GROUNDWATER MANAGEMENT IMPROVEMENTS TO MITIGATE DECLINING GROUNDWATER LEVELS — A CASE STUDY

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ABSTRACT

The A&B Irrigation District in south-central Idaho supplies water to irrigate over 76,000 acres. The district's 14,660-acre Unit A is supplied with water from the Snake River. Unit B is comprised of 62,140 acres of land irrigated by pumping groundwater from the Eastern Snake Plain Aquifer (ESPA) using 177 deep wells. Pumping depths range from 200 to 350 feet. Water from Unit B wells is distributed to irrigated lands via a system of short, unlined lateral canals averaging about 3/4-mile in length with capacities of 2 to 12 cfs.

During the period from 1975 to 2005, the average level of the ESPA under the A&B Irrigation District dropped 25 ft and as much as 40 ft in some locations. This has forced the district to deepen some existing wells and drill several new wells. To help mitigate the declining aquifer, the district and its farmers have implemented a variety of irrigation system and management improvements. Improvements have involved a concerted effort by the district, landowners, and local and federal resource agencies.

The district has installed variable speed drives on some supply wells, installed a SCADA system to remotely monitor and control well pumps, and piped portions of the open distribution laterals. This has permitted farmers to connect farm pressure pumps directly to supply well outlets. Farmers have helped by converting many of their surface irrigation application systems to sprinklers, moving farm deliveries to central locations to reduce conveyance losses, and installing systems to reclaim irrigation spills and return flows.

INTRODUCTION

The Eastern Snake Plain Aquifer

The Snake River Plain is an extensive, crescent-shaped lowland that extends from near the western boundary of Yellowstone National Park in eastern Idaho to the

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Idaho-Oregon border where the Snake River enters Hells Canyon. The area is drained by the Snake River and its tributaries. The source of the Snake River water is snowmelt from the winter snow pack in the surrounding mountains. Most the runoff occurs in the early spring before the irrigation season begins, so the water must be stored until it is needed later in the summer. The Snake River above King Hill has an extensive reservoir system with a storage capacity of about 5.5 million acre-ft.

A large regional aquifer system underlies the Snake River Plain (Fig. 1). Abrupt changes in hydrogeologic conditions along the Snake River between Salmon Falls Creek and King Hill, Idaho, serves as the dividing line between the Eastern and Western portions of the aquifer. The Eastern Snake Plain Aquifer (ESPA) is perhaps the single-most important aquifer in Idaho. Springs from the ESPA are also a major source of water for the Snake River. The eastern Snake River Plain is about 170 mi long, 60 mi wide, and covers 10,800 square miles. The plain extends from Mud Lake in the northeast to King Hill in the southwest. The ESPA is composed mostly of basalt which is over 3,000 ft thick in the center of the plain and only a few hundred feet along the margins. Total groundwater storage in the aquifer is estimated at 200- to 300 million acre-feet, roughly the equivalent of Lake Erie. Most agricultural soils are the sediments along the Snake River at the margins of the plain. The aquifer supplies water for irrigated agriculture, cities, and aquaculture.

Much of the discharge from the ESPA is through springs. Two major spring discharge areas are near the American Falls Reservoir and the Thousand Springs area near Twin Falls, Idaho. From Milner Dam to King Hill, the Snake River is entrenched in a steep basalt canyon as much as 700 feet deep. Spring flow from the north side of the canyon along with a few streams from the south rebuilds the flow in the Snake River below Milner Dam. There are several large springs along the canyon with average flow rates of 200 cubic feet per second and 400 cubic feet per second.

Surface water applied to irrigated lands above the aquifer is the largest source of aquifer recharge. Annually, this amounts to about 60% of the total recharge. As irrigation practices and technologies have improved, recharge has been reduced. Also, withdrawals from the aquifer for irrigation and other uses have increased over time. Aquifer levels have declined and have impacted all ESPA water users. Recent drought years have reduced surface water supplies for irrigation above the ESPA and have also increased groundwater pumping to supplement surface water supplies. This has resulted in further depletions of the aquifer.

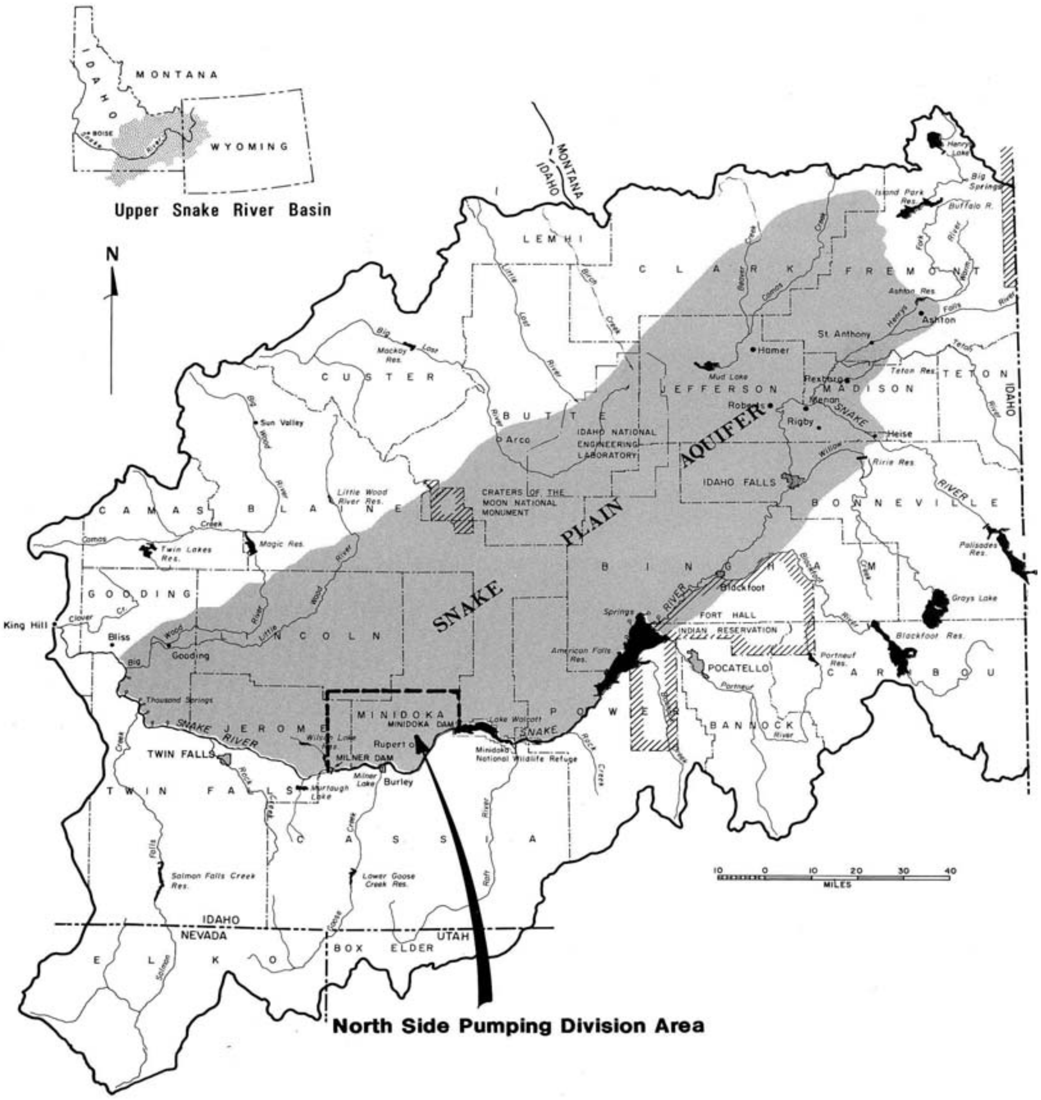

Figure 1. Location of Eastern Snake Plain Aquifer and A&B Irrigation District

As a result of the incidental recharge from surface water irrigation over the ESPA, about 70% of the flow at King Hill is now ground water discharge from the Thousand Springs. Records indicate spring flow in the Milner Dam to King Hill reach of the Snake River increased from 4,200 cfs in 1900 to 6,800 cfs in 1950. Spring flows have recently declined to less than 6,000 cfs or about 4,800,000 acre-feet per year. The cause for this decline is a combination of the reduction in incidental recharge from surface water as a result of the conversion from flood to sprinkler irrigation, and extended drought and groundwater pumping.

A&B Irrigation District

The A&B Irrigation District operates and maintains the Northside Pumping Division of the Minidoka Federal Reclamation Project. The Northside Pumping Division, located in Minidoka and Jerome Counties in south-central Idaho, was authorized by Congress in 1950. The project area is relatively compact, ranging from 2 to 7 miles in width and about 30 miles in length. Construction of the project was completed in 1959. Nearly 695 new farm units were made available for settlement within the District, almost all for homestead entry. Under the prevailing law, veterans of World War II and the Korean Conflict had preference in acquiring the new farm units.

The district contains approximately 76,800 irrigated acres, split between the 14660-acre A Unit which receives up to 270 cfs of natural flow and reservoir storage pumped from the Snake River, and the B Unit, which uses 177 deep well pumps, with a combined capacity of about 1100 cfs. The A Unit has a 5-pump plant which lifts water approximately 168 ft into a gravity distribution system of approximately 50 miles of unlined canals and laterals.

In the B Unit, water is carried from the supply wells to farms via a system of short, unlined lateral canals averaging about 3/4-mile in length with capacities of 2 to 12 cfs. Pumping depths range from 200 to 350 feet. Generally, one or two single-speed deep well pumps discharge into an open pond. The ponds have one or more gates which control deliveries to individual farms or to a lateral which serves several downstream farm deliveries. Valves at the well head regulate outflows. Mismatches between well output and irrigation deliveries are spilled into project drains or sumps.

Since the inception of the project, the District's annual farm delivery rate has remained relatively steady at approximately 3 acre-feet/acre. Soils are generally well-drained sandy or silt loams with underlying fractured basalt. Major crops include sugar beets, wheat, barley, malting barley, potatoes, and alfalfa hay.

The project originally included 370 miles of unlined, open drains, several drain water relift pumps, and 78 injections wells that discharged drain water into the fractured basalt Eastern Snake Plain Aquifer that underlies the District. In order to reduce pumping costs and to help alleviate water quality concerns, additional relift pumps and pipelines were installed in the district. The district has abandoned 62 injection wells and capped 5 others to potentially be used as future production wells.

The declining aquifer under the District has had very significant impacts on the A&B Irrigation District. The average pumping depth of the B Unit wells has dropped nearly 25 feet since the mid-1970's. There have been short periods of recovery during years with above-average precipitation, but these recoveries have been outweighed by drought cycles during the late 1970's, the early 1990's and the 1999-2004 period. Figure 2 shows a graph of the average pumping depth for all district supply wells since the inception of the district.

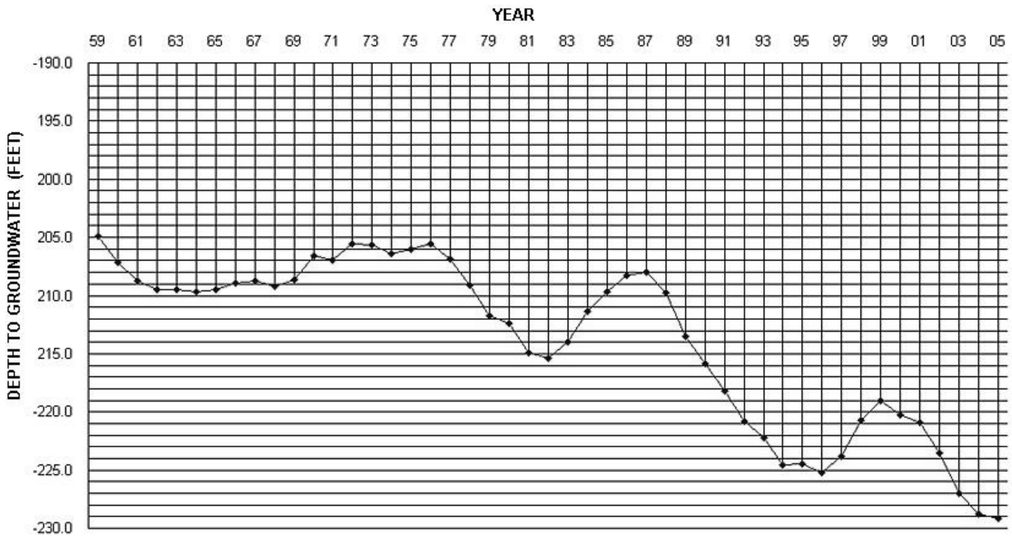

Figure 2. Average Depth to Groundwater by Year

Declining aquifer levels have increased the pumping costs and reduced well outputs. Since 1987, the district has deepened 30 wells in an attempt to regain some of the capacity lost as a result of the declining aquifer. Dozens of other well pumps have been replaced or fitted with new impellers to increase pumping head. In the western part of the district, 5 supply wells have been temporarily abandoned and 4 new wells have been drilled. In some cases, surface water from the A Unit is pumped to lands originally served by B Unit groundwater wells.

As supplies have declined, farmers in the district have improved efficiencies by converting their farm irrigation systems from surface applications to sprinklers. This helps to reduce overall water use, but also adds additional costs for pressurizing the farm systems. When coupled with low commodity prices, the increasing pumping costs and cost of application system modifications, many farms in the district are experiencing financial difficulties.

GROUNDWATER MANAGEMENT IMPROVEMENTS

A& B Irrigation District and its water users have undertaken many efforts to mitigate the impacts of the declining ESPA. These have involved a variety of equipment and management improvements. Many of the improvements have been made to improve the flexibility of both the farm application systems and the district supply systems.

SCADA

Beginning in 1998, A&B began a program to install industrial electronic controllers and radio telemetry on its irrigation supply wells to remotely control and monitor the operation. Historically, the District required 24-hour advanced scheduling of water deliveries, and pumps were operated by District staff during regular work hours. The 24-hour delivery schedule didn't necessarily coincide with actual farm irrigation schedules, wasting water and electricity.

The automated system allows the District to start and stop pumps remotely from District offices. Office personnel and on-call operators at remote locations can program starting and stopping times for individual pumps or pump systems. For example, if an irrigator anticipates completion of his irrigation cycle during the night, he can inform the District office of the time to shut off the pumps and the shut-off can be entered into the central control computer the day before. When the pump is shut off, water that is not needed for irrigation stays in the aquifer.

The SCADA system also permits District staff to monitor the performance of individual pumps in the system, including flows, power consumption, and bearing temperatures on a graphical display. Remote operation also saves staff time and pickup miles for routine water changes. This is especially valuable when it is necessary to start several pumps after power outages. The SCADA system also provides alarm notifications and call-outs for specified conditions.

Currently, 47 of the District's 200 pumps are connected into the SCADA system. The system is PC-based and provides radio and phone call-outs. The remote sites use Allen-Bradley RTU's with a variety of sensors. Communication is accomplished using a 5-watt radio network. The SCADA system is also used to monitor (but not operate) the district's A-Unit pumping plant.

Reducing or Reclaiming Lateral Losses

Since most of the District's groundwater was distributed to farm deliveries via open laterals, there were inevitable mismatches between the pumped water supply and the farm deliveries. In the early days of the district, all lands were irrigated by surface methods, which resulted in relatively continuous farm deliveries. But as more farms converted to sprinkler irrigation, farm water use became more variable and there were increases in spills from the conveyance system.

The District has used several methods to help reduce conveyance losses in laterals. In several locations where farm pumps are located near supply wells, A&B has permitted a direct connection from the well pump discharge to the farm pump inlet. Regulating valves and flow meters are installed between the well head and the farm pumps to measure and regulate the farm deliveries. Most of these valves and flow meters are connected into the district SCADA system.

In instances where new sprinkler systems are being installed, the District encourages farmers to locate their farm pressure pumps near the district's wells. Water is then conveyed by buried pipeline to the sprinkler system. The open delivery lateral can then be eliminated, which helps landowners "square up" fields and eliminate obstacles. Also, by locating farm pumps near the District's wells, landowners can take advantage of the close proximity of electric power for their pressure pumps and reduce the costs of their new electric service.

In location, several farmers have installed farm pumps on a jointly constructed storage and regulating pond. By having their water delivered to a larger pond, they have a more constant supply, they have more flexible farm system operation, and the pond catches most operational spills. A water level sensor on the pond is connected to the supply well through the district's SCADA system to shut off the well pump if the pond gets too full. A&B has also constructed two wetland sites at the end of the D and F Drains. These sites collect farm runoff, improve drain water quality and reuse the collected water for agricultural irrigation.

Variable Speed Pump Drives

A&B has installed variable speed drives on 8 supply wells to better match water supplies with the irrigation and reduce total pumping. Four wells have Variable Frequency Drives (VFD) which electronically adjust the frequency of the alternating supply current to set the speed of the electrical drive motor (Fig. 3). The outlet pipes of the wells equipped with VFD's are connected directly to the inlet of farm booster pumps.

The well pump inlets are equipped with pressure transducers and the farm pump outlets are equipped with propeller flow meters. Both pressure transducers and have electronic outputs, and flow and pressure information is read by the SCADA RTU at each site. Once in the SCADA system, this data can be relayed to the office for water use accounting. The signal from the pressure transducer on the well outlet is used to regulate the operation of the VFD.

Figure 3. Two district supply wells directly coupled to three metered farm deliveries. The well at the right has VFD to regulate pressure. A farm booster pump is installed under shade at left.

A&B has also installed four Magna-Drive variable speed drives. Unlike the electronic VFD drives, the Magna-Drive uses a magnetic clutch assembly connected between the pump motor and the pump shaft to adjust pump speed. The clutch consists of two large permanent magnets that are separated by an adjustable air gap. The drive unit's electronic controller monitors pump outlet pressure and adjusts the width of this gap using a small electric actuator. The gap is increased to slow the pump speed and decreased to increase the pump speed.

One of the Magna-Drives is installed on a 300 hp horizontal electric motor and transmits power to the well shaft through a 90-degree gearbox. The other three Magna-Drive units fit between the well shaft and a vertical electric motor and include the necessary thrust bearings for this type of installation. All 4 Magna-Drive sites are monitored by the District's SCADA system.

Both types of variable speed drives have been successful in reducing both the amount of water withdrawn from the aquifer as well as reducing power consumption. Each type of drive also has its own benefits and detriments.

The VFD's are relatively large and must be installed in small weatherproof structures. The electronic components used to adjust the frequency of the alternating current of the power supply generates a good deal of heat inside the instrument building, which must be air conditioned. VFD's are designed to work with specific voltages. The District was not able to obtain VFD's for the 2300-

volt equipment originally installed on project wells and had to install 480-volt motors and transformers at all of the VFD sites. The VFD's have helped reduce energy use and have been quite reliable. They have also been relatively easy to integrate into the district's SCADA system.

The Magna-Drive units were able to work with existing voltages, but did require additional modifications at the well sites. When the first Magna-Drive was installed, only horizontal units were available. The district had to replace the existing vertical motor with a horizontal motor and a 90-degree, oil-filled gearbox. Both Magna-Drive units have high-speed cooling fans which may not be suitable for all locations due to the fan noise. Magna-Drive units cost more than VFD units for similarly sized pumps and, with more mechanical components, have required more maintenance.

Automatic Regulating Valves

At most farm deliveries where district wells are directly connected to farm pumps, flow meters with electronic outputs are connected to the well's SCADA system to monitor flows. Automatic valves are used to control farm delivery pressures. Because A&B used federally subsidized electric power for its supply wells, farm delivery pressures must be minimal.

Two types of regulating valves are used in these installations. At one site, motorized butterfly valves with valve position sensors are adjusted by the RTU at the well to maintain proper pressures at the well outlet. At 24 other sites, Nelson diaphragm valves are installed between the well head and the farm pump to automatically regulate to the preset pressures.

On-farm Improvements

Between 1980 and 2005, the B Unit has gone from 20% to over 60% sprinkler irrigation. The A&B Irrigation District has worked closely with the local Minidoka Soil and Water Conservation District and the Natural Resources Conservation Service to assist district farmers with the conversion of their farm irrigation system from gravity application to sprinklers. Also, the Conservation District has worked with the EQIP and other federal programs to assist landowners with installation of approximately 30 new sprinkler systems since 2002.

In many cases, district distribution laterals must be relocated to "square-up" fields to install new center pivot or side-move sprinkler systems. A&B has assisted in these instances by donating district equipment and manpower to help install landowner-purchased pipelines to relocate or bury district laterals.

SUMMARY

The A&B Irrigation District and its irrigators have utilized a wide range of technologies and management improvements to help mitigate the impacts of declining water levels in the Eastern Snake Plain Aquifer in southern Idaho. Improved irrigation application methods, a district-wide SCADA network, variable speed well pump drives, and distribution system efficiency improvements have helped A&B to cope with reduced groundwater supplies and increased pumping costs.

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