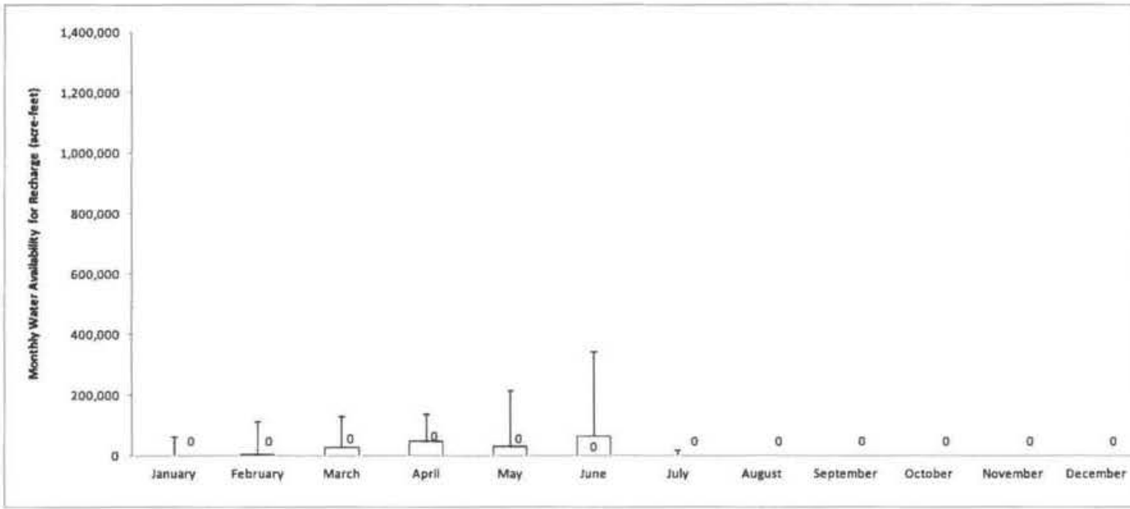

Figure 21. Monthly volumes of water available for recharge at St. Anthony.

The whiskers in Figure 21 represent the maximum volumes available for recharge during the analysis period. The median volumes are labeled. The lack of a box indicates that no water is available during any month at least 75% of the time.

Because of irrigation practices and reservoir-fill precedence, water is rarely available for recharge from July through December at locations on the Henry's Fork. Recharge water is most available from January through June. However, the State's recharge water right is typically only in priority during high-flow years, resulting in a few years with very large volumes of water for recharge interspersed with many years with little or no supply.

The data presented in Figure 17 demonstrate that significant volumes of water are consistently available at Milner Dam during the non-irrigation season, and that water is available only occasionally during the irrigation season as a result of anomalously high flows. The data presented in Figure 18 demonstrate that water is sporadically available for recharge above Minidoka Dam and availability occurs as a result of anomalously high flows. The data presented in Figures 19 – 21 demonstrate that water is only sporadically available for recharge above American Falls Dam during the early irrigation-season months and occurs as a result of anomalously high flows. Water is rarely available for recharge above Minidoka from July through December.

Visual comparison of the median annual water availability to the monthly water availabilities at a given POD indicate much larger volumes of water available annually than the sum of the monthly median values. This occurs because the annual water-availability median incorporates all monthly values – including extreme high values. Monthly water-availability medians incorporate many low values, which results in much lower monthly water-availability medians.

Median Water Availability for All Months versus Median Water Availability in Non-Zero Months

The minimum-flow locations above American Falls Reservoir exhibit median values of zero for every month of the year. However, there is water available for recharge during high-flow years. Excluding Milner, the median volumes of water when considering all years are vastly different than the median volumes for non-zero years;

indicating copious water availability during the occasional years when water is available. Table 4 illustrates the feast-or-famine nature of water availability at PODs located upstream of Minidoka Dam.

Table 4. Median monthly volume of water available for recharge for years 1992 – 2014.

	Milner		Minidoka		Blackfoot		Heise		St. Anthony	
Month	Median	Non-Zero Median	Median	Non-Zero Median	Median	Non-Zero Median	Median	Non-Zero Median	Median	Non-Zero Median
January	57,659	57,659	0	245,345	0	171,911	0	101,990	0	59,702
February	42,639	42,639	0	218,738	0	238,783	0	217,706	0	66,317
March	46,608	46,608	0	246,798	0	338,559	0	319,585	0	97,194
April	28,401	101,486	0	373,883	0	308,059	0	252,770	0	79,901
May	861	210,789	0	135,991	0	110,527	0	87,293	0	72,413
June	315	395,323	0	127,970	0	127,970	0	127,970	0	103,167
July	0	78,824	0	18,385	0	18,385	0	18,385	0	12,066
August	0	48,175	0	0	0	0	0	0	0	0
September	0	13,150	0	0	0	0	0	0	0	0
October	13,900	15,503	0	30,589	0	0	0	0	0	0
November	40,300	40,300	0	210,227	0	0	0	0	0	0
December	45,677	45,677	0	144,443	0	0	0	0	0	0

Although the median values for all non-zero years indicate that there are large volumes of water available during some years, the relatively low number of years that equal or exceed the median volume indicates the rarity of high water-availability years. Table 5 illustrates the number of years that meet or exceed the non-zero monthly median.

Table 5. Median values for years with non-zero volumes and the number of days that meet or exceed the non-zero median value during the period 1992 – 2014 (23 years).

	Milner		Minidoka		Blackfoot		Heise		St. Anthony	
Month	Non-Zero Median	Number of years >/= Median	Non-Zero Median	Number of years >/= Median	Non-Zero Median	Number of years >/= Median	Non-Zero Median	Number of years >/= Median	Non-Zero Median	Number of years >/= Median
January	57,659	12	245,345	5	171,911	2	101,990	2	59,702	2
February	42,639	11	218,738	5	238,783	3	217,706	2	66,317	3
March	46,608	11	246,798	4	338,559	4	319,585	3	97,194	4
April	101,486	10	373,883	4	308,059	4	252,770	4	79,901	4
May	210,789	8	135,991	4	110,527	4	87,293	4	72,413	4
June	395,323	7	127,970	4	127,970	4	127,970	4	103,167	4
July	78,824	5	18,385	1	18,385	1	18,385	1	12,066	1
August	48,175	1	0	--	0	--	0	--	0	--
September	13,150	6	0	--	0	--	0	--	0	--
October	15,503	11	30,589	3	0	--	0	--	0	--
November	40,300	12	210,227	2	0	--	0	--	0	--
December	45,677	12	144,443	4	0	--	0	--	0	--

Diversion Limitations

The ability to deliver water to a recharge site may limit the amount of recharge that can take place. Limitations to *diversion capacity* are generally controlled by the size of diversion and transmission structures such as gates, canals, off-canal sites, pipes, and wells. Given the general lack of recharge diversion capacity measurements (recharge diversions and surface-water returns), the preliminary diversion capacities for most sites have been estimated by reviewing historic recharge efforts.

Although the below diversion capacities (Table 6) are reasonable preliminary estimates that generally fit the recharge situation, some of the limits reported here may be lower than what can be physically diverted at the POD. Some of the diversion capacities may be refined as the recharge program develops and the relationship between recharge diversions and surface-water returns are better understood. It is also possible that some sites may be able to use different combinations of canals and off-canal features within their system to reduce returns to the river, and thus increase diversion capacity.

Table 6 lists the sources of diversion data, as well as the diversion limitations used in this study.

Table 6. Diversion capacities for recharge sites reviewed in this study.

Recharge Site	Diversion Capacity (acre-feet/month)	Comments
Aberdeen-Springfield	12,100	Based on historic recharge diversions.
Egin Lakes	15,300	Based on historic recharge diversions.
Fremont-Madison East	10,900	Based on historic recharge diversions.
Fremont-Madison West	7,200	Based on historic recharge diversions/canal manager information.
Great Feeder Area	18,100	Based on historic recharge diversions.
Hilton	7,700	Based on historic recharge diversions.
Idaho	4,500	Based on historic recharge diversions.
Jensen's Grove	1,800	Based on water-right exam data.
Lake Walcott Recharge	6,100	Based on proposed capacity of recharge wells.
Milepost 31 Recharge	18,400	Based on design capacity of diversion structure.
Milner-Gooding	46,500	Based on historic recharge diversions and MP31 design.
New Sweden	3,200	Based on historic recharge diversions.
Northside	30,700	Based on historic recharge diversions.
People's	6,000	Based on historic recharge diversions.
Riverside	5,400	Based on historic recharge diversions.
Shoshone	19,900	Based on historic recharge diversions.
Snake River Valley	4,500	Based on historic recharge diversions.
Southwest Irrigation	3,600	Based on historic recharge diversions.
United	4,500	Based on historic recharge diversions.

It may be possible to engineer larger structures to allow for greater diversion capacities at some sites; thereby increasing recharge capacity if larger recharge diversions do not result surface-water in returns to the Snake River.

Infiltration Limitations

Infiltration capacity is the physical ability for water delivered to a recharge site to seep into the aquifer. The ability to accept water is related to both the equilibrium infiltration capacity of surface soils and the hydraulic conductivity of aquifer materials. Due to the general lack of accurate infiltration measurements, preliminary infiltration capacity estimates have been garnered from several sources (Table 7).

Table 7. Infiltration capacities for recharge sites reviewed in this study.

Recharge Site	Infiltration Capacity (acre-feet/month)	Comments
Aberdeen-Springfield	7,300	Calibrated ESPAM2.1 canal seepage rate.
Egin Lakes	2,200	Published data from 2009 IWRRI recharge report.
Fremont-Madison East	6,500	Calibrated ESPAM2.1 canal seepage rate.
Fremont-Madison West	4,300	Calibrated ESPAM2.1 canal seepage rate.
Great Feeder Area	6,900	Calibrated ESPAM2.1 canal seepage rate.
Hilton	7,600	Based on historic recharge diversions.
Idaho	1,400	Calibrated ESPAM2.1 canal seepage rate.
Jensen's Grove	1,000	Based on water-right exam data.
Lake Walcott Recharge	6,100	Based on proposed capacity of recharge wells.
Milepost 31 Recharge	24,200	Based on discussion with canal manager.
Milner-Gooding	8,200	Based on discussion with canal manager.
New Sweden	1,600	Calibrated ESPAM2.1 canal seepage rate.
Northside	22,200	Published data from 1996 IWRRI recharge report.
People's	2,500	Calibrated ESPAM2.1 canal seepage rate.
Riverside	700	Calibrated ESPAM2.1 canal seepage rate.
Shoshone	21,200	Based on discussion with canal manager.
Snake River Valley	1,400	Calibrated ESPAM2.1 canal seepage rate.
Southwest Irrigation	3,600	Based on diversions, assumed due to injection.
United	600	Calibrated ESPAM2.1 canal seepage rate.

It is important to note that many of the infiltration capacities are calculated as percentages of the diversion capacities, and any inaccuracies associated with the diversion capacities will be reflected in the calculated infiltration capacities.

It may be possible to engineer certain aspects of recharge sites to allow for greater infiltration at some sites. It is also possible that some sites may be able to use different combinations of canals and off-canal features to increase infiltration capacity.

Because the Managed Recharge Program looks to recharge during the winter months in order to minimize competition with irrigation deliveries, it is important to consider temperature effects on the rate of infiltration. As temperature decreases, both the viscosity and density of water increase, making the water more resistant to flow. Therefore, infiltration rates during cold weather will likely be lower than those reported above due to the fact that the data used to develop infiltration rates are largely based on spring through fall measurements.

Differences in saturated groundwater flow based solely on temperature are calculated in Appendix D and listed in Table 8.

Table 8. Differences in saturated groundwater flow due to temperature changes.

Temperature (°F)	Percent change in flow (relative to 60 °F)
32	-37%
40	-27%
50	-14%
60	0
70	+15%
80	+31%
90	+48%
100	+65%

Limitations due to Shallow Groundwater

The depth-to-groundwater may also limit the amount of recharge that can take place (Figure 22). The term *vadose-zone capacity* is used to describe this limitation in this study. Conceptually, areas with shallow groundwater have less room to accommodate water-level changes than areas with deeper groundwater.

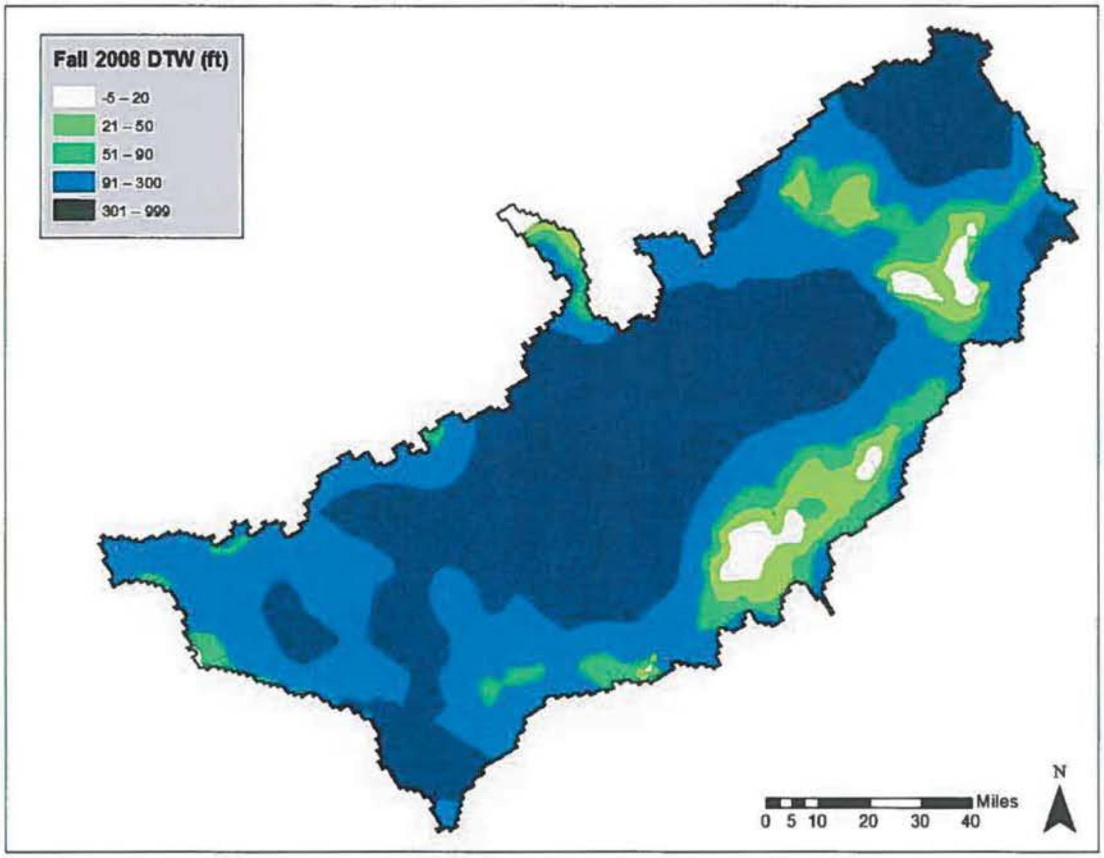

Figure 22. Depth-to-groundwater within the ESPA. Based on fall 2008 synoptic water-level measurements.

When determining how much recharge can be accommodated, some allowance should be made for man-made structures like foundations, basements, and septic/sewer systems. In addition, recharging in areas of shallow groundwater creates the risk that recharged water will not actually recharge the aquifer, but instead will exit the aquifer rapidly via drains and canals (Figures 23a – 23c).

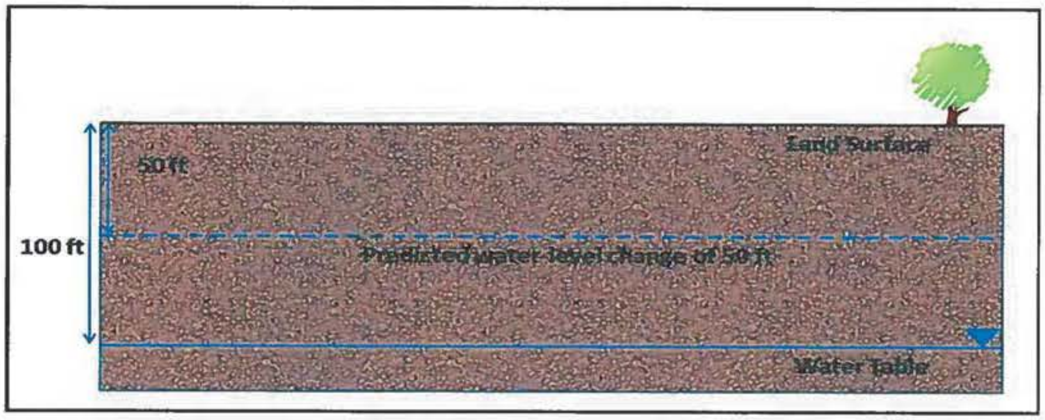

Figure 23a. Areas with sufficiently deep groundwater can accommodate recharge, and vadose-zone capacity is not a limiting factor to recharge.

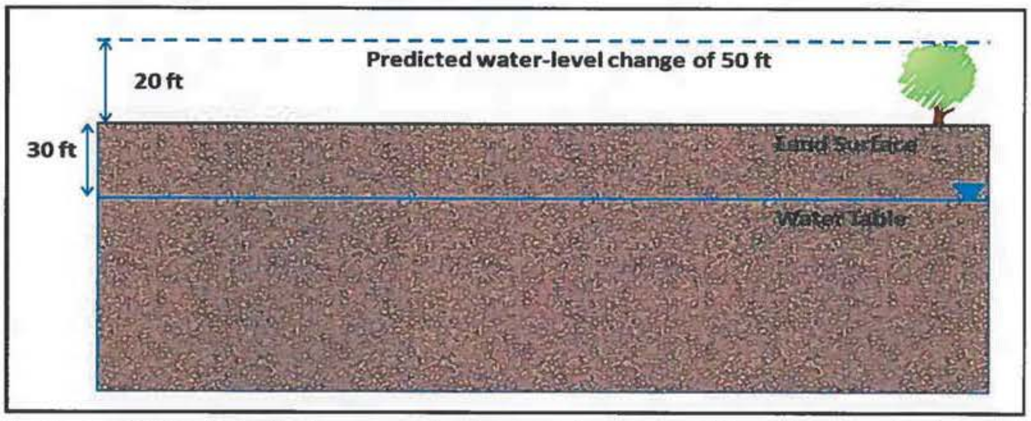

Figure 23b. Areas with insufficiently deep groundwater cannot accommodate recharge, and vadose-zone capacity is a limiting factor.

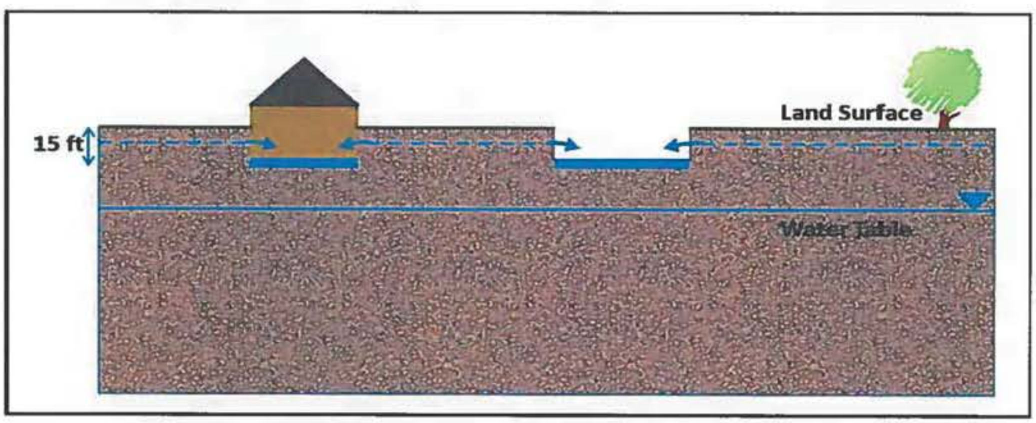

Figure 23c. To avoid wasting resources or damaging infrastructure, the determination of vadose-zone capacity should include a buffer from land surface. A 15-foot deep buffer has been implemented for this analysis.

Because no previous work has been done to quantify the relationship between managed recharge and shallow groundwater, groundwater-capacity limitations have been developed using ESPAM2.1.

For this analysis, a buffer of 15 feet below land surface has been implemented to ensure that managed recharge activities contribute to increases in aquifer storage instead of causing rapid returns to surface water or endanger infrastructure.

The calibrated EPAM2.1 does not consider shallow groundwater when running scenarios; therefore, the model has been altered by adding drains to model cells in areas with a fall 2008 depth-to-water of 20 feet or less. The drains are then used to quantify the amount of water that enters the buffer zone during a one-month recharge event. It is important to note that ESPAM2.1 river and spring cells remain as river/spring cells to avoid including water that discharges from the aquifer to the river in the estimation of vadose-zone capacity limits (Figure 24).

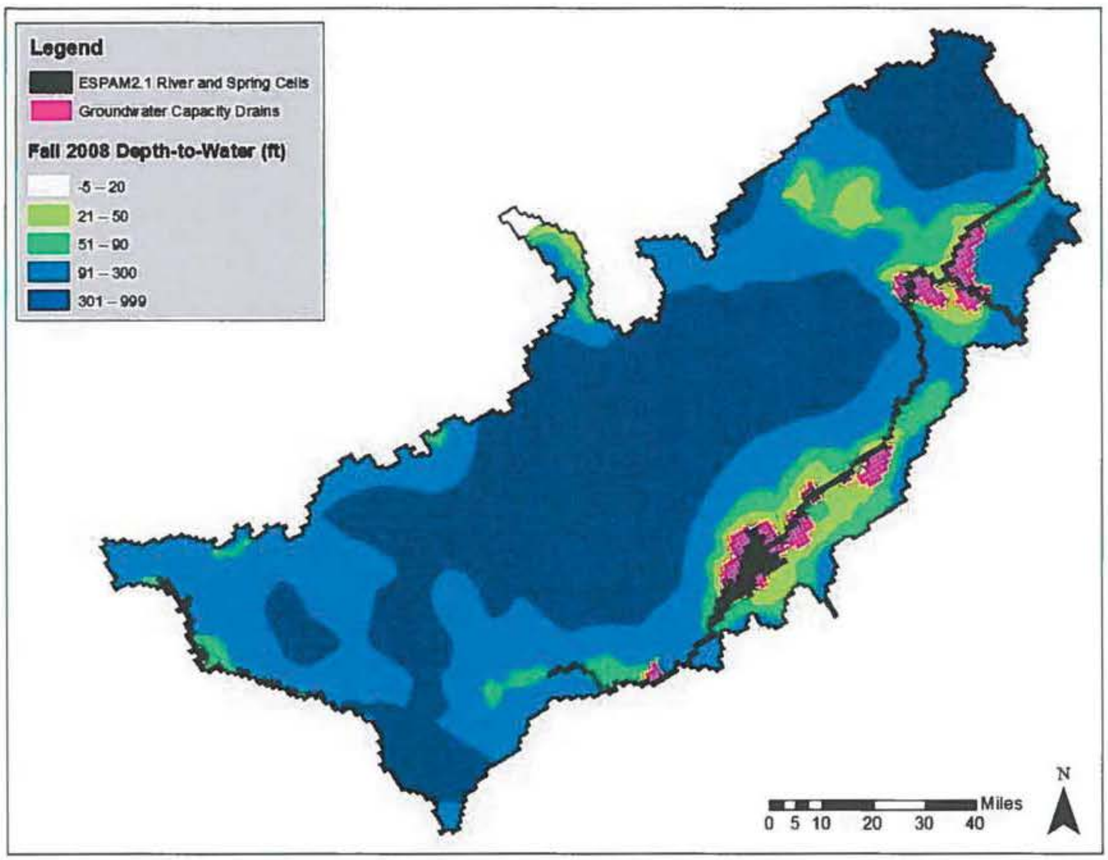

Figure 24. Drains added in locations with measured depth-to-water of 20 feet or less in the fall of 2008.

The drains have been assigned an exceedingly large conductance value of 500,000 ft^2/day to ensure that water flows easily into them when recharge-induced water-level changes raise groundwater to within 15 feet of land surface.

The following steps were taken to determine the vadose-zone capacity at each site:

1. Create seasonal depth-to-water maps using spring and fall synoptic water-level measurements.
2. Add drain boundary conditions to model cells in areas where the fall 2008 depth-to-water is 20 feet or less.
   a. Fall depth-to-water values have been employed because fall water levels are generally shallower than spring water levels, which results in a wider distribution of shallow-groundwater drain cells.
3. Run the model using increasing volumes of seasonal, one-month recharge events at each site.
   a. Seasonal analyses evaluate the spring- and fall-season depth-to-water conditions.
   b. Water is discharged into a drain when recharge raises seasonal water levels in a drain cell to within 15 feet of land surface (Figures 24 and 25).
4. Evaluate the volume of water that exits though the drains during the one-month recharge event.
   a. Vadose-zone capacity is reached when either 5% of the recharge volume or 100 AF exits though the drains during the same one-month period as recharge occurred.

It is important to note that drain cells have only been used to determine vadose-zone capacities. The use of drain cells alters ESPAM2.1, and it is not appropriate to use the altered model to assess recharge impacts. The fully calibrated model has been employed to model recharge for all analytical scenarios.

Figure 25 illustrates the selection of drain cells based on a depth-to-water of 20 feet or less, and the activation of drain cells when recharge raises water to within 15 feet of land surface. Table 9 lists the seasonal shallow groundwater limitations generated with this methodology. The distribution of seasonal vadose-zone capacities are discussed more thoroughly in Appendix E.

The shallow-groundwater recharge limits are intended to help the State prioritize recharge investment and avoid wasting recharge resources. It is important to realize that these volumes represent preliminary estimates of vadose-zone capacity that have been developed using a regional model. Therefore, it is recommended that a formal hydrogeologic or engineering investigation be performed for proposed recharge at rates greater than the vadose-zone capacity of the site. Because vadose-zone capacities are a function of the depth-to-water, it is likely not possible to increase vadose-zone capacity through engineering or construction.

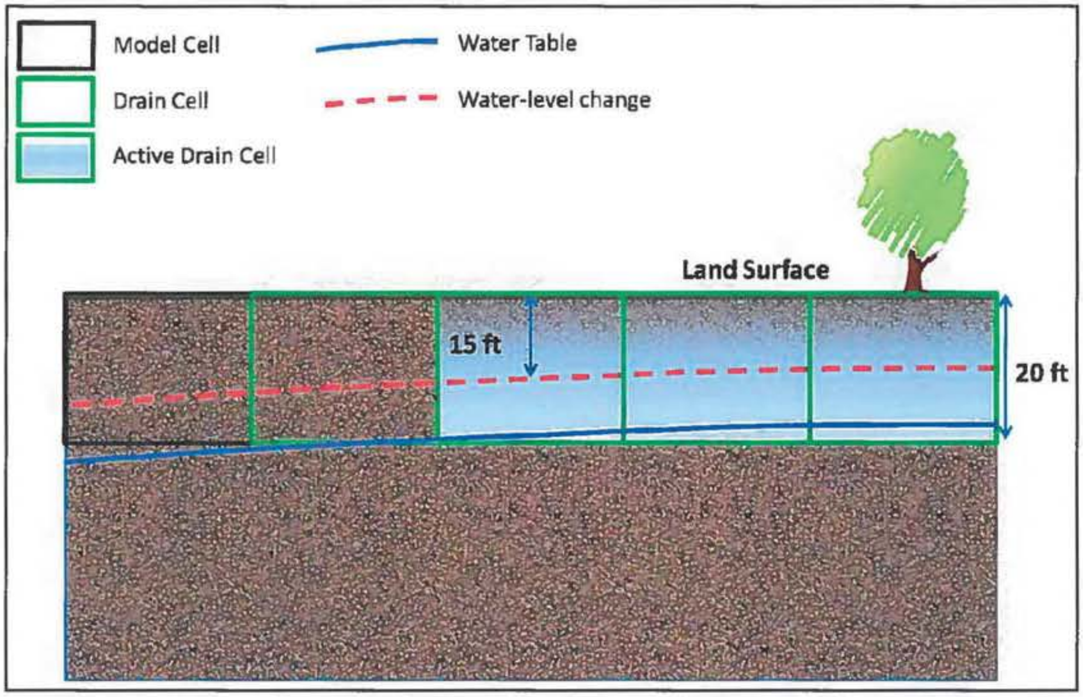

Figure 25. Illustration depicting the selection and activation of drain cells.

Table 9. Seasonal vadose-zone capacities for recharge sites reviewed in this study.

Recharge Site	SPRING Vadose-zone capacity (acre-feet/month)	FALL Vadose-zone capacity (acre-feet/month)
Aberdeen-Springfield	2,300	<100
Egin Lakes	5,000	3,800
Fremont-Madison East	17,000	12,300
Fremont-Madison West	2,600	<100
Great Feeder Area	50,000+	<100
Hilton	3,200	2,800
Idaho	8,500	<100
Jensen's Grove	6,300	3,500
Lake Walcott Recharge	50,000+	50,000+
Milepost 31 Recharge	50,000+	50,000+
Milner-Gooding	50,000+	50,000+
New Sweden	20,000	3,800
Northside	50,000+	50,000+
People's	3,400	<100
Riverside	4,300	2,200
Shoshone	50,000+	50,000+
Snake River Valley	9,400	<100
Southwest Irrigation	50,000+	50,000+
United	4,100	3,400

Recharge Capacity

The physical ability to conduct recharge at a site is termed *recharge capacity*. Recharge capacity is the lesser of diversion capacity, infiltration capacity, and the season-specific vadose-zone capacity (Tables 10 and 11). These limits represent reasonable preliminary estimates and will likely change as the recharge program matures and some values are more accurately determined.

Table 10. Spring-season recharge capacities. The recharge capacity for each site is highlighted in green.

Site	Diversion Capacity (acre-feet/month)	Infiltration Capacity (acre-feet/month)	SPRING Vadose-zone capacity (acre-feet/month)
Aberdeen	12,100	7,300	2,300
Egin Lakes	15,300	2,200	5,000
Fremont-Madison East	10,900	6,500	17,000
Fremont-Madison West	7,200	4,300	2,600
Great Feeder Area	18,100	6,900	50,000
Hilton	7,700	7,600	5,200
Idaho	4,500	1,400	8,500
Jensen's Grove	1,800	1,000	6,300
Lake Walcott	6,100	6,100	50,000
Milepost 31	18,400	24,200	50,000
Milner-Gooding	46,500	8,200	50,000
New Sweden	3,200	1,100	20,000
Northside	30,700	22,200	50,000
People's	6,000	2,500	3,400
Riverside	5,400	700	4,300
Shoshone	1,900	21,200	50,000
Snake River Valley	4,500	1,400	9,400
Southwest	3,600	3,600	50,000
United	4,500	600	4,100

Table 11. Fall-season recharge capacities. The recharge capacity for each site is highlighted in green.

Site	Diversion Capacity (acre-feet/month)	Infiltration Capacity (acre-feet/month)	FALL Vadose-zone capacity (acre-feet/month)
Aberdeen	12,100	7,300	<100
Egin Lakes	15,300	2,200	3,800
Fremont-Madison East	10,900	6,500	12,300
Fremont-Madison West	7,200	4,300	<100
Great Feeder Area	18,100	6,900	<100
Hilton	7,700	7,600	2,300
Idaho	4,500	1,400	<100
Jensen's Grove	1,800	1,000	3,500
Lake Walcott	6,100	6,100	50,000
Milepost 31	18,400	24,200	50,000
Milner-Gooding	46,500	6,200	50,000
New Sweden	3,200	1,600	3,800
Northside	30,700	22,200	50,000
People's	6,000	2,500	<100
Riverside	5,400	700	2,200
Shoshone	1,900	21,200	50,000
Snake River Valley	4,500	1,400	<100
Southwest	3,600	3,600	50,000
United	4,500	500	3,400

Recharge limitations represent relative rankings regarding the ability to conduct recharge at the sites investigated in this study. Some limiting factors can be increased via engineering and construction (e.g., diversion capacity), while little can be done to change other factors (e.g., shallow groundwater). Therefore, it is important to understand what limits recharge at any give site. The rankings are intended to help the IWRB understand the limiting factors, prioritize investment in recharge infrastructure, and coordinate recharge activities.

Recharge Modeling

ESPAM2.1 has been run in superposition mode to make quantitative evaluations of recharge effects on aquifer storage. Superposition only considers the stress that is being applied in the scenario (recharge), which allows the responses due to recharge to be evaluated separately from other aquifer stresses like precipitation, evapotranspiration, and irrigation water use.

The following scenarios represent recharge as direct injection into the aquifer, and any effects due to unsaturated sediments or perched aquifers that may exist between land surface and the regional water table are ignored. Additionally, no portions of the river are allowed to transition from perched to hydraulically connected with the aquifer during the simulation period, which may overestimate the benefit recharge has on aquifer storage at sites located near both a perched river segment and shallow groundwater.

Initial files for the superposition runs were downloaded from the Idaho Department of Water Resources website: http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/model_files/Version_2.1_Current/. These files were modified as needed to develop simulations representing appropriate recharge sites, stress periods, and time steps. The model cells used to represent the recharge sites are shown in Appendix F. Five scenarios were run to evaluate the effectiveness criteria:

1) Continuous recharge events of 100,000 acre-feet per month in each of the candidate recharge sites to visually illustrate how the distribution of hydrogeologic features influences the distribution of impacts throughout the aquifer. Recharge has been uniformly distributed among the cells identified for the recharge sites (except for Northside Canal). In Northside Canal, 2/3 of the recharge has been simulated to occur from the POD up to, and including Wilson Lake, while the remaining 1/3 has been recharged in the main canal downstream of Wilson Lake.

2) Single, one-month recharge events of 100 acre-feet per year in each of the candidate recharge sites to quantify the influence of location on the effectiveness of recharge to increase aquifer storage. As above, the recharge has been uniformly distributed among the model cells identified for the recharge sites, except for the case of Northside Canal.

3) Single, one-month recharge events at recharge capacity in each of the candidate recharge sites to quantify the influence of both location and recharge capacity on the effectiveness of recharge to increase aquifer storage. As above, the recharge has been uniformly distributed among the model cells identified for the recharge sites, except for the case of Northside Canal.

4) Recharge simulation using recurring one-month recharge events to illustrate the importance of repetition frequency. One-month recharge events that occur each year are compared with one-month events at the same location that occur every third year. Two recharge sites (with relatively high and low 5-year retention times) have been modeled to illustrate this point. The recharge has been uniformly distributed among the model cells identified for the analyzed recharge sites.