CONSIDERING REGIONAL AQUIFER EFFECTS OF SEEPAGE LOSSES FROM THE ABERDEEN-SPRINGFIELD CANAL WHILE MEASURING THE SYSTEM UNDER MAXIMUM DEMAND CONDITIONS

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AUTHORIZATION TO SUBMIT THESIS

This thesis of Heather Rice, submitted for the degree of Master of Science in Water Resources Science & Management and titled "**Considering Regional Aquifer Effects of Seepage Losses from the Aberdeen-Springfield Canal While Measuring the System Under Maximum Demand Conditions,"** has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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ABSTRACT

For optimal water delivery and efficient use of water resources in arid landscapes, canal conveyance losses should be minimized whenever possible. This is especially true in southeast Idaho where seepage losses from earthen canals often exceed 50% of total annual diversion and competition for water resources is ever increasing. Quantifying canal losses and locations provides the first crucial step for canal operators in determining how to address the numerous causes of loss and maintain the water delivery systems that communities depend on. In this study, we used a comprehensive approach including: 1) a review of the social, physical and economic irrigation complexities associated with the age-old issue of seepage losses in the Aberdeen-Springfield Canal, 2) the determination of seepage losses, regional aquifer properties and groundwater levels, and 3) an evaluation of the overall effect of the quantified losses in the region. This resulted in discharge and loss rates for every mile of the canal under peak operating conditions totaling 678.0 cfs with 52.5% of losses occurring in the upper 52.9 linear miles of canal. Near the lower end of the canal, aquifer transmissivity of 2×10^5 ft^2/day and storativity of 0.0003 were determined. These findings, combined with groundwater levels were used to predict the locations most likely to experience effects of the 195,069.2 af seepage losses that occurred in 2017.

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CHAPTER I. INTRODUCTION

1.1. Purpose & Scope of Work

Many reasons exist for investigating the transmission losses from the Aberdeen-Springfield Canal (ASC) System; some more pressing than others. The purpose of this study is to address this question: What are the seepage losses for specific reaches of the canal under maximum demand conditions? Once answered, the next logical line of inquest includes: what is the fate of the losses and what role do the losses play in the Eastern Snake Plain water budget and the aquifer. The question of canal losses to the overall aquifer water budget is a very complex issue, and cannot be fully answered in this study alone, but data and interpretations presented herein will support follow-up studies of the regional water budget and aquifer health.

The scope of work for this Thesis includes the following tasks:

Table 1.1: Scope of Work

Task	Description	Time Frame	Purpose
Social Issues Research	Review historic and legal documents pertaining to ASCC water rights.	2016-2017	Provide background to fully understand issues driving the need for the study.
Canal Flow Study	A robust investigation of discharge, velocity measured at mile intervals.	May - Aug. 2017	Determine discharges, loss rates & average velocities.
Aquifer Pumping Test	Pumping test on the Simm's Well to measure aquifer properties.	Nov. 2017	Predict responses in the aquifer to canal seepage.
Monitoring Wells	Create and review hydrographs of 19 local monitoring wells.	Fall 2017-Spring 2018	Examine possible aquifer response to canal seepage.

1.2. Background

A critical role during the late 1800's expansion in Idaho was the development of surface water irrigation systems created to tame the West's arid landscape. As a result, millions of acres of desert were converted to farmland aiding in western settlement along the Snake River Plain. This monumental transformation was not without past and present challenges, however, and various irrigation complexities continue to extend into social, economic, and physical phases of modern life (Lewis, 1924). Such social and economic irrigation complexities are herein identified as a need for the quantification of transmission losses in an irrigation canal and analysis of the effect the losses are having on the regional aquifer.

1.3. Snake River Plain

Geography & Economic Importance

Stretching across the southern half of Idaho is the Snake River Plain; a 15,600 square mile (Whitehead, 1992) depression through which the Snake River flows. The headwaters of the Snake River originate in Wyoming and mountains of Eastern Idaho and wind through the upper Snake basin before finding their way to the western side of the state. Its flows support a wide variety of beneficial uses not only for Idahoans, but for many in the west including but not limited to agriculture, power generation and recreation. The plain is thought to have originated when the North American Plate passed over the Yellowstone Caldera (Idaho State University, 1999).

High desert mountains surround the Snake River Plain and provide annual water storage in the form of snow pack that melts to supply the Snake River's many tributaries. In the eastern portion of the plain, the Snake River is a prime example of a surface water system that is highly influenced by groundwater conditions (Miller, Johnson, Cosgrove, & Larson, 2007) and interacts continuously with the underlying aquifer. The combination of these two water resources is the lifeblood that continues to sustain the majority of Idaho's population.

Hydrologic and geologic changes to the aquifer occur in the vicinity of King Hill where it naturally divides into western and eastern sections. The Eastern Snake Plain Aquifer (ESPA) is estimated to hold 200-300 million acre-feet (af) of groundwater (Idaho State University, 1999). Water resources (both surface and groundwater) in what is known as the Upper Snake

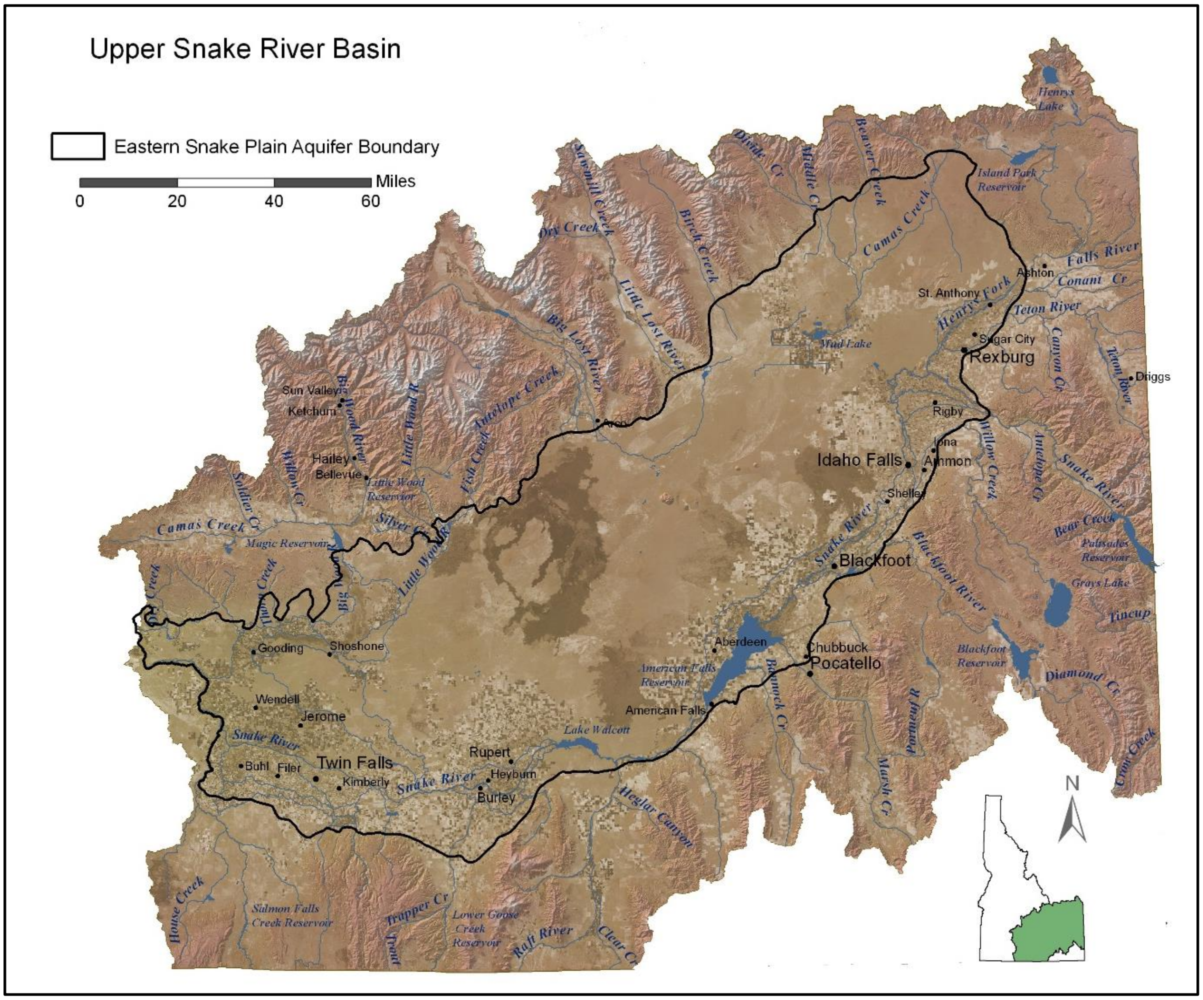


Figure 1.1: The Upper Snake River Basin Aquifer, (Idaho Water Resource Board, 2018)

River Basin of the Eastern Snake River Plain are responsible for much of Idaho's agriculture income. Within the boundary of the ESPA, approximately 33% of Idaho's goods and services are produced; totaling $14.9 billion dollars in 2012 (Stewart-Maddox, Thomas, Parham, & Hipke, 2018).

ESPA Geology & Hydrogeology

Throughout the years, much research has been accomplished with respect to the geological and hydrologic architecture of the ESPA. A substantial portion of this research has been in the form of USGS reports and professional papers which include thorough reviews. Whitehead (geology), Lindholm (water table and flows), Kjelstrom (water budgets and surface flow), and Garbedian (groundwater flow modeling) are among those most commonly cited for their contributions in backgrounds and introductions of new research. In short, the Eastern Snake River Plain is comprised mostly of highly transmissive, Quaternary basalt interbedded with sands, clay, silt, ash and unconsolidated sediments (Figure 1.2). Faults and fractures within the basalt contain direct conduits for water storage and transport (Whitehead, 1992) and the aquifer is very productive. It is generally agreed that the aquifer is unconfined and groundwater flows migrate from the northeast to southwest direction however departures from this general flow direction do exist in certain locations. In a subsurface flow modeling study, Ackerman reported that most of the horizontal flow occurs in the top 500 feet of the aquifer (Ackerman, 1995). Springs are present along the western terminal edge of the aquifer that spill into the Snake River in the “Thousand Springs" area whose flows, not unlike others, are directly related to aquifer levels. General flow directions and water elevations are illustrated in Figure 1.3. Water levels in the ESPA and along the Snake River and its tributaries are monitored and regulated closely by IDWR to ensure fair allocation of water amongst many users (I.C. §42-102 & I.C. §42-226).

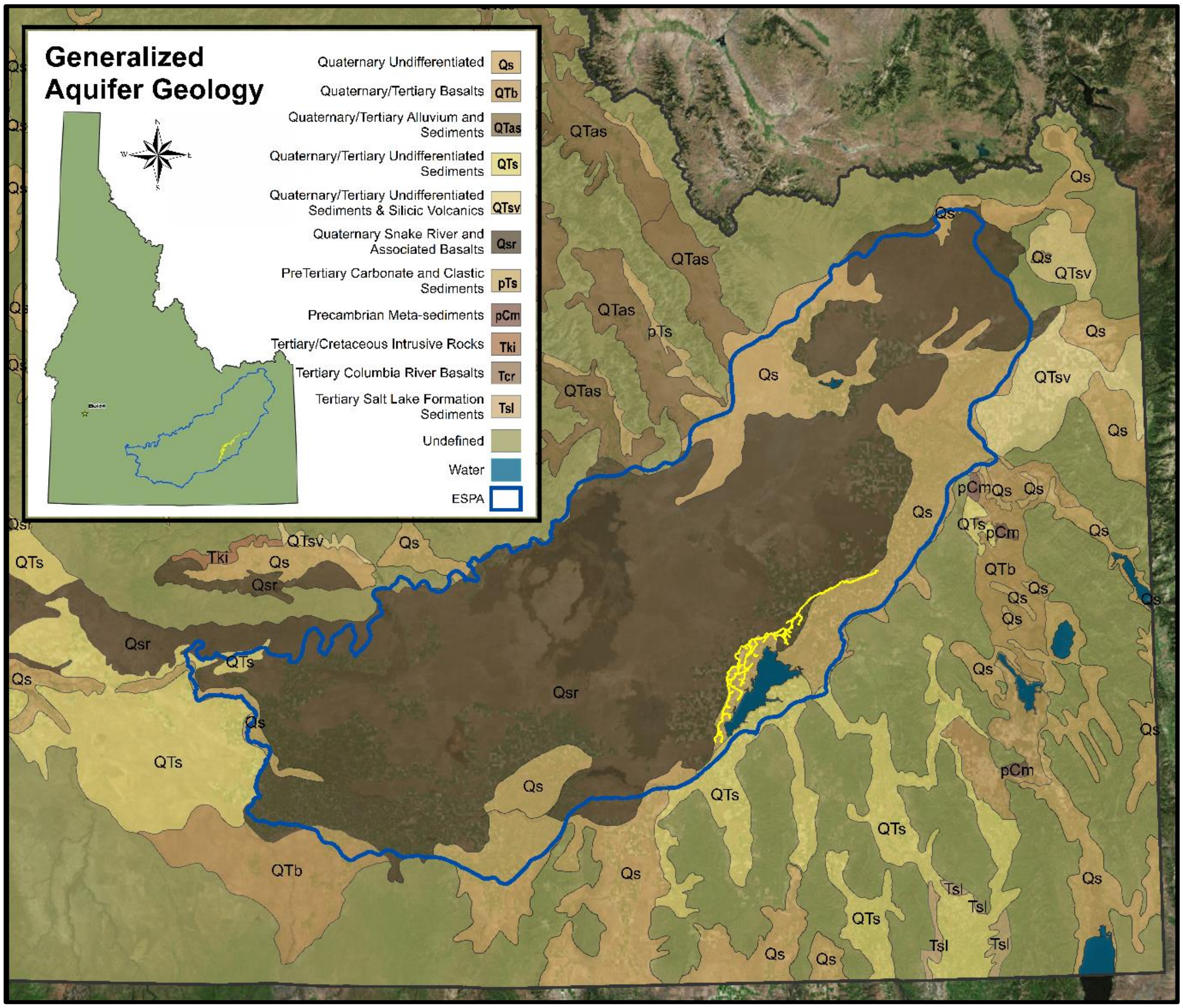


Figure 1.2: Generalized Aquifer Geology of the ESPA. The Aberdeen-Springfield Canal is shown in yellow. GIS data layer, (Idaho Department of Water Resources, 2018).

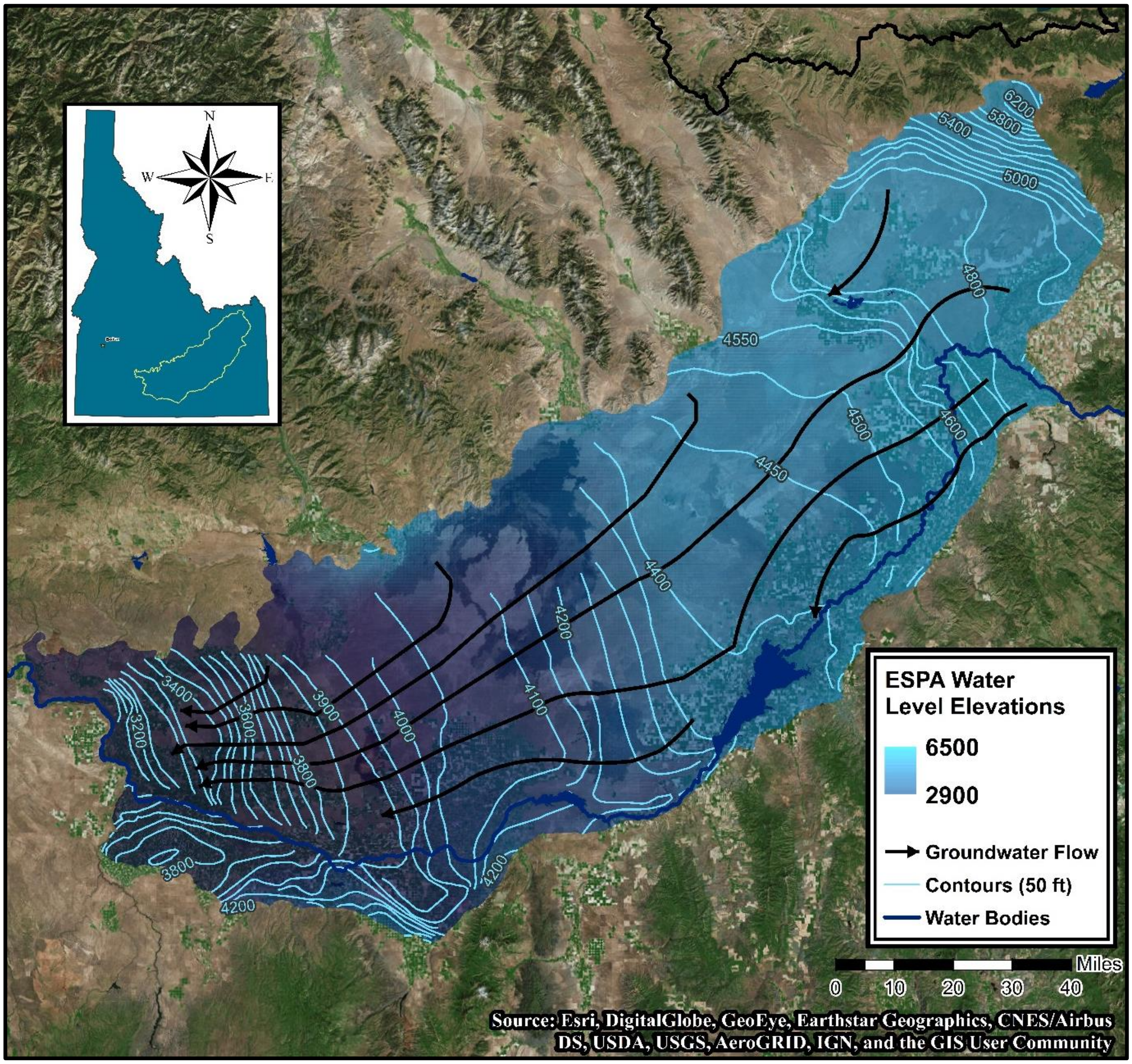


Figure 1.3: ESPA water level elevations, contour lines and general flow directions. GIS contour data layer, (Idaho Department of Water Resources, 2018).

Water Resource Administration & Policy

The ASCC has several water rights dating back to 1895 that authorize the right to appropriate publicly owned waters of the state of Idaho. Understanding the historic context of water administration in the state is key to understanding past and present decisions made by ASCC regarding management of their water rights. A brief summary of the administration of water rights in the State of Idaho is provided in this section.

In Idaho, what is known as the "Prior Appropriation Doctrine" is the governing law regarding distribution of the state's water resources. As written in I.C.§42-106:

> "PRIORITY. As between appropriators, the first in time is first in right."

Stated frankly, senior water users (those with the earliest, or "senior", water rights) have the right to use available water before junior water users. Allocation, regulation and administration of water resources is currently achieved through the state agency, The Idaho Department of Water Resources (IDWR) which has undergone several name changes since 1895 when the agency was formed (I.C.§42-1701). Primary authority of IDWR is given to its director who is appointed by the state governor. In 1965, I.C. §42-1730 was created establishing the Idaho Water Resource Board (IWRB) and designating IWRB as the single state agency (within IDWR) responsible to "formulate a comprehensive state water plan", I.C§42-1734A(1). Since 1974, the plan has gone through several revisions allowing adaptation to changes in water management through a "framework for the adoption and implementation of policies, programs, and projects that develop, utilize, conserve, and protect the state's water supplies" (Idaho Water Resource Board, 2012). The plan supports water right adjudication, recharge, conjunctive management of the ESPA and many other strategies.

Water rights and claims in the Snake River Basin underwent an extensive adjudication beginning November 19, 1987 and completed August 25, 2014. The Snake River Basin Adjudication solidified existing water rights and brought added certainty to water right holders. Throughout the years water litigation including *Hinton vs. Little (1931), Musser vs.*

Higginson (1994), Swan Falls Agreement (1984) and others have arisen. A contributing factor to these disputes is the extremely interconnected hydraulic nature of the Snake River and Eastern Snake River Plain Aquifer. In 1992, a moratorium was placed on new water right development in the Snake River Basin upstream from the USGS gauge on the Snake River near Weiser, excluding non-consumptive and domestic uses (Moratorium Order, 1992) and in 1994 the Director of IDWR promulgated Rules for Conjunctive Management of Surface and Ground Water Resources (CM Rules), IDAPA 37.03.11 (Rules for Conjunctive Management, 1994). The rules define conjunctive management to be, "Legal and hydrologic integration of administration of the diversion and use of water under water rights from surface and ground water resources, including areas having a common ground water supply" and "…prescribe procedures for responding to a delivery call made by the holder of a senior-priority surface or ground water right against the holder of a junior-priority ground water right" (Rules for Conjunctive Management, 1994). The rules have held up through legal challenges and all surface and groundwater resources within the state are said to be "conjunctively managed".

In 2009, the IWRB adopted the Eastern Snake Plain Aquifer Comprehensive Aquifer Management Plan (CAMP) in response to ongoing concerns and litigation surrounding the decline of the Eastern Snake Plain Aquifer (Figure 1.4). The Plan's objectives support the goal 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." (Idaho Water Resource Board, 2009).

Further ESPA recovery efforts in Idaho have called for a decrease in groundwater use and, after years of litigation, state politicians, attorneys, and water managers succeeded in organizing a settlement agreement between two large groups of water users known as the Surface Water Coalition (SWC) and the Idaho Groundwater Appropriators (IGWA). Signed in 2015, a main component of the agreement aims to increase ESPA water levels through the voluntary reduction of groundwater pumping and recharge activities (Settlement Agreement Entered into June 30, 2015 between participating members of the Surface Water Coalition and Participating members of the Idaho Ground Water Appropriators, Inc., 2015). While the

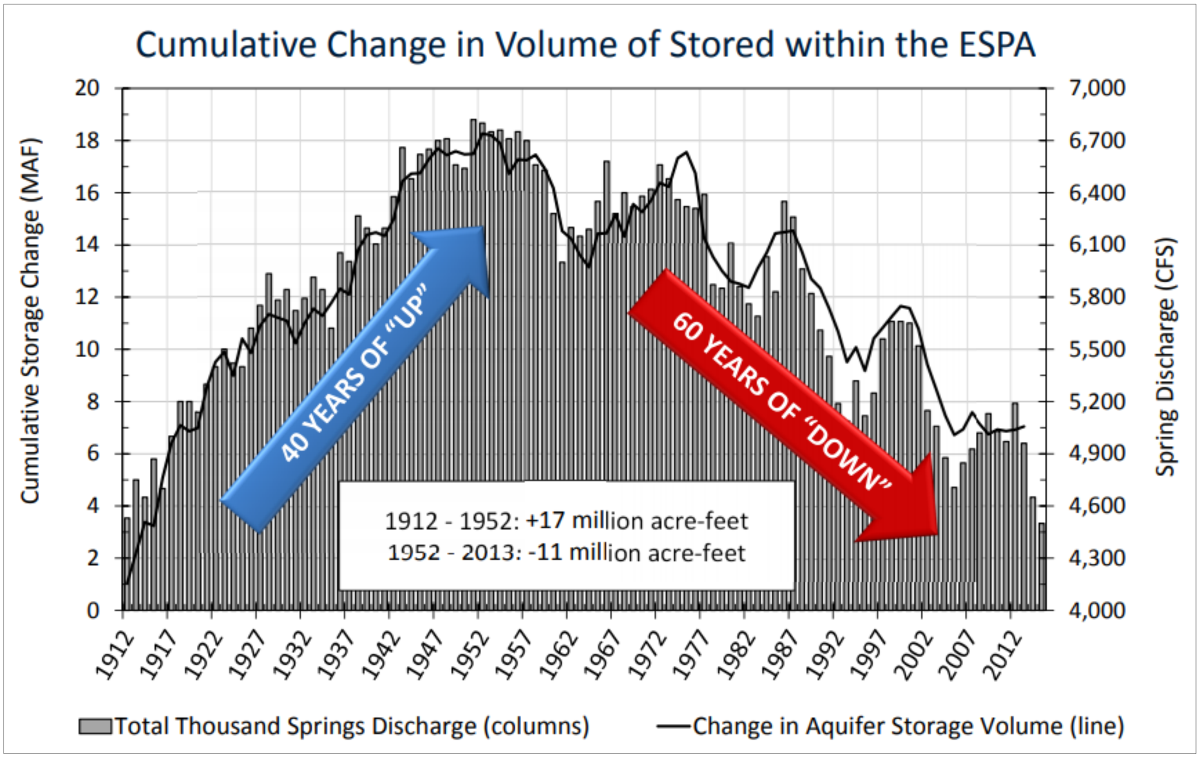


Figure 1.4: Cumulative storage in the ESPA over time, (Idaho Department of Water Resources, 2015).

agreement has aided the SWC and groundwater users in settling disputes, unintended consequences to third parties including ASCC have resulted. The increased scrutiny of groundwater use in the ESPA and changes in irrigation practices resulting from the settlement agreement has created a need for ASCC to quantify their canal flows.

1.4. The Aberdeen-Springfield Canal

History, Location & System Information

Near the southern boundary, of the central ESPA (Figure 1.2), the Aberdeen-Springfield Canal began delivery of surface water from the Snake River in 1895. Originally named the American Falls Canal and Power Company Project, the canal was the first proposed Carey Act project in April, 1896. Land was purchased from the state for 50¢ per acre bringing 80,000 acres of desert under irrigation (Lewis, 1924). This was instrumental in developing agriculture in Eastern Idaho. The main control gates divert water approximately 10 miles upstream from Blackfoot, Idaho and the canal stretches 67 miles southwest ending just west of American Falls, Idaho (Figure 1.5). The gravity fed system, which encompasses over 167 total miles of earthen main canals, laterals, and spillways currently provides water to approximately 62,000 acres of irrigated lands within its service boundary. Approximately 480 shareholders depend on the delivery system for irrigation water and typical crop mixes include potatoes, sugar beets, wheat, barley, alfalfa, pasture and corn. Annual water diversion typically averages 350,000+ af over a 190-day irrigation season beginning as early as April 1st and ending as late as November 1st. The canal is comprised of a main branch known as the "Main Canal" that forks into what are called the "Highline" and "Lowline" canals, 33 miles from the main control gates on the Snake River. Laterals extend from all three branches and are named using English alphabet letters with the exception of the "45 and "46" laterals (Figure 1.6). Shareholders place water orders with ASCC ditchriders and take delivery of their water through one of 737 recorded turnouts along the canals and laterals. Flows at the Main Gates are adjusted twice daily to accommodate changes in deliveries. Select control gates, weirs and spills are automated using a supervisory control and data acquisition (SCADA) system that provides real-time system information including flow, water levels and live video at various locations along the system. Two regulating reservoirs, the "Hilton Spill" and the "Big Fill" provide additional control over flows and excess water is spilled into the American Falls Reservoir, located southeast and down gradient of the system. The Hilton Spill is also utilized as a recharge site. Due to the nature of the local geology, much of the canal was constructed over gravels, basalts and lava tubes. Reoccurring sinkholes and crevasses exist in the canal base and are responsible for numerous leaks and losses. Estimated transmission losses have traditionally ranged between 50-60%.

The canal system has been the subject of two research studies. In 1991, a study performed by the Idaho Water Resources Research Institute provided a rough inventory of the system and flows while targeting the effects of non-continuous turnouts (Hamilton, 1991). A study by Idaho State University, conducted in 2009, characterized, modeled and mapped canal seepage (Holder, 2009) and provided various locations where seepage was thought to occur.

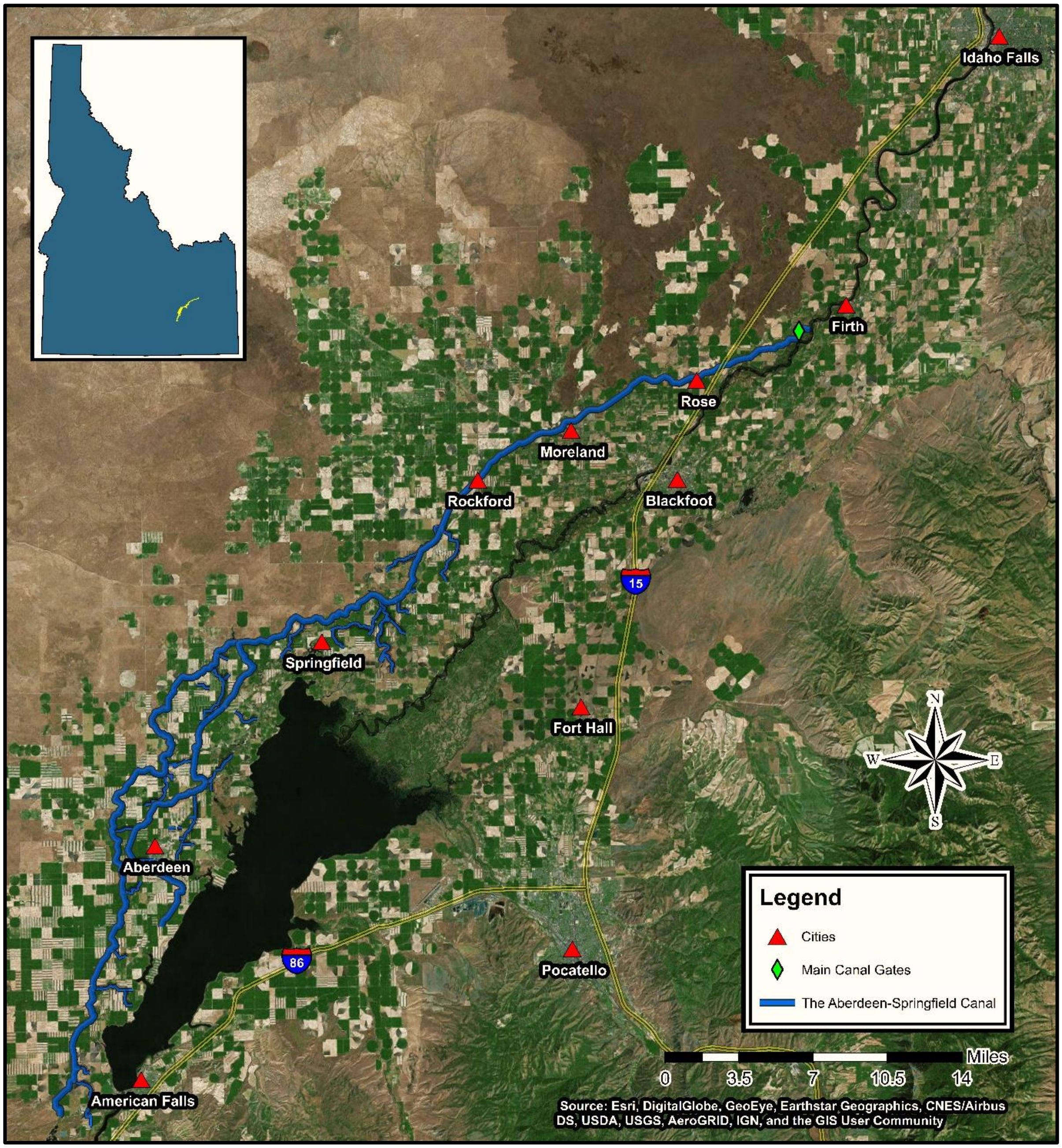


Figure 1.5: Location of the Aberdeen-Springfield Canal.

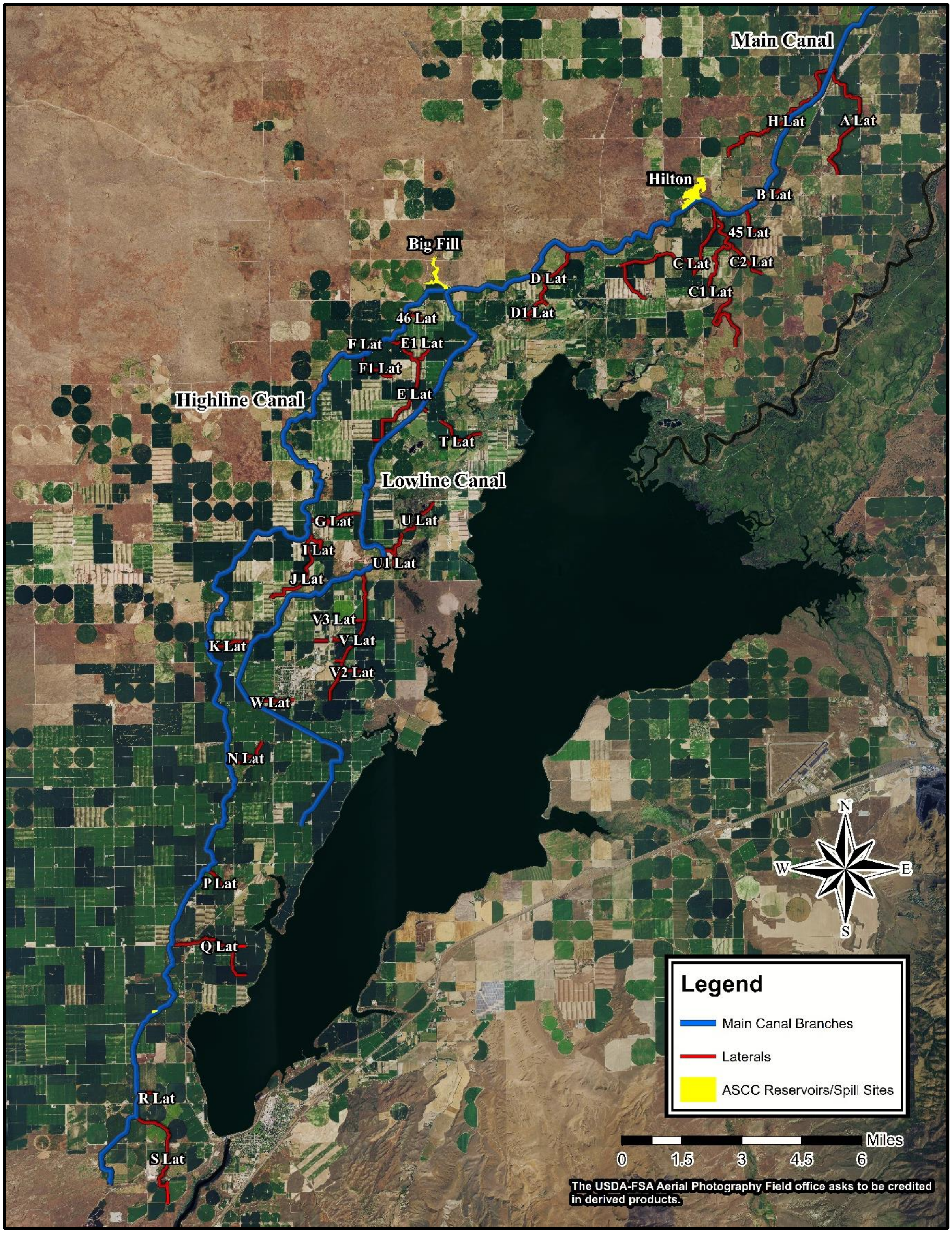


Figure 1.6: The Aberdeen-Springfield Canal system main branches and laterals.

Figure 1.7: Beginning construction of the Main Canal Gate.

Figure 1.8: Main Canal Gate construction.

Figure 1.9: Main Canal Gate completion.

Transmission Losses & Policy

Earthen irrigation canals experience transmission and seepage losses to varying degrees. In southern Idaho, low water conveyance efficiencies are not uncommon and the Aberdeen-Springfield Canal is no exception. A concern that has plagued ASCC for decades are large transmission losses that account for over half of annual diversions. Historically, this number has been estimated by subtracting ditch rider deliveries and measured spills from diversions contributing, on average 192,379 af per year to the subsurface (Company, Aberdeen-Springfield Canal, 1989-2017). As previously mentioned, the geology of the ESPA and the canal base include highly transmissive substrates. The result is a hydraulically interconnected system where interactions between surface and groundwater are continually transferring water between users (Figure 1.10). In this scenario, groundwater levels and base flows to streams and rivers near the canal are affected by canal seepage (Holder, 2009) and, local springs south of the canal feed Springfield Lake and many of the canal spills and drains pour into American Falls Reservoir (and the Snake River).

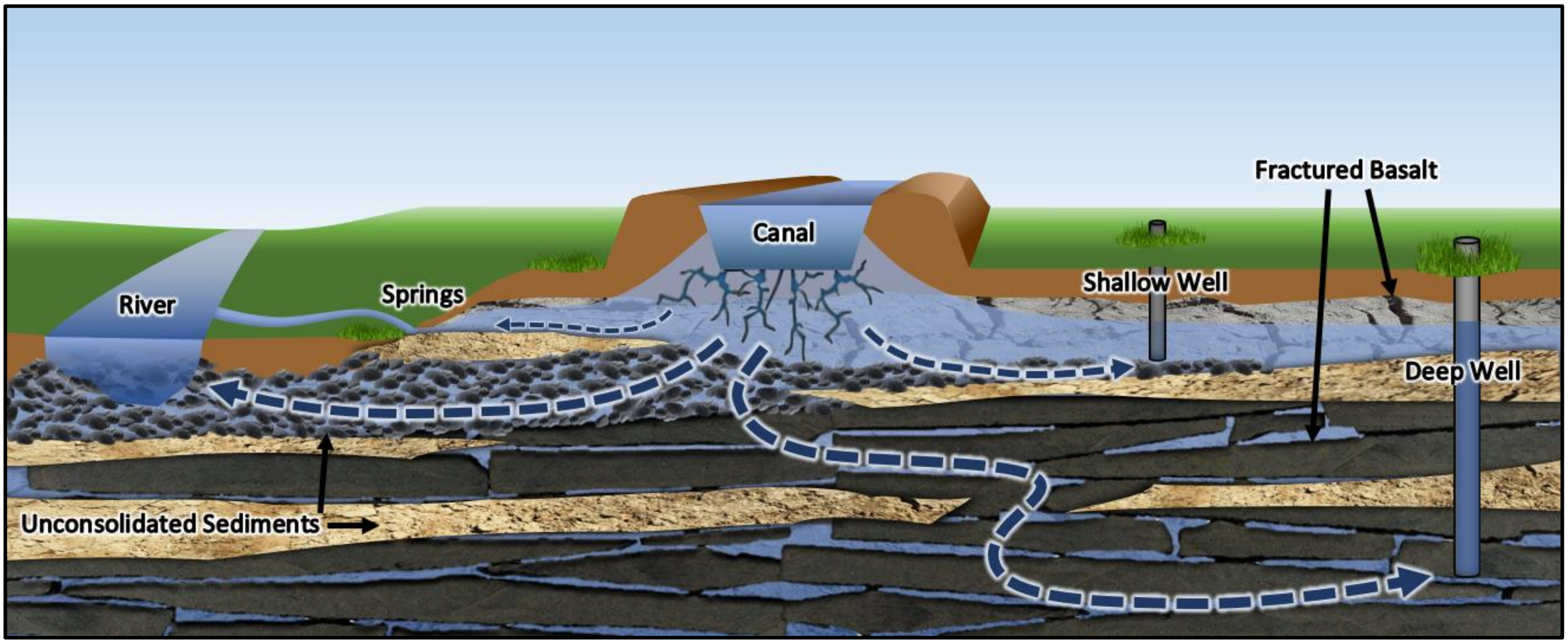


Figure 1.10: Graphic depicting canal seepage losses. A saturated water column beneath the canal creates a direct hydraulic connection to the adjacent semi-confined aquifer system. Arrows show potential outcomes of canal seepage in the springs, river reach gains and groundwater wells.

As ASCC seeks to reduce seepage losses, many ground water pumpers and downstream water users may be denied the benefits of the incidental aquifer recharge caused by the leaking canals. Seepage losses are not inconsequential to ASCC and the company has undertaken several legal challenges and management approaches to conjunctively manage the canal system together with the underlying aquifer. For example, during the Snake River Basin Adjudication, ASCC protested the source of 126 recommended groundwater claims by ASCC shareholders on the basis that the supply was, in reality, “recharge” from ASCC seepage. ASCC and IDWR reached an agreement resulting in IDWR recommending a portion of ASCC’s natural flow water right being designated as “recharge for irrigation”. Protests to the change in nature of use to the water right withstood a Special Master’s Recommendation but not a challenge to the SRBA court. The case was remanded back to the Special Master “for additional evidence and findings on basis of recharge” (Memorandum Decision and Order on Challenge, 2011) resulting in the nullification of the agreement and the official source of water right 1-23B was listed as surface water.

The use of “recovery wells” under I.C.§42-228 (a statute enacted for the drilling and use of wells for drainage or recovery of water) by ASCC has also been met with challenges. In 2013, recovery well permit 869326 was issued by IDWR for a recovery well with an estimated depth of 150 feet however during the drilling process, a confining layer was found at 62 feet and IDWR staff, on site, determined that recovery water must be limited to the shallow aquifer immediately below the canal. The well was not productive in terms of recovering seepage water and was instead used by ASCC as a monitoring well. It remained a point of contention between parties until May 2017 when it was filled in at the request of IDWR. Another recovery well was drilled in 2004 at the end of the canal system for the ability to quickly provide water to “end of the ditch” patrons in times of shortage at the lower end of the system. Once a permit was obtained, the well was drilled to a depth of 397 feet. IDWR staff expressed concerns that the water potentially being recovered did not belong to ASCC but, instead had potentially originated from American Falls Reservoir. This well currently remains unused as IDWR has issued a pending enforcement action.

During the summer of 2014, ASCC joined two shareholders in filing a *Complaint for Declaratory Relief* against IDWR after issues concerning an ASCC policy requiring shareholders to take delivery of their surface shares through existing groundwater wells. The policy was implemented by ASCC management to discourage shareholders from switching back to surface water irrigation due to increasing issues with capacity limitations of the canal system. *Motions for Summary Judgement* were filed from both parties and the District Court ultimately ruled that the use of the well did not fall within I.C. §42-228. The Court provided further analysis regarding the recovery of seepage:

> "Where the original appropriator relinquishes control of the seepage water and it returns to, and is commingled with, a natural stream or aquifer, the water loses its original characteristic and it is subject to appropriation by third parties."

The Court also disagreed with the argument that "differentiating between the specific ground water previously used to irrigate and the common ground water supply creates an unattainable condition [as in the case with a semi-confined or unconfined aquifer], which effectively eliminates the ability to develop a recovery well," and "that once water enters the ground it becomes difficult if not impossible to differentiate between the various sources of the ground water." In rebuttal to the arguments, the Court cited a remedy in the issuance of conditions on IDWR drilling permits, "such as well depth in relation to the static water level of the aquifer, to ensure that the water withdrawn from the well is indeed recovered water and not water from the common ground water supply" (Order on Motions for Summary Judgment, 2015).

The outcome that neither recovery well drilled by ASCC in 2004 or 2013 under recovery well permit conditions issued by IDWR were viable for seepage recovery is regrettable for ASCC. The current procedure of IDWR staff present during drilling to identify the first potential aquiclude a well driller hits and then suspending the drilling process provides no certainty to the permittee that they will be able to recover water from seepage and resources expended on the installment of the recovery well will not be wasted.

The above efforts by ASCC have not resulted in successful claims or recovery of transmission losses. Successful litigation would have allowed ASCC to retain ownership over portions of their water rights after it exits the bottom of the canal system. ASCC has had successes, however, in reducing seepage losses from the canal system through the implementation of several canal lining projects. Since water from seepage losses is lost to ASCC, installing canal liner along sections of the canal prone to high seepage has resulted in considerable water savings. The saved water has not only been made available in years of scarce water supply but can provide monetarily benefits in years of plenty. When surface water supply is sufficient to meet the demands of ASCC shareholders, excess water may be sold or "recharged" into the aquifer for other water users. The price per acre-foot of water fluctuates annually depending on supply but can range from $7.00-$25.00/af (Water District 1, 2018), additional fees and surcharges may apply. The value of water in desert landscapes cannot be overstated and continues to increase. It is realistic to view water as a commodity that holds monetary value since it drives many economic processes, especially in agriculture. Considering ASCC average losses of 192,379 af per year, one observer correctly noted, "If viewed as a bank account, these losses would not be tolerated." An even more pressing issue than the potential maximum amount of $4.5 million dollars in water draining from the canal base per year is the burden to deliver enough water to satisfy ASCC shareholders.

Immediate Need for Quantification of Losses

The 2015 Settlement Agreement has adversely impacted ASCC and created an immediate need for precise loss estimates to understand the canal system at large. Many ASCC shareholders currently use groundwater to irrigate lands where canal shares are also appurtenant. When approached with the option to be subject to a delivery call or reduce groundwater usage through participation in the Settlement Agreement, the latter is the obvious choice. A simple way to participate in the agreement and accomplish their groundwater reduction requirement is to turn off their groundwater well and call for delivery of their canal shares. In many cases these shares had not been used in years, however shareholders have still paid associated annual dues and have legal right to the water they represent; the canal company must deliver the shares. The result has been lands long ago serviced by the canal but irrigated with groundwater only or a combination of groundwater and surface water are being converted solely to surface water irrigation. This water management approach has not been applied since before the 1950's when wells began entering the area. Unfortunately, the canal was not designed to deliver water to all shareholders at the quantities and rates required to operate modern irrigation pumps and equipment. Prior to the 2015 Settlement Agreement, the canal system was already operating at maximum capacity during times of high-water demand during hot and dry summer months. The need for increased surface water diversion to meet delivery demand has exposed limitations throughout the canal system where the capacity to transport water is breached during high flows. Management of the system for many decades has been largely based on the professional judgement and experience of ditch riders, canal managers and sometimes water users. With an ample supply of water this approach works but, during periods of peak demand it becomes increasingly important to quantify water flow and water delivery across the system. The new changes in demands cause additional stresses on the canal system and have created a need for even greater accuracy in measurement and understanding of capacity limitations.

ASCC's response to issues associated with the increased water demand has been the creation of a canal capacity model to identify flow restrictions and available canal "freeboard". Targeted maintenance decisions can then be made to ensure that space is available in the canal for additional water deliveries and prevent lapses in capacity. To accurately predict how the canal system will respond to increased stresses at various locations, a quantitative understanding of transmission losses and locations is necessary. This detailed accounting will also support analyses of surface and groundwater interactions occurring in the region and the resolution of disputes involving policy and management decisions involving canal seepage.

1.5. An Interdisciplinary Approach to Investigating Transmission Losses

The term interdisciplinary studies can be defined as, "a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline, and draws on the disciplines with the goal of integrating their insights to construct a more comprehensive understanding" (Repko, A.F., 2012). It can be said that water resources as a subject of study is interdisciplinary in nature. This statement is evidenced by solutions to questions involving water resources often requiring knowledge from multiple disciples. Global Information Systems, Geology, Political Science, Hydrology and Hydrogeology disciplines are often combined to help resolve water resource issues. In this study, which is a detailed investigation of seepage losses and water management in a canal, a robust analysis requires an advanced knowledge of surface water hydrology, ground water hydraulics, atmospherics, aquatic biomass, mathematics, electronics, mechanical engineering, fluid dynamics, sociology, physics, interpersonal dynamics, GIS, evapotranspiration, soil mechanics, multi-phase fluid flow and geology.

Merriam-Webster defines hydrology as "a science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere" (Hydrology) and hydrogeology as "a branch of geology concerned with the occurrence, use, and functions of surface water and groundwater" (Hydrogeology). While the term hydrology encompasses the study of all earthen and atmospheric water, when used to describe a scientific discipline, it is often used only in reference to the study of surface water. Likewise, by definition, hydrogeology concerns surface and ground water but is most broadly accepted, in discipline, as describing groundwater movement ("Hydrology and Hydrogeology"). As disciplines, both Hydrology and Hydrogeology require distinctive technical expertise. This expertise includes but is not limited to measurement methods and equations applied to surface and ground water study which differ considerably. Due to their complex nature, separating the studies into the disciplines of Hydrology and Hydrogeology has allowed for a more complete knowledge of either surface or groundwater movement to be achieved.

In this instance, the necessity of disciplinary adequacy in the disciplines of Hydrology and Hydrogeology to quantify transmission losses cannot be understated. Without a comprehensive combination of both disciplines, a complete and quantitative account of water movement throughout the system at large could not be constructed. Commonality between equations used in Hydrology and Hydrogeology exists and often variables used in mathematical equations to describe groundwater movement equations are dependent upon variables found in surface water equations. For example, storage in shallow aquifers (a Hydrogeologic variable) affects the rate of seepage infiltrating the vadose zone, thus affecting losses and the flow of surface water in the canal system (a Hydrologic variable).

In our investigation, an interdisciplinary approach using a simple input-output method was employed. Through surface water measurement and study of the canal, total surface area, flow velocities, and seepage losses were characterized. Saturation of the underlying aquifer affects the rate of loss seen in the canal as does pumping for irrigation in localized regions surrounding the canal. Once basic water movement is quantified, a picture of existing water relationships and balance throughout the system begins to form. Once this picture is complete, the ability to best manage water resources in the canal system and aquifer can be achieved.

CHAPTER II. STUDY AREA

2.1. Location Defined

The main subject of this study was canal discharge measurements and seepage rates. As mentioned previously, the hydraulic connections between the Aberdeen-Springfield Canal and adjacent hydrologic features are likely to influence flow in the canal system that cannot be directly measured. These hydrologic features included the Snake River, American Falls Reservoir and portions of the aquifer underlying the canal. Hydrologic activities such as groundwater pumping, managed groundwater recharge and seepage from neighboring canals all have the potential to influence canal flows, seepage rates and groundwater levels (Figure 2.1). For this reason, it is necessary to take a rough inventory of all such activities when available. This inventory of hydrologic features, coupled with an understanding of the physical geology present, was helpful in determining the reasonableness of measured seepage rates and added to our general understanding of the hydrologic balances existing in the region.

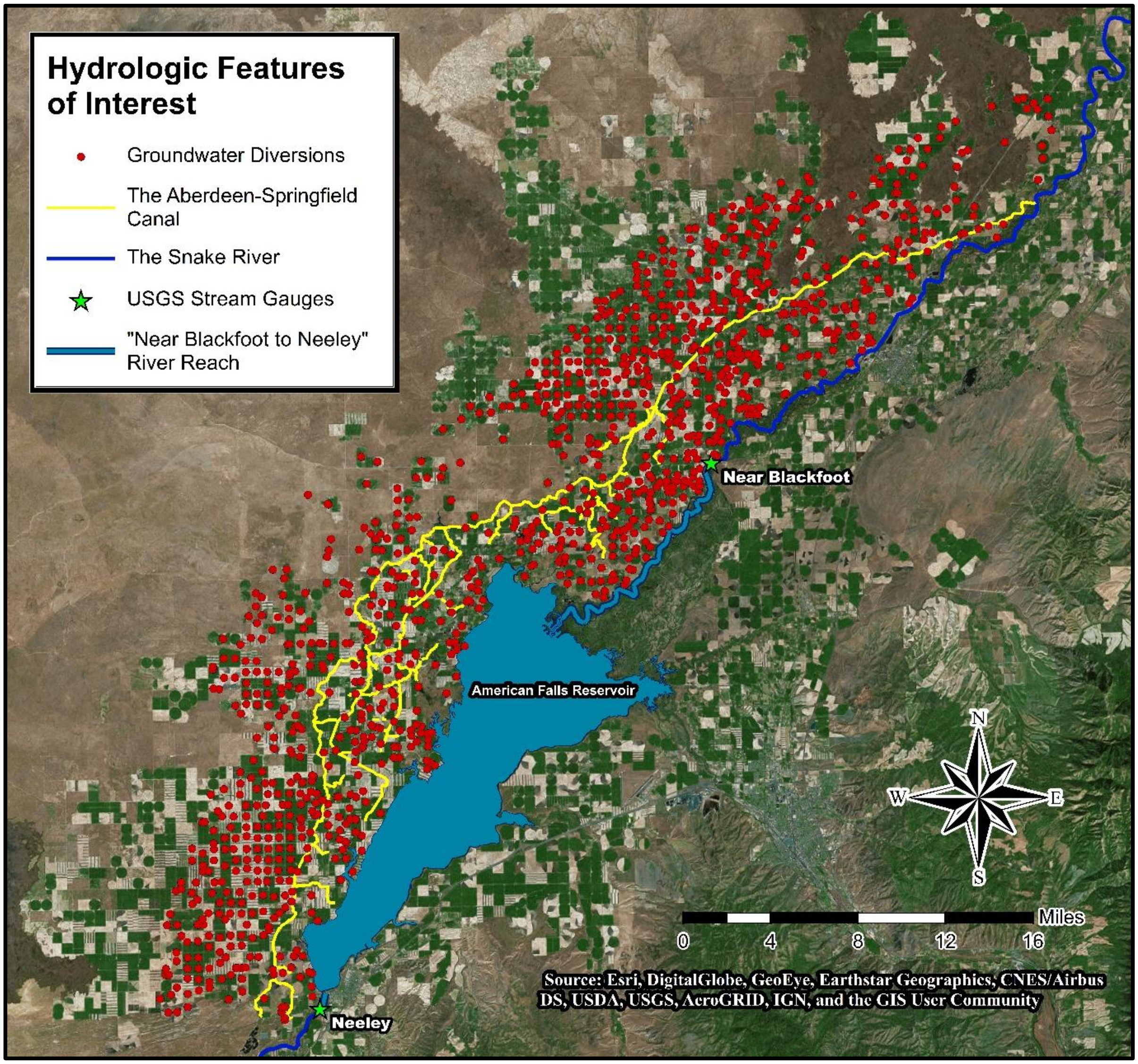


Figure 2.1: Study area & hydrologic features of interest.

Geology

A detailed map of the geological features composing the study area shows a variety of basalt flows and alluvium (Figure 2.2). Many processes contributed to the creation of this landscape. One involved eruptions of lava from vents that dammed the Snake River.

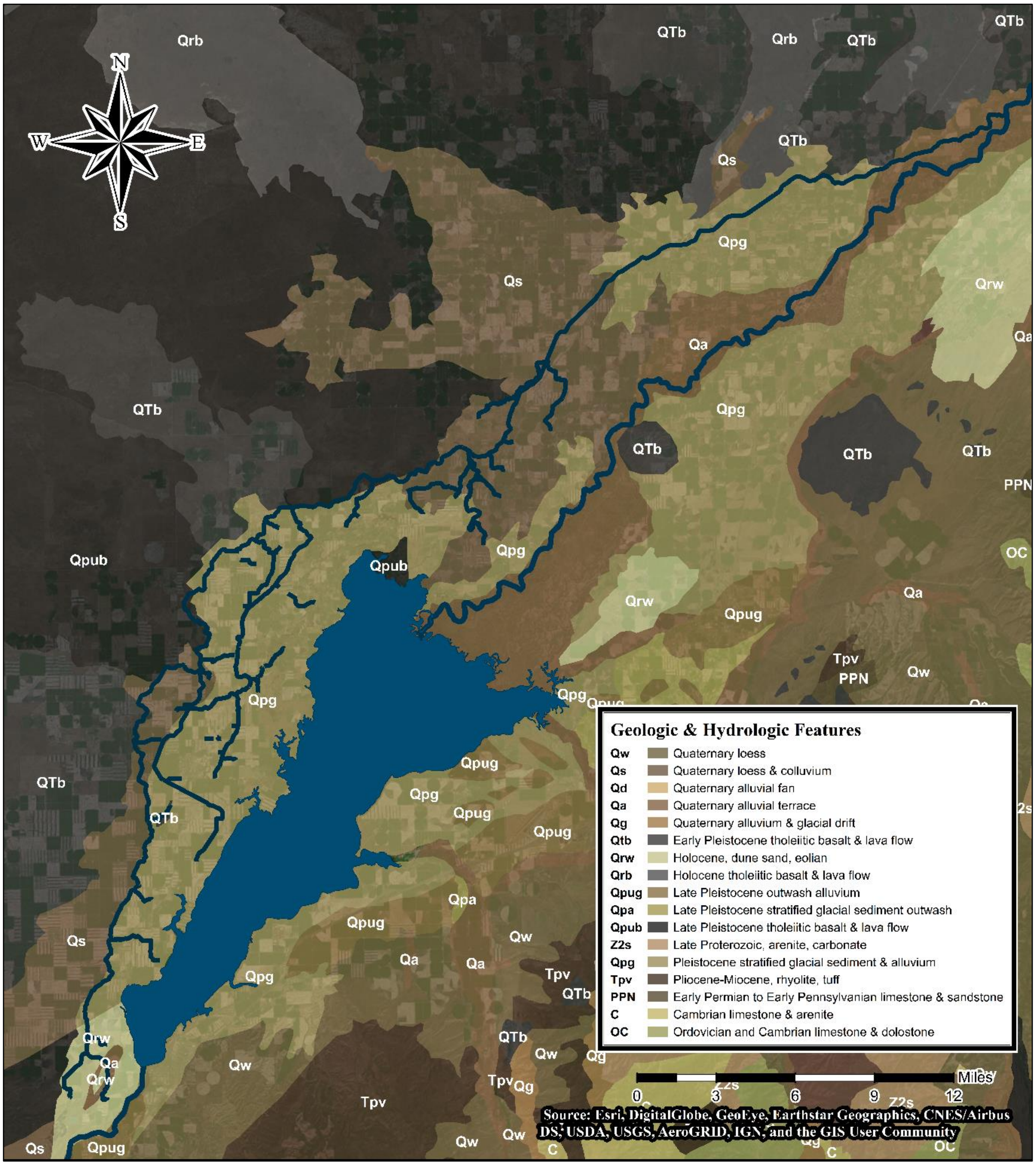


Figure 2.2: Geologic features of the study area. GIS data layer from USGS, 2005.

Deposits of silt and sand now known as the American Falls Lake Beds built up over time behind the basalt dams. The Lake Bonneville Flood breached and burst the basalt dam and the flood also deposited gravels and other sediment. Other, more recent volcanic eruptions and the deposition of Aeolian sediments also contributed to the geologic landscape. A specific account of the geologic history contributing to the geomorphology can be found in Carr & Trimble, 1963. As one can expect, the interplay between volcanic eruptions, sedimentary deposition, erosion and so forth created a heterogeneous geologic framework for the aquifer and forming the bottom of canals in the ASC system as it traverses the landscape. The heterogeneity also complicates the hydraulic response of the system to seepage losses. Two areas of interest are the upper northwest of American Falls Reservoir and the regions south and southwest of the reservoir. In 1992, Houser completed an analysis of 240 wells in the Springfield region, north of the reservoir, to create a modified geologic map (Figures 2.3 & 2.4) and several cross sections (Figures 2.5 & 2.6). She describes alluvium composed of 10-20% sandy gravel and 90% clay and sand as well as several types of Quaternary basalts. Aquifer transmissivity and storativity influencing the Springfield region obtained through a series of pumping tests conducted in 2008 were determined to be 3.2 x 10^{6} ft^2/day and 1.6 x 10^{-2} ft^2/day, respectively (Clearwater Geosciences, LLP, 2008).

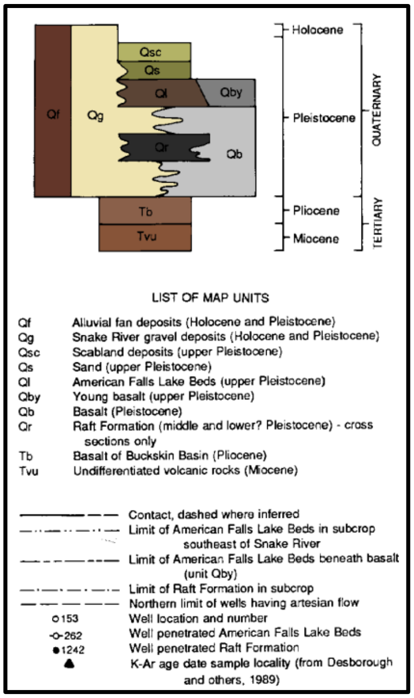


Figure 2.3: Explanation of maps from Houser, 1992, color added.

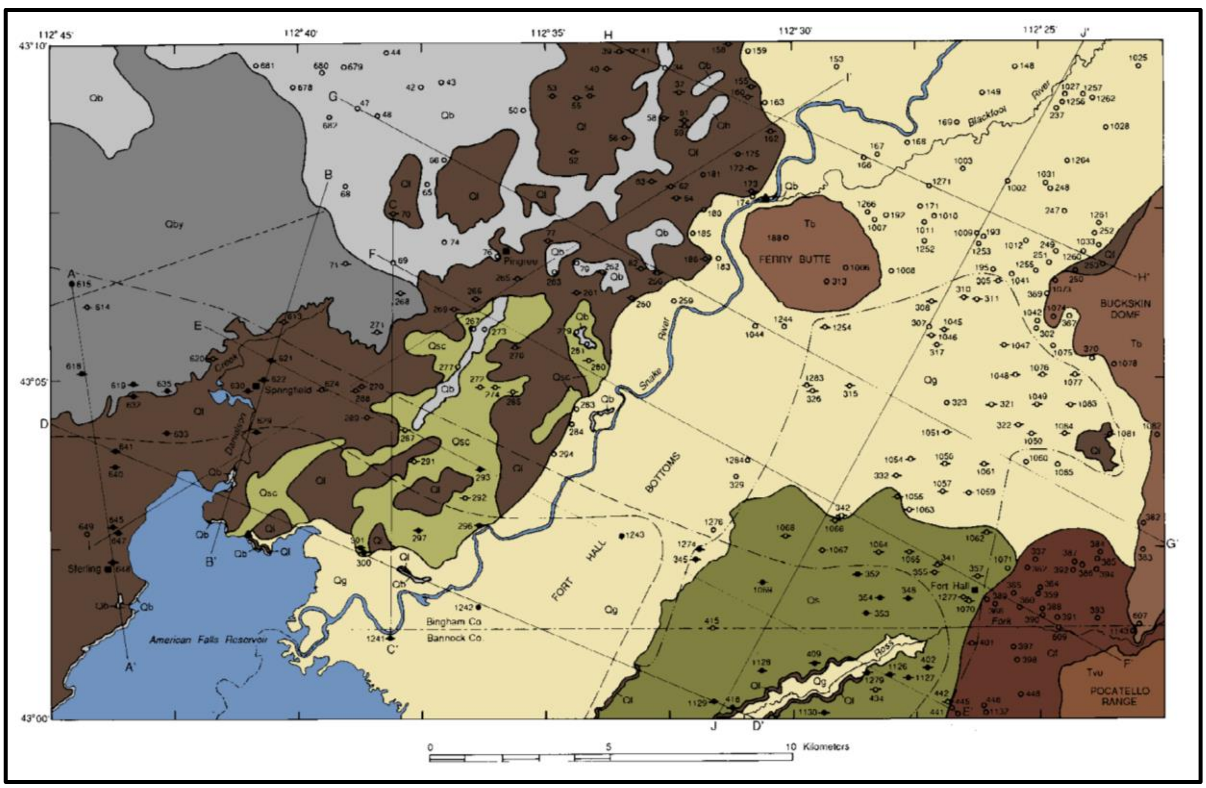


Figure 2.4: Geology of the study area from Houser, 1992, color added.

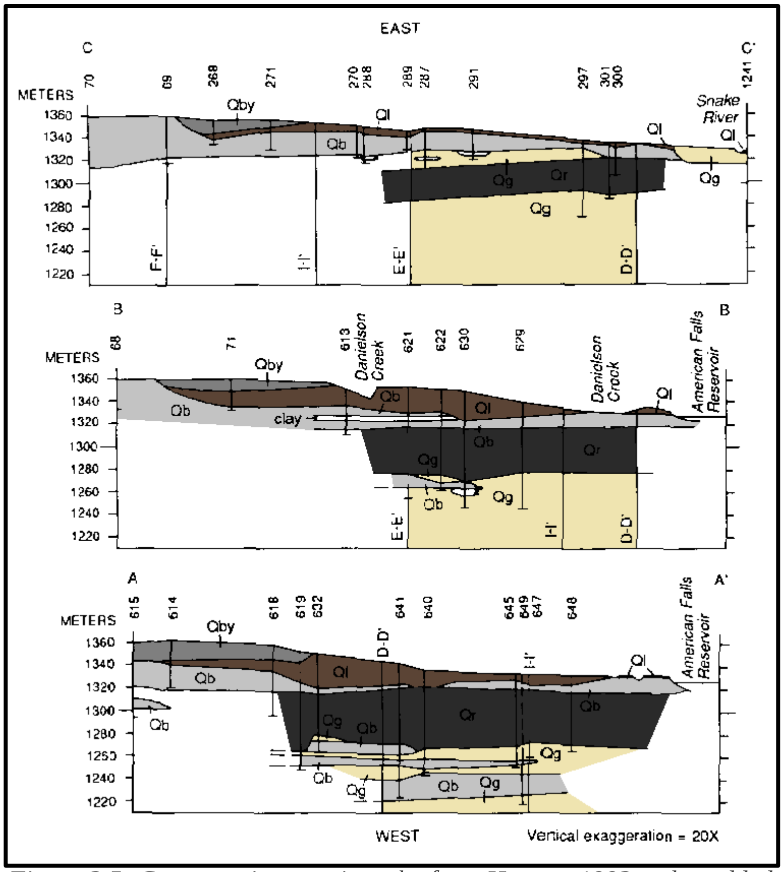


Figure 2.5: Cross-section stratigraphy from Houser, 1992, color added.

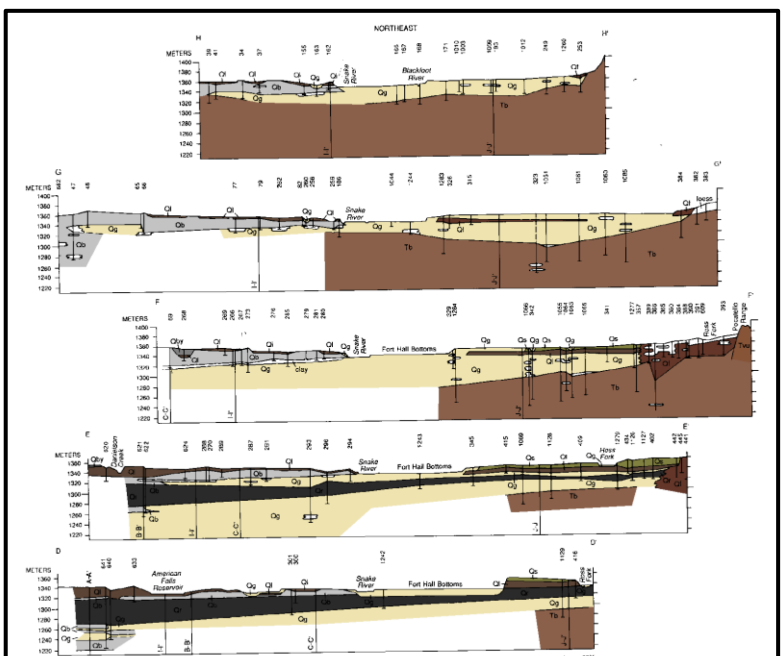


Figure 4. Geologic cross sections D-D', E-E', F-F', G-G', and H-H'. Locations of lines of section and explanation of unit symbols shown on Figure 2. Unlabeled lenticular bodies represent clay or sand lenses within gravel or basalt.

Figure 2.6: Cross-section stratigraphy from Houser, 1992, color added.

In 2009, Poulson and Welhan produced cross section stratigraphy illustrations of lands located in the Pleasant Valley region west of American Falls and that provide excellent visualization of basalt aquifers with intermittent consolidated formations (Figures 2.8-2.9). They noted, as previous researchers had, that observed groundwater levels tracked with reservoir stage and the presence of a clay layer separating an upper and lower aquifer is possible (Welhan & Poulson, 2009)

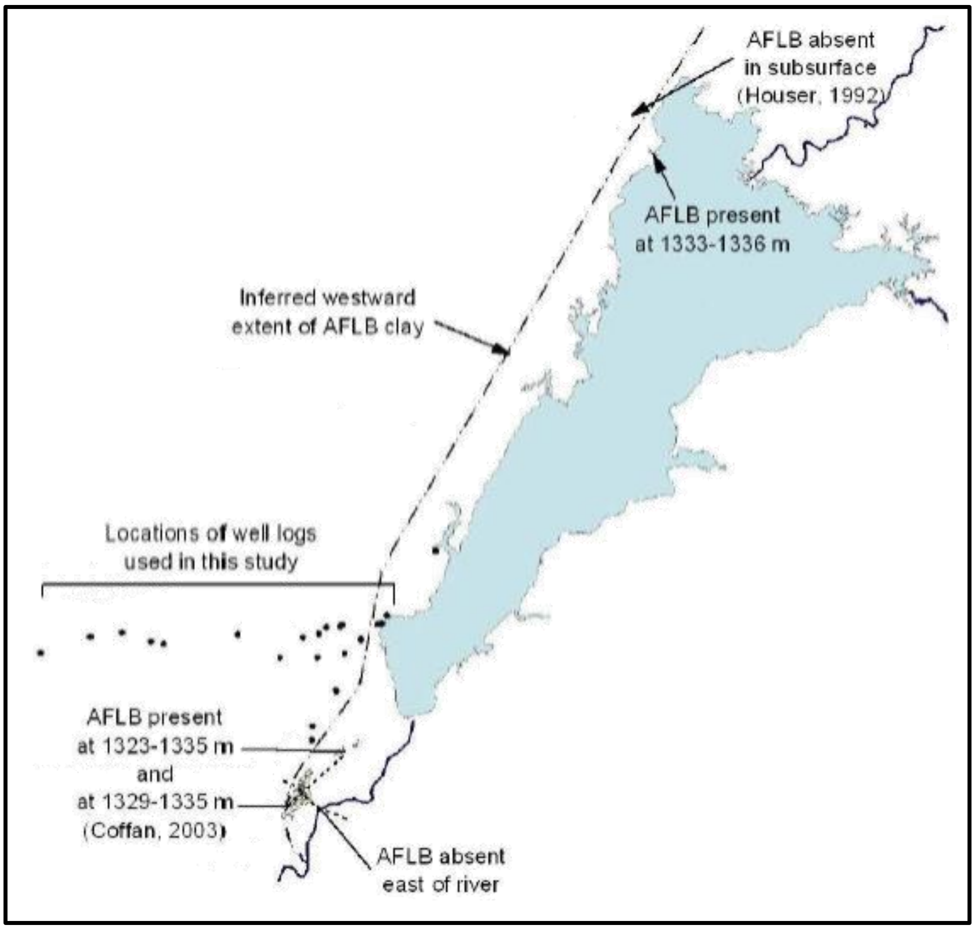


Figure 2.7: Figure 6. from Welhan & Poulson, 2009 showing the Pleasant Valley Nitrate study area and the inferred extent of the American Falls Lake Beds.

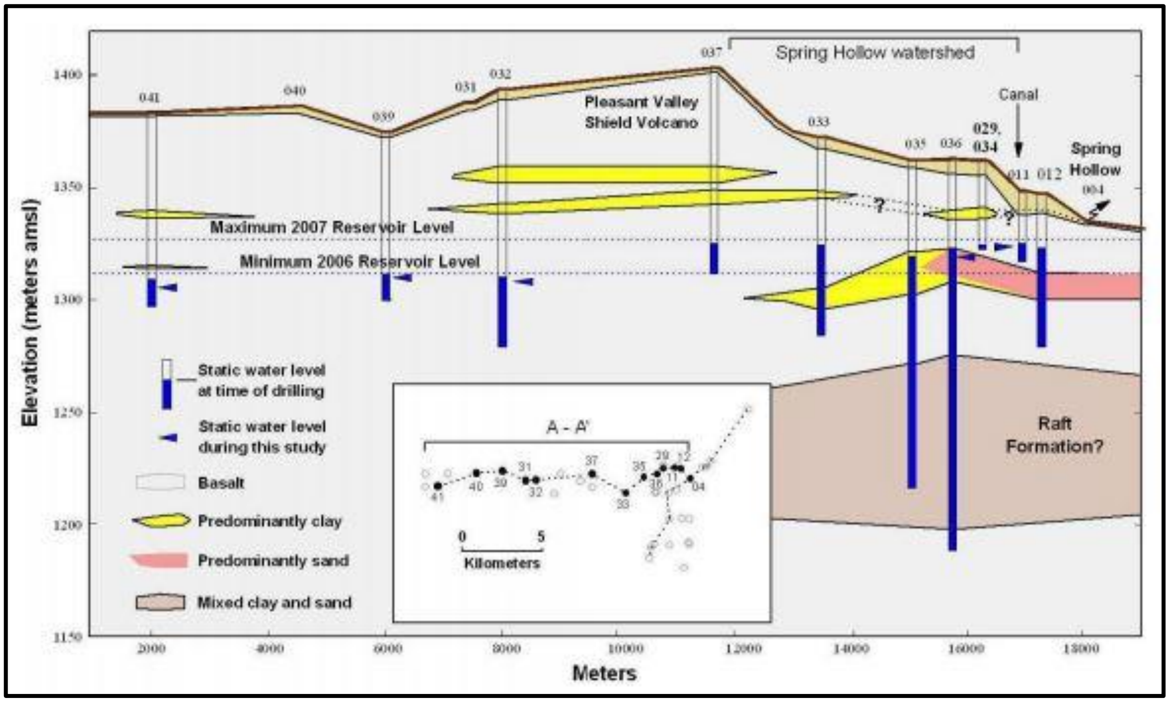


Figure 2.8: Cross-section stratigraphy of A-A' taken from Welhan & Poulson, 2009.

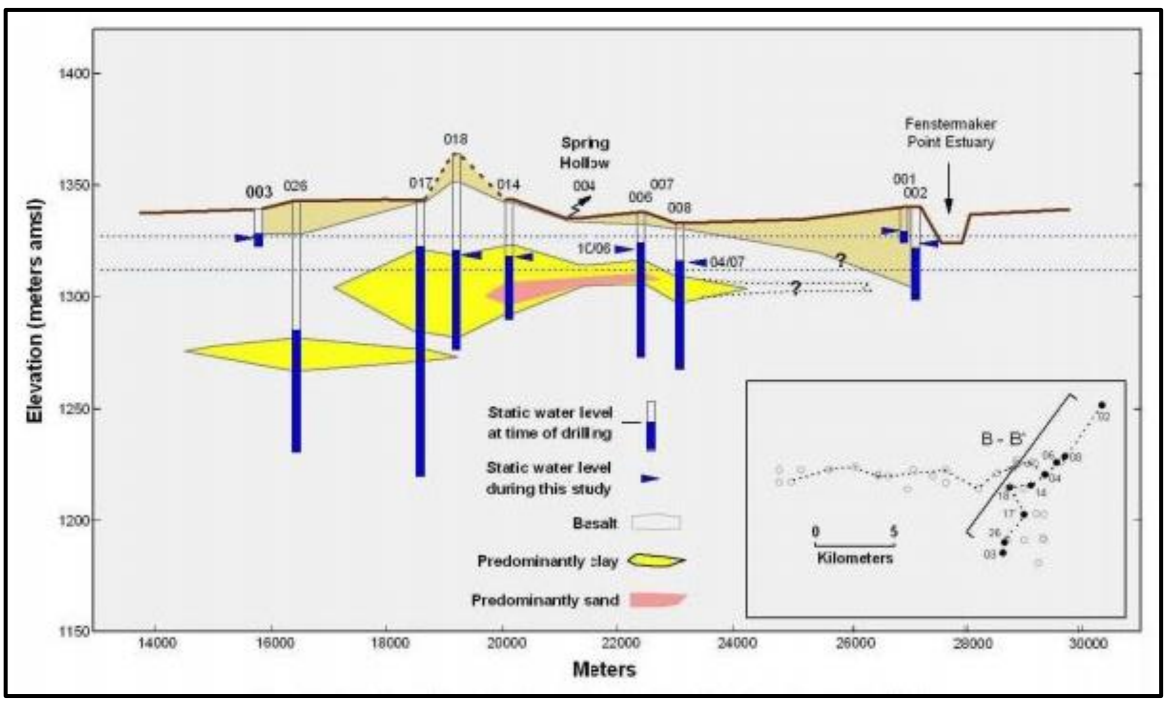


Figure 2.9: Cross-section stratigraphy of B-B' taken from Welhan & Poulson, 2009.

Whitehead estimated transmissivities based on digital modeling for the ESPA and found the majority of the study area to be 3.8 x 10^6ft²/day with lands south of the Pleasant Valley area around 1.1 x 10^6ft²/day. Because modeled transmissivity values apply to the entire saturated thickness of an aquifer, it is generally found that values obtained through aquifer testing are lower since they may only penetrate a portion of the aquifer (Whitehead, 1992).

Hydrogeology

Ground water irrigation is also prevalent in the area surrounding the canal, affecting groundwater levels and heavily taxing the ESPA aquifer. Comprehensive efforts to monitor changes in groundwater elevations along the ESPA by IDWR, USGS and other entities have cataloged regional responses over time (Figure 2.10). Some localities appear to be consistently more susceptible to groundwater elevation change over time than others. Groundwater withdrawals within the study area were 270,548 af in 2017 with the 5-year average being 306,806 af. Even with large yearly withdrawals, locations in and around the

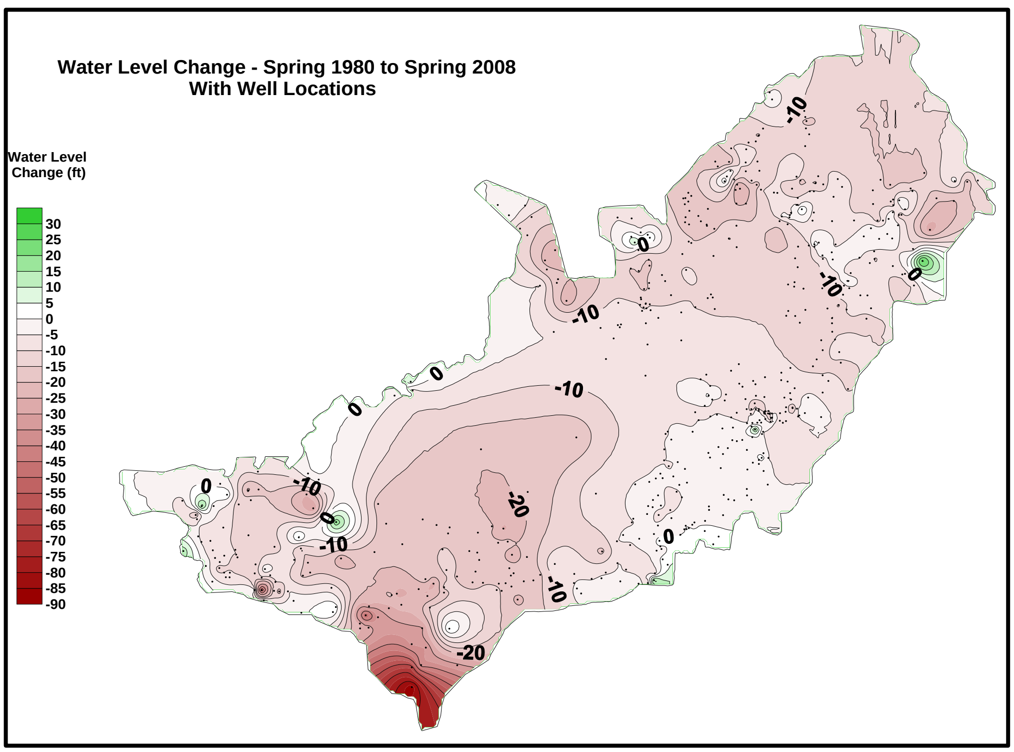


Figure 2.10: Groundwater level changes in the ESPA from Weaver, 2016.

ASC and extending northeast do not experience the extreme fluctuations in groundwater levels that those to the west and southwest of the ESPA do.

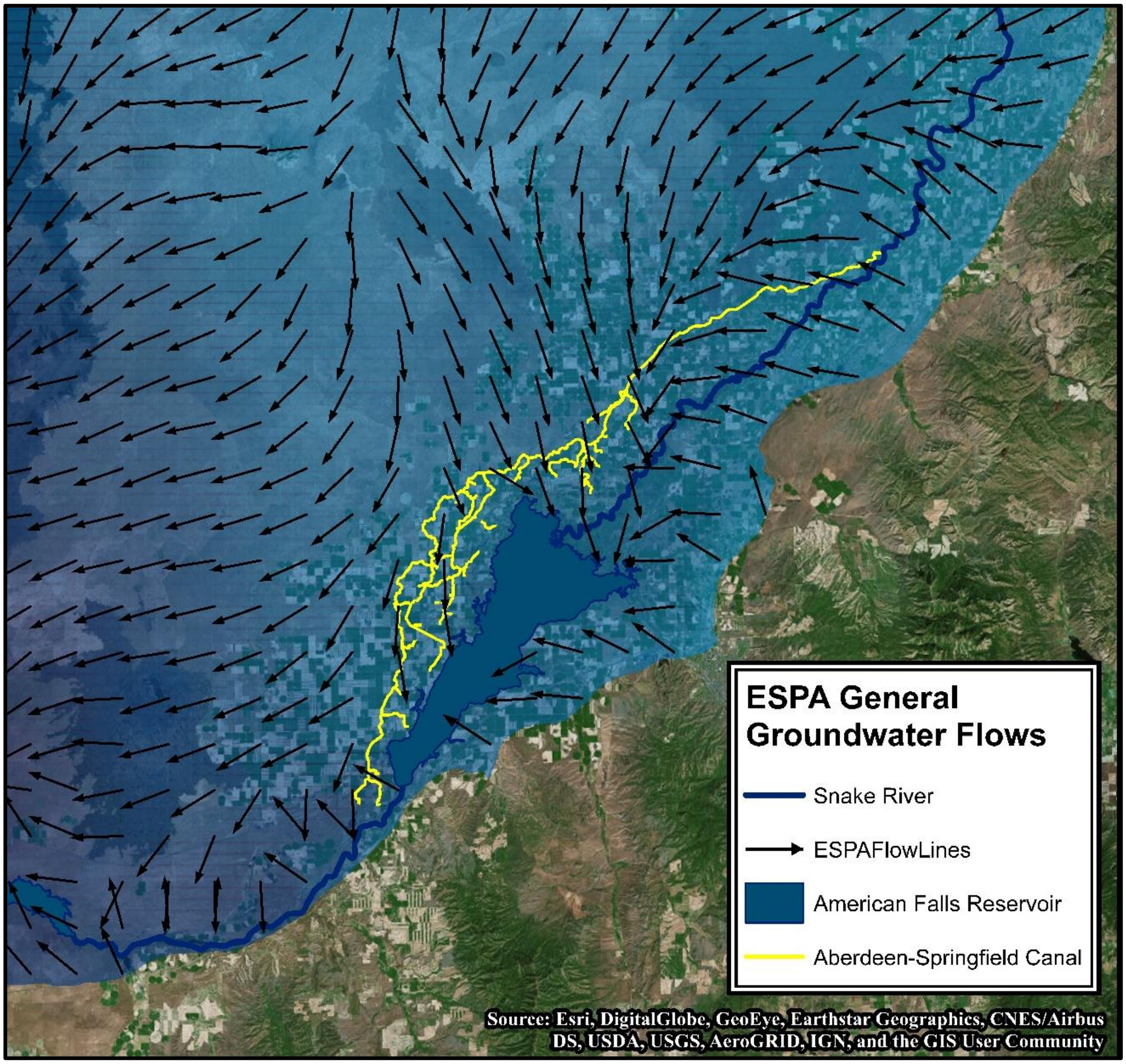


Figure 2.11: Generalized flow direction from groundwater levels. GIS data layer from IDWR, 2018.

General groundwater flows in the study area vary by location with the majority of flows lines near the upper end of American Falls Reservoir tending in the south and southeast directions (Figure 2.11).

It is thought that the lower end of the American Falls Reservoir plays a role in replenishment of groundwater through horizontal hydraulic movement near the southwest end of the reservoir (Mundorff, 1967). In Mundorff's 1967 examination of the hydrologic effects of an increase in dam storage, water levels of nearby wells seemed to track with increases and decrease in reservoir elevation (Mundorff, 1967). This was supported in 2006 and 2007 comparisons (Welhan & Poulson, 2009). Present day surface water elevation in the reservoir when "full" is 4354.5 and maximum is 4356.2.

Hydrology

The average precipitation of Blackfoot, Aberdeen and American Falls during 2017 was 14.17 inches; notably higher than the most recent 5-year average of 12.01 inches (USDA National Resource Conservation Service, 2018). In this dry environment, most water storage in the upper snake river basin is found in the form of snowpack or reservoir storage and the Snake River is the transportation system used for delivery. The river is measured at various USGS gauge locations and classified by reaches which are gaining or losing in nature. Of great importance to water users is the "Near Blackfoot to Neeley" reach. Gains from the reach are watched by downstream water users closely due to their large contributions to the overall flow in the Snake River.

A water budget analysis of groundwater inflows to the reach estimated pre-irrigation inflows in the reach to be 1,700-1,900 cfs and increasing to 2,600 cfs with the increase of surface water diversion until around 1952 when groundwater withdrawals increased (Mundorff, 1967). At present, it remains unclear what quantity of loss from ASCC is represented in the overall reach gains but sizeable contributions from the canal are suspected.

Average Near Blackfoot to Neeley reach gains derived from USGS gauge data 2013-2017 were 1,013,321 af and 1,044,267 during 2017 including 29,525 af from the ASC system which find their way into the reservoir or Snake River. Inputs from Sheep Creek and the Portneuf River were excluded in this total since they occur on the east side of the system.

CHAPTER III. DATA COLLECTION & ANALYSIS

This chapter describes the specific methods used to investigate canal flow, loss rates, evaporation and bank vegetation evapotranspiration. Open channel flow measurements were conducted during peak operating conditions in the 2017 irrigation season including May, June, July and August.

3.1. Open Channel Flow Measurements

In channels, a refined "inflow-outflow" method where measurements are made over 1 to 2 hours has merit on canals with high losses where seepage is a major percentage of total flow (Worstell, 1976). This approach is ideal for this study since large losses are known to exist in the Aberdeen-Springfield Canal and measurements can be obtained quickly over relatively short distances. This study adopts a simple "inflow-outflow" approach using a floating Acoustic Doppler Current Profiler (ADCP) and a hand-held propeller flowmeter.

Many factors affect flow and flow measurements in open channel flow. Variables influencing flow in the Aberdeen-Springfield Canal system include but are not limited to: aquatic vegetation, temperature, sedimentation, water quality (especially turbidity), evapotranspiration rates of bank vegetation, upstream delivery adjustments, canal substrate, bank vegetation, leaks, high winds, turbulence caused by canal geometry or structures, and groundwater levels. Some of the variables may even exhibit diurnal fluctuations. For instance, when discharge is low, the hydraulic radius is small, and large temperature fluctuations exist in the streambed [or canal base] and the water column, causing the greatest amplitude of the diurnal changes to exist (Gribovszki, Szilagyi, & Kalicz, 2010). The Aberdeen-Springfield Canal is prone to large temperature fluctuations, low discharge and a small hydraulic radius, especially along laterals containing high bank vegetation. Further study is required to determine the magnitude of any such diurnal fluctuations but they are believed to occur to some degree. Since the goal of this study is to quantify transmission losses under maximum flow conditions, variation in some contributing variables can be simplified. Temperature and sunlight are, correspondingly, related to the ET of bank vegetation, evaporation and aquatic vegetation growth. When a high demand for water delivery occurs, ET of bank vegetation, evaporation of the water surface and aquatic vegetation growth are expressed at near maximum values.

Early “wetting” of the canal banks and base, saturation of the underlying water column, and groundwater levels are also known to affect losses. Variance of these factors is suspected to be greatest at the beginning and ending of the irrigation season, therefore ample time following the introduction of water into the canal system was given.

In preparation for the study, preliminary flow data was collected during late summer and fall of 2016 to develop a sufficient spatial resolution and refine the ADCP settings best suited for the canal. A one-mile spatial resolution was chosen with future modeling in mind and ArcMap was used to equitably divide the canal reaches and identify measurement locations. For our purposes, a “turnout” or “delivery gate” is defined as “the point at which the control of water changes from the irrigation district [or canal company] to the customer(s)” (Burt, 2010) and a “reach” is defined as the length of canal between two measuring points. A naming convention denoting the name of the canal reach and mile from the beginning of the reach was developed (i.e. a site located 5 miles from the inception of the main canal would be listed as MC05). During the summer of 2017, flow velocities were measured across selected profiles of the main canal and large laterals using an ADCP mounted to a boat hull created for the unit. A hand-held flow probe was used in low flow channels where the ADCP is ineffective. The ADCP calculated total flow and provided a canal cross-sectional velocity, or flux, at each flow measured location. An existing supervisory control and data acquisition (SCADA) system providing real time diversion data was used as a quality control check for measured flows. The SCADA system was not used to measure flows with the exception of spills at the ends of some laterals where flow was too small to measure with either the ADCP or the flow meter. At the end of a lateral where SCADA was not available and no other means of measuring were possible, headgate measurements were applied as flow measurements. This is not ideal as the intake is submerged and the possibility of not only measuring flow through the lateral (horizontally) but an unknown amount of "storage" water in the lateral (vertically) was possible. The measurements were used only because they were the only possible method available.

The following is a detailed outline of methods and instrument settings used.

Main Canal, Highline, Lowline & Large Lateral Measurement Methods

The ADCP employs Doppler technology to measure stream flow. This is accomplished by measuring the change in wave frequency between sound waves emitted by ADCP pulses as the unit traverses the channel.

The ADCP (Teledyne Instrument StreamPro) with Extended Range Mode SPSxSEXTRG was mounted onto the Riverboat SP hull (which provides ±1% of water velocity relative to ADCP, ±2mm/s accuracy in a flow range of ±5m/s) for measurements with relatively high flow. Operation of the ADCP was in accordance with the manufacturer's operation manual (Teledyne RD Instruments, 2015) and USGS Techniques and Methods manual 3-A22 (Mueller, Wagner, Rehmel, Oberg, & Rainville, 2013).

The general procedure was to drive steel posts into the ground as anchors at each end of the profile to be measured (i.e. on each side of the canal perpendicular to the center flow) in turbulent flow (Figure 3.1). A pulley system similar to one used by investigators in a comparable canal seepage study (Kinzli, Martinez, Oad, Prior, & Gensler, 2010) was employed to stabilize the ADCP unit and normalize travel speed as it traversed the canal. During laminar flow conditions, guide ropes were affixed to each side of the unit and the other end of the ropes were held by an operator on each side of the bank. The ropes were used to move the boat across the canal to complete passes. As recommended by manufacturer, an "ADCP Test" and "Moving Bed Test" were executed at each site prior to measurement to ensure the proper functionality of software and the conditions at the canal base were interrogated. To avoid outliers, measurements were performed until four complete passes were made that reported total flows within 5% of the sample mean and these were used to determine an average velocity profile for each transect. Two of these passes began from the left wetted edge of the canal and two of the passes began at the right wetted edge of the canal. The ADCP also provides bearing data, total flow, time and temperatures that may be utilized for future calculations. It is noted that the ADCP used did not have GPS capabilities or a compass.

Figure 3.1: Pulley system employed over the Main Canal.

Small Lateral & Headgate Methods

Velocity profiles were collected in small laterals using a hand-held Global Water Flow Probe (FP111) with range of 0.3-19.9 ft/s and accuracy of ±0.1 ft/s. This flow meter was securely mounted in the vertical direction to a top-setting wading rod used to set probe depth for measurements. Depths greater than 2.5 feet were not measured using the flow probe and wading rod combination. A measuring tape was stretched across water surface perpendicular to the flow and surface water width was divided equally into equal subsections and recorded. The six-tenths method (USGS, 1982) was used to determine the water column height at which measurements were averaged for 30 seconds. Discharges in subsections were summed to provide total flow. The recorded velocities in each subsection were averaged to calculate an average velocity for each measurement site.

Within the Aberdeen-Springfield Canal water delivery system, there are 737 recorded turnouts, of which approximately one-third to one-half are thought to be operable. All turnouts positioned along the canal banks consist of a rectangular submerged orifice and headgate (Figure 3.3). To ensure proper identification of head gates in heavy vegetation or where tags may be unreadable, an existing ArcMap shapefile containing the positions and names of each turnout was loaded onto a Garmin handheld GPS. The GPS was used to identify and account for every turnout along both sides of the canal and active water deliveries were measured using the submerged orifice gates. Upon arrival at a turnout, submerged orifices were cleared of any present debris using a weed rake and inspected prior to measurement. Where debris was cleared away, ample time was given for water levels to adjust before measurement was taken. Measurement times and variables were also noted and total flows were reviewed to reduce possible calculation errors that may have occurred in the field. The area of the rectangle and the change in head from both sides of the orifice were measured. Flow was then calculated using the following equation (U.S. Bureau of Reclamation, 2001):

$$Q = 0.61A\sqrt{64.4h}$$

Where:

Q is flow (cfs)

A is area (sq. ft)

h is head (ft)

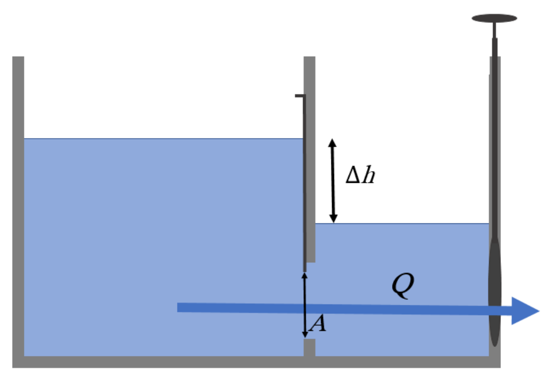


Figure 3.2: Submerged orifice flow diagram.

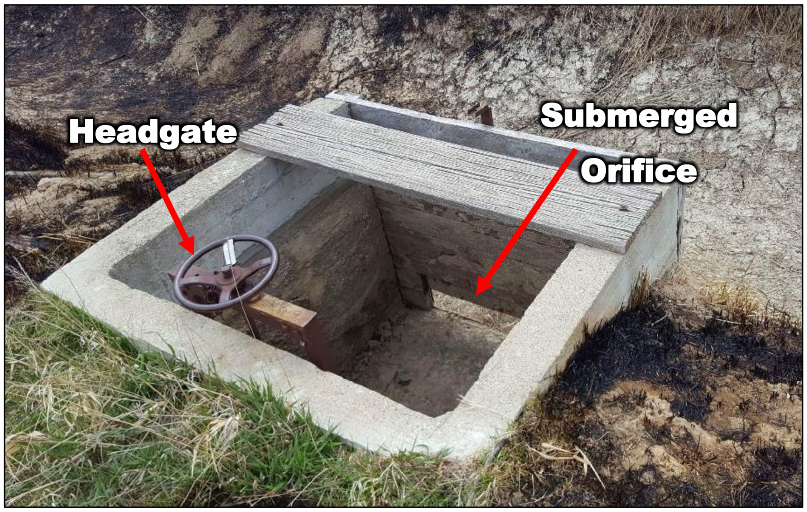


Figure 3.3: Example of a delivery gate (turnout) in an empty lateral.

3.2. Calculations

WinRiverII software was used to post-process the ADCP measurements and perform any necessary corrections. Moving bed test, bottom screening and cross -sectional area options were applied, when needed. Measurements by reach were input into an Excel spreadsheet for calculation of reach loss using the basic equation:

Water In – Deliveries + Gains – Water Out = Losses

Where:
Water In- Measurement at beginning of reach
Deliveries- Water deliveries to customers (delivery gates)
Gains- Any water entering the reach (i.e. drains or spills)
Water Out- Measured at end of reach

Columns containing total losses per reach, average velocity and loss per mile were also calculated. Total estimated maximum loss volume for the irrigation season was calculated using the following equation:

$Vol_{tot} = Q * 1.9835 * d$

Where:

Q is loss rate (cfs)

Vol_{tot} is total volume of loss (AF)

d is the number of days in 2017 irrigation season

1 cfs = 1.9835 AF/day

Evaporation rates were determined using pan evaporation data from the University of Idaho Aberdeen Experiment Station (University of Idaho, 2017), which is located centrally in relation to the canal, and ArcMap was used to estimate the total surface area of the canal. The total evaporation of 2397.5 af was applied to the total estimated yearly losses. A rough estimate of evapotranspiration was considered for the canal banks which contain substantial vegetation in the form of trees, weeds and bushes (Figure 3.4 & Figure 3.6). Evapotranspiration (ET) and Crop Irrigation requirements were estimated using 2017 evapotranspiration data (Idaho Department of Water Resources, 2018). A rate of 2.09 af/year was determined for the Aberdeen-Springfield region. This ET rate is calibrated for irrigated farmland but it was the best estimate available. Average bank vegetation widths of 10 feet for each canal branch and 5 feet for each lateral were used to approximate acreage. The total estimated canal bank vegetation was 572.6 af. To varying degrees, bank absorption or "wicking" of water from the canal was observed during dry, hot days (Figure 3.5).

Figure 3.4: Willows and heavy vegetation along the banks of the Main Canal.

Figure 3.5: Bank vegetation along the "H-Lateral".

Figure 3.6: Vertical absorption of surface water by banks during high temperatures.

Due to a wet spring in 2017, "recharge" water was available and the canal carried water for 22 days prior to the typical "irrigation season" start date of April 1st from the Main Gates to the Hilton Spill Site. The canal system was full and prepared for water delivery in early April but measurements were deferred until May 10th. An above average snowpack and precipitation in Eastern Idaho caused run off and abnormally high flows in the watershed which negatively affected water quality resulting in turbidity levels in excess of 25 NTU, (typically 0.7-6 NTU). Water clarity did not improve until August. Potentially, errors can be caused in ADCP measurements due to turbidity causing excessive attenuation and backscatter errors associated with suspended solids. Moving bed tests values were available to resolve any bottom tracking issues present from excess sedimentation but were seldom required.

3.3. Total Losses & Locations

During 2017, a total of 210 sites were measured including 37 sites using a hand-held flow probe and 173 sites using the ADCP. The number of passes (individual measurements) with the ADCP needed to evaluate the 173 sites (transects) was 1837. The total number of head gate measurements was 194. Several sites were selected and repeated for quality control. Total combined loss rates and average values for each section of the main canal and laterals are given in (Table 3.1).

Table 3.1: Losses, percent loss, and averages per branch of canal.

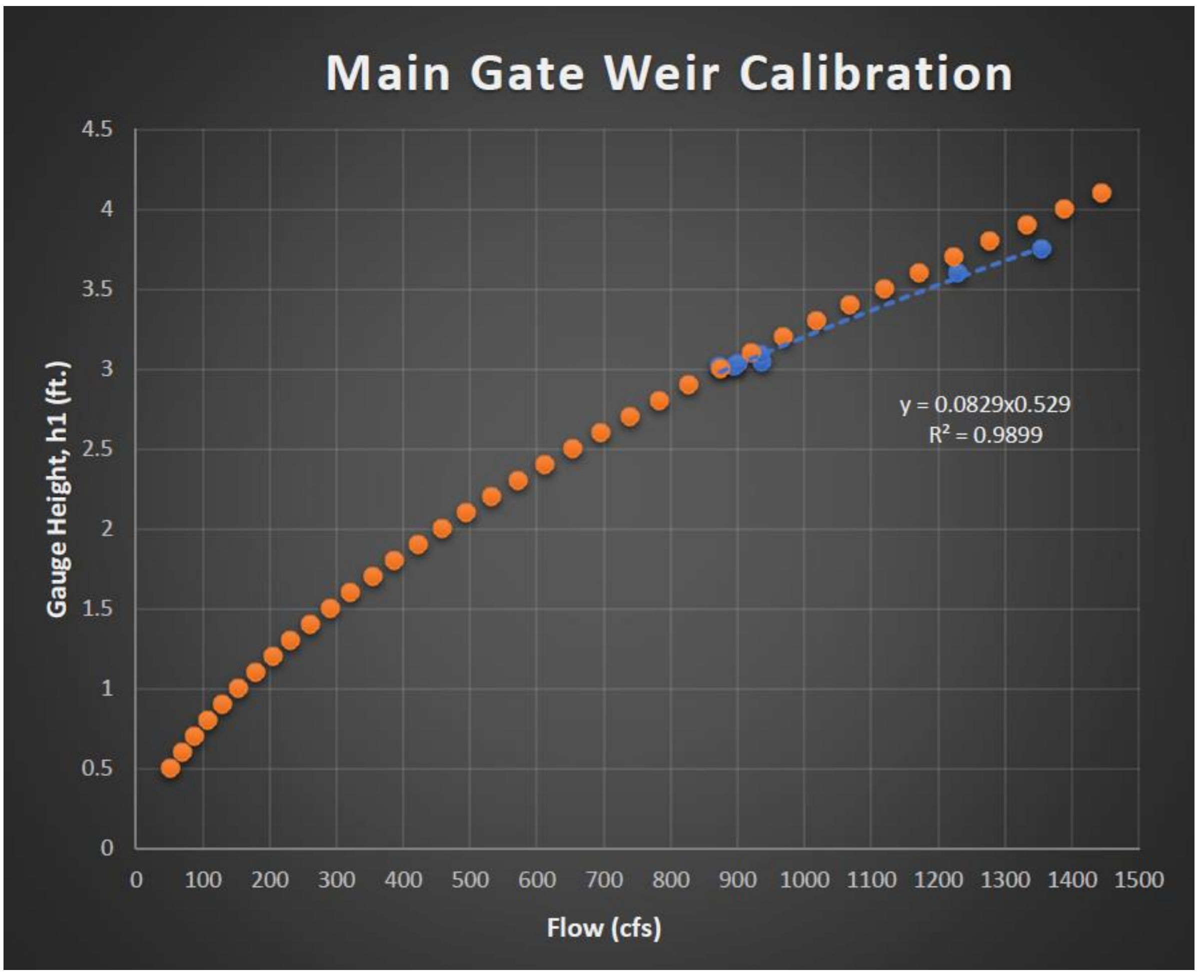
Canal Branch	Total Loss Rate (cfs)	% of Total Loss Rate	Average			
			Measured Flow (cfs)	Total Loss Rate (cfs)	Loss per Mile	Velocity (ft/s)
Main Canal	328.7	48.5%	966.9	10.3	10.5	2.6
Highline Canal	103.7	15.3%	162.3	3.3	3.6	1.1
Lowline Canal	83.6	12.3%	128.0	4.0	4.2	0.9
Laterals	162.1	23.9%	9.2	3.5	3.4	0.5

The total combined loss rate for all canal reaches during the study was 678.0 cfs. The Main Canal exhibited the greatest losses per section of canal totaling 328.7 cfs followed by the Highline and Lowline Canals for a combined 187.3 cfs and the laterals at 162.1 cfs. Losses per mile varied among reaches from 0 to 32.2 cfs with a mean total loss per reach of 5.3 cfs and an average loss per mile of 5.4 cfs. Rates and information relating to each measurement site can be viewed in Tables 3.2-3.4. The majority of reaches were "losing" reaches and several measurements did produce slightly negative values however they were within the measurement error. They are identified as negative values (Tables 3.2-3.4). Results from the 2017 study were compared with a follow-up 2018 study with the even numbered sites measured in 2017. Factors affecting yearly transmission losses such as groundwater elevation, vegetation growth and sedimentation vary annually, making comparisons between years challenging however agreement in site velocities and seepage losses exists between the 2017 and 2018 measurements. Total measured losses during 2018 were 649.6 cfs.

Along the Main Canal between reaches MC15 & MC16 measurement error resulted in the appearance of a significant gaining reach. A thunderstorm occurred between reach measurements causing a pause in measurements. Seven and ten passes were made for sites MC15 and MC16, respectively, and an average gain of -29.3 cfs was calculated. It is thought that upstream changes in deliveries are the source of the discrepancy but no change in deliveries were recorded. Runoff is also a potential source of error but most of the precipitation occurred downstream from the sites. Measurement of the subsequent site, MC17, supports this theory since it appears to be increased in comparison to prior measurements also. In 2018, the site was re-measured and found to lose approximately 4.3 cfs. This value has been substituted for the 2017 measurement since it is the best available estimate of losses in this reach.

Diversion measurements taken at the Main Gate Weir varied greatly from gauge readings at flows greater than 900 cfs. These measurements are collected by ASCC and Water District 1 (in two separate stilling well houses) using a submerged transducer calibrated to a staff gauge. ASCC uses a formula obtained by Water District 1 to calculate total flow from the staff gauge measurements. After Water District 1 staff was consulted, it was determined that the weir might encounter submergence from high tail waters above this rate, causing a break down in the flow equation above 900 cfs. To resolve potential errors in the equation, a "gain/slope offset" to the MG Weir formula (Graph 3.1) was applied using observed measurements taken with the ADCP from 2016, 2017 and 2018. This type of calibration is commonly found in digital/analog converter systems (Fry, 2012). The correction was applied to all gauge readings resulting in a flow rate of 900 cfs or above adding 13,218.1 af to the total calculated diversion from April 11 to Oct. 18. Annual recorded water budget for the Aberdeen-Springfield Canal in acre-feet were as follows:

Diversion	367,795.66
Spill	-29,525.38
Recharge	-38,454.27
Delivery	-101,776.00
Evaporation/ET	-2970.83
Seepage Losses	**195,069.18**



Graph 3.1: Calibration of the Main Gate Weir including the equation for the slope/gain correction.

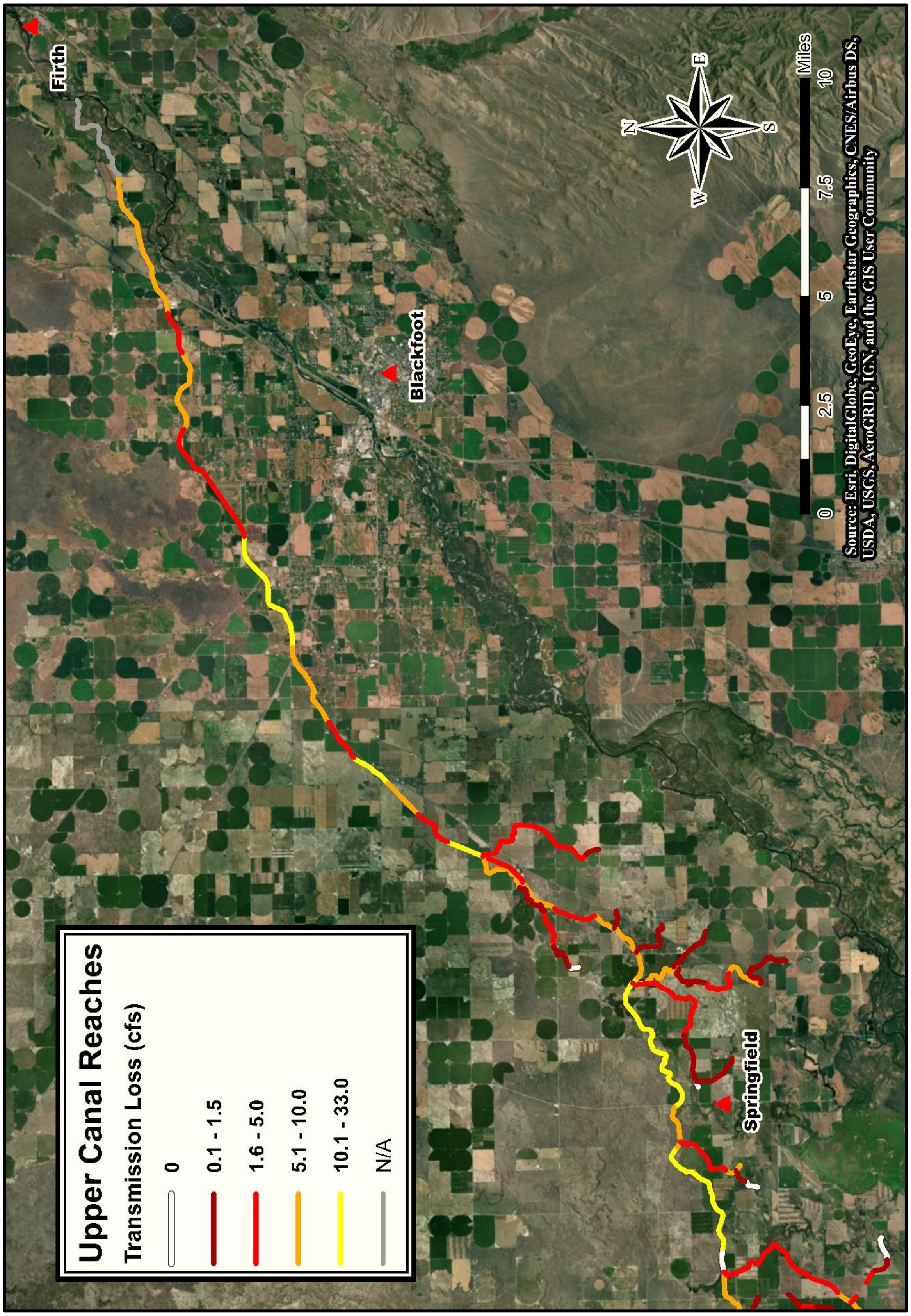


Figure 3.7: Losses per reach in the Upper Canal System.

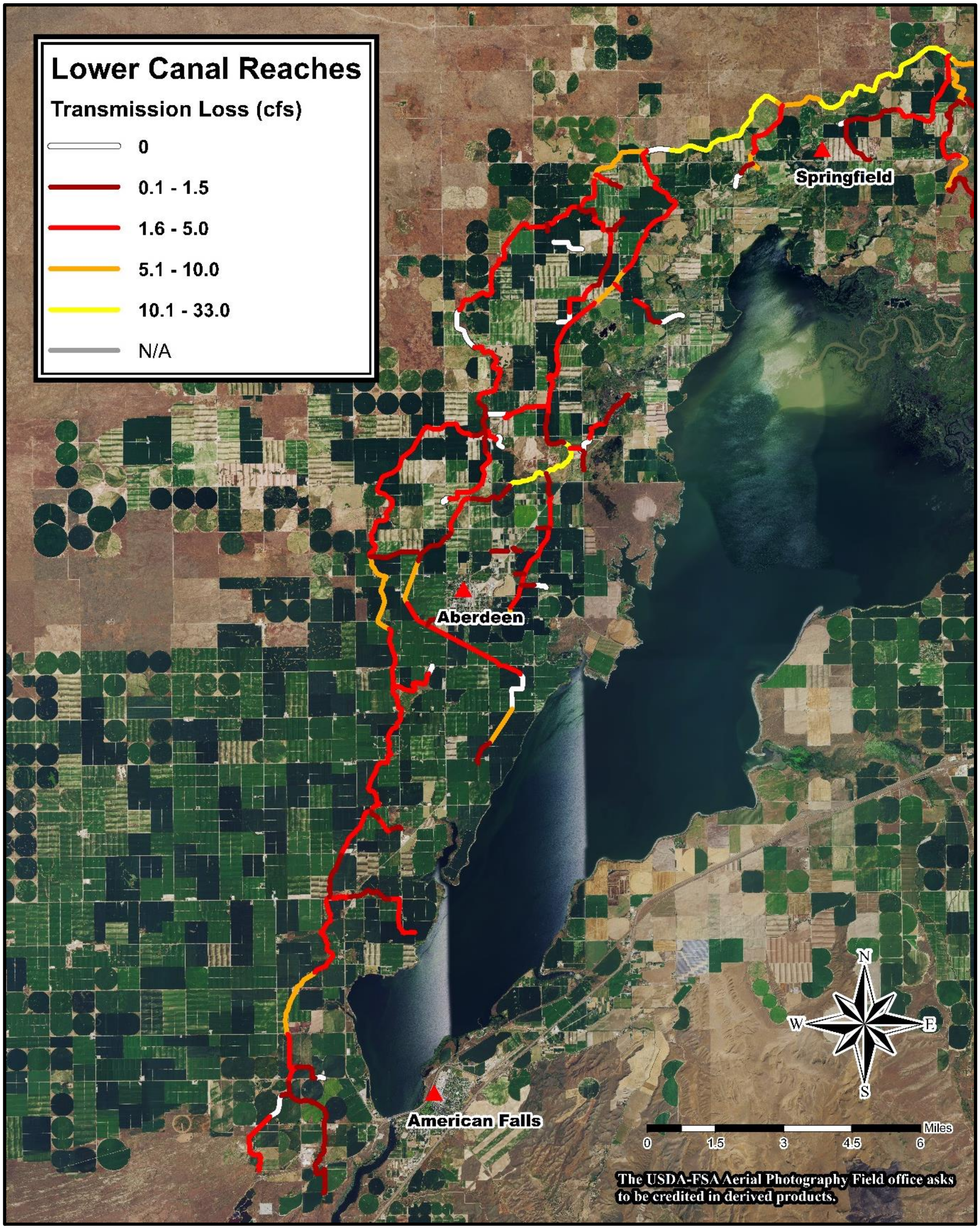


Figure 3.8: Losses per reach in the Lower Canal System.

Table 3.2: Main Canal Loss Data Table

Site ID	Measured Flow (cfs)	Reach	Deliveries	Total Loss (cfs)	Loss per Mile	Date	Time	Water Temp (C^{O})	Meas. Type	Avg. Vel (ft/s)
MC00	1305.8	MC00-MC01	0	6.3	12.7	7/6/17	1015	17.5	ADCP	4.0
MC01	1299.4	MC01-MC02	0	9.9	9.9	7/6/17	1145	17.6	ADCP	2.6
MC02	1289.5	MC02-MC03	0	6.1	6.4	7/6/17	1400	18.4	ADCP	3.8
MC03	1283.4					7/6/17	1530	18.9	ADCP	3.0
MC03	1265.2	MC03-MC04	0	9.3	8.8	7/11/17	855	17.1	ADCP	2.9
MC04	1255.9	MC04-MC05	0	3.9	3.9	7/11/17	1000	17.3	ADCP	4.5
MC05	1252.0	MC05-MC06	0	5.9	5.3	7/11/17	1100	17.7	ADCP	4.1
MC06	1246.2	MC06-MC07	0	7.4	8.4	7/11/17	1300	18.5	ADCP	5.2
MC07	1238.8					7/11/17	1415	18.7	ADCP	4.8
MC07	1179.2	MC07-MC08	0	2.8	2.8	7/12/17	840	17.3	ADCP	4.7
MC08	1176.5	MC08-MC09	0	4.9	4.9	7/12/17	945	17.6	ADCP	5.4
MC09	1171.5	MC09-MC10	0	2.0	2.0	7/12/17	1050	17.8	ADCP	5.1
MC10	1169.5	MC10-MC11	0	12.1	12.4	7/12/17	1220	18.1	ADCP	5.1
MC11	1157.4					7/12/17	1505	19.1	ADCP	5.0
MC11	1059.7	MC11-MC12	0	18.0	18.0	7/18/17	1115	18.7	ADCP	4.9
MC12	1041.7	MC12-MC13	0	11.9	11.9	7/18/17	1215	19.1	ADCP	1.8
MC13	1029.8		0			7/18/17	1350	19.8	ADCP	2.4
MC13	1023.4	MC13-MC15	3	7.5	7.5	7/20/17	930	18.8	ADCP	2.3
MC15	1013.0	MC15-MC16	0	**4.3**	**4.3**	7/20/17	1200	19.3	ADCP	2.1
MC16	1042.3	MC16-MC17	1.5	15.4	16.9	7/20/17	1440	19.8	ADCP	2.2
MC17	1025.4		0			7/20/17	1610	20.5	ADCP	2.4
MC17	1014.0	MC17-MC18	0	9.8	9.8	7/21/17	940	18.7	ADCP	2.4
MC18	1004.3	MC18-MC19	1.76	3.7	3.7	7/21/17	1100	18.9	ADCP	1.6
MC19	998.8					7/21/17	1230	19.3	ADCP	1.5
MC19	968.8	MC19-MC20	46.82	32.2	32.2	7/24/17	1315	19.4	ADCP	1.4
MC20	889.8					7/24/17	1500	20.0	ADCP	1.6
MC20	903.3	MC20-MC21	1.8	4.8	4.8	7/25/17	915	19.7	ADCP	1.6
MC21	896.7	MC21-MC22	3.2	6.8	6.8	7/25/17	1020	19.8	ADCP	1.5
MC22	886.7	MC22-MC23	3.62	3.6	3.6	7/25/17	1135	20.1	ADCP	1.5
MC23	879.5	MC23-MC24	3.88	5.8	5.8	7/25/17	1245	20.1	ADCP	1.8
MC24	869.9					7/25/17	1400	20.1	ADCP	1.6
MC24	890.8	MC24-MC25	5.46	5.3	5.3	7/26/17	1030	19.1	ADCP	1.6
MC25	880.0	MC25-MC26	138.07	25.5	25.5	7/26/17	1225	19.5	ADCP	1.7
MC26	716.4					7/26/17	1320	19.8	ADCP	2.0
MC26	678.6	MC26-MC27	0	12.8	12.8	7/28/17	1010	19.6	ADCP	1.9
MC27	665.8	MC27-MC28	0	13.1	13.1	7/28/17	1105	19.9	ADCP	1.2
MC28	652.7	MC28-MC29	4.37	18.5	18.5	7/28/17	1245	20.3	ADCP	2.5
MC29	629.8					7/28/17	1400	20.8	ADCP	1.5
MC29	599.8	MC29-MC30	22.91	8.8	8.8	7/31/17	845	20.1	ADCP	1.5

MC30	568.2	MC30-MC31	1	16.1	16.1	7/31/17	945	20.7	ADCP	1.3
MC31	551.1	MC31-MC32	0	17.6	17.6	7/31/17	1030	20.7	ADCP	1.2
MC32	533.5	MC32-MC33	3.58	16.6	15.9	7/31/17	1130	20.8	ADCP	1.2
MC33	513.3	MC33-End				7/31/17	1230	21.1	ADCP	1.1

Table 3.3: Highline and Lowline Canal Loss Data Table

Site ID	Measured Flow (cfs)	Reach	Deliveries (cfs)	Total Loss (cfs)	Loss per Mile	Date	Time	Water Temp (C^{o})	Meas. Type	Avg. Vel (ft/s)
HC00	311.6	HC00-HC01	0.0	6.1	12.1	8/4/17	1115	20.5	ADCP	0.8
HC01	305.5	HC01-HC02	7.3	7.2	7.2	8/4/17	1215	20.5	ADCP	1.1
HC02	290.9	HC02-HC03	14.3	2.6	2.6	8/4/17	1320	21.2	ADCP	1.1
HC03	274.0		0.0			8/4/17	1512	22.1	ADCP	1.4
HC03	264.2	HC03-HC04	2.0	3.0	3.0	8/7/17	920	18.9	ADCP	1.3
HC04	259.2	HC04-HC05	0.7	2.9	2.9	8/7/17	1015	19.0	ADCP	1.2
HC05	255.6	HC05-HC06	2.5	4.7	4.7	8/7/17	1100	19.2	ADCP	1.4
HC06	248.4	HC06-HC07	1.8	3.3	3.3	8/7/17	1130	19.3	ADCP	1.2
HC07	243.4	HC07-HC08	3.9	-2.7	-2.7	8/7/17	1215	19.7	ADCP	1.7
HC08	242.2	HC08-HC09	1.2	2.8	2.8	8/7/17	1250	20.2	ADCP	1.5
HC09	238.2	HC09-HC10	5.6	4.0	3.9	8/7/17	1345	20.6	ADCP	1.4
HC10	228.6	HC10-HC11	23.1	0.7	0.7	8/7/17	1435	20.7	ADCP	1.0
HC11	204.7					8/7/17	1615	21.1	ADCP	1.0
HC11	195.2	HC11-HC12	0.0	3.3	3.3	8/8/17	900	19.8	ADCP	0.9
HC12	191.9	HC12-HC13	2.7	2.4	2.4	8/8/17	930	19.7	ADCP	1.2
HC13	186.8	HC13-HC14	1.3	2.2	2.2	8/8/17	1015	19.7	ADCP	1.1
HC14	183.2	HC14-HC15	5.6	4.4	4.4	8/8/17	1050	20.1	ADCP	1.4
HC15	173.2	HC15-HC16	1.0	2.3	2.3	8/8/17	1125	20.2	ADCP	1.3
HC16	169.9	HC16-HC17	4.6	5.0	5.0	8/8/17	1245	20.3	ADCP	2.0
HC17	160.3	HC17-HC18	3.0	8.1	8.1	8/8/17	1335	20.9	ADCP	1.2
HC18	149.3	HC18-HC19	0.8	4.3	4.3	8/8/17	1430	21.2	ADCP	1.2
HC19	144.2	HC19-HC20	8.6	4.0	4.0	8/8/17	1510	21.3	ADCP	1.2
HC20	131.6					8/8/17	1600	21.9	ADCP	1.2
HC20	143.5	HC20-HC21	2.2	2.3	2.3	8/10/17	850	19.3	ADCP	1.2
HC21	139.0	HC21-HC22	0.0	3.1	3.1	8/10/17	930	19.3	ADCP	0.8
HC22	135.9	HC22-HC23	14.3	3.8	3.8	8/10/17	1000	19.4	ADCP	1.1
HC23	117.7	HC23-HC24	7.8	4.2	4.2	8/10/17	1100	19.7	ADCP	0.9
HC24	105.7	HC24-HC25	19.3	1.3	1.3	8/10/17	1145	20.0	ADCP	0.7
HC25	85.0	HC25-HC26	46.0	4.5	4.5	8/10/17	1305	20.4	ADCP	0.9
HC26	34.5	HC26-HC27	2.5	3.1	2.8	8/10/17	1400	20.8	ADCP	0.5
HC27	28.9					8/10/17	1435	21.4	ADCP	0.3
HC28	47.3	HC28-HC29	3.8	5.1	3.1	8/14/17	1115	20.3	ADCP	0.7
HC29	38.4	HC29-HC30	8.5	2.6	2.0	8/14/17	1200	20.3	ADCP	0.4
HC30	27.3	HC30-HC31	18.7	0.8	1.9	8/14/17	1250	20.4	FM	2.3
HC31	7.8	HC31-HC32				8/14/17	1310	20.2	FM	0.7
HC32	2.5	HC32-END	0.3	2.2	1.3	8/14/17	1325	20.2	FM	0.4
LC00	217.6	LC00-LC01	0.0	4.2	8.4	6/21/17	945	17.9	ADCP	1.2
LC01	213.4	LC01-LC02	3.8	2.5	2.5	6/21/17	1020	18.2	ADCP	1.2
LC02	207.1	LC02-LC03	0.7	2.9	2.9	6/21/17	1310	19.1	ADCP	1.3
LC03	203.6	LC03-LC04	6.7	3.1	3.1	6/21/17	1205	18.8	ADCP	1.6
LC04	193.8	LC04-LC05	5.0	7.7	7.7	6/21/17	1425	19.7	ADCP	1.2

LC05	181.1					6/21/17	1540	20.1	ADCP	1.1
LC04A	198.6	LC04-LC05	4.1	5.6	5.6	6/22/17	1020	17.8	ADCP	1.2
LC05	189.0	LC05-LC06	0.4	4.7	4.7	6/22/17	935	17.7	ADCP	1.1
LC06	183.9	LC06-LC07	0.0	4.8	4.8	6/22/17	1120	18.2	ADCP	1.1
LC07	179.0	LC07-LC08	5.2	2.7	2.7	6/22/17	1230	18.7	ADCP	1.3
LC08	171.1					6/22/17	1330	19.0	ADCP	1.4
LC08	184.3	LC08-LC09	1.8	1.3	1.3	6/27/17	915	18.2	ADCP	1.2
LC09	181.3	LC09-LC10	18.6	13.4	13.4	6/27/17	955	18.2	ADCP	1.1
LC10	149.2	LC10-LC11	40.6	12.0	12.0	6/27/17	1100	18.6	ADCP	1.1
LC11	96.6	LC11-LC12	2.7	0.4	0.4	6/27/17	1150	18.9	ADCP	1.3
LC12	93.5	LC12-LC13	7.4	4.2	4.2	6/27/17	1300	19.6	ADCP	1.0
LC13	81.9	LC13-LC14	0.1	0.4	0.4	6/27/17	1415	20.3	ADCP	0.6
LC14	81.4	LC14-LC15	5.6	6.1	6.1	6/27/17	1530	20.8	ADCP	0.7
LC15	69.7					6/27/17	1610	21.2	ADCP	0.7
LC15	65.2	LC15-LC16	7.4	3.7	3.7	6/28/17	900	19.1	ADCP	0.6
LC16	54.2	LC16-LC17	7.4	2.6	2.6	6/28/17	1000	19.2	ADCP	0.8
LC17	44.2	LC17-LC18	9.4	2.7	2.7	6/28/17	1100	19.8	ADCP	0.5
LC18	32.0	LC18-LC19	8.8	-0.2	-0.2	6/28/17	1251	20.6	ADCP	0.3
LC19	23.4	LC19-LC20	8.5	5.8	6.5	6/28/17	1340	21.1	ADCP	0.5
LC20	9.1	LC20-Spill	8.5	0.6	1.1	6/28/17	1430	22.1	ADCP	0.1

Table 3.4: Lateral Loss Data Table

Site ID	Measured Flow (cfs)	Reach	Deliveries (cfs)	Total Loss (cfs)	Loss per Mile	Date	Time	Water Temp (C⁰)	Meas. Type	Avg. Vel (ft/s)
45L00	3.4	45L00-45L01	2.3	0.2	0.2	6/7/17	1415	17.2	HG	1.5
45L01	0.9	45L01-End	0.0	0.9	1.9	6/7/17	1500	22.2	FM	0.6
46L00	2.7	46L00-46L01	0.0	2.1	5.9	5/30/17	1340	18.0	FM	0.5
46L01	0.7	46L01-End	0.0	0.7	2.3	5/30/17	1400	19.8	FM	0.0
AL00	18.5	AL00-AL01	0.0	3.1	6.1	5/31/17	920	16.9	ADCP	0.5
AL01	15.5	AL01-AL02	1.7	2.8	2.8	5/31/17	1000	17.6	ADCP	0.2
AL02	11.0	AL02-AL03	0.2	2.1	2.1	5/31/17	1055	17.4	ADCP	0.1
AL03	8.7	AL03-AL04	2.0	3.9	4.9	5/31/17	1210	19.1	ADCP	0.2
AL04	2.7	AL04-Aspill	2.2	0.5	1.7	5/31/17	1320	20.3	ADCP	0.1
BL00	2.4	BL00-BL01	0.0	1.1	2.6	6/29/17	1410		Weir	
BL01	1.2	BL01-End				6/29/17	1425		HG	
CL00	23.3	CL00-CL01	0.0	3.1	6.1	5/11/17	1150	13.7	ADCP	0.7
CL01	20.2	CL01-CL02	1.2	3.8	3.8	5/11/17	1300	14.9	ADCP	0.9
CL02	15.2	CL02-CL03	3.4	2.0	2.0	5/11/17	1415	16.8	FM	0.6
CL03	9.9	CL03-CL04	0.7	0.8	0.8	5/11/17	1530	18.6	FM	0.4
CL04	8.3	CL04-CL05	0.5	1.3	1.5	5/11/17	1613	19.7	FM	0.5
CL05	6.5	CL05-CSpill	2.8	0.4	1.1	5/11/17	1710	19.8	ADCP	0.2
CSpill	3.2					5/11/17	1715		SCADA	
C1L00	31.9	C1L00-C1L01	0.0	8.5	17.1	5/10/17	1115	13.1	ADCP	1.3
C1L01	23.4	C1L01-C1L02	2.9	7.4	7.4	5/10/17	1145	13.7	ADCP	1.0
C1L02	13.1	C1L02-C1L03	0.0	1.2	1.2	5/10/17	1245	15.8	ADCP	0.6
C1L03	11.9	C1L03-C1L04	0.0	3.1	3.1	5/10/17	1400	17.2	ADCP	0.5
C1L04	8.7	C1L04-C1L05	0.0	5.0	5.0	5/10/17	1515	18.2	ADCP	0.4
C1L05	3.7					5/10/17	1600	19.6	FM	0.2
C1L05	5.1	C1L05-C1L06	1.9	0.8	0.8	5/11/17	900	12.6	FM	0.3
C1L06	2.4	C1L06-C1L07	0.0	0.9	1.7	5/11/17	1015	15.1	FM	1.3
C1L07	1.5	C1L07-End				5/11/17	1015		FM	1.0
C2L00	1.2	C2L00-C2L01	0.0	0.9	3.0	7/18/17	940		HG	
C2L01	0.4					7/18/17	950		HG	
DL00	23.2	DL00-DL01	0.0	4.0	8.0	6/1/17	845	16.2	ADCP	1.0
DL01	19.2	DL01-DL02	8.1	2.0	2.1	6/1/17	915	13.3	ADCP	0.6
DL02	9.2	DL02-End	3.9	5.3	12.3	6/1/17	1020	18.2	ADCP	0.4
D1L00	0.9	D1L00-D1L01	0.0	0.6	1.7	6/1/17	1100	18.3	FM	0.4
D1L01	0.4	D1L01-D1Spill	1.0	-1.4		6/1/17	1125	18.6	FM	0.3
D1Spill	0.8					6/1/17	1125		SCADA	
EL00	27.9	EL00-EL01	0.0	1.1	2.1	6/6/17	940	16.8	ADCP	1.0
EL01	26.8	EL01-EL02	6.7	4.8	4.8	6/6/17	1040	17.1	ADCP	1.1
EL02	15.3	EL02-EL03	4.9	1.4	1.4	6/6/17	1140	17.6	ADCP	0.6

EL03	9.0	EL03-EL04	1.8	2.7	2.8	6/6/17	1220	17.7	ADCP	0.3
EL04	4.5	EL04-End				6/6/17	1300	19.2	ADCP	0.6
E1L00	5.8	E1L00-E1L01	0.0	0.2	0.9	6/6/17	1400		HG	
E1L01	5.6	E1L01-End			0.9	6/6/17	1350	19.1	ADCP	0.2
FL00	3.4	FL00-FL01	3.2	0.2	1.6	5/30/17	1110	16.3	ADCP	0.0
FL01	0.0					5/30/17	1110		HG	
GL00	6.7	GL00-GL01	0.0	-0.4	-0.6	5/30/17	1000	15.6	FM	0.7
GL01	7.1					5/30/17	940	16.1	FM	1.1
GL01	7.1	GL01-GL02	0.5	2.3	3.4	5/25/17	1410	17.0	FM	1.1
GL02	4.3	GL02-End	2.2	2.1	5.4	5/25/17	1500	18.1	ADCP	0.1
HL00	35.0	HL00-HL01	2.0	7.6	15.3	6/2/17	1530	17.8	ADCP	0.4
HL01	25.4	HL01-HL02	4.0	7.2	7.2	6/2/17	1455	18.6	ADCP	1.1
HL02	14.2	HL02-HL03	0.0	0.5	0.4	6/2/17	1400	19.2	ADCP	0.4
HL03	13.7	HL03-HL04	9.1	2.1	2.1	6/2/17	1245	18.8	ADCP	0.5
HL04	2.5	HL04-HL05	1.2	1.3	1.8	6/2/17	1045	19.0	ADCP	0.0
HL05	0.0	HL05-End	0.0	0.0	0.0	6/2/17	930	19.2	ADCP	0.0
IL00	3.0	IL00-IL01	0.0	2.0	4.8	5/25/17	1345	15.8	HG	
IL01	1.1	IL01-End	1.1	0.0	0.0	5/25/17	1300	16.6	FM	0.1
JL00	9.6	JL00-JL01	0.9	0.9	0.9	6/7/17	1000	17.1	ADCP	0.2
JL01	7.8	JL01-JL02	0.0	2.5	2.5	6/7/17	1055	18.1	ADCP	0.2
JL02	5.3	JL02-JSpill	1.7	1.9	1.9	6/7/17	1245	20.3	ADCP	0.1
JSpill	1.7	JL03-End	2.4	0.0	0.0	6/7/17	1300		SCADA	
KL00	3.0	KL00-KL01	0.0	0.6	0.6	6/6/17	1510	13.1	ADCP	0.1
KL01	2.4	KL01-End	2.4	0.0	0.0	6/6/17	1450		HG	
NL00	15.1	NL00-NL01	1.2	2.9	5.8	5/25/17	1000	15.3	ADCP	1.1
NL01	11.0	NL01-NL02	5.8	2.1	3.1	5/25/17	1045	16.1	ADCP	0.5
NL02	3.1	NL02-NSpill	5.4	0.0	0.0	5/25/17	1130	15.5	ADCP	0.1
PL00	16.4	PL00-PL01	0.0	1.1	4.9	5/20/17	1300	12.4	ADCP	1.1
PL01	15.3	PL01-PL02	6.6	4.0	8.9	5/20/17	1145	12.6	ADCP	0.8
PL02	4.6	PL02-End	4.5	0.1	0.4	5/20/17	1415	14.5	FM	0.8
QL00	20.0	QL00-QL01	0.0	1.7	3.3	5/22/17	830	14.1	ADCP	0.6
QL01	18.3	QL01-QL02	3.0	1.3	1.3	5/22/17	920	14.2	ADCP	0.7
QL02	14.0	QL02-QL03	4.6	3.0	3.4	5/22/17	1115	15.5	ADCP	0.6
QL03	6.4	QL03-QSpill	4.4	2.0	5.5	5/22/17	1200	15.8	ADCP	0.2
RL00	10.3	RL00-RL01	0.0	1.1	5.3	5/24/17	900	16.6	FM	0.8
RL01	9.2	RL01-RL02	4.2	1.1	2.6	5/24/17	930	17.1	FM	0.7
RL02	3.9	RL02-RSpill	4.7	0.0	0.0	5/24/17	1000	17.4	FM	0.3
SL00	12.4	SL00-SL01	0.0	0.5	1.1	5/23/17	1245	18.3	ADCP	0.3
SL01	11.9	SL01-SL02	6.0	0.8	0.8	5/23/17	1310	18.9	ADCP	1.2
SL02	5.1	SL02-End	0.0		0.9	5/23/17	1420	19.3	ADCP	0.3
TL00	4.7	TL00-TL02	0.0	1.9	3.7	5/30/17	1215		HG	
TL02	2.8	TL02-TL03	0.0	0.9	1.9	5/30/17	1240	18.7	FM	0.6
TL03	1.9	TL03-TSpill				5/30/17	1310	19.6	FM	0.6

UL00	18.4	UL00-UL01	0.0	3.2	14.2	5/18/17	1400	10.5	ADCP	0.5
UL01	15.2	UL01-UL02	6.7	-0.4	-0.8	5/18/17	1430	10.8	ADCP	0.6
UL02	8.8					5/18/17	1500	11.4	ADCP	0.3
UL02	6.7	UL02-UL03	1.5	1.7	3.3	5/19/17	1345	11.8	ADCP	0.2
UL03	3.5	UL03-UL04	0.0	0.2	0.4	5/19/17	1430	12.7	FM	0.3
UL04	3.3	UL04-USpill	3.2	0.1	0.3	5/19/17	1515	13.3	ADCP	0.2
U1L00	6.7	U1L00-U1L01	0.0	0.0	0.3	5/18/17	1245	10.5	FM	0.4
U1L01	6.7	U1L01-U1L02	0.0	0.9	3.8	5/18/17	1310	10.8	FM	0.8
U1L02	5.8	U1L02-End	4.6	1.2	10.9	5/18/17	1325	11.2	FM	0.6
VL00	40.4	VL00-VL01	0.0	1.0	2.1	5/23/17	800	14.3	ADCP	1.0
VL01	39.3	VL01-VL02	9.1	4.2	4.2	5/23/17	830	14.1	ADCP	0.7
VL02	26.0	VL02-VL03	3.0	4.7	4.7	5/23/17	930	14.8	ADCP	0.4
VL03	18.3	VL03-VL04	2.6	4.0	5.3	5/23/17	1105	15.2	ADCP	0.3
VL04	11.8	VL04-Spill	2.0	5.0	19.4	5/23/17	1200	16.4	ADCP	0.3
VSpill	4.7					5/23/17	1200		SCADA	
V1L00	2.5	V1L00-V1L01	0.0	1.3	6.4	5/23/17	1030	15.2	ADCP	0.1
V1L01	1.2					5/23/17			HG	1.0
V2L00	2.3	V2L00-V2L01	0.0	0.8	2.9	5/22/17	1500		FM	1.9
V2L01	1.5	V2L01-End				5/22/17	1430	18.2	FM	0.8
V3L00	1.2	V3L00-V3L01	0.0	0.1	0.1	6/29/17	1510		HG	
V3L01	1.2					6/29/17	1520		HG	
V4L00	2.4	V4L00-V4L01	0.0	0.4	1.4	5/22/17	1415	16.3	FM	0.5
V4L01	2.0					5/22/17	1345	15.9	FM	0.3
WL00	2.1	WL00-WL01	1.0	0.4	0.6	8/10/17			HG	
WL01	0.7	WL01-End	0.4	0.3	1.6	8/10/17			Weir	

3.4. Discussion

If seepage loss rates determined from this field study of 658.4 cfs (obtained by subtracting 19.6 cfs of calculated evaporation and evapotranspiration losses from the total measured transmission losses of 678.0 cfs) were continuous throughout the entire 191-day irrigation season, a total volume of 249,438.0 af would be lost to seepage from the ASC system. This is 68.7% of the total annual diversion, which is consistent with the highest estimated percentage of daily loss rates from the ASCC daily operation logs (Aberdeen-Springfield Canal Company, 1989-2017). This study was designed to measure rates at peak canal capacity where losses were expected to be greatest. Low flow rates and volumes that exist under "normal" operation were not measured, simply because for the purposes of capacity modeling, they were not relevant. Therefore, high seepage loss values representing peak operating conditions cannot be used to directly estimate the total annual seepage loss. During non-peak conditions, the seepage losses will be less than the maximums presented here of 249,438.0 af. This number represents the highest seepage potential present in the system.

Losses from the operational logs range from 36-70% (Aberdeen-Springfield Canal Company, 1989-2017). The total estimated yearly loss of 194,340.2 af (calculated from the operation logs) and the maximum yearly loss of 249,438.0 af measured above differ by 55,097.8 af. This indicates substantial variability in loss rates throughout the irrigation season. The operations logs are subject to a considerable amount of uncertainty due to several factors (as are the measured values). Possible errors in the operation logs can be associated with the flow measurement, ditchrider's delivery measurements, spill measurements, malfunctions in the orifices used to measure flow, etc. However, these are not thought to be large enough to produce the large difference in annual volume. To obtain a better measure of the annual seepage losses to the system additional flow measurements are required. These flow measurements would need to be made during non-peak flows. It is noted that during non-peak water usage, the spatial resolution of one-mile reaches may not produce loss rates at a measurable magnitude and, therefore, longer reaches should be considered.

In an attempt to estimate seepage volumes during 2017 for three regions of the canal, percentages of total loss rates were applied to the annual seepage losses calculated from the operation log in the table below.

Table 3.5: Estimated seepage volumes per region of canal

Region	Total Loss (cfs)	% of Total	Length (mi)	Loss per Mile	Equivalent Volume (af)
Firth to Springfield	342.2	50.5%	52.9	6.5	98,141.8
Springfield to Aberdeen	237.7	35.0%	56.7	4.2	68,019.1
Aberdeen to American Falls	98.1	14.5%	33.0	3.0	28,179.3

The Main Canal between Firth and Springfield exhibited the greatest measured loss rates. Regional groundwater flow paths (Figures 2.11 & 3.4) indicate that canal losses in the lower end of this region likely flow into the Near Blackfoot to Neeley reach of the Snake River. High transmissivities of the basalt in the Springfield region could easily transport canal seepage directly into the Near Blackfoot to Neeley reach or nearby springs. From Springfield to Aberdeen, the Highline & Lowline Canals and laterals combine to disperse approximately 68,019.1 af into the underlying aquifer. This seepage recharge spreads throughout the region and its effects on regional "shallow" wells is easily observed on hydrographs and travel times estimated based on responses (Holder, 2009). In the south end of the system, from Aberdeen to American Falls Reservoir, considerable losses still exist but are not as profound as those in the upper regions.

The water budget during the 2017 irrigation season reveals that only 27.7% of total diversion was applied to deliveries and 10.5% intentionally expended on managed recharge. The remaining water is attributed to operational losses (spills, evaporative and ET losses, and seepage), seepage being the greatest factor (Table 3.6). Considering the immense seepages losses, it can be said that the yearly water budget of the ASCC testifies to the geologic framework in the canal base and in the subsurface beneath it. Total direct groundwater inputs from the canal system (including managed recharge) were 233,523.5 af. In 2017, the Hilton Reservoir functioned as a managed recharge site because recharge water was available, but this is not always the case. Water discharged into the site as "operational spill" would not be "credited" to ASCC as recharge (under current water accounting rules) and would be lost to seepage and spill, resulting in even greater system losses.

Table 3.6: ASCC 2017 Water Budget

ASCC Water Budget 2017 (4/11-10/18)	2017 (AF)	% of Total Diversion
Total Diversion	367,795.7	
Deliveries	101,776.0	27.7
Spills	29,525.4	8.0
Recharge	38,454.3	10.5
Evaporation/ET	2,970.8	0.8
Seepage Loss	195,069.2	53.0
Direct GW Inputs (Seepage Loss + Recharge)	233,523.5	63.5
Direct SW Inputs (Spills)	29,525.4	8.0
Total Returned to Snake River & ESPA System	***263,048.9***	***71.5%***

2017 was not an "average" water year. The abundance of water supply brought unexpected challenges to this study including; high run off, early saturation of the vadose zone, and local flooding. Recharge water was also available in 2017. All of these conditions contributed to a rise the water table, which may have affected seepage rates, although the degree to which they were affected remains unknown. "Mounding" of groundwater in the region of the Hilton Reservoir where recharge occurred can be visualized in flow directions and groundwater level contours created from August 2017 well data (Figure 3.4). Direction of groundwater flow during seepage events indicates that a portion of seepage recharge tends toward the southwest.

Decadal long declines in ESPA water levels are not observed in the study area. In general, groundwater levels in the ESPA historically gained elevation until they peak around the 1950's and afterwards declined (Figure 1.4). This decline coincided with invention of the downhole submersible pump capable producing large amounts of groundwater from wells and the change from flood irrigation to sprinkler irrigation that led to less aquifer recharge. Water levels in the regional aquifer surrounding the Aberdeen-Springfield Canal, however, have been sustained from year to year with slight seasonal variations of over the past decade and

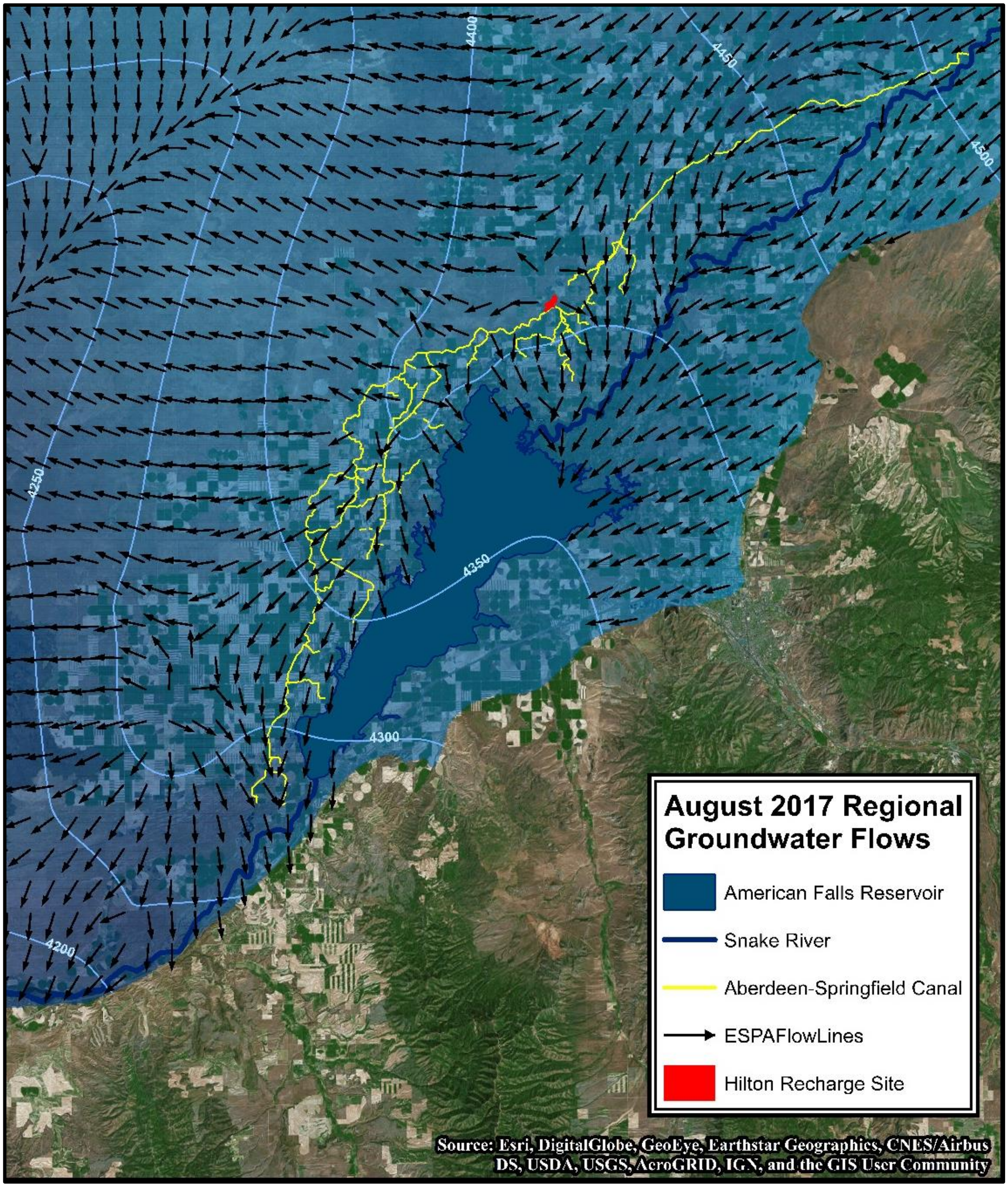


Figure 3.9: Groundwater flow lines created using Aug. 2017 groundwater levels.

only a small decline of 5 feet or less. As described previously, the ASCC has been active for more than a century and considering the volume of ASCC seepage losses, it may be that these losses have stabilized regional water levels. Furthermore, the seepage losses may have limited the effects of groundwater pumping in the aquifer(s) (both ESPA and local shallow systems) adjacent to the canal. In addition, typical surface water recharge must travel through surface soils and much is loss to evapotranspiration and runoff before percolating into the aquifer. Canal seepage is much less affected by these factors and more water gets into the deep subsurface. When highly transmissive substrate (e.g. fractured basalt or coarse gravel) composes the canal base, a fully saturated water column can be established between surface and groundwater.

CHAPTER IV. SIMM'S WELL PUMPING TEST

Understanding surface-groundwater interactions is important in conjunctively managed systems. Transmissivity and storativity are physical aquifer properties that largely control the effects propagated by pumping (Cosgrove & Johnson, 2004). These properties can be determined from time-drawdown data (Fetter, 2001) from a pumping test. To investigate the parameters influencing groundwater movement in the regional aquifer(s), hydraulic conductivity, transmissivity and storativity values were sought. In the Pleasant Valley Region, a pumping test was conducted to estimate local aquifer properties.

4.1. Background & Locations

The "Simm's Well" (Figure 4.1), a presently unused irrigation recovery well owned by ASCC, was selected to obtain aquifer properties relating to the Pleasant Valley Region west of American Falls Reservoir. Originally drilled in 2004 as a recovery well under I.C. §42-228, no active water rights are associated with the well and use of the well for groundwater withdrawal requires expressed consent from IDWR. Since irrigation withdrawals from nearby pumps could potentially affect drawdown in the test well, the pumping test was

Figure 4.1: The Simm's Well.

performed after the conclusion of the irrigation season in early November of 2017. To address the use of the well out of the permitted season of use, an application for a temporary water right was filed with IDWR on October 27, 2017 to allow the diversion of water for the purpose of the test and was approved on November 17, 2017 (Appendix 2). Water levels in two nearby domestic wells were fitted with transducers and monitored as observation wells.

4.2. Wells

Located in the NWNW of T07S, R30E, Sec. 26, the Simm's Well is used as a recovery well for irrigation and has a maximum pumping discharge rate of approximately 3500 gpm and a depth of 398 feet. It has available two observation wells at radial offsets of 244 and 344 feet (Figure 4.2). Well logs for the tested and observation wells were collected from the Idaho Department of Water Resource's webpage, www.hydro.online.com. All well logs indicate predominant lava with the presence of a clay layer around 72-225 feet deep in the subsurface (Figures 4.3, 4.4 & 4.5).

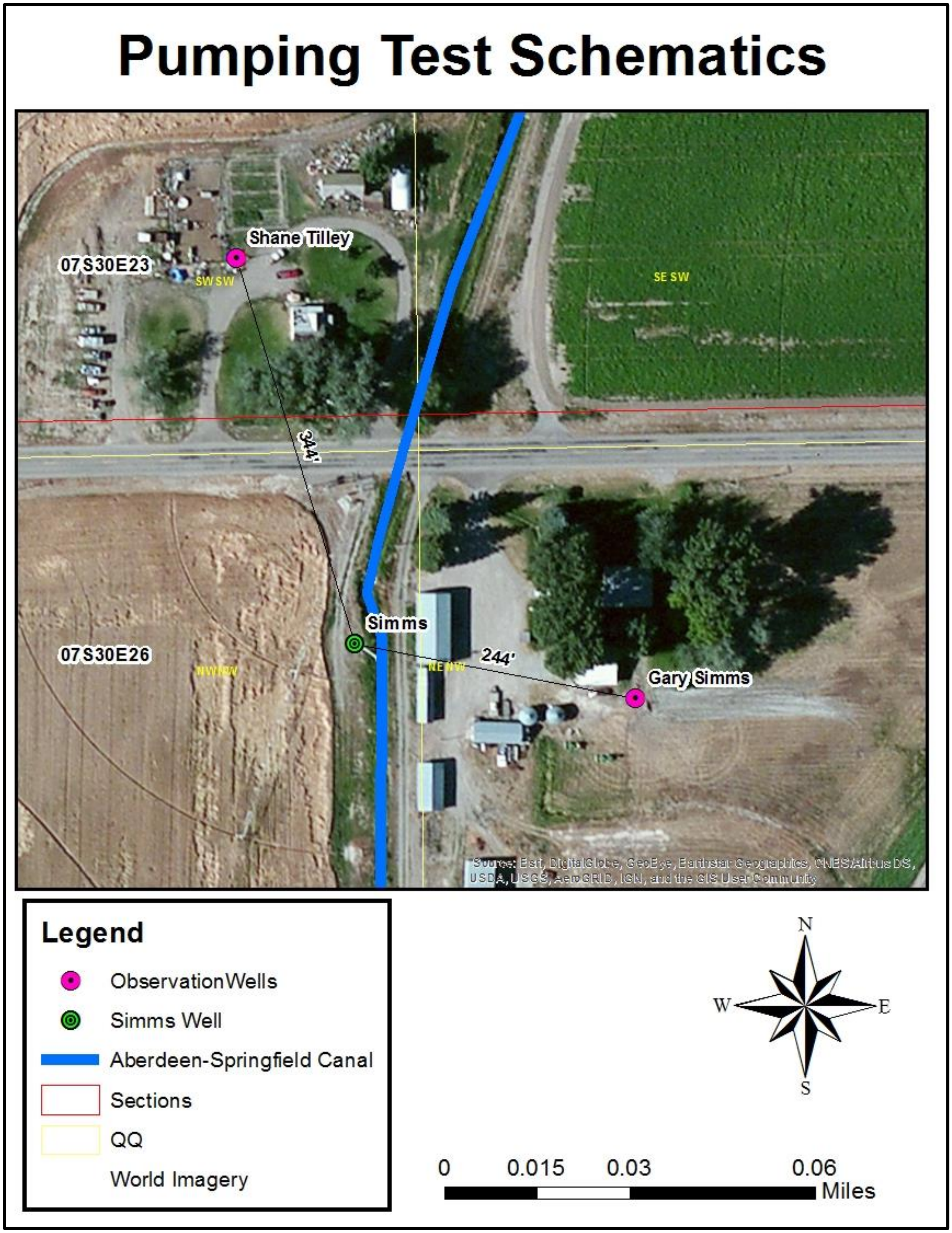
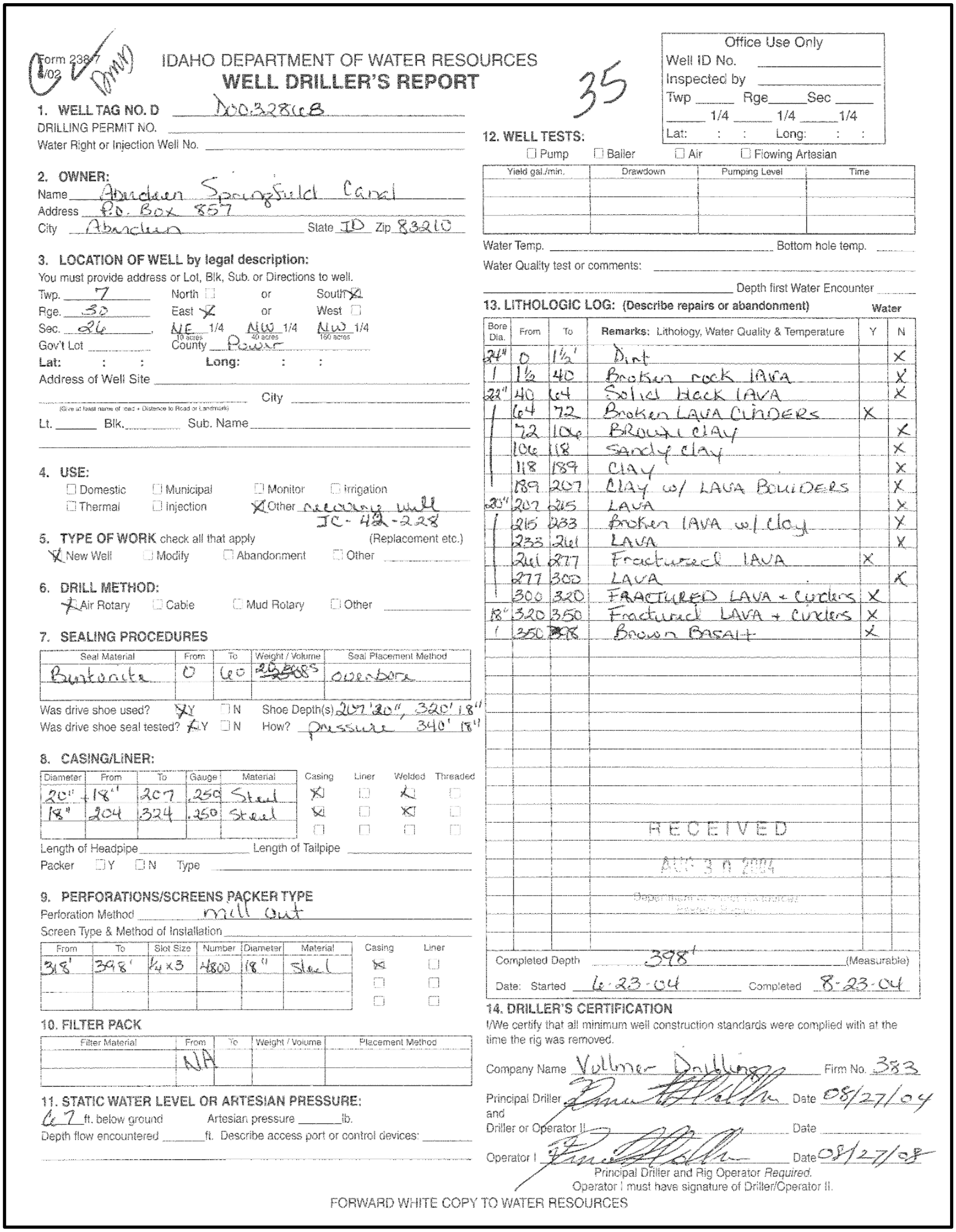


Figure 4.2: Map of test wells showing locations and distance from Simm's Well.



Form 238-7 1/02

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

35

Office Use Only
Well ID No.
Inspected by
Twp ____ Rge ____ Sec ____
____ 1/4 ____ 1/4 ____ 1/4
Lat: : : Long: : :

1. WELL TAG NO. D D0032866B
DRILLING PERMIT NO.
Water Right or Injection Well No.

2. OWNER:
Name Aberdeen Springfield Canal
Address P.O. Box 857
City Aberdeen State ID Zip 83210

3. LOCATION OF WELL by legal description:
You must provide address or Lot, Blk, Sub. or Directions to well.
Twp. 7 North or South ☒
Rge. 30 East ☒ or West
Sec. 26 NE 1/4 NW 1/4 NW 1/4
Gov't Lot County Power
Lat: : : Long: : :
Address of Well Site
City
Lt. Blk. Sub. Name

4. USE:
☐ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☒ Other recovery well JC-42-228

5. TYPE OF WORK check all that apply (Replacement etc.)
☒ New Well ☐ Modify ☐ Abandonment ☐ Other

6. DRILL METHOD:
☒ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other

7. SEALING PROCEDURES

Seal Material	From	To	Weight / Volume	Seal Placement Method
Bentonite	0	60	85	overbore

Was drive shoe used? ☒Y ☐N Shoe Depth(s) 207' 20", 320' 18"
Was drive shoe seal tested? ☒Y ☐N How? pressure 340' 18"

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
20"	+18"	207	.250	Steel	☒	☐	☒	☐
18"	204	324	.250	Steel	☒	☐	☒	☐

Length of Headpipe Length of Tailpipe
Packer ☐Y ☐N Type

9. PERFORATIONS/SCREENS PACKER TYPE
Perforation Method mill out
Screen Type & Method of Installation

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
318'	398'	1/4 x 3	4800	18"	Steel	☒	☐

10. FILTER PACK

Filter Material	From	To	Weight / Volume	Placement Method
	NA			

11. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
67 ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices:

12. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time

Water Temp. Bottom hole temp.
Water Quality test or comments:
Depth first Water Encounter

13. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Water Y	Water N
24"	0	1½'	Dirt		X
	1½	40	Broken rock lava		X
22"	40	64	Solid black lava		X
	64	72	Broken lava cinders	X	
	72	106	Brown clay		X
	106	118	Sandy clay		X
	118	189	Clay		X
	189	207	Clay w/ lava boulders		X
20"	207	215	Lava		X
	215	233	Broken lava w/ clay		X
	233	261	Lava		X
	261	277	Fractured lava	X	
	277	300	Lava		X
	300	320	Fractured lava + cinders	X	
18"	320	350	Fractured lava + cinders	X	
	350	398	Brown basalt	X	

RECEIVED
AUG 3 0 2004

Completed Depth 398' (Measurable)
Date: Started 6-23-04 Completed 8-23-04

14. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.
Company Name Vollmer Drilling Firm No. 383
Principal Driller and Date 08/27/04
Driller or Operator II Date
Operator I Date 08/27/08
Principal Driller and Rig Operator *Required.*
Operator I must have signature of Driller/Operator II.

FORWARD WHITE COPY TO WATER RESOURCES

Figure 4.3: Simm's Well driller's report.

Form 238-7
6/07

IDAHO DEPARTMENT OF WATER RESOU
WELL DRILLER'S REPORT

Location Corrected by IDWR To:
T07S R30E Sec. 26 NWNENW
By: mciscell 2013-10-16

1. WELL TAG NO. D D0058413
Drilling Permit No. ______
Water right or injection well # ______

2. OWNER: Gary & Larry Simms
Name Gary & Larry Simms
Address 3127 Pleasant Valley Road
City American Falls State ID Zip 83211

3. WELL LOCATION:
Twp. 7 North ☐ or South ☒ Rge. 30 East ☒ or West ☐
Sec. 23 ____ 1/4 (10 acres) SW 1/4 (40 acres) SW 1/4 (160 acres)
Gov't Lot ______ County Power
Lat. 42 ° 47'27.3" (Deg. and Decimal minutes)
Long. 112 ° 55'08.1" (Deg. and Decimal minutes)
Address of Well Site 3174 South Pleasant Valley Road (Give at least name of road + Distance to Road or Landmark) City American Falls
Lot. ______ Blk. ______ Sub. Name ______

4. USE:
☒ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation ☐ Thermal ☐ Injection
☐ Other ______

5. TYPE OF WORK:
☐ New well ☒ Replacement well ☐ Modify existing well
☐ Abandonment ☐ Other ______

6. DRILL METHOD:
☒ Air Rotary ☐ Mud Rotary ☐ Cable ☐ Other ______

7. SEALING PROCEDURES:

Seal material	From (ft)	To (ft)	Quantity (lbs or ft³)	Placement method/procedure
Bentonite	0	40	2450lbs	Overbore

8. CASING/LINER:

Diameter (nominal)	From (ft)	To (ft)	Gauge/ Schedule	Material	Casing	Liner	Threaded	Welded
6"	+2	225	.250	Steel	☒	☐	☐	☒
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐

Was drive shoe used? ☒ Y ☐ N Shoe Depth(s) 225'

9. PERFORATIONS/SCREENS:
Perforations ☐ Y ☒ N Method ______
Manufactured screen ☐ Y ☒ N Type ______
Method of installation ______

From (ft)	To (ft)	Slot size	Number/ft	Diameter (nominal)	Material	Gauge or Schedule

Length of Headpipe ______ Length of Tailpipe ______
Packer ☐ Y ☒ N Type ______

10. FILTER PACK:

Filter Material	From (ft)	To (ft)	Quantity (lbs or ft³)	Placement method

11. FLOWING ARTESIAN:
Flowing Artesian? ☐ Y ☒ N Artesian Pressure (PSIG) ______
Describe control device ______

12. STATIC WATER LEVEL and WELL TESTS:
Depth first water encountered (ft) ______ Static water level (ft) 84'
Water temp. (°F) ______ Bottom hole temp. (°F) ______
Describe access port Well CAp

Well test:

Drawdown (feet)	Discharge or yield (gpm)	Test duration (minutes)
	80gpm	

Test method: Pump ☐ Bailer ☐ Air ☒ Flowing artesian ☐

Water quality test or comments: ______

13. LITHOLOGIC LOG and/or repairs or abandonment:

Bore Dia. (in)	From (ft)	To (ft)	Remarks, lithology or description of repairs or abandonment, water temp.	Water Y	Water N
12"	0	4	Topsoil, Sand		X
12"	4	40	Lava		X
10"	40	75	Lava	X	
6"	75	225	Clay		X
6"	225	230	Lava		X
6"	230	237	Fractured Lava	X	
6"	237	240	Clay		X
6"	240	247	Lava	X	

RECEIVED
AUG 2 0 2010
Department of Water Resources
Eastern Region

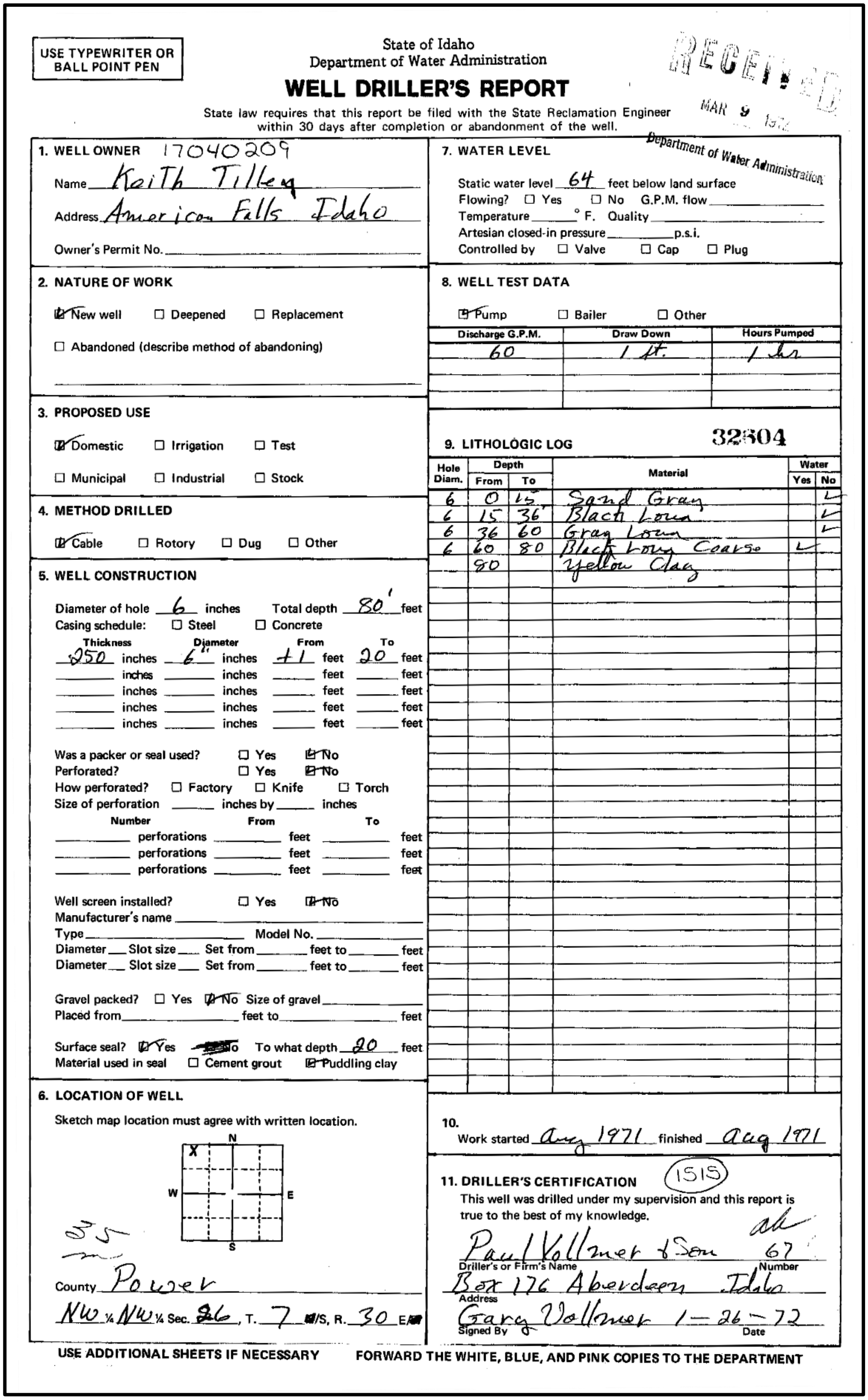
Completed Depth (Measurable): 247'
Date Started: 08-09-2010 Date Completed: 08-12-2010

14. DRILLER'S CERTIFICATION:
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Company Name Vollmer Drilling Co. No. 383
*Principal Driller [signature] Date 8-18-10
*Driller ______ Date ______
*Operator II [signature] Date 08/18/10
Operator I ______ Date ______

*** Signature of Principal Driller and rig operator are required.**

Figure 4.4: Gary Simms Well driller's report.



USE TYPEWRITER OR BALL POINT PEN

State of Idaho
Department of Water Administration

WELL DRILLER'S REPORT

RECEIVED
MAR 9 1972
Department of Water Administration

State law requires that this report be filed with the State Reclamation Engineer within 30 days after completion or abandonment of the well.

1. WELL OWNER 17040209

Name Keith Tilley

Address American Falls Idaho

Owner's Permit No. ______

2. NATURE OF WORK

☑ New well ☐ Deepened ☐ Replacement

☐ Abandoned (describe method of abandoning)

3. PROPOSED USE

☑ Domestic ☐ Irrigation ☐ Test

☐ Municipal ☐ Industrial ☐ Stock

4. METHOD DRILLED

☑ Cable ☐ Rotory ☐ Dug ☐ Other

5. WELL CONSTRUCTION

Diameter of hole 6 inches Total depth 80' feet

Casing schedule: ☐ Steel ☐ Concrete

Thickness	Diameter	From	To
.250 inches	6" inches	+1 feet	20 feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet

Was a packer or seal used? ☐ Yes ☑ No

Perforated? ☐ Yes ☑ No

How perforated? ☐ Factory ☐ Knife ☐ Torch

Size of perforation ______ inches by ______ inches

Number	From	To
perforations	feet	feet
perforations	feet	feet
perforations	feet	feet

Well screen installed? ☐ Yes ☑ No

Manufacturer's name ______

Type ______ Model No. ______

Diameter ___ Slot size ___ Set from ___ feet to ___ feet

Diameter ___ Slot size ___ Set from ___ feet to ___ feet

Gravel packed? ☐ Yes ☑ No Size of gravel ______

Placed from ______ feet to ______ feet

Surface seal? ☑ Yes ~~No~~ To what depth 20 feet

Material used in seal ☐ Cement grout ☑ Puddling clay

6. LOCATION OF WELL

Sketch map location must agree with written location.

N / W / E / S

35

County Power

NW ¼ NW ¼ Sec. 26, T. 7 N/S, R. 30 E/W

7. WATER LEVEL

Static water level 64 feet below land surface

Flowing? ☐ Yes ☐ No G.P.M. flow ______

Temperature ______ °F. Quality ______

Artesian closed-in pressure ______ p.s.i.

Controlled by ☐ Valve ☐ Cap ☐ Plug

8. WELL TEST DATA

☑ Pump ☐ Bailer ☐ Other

Discharge G.P.M.	Draw Down	Hours Pumped
60	1 ft.	1 hr

9. LITHOLOGIC LOG 32304

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
6	0	15	Sand Gray		✓
6	15	36'	Black Lava		✓
6	36	60	Gray Lava		✓
6	60	80	Black Lava Coarse	✓	
	80		Yellow Clay		

10. Work started Aug 1971 finished Aug 1971

11. DRILLER'S CERTIFICATION (1515)

This well was drilled under my supervision and this report is true to the best of my knowledge.

Paul Vollmer & Son — Driller's or Firm's Name — Number 67

Box 176 Aberdeen Idaho — Address

Gary Vollmer — Signed By — 1-26-72 — Date

USE ADDITIONAL SHEETS IF NECESSARY

FORWARD THE WHITE, BLUE, AND PINK COPIES TO THE DEPARTMENT

Figure 4.5: Tilley Well driller's report.

Figure 4.6: Gary Simms domestic observation well.

The Simms well has an existing vented KELLER Submersible Level Transmitter situated in a small diameter PVC standpipe located in the well casing. The transducer is connected to a data logger that records and stores single point water level readings every 6 seconds as well as temperature and an average water level reading every 2.6 minutes. The pipe exiting the pump is fitted with a McCrometer UltraMag magnetic flow meter, also reporting to the installed data logger. This flowmeter measures instantaneous flow and total flow.

Two domestic wells in close proximity to the pumping well (244 and 344 feet) were used as observation wells. The "Gary Simms Well" (Figure 4.6) is an active domestic well and the "Tilley Well" (Figure 4.8), contains a domestic pump, but it is not in use. Owners of the wells were contacted and agreed to allow transducers to be temporarily installed in their wells. In-Situ Inc., non-vented, Level TROLL® 400 transducers with a range of 197 feet were installed in both observation wells prior to pumping. Measuring points (MPs) were collected for each well in reference to the land surface and an electric tape was used to determine the water levels in each well prior to installing the transducers. The data can be viewed in Table 4.1 below:

Table 4.1: Pumping test well information

Well	Casing Depth	Open Interval	Depth to Water (ft)	MP (ft)	Water Level Below LSD	Transducer Depth Below Water Level	Transducer Depth below LSD (ft)
Simms	318	80	67	0	67		
Gary Simms	225	24	79.23	1.72	77.51	12.56	89.8
Tilley	20	60	2.21	-3.83'	6.04	9.08	15.12

The Tilley Well, located in T07S, R30E, Sec. 23, SWSW is approximately 344 feet to the north west of the pumping well with a total depth of 80 feet. The coordinates for the well are Lat. 42° 47’ 31.021” and Long. 112° 55’ 12.553”. The well is located in an earthen and concrete shelter below land surface (Figure 4.7). The Gary Simms Well is located in T07S, R30E, Sec. 26, NWNENW, 244 feet west of the pumping well. The coordinates for the well are Lat. 42° 47’ 27.3”, Long. 112° 55’ 08.1”. This well was deepened in 2010 and has a diameter of 6 inches and is 247 feet deep.

Figure 4.7: The Tilley observation well shelter.

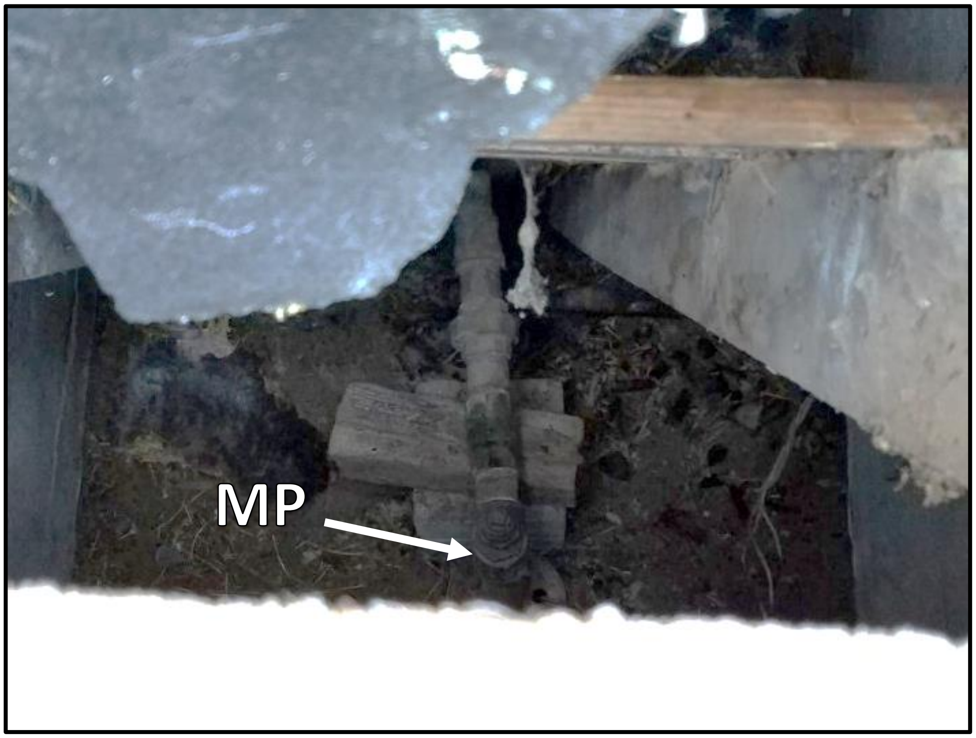


Figure 4.8: The Tilley observation well measuring point.

4.3. Testing

An In-Situ Inc. BaroTROLL® with a 15 PSI range was installed in the well shelter of the Tilley observation well prior to testing. This transducer was set to record a barometric reading every 15 minutes. The Simm's Well was started on Nov. 6, 2017 at 8:04 am with the expectation of pumping for a duration of 24 hours. The starting totalizer reading was 1,080,648k Gal or 3316.4 AF and the instantaneous flow was approximately 3.7 cfs or 1660 gallons per minute. During the test, water was diverted down the existing canal and spilled into the Snake River. Due to freezing conditions, the pump and canal were checked regularly during testing to ensure proper operation of the pump and ice build-up within the canal did not result in flooding. The Simm's Well pump was stopped at 9:14 am, Nov. 7, 2017. Data loggers in the observation wells recorded water levels until 9:00 am, Nov. 8, 2017 to capture any recovery that may have occurred once the pumping had stopped. Recovery data was also collected from the Simm's Well since the data transducer continuously records water levels.

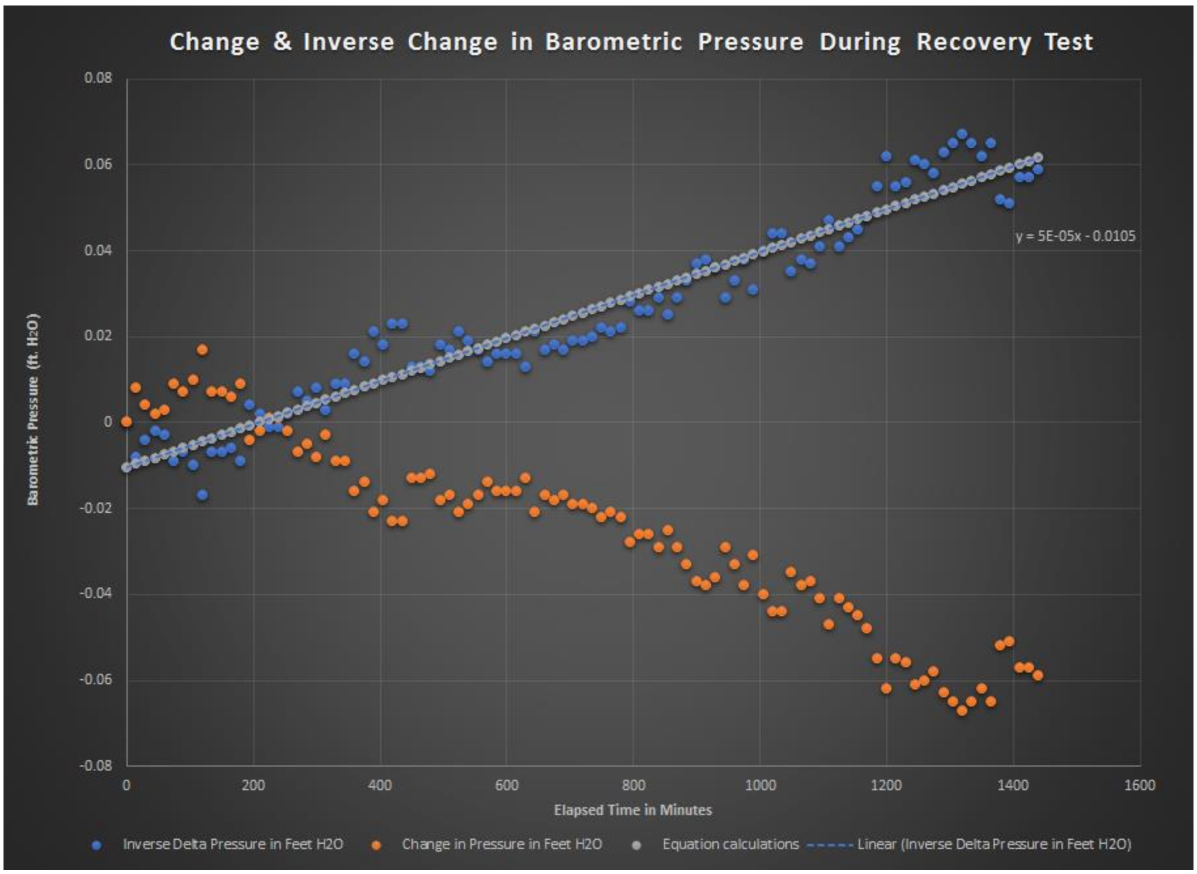
Figure 4.9: The Simm's Well during the pumping test.

4.4. Results

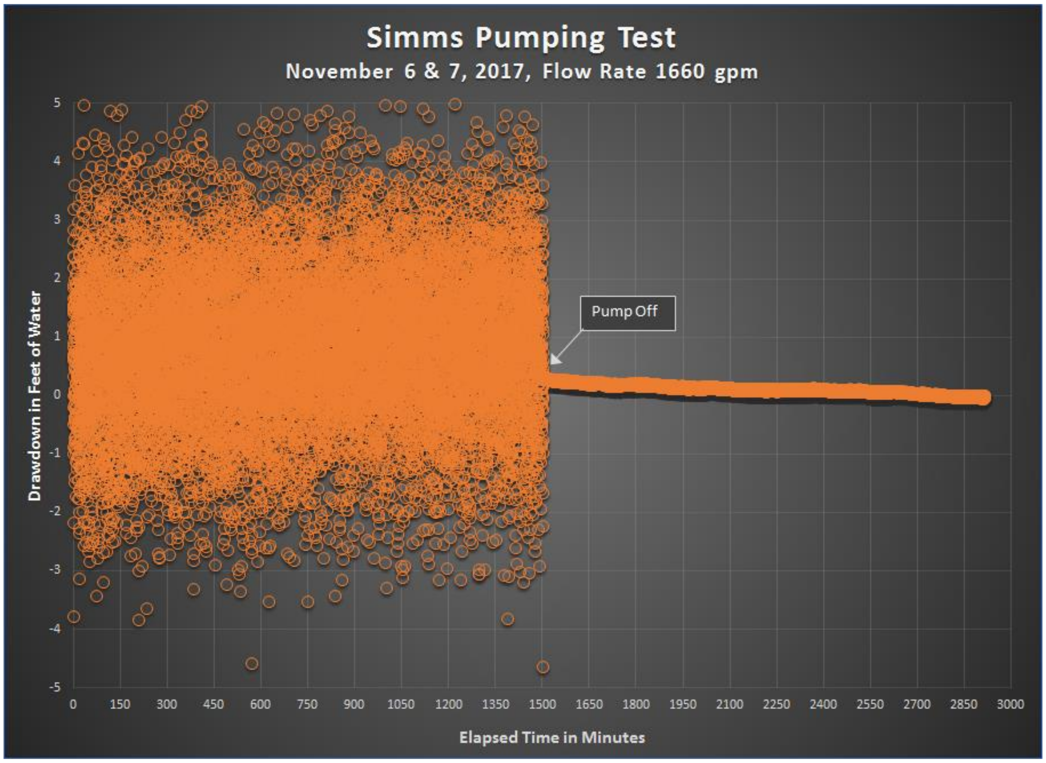
All transducer data from the pumped and observation wells was downloaded and processed to be put in terms of elapsed time, drawdown and water level elevation. Barometric corrections were made on the pumped well recovery test and the observation well data (Graph 4.1).

There was a substantial amount of noise in the Simms Well drawdown data created by the running pump. The pump surged the water column in the well vertically about 10.5 feet, making it impossible to reliably process the drawdown test (Graph 4.2). The recovery data is much less noisy and does allow for standard aquifer test analysis (Graph 4.3). Based on the recovery test, the total drawdown was approximately 0.4 ft. A drawdown of 0.4 feet at 1660 gpm yields a specific capacity of 4150 gpm/ft.

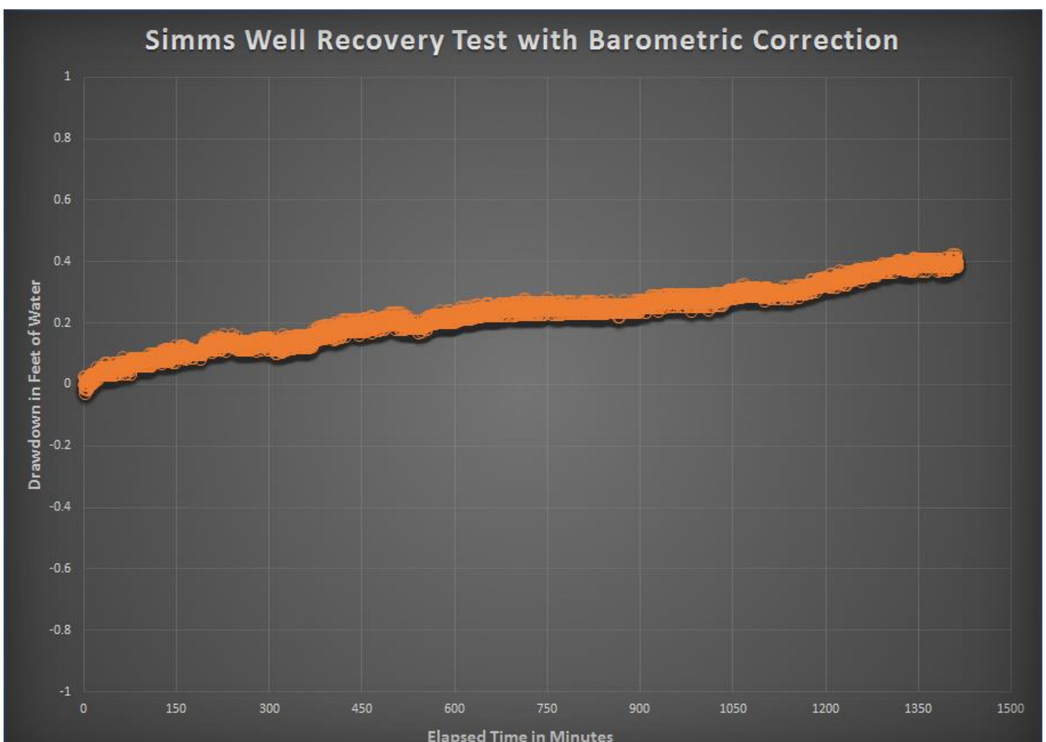
The water level was impacted in the Tilley well when the pump was turned on at about 500 minutes and at about the same time the removal pressure transducer from the well for a short time disrupted the data record (Graph 4.4). When the pressure transducer was reinstalled in the well it did not return to the same depth and causing a step in the plot of the data set. The data set from the observation wells could not be processed because there was no measurable drawdown. The most likely reason for this is that the aquifer is too transmissive to create a cone of depression that extends to the observation wells. Another reason is that the observation wells are not in hydraulic communication with the pumped well.



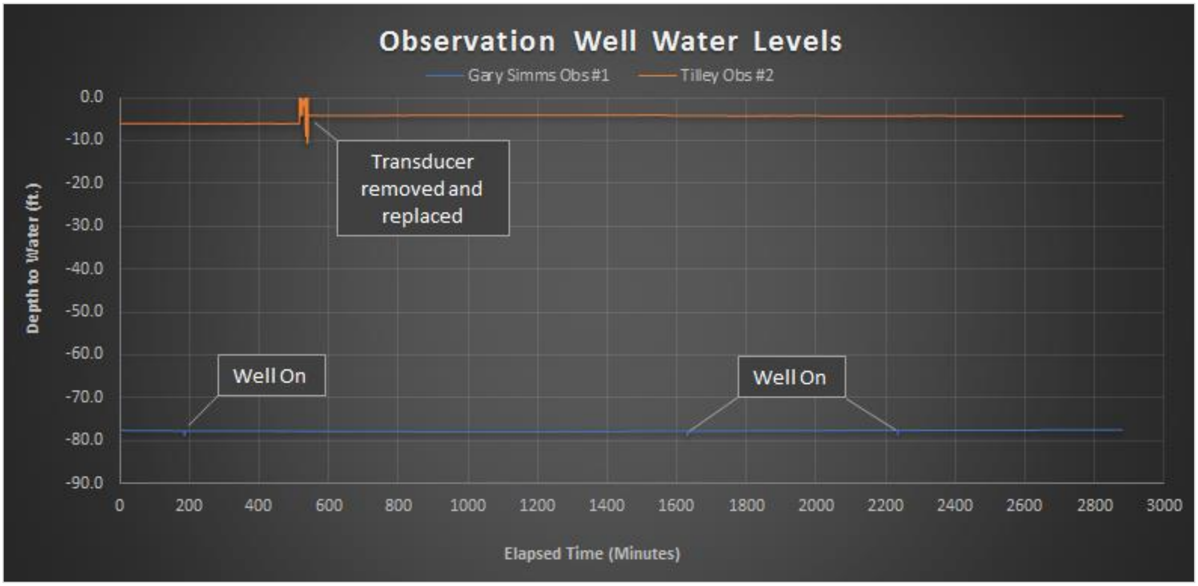
Graph 4.1: Plot of barometric pressure in feet of water vs. time during the Simm's well pumping test.



Graph 4.2: Simm's Well water levels during pumping and recovery test.



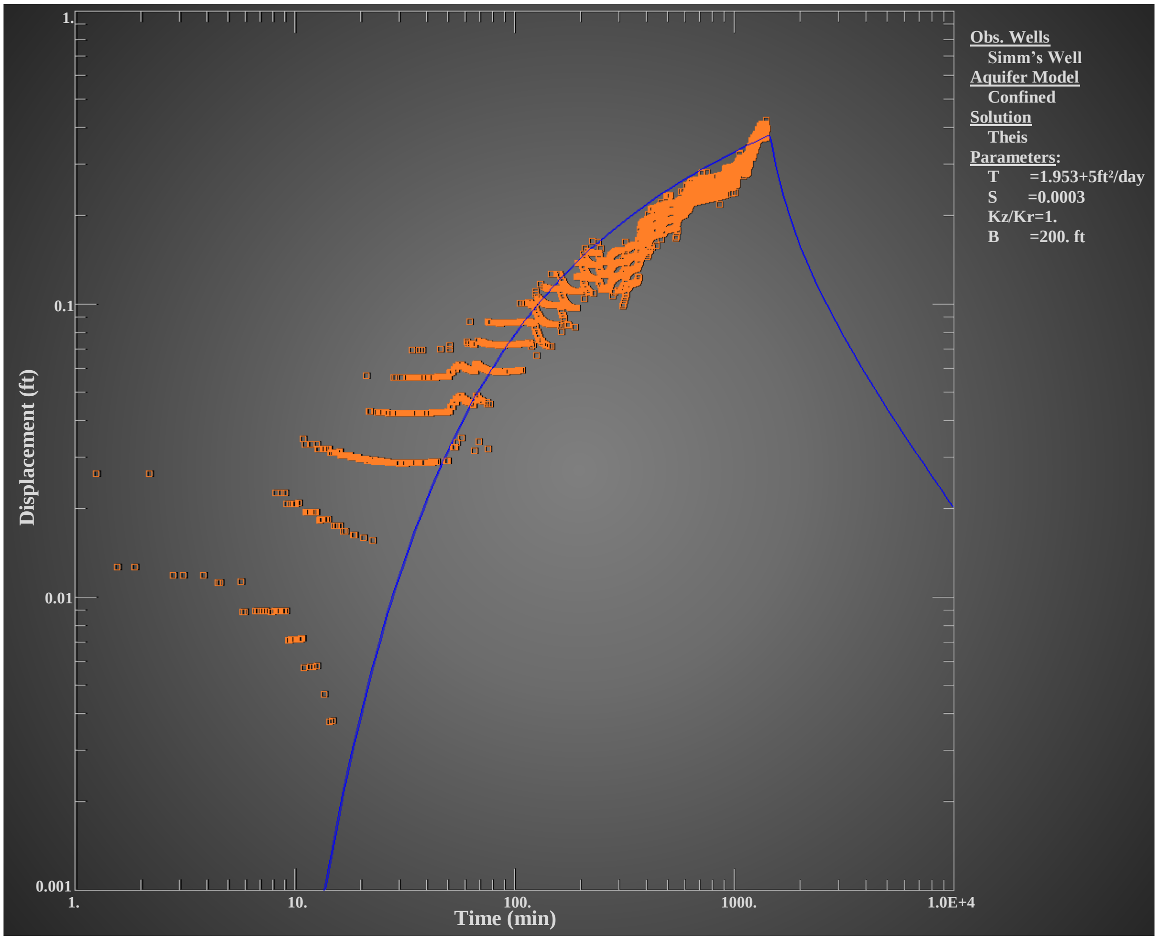
Graph 4.3: Simm's Well recovery test plot with barometric corrections showing drawdown in feet of water vs. elapsed time. Test was performed November 6 & 7, 2017 with a flow rate of 1660 gpm.



Graph 4.4: Observation well water levels during pumping and recovery testing.

The recovery test data were processed using the commercially available software AQTESOLV®. Several standard analytical solutions were employed for the analysis and none of the matches to the data by the type curves were strong. This is probably due to a combination of factors: 1) the pumping rate was not high enough to stress the aquifer sufficiently relative to its very high transmissivity; 2) the observation wells were not impacted and data from them could not be used; 3) noise generated by the well pump overwhelmed the signal in the drawdown data set making it impossible to use half the pump test data (i.e. only the recovery data set could be used); and 4) the heterogeneous and isotropic nature of the fractured rock aquifer are not a good match for the conceptual models of standard aquifer test analytical solutions.

The match of the recovery data to the standard Theis solution is presented in (Graph 4.5). As can be seen, the match to the type curve is poor caused by many if not all of the factors mentioned above. The calculated transmissivity is 2 x 10^5 ft^2/day and the aquifer storativity is 0.0003. It is noted that storativity values from single well pumping tests are generally considered to have a high level of uncertainty.

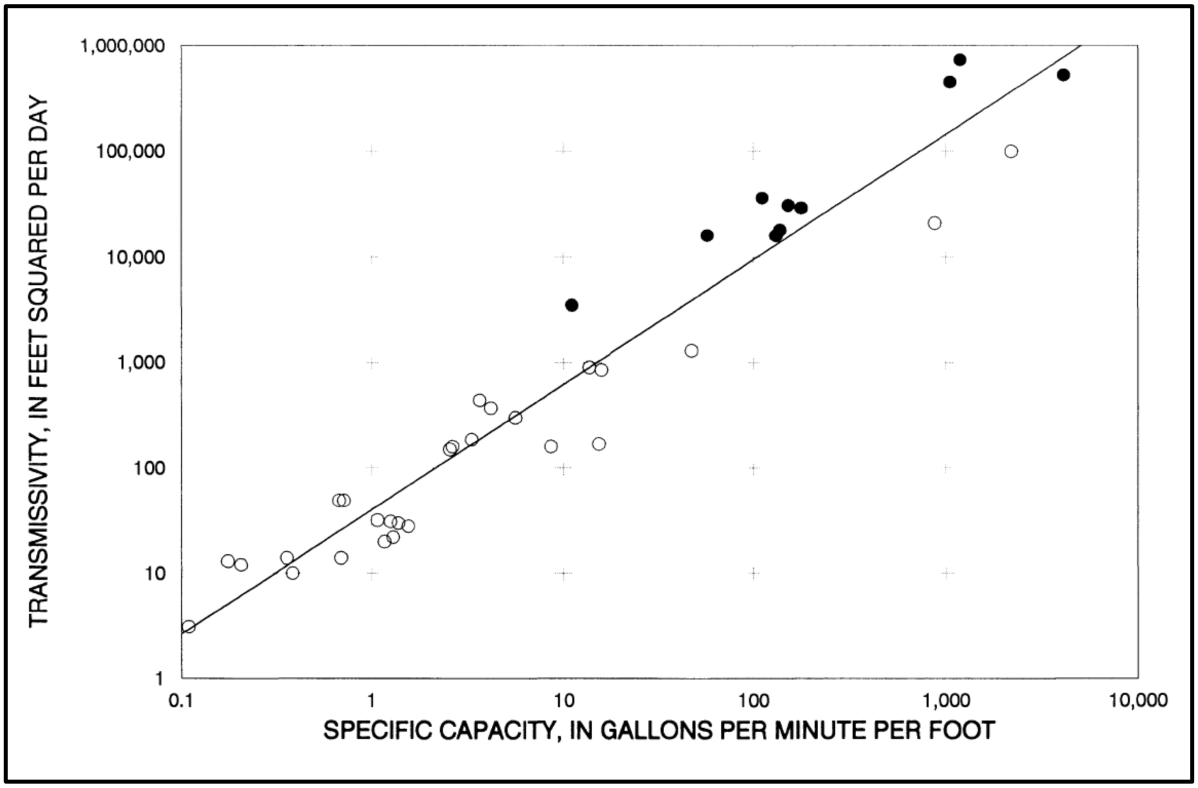


Graph 4.5: Type curve match to the Theis analytical solution using AQTESOLV®.

4.5. Discussion

The Simm's pumping test data set is subject to several limitations, most notably is that the pumping rate was too low for the aquifer transmissivity and there was not enough drawdown created in the pumped well relative to the noise level and there was no measurable drawdown in the observation wells. Nevertheless, the results of the pumping test of an aquifer transmissivity of 2 x 10^5 ft^2/day is in good agreement with other highly transmissive wells on the ESRP. Consider Graph 4.6 from Ackerman 1991. The Simm's well plots near the extreme high end of the aquifer pumping test data analyzed by Ackerman. This suggests that aquifer transmissivity values in the Pleasant Valley area are some of the highest in the region.

The implication for recharge from canal seepage is that the underlying aquifer in this area can easily “take” the high seepage loss documented in this study without showing a significant rise in water levels.



Graph 4.6: Transmissivity estimates from specific capacity data for wells at the Idaho National Laboratory. Solid symbols are Theis type-curve data, open symbols are Neuman type-curve data. Red open circle is where the Simm's data plots on the Ackerman dataset. From Ackerman (1991), Figure 8.

CHAPTER V. REGIONAL GROUNDWATER LEVELS

Regional groundwater levels have been measured and are available through the USGS, IDWR, and other sources. Since IDWR staff is often stretched thin and ASCC is interested in well data surrounding the canal, ASCC collects transducer data in wells that both entities have agreed to monitor and IDWR provides transducers and oversight. For this examination, the majority of water level data used was collected by both ASCC and IDWR from 2009 through spring 2018 (with the exception of the O'Brien and Simm's wells). Non-vented, In-Situ TROLL™ series data loggers were installed in 18 of the wells reviewed and a vented transducer is installed in the remaining well. Temperature and water levels are recorded twice daily at 12-hour intervals. In the absence of a transducer (if one is lost or is not available at the time measurements are required), manual measurements were taken until a transducer was installed. A barometric data logger was also placed in a centrally located well (Crumley) and used in barometric corrections. Data collection is ongoing.

5.1. Well Descriptions & Locations

IDWR and ASCC entered a memorandum of agreement in 2009 in a joint effort to collect data from monitoring wells in the vicinity of the Aberdeen-Springfield Canal. Many of the wells selected are shallow and domestic, however a couple penetrate into the deep aquifer. A variety of used, unused, domestic, irrigation and monitoring well types are monitored and spread from just south of Aberdeen to north of Blackfoot (Figures 5.1 & 5.2.) Information and locations of wells present in the monitoring network can be viewed in . Over recent years, the "O'Brien" and "Simm's" well have been added to the monitoring efforts by ASCC.

Table 5.1: Monitoring Well Data Table

Name	Well ID	Longitude	Lattitude	Casing Depth (ft.)	Open Interval (ft.)	MP	LSD	Well Depth
#11 Dwight Horsch	06S 31E 09AAB1	-112.8328055	42.92152868			0.8	4402	140.5
#17 USGS at Sandavol	05S 31E 19DDC2	-112.8708873	42.96660636			1.5	4420	120
#24 Wayne Lyman	05S 31E 08ADD1	-112.8498464	43.00328113		77-100	1.33	4456	100
#27	04S 31E 26CCC1	-112.8065655	43.03909086			-5.66	4432	n/a
#36 Thompson Brothers	04S 32E 10CBC1	-112.7109782	43.08506705			1.3	4448	52.4
#73 U of I	05S 31E 27ABA1	-112.8160678	42.96563151	51.15	13.85	0.5	4399	65
Blackfoot Airport	02S 35E 34BDBA1	-112.3493732	43.20693671			1.42	4481	138
Blackfoot Park	02S 35E 33DACB1	-112.3604593	43.20163566			0.75	4477	65
Crumley Rd	03S 33E 25CCC1	-112.5540626	43.12475744	185	25 (504-529)*	1.5	4450	637
Driscoll	04S 31E 36ABA1	-112.7788640	43.03834085			1	4401	18
Hilton	03S 33E 31DBD1	-112.6397123	43.11426733	18	54 (18-72)	1.42	4500	72
Leonard Phillips	04S 31E 13BDB1	-112.7817389	43.07848840			2	4447	n/a
O'Brien	04S 31E 33AAA1	-112.8286419	43.03682720			1.5	4438	51.5
Rose	02S 35E 11DDD1	-112.3176896	43.25449237	113	15 (79-94)*	2.58	4518	682
Simms	07S 30E 26BBA1	-112.9198032	42.79104955	318	80 (318-398)	0	4365	398
Stecklein	04S 33E 20CBB1	-112.6337121	43.05918884	61	4	2	4420	65
Taylor	03S 34E 02BCC1	-112.4547921	43.19064153	100.5	164.5 (100.5-265)*	1.28	4446	707
V Lat 2 Upper	05S 31E 14CCD1	-112.8041049	42.98125137	156	10 (156-166)	2.33	4403	166
V Lat 4 Lower	05S 31E 14CCD2	-112.8040968	42.98117774	64	6 (59-64)	1.96	4403	67

***Only intervals monitored with transducers are displayed in monitoring wells with multiple open intervals**

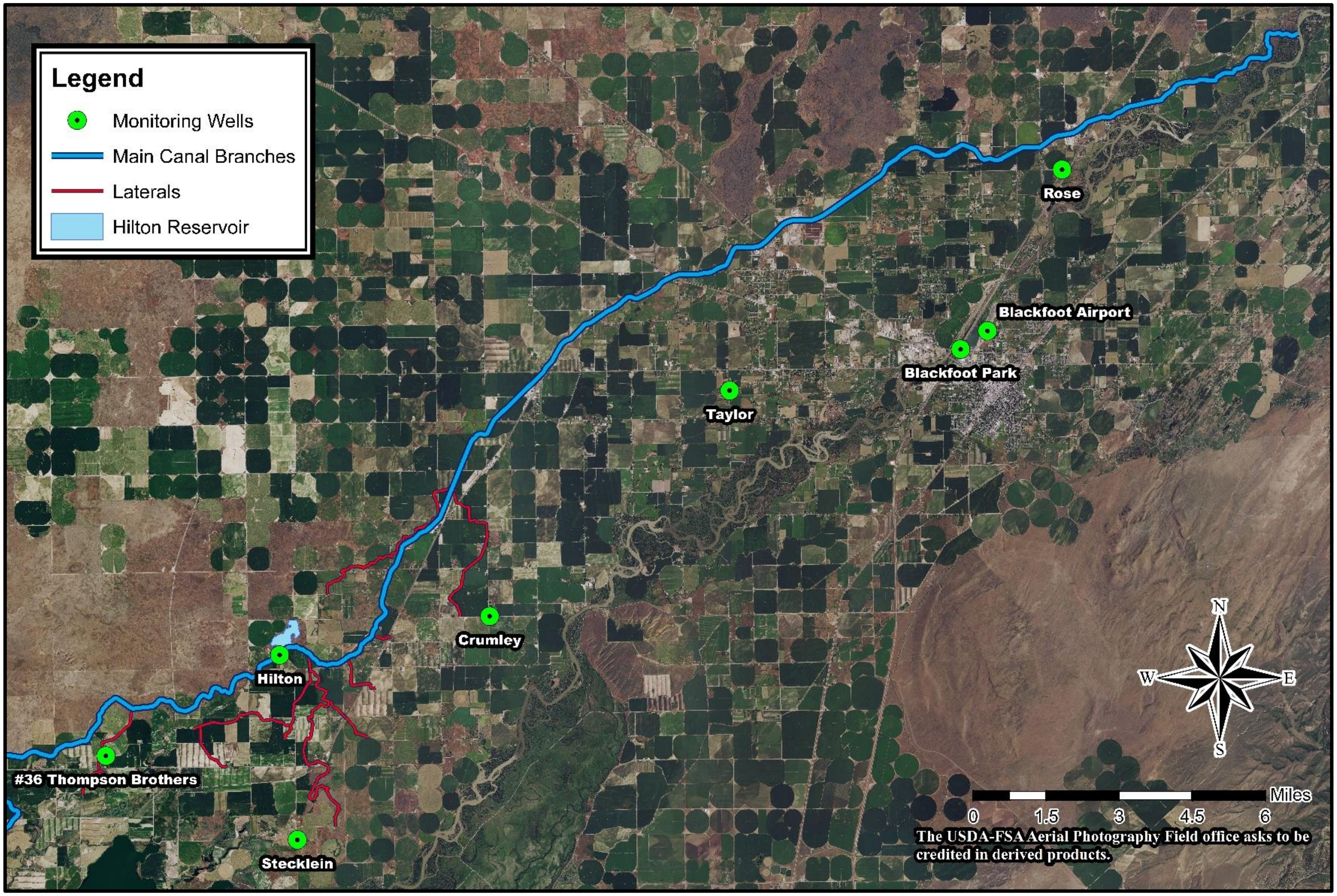


Figure 5.1: Map of monitoring wells located in the upper portion of the canal system.

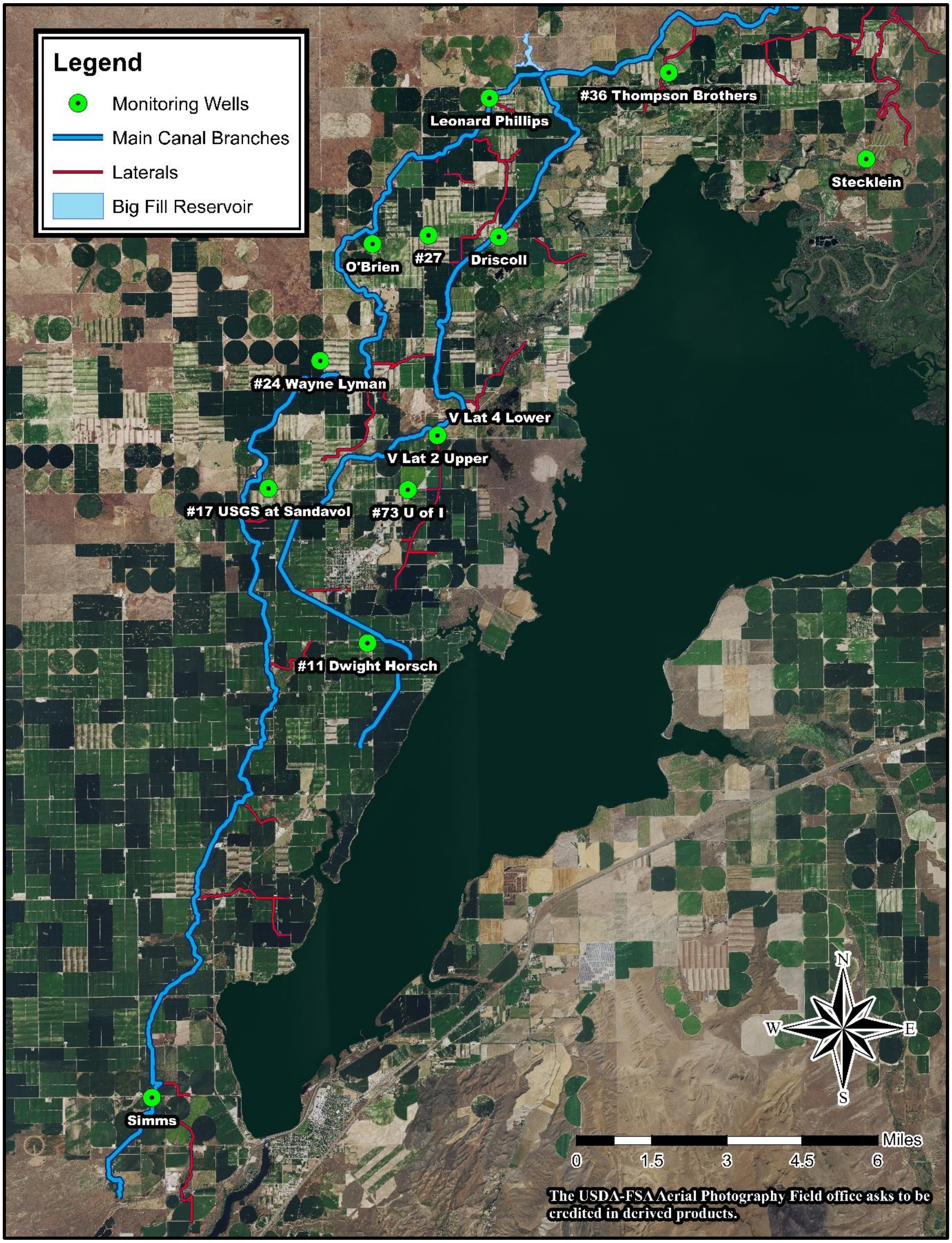


Figure 5.2: Map of monitoring wells located in the lower portion of the canal system.

5.2. Hydrographs

Transducers were downloaded at least twice annually in April and November and, in earlier years, monthly. Groundwater levels were read using an electric tape and input directly into the transducer's electronic data file during the field data collection process. Post-processing of data included exporting all data files into spreadsheets and applying barometric corrections using data obtained from a barometric data logger centrally located in the Crumley well. Total depth of water in feet above each transducer was converted from the transducer recordings using the "Level Depth" mode described by the transducer manufacturer (Smith, 2012). Transducer elevations were determined from each manual field measurement obtained and each 12-hour measurement recorded by the transducer was then added to the calculated transducer elevation. All points collected were plotted and data averaging was limited to one well (Simms) because data was collected in 5-minute intervals which was too cumbersome for graphing.

Three wells, Rose, Taylor and Crumley are multi-level in nature and multiple intervals are monitored through manual tape measurements because transducers will not fit in the well holes (Table 5.2). Groundwater elevations recorded are consistent with levels in holes containing transducers with the exception of the Rose well. In this well, groundwater levels in deeper holes share values that are approximately 20-40 feet lower, with seasonal variation, than the upper hole where the transducer is situated, demonstrating a vertical hydraulic gradient.

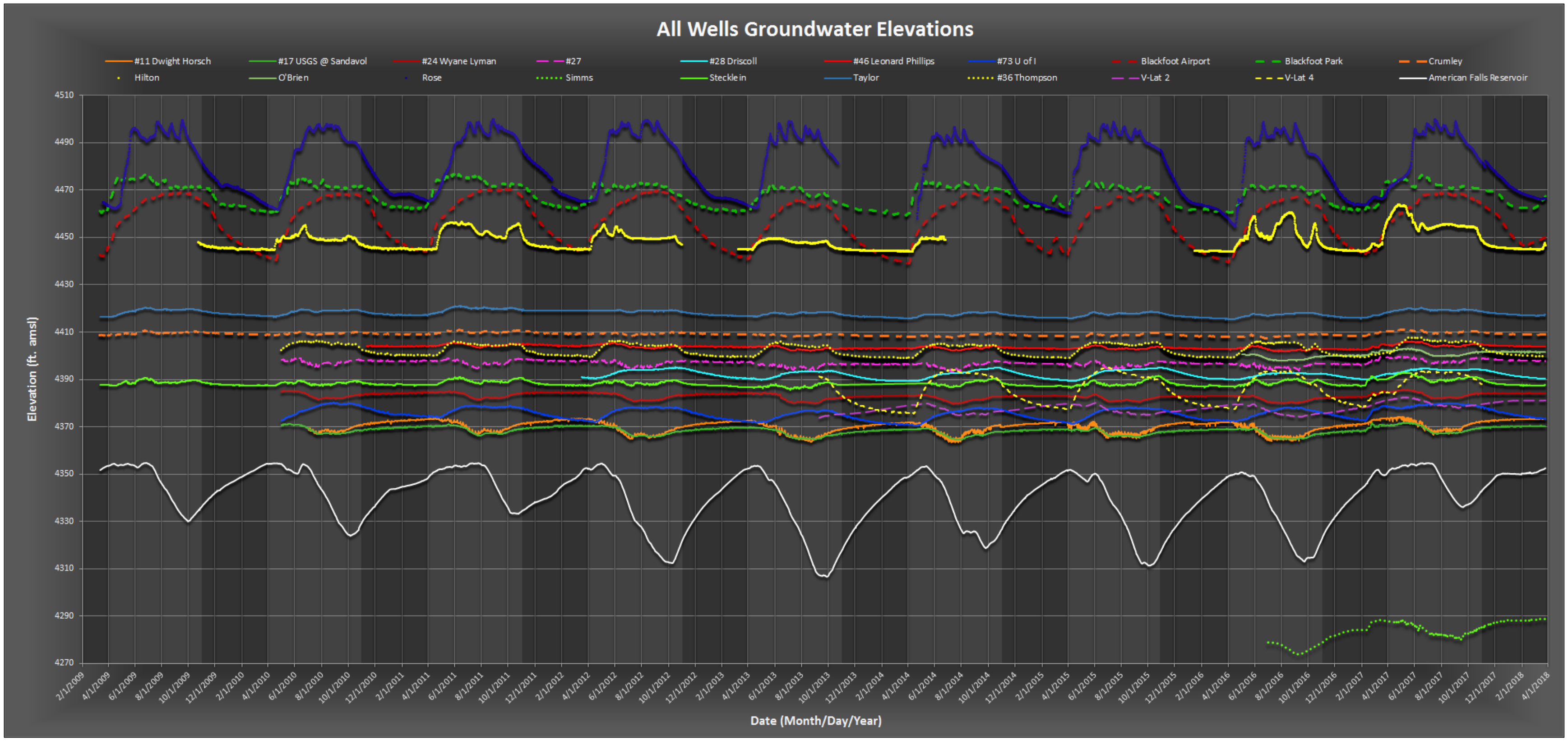
Table 5.2: Depth of holes in multi-level wells.

Name	Depth of Hole #1	Depth of Hole #2	Depth of Hole #3	Depth of Hole #4
Crumley Rd	529	637		
Taylor	265	565	707	
Rose	113	390	630	682

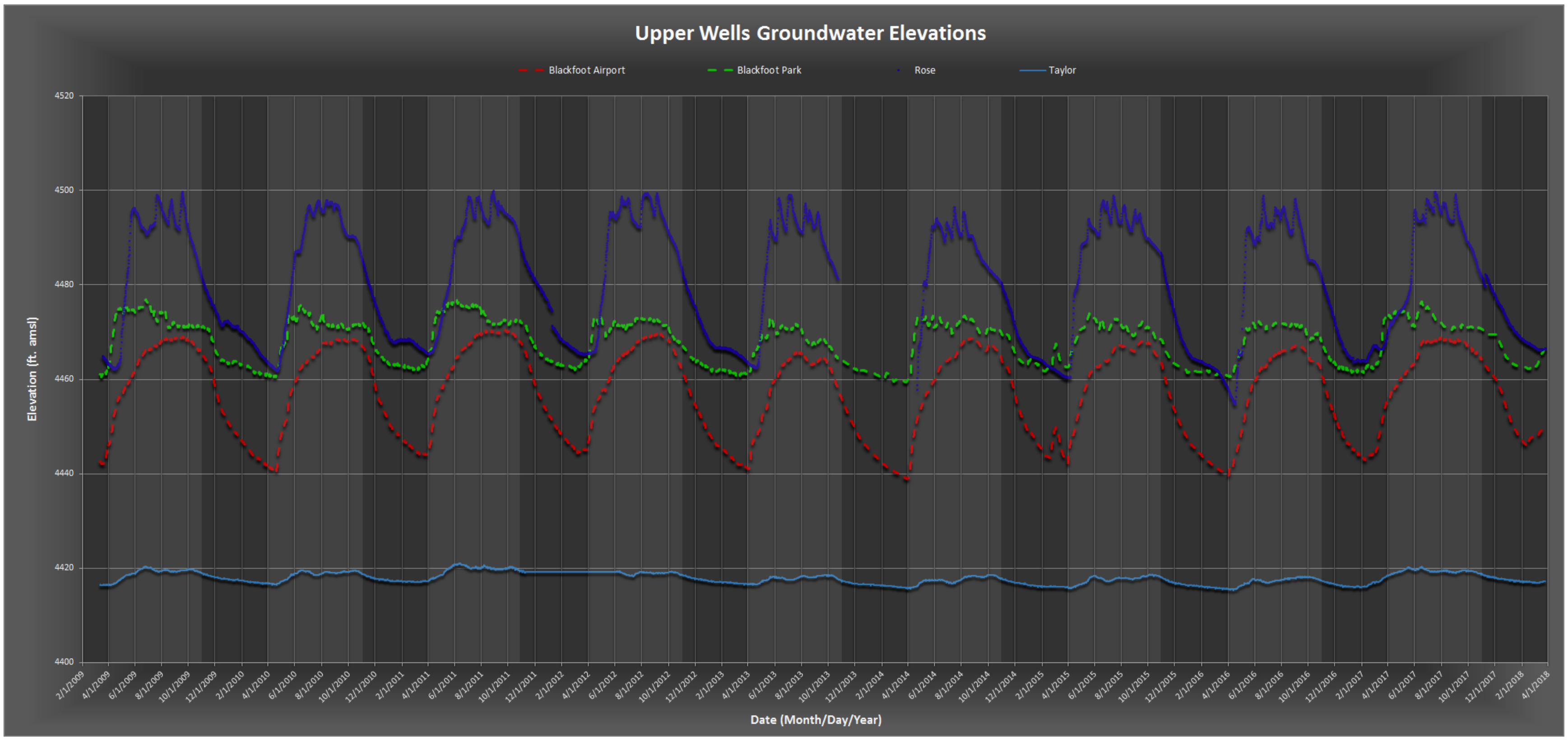
A total of 20 hydrographs were developed as part of this effort including groundwater elevations for 19 monitoring wells and American Falls Reservoir elevations. They are displayed on a single graph for ease of comparison (Graph 5.1) and grouped in accordance with geographic location (Graphs 5.2-5.5). The land surface elevation changes approximately

150 feet over the monitored region and it should be noted when viewing Graph 5.1 that groundwater elevations are reflective of the geographic location of each well. Sharp spikes observed in some hydrographs were attributed to pumping during or before the time of measurement. In some wells, transducers fell to the bottom of the well which has resulted in data gaps. Ongoing efforts are underway to recover lost transducers.

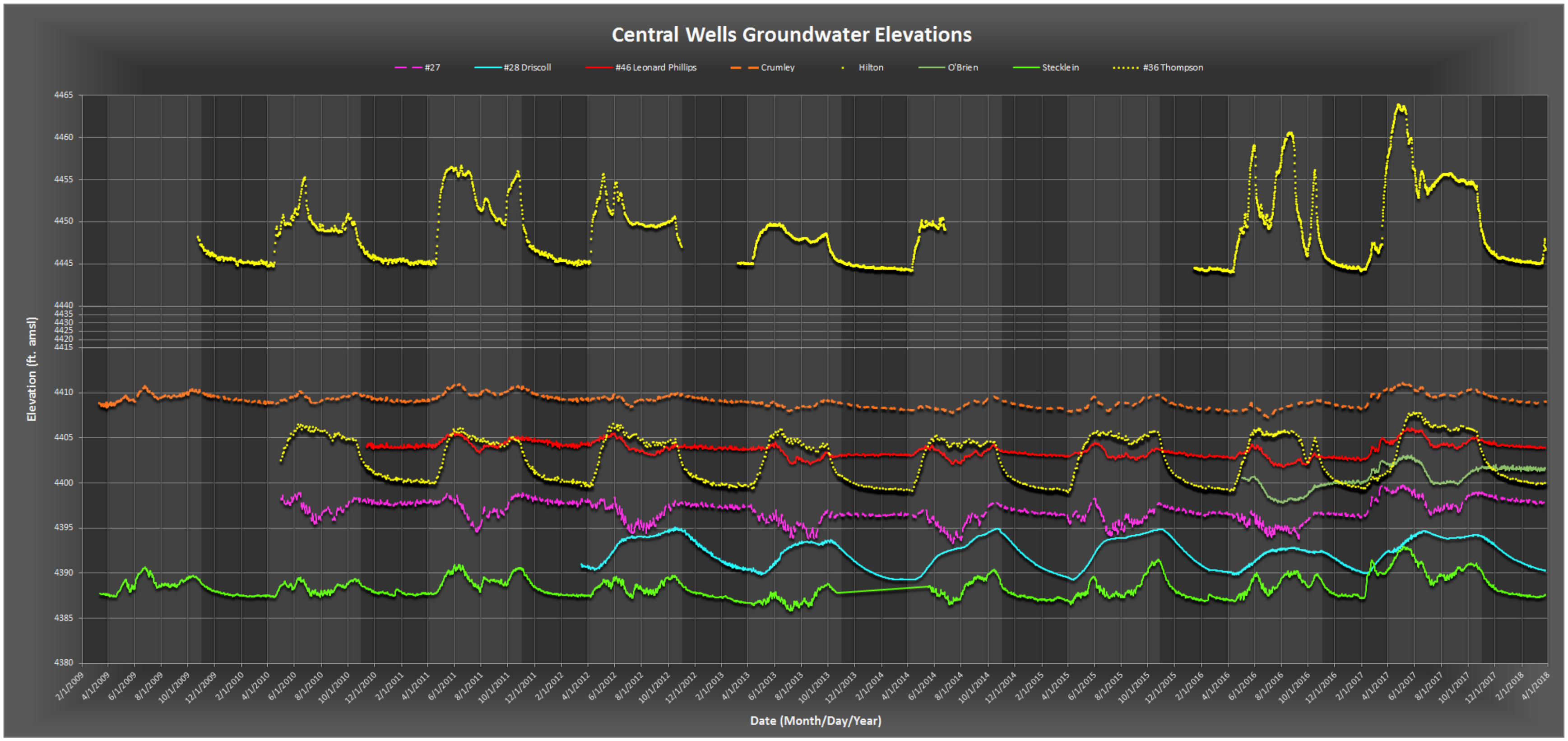
The differences in the character of the hydrographs is most likely caused by the aquifer transmissivity and/or the communication of the well monitored with the regional aquifer. For example, wells that tap zones isolated from the regional aquifer with low transmissivity may respond/recover more slowly, allowing a greater head to develop in response to canal seepage. For short periods of time, the zone will build and retain head until water is transmitted through confining layers. The magnitude of seasonal hydraulic gradient fluctuation in the wells with regard to their proximity to the canal and the impact on the response of groundwater levels to canal seepage has been well documented in Holder, 2009.



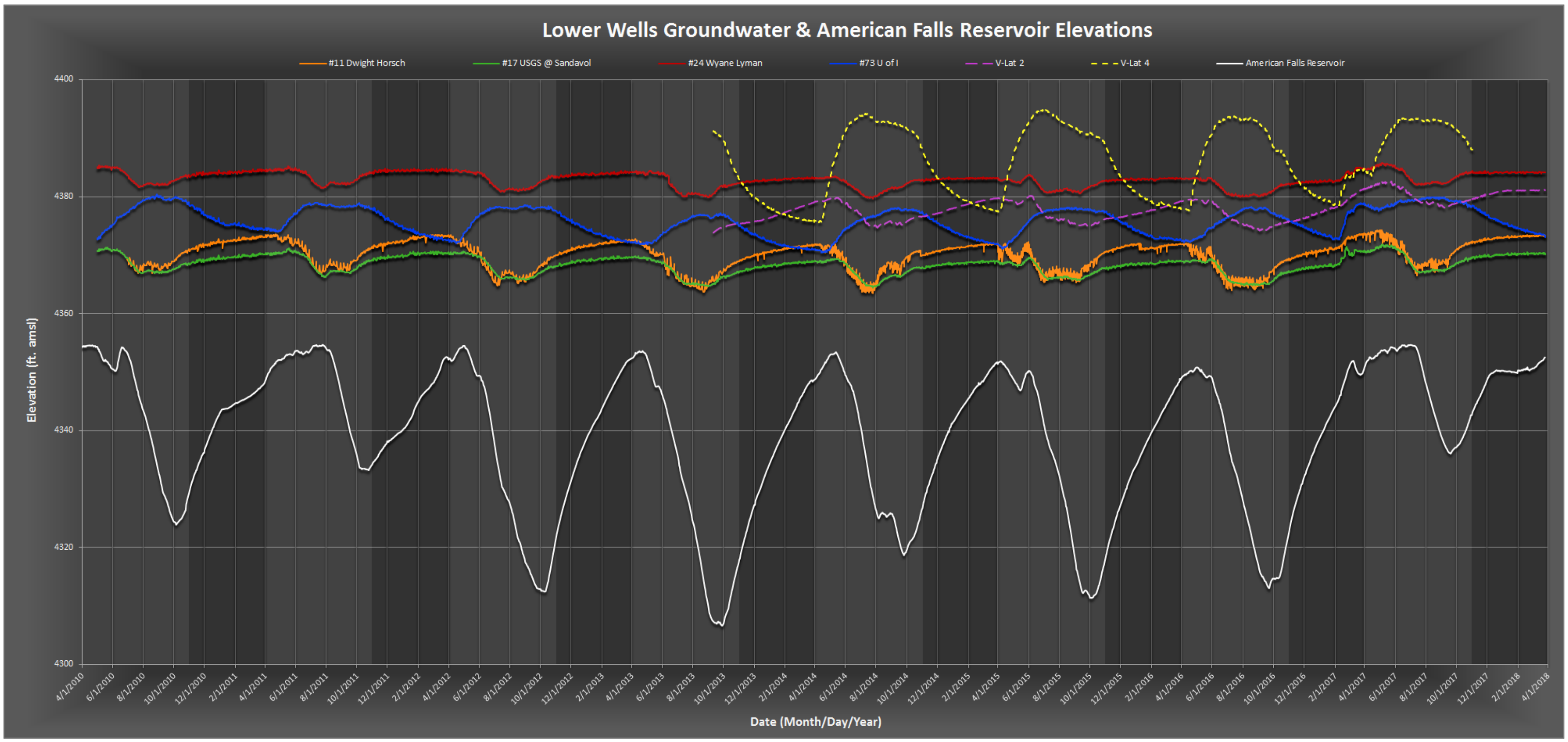
Graph 5.1: Water level elevations above mean sea level of all monitoring wells and American Falls Reservoir from Spring 2009 through Spring 2018. The irrigation season beginning April 1 and ending November 1 has been highlighted.



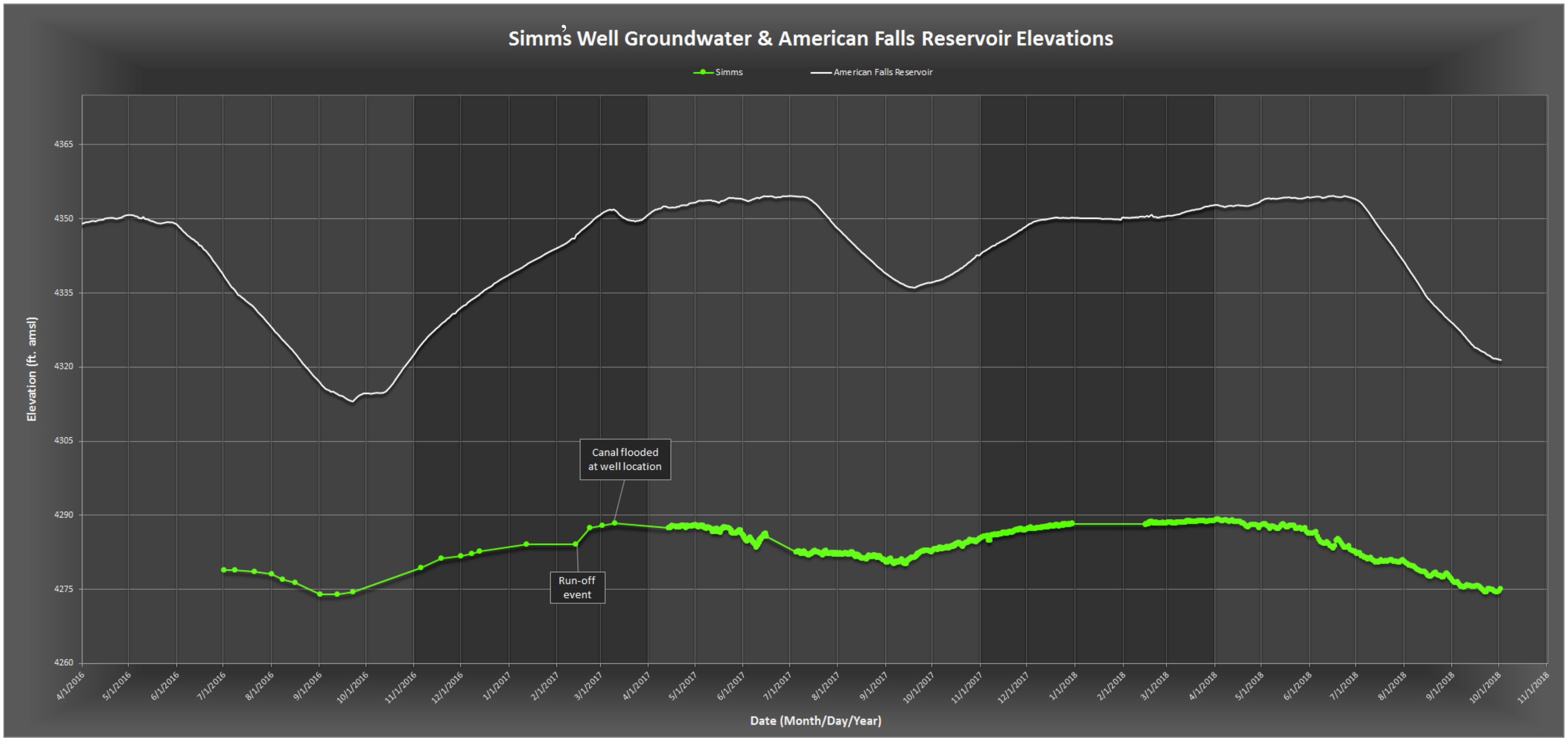
Graph 5.2: Water level elevations above mean sea level of four monitoring wells located near the upper portion of the canal system from Spring 2009 through Spring 2018. The irrigation season beginning April 1 and ending November 1 has been highlighted.



Graph 5.3: Water level elevations above mean sea level of monitoring wells located in the central portion of the canal system from Spring 2009 through Spring 2018. The irrigation season beginning April 1 and ending November 1 has been highlighted and the graph has been compressed from 4415-4440 feet amsl for ease of hydrograph comparison.



Graph 5.4: Water level elevations above mean sea level of four monitoring wells located near the lower portion of the canal system from Spring 2009 through Spring 2018. The irrigation season beginning April 1 and ending November 1 has been highlighted.



Graph 5.5: Elevations above mean sea level of water levels in the Simm's monitoring well and American Falls Reservoir from Spring 2016 through Fall 2018. The irrigation season beginning April 1 and ending November 1 has been highlighted and 2017 Spring runoff events have been marked.

5.3. Observations

Groundwater levels do not appear to exhibit much, if any, overall change from 2009 to present which agrees with IDWR's reported regional water level changes of 0-5 feet during the 1980-2008 (Figure 2.10). Regionally, groundwater levels do not display the same level of decline since the 1950's represented in Figure 1.4. A contributing factor to the insulation of the aquifer water levels from decadal drought cycles may be seepage from the ASC.

Lands northwest of the reservoir show seasonal groundwater elevation variation, "obviously related to irrigation on the Aberdeen-Springfield tract west of the reservoir" (Mundorff, 1967). From 2009 to 2018, the character of well hydrographs has continued to follow historic patterns consistent with seasonal canal seepage. As described previously, the magnitude and timing of seasonal variation in water levels is inconsistent among the wells and this was described previously by Whitehead in 1992. He attributed variations in the shape of hydrographs to the nature of aquifer confinement, although generally unconfined, the ESPA may (regionally) behave as a confined aquifer.

Other authors have attributed the presence of intermittent clay layered within the region as potential causes of seasonal variation in well responses. In past studies, individual well behaviors were categorized as either high-responding or low responding to seasonal changes in canal seepage (Holder, 2009) and losses from the canal recharge the shallow aquifer (Welhan & Poulson, 2009).

Of particular interest is well 5S31E27ABA1 (#73 U of I) since prior research has been accomplished correlating temporal variations in Danielson Creek (Kjelstrom, 1988) and groundwater discharge to the American Falls Reservoir Reach (Mundorff, 1967) with this well. When #73 U of I groundwater levels are plotted alongside American Falls Reservoir water levels and nearby wells, annual changes in water levels track well with the "V-Lat 4" well (Graph 5.4). The V-Lat 4 well is 1.24 miles from #73 U of I and the two wells have depths of 67 and 65 feet, respectively. The V-Lat 4 well is situated 50 feet from the V-Lateral and 700 feet downgradient from the Lowline Canal where averaged measured losses were

12.7 cfs. The "V-Lat 2" well is 25 feet from V-Lat 4 with a depth of 166 feet but shows a very different seasonal response. The V-Lat 2 well log indicates a 23-foot clay layer is present at 130-153 feet below the land surface however its horizontal extent is unknown. Danielson Creek originates immediately downgradient from the ASC and the Hilton Spill/Recharge Reservoir. High loss rates were measured in this region (Figure 5.3) and large sinkholes often emerge in the basalt canal base (Steve Howser, personal communication, July 2016). Large fluctuations in groundwater levels in the Hilton Well (located adjacent to the Hilton Spill/Recharge Reservoir) are correlated with spill and recharge introduced to the reservoir (Aberdeen-Springfield Canal Company, 2009-2018) and similar changes of a smaller magnitude can be observed in the nearby #36 Thompson well. The referenced hydrographs above, flow lines generated from 2017 August groundwater levels, and loss rates quantified in this study indicate seepage losses from the canal contribute to Danielson Creek flows and the seasonal variation observed in the #73 U of I well groundwater levels.

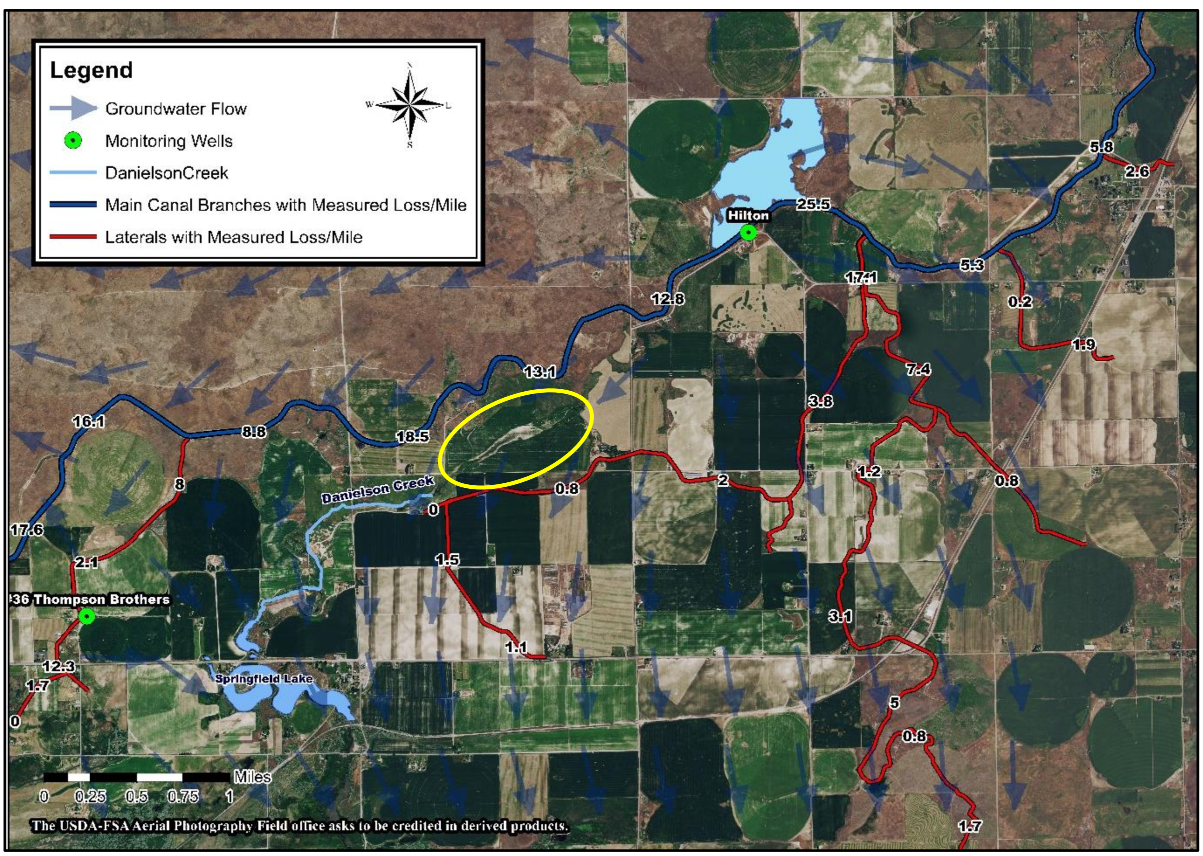


Figure 5.3: Map of measured canal losses (in cfs/mi) adjacent to Danielson Creek, Springfield Lake and the Hilton Spill/Recharge site with groundwater flow lines created from Aug. 2017 groundwater levels. Damage to crops in the field NW of the springs where Danielson Creek originates is circled in yellow. When large quantities of recharge occur at the Hilton Reservoir, as in 2017, "sumping" in the field is typical.

CHAPTER VI. SUMMARY

Measurements of discharge, flow velocities and seepage rates per mile of the Aberdeen-Springfield Canal were completed for 210 site locations during the summer of 2017. Our findings included large seepage loss rates occurring under peak system demands as high as 658.4 cfs. Some variability in seepage loss rates is expected to occur throughout the irrigation season since the total seepage loss of 195,069.2 af calculated (using ASCC operation logs) during the 2017 irrigation season requires an average loss of 514.9 cfs. Investigations to resolve uncertainties in calculations of evaporation and evapotranspiration from bank vegetation found that only 19.6 cfs, or 2.9%, of measured loss rates could be attributed to evaporation and evapotranspiration. There does not appear to be a major contributing factor causing annual water loss in the ASC other than leaky canal substrate. For example, in 2017, the ASC conveyance efficiency (including a significant amount of recharge water as a deliverable) was 38% but dropped to 31.1% when recharge was removed from consideration.

The work presented herein has defined most of the components needed for the ASCC capacity model along with aquifer properties that will allow further modeling of annual volumes contributed to adjacent aquifer(s) and reach gains. Ackerman (1995) noted during a subsurface flow study, “Most improvement in the estimates of ground-water flow directions and travel times for advective flow could be gained by better estimates of recharge from surface-water irrigation.” The results of this study can also aid in calculations of groundwater travel times, water budgets, and aquifer properties for ASCC managers, IDWR and other ESPA Stakeholders.

Losses from the Aberdeen-Springfield Canal system have benefitted Near Blackfoot to Neeley reach gains, the regional aquifer, local springs and the adjacent reservoir since the canal’s inception in the early 1900’s and continue to do so. This study shows that the canal seepage is largely driven by the geologic makeup of the subsurface beneath and adjacent to the canal. The locations of large seepage losses measured herein are consistent with springs and reach gain contributions where they have broadly been attributed in past studies. These, combined with direct surface water contributions in the form of operational spills are also substantial. Our best estimate of direct groundwater inputs through seepages losses from the canal is 195,000 af annually. State sponsored recharge efforts have averaged 249,022 af/year with an average conveyance cost of $1,971,035/year (2014-2018). From 2013-2019 over $20 million dollars has been allocated for recharge infrastructure (Wesley Hipke, personal communication, November 2018). The amount of recharge that can be accomplished by the state is dependent on water supply and often limited whereas canal seepage is a consistent source of recharge. The face that ASCC has "donated" larger yearly volumes, on average, to the aquifer than the State of Idaho has after spending millions of dollars begs the question of, "Why should ASCC spend hundreds of thousands of dollars to line or pipe leaky canals that will reduce aquifer recharge?"

The application of I.C. §42-228 and IDWR recovery permit conditions limit the recovery of canal seepage by ASCC via wells which, in turn, promotes lining and managed recharge. This may have an effect on the even distribution of recharge to the aquifer by ASCC and other canals. If canals with large losses were lined and recharge to the aquifer was only accomplished at specified sites, increased "mounding" of groundwater at recharge locations and pumping in areas previously supported by recharge due to losses could potentially result in imbalanced groundwater levels in portions of the ESPA. Such "mounding" has already resulted in crop loss due to flooded fields in and around the Hilton Reservoir. Statutes and policies that provide benefit for losses, however small, to water entities such as ASCC may prevent the inevitable reduction of recharge to underlying aquifers and reaches through lining and piping activities. Through this, existing water balances between water users may be preserved.

Additional work is needed to refine the numbers presented in this report, most importantly, the uncertainty in measurements needs to be further addressed. Uncertainty will be critically important when considering and modeling the ASCC capacity model. Refinement of variables influencing canal seepage loss rates will further identify water saving strategies.

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APPENDIX 1: WD120 & GWD 2017 REPORT

WMIS #	Reporting District	Annual Groundwater Diversion Volume (AF)				
		2013	2014	2015	2016	2017
101548	120	0	0	0	0	0
200915	120	8.00	0	0	0	0
210000	120	19.30	9.13	5.38	0	5.45
101544	120	82.97	26.02	131.86	222.51	346.58
101545	120	584.80	566.43	489.85	406.35	338.43
101546	120	184.82	266.05	194.18	413.21	331.25
101547	120	0.03	0.01	0.05	0.02	0.02
101798	120	692.40	772.14	1057.53	831.08	569.19
200097	120	0	0	0	0	0
200102	120	3.73	0	4.57	3.74	2.21
200244	120	44.51	68.02	63.33	66.26	55.40
200246	120	0	0	0	0	186.34
200614	120	329.56	393.81	304.38	314.11	349.91
200685	120	2723.38	2660.79	2537.11	2679.53	2293.12
200916	120	0	0	0.03	0.06	0.36
210011	120	656.64	686.49	481.74	568.61	559.82
210014	120	341.71	292.50	331.40	251.89	266.75
210016	120	462.17	122.78	91.73	41.36	5.87
210017	120	711.81	199.32	121.40	84.74	71.59
410104	120	0	0	0	0	0
600033	120	542.86	491.97	468.11	399.08	306.91
600039	120	339.44	270.86	280.00	276.40	258.59
600102	120	244.05	149.99	165.48	180.06	128.91
600193	120	350.02	369.29	350.46	70.80	329.93
600203	120	346.37	268.06	305.23	305.05	266.04
600204	120	280.46	266.35	261.50	209.86	258.81
600213	120	324.81	317.93	294.44	314.35	294.81
600258	120	232.85	171.89	168.22	122.31	132.88
600275	120	484.64	380.61	368.95	417.71	299.41
600276	120	265.64	254.63	251.10	301.28	207.24
1000030	120	0	0	0	0	0
1000034	120	0	0	0	0	0
1000346	120	0	0	0	0	0
1000347	120	0	0	0	0	0
1001760	120	0	0	0	0	0
1001761	120	0	0	0	0	0
1001771	120	0	0	0	0	0
1001772	120	0	0	0	0	0
1001779	120	0	0	0	0	0
1001800	120	0	0	0	0	0
1001812	120	0	0	0	0	0
1001894	120	0	0	0	0	0
1001895	120	0	0	0	0	0
1003200	120	0	0	0	0	0
1003201	120	0	0	0	0	0
1003221	120	0	0	0	0	0
200421	AAG	0	0	0	0	0
200430	AAG	160.31	214.64	206.27	218.96	190.27
200431	AAG	237.06	249.78	175.64	146.86	168.38
200483	AAG	0	0	0	0	0
200806	AAG	0	0	287.32	228.49	214.19
200809	AAG	177.72	101.83	118.36	141.94	88.24
210015	AAG	0	0	425.00	228.76	0
600004	AAG	566.95	583.08	470.26	327.80	494.78
600005	AAG	0	0	0	0	0
600006	AAG	445.13	412.90	384.35	316.21	290.02
600007	AAG	0	0	0	0	0
600009	AAG	610.57	465.64	439.91	547.10	568.19
600010	AAG	210.98	256.16	285.32	346.19	319.81

600011	AAG	673.06	715.71	855.04	681.14	730.16
600015	AAG	703.93	556.32	570.73	597.38	533.14
600016	AAG	215.14	245.05	202.50	236.60	164.95
600017	AAG	443.52	395.29	310.21	445.58	276.20
600018	AAG	133.24	146.81	135.41	149.47	131.19
600019	AAG	214.30	211.10	4.38	164.93	70.87
600022	AAG	0	0	0	0	0
600023	AAG	752.59	648.63	679.98	726.90	675.11
600025	AAG	320.64	289.64	233.31	226.43	265.79
600026	AAG	282.58	283.84	187.87	189.61	151.60
600027	AAG	277.88	259.49	232.33	216.64	235.30
600028	AAG	581.67	351.18	392.23	312.79	157.75
600029	AAG	0	0	0	0	0
600030	AAG	749.14	616.55	509.43	547.08	651.54
600032	AAG	847.97	738.59	786.62	719.20	463.09
600034	AAG	0	0	0	0	0
600037	AAG	209.16	194.69	202.89	149.09	121.32
600040	AAG	399.26	381.85	393.34	324.57	248.50
600041	AAG	656.96	521.06	736.80	432.54	264.94
600042	AAG	875.38	762.08	643.80	579.99	632.48
600043	AAG	646.11	723.48	809.81	648.46	521.87
600044	AAG	166.32	159.48	196.98	157.01	147.29
600045	AAG	443.40	371.74	350.08	431.44	340.56
600046	AAG	281.41	262.71	322.92	320.12	306.86
600047	AAG	0	0	0	0	0
600048	AAG	0	0	0	0	0
600049	AAG	195.29	207.33	326.32	172.47	201.31
600050	AAG	350.94	445.08	286.06	459.03	284.35
600051	AAG	278.99	226.74	223.87	187.56	198.77
600052	AAG	739.68	707.72	174.44	149.75	149.93
600053	AAG	376.49	435.31	679.35	455.47	403.75
600055	AAG	835.54	835.38	1065.64	1068.60	737.72
600056	AAG	500.20	605.41	768.67	508.05	516.51
600057	AAG	535.04	493.96	402.24	501.51	417.88
600058	AAG	473.50	278.93	462.75	422.30	425.13
600059	AAG	516.05	640.49	739.71	402.70	460.54
600060	AAG	374.84	363.03	305.25	293.79	178.77
600061	AAG	225.93	244.03	244.35	322.87	207.47
600063	AAG	621.47	659.08	677.51	660.28	550.91
600064	AAG	0	0	0	0	0
600068	AAG	0	0	0	0	0
600069	AAG	0	0	0	0	0
600070	AAG	0	326.08	0	0	0
600071	AAG	522.19	395.00	385.06	470.76	260.31
600072	AAG	881.19	619.04	635.53	643.73	482.50
600075	AAG	430.60	528.22	436.87	535.57	446.91
600076	AAG	476.82	269.25	327.75	279.87	299.31
600077	AAG	293.77	272.34	318.38	217.71	251.63
600078	AAG	380.22	407.39	365.56	488.10	296.88
600079	AAG	305.72	311.35	489.37	341.82	420.73
600080	AAG	292.49	354.93	262.25	301.05	316.58
600081	AAG	224.15	158.02	167.31	196.18	133.45
600082	AAG	341.47	209.50	109.57	156.89	180.72
600083	AAG	236.63	184.02	195.29	161.28	206.59
600084	AAG	390.92	166.96	348.47	246.32	304.63
600085	AAG	0	0	0	0	0
600087	AAG	202.24	144.44	249.84	108.83	68.30
600088	AAG	378.40	227.67	180.48	216.01	260.51
600090	AAG	390.33	340.17	351.06	280.24	282.28
600092	AAG	633.02	640.02	574.96	606.39	532.89
600095	AAG	505.47	695.29	809.08	774.90	767.25
600096	AAG	259.21	240.34	229.85	272.06	234.57
600097	AAG	349.42	236.48	223.54	260.81	179.59
600098	AAG	548.81	326.30	290.93	322.53	441.98
600099	AAG	432.14	519.14	587.82	453.67	412.52

600100	AAG	144.02	126.67	106.04	82.45	212.59
600101	AAG	370.90	311.01	347.09	276.62	0
600103	AAG	206.12	156.40	145.01	201.20	140.46
600104	AAG	123.44	159.09	316.46	251.77	232.20
600105	AAG	253.83	232.33	154.29	198.81	144.62
600106	AAG	144.05	143.76	136.01	121.21	102.15
600108	AAG	457.78	363.13	481.81	464.06	434.78
600109	AAG	60.34	0	0	22.65	0
600110	AAG	217.16	156.42	131.55	98.57	134.18
600111	AAG	252.44	211.05	207.16	160.67	152.72
600112	AAG	304.76	297.36	452.11	280.00	97.79
600113	AAG	347.80	432.84	351.98	310.75	296.46
600114	AAG	191.29	179.85	226.67	148.80	138.99
600115	AAG	198.37	144.34	221.08	195.11	125.92
600116	AAG	333.20	375.86	421.41	361.88	284.53
600117	AAG	319.52	341.09	283.81	294.25	291.55
600118	AAG	116.39	147.01	109.93	125.96	118.67
600119	AAG	152.06	172.49	203.07	199.71	132.94
600120	AAG	163.88	193.79	120.30	215.46	130.00
600121	AAG	244.63	208.74	239.15	232.86	182.27
600122	AAG	25.83	25.58	23.84	29.44	31.86
600123	AAG	368.60	409.83	405.41	355.23	256.45
600125	AAG	57.41	20.59	21.90	20.65	18.99
600126	AAG	59.94	41.89	64.06	35.82	44.16
600128	AAG	0	0	0	0	0
600129	AAG	678.50	679.26	505.98	613.45	507.06
600131	AAG	85.12	73.53	90.14	76.80	65.78
600132	AAG	372.32	424.32	370.28	453.68	526.59
600134	AAG	0	0	0	0	0
600135	AAG	285.10	230.67	243.79	291.37	179.43
600136	AAG	380.22	355.16	352.04	363.06	300.07
600140	AAG	324.69	371.16	405.04	305.80	364.01
600142	AAG	261.95	196.31	171.55	282.40	143.62
600143	AAG	0	0	441.95	452.64	255.17
600144	AAG	102.93	86.93	186.46	145.83	134.37
600145	AAG	285.06	320.58	274.92	336.12	256.00
600147	AAG	0	0	0	42.70	0
600151	AAG	438.76	276.70	307.79	316.77	296.81
600152	AAG	221.18	210.11	223.58	158.16	183.05
600153	AAG	133.69	119.24	134.31	142.08	100.43
600154	AAG	184.14	176.49	189.45	123.47	186.90
600156	AAG	103.33	136.34	113.78	107.59	92.48
600157	AAG	49.10	45.61	36.89	36.11	35.86
600159	AAG	323.09	180.10	265.42	262.33	229.64
600160	AAG	261.11	216.53	212.50	232.64	173.95
600161	AAG	781.89	481.97	548.64	462.35	653.20
600162	AAG	125.37	118.84	204.10	135.67	111.18
600163	AAG	379.70	368.03	220.90	283.99	225.77
600164	AAG	295.44	200.84	134.75	197.71	197.29
600165	AAG	578.46	554.89	676.84	459.08	413.22
600166	AAG	0	0	0	0	0
600167	AAG	656.88	460.90	442.31	630.24	336.24
600169	AAG	0	113.69	116.56	143.67	99.49
600170	AAG	492.20	490.31	667.19	410.02	251.30
600171	AAG	548.24	483.02	354.24	327.14	316.15
600173	AAG	545.00	576.70	765.93	486.64	587.08
600174	AAG	798.57	660.49	541.42	339.51	294.80
600184	AAG	573.09	734.50	593.63	631.92	414.24
600185	AAG	423.46	414.21	476.74	473.17	327.47
600186	AAG	668.05	549.72	628.26	340.82	643.97
600187	AAG	373.15	379.63	342.18	345.14	142.26
600188	AAG	524.37	442.20	491.08	395.98	250.98
600189	AAG	738.56	678.68	756.21	625.18	387.75
600190	AAG	0	0	0	0	0
600192	AAG	1369.41	1314.77	1116.59	976.76	744.64

600195	AAG	1034.88	871.60	981.62	1061.61	820.19
600196	AAG	534.54	468.55	728.29	409.58	431.09
600197	AAG	559.45	372.06	405.05	546.92	373.17
600198	AAG	507.52	476.59	555.84	516.33	569.68
600199	AAG	259.83	323.07	207.49	328.67	364.12
600200	AAG	745.00	417.40	449.49	499.28	520.52
600201	AAG	401.09	352.81	511.75	461.33	374.22
600202	AAG	10.85	0	0	0	0
600205	AAG	407.34	364.89	406.95	350.36	358.29
600206	AAG	692.72	438.77	466.96	528.48	613.22
600207	AAG	397.37	386.42	368.09	403.34	240.25
600208	AAG	394.91	302.48	314.24	362.37	258.39
600209	AAG	486.26	481.62	416.82	456.58	330.99
600210	AAG	350.48	283.58	0	195.13	209.56
600211	AAG	524.07	469.44	559.43	458.38	466.87
600212	AAG	597.79	545.92	677.84	640.80	504.62
600214	AAG	305.08	273.18	243.13	283.16	229.30
600218	AAG	122.80	666.00	435.98	647.55	697.02
600219	AAG	312.72	340.46	258.80	333.71	267.15
600220	AAG	262.96	225.56	281.48	233.23	181.55
600221	AAG	334.41	287.72	271.40	156.52	165.08
600222	AAG	250.56	237.88	229.34	325.78	263.62
600223	AAG	298.26	375.23	367.11	251.81	319.23
600224	AAG	272.53	172.17	277.81	174.06	175.29
600225	AAG	123.86	184.01	93.93	83.78	114.64
600226	AAG	390.00	440.64	386.27	379.90	251.72
600227	AAG	628.44	636.62	568.57	383.33	443.63
600228	AAG	0	31.08	42.01	40.81	19.68
600229	AAG	711.54	484.23	517.76	397.54	393.73
600230	AAG	224.30	209.19	248.19	186.70	195.83
600231	AAG	365.72	244.26	294.31	305.72	392.87
600234	AAG	0	0	0	0	0
600235	AAG	221.05	167.46	165.52	155.13	221.05
600236	AAG	226.31	182.16	302.29	133.94	181.71
600237	AAG	614.13	515.59	638.81	350.03	485.93
600238	AAG	566.45	583.52	536.62	636.24	428.27
600239	AAG	340.42	466.74	513.02	681.28	374.98
600240	AAG	233.35	248.11	246.00	179.05	197.96
600241	AAG	475.42	416.71	455.80	537.23	365.64
600242	AAG	298.95	277.03	384.18	252.94	289.04
600243	AAG	522.08	559.96	618.64	544.76	535.85
600244	AAG	286.66	362.34	441.10	335.40	315.42
600246	AAG	299.11	148.80	184.20	126.97	105.36
600247	AAG	86.35	61.83	57.34	67.49	61.99
600248	AAG	319.13	262.24	314.19	233.41	273.63
600249	AAG	166.74	159.02	166.74	130.22	116.95
600250	AAG	446.52	420.90	481.81	498.18	406.02
600251	AAG	236.36	284.32	0	79.50	1369.71
600252	AAG	882.60	918.23	742.02	829.22	762.75
600253	AAG	1003.73	665.42	291.67	662.77	611.90
600254	AAG	495.15	207.04	146.55	163.33	235.61
600256	AAG	447.54	458.40	299.24	383.66	282.63
600257	AAG	247.98	162.90	198.83	102.27	140.36
600259	AAG	272.93	214.01	303.94	247.00	227.68
600260	AAG	256.73	252.16	351.60	264.38	177.15
600261	AAG	651.53	469.13	654.17	507.68	508.63
600262	AAG	325.45	182.89	231.15	166.09	270.06
600263	AAG	450.52	426.13	394.37	360.78	463.14
600264	AAG	205.04	149.34	181.08	197.24	156.48
600265	AAG	199.99	199.22	169.78	167.72	143.01
600266	AAG	207.46	129.12	187.07	122.68	164.29
600267	AAG	216.43	225.21	170.65	219.43	200.97
600269	AAG	96.59	91.41	100.54	96.73	64.92
600270	AAG	745.10	517.98	522.33	543.00	377.37
600272	AAG	437.22	337.94	355.45	395.97	304.99

600273	AAG	254.17	284.32	206.71	244.84	229.26
600274	AAG	250.92	251.81	199.91	283.80	184.00
600277	AAG	444.91	359.85	362.85	0	0
600278	AAG	0	0	0	0	0
600279	AAG	316.94	302.51	296.76	266.48	314.58
600280	AAG	356.25	402.62	349.03	352.82	341.12
600281	AAG	228.78	179.89	246.22	157.14	199.12
600282	AAG	129.56	137.02	115.42	69.98	106.71
600283	AAG	265.17	250.38	247.04	205.25	213.10
600284	AAG	31.84	26.78	0	0	0
600285	AAG	732.21	481.15	542.62	559.17	393.65
600286	AAG	307.72	258.75	295.64	211.78	270.66
600288	AAG	364.31	301.98	341.45	283.94	406.80
600289	AAG	225.92	220.40	203.19	249.08	225.11
600290	AAG	180.64	146.68	164.39	138.07	140.06
600291	AAG	128.79	121.18	65.30	56.86	97.74
600292	AAG	184.50	178.98	158.72	206.27	169.39
600293	AAG	96.11	77.20	86.66	66.89	0
600294	AAG	81.82	65.86	86.02	77.21	58.18
600295	AAG	225.32	179.51	189.23	174.28	180.92
600296	AAG	354.74	295.60	381.47	306.17	252.56
600297	AAG	136.79	93.74	112.11	104.71	119.03
600298	AAG	29.81	0.08	25.38	21.96	5.50
600299	AAG	184.17	184.42	182.57	209.22	180.50
600300	AAG	150.27	154.10	0	0	0
600301	AAG	29.24	0.28	2.06	1.37	0
600303	AAG	475.61	386.37	208.62	321.07	278.98
600304	AAG	19.53	0	0	0	0
600305	AAG	186.07	153.27	149.42	210.74	195.61
600306	AAG	0	0	333.18	422.96	0
600307	AAG	166.46	161.66	136.64	0	0
600308	AAG	411.26	525.32	579.55	426.93	279.66
600312	AAG	208.64	206.26	181.51	177.03	181.65
600313	AAG	164.48	170.18	125.63	125.99	148.05
600314	AAG	183.97	197.50	148.13	279.06	379.57
600315	AAG	0	0	0	0	0
600316	AAG	267.43	0	326.59	204.72	188.44
600317	AAG	295.77	347.54	431.02	340.89	309.42
600318	AAG	0	0	0	0	0
600319	AAG	513.04	391.58	373.41	542.44	399.23
600320	AAG	468.96	217.45	283.37	197.19	0
600361	AAG	375.70	351.55	371.78	289.23	322.56
600362	AAG	575.35	1057.82	696.07	812.12	707.12
600363	AAG	310.07	213.07	322.36	332.09	397.23
600364	AAG	672.11	696.17	481.47	737.53	655.70
600365	AAG	675.45	488.91	544.41	367.40	228.32
600366	AAG	835.96	686.06	904.08	72.89	571.17
600370	AAG	300.08	225.21	244.27	196.22	222.58
600372	AAG	849.59	445.91	615.08	430.44	750.65
600373	AAG	690.85	469.22	569.84	427.47	573.75
600375	AAG	506.04	421.26	377.67	488.02	487.09
600377	AAG	711.86	707.91	809.19	517.08	789.00
600378	AAG	271.65	223.15	250.96	214.47	335.43
600379	AAG	449.13	325.63	344.17	414.60	401.55
600380	AAG	356.90	408.66	327.71	321.00	328.18
600381	AAG	537.31	390.49	447.22	480.20	352.13
600383	AAG	397.38	262.52	407.82	322.51	274.78
600385	AAG	395.02	296.57	349.27	388.43	309.62
600386	AAG	389.63	255.90	391.32	302.76	316.03
600388	AAG	318.88	294.14	290.15	243.70	286.78
600389	AAG	304.33	220.35	274.41	181.20	233.18
600390	AAG	394.38	374.45	361.68	412.82	372.61
600391	AAG	281.01	310.60	301.18	229.64	268.64
600392	AAG	311.52	249.84	291.12	286.84	264.09
600393	AAG	335.49	253.66	339.83	211.00	271.92

600394	AAG	307.01	214.00	258.73	243.33	285.19
600395	AAG	353.39	457.38	201.16	217.25	147.52
600396	AAG	466.46	435.79	355.13	397.97	244.60
600397	AAG	295.47	310.57	307.51	300.08	273.60
600398	AAG	357.32	256.81	294.08	342.12	247.22
600399	AAG	545.06	414.48	518.22	484.81	350.55
600401	AAG	464.28	510.47	357.45	575.58	383.43
600402	AAG	355.13	555.20	393.08	244.25	264.63
600403	AAG	366.55	357.50	289.15	250.00	246.26
600404	AAG	446.18	510.19	518.70	472.67	419.03
600405	AAG	226.48	185.47	218.05	209.92	181.06
600411	AAG	905.86	479.46	572.34	705.02	489.85
600412	AAG	358.34	309.06	383.01	297.70	327.41
600413	AAG	470.29	330.51	376.16	370.48	277.61
600414	AAG	269.92	265.67	230.39	235.17	0
600415	AAG	537.00	533.76	554.55	484.30	481.05
600416	AAG	270.14	213.81	299.71	229.24	270.71
600417	AAG	274.07	334.83	286.28	225.44	238.90
600418	AAG	259.67	227.66	281.70	278.42	301.24
600419	AAG	302.88	139.36	232.78	254.34	329.78
600420	AAG	310.62	299.14	309.13	323.78	240.84
600422	AAG	372.59	227.12	258.72	336.29	288.40
600423	AAG	388.76	350.92	278.67	374.83	313.02
600424	AAG	423.52	244.44	425.00	286.02	292.99
600426	AAG	265.32	346.53	270.07	243.24	182.94
600427	AAG	368.81	335.70	323.33	356.27	274.97
600429	AAG	180.17	176.17	200.78	211.65	161.23
600431	AAG	371.85	385.43	324.05	395.42	275.07
600433	AAG	159.97	152.73	156.64	140.30	188.39
600435	AAG	304.72	315.99	291.28	241.16	262.28
600437	AAG	494.31	385.64	377.22	570.07	441.19
600438	AAG	391.33	290.90	398.09	287.77	361.14
600440	AAG	468.09	276.01	406.10	288.61	311.79
600442	AAG	355.48	306.84	307.45	354.69	240.28
600443	AAG	265.76	297.25	256.29	288.27	260.44
600444	AAG	314.90	216.69	253.62	297.14	237.52
600445	AAG	329.20	262.89	383.13	292.18	222.57
600446	AAG	301.01	245.07	311.16	168.20	233.32
600447	AAG	285.49	331.23	212.73	287.51	300.38
600448	AAG	251.36	247.74	141.20	190.21	142.73
600449	AAG	323.79	274.77	386.52	252.12	241.69
600450	AAG	546.86	480.79	533.11	482.33	478.39
600451	AAG	328.77	332.68	299.44	328.16	343.23
600452	AAG	306.55	250.30	338.72	258.52	307.44
600453	AAG	309.07	368.74	381.16	333.37	353.82
600454	AAG	472.99	422.82	332.60	428.62	259.25
600455	AAG	344.40	343.13	362.81	307.36	340.81
600456	AAG	377.39	376.21	304.74	343.36	241.42
600457	AAG	349.79	340.65	382.29	310.34	292.94
600459	AAG	368.78	322.84	408.59	295.25	304.45
600461	AAG	341.50	330.60	255.01	327.96	309.19
600463	AAG	657.41	475.20	457.00	528.60	481.14
600464	AAG	175.85	251.38	299.83	390.00	219.11
600465	AAG	649.01	639.87	600.35	556.30	544.74
600469	AAG	728.15	468.42	598.99	776.19	482.33
600470	AAG	523.71	459.93	478.30	499.49	545.42
600471	AAG	715.24	505.25	555.84	701.57	486.05
600472	AAG	320.80	427.35	351.67	326.35	369.17
600473	AAG	393.46	335.53	317.39	385.66	318.35
600474	AAG	316.43	240.13	303.34	297.71	222.04
600475	AAG	353.84	289.38	328.71	327.37	248.16
600476	AAG	327.87	262.66	261.21	248.61	344.31
600477	AAG	232.50	241.24	282.64	274.30	325.22
600478	AAG	458.22	304.18	307.04	214.64	342.73
600479	AAG	310.32	276.39	388.54	205.84	258.03

600480	AAG	264.19	203.80	339.01	202.58	260.18
600481	AAG	404.66	447.69	451.52	431.74	454.49
600482	AAG	298.76	381.94	310.60	262.01	256.95
600483	AAG	0	0	0	0	0
600484	AAG	357.73	265.16	409.25	297.51	269.15
600485	AAG	362.57	284.85	248.14	318.70	315.90
600486	AAG	0	0	29.39	56.66	40.32
600487	AAG	345.88	416.96	434.76	426.59	360.36
600490	AAG	188.69	206.17	176.12	255.33	160.60
600492	AAG	617.49	432.00	562.76	385.51	344.42
600494	AAG	303.51	300.52	374.47	233.55	285.57
600497	AAG	405.09	331.29	387.43	290.31	248.89
600498	AAG	214.09	175.17	202.94	206.32	147.47
600499	AAG	287.96	292.38	429.28	194.80	270.33
600500	AAG	31.16	0	0	0	0
600501	AAG	106.46	94.99	95.65	113.75	67.79
600502	AAG	352.37	253.48	387.26	227.39	346.38
600503	AAG	483.81	466.46	592.36	532.80	402.45
600504	AAG	0	0	0	0	0
600505	AAG	736.93	532.13	656.63	445.70	486.58
600506	AAG	343.66	378.99	365.47	320.21	320.75
600507	AAG	444.52	353.77	510.45	246.51	389.46
600508	AAG	143.73	128.34	176.65	113.94	166.67
600510	AAG	340.46	312.83	333.50	0	385.60
600511	AAG	156.07	134.45	160.95	127.52	136.40
600512	AAG	208.41	214.55	258.02	202.75	213.11
600513	AAG	265.99	237.33	258.40	202.49	145.76
600514	AAG	162.07	173.52	183.25	181.43	189.79
600515	AAG	156.56	188.69	121.67	159.56	104.91
600516	AAG	91.11	103.68	101.52	67.46	82.68
600517	AAG	208.25	127.60	113.15	124.64	99.57
600518	AAG	217.57	197.37	215.98	217.95	216.34
600519	AAG	201.33	184.65	194.51	184.58	173.67
600520	AAG	236.64	235.47	257.84	169.27	99.22
600521	AAG	497.51	489.87	539.70	360.65	132.42
600522	AAG	288.73	270.08	379.19	230.06	330.01
600523	AAG	168.61	122.12	192.79	94.60	143.61
600524	AAG	164.90	111.20	143.77	60.42	75.66
600525	AAG	138.64	130.97	212.66	119.03	128.32
600526	AAG	149.73	133.69	177.32	144.98	199.14
600527	AAG	347.31	398.64	234.53	309.55	188.54
600528	AAG	274.40	262.86	232.25	259.09	218.70
600530	AAG	469.03	446.21	461.63	455.95	438.20
600531	AAG	249.62	292.32	365.94	266.45	252.97
600532	AAG	462.40	348.99	357.58	258.06	279.13
600533	AAG	111.63	72.79	119.71	97.04	73.60
600534	AAG	243.08	179.52	178.88	169.61	238.47
600535	AAG	307.42	212.45	317.32	265.23	312.62
600536	AAG	71.46	74.37	79.95	48.02	0
600537	AAG	119.90	128.10	114.18	130.20	134.12
600538	AAG	0	0	0	0	0
600539	AAG	347.58	342.52	372.25	405.16	269.90
600541	AAG	479.40	639.04	486.79	510.10	364.65
600543	AAG	452.55	370.76	525.41	402.28	394.36
600566	AAG	530.74	457.98	499.09	529.37	511.24
600567	AAG	383.69	352.06	430.88	328.57	363.97
600569	AAG	272.19	287.77	331.87	270.86	292.73
600570	AAG	901.19	853.92	915.92	679.14	700.56
600602	AAG	416.53	398.64	387.67	557.15	471.53
600603	AAG	556.66	395.06	401.76	493.99	405.45
600604	AAG	150.39	321.54	266.82	169.26	284.69
600605	AAG	515.72	543.12	470.27	477.24	515.32
600606	AAG	875.87	588.64	794.49	549.94	654.52
600608	AAG	385.89	353.91	333.14	299.16	179.68
600629	AAG	579.96	446.58	432.90	565.26	316.55

600633	AAG	427.49	492.14	466.35	451.07	401.79
600634	AAG	424.00	353.79	349.17	372.83	271.53
600635	AAG	71.55	68.37	64.96	50.04	51.68
600637	AAG	415.55	423.83	407.68	431.26	443.24
600638	AAG	659.16	420.57	452.28	603.79	377.34
600639	AAG	758.68	512.92	578.49	661.50	463.84
600640	AAG	462.71	501.21	466.37	469.55	546.84
600641	AAG	271.82	237.46	306.07	249.86	328.54
600642	AAG	351.88	328.83	470.37	286.78	274.41
600643	AAG	306.25	381.04	260.08	346.65	323.72
600644	AAG	506.53	346.87	381.83	427.04	327.98
600645	AAG	450.24	462.92	488.83	340.95	377.47
600646	AAG	364.34	344.55	414.75	329.22	348.12
600647	AAG	248.10	285.58	302.63	317.25	214.81
600648	AAG	245.10	234.06	265.02	211.68	212.79
600649	AAG	316.87	214.59	218.17	252.43	264.77
600650	AAG	299.15	251.70	185.87	205.93	242.40
600651	AAG	898.34	774.84	650.81	676.64	473.36
600652	AAG	240.13	253.79	297.03	222.65	345.07
600653	AAG	439.66	469.09	356.20	389.86	459.32
600654	AAG	274.17	230.94	349.79	337.88	269.40
600655	AAG	325.96	295.45	451.26	309.32	328.82
600656	AAG	650.59	625.86	553.49	692.56	704.23
600657	AAG	184.02	185.96	194.42	217.95	244.73
600658	AAG	437.89	302.58	346.35	342.17	253.97
600659	AAG	266.09	241.91	346.03	221.77	196.86
600660	AAG	448.93	434.24	288.47	370.79	502.92
600661	AAG	395.73	335.72	334.26	264.28	356.56
600662	AAG	441.09	335.71	290.46	300.72	266.01
600663	AAG	357.07	244.42	267.64	357.04	227.41
600664	AAG	363.89	348.08	366.11	281.10	291.77
600665	AAG	312.33	279.73	418.65	240.48	285.12
600666	AAG	311.40	478.18	389.50	321.45	418.13
600667	AAG	460.84	362.65	566.72	358.48	375.54
600668	AAG	326.01	326.21	262.62	285.17	269.21
600669	AAG	462.23	313.79	409.90	437.23	215.86
600670	AAG	286.59	245.48	337.73	214.21	266.28
600671	AAG	313.12	283.63	408.42	315.93	370.15
600672	AAG	353.71	298.45	288.38	321.80	272.10
600673	AAG	286.28	197.57	374.90	250.01	297.45
600674	AAG	309.85	242.79	304.10	208.29	234.40
600675	AAG	667.18	617.96	575.12	617.63	557.51
600676	AAG	589.14	534.22	635.19	502.52	620.49
600677	AAG	457.00	486.55	473.99	360.05	294.46
600678	AAG	527.40	373.25	346.06	372.67	253.40
600679	AAG	482.76	463.76	419.85	463.21	421.40
600680	AAG	284.95	287.84	281.15	273.78	227.00
600681	AAG	802.26	591.71	646.07	610.03	482.35
600682	AAG	526.46	620.57	472.96	518.66	480.39
600683	AAG	261.14	263.49	323.65	235.15	290.30
600684	AAG	520.83	360.90	409.93	364.21	303.19
600685	AAG	257.03	179.67	247.09	154.10	174.19
600686	AAG	457.01	290.64	269.47	361.88	342.09
600687	AAG	210.21	136.72	141.37	190.69	174.99
600688	AAG	426.23	264.71	316.15	364.81	318.61
600689	AAG	331.92	371.15	400.43	476.74	312.23
600690	AAG	583.52	0	0	0	0
600691	AAG	380.19	380.77	580.08	390.08	503.39
600692	AAG	699.21	648.89	718.66	560.29	429.83
600693	AAG	542.68	0.00	0.00	0.00	0.00
600694	AAG	217.65	147.93	259.45	241.46	188.13
600695	AAG	189.54	0	0	0	0
600696	AAG	551.03	84.64	132.75	160.75	178.27
600697	AAG	277.34	365.94	276.89	253.62	276.14
600698	AAG	1201.95	884.16	1016.08	1053.16	1043.69

600699	AAG	378.70	500.81	307.08	213.48	441.99
600700	AAG	399.41	349.35	358.85	324.13	374.47
600701	AAG	424.47	486.44	370.39	331.43	248.92
600702	AAG	211.70	245.76	257.11	301.19	233.80
600703	AAG	396.86	338.88	257.68	273.55	365.22
600704	AAG	489.53	405.30	535.64	410.09	405.42
600705	AAG	301.39	331.89	208.60	290.31	167.96
600706	AAG	511.96	399.24	361.36	414.97	325.16
600707	AAG	274.77	265.84	264.87	306.26	314.61
600708	AAG	625.10	574.44	569.42	339.99	547.65
600709	AAG	429.44	342.47	458.79	414.40	274.85
600710	AAG	378.83	245.57	347.96	264.17	206.30
600713	AAG	108.36	103.64	104.99	103.12	84.46
600714	AAG	370.86	253.41	314.52	210.09	196.99
600719	AAG	26.86	26.85	30.07	22.35	23.52
600721	AAG	266.87	211.50	154.02	111.50	136.54
600722	AAG	324.33	350.40	225.65	274.65	239.13
600783	AAG	261.21	272.76	288.49	243.45	305.12
600836	AAG	641.50	776.82	986.23	1081.32	991.25
600837	AAG	522.08	464.35	561.70	464.55	483.08
600838	AAG	0	0	0	0	0
600844	AAG	309.87	326.21	318.63	248.04	302.35
600848	AAG	339.55	345.49	253.92	404.51	271.58
600850	AAG	325.25	250.51	248.94	187.89	253.54
600853	AAG	0	0	336.90	528.51	293.53
1000014	AAG	0	0	0	0	0
1000015	AAG	75.87	84.41	65.23	73.84	64.19
1000016	AAG	0	0	0	0	0
1000017	AAG	0	0	0	0	0
1000021	AAG	0	0	0	0	0
1000031	AAG	0	0	0	0	0
1000032	AAG	0	0	0	0	0
1000042	AAG	672.38	503.71	26.46	0.82	0
1000050	AAG	0	0	0	46.95	10.41
1000406	AAG	0	0	0	0	0
1000436	AAG	0	0	0	0	0
1000437	AAG	0	0	0	0	0
1000439	AAG	0	552.69	482.16	328.49	411.40
1000440	AAG	0	0	246.12	356.82	224.44
1000443	AAG	0	368.71	462.47	321.76	546.61
1001348	AAG	1177.31	0	40.76	33.31	30.00
1001373	AAG	0	92.14	75.05	66.94	24.70
1001471	AAG	286.89	208.81	183.77	242.20	193.41
1001472	AAG	115.93	128.37	156.81	153.72	96.65
1001484	AAG	0	0	417.08	303.14	356.92
1001529	AAG	0	0	0	381.96	453.53
1001531	AAG	0	699.06	1044.20	858.35	875.66
1001532	AAG	0	0	0	154.19	212.51
1001750	AAG	479.64	769.18	869.82	747.30	594.92
1001764	AAG	0	181.68	225.76	213.96	217.54
1001766	AAG	0	0	0	0	0
1001782	AAG	0	0	0	52.15	53.05
1001783	AAG	0	398.23	371.70	440.55	0
1001854	AAG	0	0	383.13	305.48	352.30
1001861	AAG	0	0	0	0	0
1001877	AAG	0	0	0	0	0
1001878	AAG	0	0	0	0	0
1001882	AAG	0	0	0	0	0
1001884	AAG	0	0	0	0	0
1002934	AAG	0	0	0	0	0
1003220	AAG	0	0	0	0	0
200419	BJGWD	291.44	250.06	245.25	219.86	244.82
200100	BNG	79.84	79.02	77.90	79.89	72.74
200103	BNG	0	0	0	0	0
200247	BNG	225.26	236.86	212.40	257.46	168.13

200424	BNG	42.72	64.04	68.71	0	38.72
200427	BNG	17.03	15.12	19.66	17.68	0.0
200643	BNG	261.32	189.45	252.77	244.89	233.98
200644	BNG	306.51	208.71	203.96	274.10	248.32
500138	BNG	382.87	506.29	429.26	301.43	19.95
500139	BNG	630.94	612.02	444.92	362.15	375.71
500140	BNG	895.41	159.11	591.74	566.86	480.51
500141	BNG	689.07	674.33	587.57	775.60	732.81
500143	BNG	432.44	333.23	439.46	418.31	0
500144	BNG	88.09	61.69	53.62	48.19	63.49
500156	BNG	292.57	656.62	514.54	587.91	666.18
500157	BNG	0	0	0	0	0
500158	BNG	263.36	237.23	272.95	213.94	253.45
500159	BNG	258.04	241.83	285.12	219.53	0
500160	BNG	250.17	283.40	390.27	374.36	249.29
500161	BNG	202.76	239.96	261.06	267.36	177.77
500162	BNG	46.34	3.03	3.47	46.00	31.14
500163	BNG	801.22	778.42	419.40	303.86	332.70
500164	BNG	19.54	18.46	19.25	11.77	17.33
500165	BNG	701.55	591.16	502.70	510.23	401.81
500166	BNG	146.54	150.22	0	124.35	90.41
500167	BNG	252.73	131.29	306.83	312.46	314.99
500168	BNG	344.45	231.43	228.91	248.26	156.41
500169	BNG	673.98	737.48	755.34	543.24	494.95
500170	BNG	336.77	486.41	620.82	551.22	628.29
500171	BNG	229.83	300.06	261.80	283.85	213.26
500172	BNG	558.02	555.18	475.54	652.46	554.17
500182	BNG	816.20	490.33	575.46	540.72	19.95
500183	BNG	868.13	418.12	413.15	561.06	405.85
500184	BNG	611.27	510.30	456.98	546.83	428.04
500185	BNG	322.99	216.69	201.45	168.80	164.44
500186	BNG	663.98	619.19	464.59	426.27	321.14
500187	BNG	501.85	422.02	326.34	328.49	501.16
500189	BNG	166.06	165.54	197.11	174.16	141.42
500190	BNG	238.31	202.95	188.78	178.66	340.19
500191	BNG	585.30	482.68	505.04	406.36	394.33
500192	BNG	241.94	213.98	244.72	214.03	158.05
500193	BNG	540.10	680.31	566.62	488.86	458.66
500194	BNG	545.58	491.42	487.73	459.37	393.32
500195	BNG	455.47	454.91	468.83	385.64	279.18
500196	BNG	306.65	237.67	246.69	294.45	208.02
500197	BNG	469.73	246.69	299.08	256.61	283.42
500198	BNG	846.64	661.24	497.25	711.34	530.92
500200	BNG	725.19	0	0	1265.15	510.85
500201	BNG	598.02	0	0	1785.51	1417.86
500202	BNG	420.14	257.56	248.32	209.24	297.42
500203	BNG	200.34	145.22	163.96	207.87	142.89
500204	BNG	640.73	203.24	482.93	414.02	377.49
500205	BNG	215.47	187.19	336.03	327.54	411.62
500206	BNG	287.57	224.45	606.76	505.40	333.37
500207	BNG	261.51	219.37	175.87	202.18	258.49
500208	BNG	643.63	454.61	392.53	442.28	276.28
500209	BNG	696.99	631.65	571.43	403.63	546.10
500210	BNG	552.19	433.28	849.16	633.86	650.31
500211	BNG	325.48	280.22	338.82	283.25	330.90
500212	BNG	619.63	549.82	565.69	528.44	50.27
500213	BNG	335.37	264.20	226.45	207.60	180.05
500214	BNG	159.19	86.78	102.03	86.65	109.75
500215	BNG	268.48	157.78	193.59	201.99	206.52
500216	BNG	662.60	556.38	479.87	419.82	72.16
500219	BNG	213.14	267.19	154.90	281.22	193.43
500220	BNG	249.64	221.34	193.77	238.00	154.50
500221	BNG	253.00	499.70	141.46	239.26	398.75
500222	BNG	363.23	286.64	225.10	300.65	208.68
500223	BNG	654.47	369.93	300.91	367.87	262.50

500225	BNG	531.05	577.54	638.82	459.23	517.13
500226	BNG	347.30	127.66	128.79	183.11	464.26
500229	BNG	377.43	304.92	312.51	289.32	233.24
500230	BNG	447.95	371.21	266.68	300.04	340.66
500231	BNG	185.15	196.90	138.30	142.17	215.29
500232	BNG	206.91	235.46	209.91	222.42	217.08
500233	BNG	268.05	234.29	196.28	228.89	194.58
500235	BNG	168.17	130.11	136.87	142.97	130.34
500236	BNG	506.80	642.11	657.45	610.19	544.15
500237	BNG	421.82	333.12	173.32	178.34	373.35
500238	BNG	404.79	324.90	325.12	270.66	336.71
500239	BNG	264.33	242.62	302.65	302.65	311.48
500299	BNG	362.36	271.27	243.10	383.38	220.64
500302	BNG	454.53	413.21	288.89	347.64	220.86
500306	BNG	304.37	204.06	194.84	189.34	0
500328	BNG	227.86	479.13	271.38	487.02	313.87
500330	BNG	573.10	424.10	416.95	216.95	329.15
500331	BNG	385.38	497.26	225.10	264.39	309.92
500332	BNG	128.17	108.98	113.33	106.78	105.44
500334	BNG	416.88	363.17	314.56	384.45	301.68
500335	BNG	316.61	428.38	359.31	294.90	136.89
500336	BNG	171.78	149.02	148.14	153.60	144.50
500338	BNG	288.97	412.22	373.76	249.52	207.98
500339	BNG	0	0	0	0	0
500340	BNG	314.88	354.55	394.51	211.22	142.76
500341	BNG	362.87	416.58	378.66	324.20	285.98
500342	BNG	304.67	321.77	316.97	193.44	174.48
500343	BNG	323.06	395.45	233.09	234.65	233.75
500344	BNG	330.12	403.98	263.94	258.34	300.38
500345	BNG	327.69	408.00	210.53	124.11	395.54
500346	BNG	334.57	296.07	424.97	378.63	578.16
500347	BNG	592.90	634.61	542.48	443.42	290.85
500359	BNG	140.54	134.85	224.12	204.93	166.54
500361	BNG	421.18	421.09	271.41	477.15	304.58
500363	BNG	366.18	364.76	327.33	362.76	318.02
500364	BNG	173.38	179.69	152.65	213.18	153.99
500365	BNG	808.18	858.24	181.84	173.39	254.45
500366	BNG	1099.88	1039.83	1104.13	921.81	784.58
500367	BNG	523.26	564.55	536.76	378.27	272.20
500368	BNG	495.60	424.70	610.13	420.15	464.47
500370	BNG	535.83	421.29	318.42	344.73	439.91
500371	BNG	329.73	477.13	370.15	620.38	360.81
500373	BNG	445.56	453.54	462.04	426.91	340.91
500374	BNG	268.30	224.57	305.60	347.48	297.94
500375	BNG	446.27	508.76	313.32	426.33	402.94
500376	BNG	189.88	186.84	142.46	197.72	177.90
500377	BNG	567.50	574.89	585.22	610.75	596.70
500378	BNG	328.00	318.49	257.98	297.29	371.16
500381	BNG	480.47	433.95	448.19	489.04	289.71
500382	BNG	311.07	276.92	264.65	349.42	198.48
500383	BNG	344.28	325.26	307.32	298.15	264.89
500384	BNG	274.51	254.92	352.66	341.50	290.69
500385	BNG	258.91	248.55	225.96	228.07	156.53
500386	BNG	394.81	333.30	564.96	528.05	374.42
500387	BNG	405.14	333.97	398.62	430.31	498.48
500389	BNG	227.28	264.23	308.13	345.59	223.45
500390	BNG	380.03	281.47	286.86	222.82	231.10
500391	BNG	687.52	765.92	595.50	701.23	453.61
500392	BNG	596.56	641.81	549.46	473.33	407.74
500393	BNG	663.66	693.98	632.39	643.98	549.76
500395	BNG	508.51	689.71	622.52	608.24	448.96
500396	BNG	539.03	517.66	599.13	425.52	341.28
500397	BNG	254.04	290.24	226.27	183.05	213.05
500398	BNG	386.77	348.34	217.97	225.72	120.60
500399	BNG	258.77	277.57	212.56	279.52	240.06

500400	BNG	249.01	277.93	665.65	882.89	753.53
500401	BNG	451.95	498.00	581.55	552.19	629.44
500402	BNG	264.61	263.95	240.95	274.20	225.12
500403	BNG	527.30	637.59	221.43	200.48	196.19
500404	BNG	597.84	654.61	453.38	434.89	401.75
500406	BNG	96.76	91.57	99.37	90.53	66.22
500407	BNG	79.86	63.42	77.60	87.25	70.35
500408	BNG	397.18	368.94	433.81	420.88	313.79
500409	BNG	351.89	339.19	403.41	366.78	311.34
500411	BNG	179.51	237.53	140.02	202.96	121.88
500412	BNG	27.26	38.07	3.14	35.44	0.00
500413	BNG	417.85	409.20	450.38	421.76	338.56
500414	BNG	525.28	578.72	521.65	461.91	138.96
500415	BNG	350.97	346.66	473.22	372.05	285.33
500416	BNG	235.14	413.80	486.72	347.25	343.14
500418	BNG	422.34	274.54	312.13	335.14	251.47
500419	BNG	343.35	325.53	342.25	236.56	280.61
500420	BNG	369.05	247.85	327.92	290.50	263.85
500421	BNG	309.53	295.59	255.94	260.87	199.08
500422	BNG	314.13	263.88	296.52	190.60	219.16
500423	BNG	228.86	173.23	273.39	200.25	138.69
500424	BNG	238.55	205.98	297.96	286.67	245.74
500425	BNG	156.17	118.63	138.43	170.65	144.38
500426	BNG	310.62	291.23	245.69	267.94	239.92
500427	BNG	319.71	322.41	310.15	346.09	303.91
500428	BNG	938.33	516.24	499.84	449.34	508.69
500429	BNG	4.98	16.31	2.84	201.41	257.04
500430	BNG	173.74	265.48	1260.28	1015.83	1030.97
500432	BNG	176.39	186.12	323.85	316.88	84.72
500433	BNG	445.05	358.65	346.39	265.46	196.31
500434	BNG	0	0	0	0	0
500436	BNG	417.49	419.07	400.50	339.46	275.72
500437	BNG	633.60	598.01	563.46	762.90	288.46
500438	BNG	249.82	257.98	574.48	975.82	185.62
500439	BNG	460.86	170.45	138.04	133.19	347.49
500440	BNG	249.54	123.14	54.36	0	0
500441	BNG	358.10	468.08	457.41	476.39	395.17
500443	BNG	173.90	101.59	199.35	168.86	338.37
500444	BNG	209.98	179.78	209.62	124.12	105.74
500446	BNG	389.21	745.87	534.92	419.80	184.70
500447	BNG	131.80	169.86	176.27	153.12	122.56
500448	BNG	295.06	297.86	252.73	247.09	177.00
500451	BNG	70.15	79.35	70.31	92.54	61.14
500452	BNG	344.96	529.22	554.67	575.59	290.73
500455	BNG	732.91	598.69	663.10	733.68	629.87
500456	BNG	164.33	137.31	53.92	68.43	61.46
500457	BNG	3.32	1.77	5.41	16.65	25.87
500458	BNG	316.77	252.88	222.57	260.12	572.60
500459	BNG	240.04	196.41	205.63	207.76	182.20
500460	BNG	157.98	183.48	147.66	144.07	169.63
500461	BNG	200.45	167.95	121.84	137.05	123.08
500463	BNG	163.35	140.05	188.63	245.73	160.77
500464	BNG	85.77	81.93	78.28	81.97	68.61
500465	BNG	432.11	390.95	401.64	304.52	210.58
500467	BNG	134.00	129.32	106.45	112.58	77.99
500469	BNG	360.53	323.90	157.18	218.47	171.69
500470	BNG	391.79	502.73	349.80	313.11	261.87
500471	BNG	273.51	326.84	244.69	395.17	272.88
500472	BNG	262.29	268.81	929.29	1503.91	1000.02
500473	BNG	1382.90	1289.27	1086.25	1339.02	1007.00
500474	BNG	301.48	337.57	316.66	286.53	304.94
500475	BNG	586.95	550.71	550.71	562.10	503.91
500476	BNG	62.12	83.76	55.20	42.61	43.18
500477	BNG	89.37	59.38	479.19	543.08	397.77
500478	BNG	541.82	485.24	493.75	385.33	370.06

500479	BNG	257.65	280.97	406.80	452.42	355.04
500480	BNG	304.37	274.66	346.18	331.31	170.37
500481	BNG	0	0	207.84	180.58	190.74
500482	BNG	464.99	351.14	326.38	352.38	245.62
500483	BNG	138.41	283.84	217.60	358.31	0
500485	BNG	330.70	233.94	226.88	226.64	243.64
500486	BNG	107.06	150.67	141.32	106.96	78.78
500487	BNG	299.83	258.66	220.56	192.64	206.31
500488	BNG	217.00	192.68	272.77	214.10	172.21
500489	BNG	248.31	260.60	209.57	219.29	185.30
500491	BNG	280.29	251.52	198.22	181.64	200.26
500492	BNG	206.09	271.71	304.17	324.86	217.41
500493	BNG	170.75	138.61	139.57	143.30	141.65
500494	BNG	117.74	178.13	202.57	201.68	131.47
500495	BNG	27.66	20.65	0	0.69	0
500496	BNG	122.17	109.61	70.88	70.89	66.49
500498	BNG	204.49	208.72	238.03	241.39	186.31
500502	BNG	248.30	226.18	249.30	92.44	97.57
500503	BNG	159.43	126.99	138.68	134.37	28.26
500507	BNG	0	0	0	0	43.87
500508	BNG	0	0	0	0	0
500509	BNG	456.80	478.73	348.07	347.99	415.81
500510	BNG	227.06	199.93	249.39	328.08	222.65
500511	BNG	323.35	273.92	408.26	305.73	304.62
500512	BNG	142.48	115.69	86.48	130.53	99.73
500513	BNG	77.48	93.65	71.43	60.32	55.51
500514	BNG	283.58	251.87	237.01	161.21	164.58
500515	BNG	207.15	174.98	141.23	150.26	191.97
500516	BNG	138.81	124.34	139.54	156.87	212.25
500517	BNG	128.00	116.21	124.95	133.39	77.58
500518	BNG	335.56	462.61	367.31	318.45	223.89
500519	BNG	352.56	386.61	327.68	336.41	258.85
500520	BNG	230.06	320.95	264.25	215.17	241.76
500521	BNG	134.04	120.50	94.75	86.48	101.23
500522	BNG	257.19	227.75	255.87	320.12	260.58
500523	BNG	180.70	138.25	213.69	173.05	104.10
500526	BNG	192.56	176.96	86.55	55.96	66.76
500527	BNG	295.22	320.46	155.81	227.70	196.69
500528	BNG	39.70	40.49	38.82	35.31	0
500530	BNG	249.70	225.70	245.39	197.31	226.53
500532	BNG	62.96	48.84	50.52	54.09	53.39
500533	BNG	100.68	102.87	96.50	101.43	96.69
500534	BNG	0	0	18.76	14.48	14.71
500536	BNG	226.19	254.60	257.20	283.49	201.34
500537	BNG	136.32	107.61	66.37	78.13	52.82
500538	BNG	909.93	777.68	416.14	398.90	320.61
500539	BNG	642.37	567.36	358.97	355.11	439.23
500540	BNG	51.93	38.26	62.44	64.69	81.74
500541	BNG	436.98	255.30	324.22	243.79	282.16
500542	BNG	184.42	107.39	136.70	131.01	0
500544	BNG	136.60	115.69	115.43	94.29	79.27
500545	BNG	406.95	338.74	306.87	329.40	382.12
500546	BNG	269.96	212.18	253.86	303.39	161.98
500547	BNG	212.48	169.95	160.13	220.41	91.01
500548	BNG	190.30	138.53	219.14	191.12	626.23
500549	BNG	350.16	393.36	382.22	370.28	446.70
500550	BNG	237.79	172.94	52.94	73.02	99.67
500552	BNG	127.44	104.43	50.86	54.40	46.18
500553	BNG	369.56	359.14	275.13	258.09	0
500554	BNG	155.26	115.33	176.67	133.83	167.27
500555	BNG	107.96	114.79	81.33	86.03	125.71
500556	BNG	129.81	101.47	113.34	100.58	0
500557	BNG	243.28	184.51	0	0	0
500560	BNG	82.96	90.63	139.63	129.35	137.48
500561	BNG	304.03	279.32	262.22	231.71	254.19

500562	BNG	486.43	432.61	398.37	363.37	336.98
500563	BNG	37.66	55.33	42.52	39.29	0.00
500564	BNG	130.33	108.92	125.02	116.99	93.74
500566	BNG	0	0	0	0	0
500568	BNG	185.86	124.93	136.01	160.84	114.55
500569	BNG	0	0	0	0	0
500580	BNG	284.19	260.29	277.49	292.38	210.19
500581	BNG	113.77	89.36	89.63	79.10	103.01
500582	BNG	29.53	31.40	24.83	26.60	20.12
500583	BNG	255.23	299.49	170.60	195.40	258.40
500584	BNG	86.18	125.72	121.95	84.43	44.96
500586	BNG	227.50	163.69	187.80	177.44	138.91
500587	BNG	66.20	62.99	72.33	82.99	57.91
500598	BNG	156.75	117.64	111.25	114.03	89.45
500599	BNG	78.01	76.07	50.47	45.09	31.00
500600	BNG	0	0	378.04	365.02	341.52
500601	BNG	284.43	255.03	246.31	238.74	199.67
500602	BNG	204.77	195.00	169.08	242.99	162.36
500619	BNG	0	0	0	0	0
500686	BNG	322.97	252.29	261.82	262.32	181.39
500687	BNG	331.90	274.70	192.68	226.03	142.78
500688	BNG	259.35	235.69	197.81	235.88	129.44
500689	BNG	320.03	263.48	245.58	299.09	168.94
500690	BNG	184.06	229.74	211.76	187.66	185.51
500691	BNG	525.76	571.29	421.79	412.80	436.81
500708	BNG	463.77	503.77	508.06	418.18	388.08
500721	BNG	736.71	676.61	589.50	0	0
500724	BNG	318.80	341.26	292.40	408.71	252.58
500725	BNG	267.39	311.73	307.44	359.91	285.59
500726	BNG	795.31	792.34	659.37	888.45	375.87
500727	BNG	329.93	373.93	395.78	270.70	333.32
500728	BNG	339.73	253.65	204.22	202.36	214.44
500729	BNG	398.33	325.01	276.18	202.18	181.29
500730	BNG	343.58	259.85	378.50	249.25	247.74
500731	BNG	0	0	0	0	0
500732	BNG	302.94	349.39	248.70	274.78	200.06
500733	BNG	195.72	233.29	235.87	214.30	200.43
500734	BNG	309.56	234.42	337.09	257.67	222.28
500736	BNG	0	0	326.48	293.14	164.98
500737	BNG	0	0	304.28	265.52	153.44
500739	BNG	0	0	790.79	636.69	463.09
500740	BNG	0	0	292.67	299.62	291.18
500742	BNG	38.57	508.19	680.40	629.97	535.45
500743	BNG	0	0	653.59	458.29	493.76
500745	BNG	0	0	844.05	1294.40	910.03
500748	BNG	0	0	93.86	180.05	120.77
500749	BNG	77.81	84.78	131.92	109.91	59.79
500751	BNG	218.67	310.38	182.48	211.15	179.15
500752	BNG	0	0	0	0	0
500753	BNG	613.59	524.41	329.11	403.64	286.10
500754	BNG	137.89	178.72	184.80	291.84	149.48
500755	BNG	368.18	178.96	305.09	203.36	376.11
500756	BNG	297.53	332.41	296.56	0	0
500757	BNG	95.38	109.96	159.73	130.21	102.61
500758	BNG	79.41	82.97	69.60	42.17	38.73
500759	BNG	163.12	140.64	284.23	316.47	279.25
500760	BNG	182.95	192.88	179.48	227.97	137.47
500761	BNG	280.45	328.00	270.51	398.41	215.07
500762	BNG	354.28	0	405.86	348.92	259.09
500763	BNG	103.01	89.55	135.63	132.44	69.70
500764	BNG	169.91	142.01	121.12	134.48	138.21
500765	BNG	316.84	317.10	256.95	255.67	147.73
500766	BNG	328.85	247.40	302.81	217.81	214.56
500767	BNG	222.89	224.55	205.38	277.09	93.84
500768	BNG	270.87	218.13	247.42	171.50	198.69

500769	BNG	488.95	389.68	263.77	184.59	212.29
500770	BNG	178.20	329.92	218.50	351.44	181.49
500771	BNG	290.40	220.44	276.08	215.87	246.18
500772	BNG	214.35	0	189.95	293.70	246.34
500773	BNG	348.23	421.31	314.84	397.79	230.94
500774	BNG	243.12	212.46	295.74	216.27	241.33
500776	BNG	203.86	319.96	326.65	248.96	231.61
500777	BNG	370.35	365.51	375.25	378.05	268.19
500778	BNG	234.38	216.00	245.69	298.66	173.70
500779	BNG	378.35	357.12	377.24	414.72	274.77
500780	BNG	462.07	361.79	338.57	308.21	267.78
500781	BNG	708.04	503.90	720.60	474.03	180.50
500782	BNG	259.29	288.73	251.80	226.09	194.13
500783	BNG	162.71	190.03	230.61	168.33	161.71
500784	BNG	244.66	239.35	216.01	217.39	166.13
500785	BNG	320.59	351.45	227.37	392.55	181.62
500786	BNG	524.90	412.45	469.05	328.21	304.98
500787	BNG	276.21	241.56	213.94	154.28	164.54
500788	BNG	188.56	174.24	306.04	371.65	498.34
500789	BNG	213.55	218.24	183.78	283.12	404.96
500790	BNG	74.98	59.65	66.09	58.00	30.92
500791	BNG	122.69	116.15	131.06	99.88	110.68
500792	BNG	249.68	226.15	194.79	253.31	210.02
500793	BNG	212.07	199.75	164.57	130.94	183.75
500794	BNG	25.18	34.06	51.31	47.87	30.11
500795	BNG	401.16	205.94	245.28	225.55	187.96
500797	BNG	367.01	329.14	319.41	313.36	140.51
500798	BNG	294.68	286.37	264.36	189.53	255.65
500800	BNG	162.37	161.69	166.96	129.97	136.11
500801	BNG	151.49	137.68	173.75	133.72	128.54
500802	BNG	194.23	137.33	135.12	110.15	100.24
500803	BNG	230.08	177.46	168.19	209.22	122.58
500804	BNG	202.08	185.98	316.92	517.58	105.76
500805	BNG	247.32	286.58	247.45	387.19	243.17
500806	BNG	277.26	313.23	662.64	1106.77	226.93
500807	BNG	182.04	271.82	133.78	125.41	161.42
500808	BNG	239.79	197.52	189.84	246.53	154.02
500809	BNG	252.29	262.94	335.04	259.21	353.66
500810	BNG	250.14	332.08	269.75	231.35	277.99
500811	BNG	269.16	267.13	312.32	404.95	252.72
500812	BNG	336.40	311.35	173.14	242.59	186.86
500813	BNG	276.53	280.98	255.17	356.42	334.99
500814	BNG	0	0	0	0	0
500815	BNG	462.56	578.24	447.83	537.97	476.58
500816	BNG	237.33	215.66	254.99	254.87	261.00
500817	BNG	571.74	511.03	443.19	385.09	470.31
500818	BNG	390.00	352.53	332.55	221.14	267.14
500819	BNG	300.38	283.13	200.45	177.87	171.96
500820	BNG	188.29	272.85	265.28	243.88	220.53
500821	BNG	126.79	220.52	127.76	190.77	144.61
500822	BNG	194.73	179.23	188.46	56.37	104.08
500823	BNG	225.74	188.10	146.93	0	123.67
500824	BNG	325.17	503.31	479.31	457.44	313.56
500825	BNG	191.07	172.67	575.89	473.00	448.84
500826	BNG	0	0	258.07	291.47	208.53
500827	BNG	125.82	103.47	84.24	74.55	74.65
500828	BNG	354.18	285.07	469.10	0	230.93
500829	BNG	182.45	148.24	126.74	122.65	125.68
500830	BNG	411.42	329.93	271.82	394.80	231.78
500831	BNG	142.15	182.29	193.02	278.69	197.02
500832	BNG	180.18	221.73	208.70	149.92	115.41
500833	BNG	187.66	198.37	423.81	603.80	373.17
500834	BNG	129.57	132.11	279.23	352.66	272.31
500835	BNG	73.09	95.44	85.07	88.31	201.61
500837	BNG	245.85	243.40	277.68	353.67	320.61

500838	BNG	368.84	329.05	318.95	306.56	227.33
500839	BNG	0	0	0	0	0
500840	BNG	139.30	0.73	0	0	0
500841	BNG	217.62	153.54	300.15	315.05	236.96
500842	BNG	243.25	267.81	228.27	237.37	278.19
500843	BNG	260.55	290.28	257.44	228.65	0.00
500845	BNG	106.53	95.11	84.54	110.37	181.38
500846	BNG	38.66	35.84	40.57	29.17	20.01
500847	BNG	326.67	356.48	292.32	283.26	224.13
500849	BNG	270.34	211.24	501.31	476.95	434.60
500850	BNG	550.59	563.34	397.58	274.85	248.17
500852	BNG	112.51	106.81	96.27	114.76	81.91
500853	BNG	198.07	211.28	202.73	212.65	192.97
500854	BNG	321.88	246.98	208.75	0	180.83
500855	BNG	257.81	164.38	249.17	293.16	227.14
500856	BNG	19.77	14.03	13.05	9.84	6.51
500857	BNG	278.29	215.25	201.61	202.15	166.52
500858	BNG	228.47	189.86	162.57	70.35	56.68
500859	BNG	123.54	111.80	107.40	121.83	115.82
500860	BNG	109.05	141.54	126.59	111.70	95.04
500864	BNG	334.07	298.30	305.70	310.50	176.95
500866	BNG	28.38	19.21	20.77	20.70	18.32
500867	BNG	0	0	21.12	23.00	17.97
500869	BNG	59.95	41.86	15.18	19.73	14.76
500870	BNG	35.15	27.83	47.61	48.34	43.69
500871	BNG	346.81	251.46	166.83	157.76	123.16
500872	BNG	219.29	130.88	167.91	128.56	131.80
500874	BNG	76.60	77.52	83.80	73.83	58.47
500875	BNG	285.38	184.82	211.22	159.72	155.31
500876	BNG	207.44	261.77	247.44	342.65	215.43
500877	BNG	122.17	221.42	119.32	170.67	118.94
500878	BNG	39.22	37.43	22.49	31.40	24.85
500879	BNG	207.96	151.30	177.95	193.69	137.99
500880	BNG	108.68	102.53	115.71	102.53	80.80
500881	BNG	44.03	36.12	65.73	48.61	32.14
500883	BNG	0	0	163.34	0	136.06
500884	BNG	62.46	50.27	47.41	45.18	48.55
500885	BNG	520.70	351.77	338.44	342.12	391.64
500886	BNG	65.74	63.11	60.67	73.68	55.09
500887	BNG	225.26	237.12	191.14	248.80	197.11
500888	BNG	498.14	373.40	447.25	532.83	641.93
500889	BNG	340.22	421.01	286.20	306.40	293.47
500890	BNG	135.46	141.67	260.80	287.83	200.25
500891	BNG	297.38	236.14	219.33	251.00	256.51
500892	BNG	14.24	14.76	23.77	15.45	6.85
500894	BNG	307.69	291.74	256.58	306.73	298.21
500895	BNG	202.51	201.94	162.30	235.17	165.13
500896	BNG	303.54	295.49	259.87	286.48	246.63
500897	BNG	265.24	235.45	266.24	260.65	294.68
500898	BNG	235.31	239.14	356.08	333.37	208.23
500899	BNG	16.48	13.88	15.48	11.07	18.73
500901	BNG	35.73	32.28	21.84	18.03	16.67
500902	BNG	445.17	354.45	373.08	371.24	387.42
500903	BNG	26.16	28.48	33.61	26.18	20.60
500904	BNG	40.37	42.44	46.02	58.30	42.53
500906	BNG	0	0	0	0	0
500913	BNG	612.26	674.20	354.74	301.98	66.97
500914	BNG	159.39	156.30	152.05	122.66	98.14
500915	BNG	0	0	149.83	130.89	0
500917	BNG	68.69	75.10	96.75	87.83	0
500918	BNG	103.92	72.56	547.59	492.49	399.02
500919	BNG	140.51	117.48	60.87	41.58	58.03
500921	BNG	206.35	204.23	476.77	329.98	138.79
500922	BNG	66.25	86.17	71.65	78.68	59.85
500923	BNG	26.37	22.72	36.06	31.14	24.11

500925	BNG	122.34	128.98	127.68	102.50	131.63
500926	BNG	374.73	301.61	220.16	300.70	160.73
500927	BNG	48.65	45.05	40.05	60.73	29.65
500928	BNG	259.80	288.15	195.41	239.64	171.43
500929	BNG	0	0	0	0	278.63
500930	BNG	205.73	305.93	364.24	422.41	321.88
500931	BNG	250.98	232.09	241.41	217.70	214.09
500934	BNG	0	0	244.56	217.70	199.19
500935	BNG	219.61	269.09	193.08	225.70	89.94
500936	BNG	388.93	273.63	225.94	332.64	197.66
500948	BNG	186.05	169.33	341.83	267.61	242.06
500949	BNG	165.87	142.37	88.76	138.21	137.91
500950	BNG	178.10	190.46	63.00	53.31	56.11
500951	BNG	250.93	160.83	186.95	161.09	123.98
500952	BNG	122.18	67.95	115.89	128.39	76.95
500953	BNG	107.00	96.22	124.64	148.86	122.84
500954	BNG	226.19	166.57	251.06	255.90	218.39
500955	BNG	285.32	258.88	235.66	213.44	186.20
500956	BNG	136.61	138.88	192.16	184.43	137.00
500957	BNG	337.23	216.47	289.66	318.51	168.44
500958	BNG	193.96	144.72	191.70	218.95	124.01
500966	BNG	0	0	42.96	53.50	25.05
500982	BNG	126.12	200.95	270.78	209.13	136.15
500983	BNG	226.64	220.86	414.03	355.31	212.88
500984	BNG	94.76	92.95	55.37	43.38	41.63
500985	BNG	121.97	117.15	156.67	0	128.87
500986	BNG	160.76	117.72	246.21	257.18	117.24
500987	BNG	153.27	166.77	101.18	158.31	115.30
500988	BNG	177.70	127.83	298.68	250.58	212.50
500989	BNG	203.08	209.87	170.69	182.01	194.70
500990	BNG	157.88	143.37	187.62	135.80	108.56
500991	BNG	388.85	519.71	475.76	449.17	392.61
500992	BNG	96.49	66.42	58.31	0	0
500993	BNG	238.21	219.06	290.94	222.33	185.19
500994	BNG	288.73	255.39	217.01	311.33	204.60
500995	BNG	309.44	339.67	274.06	771.44	652.74
500996	BNG	130.45	152.51	82.17	77.81	49.71
500997	BNG	198.22	187.38	178.55	180.76	152.89
500998	BNG	152.26	195.42	186.75	156.71	107.40
500999	BNG	329.58	329.79	243.05	273.62	179.89
501002	BNG	283.96	266.42	276.74	193.29	174.31
501003	BNG	0	0	59.13	68.17	58.14
501004	BNG	158.92	147.62	0	0.09	101.94
501005	BNG	125.25	138.25	117.15	104.00	100.06
501006	BNG	93.49	56.17	66.25	70.69	71.59
501007	BNG	344.84	296.50	257.65	235.36	396.43
501008	BNG	385.88	223.06	299.88	219.07	26.39
501009	BNG	0	0	0	282.96	99.26
501010	BNG	49.40	43.98	51.86	0	0
501011	BNG	383.93	375.13	496.19	310.41	409.95
501012	BNG	291.61	320.48	342.34	145.62	230.05
501013	BNG	225.62	249.39	290.32	333.76	197.80
501014	BNG	170.50	148.02	168.23	189.17	152.95
501015	BNG	247.05	230.13	246.55	269.75	47.18
501016	BNG	21.97	31.51	38.65	30.45	0
501018	BNG	92.36	78.28	92.52	105.24	96.35
501019	BNG	219.75	183.76	68.30	417.00	232.01
501020	BNG	494.86	304.92	350.68	483.59	364.82
501021	BNG	365.46	266.70	302.87	354.25	509.85
501022	BNG	529.77	644.75	647.86	456.32	416.14
501023	BNG	281.29	226.83	165.13	256.51	128.90
501024	BNG	304.67	292.58	336.58	341.68	271.30
501025	BNG	0	0	0	0	0
501026	BNG	186.83	205.14	283.74	240.12	189.08
501028	BNG	316.72	296.07	331.30	275.65	320.84

501029	BNG	297.71	336.95	339.44	224.55	260.28
501030	BNG	352.30	309.03	192.22	210.42	172.85
501031	BNG	247.53	246.32	243.42	270.14	205.01
501032	BNG	262.95	271.41	245.73	146.25	119.08
501033	BNG	263.38	267.88	331.26	258.78	231.80
501034	BNG	341.47	329.39	316.32	283.64	302.56
501035	BNG	414.33	387.09	394.78	345.26	260.33
501036	BNG	538.39	489.21	151.34	393.13	312.70
501038	BNG	327.13	425.20	273.09	395.39	444.12
501039	BNG	102.80	90.72	108.20	125.36	93.40
501041	BNG	238.63	230.45	169.79	168.05	147.49
501054	BNG	259.17	263.03	248.66	187.44	169.47
501055	BNG	670.10	559.68	817.97	327.83	215.62
501056	BNG	253.68	348.75	253.52	175.46	117.68
501057	BNG	454.64	423.40	106.21	183.59	220.11
501058	BNG	0	0	0	0	0
501059	BNG	0	0	0	0	0
501067	BNG	178.60	115.94	118.83	132.03	135.91
501068	BNG	0	0	0	0	0
501070	BNG	102.29	81.18	66.15	84.94	53.69
501071	BNG	0	0	0	0	0
501073	BNG	60.25	68.89	52.94	53.51	53.52
501074	BNG	364.40	340.62	411.01	304.95	297.68
1000019	BNG	0	0	0	0	0
1000020	BNG	0	0	0	0	0
1000027	BNG	0	0	0	0	0
1000057	BNG	76.83	101.92	81.87	66.97	67.00
1000333	BNG	29.46	22.54	12.47	14.72	6.23
1001374	BNG	0	0	0	0	0
1001375	BNG	0	0	0	0	0
1001704	BNG	0	0	0	0	0
1001824	BNG	0	0	0	0	103.46
1001827	BNG	626.37	485.69	400.73	408.47	0
1001869	BNG	0	0	0	0	0
1001871	BNG	0	0	0	0	0
1001892	BNG	0	0	0	0	0
1001907	BNG	0	0	0	0	0
1001908	BNG	0	0	0	0	0
1001910	BNG	0	0	0	0	0
1001913	BNG	0	0	0	0	0
1001915	BNG	0	0	0	0	30.82
1001916	BNG	0	0	0	0	0
1001917	BNG	0	0	0	0	0
1001918	BNG	0	0	0	0	0
1001919	BNG	0	0	0	0	0
1001923	BNG	0	0	0	0	0
1001999	BNG	0	0	0	0	0
1002423	BNG	0	0	0	0	0
1003171	BNG	0	0	0	0	0
1003214	BNG	0	0	0	0	0
Total Annual Diversion		**334869.54**	**305063.76**	**316793.17**	**306755.45**	**270548.02**
5-Year Average						**306805.99**

APPENDIX 2: APPROVED APPLICATION FOR TEMPORARY WATER RIGHT

RECEIVED
OCT 27 2017
Department of Water Resources
Eastern Region

Form 202A 04/17

ID No. TP-35-17

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR TEMPORARY APPROVAL OF WATER USE

For a use not intended to become an established water right and not to exceed one (1) year in duration in accordance with Idaho Code § 42-202A.

Name of applicant Aberdeen-Springfield Canal Company Phone (208) 397-4192

Mailing address PO Box 857, 144 S Main City Aberdeen

State ID Zip 83210 Email heatherb@ascanal.org

1. Source of water Ground Water tributary to ______

2. Location of point(s) of diversion. If more than two, attach a Point of Diversion/Place of Use Supplement. ☐

TWP	RGE	SEC	GOVT LOT	¼	¼	¼	County	Source	Local name or tag #
07S	30E	26		NW	NW	NW	Power	Ground Water	

3. Location of place of use. If more rows are needed, attach a Point of Diversion/Place of Use Supplement. ☐

TWP	RGE	SEC	NE				NW				SW				SE				Totals
			NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	
07S	30E	26						X											

4. Proposed use of water:
   a. ☐ Prevention of flood damage ☐ Ground water recharge ☐ Ground water or surface water remediation
      ☒ Other (Limited to a diverted volume of 5 acre-feet.) Describe: pumping test
   b. Attach a detailed description of how the proposal will accomplish the intended objective, such as prevention of flood damage.

5. Amount of water. Complete all three:
   a. Maximum rate of diversion: 2.52 cfs; or 1131.43 gpm.
   b. Maximum daily volume: 5 AF; or 1,629,257 gallons.
   c. Maximum volume over the duration of the request: 5 AF; or 1,629,257 gallons.

6. Duration of diversion: from Nov. 1, 2017 (month-day) to Nov. 15, 2017 (month-day).

7. Describe proposed diverting works: Existing well in place with flow meter

8. a. Who owns the property at the requested point of diversion? Aberdeen-Springfield Canal Company
   b. Who owns the facilities that will convey water to the place of use? Aberdeen-Springfield Canal Company
   c. Who owns the land to be irrigated or place of use? no lands will be irrigated
   d. If any of the items above is owned by a person or entity other than the applicant, describe the arrangement allowing access and attach written evidence of the arrangement. n/a

9. Attach an 8 ½" x 11" map identifying the water source, point(s) of diversion, place(s) of use and conveyance system.

I hereby acknowledge that I assume all risk of the diversion and use of the water under this approval. I certify this is a temporary use and is ~~not~~ intended to become an established water right.

[signature] General Manager 10/24/2017

Signature of Applicant Title, if any Date

Received by ______ Date ______ Time ______

$50.00 fee receipted by [initials] # E043520 Date 10-27-2017

Watermaster comments received? ______ Date ______

Form 202A 04/17

ID No. TP-35-17

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

The Idaho Department of Water Resources ("Department") has examined this application for temporary approval to use water under the provisions of Idaho Code § 42-202A and has determined that:

___ A. The application for temporary approval should be denied because ______________________

____

____

✓ B. The application for temporary approval should be approved, since

1. The temporary approval can be properly administered.
2. Other water sources are not readily available.
3. The approval is in the public interest.
4. The approval will not injure known public values associated with the water source or any known water rights.
5. If the temporary approval is within a water district, the Department has sought and considered the recommendations of the watermater.

This application is therefore hereby:

___ A. DENIED

✓ B. APPROVED, subject to the following conditions:

1. Diversion and use of water under this approval is subject to all valid existing water rights.
2. The applicant assumes all risk of the use of the water under this approval.
3. This approval authorizes a maximum diversion volume of 5.0 AF and a maximum diversion rate of ______ cfs.
4. This approval does not grant a right-of-way across the land of another.
5. The Department may cancel or reduce the rate of flow or volume authorized by this approval. For example, the Department may cancel or reduce this approval if it concludes the water use is injuring other water rights or adversely affecting fish, wildlife or other public values.
6. The applicant shall not divert water when downstream minimum flow water rights are not being satisfied.
7. This approval does not create a continuing right to use water.
8. A temporary approval for ground water recharge or prevention of flood damage shall be an opportunistic use of surplus water and shall not interfere with the filling of surface water reservoirs.
9. For a temporary approval authorizing ground water recharge or ground water or surface water remediation, the applicant shall measure and record the weekly quantity of water diverted and report the diversion data to the Department upon request.
10. This temporary approval is not an authorization for the described water use to be used as mitigation or credit for any other purpose.
11. Other: ______________________
12. This approval expires on November 15. 2017.

Signed this 2nd day of Nov, 2017.

Lyle Swank

For the Department